Case Studies on Wood Biomass Use in the Northeastern United States

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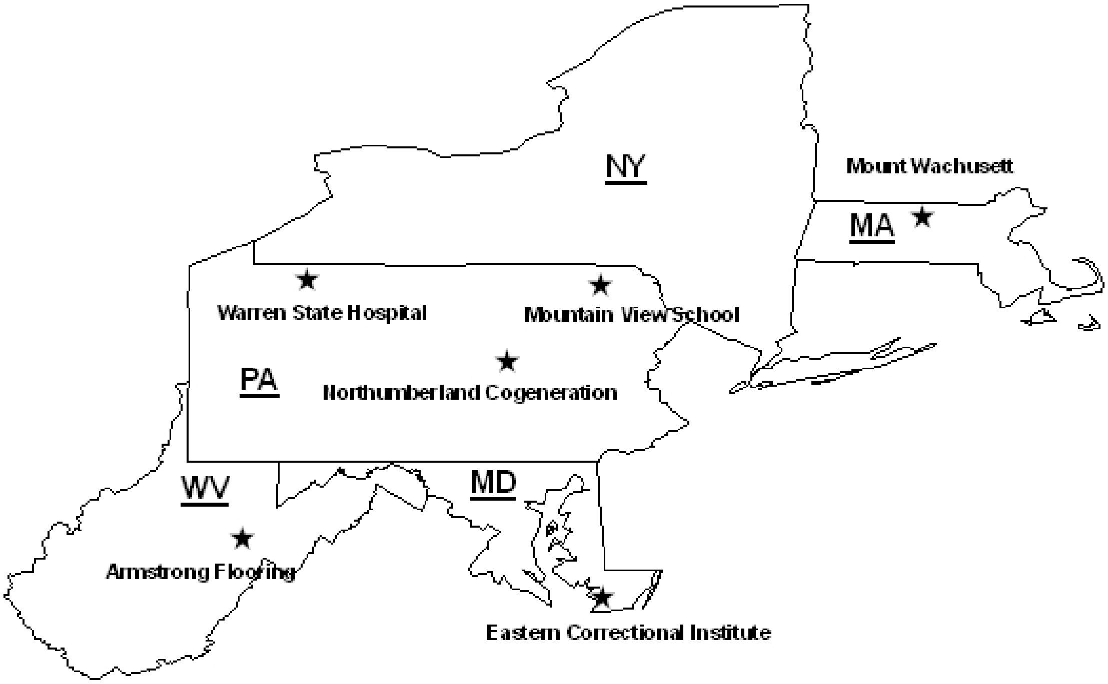
Appalachian Hardwood Center

WVU Division of Forestry

WVU Extension Service

Davis College of Agriculture, Forestry, and Consumer Sciences



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Executive Summary

This project was initiated to develop a Biomass Energy and Sustainable Forest Management Working Group in West Virginia and develop a series of case studies on the use of wood as an energy source. This document presents the information gathered at six visits to facilities that currently use wood biomass as an energy source. The culmination of this effort was achieved through collaboration among several partners including Jeff Slahor, Jody Gray and Shawn Grushecky with the Appalachian Hardwood Center, Jeff Herholdt and Bill Willis with the West Virginia Development Office, John Karakash with Viking Energy, and Ed Cesa with the USDA Forest Service Northeastern Area State and Private Forestry. We would like to thank all of the case study participants for their help in the development of this document. Without their assistance, this effort would not have been possible.

The preparation of this document was financially aided through a grant administered by the U.S. Department of Energy. The development of an Energy Conservation Program was prepared as a cooperative effort with the Energy Efficiency Program, West Virginia Development Office and the West Virginia University, Appalachian Hardwood Center

CHAPTER 1 – BIOMASS AS A FUEL SOURCE

The term “biomass” refers to plant mass that can be converted into a fuel, as well as any animal or human waste that is convertible into solid or gaseous fuel. Biomass fuels typically contain one half to two-thirds the energy densities of fossil fuels. They are very desirable energy sources because they are available over much of the earth’s surface and, unlike fossil fuels, they are renewable. Biomass as a fuel source can be separated into four main types; wood, waste, alcohol, and agricultural residues. Of these wood is currently the most inexpensive form of biomass energy.

