Preliminary Feasibility Report

Biomass Heating Analysis for The Winchendon School

Winchendon, Massachusetts

June 2012
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EXECUTIVE SUMMARY

The Winchendon School is a coeducational boarding and day school serving approximately 220 students in grades 8-12 on its campus in northwestern Massachusetts. The School, in operation since 1926, occupies a cluster of buildings nestled in a picturesque, hilltop golf course setting. The Winchendon School has an active master plan that provides multiple opportunities for introducing biomass energy to the campus.

We evaluated three different biomass scenarios that included a pellet system to serve the Main building; a pellet system to serve the string of buildings running along the south side of Ash Street (Rotenberg, Marr, Posich, Old Classroom Building, Newberry and the Merrill/Jaffee Dorm); and a woodchip system to serve all of the buildings listed above. While there is a need to upgrade the heating systems in many of the buildings analyzed on the south side of Ash Street, the low fuel usage and required piping distances make a biomass system impractical for these buildings. Therefore, this report focuses on a scenario in which a pellet system is installed to serve the Main Building at the time of the addition. There may be potential for biomass on the other side of the street if larger buildings such as the Rotenberg Gym, new Dorm and ice arena were included. Analysis of those buildings is not included in this report.

Table 1: Summary Findings of Biomass Analysis for the Winchendon School

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Projected Annual Fuel Bill w/o biomass* ($)</th>
<th>Total Estimated Project Costs ($)</th>
<th>Tons of Carbon Offset by Wood Pellets/Chips</th>
<th>Return on Investment (%)</th>
<th>Net 1st Year Fuel Savings ($)</th>
<th>Total 30 Year NPV Cumulative Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Bldg. Pellet</td>
<td>80,172</td>
<td>385,370</td>
<td>245</td>
<td>9.5%</td>
<td>36,482</td>
<td>1 million</td>
</tr>
</tbody>
</table>

*based on $3.29 per gallon of fuel oil

The analysis provided in this report indicates that the Winchendon School could save more than $1 million in operating costs over 30 years in today’s dollars even when the cost of financing is included. The analysis shows more than $36,000 in fuel savings in the first year alone of the biomass scenario.

We recommend the Winchendon School do the following to continue to investigate the potential for biomass heat:

1. The School has a detailed master plan that impacts all of the buildings evaluated in this report. Facility renovations and expansions provide an opportune time for adding a biomass boiler. The School should be sure to integrate plans for biomass heating into their current master plan.
2. The analysis assumes that the new pellet boiler will be placed in the lower level of the Main Building addition – the School should work with the architect and engineer to further investigate the feasibility of placing a new biomass boiler in the new addition.

3. Hire an engineering firm to help refine the project concept and to obtain firm local estimates on project costs. It should be noted that the analysis does not incorporate the cost of converting the electric heat in the Marr, Classroom, Newberry and Posich buildings to a hydronic heating distribution system. Scoping and estimating those costs should be done by a qualified engineering firm and are beyond the scope of this study. The School should seriously consider converting these buildings to hydronic heating distribution systems no matter what fuel they finally decide upon.

4. The US Forest Service may be able to provide a phase II engineering analysis that refines the project concept. If the District decides to move forward with a biomass project, decision-makers 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.

5. While this report analyzes a biomass system that serves the Main Building only, there is opportunity for numerous additional scenarios that the School could consider with their master planning architect. Including additional buildings to south side of Ash Street (such as Rhoads and the Rotenberg Gymnasium) would improve the economics of building a woodchip heating system on the south side of Ash Street.

6. The School should consider energy efficiency improvements simultaneously with boiler upgrades. The efficiency of the building envelope and ventilation equipment need to be considered when sizing new boiler equipment. This should be done regardless of whether or not the School moves ahead with a biomass project at this time. Information on energy efficiency programs and incentives is included in the Biomass and Green Building Resources binder accompanying this report.

7. In order to effectively measure progress toward energy efficiency goals historical energy consumption data should be collected and updated frequently. There are many tools that could help the School accomplish this electronically. 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 and provides useful reports and graphs. This software can be downloaded at: http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager.

