WOODY BIOMASS

Desk Guide & Toolkit

National Association of Conservation Districts
conserving
natural resources
for our future

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WOODY BIOMASS

Desk Guide & Toolkit

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Foreword

Since 2002, the National Association of Conservation Districts (NACD) has been working in partnership with the Department of the Interior and the U.S. Forest Service in helping to implement the National Fire Plan and related efforts to help reduce hazardous fuels through increased utilization of woody biomass.

Over the years we have published several booklets regarding the role of conservation districts in implementing the National Fire Plan. Since the publication of these documents many conservation districts have become more actively involved in fire prevention and rehabilitation activities in their communities.

NACD, at the encouragement of our Department of the Interior and U.S. Forest Service partners, has embarked in an effort to develop a set of three new desk guides and "toolkits" for use by the nation's conservation districts in assisting their communities with increasing concerns over forest health, energy, and local economies. In short, the topics for these three new desk guides involve woody biomass utilization; community wildfire mitigation; and handing woody debris after major disasters.

This "Woody Biomass Desk Guide and Toolkit" is the first in the series and is designed to serve as an easy to use "how-to" handbook for conservation district leaders in working with their communities. It is also readily applicable for use by county extension agents and leaders of Rural Conservation and Development Districts as well as other community-based organizations. The primary focus of this Desk Guide and Toolkit is the utilization of woody biomass as an energy feedstock. However, other potential uses and opportunities can be found in the ensuing pages.

Please use this Desk Guide to motivate and educate your community on the many opportunities associated with utilizing woody biomass to enhance the environment while, at the same time, developing creative solutions to address energy needs and stimulating local economies.

Charles Holmes, Chair
NACD Forestry Resources Planning Group

Acknowledgements

The need for educating landowners, local leaders, and the public about woody biomass production and utilization for renewable energy and other biobased products is becoming increasingly important. The various advantages, disadvantages, challenges, and opportunities of woody biomass must be considered when evaluating its potential as a resource. We hope that this Woody Biomass Desk Guide and Toolkit will help assist agencies and individuals who work to increase awareness about biomass utilization and empower landowner, community, and industry decision making. We are grateful to the team of talented and dedicated people who helped write, review, edit, and design the content for this guide. Their contributions are greatly appreciated. We specifically would like to thank the following individuals:

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Introduction

Purpose Of The Desk Guide And Toolkit

Communities today are challenged to develop effective strategies that support forest ecosystem health, mitigate the effects of climate change, satisfy growing energy needs, and provide local economic opportunities. For some communities, woody biomass may be a viable option for meeting these needs and deserves serious consideration. Forests in the United States represent an important potential energy and biobased product resource. The National Association of Conservation Districts (NACD), in collaboration with federal, state, and local partners is working to raise awareness about the potential for woody biomass as a primary feedstock for such products.

This Woody Biomass Desk Guide and Toolkit provides an overview of woody biomass production and utilization in the U.S., tips of how to provide effective outreach for your clientele, and educational handouts to share with your audiences. The purpose of this guide is to equip natural resource professionals and outreach specialists with the information and tools needed to increase awareness of the use of woody biomass for energy in the U.S. All of the materials in the guide are available at:

http://nacdnet.org/resources/guides/biomass/

Who Should Use the Woody Biomass Desk Guide and Toolkit?

This Guide is designed for use by conservation district, Resource Conservation & Development and Extension professionals throughout the U.S. It also contains handouts and other resources to assist in educating respective audience.

Using the Desk Guide and Toolkit

The Woody Biomass Desk Guide and Toolkit is a comprehensive guide comprised of reference sections, handouts, case studies, an introductory PowerPoint presentation, Frequently Asked Questions, a glossary, and additional resources. Here, each of these sections is explained in greater detail.

Reference Sections

The Woody Biomass Desk Guide and Toolkit consists of eight chapters. Each of the first seven chapters, contains a reference section, which provides background and overview information for natural resource professionals and outreach specialists. In textbook format, the reference sections are designed to increase understanding of the basic concepts for producing and using woody biomass for energy, transportation fuels, and other bioproducts. Additionally, the reference sections serve as a quick reference guides to answer questions from clients or the public about the production and utilization of woody biomass.

Handouts

In addition to the reference sections, most of the chapters also contain handouts. These outline important points, strategies, and information that may be useful for landowners, the public, local leaders, or other audiences.

Case Studies

Chapter 8 of the Guide is a compilation of case studies. Sometimes new concepts are easier to explain with examples. As such, these case studies provide examples of both the challenges and successes of existing or planned woody biomass production and utilization projects throughout the U.S. Case studies highlight relevant points found throughout the Guide and Toolkit and may be used as background reading or outreach handouts.

PowerPoint Presentation

The Microsoft PowerPoint® presentation included with this Guide provides a detailed introduction designed for an audience interested in learning more about woody biomass production and utilization. You can simplify this presentation or modify it to address the particular topic area you need to cover or for the particular audience or geographic location you are addressing.

Frequently Asked Questions

Towards the end of this guide is a set of frequently asked questions with answers (appendix A). These questions were collected during a series of community forums conducted by the University of Florida, and the answers were provided by experts in the wood-to-energy field. The FAQs provide insight into the concerns and misconceptions that the public has about using wood for energy. This resource may help you prepare to answer similar questions from your audiences. Additional questions from the U.S. Department of Energy, Biomass Programs website are also included in the list.

Glossary

A glossary of terms related to woody biomass production and utilization (appendix B) labeled is provided at the end of this guide to familiarize you with relevant terms.

Resources

A bibliography of books, articles, Web sites, programs, and other tools pertaining to woody biomass production and utilization is included in appendix C. These resources can help you expand your library and knowledge about woody biomass and may also be used to supplement the handouts for outreach activities.

Desk Guide and Toolkit Chapter Topics

Chapter 1– *Setting the Stage*

This chapter introduces the environmental, energy, economic, and social issues that are shaping the potential for woody biomass as an alternative to fossil fuels.

Chapter 2 – *What is Biomass?*

Chapter 2 provides a general overview of biomass types and sources and more comprehensive information on woody biomass, specifically.

Chapter 3 – *Products and Possibilities*

Electricity and ethanol are just two possible products that can be produced from woody biomass. This chapter introduces the major processes—thermochemical, biochemical, and chemical—used to convert woody biomass into products such as heat, biodiesel, char, specialty chemicals, and more.

Chapter 4 – *Implications of Producing and Using Woody Biomass*

This chapter explores, in detail, the environmental, economic, and social implications (costs and benefits) of producing and using woody biomass for bioenergy and other biobased products.

Chapter 5 – *Incentives to Produce and Use Woody Biomass*

Chapter 5 outlines many of the policies and incentives that exist nationally and at the state and local levels which influence woody biomass production and utilization. Becoming familiar with these policies and incentives can help you better assist and advise your clients or audience.

Chapter 6 – *Do-It-Yourself Supply Curve: Tools to Help You Get Involved in an Entrepreneurial Biomass Project*

The feasibility of woody biomass utilization projects depends, to a significant extent, on the cost and availability of wood resources. One way to illustrate the economic availability of the biomass resources is with supply curves. This chapter introduces several tools that you can use to construct supply curves for woody biomass resources in a particular area. These tools may be useful to potential suppliers and users of biomass or to communities considering using biomass.

Chapter 7 – *Outreach and Education*

Chapter 7 provides tips and tools for engaging in effective woody biomass outreach activities. Whether you are designing a community-wide outreach program or giving a brief slide presentation on woody biomass, this chapter may be helpful.

Chapter 8 – *Case Studies*

As previously mentioned, case studies can be an excellent resource to increase understanding, provide insight, and make concepts like woody biomass more conceivable. There are many woody biomass production and utilization projects underway throughout the U.S. This chapter provides several examples of woody biomass use for a variety of locations, scales, and applications that can be used for background reading or handouts for your audiences.

Strategies for Using the Resources

You can pick and choose from the materials in this Guide and Toolkit to create the outreach strategy or program that best meets your objectives. Whether you need to give a thirty-minute presentation to your local county commission or conduct a week-long professional development training for consulting foresters, the resources in this program can help. See chapter 7 for specific ideas on how you can use the resources in this program to provide effective outreach to your target audience.

A Special Note

This Woody Biomass Desk Guide and Toolkit was adapted from two programs: The Sustainable Forest Management for Bioenergy and Biobased Products Trainer's Curriculum Notebook (http://www.forestbioenergy.net) and the Wood to Energy Biomass Ambassador Guide (http://www.interfacesouth.org/woodybiomass). Both of these programs contain a variety of information for those working with the public, landowners, community leaders, and other audiences about woody biomass. Both programs are focused on the southern U.S. and include varying degrees of technical information.

Chapter 1 Setting the Stage

1.0 Introduction

Woody biomass has the potential to help address some of the most urgent problems facing the United States today. Concerns about global climate change, forest health, energy security, and rural and economic development are spurring research and innovation to meet the nation's growing needs. Woody biomass may provide a short-or mid-term solution to these challenges while technology finds more long-lasting answers. Besides meeting energy needs, woody biomass may also have a more long-lasting role as a feedstock for a variety of other products like specialty chemicals and bioplastics.

So what is woody biomass? Biomass is any organic matter that is renewable over time. There are many sources of biomass, including corn stover (the leaves and stalks of corn); manure; wood residue (woody material left behind after a harvest); and landfill gas. (Chapter 2 describes these and other biomass sources in more detail.) Woody biomass is the accumulated mass, above and below ground, of the roots, wood, bark, and leaves of living and dead woody shrubs, vines, and trees. Woody biomass can be used to produce heat, power, electricity, transportation fuels, and a variety of biobased products, such as chemicals and adhesives. Its renewability, versatility, and local availability (in many places) make it an attractive option for various applications. While this guide will review all types of biomass, it will focus primarily on woody biomass.

Support for woody biomass utilization in mainstream energy, fuels, and bioproducts has increased dramatically within the past decade. The first major action was the creation of the Biomass Research and Development Act of 2000. The Healthy Forest Restoration Act (HFRA) of 2003 provided complementary support. As a result of the HFRA, the United States Departments of Energy, Interior and Agriculture announced an initiative to encourage the use of woody biomass as a strategy to reduce wildfire risk on public lands. The three departments signed a memorandum of understanding stating that each would support woody biomass utilization for energy and other products as a recommended option for reducing hazardous fuels. The utilization of woody biomass was encouraged in President George W. Bush's 2006 and 2007 State of the Union addresses; the Energy Policy Act of 2007; the Energy Title of the 2008 Farm Bill; numerous state, regional, national and international technical conferences; and the "25 x 25 - America's Working Lands: Powering the Future" initiative. (chapter 5 provides more information about federal, state, and local policies and incentives for woody biomass production and utilization.)

This chapter introduces the economic, environmental, and social issues surrounding woody biomass production and utilization. The U.S. is facing major challenges with regard to energy and climate. Fluctuating fossil fuel prices, volatile world politics, and overdependence on nonrenewable energy resources are creating serious concerns about national energy security and sustainability. While no one solution is likely to resolve all of these issues, woody biomass has the potential to work in conjunction with other options to help address some of these concerns.

Table 1: *Sulfur Dioxide, Nitrogen Oxide, and Carbon Dioxide Emissions Factors for Different Energy Sources.* (U.S. DOE, 2003).

Pollutant	Woody Biomass	Coal	Heavy Oil	Natural Gas
Sulfur dioxide	0.08 lbs/ton	39 lbs/ton	157 lbs/ton	$0.6/10^6$ cubic feet (cf)
Nitrogen dioxide	1.5 lbs/ton	21 lbs/ton	47 lbs/ton	$170/10^6$ cf
Carbon dioxide	0* lbs/million Btu (mBtu)	225 lbs/mBtu	174 lbs/mBtu	117 lbs/mBtu

* Assumes wood grown and harvested for this purpose.

1.1 Global Climate Change

During the past century, the Earth's average temperature has increased about 1 degree Fahrenheit (U.S. EPA, 2007). Scientists call this increase an indication of "global warming." Average temperature change, warmer or cooler, can lead to climate change, which is the long-term change in a particular region's weather patterns (e.g., temperature, precipitation, frequency and severity of storms). The burning of fossil fuels has considerably increased atmospheric carbon and other greenhouse gases since the beginning of the Industrial Revolution. When burned, fossil fuels release carbon dioxide and other gases into the Earth's atmosphere where they trap and reflect heat, resulting in global warming. Because this carbon came from fossilized storage (carbon that was produced and stored millions of years ago), it represents a net addition of carbon into the atmosphere and more than can be sequestered (stored) by today's plants, soils, and oceans.

Global climate change has the potential to impact the planet's ecosystems and every aspect of our society. Even slight changes in climate can influence human health, agricultural productivity, and biodiversity. Changes in climate, particularly temperature, can influence the range of infective parasites that spread disease. Extreme weather events such as droughts, hurricanes, floods, and fires, all of which can be exacerbated by climate change, can directly and indirectly cause loss of human life and infrastructure. Even more subtle changes such as fluctuations in rainfall and length of growing seasons may pose further challenges to farmers worldwide.

Finding sustainable ways to meet growing energy needs while reducing greenhouse gas emissions is one way to address the threat of climate change. While wind and solar power are increasing in popularity and prevalence, so is biomass. Versatile enough to provide heat, power, electricity, transportation fuels, and other products, biomass can be used to produce energy on a larger scale than solar and wind, in many cases. It is probable that a successful and sustainable short- and mid-term response to the threat of climate change will be comprised of a suite of renewable energy options that includes woody biomass. In terms of greenhouse gas emissions, woody biomass emits less than fossil fuels and if sources are replanted on a sustainable basis, the process of using woody biomass is essentially carbon-neutral. Table 1 illustrates uncontrolled air emissions from natural gas, oil, coal, and wood. In addition, for every British thermal unit (Btu) produced by cellulosic ethanol rather than gasoline, there is a total life cycle greenhouse gas reduction of 90.9 percent (Malmsheimer et al., 2008).

Loss of Forests

Because forests absorb large amounts of carbon, deforestation is directly connected to climate change and is a growing concern, both globally and nationally. Between 1850 and 1998, the conversion of forestland around the globe contributed approximately 136 billion tonnes of carbon to the atmosphere.

This represents 33 percent of the total emissions during that time span and the second largest amount of human induced emissions (energy production was the first) (Malmsheimer et al., 2008). In 2003, forestland in the U.S. sequestered 750 million tonnes of CO_2 equivalent (U.S. EPA, 2005).

One major threat to forest cover in the U.S. is development. Rising land prices are an enticement to forest landowners to sell land for development in some areas, leading to fragmented forests and the depletion of total forestland. For instance forestland in the southeastern U.S. was appraised at approximately $415 per acre when used for forestry and $36,216 per acre when sold for development (Malmsheimer et al., 2008). Likewise, forestland in the Pacific Northwest was valued at approximately $1000 per acre when used for forestry and $20,000 per acre when sold for development (Malmsheimer et al., 2008). These economic factors make the conservation of forestland a challenge.

Climate change can also affect forests. Forest composition, structure, and function are influenced by disturbances such as fire, drought, introduced species, insect and pathogen outbreaks, hurricanes, windstorms and ice storms. Climate change can alter the frequency, intensity, duration, and timing of such disturbances. Additionally, models have shown that warmer temperatures will likely lead to more productive U.S. forests. Increased growth combined with more intense, frequent, longer-lasting disturbances could lead to overcrowded stands, compromised forest health, and increased risk of wildfire. The U.S. may already be seeing some evidence of this. Throughout the last twenty years, the U.S. has experienced record drought in terms of temperature and duration, record wildfire

Figure 1: *Climate change may lead to prolonged droughts in susceptible forests.* Photo courtesy of Ogden Archive, U.S. Forest Service.

In the U.S., a ton is equal to 2,000 lbs. In Great Britain, a ton is equal to 2,240 lbs. To distinguish between the two tons, the U.S. ton is called a "short ton" because it is the smaller of the two; whereas, the British ton is called a "long ton" because it is the larger of the two. In addition, you may sometimes see a metric tonne, which is 1,000 kg or 2,205 lbs. The spelling "t-o-n-n-e" is what distinguishes this measurement from the others.

What's the difference between a clearcut and deforestation?

A **clearcut** is a silvicultural method used for regenerating an even-aged (trees of similar ages) community of trees, where the new seedlings become established in fully exposed areas following the removal of most or all mature trees (Nyland, 1996). **Deforestation** is the removal of most or all trees in an area with no plans for regenerating a forest or for the purpose of converting the forestland to some other use, for example agriculture or development.

in terms of frequency and intensity, and record hurricanes in terms of frequency and intensity.

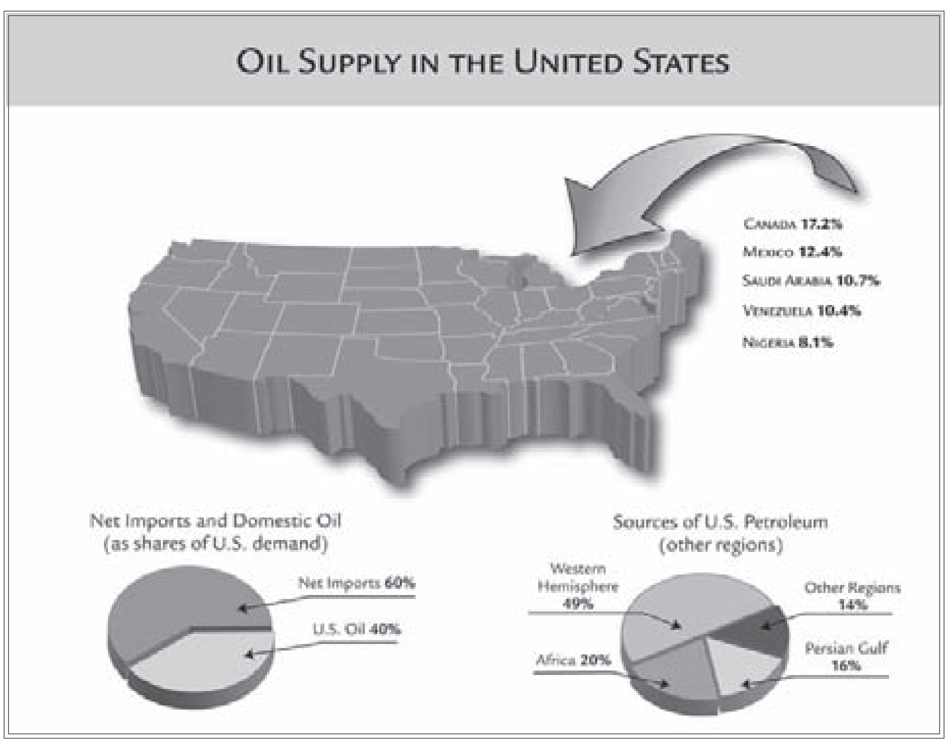
Woody biomass production and utilization create markets for wood and wood waste that may provide forest landowners with incentives to keep their land in forests. The more markets that can be developed and enhanced to help make working forests more profitable, the more likely forestland will be maintained. While some opponents of wood energy fear that increased biomass utilization will further deplete the nation's forests, the opposite may actually be true. If biomass projects involve sustainable management and harvesting of wood resources, they may help reduce or prevent the fragmentation and loss of forests.

1.2 Growing Energy Demands and Security

Another major concern facing the U.S. is energy security. While the annual per capita energy consumption has actually been decreasing in recent years, most likely due to new energy efficient technologies such as compact fluorescent light bulbs and more efficient technology, total demand is on the rise. The total annual energy consumption in the U.S. increased from about 89 quadrillion Btu in 1994 to 100 quadrillion Btu in 2004 (U.S.DOE, 2005). The current U.S. population is approximately 304 million and projected to reach 325 million by 2015. Some project that by 2030, consumption will have increased 15 percent and Americans will consume just over 118 quadrillion Btu annually (U.S. DOE, 2008). During the next twenty-five years, it is estimated that the U.S. will need to build at least 1,200 new 300-megawatt (MW) power plants to meet growing electricity demand (Malmsheimer et al., 2008).

Currently, about 85 percent of the total energy consumed nationally comes from fossil fuels, 7 percent from renewable energy sources, and 8 percent from nuclear power. Biomass provides approximately 3 percent of all energy consumed in the U.S. and is the country's single largest source of renewable energy (U.S. DOE, 2005). Woody biomass accounts for approximately 59 percent of all biomass energy consumed in the U.S. (U.S. DOE, 2008a).

Diagram 1: *Oil supply in the United States.* Adapted from EIA Petroleum Supply Annual (2002) vol.i.



So where does the U.S. get the majority of its energy? Nearly 60 percent of crude oil is imported from Canada, Mexico, Saudi Arabia, and Venezuela (Diagram 1). The U.S. depends on oil for everything from transportation of goods to running farming equipment. Because of this dependency, the U.S. is vulnerable to oil supply disruptions and price increases. While predictions vary, most estimates suggest that global peak oil production will occur sometime between now and twenty years from now, and as scarcity increases, it will drive up cost (Science Daily, 2007). In addition, the fact that much of the oil used in the U.S. today comes from politically unstable regions or those with contentious relations with the U.S. makes oil resources even less reliable.

The U.S. uses more than 1,100 million short tons of coal each year, the majority of which comes from Wyoming and West Virginia and is shipped all over the country by train (U.S. DOE, 2008b). Most natural gas comes from Texas, Wyoming, and federal offshore drilling (U.S. DOE, 2008c). While coal and natural gas are readily available domestically, the finite nature of fossil fuels means that eventually their supplies will dwindle and they cannot be counted on as a sustainable source of energy. Concerns about climate change are helping prompt a transition to renewable energy sooner than later.

In an effort to increase energy security, the U.S. is working to improve the efficiency, sustainability, and reliability of energy generation, distribution, and consumption. It has begun to harness local resources as a way to increase the security of the energy supply, reverse fossil fuel dependency, and improve the trade balance. With consumption increasing, a limited domestic supply of fossil fuels, and increased concerns about global warming and loss of forests, woody biomass may provide a viable alternative.

Figure 2: *Wildland-urban interface, the space where developed and forested lands meet, pose challenges to managing forest fuel loads.* Photo courtesy of Larry Korhnak.

Figure 3: *Reducing fuel loads in forests lessens the severity of wildfires.* Photo courtesy of Arthur Allen, U.S. Fish and Wildlife Service.

1.3 Wildfire and Forest Health

Years of fire suppression have left many U.S. forestlands dangerously overstocked. With the rapid expansion of the wildland-urban interface in some regions, the need for fire hazard reduction has become increasingly important. Wildland-urban interface is defined as any area where increased human influence and land use conversion are changing natural resource goods, services, and management (Macie and Hermansen, 2002). In the interface, homes are often located in or adjacent to heavily forested areas that can be prone to wildfire. Wildfires are expensive to fight, cause billions of dollars each year in damage to both the natural and built environment, and can negatively affect wildlife habitat as well as air and water quality. Overstocked forests may also be more susceptible to insect infestation and disease.

Because of this, natural resource managers are faced with the enormous task of enhancing, restoring, and maintaining forest health on both public and private lands. This often involves the removal of small-diameter, low-quality woody material. If markets exist, it can be harvested for other uses. According to a recent study, about 8.4 billion dry tons of vegetation have been identified nationally for treatment, yet due to accessibility limitations, recovery limits, and the merchandising of some of this wood for higher value products, only 60 million dry tons of fuel from treatment thinnings can actually be removed annually (USDA and U.S.DOE, 2005). Approximately 80 percent of this material would be removed from private forestland and the remaining 20 percent from public forests. By creating new markets for wastewood and debris from thinning, woody biomass utilization may help public agencies and private landowners pay for management activities that can help reduce the risk of wildfire and increase forest health and resilience.

1.4 Changing Forest Economy

Another driver of overstocked and unhealthy forestland in the U.S. is changing forest markets. Globalization has made it easier for countries to compete for global resources. As a result, forest industry, in an effort to provide the highest return for shareholders, has largely sold off its forestland in the U.S. Plantations in the southern hemisphere, primarily New Zealand, Australia, Chile, and subtropical regions of southeastern Brazil, with climates that support high levels of wood fiber production on very short rotations, combined with low labor and other social costs, are much more productive and less expensive than North American forestlands and plantations (Franklin and Johnson, 2004). Plantations and mills have moved south. Pulp markets used to create demand for the small diameter timber removed during thinning operations. However, as demand decreases due to this shift south, scheduled thinnings are often delayed or forgone. This delay often leads to overcrowded stands, poor forest health, and susceptibility to catastrophic fire, insects, and disease.

As we move into a more globalized economy, heavily forested, rural, and wildland-urban interface areas face new challenges to provide jobs and income from forestry. Thinned trees and pine plantations support the pulp and paper industry, particularly in the southern U.S. Globalization is squeezing the industry and shifting markets in some areas. Once reliable forest products markets are less reliable or non-existent. U.S. pulpwood markets, for example, once thrived, with the South supplying more than 70 percent of the nation's pulp needs. Because pulp and other higher value forest products can be produced faster and cheaper in the southern hemisphere, in many cases, forest industry has largely divested their U.S. holdings (land and infrastructure) and moved to South America (Best, 2002; Franklin and Johnson, 2004). Some people are concerned about how increasing the use of wood for energy and biobased products might influence competition and thus prices for wood.

Fragmented, parcelized landscapes resulting from development are also changing the forest economy in the U.S. by making timber harvesting less profitable (Sampson and Decoster, 2000). Small individual tract sizes as well as small noncontiguous patches of forestland lead to diseconomies of scale not only in the harvesting operation but also in management, planning, and marketing of products. Small tracts frequently yield smaller volumes, which are often unable to offset the high costs associated with transportation, capital investment, and operation expenses (Shaffer, 1992). Markets for woody biomass may provide value to material previously thought to be non-merchantable. This additional value may make smaller tracts of forestland more profitable.

1.5 Summary and Conclusion

New markets for woody biomass could potentially strengthen the demand for small diameter timber, reduce wildfire risk, reduce the atmospheric carbon and other greenhouse gases released into the atmosphere, and promote domestic energy security. New opportunities are emerging for utilizing sustainably produced woody biomass from forest enhancement, restoration, and maintenance activities. Additionally, utilizing woody biomass for energy and other bioproducts can help promote management to enhance forest health, reduce the risk of wildfires, and mitigate the potential effects of climate change. While woody biomass has the potential to address some of the challenging issues facing the U.S., it remains important to carefully weigh the costs and benefits. See chapter 4, "Implications of Producing and Using Woody Biomass" for information on the advantages and disadvantages of using wood for energy and other bioproducts.

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Handout 1 Electricity Production: Comparing Wood and Fossil Fuel Feedstocks

Woody biomass is a substantial renewable resource that can be used as a fuel to produce energy. This wood can come from a wide variety of sources, including land clearing for development, silvicultural activities (managing forests for timber production), urban tree and landscaping debris, and waste wood (bark, sawdust, wood chips, and wood scrap) (U.S. DOE, 2006a).

Energy can be produced from woody biomass in various ways. Wood-fueled power plants are capable of producing significant amounts of electricity and can be cleaner, renewable alternatives to many current power facilities that currently use fossil fuels (Northeast Sustainable Energy Association, 2001). In addition, woody biomass can be used to produce heat and power at facilities, such as hospitals and schools. Biomass has been the largest nonhydro renewable energy source for electricity in the United States since 2000 and offers some promising incentives for continued development and research of its use (Energy Information Administration, 2006). As technology improves, biomass is becoming a more attractive alternative to fossil fuels because it produces fewer emissions, contributes to local economies, mitigates global climate change, and can increase national security.

Cost

Cost is an important factor to consider when comparing fuel sources. Table 1 shows a comparison of the price of fuels measured in British thermal units (Btu). Depending on the type and proximity of the source and local supply and demand conditions, wood prices can be competitive with most fossil fuels.

The cost of using wood to generate energy can vary significantly depending on the technology used, the size of the facility, the wood transportation distance, and the cost of wood (Power Scorecard, 2007). 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).

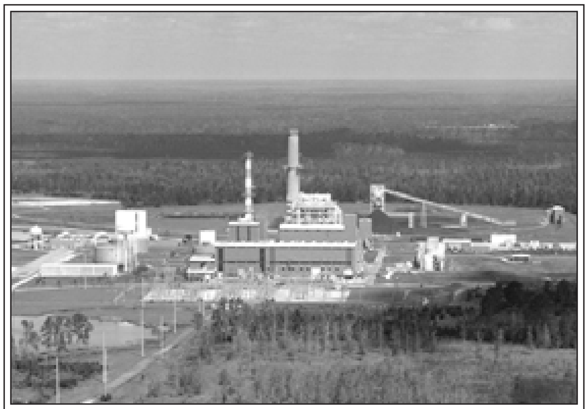
While coal has historically been significantly cheaper than wood, the price of coal has nearly tripled since November 2007 (Energy Information Administration, 2008). The full cost of coal is not included in the figures in Table 1. Because coal produces numerous toxic air emissions such as carbon dioxide, sulfur dioxide, nitrogen oxides, and carbon monoxide, which contribute to climate change, acid rain, water pollution, and health risks, its use comes with significant environmental and social costs that are not reflected in the price alone (U.S. EPA, 2007b). Communities may want to consider such indirect costs when deciding how to meet future energy needs (Figure 1).

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.

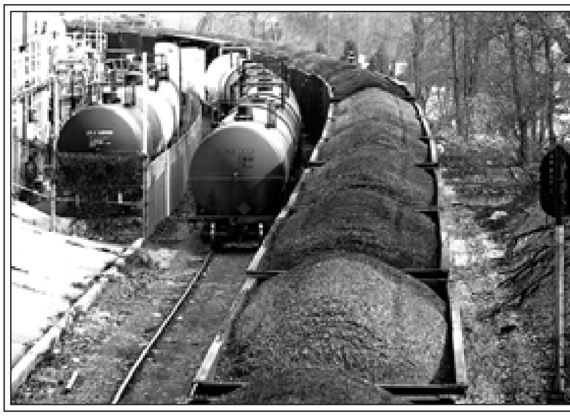
Figure 1: *Fossil fuels, such as coal, may have non-economic costs associated with them.* Photo by Larry Korhnak, University of Florida.



Environmental Impacts

Coal accounts for more than 57 percent of electrical generation in the United States. It is a popular fuel because of its abundance and low cost. However, the type of coal that has been used traditionally is also responsible for 93 percent of sulfur dioxide, 80 percent of nitrogen oxide, and 73 percent of carbon dioxide emissions that come from the electricity industry. Proper emission controls and new technologies can reduce the environmental impacts of using coal; yet, even with these improvements, emissions from burning coal can contribute to acid rain, urban smog, health problems, water pollution, and global climate change. Coal plants can also contaminate air and water with mercury, a toxin linked to a variety of neurological disorders. The environment is also impacted by the mining, processing, and transporting of coal (Figure 2). Surface mining heavily disturbs the land and contaminates the soils with heavy metals, threatening nearby water quality (U.S. DOE, 2006b). In some cases, coal is obtained through mountaintop

Figure 2: *The mining, processing, and transporting of coal can negatively impact the environment.* Photo by Larry Korhnak, University of Florida.



removal using explosives. This practice may detract from the safety, aesthetics, and quality of life for local communities (U.S. EPA, 2007a).

Natural gas creates fewer environmental impacts than coal, producing about half the amount of carbon dioxide, less particulate matter and nitrogen oxides, and negligible amounts of sulfur dioxide or mercury emissions. However, natural gas produces methane, a greenhouse gas that is twenty times more effective than carbon dioxide at trapping heat in the atmosphere, thereby contributing to climate change. Other environmental impacts associated with the drilling and natural gas explorations are erosion, landslides, and flooding (U.S. DOE, 2006b).

Biomass emissions can vary depending on the type of wood and technology that is used. If wood is the primary source for energy generation, very little sulfur dioxide is emitted. Nitrogen oxide and carbon monoxide are produced; however, emission levels of these vary greatly depending on the combustion facilities. The combustion of wood releases carbon dioxide into the atmosphere, but through the cycle of growing trees, using the wood, and replanting more trees, the carbon dioxide is recycled from the atmosphere. As long as trees are replanted at the same rate they are harvested and used, they take in approximately the same amount of carbon dioxide as is released during combustion. Therefore, using wood for energy does not contribute to climate change by adding more carbon dioxide to the atmosphere. Using wood as a fuel source can also help reduce release of methane by diverting waste wood from landfills.

Possible negative effects of managing forests for energy production are the change in wildlife habitat from periodic harvests and the decreased soil quality requiring the use of fertilizers (U.S. DOE, 2006b).

These effects can be addressed with proper forest management. For example, in order to ensure sustainable forest management, some communities have hired professional foresters to monitor the operations that provide wood for a wood-fueled facility. In many cases, the use of wood for energy can provide the economic basis for maintaining land in forests. If landowners cannot afford to maintain forestlands, they are frequently sold for housing developments and the many benefits of forestlands are lost forever.

Jobs

The current lack of employment opportunities in the rural United States is putting a burden on local economies, infrastructure, and the tax base. Using wood for energy can provide important economic benefits, such as local job creation, strengthening of forestry markets, and reduction of the national trade deficit (when the value of what we import is greater than the value of what we export) (Energy Information Administration, 2007b). Through construction, operation, maintenance, and support for bioenergy facilities, rural communities have the opportunity for more domestic jobs and increased local economic activity.

A study by the Renewable Energy Policy Project shows that co-firing biomass in existing coal facilities tends to offer more employment than coal-only operations. Furthermore, coal mining jobs are decreasing as the industry becomes more automated (U.S. DOE, 2005).

According to the National Renewable Energy Laboratory, by 2020, more than 30,000 megawatts of biomass power could be used nationwide. Approximately 60 percent of the fuel would come from energy crops and 40 percent would be supplied from woody biomass. This increase in biomass facilities could support more than 150,000 U.S. jobs that could contribute to the revitalization of rural economies (Singh and Fehrs, 2001).

National Security

Fossil fuel energy sources are nonrenewable and may not ensure a secure energy future for the United States. More than half of our daily needs of oil and petroleum products are imported each day. 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 most of the oil imported to the United States comes from politically unstable regions.

Facilities that use renewable sources of energy (e.g., biomass power plants) are typically small and geographically dispersed. 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).

Summary and Conclusion

Both wood and fossil fuels offer certain advantages as fuels for energy production. While some fossil fuels under certain circumstances may be less expensive and utilize traditional and familiar practices, wood tends to be a more environmentally sound option. In addition, using wood can help foster national security, introduce new markets for forestry, and create local jobs. Because there is not enough wood to provide all of our energy needs, we need to look at a variety of sources and continued use of fossil fuels in the near future. While wood may not be a feasible or sensible option for every community, it may help support efforts to promote more sustainable and locally generated sources of energy. In deciding how to meet growing energy demands, each community will need to carefully evaluate the advantages and disadvantages of a variety of energy options.

This handout was adapted from the following source and used with permission.

Monroe, M. C., L. W. McDonell, and A. Oxarart. 2007. Wood to energy outreach program: Biomass ambassador guide. Gainesville, FL: Florida Cooperative Extension Service, Circa 1526, University of Florida.

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Chapter 2 What is Biomass?

2.0 Introduction

In exploring the topic of woody biomass production and utilization, you will need to have a fairly thorough understanding of the various types of biomass that can be used for heat, power, electricity, transportation fuels, and other bioproducts. This chapter provides a comprehensive discussion of woody biomass and a basic overview of agricultural biomass.

2.1 Biomass

Biomass is any organic matter that is renewable over time. More simply, biomass is stored energy. During photosynthesis, plants use light from the sun's energy (light energy) to convert carbon dioxide and water into simple sugars and oxygen.

Fossil fuels are hydrocarbon deposits, such as petroleum, coal, or natural gas, derived from organic matter from a previous geologic time. They are essentially fossilized biomass and differ from present-day biomass in that they come from organic matter created millions of years ago, which has been stored below ground. In other words, the key difference between biomass and fossil fuels is age!

Fossil fuels contain carbon that was removed from the atmosphere, under different environmental conditions, millions of years ago. When burned, this carbon is released back into the atmosphere. Since the carbon being released is from ancient deposits, and new fossil fuels take millions of years to form, burning fossil fuels adds more carbon to the atmosphere than is being removed.

Biomass, on the other hand, absorbs atmospheric carbon while it grows and returns it into the atmosphere when it is consumed, all in a relatively short amount of time. Because of this, biomass utilization creates a closed-loop carbon cycle. For example, you can grow a tree over the course of ten or twenty years, cut it down, burn it, release its carbon back into the atmosphere and immediately start growing another tree in its place. With certain fast-growing biomass crops such as switchgrass, this process can occur even faster.

2.2 Woody Biomass

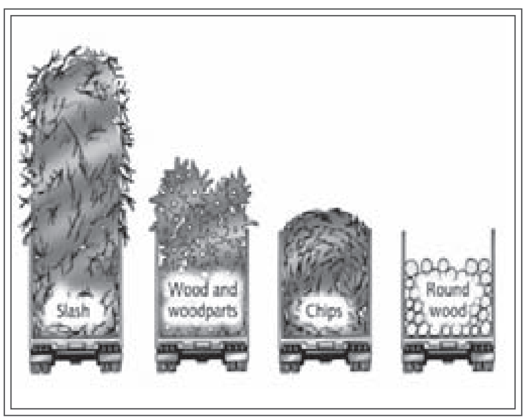
Woody biomass is the accumulated mass, above and below ground, of the roots, wood, bark, and leaves of living and dead woody shrubs and trees. Woody biomass can be used for heat, power, and electricity generation; biofuels production; and biochemicals production (e.g., adhesives, solvents, plastics, inks, and lubricants). Wood; wood residue and byproducts; and bushes, shrubs, and fast-growing trees, grown specifically for energy, are all considered woody biomass. The principle sources for woody biomass in the United States are harvest residues; mill residues; small diameter trees; cull trees; trees damaged by or at risk of wildfire, insects, and disease; urban wood waste, short rotation woody crops, and fuelwood, *Handout 2: Woody Biomass Basics*, found in the back of this chapter, provides a condensed overview of woody biomass and may be a useful handout for your audience or clientele.

Harvesting and Other Residues

Residues from forest harvesting operations include logging residues (i.e. branches, tops, and stumps) left on-site, low-quality commercially grown trees, dead wood, and other noncommercial tree species. Other residues include wood that has been cut and burned during land conversion, precommerical thinnings, and other management techniques such as a crop tree release and timber stand improvement (TSI). Harvesting residues and other removals are routinely left behind at the harvest site because they are expensive to transport and there are few markets for the material. However, harvesting residues and other removals amount to approximately 67 million dry tons annually, and of this, approximately 41 million dry tons are economically and physically available for recovery and use, according to the United States Department of Agriculture Forest Inventory and Analysis (FIA) programs' Timber Product Output (TPO) Database Retrieval System, (U.S.DOE and USDA, 2005).

The possibility of using woody biomass for energy production and other products has the potential to create markets for these harvesting residues. As a feedstock source, harvesting residues are generally delivered in one of the following three forms: unconsolidated material, comminuted material, and bundled material. It can also be converted, in-woods, to a higher value product.

Figure 1: *Volume differences of the same weight material by different product types.* Photo courtesy of USDA Forest Service, Forest Products Laboratory.



Unconsolidated

Unconsolidated material, or woody biomass in its raw form, is what remains after the trunk of the tree has been harvested. This may include stumps, bark, leaves, needles, branches, and even the trunk itself. Historically, this material was considered unmerchantable (unsellable) and in most harvest operations was left in place on the logging site or piled up at the landing—the place where wood is delimbed, sorted, and loaded onto trucks for transport. However, advances in biomass utilization promise new opportunities for the utilization of unconsolidated woody biomass feedstock. In many cases, unconsolidated harvesting residue is used as hog fuel at wood manufacturing facilities. (Hog fuel is a combination of ground wood and wood waste used to generate power or produce on-site heat and power.) For more information on conversion to heat and power, please see chapter 3, "Products and Possibilities."

One obstacle that remains in the broader use of unconsolidated material is the cost of transportation. Bulky by nature, this material has a low bulk density, in other words, a high volume-to-mass ratio (Figure 1). Compressing the material, although not widely performed, helps increase bulk density. A more conventional method of increasing the bulk density of woody biomass is to reduce its size significantly, either by chipping, grinding, or shredding.

Comminuted

Comminution is the process of making woody material smaller. Reducing the size of logging residue usually occurs in the woods or at the landing but is sometimes delayed until the feedstock reaches the processing facility. Of the three types of reduction (chipping, grinding, and shredding) chipping is the most common (Figure 2). This is because chippers are well integrated into conventional harvesting systems. Chippers have high output, high-speed cutting knives, and in most cases the ability to throw chipped material into truck vans for hauling.

Figure 2: *Comminuted material.* Photo by Sarah Ashton, Southern Regional Extension Forestry.

Bundled

One recent innovation involves the compaction of logging residues into cylindrical bales called composite residue logs (CRL) or biomass bundles (Figure 3). Typically, these bundles have a diameter of about 2.0 to 2.5 feet and are about 10 feet long. One of the most appealing aspects is that they can be handled similarly to round logs; however, production of the logs requires specialized machinery. Unlike comminuted material, these bundles can be stored for longer periods of time without decomposing.

Although technically feasible, the current market price for wood-based fuel in the U.S. does not support the cost of bundling. And at the other end, the current price of wood-based fuel does not support the transport of unconsolidated material, especially with the fluctuation of prices for petroleum-based fuels. At this time, comminuted biomass is the most economically feasible form.

Figure 3: *Composite residue logs.* Photo courtesy of Sylvain Martin, Latin Europe at John Deere Forestry.

In-woods Conversion

In areas where the cost of transporting wood remains a challenge, portable wood-to-energy conversion units may be an option. Small-scale, portable pyrolysis (a system that turns wood directly into an oil and char) and gasification (a system that turns wood directly into a gas) units can be towed to a harvesting site and utilized to produce fuel on-site. It is important to note, however, this technology is still largely in its experimental stages. See chapter 3, "Products and Possibilities" for more details on biomass conversion processes.

Forest Health Improvement

A number of management activities aimed toward increasing the health of forests can require removal of woody biomass. Fuel load reduction, removal of dead or dying wood due to insect or disease, and ecological restoration are three management activities that can result in substantial amounts of woody biomass.

Fire

Fire, often a result of lightning strikes, is a naturally occurring, necessary agent of change in wildland ecosystems. Fire performs a "cleaning" task, keeping fuels loads down and as a catalyst, driving vital ecological processes such as the regeneration of certain tree species. However, communities during the last century have feared fire and have not understood this natural process. Because of these fears, communities have made ongoing efforts to suppress fires in natural areas.

If not properly managed or exposed to natural disturbances such as fire, forests can accumulate excessive amounts of small diameter woody biomass and other vegetation

Figure 4: *Millions of dollars are spent fighting wildfires each year; harvesting biomass can reduce the intensity and frequency of these catastrophic fires.* Photo courtesy of U.S. Forest Service, National Renewable Energy Laboratory.

that can act as fuel. Fire suppression over the past century, combined with intensive forest management and a generally warmer and wetter climate, has led to increasingly dense vegetation. When wildfires occur, this heavy accumulation of biomass often leads to larger and more severe fires. Such fires threaten public health and safety, homes, businesses, timber resources, watersheds, and wildlife habitat.

Public agencies and some private forest landowners are focusing efforts on thinning forests to reduce wildfire risks and to make forest stands more resilient to insects and disease. Fuel treatment thinnings, in addition to reducing fuel loads in overstocked forest stands, can provide large volumes of woody biomass. According to a recent study, about 8.4 billion dry tons of biomass have been identified nationally for potential treatment, yet due to inaccessibility, recovery limits, and the merchandizing of some timber for higher value, more traditional forest products, only 60 million dry tons of fuel treatment thinnings can be removed annually (U.S. DOE and USDA, 2005).

Insects

Insects are another naturally occurring agent of change. However, a series of mild winters and drought-like summers in recent years has led to North America's largest ever-recorded epidemic outbreak of mountain pine beetle. Millions of acres of trees have been killed, particularly in Colorado, Alaska, and parts of Canada. If harvested immediately, a practice commonly referred to as sanitation, the majority of wood can be used in conventional forest product markets. However, if wood is badly damaged or left to sit too long after beetle kill occurs, then traditional forest product markets may not be an option. A promising alternative market for this lower quality wood is bioenergy.

Ecological Restoration

There are a number of ecological restoration efforts occurring in the U.S. that require or will require the removal of large amounts of standing biomass. Examples of these efforts include eradication of invasive species such as melaleuca trees; reestablishment of native species such as longleaf and shortleaf pine; and reversing the effects of harmful practices such as high-grading, a practice that reduces the quality of a forest stand's genetic stock. As markets for bioenergy develop, removal of standing biomass for such projects could become more affordable.

Municipal and Construction Wastes

The two major sources of urban wood residues are the woody portion of municipal solid waste (MSW) and construction and demolition debris. Of the 62.1 million dry tons of urban wood residues generated annually, about 28.3 million dry tons are economically and physically recoverable (McKeever, 2004).

Municipal Solid Waste

The portion of MSW that is wood includes items such as discarded furniture, pallets, packaging materials, processed lumber, and yard and tree trimmings. Of the 13 million dry tons of woody MSW generated annually, approximately 8 million dry tons are available for recovery (McKeever, 2004). This material is generally recycled as mulch or compost; sent to a landfill; or burned for heat, power, and electricity.

In recent years, small, portable wood chippers and bailing units that press yard debris into "logs" similar in appearance to that of traditional firewood have emerged. Some municipalities provide large yard debris carts, which are collected weekly. Other areas work with local businesses to ensure collection options such as drop-off bins and designated collection facilities.

Figure 5: Waste *wood can be utilized for energy instead of sent to landfills.* Photo courtesy of David Parsons, National Renewable Energy Laboratory.

Landfill Gas

Landfill gas (LFG) is a natural byproduct of decomposing organic matter. It is approximately 50 percent methane (CH_4) and 50 percent carbon dioxide (CO_2). Landfills can be significant sources of greenhouse gas emissions because they contain a significant amount of organic matter, and over time the organic matter breaks down and releases its gases into the atmosphere. These emissions can be captured and used to produce heat, power, electricity, and biofuels. Approximately 400 landfill gas-to-energy projects exist in the U.S. today (Riat, et al. 2006). Fairfax County, Virginia, has been using LFG since 1989 to power three electricity generating facilities, one pollution control plant, and the on-site landfill maintenance buildings.

Construction and Demolition

Residential and commercial wood frame construction and demolition generates cut-offs, scraps, and waste that constitute a relatively clean and homogeneous waste stream that can make an excellent feedstock for biomass fuel and energy production. Moreover, this particular waste is relatively easy to access. Wood waste processors can coordinate with construction contractors to designate an area for discarded wood waste or set up drop boxes on site for scraps. Of the 39.3 million dry tons of construction and demolition debris generated annually, approximately 20.3 million dry tons are available for recovery (McKeever, 2004).

Figure 6: *Unused wood from the construction of townhouses.* Photo courtesy of Kiley Barnes, Southern Regional Extension Forestry.

It is important to note that the end-use of the feedstock determines how clean and consistent it is. Sometimes, urban and construction wood waste can contain too many contaminants to be used for certain applications. For example, air quality regulations may prevent creosote-treated telephone poles from being burned for heat and power. Another example is wood waste from demolition activities. This material can contain contaminants such as paints, plastics, and known carcinogens and may not be suitable for some applications. In other cases, the wood material may be in such poor condition that the cost of cleaning limits the economic viability of processing and reusing the material.

Figure 7: *Storm damaged trees in populated areas make waste that is traditionally hauled to a landfill and/or burned in the open.* Photo courtesy of Randy Cyr, Greentree Technologies.

Figure 8: *Hurricane damaged trees.* Photo courtesy of Peter L. Lorio, Jr., U.S. Forest Service.

Natural Disasters

Clean up operations after natural disasters, such as hurricanes and ice storms, produce large amounts of debris that have traditionally been piled up to burn or rot (Figures 7 and 8). Debris from these disasters is largely underutilized, but changes have occurred in recent years. After Hurricane Ivan blew through the Florida panhandle in 2004, Escambia County managed 6.5 million cubic yards of woody debris, 60 percent of which it exported to Italy for energy generation. A company called American Biorefining shredded millions of tons of tree debris the following year after Hurricane Rita affected thousands of acres of eastern Texas forests and destroyed a number of roofs and homes. The material was then shipped to European countries for biomass fuel (Yepsen, 2008).

Processing Residues

Residues from forest products manufacturing such as sawdust, black liquor, and bark, are commonly used to create on-site energy in the form of heat and power. Char, pellets, particleboard, nonstructural panels, and animal bedding are also derived from wood processing residues. These residues come from primary and secondary wood processing mills and pulp and paper mills. This type of biomass feedstock is highly desirable because it tends to be clean, concentrated, uniform, and low in moisture, and requires little or no transportation. Currently, about 97 percent of this resource is utilized (U.S. DOE and USDA 2005).

Sawdust

Sawdust is the wood residue created when a log is cut to make lumber. It is fairly uniform in size and shape and is commonly referred to as wood flour, which indicates the particles can pass through a 20-gauge mesh screen. Sawdust with high moisture content has relatively limited uses. It can be used for residential heating in special sawdust furnaces as well as for smoking meats. When dried, sawdust is typically either densified into pellets or directly gasified, combusted, or pyrolized (made into an oil) to generate electricity, heat, and oil.

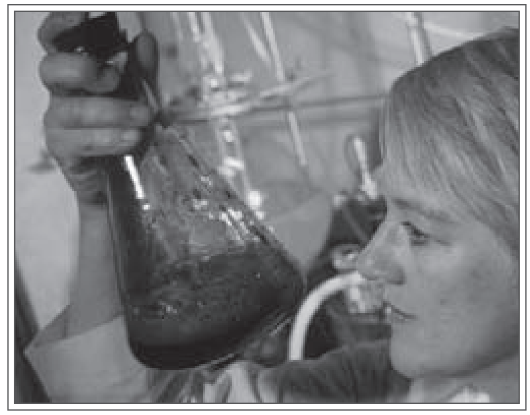
Bark

Bark is the outermost part of woody stems and branches and makes up about 9 to 15 percent of a log's volume. Bark is used to produce tannins, dyes, resins, flavorings, and medicinal products, and other chemical extracts. Bark is also used as mulch, soil amendment, a fuel source. Approximately 10 tons of bone-dry bark is the equivalent of 7 tons of coal when used for energy. In addition, bark is used in building materials such as fiber and particleboard as well as insulation board because it conducts heat less readily than wood.

Black Liquor

Black liquor is a recycled byproduct formed during the pulping of wood in the papermaking process (Figure 9). More specifically, it is the substance that remains after cellulose fibers have been broken down and removed from the original chemical slurry (a thick mixture of solids and liquid) to form paper. It consists of lignin, water, and other chemicals used in the extraction process. It is an important liquid fuel in the pulp and paper industry, typically recovered and recycled either through combustion or gasification in on-site boilers or gasifiers. The results of these processes are heat energy, carbon dioxide, and recoverable chemicals. The steam that is generated during the black liquor recovery process contributes significantly to the energy needs of pulp and paper mills. Recovered chemicals can be recycled into white liquor, which is the original slurry of chemicals used in the pulping process, reducing the pulping process's chemical needs by almost 90 percent.

Figure 9: *Black liquor.* Photo courtesy of Keith Weller, Agricultural Research Service.



Short Rotation Woody Crops

Fast growing short rotation woody crops (SRWC), such as hybrid poplars, willows, and other species, are specifically grown to be an energy feedstock (Figure 10). The species of trees are often chosen because they sprout from a cut stump. Properly managed, SRWCs can grow rapidly and be ready for harvest in four to eight years. After harvest, the site can be replanted, or the stumps can be left to regrow. Ideally, the sprouts soon form a few dominant stems, which are then ready for harvesting again within another four to eight years. For some species, this can be repeated several times before replanting becomes necessary. Growing short-rotation energy forests can also be combined with wastewater disposal, as sewage and wastewater from food processing factories and farms can contain nutrients that can accelerate tree growth. Using wastewater to irrigate a SRWC plantation offers an opportunity to mitigate point-source pollution, which is water pollution that comes from a single source such as a pipe or culvert.

Figure 10: *A stand of hybrid poplar trees in Oregon.* Photo courtesy of Warren Gretz, National Renewable Energy Laboratory.

Short rotation woody crops have shown promise as an economically viable strategy for producing a sustainable supply of wood biomass. Fast growing species can be planted at relatively low costs and harvested in less time than traditional species. Biotechnology is expected to substantially increase energy crop yields in the future.

Fuelwood

In addition to residues, waste, and dedicated energy crops, pulp wood and commercial-grade timber can be used as an energy or bioproducts feedstock. When used this way, the fiber is called fuelwood. In 2005, approximately 35 million dry tons of fuelwood was used in the residential and commercial sectors where it was harvested and burned for space- and process-heat (U.S.DOE and USDA 2005). This may become more feasible in areas where the forest products industry is not buying or paying competitive market prices for pulp and commercial grade wood due to mill closures, market shifts, or other reasons.

2.3 Agricultural Biomass

Agricultural biomass is a relatively broad category of biomass that includes: the food-based portion of crops (corn, sugarcane, soybeans, beets, etc.), the nonfood-based portion of crops (e.g., corn stover [leaves, stalks, and cobs], orchard trimmings, rice husks, perennial grasses, animal waste, and landfill gases. Traditionally, costs for recovering most agricultural residues are high, and therefore, they have not yet been widely used as an energy source; however, they can offer a sizeable biomass resource if technology and infrastructure are developed to economically recover and deliver this type of biomass to energy facilities. It is important to note that not all agricultural biomass residuals following harvest can be utilized for energy. Some portion (often as much as 50 percent) must be left on the ground to replace soil nutrients and to protect from soil erosion. *Handout 3: Agricultural Biomass* provides an overview of agricultural biomass you may find useful as a handout when presenting this topic to an audience.

Figure 12: *Current U.S. biodiesel production is primarily from oil from soybeans such as these or from recycled restaurant cooking oil.* Photo courtesy of Warren Gretz, National Renewable Energy Laboratory.

Food-based Portion of Crops

The food-based portion of crops is the part of the plant that is either oil or simple sugars. Rapeseed (used for canola oil), sunflower, soybeans, corn, sugarcane, and sugar beets are all examples of this type of agricultural biomass (Figure 12). Corn, sugar beets, and sugarcane are commonly fermented to produce ethanol. Oilseed crops can be refined into biodiesel.

Nonfood-based Portion of Crops

The nonfood-based portion of crops is the portion of the plant that is commonly discarded during processing and consists of complex carbohydrates. This category includes materials such as corn stover, wheat, barley, and oat straw, and nutshells. Stover and straw are fermented into ethanol. Nutshells are typically refined into biodiesel or combusted for heat. Due to the important function of crop residues in erosion protection and overall soil quality, their sustainable use is accomplished through the planning and monitoring of harvest rates specific to a given site.

Figure 13: *Switchgrass in the field.* Photo courtesy of Art Wiselogel, National Renewable Energy Laboratory.

Perennial Grasses

Perennial grasses have a lifecycle of several years. Some examples include big bluestem, sweet sorghum, Miscanthus, and switchgrass (Figure 13). The advantages of perennial grasses are that they have a low-nutrient demand, a large geographical growing range, and high net energy yields (Downing et al., 1995). Perennial grasses are typically fermented into biofuels such as cellulosic ethanol, or they are densified into pellets and burned directly for heat and power. Major challenges remain in reducing the alkali, chlorine, silica, and moisture content of perennial grasses. Chlorine can cause fouling (the accumulation of unwanted material on surfaces) and corrosion in boilers. Silica affects ash formation, and moisture content, if not reduced, can affect energy value.

Animal Waste

Beef cattle, dairy cattle, hogs, and poultry all produce manure, which can be used to produce energy. Manure is typically categorized as liquid, slurry, or solid. In its solid state, manure can be burned for heating and cooking or to produce a gas for energy production. As a slurry, manure releases methane (CH_4), which can be captured to produce heat, power, electricity, and biofuels.

Figure 14: *Feedlot operations result in massive accumulations of manure which can be used to produce energy.* Photo courtesy of Brian Prechtel, Agricultural Research Service.

2.5 Summary and Conclusion

There are many different types of woody biomass and agricultural biomass available for utilization for heat, power, electricity, fuel, and other bioproducts. Availability, cost, distance to the processing facility, end-product, and other factors will determine the feasibility of using any particular type of biomass for energy or other bioproducts production.

This chapter was adapted from the following sources and used with permission.

Monroe, M. C. and R. Plate. 2007. Common concerns. In *Wood to energy outreach program: Biomass ambassador guide*, eds. M. C. Monroe, L. W. McDonell, and A. Oxarart. Gainesville, FL: Florida Cooperative Extension Service, Circa 1526, University of Florida.

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Handout 2 Woody Biomass Basics

In 2006, 7 percent of the energy consumed in the United States came from renewable resources. Roughly half of that amount, 3 percent total, was producing using some form of biomass (U.S. EIA, 2008). Biomass is organic plant or animal material that is available on a renewable basis (U.S. EIA, 2008). Biomass energy resources include food crops, grassy and woody plants, agricultural and forestry residues, municipal and industrial solid wastes, and landfill gas (NREL, 2008). These resources are renewable because, although individual trees and plants are consumed, additional trees and plants can be cultivated and grown relatively quickly, and municipal and industrial solid wastes are continually produced.

Plants grow by harnessing the sun's energy through photosynthesis. During photosynthesis, plants use the sunlight, carbon dioxide, and water to produce oxygen and glucose. The glucose (or sugar) is a form of chemical energy that is stored in the cells of plants or trees (U.S. EIA, 2008). This energy is released when the plants are eaten, decomposed, or burned. Whether burned or converted through a chemical process, biomass fuels release energy that can be used to produce heat, power, electricity, and transportation fuels.

