U.S. Department of Agriculture
Northeastern Area
State and Private Forestry

WERC

WOOD EDUCATION AND RESOURCE CENTER

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Preliminary Feasibility Report

Biomass Heating Analysis for Indiana Area Senior High School

Indiana, Pennsylvania
December, 2011

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EXECUTIVE SUMMARY

The Indiana Area Senior High School serves 800 students in a single building located in Indiana, PA. The school building, constructed in 1963, is approximately 210,000 square feet and is heated entirely by natural gas. Indiana Area Senior High School recently underwent an energy assessment, making this an ideal time to consider a biomass energy project.

The School currently uses approximately 12,650 dekatherms of natural gas each year. The average price paid by the School over the past two years was $10.88 per dekatherm. At that price Indiana Area Senior High School will spend approximately $137,700 on natural gas this coming year.

This study analyzes the installation of a woodchip boiler system at Indiana Area Senior High School. While the analysis does show that a biomass system would provide the School with annual fuel savings (approximately $67,850 per year), these savings do not likely justify the capital costs, of $1.5 million, required to install a woodchip system.

This report analyzes the opportunity to utilize wood energy at Indiana Area Senior High School. While investing in a woodchip system is not practical at this time due to the current price of natural gas, as natural gas prices increase or if substantial grant funding is obtained, installation of a woodchip system may become a better investment for the School.

Table 1: Summary Findings of Analysis

	Capital Cost	1st Year Debt Service	1st Year Annual Fuel Savings	30 Year NPV Cumulative Savings	Simple Payback
Woodchip Heating System	$1.53 million	$112,330	$67,849	$262,849	22.5 years

Regardless of whether or not Indiana Area Senior High School moves forward with a biomass project, we recommend the School consider the following:

1. In order to effectively measure progress toward energy efficiency goals historical energy consumption data should be collected and updated frequently. There are many tools to help the School accomplish this. One such tool is the EPA Energy Star Portfolio Manager software. It is free public domain software that helps facility managers track energy and water use. This software can be downloaded at: http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager

If the School does decide to move forward with a biomass project we also recommend taking the following steps:

1. Hire an engineering firm to help refine the project concept and to obtain firm local estimates on project costs. The US Forest Service may be able to provide some technical assistance from an engineering team with biomass experience. If the School moves forward with this project, they should contact Lew McCreery, the US Forest Service Biomass Coordinator for the Northeastern Area to see what assistance can be provided. Contact Lew at (304)285-1538 or lmccreery@fs.fed.us

2. The School is currently undergoing an energy assessment – all findings and recommendations from this assessment should be considered in addition to a biomass energy project.

3. The School should have the area behind the building surveyed to determine the potential for locating the biomass boiler house and chip storage building in this location. The results of the survey should be reviewed by the engineer to determine the best location for the boiler house and chip storage.

4. The School should identify any heating system improvements it plans to undertake and include those projects with the biomass project. It is more cost effective to implement boiler room upgrades and heating distribution improvements at the same time a new boiler system is installed.

5. Concurrent with the design of the project, the School should cultivate potential biomass fuel suppliers. School staff should work with Mike Palko, Biomass Energy Specialist with the PA DCNR Bureau of Forestry, to identify potential Pennsylvania woodchip suppliers. Mike can be reached at (570)326-6020 or mipalko@state.pa.us.

This preliminary feasibility study was prepared by Yellow Wood Associates in collaboration with Richmond Energy Associates for the Indiana Area Senior High School. Both Yellow Wood and Richmond Energy have extensive community economic development experience and Richmond Energy specializes in biomass energy projects. This study was funded by the Wood Education and Resource Center, Northeastern Area State and Private Forestry, U.S. Department of Agriculture.

INTRODUCTION

There is a significant volume of low-grade biomass in the United States that represents a valuable economic and environmental opportunity if it can be constructively used to produce energy. Commercially available biomass heating systems can provide heat cleanly and efficiently in many commercial applications. Biomass heating technologies are being used quite successfully in over 45 public schools in Vermont and ten in Pennsylvania. The concept of heating institutions with wood is catching on in several other areas of the United States and Canada. Good candidate facilities for biomass energy systems include those that have high heating bills, those that have either steam or hot water heating distribution systems and those that have ready access to reasonably priced biomass fuel.

In addition to the potential financial benefits of installing a biomass energy system, a biomass system would: utilize locally grown and harvested wood (keeping energy dollar in the local economy); reduce the School's carbon footprint (by replacing fossil fuel with a renewable fuel source); and reduce dependence on fossil fuel, helping the State to achieve targets for renewable energy use.

This report is a pre-feasibility assessment specifically tailored to Indiana Area Senior High School outlining whether or not a biomass heating project makes sense for this facility from a practical perspective. In June, 2011, staff from Yellow Wood Associates traveled to Indiana, PA to tour the school. This assessment includes site specific fuel savings projections based on historic fuel consumption, and provides facility decision-makers suggestions and recommendations on next steps.

The study was funded by the U.S. Department of Agriculture Wood Education and Resource Center.

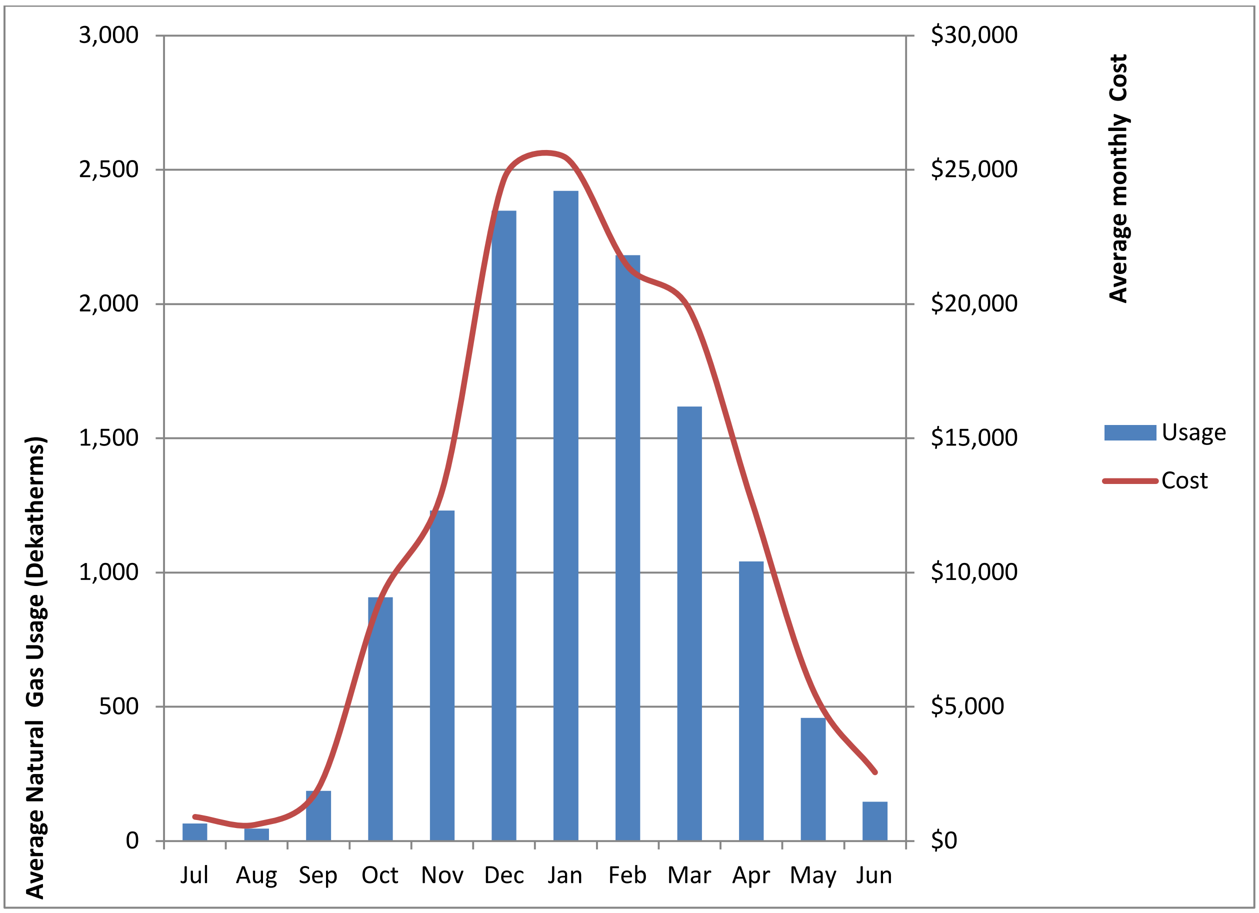
This preliminary feasibility study was prepared by Yellow Wood Associates and Richmond Energy Associates, LLC.