*Sawmill Edger, AHC Photo

Wood that is used as a fuel source mainly comes from forest residues or log processing residues. The process of turning trees into logs, logs into lumber, and lumber into finished products produces residues such as sawdust, shavings, edgings, cut offs, and bark. In the hardwood industry it has been stated that half of the wood in a tree is left in the forest as logging residue, half of the log becomes mill residue, and half of the lumber becomes machining residue. About one eighth of the wood in a tree is used in the final end product (Patterson & Zinn 1990). These residues are highly combustible and serve as an excellent fuel source; although they are not used as widely as fossil fuels. The main drawbacks to burning wood are the high initial capital investment and higher annual maintenance costs. However, these costs can be quickly recovered through fuel cost savings alone.

There are several factors that must be taken into consideration when using wood as a fuel source and determining the fuel value/Btu content of wood residue. One of the main factors that plays a very large role in the burning of wood is the moisture content. Moisture content may be summarized as the percentage of wood mass that is water weight. The vaporization of water to steam requires a heat input of 1000 Btu / lb. This reduces the combustion efficiencies because some of the energy is then spent to dry the fuel prior to burning it. Typically the higher the moisture content the lower the Btu's that are produced when burned. Wood species also plays a considerable role. Each species of wood has different cellular structures and chemical extractive contents, resulting in different densities and Btu contents. It is very important for boiler operators to have an idea of the species mix and moisture content of the fuel being used so that they can make adjustments to system parameters, such as feed rates and fire temperatures, to achieve desired boiler pressure.

Wood Fuel Characteristics

Wood fuel types	Moisture Chart (wet basis)	Gross Heating Value (Btu lb.)	Bulk Density (Lbs./Cu.ft.)
Dry Mill Residue	13	7,000	12
Green Mill Residue	40	4,800	15
Whole Tree Chips	45	4,800	23
Densified Fuel	8	8,000	45

Source: Industrial/Commercial Wood Energy Conversion, Council of Great Lakes Governors.

*Table courtesy of Great Lakes Regional Biomass Energy Program, Abby Feely

Most facilities that use wood as a fuel source for boilers follow a similar set of steps to obtain the energy from the wood. First the residue is delivered to the facility and unloaded. Once unloaded it is usually sent through a screening system to filter out objects that could potentially harm the system, such as gravel and frozen chunks of wood and mud. After the material is screened it is sent to some sort of storage system, usually silos. The storage units are generally large enough to hold several days, or weeks, worth of fuel to ensure a steady supply of material into the system.

*Dust feed system, AHC photo

Material is fed from the storage units into bins that regulate the rate of flow going into the firebox, usually referred to as metering bins. The feed rate is typically established by the amount of boiler steam pressure. Each boiler system is rated and regulated to operate at different pressures. Most fires are top fed and the material is shaken into the fire. The shaking process breaks up clumps of wood fuel that do not burn well. By sprinkling the material into the fire, complete combustion occurs as it ignites and burns completely before it hits the grates of the firebox.

*Silo, AHC photo

Another factor that plays a major role in the temperature of the fire is the air intake. Oxygen is required for combustion and most of these combustion systems are set up with an under-fire and over-fire air intake. By regulating the amount of air injected into the fire box an operator is able to control the combustion rate, and thereby control the temperature and amount of steam produced by the boilers. Very little ash is produced by systems such as these, typically around ¼ cubic yard per day. Air quality and emissions from these types of systems are also regulated by federal and state ordinances, and vary slightly from state to state.

*Photo courtesy of Appalachian Hardwood Center

A strong environmental argument for increasing the use of biomass fuels is their zero net contribution of carbon dioxide to the atmosphere. Biomass fuels release and absorb carbon dioxide at basically the same rate, unlike fossil fuels, which took millions of years to accumulate but only seconds to be released (Flora 1995). Perhaps the strongest economic reason to increase the use of biomass fuels is to reduce the United States dependency on imported fossil fuels, mainly petroleum. Biomass has proven to be economical and an excellent fuel alternative to fossil fuels. The following case studies are just a few examples of successful facilities and how they operate with these wood-burning systems.

*Photo courtesy of Berkley College

CHAPTER 2 – CASE STUDIES

Warren State Hospital

Warren State hospital is located near the town of Warren, Pennsylvania. The facility uses steam from their three boilers to produce heat, hot water and cooking steam for approximately 200 patients and 400 faculty members. Their boilers were originally installed in 1954 and were originally set up for burning coal and were retrofitted in 1967 to burn gas and oil. In 1984 boilers 1 and 2 were re-tubed and in 1990 boiler #3 was re-tubed in preparation for the conversion to wood burning. Conversion Ventures designed the wood boiler system and it was recommended to be installed at Warren State Hospital.