Woody Biomass

Woody biomass is plant material from trees and shrubs that can include roots, bark, leaves, branches, limbs, trunks, and vines. Woody biomass can come from many sources, including forestry operation residues, wood product residues, urban waste wood, trees grown specifically for energy, fuelwood, and forest thinnings that reduce damage from fires and pests.

Forest Operation Residues Residues are branches, tree tops, stumps, and other woody debris left behind after trees are harvested for timber. Removing and selling these residues for energy production can provide landowners with additional income and improve forest health by reducing susceptibility to wildfire, insects, and disease.

Figure 1: *Forest operation residues.* Photo courtesy of Diomy Zamora, University of Minnesota.

Wood Products Residues Sawdust, scraps, and other wood waste from industries that make products from wood, such as cabinet and furniture companies, can also be used to produce energy. Many wood product facilities use their own wood waste to produce heat, steam, or electricity for their operation. This reduces costs and utilizes a waste product. In some cases, industries can even sell surplus energy to local power companies.

Urban Waste Wood and Yard Waste Each time utility workers clear trees from power lines or homeowners trim their hedges, woody biomass is piled up and removed. This biomass is often mulched, taken to a landfill, or burned without emission controls. Waste wood resulting from storms and land clearing also produce woody debris, but these sources are not consistent or sustainable over the long term. Woody biomass from urban waste wood and yard waste can also be used to produce energy. People generally have to pay to dispose of urban waste wood; however, if a local wood energy market existed, this wood might represent a reasonable source of inexpensive energy.

Figure 2: *Woody biomass from urban waste wood and yard waste can be used to produce energy.* Photo courtesy of Randy Cyr, Greentree Technologies.

Energy Plantations Just as trees can be grown for lumber, they can be produced in forestry plantations for energy. Just as we grow fields of wheat for food, we can grow fields of trees to produce energy. Some species of trees or woody crops, known as short-rotation woody crops, grow quickly and also resprout after they are trimmed. Examples of short-rotation woody crops are hybrid poplar and willow. These crops produce a lot of biomass in a short time and can be harvested repeatedly before they have to be replanted. Though this form of energy wood tends to be more expensive than some wood waste, it could be a reasonable option in some places, especially on degraded lands that cannot support healthy, natural forests or be used for growing food crops.

Forest Restoration and Health Improving forest health and restoring certain ecosystems to the naturally occurring forest type typically involves removing unwanted trees and other vegetation to reduce crowding and promote healthy tree growth. Small diameter trees may need to be removed in a process called thinning, to reduce the risk of wildfire and insect pest or disease outbreaks. If the removed biomass can be sold for energy, it might help landowners pay for removal efforts.

Fuelwood In addition to residues, waste, and dedicated energy crops, pulp wood and commercial grade timber can be used as an energy or bioproducts feedstock. When used this way, the fiber is called "fuelwood." In 2005, approximately 35 million dry tons of fuelwood was used in the residential and commercial sectors where it was harvested and burned for space and process heat (U.S.DOE and USDA 2005). Harvesting fuelwood may become more feasible in areas where the forest products industry is not buying or paying competitive market prices for pulp and commercial grade wood due to mill closures, market shifts, or other reasons.

Figure 3: *Short rotation woody crop grow very quickly. For example, the hybrid poplar trees pictured above are only six years old.* Photo courtesy of Diomy Zamora, University of Minnesota.

Summary and Conclusion

Woody biomass can provide a locally available, renewable source of energy that can be combined with other energy options to help meet growing energy needs. A combination of energy conservation, using multiple renewable energy sources, and managing population growth, is the most likely recipe for success when it comes to meeting energy needs in an environmentally, socially, and economically sustainable way.

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Handout 3 Agricultural Biomass

Agricultural biomass is a relatively broad category of biomass that includes: the food-based portion of crops (such as corn, sugarcane, and beets), the nonfood-based portion of crops (such as corn stover [the leaves, stalks, and cobs], orchard trimmings, and rice husks), perennial grasses, and animal waste. Traditionally, there have been high costs associated with recovering most agricultural residues, and therefore, they have not yet been widely used for energy purposes. However, they can offer a sizeable biomass resource if technology and infrastructure are developed to economically recover and deliver this type of biomass to processing facilities.

Food-based Portion of Crops (oil and simple carbohydrates)

The food-based portion of crops is the part of the plant that is either oil or simple sugars. Rapeseed, sunflower, soybeans, corn, sugarcane, and sugar beets are all examples of this type of agricultural biomass. The sugar from corn, sugar beets, and sugar cane are commonly fermented to produce ethanol. Oilseed crops such as rapeseed, sunflower, and soybeans can be refined into biodiesel.

Nonfood Based Portion of Crops (complex carbohydrates)

The nonfood based portion of crops is the part of the plant that is commonly discarded during processing for food production. This category includes materials such as corn stover; wheat, barley, and oat straw; and nutshells. Stover and straw are fermented into ethanol. Nutshells are typically refined into biodiesel or combusted for heat. Due to the important function of crop residues in erosion protection and overall soil quality, care must be taken on a site-by-site basis to ensure sustainability.

Figure 1: *Corn is one example of the food-based portion of a crop. It is primarily fermented into ethanol.* Photo courtesy of Warren Gretz, National Renewable Energy Laboratory.

Figure 2: *The nonfood based portion of crops is commonly discarded but can be used to make bioproducts.* Photo courtesy of Warren Gretz, National Renewable Energy Laboratory.

Perennial Grasses

Perennial grasses are grasses that have a life cycle of several years. Some examples include big bluestem and switchgrass. The advantage of perennial grasses is that they have a low nutrient demand, a large geographical growing range, and high net energy yields (Downing et al., 1995). Perennial grasses are pretreated to break down cellulose and then fermented into biofuels such as cellulosic ethanol.

Figure 3: *Switchgrass.* Photo courtesy of Art Wiselogel, National Renewable Energy Laboratory.

Animal Waste

Beef cattle, dairy cattle, hogs and poultry produce manure, which can be used to produce energy. Manure is typically categorized as a liquid, slurry (a mix of liquid and solids), or solid. In its solid state, manure can be burned for heating and cooking or to produce a gas for energy production. As a slurry, manure releases methane (CH_4), which can be captured to produce heat, power, electricity, and biofuels.

Figure 4: *Feedlot operations result in large quantities of manure which can then be used to produce energy.* Photo courtesy of Brian Prechtel, Agricultural Research Service.

References

Downing, M., M. Walsh, and S. McLaughlin. 1995. Perennial grasses for energy and conservation: Evaluating some ecological, agricultural, and economic issues. Environmental Enhancement through Agriculture: Proceedings of a Conference, Boston Massachusetts, November 15-17. Center for Agriculture, Food and Environment, Tufts University, Medford, MA.

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CHAPTER 3 Products and Possibilities

3.0 INTRODUCTION

Biomass, in various forms, has been a major source of energy for thousands of years. Biomass includes everything from algae and kelp found in oceans to trees and shrubs found in forests. When processes such as combustion or decomposition break down biomass, chemical energy is released, which can be captured and used. Biomass and components of biomass can also serve as building blocks for a variety of materials and products. This chapter will introduce you to the various conversion processes used to convert woody biomass feedstocks into products such as heat, mechanical power, electricity, transportation fuels, and other products.

3.1 CONVERSION PROCESSES

The most common way to capture energy from woody biomass is through direct combustion (burning biomass to produce heat). Until the mid 1800s, woody biomass was mostly used for home heating and cooking. In many parts of the world, wood is still used for these purposes. Combustion is one of many thermochemical processes used to release energy.

Figure 1: *Wood gasification has the potential to meet energy requirements by converting the wood into a syngas that can be used in high efficiency gas turbines to generate electric power.* PHOTO COURTESY OF WARREN GRETZ, NATIONAL RENEWABLE ENERGY LABORATORY.

There are three primary paths to producing bioenergy and bioproducts: biochemical, chemical, and thermochemical. Scientists and engineers have developed and refined thermochemical processes such as gasification to produce combustible syngases (or synthetic gases) and biochemical processes such as fermentation to produce liquid transportation fuels.

Biochemical Conversion

Biochemical conversion involves the use of bacteria, yeasts, and enzymes to break down the carbohydrates that make up biomass. The three most common types of biochemical conversion are anaerobic digestion, aerobic digestion, and fermentation. A good example of this process is the production of ethanol through fermentation. This process changes biomass into alcohol, a combustible fuel.

Chemical Conversion

Chemical conversion differs from biochemical conversion in that the catalyst that causes biomass to break down is a chemical rather than a living organism. A good example is the process used to make biodiesel. This process, commonly referred to as transesterification, alters the molecular makeup of biomass oil with the addition of a base or acid. The oil then becomes liquid fuel similar to that of diesel. Gasoline additives are also produced in this manner. One of the most common products used for this method is vegetable cooking oil taken from restaurants and food services. Through refinement of the chemical conversion process, these oils become biodiesel.

Thermochemical Conversion

When plant matter is exposed to heat, it breaks down into various gases, liquids, and solids. This is the basic concept of producing bioproducts or energy via thermochemical conversion. Heat is sometimes applied in the presence of oxygen, sometimes not; sometimes the contents are under pressure, sometimes not. The most common thermochemical conversion processes are gasification, combustion, pyrolysis, liquefaction, and Fischer-Tropsch, a two-part process that catalyzes syngas into oil. Each method produces a different product.

Tip: If your audience would like a more in depth, visual explanation of thermochemical, biochemical, and chemical woody biomass conversion processes, interactive graphics are available at The National Learning Center for Private Forest and Range Landowners (http://forestandrange.org/Biomass/Modules/Module%206/Index.asp)

3.2 Electricity and Heat

Of all the products that can be produced from woody biomass, heat, mechanical power, and electricity have the most potential and are where the majority of woody biomass is used currently.

Electricity

Typically, when wood is used to produce electricity, it is burned in a boiler, through direct combustion. Wood is burned alone or in combination with other fuels, such as coal or solid waste. In most boiler systems, wood chips, ground wood, or wood pellets are carried into the combustion chamber, also known as a firebox, on a traveling metal grate. The heat from the burning wood boils water that makes steam, which activates turbines, generating electricity. The electricity can be used to power small industrial applications or large, municipal power plants. If the complete replacement of fossil fuel feedstocks with biomass feedstocks is not realistic due to material handling costs, transportation, or supply issues, then co-firing the feedstocks is an alternative. Co-firing is the process of burning a combination of fuels, such as woody biomass and coal.

Woody biomass can also undergo gasification to produce electricity. In this process, biomass is gasified, turned directly from a solid to a gas, such as carbon monoxide, hydrogen, or other gases, which are then burned in a gas turbine, generating electricity.

Small Heating Systems

If you have ever left a pot of water on a campfire a little too long, seen firefighters battling a blazing house-fire, or owned a woodstove, you can appreciate the heat energy released by burning wood. Heat is a form of energy created by the motion of atoms and molecules. Although heat has a number of applications, wood heat is primarily used for increasing air temperature, rotating turbines, and drying material.

Open fires are the oldest small heating method in the world, and they continue to play a large role in developing countries today. However, the efficiency of open fires for heating domestic space is relatively low. Additionally, emissions under open fire conditions are difficult to regulate, if at all, and often conflict with local and regional air quality guidelines. In developed countries, open fires are mostly chosen for aesthetic reasons.

Figure 2: *Researchers evaluate and label pellet fuels for efficiency, pollutant emissions, and ease of handling.* Photo courtesy of Scott Bauer, USDA Agricultural Research Center.

Wood-fired heating systems such as forced hot air, hydronic, combination, and outdoor boiler systems are affordable energy solutions for increasing the air temperature of buildings in areas where wood is plentiful. Wood heating units are either indoor boilers or stoves or outdoor furnaces. These furnaces come in a variety of sizes and are typically made from stainless steel. Outdoor wood furnaces can heat buildings up to 30,000 square feet; whereas, indoor heating units tend to be used for smaller areas.

Heating systems designed to burn wood pellets are becoming a popular alternative to more conventional methods of home heating (e.g., fuel oil). The low air pollution emissions and clean burning nature of these pellet burners have the potential to produce heat at efficiency levels in the 80 to 90 percent range.

Pellets are small biomass particles such as straw, sawdust, and wood chips that have been processed and converted into small, dense, uniformly shaped cylinders. Increasing density allows for easier handling and storage, and the uniformly low moisture content of pellets leads to high combustion efficiency. Pellets are typically 6 to 8 millimeters (mm) in diameter and 5 to 30 mm long, with maximum water content of 8 percent. The construction of pellet production facilities is increasing in the United States, partially in response to an increase in demand from European countries and to a lesser extent domestic demand.

Pellet stoves are designed to burn these dense cylinders of wood for heat production. They can be an alternative for residential or small-scale use, and as a result are increasing in popularity. The stoves, with a low fuel-to-air ratio, are energy efficient and burn cleaner than more conventional wood burning stoves. Pellet stoves also offer convenience. Bags of fuel pellets store easily and stack compactly; and the uniform and small shape of pellets allows them to flow easier, making the automation of fuel handling easy.

Process Heat

Heat is generated during the electricity production process. Under a typical scenario, about one third of the fuel's energy can be converted to electrical energy while the other two thirds are released as waste heat in the form of low temperature steam, hot water, and hot air. The usefulness of heat as energy depends on the temperature because heat transfer requires a temperature difference.

In commercial and industrial wood processing, wood-fired boilers produce either hot water or steam. The steam is used for drying and processing as well as powering turbines for electricity. When electricity and heat are produced and used simultaneously, the process is referred to as co-generation or combined heat and power (CHP). CHP, also known as cogeneration, represents the largest use of wood energy in the U.S. Large pulp and paper manufacturing plants use their waste wood or by-products internally in these systems instead of fossil fuels such as natural gas. However,

What's the difference between cogeneration and cofiring?

Cogeneration (or combined heat and power, CHP) is a process by which electricity and heat are produced simultaneously.

Cofiring is when two different feedstocks, such as biomass and coal, are burned simultaneously to produce electricity, heat, CHP.

many smaller facilities both inside and outside the forest products industry successfully use CHP systems as well. Large institutional facilities such as hospitals and colleges also use them, frequently combining them with district heating and cooling systems to distribute energy to several buildings. Part of the popularity of CHP systems is their high efficiency. The overall system efficiency can reach around 75 percent for CHP, whereas using wood for electricity production exclusively typically provides around 30 percent system efficiency.

3.3 Transportation Fuels

In the U.S., refining petroleum has been the preferred method of producing transportation fuels, such as gasoline and diesel. However, concerns over resource depletion, increasing prices, the environment, and energy security are leading to an increased interest in and use of alternative feedstocks such as wood biomass. Biofuels are by no means a new concept or product. In fact, Henry Ford's first model T automobile was designed to run on ethanol, an alcohol produced from biomass. Biofuels have, however, largely been overlooked because up until recently crude oil has been cheaper and easier to refine. Three common biofuels are ethanol, methanol, and biodiesel. The following sections will explore each in more detail.

Ethanol

Ethanol is a flammable, tasteless, colorless, mildly toxic alcohol with a distinct odor. It is the same alcohol found in alcoholic beverages and is used as a transportation fuel and an industrial product. Ethanol is produced chemically through the hydration of ethylene, biologically by fermenting sugars with yeast, and thermochemically by gasifying wood and running the resulting syngas through a catalyst. Cellulosic ethanol or wood-based ethanol is made from materials contained in the cell walls of plants. Turning wood into ethanol is typically more complex than the process that breaks down food-based, agricultural biomass such as corn and sugarcane. This is because the cellulose (sugar) has to be separated out from lignin, the glue-like substance that holds the cellulose fibers together and upright.

Figure 3: *Ethanol plant.* Photo courtesy of Reuters News Media Inc.

Cellulosic ethanol is not only created from a renewable resource but it also burns cleaner than both gasoline and diesel. It has low carbon, sulfur, and particulate emissions (ash and soot). The large-scale production of ethanol from cellulosic biomass, in particular, is important because it would mean less waste when producing biofuels from feedstocks such as corn and cane. However, when exploring these feedstocks, it is important to consider how the replacement of petroleum-based fuel with agriculture and forestry fuels could impact supplies and prices for food and fiber products.

Methanol

Methanol, also known as wood alcohol or wood spirit, is a simple, yet toxic alcohol originally derived from the distillation of wood. Today, however, it is created synthetically using natural gas and steam. Methanol is also burned as an automobile fuel on a limited basis and in the 1990s it became popular to add methanol to gasoline to increase octane. It has since been banned in many states because even small spills can lead to problematic groundwater pollution. However, there are more than a billion gallons produced each year in the U.S., and the associated high-octane properties of methanol make it a fuel suitable for high-compression internal combustion engines, which is why it is largely used in the automobile racing industry. It also remains an important feedstock or base for a variety of products including plastic, paints, solvents, and explosives.

Biodiesel

Biodiesel is a transportation fuel made from fatty acids found in plants. Fatty acids are typically found in the fruit or food-based portion of a plant and can make up about 10 percent of a dried plant's mass. Fatty acids make up 90 percent of biodiesel. The other 10 percent of biodiesel, which is methanol, can be made from wood. Methanol is added to biodiesel to reduce "gooeyness" so that it can flow easily through automobile engines. While methanol can be made from wood, the majority of methanol currently mixed with biodiesel is made from petroleum feedstocks. For more information about food-based agricultural feedstocks, please refer to chapter 2, "What is Woody Biomass?"

A recent technological advance developed at the University of Wisconsin shows new promise for cellulosic biodiesel, which is made from the nonfood-based portion of the plant. What makes this advance so attractive is that the 90 percent of dry biomass currently not suitable for production of biodiesel could be used. Moreover, because the process eliminates the need for distillation, it is exothermic, meaning it requires very little extra energy, and thus the process is more efficient. This is important because the largest cost in the current biofuel refining process is the energy it requires.

3.4 Bioproducts

Petroleum- and coal-based feedstocks have dominated as industrial inputs over the past century. Rising prices, a decline in reserves, and consumer demand for environmentally friendly products have resulted in numerous opportunities for biobased materials in the marketplace. As research and development continues, new innovative substitutes for traditional petroleum- and coal-based products are discovered at a rapid rate.

Figure 4: *Char.* Photo by Sarah Ashton, Southern Regional Extension Forestry.

Char

Char is the solid portion of biomass that does not fully react during a thermochemical conversion process. It is recycled to produce steam for heat and energy. It can also be used as a filtration agent when converted to activated carbon, and it can be processed to create fertilizer or charcoal briquettes for grilling.

Glass Aggregates

Glass aggregates are unstructured solids formed when the minerals found in various sludge effluents are subjected to heat and subsequently melt. So how is this a product of biomass? A common effluent used in this process is paper mill residue, and the minerals found in paper mill residue originate in the wood fiber used in the pulping process. Once the aggregates are formed, they are ground into various sizes depending on their ultimate use: ceramic tile, roof shingle granules, asphalt paving, material for cement, and sandblasting media.

Anaerobic Digestion Effluent

Anaerobic digestion effluent is a mixture of solids and liquids expelled from the anaerobic digestion process. Much of it comes from livestock and poultry operations where animals are managed in relatively confined areas and animal waste is concentrated. While not as abundant, effluent is also produced from the anaerobic digestion of woody biomass, which is 20 to 30 percent biosolids and comprised of nitrogen, potassium, and phosphorous. Effluent can be used for composting, fertilizer, and bedding.

Bedding Wood Shavings and Pellets

Figure 5: *Pellets made from woody biomass.* Photo by Sarah Ashton, Southern Regional Extension Forestry.

Bedding refers to any tangible material that goes into covering floors in animal husbandry structures such as horse stalls and poultry houses. It consists of anything from sand to wood chips and even plastics. People have used straw, wood shavings, and sawdust for ages and continue to do so in industries like equestrian sports, livestock shows, and traditional animal husbandry. These biomass products provide insulation and protection for animals as well as needs.

Another type of biomass bedding in production today is wood pellets. Wood pellets specially designed for bedding are a healthy and long-lasting alternative to shavings and straw. Using pellet bedding in horse stalls has the potential to reduce yearly labor costs and is quicker and easier to remove when cleaning the stalls compared to more traditional materials. The use of wood pellets for bedding also reduces stall waste and the breakdown of the used pellets is faster, making it more valuable as a soil amendment.

Bioplastics

Renewable biomass resources such as starches, fatty acids, and vegetable oils can serve as sources for bioplastics. Biodegradable plastics—such as starch esters, cellulose acetate blends, polylactide, and thermoplastic proteins are all derived from cellulose. Rayon, for example, is a fabric woven from fibers of spun wood cellulose (Monroe, 2007). Cellulose is also processed and purified into cellulose gum to thicken low-fat dressings, paint, and shampoo (Monroe, 2007).

Ash

Ash is a byproduct produced when woody biomass s combusted. It comes from the minerals present in the wood and soil contamination. Properties of wood ash depend on a variety of factors including the type of plant; part of the plant (bark, wood, or leaves); type of feedstock (wood, pulp, or paper residue); combination with other fuels; type of soil and climate; and conditions of conversion (e.g., combustion, gasification, pyrolysis).

Figure 6: *Ash remnants from burning woody biomass.* Photo courtesy of D. E. Wieprecht, USGS.

There are a number of uses for ash generated from wood. Wood ash stimulates microbial activities and mineralization in soil by improving the soil's physical and chemical properties. It is highly alkaline, so it is often used to raise the pH of acidic soils. In the U.S., wood ash applications are used as a source for potash production, as a liming agent, a source of nutrients, and as a tannin-neutralizing agent. It also neutralizes soil acidification caused by acid deposition and nutrient export caused when whole trees are harvested. Wood ash, because it is a direct source of phosphorous, calcium, magnesium, and potassium, is also used to correct nutrient deficiencies. Wood ash is sometimes used to reduce the total carbon and nitrogen in a soil. When wood is co-fired with other fuels, however, the resulting ash cannot be used as wood ash.

3.5 Biochemicals

Steady advances in the production technology have made biobased chemicals a competitive commodity. The use of biobased chemicals derived from biomass can alleviate our dependency on high-cost, crude oil-based chemicals by providing a renewable alternative.

Acids

Acids are a vital component of many industrial products and processes including the production of food preservatives and plastics. Increasing the feedstock for the production of acids is necessary for the U.S. to stay economically competitive in the global market. Acetic acid, fatty acid, itaconic acid, lactic acid, and succinic acid can all be recovered from forest residues.

Specialty Chemicals

Specialty chemicals also play an important role in the U.S. economy. Currently, organic chemicals are made primarily from petroleum and used for the production of paints, solvents, fibers, pharmaceuticals, and plastics. There is a growing market for specialty chemicals made from woody biomass, including ethylene, enzymes, PDO, 3-HP, biobased fuel gas, syngas, butanol, and glycerin.

Figure 7: *Bio-oil liquid can be used in fuel applications in addition to extracting useful chemical compounds.* Photo courtesy of Warren Gretz, National Renewable Energy Laboratory.

Oils

Raw liquefaction oil is a free-flowing dark liquid produced by a thermochemical conversion process called liquefaction. It is easily stored and transported. Some light liquefaction oils are even used as refined biodiesel. Some chemical components of liquefaction oil are used as solvents, which can then be found in paint remover and nylon, used as additives to rubber and waxes, and used in the manufacturing of explosives and jet fuel to increase octane (the quality of fuel).

Pyrolytic bio-oil is a complex, combustible mixture produced by pyrolysis, the breakdown of biomass at high temperatures in the absence of oxygen. Pyrolytic bio-oil or biocrude is marketed as a free-flowing, dark brown liquid that can be stored and transported easily. It has been used commercially for industrial heat since the early 1930s and is currently being tested as a fuel for diesel transportation and stationary turbine and diesel power. Extracted additives from pyrolyticbio-oil produced in a fast pyrolysis process are used to infuse ”smoked”, “roasted”, or “grilled” flavors in food.

3.6 Carbon

In addition to the tangible goods derived from woody biomass, there are also important ecological services. One such service is carbon sequestration.

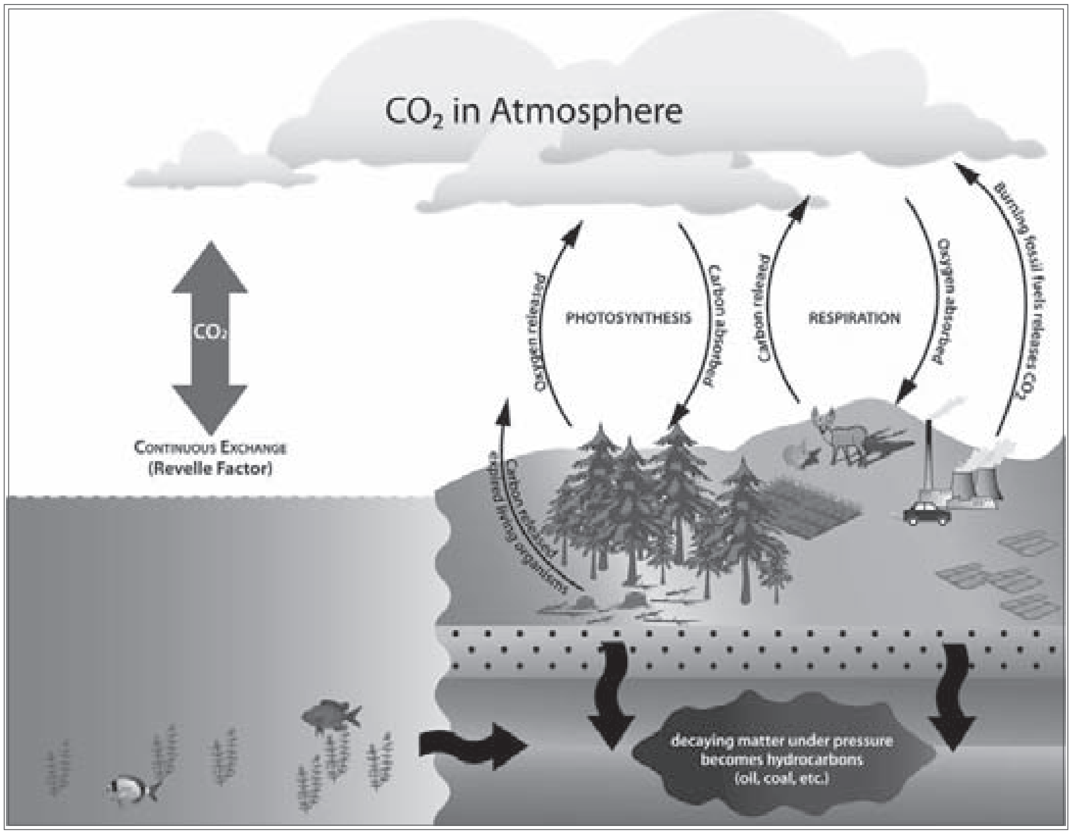
Carbon cycles continuously through all plants and animals, soils, oceans, and the atmosphere (Diagram 1). This cycle results in a natural balance of carbon dioxide levels. Carbon is a major component of all living organisms. Humans and animals get carbon from food. Green plants absorb carbon from the atmosphere during photosynthesis. As plants and animals grow, they store and release carbon. As they decompose, they also release carbon. Tree growth and wood decomposition represents a short-term carbon cycle, where growing trees convert carbon dioxide to cellulose and decomposition releases the carbon back into the atmosphere. Whether trees naturally decompose or are burned, carbon combines with oxygen and is emitted back into the atmosphere, replacing the carbon dioxide that was recently sequestered. When fossil fuels are burned, on the other hand, they release carbon that has been stored for millions of years back into the atmosphere.

Internationally, some governments, in an effort to reduce carbon emissions, have set carbon emission cap-and-trade policies, which set a total allowable carbon dioxide emission or “cap,” and thereby establish a market value or price for carbon. If an industry or utility emits more carbon than allowed, it has a choice: reduce carbon emissions or purchase carbon credits from a seller. A seller is a person or entity that, by some action, is producing fewer carbon emissions than allowed by the cap or else is sequestering carbon. Adoption of some form of carbon trading or regulation within the U.S. has been an increasing discussion by Congress and the President and his administration.

Working forests sequester a significant amount of carbon. Young stands absorb 2 to 9 tons of carbon dioxide a year as they grow; although older stands store more carbon overall, they sequester less because of reduced growth rates and higher respiratory losses (Birdsey, 1996). In all, U.S. forests sequester between 200 and 280 million metric tons (a metric ton is 2,200 lbs) of carbon each year, offsetting approximately 12 percent of U.S. greenhouse gas emissions (Birdsey and Health, 1995 and Murray et al., 1995). By owning and managing forests, landowners may qualify as carbon credit holders. Carbon credit programs and a carbon market are still in their infancy, but at some point, there may be a significant value landowners can capture.

Carbon sequestration refers to the condition of long-term storage of carbon in the terrestrial biosphere, underground, or the oceans to help slow or reduce the buildup of carbon dioxide.

Diagram 1: *Carbon cycle.* Illustration adapted by Camilla Geniatulina.



3.7 Summary and Conclusion

Research and development have created technologies to replace many petrochemically derived products with products derived from biomass. Scientists and engineers also continue to make progress in the development of processes that reduce the real cost of converting plant matter into value-added products. At the same time, environmental concerns and legislation are intensifying the interest in agricultural and forestry resources as renewable feedstocks. Sustained growth of this developing industry will depend on new market development and the cost competiveness of bioenergy and biobased industrial products.

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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.

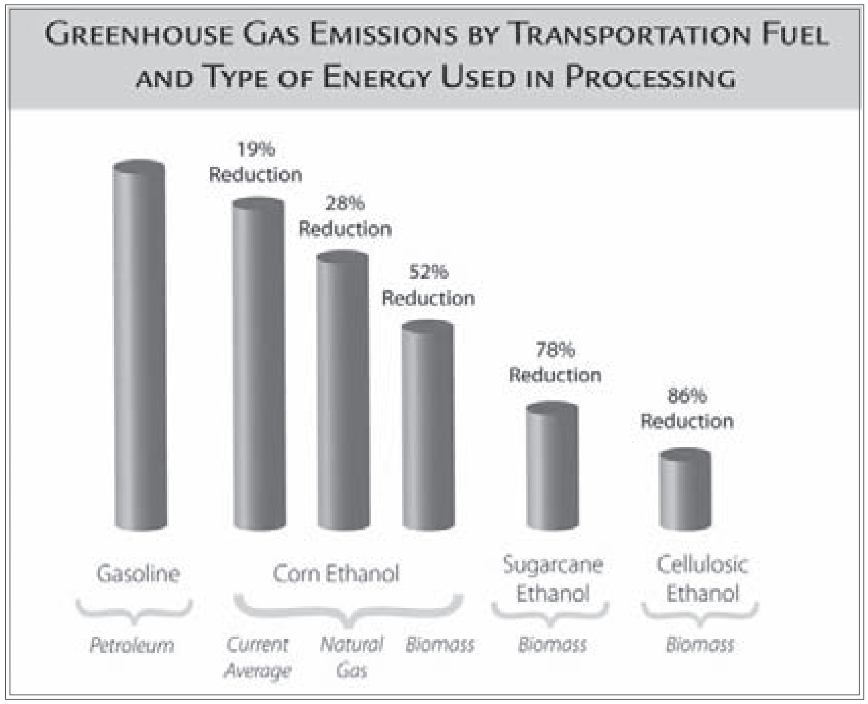
Some sources of woody biomass, such as yard trimmings and debris from land clearing for development, are often burned in open fields without emission controls. Burning these wood resources in the controlled environment of a power plant can significantly reduce the air quality impacts created by these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

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

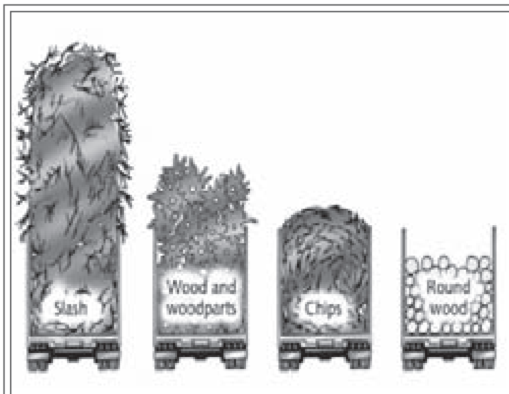
Fuel Type	Dollars per million Btu
Oil (residential)	$22.42
Wood*	$9.09
Natural Gas	$12.40
Coal	$8.03

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

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?"

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

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



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).

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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Handout 4 Implications of Using Woody Biomass for Energy and Other Products

Like with many natural resource-related issues, the production and utilization of woody biomass for heat, power, electricity, transportation fuels, and industrial-scale bioproducts can be controversial. Like all feedstocks, woody biomass has benefits and costs that must be carefully considered.

Advantages

Some potential advantages of producing and utilizing woody biomass for bioenergy, biofuels, and bioproducts are:

Wildfire Mitigation and Healthy Forests Landowners have the opportunity to market materials for biomass that are removed during forest management activities, such as those that help reduce wildfire risk and prevent insect infestations and disease.

Economic Development Markets are key components of the woody biomass value chain. Viable, local biomass markets provide financial opportunities for bolstering rural communities, providing additional income to forest landowners, insuring local flow of money, and diversifying local economies. Woody biomass production and use can also create new jobs, further stimulating local economies.

Increased Energy Security The United States is vulnerable to oil supply disruptions and price increases because it imports much of its oil from politically unstable countries. Woody biomass offers an opportunity to lessen the dependence on foreign supplies of fossil fuels by providing an alternative, “homegrown,” renewable source of energy.

Environmental Benefits Wood offers many environmental benefits including improved air and water quality, incentives for better forest management, and reductions in greenhouse gases. When burned, trees do not add more carbon dioxide into the atmosphere than they removed while growing. As long as trees are replanted, wood is an essentially carbon-neutral energy source. Fossil fuels, on the other hand, release carbon that was sequestered thousands of years ago.

Disadvantages

Some potential disadvantages of producing and utilizing woody biomass for bioenergy, biofuels, and bioproducts are:

Size of Facility Power plants that strictly use wood cannot typically be built to produce as much power as their traditional coal-fueled counterparts. While a large wood plant may produce up to 50 megawatts of power, coal plants can be built to produce thousands of megawatts

Sustainable Supply of Wood Needed Communities need an ample, sustainable supply of wood in order for a woody biomass facility to be successful. For example, urban areas surrounded by expansive suburbs do not lend themselves to wood supply accessibility. Wood must be plentiful and relatively easy to access and transport.

Loss of Soil Fertility and Habitat Change Removing debris that would otherwise become organic matter under natural conditions may have long-term negative effects on soil fertility and wildlife habitat. Woody biomass utilization must incorporate management standards based on sustainability and facilitating a healthy forest ecosystem, including the health of the soil and wildlife habitat.

Wood May Not Be Cost Competitive The cost of woody biomass varies depending on location, availability, type and quality; environmental regulations; and transportation and processing options. In some communities and at some scales, wood may be more expensive than traditional fossil fuels, such as coal.

Is There Enough Wood to Meet Our Needs? Concerns exist about whether or not there are sufficient amounts of wood for wood-based needs: paper and timber, energy, green landscapes, recreation, wildlife habitat, and watershed protection. The emergence of new and growing markets for bioenergy and biobased products will likely place an even greater burden on already heavily used forest resources, further supporting the need for sustainable forest management and effective land-use and energy policies

Summary and Conclusion

Like all feedstocks, the production and utilization of woody biomass has advantages and disadvantages that should be weighed carefully as individuals, industries, and communities decide whether or not to choose wood. While no energy source or raw material is perfect, wood may be a viable option in some cases.

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Chapter 5 Incentives to Produce and Use Woody Biomass

5.0 Introduction

Many national, state, and local policies and incentives encourage woody biomass production and utilization. Becoming familiar with these policies and incentives can help you better assist and advise your clients with bioenergy and bioproducts information and advice. Since legislation is constantly evolving, it is wise to review specific details that you share with your target audience to make sure they are current.

5.1 Federal Policies and Incentives

The federal government actively encourages the use of woody biomass for energy and biobased products such as cellulosic ethanol and biodiesel (Figure 1) by setting policy and providing incentives. Efforts to encourage the electric utility industry to use resources other than coal and natural gas began with the Public Utility Regulatory Policies Act of 1978 (PURPA). This act was designed to help promote energy conservation and the use of renewable resources. More recent policy efforts to encourage development of biomass energy include the following (U.S. DOE, 2007):

- The National Energy Policy Act of 1992 contains several provisions to encourage the use of renewable energy sources.
- Executive Order 13134, issued by Executive Memorandum in August 1999, encourages the development and promotion of biobased products and bioenergy.
- The Biomass Research and Development Act of 2000 describes the need for biomass research, encourages coordination between the United States Department of Energy (U.S.DOE) and United States Department of Agriculture (USDA), created the Biomass Research and Development Board, and set the scope of the joint U.S.DOE-USDA Biomass Initiative.
- The Farm Bill of 2002, Title IX, supported biomass through federal procurement procedures, renewable fuels development programs, cooperative extension and research programs, and the Biobased Products and Bioenergy Coordination Council.
- The Healthy Forest Restoration Act of 2003 recommended thinning programs to reduce accumulation of woody fuel to lower the risk of catastrophic wildfire. The collection and removal of small-diameter trees and understory shrubs has spawned local biomass utilization efforts.
- The Energy Policy Act of 2005(EPACT) provided for a federal tax credit for energy production using renewable fuels; grants for forest biomass utilization; and grants for small enterprises, training, and outreach (see the following section, "Incentives," for more information).

Figure 1: *The federal government offers incentives to forest landowners to ensure the protection of watersheds and health water supplies.*
Photo courtesy of Forest Stewardship Program.

- The Energy Independence and Security Act of 2007 (EISACT) reauthorized a number of the programs found in the Energy Policy Act of 2005. In addition, it set a mandatory Renewable Fuel Standard (RFS) that requires energy producers to use at least 36 billion gallons of biofuel in 2022. (See the following section, "Incentives," for more information.)

- The Food Conservation and Energy Act of 2008 reauthorizes 2002 Farm Bill programs and provides grants for investment in renewable technologies, financial incentives to use agricultural and forestry crops for bioenergy. It also established a biobased markets program. (See the following section, "Incentives," for more information.)

In an effort to maximize expert input and help ensure efficient usages of funding, federal agencies are working together to address issues surrounding woody biomass production and utilization. Multiagency projects, such as the Biomass Research and Development Initiative (BRDI), a collaboration between USDA and U.S.DOE, specifically work to address cellulosic ethanol costs, logistics of biomass use, biobased products, and related policies. BRDI is managed by two groups, an advisory committee consisting of thirty appointed members from industry, academia, environmental groups, and state or tribal government; and an oversight committee with members representing the following agencies (U.S.DOE, 2008):

- Department of Agriculture
- Department of Commerce
- Department of Defense
- Department of Energy
- Department of Interior
- Department of Transportation
- Department of the Treasury
- Environmental Protection Agency
- National Science Foundation
- Office of the Federal Environmental Executive
- Office of Science and Technology Policy

In 2003, the U.S. departments of Agriculture, Interior, and Energy produced a joint Memorandum of Understanding (MOU) agreeing to cooperate to support the use of woody biomass where economically and ecologically appropriate. This MOU raised awareness about the possibilities of using wood for energy production among agency employees, collaborators, natural resource professionals, and communities as well as prompting the development of joint programs to provide support. Furthermore, the MOU outlined several policy principles to guide the processes by which agencies work with communities to promote woody biomass utilization (NACD, 2005):

- Collaborate with local communities to create woody biomass utilization strategies.
- Increase public understanding of the amount and value of woody biomass, and that it can be an effective element of habitat restoration and wildlife risk reduction activities.
- Develop and apply the best scientific knowledge to manage forests for woody biomass production
- Encourage the use of contracts and other agreements with growers, suppliers, and haulers to reduce wildland fuels and provide reliable, long-term supplies of woody biomass.
- Develop woody biomass systems to create jobs and new economic opportunities.

The U.S. Forest Service, Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (FWS), U.S. Environmental Protection Agency (EPA), and U.S. Department of Energy (U.S.DOE) are actively participating in biomass utilization efforts. For instance, under a closely monitored program, the BLM authorizes contractors to remove woody biomass from lands it manages through stewardship contracts that exchange cost of thinning and removal for the value of the harvested wood. These practices often receive strong opposition from some environmental groups who are concerned that forests may be overharvested.

Federal Incentives

Federal agencies use various incentive programs to encourage the use of woody biomass. The following programs help provide funding for research and development of new technologies and investment in and use of renewable forms of energy. Tax credits are available for those who produce energy from renewable sources. The Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007 (U.S.DOE, 2007) provide several incentives that apply to woody biomass.

Federal Renewable Energy Production Tax Credit

The production tax credit is an inflation-adjusted tax credit for electricity produced from qualifying renewable energy sources or technologies. EPACT 2005 expanded the types of qualifying sources and systems (U.S.DOE, 2007). Three different rates of tax credits are available for producers of energy from biomass. A credit of 1.5 cents per kilowatt-hour (kWh) is available for facilities that use wood from trees planted for energy use (closed-loop biomass). If the wood is mixed with coal in a co-firing facility, the 1.5 cents credit is reduced to match the ratio of wood fuel used. Using waste wood from any source enables facilities to earn 0.75 cents per kilowatt-hour (kWh) in tax credits. For the year 2005, the credit was adjusted for inflation to make the credit 1.9 cents per kWh for wind energy, closed-loop biomass, geothermal and solar, and 0.9 cents per kWh for open-loop biomass (NRBP, 2005).

Grants for Forest Biomass Utilization

Sections 209, 210, and 944 of EPACT 2005 enable grant programs for rural or remote communities. One program is for communities that improve the commercial value of woody biomass for increased efficiency or use, and the other is for small business bioproduct marketing and certification (Ashworth, 2006). USDA is authorized to issue grants to improve the commercial value of forest biomass for such uses as electric power and heat. Eligible communities can get up to $500,000 total or up to $20 per ton of green forest biomass for utilization. USDA may also issue grants for small business bioproduct marketing and certification and may match grants up to $100,000 for a total of $1 million per year. U.S.DOE may issue grants for rural and remote community electrification, with grants up to $20 million per year available for increased efficiency or use of renewable energy sources including woody biomass.

Grants for Forest Biomass Utilization Research and Development

Section 223 EISACT 2007 authorizes $25 million for each of the fiscal years 2008 through 2010 for grants for research, development, demonstration, and commercial application of biofuel production technologies in states with low rates of ethanol production, including low rates of production of cellulosic biomass ethanol, as determined by the Secretary. Section 234 of the EISACT 2007 authorizes $25 million for establishment of a competitive grant program, in a geographically diverse manner, for projects submitted for consideration by institutions of higher education to conduct research and development of renewable energy technologies.

Grants for Small Enterprises, Training, and Outreach

Millions of dollars in grants have been awarded to small enterprises, universities, and research institutions to develop new uses for woody biomass, to explore policy issues, and to develop training and outreach programs.

Incentives for Biomass Producers

The Food, Conservation, and Energy Act of 2008 (formerly the 2008 Farm Bill) includes several new provisions, which address biomass and bioenergy. It allots $1 billion for programs designed to encourage investment in renewable energy and technology. The act also creates the Rural Energy for America Program (REAP), which assists agricultural producers and rural small businesses in planning and preparing feasibility studies for renewable energy projects. The Bioenergy Program receives $300 million in funding to provide incentives for using agricultural and forestry crops and waste to produce bioenergy and provides for multiyear contracts for crop and forest producers to grow dedicated energy crops. In addition, the act establishes the Biobased Markets Program, designed to provide a USDA certification system for qualifying biobased products. This provision also establishes a federal procurement preference for biobased products.

As renewable and local sources of energy become more valuable, a variety of policies and incentive programs such as those just described may make it easier for communities, industries, and forest landowners to develop woody biomass systems.

5.2 State and Local Policies and Incentives

State and local governments usually follow the regulatory policies set by federal governments; however, in some cases they may adopt their own policies and incentives to further promote the use of renewable resources for energy production.

State and Local Policies

Several policies related to renewable energy, including woody biomass, have been established in the U.S., including generation disclosure rules, renewable portfolio standards, interconnection, construction and design standards, and green power purchase. While not specifying woody biomass, many of these policies make it easier for institutions and businesses to use alternative energy resources. These regulations can be implemented at the state or local level or by regional utilities. The following explains these rules, regulations, and policies in greater detail.

Generation Disclosure Rules

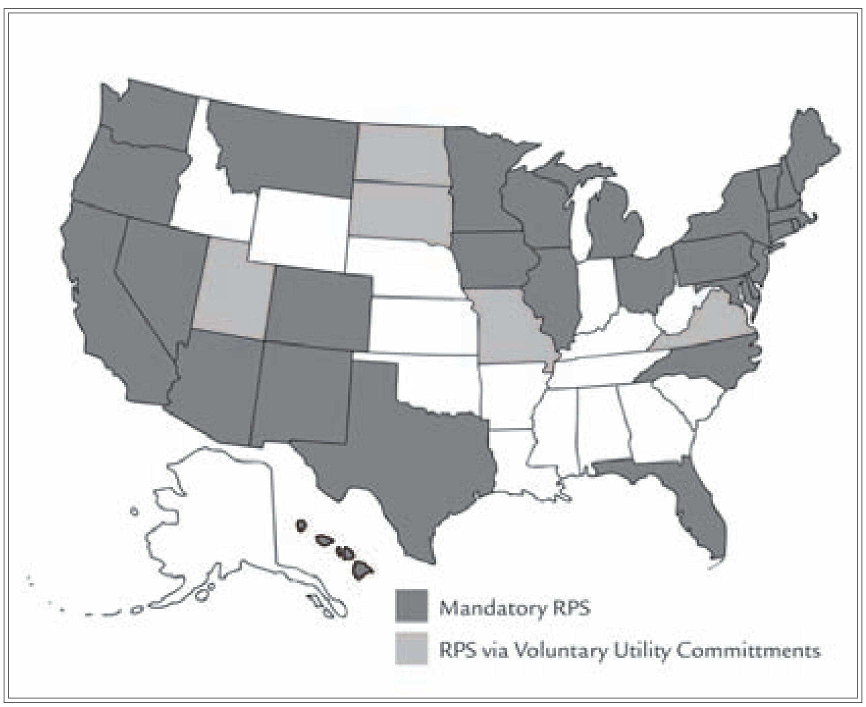
Generation disclosure rules require utility companies to provide information regarding the energy they supply to their customers. This type of information, which may include fuel mix percentages and emission statistics, is often included on a customer's monthly bill. Customers can also access fuel source data on the U.S. Environmental Protection Agency Clean Energy Web site at: http://www.epa.gov/cleanenergy/energy-and-you/how-clean.html by entering a zip code and selecting from a list of energy providers.

Related to disclosure, certification is an industry practice that guarantees customers that the utility company uses the types and amounts of renewable energy it claims to. By providing consumers with detailed information about local energy systems, practices like disclosure and certification can help raise consumers' awareness about their energy supplies (North Carolina State University, 2007).

Renewable Portfolio Standards/Set Aside

These standards require that utility companies generate a certain amount of energy from renewable resources by a certain date. For example, a certain percentage of the utility's electric power sales, measured in megawatt-hours (MWh), must be generated from renewable resources such as wood, wind, and solar by a determined year. The term "set aside" refers to similar regulations that require new utility installations to have a certain amount of generating capacity from renewable resources (North Carolina State University, 2007). Twenty-three states and the District of Columbia have set renewable portfolio standards (Diagram 1) (Pew Center for Climate Change, 2008). Standard levels and definitions of renewable energy vary from state to state. Some states have specific mandates concerning power generation from renewable energy.

Diagram 1: *Several states have implemented Renewable Portfolio Standards.* Pew Center on Global Climate Change 2008.



Interconnection or Line Extension Analysis

Many states have policies regarding interconnection or line extension analysis. When power lines are extended to customers outside of the existing power grid, the customers are charged distance-based fees. In some of these cases, it may be more economical for customers to generate their own energy on-site using renewable energy systems rather than pay the extra fees associated with distance. In some states, utility companies are required to provide information on renewable energy options when customers request a line extension (North Carolina State University, 2007).

Construction and Design Standards

Several types of building construction and design policies are included in this category. State construction policies require an evaluation of the costs and benefits of using renewable energy technologies for new state construction projects, such as schools, office buildings, and other new facilities. In addition, green building guidelines are being developed in many cities to either encourage or require developers, architects, builders, and engineers to design and construct projects that feature renewable energy technologies.

Local energy codes are another type of standard that can be implemented to increase energy efficiency by requiring building construction or renovation to exceed the state requirements for resource conservation. Builders or renovators can meet this requirement by incorporating renewable energy technologies (North Carolina State University, 2007).

Green Power Purchasing/Aggregation Policies

State and local governments, businesses, and other nonresidential customers can serve as role models to the rest of the community by purchasing electricity from renewable resources, a practice commonly called green power purchasing. Some states even require that state government buildings use a certain amount of renewable energy. Green power purchasing can supply energy for various applications, including local governmental facilities, street lights, or water pumping stations. The process by which local governments combine electric loads from the whole community, or in cooperation with other communities, to form a green power purchasing block is called "community aggregation" or sometimes "community choice." Utility green pricing programs, green power marketers, special contracts, or community aggregation are different ways to achieve green power purchasing (North Carolina State University, 2007). State and local regulations and policies may also include green pricing programs, required utility green power option programs, statewide net metering, and public benefits funds, as described in the next section.

Green Pricing Programs

Green pricing programs offer customers the option to pay an additional fee beyond their regular electric bills to support the utility's effort to provide power from renewable sources (Diagram 2). Customers who participate in these types of programs do not receive "green energy" directly, but help fund utilities' efforts to generate or purchase more of its power from renewable sources (Pew Center for Global Climate Change, 2008). In 2006, there were 484 electric utilities in 44 states offering green power to their customers (U.S.DOE, 2008b). Some states have mandatory green pricing programs, where utilities are required to offer customers the option to purchase power from renewable energy sources, while in other states it is voluntary for utilities. Utilities may fulfill this requirement by generating power from their own renewable resources, through contracts, or through purchasing credits from a certified renewable energy provider (North Carolina State University, 2007).

State and Local Incentives

Net Metering

Twenty-one states and the District of Columbia had statewide net metering statutes in 2008 (Diagram 3) (Pew Center for Climate Change, 2008). Net metering is a system for customers who have their own electricity generating units. When customers generate more electricity than their demand, the excess electricity is provided to the local power grid. The customers' electric meter keeps track of the excess electricity as credit toward future power purchases (North Carolina State University, 2007).

Public Benefit Funds

Some states have funds, called Public Benefit Funds (PBF), which are used to support efforts such as energy efficiency, renewable energy projects, and programs for low-income households. The money for these support funds is commonly acquired by charging customers an added fee (as small as 0.2 cents per kWh) based on their electricity consumption. These funds can be used for rebates on renewable energy systems, funding for renewable energy research and development (R&D), and development of renewable energy education programs. The Clean Energy States Alliance consists of twelve states that work together to direct investments in renewable energy that are supported with public benefit funds (North Carolina State University, 2007).

Various state and local incentives also exist for generating energy from renewable resources, including woody biomass. Incentives are

Diagram 2: *The majority of states offer green pricing programs.* Pew Center on Global Climate Change 2008.

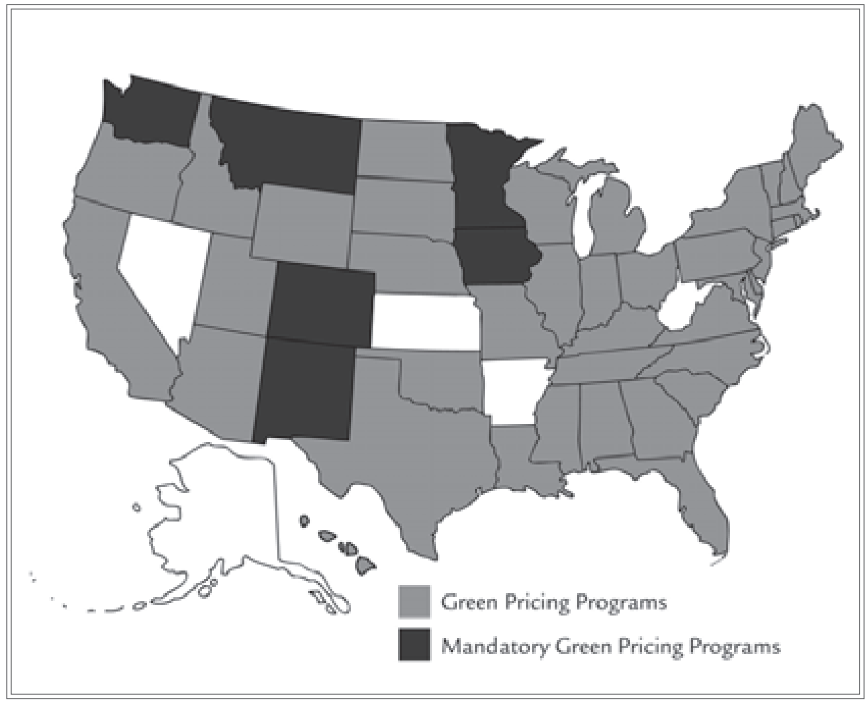
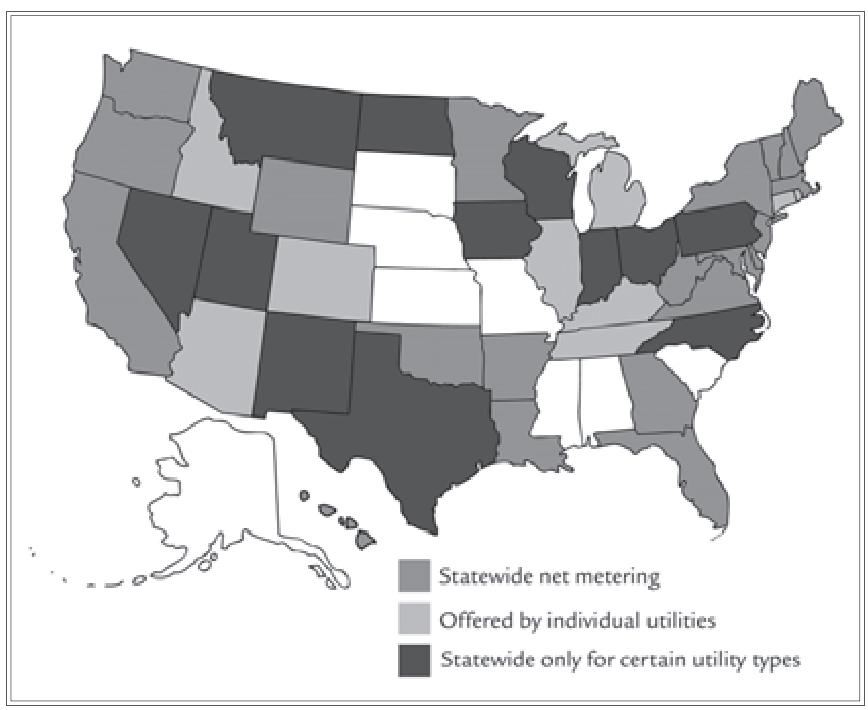


Diagram 3: *More than 20 states have statewide net metering statutes.* Pew Center on Global Climate Change 2008.



usually expressed in state and local policies in the form of tax credits, rebates, grant and loan programs, or industrial and production incentives (Werner, 2004). For example, in Florida, a comprehensive four-year plan, the Florida Renewable Energy,

Technology & Energy Efficiency Act of 2006 provides rebates, grants, and tax incentives in order to increase the state's investments in renewable energy resources such as solar, hydrogen, and biofuels (Florida Energy Office, 2006).

5.3 Financing Options for Bioenergy Projects

There are several loan and grant programs that can help fund bioenergy projects in the U.S. Following is a brief summary of some of these programs. See the financing handout in chapter 6 for more details. Resources and regulations concerning financial support change often; so it is wise to check frequently for updated information.

U.S. Department of Agriculture

The Food, Conservation, and Energy Act of 2008

The Food, Conservation, and Energy Act of 2008 provides $320 million in loan guarantees for biorefineries using biomass to produce advanced biofuels. There are a number of other grant programs established by this act such as the bioenergy program, biodiesel fuel education program, and the rural energy for American program.

Business and Industry (B&I) Guarantee Loan Program

The B&I Guarantee Loan Program provides up to a 90 percent loan guarantee to banks for businesses located in areas with 50,000 in population or less. The primary objective of the program is creation or preservation of jobs in rural areas. Personal guarantees are required along with a minimum of 25 percent tangible equity for companies that produce energy from renewable sources.

Rural Utilities Service (RUS)

Approximately $200 million in direct loans is available through USDA's Rural Utility Service for electricity produced from biomass energy that is generated for sale to rural utilities and power companies with a significant "rural customer load." The technology must be "proven" and "renewable."

Renewable Energy Grant and Loan Program

The USDA Rural Business Service offers entrepreneurs a grant-and-guarantee loan program. Commercial entities and agricultural and forestry producers are eligible. This program has $11.4 million available for grants and $176 million in guarantee loan authority available for projects that produce energy from renewable sources. Grants can cover 25 percent of eligible project costs and guarantee loans can be for up to 50 percent of project costs. Loan terms are similar to B&I loan terms and conditions.

Value-Added Agricultural Product Market Development Grants

In 1994, the Rural Business-Cooperative Service began offering grants to help independent producers, such as forest owners, enter into value-added activities. The primary objective of this grant program is to help eligible applicants develop business plans and strategies for viable marketing opportunities. Grants of up to $500,000 are available. All applicants must be producers of agricultural commodities or products, including aquaculture and wood lot enterprises. Grants are available for planning and working capital.