ANALYSIS ASSUMPTIONS

DESCRIPTION OF THE EXISTING HEATING SYSTEMS

The Indiana Area Senior High School serves approximately 800 students in 210,000 square feet of conditioned space. The school building is heated from a central boiler room that includes two 5.8 mmBtu hot water boilers that run on natural gas. The school is served by a hot water distribution system. The boilers were purchased in 1991 and are in good condition. The school uses an average of 12,653 dekatherms of natural gas each year.

Figure 1: Natural Gas Usage



LIFE CYCLE COST METHODOLOGY

Decision makers need practical methods for evaluating the economic performance of alternative choices for any given purchasing decision. When making a choice between mutually exclusive capital investments, it is prudent to compare all equipment and operating costs spent over the life of the longest lived alternative in order to determine the true least cost choice. The total cost of acquisition, fuel costs, operation and maintenance of an item throughout its useful life is known as its "life cycle cost." Life cycle costs that should be considered in a life cycle cost analysis include:

- Capital costs for purchasing and installing equipment
- Fuel costs
- Inflation for fuels, operational labor and major repairs
- Annual operation and maintenance costs including scheduled major repairs
- Salvage costs of equipment and buildings at the end of the analysis period

It is useful for decision makers to consider the impact of debt service if the project is to be financed in order to get a clearer picture of how a project might affect annual budgets. When viewed in this light, equipment with significant capital costs may still be the least-cost alternative. In some cases, a significant capital investment may actually lower annual expenses, if there are sufficient fuel savings to offset debt service and any incremental increases in operation and maintenance costs.

The analysis performed for this facility compares different scenarios over a 30-year horizon and takes into consideration life cycle cost factors. A 30-year time frame is used because it is the expected life of a new boiler.

The alternative biomass scenario envisions installing a new woodchip heating system that would serve the Indiana Area Senior High School. The scenario includes all ancillary equipment and interconnection costs. Under the biomass scenario, the existing heating equipment would still be used to provide supplemental heat during the coldest days of the year if necessary and potentially for the warmer shoulder season months when buildings only require minimal heating during chilly weather.

The analysis projects current and future annual heating bills and compares that cost against the cost of operating a biomass system. Savings are presented in today's dollars using a net present value calculation. Net present value (NPV) is defined as the present dollar value of net cash flows over time. This is a standard method for using the time value of money to compare the cost effectiveness of long-term projects.

It is not the intent of this project, nor was it in the scope of work, to develop detailed cost estimates for a biomass heating system. It is recommended that for a project of this scale, the School hire a qualified design team to refine the project concept and to develop firm local cost estimates. Therefore the capital costs used for the biomass scenario are generic estimates based on our experience with similar scale projects.

NATURAL GAS COST ASSUMPTIONS

During the past two years, the Indiana Area Senior High School used an average 12,653 dekatherms of natural gas to heat the school. The total of 12,653 dekatherms of natural gas was the assumed annual fuel consumption used for the base case in the analysis. The average price paid for natural gas over the past two years was $10.88 per dekatherm according to the school's fuel history. At that price, Indiana Area School District will spend more than $137,665 to heat the Senior High School next year.

WOODCHIP FUEL COST ASSUMPTIONS

Frequently, operators of institutional woodchip systems don't fire up their biomass boilers until there is constant demand for building heat. During the fall and spring, fossil fuel boilers are often used as they are easier to start up and turn down. Woodchip boilers are then typically used in place of fossil fuel boilers for the bulk of the winter heating season. In Vermont, where there are over 45 schools that heat with wood, the average annual wood utilization is about 85%.

After consulting with other woodchip users in the region, we are projecting a first year cost of $40 per ton for woodchips which is equivalent to about $4.70 per dekatherm of natural gas. The remaining 15% of the heating needs were then assumed to be provided by the existing natural gas boilers consuming about 1,898 dekatherms of natural gas. The cost for supplemental natural gas (starting at $10.88 per dekatherm) is then adjusted for inflation each year over the 30-year horizon.

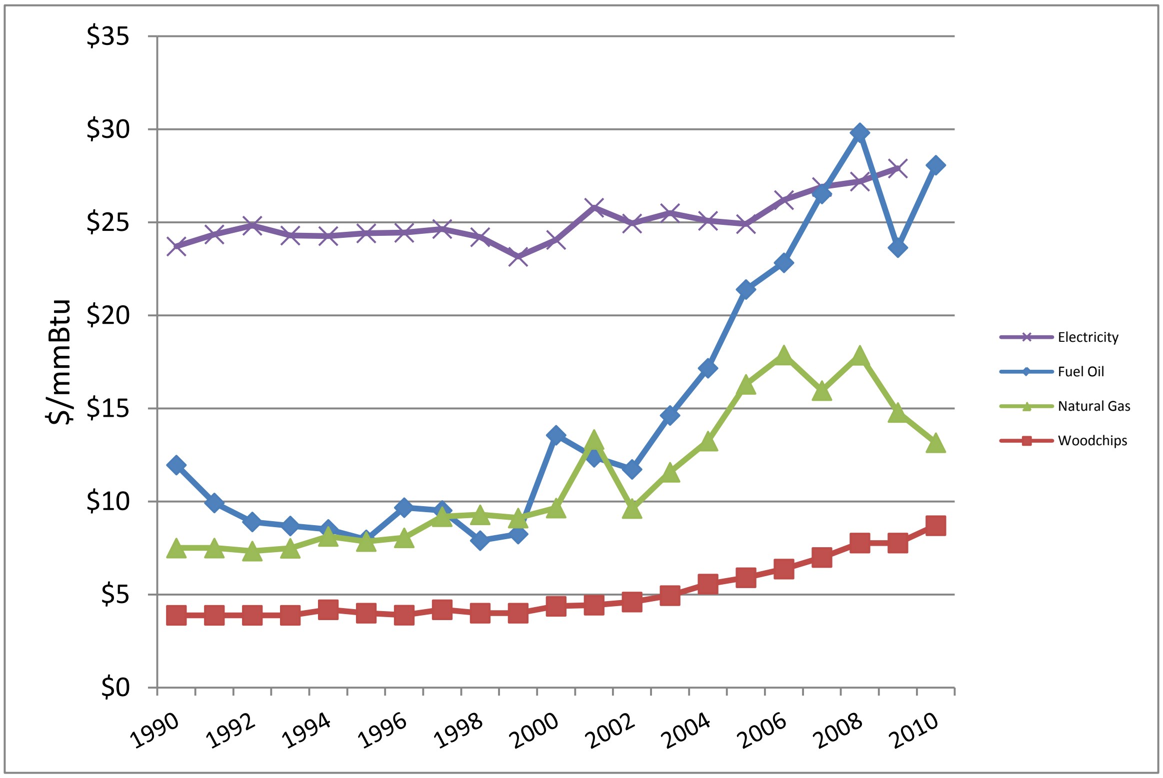
INFLATION ASSUMPTIONS

Estimating future fuel costs over time is difficult at best. Over the past few years it has become even more difficult as fuel prices have fluctuated dramatically. Nevertheless, in order to more accurately reflect future costs in a thirty-year analysis, some rate of inflation needs to be applied to future fuel costs.

We looked retrospectively over the last 20 years (1990 – 2010) using US Energy Information Agency data and found that the average annual increase for natural gas in Pennsylvania was 4% per year. The analysis projects this average inflation rates for natural gas forward over the thirty-year analysis period. The School's natural gas rate of $10.88 per Dth was used for the first year of the analysis and then inflated each year at 4%.

The cost of woodchips used for heating fuel tends to increase more slowly and has historically been much more stable in price over the past two decades than fossil fuels. In Vermont for example, the statewide average woodchip fuel price for institutional biomass heating systems rose from $25/ton to $56/ton in the period between 1990 and 2010. The average annual increase during this period was about 3.6% annually[1] with the greatest increases happening recently. Because woodchip fuel is locally produced from what is generally considered a waste product from some other forest product business, it does not have the same geopolitical pressures that fossil fuels have. Over the past twenty years, woodchip fuel costs have been far less volatile than fossil fuels.

Figure 2: Pennsylvania Fossil Fuel Price History vs. Vermont Woodchip Price History[1]



The overall Consumer Price Index for the period between 1990 and 2009, the last year for which full data is available, increased an average of 2.7% annually. This is the annual inflation rate that was used in projecting all future labor costs, operations and maintenance costs and scheduled major repair costs for the biomass scenario.

[1] Extrapolated from Vermont Superintendent Association School Energy Management Program data. Woodchip price history is taken from Vermont because this State has the longest and best recorded, woodchip pricing history.

