Heating with Biomass:

A Feasibility Study of Wisconsin Schools Heated with Wood

Prepared by

P Squared Group LLC and Biomass Energy Resource Center

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The Biomass Energy Resource Center (BERC) is a national not-for-profit organization based in Montpelier, Vermont. Our mission is to develop energy projects using sustainable biomass resources for environmental benefit and local economic development. We use our expertise in institutional and community-scale wood energy systems to help industries, schools, and institutions to get biomass projects initiated and built to serve their heating and power needs. In the short time since its inception in 2001, BERC has established itself as a national leader in biomass heating and power generation from forest and agricultural sources.

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TABLE OF CONTENTS

SUMMARY

In 2003, the Biomass Energy Resource Center (BERC) undertook a preliminary "Wisconsin School Wood Energy" feasibility study for the Wisconsin Division on Energy, outlining a school energy program for Wisconsin. P Squared Group LLC has partnered with BERC to produce an update to that report.

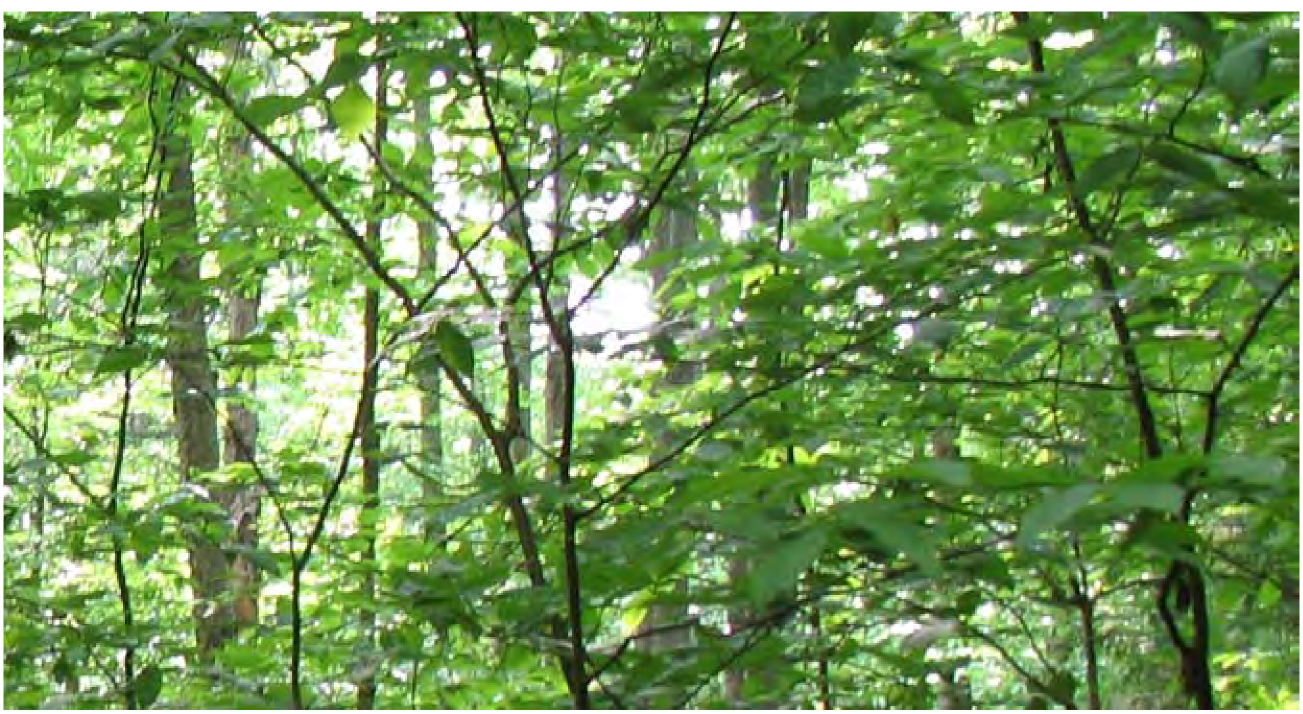
Much of the information in the original report, particularly pieces outlining the benefits and different types of biomass systems, remains essentially unchanged since 2003. Those sections are not addressed in this update, thus the reader may at times need to refer to the 2003 report. This revised study uses updated costing and economic information, and includes results more reflective of reality today.

For this update, we visited and collected data on four schools in Wisconsin that currently heat with biomass, and developed case studies on each (beginning on page 18).

School selection criteria were outlined using recent fuel use and pricing from the 2006 Focus on Energy benchmarking study of school energy use. Updated pricing information for fuel and combustion systems was used for BERC's life-cycle cost analysis tool.

Schools paying $8.99 per decatherm (DK) for natural gas and using more than 7,500 DK per year, and those paying $10.86 per DK and using 5,000 DK per year were found to be good candidates for converting to wood heating.

This study found that 200-300 schools in Wisconsin now heating with natural gas may find biomass heating economical at current fuel prices. These systems will often cash flow positive in the first year of installation.



BACKGROUND

HISTORY OF WOOD BOILER SYSTEMS IN WISCONSIN

The majority of school wood boiler systems were installed in the mid-1980s with support from the Institutional Conservation Program (ICP), a state-administered federal program. It provided matching grants to help schools (and hospitals) pay for energy studies and purchase and install energy conservation measures.

A 1987 Wisconsin Department of Administration study[1] of these early systems observed the following:

- Wood is available and economical for approximately three-fourths of the state—those living above a line running from Kewaunee to Monroe
- Unlike gas and oil, wood is a renewable resource and, if properly managed, will never run out
- Wood systems are most efficient when operated near capacity, therefore should be sized for average loads. Peak loads can be met with secondary systems (typically gas or oil)
- Fuel quality is critical for success
- The design of the boiler room affects the ease of operation
- Operating systems with minimal excess air can improve efficiency and is easy to do
- Although older wood systems take a lot of maintenance (the equivalent of a half-time staff person), today's modern systems (with computerization, automatic fuel delivery, and ashing) require less than one hour of maintenance per day

SCOPE OF WORK

For this study, the authors identified 10 schools in Wisconsin that heat with wood, and one, Shell Lake High, that is using corn. Of these 11 schools, 4 were visited (see case studies and full list of schools at the end of this report).

Because the feasibility study considered numerous economic factors that may have since become outdated, it was necessary to revisit the study with updated assumptions and factors. The objectives for this project included:

- Updating the 2003 "Wisconsin School Wood Energy" feasibility study
- Reviewing past efforts and studying current policies, funding, and incentives impacting the use of biomass thermal systems in schools
- Identifying a strategy to build a sustainable Fuels For Schools program in Wisconsin
- Getting comments from key institutional partners

METHODOLOGY

Benchmarking Study

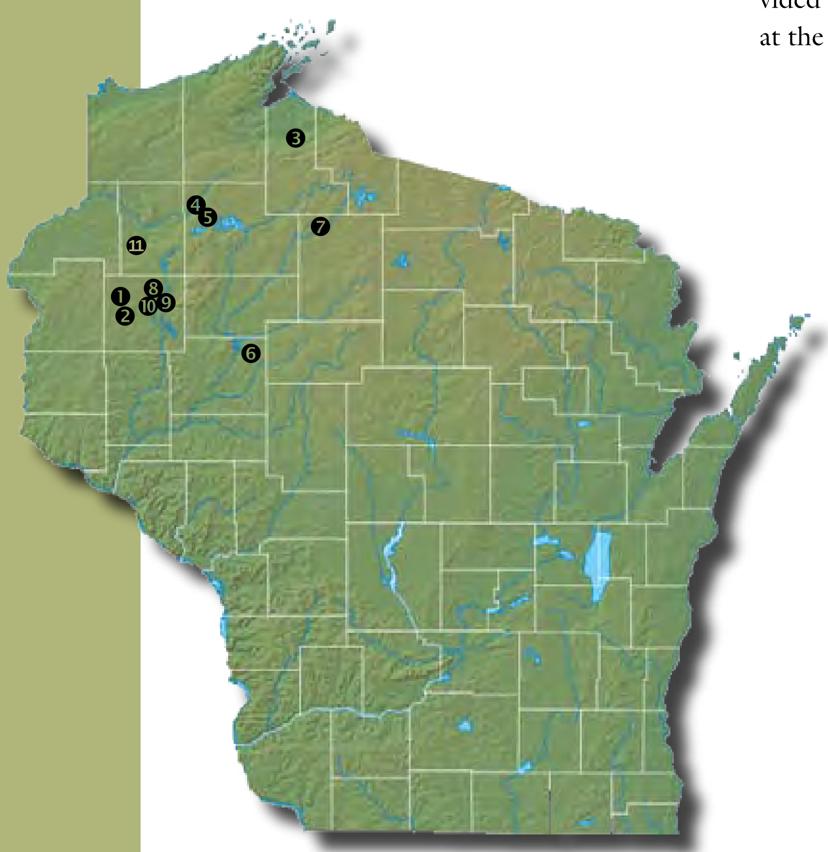
To update the 2003 feasibility study, the authors utilized Focus on Energy's "Energy Benchmarking Study of Wisconsin's K-12 Schools."[2] This voluntary study of 1,293 schools and 226 school districts, completed in April 2006, was conducted to provide facility managers with information on school energy use, and assist schools in both planning energy-efficiency improvements and measuring the impact of their actions.

Fuel Supply Assessment

BERC used existing information and knowledge of woody fuel specifications to develop recommendations on fuel supply sourcing. Wisconsin wood products industries were also surveyed for this report.

Case Studies

We visited four schools in Wisconsin that are currently using biomass fuels for heating. Information collected on these schools is provided in the case studies and in a compiled list at the end of this report.[3]



Biomass-Heated School Locations

1. Barron High, Barron, WI
2. Woodland Elementary, Barron WI
3. Glidden High, Glidden, WI
4. Hayward Middle, Hayward, WI
5. Hayward High, Hayward, WI
6. Lake Holcombe High, Lake Holcombe, WI
7. Park Falls High, Park Falls, WI
8. Rice Lake High, Rice Lake, WI
9. Rice Lake Middle, Rice Lake, WI
10. Hilltop Elementary, Rice Lake, WI
11. Shell Lake High, Shell Lake, WI

SCHOOL SELECTION CRITERIA

Project economics, which are largely dependent on the price paid for natural gas and the amount of natural gas used, are the single most important factor in selecting schools for a wood heating system project.

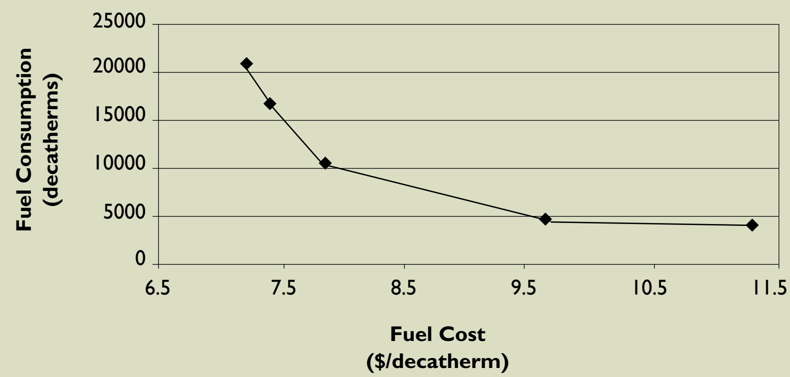
Another important factor is proximity to wood supply. The further wood fuel is trucked, the more it costs and the more fossil fuel is used in transporting it, diminishing the carbon neutrality of the fuel. Schools in the more heavily forested northern part of the state should be considered before similar schools in the southern part of the state. The 'Fuel Supply' section later in this report provides more discussion on this factor.

ECONOMIC ANALYSIS

Detailed heating and fuel information for 1,293 schools was provided by Focus on Energy, Wisconsin's state efficiency and renewable energy program. Approximately 1,136 schools, or 97% of Wisconsin's schools, are heated by natural gas. The average price paid for natural gas by schools over the last two years was $8.99 per decatherm (DK). At this price point, schools using more than 7,500 DK of natural gas annually are good prospects for biomass heating. BERC found that 194 Wisconsin schools consume more than 7,500 DK of natural gas annually.