Biomass Research and Development Initiative (BRDI)

As mentioned previously, USDA and U.S.DOE jointly administer the BRDI to provide assistance for research, development, and demonstration of biomass-based products, bioenergy, and biofuels. The intent is to promote greater innovation and development related to biomass. Approximately $15 million is available for grants in each fiscal year. The maximum grant amount is $2 million and requires a 20 percent match by the applicant.

Cooperative Services

For cooperative-owned businesses, there are special programs by USDA that may include grants for projects that support the use of renewable fuels. This may involve a partnership with a nonprofit or university if further research and development is involved. These programs are typically for energy projects involving farmer or producer-owned entities. However, even a utility can access these programs if an alliance with producers is established to provide the necessary feedstock to produce energy.

Economic Action Program

The U.S. Forest Service has in recent years offered funding for projects utilizing woody biomass for value-added purposes. The Economic Action Program is designed to assist projects that promote rural economic development, assist rural communities recovering from changes in natural resource management, and provide new ways for rural communities to rebuild or replace transportation and recreation infrastructure while stimulating markets for local wood products.

Additional Financing Resources

In addition to these USDA programs there are other economic development programs that can be accessed to provide grants, equity, and favorable rates and terms for debt financing. Following are descriptions of some of these programs.

U.S.DOE Tribal Energy Program Grant

This federal grant program administered by U.S.DOE's Office of Energy Efficiency and Renewable Energy (EERE) provides financial and technical assistance to Native American tribes for feasibility studies and shares the cost of implementing sustainable installations that use renewable energy sources on tribal lands. Eligible technologies include the use of passive-solar space heat, solar water heat, photovoltaics, wind, biomass, hydroelectric, geothermal, electric, and geothermal heat pumps. The program provides approximately $2.7 million in funding to selected tribal governments through a competitive grant process.

Revenue Ruling 63-20 Bonds

These tax exempt bonds can be used to provide long-term fixed rate loans for projects that are "public in nature." Bonds are issued by local governments on behalf of a non-profit entity. The political subdivision issuing the bonds must have a beneficial interest in the nonprofit entity while the indebtedness remains outstanding. The political subdivision must obtain full legal title to the property upon debt retirement.

Tax Increment Financing (TIF)

Bonds can be issued by local governments for infrastructure improvements in an area predetermined to be part of a "tax increment financing district." Bond proceeds are used to entice businesses to bring revenue-producing properties to an area. Bonds are retired by the property and/or sales taxes generated by businesses locating in the tax increment district. These bonds are an excellent way to offset the costs of infrastructure associated with projects that produces energy from renewable sources.

General Obligation and Revenue Bonds

General Obligation/Revenue Bonds issued by the state, county, or municipality provide long-term, fixed rate financing at tax exempt bond rates. These bonds provide funding to governments to enable them to attract new industry and economic development to an area.

5.4 Summary and Conclusion

Political and economic support for bioenergy and biofuels will be increasingly important as the United States moves towards goals of energy independence and sustainability. There are many policies, incentives, and resources at the federal, state, and local level that can encourage and support the production and utilization of biomass and bioenergy.

This chapter was adapted from the following sources and used with permission.

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Handout 5 State and Local Policies and Incentives to Produce and Use Woody Biomass

Several policies related to renewable energy, including woody biomass, have been established in the U.S., including generation disclosure rules, renewable portfolio standards, interconnection, construction and design standards, and green power purchase. These regulations can be implemented at the state or local level or by regional utilities.

State and Local Policies

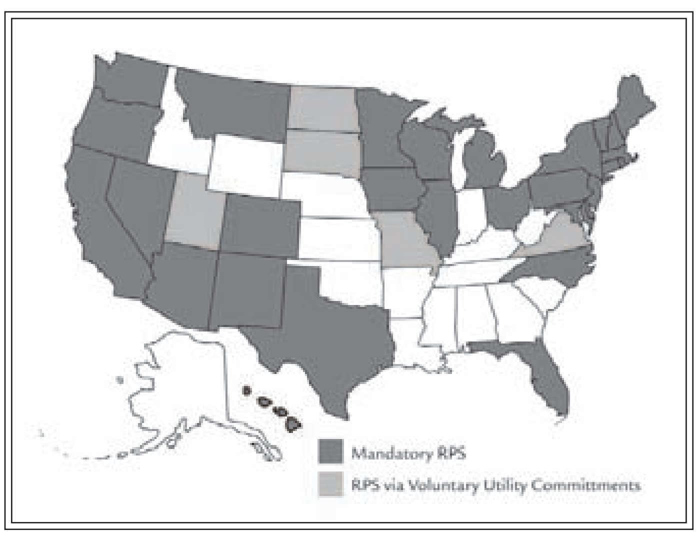
Generation Disclosure Rules require utility companies to provide information regarding the energy they supply to their customers, which may include fuel mix percentages and emission statistics (North Carolina State University, 2007).

Renewable Portfolio Standards/Set Aside require that utility companies generate a certain amount of their energy from renewable resources, such as wood, wind, and solar by a determined year. The term "set aside" refers to similar regulations that require new utility installations to have a certain amount of generating capacity from renewable resources (North Carolina State University, 2007).

Interconnection or Line Extension Analysis exists in many states. When power lines are extended to customers outside of the existing power grid, the customers are charged distance-based fees. In some of these cases, it may be more economical for customers to generate their own energy on-site using renewable energy systems rather than pay the extra fees associated with distance (North Carolina State University, 2007).

Construction and Design Standards may require an evaluation of the costs and benefits of using renewable energy technologies for new state construction projects, such as schools, office buildings, and other new facilities. In addition, green building guidelines are being developed in many cities to either encourage or require design and construction projects to consider renewable energy technologies. Local energy codes are another type of standard that can be implemented to increase energy efficiency by requiring building construction or renovation to exceed the state requirements for resource conservation. Builders or renovators can meet this requirement by incorporating renewable energy technologies (North Carolina State University, 2007).

Figure 1: *Several states have implemented Renewable Portfolio Standards.* Pew Center on Global Climate Change 2008.



Green Power Purchasing/Aggregation Policies allow state and local governments, businesses, and other nonresidential customers to serve as role models to the rest of the community by purchasing electricity from renewable resources, through a practice commonly called green power purchasing. Some states even require that state government buildings use a certain amount of renewable energy. The process by which local governments combine electric loads from the whole community, or in cooperation with other communities, to form a green power purchasing block is called "community aggregation" or sometimes "community choice" (North Carolina State University, 2007).

Green Pricing Programs offer customers the option to pay an additional fee beyond their regular electric bills to support the utility's effort to provide power from renewable sources. Customers who participate in these types of programs do not receive "green energy" directly, but rather help enhance the utility's ability to generate or purchase more of its power from renewable sources (Pew Center for Global Climate Change, 2008). In 2006, there were 484 electric utilities in 44 states now offering green power to their customers (U.S. DOE, 2008). Some states have mandatory green pricing programs, where utilities are required to offer customers the option to purchase power from renewable energy sources, while in other states it is voluntary for utilities.

Figure 2: *The majority of states offer green pricing programs.* Pew Center on Global Climate Change 2008.

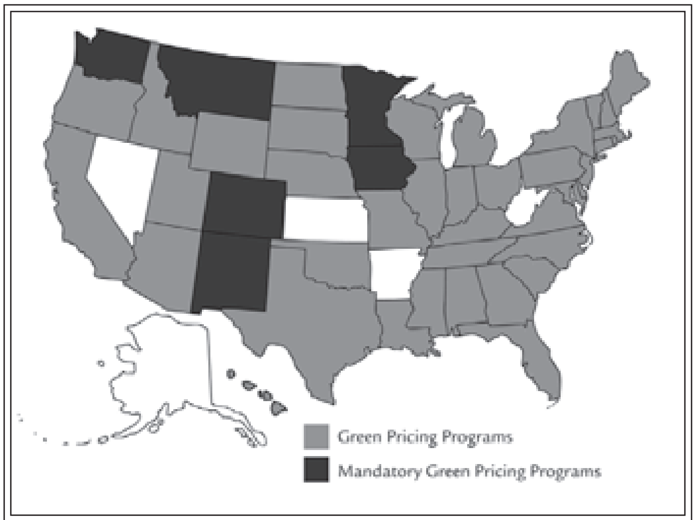
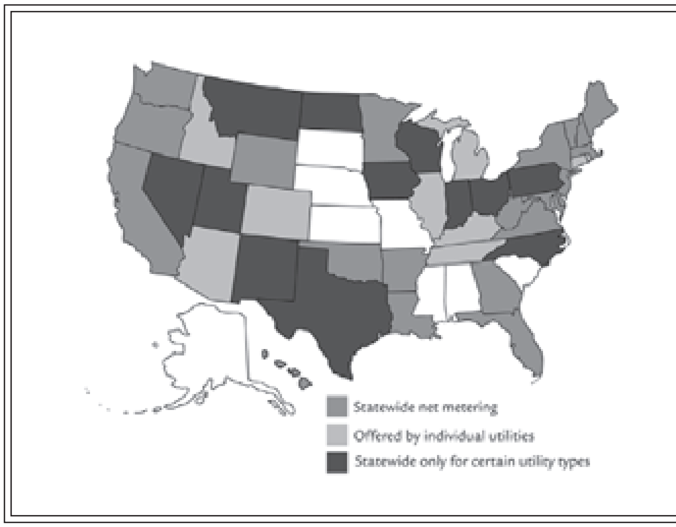


Figure 3: . *More than 20 states have statewide net metering statutes.* Pew Center on Global Climate Change 2008.



State and Local Incentives

Net Metering is a system for customers who have their own electricity generating units. When customers generate more electricity than their demand, the excess electricity is provided to the local power grid. The customers' electric meter keeps track of the excess electricity as credit toward future power purchases (North Carolina State University, 2007). Twenty-one states and the District of Columbia had statewide net metering statutes in 2008 (Pew Center for Climate Change, 2008).

Public Benefit Funds (PBF) are used to support efforts such as energy efficiency, renewable energy projects, and programs for low-income households. The money for these support funds is commonly acquired by charging customers an added fee based on their electricity consumption. For example, the customer may be charged 0.2 cents for each kilowatt hour used. These funds can be used for rebates on renewable energy systems, funding for renewable energy research and development (R&D), and development of renewable energy education programs.

Various state and local incentives also exist for generating energy from renewable resources, including woody biomass. Incentives are usually expressed in state and local policies in the form of tax credits, rebates, grant and loan programs, or industrial and production incentives (Werner, 2004). For example, in Florida, a comprehensive four-year plan, the Florida Renewable Energy, Technology & Energy Efficiency Act of 2006 provides rebates, grants, and tax incentives in order to increase the state's investments in renewable energy resources such as solar, hydrogen, and biofuels (Florida Energy Office, 2006).

As renewable and local sources of energy become more valuable, a variety of policies and incentive programs may make it easier for communities, industries, and forest landowners to develop woody biomass systems.

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Rahmani, M.; A. W. Hodges, and M. C. Monroe. 2007. *Federal Policies and Incentives*, Wood to Energy Outreach Program. Florida Cooperative Extension Service, Circ 1526. University of Florida, Gainesville, FL,

Rahmani, M.; A. W. Hodges, and M. C. Monroe. 2007. *State and Local Policies and Incentives*, Wood to Energy Outreach Program. Florida Cooperative Extension Service, Circ 1526. University of Florida, Gainesville, FL,

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Florida Energy Office. 2006. Florida's Energy Act.

North Carolina State University. 2007. Database of State Incentives for Renewable Energy. North Carolina Solar Center and Interstate Renewable Energy Council. http://www.dsireusa.org/index.cfm(accessed August 28, 2008).

Pew Center for Global Climate Change. 2008. Energy Sector State Action Maps. http://www.pewclimate.org/what_s_being_done/in_the_states/state_action_maps.cfm (accessed August 28, 2008).

U.S. Department of Energy. Energy Information Administration. 2008b. Green Pricing and Net Metering Programs. http://www.eia.doe.gov/cneaf/solar.renewables/page/greenprice/green_pricing.html (accessed August 28, 2008).

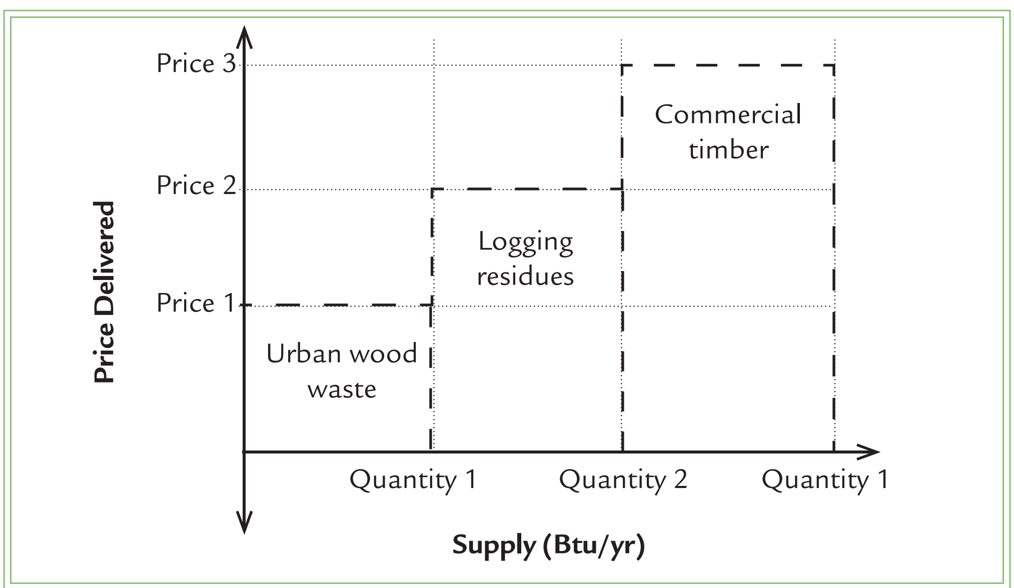
Chapter 6 Do-It-Yourself Supply Curve: Tools to Help You Get Involved in an Entrepreneurial Woody Biomass Project

6.0 Introduction

The feasibility of woody biomass utilization projects depends, in part, on the cost and availability of the wood resources. Identifying and communicating the availability and cost of biomass in an area is often the first step in gaining interest in and support for a biomass project. One way to illustrate the economic availability of biomass resources is with a supply curve. This chapter introduces several tools that you can use to construct supply curves for woody biomass resources in your area of interest (AOI). These tools may be useful to potential suppliers and users of biomass or to communities considering using biomass.

A supply curve is a basic economic tool used to determine the price of a resource at a given quantity of demand. For example, Figure 1 illustrates a hypothetical woody biomass resource supply curve. In this example, a small amount of biomass (Quantity 1) is available at low cost (Price 1) in the form of urban wood waste. When this supply runs out, more biomass (Quantity 2) can be acquired in the form of logging residues, though at a higher price (Price 2). If logging residues are also not sufficient to meet the demand, even more biomass (Quantity 3) can be purchased from commercial timber suppliers, though it would be the most expensive (Price 3). Thus, a supply curve shows the price of biomass at various levels of demand. If enough biomass (the x-axis) can be delivered continuously at a low enough price (the y-axis) then enough wood

Figure 1: *Hypothetical supply curve illustrating price at various levels of demand.*



Important questions to ask when considering an entrepreneurial woody biomass project:

- Is there a market?
- What are the product specifications?
- Are there time and volume supply commitments and if so, can they be met?
- Are there storage constraints at the facility planning to use biomass?
- Are there loading and unloading constraints? Transportation challenges?
- Are there environmental factors related to certification programs such as the Forest Stewardship Council (FSC) or Sustainable Forestry Initiative (SFI) that must be considered?
- Is the operation expected to be profitable?

may be available to supply a bioenergy project. A more complete supply curve might include other available resources and account for transportation costs in ranking the economic availability of these resources of different types at different travel times.

The following sections provide you with various tools, that when used together, can help you construct a "preliminary" biomass supply curve for a particular AOI. Using these tools and this approach, it is possible to develop a preliminary supply curve in just a few hours. This process is valuable because it allows you to get an initial assessment of the economic availability of various biomass resources in an AOI. It also allows you to make comparisons between different AOIs, which is an important step in site selection for bioenergy projects. Some of the individual tools or steps in the process may be useful in evaluating biomass resources.

After a preliminary supply curve has been constructed, the actual supplies and costs can be verified by contacting local suppliers. During this process of verifying the preliminary supply analysis, do not be surprised to find that the actual supply of biomass resources is shown to be higher or lower than that shown in the preliminary analysis. This will likely be because local supply and cost conditions vary and because you may identify additional resources not included in the preliminary assessment.

These instructions are provided using Microsoft® Excel 2007, though the basic approach could be applied by other means. The preliminary process includes the following:

1. Identify a potential bioenergy facility location.
2. Survey quantities of locally available biomass resources.
3. Estimate costs of locally available biomass resources.
4. Rank resources from cheapest to most expensive.
5. Create the supply curve.

6.1 Tool 1: Using Google Earth to Identify a Potential Biomass Utilization Facility Location

You may be interested in identifying or may be asked to help identify a tentative location for a biomass utilization facility. Google Earth is a good tool to help you get start-

Figure 2: *Google Earth showing a proposed bioenergy facility, nearby counties, and useful tools.*

ed with this task. (If you do not have Google Earth on your computer, go to http://earth.google.com to download the free program.) Some tools in Google Earth that may be useful in helping you identify a facility location are highlighted in Figure 2. If you are doing this analysis for a specific project, your location may already be proposed. If not, here are a few concepts to keep in mind: the location should be close to the community or industry that needs energy, have good access to transportation such as highway or rail, be close to biomass resources, and not be placed in high-traffic areas. The location may be an existing energy facility. If this is just a rough analysis of resources in the area, you might simply select a point near the center of your AOI until more information is available.

6.2 Tool 2: Surveying Quantities of Locally Available Biomass

The next tool is a biomass supply calculator. This will help you gather information about what woody biomass resources are available near the proposed facility location, and how much of each resource is available at what price. This information is needed to evaluate the viability of a bioenergy project. The price should be expressed as the total delivered cost to the facility, meaning it will include purchase, harvest, process, and transportation costs.

The following sections show how to calculate supply in your region for: urban waste wood, logging residues, construction and demolition debris, and wood from forest thinning for improved forest health and wildfire mitigation.

Quantifying urban waste wood using U.S. census data

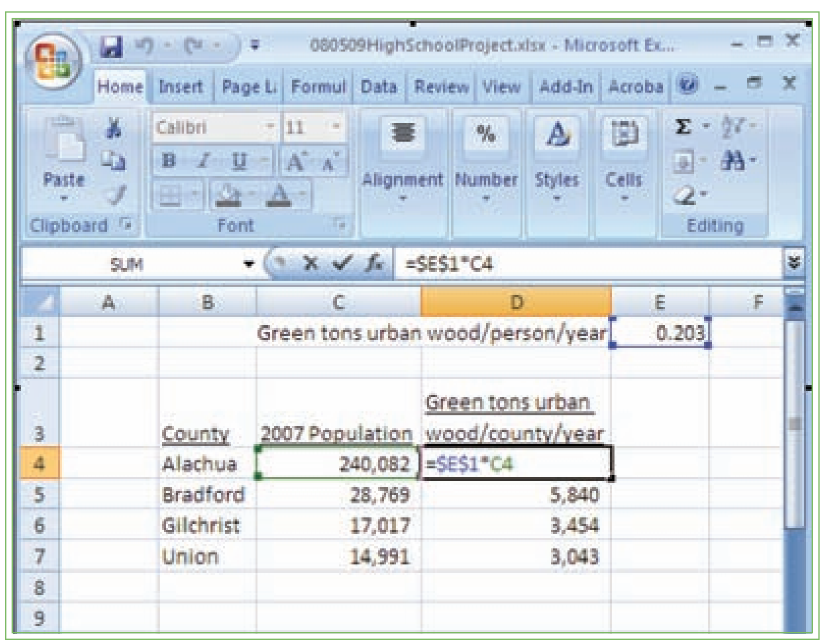
Urban wood waste, waste generated when trees growing in urban areas are pruned, blown down, or removed, is typically hauled away by tree servicing companies, which charge homeowners or utility companies to remove trees. Tree-hauling companies then pay about $20/green ton[1] to dispose of this wood.

[1]"Green" ton indicates that the weight includes both the wood and moisture content in the wood. Freshly cut wood is about 50 percent water by weight. Air-dried wood is about 20 to 30 percent water by weight.

To quantify how much waste wood is being produced in these communities, use a per capita estimate of annual production of urban wood waste and multiply this by population in each area. Research shows that an average of 0.203 green tons of urban wood waste are produced per person per year in the United States (Wiltsee, 1998). This can serve as your per capita estimate. Now use Google Earth (http://earth.google.com/) or other maps to identify counties within about one hour, or fifty miles, from your proposed bioenergy facility location. Fifty miles is an appropriate distance because beyond this, transportation cost alone surpasses $15/ton, and because resources beyond this distance may be more competitive to other biomass users in surrounding locations. Make a table in Excel with a row for each community you are assessing. Go to http://www.census.gov and type each county name (one at a time) into the box shown in Figure 3 to find the most recent county census popula-

Figure 3: *U.S. Census Bureau Web site at http://www.census.gov, where county population data can be retrieved.*

Figure 4: *Calculation of urban wood waste/county/year.*



tion data. Enter these numbers in a second column (next to their corresponding county name) in your Excel spreadsheet. Multiply the population of each community by 0.203 green tons/person per year to find an estimate of the green tons/community/year as shown in Figure 4.

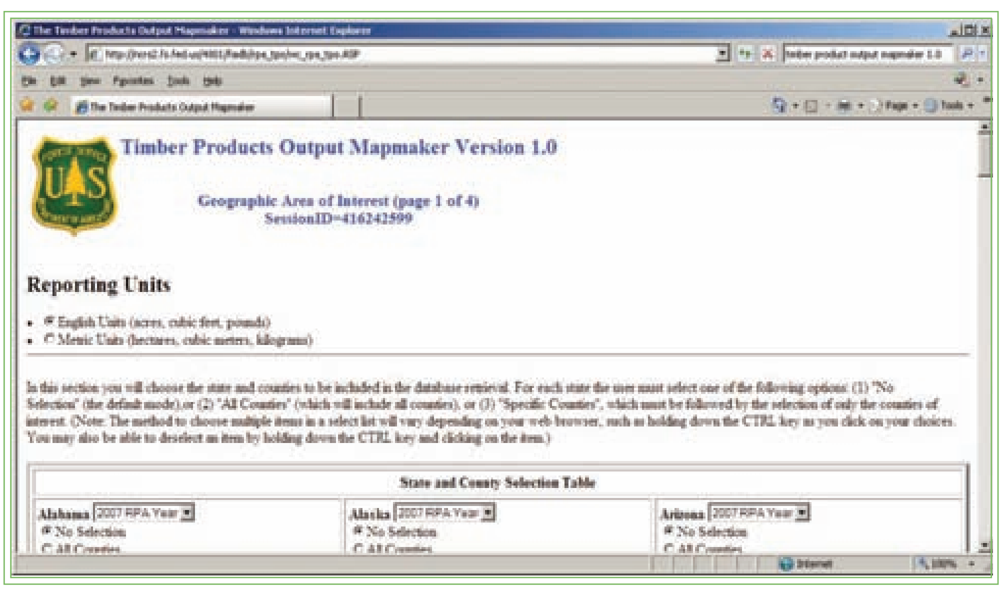
Quantify logging residues from FIA Data

When trees are harvested, logging residues (unmerchantable trees, tree tops, and branches) are produced in the harvesting operation and may be a low-cost biomass resource. These resources must be quantified if they are to be considered in a bioenergy project. Probably the best source of information on quantities of logging residues and other forest biomass is the Forest Inventory and Analysis (FIA) Program of the U.S. Forest Service. FIA collects, manages, and reports information on forests in the United States. The Timber Product Output (TPO) program of FIA generates county-level data on logging residues and forest products based on both FIA plot data and more frequent mill surveys (visit http://fia.fs.fed.us/program-features/tpo/ for more information). This information is available for the entire lower forty-eight states, covering both public and private lands. You may also contact your local forest service office for assistance.

This FIA and TPO data can be accessed in various ways. Raw data from the FIA database (FIADB) can be downloaded directly from the FIA DataMart (http://fiatools.fs.fed.us/fiadb-downloads/fiadb3.html) and can be imported to Microsoft Access or Microsoft Excel. Users' Manuals for the FIADB are available at http://fia.fs.fed.us/library/database-documentation/. Alternatively, tools are available online to query the FIADB for data specific to a user's needs and geographical area.

The U.S. Forest Service FIA TPO program reports the amount of logging residues by county. The following steps show how you can retrieve quantities of logging residues produced in counties that are within fifty miles of a proposed bioenergy facility. First, go to the U.S. Forest Service Timber Products Output Mapmaker[2] at http://www.ncrs2.fs.fed.us/4801/fiadb/rpa_tpo/wc_rpa_tpo.ASP (Figure 5).

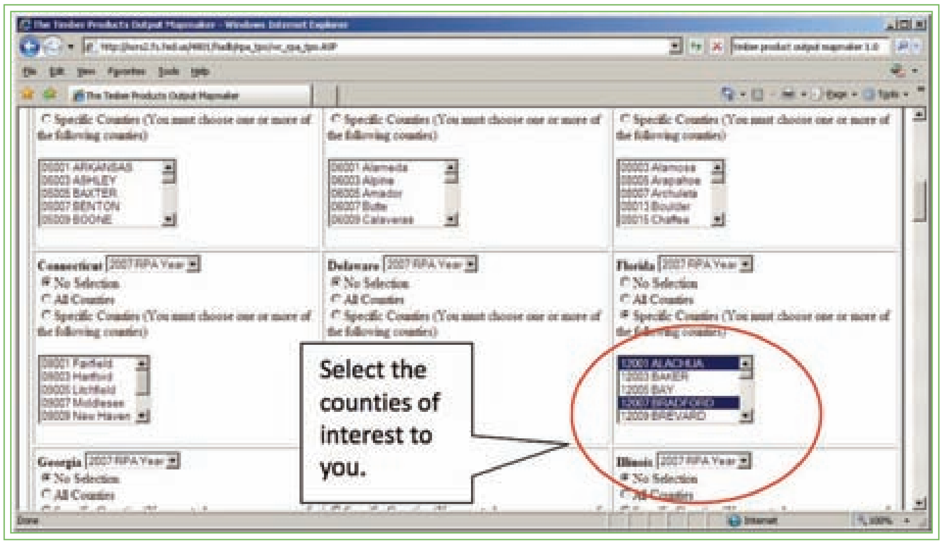
Figure 5: *U.S. Forest Service Timber Products Output Mapmaker home page.*



[2] At this writing, FIA Mapmaker is likely to be superseded by FIA Forest Inventory Data Online (FIDO).

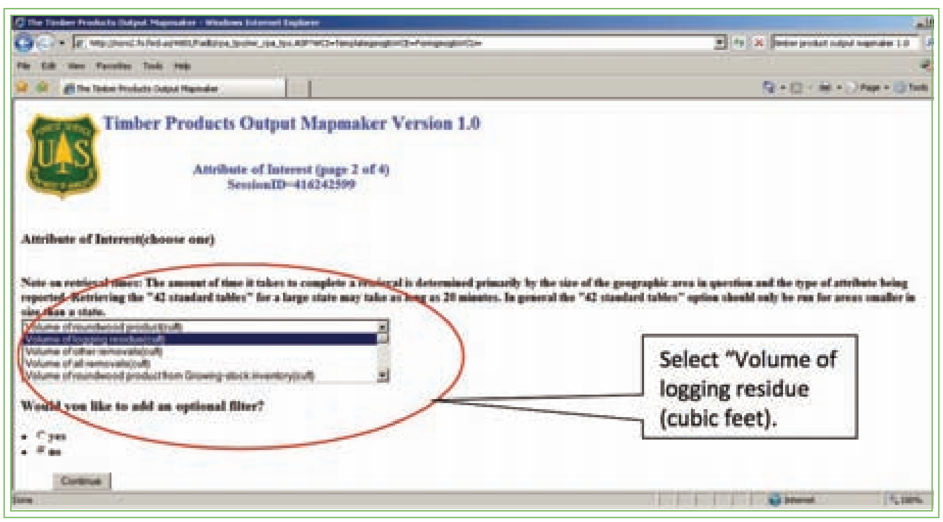
Next, go to your state, and select the radial button marked **Specific Counties**. Hold down the CTRL key as you select the counties within about fifty miles of your proposed location. Then click on **Continue** at the bottom of the page (Figure 6).

Figure 6: *Selecting counties from the U.S. Forest Service Timber Products Output Mapmaker.*



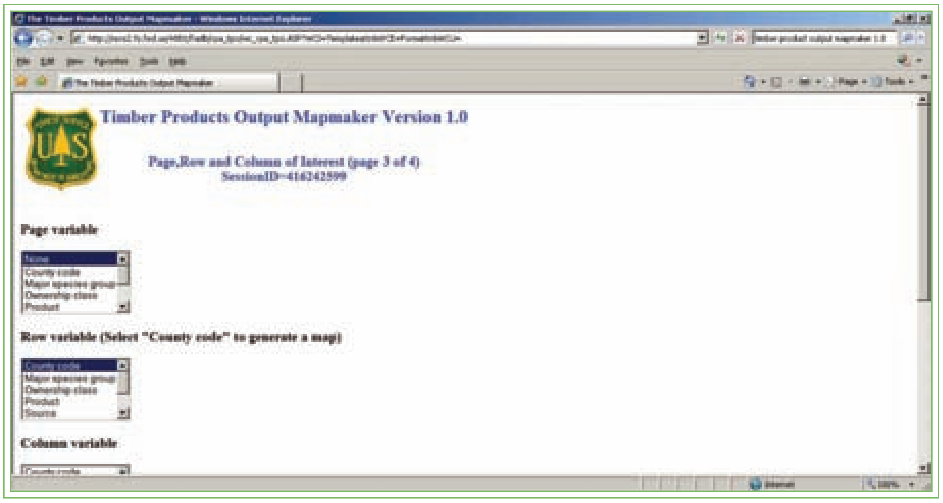
From the next page, select **Volume Of Logging Residue (Cuft)** and click **Continue** (Figure 7).

Figure 7: *Select attribute of interest from U.S. Forest Service Timber Products Output Mapmaker.*



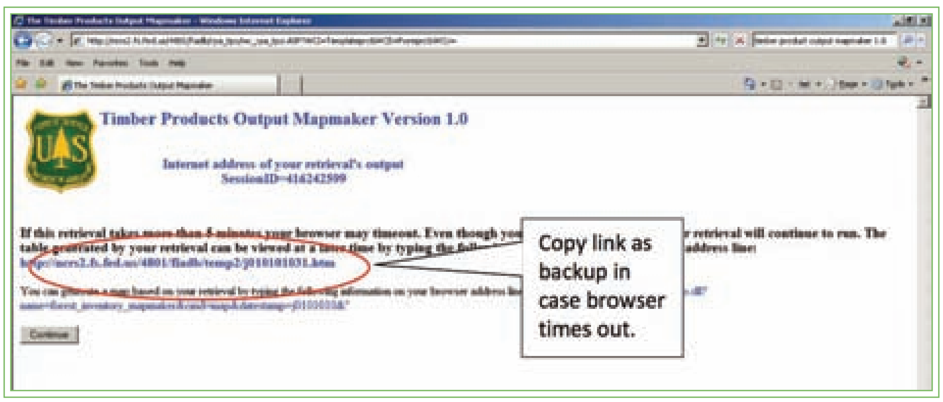
Accept with default Page, Row, and Column variables, and click **Continue** (Figure 8).

Figure 8: *Default Page, Row, and Column variables of U.S. Forest Service Timber Products Output Mapmaker.*



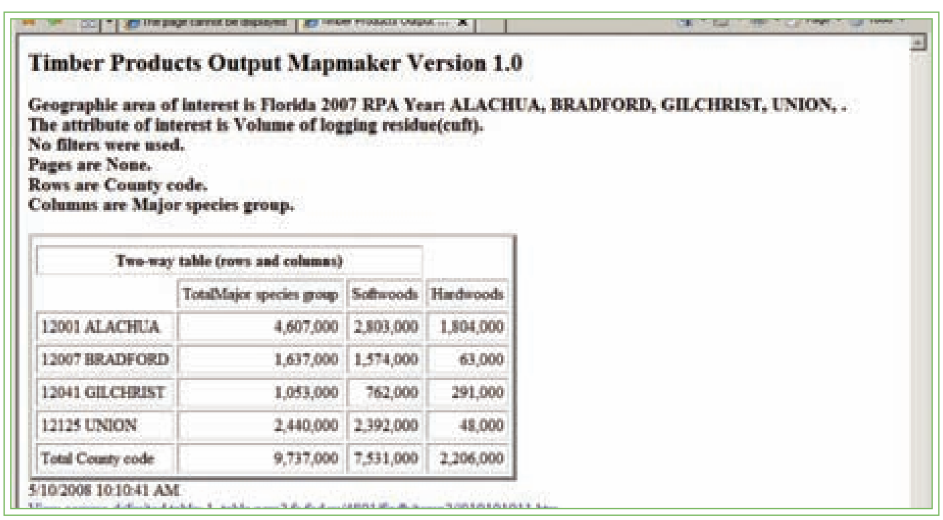
Select **Continue** from the next page to retrieve your data (Figure 9).

Figure 9: *Last page before retrieving data from the U.S. Forest Service Timber Products Output Mapmaker.*



Finally, logging residues are reported as hardwoods and softwood for your selected counties (Figure 10).

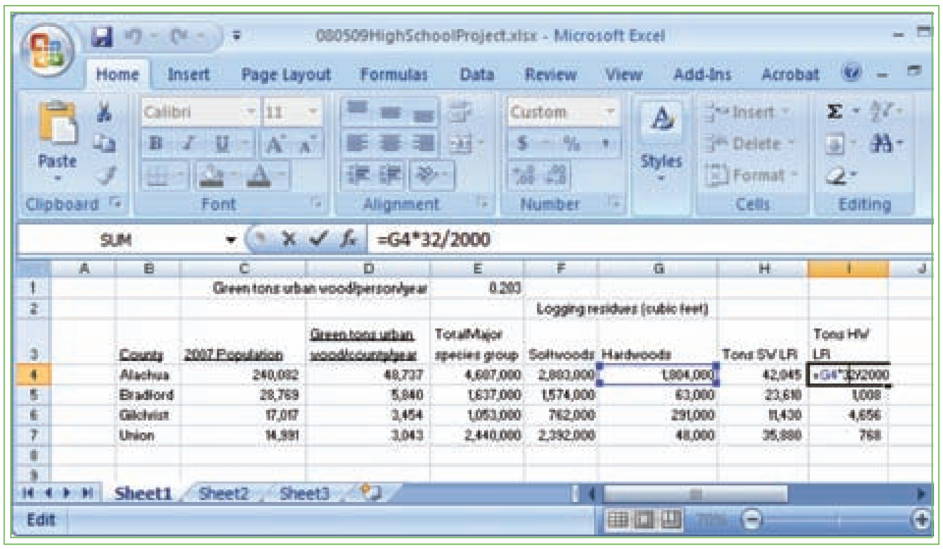
Figure 10: *Data reported from U.S. Forest Service Timber Products Output Mapmaker.*



Copy the data retrieved from the U.S. Forest Service Timber Products Output Mapmaker and paste it into your Excel worksheet. The Web site reports logging residue data in cubic feet, which is a measure of volume. Because wood used in biomass facilities is measured by weight, you need to convert the volume of residue to weight to continue calculations for the supply curve. Hardwoods are trees with broad leaves, such as oak, maple, and sweetgum. Softwoods are conifers such as pine and cypress. Because hardwood is denser than softwood, an equal volume of branches should have slightly different weights.

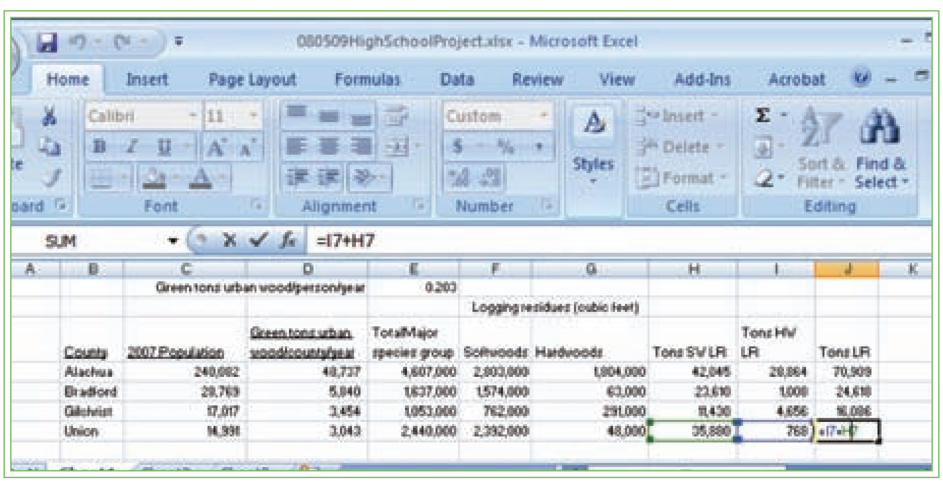
The data are reported in cubic feet/year, which should be converted to tons/year to make the units comparable with the urban wood waste quantities. Multiply the reported softwood cubic feet by 30 lbs/cubic foot and divide by 2,000 lbs/ton to calculate dry tons of softwood logging residues produced per year. Multiply the reported hardwood cubic feet by 32 lbs/cubic foot and divide by 2,000 lbs/ton to calculate dry tons of hardwood logging residues produced per year (Figure 11).

Figure 11: *Importing data from U.S. Forest Service Timber Products Output Mapmaker and converting to dry tons.*



Sum the columns of hardwood and softwood logging residues to get total logging residues produced per county per year (Figure 12).

Figure 12: *Calculating total logging residues per county per year.*

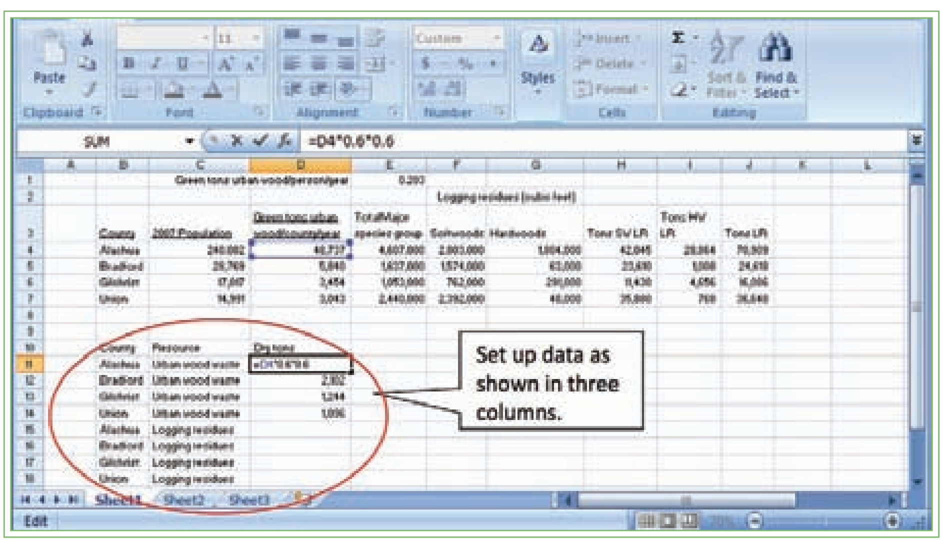


Other biomass resources may also be available in your area. For example, if industrial demand for pulpwood or small-diameter timber in your AOI is projected to decline, some of this resource may be available for energy. Similarly, small-diameter timber close to a proposed bioenergy facility may be available at a competitive price. Pulpwood harvests by county are reported at http://srsfia2.fs.fed.us/php/tpo2/tpo2.php and can be included in a supply analysis. Other types of resources such as agricultural residues may also be available in your AOI. A good starting point for learning about these resources is "A Geographic Perspective on the Current Biomass Resource Availability in the United States" available at http://www.nrel.gov/docs/fy06osti/39181.pdf.

Construction and demolition debris is available from populated areas at a rate of about 0.09 tons per person per year (Wiltsee, 1998), though it may be expensive to sort clean wood out of this resource. Wood from thinning to improve forest health, such as for beetle control or to reduce wildfire fuel loads, may be available, though these data are not available nationally. Talk to a local Resource Conservation and Development (RC&D) Council person or forest extension agent to learn about quantifying this resource in your area. For every available form of biomass, obtain the quantity available on a sustainable basis per year, and enter dry tons into your spreadsheet. Information should be reported in dry tons to keep the units consistent.

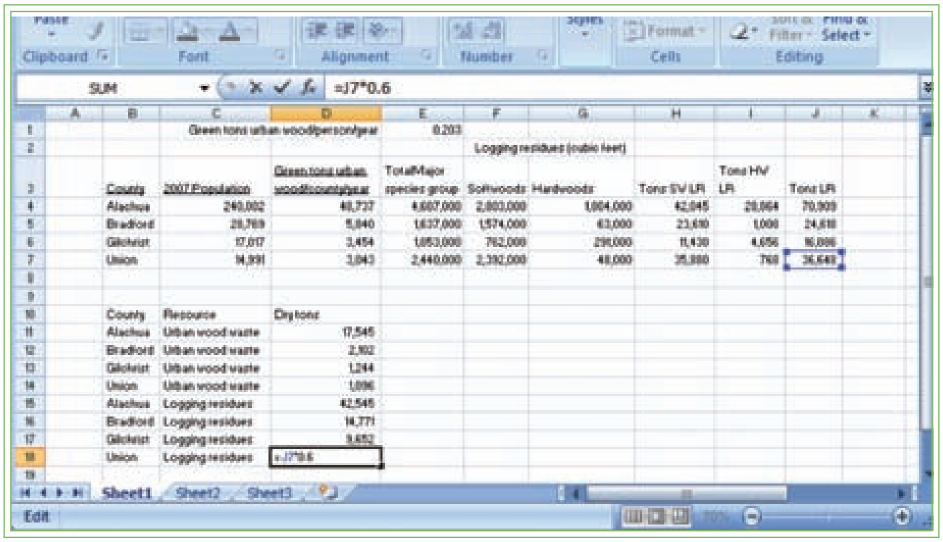
Set up your data as shown in cells B10–D18 in Figure 13 to make the next steps easier. Convert the urban wood waste to dry ton equivalent. Assuming urban wood waste is 40 percent moisture, then the wood content is 60 percent. Multiply the green ton amount by 0.6 to calculate the dry ton equivalent. If you'd like to assume that not all the urban wood waste is available for energy, you can reduce this quantity again. Multiply again by 0.6 to indicate that only 60 percent of the urban wood waste might be captured for energy. These calculations are shown in Figure 13, cell D11:

Figure 13: *Converting green tons to available dry tons of urban wood waste.*



As with urban waste wood, assume that only 60 percent of the logging residue will be collected and available. Multiple your dry tons of residue by 0.6 and add these data to your chart with the urban waste data as shown here (Figure 14).

Figure 14: *Converting to available dry tons of logging residues.*



After you have estimated the quantities of locally available biomass resources, you will need to estimate the price of these resources as shown in the next section.

6.3 Tool 4: Estimate Costs of Locally Available Biomass Resources

Table1: *Summary of cost assumptions for woody biomass resources.*

	Urban Wood Waste	Logging Residues
	($ dry ton^{-1})	
Purchase cost[a]	25.00	3.00
Harvest and process[b]	30.00	33.00
Load and unload	1.98	1.80
Two-way haul (per hour)[c]	11.86	10.78
Example total delivered cost of a 1 hour haul[d]	18.84	48.58

[a] The cost of purchasing wood on site. Negative costs for urban wood waste reflect disposal costs, known as "tipping fees."

[b] Includes the costs of bundling, collecting, and chipping

[c] The cost per ton to transport wood for one hour and return with an empty truck (for a total of two hours of driving time). A truck can carry 23 tons and typically gets 6 mpg.

[d] Equals the sum of the four cost categories.

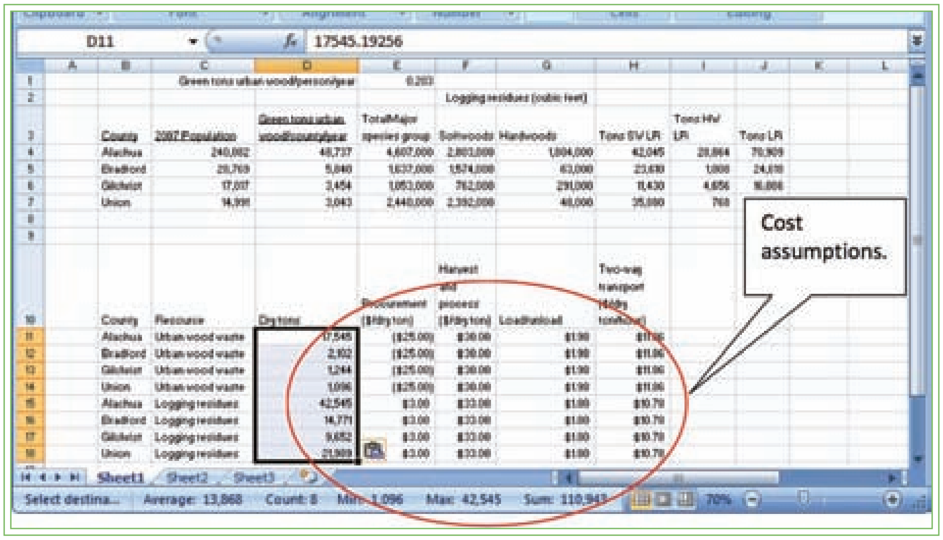
To evaluate the economic availability of biomass resources, it is necessary to assign prices to the resources that were quantified in the previous section. Future prices cannot be known with certainty, as economic conditions are constantly changing. However, if a project is to be considered, some sort of cost estimates need to be made.

The total delivered cost of forest products is the sum of (1) the price to purchase the wood from the landowner, (2) the price paid to the logger to gather the material, and (3) the price needed to haul the material from the forest to the processing facility. As gasoline costs rise, the price of hauling wood will also change.

Table 1 shows typical costs of urban wood waste and logging residues in Florida in December 2007. You can use these costs in your cost analysis, or update them with costs you find for your AOI. Local contacts, RC&D Council representatives, consultants, and extension agents may be able to provide local cost estimates. Note that the procurement cost of urban wood waste is negative in Table 1, because tree service companies pay to get rid of, rather than sell, their waste wood.

Copy the cost values from Table 1 into your Excel spreadsheet as shown in Figure 15. If you include additional biomass resources, you'll need to include some cost assumptions for these resources as well, either from local contacts, an extension agent, or a consultant.

Figure 15: *Adding cost assumptions by resource type.*

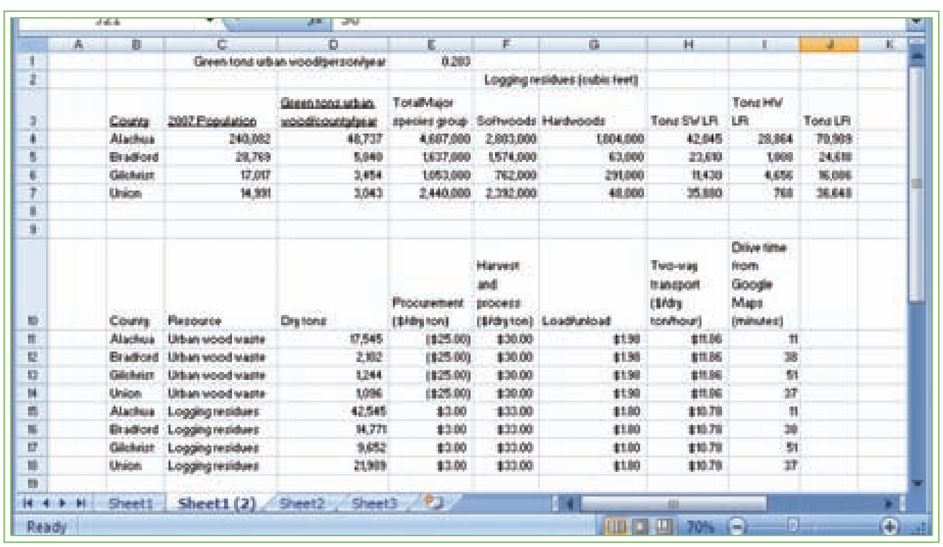


	Green tons urban wood/person/year	0.203						
			Logging residues (cubic feet)					
County	2007 Population	Green tons urban wood/county/year	Total/Major species group	Softwoods	Hardwoods	Tons SW LR	Tons HW LR	Tons LR
Alachua	240,082	48,737	4,607,000	2,803,000	1,804,000	42,045	28,864	70,909
Bradford	28,769	5,840	1,637,000	1,574,000	63,000	23,610	1,008	24,618
Gilchrist	17,017	3,454	1,053,000	762,000	291,000	11,430	4,656	16,086
Union	14,991	3,043	2,440,000	2,392,000	48,000	35,880	768	

County	Resource	Dry tons	Procurement ($/dry ton)	Harvest and process ($/dry ton)	Load/unload	Two-way transport ($/dry ton/hour)
Alachua	Urban wood waste	17,545	($25.00)	$30.00	$1.90	$11.06
Bradford	Urban wood waste	2,102	($25.00)	$30.00	$1.90	$11.06
Gilchrist	Urban wood waste	1,244	($25.00)	$30.00	$1.90	$11.06
Union	Urban wood waste	1,096	($25.00)	$30.00	$1.90	$11.06
Alachua	Logging residues	42,545	$3.00	$33.00	$1.80	$10.79
Bradford	Logging residues	14,771	$3.00	$33.00	$1.80	$10.79
Gilchrist	Logging residues	9,652	$3.00	$33.00	$1.80	$10.79
Union	Logging residues	21,909	$3.00	$33.00	$1.80	$10.79

Transportation costs increase with both the distance of the haul and with time on the road. Transportation costs can be calculated based on the time truckers spend driving. You can use Google Maps, Mapquest, or Yahoo Maps to estimate drive time from the forest to the proposed facility or site. Add the haul times to your Excel spreadsheet for each source county center to the proposed facility (Figure 16).

Figure 16: *Adding haul time.*

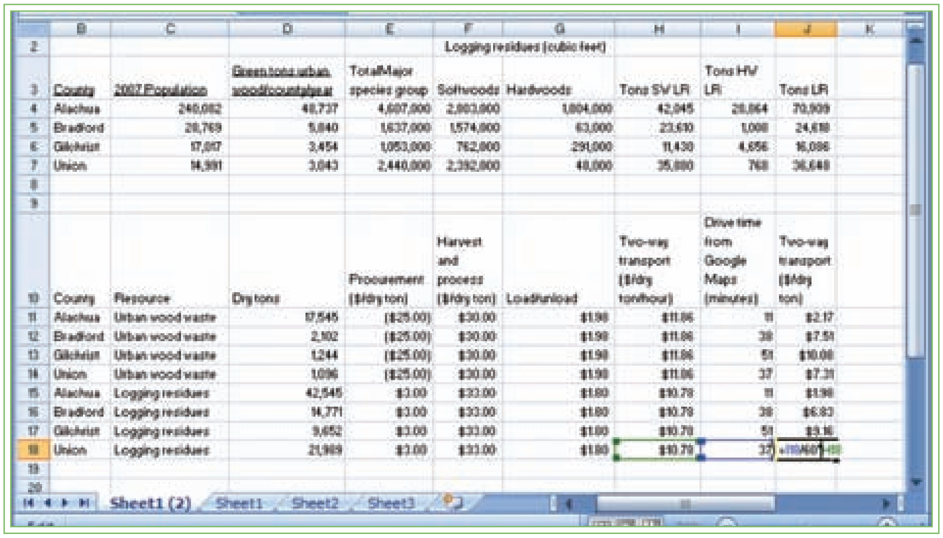


	Green tons urban wood/person/year	0.203						
			Logging residues (cubic feet)					
County	2007 Population	Green tons urban wood/county/year	Total/Major species group	Softwoods	Hardwoods	Tons SW LR	Tons HW LR	Tons LR
Alachua	240,082	48,737	4,607,000	2,803,000	1,804,000	42,045	28,864	70,909
Bradford	28,769	5,840	1,637,000	1,574,000	63,000	23,610	1,008	24,618
Gilchrist	17,017	3,454	1,053,000	762,000	291,000	11,430	4,656	16,086
Union	14,991	3,043	2,440,000	2,392,000	48,000	35,880	768	36,648

County	Resource	Dry tons	Procurement ($/dry ton)	Harvest and process ($/dry ton)	Load/unload	Two-way transport ($/dry ton/hour)	Drive time from Google Maps (minutes)
Alachua	Urban wood waste	17,545	($25.00)	$30.00	$1.90	$11.06	11
Bradford	Urban wood waste	2,102	($25.00)	$30.00	$1.90	$11.06	38
Gilchrist	Urban wood waste	1,244	($25.00)	$30.00	$1.90	$11.06	51
Union	Urban wood waste	1,096	($25.00)	$30.00	$1.90	$11.06	37
Alachua	Logging residues	42,545	$3.00	$33.00	$1.80	$10.79	11
Bradford	Logging residues	14,771	$3.00	$33.00	$1.80	$10.79	38
Gilchrist	Logging residues	9,652	$3.00	$33.00	$1.80	$10.79	51
Union	Logging residues	21,909	$3.00	$33.00	$1.80	$10.79	37

Divide haul times by 60 to convert minutes to hours, and multiply by the two-way transportation cost to calculate a haul cost for each county (Figure 17).

Figure 17: *Convert haul time to two-way transportation cost.*

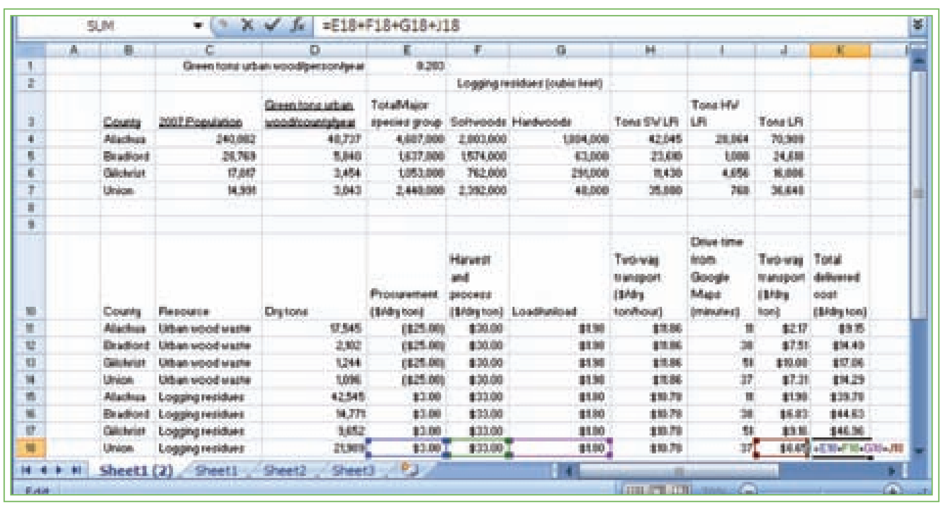


	B	C	D	E	F	G	H	I	J
2					Logging residues (cubic feet)				
3	County	2007 Population	Green tons urban wood/county/year	TotalMajor species group	Softwoods	Hardwoods	Tons SW LR	Tons HW LR	Tons LR
4	Alachua	240,082	48,737	4,607,000	2,803,000	1,804,000	42,045	28,864	70,909
5	Bradford	28,769	5,840	1,637,000	1,574,000	63,000	23,610	1,008	24,618
6	Gilchrist	17,017	3,454	1,053,000	762,000	291,000	11,430	4,656	16,086
7	Union	14,991	3,043	2,440,000	2,392,000	48,000	35,880	768	36,648

	B	C	D	E	F	G	H	I	J
10	County	Resource	Dry tons	Procurement ($/dry ton)	Harvest and process ($/dry ton)	Load/unload	Two-way transport ($/dry ton/hour)	Drive time from Google Maps (minutes)	Two-way transport ($/dry ton)
11	Alachua	Urban wood waste	17,545	($25.00)	$30.00	$1.98	$11.86	11	$2.17
12	Bradford	Urban wood waste	2,102	($25.00)	$30.00	$1.98	$11.86	38	$7.51
13	Gilchrist	Urban wood waste	1,244	($25.00)	$30.00	$1.98	$11.86	51	$10.08
14	Union	Urban wood waste	1,096	($25.00)	$30.00	$1.98	$11.86	37	$7.31
15	Alachua	Logging residues	42,545	$3.00	$33.00	$1.80	$10.79	11	$1.98
16	Bradford	Logging residues	14,771	$3.00	$33.00	$1.80	$10.79	38	$6.83
17	Gilchrist	Logging residues	9,652	$3.00	$33.00	$1.80	$10.79	51	$9.16
18	Union	Logging residues	21,989	$3.00	$33.00	$1.80	$10.79	37	=I18/60*H18

Add a new column titled **Total Delivered Cost ($/Dry Ton)**. Sum procurement cost, harvest and process cost, load and unload cost, and two-way transportation cost in this column (Figure 18).