Target production of the system is 16,000 to 18,000 lb steam/hr and they are limited by the DEP to a maximum production of 21,000 lb/hr. They consume approximately 71 tons of wood residue per day in the winter months and 35 tons per day in the summer months and an annual average of 7520 tons. At an average cost of $19.27 per ton this system costs approximately $145,000 per year and saves $400,000 over a gas burning system annually. Warren has a contract with a residue broker, Oaks Forestry, to supply fuel. The supply radius for the residue is up to 80 miles and during the winter months can still become hard to obtain. In the event that fuel runs low, Warren has the ability to burn gas as well. Written in their supply contract is the contingency that if fuel runs low and the need for gas arises, the broker must pay for the cost of burning gas. Fuel arrives to the mill pre screened; this stipulation resulted from an incident in which they received gravel in the fuel. The gravel jammed their disc screen and broke the drive shaft, causing significant down time.

Up time on the system is 70 – 80% and the majority of the down time is scheduled. They take the system down twice annually for preventative maintenance, in the spring and fall. During this time the entire system is inspected for any potential problems. For the first four years of operation they had a service contract with Laidig to perform this maintenance. Recently, the state decided to drop the contract.

* Unloading station, AHC photo

Delivery trucks must have a moving floor to be able to unload, which takes about 45 minutes. The residue is then fed via conveyor to a disc screen. The screen sorts out particles too large to burn in the system and dumps them into a barrel. During the winter months when some of the particles are frozen together into clumps they also get sorted out. Those clumps are allowed to thaw and then simply fed back into the system; chunks of wood that are too large are land filled. After disc screening the particles move on to a bucket elevator where they are carried up and dumped into the silo. The storage silo at Warren holds 59,000 ft^3, about one week's worth of fuel, as mandated by the state. They suggest that it would be of best interest to have an emergency shutdown on the silo in case of malfunction, to prevent damage further along the fuel stream. They also advised that the auger and other dust handling parts be coated with Teflon to help increase wear life.

This system was designed to burn the particles in suspension, before they hit the grates, maintaining a temperature of approximately 1100^{o} F. Currently they only have one thermo-couple in the firebox, however they plan to add two more, so they have a better profile of the temperature range within the furnace. There are 13 over fire air jets in the system to provide sufficient oxygen. The under fire air jets provide air to the underside of the fire that has been heated to 224^{o} F. If the system has been down long enough to cool, they bring it pack up to temperature using gas. It usually takes 8 – 12 hours of burning gas to get the brick temperature up high enough to switch to wood.

Once the ash is removed from the system it is dumped into a three cubic yard dumpster. Approximately one dumpster full per week is produced. In 1996 the DEP stated that the ash needed to be land filled, which costs the hospital an additional $280.00 per month.

Warren keeps one plant mechanic, one floater, and two operators on hand each shift to run their system. They also emphasize the importance of having well trained operators who are comfortable with and like the system. One interesting note highlighted by WSH staff is that when they were considering converting to wood fuel, the local gas company offered to cut the gas rates for the facility by 50%.

Armstrong flooring

Armstrong is one of the leading floor covering producers in the country. Their Beverly, WV facility, formerly Bruce Hardwoods, produces approximately 1 1/2 million square feet of pre-finished hardwood flooring per week. They believe in and strive for complete utilization of all wood fiber that comes into their facility. Currently they are running 6 mill lines and 2 sanding/finishing lines that produce dust from three primary species of wood, Red Oak, White Oak, and Hard Maple. From this they produce three primary types of residue; course from the mill, finish dust from the sanders, and ball splinters and sawdust from the hog grinder. At this current rate of production, Armstrong fills approximately one tractor-trailer load of saw and sander dust per hour of operation. This level of production is much more than they need to fuel their boiler system. To deal with this level of production, they market and sell all excess dust and edgings. Each by-product has its own unique market.