8. If the School decides to move forward with a biomass system, they should work with Gordon Boyce, Marketing and Utilization Forester with the Massachusetts Department of Conservation & Recreation, to cultivate potential biomass fuel suppliers concurrent with the design of the biomass system. One supplier of particular interest might be New England Wood Pellet located less than 15 miles away in Jaffrey, NH.
This preliminary feasibility study was prepared by Yellow Wood Associates in collaboration with Richmond Energy Associates for the Winchendon 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 58 public schools in Vermont and several Massachusetts facilities. The concept of heating institutions with wood is catching on in 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 Massachusetts to achieve targets for renewable energy use. This analysis indicates that the Winchendon School would offset 245 tons of CO₂ annually by installing a biomass system at the school.

This report is a pre-feasibility assessment specifically tailored to the Winchendon School outlining whether or not biomass heat makes sense for this facility from a practical perspective. In December of 2011 staff from Yellow Wood Associates traveled to Winchendon to tour the campus. 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

EXISTING HEATING SYSTEMS AND FUEL USAGE

The Main Building is heated by multiple hot water distribution systems. These systems are not currently connected. The larger portion of the building is served by a 2.9 mmBtu fuel oil steam boiler, installed in 1980, and the East Wing is served by a 278,000 Btu fuel oil hot water boiler, installed in 1990. The School’s Master Plan calls for a 15,000 square foot addition to the Main Building (off of the Dining Hall) in the next 2 years. Current plans call for the use of rooftop heating units. The Main Building currently uses an average of 24,368 gallons of fuel oil each year.

Figure 1: Main Building Fuel Oil 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 also 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 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 assumes that 100% of the electric heat load will be replaced by either the biomass boilers or the existing fuel oil boilers which already have sufficient capacity to provide back-up and supplemental heat for all buildings in each scenario.

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.

**FUEL OIL COST ASSUMPTIONS**

During the past two years, the school used an average of 24,368 gallons of fuel oil to heat the Main Building. This was the assumed annual fuel consumption used for the base case in the analysis. The Winchendon School currently pays $3.29 per gallon of fuel oil – this price is locked in for the heating season and is the price used in the base case of the analysis.

**WOOD PELLET FUEL COST ASSUMPTIONS**

Pellet fuel is a manufactured product that competes directly with fossil fuels. Consequently, pellet fuel prices track more closely to fossil fuels and fluctuate more than other biomass fuel. However, pellets are still a relatively local product, especially for the Winchendon School, so they won’t likely have the same geopolitical pressures as fossil fuels. After consulting with the local pellet manufacturer and delivery company, we are projecting a first year cost of $195 per ton for pellets, which is equivalent to about $1.65 per gallon of fuel oil. The costs for pellets are adjusted for inflation each year over the thirty-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 30-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 fuel oil in Massachusetts was 6.1% per year. The analyses in this report project these average inflation rates for fuel oil and electricity forward over the 30-year analysis period.

Pellet fuel pricing tends to track that of fossil fuels more closely than woodchips for two reasons. First, it takes a considerable amount of energy to produce pellets. Woodchip and sawdust feedstock need to be dried, which requires energy, and then it also takes energy to compress the feedstock into pellets. Second, wood pellet fuel is used almost exclusively as a heating fuel. It competes directly with fossil fuels used for heat. While it is true that wood pellet fuel tends to be produced relatively locally and therefore has less geopolitical volatility than fossil fuels, there does appear to be a link between pellet fuel prices
and fuel oil prices. The Biomass Energy Resource Center uses 4.25% as an inflation factor for pellet fuel. This is more than the average rate of inflation for woodchip fuel over the past twenty years but less than the rate of inflation over the same period for fuel oil. For this analysis it was assumed that wood pellet fuel would inflate at 4.25% per year.

**Figure 2: Biomass and Massachusetts Fossil Fuel Inflation**

<table>
<thead>
<tr>
<th>Year</th>
<th>Electricity</th>
<th>Fuel Oil</th>
<th>Wood Pellets</th>
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<td>2010</td>
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*Wood pellet pricing based on 2010-2011 average price paid and projected back five years assuming a 4.25% inflation rate.

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 2.6% 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 scenarios.

