Preliminary Feasibility Report

Biomass Heating Analysis for Barnet School

Barnet, Vermont

August, 2012

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The Barnet Elementary School serves 250 students in the Caledonia Central Supervisory Union District. The 36,000 square foot school was built in 1988 (with renovations in 1999) and is currently heated with six 330,000 Btu hot water boilers. The boilers are nearing the end of their useful life and need to be replaced.

The School currently uses 12,000 gallons of fuel oil on average each year and currently pays $3.45 per gallon of fuel oil. At that price the District will spend more than $41,000 on fuel oil for the Barnet Elementary School this coming year. This report analyzes the installation of a containerized pellet boiler to provide heat and hot water at the Barnet Elementary School.

Table 1: Summary Findings of Biomass Analysis for the Barnet Elementary School

<table>
<thead>
<tr>
<th>Current Annual fuel oil (gallons)</th>
<th>Projected Annual Fuel Bill*</th>
<th>Total Estimated Project Costs</th>
<th>Annual Tons of Wood Pellets</th>
<th>Tons of Carbon Offset by Wood Pellets</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>12,000 (fuel oil)</td>
<td>$41,400</td>
<td>$279,329</td>
<td>79</td>
<td>121</td>
<td>6.9%</td>
<td>$19,375</td>
<td>$922,941</td>
</tr>
</tbody>
</table>

*based on $3.45 per gallon of fuel oil

The analysis provided in this report indicates that the District could save over $922,000 in operating costs over 30 years in today’s dollars even when the cost of financing is included. The analysis shows more than $19,000 in fuel savings in the first year alone.

The Barnet Elementary School appears to be a good candidate for a wood pellet heating system. We recommend the District take the following steps to further investigate the feasibility of a biomass heating system:

1. Hire an engineering firm to help refine the project concept and to obtain firm local estimates on project costs. An important issue for the project engineers to consider is thermal storage. Biomass heating systems, especially pellet boiler systems, operate significantly more efficiently and effectively (improving cost savings) if thermal storage is designed into the overall system. With thermal storage, a biomass boiler can quickly ramp up to high fire and will shut down when the thermal storage has reached its optimum temperature, this type of system can supply a greater portion of the annual heating load and will therefore provide greater savings. We strongly recommend that any pellet boiler system that is specified for this project include thermal storage as a component of the overall design.

2. If the District moves forward with a biomass project the domestic hot water system should be carefully evaluated to see if it can be incorporated into the biomass project. Adding the domestic hot water load to the project has the potential for greater savings.
3. 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.

4. A complete mechanical analysis that provides an independent assessment of how to improve efficiencies and the operations and maintenance of boiler equipment, ventilation equipment and controls should be performed before investing in any boiler system. Upgrades could include outdoor temperature reset, DDC controls for unit ventilators and improved boiler controls. A mechanical evaluation will more than likely pay for itself many times over regardless of whether or not the District moves forward with a biomass system.

5. The District 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 District 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. The analysis in this report assumes a 4% 20-year bond for the entire cost of the project. How the project is financed can make a big difference on the potential savings and additional financing options should be investigated. Alternatives may include Municipal Leasing, a commercial loan or even borrowing from available internal funds such as a capital reserve fund. If the district is earning a minimal return on existing fund balances, then investing money from the fund into a biomass system could provide an opportunity for greater return. Fuel savings from the biomass system could then be used to repay the fund. Yellow Wood can provide alternative analysis based on different financial assumptions upon request.

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 District 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. The District should consider working with other bulk pellet users in the region (such as the Craftsbury School) to identify any opportunities for reducing delivery costs by cooperatively scheduling deliveries. One of the significant cost drivers of using pellet fuel is the cost of transportation. Working with other users in the region to schedule bulk deliveries may significantly reduce per ton costs for pellet fuel.
This preliminary feasibility study was prepared by Yellow Wood Associates in collaboration with Richmond Energy Associates for the Barnet Elementary 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 (including woodchips and pellets) are being used quite successfully in 48 Vermont schools. 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 dollars in the local economy); reduce the District’s carbon footprint (by replacing fossil fuel with a renewable fuel source); and reduce dependence on fossil fuel, helping Vermont to achieve targets for renewable energy use. This analysis indicates that the Barnet Elementary School would offset 121 tons of CO₂ annually by installing a biomass system.