OPERATION AND MAINTENANCE ASSUMPTIONS

It is typical for operators of fully automated woodchip heating systems of this size to spend 15-30 minutes per day to clean ashes[2] and to check on pumps, motors and controls. For the woodchip scenario, it was assumed that existing on-site staff would spend on average approximately one half hour per day in addition to their current boiler maintenance for 150 days per year and 20 hours during the summer months for routine maintenance. At a loaded labor rate of $25/hr, this equals $2,375 annually. An additional $6,000 in annual operational costs is assumed for electricity to run pumps, motors and pollution control equipment.

Another operations and maintenance cost that is included in the analysis is periodic repair or replacement of major items on the boiler such as the furnace refractory. It is reasonable to anticipate these types of costs on a 10-15 year cycle. For this analysis, $25,000 of scheduled maintenance was anticipated in years 10, 20 and 30 and then annualized at $2,500 per year to simulate a sinking fund for major repairs. This $2,500 was then inflated at the general annual inflation rate.

Figure 3: Williamstown, VT High School Woodchip Boiler Plant

Under any biomass scenario, a case could be made that the existing heating units will require less maintenance and may last longer since they will only be used for a small portion of the heating season. However, all heating equipment should be serviced at least annually no matter how much it is used. Additionally it is very difficult to estimate how long the replacement of the existing units might be delayed. For these reasons, no additional annual maintenance, scheduled repair or planned replacement costs for the existing natural gas boilers were taken into consideration as these are considered costs that the School would have paid anyway. It was assumed that all costs for the operation and maintenance of a biomass boiler are incremental additional costs.

[2] Wood ash is generally not considered a hazardous material in most states and can be landfilled or land applied as a soil amendment by farmers or on-site maintenance staff.

FINANCING ASSUMPTIONS

Financing costs were included in the analysis to give facility decision makers a sense of how this project may impact their annual budget. This analysis assumes that the School will finance the entire cost of the biomass project with a low interest 4% loan. At this time the analysis does not take into account any potential tax credits, grants or lower interest loans. Other financing schedules could create more favorable cash flows depending on how much of the project costs are financed and how the remaining costs are financed. See the section in this report on Project Funding Opportunities to learn about alternative funding and financing options.

A sensitivity analysis is included in the appendices to this report that show the relative life cycle cost savings under various financing scenarios. If the School would like to see other cash flows using different financing schemes, Yellow Wood can provide additional analysis.

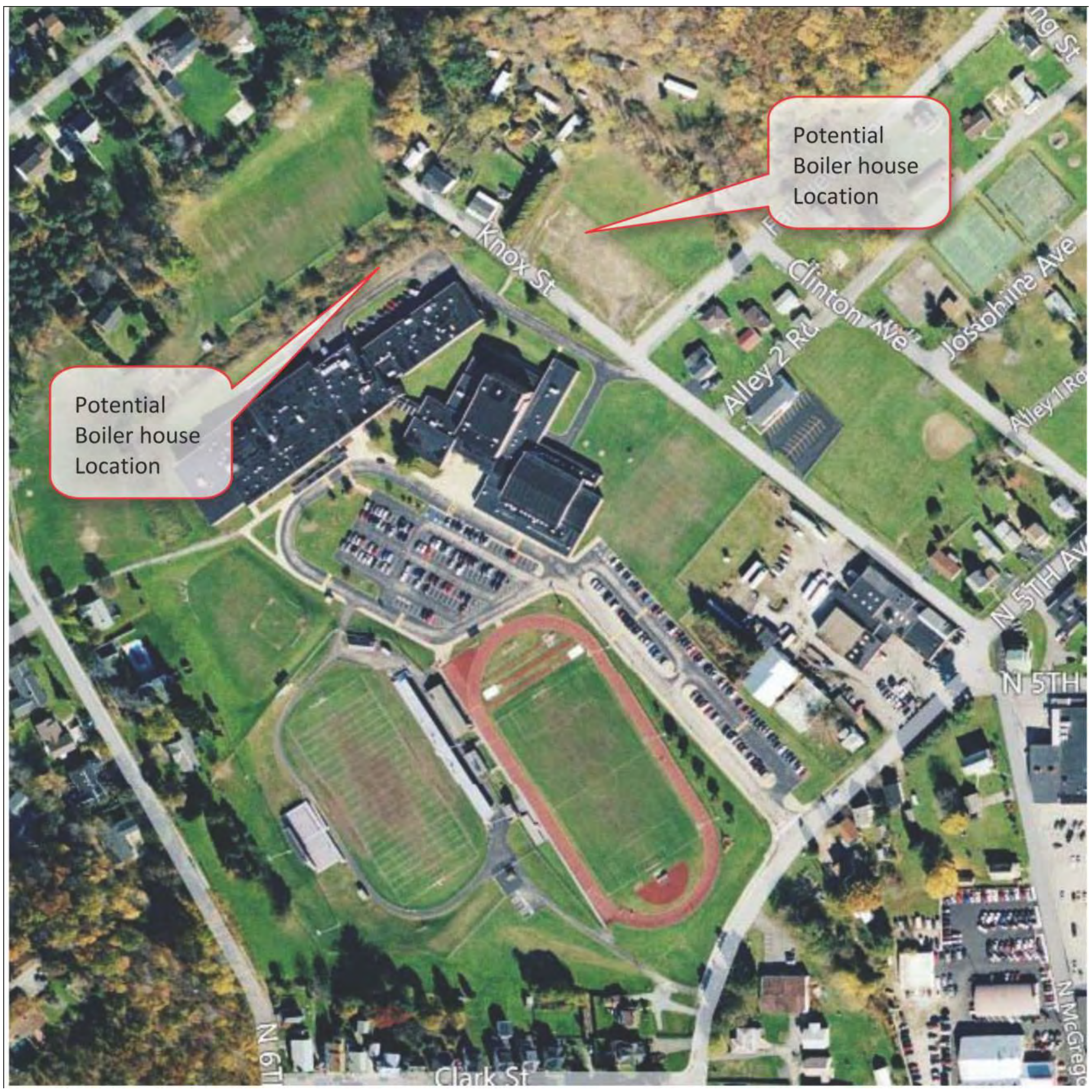
Figure 4: Underground Insulated Piping

BIOMASS SCENARIO ANALYSIS

DESCRIPTION OF THE PROPOSED BIOMASS SYSTEM

The biomass scenario proposes building a 2,500 sf stand-alone boiler house and chip storage facility that would house a 4.2 mmBtu woodchip hot water boiler, woodchip fuel storage and fuel handling equipment to feed the boiler automatically. Hot water from the woodchip boiler house would be tied into the existing HVAC systems via approximately 250 feet of underground insulated piping. The scenario assumes the existing natural gas boilers would remain to provide back-up heat for the shoulder seasons and supplemental heat during the coldest days of the year if necessary.

Figure 5: Site Plan



A pollution control system may be required by state air quality regulators for a system this size. Included in the analysis is an allowance for pollution control equipment. The facility should direct its design engineers to investigate appropriate pollution control strategies to determine which will work best for this site and project. Costs for an underground woodchip storage bin were included, as below grade chip storage bins are less likely to freeze in the coldest winter weather, and chip delivery using self unloading trailers into below grade bins is fast and easy.

A thermal storage system is included in the capital cost estimate for this study. In this case the thermal storage system includes a large, insulated hot water tank and ancillary piping and pumps that connect the insulated storage tank to the wood fired boiler and to the building heating system. Heat from the wood boiler is stored in the water in the insulated tank until needed by the building system. This allows the boiler to operate in a high fire state at peak efficiency and then be turned off or to go into a stand-by mode where a minimal amount of fuel is being burned.

The improved efficiency from thermal storage means fuel savings and reduced emissions. A thermal storage system also allows peak load shaving and, as a result, a smaller combustion system can be installed. The stored energy in the tank provides a buffer for peak loads during the day. The boiler loads energy into the tank during periods of low demand. When periods of peak demand occur, the energy stored in the tank responds immediately to the buildings' demand while the wood-fired boiler is reaching a "high fire" state. Then the boiler can provide the additional energy required to meet the peak demand. In commercial or school settings, these peak demand periods are often periods of maximum air exchange with the outdoors.

Additional benefits of the thermal storage system include the ability to extend the operation of the wood combustion system during warmer spring and fall periods, and in some cases, to address summer domestic hot water needs. Additionally solar thermal energy systems can be connected to the storage tank. In fact such combination systems are often used in Europe to meet summer domestic hot water needs and increase overall system efficiency.

A healthy construction contingency, standard general contractor mark-up and professional design fees were also included.