More recent data, as of June 2007 from the US Energy Information Administration, places the average commercial price for natural gas in Wisconsin at $10.86 per DK. At this price point, even schools using less than 5,000 DK of natural gas may find biomass heating to be cost effective. There are more than 300 schools with an annual natural gas consumption of 5,000 DK or more. Individual schools may be paying more or less than $10.86 per DK and will need to be evaluated on a case-by-case basis.

PRICE POINT AT WHICH WOOD BECOMES ECONOMICAL



Smaller schools may still be cost effective, depending on other factors such as proximity to a source of biomass fuel at a very low price (such as a local sawmill) or schools that can use existing boiler rooms and save on construction costs. Pellet systems or semi-automated systems may also prove cost effective for some of the smaller schools with lower heating bills (see 2003 "Wisconsin School Wood Energy" feasibility study report for more information on these technologies). These systems are a particularly good choice for smaller schools with an underutilized full-time maintenance staff.

LIFE CYCLE COST (LCC) ANALYSIS

LCC Tool

BERC has developed an LCC tool that is used to analyze the cost effectiveness of purchasing, operating, and maintaining a woodchip heating system over its 30-year life. The LCC tool looks at multiple inputs, including the consumption and price paid for both fossil and woodchip fuels and the cost of installing and maintaining the woodchip system. The LCC is a decision-making tool that allows the user to compare the cost of a new woodchip heating system to the cost of an existing fossil fuel heating system.

First-Year and 30-Year Fuel Cost Savings

Two resulting calculations are of particular interest when assessing the outcome. First-year fuel cost savings can be shown as a a percentage or dollar amount. Net present value (NPV) can be defined as the amount of savings beyond the investment, or the difference between the present value of the cash inflows and the present value of the cash outflows associated with an investment project. Thirty-year NPV is inflated to future values and then discounted back to today's dollars for comparison. A positive 30-year NPV indicates that the savings in fuel costs will pay for the system and then some; the dollar amount is the value of fuel cost savings (in current-year dollars) after the initial investment is paid back.

Green Ton Woodchip Pricing

For each analysis, the school's reported fossil fuel prices were used. Two wood prices were considered for the analysis and the results were presented in tables for comparison (see opposite page). Some schools in the region reported paying $32 per green ton, therefore this was the price used in round one of the analyses. It is important to note, however, that BERC's analysis of the wood markets in this region resulted in assuming a higher price of $43 per ton based on certain economic and infrastructure-related factors, in round two of the LCC analyses. (These factors are discussed in greater detail in the "Wood Fuel Pricing" segment of the "Fuel Supply" portion of this report.) A system cost of $80,000 per million Btu per hour (MMBtu/hour) was assumed to develop project capital costs.

LCC Scenarios: Natural Gas and Oil Compared to Woodchips

LCC analyses were performed on several different schools using natural gas and oil to determine the fuel usage and price points at which woodchips become economically feasible. The following page demonstrates the finding of two LCC scenarios that showed positive economics for natural gas (Schools A and B) and one LCC that showed positive economics for oil (School C). Full treatments of the three LCC analyses are included at the end of this report.

Schools A and B are both good examples of a cost-effective biomass heating system replacing natural gas. As School C demonstrates, even small schools using oil are likely good candidates for woodchip heating due to rapidly rising oil prices.

SCHOOL LIFE-CYCLE COST ANALYSES

LCC Analysis for School A: Natural Gas (Larger System)

School A consumed an average of 21,817 DK of natural gas annually and reported paying $7.98 per DK. Based on this annual consumption of natural gas, an 11 MMBtu/hour system would be required. If the school were to heat with wood 100% of the time, it would consume 2,712 tons of green woodchips annually. A more realistic situation is that the school will heat with wood roughly 85% of the time, with the remaining portion of the heat load being covered by the backup natural gas system. In this case, the school could expect to consume 2,305 tons of green woodchips plus 3,273 DK of natural gas per year.

Even paying a low price for natural gas, large schools consuming greater amounts of natural gas can still save considerable amounts of money by switching to woodchips.

WOOD FUEL PRICE/ GREEN TON[4]	$32	$43
First year fuel cost savings ($)	$79,582	$53,398
First year fuel cost savings (%)	43%	29%
NPV Total 30-year cost, natural gas system	$5,846,433	$5,846,433
NPV Total 30-year cost, wood system	$4,731,734	$5,366,503
Difference in cost (30-year NPV of savings)	$1,114,699	$479,930

LCC Analysis for School B: Natural Gas (Smaller System)

School B is a smaller facility that paid a higher price for natural gas. (Many smaller schools are likely paying higher than the average price for natural gas due to economies of scale.) School B reported using 10,654 DK of natural gas annually and paid $11.74 per DK. If the school were to heat with wood 100% of the time, it would use 1,325 tons of green woodchips annually; however, a more realistic assumption would be that 85% of the heat load was covered by wood so that the school could expect to consume 1,126 tons of green woodchips plus 1,598 DK of natural gas per year.

WOOD FUEL PRICE/ GREEN TON[5]	$32	$43
First year fuel cost savings ($)	$74,700	$61,914
First year fuel cost savings (%)	57%	47%
NPV Total 30-year cost, natural gas system	$4,200,237	$4,200,237
NPV Total 30-year cost, wood system	$2,671,040	$2,981,020
Difference in cost (30-year NPV of Savings)	$1,529,197	$1,219,217

LCC Analysis for School C: Oil

School C is a smaller building using oil for heat. This school reported using 26,844 gallons of oil annually and would require a 2MMBtu/hour system. Few, if any, of the schools using natural gas at that size range will find it to be cost effective to switch over to biomass heating; however, high oil prices result in positive economics for this project. If this school were to heat with wood 100% of the time, it would use 432 tons of green woodchips per year; however, a more realistic approach would be to assume that wood will cover roughly 85% of the school's heat load, while the oil system will serve as a backup. Under this assumption, the school could expect to consume 367 tons of green woodchips plus 4,027 gallons of oil per year.

WOOD FUEL PRICE/ GREEN TON[6]	$32	$43
First year fuel cost savings ($)	$35,905	$31,737
First year fuel cost savings (%)	64%	56%
NPV Total 30-year cost, natural gas system	$1,802,894	$1,802,894
NPV Total 30-year cost, wood system	$1,278,334	$1,379,379
Difference in cost (30-year NPV of Savings)	$524,561	$423,515

FUEL SUPPLY

FOREST RESOURCE

Wisconsin's forests cover approximately 16.1 million acres or 46% of the total land area.[7] The amount of forested land area has remained steady over the past decade, if not slightly increased. Hardwood species—specifically maple, beech, birch, oak, hickory, and aspen—account for more than 84% of the forest biomass. Nearly 70% of Wisconsin's timberland (productive and unencumbered forest land) area is in private ownership.

While Wisconsin has a large forest resource, a substantial majority of this forest resource is concentrated in the northern half of the state. In addition to these forests, the southwestern corner of Wisconsin also has a significant amount of forested land.

Despite the appetite of a strong forest products industry, Wisconsin's forests have been growing in timber volume for the past 50 years. USDA Forest Service data indicates that the volume of timber has increased by 19 percent since 1983.[8]

The timberland ownership in Wisconsin is predominately private. This private ownership is spread among approximately 230,600 landowners. Private timberland tract size can be a general indicator of timber resource accessibility. Smaller timberland tracts tend to be harder to access for harvesting and are generally less economically feasible due to low volumes of harvested wood. In Wisconsin, only 8 percent of private timberland owners own parcels larger than 100 acres.[9]

FOREST PRODUCTS INDUSTRY

Wisconsin has a strong forest products industry. While the most complete review of the Timber Product Output (TPO) in Wisconsin was conducted in 1999, the volumes harvested to feed the mills in Wisconsin have not changed significantly in recent years. In 1999, Wisconsin's forest products industry processed more than 371 million cubic feet (nearly 11 million green tons) of roundwood (veneer, sawlogs, and pulpwood), a 6% decrease from the volume of roundwood processed in 1996. Hardwood species account for approximately three-quarters of the total volume harvested.

Loggers are the vital link between the wood growing in the forest and the forest products manufacturers. There are an estimated 1,100 logging firms in Wisconsin[10] and a broad spectrum of logging firm sizes—from the small one-person crew using a chainsaw to the larger firms using completely mechanized harvesting techniques. A recent study found that the average age of loggers in Wisconsin and the Upper Peninsula of Michigan is 47 and that 23% are at or within 10 years of retirement age.[11]

According to the USDA Forest Service North Central Research Station (located in St. Paul, MN), Wisconsin currently has 355 sawmills in operation. These sawmills range in production from a few hundred thousand board feet annually to more than 20 million board feet of lumber cut annually. In addition to the traditional sawmills, Wisconsin has 15 veneer mills, two post and pole mills, and numerous other wood processors.

Wisconsin is home to more pulpmills than any other state in the country. There are 17 active pulpmills in Wisconsin consuming both harvested pulpwood and mill residues to produce pulp for paper making and fueling their boilers. While pulpwood harvesting fluctuates widely from year to year based on market conditions and weather, in 1999, more than 3 million cords (7.5 million green tons) of pulpwood were harvested.

WOOD FUEL SOURCES

There are many types of wood fuel from a wide variety of sources. Certain types and sources of woodchips can often be better suited for certain applications than others. In addition to high-quality planning, engineering, and construction, successful biomass heating projects need to secure a sufficient fuel supply at the right price. Equally important is that the type and source of chip is properly suited to the size and design of the heating system.

There are two main categories of wood species—hardwoods and softwoods. Hardwoods are typically deciduous trees like maple, oak, birch, and ash. Softwoods are typically coniferous trees like pine, cedar, hemlock, spruce, and fir. Both have similar energy values but softwoods generally have a slightly higher moisture content and can be less dense. For these reasons, hardwood trees are generally preferable to softwood as a fuel source.

There are four main source categories of woody biomass fuels:

1. Residues from sawmills
2. Low-grade wood from forest management
3. Low-grade wood from land development
4. Wood waste from communities

Residues from Sawmills

There are typically three types of wood residues from sawmills—bark removed from the log prior to sawing, sawdust and shavings, and chips made from the slabs and off cuts. Each material has different characteristics that dictate the best use.

Bark. Bark is typically burned onsite to fire the mill's wood kilns or is sold as mulch. Soft wood bark like hemlock, cedar, and to a lesser extent, pine have a high market value for mulch in gardens and flower beds. Hardwood bark is sometimes used as a bulking agent for composting. Although bark has a high Btu content per pound (more than chips), bark also has a higher mineral/ash content.

Sawdust. Sawdust is typically sold to farmers as bedding for livestock. Sawdust is also used in making wood fuel pellets. Sawdust is frequently burned in kilns for drying lumber, but this practice is now less common than in the past.

Woodchips. Woodchips are the best-suited fuel for institutional-scale biomass heating systems. Mill chips tend to be the highest-quality fuel available for chip-fired heating systems. Mill chips are produced from the waste wood (off cuts and slabs from sawing logs into lumber). Because logs are debarked before sawing, mill chips are very clean and have a relatively low ash content.

In addition to sawmill by-products such as sawdust, bark, and woodchips that can be used directly as a biomass fuel, these materials (primarily sawdust and shavings) can be further processed into a refined biomass fuel—pellets. Historically, pellets have been sold almost exclusively in bags to the residential heating market; however, they are now being delivered in bulk to fuel central boiler systems.

Low-Grade Wood from Forest Management

There are three main grades of wood harvested from the forest:

- **Veneer logs** are of the highest value and are used in furniture production
- **Saw logs** are valuable and used for a wide range of wood products—from furniture to lumber
- **Pulpwood, or low-grade wood,** is from trees that are damaged, blemished, crooked, or diseased, but can be used for producing pulp for making paper or fuel

There are two main ways low-grade wood is removed from the forests—as chips (processed at the landing) or as logs.