The material that Armstrong does not sell is used to fuel their two boilers, which produce steam to dry the wood used to manufacture flooring and heat the facility. By using wood to fuel their boilers they are able to use very little natural gas, or other energy sources. The only area of the mill that uses any other source of fuel is their finishing process. Both boilers are 1175 hp manufactured by the Industrial Boiler Company (IBC), recently bought by McBurney in Georgia. They were built in 1989 and have a maximum rated pressure of 300 psi, although they normally run between 125 – 130 psi, resulting in a load of 37,000 lbs/hr. One boiler hp equates to 33,700 Btu, which is quite considerable. Their facility requires them to burn approximately 20 – 25 tons of dust per day to maintain operations. Recent studies by Armstrong revealed that the Oak/Maple mixture they burn produces approximately 8000 Btu's / hour. And the heat content of steam at 120 psi and 375^0 F is 1193 Btu/ lb.

Armstrong pays particular attention to air quality emissions. They have large investments into air pollution control equipment. They have added an electrostatic precipitator to remove fine particulates from the air, along with oxygen analyzers in the stacks for safety and to control emissions.

The silo system, or fuel storage system, that Armstrong uses has the ability to feed either the boilers or a truck-loading bin. If the dust is not needed in the burning system, it is sent to the truck-loading bin for outside markets. Their system requires that boiler operators monitor the system constantly. Changes in the moisture content of the dust, as well as the particulate size, require constant adjustments to the system to consistently produce the required level of steam.

*Armstrong lumberyard, photo courtesy of AHC

As with most other wood burning facilities, Armstrong suggests that there be an alternative fuel supply. If problems arise with the burning of wood, one still has the option of switching to gas. They also emphasized the importance of keeping dust in the system. Most systems are equipped with an abort function, which diverts dust out of the system if a problem were to arise. When this happens, the diverted dust must then be cleaned up and returned to the system, requiring a considerable amount of manpower and time. Armstrong also suggests the implementation of a gas ignition system. Currently their boilers must be started by hand. This basically requires that operators build a small fire in the bottom of the burning chamber until temperature raises enough to start feeding wood dust into the system. This process is somewhat time consuming and complicated.

Mountain View School District


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The Mountain View School District constructed a new elementary school building in 1991 in Kingsley, PA. This building is located approximately 800 feet from the high school that was constructed in 1956. The buildings encompass approximately 200,000 square feet. As the result of a presentation to the school board by the Pennsylvania Energy Center, a thorough investigation into wood fueled heating systems was initiated. After extensive research and some field trips to view existing systems a commitment to a primary wood fueled heating system was made. Sylva Energy, Inc designed the system.

The system was financed within the total building construction budget and installed in the elementary school building with the heating water for the high school building pumped via well-insulated pipes under the roadway separating the two. It is a direct-fired sloped combustion system with the fuel entering the combustion chamber at the top of the slope and slowly moving down slope by gravity and the force of new fuel entering. Virtually complete combustion results in minimal ash. It is used as the primary heat system for both buildings during the peak heating months of November to April. As an emergency back up two 40 GPH HB Smith fuel oil furnaces were also installed. These are also used on the 'wings' of the peak heating time to take the chill off in the morning or to cover unusually cool days.

The energy from the combustion of the wood fuel is used to heat a boiler (a bit of a misnomer as the water is heated to 190^{O} F) with an output of 10,798 MBH equivalent to 323 HP. The system requires minimal manual oversight, as it is computer controlled from drawing the fuel from the storage bunkers to maintaining the required amount of fuel in the feed hopper that is the immediate source of fuel to the combustion chamber.

The software was designed to respond to the demands for more or less heat by increasing the fuel introduction rate as well as to control fans that introduce air over the burning fuel in order to maintain optimal combustion. The main source of feedback for the computerized control of the combustion chamber is the temperature of the outgoing and return water, which are set at 190^{O} F and 140^{O} F, respectively. The software is also designed to allow monitoring and adjustment of heating conditions in individual classrooms, offices, etc.

Fuel for the system is obtained from a local land-clearing firm that does whole tree chipping. They supply a chip of approximately two inches in size at moisture content of 30-55%. Fuel contracts are put out for bid yearly with a current price of $25 per ton. Fuel consumption over the years has averaged in the range of 1200 to 1600 tons per year. Fuel storage consists of two side by side below grade concrete bunkers holding approximately 350 cubic yards of material that equals a 3-4 day

*AHC Photo

supply. Chips are delivered via live bottom trailers that minimize spillage, which would require manual clean up. The chips are automatically moved forward to an auger by a series of piston driven rakes. The auger then delivers the chips to the feed hopper that in turn meters the chips to the combustion chamber as described above.