**OPERATION AND MAINTENANCE ASSUMPTIONS**

**Pellet** boilers require very little maintenance in comparison to woodchip boilers. For the pellet scenario it was assumed that existing on-site staff would spend on average approximately one hour per week in addition to their current boiler maintenance for 30 weeks per year and 20 hours during the summer months for routine maintenance. At a loaded labor rate of $25/hr this equals $1,250 annually. An additional $750 in annual operational costs is assumed for electricity to run pumps and motors.

Another operations and maintenance cost that is included in the analysis is periodic repair or replacement of major items on the boilers such as the furnace refractory. It is reasonable to anticipate these types of costs on a 10-15 year cycle. **Pellet** boiler systems have fewer moving parts and should not
require as much scheduled maintenance as a woodchip system. An annualized maintenance cost of $1,000 per year was included in the pellet scenario analysis and then inflated at the general inflation rate.

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 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.

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 5% 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.
BIOMASS SCENARIO

The biomass scenario envisions a pellet boiler system located in the basement of the planned addition to the Main Building. A pellet silo, for storage, would be located outside of the addition, or a smaller pellet storage system can be designed to be placed inside the building. For this scenario we are assuming the pellet boiler will meet 90% of the annual heating needs currently met with fuel oil at the Main Building. The scenario analyzes the installation of a 1.7 mmBtu pellet boiler and 1,700 gallons of thermal storage. Hot water from the boilers would be tied into the exiting HVAC systems in the Main Building. Costs for a 40-ton pellet storage silo and an allowance for interconnecting to the existing heating distribution systems are included in the proposed capital costs.

THERMAL STORAGE

A thermal storage system is included in the capital cost estimate for all three scenarios. 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.
BIOMASS SCENARIO ANALYSIS

The analysis shows that the Winchendon School could save close more than $1 million in today’s dollars in operating costs over the next 30 years - even including debt service on the cost of the system - by installing a wood pellet system to provide heat and hot water for the Main Building. Annual fuel savings are projected to be $36,482 per year in the first year and should increase over time as fossil fuel prices continue to climb. The return on investment from fuel savings is estimated at 9.5% and this project would have a positive annual cash flow in the first year.

Table 2: Analysis Assumption

<table>
<thead>
<tr>
<th>Winchendon School Scenario One - Pellet</th>
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<tr>
<td><strong>Capital Cost Assumptions</strong></td>
</tr>
<tr>
<td>One 1.7 mmBtu pellet hot water boilers including installation</td>
</tr>
<tr>
<td>40 ton pellet storage</td>
</tr>
<tr>
<td>Thermal Storage 1,700 gallon</td>
</tr>
<tr>
<td>Interconnect to existing boiler system</td>
</tr>
<tr>
<td>GC markup at 10%</td>
</tr>
<tr>
<td>Construction contingency at 15%</td>
</tr>
<tr>
<td>Design at 12%</td>
</tr>
<tr>
<td><strong>Total estimated project costs</strong></td>
</tr>
</tbody>
</table>

| **Financing Costs** | |
| Financing, annual interest rate | 5% |
| Finance term (years) | 20 |
| 1st full year debt service | $30,523 |

| **Fuel Cost Assumptions** | |
| Current annual fuel oil use (gal) | 24,368 |
| Assumed fuel oil price in 1st year | $3.29 |
| Projected annual fuel oil bill | $80,172 |
| Percent pellet fuel utilization | 90% |
| Fuel oil (gal)/ton ratio | 120 |
| Assumed pellet price in 1st year (per ton) | $195 |
| Projected 1st year pellet fuel bill | $55,673 |
| Projected 1st year supplemental fuel oil bill | $8,017 |

| **Inflation Assumptions** | |
| General inflation rate (twenty year average CPI) | 2.6% |
| Fuel oil inflation rate (twenty year EIA average for Massachusetts) | 6.1% |
| Pellet inflation rate (estimate from Biomass Energy Resource Center) | 4.23% |

| **O&M Assumptions** | |
| Annual pellet O&M cost, including electricity for additional pumps and motors and staff time for daily and yearly maintenance | $2,000 |
| Major repairs (annualized) | $1,000 |

| **Savings** | |
| Return on Investment | 9.5% |
| Net 1” year fuel savings | $36,482 |
| Total 30 year NPV cumulative savings | $1,022,094 |
Figure 3: Annual Cash Flow Graph