Whole-Tree Chips. There are trees in managed forests that hold little commercial value for lumber that often should be removed from the forest to improve future commercial timber value. This low-grade wood can be an excellent source from which to produce woodchips to fuel biomass systems.

Whole-tree chips can be produced from commercial timber harvests that use fully mechanized equipment to fell trees and move them from stump to a landing. Once at the landing, whole-tree chips are produced by either chipping the entire low-grade tree or from only the tops and limbs severed from higher-value logs.

Although this source is not technically a "waste wood," the cost to harvest, chip, and transport it can sometimes be partially reduced by the economics of harvesting commercial sawlogs at the same time as the low-grade wood. The main drawback to using whole-tree chips for biomass heating is that they often contain long slender sticks that pass through the chipper uncut. These "stringers" can present problems for the automated feed systems by jamming the augers.

Bole Chips. Bole chips are produced from low-grade or pulp logs. The difference between whole-tree chips and bole chips is that bole chips do not include the branches or foliage. When the trees are harvested, the limbs are removed and the slash is left on the ground in the woods or at the log landing (depending upon whether the tree was de-limbed where it fell or at the landing).

While bole chips can make for high-quality fuel and help forest soil health by returning a portion of the biomass and nutrients to the soil, they are typically also the most expensive chips. It costs the same to fell, de-limb, skid or forward, and load a saw-grade as a pulp-grade log. The difference is that saw-grade logs fetch a much higher price at the sawmill than do pulp-grade logs at the pulp mill or on the firewood market. There is not currently a large market demand for bole chips, mostly because whole-tree chips can be produced more efficiently and high-quality mill chips are generally available.

Low-Grade Wood from Land Development

A majority of whole-tree chips are generated from forest management activity; however, whole-tree chips are frequently produced from land clearing and land-use conversion projects. Land clearing contractors are paid to remove trees and vegetation to make way for roads, parking lots, buildings, and open spaces. The felled trees are typically chipped onsite and the chips are blown directly into delivery trucks. The stumps and root systems are typically dug up later and ground into mulch. The alternate disposal options for waste wood from land clearing are typically onsite pile burning, grinding for horticulture markets, or sending to a landfill. Biomass-fueled power generation and heating facilities are an excellent market for the waste wood from land clearing. Because the land clearing cost is typically paid for by the developer, the cost of whole-tree chips from land clearing is relatively low.

Wood Waste from Communities

Woodchips produced from wood pallets, tree limbs, brush, and other community wood waste is a low-grade wood fuel. The material is usually ground rather than chipped and therefore is less uniform and consistent than other types of chips. Although these chips are predominantly made from clean wood waste sources, there is risk that these chips will contain chemically treated wood. Urban wood waste is often called "hog fuel" and is typically suited only for fuel in large boilers at power plants and pulpmills. Chip brokers usually work with local solid waste management agencies and municipalities to find markets for ground urban wood waste. The predominant outlets for this material are as mulch, as a bulking agent for composting, and as fuel for some biomass boilers.

QUALITY CONSIDERATIONS

There are numerous factors that affect the properties of woodchips and their overall quality for use as fuel. Wood can come in all shapes and sizes—and usually does. The following are the most important parameters governing the chip's overall quality for use as a heating fuel.

Chip Size, Shape, and Uniformity

Quality chips are consistent in shape and size. Typical high-quality chips vary in size from 1" x 1" x 1/8" thick to 2 ¼" x 2 ¼" x ¼" thick. Chips that are relatively square and flat are easily conveyed and augured, feeding into systems smoothly.

While the majority of woodchip heating systems can handle some oversized material, long "stringers" can present a risk by jamming feed augers and shutting the system down. Long stringy wood often "bridges," forming hollow cavities in hoppers and bins as the material below is removed. Material bridging can cause some systems to shut down due to the perception that the bin is out of fuel. Similarly, while most woodchip heating systems are designed to handle some amount of wood "fines," too much fines content can present issues when moisture content is either too low or too high.

Wood Energy Properties

Wood energy values vary widely (8,000-12,200 Btu per dry pound).[12] The energy value of bark can range from 7,200-10,800 Btu per dry pound. The species of tree that the wood came from can make a difference in a chip's heating fuel value. Softwoods typically have a higher Btu value than hardwoods on a dry weight basis. The major factors that vary among species are the moisture content and the density of the wood. Additionally, certain species have higher oil contents that can boost the Btu per pound properties.

Moisture Content

The moisture content of wood fuel evaporates and absorbs energy during combustion. This water usually escapes out the stack as heated water vapor. Most eastern hardwood species have a higher heating value of about 8,400 Btu per dry pound; however, the water content of the wood quickly reduces the energy content to a lower heating value. Higher moisture content means lower combustion efficiency.

Additionally, if the moisture content is too high, the material will be difficult to handle, may freeze in winter, and have a lower fuel value resulting in the need to burn significantly more fuel to extract the same amount of energy as would a drier fuel. Alternatively, if the material is too dry, there can be problems from dust and higher particulate emissions.

The target moisture content is 30-45%, but most woodchip combustion systems can handle wood fuel that ranges from 15%-50%. Consistency in moisture content is almost as important as the fuel being within the acceptable moisture content range.

Mineral Content

The mineral content of the fuel is also an important factor in the overall chip quality. Minerals bound in wood contribute to the formation of ash once the rest of the wood is combusted. Certain forms of minerals in the fuel can cause complications in some biomass heating systems during combustion.

In general, the lower the mineral or ash content, the better. Ideally the ash content of chips for heating should be below 3%. Ash can come from two main sources—the naturally occurring minerals contained in the tree itself and the dirt and debris picked up from the soil in the process of harvesting.

The silica and alkali mineral content of the ash is another important factor. Wood fuel that contains significant amounts of potassium or sodium, sulfur, chlorine, and silica (high-alkali elements) form "clinkers," or fused minerals, that melt and bind to the combustion grates and refractory, limiting the combustion efficiency by blocking air flow. As the alkali content of the ash approaches 0.4 pounds per million Btu, the potential for mineral fusion increases significantly.

Different parts of trees contain varying levels and types of minerals. "White wood" contains the lowest amounts of ash-producing minerals (under 1%) whereas bark contains 6-7%. Needles from softwood tree species contain relatively high levels of minerals and are the primary source of silica (20%) in wood fuels, contributing to the formation of clinkers at standard combustion temperatures. Softwood tree needles contain exceptionally high concentrations of alkali minerals.

Total ash content greater than 8% becomes problematic for most woodchip heating systems. High-quality heating fuel will have the absolute lowest possible ash content.

Dirt and Other Debris

How clean the wood fuel is is yet another important factor that relates closely to the ash content factor discussed above. In addition to generating more ash, dirt and grit can be extremely abrasive and wear down chipping equipment and other material handling equipment used to deliver fuel to the combustion chamber. Wood fuel should be kept clean and free of other foreign materials such as metal objects like nails, chipper knives, and bolts.

WOOD FUEL PRICING

The price of woodchips is affected by numerous factors. Primary among these factors are:

- **Wood source** (whether the wood is a by-product of some more lucrative activity)
- **Regional supply and demand**
- **Trucking distance** from point of generation to end market

Paper-grade woodchips from sawmills are by far the preferred chip fuel type for seasonal heating systems. The combination of high-quality, consistent chips and the relatively low price of a by-product make sawmill chips the first choice fuel.

Wisconsin's strong pulp industry has been the primary outlet for chips from sawmills, as has the growth of such other markets as wood pellet production and composite wood products manufacturing. Prices paid to sawmills in Wisconsin for hardwood chips by large year-round markets vary, but is typically within the $24-$34 per green ton price range.

While the annual amount of fuel consumed by a typical institutional seasonal heating system is comparatively small and many sawmills are happy to divert a small portion of their chips to supply a local school or other facility, the seasonal heating market is at a competitive disadvantage. Seasonal heating markets only require chips 4-5 months of the year and many competing industries consistently take shipments of chips year round.

In addition, schools require that chip deliveries be made using self unloading (live-bottom) trailers that are more expensive than basic box trailers. To compensate, most seasonal heating consumers tend to pay $6-$10 more per ton to ensure a supply in the winter months. A conservative, but realistic, estimate of fuel supply from Wisconsin sawmills would be $43 per green ton.

Whole-tree chips are an excellent and cost effective fuel for larger systems that are designed to handle oversized chips; however, they can prove to be problematic for smaller seasonal heating systems. Whole-tree chips in Wisconsin also range widely in price but are most commonly available within the range of $18-$32 per green ton.

Bole chips are not commonly produced in Wisconsin but are a viable option for heating systems located in the state. Bole chips in the US Northeast are usually available to the seasonal heating market for $46-$56 per green ton. With a strong pulp market in Wisconsin, it may be difficult to initially convince loggers or chipping contractors to chip pulpwood that would otherwise be sent to the pulpmill.

GENERAL PROCUREMENT RECOMMENDATIONS

Securing an available, reliable, and sustainable woodchip fuel supply is seldom as simple as picking up the phone, getting three or more quotes, and receiving the first shipment the following day. To get the best quality fuel at the lowest possible price, fuel buyers must first be willing to work with fuel suppliers to encourage the growth of a fuel supply industry.

Fuel chip suppliers—whether sawmills, loggers, or general contractors—are usually not in business exclusively to supply chips for heating. Most suppliers are getting into the business as an add-on to their core business. If supplying heating markets is troublesome and not lucrative, they may decide to get out of that business and focus on their primary work. For this reason, it is extremely important to cooperate closely with new suppliers to work through issues that may come up over time. It is also important to consider that a business that may need to invest significant capital in specialized equipment in order to supply quality woodchips at a fair price will require multiple customers all requiring the same type of woodchip. For example, a single school may burn only 500 tons per year; for a logger to justify purchasing a large chipper (s)he will need markets for more than 15,000 tons.

It is also important, when considering wood supply sources and fuel specifications, to pool demand for similar sources and specifications with other woodchip consumers. Developing regional "clusters" of biomass energy users helps aggregate resources to reach the volumes necessary to support profitable chipping businesses.

The following is a list of recommendations to help improve the overall success of the project and the long-term reliability of the fuel supply.

- **Understand the selected heating system's capacity to handle variations in woodchip quality.** Auger size, fuel-feed configuration, combustion controls, auger and conveyor belt motor size, and many other variables dictate a system's capacity to handle more challenging biomass fuels. A woodchip specification can be chosen after the system is selected, but generally it is best to choose a fuel specification first.
- **For smaller heating systems like schools, consider structuring payment by the green ton, rather than contracting payment by the dry ton.** Use the chip specifications and material handling guidelines to ensure that the fuel is not excessively wet. This helps avoid overly complicated billing arrangements and possible conflicts over moisture content.
- **Build long-term relationships with supplier(s).** Encourage the supplier's commitment to staying in the business of supplying woodchips.
- **Work through issues of variance in woodchip specifications and supply-chain interruptions with the supplier.**
- **Conduct lab analysis on fuel samples at the outset of the supply contract** and re-check annually on a random basis.
- **Do not always take the lowest bid when contracting for fuel supply.** Take price into the overall consideration of the availability, reliability, and sustainability of the fuel supply.
- **Chipping equipment is recommended for all but ground community wood waste.** Grinding of random sized and shaped material is generally more efficient; chipping of logs, whole trees, and even slash can produce a much higher-quality woodchip.
- **Consider stockpiling chips onsite to build inventory and reduce the risk of fuel supply interruptions in the winter months.** By chipping in the summer and fall when the material is not frozen, the cost per delivered ton can be kept low; however, chips cannot be stored reliably for longer than 3-4 months. Accumulating logs at the log landing or a log yard is a better alternative as logs can be stored over longer periods of time without problems. After several months of accumulating and drying, logs can be chipped in the fall and winter months. *It is generally not recommended to keep large stock piles of woodchips or logs at public facilities like schools.*
- **Consider signing longer-term fuel supply agreements.** While most agreements are 1-2 years, longer-term agreements can be useful to suppliers when securing the necessary capital to purchase chippers and other equipment. If necessary, termination clauses can be used to reduce the risks of signing 3-5 year contracts. For supply contracts longer than 1 or 2 years, some price escalation may be necessary. Contracted wood fuel price escalation could be based on a price index, such as the consumer price index.
- **Secure back-up supply contracts with a secondary fuel supplier.** If the primary fuel supplier runs into difficulties delivering woodchips, it is much less expensive to pay $10/ton more for chips from a secondary supplier than to switch back to burning expensive fossil fuels for heating.
- **Keep supply arrangements and relationships as simple as possible.**
- **Select the intended fuel specification as early in the project development/construction process as possible.** Knowing the intended fuel source and type prior to putting the project out to bid and selecting a system type and vendor can be advantageous.