Regular maintenance as well as unexpected downtime has been minimal. Thanks mostly to the live bottom trailers and the automatic fuel delivery, regular system maintenance generally consists of cleaning up a wheelbarrow worth of chips spilled from the trailers, taking out the bottom ash, changing the 55-gallon drums that collect the fly ash, and occasionally checking the fuel delivery system when warned by the software a problem has occurred. The latter is usually due to an off size piece of fuel bridging and stopping up the fuel flow. Since construction, only three unplanned maintenance/improvements events have occurred. One was the upgrading of the computer control system. The second was the installation of an automatic boiler tube cleaning system which eliminated the required manual cleaning of the tubes which had to be done 2-3 times a year, each taking a day or two to complete plus a day or more prior in order to allow for sufficient cooling. The third upgrade points out the need for as much initial planning as possible. This unexpected upgrade involved putting a water drain under the furnace at the lowest point of the entire set-up. A relatively high water table had not been considered and this type of retrofit was very expensive.

The heating system falls under the requirements set forth by the Pennsylvania DEP covering air quality/emissions. There have been no difficulties meeting or exceeding the specified requirements with the cyclone exhaust cleaning system removing much of the particulate material. The ash collected falls into two categories and, as with any combustion system of any size, is a potentially regulated waste. The DEP has found that the ash, both bottom ash from the combustion chamber and fly ash from the cyclone exhaust cleaner are safe enough to use as a soil amendment. It is used on the grounds as such.

One way to judge the success of any major financial undertaking such as the installation of a new or replacement heating system is cost savings. For the Mountain View School District this can be summed up in a memo from Ted Dellert, Supervisor of Maintenance, Buildings, and Grounds to the Superintendent and Business Manager of the school district dated May, 8, 2003.

“Fuel oil has a rated potential of 139,000 Btu per gallon. Based upon published standards one ton (2000 lb) of wood @ 4000 Btu/lb provides 8,000,000 Btu of heat. This translates into $0.000002875 per Btu cost for wood @ $23/ton. 139,600 Btu provided by wood costs $0.401, therefore burning wood is approximately equal to burning $0.40 per gallon fuel oil. Mountain View pays .8166 per gallon of fuel oil purchased on bid for 2002-2003 school year. Based on these numbers the apparent savings realized by utilizing wood fuel during the 2002-2003 school year has been $28,848.00.”


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Eastern Correctional Institution

The Eastern Correctional Institution located in Westover, Maryland houses approximately 450 inmates. The prison opened in 1987. In order to assure an uninterrupted supply of electricity the Maryland Division of Corrections had a twin boiler 2.3-2.5 MW generating plant constructed that is fueled with locally produced wood chips. The plant provides approximately 90% of the prison's electricity with the remainder being purchased from local electric utility company.

The system was built such that the prison can be disconnected from the utility power grid with the threat of impending bad weather. The two back up 1 MW diesel generators can then be started which, when combined with the wood fueled generators, provide 100% of the electricity required by the prison. In addition to providing most of the prisons electricity as well as a secure back-up power source, the expanded steam is also sent to the prison where it is used for "hotel" services such as cleaning and laundry, to produce hot water, as well as air conditioning.

Several days supply of wood chips are piled outside a fuel storage building. The chips, delivered in live-bottom trailers, are a mix of hard

*AHC photo

wood and softwood averaging about 45% in moisture content. The size of chip currently is specified as a large 2.5”.

This size specification was used in order to reduce problems at points in the generation process, and in the combustion chamber, from “fines”. Fines are basically powder sized wood material that was found to collect in between and clog the heat transfer tubes at the top of the combustion chamber. From this pile front-end loader moves chips into a concrete building with a ‘walking floor’. The floor moves chips to an auger, which deposits them on a belt outside the building, which begins the trip to the combustion chamber. The wide belt with raised “tread” carries the chips up to a sorter. On the way to the sorter the chips pass by a magnet to remove any metal. The magnet is surrounded by a belt that is rotated by an electric motor past a scraper to remove the metal into a collection box. A sensor immediately past the magnet automatically shuts down the belt if anything should get past the magnet.

*AHC photos

Beyond the magnet, at the top of the belt, the chips drop into a sorter, which kicks out over-size chips into a hammer mill where they are reduced in size and returned to the fuel stream. From the sorter, chips are moved by auger to a bucket elevator, which carries the chips to the top of the concrete storage silo, which holds 840 tons of chips. From the base of the silo the chips are now moved, again by auger, up to another bucket elevator, which carries the fuel into the building, which houses the twin combustion chambers. There is an emergency bypass placed before the bucket elevator taking the chips to the top of the storage silo. If problems arise such that chips cannot be drawn from the silo the bypass kicks in and an auger delivers chips from just past the sorter directly to the bucket elevator taking chips into the combustion chambers.