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 pellets versus the cost of fuel oil), projected revenue and projected debt service.
<table>
<thead>
<tr>
<th>Yr</th>
<th>Fuel Costs</th>
<th>Finance Cost</th>
<th>Pellet Cost</th>
<th>Partial Fuel Oil Cost</th>
<th>O&amp;M</th>
<th>Scheduled Repairs</th>
<th>Total Costs</th>
<th>Annual Cashflow</th>
<th>Cumulative Cashflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$30,923</td>
<td>$80,172</td>
<td>$35,673</td>
<td>$8,017</td>
<td>$2,000</td>
<td>$1,000</td>
<td>$36,682</td>
<td>$1,022,094</td>
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<tr>
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<td>$30,923</td>
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</table>

**Winchendon School Preliminary Life Cycle Cost Estimate**

**Scenarios - Pellet**

| Total estimated construction costs | $385,370 |
| Terms of loan | 20 |
| Total estimated construction costs | $385,370 |

<table>
<thead>
<tr>
<th>Scenario One - Pellet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total estimated construction costs</td>
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<tr>
<td>Oil heat consumption</td>
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<tr>
<td>Projected pellet utilization</td>
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<td>Projected 1st year pellet cost</td>
</tr>
<tr>
<td>Projected 1st year estimated pellet consumption</td>
</tr>
<tr>
<td>Projected 1st year partial fuel cost</td>
</tr>
</tbody>
</table>

**General Inflation:**
- 2.6% annually
- Oil Inflation: 5.0%
- Projected pellet inflation: 4.23% annually
- O & M: $2,000 in Year 1
- Major Repairs: $1,000

20 year average annual US Labor Dept. Consumer Price Index increases

Average increase for Massachusetts Commercial Fuel Oil from 1990-2010 (US EIA) Estimate from Biomass Energy Resource Center Estimate of additional electricity for fixed system motors and additional maintenance staff time

Contingency for major repair (e.g. refractory replacement) at Years 10, 20 and 30 annualized

**30 Yr. NPV at 5.0% Discount Rate**
- $2,655,977
- $385,370
- $80,172

**Return on Investment**
- 9.5%
ADDITIONAL ISSUES TO CONSIDER

SYSTEM SIZING

Because the school is planning to add heat load by building one or more additions it is difficult to estimate the exact boiler size for this biomass scenario. It is common for mechanical engineers to size boilers to exceed peak design loads. However, with biomass projects it is usually ideal to size a biomass boiler to approximately 60% of the peak demand. This is because all boilers and especially biomass boilers operate more efficiently when they operate on high fire. With a smaller boiler there is greater potential for operating on high fire more of the time. A biomass boiler sized to 60% of the peak demand will cover 90% of the heat load. Because we always recommend a fully redundant, back-up, fossil fuel boiler system, it is not necessary to size the biomass boilers to meet peak demand during the year. On particularly cold nights, if the biomass boiler is insufficient to meet peak demand, then the fossil fuel boilers can be used to provide additional supplemental heat if needed.

Figure 4: Boiler Sizing\(^1\)

The graphic at left shows the percent of the annual heat load (heat requirements) met by different sized boilers (as a percentage of the building’s peak load). This graphic shows that a boiler sized at 60% of the peak load will cover 90% of the annual heat load.

If the School decides to move forward with a biomass project, we recommend that the School engage an owner’s advocate with biomass experience as part of the design team to help the design engineers properly size the biomass equipment. The US Forest Service may be able to provide additional technical assistance from engineers with biomass experience to help with conceptual design.

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\(^1\) Graphic courtesy of Joe Kohler, Kohler and Lewis Mechanical Engineers.
CARBON REDUCTIONS

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. There are few measures the Winchendon School could undertake that would reduce its carbon footprint more than switching their heating fuel use from fuel oil and electricity to a biomass fuel.

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. CO2 avoidance is based on the emissions profile (Lbs. CO2 /Btu) of the displaced fuel.

The US EPA calculates that 22.37 lbs. of CO2 is produced from each gallon of fuel oil consumed. It is projected that the Winchendon School can offset approximately 21,931 gallons of fuel oil per year by replacing that heat using biomass. This is equivalent to about 245 tons of CO2 annually.