This report is a pre-feasibility assessment specifically tailored to the Barnet Elementary School outlining whether or not a wood pellet heating system makes sense for this facility from a practical perspective. In April of 2012 staff from Yellow Wood Associates traveled to Barnet to tour the Barnet Elementary 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

EXISTING HEATING SYSTEM AND FUEL USAGE

The Barnet Elementary School is currently heated by six 330,000 Btu hot water boilers that are ganged together and staged, and a hot water distribution system. The heating system was installed in 1988 and the boilers are nearing the end of their useful life. The School received estimates for replacing all six boilers with two 750,000 Btu boilers and the School Board received approval to move forward with the boiler replacement project ($60,000). The new boilers would be more than adequate to provide back up and shoulder season heat if a biomass boiler is installed.

Over the past two years, the Barnet Elementary School used an average of 12,000 gallons of fuel oil. The new boilers will be more efficient than the older boilers and will require less fuel to heat the school. This analysis is based on historical fuel use (before the new boilers were installed). If the School decides to move forward with a biomass system the sizing of the system and required fuel volume should be reevaluated.

Figure 1: Fuel Oil Usage

![Fuel Oil Usage Chart]

Even with a biomass system, during the fall and spring, fossil fuel boilers are often used as they are easier to start up and turn down. Biomass boilers are then typically used in place of fossil fuel boilers for the bulk of the winter heating season. In Vermont, where there are 48 schools that heat with wood, the average annual wood utilization is about 85%. The utilization can increase to about 90% with pellet boilers using thermal storage and automated controls.
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 pellet boiler and thermal storage system that would serve the Barnet Elementary 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 energy project. The capital costs used for the biomass scenario are generic estimates based on our
experience with similar scale projects. It is recommended that the School hire a qualified design team to refine the project concept and to develop firm local cost estimates.

**FUEL OIL COST ASSUMPTIONS**

During the past three years the Barnet Elementary School used an average of 12,000 gallons of fuel oil for heat and hot water. This is the amount of fuel oil and propane used for the base case in the analysis. The District paid $3.45 per gallon of fuel oil on their most recent fuel bill – this is the price used in the base case of the analysis. At that price, the District will spend more than $41,000 to heat the Barnet Elementary School next year.

**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 (such as woodchips). However, pellets are still a relatively local product so they will not likely have the same geopolitical pressures as fossil fuels. After consulting with the Vermont Department of Forests, Parks and Recreation, we are projecting a first year cost of $226 per ton of pellets, which is equivalent to about $1.87 per gallon of fuel oil.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Input mmBtu/Unit</th>
<th>Cost/Unit</th>
<th>Assumed Efficiency**</th>
<th>Output mmBtu/Unit</th>
<th>Cost/mmBtu Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood Pellet (ton)</td>
<td>15.5*</td>
<td>$226</td>
<td>85%</td>
<td>13.175</td>
<td>$17.15</td>
</tr>
<tr>
<td>Fuel Oil (gallon)</td>
<td>0.138</td>
<td>$3.45</td>
<td>70%</td>
<td>0.0966</td>
<td>$35.71</td>
</tr>
</tbody>
</table>

*Assumes 6% moisture content  
**Average seasonal efficiency

The biomass scenario assumes the facility will meet 90% of its winter heating needs with pellets and therefore consume 79 tons of pellets per year at $226 per ton in the first year. The remaining 10% of the heating needs were then assumed to be provided by fuel oil, consuming about 1,200 gallons of fuel oil per year. The costs for supplemental fuel oil and pellets are 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 30-year analysis, some rate of inflation needs to be applied to future fuel costs.
We looked retrospectively over the last 20 years (1991 – 2011) using US Energy Information Agency data and found that the average rate of increase for fuel oil in Vermont was 6.56% per year. The analysis projects this inflation rate for fuel oil forward over the 30-year analysis period. The Barnet Elementary School’s fuel rate of $3.45 per gallon of fuel oil was used for the first year of the analysis and then inflated each year at 6.56%.