Once inside the building the chips are moved to the two feed hoppers (one for each boiler) by auger. The level in each hopper is electronically monitored which, in turn, controls the over-all speed of the movement of chips from storage to the feed hoppers. From the feed hopper twin augers move the chips to the top of the combustion chamber. The combustion chamber is a sloped shaking grate type. It does not revolve as a belt (a moving grate system) but rather moves back and forth similar to a walking floor. At the bottom of the grate the bottom ash falls into a collection area from which it is blown into an outdoor hopper and collected in a bin. As is the case with many systems such as this, bottom ash can be used as a soil amendment. Fly ash is collected from the exhaust stream by a cyclone device, is collected in 55-gallon drums, and disposed of as hazardous waste.

During our visit fairly extensive improvements specific to the boiler system were under way. One of the twin wood fueled boilers was completely off line and having a larger over fire oxygen/air intake system installed. This is anticipated to have two large positive effects on

*AHC photo

future operation, based on the new system allowing for the use of a more standard sized (substantially smaller than the current 2.5”) fuel chip.

- Far fewer “fines” equals less clogging and subsequent downtime, and
- Greater competition among fuel suppliers (lowered cost) as there are only two sources for the current oversized chip.

As stated above, the chip size specified for the plant is far larger than the average pulp chip. The size was decided on in the early stages of operation when various sources of biomass, including chicken litter, were experimentally tested. The “fines” caused several problems from start to finish. They would fall out of the fuel transport system and collect at various areas. These would then need to be manually collected and removed. Also, once in the combustion chamber, some of the un-combusted fines would drift up into the heat tube exchange area. Because the system was originally designed for oil or natural gas, combustion systems in which fines in the combustion area are not a problem, the heat exchange tubes ran fairly close together. The wood fines would build up and bridge these spaces reducing heat exchange efficiency. So the larger over fire intake system will keep the fines down, resulting in better combustion and keeping the exchange tubes unclogged. But it should also allow the use of a more standard size chip. The latter will serve to increase the plants potential fuel suppliers considerably as there are currently only two suppliers capable of producing the oversize chip.

Summary

The Eastern Correctional Institution is win-win system for all involved. It utilizes forest thinnings and land-clearing material that might otherwise be open burned or left to rot. It maintains a high level of security at the correctional facility by guaranteeing an uninterrupted power supply. And it reduces the cost to Maryland taxpayers by reducing unavoidable utility costs.

Northumberland Cogeneration Facility

The Northumberland Cogeneration Facility (originally known as Viking Energy of Northumberland), owned by Tractebel Power, is located in Northumberland, PA. Construction began on the project in March 1987 and the facility became commercially operational in December1989. The facility sells electricity to PPL Electric and steam to Furman Foods, inc., both under long-term contracts. Steam is also supplied (at no cost since 1989) to adjacent Tuckahoe Fire Department for space heat.

*AHC photo

Wood fuel for the facility is obtained from a range of types and sources. They include chips and shredded wood from conventional logging, recycling and salvage sources: tree debris from development land clearing, yard waste, storm damage, sawmill residue, and recycling of ground pallets. Fuel is purchased from local suppliers who deliver the wood to the facility in standard tractor-trailers. They are weighed on a standard truck scale and then back onto a Phelps wood truck dumper (a tilt-lift system).

*AHC photo

The rear doors of the trailer are locked open and the dumper raises the bed of the lift to a sufficient angle for gravity to cause the wood to slide out into a large hopper. The dumper is then lowered, the truck reweighed with the difference being the tons of fuel purchased. Amount paid for the fuel will depend on several factors including quality, moisture content and species.

Chips in the hopper are then initially screened to remove oversized pieces, sorted, run past a magnet to remove metal, and deposited on top of the working fuel pile (the source of currently used chips) via a belt on a Kohlberg stacker.