PROGRAM DEVELOPMENT

Vermont was the first state to develop a school wood heating program (Fuels For Schools). Today, more than 20% of Vermont's school children attend a school heated with wood. Building on Vermont's success, similar programs have been initiated in six states (Idaho, Montana, Nevada, North Dakota, Utah, and Wyoming). In addition to Wisconsin, New Hampshire, Pennsylvania, and Maine are currently exploring school wood energy programs.

A successful state program has five key program elements:

1. Project Steering Committee

Successful state programs are driven by a lead agency working closely with the appropriate state agency partners (i.e., education, forestry, and state buildings, etc.); however, the steering committee should not be too big and unwieldy. In Wisconsin, a partnership might include: the Department of Public Instruction, the Department of Natural Resources, the Department of Adminstration, the Focus on Energy Program, and the Office of Energy Independence. The Department of Agriculture, Trade and Consumer Protection may also be an important partner in program design, particularly if privately owned farm woodlots (especially in southwestern Wisconsin) or agricultural biomass are envisioned as a source of fuel for rural schools.

STATES WITH FUELS FOR SCHOOLS PROGAMS:	STATES EXPLORING FUELS FOR SCHOOLS PROGRAMS:
• **Vermont**	• **Wisconsin**
• **Idaho**	• **Maine**
• **Montana**	• **New Hampshire**
• **Nevada**	• **Pennsylvania**
• **North Dakota**	
• **Utah**	
• **Wyoming**	

2. Dedicated Staff

Although successful programs can be developed with very modest staffing, it is recommended that staff be created or re-assigned to manage, coordinate, and promote the program. It is difficult to make a program go if there is no one person responsible for the its development.

3. Analytic Capacity

To help schools make good decisions and assure public investments go to sound projects, a new Fuels For Schools program must have proper analytical capacity. The program should be designed to estimate project budgets, carry out a life-cycle cost analysis, and conduct a preliminary assessment of associated mechanical work. Some of these tasks may be contracted out.

4. Organizational Budget

Modest funding is needed for staffing, promotional materials, and contract work. A preliminary state program budget can range from $100,000 to $500,000 per year.

5. Capital Cost Share or Incentives

For the initiation of a state Fuels For Schools program, it is recommended that seed funding in the form of grants and low-interest loans be offered. An emphasis on designing projects that build local economies should be developed. This funding should assist both schools and businesses interested in packaging systems for schools.

Finally, a Wisconsin Fuels For Schools pilot program might focus on two distinct regions, the northern two thirds of the state (with a developed wood economy) and the more agricultural western/southwest part of the state. The fuel source for a more southerly program might focus on farm wood lots along with agricultural biomass crops or agricultural residues.

FINANCING RENEWABLE ENERGY SYSTEMS

On average, Wisconsin schools spend close to $200 million a year on energy. In many cases, a wood heating system will save a school tens of thousands of dollars in heating costs. The systems will often see a positive cash flow in the first year of installation. The question facing school administrators is: What is the best way to finance the system?

In 2001, Wisconsin state law (Act 16) implemented revenue limits on school districts. A district's revenue limit is the maximum amount of revenue it may raise through state general aid and the property tax.

Revenue limits offer a major budget challenge to school administrators facing ever-increasing costs. Schools interested in purchasing a wood system have several options:

Exceed Revenue Limits through Referendum

A school district may exceed its revenue limit by receiving voter approval through referendum. A school board may call a special referendum or hold one during primary or general elections. This approach is not recommended unless schools anticipate a major addition or renovation and the costs for a wood system can be rolled into those project costs. Referenda offer risk as well, as they may not enjoy political support.

Fund Balances and Borrow Funds

The Wisconsin Statutes[13] provide authority for school districts to borrow up to $1,000,000 without a voter-approved referendum. Schools might use existing fund balances along with short-term loans to finance a system.

Schools could also borrow from the common school fund, a state trust fund established by the Wisconsin constitution (historically set up from the sale of federal lands granted to the state). The more than $600 million common school fund is managed by the Wisconsin Board of Commissioners of Public Lands (BCPL). The BCPL is authorized to loan money to school districts and local governments for public purposes while the interest of the fund is distributed to Wisconsin's public schools for the support of libraries.

In 2006, the library aid distribution was $28.2 million. The interest rates for loans (as of October 2007) were 4.75%, 5.0%, and 5.25% for 5-, 10-, and 20-year terms.

Grants and Other

Private, federal, or state grant funds obtained by schools are considered outside the revenue limits.

Additionally, the state might explore establishing a categorical aid for energy. Categorical aids are state or federal aids intended to finance or reimburse some specific category or instructional or supporting program, or to aid a particular target group of pupils. Examples of categorical aids include: special education, transportation, and library.

The state could also use its authority to underwrite the interest on loans obtained by schools. Both options require legislation.

CONCLUSIONS

Fuel Cost Savings

In many cases, a wood heating system will save a single school tens of thousands of dollars in heating costs per year. Wisconsin schools spend close to $200 million a year on energy.

The amount of heating fuel used and the price paid are the most important factors in considering the installation of a wood heating system. Those schools paying $8.99 per decatherm (DK) of natural gas and using more than 7,500 DK per year were found to be likely candidates for conversion to biomass heating; those paying $10.86 per DK and using 5,000 DK per year would be good candidates as well.

This study found that 200-300 schools in Wisconsin now heating with natural gas may find biomass heating economical at current fuel prices. These systems will often cash flow positive in the first year of installation.

Wood Fuel Supply

Wood fuel availability, quality, and pricing are key factors in the success of biomass heating projects. Schools should understand their fuel requirements given their chosen wood heating technology and the intended fuel specification should be selected early in the project.

A solid, long-term relationship should be built with one primary and one backup supplier, with arrangements for purchasing fuel on a per green ton basis. Lab analysis should be conducted on a random annual basis to ensure fuel quality.

Geographic Regions

A Wisconsin school biomass energy program should focus primarily on two distinct regions of the state: the northern two-thirds with a well-developed wood economy, and the southwestern part that has significant wood and agricultural biomass resources.

Project Steering Committee

Successful programs are driven by a lead agency working closely with the appropriate state agency partners. A project steering committee might include the Department of Public Instruction, Department of Natural Resources, Department of Administration, Department of Agriculture, Trade and Consumer Protection, the Focus on Energy Program, and the Office of Energy Independence.

Program Development and Management

An emphasis should be put on designing programs that build local economies. Staff should be created or re-assigned to manage, coordinate, and promote the program as well as trained to use the analytic tools necessary to conduct preliminary assessments of potential projects. Modest funding, ranging from $100,000-500,000, will be needed for staffing, promotion materials, and any contract work. In addition to program funding, seed funding should be available to projects in both schools and businesses as grants or low-interest loans. Funding should assist both schools and businesses interested in packaging systems for schools.

Financing Options

Although revenue limits (WI Act 16) are a major budget challenge to administrators, schools interested in purchasing a wood system have several options. Schools with installed wood systems have either used existing fund balances along with short-term loans, borrowed funds (Wisconsin statutes provide authority for borrowing up to $1 million without a voter approved referendum), or received grants.

In addition, any private, federal, or state grant funds are considered to be outside the revenue limits.

There are also legislative options, such as having the state underwrite the interest on loans obtained by schools, or establishing a categorical aid for energy.

WISCONSIN SCHOOL WOOD ENERGY Case Study

BARRON HIGH SCHOOL

BARRON, WI

HISTORY

Like most Wisconsin communities, Barron has a long history of heating buildings with wood. Decades ago, a local creamery built a district heating system that heated not only the creamery, but several homes and the local hospital.

In 1981, Barron High School continued this district heating tradition by partnering with the hospital to build a new district steam system. It heats the high school (119,000 SF), elementary school (65,000 SF), and a hospital complex (approximately 200,000 SF). The hospital complex includes a hospital, health clinic, nursing home, and senior apartments. This year, the Barron Area Community Center will be added.

Meters on the system measure the amount of steam used by the community center and hospital, and costs are shared based on use, which is helpful to the school. Barron is working with an engineering firm to explore the use of wood for its air conditioning needs.

The entrance to the high school reads, "Welcome to Barron High School, where students pursue their dreams and positively impact the world."

FUEL

Barron High School uses both woodchips and wood shavings for fuel. The shavings are supplied from a local telephone pole manufacturer and are 4 times less expensive per ton than woodchips. In 2006, shavings supplied approximately 75% of Barron's fuel needs. Barron also has an automatic ash removal system that is far more convenient than a manual removal system.

A good fuel supplier is critical. Barron has been very pleased with its fuel supplier; however, schools must take care to ensure they have clean, high-quality woodchips free from sticks and limbs that can cause jams.

ISSUES

Maintenance. Like other wood systems, the one at Barron High School takes more maintenance than a natural gas or oil system. On average, Barron spends about 1-1.5 hours a day ashing the system and doing general maintenance. Nevertheless, including these additional labor costs, Barron High school is saving an average of $100,000 per year.

Fuel Moisture Content. The wood shavings that Barron uses are wetter and harder to ignite (at start up, in between loads, or when the system goes down) than green woodchips. They are also more difficult to use in moderate winter weather (when the boiler is not working as hard). The shavings work well in cold weather when the system is working hard and the combustion and boiler output is high.

Barron Middle School (River View) is exploring the purchase of a new closely coupled wood gasifier system.

Q & A

Would you recommend that other schools use wood for heat?

"Yes. I would definitely recommend a wood system for other schools. We ran the budget numbers for our system and a gas system is approximately 3 times more expensive.

A wood system is definitely more work maintenance wise. And, you have to keep a constant eye on your wood source. But the cost savings alone make it worth it. We're saving close to $100,000 a year on our wood system even when we calculate in the additional labor needed. For most schools, $100,000 is a lot of savings."

- Stacy Hohms, Building and Grounds Supervisor

Above: Stacy Holms, Barron High School (left) and Bob Drevlow of Focus on Energy.

While wood system components like chip conveyers (pictured above) and augers require additional maintenance, the time allocation can be offset by fuel cost savings.

WISCONSIN SCHOOL WOOD ENERGY Case Study

SHELL LAKE HIGH SCHOOL

SHELL LAKE, WI

HISTORY

In 2006, Shell Lake High School made a decision to install a corn-kernel fueled hot water system (Pelco boiler) to gain greater control over heating costs. With a corn system, they were able to lock into an annual fuel contract with greater cost certainty than natural gas.

The corn system was designed to produce 70% of what the school needs at peak capacity. It ties into their existing natural gas-fueled hot water system. On cool or moderately cold days, the corn system can heat the entire school. On very cold days, the gas and corn systems work together to heat the school.

The cost for the new system was $95,000 with a 4.5-to-5 year payback. The system was financed through an existing fund balance in the capital fund (Fund 41) a fuel cost savings of $20,264 a year and a one-year short-term loan of $30,000. This loan was paid off in six months.

The availability of corn makes it a common-sense source of heating fuel for Shell Lake. The school's boiler can also burn wood pellets.

FUEL

Shell Lake's Pelco system is capable of burning corn, wood, switchgrass, or other agro-pellets. Currently, the school uses corn purchased from the Burnett Dairy Cooperative located approximately 25 miles east of Shell Lake. A grain truck delivers a load of corn to the school about every 10 days. The grain is dumped into a 1,000 bushel (approximately 28 tons) storage hopper located outside the school. The corn is augured into a boiler furnace that heats up a 500-gallon jacket of water.