Table 2: Biomass Scenario Analysis Assumptions

Indiana Area Senior High School
Analysis Assumptions

Capital Cost Assumptions					
One 4.2 mmBtu biomass boiler installed in new boilerhouse					$450,000
70 ft stack					$35,000
Pollution control equipment					$100,000
Biomass boiler house	2,500	SF	$150	/SF	$375,000
Pex Pipe (Combination of 4" and 6" supply and return)	250	LF	$150	LF	$37,500
Thermal storage 3,000 gallon					$30,000
Interconnection to existing boiler room					$50,000
GC markup at 10%					$107,750
Construction contingency at 15%					$177,788
Design at 12%					$163,565
Subtotal					$1,526,602
Grant					$0
Total estimated project costs					$1,526,602
Finance Assumptions					
Assumed Interest Rate					4%
First year debt service					$112,330
Fuel Cost Assumptions					
Current annual natural gas use in Dekatherms (Dkth)					12,653
Assumed natural gas price in 1st year (per Dkth)					$10.88
Projected annual natural gas bill					$137,665
Assumed wood price in 1st year (per ton)					$40
Projected 1st year wood fuel bill					$49,166
Projected 1st year supplemental natural gas bill					$20,650
Inflation Assumptions					
General inflation rate (twenty year average CPI)					2.7%
Natural gas inflation rate (twenty year average EIA)					4.0%
Wood inflation rate (average increase in VT from 1990 - 2010)					3.6%
O&M Assumptions					
Annual Wood O&M cost, including electricity for additional pumps and motors and staff time for daily and yearly maintenance					$8,375
Major repairs (annualized)					$2,500
Savings					
Return on Investment					**4.4%**
Net 1st year fuel savings					**$67,849**
Total 30 year NPV cumulative savings					**$262,849**

This graph shows the projected cash flow over the 30 year life-cycle of the biomass boiler. The graph takes into account projected heating fuel savings (cost of woodchips versus the cost of natural gas), projected revenue and projected debt service.

Figure 6: Annual Cash Flow Graph for Biomass Scenario

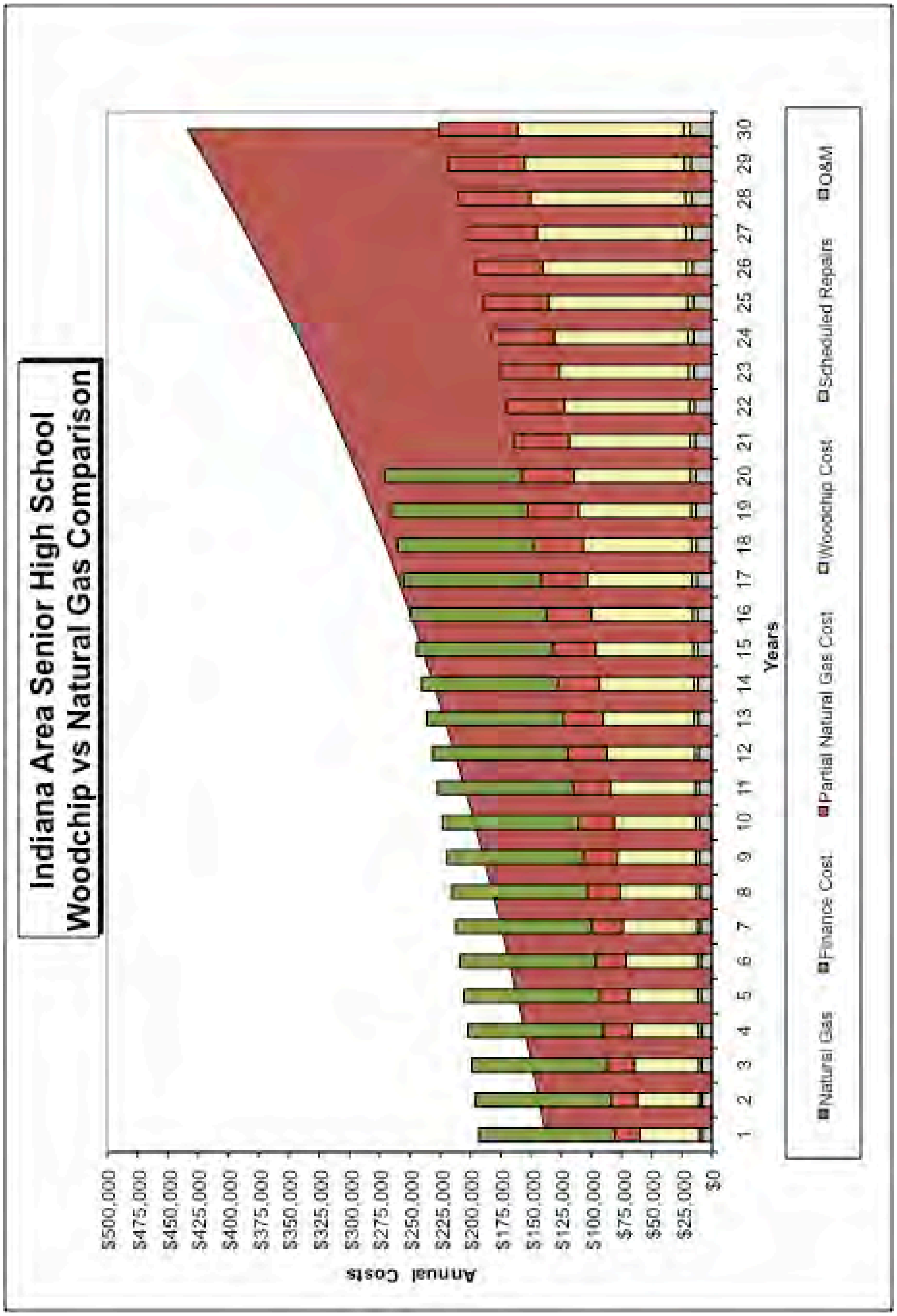


Table 3: 30-Year Life Cycle Analysis Spreadsheet for Biomass Scenario

Indiana Area Senior High School — **Preliminary Life Cycle Cost Estimate**

Total estimated construction costs	***$1,526,602***		
Financing:	**4.0%**	*Assumed interest rate each year, 20 years*	
Natural Gas consumption	**12,653**	Dkth/year	15% Natural Gas = 1,898 Dkth; 9 Dkth / ton of woodchips
Natural Gas price	**$10.88**	/gallon in year 1	
Natural Gas cost	**$137,665**		1,446 tons if 100% woodchips for Natural Gas
Estimated woodchip utilization	**85%**		
Projected woodchip consumption	**1,229**	tons	
Estimated 1st year woodchip price	**$40**	/ ton Year 1	
Projected 1st year woodchip cost	**$49,166**		
General Inflation:	**2.7%**	**annually**	*Twenty year average annual US Labor Dept. Consumer Price Index increases*
Natural Gas inflation:	**4.0%**	**annually**	*Average increase for Commercial Natural Gas in PA from 1990 - 2010 (US EIA)*
Woodchip Inflation:	**3.6%**	**annually**	*Average increase for woodchips for schools in Vermont from 1990 - 2010 is 3.6%. (VSA)*
O & M.:	**$8,375**	**in Year 1 $**	*Estimate of additional electricity for feed system motors and additional maintenance staff time*
Major Repairs:	**$2,500**		*Contingency for major repair (e.g. refractory replacement) at Years 10, 20 and 30 annualized*