Figure 18: *Sum costs to calculate total delivered costs by resource.*



=E18+F18+G18+J18

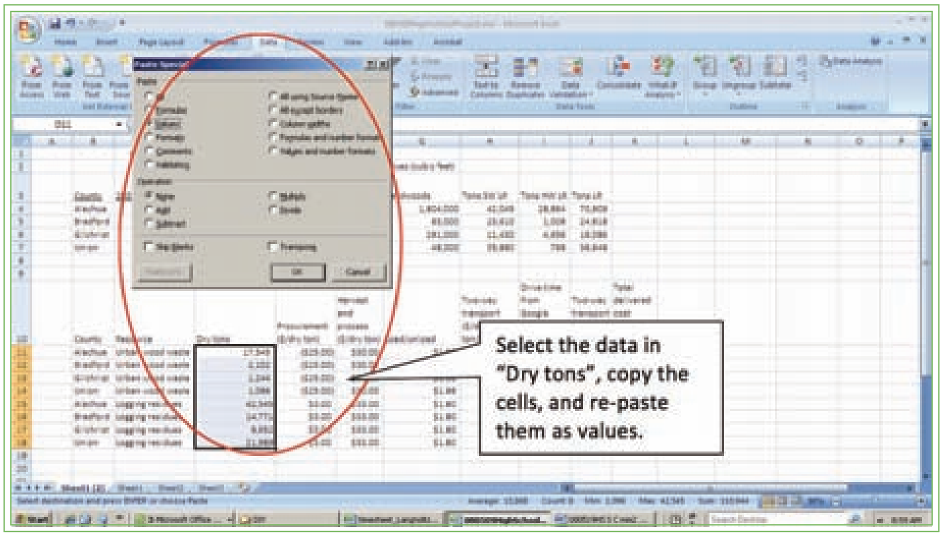
	B	C	D	E	F	G	H	I	J	K
1		Green tons urban wood/person/year		0.203						
2					Logging residues (cubic feet)					
3	County	2007 Population	Green tons urban wood/county/year	TotalMajor species group	Softwoods	Hardwoods	Tons SW LR	Tons HW LR	Tons LR	
4	Alachua	240,082	48,737	4,607,000	2,803,000	1,804,000	42,045	28,864	70,909	
5	Bradford	28,769	5,840	1,637,000	1,574,000	63,000	23,610	1,008	24,618	
6	Gilchrist	17,017	3,454	1,053,000	762,000	291,000	11,430	4,656	16,086	
7	Union	14,991	3,043	2,440,000	2,392,000	48,000	35,880	768	36,648	

	B	C	D	E	F	G	H	I	J	K
10	County	Resource	Dry tons	Procurement ($/dry ton)	Harvest and process ($/dry ton)	Load/unload	Two-way transport ($/dry ton/hour)	Drive time from Google Maps (minutes)	Two-way transport ($/dry ton)	Total delivered cost ($/dry ton)
11	Alachua	Urban wood waste	17,545	($25.00)	$30.00	$1.98	$11.86	11	$2.17	$9.15
12	Bradford	Urban wood waste	2,102	($25.00)	$30.00	$1.98	$11.86	38	$7.51	$14.49
13	Gilchrist	Urban wood waste	1,244	($25.00)	$30.00	$1.98	$11.86	51	$10.08	$17.06
14	Union	Urban wood waste	1,096	($25.00)	$30.00	$1.98	$11.86	37	$7.31	$14.29
15	Alachua	Logging residues	42,545	$3.00	$33.00	$1.80	$10.79	11	$1.98	$39.78
16	Bradford	Logging residues	14,771	$3.00	$33.00	$1.80	$10.79	38	$6.83	$44.63
17	Gilchrist	Logging residues	9,652	$3.00	$33.00	$1.80	$10.79	51	$9.16	$46.36
18	Union	Logging residues	21,989	$3.00	$33.00	$1.80	$10.79	37	$6.65	=E18+F18+G18+J18

Rank resources from cheapest to most expensive

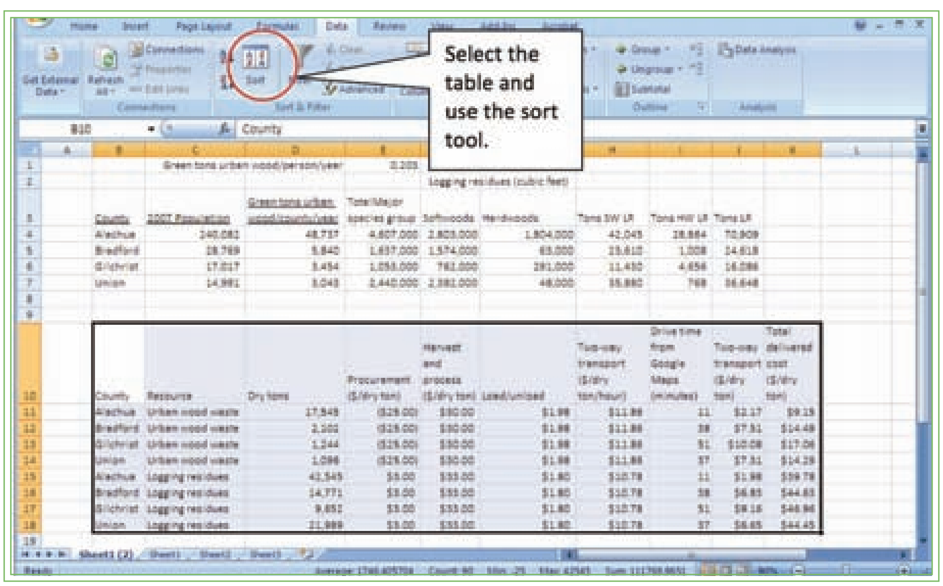
The next step in assessing the economic availability of these resources is to rank the resources from cheapest to most expensive. This step can be done manually. Alternatively, the data can be ranked automatically. To do this, start by making sure that the quantities are values rather than references. To do this, you can select the data in the column DRY TONS, copy the cells, and paste them as values by using the PASTE SPECIAL function (Figure 19).

Figure 19: *Paste special to convert formulas to values.*



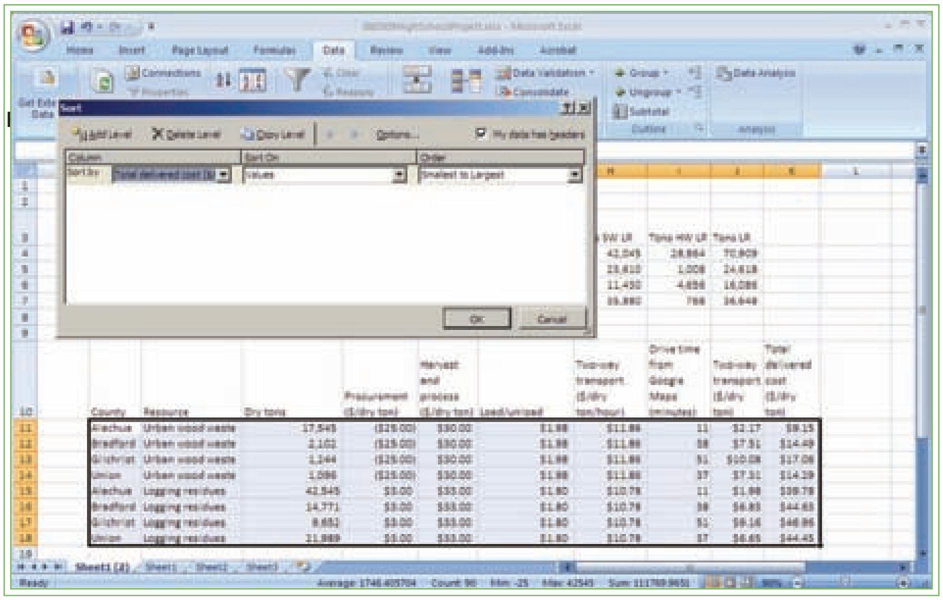
Select all the data in the table, and click SORT under the DATA ribbon (Figure 20).

Figure 20: *Select the sort tool.*



Next, sort the data by **Total Delivered** cost from smallest to largest (Figure 21).

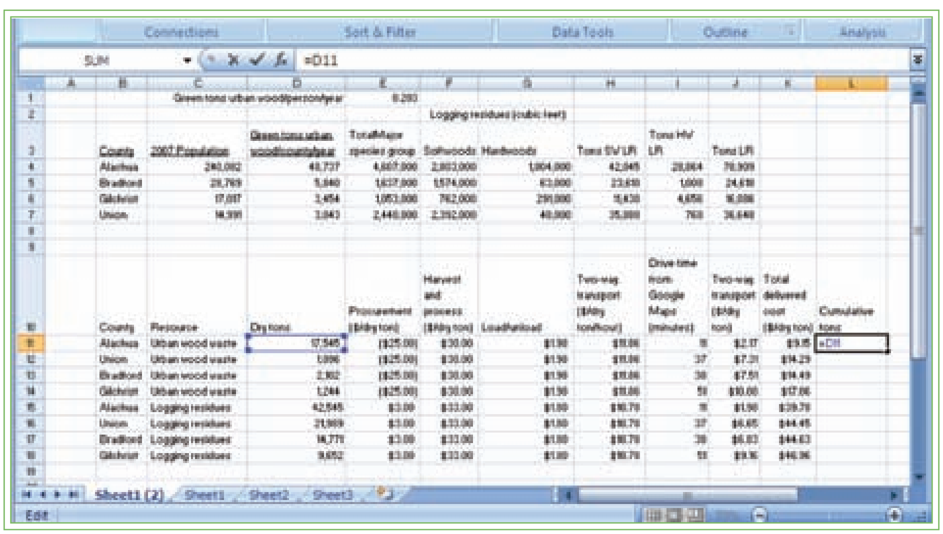
Figure 21: *Sort the data from cheapest to most expensive.*



6.4 Tool 5: Create the Supply Curve

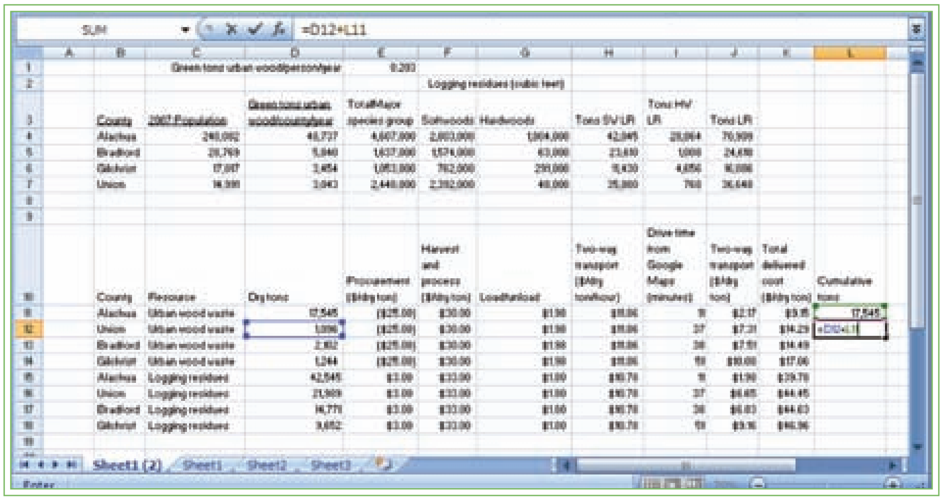
To construct a supply curve, add a column called **Cumulative Tons**. This column will list a cumulative quantity of wood, so that each entry is added to the total above it. Make the first cell in the column equal to the original tons (Figure 22).

Figure 22: *Add a "Cumulative tons" column.*



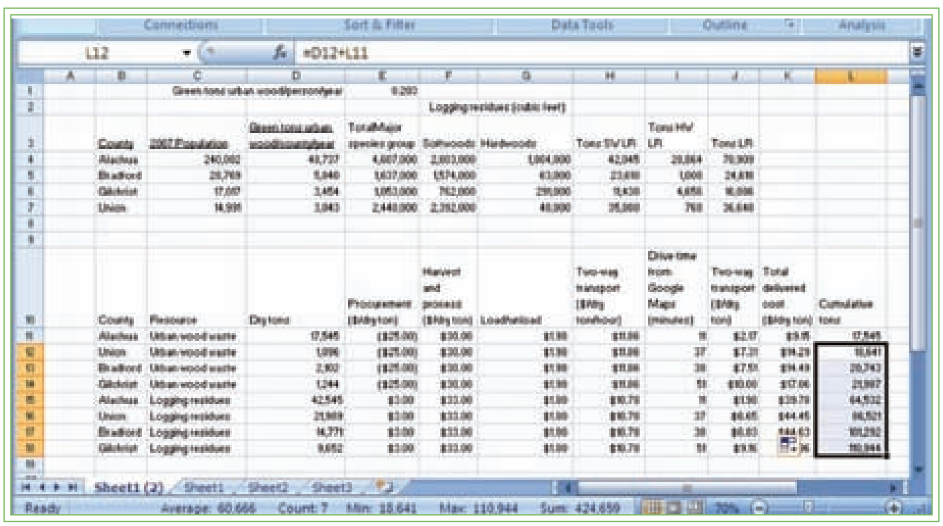
Make the second cell in the column equal to the second quantity plus the original quantity (17,545 + 1,096 = 18,641) (Figure 23).

Figure 23: *Calculate cumulative tons.*



Drag this cell down (or copy and paste it down the remainder of the table) to create a cumulative sum of quantities from cheapest to most expensive (Figure 24).

Figure 24: *Finish calculating cumulative tons.*



You now have compiled important information about resource supply and cost. If desired, this information can be presented as a table, showing each resource, its cost per ton, the amount available per year, and the cumulative supply available up to a given cost per ton. A project planner looking for 100,000 dry tons equivalent of woody biomass per year, for example, would look down column L and find that this quantity is probably available at a price of up to $44.63 per dry ton (cell K17). For comparison, examples of quantities used by actual projects are shown in Table 2.

To show this information graphically, it can be converted into a supply curve, where the cumulative tons are shown as the x-axis, and the total cost per ton is shown as the y-axis. This is explained on page 73.

Table 2: *Example bioenergy projects and quantities used.*

Example Use	Resource	Quantity used (dry tons/year)	Energy produced	Net energy produced
Dakota Adventist Academy, Bismarck, ND	Wood chips	517	Heat	12,100 MMBtu/year
Rowan High school, Moorhead, KY	Waste sawdust	756	Heat	0.15 Thermal MW
McNeil Facility in Burlington, VT	Wood chips	231,000	Electricity	50MW
Range Fuels Ethanol, Soperton, GA[a]	Waste wood	216,000	Ethanol	40 million gallons/yr
Pyrolysis/Gasification[b]	Waste wood	1,000,000	Electricity	100 MW

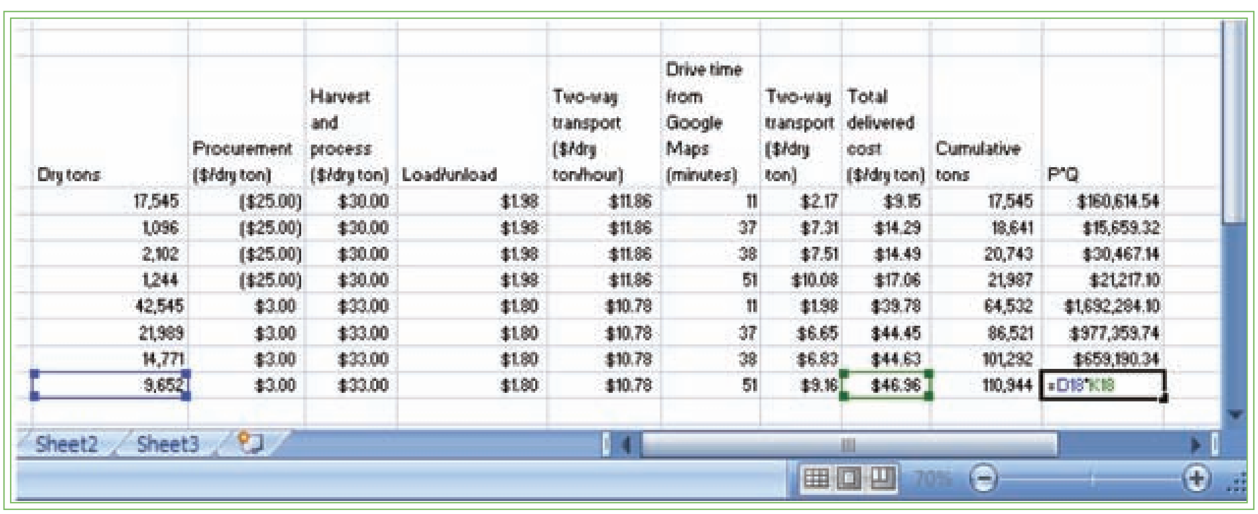
[a]Under construction, July 2008.

[b]Alex Green, personal communication, October 26th, 2008.

Another curve that may be useful is the "blended price" supply curve. This curve shows the weighted average price at the level of supply. For example: a buyer purchases 80 tons of biomass at $10.00 per ton, and then buys 20 additional tons at $20.00 per ton. The average price at the total of 100 tons is $15.00 per ton. But the blended price at the total of 100 tons is only $12.00/ton, because 80 percent of the supply was purchased at the lower rate. Showing the blended price is important because it explains the overall cost of biomass to a bioenergy producer. The following steps show how to add the data needed for a blended price supply curve, and then how to show both curves in an Excel graph.

Add a column titled **P*Q** which stands for Price times Quantity. In this column, multiply dry tons by total delivered cost for each row (Figure 25).

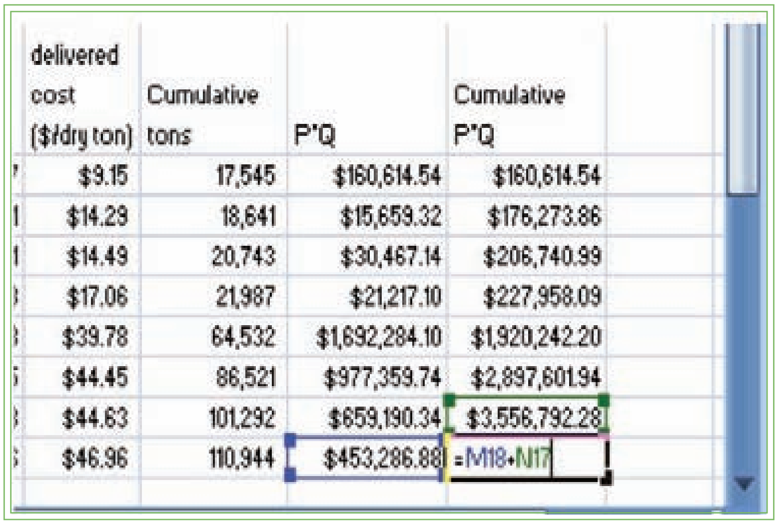
Figure 25: *Multiply price by quantity for each resource.*



Dry tons	Procurement ($/dry ton)	Harvest and process ($/dry ton)	Load/unload	Two-way transport ($/dry ton/hour)	Drive time from Google Maps (minutes)	Two-way transport ($/dry ton)	Total delivered cost ($/dry ton)	Cumulative tons	P*Q
17,545	($25.00)	$30.00	$1.98	$11.86	11	$2.17	$9.15	17,545	$160,614.54
1,096	($25.00)	$30.00	$1.98	$11.86	37	$7.31	$14.29	18,641	$15,659.32
2,102	($25.00)	$30.00	$1.98	$11.86	38	$7.51	$14.49	20,743	$30,467.14
1,244	($25.00)	$30.00	$1.98	$11.86	51	$10.08	$17.06	21,987	$21,217.10
42,545	$3.00	$33.00	$1.80	$10.78	11	$1.98	$39.78	64,532	$1,692,284.10
21,989	$3.00	$33.00	$1.80	$10.78	37	$6.65	$44.45	86,521	$977,359.74
14,771	$3.00	$33.00	$1.80	$10.78	38	$6.83	$44.63	101,292	$659,190.34
9,652	$3.00	$33.00	$1.80	$10.78	51	$9.16	$46.96	110,944	=D18*K18

Add a column titled **Cumulative P*Q**. In this column, calculate the cumulative price from the column **P*Q** in the same way you generated the column **Cumulative Sum** (Figure 26).

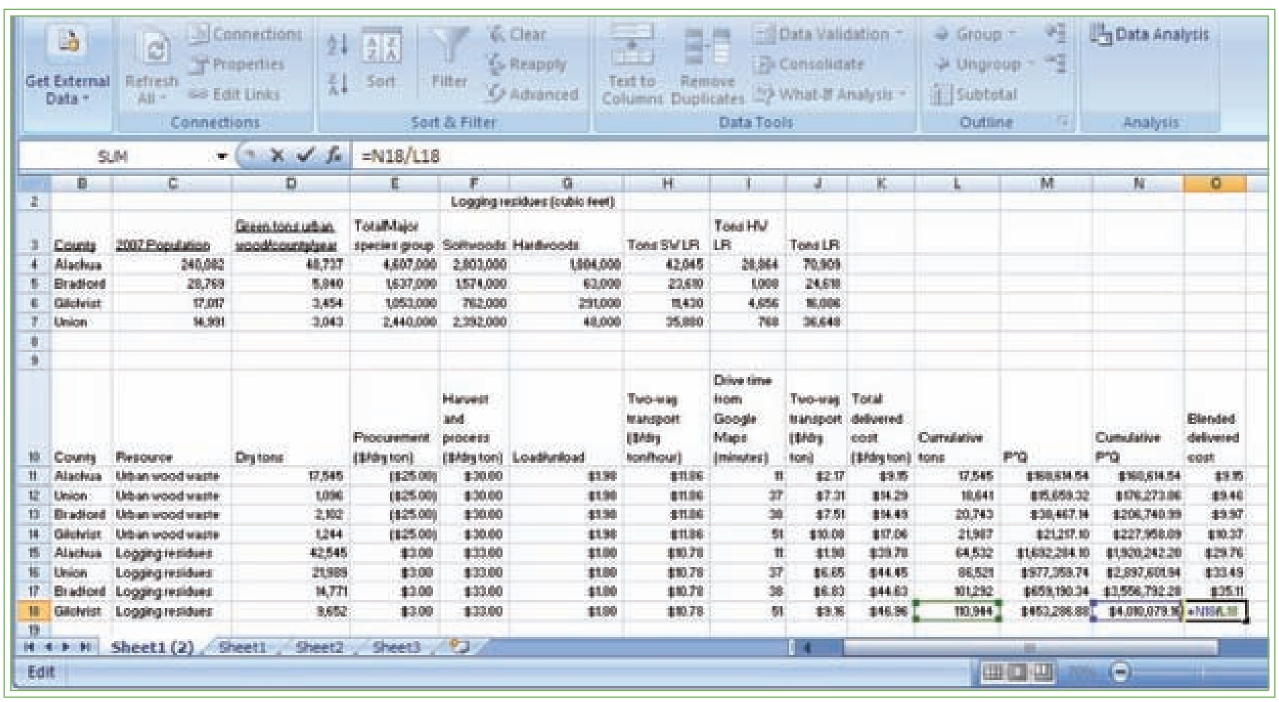
Figure 26: *Calculate cumulative cost.*



delivered cost ($/dry ton)	Cumulative tons	P*Q	Cumulative P*Q
$9.15	17,545	$160,614.54	$160,614.54
$14.29	18,641	$15,659.32	$176,273.86
$14.49	20,743	$30,467.14	$206,740.99
$17.06	21,987	$21,217.10	$227,958.09
$39.78	64,532	$1,692,284.10	$1,920,242.20
$44.45	86,521	$977,359.74	$2,897,601.94
$44.63	101,292	$659,190.34	$3,556,792.28
$46.96	110,944	$453,286.88	=M18+N17

Add a column titled **Blended Delivered Cost**. In this column, divide **Cumulative P*Q** by **Cumulative Cost** to get the running average cost of the total supply (Figure 27).

Figure 27: *Calculate blended delivered cost.*

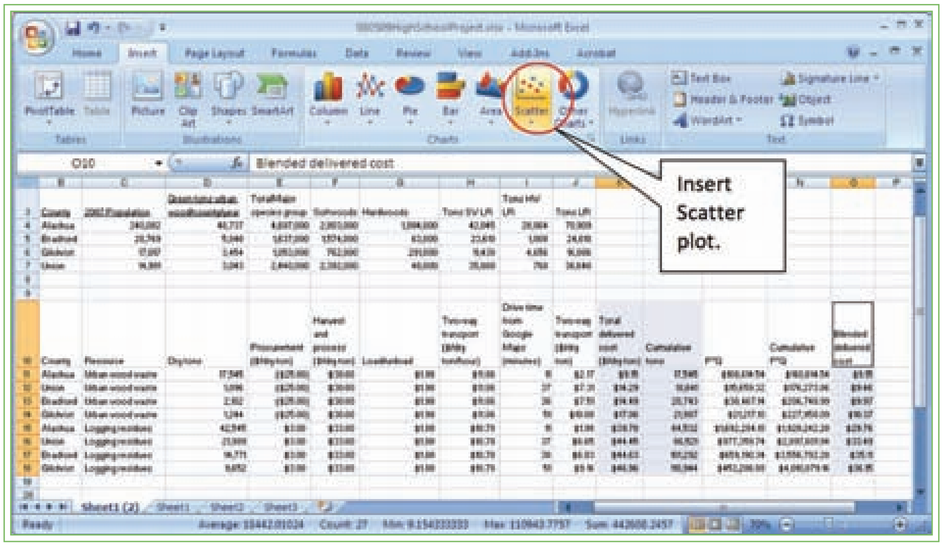


	B	C	D	E	F	G	H	I	J
2					Logging residues (cubic feet)				
3	County	2007 Population	Green tons urban wood/county/year	Total Major species group	Softwoods	Hardwoods	Tons SW LR	Tons HW LR	Tons LR
4	Alachua	240,082	48,737	4,607,000	2,803,000	1,804,000	42,045	28,864	70,909
5	Bradford	28,769	5,840	1,637,000	1,574,000	63,000	23,610	1,008	24,618
6	Gilchrist	17,017	3,454	1,053,000	762,000	291,000	11,430	4,656	16,086
7	Union	14,991	3,043	2,440,000	2,392,000	48,000	35,880	768	36,648

	B	C	D	E	F	G	H	I	J	K	L	M	N	O
10	County	Resource	Dry tons	Procurement ($/dry ton)	Harvest and process ($/dry ton)	Load/unload	Two-way transport ($/dry ton/hour)	Drive time from Google Maps (minutes)	Two-way transport ($/dry ton)	Total delivered cost ($/dry ton)	Cumulative tons	P*Q	Cumulative P*Q	Blended delivered cost
11	Alachua	Urban wood waste	17,545	($25.00)	$30.00	$1.98	$11.86	11	$2.17	$9.15	17,545	$160,614.54	$160,614.54	$9.15
12	Union	Urban wood waste	1,096	($25.00)	$30.00	$1.98	$11.86	37	$7.31	$14.29	18,641	$15,659.32	$176,273.86	$9.46
13	Bradford	Urban wood waste	2,102	($25.00)	$30.00	$1.98	$11.86	38	$7.51	$14.49	20,743	$30,467.14	$206,740.99	$9.97
14	Gilchrist	Urban wood waste	1,244	($25.00)	$30.00	$1.98	$11.86	51	$10.08	$17.06	21,987	$21,217.10	$227,958.09	$10.37
15	Alachua	Logging residues	42,545	$3.00	$33.00	$1.80	$10.78	11	$1.98	$39.78	64,532	$1,692,284.10	$1,920,242.20	$29.76
16	Union	Logging residues	21,989	$3.00	$33.00	$1.80	$10.78	37	$6.65	$44.45	86,521	$977,359.74	$2,897,601.94	$33.49
17	Bradford	Logging residues	14,771	$3.00	$33.00	$1.80	$10.78	38	$6.83	$44.63	101,292	$659,190.34	$3,556,792.28	$35.11
18	Gilchrist	Logging residues	9,652	$3.00	$33.00	$1.80	$10.78	51	$9.16	$46.96	110,944	$453,286.88	$4,010,079.16	=N18/L18

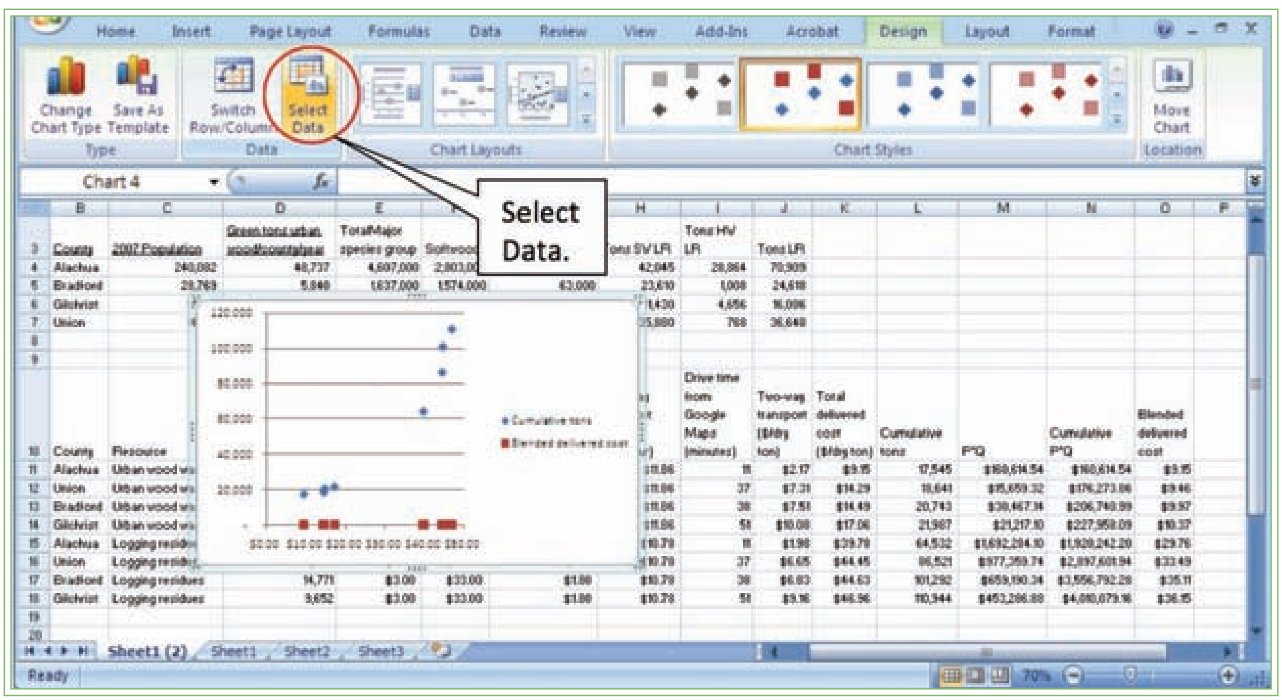
Now create two supply curves on a graph. To do this, select **Scatter Plot** from the **Insert** ribbon (Figure 28).

Figure 28: *Insert scatter plot.*



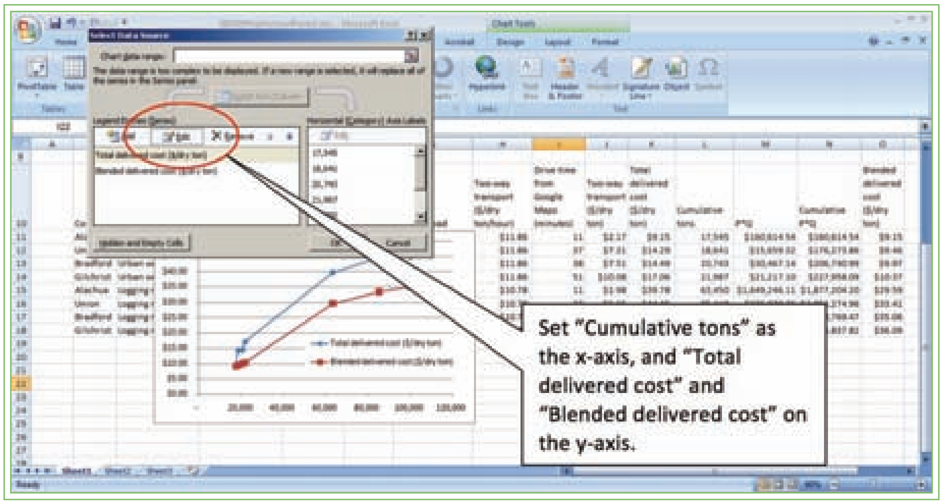
Select the chart, and click **Select Data** from the Design ribbon (Figure 29).

Figure 29: *Select data for the supply curves.*



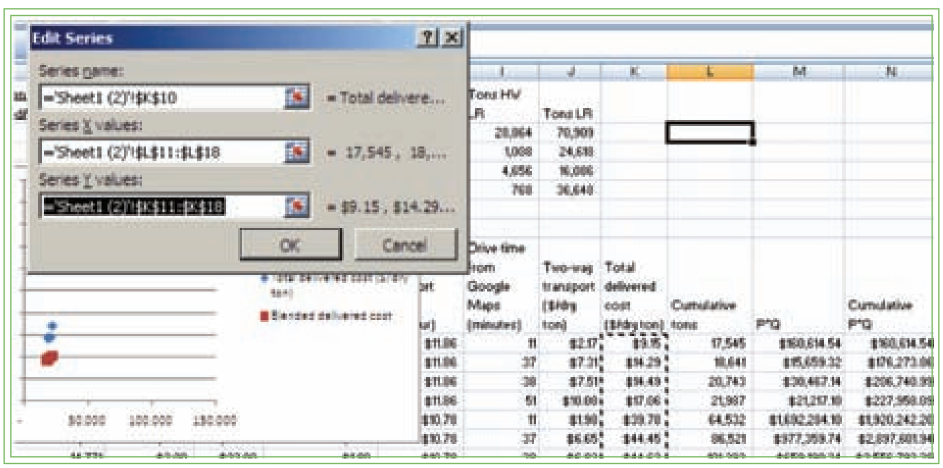
Click **Edit** to select the data for the graphs (Figure 30).

Figure 30: *Using the* **Select Data Source** *dialog box.*



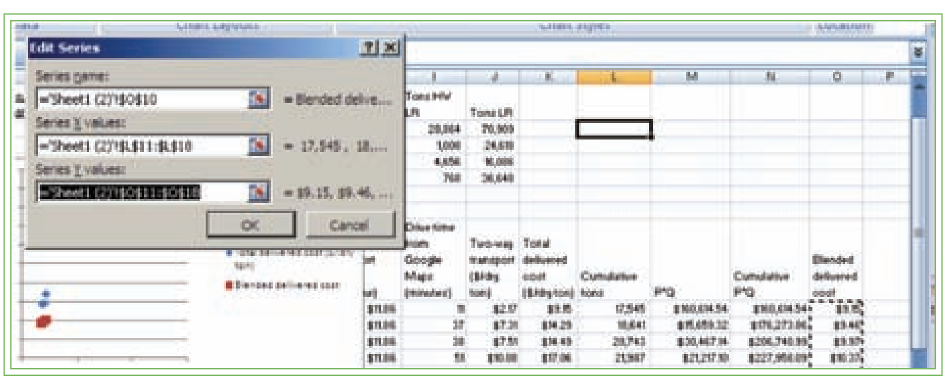
Set **Cumulative Tons** as the x-axis, and **Total Delivered Cost** to create the first supply curve (Figure 31).

Figure 31: *Selecting the supply curve data.*



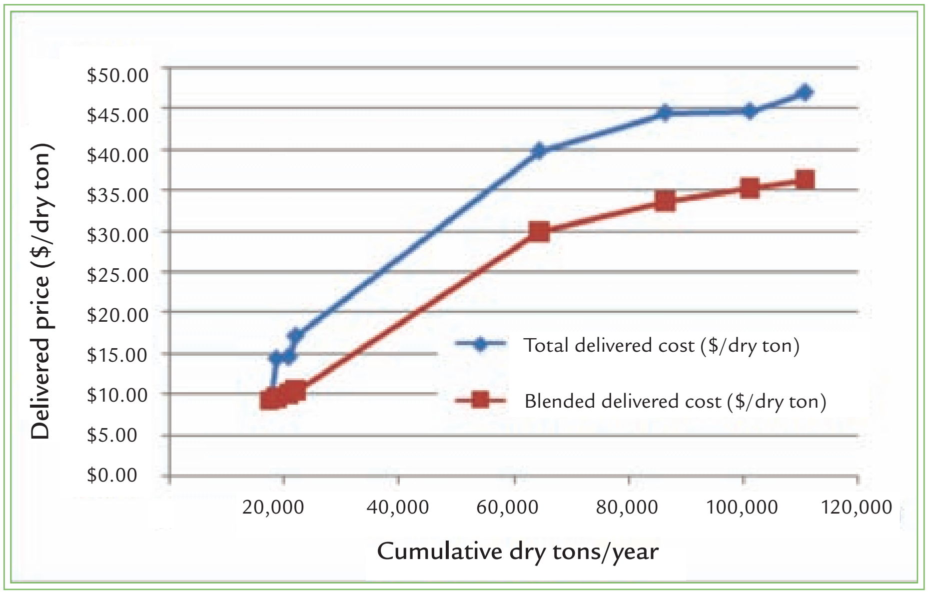
Set **Cumulative Tons** as the x-axis, and **Blended Delivered Cost** on the y-axis to create the blended supply curve (Figure 32).

Figure 32: *Selecting the blended supply curve data.*



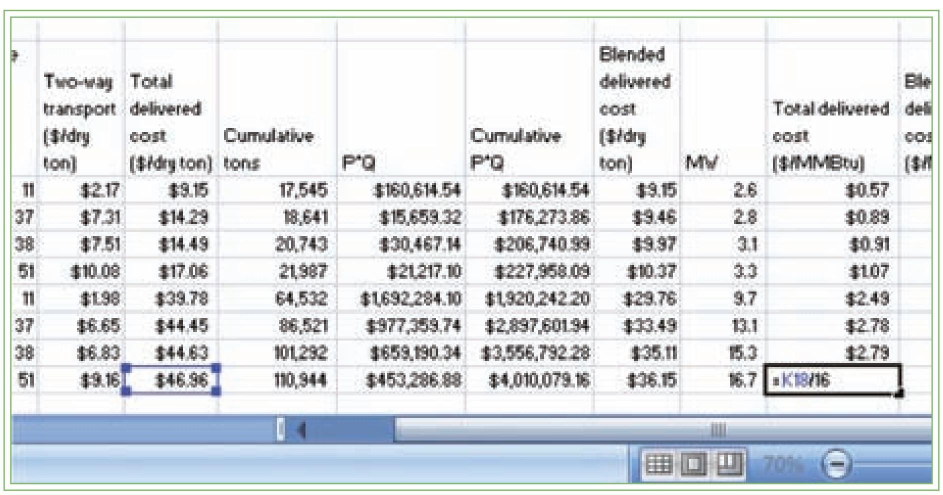
Now you should have a graph that shows the cost of a ton of biomass as well as the blended cost of a ton of biomass at any supply level along the x-axis. You can right-click on the data series and click on **Format Data Series** to add lines to the data points. Edit the graph as appropriate. Here's an example product (Figure 33).

Figure 33: *Supply curve and blended cost supply curve.*



Finally, you can convert these values into electricity generating capacity and energy units. One Megawatt (MW) of electricity is produced when about 6,600 dry tons of wood is burned. Add a column titled **MW** and calculate this column by dividing Cumulative Tons by 6,600. Add a column titled **Total Delivered Cost ($/MMBtu[3])** and divide the original **Total Delivered Cost** by 16 (about a ton of dry wood produces about 16 million Btu) to get total delivered cost per million Btu. Add a column titled **Blended Delivered Cost ($/MMBtu)** and divide the original blended by 16 to get blended delivered cost per million Btu (Figure 34).

Figure 34: *Calculating price/MMBtu.*

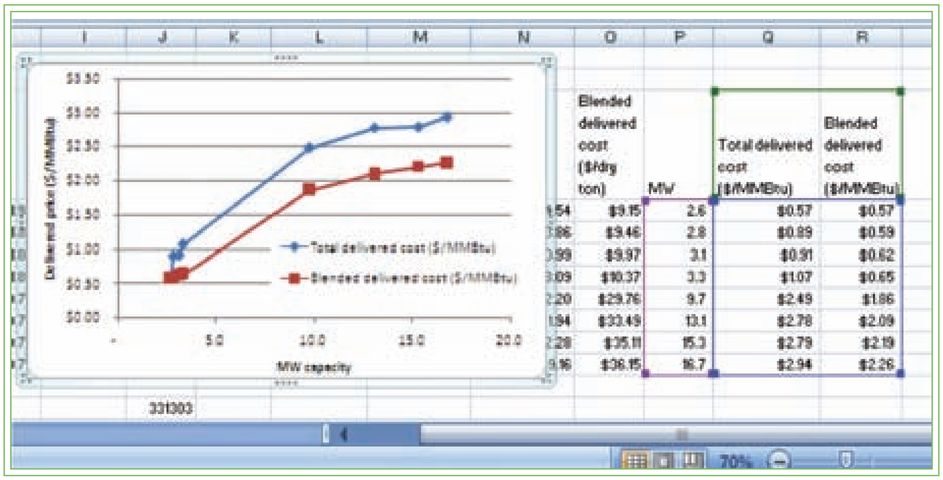


	Two-way transport ($/dry ton)	Total delivered cost ($/dry ton)	Cumulative tons	P*Q	Cumulative P*Q	Blended delivered cost ($/dry ton)	MW	Total delivered cost ($/MMBtu)	Ble deli cos ($/I
11	$2.17	$9.15	17,545	$160,614.54	$160,614.54	$9.15	2.6	$0.57	
37	$7.31	$14.29	18,641	$15,659.32	$176,273.86	$9.46	2.8	$0.89	
38	$7.51	$14.49	20,743	$30,467.14	$206,740.99	$9.97	3.1	$0.91	
51	$10.08	$17.06	21,987	$21,217.10	$227,958.09	$10.37	3.3	$1.07	
11	$1.98	$39.78	64,532	$1,692,284.10	$1,920,242.20	$29.76	9.7	$2.49	
37	$6.65	$44.45	86,521	$977,359.74	$2,897,601.94	$33.49	13.1	$2.78	
38	$6.83	$44.63	101,292	$659,190.34	$3,556,792.28	$35.11	15.3	$2.79	
51	$9.16	$46.96	110,944	$453,286.88	$4,010,079.16	$36.15	16.7	=K18/16	

[3] "Btu" stands for British thermal unit, a unit of energy. In the electric industry, "MMBtu" stands for "Thousand thousand Btu," which is one million Btu.

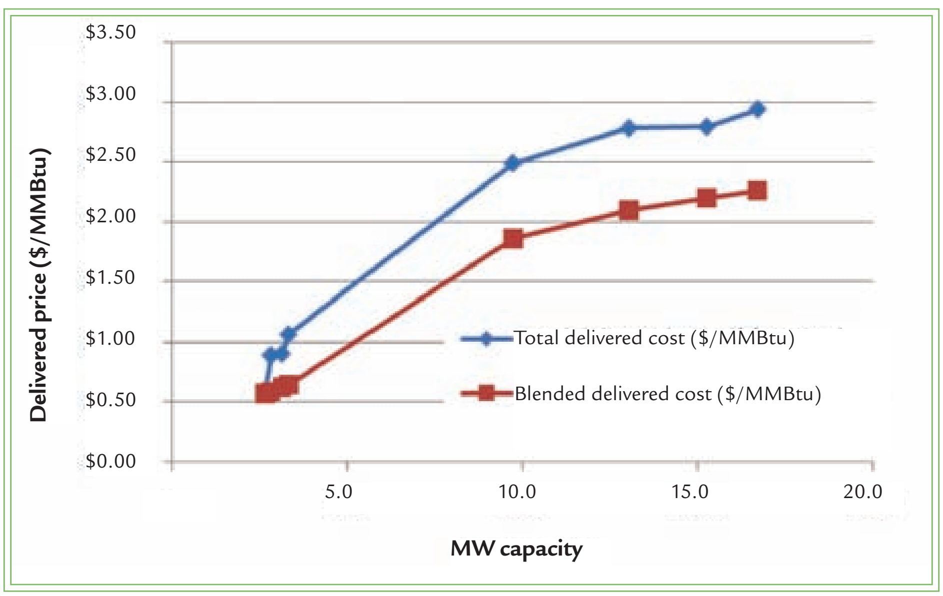
Copy the original graph and drag the data points to show MW capacity on the x-axis and price in $/million Btu on the y-axis as shown here (Figure 35).

Figure 35: *Generating graph in cost per MMBtu and MW capacity.*



Now a new graph is generated showing MW capacity and price in units of energy (Figure 36).

Figure 36: *Graph showing cost/MMBtu and MW capacity.*



Coal currently costs an equivalent of about $3.00/MMBtu in many states. You can use this new graph to indicate how many MW of capacity might be produced from woody biomass on a sustainable basis at a price competative with conventional coal energy.

6.5 Summary and Conclusion

Producing forest biomass for energy and other bioproducts generates not only additional revenue from biomass sales but also a variety of other benefits to landowners and communities. Financing a bioenergy project requires demonstrating that feedstocks are available in sufficient quantity at a low enough price. This information may also be helpful for landowners considering biomass production, community leaders examining wood as a potential way to meet growing energy needs, or a venture capitalist searching for a good investment. In this section, several tools for developing suppy curves to evaluate the economic availability of biomass resources were presented. This general approach can be modified to reflect resources and costs in your AOI. For information about funding opportunities for biomas projects, see *Handout 6: Financing a Bioenergy Project.*

For examples showing economic analyses of other woodsheds, see the Supply and Cost Profiles in *Appendices D through F.* The Supply and Cost Profiles represent analyses from three regions of the U.S.: Alaska, Florida, and Massachusettes. Profiles were adapted from existing projects and vary in terms of the types of wood resources considered, the breadth of the data, and the characteristics unique to each area and provide opportunities for comparison of methods and findings.

This chapter was adapted from the following source and used with permission.

Langholtz, M., D. Carter, R. Schroeder, and M. C. Monroe. 2007. Do-It-Yourself supply curves. In *Wood to energy outreach program: Biomass ambassador guide*, eds. M. C. Monroe, L. W. McDonell, and A. Oxarart. Gainesville, FL: Florida Cooperative Extension Service, Circa 1526, University of Florida.

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Prestemon, J., J. Pye, et al. 2005. U.S. wood-using mill locations. http://www.srs.fs.usda.gov/econ/data/mills/mill2005.htm (accessed July 15, 2008).

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Handout 6 Financing a Bioenergy Project

There are many federal, state, private, and foundation-based funding opportunities for research and training activities in bioenergy production, utilization, and commercialization. This handout primarily focuses on funding opportunities for the commercialization of woody biomass. Commercialization of any new energy source using new technology is considered new product development until a commercial-sized energy facility is successfully operated for an extended period of time on a consistent basis. For some communities and industries considering wood-to-energy facilities, it may be possible to tap financial resources that are typically reserved for the commercialization of new technology.

The financial services sector, be it a Wall Street venture capital group or a "Main Street" bank, possesses an institutional fear of anything new and unproven. Though woody biomass has been used in small-scale projects for years, bioenergy companies may have trouble raising equity because many woody biomass-related projects and entrepreneurs are rural-based businesses that have yet to demonstrate the viability of the technology and the ability to penetrate the marketplace. They may also lack the proven managerial and marketing expertise needed in order to be successful. For some venture capitalists located almost exclusively in the nation's cities, a rural start-up business commercializing an agricultural-based product is unfamiliar. Others, however, may be looking for those unusual and risky but potentially highly rewarding opportunities that lie outside the mainstream.

Despite these challenges, various sources of funding are available if entrepreneurs and companies know where to look. These sources not only provide funding but alleviate the worries and trepidation on the part of the borrowing and lending communities.

In addition to owner equity, which is, of course, essential, a project may obtain grants, tax credits, state and local incentives, bonds, appropriated dollars, loans, guarantee loans, and other financial resources to make the project commercially viable. Therefore when beginning a project, planners should seek out experts who can identify funding, open doors, find private and public lending resources, and arrange for these multiple funding sources. Doing so can greatly reduce the time and expense incurred during the commercialization phase and can also reduce the amount of private capital needed for a successful venture.

Start-up ventures are the most difficult to finance and may require the most steps and financial resources. One of the best sources of funds especially for start-ups can come from the very group with the most to gain from commercialization—the growers or producers who supply the biomass feedstock. By contributing cash or even a supply of raw materials, forest landowners can receive equity and a return on their investment if the company's commercialization efforts are successful. Also, in some cases, the raw material can be counted as an asset that can be used to attract debt financing.

Federal, state, and local government assistance may be available in certain cases. This assistance can come in the form of direct appropriations, tax abatements, tax increment financing for infrastructure financing, and even grants for job training and other assistance. Also, federal tax credits may be available, which can be used by the investors or, in some cases, sold and converted to cash and used to attract debt financing. All of these sources can be difficult to obtain without the assistance of someone familiar with the appropriate public entities, funding sources, and governmental officials.

Other sources available to those new ventures fortunate enough to find them are known as "angels." Angels are investors who are bullish enough on the new venture to provide the early stage investment necessary to get it off the ground. Angel investors are usually more patient investors than venture capital firms and may not require the substantial return on investment normally sought by venture capital firms, or they may accept delayed repayment.

Companies already in business manufacturing and selling value-added products have some attractive sources of financing unavailable to start-up companies, because lenders prefer companies with a track record. Even more attractive terms and rates may be available under certain circumstances. Existing companies can form special subsidiaries or nonprofit entities for the purpose of developing new sources of energy.

The following sections describe some of the many resources available and the governmental sources that provide them. Note: specific terms and dollar amounts will change with time. It is always advisable to research specific, up-to-date information when planning project financing.

U.S. Department of Agriculture

Business & Industry (B&I) Guarantee Loan Program The B&I Guarantee Loan Program provides up to a 90 percent loan guarantee to banks for businesses located in areas with 50,000 in population or less. The primary objective of the program is creation or preservation of jobs in rural areas. Loan proceeds may be used for working capital (seven-year amortization), machinery and equipment (fifteen-year amortization), buildings and real estate (up to thirty-year amortization), and certain types of debt refinancing. The maximum loan amount is $40 million, and loans can include a fixed interest rate. Personal guarantees are required along with a minimum of 25 percent tangible equity for companies that produce energy from renewable sources. Obtaining the guarantee is a complicated process but is well worth it. It is especially helpful in small communities with small lenders that have limited lending capacity. A 70 to 90 percent loan guarantee can permit these small banks to make loans that otherwise would be considered too risky or do not meet established lending guidelines.

Rural Utilities Service (RUS) Approximately $200 million in direct loans is available through USDA's Rural Utility Service for electricity produced from biomass energy that is generated for sale to rural utilities and power companies with a significant "rural customer load." Loan interest rates are tied to municipal bond rates and the rate is a fixed rate that is amortized for 25 years. This loan requires cooperative arrangement with local rural electric cooperatives or other power companies with a significant rural customer load. The technology must be "proven" and "renewable," however, the equity requirement for the borrower is flexible.

Renewable Energy Grant and Loan Program The USDA Rural Business Service offers entrepreneurs a grant and guarantee loan program. Commercial entities and agricultural and forestry producers are eligible. This program has $11.4 million available for grants and $176 million in guarantee loan authority available for projects that produce energy from renewable sources. Grants can cover 25 percent of eligible project costs and guarantee loans can be for up to 50 percent of project costs. Loan terms are similar to B&I loan terms and conditions. Companies must demonstrate financial need in order to qualify.

Value-Added Agricultural Product Market Development Grants The Rural Business-Cooperative Service now offers grants to help independent producers, such as forest owners, enter into value-added activities. The primary objective of this grant program is to help eligible applicants develop business plans and strategies for viable marketing opportunities. Grants of up to $500,000 are available. All applicants must be producers of agricultural commodities or products, including aquaculture and wood lot enterprises. Grants are available for planning and working capital.

Biomass Research and Development Initiative (BRDI) The USDA and U.S.DOE jointly administer the BRDI to provide assistance for research, development, and demonstration of biomass-based products, bioenergy, and biofuels. The intent is to promote greater innovation and development related to biomass. Technical topic areas include feedstock development and production, biobased product development, environmental and economic performance, integrated resource management and biomass use, and incentive analysis for commercialization. Approximately $15 million is available for grants in each fiscal year. The maximum grant amount is $2 million and requires a 20 percent match by the applicant. Pre-applications are due in February and the full applications are typically due in April.

Cooperative Services For cooperative-owned businesses, there are special programs by USDA that may include grants for projects that support the use of renewable fuels. This may involve a partnership with a nonprofit or university if further research and development is involved. These programs are typically for energy projects involving farmer or producer-owned entities. However, even a utility can access these programs if an alliance with producers is established to provide the necessary feedstock to produce energy.

Economic Action Program The U.S. Forest Service has in recent years offered funding for projects utilizing woody biomass for value-added purposes. The Economic Action Program is designed to assist projects meeting the following objectives.

- Rural Development: Encourages rural communities through education and seed money to develop natural resource-based opportunities. Emphasis is on addressing community-identified needs and working with businesses.

- Economic Recovery: Assists rural communities experiencing acute economic problems associated with changes in natural resource management to diversify and expand their economic potential.

- Wood in Transportation: Provides cost saving options to rural communities to rebuild or replace their transportation and recreation infrastructure while stimulating diverse markets for local wood products.

It is uncertain if this program, which historically has been funded at levels of approximately $25 million, will be funded each fiscal year.

In addition to these USDA programs there are other economic development programs that can be accessed to provide grants, equity, and favorable rates and terms for debt financing. Following is a description of some of these programs.

U.S.DOE Tribal Energy Program Grant

This federal grant program administered by U.S.DOE's Office of Energy Efficiency and Renewable Energy (EERE) provides financial and technical assistance to Native American tribes for feasibility studies and shares the cost of implementing sustainable installations that use renewable energy sources on tribal lands. Eligible technologies include the use of passive-solar space heat, solar water heat, photovoltaics, wind, biomass, hydroelectric, geothermal, electric, and geothermal heat pumps. Eligible applicants are tribal governments. The program provides approximately $2.7 million in funding, with $1 million going to the Council of Energy Resource Tribes (CERT) and $1.7 million available for other applicants.

New Market Tax Credits

Congress created the New Market Tax Credit program to encourage $15 billion in investments in low-income communities. Qualified Community Development Entities (CDEs) are eligible for allocations of credits and must apply to the Community Development Financial Institutions (CDFI) Fund for an award of New Market Tax Credits. The CDE then seeks taxpayers to make qualifying equity investments in the CDE. Equity investments or loans are then used to make Qualified Low-Income Community investments in Qualified Active Low-Income Businesses in low-income areas. The investors are eligible to claim a tax credit equal to 39 percent of the total investment in the CDE.

Revenue Ruling 63-20 Bonds

These tax exempt bonds can be used to provide long-term fixed rate loans for projects with a purpose that is "public in nature." Bonds are issued by local governments on behalf of a nonprofit entity. The political subdivision issuing the bonds must have a beneficial interest in the nonprofit entity while the indebtedness remains outstanding. The political subdivision must obtain full legal title to the property upon debt retirement.

Tax Increment Financing (TIF)

These bonds are issued by local governments for infrastructure improvements in an area predetermined to be part of a "tax increment financing district." Bond proceeds are used to entice businesses to bring revenue-producing properties to an area. Bonds are retired by the property and/or sales taxes generated by businesses locating in the tax increment district. These bonds are an excellent way to offset the costs of infrastructure associated with a project that produces energy from renewable sources.

General Obligation and Revenue Bonds

General Obligation/Revenue Bonds issued by the state, county, or municipality provide long-term, fixed rate financing at tax exempt bond rates. With these bonds the government is obligated for repayment of debt that is issued as a means to attract new industry and economic development to an area.

State and Local Government Incentive Programs

Perhaps the best source of funding may be found right at home through your own state's economic development agency. These agencies are in business to attract and create jobs and offer many incentives that can complement private and other governmental programs. Types of assistance available may be in the form of grants, direct loans and loan guarantees, infrastructure financing, tax credits and abatements, and even job training programs for workers.

Food, Conservation, and Energy Act of 2008

Formerly known as the 2008 Farm Bill, the Food Conservation and Energy Act of 2008 reauthorized 2002 Farm Bill programs. It provides grants for investment in renewable technologies, financial incentives to use agricultural and forestry crops for bioenergy, and establishes a biobased markets program. The Food, Conservation, and Energy Act of 2008 includes several new provisions that address biomass and bioenergy. It allots $1 billion for programs designed to encourage investment in renewable energy and technology. The Act also creates the Rural Energy for America Program (REAP), which assists agricultural producers and rural small businesses in planning and preparing feasibility studies for renewable energy projects. The Bioenergy Program receives $300 million in funding to provide incentives for using agricultural and forestry crops and waste to produce bioenergy and provides for multi-year contracts for crop and forest producers to grow dedicated energy crops. In addition, the Act establishes the Biobased Markets Program, designed to provide a USDA certification system for qualifying biobased products. This provision also establishes a federal procurement preference for biobased products.

Summary and Conclusion

This is a brief review of the types of financing that are available to support woody biomass energy. Of course, other programs and funding sources may exist, and potential biomass program developers should explore all options prior to beginning any new venture. In addition, organizations should also seek enough funding to make it through the lean times that always occur during the early stages of new ventures. And funds should be sought and set aside for marketing, ongoing product research and development, and other business contingencies.

The lending community's appetite for the use of renewable energy sources has never been greater. However, due to the lack of understanding and the anxiety associated with funding "out-of-the-box" ventures, it is imperative that the entrepreneur use any and all means necessary to buy down the size of the funding needed with tax credits, grants, and other governmental assistance and seek loan guarantees, third party feasibility studies, and other means to mitigate the risk exposure for lenders.

This handout was adapted from the following source and used with permission.