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 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.

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2 Illustration taken from a handout produced by the Biomass Energy Resource Center
ENERGY EFFICIENCY

Whether the Winchendon School converts to biomass or stays with fuel oil and electricity, the facility should use its heating fuel efficiently. There are several energy efficiency resources available in Massachusetts, through MassSave. If the School decides to move forward with a biomass energy project, it should work with MassSave to identify other efficiency projects that could be completed at the same time.

General information on efficiency programs in Massachusetts are 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 recommend that the Winchendon 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. As commissioning typically improves the efficiency of energy systems, it often pays for itself over several years. National Grid may contribute toward the owner’s commissioning expenses. Consult your account executive for more information.
PROJECT FUNDING POSSIBILITIES

MASSDEVELOPMENT GREEN LOAN PROGRAM

The Green Loan Program is designed to bridge the gap between energy efficiency project costs and the rebates or subsidies provided by utility companies and state/federal incentive programs. Eligible institutions must be a Massachusetts non-profit or for-profit business that has been in existence for a minimum of five years. Loans are available from $50,000 - $500,000 for:

- HVAC replacements or improvements
- Windows, insulation, and other building improvements
- Lighting
- Energy control systems
- Chillers and Boilers
- Hot water heaters
- Photovoltaic panels

For more information, and to download an application, go to:
http://www.massdevelopment.com/financing/loans-guarantees/green-loan-program/

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.

Applications for 2011 funding were due on April 1st, 2012. A new announcement, for a 2013 round of funding has not yet been announced. For more information on the grant program, contact:

Lew McCreery, Northeastern Area—S&PF, 11 Campus Blvd., Suite 200 Newtown Square, PA 19073–3200
lmcreery@fs.fed.us
(304) 285–1538
EMISSIONS & 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 75% – 80%. 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

<table>
<thead>
<tr>
<th>PM$_{10}$</th>
<th>Wood (lbs/million Btu output)</th>
<th>Distillate Oil (lbs/million Btu output)</th>
<th>Natural Gas (lbs/million Btu output)</th>
<th>Propane (lbs/million Btu output)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO$_X$</td>
<td>0.1650</td>
<td>0.1430</td>
<td>0.09</td>
<td>0.154</td>
</tr>
<tr>
<td>CO</td>
<td>0.7300</td>
<td>0.0350</td>
<td>0.08</td>
<td>0.021</td>
</tr>
<tr>
<td>SO$_2$</td>
<td>0.0082</td>
<td>0.5000</td>
<td>0.0005</td>
<td>0.016</td>
</tr>
<tr>
<td>TOC</td>
<td>0.0242</td>
<td>0.0039</td>
<td>0.01</td>
<td>0.005</td>
</tr>
</tbody>
</table>

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.

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

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school in a climate like Vermont may have the same particulate emissions as four or five houses heated with wood stoves.

Figure 6: Particulate Emissions

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.

Massachusetts Regulations

Massachusetts has one of the most stringent emission requirements for boilers in the region, requiring automatic-feed boilers three million Btu (3 mmBtu) or larger to limit particulate matter (PM) emissions to 0.10 – 0.20 lbs/mmBtu. These restrictions apply to non-automatic fed boilers that are 1.0 mmBtu or larger. The boiler analyzed in this report is an automatic-fed boiler. We recommend the School works with its design engineers to investigate the costs and benefits of different types of pollution control equipment regardless of the system installed.

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CONCLUSIONS AND RECOMMENDATIONS

We recommend the Winchendon School do the following to continue to investigate the potential for biomass heat:

1. The School has a detailed master plan that impacts all of the buildings evaluated in this report. Facility renovations and expansions provide an opportune time for adding a biomass boiler. The School should be sure to integrate plans for biomass heating into their current master plan.

2. The analysis assumes that the new pellet boiler will be placed in the lower level of the Main Building addition – the School should work with the architect and engineer to further investigate the feasibility of placing a new biomass boiler in the new addition.

3. Hire an engineering firm to help refine the project concept and to obtain firm local estimates on project costs. It should be noted that the analysis does not incorporate the cost of converting the electric heat in the Marr, Classroom, Newberry and Posich buildings to a hydronic heating distribution system. Scoping and estimating those costs should be done by a qualified engineering firm and are beyond the scope of this study. The School should seriously consider converting these buildings to hydronic heating distribution systems no matter what fuel they finally decide upon.