Yr.	Natural Gas Cost	Finance Cost	Woodchip Cost	Partial Natural Gas Cost	O&M	Scheduled Repairs	Total Costs	Annual Cashflow	Cumulative Cashflow
1	$137,665	$112,330	$49,166	$20,650	$8,375	$2,500	$193,021	-$55,356	-$55,356
2	$143,226	$112,330	$50,936	$21,484	$8,601	$2,568	$195,919	-$52,692	-$108,048
3	$149,013	$112,330	$52,770	$22,352	$8,833	$2,637	$198,922	-$49,909	-$157,957
4	$155,033	$112,330	$54,669	$23,255	$9,072	$2,708	$202,034	-$47,001	-$204,959
5	$161,296	$112,330	$56,637	$24,194	$9,317	$2,781	$205,260	-$43,964	-$248,923
6	$167,812	$112,330	$58,676	$25,172	$9,568	$2,856	$208,603	-$40,790	-$289,713
7	$174,592	$112,330	$60,789	$26,189	$9,827	$2,933	$212,068	-$37,476	-$327,189
8	$181,646	$112,330	$62,977	$27,247	$10,092	$3,013	$215,659	-$34,013	-$361,201
9	$188,984	$112,330	$65,244	$28,348	$10,365	$3,094	$219,380	-$30,396	-$391,598
10	$196,619	$112,330	$67,593	$29,493	$10,644	$3,177	$223,238	-$26,619	-$418,216
11	$204,562	$112,330	$70,026	$30,684	$10,932	$3,263	$227,236	-$22,673	-$440,890
12	$212,827	$112,330	$72,547	$31,924	$11,227	$3,351	$231,380	-$18,553	-$459,443
13	$221,425	$112,330	$75,159	$33,214	$11,530	$3,442	$235,675	-$14,250	-$473,692
14	$230,371	$112,330	$77,865	$34,556	$11,841	$3,535	$240,126	-$9,756	-$483,448
15	$239,677	$112,330	$80,668	$35,952	$12,161	$3,630	$244,741	-$5,063	-$488,512
16	$249,360	$112,330	$83,572	$37,404	$12,489	$3,728	$249,524	-$163	-$488,675
17	$259,435	$112,330	$86,581	$38,915	$12,827	$3,829	$254,481	$4,953	-$483,722
18	$269,916	$112,330	$89,697	$40,487	$13,173	$3,932	$259,620	$10,296	-$473,426
19	$280,820	$112,330	$92,927	$42,123	$13,529	$4,038	$264,947	$15,874	-$457,552
20	$292,165	$112,330	$96,272	$43,825	$13,894	$4,147	$270,468	$21,697	-$435,855
21	$303,969		$99,738	$45,595	$14,269	$4,259	$163,861	$140,107	-$295,747
22	$316,249		$103,328	$47,437	$14,654	$4,374	$169,794	$146,455	-$149,292
23	$329,026		$107,048	$49,354	$15,050	$4,493	$175,944	$153,081	$3,789
24	$342,318		$110,902	$51,348	$15,456	$4,614	$182,320	$159,999	$163,788
25	$356,148		$114,894	$53,422	$15,874	$4,738	$188,929	$167,220	$331,007
26	$370,536		$119,030	$55,580	$16,302	$4,866	$195,779	$174,757	$505,764
27	$385,506		$123,316	$57,826	$16,742	$4,998	$202,882	$182,625	$688,389
28	$401,081		$127,755	$60,162	$17,194	$5,133	$210,244	$190,837	$879,225
29	$417,284		$132,354	$62,593	$17,659	$5,271	$217,877	$199,408	$1,078,633
30	$434,143		$137,119	$65,121	$18,135	$5,414	$225,789	$208,353	$1,286,986
Totals	$7,772,705	$2,246,601	$2,580,256	$1,165,906	$379,633	$113,323	$6,485,719	$1,286,986	
	Discount Rate	4%							
	$3,993,322	$1,526,602	$1,341,921	$598,998	$202,503	$60,449	$3,730,473	$262,849	

Total Annual Heating Costs	Natural Gas + Woodchips	Woodchip System O&M /Year	Scheduled Repair Allowance / Year	Woodchip + Fuel + O&M + Contingency	Annual Fuel Cost Savings	Total Project Cost	Simple Payback (yrs)	30 Yr. NPV Savings	Return on Investment
$137,665	$69,816	$8,375	$2,500	$80,691	$67,849	$1,526,602	22.5	$262,849	4.4%

ADDITIONAL ISSUES TO CONSIDER

ENERGY MANAGEMENT

In order to effectively manage energy use and to identify efficiency opportunities in buildings it is very important to track energy usage. Unless energy consumption is measured over time, it is difficult or impossible to know the impact of efficiency improvements or renewable energy investments. The Environmental Protection Agency has developed a public domain software program called Portfolio Manager that can track and assess energy and water consumption across an entire portfolio of buildings. Portfolio Manager can help set efficiency priorities, identify under-performing buildings, verify efficiency improvements, and receive EPA recognition for superior energy performance. Yellow Wood recommends that the Indiana Area Senior High School input several years' worth of energy and water use data into *Portfolio Manager* as soon as it can. The EPA *Portfolio Manager* software can be downloaded at the following address:
http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager

ENERGY EFFICIENCY

Whether Indiana Area Senior High School converts to biomass or stays with natural gas, the School should use its heating fuel efficiently. If the School decides to move forward with a biomass energy project, it should work with Penelec to identify other efficiency projects that could be completed at the same time. Penelec efficiency resources include and energy audit program for school customers as well as lighting and HVAC incentives. To learn more about efficiency resources available through Penelec, go to: https://www.firstenergycorp.com/save_energy/save_energy_pennsylvania.html.

General information on efficiency programs as well as information on Penelec's efficiency programs, is included in the *Biomass and Green Building Resources Binder* accompanying this report.

COMMISSIONING

Building, or systems, commissioning is a process that verifies that a facility and/or system is functioning properly. The commissioning process takes place at all phases of construction, from planning to operation, to confirm that facilities and systems are performing as specified. Commissioning of a new system provides quality assurance, identifies potential equipment problems early on and provides financial savings on utility and maintenance costs during system operations. A recent study of 224 buildings found that the energy savings from commissioning new buildings had a payback period of less than five years. Additional benefits of commissioning include: improved indoor air quality, fewer deficiencies and increased system reliability. We strongly recommend that the School work with an independent, third-party, commissioning agent during the design and construction of a biomass heating system. See the *Biomass and Green Building Resources* binder for more information on commissioning.

PROJECT FUNDING POSSIBILITIES

PENNSYLVANIA ALTERNATIVE AND CLEAN ENERGY PROGRAM

The Pennsylvania Alternative and Clean Energy Program provides grants and loans to be used for the development of alternative and clean energy projects in Pennsylvania. Businesses, economic development organizations and municipalities, counties and school districts are all eligible to apply for loans. Grants up to $2 million and loan guarantees up to $5 million are available for clean energy projects (including the purchase and installation of a biomass boiler to provide heat). There is a $1 to $1 matching requirement for both loans and grant funding. More information about the program is available at:

http://www.newpa.com/find-and-apply-for-funding/funding-and-program-finder/alternative-and-clean-energy-program

You can apply for funding through this program through the *Single Application for Assistance* at: http://www.newpa.com/what-can-pa-do-for-you/single-application

Or through the *Customer Service Center*: http://www.newpa.com/contact-us

WEST PENN POWER SUSTAINABLE ENERGY FUND

The West Penn Power Sustainable Energy Fund provides grants for renewable energy projects. While the fund is not currently accepting new proposals, they are in the process of developing a program that would provide funding for school biomass, and other demonstration, projects. For more information, contact:

Joel L. Morrison
WPPSEF Program Administrator
814-865-4802
wppsef@ems.psu.edu
http://www.wppsef.org

PENNSYLVANIA ENERGY DEVELOPMENT AUTHORITY (PEDA) GRANTS

PEDA grants provide financial assistance for alternative energy projects including biomass and energy efficiency. Funding can be used for capital costs such as construction and equipment purchase. Funding requires the project to have a research component and have a measureable environmental benefit for the commonwealth. The most recent round of PEDA grants closed in June. You can access more information on PEDA grants and sign up to be notified when the next PEDA round opens at: http://www.portal.state.pa.us/portal/server.pt/community/peda-move_to_grants/10496

PENNSYLVANIA GREEN ENERGY LOAN FUND (GELF)

The GELF energy loans provide low interest financing (3.5%) for building energy efficiency retrofits and high-performance energy systems that result in a 25% reduction in energy consumption. The GELF

accepts loan applications on a rolling basis. For more information about the program and to download an application, go to:
http://www.trfund.com/financing/energy/pagelf.html

WOODY BIOMASS UTILIZATION GRANT PROGRAM

The Woody Biomass Utilization Grant program, administered by the Department of Agriculture, provides grant funding for wood energy projects requiring engineering services. The woody biomass shall be used in a bioenergy facility that uses commercially proven technologies to produce thermal, electrical, or liquid/gaseous bioenergy. The funds from the Woody Biomass Utilization Grant program (WBU) must be used to further the planning of such facilities by funding the engineering services necessary for final design and cost analysis. This program is aimed at helping applicants complete the necessary design work needed to secure public and/or private investment for construction. In particular, USDA Rural Development has established grants and loan programs that might help fund construction of such facilities.

Applications for 2011 funding were due on March 1st, 2011. A new announcement, for a 2012 round of funding has not yet been announced. For more information on the grant program, contact:

Lew R. McCreery, Biomass Coordinator
USFS Northeastern Area
180 Canfield St.
Morgantown, WV 26505
(304) 285-1538
lmccreery@fs.fed.us

To see last year's request for proposals go to:
http://www.grants.gov/search/search.do?mode=VIEW&oppId=58881

USDA FUNDING OPPORTUNITIES

2008 Farm Bill

The 2008 Farm Bill has a number of provisions that may help rural communities consider and implement renewable energy and energy efficiency projects.

- **Section 9009** provides grants for the purpose of enabling rural communities to increase their energy self-sufficiency.
- **Section 9013** provides grants to state and local governments to acquire wood energy systems.

These grants and loan guarantee programs are competitive. The School should check with the local USDA office to express interest and to get program updates.

Rural Community Facilities Grant and Loan Program

The USDA provides grants and loans to assist the development of essential community facilities. Grants can be used to construct, enlarge or improve community facilities for health care, public safety and other community and public services. The amount of grant assistance depends on the median household income and the population of the community where the project is located.