Crain, B., A. W. Hodges and M. C. Monroe. 2007. Financing woody biomass facilities. In *Wood to energy outreach program: Biomass ambassador guide,* eds. M. C. Monroe, L. W. McDonell, and A. Oxarart. Gainesville, FL: Florida Cooperative Extension Service, Circa 1526, University of Florida.

Chapter 7 Outreach and Education

7.0 Introduction

Bioproducts such as biomass and biofuels are becoming important topics of discussion among politicians, natural resource professionals, environmental groups, and the general public. Much of the discussion includes conflicting opinions and questions—two indicators that outreach and education are needed. For example, public perceptions research suggests that most people know little about energy, in general, and even less about bioenergy. In order for landowners, community members, and other stakeholders to decide if biomass is something they should or should not embrace, education is essential. If people come to you for information, resources, and assistance, there are many ways you can provide outreach and educational resources. This chapter is designed to help you think about how to do it effectively. While the concepts presented in this chapter focus on woody biomass, most tools and strategies could easily be used with other types of biomass. The following are scenarios you might encounter in your work.

1) A local forest landowner approaches you with questions. His land has been in forestry for three generations. Recently, he's received numerous offers from developers for his property and isn't sure what he should do. He wants to be able to pass the land on to his children and would rather find ways to keep his forest working for him. He heard that bioenergy markets are coming to your region and wants you to help him determine how to take advantage of this possibility.

2) Your county is exploring the possibility of using wood to help meet growing electricity needs. Some members of the community are proposing a 30 Megawatt wood-powered plant to be built within the next three years. Two local environmental groups are strongly opposed to the plan, while one is in favor. A county commissioner calls, asking if you can give a "wood-to-energy 101" presentation to the commission during a public meeting.

3) Your boss thinks there might be potential for a cellulosic ethanol facility in the community and has asked you to put together an outreach program on the topic. She wants you to get a community discussion going on the possibility of stimulating economic development through cellulosic ethanol production.

Figure 1: *Effective outreach is clear, concise, and relevant to the audience.* Photo by Lauren McDonell, University of Florida.

7.1 Principles of Effective Outreach

The possibilities for outreach opportunities are almost endless. No matter who your target audience is, however, there are a few principles to keep in mind when developing your plans for educational efforts. Effective outreach needs to be (Jacobson et al., 2006)

- clear and concise,
- simple and easy to understand,
- at an appropriate technical level for your audience,
- accurate and up-to-date,

- personally relevant to your audience,
- credible and trustworthy, and
- detailed enough to provide a basic understanding and foundation for learning more.

If you're not sure what information is appropriate for your audience, ask them! Either conduct a needs assessment (e.g., a brief questionnaire) or ask individual clients directly what information will best meet their needs. Your most important focus is the audience you are trying to reach, rather than the general public so you will want to learn and understand what they already know and what they need to know.

7.2 Understanding Your Audience

Who is your audience? Farmers, forestland owners, or elected officials? Adults or youth? People looking to sell woody biomass or use it? Is your audience approaching you with questions or are you trying to gain their participation in an educational program?

Responding to Your Audience

There is a good chance that many of your outreach activities will either involve people contacting you with questions or requests to do a presentation on woody biomass. When people come to you with questions, keep it simple. Ask questions to find out what they know, what they care about, and what misconceptions they may have about woody biomass. Misconceptions are important because when people believe something that may not be true, they are not likely to accept information that contradicts what they believe (Monroe, 2005). If you know about some potential misconceptions that your audience may have, you can tailor your outreach approach to acknowledge the misconceptions and gently correct them by providing science-based facts. Provide your audience with basic handouts (you can use the ones provided in this guide or create your own). Consider the list of outreach tools provided later in this chapter and determine which ones will be most useful with specific clients. If, as in scenario 1, a forest landowner wants help figuring out if woody biomass production might be a good option for him, you might give a basic overview of some of the possible sources of woody biomass, existing or planned local and regional facilities that use wood (if any), and the potential prices he might be able to expect.

If you are asked to give a presentation on woody biomass at a public meeting, as in scenario 2, use the PowerPoint® presentations provided with this guide as a starting point. You can pick and choose which slides and information you think will be most relevant and helpful to your audience, and add local data and examples where possible. Keep your presentation basic and concise and be sure to leave time for questions.

Attracting an Audience

If you are responsible for delivering a community-based program, as in scenario 3, you will need to attract an audience. Jumping up and down may not be the best approach. You can attract an audience by focusing on common concerns that people have, and as you learn more about their specific concerns, you can adapt the details of your message to address what they care about and need to know.

A community is an area where people live and interact with one another. The area may be defined by a town, city, county, or region. In this case, we are referring to people who may be affected by woody biomass production or utilization. There are a few key questions that you should consider when creating a community outreach program. Is biomass on the community's radar at all, or is it a completely new concept? Is there enough wood growing locally to supply a bioenergy or bioproducts facility? Is there a desire to figure out where a biomass-using facility might work but no formal plan? Or are there plans for a facility already? Is the community preparing to gather public input on plans for a facility? Answers to these questions will help determine what information will be most helpful to your target audience and which outreach tools and strategies will be most effective. In scenario 3 given earlier, an effective approach might include learning about existing forestry or energy industries within the region; finding out if plans or interest exist to develop a cellulosic ethanol or other woody biomass facility; and identifying and exploring concerns within the local community, such as the need for more jobs, the desire for increased energy independence, and the fate of local forests.

Figure 2: *Knowing whether or not a community is considering producing or using woody biomass is essential to designing an effective community outreach program.* Photo by Martha C. Monroe, University of Florida.

Whatever your role in public outreach and engagement, do your best to make sure that the public's concerns are addressed and their questions are answered. If you are asked questions that you cannot answer, explain that you need to research the answer and will respond later via email or phone. See the "Frequently Asked Questions" in the appendix to help prepare for questions you might be asked. The *Common Concerns* handout also may be useful.

Public Perceptions

Whether you help engage the public in a community discussion or provide information to individuals, having a general idea of public perceptions can help you identify potential informational needs and respond to common concerns and misconceptions about woody biomass. Public perceptions research has identified a need for education about energy and more specifically, the production and use of woody biomass. A national study in 2001 revealed that only 12 percent of Americans can pass a basic energy quiz (NEETF, 2002). The University of Florida conducted a random mail survey of 298 single-family home and mobile home owners in Alachua County, Florida, about their knowledge and attitudes concerning using wood for energy. Fifty-four percent of respondents said they were "not at all knowledgeable" about using wood for energy and only 5 percent consider themselves "very knowledgeable". Seventy-one percent of respondents support using waste wood, while 61 percent support using wood grown for energy (Monroe et al., 2007).

Information such as this can help shape your outreach messages and make them resonate with your audience. For instance, if you know

Dealing with Controversial Issues

In some cases, the concept of using wood for energy production or biobased products can be a controversial subject. There may be groups or members of the public who strongly oppose the idea. Be prepared to listen to their thoughts and concerns and acknowledge that their points of view is important. Maintain professionalism as you share facts, gently correct misconceptions, and answer questions. When dealing with contentious issues, it is especially important to avoid the appearance of bias.

In general, the University of Florida study respondents reported the following:

- local forests and good air quality are important things to keep
- using waste wood for energy production is acceptable
- solar and wind are the best energy sources,
- burning wood increases atmospheric CO_2
- wood is dirtier than natural gas
- healthy forests are unmanaged forests
- and foresters, environmental groups and extension agents are reliable sources of information

the public is concerned about forest sustainability, you can ensure that your materials and conversations respond to that concern. If you know the public is generally comfortable with the idea of using wastewood for energy and biobased products, but opposes growing trees for these purposes, your message can focus on local sources of wastewood. If you learn that your audience believes wood bioenergy will contribute to global climate change, you can tailor your outreach activities to address this misconception.

Public perceptions are also important because public support, or lack of it, can have a tremendous impact on the outcome of a biomass utilization proposal. For example, in North Wiltshire in the United Kingdom, a utility company proposed a 5.5 megawatt (MW) plant to power 10,000 homes using advanced gasification technology. Local people, who worried about negative effects to the local environment, formed an action group called Biomass Lumbered on Our Town (BLOT) to stop the proposal. Using letter campaigns and surveys, residents convinced the North Wiltshire District Council to reject the proposal. The utility company's appeal was also dismissed (Upreti and Van der Horst, 2004).

Conversely, in Burlington, Vermont, citizens were engaged in a process of determining how best to use local wood for energy. They were given ideas of how such a system would be set up and then they created additional options. In the end, the citizens approved a system that would use woody biomass from timber stand improvement activities that would be shipped to their urban utility by rail at specified times of day to reduce impact on local traffic. See the case study, "Community Involvement in Developing a Wood-powered Utility," in chapter 8 for more information.

Clearly, good outreach and education can be essential, and part of what makes an outreach program successful is a keen understanding of public perceptions. You may be able to find additional existing research about public perceptions or you can gather your own local data by conducting a survey or series of focus groups designed to find out what people know and don't know, and what they value. Another option would be to start slowly and spend time listening. Use feedback to improve your presentations. Ask questions to find out what was too complicated and what made sense. The handouts provided in this guide were designed to meet educational needs identified by public perceptions research conducted in the South. They might work for you.

7.3 Defining Your Goals and Objectives

Defining goals and objectives for your activities is an important next step in the outreach process. A goal is an overarching statement or purpose that guides your outreach efforts; objectives are more specific and measurable descriptions of what you want each outreach activity to accomplish. If you don't have a target audience identified, defining your goals and objectives can help direct and focus your program. For example, your goal might be to raise community awareness about using wood for ethanol production. Your objectives might be to (1) introduce Earth Day festival attendees to the idea that wood can be a sustainable, renewable source of ethanol; (2) inform local landowners about potential biomass markets; and (3) educate the local city commission about the functions of basic wood-to-ethanol facilities. These objectives help define the target audience, which in this case would be Earth Day festival attendees, local landowners, and elected officials.

7.4 Selecting a Medium and a Message

Once you have identified and understood your target audience or community and defined your goals and objectives, you can begin selecting your outreach tool(s) and defining your message. Following is a list of outreach tools that may help you in your efforts. When choosing which tool or tools to use, consider what will make it easiest to connect with your target audience, which tools will help you achieve your objectives and ultimately your goal, and which tools are feasible for you to implement. Remember to use what you know about public perceptions to guide your selection of outreach tools. The "Outreach Planning Worksheet" in the appendix can help you clarify your outreach plans. Some outreach tools are much more time consuming and resource intensive than others. Be realistic when estimating what you will be able to contribute to your outreach efforts. Developing a Web site or video might seem like perfect approaches for your audience and objectives, but only if you have the resources to complete them. Instead, using already developed fact sheets, brochures, and Web sites can save time and money. Make sure you have a clear idea of what your outreach message is and that your outreach tools communicate that message effectively. Our Woody Biomass 101 presenter in scenario 2, for example, could use flip charts, posters, handouts, a demonstration, or slides to illustrate a presentation. A community outreach program could resemble a media campaign or take a more conservative approach to education with workshops and handouts.

Education vs. Advocacy

Some agency staff may be able to advocate one perspective when it comes to woody biomass outreach, while others must walk the fine line between education and advocacy. In situations where there is distrust, opposition, or a need to establish credibility, it may be especially important to avoid the appearance of communicating only one side. Some factors that create the image of advocacy are unavoidable but carefully considering how you, your outreach team, and your approach are perceived can minimize the issue. Here are some ideas on how to avoid the appearance of advocacy:

- When possible, include the advantages and disadvantages of using wood.
- When comparing wood to other fuel sources, try to weigh both evenly and be careful about word choices (e.g., avoid "coal-bashing").
- Stick to facts and avoid assumptions, appeals to emotion, or opinionated statements.
- In a forum or community meeting, it can be helpful to use an independent facilitator.
- Openly state that there are many options and wood is just the one you'd like to explore at this time. People appreciate honesty.

Outreach Tools

The following descriptions of the suggested outreach tools are based on two books that comprehensively cover many outreach tools for use in the natural resource field: *Conservation Education and Outreach Techniques* by Susan K. Jacobson, Mallory D. McDuff, and Martha C. Monroe and *Communication Skills for Conservation Professionals* by Susan K. Jacobson.

Dear neighbor letter – Write a friendly letter to local residents to invite them to an upcoming event, introduce the idea of biomass production and utilization, or provide other relevant information. This can be a good way to reach your audience if you have postal or e-mail addresses for them. To save postage, this letter can also be sent by e-mail. But remember that while most people have access to the Internet in their homes or public libraries, a portion of the population cannot be reached this way. See the appendix for a sample dear neighbor letter.

Media opportunities – Use the mass media to communicate with the public through an article, a series of articles, a radio/television interview, or a news story. This can be a great way to reach a broad spectrum of people with general information and few details. Send a news release to the local newspapers, television stations, or radio stations and talk with editors and reporters about covering the issue of biomass production and utilization. You can also use the media to publicize an upcoming outreach event. For the cellulosic ethanol outreach program in scenario 3, newspaper, radio, and television announcements might help raise awareness and improve turnout for community forums. See the appendix for a sample press release.

Newsletters – Write articles for newsletters published by local organizations such as environmental groups (make sure you know their stance on bioenergy), civic clubs, county extension offices, faith-based groups, or create your own newsletter. Such an article can contain information on biomass production and utilization, interviews with key community leaders or experts, and lists of upcoming related events. Distribute the newsletter by mail, e-mail, or place copies around the community and with interested organizations. If you have trouble gaining access to postal or e-mail addresses, consider posting your newsletter on electronic mailing lists for various organizations.

Posters and signs – Develop a poster or sign to depict some aspect of biomass and display it at meetings and conferences, or get permission to hang it in appropriate buildings such as the city hall, libraries, or community centers. To build community awareness, create a simple, balanced message about bioenergy and where to get more information. These methods can reach a wide range of people; however, this method is difficult to manage in terms of measuring who your message reaches.

Brochures or handouts – Brochures or handouts can be strategically placed at state forestry and county extension offices, community centers, stores, and libraries. These tools may contain basic information or may be more technical. Make sure the information is at an appropriate level for the audience you want to reach. Check back often to assess whether people are picking up materials and replenish when necessary. This is a good method to reach many people with a fairly detailed message but is limited in terms of personal interaction with the community. A handout might be helpful for the forest landowner in scenario 1 who wants specific information, which would supplement the information given to him verbally and provide a resource for him to refer to later.

Field trip – Invite interested community members, landowners, or community leaders to an organized tour of a nearby biomass-powered facility, a wood-handling operation, or a local forest that is sustainably managed. While the field trip may involve a substantial time commitment from participants, experiential learning opportunities like these can be beneficial and memorable.

Conference/Symposium presentation – You may be invited to give a presentation at a conference or symposium. These venues can be great places to network with people of similar interests, share ideas, and build new skills. Conference audiences are often interested in more detailed information.

Presentations at city or county commission meetings – As in scenario 2, you may receive a request to give a basic overview presentation on woody biomass. You might even request time to speak at local governmental meetings and plan a presentation that is relevant to the community leaders. You can provide an introduction to using biomass for energy, transportation fuels, and other products, costs and benefits of using wood, the sustainable supply of biomass, the economic impacts, etc. Such a presentation provides an opportunity to share specific information with local leaders, and because these meetings are open to the public, you will be able to inform the residents about using biomass. Bring enough copies of simple, accurate handouts to share with the commission and attendees. If you choose this approach, be prepared to deal with individuals or groups who oppose the idea of using biomass. If the thought of using an LCD projector to give a PowerPoint® presentation makes you feel anxious, refer to Box 3 for some simple tips.

The Nitty Gritty of Using an LCD Projector (eHow Business Editor 2008)

Steps for using an LCD projector:

1) Plug the LCD projector power cord into an outlet and plug the power cord into the back of the LCD projector.
2) Use the VGA cable (usually a 15-pin male-to-male) to connect the laptop to the projector. If the projector has more than one VGA connector, use the connector that says something like "line in" or "in from computer."
3) Turn on your laptop, then turn on the projector, giving it a few minutes to warm up. Open your presentation file and click on "slide show view" on the top taskbar. When you are ready to project your image, press "Function" (Fn) and at the same time as "F8."
4) You can move back and forward in your presentation using the and buttons, "Page Up" or "Page Down," the spacebar and backspace, the N and P keys (next and previous), or a handheld remote.
5) When you're done with your presentation, press the "off" button on the projector.Sometimes a dialog box appears on your laptop asking if you are sure you want to turn it off. Press the "off" button again, and the machine powers down. Leave the machine plugged in until the cooling fan stops. Replace the lens cap and pack it into its case, once cool.

General Tips:

- Make sure you have a clean screen or white wall on which to project your presentation.
- If possible, keep the projector manual close by.
- Position the projector near the center of the screen at which it is aiming.
- Use the projector's adjustable feet to make your projection image level. You can also place the projector on a book or two to raise it up, if necessary.
- Most projectors have focus knobs to help make the image clearer.
- For safety, avoid running cords across walking areas.
- Test the laptop, the presentation file, and the projector at least a day before your presentation. Make sure you know where to find replacement light bulbs for the projector.
- Make sure to turn off the screensaver on the computer you're using so it doesn't interrupt your presentation.
- To turn the screen black before your presentation starts, press "B". Once you're ready to start, press "Esc".
- Have your presentation saved on at least two storage devices, such as a USB stick and a CD. Some people like to have their slide notes printed out, just in case technology fails altogether.

7.5 How to Organize a Community Forum or Meeting

In addition to the outreach tools described, organizing your own small meeting or community forum may be a useful approach to reaching your target audience, especially if you are conducting a community outreach program. Following are some important considerations when planning public events.

The community forum is one way to create opportunities for the public to increase their knowledge about biomass by first providing information and then stimulating discussion. Somewhat different from a meeting or presentation, this interaction allows community members to become engaged in the discussion of local energy options. Forums consist mainly of two parts: (1) a short introductory presentation of using wood for energy, fuel, or other bioproducts (see the presentations on the CD-ROM provided with this guide) and (2) an engaging discussion that allows participants to ask questions and voice their perspectives. Participants' perceptions, ideas, and concerns can be collected through surveys or by taking notes during the discussion. These ideas can be reported to community leaders to help guide their decision making. The community forum model might be especially useful for the professional in scenario 3 who needs to foster local discussions about cellulosic ethanol.

Figure 3: *Community forums can increase public knowledge and stimulate community discussions about woody biomass.* Photo by Lauren McDonell, Unviersity of Florida.

Whether you're holding a community forum or meeting for the general public, elected officials, or interest groups, there are a few key concepts to keep in mind. Choose a neutral, comfortable meeting space. A public library, a community college, or an extension office may be able to offer a room for ten to twenty people to meet at no cost. One to two hours is probably sufficient for most gatherings; provide coffee and snacks if possible. Invite people to participate in the meeting with an invitation (by e-mail or post) that introduces the purpose and possibilities. Develop an agenda for your meeting. Box 4 shows a sample forum agenda that could be used to introduce people to the concept of using wood for energy.

Bringing in Experts

If you are planning a community forum or meeting, you may want to identify a team of resource people to help present the information. The following combination of experts may be helpful:

- State forestry staff
- Cooperative Extension agents or specialists
- Resource Conservation and Development (RC&D) council members
- Researchers who understand economic impacts, biomass costs, forest manage ment, biomass harvesting, climate change, combustion and gasification tech nology, biofuels, and wood utilization
- Industrial wood users such as buyers and sellers of wood, generators of wood waste, and wood haulers
- State and local energy staff
- Biofuels or biobased products experts

- Environmental or civic leaders
- Elected officials
- Renewable energy or carbon tax experts

Following are some general guidelines to help you organize community forums. Many of these tips are useful for any kind of face-to-face outreach activity.

1) Existing meetings: Community forums can be held in conjunction with an organization's meeting. For example, community service organizations such as the Kiwanis and Rotary clubs, neighborhood associations, environmental groups, political groups, or faith-based groups have ready-made audiences who are often looking for speakers. Be aware of the format and timeframe that the organization is accustomed to and plan accordingly.

2) Public forums: You can also hold forums that are open to the public, where the primary purpose for meeting is the forum itself. This type of forum can be held at public libraries or community centers, which often have meeting rooms that can be reserved (sometimes free of charge). Think about the best time and location for community attendance.

3) Underserved communities: Choosing a diversity of locations and clubs for forums is very important to reach different segments of the community. For example, holding a community forum on a Native American Reservation or in conjunction with a local minority organization, such as the National Association for the Advancement of Colored People (NAACP), can reach community members who may not attend other forums.

4) Advertise: In order to assure a good turnout, begin advertising your forum well in advance. If the forum is open to the public and not a regularly scheduled meeting, it is essential that you promote the event. You can make flyers to place at popular stores, restaurants, and community bulletin boards in the area; send news releases to local television and radio stations and newspapers; and spread the word via electronic mailing lists. Organizations and clubs will usually have their own forms of advertising via a newsletter or Web site. In addition, you could ask to send an announcement to the organization's e-mail list, notifying all members about the forum and where to get additional information.

5) Get prepared: Before the forum, practice the presentation, especially if other people are involved. Also, think about the types of questions people are likely to ask. See the "Frequently Asked Questions" appendix in the appendix for ideas. Depending on what equipment is available at the location, you may need to bring a laptop computer, projector, extension cords, and a projector screen. Find out ahead of time what will be provided and what you'll need to bring. Gather appropriate

Sample Community Forum Agenda

- Welcome folks at the door, provide name tags and snacks
- Introduce the topic, your speakers, and ask everyone to introduce themselves (10 min)
- Speaker 1: Our community, current energy sources, anticipated energy needs (4 min)
- Speaker 2: Our forest resources—now and in the future (4 min)
- Speaker 3: The benefits and concerns associated with using wood for energy (4 min)
- Speaker 4: How industry already uses wood for energy (4 min)
- Speaker 5: The potential in this community (4 min)
- Questions and discussion (30 min)

Figure 4: *Holding community forums during regularly scheduled club and organization meetings may be a good way of reaching a captive and interested audience.* Photo by Lauren McDonell, University of Florida.

handouts and if possible, organize them in folders for easy distribution. Remember to bring a sign-in sheet so you'll be able to send additional information to participants in the future. In addition, you may want to bring refreshments to encourage participant interaction and satisfaction.

6) Meeting details: The agenda for the forum can be rather straightforward or it can be modified to meet time constraints. At the beginning of the forum, pass around the sign-in list and let the participants know that you will only contact them to send additional information about woody biomass. The introductory presentation should be just long enough to provide a brief overview of using wood (or other types of biomass) for energy, fuel, and other bioproducts (about 20 to 30 minutes). The rest of the time the floor should be open to participant questions and comments. The forum atmosphere should be comfortable, open, and inviting. Encourage participants to voice their questions and concerns and also to be respectful and understanding of others' views.

7) Neutral facilitator: You may want to have an independent facilitator help coordinate the forum. Facilitators can help keep participants on topic, manage the time, and keep the forum from becoming a divisive debate. If you cannot afford to hire an outside facilitator, there are many resources available that can assist you in improving your or the team's facilitation skills (see the "Resource List" in the appendix for some ideas).

8) The simpler, the better: Keep presentations simple and concise. Use graphics, photographs, and other visuals to illustrate the presented information, when possible. The information should be relevant to the community and paint a clear picture of what biomass utilization might look like in the participants' community. Use analogies to explain difficult concepts and explain all terms (sustainable forestry, cogeneration, etc.).

9) Just the facts: Misconceptions can derail discussions and make it difficult for people to understand new information. The benefit of a community forum is the opportunity to engage people in a discussion that reveals their misconceptions and allows the experts to gently offer new ways of seeing the situation.

10) A respectful tone: Make sure speakers avoid phrases such as, "You've got to understand that..." or "My professional opinion is..." which create a distance between the agent or expert and the audience, which reduces the likelihood of joint exploration and understanding. Responses which suggest that a variety of views are reasonable and helpful, that every question is interesting, and that audience members have good ideas are preferred.

7.6 Evaluation

You will more than likely need to report to someone whether your time and energy for the outreach effort were well spent. Keep track of how many people attended, how many brochures were distributed, how many landowners were reached, and how many questions you answered. You may want to pass out an evaluation at the end of your meeting or event. If you are able to get attendee contact information, you can send participants a short survey asking if their questions were answered and what else they would like to know. If you are involved in a long-term community education program, one of the partnering organizations may be able to conduct a public survey. And, if your efforts can be reported in terms of a city commission vote or acres managed or dollars saved, all the better.

7.7 Summary and Conclusion

Educating your audience about biomass and bioenergy concepts may be an increasingly important part of your work but getting started can be overwhelming. Use the tips and ideas in this chapter as a foundation and gather additional resources (see the "Resource List" section in the appendix) to help you become familiar with relevant issues and topics. Defining and understanding your audience, developing goals and objectives for your outreach work, and finally selecting outreach tools that will best fit your audience's needs are essential steps to creating a successful outreach program. Be sure to start with the concepts and tools that you're comfortable with and gradually try new and more ambitious approaches. As long as you prepare adequately, maintain a professional and courteous demeanor, use reliable information, and find effective ways to engage your target audience, your outreach efforts are bound to be helpful.

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Monroe, M. C., L. W. McDonell, and A. Oxarart. 2007. Wood to energy outreach program: Biomass ambassador guide. Gainesville, FL: Florida Cooperative Extension Service, Circa 1526, University of Florida.

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Handout 7 Common Concerns

As a community considers whether or not to use wood for energy and other biobased products, residents and leaders must weigh various factors, such as existing energy sources, existing facility permits, air quality, available supplies of wood, the environment, and economics. This handout explores common questions about biomass utilization technology to help individuals and communities with this decision.

Question 1: Will a wood-to-energy facility produce a lot of air pollution?

Many people worry that burning wood or wood-based fuels will affect air quality. They might associate burning wood with burning coal, believing that both sources of energy produce more emissions than natural gas. Indeed, the American Lung Association reports that burning wood in fireplaces, wood stoves, and campfires is the largest source of particulate matter emissions generated by residences, and the U.S. Environmental Protection Agency has linked particulate matter emissions to respiratory illnesses, such as asthma (American Lung Association, 2000).

However, unlike the process of combustion of wood in a fireplace or campfire, which is uncontrolled and sends unfiltered smoke directly into the air, a modern power plant that uses wood controls the combustion temperature, the moisture level, and the size of the wood particles, all of which reduce air pollutants. Air emission control devices can also capture and filter pollution. These processes greatly reduce the amount of pollution produced by the wood-burning facilities.

Question 2: Will burning cellulosic ethanol (ethanol made from wood) in vehicles produce a lot of air pollution?

When cellulosic ethanol is burned in a vehicle, there are significantly fewer greenhouse gas (GHG) emissions than when gasoline is used. In fact cellulosic ethanol has the potential to lower GHG emission by up to 86 percent (Department of Energy, 2008). The higher the amount of ethanol blended with gasoline the lower the resulting GHG emissions.

Question 3: If we use wood for electricity and other bioproducts, will we lose all our forests?

Unlike fossil fuels, wood is a renewable resource and with proper management local forests can produce wood for centuries. In some communities, waste wood from utility line trimmings or from forest operations can be used to supply wood-to-energy facilities so that additional trees are not harvested. Our Cost and Supply Profiles include estimates of wood supplies based on current forest harvesting practices and urban waste resources from selected communities. Residents would not notice any loss of nearby forests if extracting these amounts of wood.

Some people are concerned that if wood is such a good solution to providing energy or other products, everyone will start harvesting and using wood. Indeed, competition for wood within a region is an important factor when considering a wood-using facility. 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. This could also eventually make it uneconomical to burn wood. No facility wants to use up its fuel source faster than fuel can be provided, so it is not likely to propose a risky endeavor. Still, there can be differences of opinion about how much harvesting will negatively impact soil, water, and wildlife resources.

Moreover, woody biomass utilization facilities may in some situations help maintain forests by increasing their economic value. As a result of increased competition from international wood suppliers and increased land values here at home, the markets for small-diameter, low quality wood have been declining in some parts of the country over the last decade. Providing a new market for wood and increasing the price of wood could allow forest landowners to make a living from their land and resist offers to sell their property to developers. Their working forests, if sustainably harvested, can provide a green landscape for both aesthetic and conservation purposes, which may be for many communities a preferable alternative to the addition of more subdivisions and shopping plazas.

Question 4: If we use the waste wood from logging operations for fuel, will we deplete the forest of all its nutrients?

Whenever trees are harvested, the branches, leaves and stumps unsuitable for pulp or lumber are left behind as waste. While leaves and stumps are generally not removed, the wood from branches and other residue can be collected and used as feedstock for biomass utilization facilities.

It is possible to reduce soil nutrients over time through intensive agriculture if nutrients are removed faster than they are replaced. In these agricultural systems, nutrient-rich plants are harvested annually. Harvesting corn, for example removes 120 kilograms per hectare (kg/ha) of nitrogen every year, which is typically restored by adding fertilizer.

Nutrient removal from harvesting trees, however, is low in comparison (5 kg/ha per year for loblolly pine trees) because most of a tree's nutrients are contained in the leaves, not the wood. Leaves fall off branches and are difficult to collect. By minimizing the removal of leaves when harvesting wood, nutrient loss can be kept very low.

Question 5: Will the cost of energy from a wood-to-energy facility be too high?

If a new facility is needed, the cost of construction is likely to be significant, as it would be for any energy generating complex. The annual operating cost associated with facilities that use wood depends largely upon the size of the facility, fuel sources, and proximity of fuel wood available. By using waste wood, sizing the facility to match available resources, and choosing a site that minimizes transportation costs, a wood-to-energy plant can be an attractive alternative to one that burns fossil fuels. Vast fluctuations in the cost of fossil fuels coupled with large increases in cost have also made alternative fuel sources, such as wood, economically attractive.

There are additional costs and benefits of a woody biomass energy facility that are not often included in an economic analysis that, nonetheless, make a big difference in quality of life. For example, the enjoyment one might get from viewing a forest on the way to work, the satisfaction that one's electricity is stimulating the local economy and not contributing to climate change, and the security of having a locally produced fuel source are all advantages not easily calculated in an economic analysis.

Question 6: Has wood-to-energy technology been tested? Should we wait until we know more?

There are already facilities in the country that use wood waste to run machinery and produce electricity. Sawmills and paper mills frequently use their own bark and wood debris to power their equipment, and have been doing so for decades. Other facilities purchase wood or accept waste wood and generate power (see the Chapter 8: Case Studies). The generation of this type of power is not a new concept; the technology is readily available and trustworthy. Additional technologies have not yet been tested on large scales or over a long time but are rapidly emerging, such as converting wood to gas, ethanol, and oil.

Question 7: Are we better off using other alternative energy sources, like solar and wind?

Many people consider solar or wind energy preferable because these sources are continuous and do not involve combustion. Indeed, both solar and wind energy represent promising approaches to meet current and future energy needs. On a national level, shifting to sustainable sources of energy will involve a combination of solar, wind, and biomass. However, neither solar nor wind energy currently represents a viable option for large-scale power production in the most parts of the country. With current technology, solar energy is best suited to supplying individual homes with hot water, heat, and electricity. It is currently too expensive to produce energy in a utility plant. Wind is a less consistent energy source in some parts of the country than in others for large-scale facilities. Both solar energy and wind are available during limited times and therefore require energy storage systems. Wood is essentially a form of stored solar energy that is convenient to use.

Question 8: How does wood compare to coal and natural gas?

Coal and natural gas are fossil fuels widely used to generate electricity. Coal-fired power plants require air pollution control devices to keep sulfur and mercury out of the air. The combustion of natural gas and wood does not emit much sulfur and mercury, and tends to have smaller amounts of nitrogen oxides and carbon monoxide than coal. The combustion of wood from fast-grown trees, however, may emit some metals, but far less than coal.

Cost comparisons among the resources show that the cost of wood is dependent upon the source and distance from the facility (see the Massachusetts Supply Profile found in appendix F of this program) and other factors. Coal is relatively available and cheap (between $5 and $6 per million Btu), and the price of natural gas fluctuates considerably but has been high enough to cause utility operators to consider other fuels. Because wood is locally available, the money that is spent to buy the wood stays in the local economy, supporting local jobs. If your community does not produce coal or natural gas, spending money to buy these fuels takes money out of your local economy.

Using local wood for energy is one step toward becoming more self-sufficient and sustainable. Using a locally available energy supply may help increase awareness and knowledge of how we produce, use, and conserve energy. Finally, wood also differs from fossil fuels in terms of carbon and climate, which is explained in the answer to question 9.

Question 9: Doesn't wood put carbon in the air, just like fossil fuels?

Wood, coal, and natural gas are made of carbon-based compounds. Burning them releases carbon, which becomes carbon dioxide in the atmosphere. Decomposing wood releases the same amount of carbon, which eventually goes into the atmosphere or the soil. The big difference between wood and fossil fuels is that the carbon released by burning or decomposing wood has been recently circulating through the atmosphere. Growing plants and animals absorb and release carbon every day, and cycling this amount of carbon is a benefit that our ecosystems provide to us. Burning coal and natural gas releases fossilized carbon that has been out of the system for millions of years. This newly released carbon, when added to the atmosphere, is thought to be responsible for a significant amount of the changing global climate. In addition, the newly planted trees that replace those harvested for energy will absorb the same amount of carbon during their lifetime.

Summary and Conclusion

Many of the concerns about using wood for energy are based on elements of truth. Across the country, variations in topography, industrial forests, energy availability, harvesting practices, road networks, and population density affect projections about the possibility of using wood for energy and other products. It is important to investigate local assumptions and factors in order to create a strategy that is best for your area.

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Chapter 8 Case Studies

8.0 Introduction

New concepts are easier to explain with examples. This chapter contains ten case studies that provide short descriptions of utilities, industries, and facilities that are using or planning to use wood for energy, transportation fuels, and other bioproducts. Interviews were conducted with employees at each facility to obtain this information. Our intent was to report both the challenges and the benefits of the systems in each case study in order to provide the reader with realistic and useful information.

The following table will help you choose which case studies might be most helpful to you in designing your outreach program or for working with specific clients or communities.

Case Study	State	Feedstock	Product	Scale
Fuels for Schools Warms and Heats a Community	ID	Fuel treatment thinnings	Heating and air conditioning	Small
BioOil® Hits the Midwest	MO	Forest residues	Oil	Medium
Biomass Powers Texas	TX	Forest residues	Electricity	Large
Woody Biomass to Pellets	GA	Mill residues	Heating	Large
Community Involvement	VT	Urban wood residues	Electricity	Large
Powering the Grid with Waste	FL	Urban wood residues	Electricity	Large
Wood and Paper Trim the Energy Bill	MO	Forest and mill residues	Heat	Medium
Wood Power Heats a Public School	KY	Forest and mill residues	Heat	Small
Co-firing with Wood and Sugarcane	FL	Sugarcane	Electricity and Power	Large
Co-firing with Wood and Switchgrass	AL	Switchgrass	Heat	Large

8.1 Fuels for Schools Warms and Cools a Community

Council is the county seat of Adams County, Idaho, and roughly a two-hour drive north of Boise. Situated in the Weiser River valley, it is surrounded by national forests and has a population of about 800. A major employer in town, a Boise Cascade sawmill, closed its doors more than ten years ago and the area since has found itself economically depressed. Nearly 60 percent of the students in the schools are either on free or reduced-cost lunch; unemployment is one of the highest in the state at 14 percent. The school system has virtually no room for major expenditures with such a little tax base. In 2002, after many years of high heating costs, the superintendent of Idaho's Council School District, Murray Dalgleish, faced a difficult situation. The district's nearly fifty-year old diesel oil boiler and radiant electric heating system that serviced four buildings needed to be replaced. Due to the archaic nature of the equipment and the currently high costs of fuel, some monthly bills were as high as $10,000 to heat space used by approximately 300 students and teachers.

Figure 1: *School administrators ensure adequate boiler feedstock by contracting and storing chip supplies well in advance.* Photo by Kiley Barnes, Southern Regional Extension Forestry.

School administrators looked at a number of solutions, one of which was replacing the existing boiler with a modern biomass-fired boiler. While researching alternatives, administrators discovered a grant opportunity through the U.S. Forest Service called "Fuels for Schools and Beyond Program." This innovative program assists public schools and other public facilities reduce heating costs while helping improve forest health by partnering with area national forests (Figure 1). The program began after severe wildfires in the summer of 2000 led a resident in the Bitterroots area of Montana to find ways to link economic development to fuels-reduction practices, thus reducing wildfire risk. After discovering a case in Vermont where waste wood was being used to heat schools, he approached the leaders of his community in Darby, Montana. Since then, six states in the western U.S. have joined the program.

But why not replace the aging boiler with a modern diesel oil boiler? Adding a new biomass boiler with its various system components would cost more than replacing the existing boiler with a modern oil boiler. Initially, yes, replacing the existing boiler with a fuel oil-fired boiler would have been cheaper. However, with the cost of fuel oil increasing, it would not take long before operating costs exceeded that of a biomass-fired boiler. Biomass supply in the form of wood is not a problem for Council; it is surrounded by the Payette National Forest, which is comprised of more than 2.3 million acres of forestland; with fuels reduction practices alone, there was plenty of wood fuel in the immediate area. Also, the financial incentive provided through the Fuels for Schools and Beyond Program required a wood-fired heating system.

After lengthy discussions, school officials decided to apply for the Fuels for Schools grant. Forest Service officials sent out an engineering team to evaluate the school facilities in Council and determine suitability as a part of the grant awards process. In 2003, the Council school district was awarded Idaho's first Fuels for Schools grant. Siemens ESCO, the Council school district's performance contractor drafted an estimate of $2.86 million to design and install a new woody biomass heating and cooling system. The Forest Service grant provided $510,000, representing less than 15 percent of the total costs. The ventilation ducts, lighting, wiring, and piping all had to be replaced. Further, the recent introduction of summer school classes required that there be some type of air conditioning capability. The school's facilities called for a complete retrofit, requiring work in every classroom. The system, although expensive, when completed would be the first of its kind in Idaho and cutting edge in regards to energy conservation.

In April 2004, the district asked the community to vote on a $2.2 million public bond called a Qualified Zone Academy Bond (QZAB) to help pay for the new system. This is a federally backed, special zero percent interest bond for low-income rural districts to finance building renovations. The remaining $660,000 needed would need to come from the district, $510,000 of which would be provided via Fuels for Schools. With concerns about increasing the tax burden for an already impoverished community, the bond failed by 10 votes. At this point, it became clear, outreach was essential. School officials worked to inform the public about the situation. By hosting public meetings and visiting with individuals and select groups, school representatives presented the long-term cost savings a woody biomass-powered heating and cooling system would provide. The following November, the bond received more than 74 percent of the vote.

The energy costs savings for using wood fuel in place of fuel oil was estimated at $1 million over the length of the bond; the savings would be used to pay the bond down. To back their energy conservation estimates, Siemens ESCO guaranteed the $1 million energy savings quote with a performance contract. (A performance contract is an agreement that specifies the end results desired rather than the means to reaching said results.) The new woody biomass heating and cooling system became operational in September 2005. The design focused on system efficiency, employing heat pumps to heat water to 86 degrees Fahrenheit instead of the 175 degrees Fahrenheit typically required for conventional boilers. This practice extends the life of the system and allows it to function on half the wood fuel found in other Fuels for Schools related systems. The system requires only about 350 tons of wood fuel a year for heating. In comparison, a private lumber company located just North of Council uses this same amount of wood fuel to fire its boilers for one day. In addition, there is a propane-fired boiler back-up system to ensure heat if the main biomass boiler is out of service, and when the school is in its summer session, an evaporative cooling system uses the heat pumps to circulate air-chilled water through the cooling vents. With hopes of preparing students for potential careers, the school district also applied for and received a grant from the Resource Advisory Committee for Southwest Idaho to build a 2,000 square-foot greenhouse that would be heated by the new system. The greenhouse, when complete, would house growing native plants for the Payette National Forest (NF) thus allowing students to collect, germinate, grow, and plant native species on school grounds. The biomass project made the greenhouse project viable, as the new heating system provided inexpensive heat to the greenhouse.

The greenhouse along with participation in the operation of the boiler added an academic element for students in the areas of new technology and natural resources development. As a pilot program, the schools see many visitors interested in the system. Selected students are trained to give tours, explain the science behind it, and describe the overall operation. Students are also involved in monitoring the fuel moisture content, British Thermal Units (Btu) output from differing woods, and emissions testing.

Operation of the biomass boiler is fully automated and can be controlled remotely via the Internet. Motion sensors control lighting and heating in each classroom. The sensors recognize when the rooms are empty and after 8 minutes lights automatically turn off and the temperature in the room returns to a preset energy efficient level. Although the system is self-correcting and requires very little maintenance, it does require 24-hour a day, 7 days a week monitoring. The school employs a full-time, on-call operator, and there is an incident command procedure for backup in case the operator is absent. Maintenance of the systems includes procedures for dealing with waste and keeping the equipment clean. One ton of the woody biomass burned produces about a gallon of ash. The amount of ash depends on the type of woody biomass used. Typically the supply comes from the Payette NF and is made up of several tree species including larch, ponderosa pine, Douglas-fir, Englemann spruce, and other western species (Figure 2).

The boiler is cleaned several times a week; the ash is used to fertilize the school grounds and football field. Slag, the accumulated glass-like by product that results from burning wood, contains silica but is not of sufficient quantity to be a marketable product and is discarded as garbage. In larger biomass boiler operations where it is economically feasible, slag can be refined to produce glass aggregates for asphalt paving, shingle granules, and ceramic tile. Though there have been many challenges, the community of Council considers the project a success. Annually, the biomass system saves the school district around $50,000 in energy expenses. It also provides student, teachers, community members, and visitors an invaluable learning experience.

Figure 2: *Contracts with producers for boiler feedstock supports the local economy while at the same time helping to reduce the wildland fire fuel load in the Payette National Forest.* Photo by Kiley Barnes, Southern Regional Extension Forestry.

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8.2 BioOil® Hits the Midwest

Liquid biofuels derived from cellulosic biomass wills soon be produced in Missouri. Dynamotive Energy Systems Corporation recently announced plans to build a commercial biofuels plant in Willow Springs, approximately 180 miles southwest of St. Louis.

The Missouri site was chosen for its ready access to rail transport, proximity to biomass resources, and its potential for expansion of up to four additional facilities. The facility will use the company's patented "fast pyrolysis" process to convert forest residues such as bark, sawdust, and shavings; and agricultural residues such as sugar cane, cornhusks, bagasse, and wheat straw into liquid BioOil® and char. Each day, the Willow Springs facility will convert 200 tons of residues into 34,000 gallons of BioOil®. Local wood-based feedstock providers have signed supply contracts with Dynamotive to ensure a constant supply to the plant. Opportunities abound for a significant expansion of operations, with more than 1.1 million dry long tons of biomass available per year in Missouri alone.

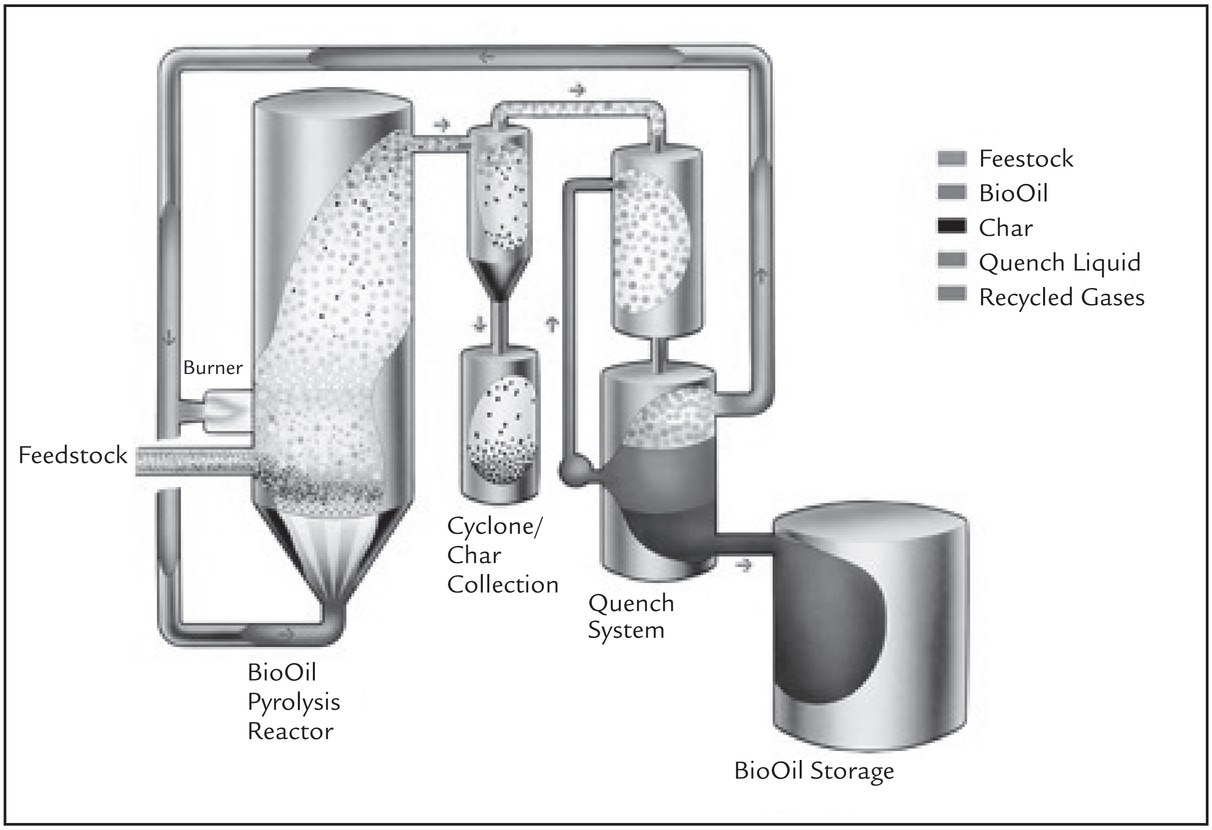
The pyrolysis process used is relatively simple in theory (Diagram 1). Feedstock is fed into a fluid-bed reactor, which is heated to between 840 and 930 degrees Fahrenheit in the absence of oxygen. This system uses lower temperatures than conventional pyrolysis systems, creating higher overall energy conversion efficiency. The feedstock flashes and vaporizes, in a similar manner to water droplets splashed into a hot frying pan. The resulting gases pass into a cyclone where solid char particles are extracted. The gases then enter a tower where they are quickly cooled using previously made BioOil®. The gases condense into BioOil®, which then falls into the product tank. Non-condensable gases are returned to the reactor to maintain process heating.

The entire reaction takes only two seconds, and this highly efficient process utilizes 100 percent of the biofeedstock. Three primary products are: BioOil® (60 to 75 percent by weight), char (15 to 20 percent by weight) and non-condensable gases (10-20 percent by weight). A fourth product, BioOil Plus™, can be produced by adding a finely ground form of the separated char, about 8 microns in size, back into the BioOil®.

BioOil® is a greenhouse gas-neutral fuel with highly desirable combustion properties. BioOil® and BioOil Plus™ are price competitive alternatives to #2 and #6 heating oils, which are widely used in industrial boilers and furnaces. BioOil® can be further converted into transportation fuels and industrial chemicals. When combusted, BioOil® produces less nitrous oxide (NO_X) emissions than conventional oil as well as little or no sulfur oxide (SO_X) emissions, a prime contributor to acid rain. The fuels are also economically competitive with fossil fuels. The char produced by this process is a high Btu (heating value) solid fuel that can be used in kilns, boilers, the briquette industry, and activated char applications.

The current feedstock requirements of the Missouri plant can be met by sawdust from the 40 to 50 mile radius around the plant. Should the plant's requirements increase, the company can use logging residues from the local area, according to John Tuttle, wood utilization specialist with the Missouri Department of Conservation.

Diagram 1: *Fast pyrolysis process.* Courtesy of Dynamotive Energy Systems Corporation.



In its early stages, the establishment of the Dynamotive facility created some good, friendly competition among local users of wood products. Local sawmills have another option for marketing sawdust.

Despite this friendly competition, the local forest industry is concerned about sustainability. According to Tuttle, the main concern is that the BioOil plant procedures be "done in a sustainable manner." Dynamotive has assured those concerned that sustainable practices are being followed. IN response to concerns, the Missouri Department of Conservation has begun development of a set of Best Management Practices created specifically for biomass harvesting using a model from in Minnesota.
The Missouri plant is scheduled for completion in 2009. Plans call for the plant to employ 27 workers. Dynamotive Energy Systems Corporation is an energy solutions provider headquartered in Vancouver, Canada, with offices in the United States, United Kingdom, and Argentina. The Missouri facility will be based on designs currently in use at two operational facilities in Canada. One facility is located in West Lorne, Ontario, Canada at Erie Flooring and Woody Products; and the other is located in Guelph, Ontario, Canada. As of this writing, negotiations were in process for a facility in Webster Parish, Louisiana.

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8.3 Biomass Powers Texas

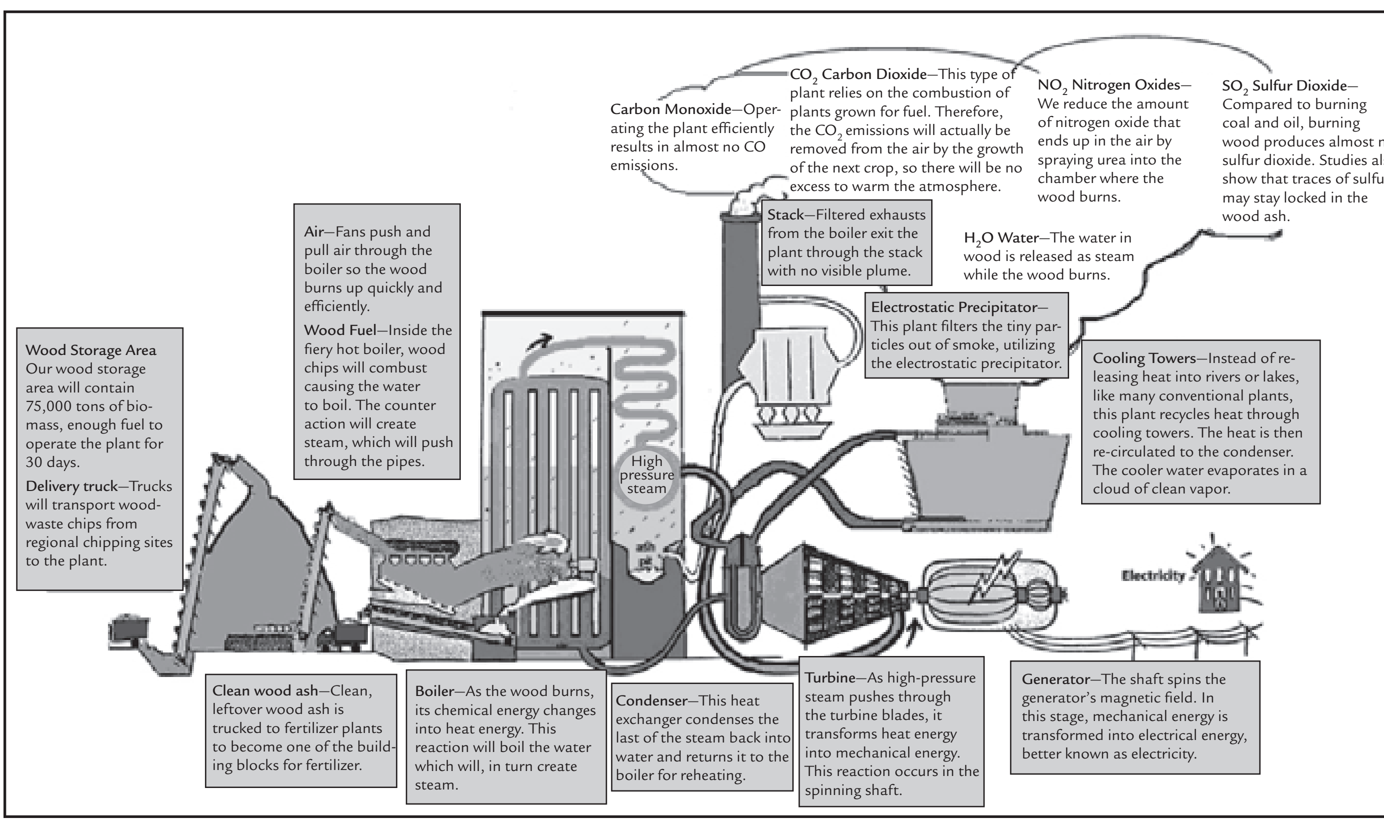
Aspen Power, LLC, is in the process of constructing Texas' first biomass bioelectric power plant. The 50 megawatt (MW) plant is to be located in Lufkin, Texas, and will utilize about 525,000 green tons of logging debris and municipal wood waste per year. The estimated cost is approximately of the plant is $87 million and will be financed by a combination of company investment and tax-free bonds.

Aspen Power Plant

The Aspen Power plant will produce steam utilizing Stoker technology. Stoker technology burns bioenergy feedstock directly to produce steam that is expanded across a high efficiency steam turbine connected to an electrical generator, which produces electricity.

The furnace will be a RotoStroker hydrograte system that utilizes a water-cooled vibrating grate system designed to maintain the desired fuel-to-ash bed conditions. The boiler will be a single pass, membrane wall boiler that will generate 458,000 pounds per hour of steam at 1,250 pounds per square inch and 900 degrees as measured by a true surface thermocouple. The steam exiting the boiler will be expanded across the steam turbines to produce shaft energy that is then utilized to drive electrical generators to produce electricity (Diagram 1).

Diagram 1: *Schematic of the process utilized by Aspen Power, LLC for generating electricity.* Image Courtesy of Aspen Power, LLC.



Water supply and water quality are important requirements to the production of electricity. To ensure the availability of both volume and quality the company will develop two dedicated water wells on the facility property. In addition, the company has agreements with the city of Lufkin to provide backup water needs.

Location And City Approval Process

When looking for a good plant site, two elements had to be considered. First, there had to be a sufficient fuel supply from logging debris and municipal biomass within a seventy-mile radius of the plant's location. Since Lufkin is in the center of the Pineywoods region of East Texas, that requirement was not a problem. Second, there had to be enough transmission capacity near the plant site. Four 138,000-volt power transmission lines cross the plant site.

The plant will be built on a sixty-seven-acre tract of land within the city limits of Lufkin, Texas.

Ten acres of the tract were not zoned for such a facility. As a result, Aspen management submitted a zone change request to the City of Lufkin Planning and Zoning Commission. This request initially met a great deal of resistance from the neighbors. Concerns about noise, air pollution, and increased traffic were the primary objections to the zone change. In order to address these concerns, Danny Vines, president of Aspen Power, agreed to hold a series of town hall meetings designed to explain the operation of the plant. In addition, Vines arranged for nine individuals, selected by the neighborhood of the proposed plant location, to visit a power plant in downtown St. Paul, Minnesota, that is very similar to the Lufkin plant. That group sent several days visiting with and gathering information from the mayor, health department officials, and other city officials. In addition the group interviewed 268 individuals from the area surrounding the St. Paul plant and none expressed concerns or complaints about the plant. Upon returning to Lufkin the group unanimously agreed that the plant would indeed be a positive contribution to their neighborhood and the greater community. Few objections were expressed at the final town hall meeting and the Lufkin City Council approved the zone change.

Wood Supply

A large portion of the cost associated with biomass power comes from the collection, processing, transporting, and handling of wood waste to provide a consistent usable wood fuel. Angelina Fuels LLC, an affiliate of Aspen Power, will be contracted to acquire wood biomass and to provide transportation of the woody biomass to the facility.

The company will utilize four primary sources to fulfill its wood biomass requirements:
(1) logging debris
(2) wood waste of cities, counties, and other municipalities (urban biomass)
(3) inwoods (done in the timber stands) chipping
(4) mill waste

The company estimates that it will use approximately 1,500 tons of wood biomass per day to operate the facility, assuming 40 percent moisture. Wood biomass from forest areas in and around Lufkin, Texas, will be used to provide fuel for the facility. The Texas Forest Services 2005 Harvest Trends Report, which details trends and usage in the timber industry, found that Angelina County, of which Lufkin is the county seat, was one of the top five timber producing counties in Texas, with approximately 29.8 million cubic feet of pine and 3.9 million cubic feet of hardwood harvested annually. Wood biomass comes in many forms, but the company will use four primary sources listed previously.

Logging Debris

The company expects that its largest source of wood biomass will be from logging debris. According to the Texas Forest Service, in 2005 approximately 8.4 billion pounds of logging debris was left to rot or be burned following completion of logging operations. This represents approximately 8,900 tons per day of wood biomass fuel currently available. The company will initially be the only entity in Texas converting logging debris to boiler fuel for the production of electricity. Angelina Fuels intends to place chippers and grinders into timber stands at logging sites through agreements with logging contractors. Angelina Fuels will then chip, grind, and transport converted wood biomass to the facility. The company anticipates 50 to 60 loads per day, with each load representing 25 to 28 tons, which will provide 1,800 tons of wood biomass for the facility. In addition, the company has long-term wood purchase agreements with several regional timber entities that own more than 5 million acres of timberland.

Urban Biomass

In the course of activities such as road construction, rights-of-way clearing, municipalities generate large amounts of wood waste that is often taken to landfills. The company has agreements with several cities to accept this wood waste. The wood waste will be converted to wood biomass using a 1,250 HP Diamond Z grinder. The company expects to generate approximately 12,000 tons of wood biomass per month, or approximately 400 tons per day, from this type of wood waste.