4. The US Forest Service may be able to provide a phase II engineering analysis that refines the project concept. If the District decides to move forward with a biomass project, decision-makers 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.

5. The School should consider energy efficiency improvements simultaneously with boiler upgrades. The efficiency of the building envelope and ventilation equipment need to be considered when sizing new boiler equipment. This should be done regardless of whether or not the School moves ahead with a biomass project at this time. Information on energy efficiency programs and incentives is included in the Biomass and Green Building Resources binder accompanying this report.

6. In order to effectively measure progress toward energy efficiency goals historical energy consumption data should be collected and updated frequently. There are many tools that could help the School accomplish this electronically. 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 and provides useful reports and graphs. This software can be downloaded at: http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager.

8. If the School decides to move forward with a biomass system, they should work with Gordon Boyce, Marketing and Utilization Forester with the Massachusetts Department of Conservation & Recreation, to cultivate potential biomass fuel suppliers concurrent with the design of the biomass system. One supplier of particular interest might be New England Wood Pellet located less than 15 miles away in Jaffrey, NH.
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 showing the Net Present Value (NPV) of the installation of a pellet system at the Main Building based on varying grant funding. In this analysis all of the assumptions presented in Table 2 are held constant with a reduction in the capital cost based on grant funding. For example, if the Winchendon School was able to obtain a grant for $250,000, the first year cash flow would increase to $4,429 and the 30-Year NPV for the system would be over $1.5 million.

Table 5: 1st Year Cash Flow and 30-Year Net Present Value (NPV) when Grant Funding Is Available

<table>
<thead>
<tr>
<th></th>
<th>Project Costs (Capital – Grant/Tax Credit)</th>
<th>1st Year Cash Flow</th>
<th>30-Year NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>No grant funding</td>
<td>$612,058</td>
<td>($15,632)</td>
<td>$1,299,191</td>
</tr>
<tr>
<td>$100,000 grant</td>
<td>$512,058</td>
<td>($7,607)</td>
<td>$1,399,191</td>
</tr>
<tr>
<td>$250,000 Grant</td>
<td>$362,058</td>
<td>$4,429</td>
<td>$1,549,191</td>
</tr>
<tr>
<td>$500,000 Grant</td>
<td>$112,058</td>
<td>$24,490</td>
<td>$1,799,191</td>
</tr>
</tbody>
</table>
THE WINCHENDON SCHOOL FUEL HISTORY

The table below summarizes the fuel oil history provided by the Winchendon School for this biomass pre-feasibility study.

Table 6: Fuel Oil Usage 2009 - 2011

<table>
<thead>
<tr>
<th></th>
<th>2009-2010</th>
<th></th>
<th></th>
<th>2010-2011</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Main</td>
<td>Merril/Jaffee</td>
<td>Rotenberg</td>
<td>Main</td>
<td>Merril/Jaffee</td>
<td>Rotenberg</td>
</tr>
<tr>
<td></td>
<td>Building</td>
<td></td>
<td></td>
<td>Building</td>
<td></td>
<td></td>
</tr>
<tr>
<td>August</td>
<td>188</td>
<td>263</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>September</td>
<td>930</td>
<td>351</td>
<td>74</td>
<td>806</td>
<td>439</td>
<td>0</td>
</tr>
<tr>
<td>October</td>
<td>755</td>
<td>973</td>
<td>0</td>
<td>1,606</td>
<td>831</td>
<td>229</td>
</tr>
<tr>
<td>November</td>
<td>3,538</td>
<td>1,209</td>
<td>0</td>
<td>3,193</td>
<td>1,023</td>
<td>77</td>
</tr>
<tr>
<td>December</td>
<td>4,172</td>
<td>2,066</td>
<td>73</td>
<td>4,284</td>
<td>1,942</td>
<td>82</td>
</tr>
<tr>
<td>January</td>
<td>4,578</td>
<td>1,602</td>
<td>129</td>
<td>1,044</td>
<td>349</td>
<td>72</td>
</tr>
<tr>
<td>February</td>
<td>4,642</td>
<td>2,177</td>
<td>127</td>
<td>4,444</td>
<td>1,115</td>
<td>124</td>
</tr>
<tr>
<td>March</td>
<td>3,471</td>
<td>1,339</td>
<td>0</td>
<td>3,336</td>
<td>1,509</td>
<td>0</td>
</tr>
<tr>
<td>April</td>
<td>2,474</td>
<td>1,548</td>
<td>0</td>
<td>1,357</td>
<td>1,060</td>
<td>128</td>
</tr>
<tr>
<td>May</td>
<td>1,222</td>
<td>345</td>
<td>156</td>
<td>1,889</td>
<td>527</td>
<td>0</td>
</tr>
<tr>
<td>June</td>
<td>318</td>
<td>378</td>
<td>0</td>
<td>170</td>
<td>268</td>
<td>0</td>
</tr>
<tr>
<td>July</td>
<td>111</td>
<td>0</td>
<td>0</td>
<td>210</td>
<td>476</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>26,398</td>
<td>12,252</td>
<td>559</td>
<td>22,339</td>
<td>9,539</td>
<td>712</td>
</tr>
</tbody>
</table>
WOOD PELLET FUEL