Pellet fuel pricing tends to track that of fossil fuels for two reasons. First, it takes a considerable amount of energy to produce pellets. 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: VT Biomass and Fossil Fuel Inflation**

*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 1991 and 2011, 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 scenario.
OPERATION AND MAINTENANCE ASSUMPTIONS

This analysis assumes 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 pellet boiler 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.

An additional operations and maintenance cost is the 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. Analysis for the biomass scenario included $10,000 of scheduled maintenance anticipated in years 10, 20 and 30 and then annualized at $1,000 per year to simulate a sinking fund for major repairs. The $1,000 annual payments were inflated at the general annual 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 hot water boilers and hot air units were taken into consideration as these are considered costs that the District 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 District will finance the entire cost of the biomass project with a bond at a 4% interest rate. A typical bond repayment schedule was used where the principal remains fixed and the interest payment declines as the bond matures. At this time the analysis does not take into account any potential grants, lease arrangements or the impact of financing only a portion of the project cost. Other financing plans 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.

Sensitivity analyses are included in the appendices that show the relative life cycle cost savings under various financing and fuel price scenarios. If the District would like to see other cash flows using different financing schemes, Yellow Wood can provide additional analysis.
BIOMASS SCENARIO

DESCRIPTION OF THE PROPOSED BIOMASS SYSTEM

The biomass scenario envisions the addition of a containerized pellet system, located at the northeast corner of the building. The scenario analyzes the installation of a 500,000 Btu pellet boiler and 500 gallons of thermal storage. Hot water from the boiler would be tied into the existing heating system via approximately 165 feet of underground insulated piping and connect with the existing boiler room. The scenario assumes that the pellet boiler will meet 90% of the annual heating needs currently met with fuel oil at the School. Costs for a 30-ton pellet storage silo and an allowance for interconnecting to the existing heating distribution systems are included in the proposed capital costs. A healthy construction contingency, standard general contractor mark-up and professional design fees were also included.

Figure 3: Site Plan
BIOMASS SCENARIO ANALYSIS

The analysis of the biomass scenario shows that the School could save more than $922,000 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 boiler at the School. Annual fuel savings alone are projected to be $19,375 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 6.9% and this project would have a positive annual cash flow in the fifth year.

**Table 3: Biomass Scenario Analysis Assumptions**

<table>
<thead>
<tr>
<th>Capital Cost Assumptions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>One 500,000 Btu containerized pellet hot water boiler system including installation</td>
<td>$135,000</td>
</tr>
<tr>
<td>Underground insulated hot water piping from boiler house to school</td>
<td>165 LF, $150/LF</td>
</tr>
<tr>
<td>30 ton pellet storage silo</td>
<td>$24,000</td>
</tr>
<tr>
<td>Thermal Storage 500 gallon</td>
<td>$5,000</td>
</tr>
<tr>
<td>Interconnect to existing boiler system</td>
<td>$25,000</td>
</tr>
<tr>
<td>GC markup at 10%</td>
<td>$21,375</td>
</tr>
<tr>
<td>Construction contingency at 10%</td>
<td>$23,513</td>
</tr>
<tr>
<td>Design at 8%</td>
<td>$20,691</td>
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<tr>
<td><strong>Total estimated project costs</strong></td>
<td>$279,329</td>
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</table>