Inwoods Chipping

There are many tracts of land, referred to as “chip tracts,” in East Texas that are timber tracts that were not properly managed for timber production and are in need of site preparation prior to reforestation. The cleared materials will be ground and converted to wood biomass. Angelina Fuels intends to have two crews, with each crew producing eight loads, or approximately 250 tons of wood biomass, per day to produce this material.

Mill Waste

The Angelina Fuels business plan was developed to utilize available mill waste while minimizing the impact of existing wood utilizing facilities. The company plans to purchase excess mill waste as it becomes available. Urban biomass and mill waste material is generally better suited for grinding equipment rather than chipping. Large, slow speed grinders are capable of handling large volumes of material from a central location and loading the biomass into a truck or chip van for transportation. The trucks will require special purpose configuration to reliably provide the off and on road characteristics of chip hauling. These trucks will also require a wet-kit hydraulic system to accommodate the live floors (self-unloading) and/or dump characteristics of the chip vans.

Wood biomass will be shipped to its final destination by trucks or rail cars. Approximately 45,000 tons of wood biomass can be stored at the facility. The plant will use approximately 1,500 tons of biomass per day (depending on the moisture content of the wood biomass). Prior to chipping, wood biomass can be stored in inventory for up to a year and still be used to generate electricity. However once chipped, wood biomass typically has a shelf life of between 90 and 180 days depending on various factors, including moisture and temperature.

Electricity Generation

Aspen Power Company has completed an interconnection study with the Electrical Reliability Council of Texas (ERCOT) using transmission lines (owned by ONCOR, an electricity delivery company, that intersect the facility site. ONCOR is currently using the ERCOT interconnection study to establish the physical interconnect configuration for the facility. Based on meetings with ONCOR, Aspen Power has determined that the facility site appears to be optimal with the ERCOT grid, and ONCOR has given preliminary indications that they can interconnect through one or all four of ONCOR's existing 138,000-volt power lines that intersect the facility site near the Keltys Street substation. The Keltys Street substation is approximately 450 yards from the facility site and supplies power to the city of Lufkin.

The company will deliver the electricity to the ERCOT grid through a Qualified Scheduling Entity (QSE). QSEs provide scheduling, dispatch, and exchange services on behalf of resource entities or load-serving entities, such as retail electric providers. QSEs must submit daily schedules to ERCOT for their transactions with total generation and demand, specified at certain levels for balancing up and balancing down the energy. The schedules for generation and demand are required to be balanced so that supply equals demand within the ERCOT grid. QSEs also settle financial payments with ERCOT. The company has contracted with Coral Power, LLC, a subsidiary of Royal Dutch Shell, to provide the QSE services and to purchase all power not otherwise sold by the company through a retail transaction to an end user. ERCOT will make payments to Coral Power, as the QSE, for the electricity received twenty-one days after the end of each month, and Coral Power will then direct the proceeds to the company.

The company expects to operate at full capacity and generate and deliver to the ERCOT grid approximately 50 MW net per day, seven days per week. This will make the facility a "base load provider," as opposed to a "peak provider," which is a plant that is turned on or off as demand increases or decreases. As discussed above, one of the primary considerations for ERCOT in monitoring the flow of electricity is the cost of production. Of the four primary forms of electricity generation in Texas (biomass, nuclear, natural gas, and coal), biomass is currently a close second to nuclear power in terms of its cost and efficiency, and these plants generate approximately 10percent of the electricity for Texas. Coal and gas fuels are significantly more expensive than both biomass and nuclear power and make up the vast majority of the electricity generated in Texas. Because the most efficient forms of electricity make up such a small portion of the total electricity generated in Texas, the company believes that ERCOT will be able to accept all of the electricity generated by the facility.

Anticipated Economic Impact

The biomass power plant will make a significant impact on the City of Lufkin and the surrounding area in terms of employment and economic development. The energy-generating plant and wood supply company will directly employ approximately 160 individuals. Prior to construction completion and commencement of operations, the company intends to hire 63 full-time employees (21 employees per shift), including a general manager for the facility. An additional 100 employees will work in woods crews and as truck drivers. In terms of economic development, a study conducted by the City of Lufkin Economic Development Department indicates the following economic impact during the next ten years:

Anticipated Economic Impact

- Total permanent direct and indirect jobs created = 405
- Salaries paid to direct and indirect workers = $151,576,322
- Taxable sales and purchases expected in the City = $67,788,386
- Plant's assets on local tax rolls = $95,500,000
- Net benefits for local taxing districts = $12,362,511

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8.4 Woody Biomass to Pellets

The term "biofuel" typically makes people think of ethanol and biodiesel. This probably comes as no surprise to those who remember former President Bush's State of the Union addresses in 2006 and 2007 when he mentioned both ethanol and biodiesel as a way to alleviate our nation's dependence on foreign oil.

However, what might come as a surprise is the significance of a less well-known biofuel: wood pellets. Pellet stoves have been around since the 1980s, but rarely does one think of wood pellets as a major biofuel. Nevertheless, the markets for wood pellets continue to grow, notably the international market, but some U.S. companies also are beginning to tap into these markets.

Figure 1: *Appling County Pellets Inc. produces wood pellets, which are shipped overseas to European markets.* Photo by Sarah Ashton, Southern Regional Extension Forestry.

Fram Renewable Fuels, LLC, is one such U.S. company. The name, Fram, means "forward" in Norwegian, and forward epitomizes the company's vision. Established in October 2005 with backing from a Norwegian shipping magnate, the company is lead by a trained forester and a veteran of U.S. forest industry. Fram is dedicated to helping its customers meet their renewable fuel obligations by producing products that lead to both electricity generation and the reduction of fossil fuel emissions. The company started producing pellets at its first fully owned and operated subsidiary, Appling County Pellets, LLC, in November 2007 and has plans for several additional pellet mills in the near future.

Appling County Pellets, LLC, is located in Appling County, Georgia, within ninety miles of Georgia's Atlantic ports of Brunswick and Savannah. The mill receives, sorts, grinds, dries, compresses, and bags waste biomass into pelletized fuel. Its capacity is 280,000 short tons per year of raw material intake (e.g., saw dust, bark, whole tree chips, and logging debris) and 145,000 short tons per year of final product. Two types of pellets are produced at the mill: premium and industrial. Premium pellets are made from clean hardwood and pine. Pellets must have an ash content of one percent or less to be classified as "premium." Industrial or "standard" pellets are made primarily with hardwood and pine but also contain a small percentage of bark and other harvesting residues. Ash content for industrial pellets can be as high as three percent.

The total cost to build the facility was about $25 million. Start-up capital for Fram's pellet mill largely came from private investment but also included $19.5 million in loan guarantees provided through the USDA 2002 Farm Bill program for agricultural producers and small businesses to install renewable energy projects and to make energy efficient improvements. The loan agreement stipulates that Appling County Pellets must produce 130,000 metric tons of wood pellets to be sold in domestic as well as international markets.

Harold Arnold, vice president of Fram Renewable Fuels, indicated that "major markets will be in Europe, where the pellets can be used to generate electricity, eliminating much of the fossil fuel emissions that contribute to global warming.” Appling County, Georgia was chosen, “because of the rich forestry resources, great community support, and easy access to our markets through the Brunswick and Savannah ports.” The Kyoto Protocol is what drives the bulk market in Europe. The Kyoto Protocol, developed at the United Nations Conference on Environment and Development in 1992, created legally binding commitments for all member countries to achieve specific greenhouse gas reductions in an effort to avoid dangerous human-caused disruption in climate systems. European countries offer subsidies and tax breaks among other incentives for the use of renewable fuels. Markets include Sweden, Denmark, Netherlands, Germany, the United Kingdom, Italy, Spain, and Japan. Fram currently has contracts with a Swedish utility and a Danish distributor and more contracts in the near future.

Figure 2: *This is an example of finished product made from furniture mill residue.* Photo by Sarah Ashton, Southern Regional Extension Forestry.

Fram hopes to tap into domestic markets as well someday. Currently, however, very few such markets exist, especially in the South. Pellets are not widely used in the U.S., and without an agreement such as the Kyoto Protocol, there is very little incentive to move towards the use of a biofuel like wood pellets. For now, though, Fram is making a go of it. Time will tell what the future brings for Fram and other such mills.

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8.5 Community Involvement in Developing a Wood-Powered Utility

Rising energy requirements and a growing demand for reliable sources of energy are on the minds of many people these days. Two and a half decades ago, the residents of Burlington, Vermont, were faced with energy issues similar to those confronting many communities today. With oil and natural gas prices at all-time highs, residents in the Northeast were uneasy about the costs and availability of heating oil when facing long, cold winters. Upset about high energy prices and fossil fuel emissions, they began to investigate alternative sources of power. The residents were clear that not just any new power station would do. The new station would have to be reliable, cost effective, nonpolluting, and acceptable to the environmental standards of the local citizens. Their search for solutions that would meet all of these conditions led them to woody biomass.

For years, the pulp and paper industry in the area used bark and wood chips efficiently to generate power with environmental controls for air and water emissions. The residents of Burlington decided to consider the use of wood as a fuel source because it had the potential to provide environmental and economic benefits to the community. It would stimulate the local economy by providing jobs and could revitalize the health of the state's forests.

But despite these potential advantages, some Burlington residents were uneasy about building a large, industrial power-generating facility in proximity to residential neighborhoods. Chief among their concerns was the rumble of three or more truckloads of wood per hour through suburban streets for delivery to the station. So the Burlington Electric Department (BED) agreed to receive 75 percent of all wood fuel deliveries by rail from a remote loading yard thirty-five miles away, even though it would mean a 20 percent increase in transportation costs.

Local residents also were concerned that the increased demand for 500,000 tons of wood per year might devastate nearby forests. Addressing forest management concerns, BED and the State of Vermont jointly developed strict guidelines for wood harvesting that require a staff of four professional foresters to manage wood fuel procurement. As of this writing, each harvest site and plan requires review by a forester and the state government to ensure the impacts on land and wildlife are minimized and to maximize the potential for forest regeneration. Clear-cutting is limited to twenty-five-acre parcels and is allowed only in stands of low-quality trees.

In 1978, 73 percent of Burlington voters approved financing for construction of the McNeil Generating Station, and on June 1, 1984, the McNeil Generating Station went into operation. With plant operations fully underway, other challenges surfaced. Nearby residents complained about excessive noise from plant activity and vibration from unloading railcars. They also blamed the plant for dust in their neighborhood, so an enclosure for the rail unloading facility was built, designed to resemble a historic covered bridge. When the dust remained a concern, studies revealed that the plant was not the source; increased development activities and road dust from other areas of Burlington were the culprits.

In the beginning, wood chip storage was also a challenge. Massive piles of wood chips fermented, producing an unpleasant smell, and occasionally spontaneously combusting. To address these problems, a strict regimen for on-site chip handling was implemented. The wood chips are configured in long, low piles that do not produce odors or smolder (Figure 1). Equipment modifications and new operating procedures reduced plant noise. By 1988, all complaints about the McNeil Generating Station had been addressed.

Figure 1: *Wood chips are stored in long, low piles to prevent fermentation.* Photo courtesy of Mcneil Generating Station.

In 1989, the station was retrofitted to include burning natural gas. This allowed the McNeil station to generate more power and take advantage of more cost-effective fuels as wood prices rose. Since that time, however, the cost for wood costs has remained relatively low and wood has remained the predominant fuel used at the station.

In 1996, McNeil participated in an experimental wood gasification unit funded by the U.S. Department of Energy (U.S.DOE). By using a local renewable wood resource this facility has infused an estimated $200 million into the local economy, rather than sending money out of the region to purchase other energy sources.

Today, 70 percent of the wood chips used by McNeil are from low-quality trees and residue from forestry operations. An additional 25 percent comes from sawmill waste products such as bark and sawdust; the remaining 5 percent comes from clean, urban wood waste. An on-site trial plantation of willow and poplar trees is currently being studied as a potential future source of wood fuel.

The McNeil Station is equipped with a series of air-quality control devices that limit the particulate stack emissions to one-tenth (0.1) the level allowed by Vermont state regulations. McNeil's emissions are one one-hundredth (0.01) of the allowable federal level at the time the plant was built. The only visible emission from the plant is water vapor during the cooler months of the year. Water discharged from the McNeil Station is monitored for pH, temperature, flow, and heavy metals. It is treated to maintain a balanced pH, allowed to cool to a temperature that will not adversely affect aquatic life, and then is pumped to the Winooski River. The wastewater quality is required to be equal to or better than that of drinking water for most parameters before being discharged to the river. Local contractors collect residual ash from the station and mix it with agricultural grade limestone. The mixture is used as a base for new road beds and as a conditioner for acidic soils.

Today, two-thirds of the electricity consumed by citizens of Burlington comes from wood and other renewable resources. While the McNeil Generating Station has encountered challenges due to its proximity to residential neighborhoods, it has been sensitive to the public's concerns and has worked to address them. The station also provides the community with a number of benefits. It employs approximately thirty-eight staff at any given time, provides useful disposal of wood waste, and offers the potential for linking the plant's steam output to a district heating system. Use of the steam for heating would make this a combined heat and power (CHP) plant and greatly increase the plant's overall efficiency.

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8.6 Powering the Grid with Waste

Ridge Generating Station opened in 1994 to satisfy the energy needs of growing communities in south-central Florida. Ridge is located in Auburndale, between Tampa and Orlando. Energy made at Ridge is sold to Progress Energy, which supplies power to both cities. Because the cost of traditional fuels was on the rise during the station's development stages, Ridge looked to alternative fuels such as wood. But wood sources, found mainly in the northern part of the state, are uneconomical to transport. A survey by city developers found that central Floridians generate around 1.5 million tons of usable solid waste per year. Disposal of this ever-increasing waste generated by an ever-increasing population is a major concern. Existing landfills have limited space and pose a possible threat to the Floridan Aquifer, the primary source of the state's drinking water.

Ridge's 31.4-acre facility can process and store a variety of fuels (Figure 1). The plant's manager, Phil Tuohy, estimates 75 percent of the fuel used by the plant is wood waste. These wastes include municipalities' and utility crews' tree trimmings, poles, and railroad ties as well as industrial waste such as pallets and reels. Demolition debris, construction waste, and local yard waste are also used. Palm tree wood, which is very fibrous, is the only wood resource that is rejected.

Figure 1: *The Ridge Generating Station uses a variety of fuels including tree trimmings, railroad ties, and pallets.* Photo by Martha C. Monroe, University of Florida.

The plant operates as part of the region's waste management system. County landfill personnel, seeking a way to conserve space, sort and deliver waste to the station. Materials are screened to remove sand and dirt, and most are ground or chipped first enabling a greater quantity to be transported at one time.

Scrap tires are another waste source. Abandoned tire dumps have been known to impair the state's water quality. Tires have a high energy content and generate around 20 percent of the fuel used by Ridge. Tires may be delivered shredded or whole, and an on-site shredder reduces them to the necessary two-inch particle size.

At the Ridge plant, fuel passes over a traveling grate in a waterwall boiler capable of producing 345,000 pounds of steam per hour. The steam turns a condensing turbine generator. It takes 4.4 megawatts (MW) to run the plant and the remaining 40 MW are sold to the grid. Along with tires and wood, Ridge uses methane gas from an adjacent landfill to supply about 5 percent of the plant's total fuel use.
The stacks on the facility's boiler are equipped with multiple systems for controlling or removing pollutants. Sulfur dioxide (SO_2) and other trace contaminants are removed by a spray-dryer lime scrubber, and fly ash is removed with a fabric filter bag house. Urea is used to control nitrogen oxide (NO_x) emissions.

Mr. Tuohy admits that the economics of using waste for fuel can be challenging. High sand content in the wood waste is Ridge Generating Station's biggest problem.

Figure 2: *The ability to process and combust a variety and combination of fuels is a key to the Ridge Generating Station's success.* Photo by Martha C. Monroe, University of Florida.

Florida's sandy soils cause a bigger problem than those faced by facilities in the North. The excess sand causes significant maintenance problems and expensive equipment repairs.

The keys to the Ridge Plant's success include flexibility and location. Using a system that can process and combust a large combination of fuels enables Ridge to recycle the vast amounts of scrap tires and waste wood within its fifty-mile operating radius (Figure 2). Being located adjacent to a landfill also helps; it was easier to obtain permits and the local roads were already approved for truck traffic. The generating plant employs forty full-time workers and ten laborers. Managers estimate the plant has a regional economic impact of more than $6 million per year. While operations and maintenance are an ongoing struggle, the benefits of turning waste into energy continue to outweigh the costs at Ridge Generating Station.

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8.7 Wood and Paper Trim the Energy Bill

Maryville is nestled in the rolling hills and farmland of northwest Missouri. This small college town is home to two large corporations, Kawasaki and Energizer. The community of 11,000 residents is blessed with an abundance of natural resources, including the 1,000-acre Mozingo Lake—stocked with fish that beckon anglers and boaters—and a beautiful park that attracts campers and other visitors.

Maryville is also home to Northwest Missouri State University, which serves an estimated 6,500 students (Figure 1). More than seventy species of trees thrive on the 350-acre main campus, which is the official Missouri State Arboretum. The university has its own thermal energy plant, supervised by James Teaney, a self-proclaimed jack-of-all-trades who became the wood-fueled facility's supervisor twelve years ago. "This is a job you have to want," says Teaney who admits enjoying the work" Because the wood and paper boilers, as well as three natural gas lines, require constant management and adjustment to accommodate available fuel and weather, Teaney finds himself routinely on call to ensure that the boilers, which run twenty-four hours a day, operate smoothly.

Figure 1: *Northwest Missouri State University has a student population of more than 6,500.* Photo courtesy of creative commons attribution share alike 2.5.

Maryville began considering using wood for energy during the 1970s energy crisis, when one winter temperatures dropped below zero degrees Fahrenheit (°F) and the university's natural gas supply was suspended. Knowing that energy prices were likely to rise, the university began searching for alternate fuel sources. In 1978, the university's Energy Committee established criteria for choosing a new source of energy. The committee agreed that the energy source must meet the follow requirements: it must be readily available, clean burning, renewable, and easily stored; its use must lead to conservation of traditional fuels; and it must be suitable for an aesthetically pleasing on-campus thermal energy facility. Wood chips, a by-product of the local forest products industry, met all six criteria.

University studies suggested the estimated 100,000 to 150,000 tons of wood waste available from communities along the Missouri River were enough to operate a small wood-fueled facility. A variety of grants and a privately funded $2 million lease allowed the university to move forward with a plan to use woody biomass for thermal energy in 1982.

The facility combusts wood in a Zurn watertube boiler with an inclined grate. Boiler temperature reaches 1,500 °F and produces up to 30,000 pounds of steam per hour at 80 pounds per square inch (psi). According to manager Teaney, "We can burn one semi (truck) load every eight hours when we are burning hard."

Contracts for wood are established with suppliers at the beginning of each fiscal year. The university owns four trucks, which transport the wood fuel from local sawmills. Emphasizing the need for clean wood, Teaney refers to his drivers as the "first line of quality control." He says they reserve the right to refuse to pick up a pile if it doesn't meet quality control standards. Suppliers may deliver their wood to the plant, but loads still must meet strict standards. All chips must be smaller than two and one-half inches long and screened for dirt. The university upholds a "one strike" policy, whereby suppliers who fail to meet standards more than once may have their contracts canceled.

Up to 3,000 tons of wood chips can be stored on-site in an outdoor pile. Wood is not dried prior to use but is tested for moisture content, since combusting wood with more than 45 percent moisture is inefficient.

The facility uses a wet scrubber to remove air contaminants and ash is collected and used throughout the campus for soil enrichment. Previously, ash was used as a daily cover at a nearby landfill, until the landfill closed. Teaney sees ash disposal as a potential problem in the future but hopes that new markets for ash will be developed, for example, as a component in garage flooring.

Northwest Missouri State University is an example of a wood-to-energy operation that has adapted to change and continues to improve. For instance, when the facility experienced supply shortages several years ago, it expanded its hauling radius to 250 miles. In some cases, change has brought new opportunities. The Missouri Senate passed a bill in 1990 calling for an annual 40 percent reduction in the overall amount of waste accepted at state landfills. A pilot study found that discarded newspapers, magazines, and cardboard could be burned to produce energy at the campus biomass plant. Grants from the Missouri Department of Natural Resources, Division of Energy and Division of Environmental Quality, as well as an interest-free loan from the U.S. Rural Electrification Administration, enabled the university to retrofit a boiler and construct a pelletizing station, which compresses waste paper into uniform pellets.

The Northwest Regional Council of Governments launched an educational program encouraging residents to separate recyclables from their trash, and worked with local collectors and the city to deliver the clean paper waste to Northwest Missouri State University. Because the wood-fueled facility was able to help the community achieve waste reduction goals, the university received the 4th Annual Governor's Pollution Prevention Award in 1997.

Northwest Missouri State University calculates it has saved an average of $375,000 per year for the past twenty years by using wood to produce energy. Perhaps just as important, biomass fuels provide a locally controlled, secure fuel supply. Wood currently provides 65 percent of the thermal energy needed to heat 1.7 million square feet of building space, and also provides some cooling. The university is experimenting with utilizing livestock waste and switchgrass but plans to rely on wood until other fuels become less costly.

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8.8 Wood Power Heats a Public School

Rowan County High School is located in Morehead, Kentucky, a small rural town of 6,000 people in the Appalachian foothills just outside Daniel Boone National Forest. It is the only high school serving Rowan County in the eastern coalfield region of Kentucky.

Formed in 1865 from what originally were parts of Morgan County and Fleming County, Rowan County is home to 22,000 residents. Its breathtaking vistas and many special events and attractions—including the Poppy Mountain Bluegrass Festival and muskie fishing on Cave Run Lake—are enjoyed by residents and visitors alike. But Rowan County's bountiful natural resources do more than provide scenic beauty and recreational opportunities; they also help provide clean air and water, wildlife habitat, and numerous wood products. In the early 1980s, members of the Rowan County Board of Education found themselves asking challenging questions about how to meet growing energy demands. Charged with the task of building a new high school and ensuring a reliable and affordable source of space heat, the board considered numerous fuel options including wood, coal, and natural gas, as well as purchasing electricity from the local power grid. The board's decision to use woody biomass offered an environmentally and economically sound solution for heating the new school building, while also providing a market for waste sawdust material produced by local timber and lumber companies (Figure 1).

Figure 1: *The high school's wood-to-energy facility provides a market for local sawdust.* Photo courtesy of Mississippi Alternative Energy Enterprise.

The school's sawdust combustion unit was installed in 1982 by Energy Resource Systems of Minneapolis, Minnesota. In 2007 when this article was written, the same unit continued to generate enough energy to heat the 125,000-square-foot high school building and a nearby 60,000-square-foot vocational technical institute. The combustion unit, which burns nearly 756 tons of pure sawdust each year, is capable of generating a maximum energy output of 0.15 thermal megawatts (MW). One-third of the steam output produced by the unit is sold to Rowan Technical College to meet its utility needs at a cost comparable to using natural gas. The biomass facility has enjoyed public support since its construction. Many of the school's fuel suppliers are local lumberyards operated by residents who are also alumni of the Rowan County school district. The district has been able to maintain a suitable level of hardwood sawdust to meet its heating needs.

The sawdust is stored at a 120-ton silo located on campus. An auger system located at the base of the silo dispenses the sawdust into a metering bin, which is automatically controlled by steam demand. Combustion occurs on an inclined grate system supplied with underfire air. The temperature of the combustion unit is controlled by regulating the amount of underfire air, or heat, entering the system. The fuel is injected into the boiler via a pneumatic, or pressurized air, system. The manufacturer installed a pollution control feature, a multitube collector, to remove particulate matter such as ash and soot. Steam from the boiler is used to heat hot water, which is circulated via pipes throughout the two buildings.

The board has encountered a few minor challenges with the unit's operation. One recurring issue involves calibrating the unit's controls to provide optimal energy output—especially during the summer months when the unit runs alongside the school's cooling system—to generate energy for the vocational technical institute. The supply of sawdust also is unreliable at times, due to a decline in timber-related activities as well as competition from a growing number of wood-fired facilities in the region.

Despite these challenges, the board—whose motto is "Together We Can!"—considers the project a success. With relatively few maintenance problems, the cost savings enjoyed by the school far outweigh those of other fuel options. The board's decision to install a combustion unit at the initial price of $347,000 was well worth the cost. Rowan County High School is the only public school in the district that can claim it is actually paid to make classrooms comfortable for its students with an environmentally friendly source of heat. As a bonus, the school saves an estimated $21,000 per year thanks to its woody biomass combustion unit.

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8.9 Co-firing with Wood and Sugarcane Waste

Joan Hourican has lived in South Florida for most of her life. She loves the open marshes of the Everglades and the diversity of birds that live there. She knows that the electricity that powers her West Palm Beach home comes from a number of different power plants, most of which are located along the heavily populated ocean corridor, where sea breezes disperse air pollutants. One, however, is farther to the west, at the edge of the Everglades. Although she knows little else, she is aware that plant does burn coal.

The Okeelanta Cogeneration Facility near Lake Okeechobee is not where you would expect to find the nation's largest woody biomass power plant. There are no forests as far as the eye can see. There is no rail service. Human settlement is sparse. But what it has, it has in abundance, and that is sugar cane.

The power plant is located next to Florida Crystal's largest sugar mill, operated by the Okeelanta Corporation. The company farms approximately 168,000 acres of sugar cane to produce, refine, and market more than 385,000 tons of sugar a year. The first priority of the power plant is to provide steam power to the sugar mill during sugar cane processing season, which is October through March. The power plant is permitted to generate 140 megawatts of electricity year round that is sold under contract to regional utilities (Figure 1).

Figure 1: *The Okeelanta Cogeneration Facility produces steam power to run Florida Crystal's largest sugar mill and sells surplus energy to the power grid.* Photo by Martha C. Monroe, University of Florida.

During grinding season, the mill provides two-thirds of the power plant's fuel needs with squeezed, used sugar cane, known as "bagasse." Because the shredded bagasse fibers are high in moisture and relatively low in energy, the bagasse is mixed with wood chips to improve the quality of the combustion and efficiency of the boiler. When it is not processing season, a greater percentage of wood is used because bagasse cannot be stored for long periods of time.

The wood chips are purchased from land clearing and urban tree trimming activities across South Florida, usually from the east (Miami, Fort Lauderdale, and West Palm Beach), but sometimes from Naples and Fort Myers. Contracts and long-term relationships with vendors help ensure that the supply of chips meets the facility's specifications: no pressure-treated wood, no stumps, just clean chipped wood. There is a chipper on site if whole wood is delivered, but most arrives already chipped. For example, truckloads of melaleuca trees, an invasive species, removed by the South Florida Water Management District are also a part of the facility's fuel supply. The trees were introduced to South Florida decades ago to make the Everglades more suitable for development. Each tree is capable of soaking up fifty gallons of water a day, but also reproduces quickly and displaces native plant species. Now, these harmful exotic trees are being removed from the Everglades National Park and management areas, and the waste wood is being used at Okeelanta as fuel for generating energy.

Figure 2: *The Okeelanta Cogeneration Facility also burns invasive exotic melaleuca trees for fuel.* Photo by Martha C. Monroe, University of Florida.

Wood fuel is stored, but not dried, until it is ready to be used in one of three water-cooled vibrating grate stoker boilers (Figure 2), which are designed to produce 440,000 pounds of steam per hour. As the wood travels into the boiler, it is heated and dried. Each boiler also has a selective noncatalytic reduction system that injects urea at two levels to control nitrogen oxide (NOx) emissions. The fuel for this facility is clean, so there is no need for scrubbers and other air pollution control devices usually found at coal-burning plants. The air and water emissions fall below the permitted levels; the ash can be buried in a municipal landfill. An electrostatic precipitator on each boiler removes fine particles of unburned carbon and other materials from the air.

"Materials handling and storage is the key to a biomass facility," says Rodney Williams, the Okeelanta plant manager. "The volume of material we burn is three times greater than coal would be, to get the same amount of power. That means we need to think about significantly larger piles, longer conveyor lines, and more efficient dumping and moving patterns than the traditional coal plant." The facility has forty-four full-time employees and creates more employment associated with the wood harvesting, chipping, and transporting process.

Converting two waste products—bagasse and woody debris—into a valuable commodity, power, is also an important service the Okeelanta Cogeneration Facility provides South Florida. There aren't enough landfill sites to accommodate all the wood waste that the area produces, and burning this wood in open piles would generate far more air pollution. The power plant at Okeelanta has been successful at meeting a need for power and doing so in a sustainable way that also helps the community.

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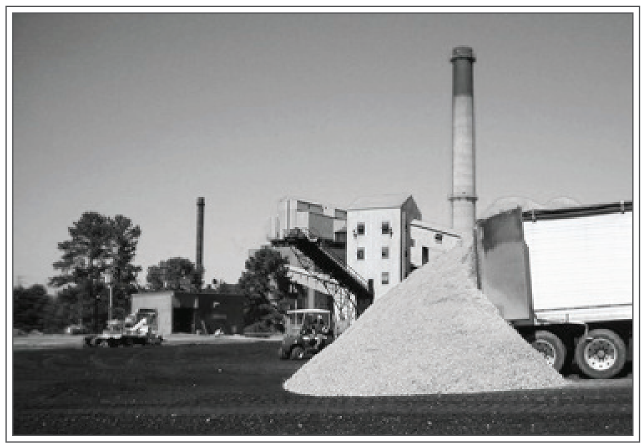
8.10 Co-firing with Wood and Switchgrass

Like many states, Alabama is home to thousands of acres of forest land that harbor tons of readily available woody biomass for use in energy production. One utility company tapping into this renewable resource is Alabama Power, a subsidiary of Southern Company. Southern Company has been involved with research and development of co-firing woody biomass and switchgrass at the Gadsden Steam Plant since 2001. The plant is located in northeast Alabama along the Coosa River. The company's efforts provide many valuable insights for others who are considering the use of co-firing systems to meet energy demands.

Alabama Power's Plant Gadsden has two 70-megawatt (MW) pulverized coal units. Unit 1 is used to test co-firing coal with sawdust and wood chips; Unit 2 co-fires coal with switchgrass (Figure 1). Early trials in Unit 1 demonstrated some problems with wood. Wood chips over one-quarter inch in length were too big for use in the pulverized coal system. Wood fibers clogged the intake system resulting in the shutdown of the unit. Ongoing research continues to look at efficient strategies for burning wood.

Figure 1. *The Plant Gadsden uses coal, wood chips, sawdust, and switchgrass.* Photo courtesy of Southern Company.

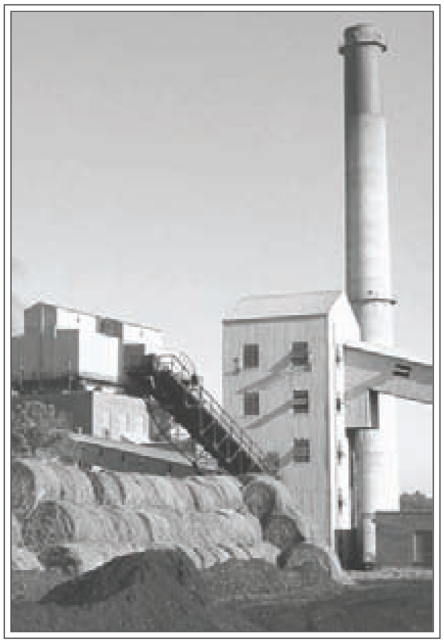


The few hundred tons of woody biomass used by Plant Gadsden each year are supplied by a sawmill; the switchgrass is supplied by a local farmer. Both sources of biomass are purchased directly from their respective suppliers. The price of each fuel source has recently increased due to higher transportation costs. Given that the tests are being conducted on a small scale, managers express little concern over the cost and availability of the woody materials, though they caution that significant gains in biomass utilization could result in further price increases.

After transportation to the plant, the sawdust and wood chips are stored outdoors in an open pile near the pulverized coal. A bulldozer is used to mix each type of fuel source with the coal. The composite material is then fed into the Unit 1 boiler through the existing pulverized coal system. Round switchgrass bales are ground and fed into the Unit 2 boiler through a pneumatic direct injection system (Figure 2). Steam from the boiler system turns a conventional turbine, which generates the usable energy. Switchgrass is used to generate only 5 percent of the unit's potential electrical output, equivalent to approximately three MW of energy. All electrical energy output is placed directly on the grid to supply retail customers. The switchgrass co-firing system operates about 250 hours per year to support a small-scale renewable pricing program offered by Alabama Power.

Managers at Plant Gadsden urge those interested in pursuing the use of woody biomass to use waste wood products such as harvest residues, forest thinnings, and wood processing residues to help keep costs low. They also recommend having adequate on-site storage to maintain a sufficient inventory of biomass. Utilizing forms of woody

Figure 2: *Switchgrass is delivered in round bales and fed into a boiler through apneumatic direct injection system.* Photo courtesy of Southern Company.



biomass that are compatible with boiler systems currently in use is also recommended.

Efforts by Southern Company and Alabama Power are helping land managers faced with a depressed pulpwood market and increasing pressure for wildfire management understand how using woody biomass to generate energy can serve as an effective tool for managing forests. Southern Company is conducting feasibility studies to determine the most economical methods to generate power from biomass at their existing plants. The lessons they learn through this research and development program will help shape the future of biomass utilization and emerging markets for biomass products in the United States.

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Reference to commercial products or trade names is made with the understanding that no discrimination is intended and no endorsement implied.

Appendix A Frequently Asked Questions

Biomass Energy

1. How many acres of forest per British thermal unit (Btu)? Is there an average or an analogy to help us understand, since this number depends on different sources, stand densities, etc.?

A typical pine plantation under low-intensity management, meaning no fertilization, herbicides, controlled burns, or bedding (a site preparation method for wet or flood-prone soils), grows about 4 green tons/acre/year (1.7 dry tons/acre/year) of merchantable wood, not including the bark, branches, or leaves (based on the slash pine growth and yield model by Pienaar and Rheney 1995). This is equivalent to 25.5 million Btu per year. As the question points out, this value varies with different types of management; the value can be lower with less intensive plantation management or almost twice as high with more intensive management. Assuming that 101,672 million Btu per year equals 1 megawatt (MW) per year, 3,987 acres of typical pine plantations would produce 1 MW per year, which could provide power for 400 to 800 homes annually. To put this land area in perspective, there are 201,061 acres within a 10-mile radius of a given point, so producing 1 MW exclusively from plantation wood within a 10-mile radius would require 2 percent of the area. Land area increases exponentially as the radius of the woodshed increases.

2. How do different crops being used for biomass (pine, maidencane, sugarcane, corn, bamboo, hemp, etc.) compare in terms of yields and earnings per acre per year?

Different crops can be specifically grown as fuels for energy generation. Important considerations for deciding what crops to utilize include local availability, cost, and potential environmental impacts of production. Many things influence yields such as climate, rainfall, planting density, and fertilization. In general, an unmanaged forest will generate 1-2 dry tons/acre/yr and managed forest will generate 3-4 dry tons/acre/yr. Short rotation woody crops are intensively managed and generally generate 5-6 dry tons/acre/yr, which is similar to yields of herbaceous crops in temperate climates. Bamboo can yield 30 dry tons/acre/year in Puerto Rico. Sugarcane can be similarly prolific; however, it only grows in tropical or subtropical climates. Earnings per acre are dependent upon variables such as availability and locations of markets for biomass, biomass quality, who harvests it, and who owns the equipment.

3. How much energy is generated per ton of wood?

A general estimate is approximately 17 million Btu/dry ton of wood. Another general rule of thumb is that 1 ton of dry wood = 1 MW/hour and 2 tons of green wood equals 1 MW/hour. These amounts depend on the moisture content and the quality of the wood.

4. What tree species produce high yields of wood?

Tree species such as eucalyptus or poplar are fast growing and produce high yields of wood. There are some potential risks involved with using exotic species, such as eucalyptus, for energy production. See Question 24 for more discussion.

Biofuels

5. What is the difference between E10 and E85?

Ethanol can be blended with gasoline in varying quantities to reduce the consumption of petroleum fuels, as well as to reduce air pollution. It is increasingly used as an oxygenate additive for standard gasoline, as a replacement for methyl t-butyl ether (MTBE), which is responsible for groundwater and soil contamination. Most of today's commercially available vehicles can run on blends of E10, which is a blend of 10 percent ethanol and 90 percent gasoline, or lower. Many areas in the United States have mandated its use as a replacement for MTBE.

Ethanol can also be blended with gasoline to create E85, which is a blend of 85 percent ethanol and 15 percent gasoline. Due to the corrosive effects of E85, because of its high alcohol content, traditional vehicles cannot use E85. Flex fuel vehicles (FFVs), however, have engines modified to accept higher concentrations of ethanol.

6. How much biofuel is produced in the U.S. today?

According to the Renewable Fuels Association, the United States produced 5.4 billion gallons of ethanol in 2007. 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. According to the National Biodiesel Boards, as of January 2008, annual U.S. biodiesel production capacity was 2.24 billion gallons.

7. Will I get lower gas mileage with ethanol-blended fuels than with traditional gasoline?

The ethanol blends used today have little impact on fuel economy or vehicle performance.

Energy Systems and Technology

8. Is cogeneration an option to produce heating?

Yes, cogeneration is an option to produce heating and cooling for large buildings. Vermont Fuels for Schools Program is an example of using cogeneration to produce heating. Cogeneration is used more frequently in the northern states.

9. What is attributing to the increase in demand for electricity?

Increases in population, new developments, and buildings, along with more appliances in households attribute to increases in electricity demand.

10. Why isn't there more use of wood for energy in the paper industry?

Many companies in the forest products industry have been energy self-sufficient for years. They serve as good examples to other small facilities interested in generating their own heat and/or power.

11. Do prefabricated boilers exist in the United States?

Yes. A boiler is a vessel or tank where fuel is combusted to produce hot water or steam. This hot water or steam can be used for a variety of applications ranging from space heating and power production to industrial process heat. A prefabricated or packaged boiler is a boiler that comes assembled with the necessary components and is ready for installation on-site. While packaged boilers exist in the United States, they are not utility grade.

12. Is there a difference in the scrubbers needed in coal-fired power plants and wood-fired power plants?

Yes. Burning wood produces almost no sulfur, so sulfur dioxide scrubbers are not needed. Wood-fi red power plants also produce lower levels of mercury and nitrogen. Wood will have more particulate matter (ash and soot), which can be removed fairly easily with simple mechanical systems such as cyclones and baghouses.

13. What happens to by-products of burning wood, even if "scrubbed" from stacks? How does mixing coal with wood affect how the ash is handled?

Pure wood ash can be used for landfill cover or can be applied to soil to recycle the nutrients or condition acidic soils by raising their pH. The primary market for pure coal ash is the construction industry. Among other uses, coal ash is used for concrete and cement production, road-base materials, and highway fill. Regulations prevent mixed wood and coal ash from being used for these purposes. If the ash is being sold, there is actually a bigger economic impact on the coal ash than the wood ash from mixing the two. A coal-fi red power plant generates a lot of ash and changing it into a product instead of a waste has significant economic impacts for the coal ash generator. Standards have been developed by the American Society for Testing and Materials (ASTM) and other organizations that allow coal ash to be readily marketed, and the presence of anything else in the ash negates these standards.

14. Does "green" woody material require energy inputs for drying or aging on-site to be burned efficiently?

A general rule of thumb is that 1 ton of dry wood—1 MW/hour and 2 tons of green wood—1 MW/hour. Dry wood does burn more efficiently. Fortunately, it does not take a lot of energy to dry wood nor does it take high temperatures. Waste heat from the power plant is commonly used to dry the wood. Chipped wood can also be air-dried rather quickly. The amount of time it takes to dry the wood depends on the method of drying, the temperatures involved, the size of the wood particles, and other factors. Dryers commonly used in the forestry products industry to dry wood chips usually take a few minutes using relatively low temperatures.

15. How does the process work for burning wood? Are there still giant smokestacks?

Wood can be used for fuel at utilities similar to the way that coal is used, to generate electricity. Although there are lots of different ways to convert wood to energy, typically, fuel (wood or coal) is burned to heat water to create steam in boilers, which is passed through steam turbines to generate power. Wood can also be converted into gas or oil, and those synfuels can be burned. Wood-fired power plants look similar to coal-fi red power plants except that they are much smaller. Neither power plant will have visible smoke emissions unless something is wrong with the emissions-control systems. However, one may see condensing water vapor coming out the stack of either, which people may mistake for smoke. Typically, the stacks on wood-fired power plants are shorter than for coal-fi red power plants.

16. Is a bigger facility better? Can we build a bigger facility if technology improves?

A bigger wood-fired plant means you must go farther for wood resources. The size of the plant is determined by the sustainable supply of wood within a reasonable hauling distance. The optimal range for sustainable wood supply is from 30 to 70 MW. If you took all wood going to a pulp mill you would have a 100 MW wood-fired plant. A larger wood-fired plant would have a similar infrastructure.

17. What about the efficiency of wood? What is the impact on efficiency of having smaller wood-fired power plants?

Coal has an energy content of 12,800 Btu/pound. Depending on moisture levels, wood has an energy content of 5,000 to 8,600 Btu/pound. Both wood and coal are burned in the boiler at about the same temperature, and therefore have similar thermal efficiencies. Efficiency is also dependent on the type of system that a power plant uses. There is a difference in the efficiency of scale because wood-fi red power plants are generally smaller than power plants that use fossil fuels. The volume to surface area ratio is larger for small power plants, which allows more heat to be lost. However, smaller plants can offset this heat loss by including the use of combined heat and power (or cogeneration) in the energy system. In other words, heat that is otherwise lost is recovered and used for heating and cooling in buildings or industry.

18. Does providing more energy increase development?

In general, the expected increase for energy demand is based on growth projections. The utility company plans for normal growth to meet the needs of the community. Using woody biomass as part of the solution to meet the energy demand may help keep more forestland around by increasing forests' economic value, which could cause less land to be developed.

19. What happens if using woody biomass to generate electricity becomes very common and successful?

A very successful future for woody biomass might mean several facilities in a region each drawing from adjacent woodsheds. There is a limit to how many wood-fi red facilities can be built based on the sustainable supply of wood within reasonable haul time. Energy generation cannot surpass sustainable woody biomass yields without depleting woody biomass resources. Once a certain-sized power plant is built, it seems unlikely that it would become "too successful" because it wouldn't be able to exceed its capacity. Any utility in the area attempting to join in the success would have to look at sustainable annual yields from various resources within a given area to figure out (1) if wood can be used as a fuel source and (2) how big the facility should be. A utility would set itself up for an economic failure if it were to build a wood-fired power plant that requires more biomass than is sustainably available.

Competition for wood resources would cause the prices to increase, and operations of the facility would become too expensive. The utility plant would no longer be cost effective, and the utility's investment would be lost.

20. How far apart, in distance, can you have wood-burning power plants? Is there a limit on total amount produced within a certain region?

Yes, there is a limit to how many wood-fueled power plants you can have within a certain region. Facilities must consider the sustainable supply within a reasonable haul time, as well as overlapping demand for wood resources when placing a wood-fired power plant. If a one-hour haul time is reasonable, then power plants would be at least two hours apart.

Comparing Wood and Coal

21. How do truck/rail emissions compare using wood and coal? What about CO_2 emissions from trucks? Would there be as much truck traffic as Dollar General or Wal-Mart distribution centers? Do we know the average increase in truck/rail traffic compared with coal?

It depends on whether the fuel (wood or coal) is transported by rail or truck. In many areas, wood is transported by trucks because roads go to forests and coal is transported by rail because rail lines run from coal-producing parts of the nation. A railroad hopper car can haul up to 120 tons whereas trucks are limited to hauling roughly 26 to 27 tons each. While trucks cannot haul as many tons and are less efficient than trains on a fuel gallon per ton basis, the trucks will be traveling significantly shorter distances, since the wood is locally grown. Both rail and truck transportation methods currently use diesel engines, which emit carbon dioxide. However, if biofuels are used in place of conventional fuels, emissions could be reduced. A general rule of thumb is 2 truckloads per day per MW, so a 40 MW facility would require about 80 truckloads per day. This can be compared to other industries including the forest products industry. Sawmills generally have about 150 truckloads per day, and pulp mills have about 600 truckloads per day. The increase in the amount of truck traffic would not be as much as a Wal-Mart Distribution Center. According to the Gainesville Council for Economic Outreach, this type of facility adds about 500 trucks per day to existing truck traffic, or 21 trucks per hour, if they arrive 24 hours a day. (http://www.gceo.com/news_details.asp?xid=&id=29&cid=1&rs=10&ds=0&n=13&page_id=1&n=13).

22. How does wood compare to coal for carbon dioxide (CO_2) emissions and cost per kilowatt hour (kWh)?

When comparing CO_2 emissions for wood and coal, we need to consider both CO_2 that is emitted by burning the fuel and CO_2 that is emitted during the harvesting, processing, and transporting of the fuel. Using wood as a fuel produces less CO_2 per kWh than using coal. Please refer to the table below for specific emission and cost quantities. When and where wood is readily available on a sustainable basis, energy from wood is economically competitive with energy from coal. A wood-fired power plant, even using relatively old technology, can compete successfully against coal in cost per kWh. This was demonstrated in an open bidding process about 15 years ago when a private developer in Virginia successfully competed against coal plants to construct an 80 MW wood waste fi red power plant in south central Virginia. The private developer's bid was $0.05/kWh.'

Environmental Impacts

23. How is burning wood carbon-neutral?

Burning wood is carbon-neutral because it does not increase the amount of carbon dioxide, a regularly occurring molecule but also a greenhouse gas, cycling through the atmosphere. Carbon is continually cycling through all living plants and animals. Tree growth and wood decomposition represent a short-term carbon cycle, where growing trees convert carbon dioxide to woody biomass and decomposing trees release carbon dioxide back into the atmosphere. Whether trees naturally decompose or burn, carbon dioxide is emitted back into the atmosphere, replacing what was just taken out. As long as trees are replanted at least as fast as wood is burned, the carbon cycle remains in balance; there is no net increase of carbon in the atmosphere.

Conversely, fossil fuels are carbon deposits that have been buried beneath the soil for millions of years and are no longer part of the balanced carbon cycle. When fossil fuels are burned, carbon dioxide is added to the atmosphere; most of it cannot be absorbed into the carbon cycle. Unlike wood, there is no corresponding process by which this carbon emitted from fossil fuels is removed from the atmosphere. Planting trees will help, but we need to plant more trees every year, and we do not have enough land surface for all the trees we would need to plant. So the amount of carbon dioxide increases, which plays a significant role in global climate change. Because fossil fuels are currently used for harvesting, transporting, and processing woody biomass, there is a small net increase in atmospheric carbon. As mentioned in Question 20, this amount could be reduced if biofuels were used.

24. Do managed plantations result in monocultures that reduce biodiversity of animal life?

When forests are managed intensively, a smaller variety of tree species exist and overall diversity is reduced. There are certain animals (such as deer and turkey) that prefer such habitats for specific needs. Many of the methods used in intensive management (fertilizer, controlled burning, thinning) can actually promote grasses and herbaceous plants that have a positive impact on diversity. If surrounding forests vary in their management intensity, diversity can be maintained on a landscape scale. So there is not a simple, uniform answer.

25. What usually happens to "waste" foliage?

In the case of urban wood waste, foliage is collected and typically ground up with other waste wood. The foliage can be used as mulch or converted to compost. In the case of harvesting commercial timber, it depends on the harvesting operation. In "cut to length" (trees are cut to the required length above the stump) operations, foliage is typically left on-site, is distributed throughout the forest, or may build up in piles if trees are passed through a delimber (a machine used to remove limbs) before being removed. Foliage is usually harvested in whole-tree harvesting operations, though this practice is less common and is usually avoided to help maintain soil nutrients on-site.

26. Many organisms live on decaying wood, so if decaying wood is removed, then the native ecology may be disrupted. What would be the long-term consequences to wildlife and consequences to atmosphere (CO_2 levels, O_2 levels, air pollution)?

The native ecology of decomposers will be disrupted to some degree although how much is not well known, and there would still be woody stems of shrubs, branches from the next rotation of trees, and foliage from herbaceous and shrub plants contributing carbon for decay on the forest floor. Stumps and roots represent as much biomass as the trunk and branches, and as long as roots remain in the ground, there could be sufficient biomass for decomposers. Also, decaying wood is generally not desirable for fuel, so dead trees, also called snags, are typically left in the forest. In terms of atmospheric levels of carbon dioxide and oxygen (CO_2 and O_2), there should be little change because both will be exchanged in the atmosphere whether by burning or decomposition. Both processes are essentially the breakdown of photosynthetic products, just at very different rates. In addition, the burning of wood in power plants lessens the release of methane, a greenhouse gas, which occurs during decomposition.

27. How often would fertilization be necessary?

Tree plantations requiring additional fertilizer typically receive only two or three applications in 20 years. In comparison, fertilizer applications for agricultural crops are typically applied several times during a growing season.

28. Can landowners put the ash back on the land, and does the ash change the soil pH?

Pure wood ash can be applied to soils to recycle nutrients or condition acidic soils by raising their pH. Ash is applied to the soil in Norway and Finland, but their trees and soils are different from the South's trees and soils. Research on applying ash to soils in the South would be necessary before such action could be recommended.

29. How will you ensure that harvesting wood for energy is sustainable? Is there a possibility of deforestation?

Certification could help ensure forest sustainability. A number of programs are available to help landowners develop management plans, conduct sustainable management practices, and require landowners to meet various standards for long term sustainability before they are certified as sustainable. The Forest Stewardship Council and the Sustainable Forestry Initiative both offer accreditation programs. More information is available at http://www.fsc.org/en/about/accreditation and http://www.sfiprogram.org/certification.cfm.

30. If we contract with someone other than the utility to get wood resources, how can we ensure our values are addressed (e.g., concerns about deforestation and wildlife)? How can we be sure that habitat isn't being harmed to supply the wood?

The utility can have regulations for wood suppliers that help maintain citizen values. For example, the utility can require all purchased wood to come from certified forests.

31. What are the air emissions of burning wood?

In comparison to other fuels (coal, natural gas, and oil), wood has low nitrogen oxides (NOx); carbon monoxide (CO), which is a product of incomplete combustion; sulfur dioxide (SO_2); and mercury (Hg) emissions. Effective methods of particulate control have been developed to remove most of the particles from the exhaust air of wood combustion facilities. In addition, unlike fossil fuels, wood is a carbon-neutral source of energy, meaning it does not increase the amount of carbon dioxide, a greenhouse gas, cycling through the atmosphere.

32. Does ethanol result in more or less greenhouse gas (GHG) emissions than gasoline?

Ethanol results in fewer greenhouse gas emissions than gasoline. The higher the amount of ethanol blended with gasoline the lower the resulting GHG emissions. Cellulosic ethanol has the potential to reduce GHG emissions by up to 86 percent. The use of ethanol, however, can increase the emissions of some air pollutants due to the fossil fuel inputs used for farming and biofuels production. Such emissions can be reduced by using improved farming methods and renewable power in the production process.

Economic Impacts

33. What is the pay rate of local jobs added by a wood-fired plant?

The pay rate is state dependent. In Florida, for the occupational groups that would be impacted by a 40 MW wood-fi red power plant, the average annual earnings range from $16,470 (farmworkers and laborers, crop, nursery, and greenhouse occupations) to $99,710 (engineering managers). The average annual earnings of all the impacted occupational groups is $39,083.

34. What if the harvested wood is exported to another region to use for energy, instead of using the wood locally for energy?

If the wood is processed in one area and then exported to another area for use, the economic impacts provided in the community economic profiles would significantly change. The economic impacts calculated assumed the addition of a 20 or 40 MW facility in an area, with the wood sources being collected and processed within a reasonable haul time. However, exportation of woody biomass is certainly a possibility. In our global marketplace, products are readily shipped around the world to the highest bidder (or from the lowest seller). As other countries continue to adjust to carbon tax systems, which are becoming more common due to the Kyoto Protocol, they may be willing to pay a premium for wood. This potential demand needs to be considered when communities think about meeting energy needs with woody biomass. In most cases, contracts can be designed to ensure that enough wood is available to meet the needs of the local power plant. In addition, when looking toward sustainability, we should aim to use local resources to meet local needs. The pelletization and shipping of wood works in some regions because of the large amount of wood resources, which makes wood relatively low cost, and the proximity of the wood and pellet mills to ports.

35. Does the large number of jobs in a biomass plant mean higher operating costs?

The greater employment impacts associated with biomass plants do not necessarily mean higher operating costs. Rather, they represent a substitution of imported fossil fuels with local wood resources and local labor. According to the Department of Energy (DOE), the non-fuel operating costs for biomass plants are very similar to coal-fi red or natural gas-fi red plants. This certainly holds within the range of biomass plant sizes that we have considered (20 to 40 MW) in our community economic profiles; however, for larger plants, it might be expected that higher costs for transportation of wood fuels could lead to greater overall operating costs.

36. How much would a landowner make per year in revenue by selling wood?

A landowner can expect $3000 to $4000 per acre if the tree stand is about twenty-five years old.

37. How will you convince landowners not to sell to developers, when it is not economically feasible?

Many forest landowners would like to continue living on and/or maintaining forested lands, but they may need economic incentives to do so.

38. Assuming forest owners are getting $7 per ton of pulpwood, what would be the economic benefit of forest production?

The economic benefit would not be any higher than pulpwood. However, using wood for energy would create another market for wood, and wood suppliers have been struggling recently to find buyers.

39. What is the difference in cost of construction of a coal-fi red plant and a wood-fired plant?

The construction costs for a wood-fi red plant are comparable to those of a coal-fired plant.

40. What would be the approximate cost (in time, money, and equipment) and possibility of building a woody biomass facility and then if it doesn't work out, to switch the facility to burning coal (partially or completely)? In other words, once you commit to a 50 MW plant, are you committed forever, or is it an easy transfer to something else?

A plant can be designed to burn either wood or coal or a mixture. If the plant is not designed initially to burn both, it still may be able to depending on the design or may be able to do so with minor modifications. There are different emission controls and methods of material handling for using coal or wood for fuel sources. The cost depends on the type of equipment, the design, and a number of factors. Many existing coal plants are being adapted to also burn wood, so this is not an impossible idea. It could be easier, however, to determine if you might need to burn coal in the future and to design the original wood facility to accommodate other fuels.

41. As competition for wood increases or when there are no more trees, then won't the price of wood become more expensive?

Yes, competition for wood resources would cause wood prices to increase.

Woody Biomass Sources and Supply

42. Can all types of trees and debris be used?

The facility's infrastructure dictates what types of fuels can be used. Facilities must be careful when using construction debris. Debris may be processed or treated wood, which would require extra pollution control measures such as scrubbers. Leaves contain chlorides, which are corrosive and can damage boilers, so the facility would rather use just woody biomass, not foliage.

43. What are the sources of woody biomass?

Urban waste wood, forestry residues, wood grown purposefully for energy, and wood from forest health thinning activities (for restoration, wildfire mitigation, or insect mitigation).

44. Will there be only wood or multiple sources (e.g., tires, trash) of fuel used?

It depends on the facility's system. The Wood to Energy Outreach Program includes only wood resources, not refuse. A significant amount of fuel could come from urban waste wood. Some facilities are designed to accommodate a variety of fuels.

45. Can we use storm debris?

If the system has the infrastructure to handle wood from storm debris, then this wood is considered an opportunity fuel; however, it does not represent a reliable or constant supply.

46. How long would local wood resources last to supply a facility?

The quantities discussed in the community economic profiles are annual projections. These numbers will not change as long as land use does not change; hence there is a sustainable amount of wood resources.

47. Can wood be renewed fast enough to meet our energy needs?

Investors are going to make sure there's a reliable wood supply and will not develop a wood-fired plant if there are not enough resources to sustain the supply. No one-time harvest is sustainable. Planners must also consider overlapping demand for wood resources when choosing a site for a wood-fired power plant.

Other Concerns

48. What problems do you see in terms of public perceptions?

There are a variety of concerns and solutions, but sustaining local forests and air quality are two of the most significant concerns. This is why community participation and input is important. Citizen priorities can be addressed by including their input in the local energy plan.

49. Shouldn't we start with conservation education, little changes—bigger impacts?

Most utilities do have conservation programs, which recognize that an important part of changing energy consumption is reducing the overall amount of energy each person needs through conservation and increased efficiency. Conservation should always be part of the energy picture but, in many places of the South, will not be sufficient. As human populations grow, we will also need to find new solutions for increased energy needs. Communities should consider a variety of energy options and decide how they can best plan for a sustainable future. Using wood to generate energy may be part of this discussion in some communities.

50. What are some trade-offs we should consider when deciding whether a wood-for-energy facility is right for our community?

While trade-offs are location-specific, communities can consider the types of fuel they are currently using and the associated costs and benefits and compare these with the costs and benefits of using wood as an energy source.

51. What happens when we run out of trees because of development?

The wood supply estimates expressed in the community economic profiles are based on existing land use. Changing land use from forested areas to developments will affect the sustainable supply of wood resources. However, using woody biomass as part of the solution to meet the energy demand may cause less land to be developed by increasing forests' economic value.

52. What are the reasons not to use wood for energy?

Communities should discuss a number of factors when considering whether using wood for energy is the right choice. While many factors may be location-specific, some factors to consider include the cost and supply of wood resources within a reasonable hauling distance, environmental sustainability, local economic impacts, transportation and processing of wood resources, and competing demand for wood resources.

Appendix B Glossary

Anaerobic Digestion
: Decomposition of biological wastes by microorganisms, usually under wet conditions, in the absence of air (oxygen), to produce a gas comprising mostly methane and carbon dioxide.

Annual Removals
: The net volume of growing stock trees removed from inventory during a specified year by harvesting, cultural operations such as timber stand improvement, or land clearing.

Ash
: The noncombustible components of fuel.