Wood pellets are made from wood waste materials that are compressed into pellets under heat and pressure. Natural plant lignin holds the pellets together without glues or additives. Wood pellets are of uniform size, shape and composition making them easy to store and to burn.

Much of the pellet fuel market is geared toward supplying 40 pound bags for residential scale pellet stoves and boilers. Commercial scale systems typically have bulk storage of pellet fuel that can then be fed into the boiler automatically. Therefore pellet fuel suppliers for a commercial scale system need to have the ability to deliver in self-unloading trucks. Bulk pellets are typically unloaded into an outdoor pellet silo (see figure 7 below) but there are also interior pellet storage options (Figure 8).

Figure 7: Outdoor Pellet Storage and Delivery

Figure 8: Indoor Pellet Storage

The School is located within 15 miles of a Pellet Manufacturing plant (New England Wood Pellet) and should work directly with this plant if moving forward with a pellet system.

It is best to secure a supplier that will guarantee supply for at least a complete heating season. Distance from the manufacturer will affect cost so generally the closer the supplier, the better the delivered price.

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5 Photo taken from the Wood Pellet Heating Guidebook published by Massachusetts Division of Energy Resources.

6 Photo courtesy of A.B.S. Flexible Silos.
BIOMASS AND GREEN BUILDING RESOURCES BINDER

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➢ Financing Resources
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  o The National Grid Small and Midsize Business Direct Install Program
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  o Reference Guide for EPA Portfolio Manager software
  o Advanced Energy Design Guide Information
  o Collaborative for High Performance Schools and Green Schools Resources (ON ENCLOSED CD)
  o EPA Indoor Air Quality Tools for Schools Reference Guide (ON ENCLOSED CD)

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    ACT Bioenergy
    Okofen
    Solagen
    SWEBO
    TARM Biomass
    Viessman / KOB

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  o North America’s Wood Pellet Sector - USDA
  o Pellet Fuel – Pellet Fuels Institute
  o The Wider World of Pellet Fuel – Pellet Fuels Institute
  o Pellet Fuel Standards – Pellet Fuels Institute
  o Demonstration and Public Education at the W!ld Center – NYSERDA
  o Winnisquam Schools Biomass Heating Case Study
  o Commercial-Scale Biomass Boilers Market Growing in the Northeast – David Dungate, Northeast Sun
  o Massachusetts Renewable Heating and Cooling: Opportunities and Impacts Study (ON ENCLOSED CD)
  o Wood Pellet Heating Guide Book (ON ENCLOSED CD)
  o Emission Controls for Small Wood Fired Boilers (ON ENCLOSED CD)
  o Biomass Boiler and Furnace Emissions and Safety Regulations in the Northeast States (ON ENCLOSED CD)
APPLICATION FOR BIOMASS PRE-FEASIBILITY STUDY

US Forest Service Wood Education and Resource Center
Wood Energy Utilization Support Program
Application for Biomass Pre-feasibility Study

Facility Information:
Facility name and mailing address
Year of Building Construction:
Years of major renovation(s):
First renovation: 2000
Second renovation: 

Public or Private

Contact person for questions regarding this form:
Name: 
Title: 
Phone: 
Fax: 
E-mail address: 
Date form was completed: 

Type of facility (check one)
School
College/University
Hospital
Industrial
Prison
Other

Number of Occupants:

Buildings:
If the facility has multiple buildings, list each building below, give its size in square feet and state whether it is heated from a central boiler plant.

