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).

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.

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.

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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.

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.

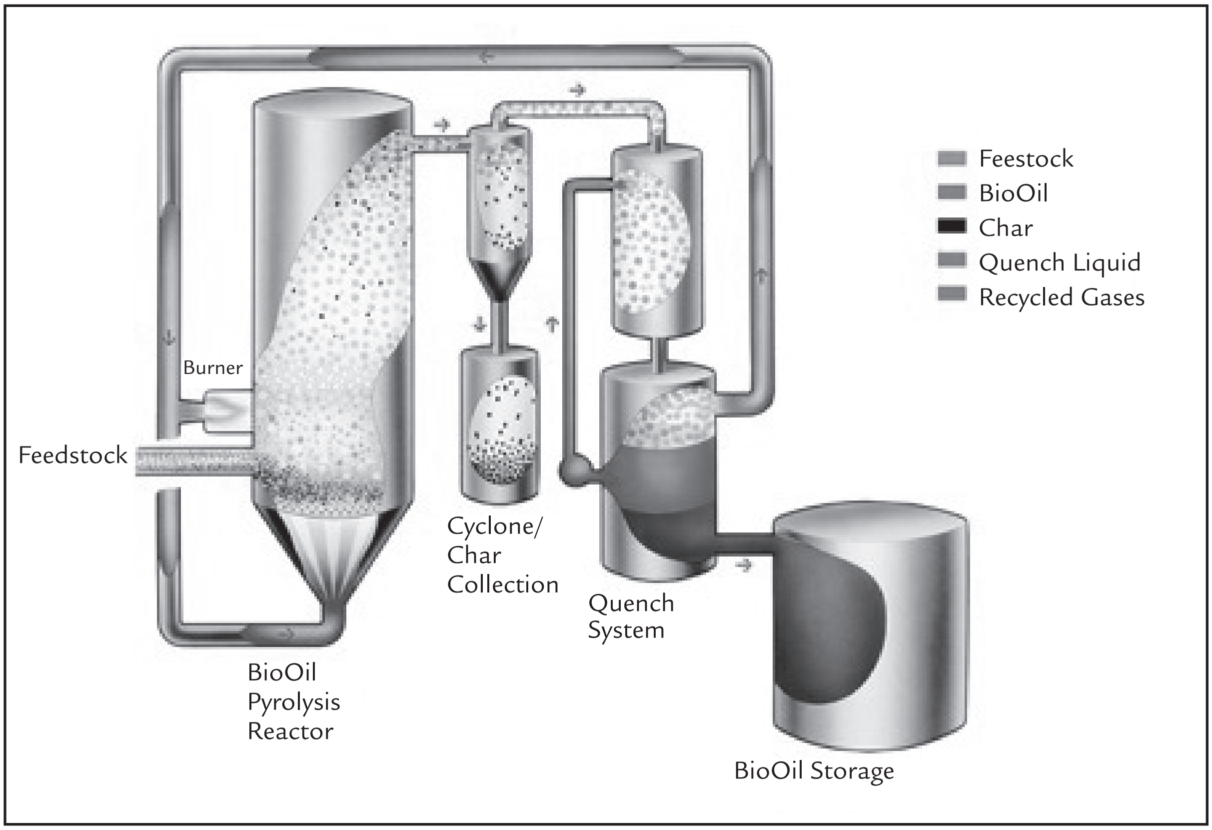
The pyrolysis process used is relatively simple in theory (Diagram 1). Feedstock is fed into a fluid-bed reactor, which is heated to between 840 and 930 degrees Fahrenheit in the absence of oxygen. This system uses lower temperatures than conventional pyrolysis systems, creating higher overall energy 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