Bagasse
: The fibrous material remaining after the extraction of juice from sugarcane; often burned by sugar mills as a source of energy.

Barrel of Oil Equivalent (BOE)
: The amount of energy contained in a barrel of crude oil, i.e. approximately 6.1 gigajoules (GJ) (5.8 million British thermal units), equivalent to 1,700 kWh. A "petroleum barrel" is a liquid measure equal to 42 U.S. gallons (35 Imperial gallons or 159 liters); about 7.2 barrels are equivalent to one tonne of oil (metric).

Best Management Practices
: Management guidelines formulated by each state to enable forest managers to maintain and improve the environmental values of forests associated with soils, water, and biological diversity; primarily used for the protection of water quality.

Biobased Products
: Products determined by the U.S. Secretary of Agriculture to be commercial or industrial, other than food or feed, that are composed in whole or in significant part, of biological products or renewable domestic agricultural materials including plant, animal, marine materials, or forestry materials.

Biochemical Conversion
: The use of fermentation or anaerobic digestion to produce fuels and chemicals from organic sources.

Biodiversity
: Diversity of species, genes, ecosystem function, and habitats.

Bioenergy
: Heat and/or electricity produced from biomass energy systems, usually measured in J/g (Joules of energy per gram of fuel), MJ/g, or GJ/g.

Biofuels
: Fuels made from biomass resources, or their processing and conversion derivatives. Biofuels include ethanol, biodiesel, and methanol.

Biogas
A gas produced from biomass, usually combustible.

Biomass
Any organic matter including forest and mill residues, agricultural crops and wastes, wood and wood wastes, animal wastes, livestock operation residues, aquatic plants, and municipal and industrial wastes.

Biorefinery
A facility that processes and converts biomass into value-added products. These products can range from biomaterials to fuels such as ethanol or important feedstocks for the production of chemicals and other materials. Biorefineries can be based on a number of processing platforms using mechanical, thermal, chemical, and biochemical processes.

Biosolids
Solids removed from wastewater during the treatment process; can be used as fertilizer.

Black Liquor
Solution of lignin-residue and the pulping chemicals used to extract lignin during the manufacture of paper.

Boiler
A vessel or tank where heat produced from the combustion of fuels such, as natural gas, fuel oil, or coal, is used to generate hot water or steam for applications ranging from space heating for buildings to electric power production or industrial process heat.

Bottom Ash
Ash that collects under the grates of a combustion furnace.

British Thermal Unit
A nonmetric unit of heat, still widely used by engineers. One Btu is the heat energy needed to raise the temperature of one pound of water from 60°F to 61°F at one atmosphere pressure: 1 Btu = 1055 joules (1.055 kJ).

Bundlers
A machine that collects, compresses, and binds forest residues in cylindrical bundles.

Calorific Value
The maximum amount of energy that is available from burning a substance.

Carbon Cycle
The process of transporting and transforming carbon throughout the natural life cycle of a tree from the removal of carbon dioxide from the atmosphere to the accumulation of carbon in the tree as it grows, and the release of carbon dioxide back into the atmosphere when the tree naturally decays or is burned.

Carbon Displacement
Offsetting of CO_2 emissions from fossil fuel combustion by substituting fossil fuels with bioenergy.

Carbon Sequestration

The provision of long-term storage of carbon in the terrestrial biosphere, underground, or oceans, so that the buildup of carbon dioxide (a principle greenhouse gas) concentration in the atmosphere reduces or slows.

Cellulose

A straight-chain polymer built of a large number of glucose anhydride molecules with the empirical formula of ($C_6H_{10}O_{5)}$ that is the principle chemical constituent of the cell secondary walls of higher plants and occurs mainly as long, hollow, chains called fibers.

Char

The remains of solid biomass that has been incompletely combusted, such as charcoal if wood is incompletely burned.

Chipper

A large mechanized device that reduces logs, whole trees, slab wood, or lumber to chips of more or less uniform size. Stationary chippers are used in sawmills, while trailer-mounted whole-tree chippers are used in the woods.

Chip Van

Enclosed box trailers, generally 8 to 8.5 feet in width, designed to be less than 12.50 feet high when pulled by a road tractor. The difference between the box trailers seen on most highways and vans hauling harvesting products (bulk vans) is that most box trailers are built for containerized cargo (commodities in boxes or on pallets).

Clean Chips

Chipped wood free of bark, needles, leaves, and soil contamination.

Clear-cutting

Regeneration or harvesting method that removes essentially all woody vegetation that might compete with the desired crop trees in one harvesting operations.

Co-firing

Utilization of bioenergy feedstocks as a supplementary energy source in high efficiency boilers.

Cogeneration

The sequential production of electricity and useful thermal energy from a common fuel source. Heat from this industrial process can be used to power an electric generator, used for industrial processes, or space and water heating purposes.

Combined Heat and Power (CHP)

The simultaneous production of heat and mechanical work or electricity from a single fuel.

Combustion

Burning. The transformation of biomass fuel into heat, chemicals, and gases through chemical combination of hydrogen and carbon in the fuel with oxygen in the air.

Combustion Efficiency

The effeciency of converting available chemical energy in the fuel to heat.

Combustor
The primary combustion unit, usually located next to the boiler or heat exchanger.

Comminuted Material
Biomass material that has been pulverized or precision reduced into smaller sized material.

Composite Residue Log
Compacted logging residues that have been made into cylindrical bales or bundles.

Container Trailer
A trailer designed to hold bulk material with container constructed to be handled full. Sturdy walls and supports make the total capacity in cubic volume less than bulk vans or log trailers. However, they can be left on a site and filled as desired, and efficiently removed and replaced with an empty.

Crown Thinning
Removal of trees from the upper level in the canopy in order to favor desired crop trees whose crowns are at a lower position in the canopy.

Cut-to-Length
This is when trees are felled, delimbed, and bucked to various assortments or dimensions.

Deadwood
Dead, standing or fallen, woody biomass from trees or woody shrubs in natural or managed forests that were killed in various ways including old age, fire, disease, or logging.

Direct Combustion Systems
A method of burning wood directly in its solid form instead of first gasifying or converting into a liquid fuel before combustion takes place.

Direct Energy System
A system using central energy plants to meet the heating and/or cooling needs of residential, institutional, commercial, and industrial buildings.

Habitat
The place or environment where a plant or animal naturally or normally lives, grows, and reproduces.

Digester
An airtight vessel or enclosure in which bacteria decomposes biomass in water to produce gas.

Direct Impacts
The set of expenditures applied to the predictive model for impact analysis in input-output modeling.

Dirty Chips
Chipped wood containing bark, needles, leaves, and soil.

Dry ton (of wood)
Wood that contains 10 percent or less moisture.

Effluent
The liquid or gas discharged from a process or chemical reactor, usually containing residues from that process.

Emissions
A substance or pollutant emitted as a result of a process.

Energy Ratio
The ratio of the energy output versus the energy input, compared to the conventional fuel lifecycle. An energy ratio below one suggests energy input is higher than energy output.

Even-aged Management
Management technique for a stand of trees composed of a single age class.

Extinction
The loss of an animal or plant species from the world.

Feedstock
Raw material used for the generation of bioenergy and the creation of other bioproducts.

Fermentation
Conversion of carbon-containing compounds by microorganisms for production of fuels and chemicals such as alcohols, acids, or energy-rich gases.

Flail Delimber
A machine used for delimbing multiple elongated tree stems, which includes a pair of vertically mounted, longitudinally offset flail members with flexible impact members mounted on rotatable drums.

Fly Ash
Ash transported through the combustion chamber by the exhaust gases and generally deposited in the boiler heat exchanger.

Forest Biomass
The accumulated above- and below-ground vegetation, including bark, leaves, and wood from living and dead woody shrubs and trees.

Forest Residues
The above-ground residues from precommercial thinnings and harvesting operations. The leftover materials from harvesting operations are also called logging residues.

Fossil Fuels
Solid, liquid, or gaseous fuels formed in the ground after millions of years by chemical and physical changes in plant and animal residues under high temperature and pressure. Oil, natural gas, and coal are fossil fuels.

Forwarder
A vehicle that carries logs completely off the ground from stump to road side landing.

Fuel Cell
A device that converts the energy of a fuel directly to electricity and heat, without combustion.

Fuel Treatment Thinnings
Trees removed from the forest for the sole purpose of reducing the risk of wildfires.

Full Cost Method
Cost accounting method that allocates the total production cost across biomass and conventional wood products.

Furnace
An enclosed chamber or container used to burn biomass in a controlled manner to produce heat for space or process heating.

Gas Turbine
A turbine that converts the energy of hot compressed gases, produced by burning fuel in compressed air, into mechanical power; often fired by natural gas or fuel oil.

Gasification
A chemical or heat process to convert a solid fuel to a gaseous form.

Gasifier
A device for converting solid fuel into gaseous fuel. In biomass systems, the process is referred to as pyrolitic distillation.

Gigawatt (GW)
A measure of electrical power equal to 1 billion watts or 1 million kilowatts. A large coal or nuclear power station typically has a capacity of about 1 GW.

Grate
A combustion device floor, which may be inclined or horizontal, that has openings to allow the passage of air to aid in combustion and to allow ash to fall through. The “floor” may be a stationary surface or a moving chain.

Green Ton (of wood)
Wood that contains more than 10 percent water and usually refers to wood containing 40 to 50 percent water.

Grinder
A machine that reduce particles in size by repeatedly pounding them into smaller pieces through a combination of tensile, shear, and compressive forces.

Group Selection
Regeneration method in which trees are removed and new age classes are established in small groups.

Heat Rate
The amount of fuel energy required by a power plant to produce one kilowatt-hour

of electrical output. A measure of generating station thermal efficiency, generally expressed in Btu per net kWh. It is computed by dividing the total Btu content of fuel burned for electric generation by the resulting net kWh generation.

Heating Value
The maximum amount of energy that is available from burning a substance.

Higher Heating Value
The maximum potential energy in dry fuel. For wood, the range is from 7,600 to 9,600 Btu per pound.

Hog Fuel
Biomass generated by grinding wood and wood waste for use in a combustor.

Hydrocarbon Feedstock
Petroleum (hydrocarbon) based substance used as a raw material in an industrial process. Examples of petrochemical feedstocks are ethylene, propylene, butadiene, benzene, toluene, xylene, and naphthalene.

Improvement Cutting
Used in mixed species stands past the sapling stage where trees of undesirable species or form are removed from the main canopy to favor the more desirable species.

Incinerator
Any device used to burn solid or liquid residues or wastes as a method of disposal. In some incinerators, provisions are made for recovering the heat produced.

Inclined Grate
A type of furnace in which fuel enters at the top part of a grate in a continuous ribbon, passes over the upper drying section where moisture is removed, and descends into the lower burning section. Ash is removed at the lower part of the grate.

Indirect Impacts
The interindustry effects of input-output analysis; the impacts above and beyond the direct effects when applied to Type I multipliers.

Indirect Liquefaction
Conversion of biomass to a liquid fuel through a synthesis gas intermediate step.

Induced Impacts
The impacts of household expenditures in input-output analysis.

Industrial Process Heat
The thermal energy used in an industrial process.

Joule (J or j)
Metric unit of energy, equivalent to the work done by a force of one Newton applied over a distance of one meter. One joule = 0.239 calories.

Kilowatt (kW)
A measure of electrical power equal to 1,000 watts. 1 kW = 3412 Btu per hour.

Kilowatt-Hour (kWh)
A measure of energy equivalent to the expenditure of one kilowatt for one hour. For example, 1 kWh will light a 100-watt light bulb for ten hours.

Liberation Cutting
Removal of poor quality or non-merchantable trees to favor the growth of desirable trees.

Lignin
Structural constituent of wood and (to a lesser extent) other plant tissues that encrust the cell walls and cements the cells together.

Logging Residues
The unused portions of growing stock and nongrowing stock trees cut or killed by logging and left in the woods.

Log Trailer
A trailer designed to haul trees, poles, or shortwood in racks. They are lightweight and as a result have high payload capacities. Most require unloading equipment at the receiving facility, although some are modified to drop one side of the log restraints and allow a front loader to push the load off one side of the trailer.

Low Thinning
Removal of smaller, weaker, and most deformed trees whose crowns are in the lower portion of the stand canopy.

Marginal Cost Method
Cost accounting method that counts only the additional costs from the conventional logging operation as the biomass production cost.

Merchantable Timber
Trees that are economically valuable to harvest.

Megawatt (MW)
A common measure of power plant electricity generation capacity which is equal to one million watts.

Mill Residues
Excess material generated from wood processing mills and pulp and paper mills.

Moisture Content
The weight of the water contained in wood, usually expressed as a percentage of weight, either oven dried or as received (green).

Net Energy Yield
The gross energy produced by the biomass, minus the energy provided from the fossil fuels used in the production and processing of the biomass and usually expressed on a per unit basis.

Non-industrial Private Landowner
A person owning less than 1000 acres of forested land who is not directly affiliated with a wood processing plant.

Non-merchantable
Trees that are not harvested because they are too small, of poor quality, or not an economically valuable source.

Output
The value of production by industry for a specific time period.

Particulates
Minute, solid, airborne particles that result from combustion.

Pellets
Solid fuels made primarily from wood sawdust that is compacted under high pressure to form small pellets for use in a pellet stove or combuster.

Petrochemical Feedstock
Petroleum (hydrocarbon) based substance used as a raw material in an industrial process. Examples of petrochemical feedstocks are ethylene, propylene, butadiene, benzene, toluene, xylene, and naphthalene.

Petroleum-based Feedstock
Petroleum (hydrocarbon) based substance used as a raw material in an industrial process. Examples of petrochemical feedstocks are ethylene, propylene, butadiene, benzene, toluene, xylene, and naphthalene.

Phytoremediation
The use of trees or other vegetation to remove contaminants (such as heavy metals) and restore degraded land.

Precommercial Thinning
Thinning that occurs when trees are too young or too small, or of species undesirable to be used for traditional timber products.

Process Heat
Heat used in an industrial process rather than for space heating or other housekeeping purposes.

Producer Gas
Fuel gas high in carbon monoxide and hydrogen, produced by burning a solid fuel with insufficient air or by passing a mixture of air and steam through a burning bed of solid fuel.

Pulpwood
Small diameter trees (3.6 to 6.5 inches diameter at breast height) that are usually harvested for manufacturing paper, purified cellulose products (such as absorbents, filters, rayon, and acetate), and oleoresin products (such as pine oils, fragrances, cosmetics, and thinners).

Pyrolysis
The thermal decomposition of biomass at high temperatures (greater than 400° F, or 200° C) in the absence of air. The end product of pyrolysis is a mixture of solids (char), liquids (oxygenated oils), and gases (methane, carbon monoxide, and carbon dioxide) with proportions determined by operating temperature, pressure, oxygen content, and other conditions.

Refuse-derived fuel (RDF)

A solid fuel produced by shredding municipal solid waste (MSW). Noncombustible materials such as glass and metals are generally removed prior to making RDF. The residual material is sold as it is or compressed into pellets, bricks, or logs.

Renewable Energy

Energy derived from resources that are regenerative or for all practical purposes can not be depleted. Types of renewable energy resources include moving water (hydro, tidal, and wave power), thermal gradients in ocean water, biomass geothermal energy, solar energy, and wind energy.

Salvage Cutting

Removal of trees that have dead, damaged, or are expected to die, generally as a result of natural disaster.

Sanitation Cut

Removal of dead and weaker trees in an overstocked stand to reduce the danger of natural disasters.

Sawtimber

Trees that meet minimum diameter and stem quality requirements, making them suitable for conversion to lumber.

Seed-tree Silvicultural System

A silvicultural system in which all trees are harvested except for a small number of selected trees are retained for seed production for natural regeneration.

Shelterwood Silvicultural System

A silvicultural system in which trees are removed in a series of cuts, leaving those needed to produce sufficient shade to produce a new age class in a moderated microenvironment.

Short-rotation Woody Crops

Fast growing species, such as willows and poplars, that are grown specifically for the production of energy.

Shredder

A machine that tears material apart by shearing rather than smashing.

Silviculture

Science and art of managing the establishment, growth, composition, and quality of forest stands and woodlands for the desired needs and values of landowners and society on a sustainable basis.

Site Productivity

Combination of soil and climatic factors contributing to plant growth and development; may be measured as biomass accumulation as a function of time.

Skidder

Machinery used to pull logs from stump to a roadside landing. Logs are pulled with a grapple, cable-winch, or clam-bunk.

Soil Fertility
The total availability, concentration, and amount of essential plant nutrients.

Soil Function
The role that soils play in the environment and managed landscapes.

Soil Productivity
The capacity of a soil to contribute to the production of a crop, whether it is agricultural crops or forest biomass.

Steam
Water in vapor form; used as the working fluid in steam turbines and heating systems.

Stoker
A method of feeding fuel to a burning device that may include blowing the fuel into the combustion chamber with air, pushing the fuel up from below the grate, mechanically spreading the fuel onto a moving grate, or other methods.

Streamside Management Zones
Buffer zones in which cover is retained in riparian areas adjacent to surface water and aquatic habitat.

Sustainability
The capacity of forests, ranging from stands to ecoregions, to maintain their health, productivity, diversity, and overall integrity, in the long run and in the context of human activity and use.

Sustainable Forest Management
Forest management that ensures that forest resources will be managed to supply goods and services to meet the current demands of society while conserving and renewing the availability and quality of the resource for future generations.

Sustained Yield
A forest management strategy in which the net growth and yield are such that a forest can produce continuously at a given intensity of management.

Syngas
A gas mixture that contains varying amounts of carbon monoxide and hydrogen generated by the gasification of a carbon containing fuel to a gaseous product with a heating value.

Thinning
Silvicultural practice of reducing tree numbers in a stand in order to favor the growth and health of the remaining crop trees.

Transpiration Drying
The natural drying that occurs in when leafy material is left on trees. Water evaporates from the various leaf parts, in particular the stomata.

Tree-length
Trees are felled, delimbed, and topped in the stump area and processed at the landing.

Turbine

A device for converting the flow of a fluid (air, steam, water, or hot gases) into mechanical motion.

Uneven-aged Management

Regeneration and management technique that removes some trees in all size classes either singly, in small groups, or strips in order to maintain a multi-aged stand.

Urban Residues

Wood and yard waste; construction and demolition debris.

Value-added

Payments made by industry to workers, interest, profits, and indirect business taxes.

Water Quality

Suitability of the water coming from ground and surface supplies for drinking water, recreational uses, and as habitat for aquatic organisms and other wildlife.

Water Quantity

Timing and total yield of water from a watershed.

Watt (w)

The basic measurement of electricity.

Whole Tree

Trees that are felled and transported to roadside with branches and top intact. Processing occurs at the roadside landing.

Wood Ash

Ash recovered from the combustion of woody biomass; may be used as fertilizer or soil liming agent to reduce soil pH.

Wood Processing Residue

The unused portion of materials generated during wood processing or byproducts created during the pulping process.

Appendix C Resources

This section provides a list of resources including articles, books, Web sites, possible field trips, potential guest speakers, and other ideas and materials that may be helpful as you design outreach programs and answer questions about woody biomass.

Articles and Reports

Assessment of Power Production at Rural Utilities Using Forest Thinnings and Commercially Available Biomass Power Technologies. By C. P. Demeter, D. F. Knowles, J. Olmstead, M. Jerla, and P. Shah, 2003. Landover, MD: Antares Group, Inc., 15-5 through 15-7. (Available at http://www.antaresgroupinc.com/DOERUSreport.htm). Provides information to consider in the first part of a feasibility study for a biomass power facility, such as biomass supply, power plant location, technology, and economics.

Availability of logging residues and potential for electricity production and carbon displacement in the U.S. Biomass and Bioenergy**.** By J. Gan and C. T. Smith. 2006. 30(12): 1011–1020. (Available at http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V22-4M1CYX0-3&_user=655127&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_version=1&_urlVersion=0&_userid=655127&md5=385d4ad2326a7701182e7dd6e9205ce6). Assessed the abundance and regional distribution of logging residues and their potential for electricity generation and CO2 emission displacement in the United States.

Bioenergy: Technologies, Federal and State Incentives. By C. Werner, 2004.Washington, DC: Environment & Energy Study Institute. (Available at http://www.eesi.org/programs/agriculture/1.23.04%20bioenergy.pdf). Highlights important aspects of several federal and state incentives related to using biomass for energy.

Biofueling Rural Development: Making the Case for Linking Biofuel Production to Rural Revitalization. By J. Kleinschmit, 2007. Carsey Institute Policy Brief No. 5, University of New Hampshire. (Available at http://www.carseyinstitute.unh.edu/documents/Biofuels_fi nal.pdf). Covers important concepts related to how rural communities can develop biomass resources for use in the energy sector.

Biofuels: Production and Potential. By J. I. Zerbe, Forum for Applied Research and Public Policy, Winter, 1998. (Available at http://www.fpl.fs.fed.us/documnts/pdf1988/zerbe88a.pdf). Provides a historical perspective on how U.S. policies have shaped the development and implementation of biobased energy production methods.

Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply. By R. D. Perlack, L. L. Wright, A. Turhollow, R. L. Graham, B. Stokes, and D. C. Erbach. 2005. Washington DC: 73. U. S. Department of Energy and U. S. Department of Agriculture, Forest Service. Report number: ORNL/TM-2005/66. (Available at http://www.google.com/url?sa=t&source=web&ct=res&cd=2&url=http%3A%2F%2Fwww1.eere.energy.gov%2Fbiomass%2Fpdfs%2Ffinal_billionton_vision_report2.pdf&ei=DtjjSJnxMI32ugW-4KitBg&usg=AFQjCNGvWqfqKGcpaOrEi2PJOjIJBwdjDw&sig2=xUk1unZvl7693gCR_h3dOA). Analyzes whether the land resources of the U.S. are capable of producing a sustainable supply of biomass sufficient to displace 30 percent or more of the country's present petroleum consumption--the goal set by the advisory committee in their vision for biomass technologies.

Biomass Cofiring: Economics, Policy, and Opportunities. In Biomass and Bioenergy**.** By E. Hughes. 2000. 19 (2000), pg 457–465. (Available at http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V22-41TN69H-9&_user=655127&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_version=1&_urlVersion=0&_userid=655127&md5=26c84228ec011140dd67d43a8de07500). Focuses on the Department of Energy's Electric Power Research Institute and the process of evaluating, testing, and applying technology that can give a new mission to existing coal-fired power plants in terms of co-firing with wood.

Biopower Program: Activities Overview: Biopower Fact Sheet. National Renewable Energy Laboratory, U.S. Department of Energy, 2000. (Available at http://www.nrel.gov/docs/fy00osti/27980.pdf). Introduces biomass power generation and the Department of Energy's Biopower Program. It also provides information on the environmental and economic benefits of using biomass and the activities of the Biopower program.

The Carbon Connection. By D. W. Orr, 2007. *Conservation Biology* 21 (2), 289–292. Addresses some of the indirect social and environmental costs of using coal for power production.

Chip Pile Storage. By W. S. Fuller. 1985. Tappi. 68(8): 48–51. (Available at http://frm-consulting.net/articles/storage.pdf). Provides a review of practices to avoid deterioration and economic losses in a summary that brings past works together into a prescription for wood chip pile management that can be adapted to any mill that stores chips.

Co-Benefits of Utilizing Logging Residues for Bioenergy Production: The Case for East Texas, USA. In ***Biomass and Bioenergy***. By J. Gan and T. C. Smith. 2006. (Available at: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V22-4PBG1D7-1&_user=655127&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000033918&_version=1&_urlVersion=0&_userid=655127&md5=3572a5cf03ee38c7a99f436b794bbdc5). Describes a study that evaluated the benefits associated with the utilization of logging residues for electricity production in East Texas.

Community-based Forestry Perspectives on Woody Biomass, Briefing Paper, *Rural Voices for Conservation Newsletter,* March 2005. (Available at http://209.85.165.104/search?q=cache:yT4WijbCwbkJ:www.sustainablenorthwest.org/pdf/policy/biomass/biobrief.pdf+woody+biomass+economic&hl=en&ct=clnk&cd=1&gl=us&client=firefox-a). Discusses key considerations for biomass utilization policy, forest restoration and potential for woody biomass, the benefits of woody biomass, impediments to its utilization, and the importance of public involvement.

A Comparative Analysis of Woody Biomass and Coal for Electricity Generation under Various CO_2 Emissions Reductions and Taxes. In Biomass and Bioenergy. By J. Gan and C. T. Smith. 2006. (Available at: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V22-4HVDJC8-1&_user=655127&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000033918&_version=1&_urlVersion=0&_userid=655127&md5=323ce32eae95763d72560dadf5ffba21). Discusses a study that investigated the cost competitiveness of woody biomass for electricity production in the U.S. under alternative CO_2 emission reductions and taxes.

The Contribution of Biomass in the Future Global Energy Supply: A Review of 17 Studies. By G. Berndesa, M. Hoogwijkb, and R. van den Broek. 2003. *Biomass and Bioenergy:* Volume 25. Discusses the contributions of biomass to the future global energy supply. The discussion is based on a review of seventeen earlier studies on the subject. These studies have arrived at widely different conclusions about the possible contribution of biomass in the future global energy supply.

The Economics of Forest-based Biomass Supply. In *Energy and Policy*. By R. A. Sedjo, 1997. Volume 25(6): 559–566. Examines the economics of increasing energy generation from woody biomass and briefly covers the environmental impacts of using biomass versus fossil fuels.

Energy from Wood. By J. I. Zerbe, 2004. Encyclopedia of Forest Sciences: Volume 2. (Available at: http://www.treesearch.fs.fed.us/pubs/7120). Provides descriptions of the various forms of fuel inputs derived from woody biomass and the common uses of biomass as a source of energy.

European Union Common Agricultural Policy. (Available at http://www.tiscali.co.uk/reference/encyclopaedia/hutchinson/m0037992.html). Provides a brief description of the European Union's approach to agriculture.

Evolving Forestry and Rural Development Beliefs at Midpoint and Close of the 20th Century. In *Forest Policy and Economics*. By J. J. Kennedy, J. W. Thomas, and P. Glueck. 2001. 3: 81–95.308 (Available at http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VT4-43F8M1W-8&_user=655127&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000033918&_version=1&_urlVersion=0&_userid=655127&md5=67a5f0c0026086fb5db2256fac057c7a). Compares traditional forest values with emerging values and views about the role of forest management and managers in rural economic development.

Forests for Energy and the Role of Planted Trees. In ***Critical Reviews in Plant Sciences.*** By D. J. Mead. 2005a. 24: 407–421. (Available at http://www.informaworld.com/smpp/content~content=a737739593~db=all~jumptype=rss). Discusses the potential wood has as fuels in developed countries, taking into consideration the influence on fossil fuel price increases, as well as on ecological and social issues.

Fuel for the Future. In *Inside Agroforestry*. USDA National Agroforestry Center, 2006. Volume 15, Issue 3. (Available at http://www.unl.edu/nac/insideagroforestry/vol15issue3.pdf). Provides an excellent example of how to create attractive and appealing informative materials that encourage communities to pursue biomass resources produced through agroforestry techniques.

Fuel Value Calculator. By Forest Products Laboratory, 2004. Madison, WI: State and Private Forest Technology Marketing Unit. Publication WO-3. (Available at http://www.fpl.fs.fed.us/documnts/techline/fuel-value-alculator.pdf). Provides a user-friendly way to compare typical unit costs of various fuel sources, such as comparing the cost of using wood to the cost of using natural gas.

Liquid Fuels from Wood-Ethanol, Methanol, Diesel. In *World Resources Review***.** By J. Zerbe. 3(4): 406–414.1992. (Available at http://www.fpl.fs.fed.us/documnts/pdf1991/zerbe91a.pdf). Reviews the suitability of a variety of liquid fuels made from wood in today's global economic and international trade situation and provides some estimates of domestic supply and cost of wood for use in production of liquid fuels.

Measuring the Economics of Biofuel Availability. By M. Langholtz, D. R. Carter, M. Marsik, and R. Schroeder. (Available at http://www.esri.com/news/arcuser/1006/biomass1of2.html). Based on research done for the Wood to Energy Outreach Program, this article discusses strategies for determining the economic availability or total delivered price for a given quantity of woody biomass in selected counties. This assessment takes into account a number of factors, including biomass type, distance, and transportation infrastructure using ArcGIS Network Analyst.

Opportunities for Improving Plantation Productivity: How much? How quickly? How realistic? In *Biomass and Bioenergy*. By D. J. Mead. 2005b. 28: 249–266. (Available at http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V22-4DDR6CP-1&_user=655127&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_version=1&_urlVersion=0&_userid=655127&md5=e684582bdc23ac1ab02ce39559d82ded). Reviews the potential of intensive silviculture to increase productivity of short and longer rotation hardwood and conifer plantations.

Primer on Wood Biomass for Energy, U.S. Forest Service Report. By R. Bergman and J. Zerbe, 2004. U.S. Forest Service, State and Private Forestry Technology Marketing Unit, Forest Products Laboratory, Madison, Wisconsin. (Available at http://www.state.co.us/oemc/programs/waste/biomass/resources/Primer_on_Wood_Biomass.pdf). Summarizes the concepts of wood energy on a residential, commercial, and industrial scale in the U.S.

Renewable Electricity Production Tax Credit, Energy Policy Act of 2005. By the Northeast Regional Biomass Program (NRBP), 2005. Washington, DC (Available at http://www.nrbp.org/pdfs/energy_policy_act_2005.pdf). Summarizes the available tax credits for qualifying resources provided by the Energy Policy Act of 2005.

Short-term Energy Outlook. By the Energy Information Administration, 2006. (Available at http://www.eia.doe.gov/emeu/steo/pub/contents.html). Provides market forecasts and trends for coal, electricity, natural gas, and petroleum.

Socio-Economic Drivers in Implementing Bioenergy Projects. In *Biomass and Bioenergy.* By J. Domac, K. Richards, and S Risovic. 2005. 28: 97–106. (Available at http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V22-4DHXDSN-2&_user=655127&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_version=1&_urlVersion=0&_userid=655127&md5=7db210b357e1a49e3b8367e1a89fb733). Provides a descriptive review of literature on employment and other socio-economic aspects of bioenergy systems as drivers for implementing bioenergy projects.

Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies. In *Science.* By S. Pacala and R. Socolow. August 2006. Vol. 305. Examines how current scientific knowledge and technologies could be used to limit atmospheric carbon to a concentration that would prevent most damaging climate change.

Sustainable Production of Woody Biomass for Energy. By the IEA Bioenergy Executive Committee, 2003. (Available at http://www.ieabioenergy.com/library/157_PositionPaper-SustainableProductionofWoodyBiomassforEnergy.pdf). Discusses traditional woody biomass production systems and sustainability issues and indicators; and makes general recommendations for sustainable production.

Thermal Energy, Electricity, and Transportation Fuels from Wood. In *Forest Products Journal***.** By J. I. Zerbe, 2006. 56(1). (Available at http://www.treesearch.fe.fed.us/pubs/22991). Provides an economic perspective on the potential for energy produced from woody biomass to help satisfy the nation's growing demand for a variety of dependable fuel sources.

Urban Wood Waste Resource Assessment. By G. Wiltsee, 1998. Golden, CO: National Renewable Energy Laboratory. (Available at http://www.p2pays.org/ref/19/18947.pdf). Examines wood waste resources in thirty U.S. metropolitan areas in order to develop predictive tools for estimating urban waste wood resources based on an area's demographic and economic variables.

Use of Energy Analysis in Silvicultural Decision Making. In *Biomass and Bioenergy***.** By D. J. Mead and D. Pimentel. 2006. 30: 357–362. (Available at http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V22-4J2KTBJ-1&_user=655127&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000033918&_version=1&_urlVersion=0&_userid=655127&md5=2bbaeedbc045f6b8baba8e008801b251). Outlines a study in which selected inputs for hypothetical pine and eucalyptus plantations were evaluated.

Woody Biomass Users' Experiences Offer Insights for Government Efforts Aimed at Promoting Its Use. By United States Government Accountability Office, 2006. Report No. GAO-06-336. (Available at http://www.gao.gov/new.items/d06336.pdf). Provides a review of the successes and challenges of thirteen current woody biomass users located in the U.S., including power plants, pulp and paper mills, schools, and hospitals.

Books/Booklets/Periodicals

Bioenergy from Sustainable Forestry. By J. Richardson, R. Bjorheden, P. Hakkila, A. T. Lowe, and C. T. Smith (Eds.). 2002. Boston, MA: Kluwer Academic Publishers. Outlines information needed to design or implement sustainable forest management systems for production of biomass for energy in conjunction with other forest products.

Bioenergy: Realizing the Potential. By S. Silveira. 2005. The Netherlands: Elsevier. Looks at the possibilities that exist for bioenergy from a global perspective.

Biofuels for Transport: Global Potential and Implications for Sustainable Energy and Agriculture. By the Worldwatch Institute. 2008. Discusses new biofuel technologies and crops, key economic and social issues, policy implications, and recommendations for decision makers.

Biomass Magazine. (Available online at http://www.biomassmagazine.com/index.jsp). Covers a wide range of topics related to biomass including new technologies, case studies, industry news, and much more. Visit https://ssl.bbibiofuels.com/bmm/subscribe-payment.jsp to subscribe to receive hard copies.

The Brilliance of Bioenergy in Business and in Practice. By R. E. H. Sims, 2002. London, UK: James and James. Covers several aspects of using biomass to generate energy, including business opportunities and technologies. In addition, case studies are provided within the chapters to convey successes and challenges of implanting such systems.

Communication Skills for Conservation Professionals. By S. K. Jacobson, 1999. Washington, DC: Island Press. Covers communication program design and strategies for natural resource professionals.

Conservation Education and Outreach Techniques. By S. K. Jacobson, M. D. McDuff, and M C. Monroe, 2006. Oxford, UK: Oxford University Press. Discusses relevant theories along with strategies for planning, implementing, and evaluating a wide range of techniques. This book is a practical guide for applying conservation education and outreach programs.

Energy Efficiency Best Practices Workbook for Local Governments. Sponsored by the California Local Energy Efficiency Program (CALeep). Designed to help communities that are looking to reduce energy use, costs, and greenhouse gas emissions. It describes a basic five-step process that communities can follow to increase their level of energy efficiency, whether starting from scratch or building on existing energy efficiency activities.

Energy from Biomass: A Review of Combustion and Gasification Technologies. By P. Quaak, H. Knoef, and H. Stassen, 1999. Washington, DC World Bank. Technical Paper No. 422. Provides a comprehensive review of current biomass combustion and gasification systems, including advantages and disadvantages.

Facilitator's Guide to Participatory Decision-Making, 2nd Edition. By S. Kaner, L. Lind, C. Toldi, S. Fisk, and D. Berger, 2007. San Francisco, CA: Jossey Bass. A valuable resource for learning the skills necessary for group facilitation.

Forest Management to Sustain Ecological, Economic, and Social Values. By L .S. Davis, K. N. Johnson, P. S. Bettinger, and T. E. Howard. New York: McGraw-Hill. Offers an authoritative, up-to-date coverage of broad-scope concepts and ideas for those entering the fields of forest management, forest economics, and forest ecology.

Forest Measurements. By T. E. Avery and H. E. Burkhart. 2002. New York, NY: McGraw-Hill. Provides an introduction to forest measurement, including such areas as the measurement of timber, measuring attributes of standing trees, inventorying volumes of forest stands, and predicting growth of individual trees and stands of trees.

The Hidden Treasure. (Available at http://forestry.nacdnet.org/comic.htm). As a teaching tool for late elementary to middle school children, *Hidden Treasure* illustrates how forest renewal improves the health of forests and provides biomass for many productive uses. It also describes how woody biomass will play an important role in our nation's future, including energy security through the production of biofuels, biochemicals, and other sources of energy. You can learn more and request a copy from the Web site.

***Short Rotation Forestry Handbook* (online)**. University of Aberdeen, Scotland. (Available at http://www.abdn.ac.uk/wsrg/srfhbook/). Details how to grow short rotation forests, and the various processes involved including for example inputs and economics.

Successful Public Meetings. By E. Cogan, 2000. Chicago, IL: APA Planners Press. Offers details on successful meetings, crucial tasks, how to avoid disasters, and ways to manage difficult participants.

Timber Management: A Quantitative Approach. By J. L. Clutter, J. C. Fortson, L. V., Pienaar, L. V., G. H. Brister, and R. L Bailey. 1983. New York, New York: John Wiley & Sons. Outlines timber management from a numbers perspective, including treatment of models to predict tree and stand volume and growth; concepts of discounted cash flows, compound interest, internal rate of return and taxes related to timber management; and stand-level and forest-level planning using treatment models.

Organizations and Agencies

Chicago Climate Exchange (CCX). (http://www.chicagoclimatex.com/). North America's only and the world's first global marketplace for integrating voluntary, legally binding greenhouse reductions with emissions trading and offsets for all six greenhouse gases.

Energy Information Administration (EIA). (http://www.eia.doe.gov). Provides policy-neutral data, projections, and analyses to promote effective policy making, efficient markets, and increased public understanding about energy and its connections with the economy and the environment.

IEA Bioenergy Task 31: Biomass Production for Energy from Sustainable Forestry. (http://www.ieabioenergytask31.org/IEA_Bioenergy_Task_31.htm). Provides shared and synthesized research information, analyzes policy relevance, and disseminates information to help promote the sustainable development goals of national programs such as biomass in participating countries including Canada, Denmark, Finland, Germany, Norway, Sweden, The Netherlands, the United Kingdom, and the United States.

SunGrant Initiative, Southeastern Regional Center. (http://sungrant.tennessee.edu). Tennessee Agricultural Experiment Station. Provides university-based research, extension and educational programs for biobased energy technologies.

United States Department of Agriculture (USDA). (http://www.usda.gov/wps/portal/usdahome). Provides leadership on food, agriculture, natural resources, and related issues, guiding the development of sound public policy based on the best available science, and promoting efficient management.

U.S. Department of Agriculture Economic Research Service. (http://www.ers.usda.gov). A primary source of economic information and research in the U.S. Department of Agriculture.

United States Department of Energy (DOE). (http://www.energy.gov). Advances the national, economic, and energy security of the U.S. while promoting scientific and technological innovation in support of that mission; and ensuring the environmental cleanup of the national nuclear weapons complex.

U.S. Forest Service, Forest Products Lab, State and Private Forestry Technology Marketing Unit. (http://www.fpl.fs.fed.us/tmu/wood_for_energy/wood_for_energy.html). Provides technical assistance for improving utilization and marketing of forest products. This Web site provides links to several publications and other materials that may be helpful for understanding the use of wood for energy.

Web sites

Answers to ten frequently asked questions about bioenergy, carbon sinks and their role in global climate change. By Robert Matthews and Kimberly Robertson, 2005. IEA Bioenergy, Task 38. (Available at http://www.ieabioenergy-task38.org/publications/faq/). Explains basic concepts of using biomass for energy, carbon dioxide emissions, and carbon sequestration by biomass.

BioMass Energy Concepts (BEC). (http://www.becllcusa.com). Provides a variety of services related to the sale of biomass energy equipment packages. BEC specializes in creating tailored biomass fueled energy systems that meet the specific needs of their customers and offers engineering assistance.

Biomass Research and Development Initiative. (http://www.brdisolutions.com/). Coordinates all federal products, research, and development related to bioenergy. This Web site is a resource for recent news, publications, upcoming events, and links to additional resources.

Biomass Trader Site. (http://www.ncbiomasstrader.com/home.aspx). Provides contact information for and resource descriptions of biobased manufacturing products to help biomass energy suppliers connect with prospective buyers in the state of North Carolina. This resource might provide a useful model for other states.

Comprehensive online database of diameter-based biomass regressions for North American tree species. (http://www.treesearch.fs.fed.us/pubs/7058). By J.C. Jenkins, D.C. Chojnacky, L.S. Heath, and R.A. Birdsey. 2004. Newtown Square, PA: 45. U. S. Department of Agriculture, U.S. Forest Service, Northeastern Research Station. Report number: Gen. Tech. Rep. NE-319.306. Contains 2,640 equations compiled from the literature for predicting the biomass of trees and tree components from diameter measurements of species found in North America.

Education Web Site on Biomass and Bioenergy. (http://www.aboutbioenergy.info/). Provides tools, papers, brochures, links, and other resources about biomass technologies, economics, benefits, and implementation.

Energy Information Administration, Renewables and Alternate Fuels, Wood and Wood Waste. (http://www.eia.doe.gov/cneaf/solar.renewables/page/wood/wood.html). Provides data on biomass energy consumption by industry and by source of biomass. Links to additional data on wood and wood waste are also provided.

Eprida, Inc. (http://www.eprida.com/eprida_fl ash.php4). Provides information on Eprida, Inc., founded in 2002 to provide a commercial vehicle for exploring innovative solutions to global challenges. The Delaware-based corporation's early research focused on addressing global climate change. This work has led to breakthrough innovations in renewable energy, carbon capture, and carbon utilization for sustainable agriculture.

Federal Biomass Policy, Biomass Program, Energy Efficiency and Renewable Energy. (http://www1.eere.energy.gov/biomass/federal_biomass.html). U.S. Department of Energy (U.S. DOE). Provides a comprehensive overview of the major federal laws, executive orders, and reports related to using biomass for energy.

Forest*A*Syst. (http://www.utextension.utk.edu/publications/pbfiles/PB1679.pdf). Provides private forest landowners explanations and options as they relate to proper forest management.

Forest Bioenergy. (http://www.forestbioenergy.net). Designed for information sharing among natural resource management, extension, and community planning and development professionals. Developed as part of the Southern Forest Research Partnership bioenergy training initiative, the site contains a variety of resources and information related to biomass utilization, including publications, presentations, additional links, events, and images. Materials cover a wide range of topics including southern wood supply, management, harvesting, economics, and forest sustainability.

Forest Encyclopedia Network. (http://www.forestencyclopedia.net). Connects scientific results, conclusions, and impacts with forestry management needs and issues.

Fuels for Schools Partnership. (http://www.fuelsforschools.org). Promotes the use of woody biomass as a renewable, natural resource that provides a clean, readily available energy source for use in heating systems in public and private buildings. This Web site contains useful assessments, photographs, presentations, and information for those interested in pursuing biomass energy as an efficient and cost-saving heat source in their own facilities.

Georgia Forestry Commission Research Papers (online). (http://www.gatrees.org/Resources/Publications/ForestMarketing/researchpapers.cfm). This collection of research papers related to forestry and biomass is provided by the Georgia Forestry Commission.

International Energy Agency (IEA) Bioenergy. (http://www.ieabioenergy.com). Provides a global perspective on biomass energy use with event listings, media centre, and well-produced publications and informative materials for promoting the utilization of woody biomass as a sustainable fuel source.

Northeast Sustainable Energy Association, Biopower. (http://www.nesea.org/energy/info/biopower.html). Overviews biomass power, including sources and economic and environmental impacts.

Phyllis. (http://www.ecn.nl/phyllis/). Contains information on the composition of a variety of fuels including grasses, sugarcane bagasse, husks, algae, fossil fuels, and manure.

Pinchot Institute for Conservation. Outlook Forum 2007 on Climate Change, Forests, and Bioenergy. (http://pinchot.org/outlook_forums/2007). Features a summary of the 2007 forum, presentations, and speaker bios.

Plant Power: Energy and the Environment. (http://www.treepower.org/). Features project descriptions and research reports from studies by the Common Purpose Institute, the University of Florida, the U.S. Department of Energy, farmers, power providers, biofuel producers, and others. The organization works to find ways to grow, harvest, and use fast-growing crops and biomass waste streams to fuel power plants and to provide industrial biogas, transportation fuels (ethanol and biodiesel), and steam power.

Power Scorecard, Electricity and the Environment. (http://www.powerscorecard.org/elec_env.cfm). Offers a tool that is useful for comparing types of power generation sources and their effects on the environment.

Renewable Energy Sources: A Consumer's Guide, Energy Information Brochures, Official Energy Statistics from the U.S. Government, Renewable Energy Trends. By the U.S. Department of Energy, Energy Information Administration (U.S. DOE/EIA), 2004. (http://www.eia.doe.gov/neic/brochure/renew05/renewable.html). Provides a general overview of all sources of renewable energy and includes figures depicting energy consumption and electricity generation by fuel source.

Smallwood Utilization Network (SUN). (http://smallwoodnews.com). Offers a broad network for dealing with the complex set of challenges in supply, production, and marketing for the emerging smallwood industry. You can sign up for the Smallwood Newsletter, which includes up-to-date articles on woody biomass utilization.

State Incentives for Renewable Energy (online database). (http://www.dsireusa.org/). A comprehensive source of information on state, local, utility, and federal incentives that promote renewable energy and energy efficiency.

Sustainable Hardwoods Network. (http://sustainablehardwoods.net/biomass). Provides information from forum presentations, including the types and properties of biomass materials, small-scale biopower systems, and safeguarding rural communities through fuels utilization.

Timber Buy Sell Site. (http://www.timberbuysell.com). Serves as a marketplace for forest resources. Users can search ads from buyers and sellers of forest residue, logs, mill residue, and standing timber.

University of Minnesota Extension Service Biomass Web site. (http://www.extension.umn.edu/woodlands/biomass#download). Provides resources from three 2006 workshops (titled "Woody Biomass Harvesting & Utilization") hosted by the University of Minnesota Extension Service. In Grand Rapids, St. Cloud, and Rochester, Minnesota.

University of Minnesota's National Database of State Woody Biomass Utilization Policies. (http://www.forestry.umn.edu/publications/staffpapers/Staffpaper199.pdf). Provides a comprehensive guide to biomass legislation for each state in the country as of 2008.

U.S. Department of Energy, Biomass Program. (http://www1.eere.energy.gov/biomass/). Provides information about the benefits of biomass utilization, current issues, feedstocks, technologies, and research and development activities, as well as a database of documents on biomass.

U.S. Department of Energy, Energy Efficiency and Renewable Energy, Biomass program: Economic growth. (http://www1.eere.energy.gov/biomass/economic_growth.html). Provides information about the economic impacts of using biomass for energy and provides links to several related reports and documents.

U.S. Department of Energy, Energy Efficiency and Renewable Energy, a Consumer's Guide to Energy Efficiency and Renewable Energy. (http://www.eere.energy.gov/consumer/your_home/electricity/index.cfm/mytopic=10450). Describes the common technologies behind using biomass to produce energy. Links to a biomass resource map and additional information on bioenergy basics, gasification, and power production are also provided.

U.S. Department of Energy, Energy Efficiency and Renewable Energy, Glossary of Energy-Related Terms. (http://www.eere.energy.gov/consumer/information_resources/index.cfm/mytopic=60001). Provides an easy to use glossary of energy-related terms.

U.S. Department of Energy, Energy Efficiency and Renewable Energy, State Energy Program. (http://www.eere.energy.gov/state_energy_program/projects_state.cfm). Features links to, and information about, state energy programs and special projects, grants, and case studies.

U.S. EPA Clean Energy Program. (http://www.epa.gov/cleanenergy/epaclean.htm). Provides links and information about initiatives related to combined heat and power, green power, state energy programs, energy efficiency, and renewable energy.

U.S. Forest Service Woody Biomass Utilization. (http://www.fs.fed.us/woodybiomass/). Provides information on the Forest Service program tasked with increasing the amount of America's energy that comes from forests.

WoodFuel.com. (http://www.woodfuel.com). Provides an online forum for the growing network of biomass suppliers and consumers to exchange products and services. WoodFuel forms trade alliances with the equipment and transportation industries involved with biomass energy production and uses the latest Internet technologies to complete an efficient supply chain for the entire industry.

Wood to Energy Outreach Program. (http://www.interfacesouth.org/woodybiomass/). A program designed to foster community understanding and discussion about the possibility of using wood for energy in the South.

Wood Utilization Solutions to Hazardous Fuels. (http://www.emmps.wsu.edu/woodutilization/secondary/Proceedings.html). Provides information from the 2004 "Wood Utilization Solutions to Hazardous Fuels" workshop held in Spokane, Washington, and includes several slide presentations that focus on biomass energy solutions. Presentation topics include small-scale biomass energy production, biomass energy plants, and small-scale gasifiers.

Presentations

Biomass, the Energy Policy Act of 2005 and the President's Biofuels Initiative. By John Ashworth, 2006. Golden, CO: National Renewable Energy Laboratory. (Available at http://www.nationalbiomassconference.org/presentations/Ashworth.pdf). Provides an overview of the Energy Policy Act of 2005, the Department of Energy's response to the Act, and the Biofuels Initiative (30 x 30).

Wood Biomass Feedstock for Bioenergy and Bioproducts: A North American Solution slide presentation. By Ed White, Lawrence Abrahamson, Timothy Volk, Lawrence Smart, James Nakas, and Thomas Amidon, SUNY-ESF, Syracuse, NY, 2006.(Available at http://66.48.22.171/documents/EdWhitePresentation-5December2006.pdf). Covers national energy issues, federal and state biomass initiatives, and national biomass supply.

Wood to Energy Outreach Presentation Collection. University of Florida. (Available at http://interfacesouth.org/woodybiomass/presentation.html). Is a collection of slide presentations from the Wood to Energy Outreach Program and Sustainable Forestry for Bioenergy and Biobased-Products Program on the following topics: basic woody biomass overview; woody biomass products and possibilities; economics; public perceptions; sustainable production, transporting, drying, and storing; public perceptions; and education versus advocacy.

Forest Bioenergy. Southern Forest Research Partnership, Inc. (Available at http://www.forestbioenergy.net/training-materials/powerpoint-presentations/ and http://www.forestbioenergy.net/presentations). A collection of slide presentations from the Sustainable Forestry for Bioenergy and Bio-based Products Program. They cover a variety of woody biomass topics, including understanding bioenergy resources, economics, environmentally sustainable production systems, cellulosic ethanol, and others.

Videos

Energy from the National Forest Video from the Shasta-Trinity National Forest. (Available at http://www.fs.fed.us/r5/shastatrinity/news/podcasts.shtml). Running Time: 10:22 (audio version), 5:52 (video version). Another wildfire burns in northern California releasing carbon the trees removed from the atmosphere as they grew. Wildfires have become more intense and destructive due to decades of aggressive suppression allowing fuels to accumulate. A partnership between the U.S. Forest Service and private industry is removing excess biomass from the Shasta-Trinity National Forest and using it to generate electricity resulting in a healthier forest and less reliance on fossil fuel.

Video Tour of New Biomass Gasification Plant at Middlebury College. (Available at http://blogs.middlebury.edu/biomass/about/video-tour/). Middlebury's new biomass gasification plant connects climate, energy, and community for a more sustainable energy future. For more than a decade, carbon reduction has been a community driven initiative at the College, and in 2007 Middlebury set a goal of achieving carbon neutrality by 2016. The completion of the biomass gasification facility marks a significant milestone toward that goal. Students, staff, and faculty from many different departments across campus were involved at every stage of this project.

Suggested Field Trips

•Many wood-to-energy facilities will provide tours if you contact them ahead of time.

•A timber plantation that is a certified producer of sustainable forest products

•A tour of a utility or industry that uses wood to produce energy

•A utility or industry that has implemented an innovative technology in their use of wood for energy

•A utility or industry that uses wood for energy and is willing to discuss economic aspects

Suggested Guest Speakers

•Biomass financing consultants

•Certified sustainable forest products producer

•Consulting forester

•Economic development experts

•Energy experts

•Engineers or consultants who specialize in biomass conversion technologies

•Environmental managers from utilities or industries that use wood for energy

•Forester from a state or county forestry agency

•Forestry extension agent or specialist

•Forestry market experts

•Local leaders who have been involved in energy policy issues

•Policy-maker who specializes in energy issues

•Representative from an environmental organization that has expertise in energy, renewable energy, or woody biomass

•State Energy Policy Office members

Appendix D Biomass Supply and Cost Profile: Matanuska-Susitna Borough-owned Lands, Alaska

Introduction

The biomass resources in the western United States have both similarities with, and differences from, those from other regions in the country. Issues of forest health on public lands play a significant role in the West, and management of naturally regenerated stands is more prevalent than tree plantations. In this supply and cost profile, we present a simplified approach to assessing the availability of biomass resources, which may be used for small-scale projects, or where data may not be widely available.

Background

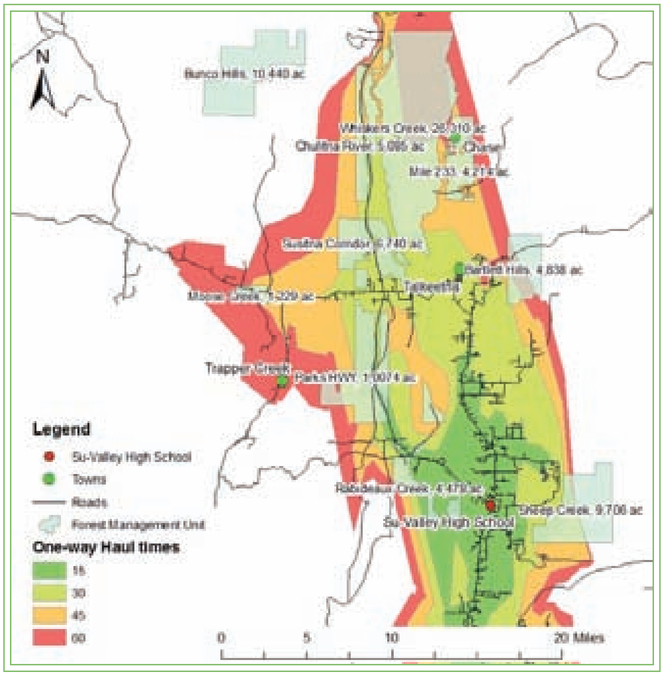
The Matanaska-Susitna Borough, north of Anchorage, Alaska, contains about 24,600 miles of land, and in 2000 had a population of about 59,000. The area has abundant natural resources, including woody biomass. Thirteen Forest Management Units in the borough comprise 105,175 forested acres containing more than 2.1 million green tons of wood. There are three commercial manufacturing facilities, a wood chip export company, and many smaller firms that supply firewood and logs in the Matanuska-Susitna Valley (Northern Economics Inc., 2007).

Nowhere in the U.S. is the issue of climate change more significant than in Alaska, where climate-related forest health issues have been documented. Rising temperatures cause insect outbreaks and make forests vulnerable to fire, which environmentalists cite as one reason to mitigate climate change globally. Simultaneously, forest thinning is needed to improve forest health and reduce forest fuel loads, providing an opportunity to produce carbon-neutral renewable energy from forest biomass.

Figure 1: *Location of Matanuska-Susitna Borough and the Su-Valley High School.*

At this writing, one potential bioenergy project in the Matanuska-Susitna Valley is the Su-Valley High School in Talkeetna. The school was destroyed by a fire in 2007, and reconstruction efforts aim to provide for heating the school with locally available firewood (CE2 Engineers Inc., 2008). Heating the school with firewood rather than fuel oil would provide economic and environmental benefits locally. This analysis provides an assessment of the economic availability of biomass fuels for a local bioenergy project such as the Su-Valley High School in Talkeetna, AK. Fuelwood assessed is

Figure 2: *Forest Management Units in the Matanuska-Susitna Valley area and haul times from the Su-Valley High School.*



limited to sustainably produced biomass from Matanaska-Susitna Borough Forest Management Units.

The Matanaska-Susitna Borough Land and Resource Management Division manages Forest Management Units for a variety of uses, including recreation, mining, and forestry. Operable forests in the Matanuska-Susitna Valley are primarily mature birch-spruce mixed forests, with scattered volumes of aspen and cottonwood. Spruce, a softwood saw timber species, has the highest value. Birch, a hardwood, comprises about 60 percent of Matanuska-Susitna Valley operable forest lands and is harvested for export as wood chips, with some higher-value uses as lumber, flooring, and specialty products. A significant amount of lower-quality fiber is available from birch and other species, suitable for wood chips and firewood (Northern Economics Inc., 2007). The Land and Resource Management Division administers the Wildfire Fuel Reduction Program, which is designed to reduced fuel loads and wildfire risk on Forest Management Units lands. Woody biomass for bioenergy could come from forest thinning prescribed by this program. Some combination of logging residues and forest thinnings from overstocked stands would probably provide the least-cost biomass resources in the in the Matanuska-Susitna Valley.

Economic concerns are major determinants of the feasibility of bioenergy projects. Assessing the economic availability of biomass requires learning about the delivered cost of wood, the quantity of wood that's available, and its geographic distribution. In this profile, we assess the availability of biomass that may be derived from ten area Forest Management Units, and the cost of biomass from these areas delivered to the Su-Valley High School in Talkeetna. The cost of each ton of biomass (i.e., marginal cost) at a range of quantities is then displayed in a supply curve.