ISSUES

Conversion. The biggest issue facing schools interested in converting to a corn, wood, or switchgrass pellet system is the type of heat delivery system a school currently has. If it has a hot water system, converting to corn, wood, or switchgrass pellets is relatively easy.

Maintenance. A corn system is more maintenance than gas. But, compared to woodchips, corn has far less maintenance. The Shell Lake staff spend approximately a half hour each day on maintenance; emptying out the ash can (approximately 35 lbs) once a day into a waste bin and pulling a clinker from the stove twice a day (am/pm). Three times a year they have to oil the chains in the system (about a 10-minute job).

Supply. Shell Lake would be interested in burning wood or switchgrass pellets but currently does not have a pellet source.

Q & A

Would you recommend that other schools use wood for heat?

"I'd definitely recommend a corn system for other schools. It gives schools more control. Today, corn is our primary fuel and we use gas as our backup. In the past, we had no control over the price of gas. With corn or wood, you can lock into a price for the whole season.

Our maintenance is a walk in the park compared to a woodchip system. We only have to spend about 15 minutes a day on maintenance. And, we can switch from corn kernels to wood pellets without changing a thing. That gives us flexibility in terms of fuel source and price.

The bottom line for me is, if you can use a renewable resource and save the school $20,000 a year – why not look into it?"

- Tim Ullums, Maintenance Supervisor

"I'd recommend corn or wood pellets as a very viable option for schools. I think all schools should take a close look at alternative fuels. My philosophy as an administrator has been to spend money early with energy retrofits because of the long-term energy savings.

The corn system we purchased has a payback of 4-5 years. The system provides a market for our local farmers, shows students a practical example of renewable energy, and it has saved the school district money. My goal is to save energy costs so we can spend more in the classroom."

- Jerry Gauderman, Superintendent

Above: Tim Ullums, maintenance supervisor (left), shows Focus on Energy's Bob Drevlow, Shell Lake High School's corn-kernel fueled hot water system.

Switchgrass, a native prairie grass, is also being pelletized and used for fuel in the midwest.

WISCONSIN SCHOOL WOOD ENERGY Case Study

HAYWARD HIGH SCHOOL

HAYWOOD, WI

HISTORY

Hayward High School installed a wood heat system in 1981 and the Middle School wood system was installed in 2000. Both are hot water distribution systems.

FUEL

The schools use green woodchips purchased from Prieme Wood Products. Both schools receive approximately one load a week, delivered via a self-unloading trailer. The high school has a cement silo inside the school to hold the chips while the middle school uses a bunker type storage system. The storage capacity for each is approximately 30 tons.

Wood fuel system augers like the one pictured above work best with evenly sized woodchips.

In 2006, Hayward spent $75,000 to upgrade and automate the control system (Siemens) at the high school. They also added variable speed drives on the feed-handling systems. The school now can now monitor the oxygen content, speed of delivery of chips, etc. The new controls allow a more precise delivery of fuel resulting in a better and cleaner burn. This improvement has meant fewer woodchips purchased and additional savings to the school.

ISSUES

Ash Handling. The middle and high school ash-handling systems are not automated and ash must be shoveled out of the furnaces by hand three times a day. While this is doable, it is time consuming and somewhat inconvenient. (New systems typically have automated ash-removal.)

Auger Jams. A lack of consistency in wood-chip quality means that larger sticks and stems sometimes jam the augers. A jam shuts down the fuel delivery system and wood boiler and automatically kicks on the back-up gas system. Much of this jamming could be fixed with chips that were more consistent in size.

Boiler Sizing. One thing that was mentioned that could be improved upon was the boiler sizing. The middle school boiler is fairly large for the size of the building. This means that the system doesn't work as efficiently when it is not working hard (for example, a mild winter day). Hayward is looking into ways to adjust the boiler so it can burn better when it is idling.

Q & A

Would you recommend that other schools use wood for heat?

"Yes. I think our wood system is good. It's a lot cheaper than gas. For example, we're spending approximately $2,500 a month at the high school and $4,000 a month at the middle school for the chips to heat our schools. Gas would be at least double that.

But, these systems take a lot of work. I'd recommend that if a school were planning to invest in a wood system that they spend the money required at the front end to automate it. This will help out a lot in the long run.

The biggest concern I see with our wood system is the time factor. It takes more time to handle the ash, and more time to fix and maintain the equipment.

Also, there is only one fuel supplier in this region. They do a good job but, but I'd feel a bit more secure if there were more suppliers in the business."

- Dave Disera, Building and Grounds Supervisor

Above: Dave Disera, Building and Grounds Supervisor, Hayward Schools.

WISCONSIN SCHOOL WOOD ENERGY Case Study

RICE LAKE HIGH SCHOOL

RICE LAKE, WI

HISTORY

In the early 1900s, a creamery (owned by the Gerland Brothers) in Rice Lake was built and the waste heat from the creamery's milk processing plant, in the form of steam, was sold to a large percentage of the community.

In approximately 1980, the creamery went out of business and the community had a decision on its hands. The school district evaluated its options and decided that a district heating system continued to make sense. Wood was the chosen fuel because it was the most economical, in ample supply, and was price predictable.

Today, the Rice Lake School energy plant heats approximately 400,000 SF including the high, middle, and Hilltop Elementary Schools as well as the municipal swimming pool.

The high school at Rice Lake burns woodchips purchased from a local supplier.

In April 2007, Rice Lake passed a referendum to build a new, more efficient wood heating system, with which the school chose to go "owner direct." This requires a triangle partnership: the school district, the architect and engineering (A&E) firm, and the wood gasifier boiler manufacturer (Chiptec). Rice Lake's A&E firm developed the footprint and design specifications and Chiptec will design and install the system.

FUEL

Rice Lake uses woodchips purchased from a local supplier. The school has an inside storage facility (bunker) with a walking bottom floor that holds approximately 100 tons (4 semi loads) of chips. In 2006, the school burned 1,686 tons of woodchips.

ISSUES

Maintenance. Wood is more maintenance than a gas boiler. It has augers and conveyers, and requires more attention.

Air Permits. Depending on the size of the system, schools may need to obtain air permits from the Department of Natural Resources.

Revenue Caps. Revenue caps do not prevent districts from considering wood heating options, but they do make the decision more difficult. Schools interested in considering heating with wood should (in conjunction with an engineer) do a cost-benefit analysis. Both energy performance contracting (i.e., Westinghouse, Honeywell, Siemens, Johnson Controls etc.) and long-term loans should be considered. Most schools will be able to build a system on a 20-year or less loan.

Q & A

Would you recommend that other schools use wood for heat?

"Yes. To me, both from a person who is concerned about our environment as well as a person that must make ends meet for a school, district heating with wood makes sense. We've found that based upon our estimates, wood heating is about one third the cost of heating with natural gas.

Burning a local, renewable resource is also a good thing to model to our students and community. It's an environmentally sound way of providing heat in our buildings. By burning wood we are minimizing our impact on the carbon cycle (not adding carbon into it) because we are burning carbon that is already on the surface of the earth. This reduces the district's impact on global warming.

Each year we bring students through our plant and teach them what we're doing and why we're doing it. We show them that burning wood is cheaper and it is also better for the environment and the community.

Our numbers showed that burning wood saves us in the range of $50,000-100,000 per year approximately. And with wood, we don't have the volatility inherent in the natural gas market. The bottom line for me is, we have to heat the buildings anyway, why not do it responsibly?

-Pat Blackaller, Business Manager

"Yes. It's kind of a no brainer. Compared to natural gas, wood is a lot cheaper. And today there are a far more efficient wood systems on the market to choose from.

When I first came to Rice Lake, I thought it was going to be a lot of work to learn the system. But wood kind of takes care of itself. I don't think a whole lot of training is required."

- Steve Lewis, Building and Grounds Maintenance Supervisor

Above: Steve Lewis, Building and Grounds Supervisor, Rice Lake Schools.

Gasifier systems like the one pictured above are being closely looked at by Wisconsin schools because of the increased efficiencies at which these systems operate.

SCHOOL LIFE-CYCLE COST ANALYSES: FULL TREATMENTS

Life-cycle cost analyses (LCC) were performed on three different schools using natural gas and oil to determine the fuel usage and price points at which woodchips become economically feasible.

The findings from these analyses are summarized for schools A, B, and C on page 6 of this report using both $32 and $43 per green ton of woodchip fuel.

The full treatments of the these analyses are detailed on the following six pages. They are:

- **School A: Natural Gas** at $32/green ton
- **School A: Natural Gas** at $43/green ton

- **School B: Natural Gas** at $32 per green ton
- **School B: Natural Gas** at $43 per green ton

- **School C: Oil** at $32 per green ton
- **School C: Oil** at $43 per green ton

Biomass Energy Resource Center

LIFE CYCLE COST ANALYSIS

(compared to operating existing fossil fuel system)

Organization Conducting Analysis	BERC	**Facility Name**	Scenario A	**Biomass Boiler Size:**	11.0 MMBtu

Assumptions

Total Project Cost	**$1,572,500**
Percentage cost share	**0%**
Financing, annual bond rate	**4.50%**
Finance term (years)	**20**
Current fuel	**natural gas**
Current fuel units	**decatherm**
Current fuel price per unit	**$7.98**
Annual units, current fuel	**21,817**
Wood price, yr 1 (per ton)	**$32**
Wood fraction (ann. heat load)	**85%**
General annual inflation rate	**3.25%**
Discount rate	**4.50%**
Fossil Fuel inflation (w/ genl inflation)	**5.25%**
Wood inflation (w/ genl inflation)	**3.25%**
Ann. Wood O&M cost, yr 1	**$11,599**
Major repairs (annualized)	**$11,000**
Estimated Boiler Life	**40**
Estimated Building Life	**60**

Capital Cost

Wood system	**$880,000**
Stack	**$25,000**
System Controls	**$8,000**
Electrical Connections	**$5,000**
Interconnection	**$40,000**
Building ($140/SF)	**$300,000**
Total capital	**$1,258,000**
GC markup 15%	$188,700
Design 10%	$125,800
Grand Total	**$1,572,500**

Calculated values

Financed amount		**$1,572,500**
Value of cost share		**$0**
Annual wood use, if 100% wood (tons)		**2,712**
Wood/current fuel system:		
Annual wood use	tons	**2,305**
Annual natural gas use	decatherm	**3,273**
First year fuel cost savings (%)		**43%**
First year fuel cost savings ($)		**$79,582**

30 Year NPV

Total 30-Year Cost, natural gas system	**5,846,433**
Total 30-Year Cost, wood system	**4,731,734**
Difference (30-year NPV of savings)	**$1,114,699**