These grants and loans are also competitive. Highest priority projects are those that serve small communities, those that serve low-income communities and those that are highly leveraged with other loan and grant awards.

For more information about USDA programs and services, contact your local USDA office. Information on programs and contact information is provided in the *Biomass and Green Building Resources Binder.*

MUNICIPAL LEASE PURCHASE

As a municipal entity, the Indiana Area Senior High School may be eligible for a municipal lease/purchase arrangement to finance the anticipated project costs for a biomass heating system. A municipal lease is a contract that has many of the characteristics of a standard commercial lease, with at least two primary differences:

- In a municipal lease, the intent of the lessee is to purchase and take title to the equipment. The financing is a full payout contract with no significant residual or balloon payments at the end of the lease term.
- The lease payments include the return of principal and interest, with the interest being exempt from Federal income taxation to the recipient. Because the interest is exempt from federal tax, a tax-exempt lease offers the lessee a significant cost savings when compared to conventional leasing.

There are a number of companies that provide municipal leases. Information about municipal leases is included in the *Biomass and Green Building Resources Binder* accompanying this report.

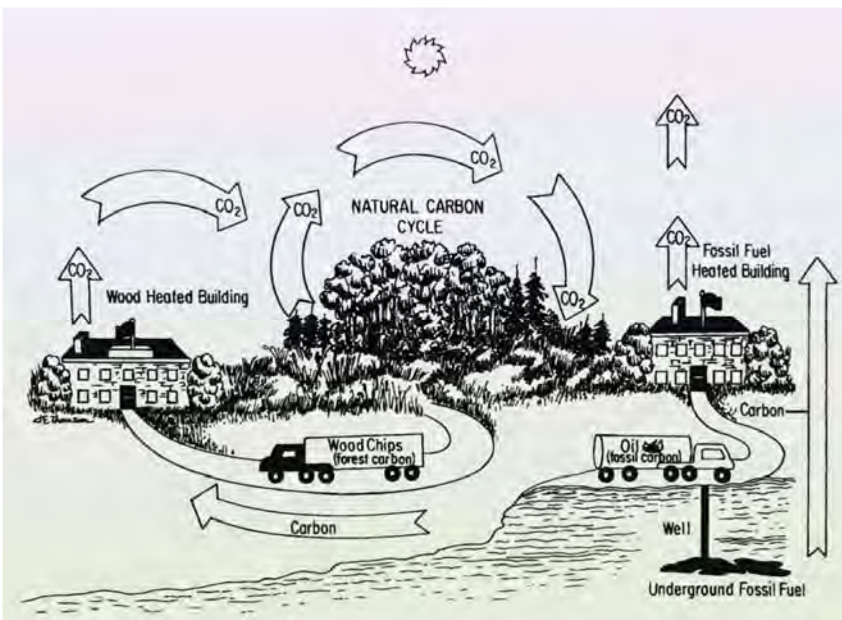
CARBON OFFSETS

While fossil fuels introduce carbon that has been sequestered for millions of years into the atmosphere, the carbon dioxide emitted from burning biomass comes from carbon that is already above the ground and in the carbon cycle. Biomass fuels typically come from the waste of some other industrial activity such as a logging operation or from sawmill production. The carbon from this waste would soon wind up in the atmosphere whether it was left to decompose or it was burned as slash. The Indiana Area Senior High

School could reduce its carbon footprint more than switching their heating fuel use from natural gas to a biomass fuel.

Carbon offsets help fund projects that reduce greenhouse gases emissions. Carbon offset providers sell the greenhouse gas reductions associated with projects like wind farms or biomass projects to customers who want to offset the emissions they caused by flying, driving, or using electricity. Selling offsets is a way for some renewable energy projects to become more financially viable. Buying offsets is a way for companies and individuals to compensate for the CO_2 pollution they create.

Figure 7: Carbon Cycle Illustration[3]



For a biomass heat-only project, a Btu-for-Btu displacement of heating fuel (based on historic purchase records) by biomass is assumed over the project's predicted operating life. CO_2 avoidance is based on the emissions profile (Lbs. CO_2 /Btu) of the displaced fuel. The US EPA calculates that 11.7 lbs. of CO_2 is produced from each them of natural gas consumed. It is projected that the Senior High School can offset approximately 10,755 dekatherms (107,550 therms) of natural gas per year by replacing that heat using biomass. This is equivalent to about 630 tons of CO_2 annually. The market value of this type of offset is between $3/ton and $5/ton. These offsets can be negotiated as either a lump sum offset for up to 10 years or can be paid out as an annual payment. This could mean annual payments of $1,890 - $3,150 or a lump sum up front payment of as much as $31,500.

[3] Illustration taken from a handout produced by the Biomass Energy Resource Center

There are a number of companies that are interested in contributing to the construction of new sources of clean and renewable energy through carbon offsets. Information about carbon offsets is included in the *Biomass and Green Building Resources Binder* accompanying this report.

PERMITTING

Modern biomass boiler technology is both clean and efficient. Controls moderate both the biomass fuel and air to create either a small hot fire or a large hot fire depending on heat demand from the building. Under full load, modern woodchip boilers routinely operate at steady state efficiencies of 70% – 75%. Operating temperatures in commercial scale biomass boilers can reach up to 2,000 degrees and more, completely eliminating creosote and the need to clean stacks. The amount of ash produced from a 25 ton tractor trailer load of green hardwood chips can fit in a 25 gallon trash can, is not considered a hazardous waste and can be used as a soil amendment on lawns, gardens and playing fields.

However, as with any combustion process, there are emissions from biomass boilers. There is no question that natural gas is the cleanest fuel used for heating. However, biomass compares favorably with fuel oil and modern commercial scale biomass boilers with the appropriate pollution control devices can burn very cleanly and efficiently.

Table 4: Comparison of Boiler Emissions Fired by Wood, Distillate Oil, Natural Gas and Propane[4]

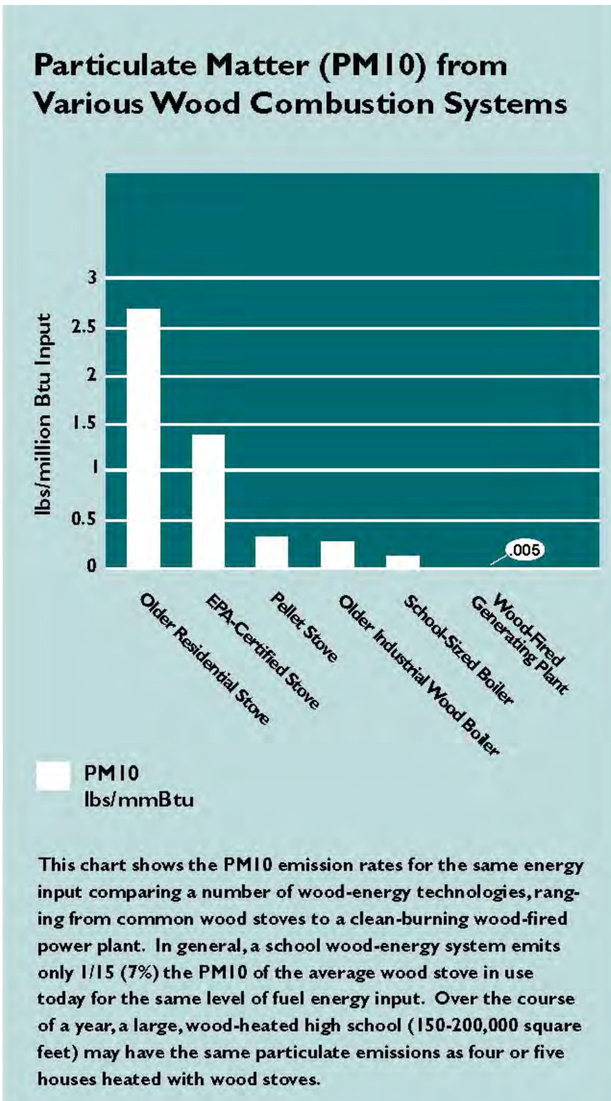
(Pounds per million Btu output)				
	Wood	Distillate Oil	Natural Gas	Propane
PM_{10}	0.1000	0.0140	0.007	0.004
NO_X	0.1650	0.1430	0.09	0.154
CO	0.7300	0.0350	0.08	0.021
SO_2	0.0082	0.5000	0.0005	0.016
TOC	0.0242	0.0039	0.01	0.005
CO_2	gross 220 (net 0)	159	118	137

The pollutant of greatest concern with biomass is particulates (PM_{10}). Biomass boilers clearly generate more particulates than fuel oil or gas boilers. That is why it is important to install appropriate pollution control equipment. Many modern types of emission control equipment, capable of reducing particulate matter emissions from 50-99 percent, are commercially available in the US. The most common emission control equipment technologies are baghouses, cyclones, multi-cyclones, electrostatic precipitators, and wet scrubbers. Appropriate emission control equipment technologies should be identified in consultation with local air quality regulators. The emissions from a modern woodchip boiler are much less than most people think.