Table 1: *Forest Management Units (FMU), acres, operable forest acres, and estimated annual availability of fuelwood.*

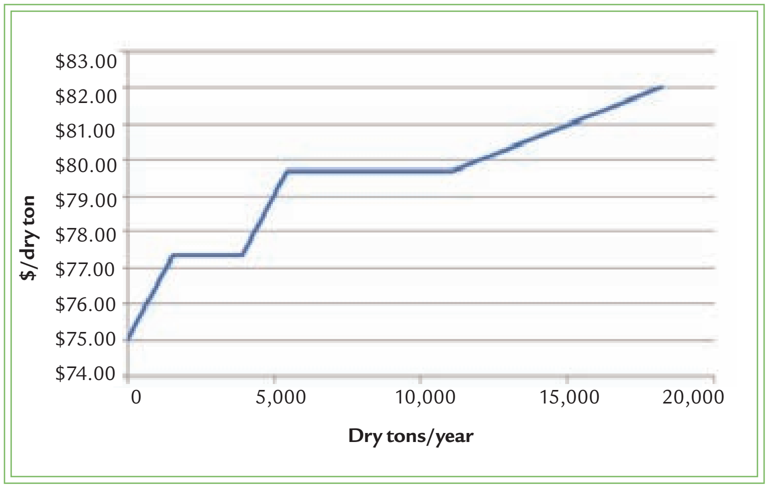
FMU Name	Operable Forest Land Acres	Assumed Fuelwood Yield (t/ac/yr)	Total t/ac/yr
Rabideaux Creek	1,568	1.0	1,568
Susitna Corridor	2,330	1.0	2,330
Parks HWY	1,540	1.0	1,540
Mile 233	3,211	1.0	3,211
Moose Creek	0	1.0	0
Sheep Creek	1,576	1.0	1,576
Chulitna River	817	1.0	817
Whiskers Creek	7,131	1.0	7,131
Bartlett Hills	2833	1.0	2833

Biomass Availability

The Matanaska-Susitna Borough owns 11 Forest Management Units totaling 105,175 acres and 49,044 operable forest land acres. Forest Management Units in and around the Matanuska-Susitna Valley and haul time from the assumed point of delivery are show in Figure 38. Assuming operable forest lands yield 1.0 dry tons per acre per year of fuelwood, estimated annual availability of biomass is shown in Table 1.

Firewood cut and delivered unsplit is available locally at about $110.00 to$120.00 per cord (Northern Economics Inc., 2007), or about $75.00 to $82.00/ dry ton, assuming 1.5 dry tons per cord. To account for transportation cost, we assume the lower cost of $75.00 per dry ton for biomass harvested from Forest Management Units that are within a 15-minute drive of the delivery point, and the higher cost of $82.00 per dry ton for biomass 1 hour from the delivery point. We interpolate between 15 minutes and 1 hour using linear regression, and calculate a cost of $77.34 per dry ton and $79.67 per dry ton for biomass from a 30-minute and 45-minute haul time, respectively. The resulting supply curve is shown in Figure 3.

Figure 3: *Supply curve for fuelwood to the Su-Valley High School.*



Summary and Conclusion

Assuming a yield of 1 dry ton per acre per year of fuelwood production from operable forestlands, approximately 21,000 tons of fuelwood are available annually from about as many acres of operable forest lands on Forest Management Units near Talkeetna, AK. This biomass is probably available for about $75.00 to $82.00 per dry ton based on existing fuelwood markets. This would total about 337 billion Btu per year, or enough biomass to power a 3 megawatt facility. This is many times the 439 green tons, or approximately 4.7 billion Btu per year that would be required for the wood-fired boiler for the Su-Valley High School described by CE2 Engineers Inc. (2008).

Acknowledgments: We are grateful for assistance provided by Bob Wheeler, University of Alaska Cooperative Extension Service, Fairbanks, AK.

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Northern Economics Inc. (2007). Matanaska-Susitna Borough Market Analysis and Timber Appraisal Report. Anchorage, AK.

Appendix E Biomass Supply and Cost Profile: Five North Florida Counties

Introduction

The Wood to Energy Project at the University of Florida School of Forest Resources and Conservation assessed the economic availability of biomass resources in twenty-eight communities a cross thirteen southeast U.S. states (Monroe et al., 2007). As an example, the following describes the methodology used for these communities, and results from five communities in North Florida. These results can be compared with those from the other twenty-three communities evaluated by the Wood to Energy project, which used the same methodology. The methodology used here is one approach that can be used in evaluating the availability of biomass resources, and can be compared to methodologies developed for the two other supply/cost profiles included in this desktop guide.

Background

Florida is the fourth most populated state in the nation, yet it boasts an abundance of natural beauty. About half of Florida, or 16.2 million acres, is covered by forests that contain diverse plant and wildlife species. Florida's forests provide many benefits and opportunities to residents and tourists alike. Approximately 49 percent of Florida's forests are owned by private family landowners, and another 32 percent are owned by private forest industries and investment companies. Near urban areas, these privately owned lands are susceptible to development pressures. The northern half of Florida contains expanding communities, farmland, and 82 percent of the state's timberland, which supports a thriving forest products industry. About 19 percent of the state's land area is publicly owned and maintained by state parks, state forests, water management districts, national forests, and national parks (Florida Division of Forestry, 2005). These public conservation lands contain natural habitats such as pine flatwoods, hardwood hammocks, cypress swamps, as well as rivers, lakes, and springs. In addition, many Florida communities enjoy healthy and extensive urban forests that provide benefits to both residents and natural resources.

Nassau, Clay, Alachua, Leon, and Santa Rosa counties are located in north Florida (Figure 1), and each has a wealth of natural resources that contribute to the residential quality of life. Both Nassau and Clay counties are near the Jacksonville metropolitan area, and while they contain some bedroom communities for the city, these counties remain largely rural. Nassau County lies on the Atlantic Ocean coastline, which provides recreation and tourism opportunities, and the beautiful St. John's River flows along Clay County's eastern border. Tucked between Georgia and the Gulf Coast, Leon County's largest urban area, Tallahassee, is the state capital. It has two major universities—Florida State University and Florida Agricultural and Mechanical University (FAMU)—both of which provide economic benefits and employment for the region. Similarly, the commercial hub of Alachua County is Gainesville, the home of the University of Florida and about half of the county's residents. Santa Rosa County, located in the western panhandle on the Gulf of Mexico, attracts tourists to its beautiful beaches while hosting successful agricultural and manufacturing industries. Many of the largest cities within these five counties, such as Tallahassee, Gulf Breeze, Green Cove Springs, Orange Park, and Gainesville, are nationally recognized as Tree City USA communities. These counties are fortunate to contain areas with large amounts of forested lands and prominent natural features, as well as communities with the small-town atmosphere that many people enjoy.

According to the U.S. Census Bureau, each of these counties is experiencing moderate to heavy population growth (Table 1). With this growth comes the need for additional energy. Cognizant of environmental and sustainability issues, some communities are considering renewable fuel sources and efforts to promote energy conservation. For example, in Alachua County, public opposition to a proposal to build another large coal-fired power plant has led city-owned Gainesville Regional Utilities to accept a proposal for a 100 MW bioenergy facility. In Leon County, the city of Tallahassee agreed to buy up to 35 megawatts (MW) of biomass energy from Biomass Gas and Electric Company in 2006. As of 2005, Jacksonville's public utility, Jacksonville Electric Authority, plans to purchase up to 70 MW of energy from a biomass power plant proposed by Biomass Industries, Inc. This biomass facility plans to use non-woody biomass, although wood from neighboring Clay and Nassau counties could potentially be used as a supplemental fuel source. Additionally, just east of Leon County in Jackson County, a wood pellet plant has been constructed that processes wood pellets for export to Europe for energy use. Similar wood pellet plants could supply wood domestically if there is a demand. Increases in population; energy demand projections; and the presence of local, sustainable wood resources create an opportunity for these five counties to consider using woody biomass to generate electricity.

Woody biomass from urban wood waste, logging residues, and forest thinnings can be used to generate renewable energy. Using wood to generate electricity provides many potential benefits such as reduced greenhouse gas emissions, healthier forests, and local jobs and other economic benefits.

To estimate the amount of wood that could be available in a community we include three sources: urban wood waste, logging residues, and pulpwood. While other woody biomass resources exist and could be added to the resource assessments, we include only these resources, for which cost and supply data are available. Urban wood waste is generated from tree and yard trimmings, the commercial tree care industry, utility line clearings, and greenspace maintenance. Logging residue is comprised of the leftovers from forest harvesting, such as tree tops and limbs, and poorly formed trees. Pulpwood refers to small diameter trees (3.6 to 6.5 inches diameter at breast height) that are usually harvested for manufacturing paper, purified cellulose products (such as absorbents, filters, rayon and acetate), and oleoresin products (such as pine oils, fragrances, cosmetics, and thinners).

Table 1: *Population data for selected Florida counties.*

County	2000	2005	Population Growth from 2000 to 2005
Alachua	217,955	223,852	2.7%
Clay	140,814	171,095	21.5%
Leon	239,452	245,756	2.6%
Nassau	57,663	64,746	12.3%
Santa Rosa	117,743	143,105	21.5%

This fact sheet excludes secondary woody waste from sawmills and furniture makers, which is available but may already be used within the industry to produce energy.

Economic concerns are major determinants of the feasibility of bioenergy (energy generated from biomass) projects—both the cost of fuel and the jobs that could be created. Assessing the economic availability of biomass requires learning about the delivered cost of wood, the quantity of wood that's available, and its geographic distribution. This information is then used to create biomass resource supply curves, which express price per unit of biomass at a range of potential quantities of consumption. The following summary uses these methods to assess the economic availability of wood resources for Alachua, Clay, Leon, Nassau, and Santa Rosa Counties in Florida.

Cost Calculations

The delivered cost of woody biomass to a facility is the sum of the amount paid to buy the wood from the original owner (procurement), the harvest cost, and the transportation cost. Although rail transportation could be used in some cases, woody biomass is typically transported by truck. The cost of transportation depends on the time it takes a truck to travel from the harvest site to the facility. Haul times to the central delivery point in each county are calculated using a software program called ArcGIS Network Analyst Extension (Figure 1). Assuming that haulers drive the speed limit on the quickest route available to them, we calculate total transportation times for the forested areas around the delivery point, and then increase haul times (and thus costs) by 25 percent to account for delays, such as traffic and stops. These haul-time areas delineate potential "woodsheds" or areas that can provide wood for a specific community or biomass user. If demand is established in more than one area in close proximity woodsheds can overlap, causing competing demand for biomass (Figure 1).

The sum of the procurement, harvest, and transportation costs are calculated to obtain the total delivered cost of urban wood waste, logging residues, and pulpwood at fifteen-minute increments up to one hour from each delivery point. Delivered costs allow us to see the progression of the most- to least-expensive woody biomass resources. For example, if urban waste wood were delivered within the one-hour limit, the total delivered cost would be \$19.46 per dry ton, or \$1.25 per million British Thermal Units (MMBtu). However, if pulpwood were delivered from the same distance, the delivered cost would increase to \$49.14 per dry ton, or \$3.04 per MMBtu, primarily because pulpwood is more expensive than urban wood waste.

Figure 1: *One-hour woodsheds of Alachua, Clay, Leon, Nassau, and Santa Rosa counties in Florida.*

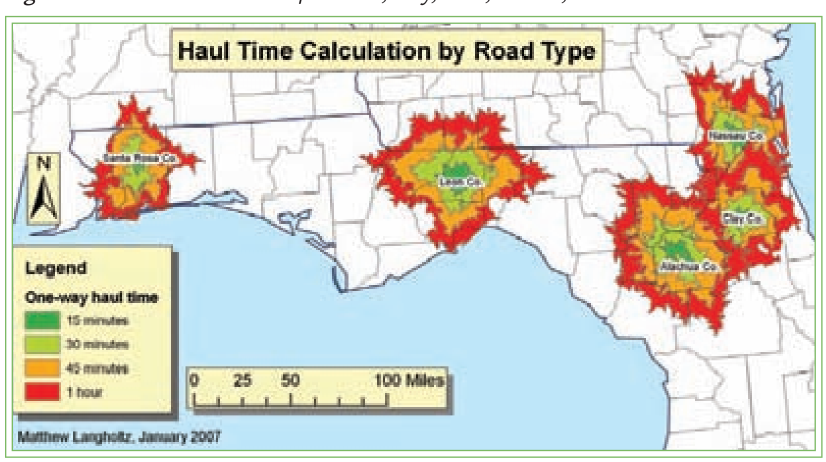


Table 2: *Harvested pulpwood and available urban wood waste and logging residues (green tons/year) for five Florida counties.*

County	Available urban wood waste	Available logging residues	Harvested pulpwood
Alachua	26,000	85,900	292,500
Clay	19,800	50,000	239,000
Leon	28,500	32,600	156,800
Nassau	7,500	94,500	300,400
Santa Rosa	16,600	55,400	235,900

Physical Availability

In addition to the delivered cost of wood, knowing how much of each type of woody biomass is available is necessary to construct supply curves. Annually harvested pulpwood, and annually available urban wood waste and logging residues within the five Florida counties are shown in Table 2. For urban wood waste, it is assumed that 0.203 green tons (40 percent moisture content) of urban wood waste is generated per person per year (from Wiltsee, 1998). This includes municipal solid waste wood from yard waste and tree trimming but excludes industrial wood (e.g., cabinet and pallet production) and construction and demolition debris. This average yield was multiplied by county population estimates (U.S. Census Bureau), and reduced by 40 percent to estimate total annual county yield of urban wood waste. For example, in Alachua County, this results in 26,000 green tons of urban wood waste per year.

The amount of logging residue and pulpwood for all counties in Florida is obtained from the USDA Southern Research Station 2003 Timber Product Output Reports. This database provides forest inventory and harvest information, including annual yields of forest residues and pulpwood. We reduced the figure for logging residues by 30 percent to exclude stumps. For example, in Leon County, there are 32,600 green tons (37 percent moisture) of logging residues available annually from existing forestry operations. There are also 156,800 green tons (50 percent moisture) of pulpwood harvested annually. Because the pulpwood harvest is currently used to produce pulp and paper products, not all of this resource is economically available for bioenergy. However, additional biomass is available from forest thinnings, which is not included in this assessment.

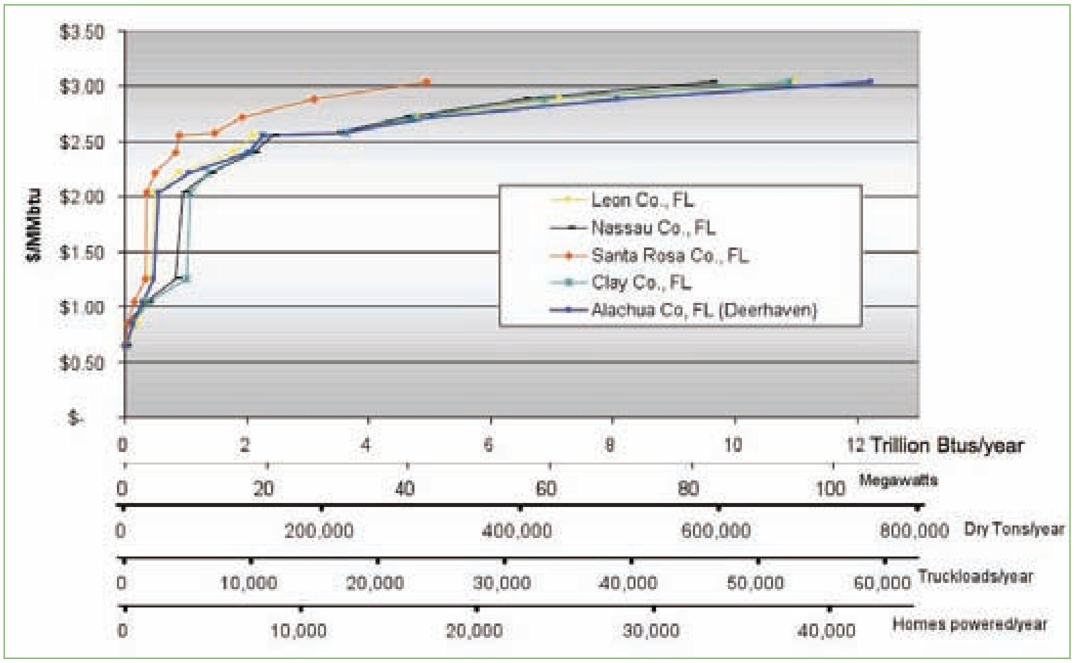
Supply Curve Construction

Given information regarding cost, quantity, and distribution of all three types of woody biomass, supply curves can be generated for five selected Florida counties. Figure 2 on the next page shows the price of wood at different quantities needed. The y-axis represents price per million Btus of energy and the x-axis represents the total amount of wood available in 15-minute increments. Several scales are provided to translate the quantity of wood into tons, energy content, and houses electrified (Figure 2). Biomass sources include urban wood waste, logging residues, and pulpwood within a one hour haul radius of each county center (or the Deerhaven facility in the case of Alachua County).

Supply Analysis Results

Energy resources and costs for each resource-haul time category for the five counties are shown in Table 3 on the next page, and these values were used to construct the supply curves shown in Figure 2. The supply curves suggest that 1.5 to 3.6 trillion Btus (or 13 to 31 MW of electricity, which is enough to power approximately 5,000 to 12,500 households (Bellemar, 2003) are available for less than $2.60 per million

Figure 2: *Biomass resource supply curves for five select Florida counties.*



Btus in each of the five woodsheds, which is competitive with the current costs of coal. Within a one-hour haul radius, up to 0.3 to 1.0 trillion Btus can be provided from urban wood waste alone. With the addition of logging residues, 1.40 to 3.43 trillion Btus can be produced. Other types of wood may be available from thinnings to improve forest health, although estimates of this wood are not available. As the

Table 3: *Available energy and delivered cost for each wood resource/haul time category and county included in this analysis. Resources are ranked from cheapest to most expensive based delivered cost of energy.*

		Trillion Btus available per year within a one hour haul radius				
Delivered cost ($/MMBtu)	**Resource/Haul time category**	**Alachua [1]**	**Clay [2]**	**Leon [2]**	**Nassau [2]**	**Santa Rosa [2]**
$0.65	Urban wood: 0-15 minutes	0.02	.02	0.06	0.01	0.01
$0.85	Urban wood: 15-30 minutes	0.11	0.10	0.15	0.04	0.04
$1.05	Urban wood: 30-45 minutes	0.16	0.29	0.12	0.31	0.11
$1.25	Urban wood: 45-60 minutes	0.17	0.62	0.09	0.49	0.19
$2.03	Logging residues: 0-15 minutes	0.09	0.05	0.08	0.12	0.02
$2.21	Logging residues: 15-30 minutes	0.50	0.29	0.40	0.43	0.13
$2.39	Logging residues: 30-45 minutes	0.97	0.69	0.88	0.73	0.34
$2.56	Pulpwood 0-15 minutes	0.24	0.21	0.32	0.30	0.06
$2.57	Logging residues: 45-60 minutes	1.29	1.36	1.41	1.06	0.56
$2.72	Pulpwood 15-30 minutes	1.50	1.09	1.27	1.12	0.47
$2.88	Pulpwood 30-45 minutes	3.03	2.15	2.36	1.95	1.17
$3.04	Pulpwood 45-60 minutes	4.14	4.01	3.83	3.06	1.85

[1]Delivery to the Deerhaven Facility.
[2]Delivery to the county center

cost of oil increases, all price estimates increase (with petroleum inputs for harvesting and transportation), but so does the costs of coal and natural gas. In other words, as fossil fuels become more expensive, the delivered cost of wood will increase but will become increasingly competitive with non-renewable fuels.

Economic Impact Analysis

The potential economic impacts of developing a 20 or 40 MW wood-fueled power plant in these five counties in Florida are an important consideration. The construction impacts of the project would be one-time event that is assumed to occur within a year, while the impacts of plant operations continue each year. Fuel costs were calculated from the supply curves, and economic impacts were estimated using a software program called IMPLAN together with regional databases for each county. Note that these estimates included not only the direct impacts of plant construction and operation, but also the indirect impacts from local purchases to operate the plant and those associated with employee household spending.

Total construction costs were valued at $48.7 million for the 20 MW plant and $86.8 million for the 40 MW plant, including land, site work, construction, plant equipment, and engineering fees. The largest construction expenses were the boilers and turbines, ranging from $45 to $90 million. The total annual operating expenses (first year) for a wood-fueled power plant averaged $8.0 million for 20 MW and $16.1 million for 40 MW. Fuel typically represents the largest operating cost for a facility, and averaged $4.0 and $9.9 million for the 20 or 40 MW plants, respectively. However, fuel costs varied across counties from $9.1 million to nearly $11.2 million for the 40 MW plant, due to differences in availability of forest and wood waste resources, as well as transportation infrastructure.

The estimated economic impacts that would result from construction and operation of wood-fueled power plants in each of the counties are summarized in Table 4. The large range of values is due to the fact that some counties have industries that produce some of the major items needed for construction, while other counties must import these items from other regions, representing a leakage from the local economy. For example, Santa Rosa County would experience greater economic impacts from plant construction because it has existing industries that manufacture key plant equipment such as boilers and turbines.

The economic impacts of annual operations in the first year are also shown in Table 4. These results can be considered as permanent or recurring impacts. The impacts varied among counties due to differences in the specific makeup of the local economy, and in some cases the absence of key sectors serving wood-fueled power plant operations.

Often it is helpful to predict the distribution of economic impacts across various sectors of the local economy. More than 60 percent of all jobs would occur in the agriculture and forestry sector, which supplies wood fuel to these plants. However, there would also be significant employment impacts in the sectors for professional services, retail trade, and government, reflecting the indirect effects on the local economy associated with purchased supplies and employee household spending.

Table 4: *Wood fuel costs and economic impacts of operations and plant construction for 20 and 40 MW power plants in selected Florida counties.*

Florida County	Wood Fuel Cost (Mn $)	Annual Operations Impacts (first year)			Plant Construction Impacts		
		Output ($Mn)	Employment (Jobs)	Value Added ($Mn)	Output ($Mn)	Employment (Jobs)	Value Added ($Mn)
20 MW							
Alachua	3.84	13.52	196	8.38	8.00	81	4.30
Clay	3.37	11.73	182	7.10	7.60	74	3.70
Leon	4.52	13.41	156	8.55	7.80	74	4.10
Nassau	3.69	10.80	137	6.71	6.70	63	3.30
Santa Rosa	4.70	12.47	147	7.70	37.70	335	15.40
Average	4.02	12.39	164	7.69	13.56	125	15.40
40 MW							
Alachua	9.28	27.54	413	17.08	10.80	107	10.80
Clay	9.05	25.30	420	15.35	10.30	98	4.80
Leon	10.57	27.54	318	17.35	10.70	100	5.40
Nassau	9.46	27.54	297	14.56	9.00	82	4.20
Santa Rosa	11.23	27.54	307	16.18	65.50	578	26.30
Average	9.92	27.54	351	16.10	21.26	193	10.30

Summary and Conclusion

Economic concerns are important to discussions of using wood for energy. For many communities, the conversation begins with the recognition that there might be enough wood at an affordable cost. The supply analysis suggests that indeed, enough wood at a reasonable cost is available in Alachua, Clay, Leon, Nassau, and Santa Rosa counties to make a continued conversation possible. Up to 1.5 to 3.6 trillion Btus (i.e. 13 to 31 MW or energy to power 5,000 to 12,500 homes annually) of woody biomass are available at less than \$2.60 $MMBtu^{-1}$ in these five north Florida counties. These general estimates could be improved with more site specific information.

Additional assessments of local conditions, population density, distribution of wood, competition from pulp mills, restoration activities, and other factors would improve the accuracy of these biomass resource assessments. The following caveats should be considered when interpreting the results presented in this analysis:

- The supply considered in this fact sheet includes only urban wood waste, logging residues, and pulpwood. It excludes stumps, waste from forest operations, and waste from wood industries.
- Because the data are available at the county level, homogeneous distribution of resources within counties is assumed. Resource distribution within counties and location of bioenergy generating facilities will influence the actual economic availability of woody biomass for generation. More detailed local analysis might consider the distribution of biomass resources within counties, especially for site selection of biomass using facilities.
- The inclusion of other resources such as mill wastes or thinnings for forest management and habitat restoration would increase available resources.

- This analysis is not intended to be a definitive resource assessment, but is rather meant to provide a starting point for discussions about the feasibility of using wood. Resources can be excluded or added as more information becomes available and prices can be modified to reflect local conditions.
- A rise in the price of oil would increase the cost of the resources shown here, as well as costs of conventional energy sources such as coal.
- Some assumptions made in this analysis are subject to change. For example, large-scale bioenergy development in the area could increase competing demand for wood resources. The population in Florida is increasing, which might increase the availability of urban wood waste resources, though it could decrease overall available biomass resources.
- Rail transportation was not considered in this analysis, which could reduce transportation costs and make biomass resources from other areas more available.
- Construction and operation of wood-fueled power plants may have significant local economic impacts, but these impacts varied widely among selected counties, depending upon the particular makeup of the local economy.
- Wood fuel represents one of the largest expenditures for a power plant, and gives rise to large impacts in the local forestry and forestry services sectors. Other sectors of the local economy are also impacted through the indirect effects associated with purchased supplies and employee household spending.
- Impacts of a 40-megawatt power plant are greater than for a 20 MW plant, although not in proportion to the power output, due to economies of scale.

This profile was adapted from the following source and used with permission.

Langholtz, M., A. Oxarart, D. R. Carter, R. Schroeder, and A. Hodges. 2007. Wood to energy community economic profile: Florida: Alachua, Clay, Leon, Nassau, and Santa Rosa Counties. In *Wood to energy outreach program: Biomass ambassador guide*, eds. M. C. Monroe, L. W. McDonell, and A. Oxarart. Gainesville, FL: Florida Cooperative Extension Service, Circa 1526, University of Florida.

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Appendix F

Biomass Supply and Cost Profile: Worcester, Massachusetts

Introduction

This analysis looks at the biomass fuel availability for the area surrounding Worcester, Massachusetts. About forty miles west of Boston, Worcester is the second-largest city in Massachusetts, and the county seat of Worcester County. As of 2006, Worcester had about 176,000 residents. Analyses were also completed for the areas around Pittsfield and Springfield counties, and the five counties of western Massachusetts (Berkshire, Franklin, Hampshire, Hampden, and Worcester). We present these results from Worcester County as one example from Massachusetts. Results from the Pittsfield analysis are shown at the end of this report for purposes of comparison with a rural community. All reports are available at http://www.mass.gov/doer/programs/renew/bio-initiative.htm (search terms "MA Sustainable Forest Bioenergy Initiative").

Biomass Resources Near Worcester

Forest Resources

An analysis of the area surrounding Worcester was conducted using the United States Department of Agriculture Forest Service Forest Inventory & Analysis (FIA) system[1]. As discussed in chapter 6 of this guide and toolkit, the FIA system provides a better understanding of an area's standing forest inventory, land ownership patterns, timber growth and harvest volumes, and timber mortality volume.

Figure 1: *90-minute drive time and 60-mile radius, Worcester, MA*.

The FIA allows analysis on a radius from a point; in this example, the point is Worcester. Analysis was conducted for a 60-mile radius. Figure 1 shows a 60-mile radius (in red) and approximates a 90-minute drive time (in blue).

Within a 60-mile radius of Worcester there are 3,933,636 acres of timberland, representing 61 percent of the land area in the region. Of this timberland, 83 percent is privately owned, with the remainder under municipal, county, state or federal ownership.

Table 1 and Figure 2 show the distribution of land ownership within the region.

Within a 60-mile radius of Worcester the standing timber inventory is roughly 68 percent hardwood and 32 percent softwood. Annual net growth in the region is estimated at more than 3.3 million green tons per year[2], with harvest levels fewer than 1 mil-

Table 1: *Land classifications within a 60-mile radius of Worcester, MA.*

All Land	Acres	Percent of Timberland	Percent All Land
Private	6,412,938	83%	51%
Municipal/ County	3,277,053	6%	4%
State	362,736	9%	6%
Federal	40,099	1%	1%
Timberland	3,933,636	143,105	61%

Figure 2: *Land classifications within a 60-mile radius of Worcester, MA.*

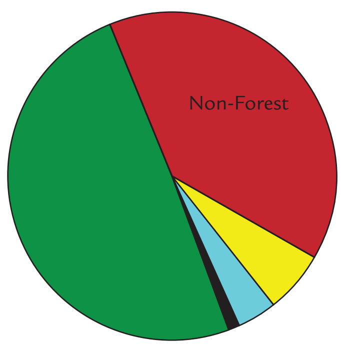


Table 2: *Annual growth and drain, 60-mile radius of Worcester, MA*[3].

	Softwood	Hardwood	Total
		Green Tons	
Standing Volume	77,540,036	161,599,152	239,139,187
Annual Net Growth	1,432,872	2,448,896	3,881,768
Annual Removals	767,661	1,654,757	2,422,418
Net Growth Less Removals	665,211	794,139	1,459,350

Table 3: *Annual growth and drain (without branches), 60-mile radius, Worcester, MA.*

	Softwood	Hardwood	Total
		Green Tons	
Standing Volume	100,026,646	208,462,905	308,489,552
Annual Net Growth	1,848,405	3,159,076	5,007,481
Annual Removals	990,282	2,134,637	3,124,919
Net Growth Less Removals	858,123	1,024,439	1,882,562

lion green tons annually. So, growth above current harvest and mortality levels is roughly 2.4 million green tons annually. Table 2 shows the estimated annual standing volume, growth, and removal for timberland within a 60-mile radius of Worcester.

It is important to note that the USDA Forest Inventory and Analysis, used to develop the data in Table 2, accounts for only merchantable stems of the trees-the wood that traditionally goes to roundwood markets such as lumber, veneer, pulp, or engineered wood products. While this wood, particularly the lower grades, is available for biomass, the branches and tops of a tree are also potentially available. In the northeastern U.S., it is estimated that for every ton of biomass contained in the stem of a tree, another 0.29 tons of biomass are contained in the branches and tops[4] (Table 3). To account for tops and branches, values in Table 2 are multiplied by 1.29 to yield the values in Table 3.

It is important to note that a considerable amount of the nutrients contained in a tree are in the tops (particularly when leaves are attached), and removal of high volumes of this material from a logging job can raise concerns about long-term sustainability. For this reason, as well as practical availability[5], Innovative Natural Resource Solutions (INRS) recommends that availability of tops and branches be considered at no more than 50 percent of reported availability . Subtracting 1.459 million green tons total net growth minus removals (Table 2) from 1.883 million green tons total net growth minus removals (Table 3) yields 0.424 million green tons total net growth minus removals of branches. Fifty percent of 0.424 million green tons is 0.212 million green tons that are available from tops and branches. Adding 0.212 million green tons of available tops and branches to the original 1.459 million green tons total net growth minus removals (Table 2) yields nearly 1.7 million green tons of wood that could be available before harvest and mortality exceeds growth. This volume of wood is enough to support more than 125 megawatts of electric power capacity operationg at industry standard efficiency and capacity factors. Because forest biomass is widely dispersed, it is highly unlikely that all this volume of wood could be harvested in an economic or environmentally responsible manner to supply biomass fuel. Further, some of this wood is comprised of sawlogs or other high-value material, and as such would be sent to other markets.

Wood Residues

Using data from the U.S. Forest Service, the U.S. Environmental Protection Agency, the National Renewable Energy Laboratory/U.S. Deparment of Energy, and the U.S. Census Bureau, INRS developed a national database of biomass residues available by county. The following counties, within a 90-minute drive time of Worcester, are included in the analysis (Figure 3):

Massachusetts: Bristol, Plymouth, Norfolk, Middlesex, Worcester, Essex, Franklin, Hampshire, Hampden

Connecticut: Tollend, Windham, New London, Hartford, Middlesex

New Hampshire: Cheshire, Hillsborough, Rockingham

Rhode Island: Providence, Kent, Washington, Bristol, Newport

Figure 3: *Counties within a 90-minute drive time of Worcester, MA.*

Forest Harvest Residues

Forest harvest residue is wood that is left in the forest because there is no market demand for it. In most areas, this includes tops, branches, and pieces that do not meet local specifications for sawlogs and pulpwood. Forest harvest residue is estimated to be roughly 1 million green tons a year in the counties surrounding Worcester[6]. This is largely a function of existing harvesting activity; in locations with high volumes of existing logging activity, volumes of forest harvest residue tend to be higher. Figure 4 shows annual harvest residue density by county.

Notably, the region surrounding Worcester has relatively low concentrations of harvest residues. This is a reflection of forest harvesting activity in the region, which is active but modest. This region does not currently have the level of forest harvesting seen in neighboring New Hampshire, a state with a relatively large biomass energy industry.

Figure 4: *Forest residues available by county (estimated).*

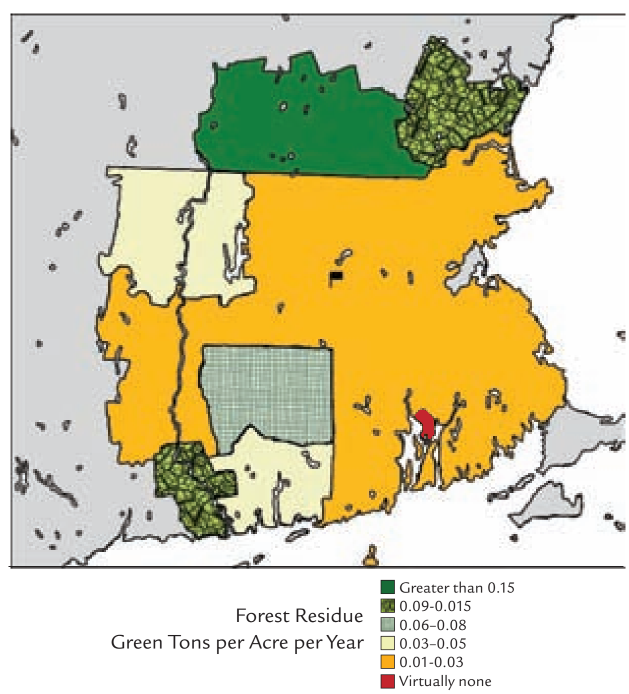


Figure 5: *Sawmill residues available by county (estimated).*

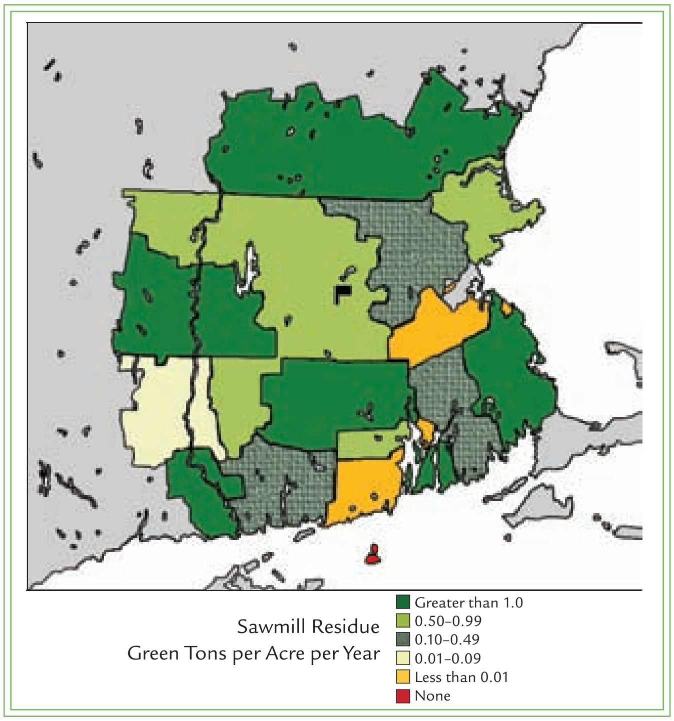
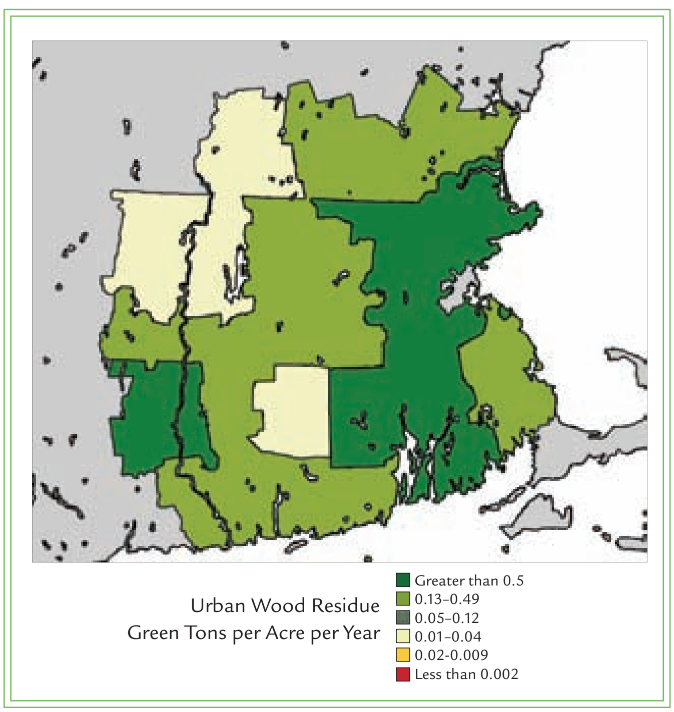


Figure 6: *Urban wood residues available by county (estimated).*



Sawmill Residue

When sawmills cut cylindrical logs into rectangular boards, residue is produced, including bark, sawdust, and mill chips. Actual residue generation varies by species and mill equipment, but a general rule of thumb is that a log in a sawmill produces 60 to 70 percent of useful timber as boards, 20 to 30 percent as wood chips, and 10 percent as sawdust[7].

Based upon the latest U.S. Forest Service Timber Product Output information, sawmill residue (chips, bark, and sawdust) in the region is roughly 850,000 green tons in the counties surrounding Worcester.

Urban Wood Residues

Urban wood residues consist of most wood generated as a result of activity in and around urban and suburban areas, and include tree trimmings, utility right-of-way clearing, ground pallets, and the clean woody fraction of construction and demolition debris.

In the counties surrounding Worcester, there is roughly 1 million green tons of urban wood available. This includes an estimated 530,000 green tons of wood from land clearing in the region.

Figure 7 shows the concentration of housing starts in the counties proximate to Worcester. Housing starts are a very good indication of the volume of land clearing expected in an area. It is important to note that land clearing activity is heavily tied to new construction activity; when construction activity slows, lower volumes of land clearing wood can be expected.

Biomass Supply Pricing

Table 4 shows anticipated biomass supply pricing, by source, for a hypothetical large biomass facility in Worcester, including the incremental volume and delivered pricing[8] by fuel source, the weighted average price, and the total tons. These results are shown as a stepwise supply curve in Figure 8.

For purposes of comparison, the results of the same methodology applied to the area around Pittsfield, Massachusetts, are shown in Figure 9. These results suggest that Pittsfield, which is more rural than Worcester, has less material from pallets, but greater access to forestry waste, resulting in a similar economic availability of woody biomass for both communities. (Complete supply reports for Pittsfield and other Massachusetts communities can be found at http://www.mass.gov/doer/programs/renew/bio-initiative.htm).

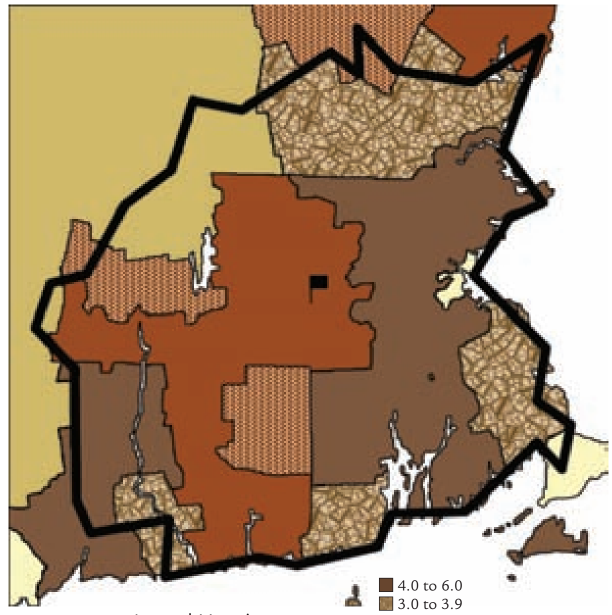


Figure 7: *Land clearing in the region surrounding Worcester, MA, with 90-minute drive time.*

This pricing assumes that the facility has fast unloading capabilities (including truck dumps), the ability to unload and handle a variety of fuels, a screening and processing system for fuel not meeting the facility's specifications, professional management of fuel procurement; and will purchase at least 200,000 green tons annually. Prices during the first year of start-up would be higher than listed in Figure 8 as regional supply capacity is built.

Each price grouping in the previous figures includes multiple suppliers, with price reflecting the average price within each grouping. For example, some land clearing chips may be available at less than $19 per green ton, but because there is a modest amount of land clearing in the immediate region, this only reflects an average price for the first 60,000 green tons. Price increases within like supplier groupings reflect increased distance to Worcester, need for companies to add processing equipment to existing operations (a significant need in the area around Worcester), and the need to compete directly with other markets as distance increases.

Pricing expectations were established based upon interviews with potential suppliers, INRS knowledge of operating costs of various types of biomass fuel suppliers, knowledge of the existing and potential supply infrastructure, and historic pricing for biomass supply in New England.

Table 4: *Anticipated Biomass Fuel Supply and Pricing.*

Source	Volume (green tons equivalent)	Price (green tons equivalent)	Extended	Weighted Average Price	Total Tons
Pallets	50,000	$18.00	$900,000	$18.00	50,000
Land clearing	60,000	$19.00	$1,140,000	$18.55	110,000
Land clearing	60,000	$20.00	$1,200,000	$19.06	170,000
Pallets	20,000	$20.00	$400,000	$19.16	190,000
Sawmill	20,000	$21.00	$420,000	$19.33	210,000
Forestry	70,000	$22.00	$1,540,000	$20.00	280,000
Forestry	60,000	$24.00	$1,440,000	$20.71	340,000
Sawmill	30,000	$25.00	$750,000	$21.05	370,000
Forestry	50,000	$26.00	$1,300,000	$21.64	420,000
Forestry	50,000	$28.00	$1,400,000	$22.32	470,000
Sawmill	40,000	$28.00	$1,1200,000	$22.76	510,000
Forestry	50,000	$30.00	$1,500,000	$23.41	560,000
Forestry	40,000	$32.00	$1,280,000	$23.98	600,000
Forestry	40,000	$34.00	$1,360,000	$24.61	640,000

Figure 8: *Anticipated biomass fuel supply and pricing for Worcester, MA.*

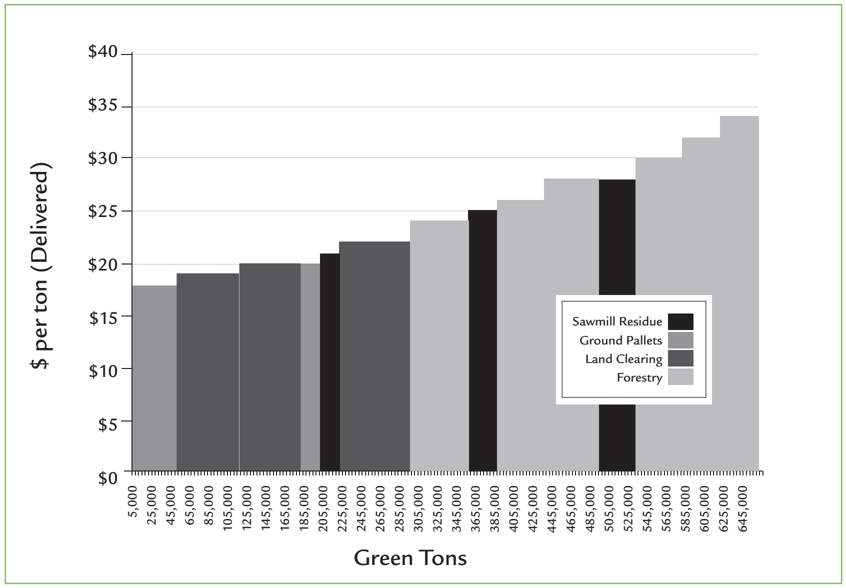
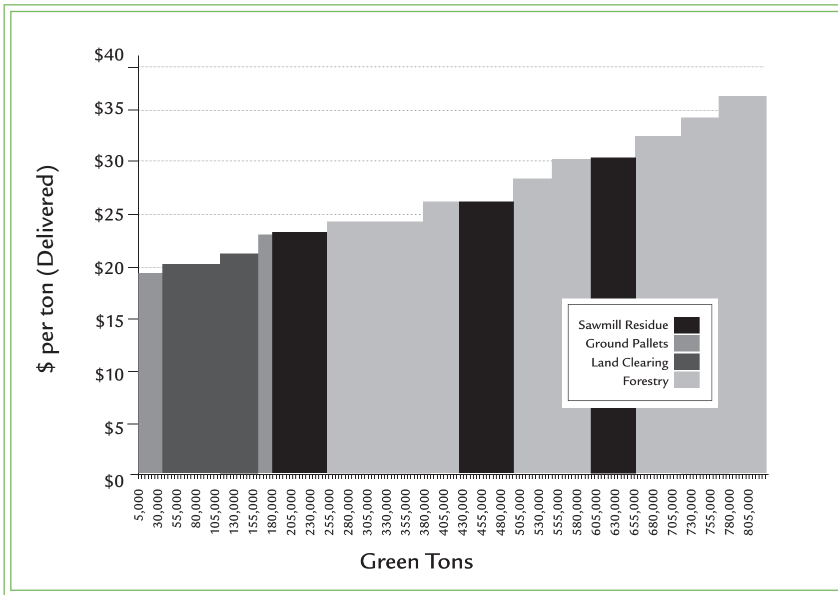


Figure 9: *Anticipated biomass fuel supply and pricing.*



Regional Markets For Low-Grade Wood

A number of markets exist or are proposed for low-grade wood, including but not limited to biomass fuel, in the region surrounding Worcester. Figure 9 shows the areas within a 30-, 60-, 90- and 120-minute drive time of Worcester.

In a 120-mile drive time of Worcester, there are ten active, idle or proposed facilities that use biomass, or low-grade wood that comptes with biomass energy production.

- Three operating facilities, with combined annual wood use of up to 840,000 green tons

•Two idle facilities
•Five publicly proposed facilities, in various stages of development

Wood use from all of the listed facilities has the potential to reach over 3.1 million green tons.

In addition to these facilities, there are many projects in the early stages of development that have not made public announcements or taken obvious steps to begin development activities. Figure 10 and Tables 6-8, show only markets large enough to exert their own market influence. Small facilities, such as those typically used at schools and hospitals, present excellent opportunities for biomass development, but do not individually influence the overall market for and pricing of biomass fuel.

Figure 10: *Urban wood residues available by county (estimated).*

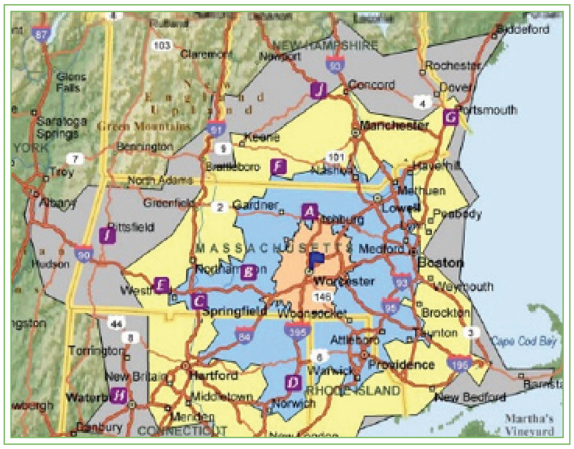


Table 5: *Facilities Using Low-Grade Wood near Worcester, MA.*

Drive Time (minutes)	Facility	Current	Potential
		Green tons	
60	Pinetree-Fitchburg	180,000	180,000
	Ware Co-Gen	-	50,000
	Palmer Renewable Energy	-	235,000
	Plainfield Renewable Energy	-	400,000
	Subtotal	180,000	865,000
90	Russell Biomass	-	630,000
	New England Wood Pellet	160,000	160,000
	PSNH Schiller Station	500,000	500,000
	Subtotal	660,000	1,290,000
	Running Total	840,000	2,155,000
120	Watertown Renewable Power	-	400,000
	Berkshire Renewable Power	-	600,000
	Bio-Energy	-	140,000
	Subtotal	-	1,000,000
	Total	840,000	3,155,000

Table 6: *Facilities within 60-minute drive time of Worcester, MA.*

Facility A	Pinetree-Fitchburg
Location	Westminster, MA
Status	Operating
Product	Electricity
Owner	Suez Energy North America
Size	17 MW (14 MW wood boiler, 3 MW landfill gas)
Fuel	Whole-tree chips, sawmill residue, ground pallets, paper cubes, and landfill gas
Annual wood use (est.)	180,000 tons
Worcester - road miles	24 miles
Worcester - minutes	31 minutes

Table 6 cont.: *Facilities within 60-minute drive time of Worcester, MA.*

Facility B	Ware Co-Gen
Location	Ware, MA
Status	Idle, approved for MA REC's
Product	Electricity
Owner	Ware Energy Company
Size	8.6 MW (2 units)
Fuel	Construction and demolition
Annual wood use (est.)	50,000 tons (estimate)
Worcester - road miles	28 miles
Worcester - minutes	41 minutes

Facility C	Palmer Renewable Energy
Location	Springfield, MA
Status	Proposed
Product	Electricity
Owner	Palmer Renewable Energy
Size	30 MW
Fuel	Wood, derived from a variety of sources
Annual wood use (est.)	235,000 tons
Worcester - road miles	52 miles
Worcester - minutes	53 minutes

Facility D	Plainfield Renewable Energy
Location	Plainfield, CT
Status	Proposed, in permitting
Product	Electricity
Owner	Decker Energy International and NuPower
Size	30 MW
Fuel	Whole tree chips; pallets, sawmill residue, and the wood fraction of construction; and demolition debris
Annual wood use (est.)	400,000 tons
Worcester - road miles	44 miles
Worcester - minutes	46 minutes

Table 7: *Facilities within 90-minute drive time of Worcester, MA.*

Facility E	Russell Biomass
Location	Russell, MA
Status	Proposed, in permitting
Product	Electricity
Owner	Russell Biomass LLC
Size	50 MW
Fuel	Whole-tree chips, sawmill residue, and pallets
Annual wood use (est.)	630,000 tons
Worcester - road miles	67 miles
Worcester - minutes	1 hour, 10 minutes

Facility F	New England Wood Pellet
Location	Jeffrey, NH
Status	Operating
Product	Wood pellets
Owner	New England Wood Pellet, http://www.pelletheat.com
Fuel	Sawmill residue, sawdust, and pulp quality chips
Annual wood use (est.)	120,000 tons (equivalent of roughly 160,000 green tons)
Worcester - road miles	49 miles
Worcester - minutes	1 hour, 1 minute

Facility G	Northern Wood Power Station (Schiller Station)
Location	Portsmouth, NH
Status	Operating
Product	Electricity
Owner	Public Service of New Hampshire
Size	50 MW
Fuel	Whole-tree chips with some sawmill residue and pallets
Annual wood use (est.)	500,000 tons
Worcester - road miles	88 miles
Worcester - minutes	1 hour, 32 minutes

Table 8: *Facilities within 120-minute drive time of Worcester, MA.*

FACILITY H	WATERTOWN RENEWABLE POWER
Location	Watertown, CT
Status	Proposed, in permitting
Product	Electricity
Owner	Tamarack Energy
Size	30 MW
Fuel	Whole-tree chips, sawmill residue, and pallets
Annual wood use (est.)	400,000 tons
Worcester - road miles	94 miles
Worcester - minutes	1 hour, 42 minutes

FACILITY I	BERKSHIRE RENEWABLE POWER
Location	Pittsfield, MA
Status	Proposed
Product	Electricity
Owner	Tamarack Energy
Size	30-50MW
Fuel	Whole-tree chips, sawmill residue, and pallets
Annual wood use (est.)	Up to 600,000 tons
Worcester - road miles	100 miles
Worcester - minutes	1 hour, 42 minutes

FACILITY J	BIOENERGY
Location	Hopkinton, NH
Status	Idle
Product	Electricity and thermal energy
Owner	Bio Energy Corporation (privately held)
Size	50MW
Fuel	Traditionally whole-tree chips and pallets
Annual wood use (est.)	135,000-145,000 tons per year
Worcester - road miles	98 miles
Worcester - minutes	1 hour, 35 minutes

Summary and Conclusion

Economic concerns are important to discussions of using wood for energy. For many communities, the conversation begins with the recognition that there might be enough wood at an affordable cost. This supply analysis suggests that about 400,000 green tons of wood per year are available in areas surrounding both Worcester and Pittsfield at prices up to $25.00 per green ton delivered. This is equivalent to about $3.00 per million Btu, a price competitive with other fuel options. The total of about 800,000 green tons per year is equivalent to about 60 MW of electricity generation capacity.

This profile was adapted from the following source and used with permission. Biomass Availability Analysis, Worcester, Massachusetts. Prepared by Innovative Natural Resource Solutions, LLC, for the Massachusetts Division of Energy Resources & Massachusetts Department of Conservation and Recreation, January 2007.

Endnotes

[1] Data developed using latest publicly available complete USDA Forest Service Forest Inventory & Analysis information – Massachusetts 1998, Connecticut 1998, New Hampshire 1997, New York 1993, Rhode Island 1998, and Vermont 1997.

[2] All USDA Forest Service Forest Inventory & Analysis is presented in cubic feet; converted to green tons assuming 85 cubic feet of solid wood in a cord, a cord of hardwood weighing 2.6 tons, and a cord of softwood weighing 2.3 tons.

[3] Data developed using latest publicly available complete USDA Forest Service Forest Inventory & Analysis information – Massachusetts 1998, Connecticut 1998, New Hampshire 1997, New York 1993, Rhode Island 1998, and Vermont 1997.

[4] North East State Foresters Association. *Carbon Sequestration and Its Impacts on Forest Management in the Northeast*. December 19, 2002. http://www.nefainfo.org

[5] The issue of forest sustainability standards for biomass fuel is beyond the scope of this report, and is a complex and controversial subject matter. However, at least one state, Minnesota, has developed draft biomass harvesting standards. *Draft Biomass Harvesting on Forest Management Sites in Minnesota*. Prepared by the Minnesota Forest Resources Council Biomass Harvesting Guideline Development Committee. May 1, 2007. http://www.forestrycenter.org

[6] This figure includes a remarkably high volume of logging residue in Cheshire County, New Hampshire. This information could be incorrect or could be the result of unique local conditions. INRS has confirmed the data with the USDA Forest Service and the US Department of Energy / National Renewable Laboratory, and both parties indicate that the baseline data as reported is correctly listed.

[7] Wakefield, Emily. “PyNe Workshop Report.” *ThermalNet*. Issue 04. June 2007.

[8] These prices assume 2007 dollars and oil at $75 per barrel.

Outreach Planning Worksheet

1) My Audience(s): ______________________________
(select two or fewer and be as specific as possible.)

2) Anticipated audience needs, values, concerns related to biomass and bioenergy:

____

____

3) The goal of my outreach activities is: ______________________________

____

4) Objectives of my outreach activities are:

1) ______________________________

2) ______________________________

3) ______________________________

5) The best tools for the job are (make sure these are appropriate for your audience, will help you meet your objectives, and are feasible with the time and money available to you):

____

____

____

6) Experts I can call on (titles or specific names):

____

____

____

____

7) Notes, next steps, draft agenda etc.:

____

____

____

Appendix H Sample Dear Neighbor Letter

Dear Neighbor:

Concerns about global climate change and our over-reliance on foreign fuel are creating increased attention for alternatives to fossil fuels—such as solar and wind power, biofuels, and woody biomass. Locally, wood may provide a good alternative to fossil fuels, and just like solar and wind power, wood represents an ongoing source of energy, as long as forests are managed properly and sustainably. Local forests can be managed properly to ensure that harvest rates do not exceed growth rates and that wildlife, soil, and water resources are not negatively affected. In addition, wood is a carbon-neutral source of energy, meaning that it does not raise the level of carbon dioxide in the atmosphere, providing trees are replanted.

There may be opportunities in the Hatchet County area to use wood for local electricity production or to supply a production plant that would convert wood into cellulosic ethanol (a renewable transportation fuel). There are still a number of concerns regarding the use of wood for fuel, including the effects on local forests, the likely increase of truck traffic to deliver the wood, and potential impacts on air quality. These and other issues warrant careful consideration. I believe the residents of Bloomington and Hatchet County can play an important role in this decision-making process by getting involved and participating in the local discussions about energy issues.

I invite you to a community discussion about this topic on Tuesday, December 14th at 6 p.m. at Bloomington Community Center. I'll provide a brief overview of the process of using wood for energy, and then we'll have ample time for questions and discussion. Several local experts from Utopia Energy and State University will join me. I'm excited to hear what you think about the idea of using our plentiful wood resources for sustainable energy, so I hope you can attend. Please feel free to contact me at (123) 653-2947 if you have questions or want more information.

Sincerely,
Dave Patterson
Hatchet County RC&D Council

Appendix I Sample News Release for Publicity

For Immediate Release
November 1, 2008
Contact: Scarlet Wilson, wood2energy@csu .edu

UPCOMING COMMUNITY FORUMS FOCUS ON USING WOOD FOR ENERGY

White River, Colorado

As the White River City Commission considers a wood-fueled power plant among the options for meeting our future energy needs, a series of community forums about wood-to-energy possibilities will be offered to involve residents in the discussion. During the next two weeks, the forums will be held in the evening at different locations in the White River area.

The purpose of the forums is to help residents educate themselves about the advantages and disadvantages of using wood to generate power. Scarlet Wilson, associate professor at Colorado State University, believes there is an important role for the public to play in environmental decisions. "The most valuable opinions are those based on informed judgment. This series of community forums shares the information we have about woody biomass and provides an opportunity for residents to ask questions, discuss the issues, and voice concerns," she said.

Information will be provided on various aspects of using wood for energy, such as environmental and economic impacts, potential sources for wood locally, the technology used in wood-fueled power plants, and sustainable forestry practices. You are invited to come and learn more about the energy possibilities in your town!

Times and places for the community forums are as follows:

– Wednesday, November 15th, 7pm-8pm, Civic Media Center, 123 University Avenue,

– Monday, November 27th, 7pm-8pm, Main Branch Library, 432 E. University Avenue,

– Tuesday, November 28th, 7pm-8pm, Hillhopper Branch Library, 5678 NW 99th Street.