LIFE CYCLE COST ANALYSIS

Yr.	Inflation Calculator	**Natural Gas** Total Annual Cost	Capital Cost	**Woodchip/Natural Gas System** Wood Cost	Natural Gas Cost	Incremental Annualized O&M	Annualized Major Repairs	Non-capital Total 30-Year Cost	Total 30-Year Cost (w/o Finance)	Total Annualized Savings
0	1.000	$174,100	$1,572,500	$0	$0	$0	$0	$0	1,572,500	($1,572,500)
1	1.033	$183,240	$0	$76,172	$27,486	$11,976	$11,358	$126,991	126,991	$56,248
2	1.066	$192,860	$0	$78,648	$28,929	$12,365	$11,727	$131,668	131,668	$61,192
3	1.101	$202,985	$0	$81,204	$30,448	$12,767	$12,108	$136,526	136,526	$66,459
4	1.136	$213,642	$0	$83,843	$32,046	$13,182	$12,501	$141,572	141,572	$72,070
5	1.173	$224,858	$0	$86,568	$33,729	$13,610	$12,908	$146,814	146,814	$78,044
6	1.212	$236,663	$0	$89,381	$35,499	$14,053	$13,327	$152,260	152,260	$84,403
7	1.251	$249,088	$0	$92,286	$37,363	$14,509	$13,760	$157,919	157,919	$91,169
8	1.292	$262,165	$0	$95,285	$39,325	$14,981	$14,207	$163,798	163,798	$98,367
9	1.334	$275,929	$0	$98,382	$41,389	$15,468	$14,669	$169,908	169,908	$106,020
10	1.377	$290,415	$0	$101,579	$43,562	$15,971	$15,146	$176,258	176,258	$114,157
11	1.422	$305,662	$0	$104,881	$45,849	$16,490	$15,638	$182,858	182,858	$122,804
12	1.468	$321,709	$0	$108,289	$48,256	$17,026	$16,146	$189,718	189,718	$131,991
13	1.516	$338,599	$0	$111,809	$50,790	$17,579	$16,671	$196,849	196,849	$141,750
14	1.565	$356,375	$0	$115,443	$53,456	$18,150	$17,213	$204,262	204,262	$152,113
15	1.616	$375,085	$0	$119,195	$56,263	$18,740	$17,772	$211,970	211,970	$163,115
16	1.668	$394,777	$0	$123,068	$59,217	$19,349	$18,350	$219,984	219,984	$174,793
17	1.722	$415,503	$0	$127,068	$62,325	$19,978	$18,946	$228,318	228,318	$187,185
18	1.778	$437,316	$0	$131,198	$65,597	$20,627	$19,562	$236,985	236,985	$200,332
19	1.836	$460,276	$0	$135,462	$69,041	$21,298	$20,198	$245,998	245,998	$214,277
20	1.896	$484,440	$0	$139,864	$72,666	$21,990	$20,854	$255,374	255,374	$229,066
21	1.957	$509,873	$0	$144,410	$76,481	$22,704	$21,532	$265,127	265,127	$244,746
22	2.021	$536,641	$0	$149,103	$80,496	$23,442	$22,232	$275,273	275,273	$261,368
23	2.087	$564,815	$0	$153,949	$84,722	$24,204	$22,954	$285,830	285,830	$278,985
24	2.155	$594,468	$0	$158,952	$89,170	$24,991	$23,700	$296,814	296,814	$297,654
25	2.225	$625,677	$0	$164,118	$93,852	$25,803	$24,471	$308,244	308,244	$317,434
26	2.297	$658,526	$0	$169,452	$98,779	$26,642	$25,266	$320,139	320,139	$338,387
27	2.372	$693,098	$0	$174,959	$103,965	$27,508	$26,087	$332,519	332,519	$360,580
28	2.449	$729,486	$0	$180,645	$109,423	$28,402	$26,935	$345,405	345,405	$384,081
29	2.528	$767,784	$0	$186,516	$115,168	$29,325	$27,810	$358,819	358,819	$408,965
30	2.610	$808,092	($486,875)	$192,578	$121,214	$30,278	$28,714	$372,784	(114,091)	$922,184
Totals		$12,710,046		$3,774,308	$1,906,507	$593,407	$562,762	$6,836,983	$6,350,108	$6,359,938
30 YR NPV:		**$5,846,433**	**$1,442,504**	**$1,846,602**	**$876,965**	**$290,328**	**$275,334**	**$3,289,229**	**$4,731,734**	**$1,114,699**

Biomass Energy Resource Center

LIFE CYCLE COST ANALYSIS

(compared to operating existing fossil fuel system)

Organization Conducting Analysis	BERC	Facility Name	Scenario A	Biomass Boiler Size:	11.0 MMBtu

Assumptions

Total Project Cost	**$1,572,500**
Percentage cost share	**0%**
Financing, annual bond rate	**4.50%**
Finance term (years)	**20**
Current fuel	**natural gas**
Current fuel units	**decatherm**
Current fuel price per unit	**$7.98**
Annual units, current fuel	**21,817**
Wood price, yr 1 (per ton)	**$43**
Wood fraction (ann. heat load)	**85%**
General annual inflation rate	**3.25%**
Discount rate	**4.50%**
Fossil Fuel inflation (w/ genl inflation)	**5.25%**
Wood inflation (w/ genl inflation)	**3.25%**
Ann. Wood O&M cost, yr 1	**$11,599**
Major repairs (annualized)	**$11,000**
Estimated Boiler Life	**40**
Estimated Building Life	**60**

Capital Cost

Wood system	**$880,000**
Stack	**$25,000**
System Controls	**$8,000**
Electrical Connections	**$5,000**
Interconnection	**$40,000**
Building ($140/SF)	**$300,000**
Total capital	**$1,258,000**
GC markup 15%	$188,700
Design 10%	$125,800
Grand Total	**$1,572,500**

Calculated values

Financed amount		**$1,572,500**
Value of cost share		**$0**
Annual wood use, if 100% wood (tons)		**2,712**
Wood/current fuel system:		
Annual wood use	tons	**2,305**
Annual natural gas use	decatherm	**3,273**
First year fuel cost savings (%)		**29%**
First year fuel cost savings ($)		**$53,398**

30 Year NPV

Total 30-Year Cost, natural gas system	**5,846,433**
Total 30-Year Cost, wood system	**5,366,503**
Difference (30-year NPV of savings)	**$479,930**

LIFE CYCLE COST ANALYSIS

Yr.	Inflation Calculator	**Natural Gas** Total Annual Cost	Capital Cost	**Woodchip/Natural Gas System** Wood Cost	Natural Gas Cost	Incremental Annualized O&M	Annualized Major Repairs	Non-capital Total 30-Year Cost	Total 30-Year Cost (w/o Finance)	Total Annualized Savings
0	1.000	$174,100	$1,572,500	$0	$0	$0	$0	$0	1,572,500	($1,572,500)
1	1.033	$183,240	$0	$102,356	$27,486	$11,976	$11,358	$153,176	153,176	$30,064
2	1.066	$192,860	$0	$105,683	$28,929	$12,365	$11,727	$158,704	158,704	$34,156
3	1.101	$202,985	$0	$109,117	$30,448	$12,767	$12,108	$164,440	164,440	$38,545
4	1.136	$213,642	$0	$112,664	$32,046	$13,182	$12,501	$170,393	170,393	$43,249
5	1.173	$224,858	$0	$116,325	$33,729	$13,610	$12,908	$176,572	176,572	$48,286
6	1.212	$236,663	$0	$120,106	$35,499	$14,053	$13,327	$182,985	182,985	$53,678
7	1.251	$249,088	$0	$124,009	$37,363	$14,509	$13,760	$189,642	189,642	$59,446
8	1.292	$262,165	$0	$128,040	$39,325	$14,981	$14,207	$196,553	196,553	$65,612
9	1.334	$275,929	$0	$132,201	$41,389	$15,468	$14,669	$203,727	203,727	$72,202
10	1.377	$290,415	$0	$136,497	$43,562	$15,971	$15,146	$211,176	211,176	$79,239
11	1.422	$305,662	$0	$140,934	$45,849	$16,490	$15,638	$218,911	218,911	$86,751
12	1.468	$321,709	$0	$145,514	$48,256	$17,026	$16,146	$226,942	226,942	$94,767
13	1.516	$338,599	$0	$150,243	$50,790	$17,579	$16,671	$235,283	235,283	$103,316
14	1.565	$356,375	$0	$155,126	$53,456	$18,150	$17,213	$243,945	243,945	$112,430
15	1.616	$375,085	$0	$160,168	$56,263	$18,740	$17,772	$252,943	252,943	$122,142
16	1.668	$394,777	$0	$165,373	$59,217	$19,349	$18,350	$262,289	262,289	$132,488
17	1.722	$415,503	$0	$170,748	$62,325	$19,978	$18,946	$271,997	271,997	$143,505
18	1.778	$437,316	$0	$176,297	$65,597	$20,627	$19,562	$282,084	282,084	$155,233
19	1.836	$460,276	$0	$182,027	$69,041	$21,298	$20,198	$292,563	292,563	$167,712
20	1.896	$484,440	$0	$187,943	$72,666	$21,990	$20,854	$303,453	303,453	$180,987
21	1.957	$509,873	$0	$194,051	$76,481	$22,704	$21,532	$314,768	314,768	$195,105
22	2.021	$536,641	$0	$200,357	$80,496	$23,442	$22,232	$326,528	326,528	$210,114
23	2.087	$564,815	$0	$206,869	$84,722	$24,204	$22,954	$338,750	338,750	$226,065
24	2.155	$594,468	$0	$213,592	$89,170	$24,991	$23,700	$351,454	351,454	$243,014
25	2.225	$625,677	$0	$220,534	$93,852	$25,803	$24,471	$364,659	364,659	$261,018
26	2.297	$658,526	$0	$227,701	$98,779	$26,642	$25,266	$378,388	378,388	$280,138
27	2.372	$693,098	$0	$235,102	$103,965	$27,508	$26,087	$392,661	392,661	$300,437
28	2.449	$729,486	$0	$242,742	$109,423	$28,402	$26,935	$407,502	407,502	$321,984
29	2.528	$767,784	$0	$250,631	$115,168	$29,325	$27,810	$422,934	422,934	$344,850
30	2.610	$808,092	($486,875)	$258,777	$121,214	$30,278	$28,714	$438,983	(47,892)	$855,985
Totals		$12,710,046		$5,071,726	$1,906,507	$593,407	$562,762	$8,134,402	$7,647,527	$5,062,520
30 YR NPV:		**$5,846,433**	**$1,442,504**	**$2,481,372**	**$876,965**	**$290,328**	**$275,334**	**$3,923,999**	**$5,366,503**	**$479,930**

Biomass Energy Resource Center

LIFE CYCLE COST ANALYSIS

(compared to operating existing fossil fuel system)

Organization Conducting Analysis	BERC	**Facility Name**	Scenario B	**Biomass Boiler Size:**	5.0 MMBtu

Assumptions

Total Project Cost	**$928,750**
Percentage cost share	**0%**
Financing, annual bond rate	**4.50%**
Finance term (years)	**20**
Current fuel	**natural gas**
Current fuel units	**decatherm**
Current fuel price per unit	**$11.74**
Annual units, current fuel	**10,654**
Wood price, yr 1 (per ton)	**$32**
Wood fraction (ann. heat load)	**85%**
General annual inflation rate	**3.25%**
Discount rate	**4.50%**
Fossil Fuel inflation (w/ genl inflation)	**5.25%**
Wood inflation (w/ genl inflation)	**3.25%**
Ann. Wood O&M cost, yr 1	**$6,803**
Major repairs (annualized)	**$5,000**
Estimated Boiler Life	**40**
Estimated Building Life	**60**

Capital Cost

Wood system	**$400,000**
Stack	**$25,000**
System Controls	**$8,000**
Electrical Connections	**$5,000**
Interconnection	**$30,000**
Building ($140/SF)	**$275,000**
Total capital	**$743,000**
GC markup 15%	$111,450
Design 10%	$74,300
Grand Total	**$928,750**

Calculated values

Financed amount		**$928,750**
Value of cost share		**$0**
Annual wood use, if 100% wood (tons)		**1,325**
Wood/current fuel system:		
Annual wood use	tons	**1,126**
Annual natural gas use	decatherm	**1,598**
First year fuel cost savings (%)		**57%**
First year fuel cost savings ($)		**$74,700**

30 Year NPV

Total 30-Year Cost, natural gas system	**4,200,237**
Total 30-Year Cost, wood system	**2,671,040**
Difference (30-year NPV of savings)	**$1,529,197**