*AHC photo

The stacker is capable of stacking 130 tons per hour and evenly distributes the chips over an 180^{O} arc at the top of the pile. A section of the pile is held as back-up fuel that is regularly rotated into use to prevent spontaneous combustion. At the bottom of the working pile is an auger on a central pivot moving chips to another auger that moves the chips to the screening bunker. This is an under ground building, where further screening is done and the feed system into the building becomes redundant, where if one feed-line fails the other can be switched on. From the screening bunker the chips are moved via belts to the top of the combustion chamber and into a feed hopper where the fill level is monitored and controlled by electronic sensors. Augers then move the chips from the feed hopper into the top of the combustion chamber, which is a sloping moving grate system.

All of the fuel handling from the screening bunker onward are both redundant and monitored electronically such that any event interrupting the flow;

- of fuel to the combustion chamber,
- of proper combustion and emissions levels,
- of the end product of 16.2 MW (Net) and the expanded steam sold

to a nearby food processing plant, and
- all return stem condensate (as this is a virtually closed loop system),

will set off warnings in the control room allowing the operator to direct attention to the area in need of correction. The system is efficient enough to allow for a night shift of only two people.

The Facility consumes 600-700 tons of wood chips per average day. While the plant directly employs 21 people, its fuel source, wood, results in an additional 900 estimated jobs in service businesses needed to keep the plant operating safely and efficiently. These jobs would include people involved in the following support roles.

- On a daily basis, forest products, fuel production/delivery, ash sale and use
- On an occasional basis, contractors for equipment maintenance and repair
- On a weekly basis, operational supplies and services

*AHC photo

The facility was developed after the second oil price rise of 1979 as a locally self-sufficient energy supplier. As with most businesses it received limited tax incentives but otherwise no grants or direct government funding. The single largest alteration that operators would make to the process would be to improve the screening of the delivered fuel such that material that is too large would be automatically fed into a subsystem and then redirected into the fuel flow. Also, the magnet currently used to remove metal must be manually cleaned. An automatic cleaning system is in the planning stages as well.

The plant meets Title V air quality standards as well as other required areas of control such as water discharge and surface run-off covered by the National Pollution Discharge Elimination System. The Facility is a good example of converting waste material into salable products. Wood ash is created in two-forms, as with any combustion of this sort, fly ash and bottom ash. Fly ash is small particles removed from the chimney exhaust by a state of the art air quality control system. It can be used/sold as a liming agent and nutrient additive to potting soil and landscape mulch. It can also be used as an odor control agent in composting operations. Bottom ash remains after wood is fully combusted and consists of the sand and stone that was not removed in screenings, chunks of ‘slag’ or fused fly ash, and some steel or other metals (as from scrap wood pallets) that also made it through screenings and the metal detecting system. Bottom ash substitutes well for quarry stone as a road base.

Summary

The Northumberland Cogeneration Facility is an excellent example of turning what might otherwise be a waste wood material, into a fuel for generating electricity, industrial steam usage, and space heat. The end products of combustion are in turn marketed and sold as product, as opposed to being handled as waste.

Mount Wachusett Community College

Mount Wachusett Community College, located in Gardner, MA, began an analysis in 1996 focused towards reducing energy consumption and the concomitant. With the entire system based on electricity, initial action included the purchase of lower priced electricity from a consortium, installation of energy efficient lighting, variable speed motors, high efficiency water chillers for air conditioning, as well as low flow toilets. This resulted in an immediate savings of $125,000 per year. More recently, faced with the loss of lower priced electricity from the consortium, the college was faced with a potential doubling of electric rates. This forced an extensive study of space heating With total energy costs of approximately $850,000 per year, any and all sources of potential savings and improved efficiency were closely investigated. With the alternatives to the existing electric resistance heaters throughout the approximately 500,000 square foot building.

All viable alternatives to electricity were considered which boiled down to three options:

- fuel oil,
- natural gas, and
- biomass (as wood).

When historic fluctuations in the price of fuel oil and natural gas were compared to the historically steady cost of wood as fuel, the later was chosen as the fuel of choice. It took most of five years of discussion, study, and fund raising to get all of the essential participants to agree as to exactly what system would be installed. An Energy Service Provider Company (commonly called an ESCO) was hired to develop the system from wood fuel storage to emission controls. A turnkey system was designed for the school and a final tax-exempt loan of approximately $1. 5 million allowed for purchase, installation, and operation in the 2002-2003 heating season. Because it was a retrofit, only 85% of the total heating space could feasibly be reached with the piping necessary for the new closed-loop hydronic heating system. The remaining 15% of space remain with electric resistance heaters. A fuel oil boiler was installed both for emergency back up and for use in the spring and fall months when heating requirements are minimal or intermittent.