[4] Data excerpted from the paper *An Evaluation of Air Pollution Control Technologies for Small Wood-Fired Boilers* prepared by Resource Systems Group, Inc. White River Jct., VT, for the New York Department of Public Service and others, Revised September 2001.

One of the most common misconceptions about institutional/commercial biomass energy systems comes from the experience people have with residential wood stoves and outdoor wood boilers. In general, an institutional/commercial-scale wood energy system emits only one fifteenth (seven percent) the PM_{10} of the average wood stove on a Btu basis. Over the course of a year, a large, woodchip heated school in a climate like Vermont may have the same particulate emissions as four or five houses heated with wood stoves.

Figure 8: Particulate Emissions[5]



New EPA Regulations

On February 21, 2011, the Environmental Protection Agency (EPA) issued a final rule that will reduce emissions of toxic air pollutants (including mercury, metals and organic air toxics, including dioxins) from existing and new industrial, commercial and institutional boilers. For area source boilers (those that emit less than 10 tons per year (tpy) of any single air toxic or less than 25 tpy of any combination of air toxics) the EPA is issuing regulations based on boiler design. Biomass boilers with heat input equal to or greater than 10 million Btu per hour must meet emission limits for particulate matter (PM) only. Biomass boilers with heat input less than 10 million Btu must perform a boiler tune-up every two years.

The boiler analyzed in this report is smaller than 10 million Btu – under the new regulations the Indiana Area Senior High School would be required to perform a boiler tune-up every two years on the biomass boiler. Starting on September 17, 2011 the EPA requires an *Area Source Notification Form* for new boilers 120 days after the startup of the new boiler.

[5] Excerpted from Air Emissions From Modern Wood Energy Systems, Biomass Energy Resource Center.

To access the notification form with instructions, go to:
www.epa.gov/ttn/atw/boiler/area_**initial_notification**.doc.
Up-to-date information on EPA emission requirements is available at:
www.epa.gov/airquality/combustion/

In order to install a new woodchip boiler, it is often necessary to obtain an air quality permit or an amendment to an existing permit. For a woodchip boiler, the permit would likely include requirements for pollution control equipment along with a requirement for a tall stack to help with dispersion. Costs for pollution control equipment are included in the cost estimates for the woodchip scenario analysis in this report. Other permit conditions might include testing for emissions and efficiency, keeping records of fuel consumption and test results and making periodic submittals to regulatory agencies.

CONCLUSIONS AND RECOMMENDATIONS

This report analyzes the opportunity to utilize wood energy at Indiana Area Senior High School. While investing in a woodchip system is not practical at this time due to the current price of natural gas, as natural gas prices increase or if substantial grant funding is obtained, installation of a woodchip system may become a better investment for the School.

Regardless of whether or not Indiana Area Senior High School moves forward with a biomass project, we recommend the School consider the following:

1. In order to effectively measure progress toward energy efficiency goals historical energy consumption data should be collected and updated frequently. There are many tools to help the School accomplish this. One such tool is the EPA Energy Star Portfolio Manager software. It is free public domain software that helps facility managers track energy and water use. This software can be downloaded at:
   http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager

If the School does decide to move forward with a biomass project we also recommend taking the following steps:

1. Hire an engineering firm to help refine the project concept and to obtain firm local estimates on project costs. The US Forest Service may be able to provide some technical assistance from an engineering team with biomass experience. If the School moves forward with this project, they should contact Lew McCreery, the US Forest Service Biomass Coordinator for the Northeastern Area to see what assistance can be provided. Contact Lew at (304)285-1538 or lmccreery@fs.fed.us
2. The School is currently undergoing an energy assessment – all findings and recommendations from this assessment should be considered in addition to a biomass energy project.
3. The School should have the area behind the building surveyed to determine the potential for locating the biomass boiler house and chip storage building in this location. The results of the survey should be reviewed by the engineer to determine the best location for the boiler house and chip storage.
4. The School should identify any heating system improvements it plans to undertake and include those projects with the biomass project. It is more cost effective to implement boiler room upgrades and heating distribution improvements at the same time a new boiler system is installed.
5. Concurrent with the design of the project, the School should cultivate potential biomass fuel suppliers. School staff should work with Mike Palko, Biomass Energy Specialist with the PA DCNR Bureau of Forestry, to identify potential Pennsylvania woodchip suppliers. Mike can be reached at (570)326-6020 or mipalko@state.pa.us.

WHO WE ARE

Yellow Wood Associates

Yellow Wood Associates (Yellow Wood) is a woman-owned small business specializing in rural community economic development since 1985. Yellow Wood has experience in green infrastructure, program evaluation, business development, market research, business plans, feasibility studies, and strategic planning for rural communities. Yellow Wood provides a range of services that include measurement training, facilitation, research, and program management.

Richmond Energy Associates

Richmond Energy Associates was created in 1997 to provide consulting services to business and organizations on energy efficiency and renewable energy program design and implementation. Richmond Energy has extensive experience in wood energy systems. Jeff Forward provides analysis and project management on specific biomass projects and works with state, regional and federal agencies to develop initiatives to promote biomass utilization around the country. In addition to his own consulting business, he is also a Senior Associate with Yellow Wood.

APPENDICES

SENSITIVITY ANALYSIS

Table 5 is a sensitivity analysis comparing annual fuel savings from the installation of a woodchip heating system based on varying prices for wood and natural gas. In this analysis the assumed loan interest rate of 4% and the inflation rates outlined in the assumptions are held constant. For example, if natural gas prices rise to $16 per dekatherm and woodchip prices rise to $50 per ton, the annual fuel savings would be $110,623.

Table 5: Annual Fuel Savings When Wood and Natural Gas Prices Vary

Woodchip $/ton	***Natural Gas $/Dth***				
	$8.00	**$10.00**	**$12.00**	**$14.00**	**$16.00**
$35	$43,020	$64,530	$86,040	$107,551	$129,061
$40	$36,874	$58,385	$79,895	$101,405	$122,915
$45	$30,729	$52,239	$73,749	$95,259	$116,769
$50	$24,583	$46,093	$67,603	$89,113	$110,623
$55	$18,437	$39,947	$61,457	$82,968	$104,478

Table 6 is a sensitivity analysis showing the first year cash flow and net present value (NPV) of the installation of a woodchip heating system based on varying rates of grant funding. In this analysis all of the assumptions presented in Table 2 are held constant. For example, if Indiana Area Senior High School were able to get $300,000 in grant funding for the project, the first year cash flow would be minus $33,282 and the 30 year NPV would rise to $562,849 (the annual fuel savings would be unchanged).

Table 6: 30-Year Net Present Value (NPV) when Grant Funding is available

	Project Costs (Capital – Grant)	**1st Year Cash Flow**	**30-Year NPV**
No grant funding	$1,526,602	($55,356)	$262,849
$100,000 grant	$1,426,602	($47,998)	$362,849
$300,000 grant	$1,226,602	($33,282)	$562,849
$500,000 grant	$1,026,602	($18,565)	$762,849

INDIANA AREA SENIOR HIGH SCHOOL FUEL HISTORY

The tables below summarize fuel history provided by the Indiana Area Senior High School as part of the application for a biomass pre-feasibility study.

Table 7: Natural Gas Usage for Indiana Area Senior High School

	2009-2010		2008-2009	
	Dth	Total $	Dth	Total $
Jul	86.9	$968	44.9	$832
Aug	21	$276	70.6	$962
Sep	179.7	$1,440	193.6	$2,526
Oct	1071.3	$8,438	745.2	$9,561
Nov	943.6	$7,643	1517.6	$18,493
Dec	2236.9	$19,032	2457.4	$30,279
Jan	2342.9	$21,719	2499.5	$29,167
Feb	2321.4	$20,824	2042.6	$21,969
Mar	1430.1	$20,223	1807.3	$19,339
Apr	797.4	$11,704	1284.9	$13,683
May	385.2	$5,585	531.7	$5,644
Jun	50.8	$2,505	243.1	$2,610
Total	**11,867**	**$120,357**	**13,438**	**$155,065**
Average $/Dth		$10.88		

Table 8: Electricity Usage for Indiana Area Senior High School

	2009-2010		2008-2009	
	kWh	Cost	kWh	Cost
Jul	118,500	$6,769	127,000	$9,372
Aug	139,058	$10,608	127,000	$9,772
Sep	164,525	$12,634	191,508	$14,510
Oct	174,331	$12,448	166,848	$12,238
Nov	153,045	$10,435	149,031	$11,277
Dec	156,504	$11,520	135,500	$10,503
Jan	134,000	$10,530	139,505	$10,594
Feb	136,500	$10,264	164,003	$11,932
Mar	142,500	$11,346	147,005	$11,042
Apr	141,699	$10,490	150,003	$11,169
May	171,004	$12,438	171,004	$12,558
Jun	112,500	$9,464	136,501	$10,538
Total	**1,744,166**	**$128,946**	**1,804,908**	**$135,505**
Average $/kWh		$0.07		

DISCUSSION OF BIOMASS FUELS

Purchasing wood fuel is a different exercise than purchasing fossil fuels. While conventional fuels are delivered to the site with little interaction from facility managers, biomass fuel suppliers will need to be cultivated and educated about the type of fuel needed, its characteristics and the frequency of deliveries. Concurrently with designing a wood-energy system, Indiana Area Senior High School should also be cultivating potential biomass fuel suppliers.