LIFE CYCLE COST ANALYSIS

Yr.	Inflation Calculator	**Natural Gas** Total Annual Cost	Capital Cost	**Woodchip/Natural Gas System** Wood Cost	Natural Gas Cost	Incremental Annualized O&M	Annualized Major Repairs	Non-capital Total 30-Year Cost	Total 30-Year Cost (w/o Finance)	Total Annualized Savings
0	1.000	$125,078	$928,750	$0	$0	$0	$0	$0	928,750	($928,750)
1	1.033	$131,645	$0	$37,197	$19,747	$7,024	$5,163	$69,131	69,131	$62,514
2	1.066	$138,556	$0	$38,406	$20,783	$7,252	$5,330	$71,772	71,772	$66,783
3	1.101	$145,830	$0	$39,655	$21,875	$7,488	$5,504	$74,521	74,521	$71,309
4	1.136	$153,486	$0	$40,943	$23,023	$7,731	$5,682	$77,380	77,380	$76,106
5	1.173	$161,544	$0	$42,274	$24,232	$7,983	$5,867	$80,355	80,355	$81,189
6	1.212	$170,025	$0	$43,648	$25,504	$8,242	$6,058	$83,452	83,452	$86,574
7	1.251	$178,952	$0	$45,066	$26,843	$8,510	$6,255	$86,674	86,674	$92,278
8	1.292	$188,347	$0	$46,531	$28,252	$8,787	$6,458	$90,028	90,028	$98,319
9	1.334	$198,235	$0	$48,043	$29,735	$9,072	$6,668	$93,519	93,519	$104,716
10	1.377	$208,642	$0	$49,605	$31,296	$9,367	$6,884	$97,153	97,153	$111,489
11	1.422	$219,596	$0	$51,217	$32,939	$9,671	$7,108	$100,936	100,936	$118,660
12	1.468	$231,125	$0	$52,881	$34,669	$9,986	$7,339	$104,875	104,875	$126,249
13	1.516	$243,259	$0	$54,600	$36,489	$10,310	$7,578	$108,977	108,977	$134,282
14	1.565	$256,030	$0	$56,375	$38,404	$10,645	$7,824	$113,249	113,249	$142,781
15	1.616	$269,471	$0	$58,207	$40,421	$10,991	$8,078	$117,697	117,697	$151,774
16	1.668	$283,618	$0	$60,099	$42,543	$11,349	$8,341	$122,331	122,331	$161,288
17	1.722	$298,508	$0	$62,052	$44,776	$11,717	$8,612	$127,157	127,157	$171,351
18	1.778	$314,180	$0	$64,068	$47,127	$12,098	$8,892	$132,186	132,186	$181,995
19	1.836	$330,675	$0	$66,151	$49,601	$12,491	$9,181	$137,424	137,424	$193,250
20	1.896	$348,035	$0	$68,301	$52,205	$12,897	$9,479	$142,882	142,882	$205,153
21	1.957	$366,307	$0	$70,520	$54,946	$13,317	$9,787	$148,570	148,570	$217,737
22	2.021	$385,538	$0	$72,812	$57,831	$13,749	$10,105	$154,498	154,498	$231,040
23	2.087	$405,779	$0	$75,179	$60,867	$14,196	$10,434	$160,675	160,675	$245,103
24	2.155	$427,082	$0	$77,622	$64,062	$14,658	$10,773	$167,115	167,115	$259,967
25	2.225	$449,504	$0	$80,145	$67,426	$15,134	$11,123	$173,827	173,827	$275,677
26	2.297	$473,103	$0	$82,749	$70,965	$15,626	$11,484	$180,825	180,825	$292,278
27	2.372	$497,941	$0	$85,439	$74,691	$16,134	$11,858	$188,121	188,121	$309,820
28	2.449	$524,083	$0	$88,215	$78,612	$16,658	$12,243	$195,729	195,729	$328,354
29	2.528	$551,597	$0	$91,082	$82,740	$17,199	$12,641	$203,662	203,662	$347,935
30	2.610	$580,556	($318,125)	$94,043	$87,083	$17,758	$13,052	$211,936	(106,189)	$686,745
Totals		$9,131,245		$1,843,126	$1,369,687	$348,043	$255,801	$3,816,656	$3,498,531	$5,632,714
30 YR NPV:		**$4,200,237**	**$843,811**	**$901,760**	**$630,036**	**$170,282**	**$125,152**	**$1,827,230**	**$2,671,040**	**$1,529,197**

Biomass Energy Resource Center

LIFE CYCLE COST ANALYSIS

(compared to operating existing fossil fuel system)

Organization Conducting Analysis	BERC	Facility Name	Scenario B	Biomass Boiler Size:	5.0 MMBtu

Assumptions

Total Project Cost	**$928,750**
Percentage cost share	**0%**
Financing, annual bond rate	**4.50%**
Finance term (years)	**20**
Current fuel	**natural gas**
Current fuel units	**decatherm**
Current fuel price per unit	**$11.74**
Annual units, current fuel	**10,654**
Wood price, yr 1 (per ton)	**$43**
Wood fraction (ann. heat load)	**85%**
General annual inflation rate	**3.25%**
Discount rate	**4.50%**
Fossil Fuel inflation (w/ genl inflation)	**5.25%**
Wood inflation (w/ genl inflation)	**3.25%**
Ann. Wood O&M cost, yr 1	**$6,803**
Major repairs (annualized)	**$5,000**
Estimated Boiler Life	**40**
Estimated Building Life	**60**

Capital Cost

Wood system	**$400,000**
Stack	**$25,000**
System Controls	**$8,000**
Electrical Connections	**$5,000**
Interconnection	**$30,000**
Building ($140/SF)	**$275,000**
Total capital	**$743,000**
GC markup 15%	$111,450
Design 10%	$74,300
Grand Total	**$928,750**

Calculated values

Financed amount		**$928,750**
Value of cost share		**$0**
Annual wood use, if 100% wood (tons)		**1,325**
Wood/current fuel system:		
Annual wood use	tons	**1,126**
Annual natural gas use	decatherm	**1,598**
First year fuel cost savings (%)		**47%**
First year fuel cost savings ($)		**$61,914**

30 Year NPV

Total 30-Year Cost, natural gas system	**4,200,237**
Total 30-Year Cost, wood system	**2,981,020**
Difference (30-year NPV of savings)	**$1,219,217**

LIFE CYCLE COST ANALYSIS

Yr.	Inflation Calculator	**Natural Gas** Total Annual Cost	Capital Cost	**Woodchip/Natural Gas System** Wood Cost	Natural Gas Cost	Incremental Annualized O&M	Annualized Major Repairs	Non-capital Total 30-Year Cost	Total 30-Year Cost (w/o Finance)	Total Annualized Savings
0	1.000	$125,078	$928,750	$0	$0	$0	$0	$0	928,750	($928,750)
1	1.033	$131,645	$0	$49,984	$19,747	$7,024	$5,163	$81,917	81,917	$49,727
2	1.066	$138,556	$0	$51,609	$20,783	$7,252	$5,330	$84,975	84,975	$53,581
3	1.101	$145,830	$0	$53,286	$21,875	$7,488	$5,504	$88,152	88,152	$57,678
4	1.136	$153,486	$0	$55,018	$23,023	$7,731	$5,682	$91,454	91,454	$62,032
5	1.173	$161,544	$0	$56,806	$24,232	$7,983	$5,867	$94,887	94,887	$66,657
6	1.212	$170,025	$0	$58,652	$25,504	$8,242	$6,058	$98,456	98,456	$71,570
7	1.251	$178,952	$0	$60,558	$26,843	$8,510	$6,255	$102,165	102,165	$76,786
8	1.292	$188,347	$0	$62,526	$28,252	$8,787	$6,458	$106,023	106,023	$82,324
9	1.334	$198,235	$0	$64,558	$29,735	$9,072	$6,668	$110,033	110,033	$88,201
10	1.377	$208,642	$0	$66,656	$31,296	$9,367	$6,884	$114,204	114,204	$94,438
11	1.422	$219,596	$0	$68,823	$32,939	$9,671	$7,108	$118,542	118,542	$101,054
12	1.468	$231,125	$0	$71,060	$34,669	$9,986	$7,339	$123,053	123,053	$108,071
13	1.516	$243,259	$0	$73,369	$36,489	$10,310	$7,578	$127,746	127,746	$115,513
14	1.565	$256,030	$0	$75,753	$38,404	$10,645	$7,824	$132,627	132,627	$123,402
15	1.616	$269,471	$0	$78,215	$40,421	$10,991	$8,078	$137,706	137,706	$131,765
16	1.668	$283,618	$0	$80,757	$42,543	$11,349	$8,341	$142,990	142,990	$140,629
17	1.722	$298,508	$0	$83,382	$44,776	$11,717	$8,612	$148,488	148,488	$150,021
18	1.778	$314,180	$0	$86,092	$47,127	$12,098	$8,892	$154,209	154,209	$159,971
19	1.836	$330,675	$0	$88,890	$49,601	$12,491	$9,181	$160,163	160,163	$170,511
20	1.896	$348,035	$0	$91,779	$52,205	$12,897	$9,479	$166,361	166,361	$181,674
21	1.957	$366,307	$0	$94,762	$54,946	$13,317	$9,787	$172,812	172,812	$193,495
22	2.021	$385,538	$0	$97,841	$57,831	$13,749	$10,105	$179,527	179,527	$206,011
23	2.087	$405,779	$0	$101,021	$60,867	$14,196	$10,434	$186,518	186,518	$219,261
24	2.155	$427,082	$0	$104,304	$64,062	$14,658	$10,773	$193,797	193,797	$233,285
25	2.225	$449,504	$0	$107,694	$67,426	$15,134	$11,123	$201,377	201,377	$248,127
26	2.297	$473,103	$0	$111,194	$70,965	$15,626	$11,484	$209,270	209,270	$263,833
27	2.372	$497,941	$0	$114,808	$74,691	$16,134	$11,858	$217,491	217,491	$280,450
28	2.449	$524,083	$0	$118,540	$78,612	$16,658	$12,243	$226,053	226,053	$298,030
29	2.528	$551,597	$0	$122,392	$82,740	$17,199	$12,641	$234,972	234,972	$316,625
30	2.610	$580,556	($318,125)	$126,370	$87,083	$17,758	$13,052	$244,263	(73,862)	$654,417
Totals		$9,131,245		$2,476,700	$1,369,687	$348,043	$255,801	$4,450,231	$4,132,106	$4,999,140
30 YR NPV:		**$4,200,237**	**$843,811**	**$1,211,740**	**$630,036**	**$170,282**	**$125,152**	**$2,137,210**	**$2,981,020**	**$1,219,217**

Biomass Energy Resource Center

LIFE CYCLE COST ANALYSIS

(compared to operating existing fossil fuel system)

Organization Conducting Analysis	BERC	Facility Name	Scenario C	Biomass Boiler Size:	2.0 MMBtu

Assumptions

Total Project Cost	**$597,500**
Percentage cost share	**0%**
Financing, annual bond rate	**4.50%**
Finance term (years)	**20**
Current fuel	**oil**
Current fuel units	**gallons**
Current fuel price per unit	**$2.00**
Annual units, current fuel	**26,844**
Wood price, yr 1 (per ton)	**$32**
Wood fraction (ann. heat load)	**85%**
General annual inflation rate	**3.25%**
Discount rate	**4.50%**
Fossil Fuel inflation (w/ genl inflation)	**5.25%**
Wood inflation (w/ genl inflation)	**3.25%**
Ann. Wood O&M cost, yr 1	**$5,079**
Major repairs (annualized)	**$2,000**
Estimated Boiler Life	**40**
Estimated Building Life	**60**

Capital Cost

Wood system	**$160,000**
Stack	**$25,000**
System Controls	**$8,000**
Electrical Connections	**$5,000**
Interconnection	**$30,000**
Building ($140/SF)	**$250,000**
Total capital	**$478,000**
GC markup 15%	$71,700
Design 10%	$47,800
Grand Total	**$597,500**

Calculated values

Financed amount		**$597,500**
Value of cost share		**$0**
Annual wood use, if 100% wood (tons)		**432**
Wood/current fuel system:		
Annual wood use	tons	**367**
Annual oil use	gallons	**4,027**
First year fuel cost savings (%)		**64%**
First year fuel cost savings ($)		**$35,905**

30 Year NPV

Total 30-Year Cost, oil system	**1,802,894**
Total 30-Year Cost, wood system	**1,278,334**
Difference (30-year NPV of savings)	**$524,561**