*AHC photo

An automated computer control system minimizes maintenance cost specifically in dollar amount as well as in labor hours involved. The computer system allows for a +/- 2^{O} F temperature control in each room. The small maintenance crew of the college was very concerned that the system would add undue burden to the demands on their time. The planning process used site visits to existing wood fueled facilities to demonstrate to the maintenance personnel that there would be no increase in the workload relative to the heating system. Anecdotally, the maintenance people report fewer heating related complaints since the new system has been operating. The only regular maintenance activities involved are raking down the bottom ash in the combustion chamber and the weekly need to clean up a small amount of wood chips spilled from the live-bottom trailers that deliver the fuel. One anticipated problem was the need to work out software bugs in order to fully integrate the heating system with the rest of the systems in the building. The only unanticipated downtime in the two heating seasons of use has been the failure of what is essentially the motherboard of the computer control.

Fuel consists of green hardwood chips currently purchased from a local mill. Moisture content is not specified but has been averaging approximately 35%. Request for proposals are circulated yearly for bids to supply the coming seasons fuel. Average cost for fuel over the past two years has been $26.50 per ton. As stated previously, fuel is delivered in live bottom trailers that minimize spillage.

*AHC photo

The chips are stored in an enclosure that houses a below grade concrete bunker. The bunker holds approximately a weeks worth of fuel. During peak heating times the system consumes about four truckloads a week. A floating auger slowly cycles along the bottom of the chips from one side of the bunker to other. This auger pulls the chips into another section of the building where they fall onto a moving belt.

This belt moves the chips to a set of opposed belts that act as bread in a chip sandwich, carrying the fuel up approximately 10 feet to the combustion chamber feed hopper. Electronic sensors that provide feedback, that in turn control

*AHC photo

*AHC photo

the speed of belts and augers leading to it, control the fill level of the feed hopper. From the feed hopper, three augers move the chips to the top of the sloped grate Messerschmidt combustion system. From here the wood begins to combust and move toward the bottom of the chamber under the combined force of gravity and pressure from the addition of new fuel at the top. Oxygen/air intake fans at six locations along the path of the fuel are turned on or off based on sensor feedback to the computer relative to the efficiency of combustion. As with any combustion system, waste is produced in the form of ash. Bottom ash is manually removed from the chamber. This material is applied to the grounds of the College as a soil amendment under a beneficial use permit. Fly ash, collected out of the exhaust stream with a cyclone core separator, is collected in 55-gallon drums. The later must be sent to a hazardous waste landfill under Massachusetts DEP regulations, only because the extremely small particulate size is considered an inhalation hazard. Biannual testing of the ash is also required under the College's permits to ensure that no treated wood is being used as fuel.

*AHC photo

The fly ash collection system is the only problem area that has not been fully resolved in the first two years of operation. The systems emissions permit specifies a particulate level of no more than 0.1 parts per million Btu produced. With the installed collectors the best that was achieved was 0.13 parts per million. A second smaller cyclone device was installed between the combustion chamber and the original collector but this system resulted in no net improvement. The colleges engineering staff is determining how to install a bag house, which is anticipated to more than meet the specified particulate level. This problem highlights a key point for anyone considering installing such a system. When the College accepted the system that was proposed by the ESCO, the subsequent contracts specified that the system would meet or exceed all Federal and State environmental permitting requirements. As such the cost of getting the system into compliance has fallen on the ESCO and not the College. The permitting agency has been very cooperative in allowing this problem to be worked out.

Because the make-up of the College's electric bill is not itemized by any individual devices consumption it would be difficult to put an exact dollar number on the savings from the installation of this new wood fueled system. However during the 2003-2004 heating season, it was estimated that the resistance heating system would have added approximately $300,000 to the bottom line. The new system, by stark contrast, was fueled by approximately $25,000 worth of wood chips. Other, less tangible, positives can be added to the final evaluation such as using a locally produced renewable resource which helps maintain local jobs and use of a non-fossil fuel that does not contribute to global warming.

Summary

Mount Wachusett Community College is a stellar example of the successful retrofit of an existing building with an automated wood fueled heating system that resulted in spectacular energy, and hence, monetary savings. At a time when the College was facing a steep rise in operating costs which would have resulted in budget cuts and tuition increases it was decided to invest in a system which, while initially more expensive than competing systems, would lower energy costs both immediately and in the long run.

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