Name of building
Size in square feet
Central boiler?

Expansion Plans:
An opportune time for adding a boiler is when a facility is undergoing an expansion or major renovation. Do you have any plans for expansion or major renovation in the foreseeable future? □ Yes □ No
If so please describe below, including project timing.

Heating System:
Do you have a central heating system? □ Yes □ No
Do you have more than one heating system? □ Yes □ No
Do you have one heating plant in one location? □ Yes □ No
Do you have heating plants in multiple locations? □ Yes □ No

How is heat delivered to rooms?
(check all that are applicable)
□ Hot water
□ Steam
□ Ducted air
□ Electric resistance

How is heat generated?
(check all major systems that are applicable (those that serve 20% or more of the building(s))
□ Hot water boiler
□ Steam boiler
□ Hot air furnace
□ Electric baseboard
□ Rooftop packaged units
□ Heat pumps

Date Printed: 9/14/2010
### Heating equipment

List each piece of heating equipment separately below. Include size in boiler horsepower or BTU, state type of equipment, what fuel it uses, when it was installed, and its condition (Poor, Fair, Good, Excellent).

<table>
<thead>
<tr>
<th>Size</th>
<th>Type of Heater</th>
<th>Fuel Type, year installed, and condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5 MMBtu or 200 BHP</td>
<td>Hot water boiler</td>
<td>#2 fuel oil, installed in 1996, fair</td>
</tr>
<tr>
<td>200 K</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If buried steam lines or hot water lines are used to connect multiple buildings to a central boiler plant, what condition are the lines? Check One: ☐ Poor ☐ Fair ☐ Good ☐ Excellent

### Fuel Usage

Please review your heating fuel bills from the past year and list each type of heating fuel used, the total volume and the total spent on each heating fuel in the past year. (This information can be collected from your fuel bills or by contacting your fuel dealer(s)). In the last column list what percentage of your building square footage is heated by each type of fuel used for heat.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Year</th>
<th>Volume</th>
<th>Units</th>
<th>Cost $</th>
<th>% of Total SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex. Fuel Oil</td>
<td>2009</td>
<td>20,000</td>
<td>Gallons</td>
<td>$30,000</td>
<td>100%</td>
</tr>
<tr>
<td>#2 Fuel Oil</td>
<td>2011</td>
<td>35,35</td>
<td>Gallons</td>
<td>$30,000</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Domestic Hot Water

Is your domestic hot water provided by a different boiler than your space heat? ☐ Yes ☐ No

Is your domestic hot water heated from a central boiler? ☐ Yes ☐ No

If your domestic hot water is provided by a different boiler than your space heat, please list the type of fuel used to heat your domestic hot water, the total volume used and the total dollars spent in 2009 on hot water.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Year</th>
<th>Volume</th>
<th>Units</th>
<th>Cost</th>
</tr>
</thead>
</table>

### Other Information

Has your facility recently undergone an energy audit? ☐ Yes ☐ No

If yes, please provide contact information.

Are there community or institutional policy that supports the use of biomass or its benefits? ☐ Yes ☐ No

If there are other institutions/buildings in the vicinity that have expressed interest in participating? ☐ Yes ☐ No

### Required Attachments

1. If the facility has multiple heating plants in separate locations, please provide a rough sketch on a separate page of the campus and locate each heating system on the sketch. Feel free to use a pre-printed campus map or building floor plan if one is available.

2. Please provide a copy of your latest fuel bill and electric bill for all accounts on site that includes account number and cost of fuel.

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Email, Mail or fax completed application form to: ginger@yellowwood.org

Yellow Wood Associates, Inc.
228 North Main Street, St. Albans, VT 05478
Fax 802-524-6643; Phone 802-524-6141

USDA Forest Service – Wood Education and Resource Center

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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.

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