LIFE CYCLE COST ANALYSIS

Yr.	Inflation Calculator	**Oil** Total Annual Cost	Capital Cost	**Woodchip/Oil System** Wood Cost	Oil Cost	Incremental Annualized O&M	Annualized Major Repairs	Non-capital Total 30-Year Cost	Total 30-Year Cost (w/o Finance)	Total Annualized Savings
0	1.000	$53,688	$597,500	$0	$0	$0	$0	$0	597,500	($597,500)
1	1.033	$56,507	$0	$12,125	$8,476	$5,244	$2,065	$27,911	27,911	$28,596
2	1.066	$59,473	$0	$12,520	$8,921	$5,414	$2,132	$28,987	28,987	$30,486
3	1.101	$62,596	$0	$12,926	$9,389	$5,590	$2,201	$30,108	30,108	$32,488
4	1.136	$65,882	$0	$13,347	$9,882	$5,772	$2,273	$31,274	31,274	$34,608
5	1.173	$69,341	$0	$13,780	$10,401	$5,960	$2,347	$32,488	32,488	$36,853
6	1.212	$72,981	$0	$14,228	$10,947	$6,153	$2,423	$33,752	33,752	$39,229
7	1.251	$76,813	$0	$14,691	$11,522	$6,353	$2,502	$35,068	35,068	$41,745
8	1.292	$80,845	$0	$15,168	$12,127	$6,560	$2,583	$36,438	36,438	$44,407
9	1.334	$85,090	$0	$15,661	$12,763	$6,773	$2,667	$37,865	37,865	$47,225
10	1.377	$89,557	$0	$16,170	$13,434	$6,993	$2,754	$39,350	39,350	$50,206
11	1.422	$94,258	$0	$16,695	$14,139	$7,221	$2,843	$40,898	40,898	$53,360
12	1.468	$99,207	$0	$17,238	$14,881	$7,455	$2,936	$42,510	42,510	$56,697
13	1.516	$104,415	$0	$17,798	$15,662	$7,697	$3,031	$44,189	44,189	$60,226
14	1.565	$109,897	$0	$18,377	$16,485	$7,948	$3,130	$45,939	45,939	$63,959
15	1.616	$115,667	$0	$18,974	$17,350	$8,206	$3,231	$47,761	47,761	$67,906
16	1.668	$121,739	$0	$19,591	$18,261	$8,473	$3,336	$49,661	49,661	$72,079
17	1.722	$128,131	$0	$20,227	$19,220	$8,748	$3,445	$51,640	51,640	$76,491
18	1.778	$134,858	$0	$20,885	$20,229	$9,032	$3,557	$53,702	53,702	$81,155
19	1.836	$141,938	$0	$21,563	$21,291	$9,326	$3,672	$55,852	55,852	$86,085
20	1.896	$149,389	$0	$22,264	$22,408	$9,629	$3,792	$58,093	58,093	$91,296
21	1.957	$157,232	$0	$22,988	$23,585	$9,942	$3,915	$60,430	60,430	$96,803
22	2.021	$165,487	$0	$23,735	$24,823	$10,265	$4,042	$62,865	62,865	$102,622
23	2.087	$174,175	$0	$24,506	$26,126	$10,599	$4,174	$65,405	65,405	$108,770
24	2.155	$183,319	$0	$25,303	$27,498	$10,943	$4,309	$68,053	68,053	$115,266
25	2.225	$192,943	$0	$26,125	$28,942	$11,299	$4,449	$70,815	70,815	$122,129
26	2.297	$203,073	$0	$26,974	$30,461	$11,666	$4,594	$73,695	73,695	$129,378
27	2.372	$213,734	$0	$27,851	$32,060	$12,045	$4,743	$76,699	76,699	$137,035
28	2.449	$224,955	$0	$28,756	$33,743	$12,437	$4,897	$79,833	79,833	$145,122
29	2.528	$236,765	$0	$29,691	$35,515	$12,841	$5,056	$83,103	83,103	$153,663
30	2.610	$249,196	($227,500)	$30,656	$37,379	$13,258	$5,221	$86,514	(140,986)	$390,182
Totals		$3,919,462		$600,814	$587,919	$259,842	$102,320	$1,550,896	$1,323,396	$2,596,066
30 YR NPV:		**$1,802,894**	**$536,757**	**$293,952**	**$270,434**	**$127,129**	**$50,061**	**$741,576**	**$1,278,334**	**$524,561**

Biomass Energy Resource Center

LIFE CYCLE COST ANALYSIS

(compared to operating existing fossil fuel system)

Organization Conducting Analysis	BERC	**Facility Name**	Scenario C	**Biomass Boiler Size:**	2.0 MMBtu

Assumptions

Total Project Cost	**$597,500**
Percentage cost share	**0%**
Financing, annual bond rate	**4.50%**
Finance term (years)	**20**

Current fuel	**oil**
Current fuel units	**gallons**
Current fuel price per unit	**$2.00**
Annual units, current fuel	**26,844**

Wood price, yr 1 (per ton)	**$43**
Wood fraction (ann. heat load)	**85%**

General annual inflation rate	**3.25%**
Discount rate	**4.50%**
Fossil Fuel inflation (w/ genl inflation)	**5.25%**
Wood inflation (w/ genl inflation)	**3.25%**

Ann. Wood O&M cost, yr 1	**$5,079**
Major repairs (annualized)	**$2,000**
Estimated Boiler Life	**40**
Estimated Building Life	**60**

Capital Cost

Wood system	**$160,000**
Stack	**$25,000**
System Controls	**$8,000**
Electrical Connections	**$5,000**
Interconnection	**$30,000**
Building ($140/SF)	**$250,000**
Total capital	**$478,000**
GC markup 15%	$71,700
Design 10%	$47,800
Grand Total	**$597,500**

Calculated values

Financed amount		**$597,500**
Value of cost share		**$0**
Annual wood use, if 100% wood (tons)		**432**
Wood/current fuel system:		
Annual wood use	tons	**367**
Annual oil use	gallons	**4,027**
First year fuel cost savings (%)		**56%**
First year fuel cost savings ($)		**$31,737**

30 Year NPV

Total 30-Year Cost, oil system	**1,802,894**
Total 30-Year Cost, wood system	**1,379,379**
Difference (30-year NPV of savings)	**$423,515**

LIFE CYCLE COST ANALYSIS

Yr.	Inflation Calculator	**Oil** Total Annual Cost	Capital Cost	**Woodchip/Oil System** Wood Cost	Oil Cost	Incremental Annualized O&M	Annualized Major Repairs	Non-capital Total 30-Year Cost	Total 30-Year Cost (w/o Finance)	Total Annualized Savings
0	1.000	$53,688	$597,500	$0	$0	$0	$0	$0	597,500	($597,500)
1	1.033	$56,507	$0	$16,294	$8,476	$5,244	$2,065	$32,079	32,079	$24,428
2	1.066	$59,473	$0	$16,823	$8,921	$5,414	$2,132	$33,291	33,291	$26,183
3	1.101	$62,596	$0	$17,370	$9,389	$5,590	$2,201	$34,551	34,551	$28,044
4	1.136	$65,882	$0	$17,934	$9,882	$5,772	$2,273	$35,862	35,862	$30,020
5	1.173	$69,341	$0	$18,517	$10,401	$5,960	$2,347	$37,225	37,225	$32,116
6	1.212	$72,981	$0	$19,119	$10,947	$6,153	$2,423	$38,643	38,643	$34,338
7	1.251	$76,813	$0	$19,740	$11,522	$6,353	$2,502	$40,118	40,118	$36,695
8	1.292	$80,845	$0	$20,382	$12,127	$6,560	$2,583	$41,652	41,652	$39,193
9	1.334	$85,090	$0	$21,044	$12,763	$6,773	$2,667	$43,248	43,248	$41,841
10	1.377	$89,557	$0	$21,728	$13,434	$6,993	$2,754	$44,909	44,909	$44,648
11	1.422	$94,258	$0	$22,435	$14,139	$7,221	$2,843	$46,637	46,637	$47,621
12	1.468	$99,207	$0	$23,164	$14,881	$7,455	$2,936	$48,436	48,436	$50,771
13	1.516	$104,415	$0	$23,916	$15,662	$7,697	$3,031	$50,307	50,307	$54,108
14	1.565	$109,897	$0	$24,694	$16,485	$7,948	$3,130	$52,256	52,256	$57,642
15	1.616	$115,667	$0	$25,496	$17,350	$8,206	$3,231	$54,284	54,284	$61,383
16	1.668	$121,739	$0	$26,325	$18,261	$8,473	$3,336	$56,395	56,395	$65,344
17	1.722	$128,131	$0	$27,180	$19,220	$8,748	$3,445	$58,593	58,593	$69,538
18	1.778	$134,858	$0	$28,064	$20,229	$9,032	$3,557	$60,882	60,882	$73,976
19	1.836	$141,938	$0	$28,976	$21,291	$9,326	$3,672	$63,265	63,265	$78,673
20	1.896	$149,389	$0	$29,918	$22,408	$9,629	$3,792	$65,747	65,747	$83,643
21	1.957	$157,232	$0	$30,890	$23,585	$9,942	$3,915	$68,332	68,332	$88,901
22	2.021	$165,487	$0	$31,894	$24,823	$10,265	$4,042	$71,024	71,024	$94,463
23	2.087	$174,175	$0	$32,930	$26,126	$10,599	$4,174	$73,829	73,829	$100,346
24	2.155	$183,319	$0	$34,001	$27,498	$10,943	$4,309	$76,751	76,751	$106,568
25	2.225	$192,943	$0	$35,106	$28,942	$11,299	$4,449	$79,795	79,795	$113,148
26	2.297	$203,073	$0	$36,247	$30,461	$11,666	$4,594	$82,967	82,967	$120,106
27	2.372	$213,734	$0	$37,425	$32,060	$12,045	$4,743	$86,273	86,273	$127,461
28	2.449	$224,955	$0	$38,641	$33,743	$12,437	$4,897	$89,718	89,718	$135,237
29	2.528	$236,765	$0	$39,897	$35,515	$12,841	$5,056	$93,309	93,309	$143,457
30	2.610	$249,196	($227,500)	$41,193	$37,379	$13,258	$5,221	$97,052	(130,448)	$379,644
Totals		$3,919,462		$807,344	$587,919	$259,842	$102,320	$1,757,426	$1,529,926	$2,389,536
30 YR NPV:		**$1,802,894**	**$536,757**	**$394,998**	**$270,434**	**$127,129**	**$50,061**	**$842,622**	**$1,379,379**	**$423,515**

CONTACT INFORMATION FOR SCHOOLS IN THIS STUDY

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Park Falls High School

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ENDNOTES

[1] Wisconsin Division of State Energy and Coastal Management, Department of Administration. May 1987. "Wood Boiler Systems in Northern Wisconsin School and Hospital."

[2] To protect the confidentiality agreement districts have with the Focus on Energy Program, data used for this study did not include school names.

[3] Pam Porter, Monte Lamer, and Bob Drevlow toured the four schools studied in this report.

[4] Please see the discussion above and in the "Wood Fuel Pricing" segment of the "Fuel Supply" section of this report for explanation of fuel price assumptions.

[5] Please see the discussion above and in the "Wood Fuel Pricing" segment of the "Fuel Supply" section of this report for explanation of fuel price assumptions.

[6] Please see the discussion above and in the "Wood Fuel Pricing" segment of the "Fuel Supply" section of this report for explanation of fuel price assumptions.

[7] Perry, Charles H. Brand, Gary J. Wisconsin's Forest Resources, 2005. USDA Forest Service. October 2006.

[8] http://ncrs.fs.fed.us/hottopics/fpwi.asp.

[9] Ibid.

[10] Rickenbach, Mark. Steele, Thomas. Schira, Mike Status of Logging Sector in Wisconsin and Michigan's Upper Peninsula, 2003. University of Wisconsin, 2005.

[11] Rickenbach, Mark. Steele, Thomas. Schira, Mike Status of Logging Sector in Wisconsin and Michigan's Upper Peninsula, 2003. University of Wisconsin, 2005.

[12] Ince, Peter J. 1979. How to Estimate Recoverable Heat Energy in Wood or Bark Fuels, USDA Forest Products Laboratory.

[13] Sections 67.05(6a)(b) and 67.12(12(e)(2g)) of the Wisconsin Statutes.

Heating with Biomass:
A Feasibility Study of Wisconsin Schools Heated with Wood

Prepared by:

P Squared Group LLC and Biomass Energy Resource Center