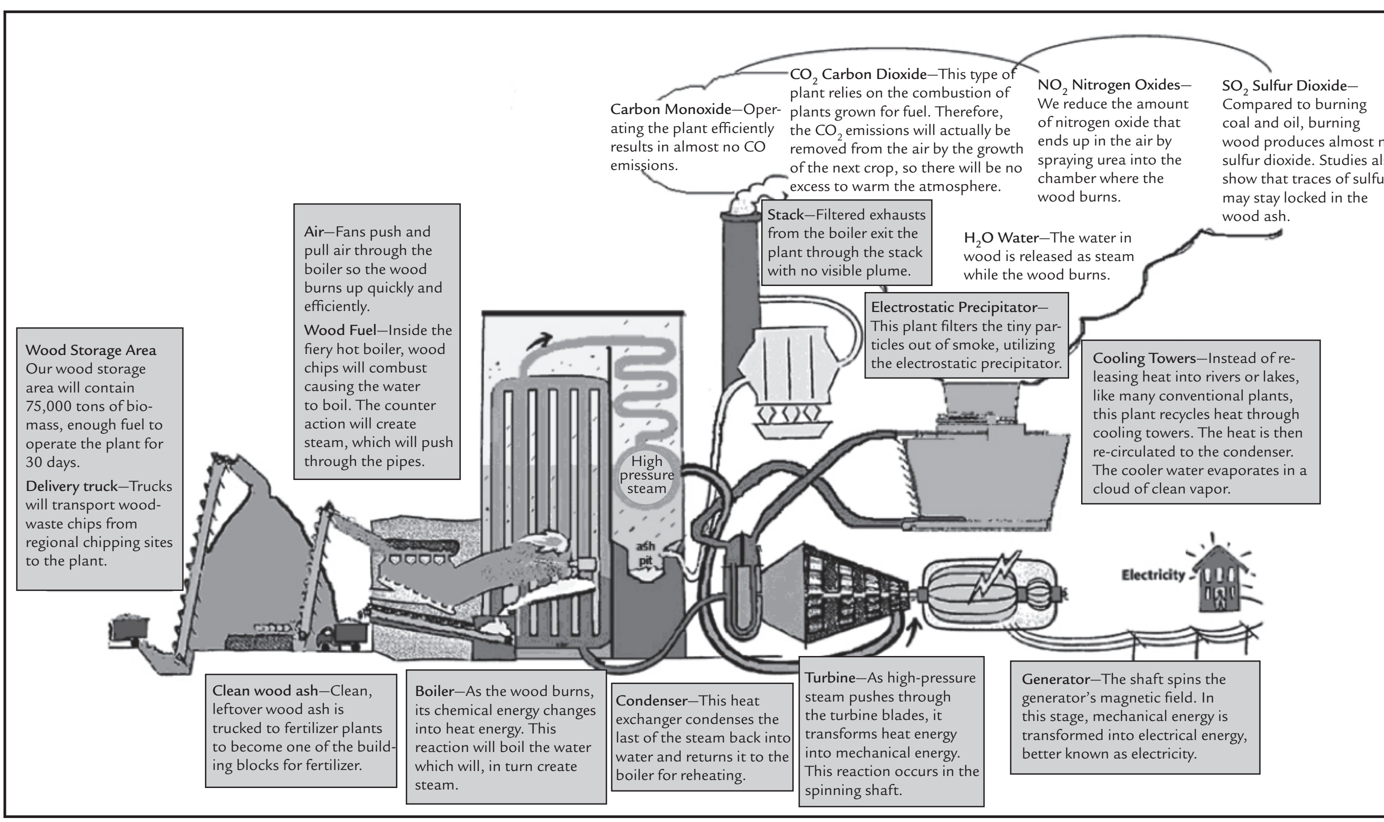
Aspen Power, LLC, is in the process of constructing Texas' first biomass bioelectric power plant. The 50 megawatt (MW) plant is to be located in Lufkin, Texas, and will utilize about 525,000 green tons of logging debris and municipal wood waste per year. The estimated cost is approximately of the plant 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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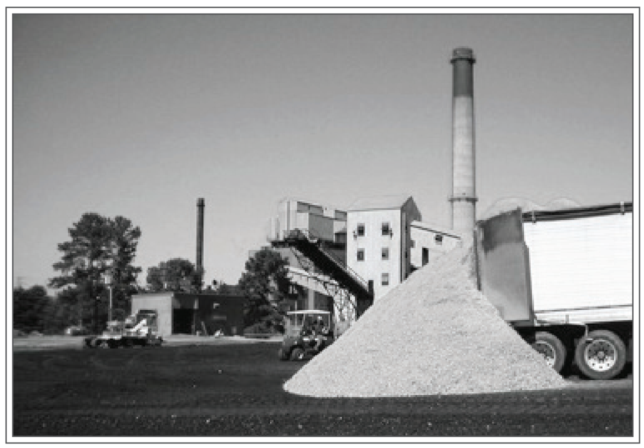
8.10 Co-firing with Wood and Switchgrass

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.

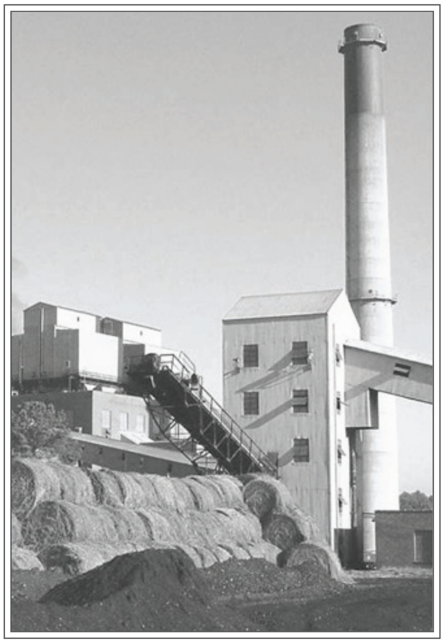


The few hundred tons of woody biomass used by Plant Gadsden each year are supplied by a sawmill; the switchgrass is supplied by a local farmer. Both sources of biomass are purchased directly from their respective suppliers. The price of each fuel source has recently increased due to higher transportation 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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