Potential wood fuel suppliers include sawmills, loggers, chip brokers and large industrial users such as paper mills or power plants. Many of these forest products producers already make woodchips for pulp and to reduce waste, but may not have much experience dealing with the needs of smaller volume customers. Woodchips produced for institutional/commercial biomass boilers have more stringent specifications than those produced for large industrial customers. And woodchip fuel may need to be delivered in different trailers.

When talking to potential woodchip fuel suppliers, it is important to have the wood fuel specification in mind. A one to three inch square chip is ideal. If possible, woodchips for institutional/commercial biomass systems will come from logs that are debarked prior to chipping because bark produces more ash which translates into a little more daily maintenance. Pieces or small branches that are six inches or longer can jam augers and conveyors which will interrupt the operation of automated fuel handling equipment. Institutional/commercial scale biomass boiler systems in the Northeast are typically designed to operate with wood fuel that is within a 35% to 45% range for moisture content.

Typically institutional/commercial biomass systems of this scale have limited chip storage capacity which means they may need deliveries on relatively short notice. Woodchip fuel suppliers will need to be within a 100 to 150 mile radius or so of the user, the closer the better, as transportation costs will affect price. Chip deliveries are typically made in "live bottom" trailers that will self unload into below-grade chip storage bins. Therefore, potential suppliers must have access to a self-unloading trailer for deliveries.

It is possible to design a wood-energy system that uses any one of a variety of biomass fuels, but green hardwood chips make the best fuel. If it is readily available, it should be the fuel of choice. In addition, users should focus on reliability of supply and consistency of the fuel rather than just lowest cost. The goal should be to minimize maintenance and optimize system performance.

Whichever fuel is used, the fuel type needs to be part of the combustion system design process, and the wood system should be operated using the fuel it is set up to use. Ideally, sample fuel chips should be sent to the manufacturer of the biomass heating equipment so that they can design the fuel handling equipment around the type of fuel and calibrate the system properly when setting the system up. No system handles widely varying fuel types at the same time very well. A system can be re-calibrated for a different fuel type, but the most practical approach is to stick with one fuel type, at least for a given heating season. If, for some reason, that fuel type becomes unavailable, the manufacturer of the equipment should be consulted to help reconfigure or retune the system for another fuel.

It is best to try to locate several potential suppliers. By doing so, Indiana Area Senior High School will have the security of knowing there will be back-up in case of an interruption from their primary supplier. This will also generate some competition. Contact Mike Palko, Biomass Energy Specialist for a list of local suppliers.

Michael T. Palko, Biomass Energy Specialist
PA Department of Conservation & Natural Resources
Bureau of Forestry
330 Pine Street, Suite 200
Williamsport, PA 17701
Phone: 570.326.6020
Fax: 570.322.2914
E-mail: mipalko@state.pa.us

The bottom line is that both Indiana Area Senior High School and fuel suppliers need to clearly understand the characteristics of fuel needed for their particular system. Consistent particle size and moisture content is particularly important for institutional/commercial customers, and the School should insist on the quality of the chip. A sample fuel specification is included in the *Biomass and Green Building Resources Binder* to give an idea of the types of characteristics to look for in woodchip fuel. Below is a description of the advantages and disadvantages of different types of biomass fuels in order of preference.

Green Hardwood Chips

A consistent green hardwood chip is the easiest fuel for institutional/commercial scale automated biomass heating systems to handle. Rarely will they jam an auger or conveyor. Green chips burn somewhat cooler than most other biomass fuels making it easier to control the combustion. With proper controls, they burn very cleanly with minimal particulate emissions and little ash. They have less dust than other biomass fuels so they are less messy and safer to handle. Ideally moisture content will be between 35% and 45% on a wet basis. Green hardwood chips can come from sawmill residues or timber harvest operations.

Mill Residues vs. Harvest Residues

Woodchips can be produced at sawmills or other primary wood products industrial sites as part of their waste wood disposal process. Mill residues are typically the most desirable source of fuel woodchips. Mills can produce a bark-free chip with few long pieces or branches that can jam augers and fuel conveyors. A mill supplier can easily calculate trucking costs and can negotiate dependable delivery at a consistent price.

Another potential type of wood fuel is whole tree chips which are produced as part of tree harvesting. Whole tree chips tend to be a dirtier fuel than sawmill residues and may contain small branches, bark, twigs and leaves. The longer pieces can jam the relatively small augers of an institutional/commercial scale biomass system and can add to the daily maintenance because they produce more ash.

The bole of a tree is the de-limbed trunk or stem. Chips made from boles are in-between the quality of a sawmill chip and a whole tree chip. Bole-tree chips tend to have fewer twigs and long stringers than whole tree chips. Both bole-chips and whole-tree chips can be potentially good sources for biomass fuels, although they have a greater likelihood of including oversized chips and they will produce somewhat more ash, compared to mill residues.

Softwood Chips

Green softwood chips will generally have less energy and more water content per truckload, and therefore they will be more expensive to transport than hardwood chips. As long as the combustion and fuel handling equipment is properly calibrated for softwood chips, an automated woodchip heating system can operate satisfactorily with softwood chips. Softwoods tend to have higher moisture contents and can range up to 60% moisture on a wet basis. The best biomass fuel will have less than 50% moisture. One species to avoid altogether is white pine. It has a very high moisture content and therefore relatively low bulk density. The experience in Vermont schools with white pine is that it is a poor biomass fuel for institutional/commercial-scale woodchip systems.

Dry Chips vs. Green Chips

Dry chips (less than 20% moisture on a wet basis) burn considerably hotter than green chips and typically have more dust. The increased operating temperature can deteriorate furnace refractory faster increasing maintenance costs slightly. The dust can make for a somewhat dirtier boiler room which will be a problem for some maintenance staff. Dry chips are also easier to accidentally ignite in the fuel storage bin or fuel handling system. If dry chips are used, the combustion equipment needs to be carefully calibrated to handle these higher temperatures. Dry chips are not generally recommended for institutional/commercial settings.

Bark

Bark has a high energy value, but it also comes with significant maintenance costs. It produces a considerable amount of ash that needs disposal; it can create more smoke than green chips; and it can cause other routine maintenance problems such as frequent jamming of augers from rocks. Bark can be an inexpensive fuel, but the additional maintenance costs make it unattractive for institutional/commercial biomass systems.

Sawdust and Shavings

Sawdust and shavings should ordinarily be ruled out for the institutional/commercial wood heating market. Dry sawdust can be dusty to handle and raises fire safety and explosion issues. Shavings are also dusty and easily ignited and are difficult to handle with typical fuel handling equipment. This fuel type can work fine in an industrial setting, but institutions typically do not have the maintenance staff that can provide the supervision that these fuels need.

Ground or "Hog" Fuel

Ground or "Hog" fuel is common in the logging industry. It is typically made by grinding any manner of woody material by using a "tub grinder". Hog fuel does not typically make good wood fuel for institutional scale biomass energy systems. The fuel is "dirty" meaning there are many contaminants such as bark, dirt, gravel and foreign objects. The material is typically rough and is irregularly shaped making it difficult to handle in the relatively small augers and conveyors of institutional scale wood fuel handling equipment. Additionally, since the fuel might come from a variety of sources, hog fuel can have a wider range of moisture content than wood chip fuel. Hog fuel can work well in industrial biomass energy systems, but institutions typically do not have the maintenance staff that can deal with these kinds of fuels.

BIOMASS AND GREEN BUILDING RESOURCES BINDER

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WERC

WOOD EDUCATION AND RESOURCE CENTER

The Wood Education and Resource Center is located in Princeton, W.Va., and administered by the Northeastern Area State and Private Forestry unit of the U.S. Department of Agriculture Forest Service. The Center's mission is to work with the forest products industry toward sustainable forest products production for the eastern hardwood forest region. It provides state-of-the-art training, technology transfer, networking opportunities, applied research, and information. Visit www.na.fs.fed.us/werc for more information about the Center.