<table>
<thead>
<tr>
<th>Financing Costs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Financing, annual interest rate</td>
<td>4.0%</td>
</tr>
<tr>
<td>Finance term (years)</td>
<td>20</td>
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<tr>
<td>1st full year debt service</td>
<td>$24,860</td>
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<table>
<thead>
<tr>
<th>Fuel Cost Assumptions</th>
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<tr>
<td>Current annual fuel oil use (gal)</td>
<td>12,000</td>
</tr>
<tr>
<td>Assumed fuel oil price in 1st year</td>
<td>$3.45</td>
</tr>
<tr>
<td>Projected annual fuel oil bill</td>
<td>$41,400</td>
</tr>
<tr>
<td>Percent pellet fuel utilization</td>
<td>90%</td>
</tr>
<tr>
<td>Assumed pellet price in 1st year (per ton)</td>
<td>$226</td>
</tr>
<tr>
<td>Projected 1st year pellet fuel bill</td>
<td>$17,885</td>
</tr>
<tr>
<td>Projected 1st year supplemental fuel oil bill</td>
<td>$4,140</td>
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<table>
<thead>
<tr>
<th>Inflation Assumptions</th>
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<tbody>
<tr>
<td>General inflation rate (twenty year average CPI)</td>
<td>2.6%</td>
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<tr>
<td>Fuel oil inflation rate (twenty year EIA average for Vermont)</td>
<td>6.56%</td>
</tr>
<tr>
<td>Pellet inflation rate (estimate from Biomass Energy Resource Center)</td>
<td>4.25%</td>
</tr>
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<table>
<thead>
<tr>
<th>O&amp;M Assumptions</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Annual pellet O&amp;M cost, including electricity for additional pumps and motors and staff time for daily and yearly maintenance</td>
<td>$2,000</td>
</tr>
<tr>
<td>Major repairs (annualized)</td>
<td>$1,000</td>
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<table>
<thead>
<tr>
<th>Savings</th>
<th></th>
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<tbody>
<tr>
<td><strong>Return on Investment</strong></td>
<td>6.9%</td>
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<tr>
<td>Net 1st year fuel savings</td>
<td>$19,375</td>
</tr>
<tr>
<td>Total 30 year NPV cumulative savings</td>
<td>$922,941</td>
</tr>
</tbody>
</table>
Figure 4: Annual Cash Flow Graph for Biomass Scenario

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.

Figure 5: Underground Insulated Piping
## Barnet Elementary School

### Preliminary Life Cycle Cost Estimate

**Pellets - Heat Only**

<table>
<thead>
<tr>
<th>Total estimated construction costs $279,329</th>
</tr>
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<tbody>
<tr>
<td>Financing: 4.0% Bond interest rate</td>
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<table>
<thead>
<tr>
<th>Oil heat consumption 12,000 gal.</th>
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</thead>
<tbody>
<tr>
<td>Includes pellet BTUs</td>
</tr>
<tr>
<td>10% Load covered by Fuel oil = 1,200 gallons</td>
</tr>
<tr>
<td>136 gal. / ton of pellets</td>
</tr>
</tbody>
</table>

| Oil heat price $3.45 |
| Oil heat cost $4,140 |

| Estimated pellet utilization 99% |
| Projected pellet consumption 79 tons |
| Estimated 1st year pellet price $226 / ton Year 1 |
| Projected 1st year pellet cost $17,885 |
| Projected 1st year partial fuel oil cost $4,140 |

**General Inflation:**

- 2.6% annually

**Oil Inflation:** 6.6%

**Pellet Inflation:** 4.2% annually

**O & M:** $2,000 in Year 1

### Current Fuel Costs

<table>
<thead>
<tr>
<th>Yr</th>
<th>Fuel oil</th>
<th>Finance Cost For Entire Project $41,400</th>
<th>Pellet Cost $17,885</th>
<th>Partial Fuel oil Cost $4,140</th>
<th>O&amp;M Cost $1,000</th>
<th>Scheduled Repairs Cost $0</th>
<th>Total Fuel Costs $46,650</th>
<th>Annual Fuel Savings $4,559</th>
<th>Annual Cashflow $42,091</th>
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<tr>
<td>1</td>
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<td>$24,980</td>
<td>$17,885</td>
<td>$4,140</td>
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<td>$1,043</td>
<td>$0</td>
<td>$34,993</td>
<td>$4,430</td>
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<td>4</td>
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<td>$20,263</td>
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<td>$5,009</td>
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<td>$0</td>
<td>$34,532</td>
<td>$4,431</td>
<td>$30,091</td>
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<td>$21,124</td>
<td>$5,336</td>
<td>$1,089</td>
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| Totals $3,14,434 | $391,060 | $1,045,389 | $361,434 | $69,504 | $4,475 | $1,032,730 | $2,206,921 | $1,681,005 |

| 30 Yr. NPV at Discount Rate 2.6% $2,202,845 | $300,760 | $633,192 | $220,288 | $58,468 | $29,234 | $1,279,942 | $1,319,403 | $922,941 |

| Total Annual Heating Costs | $41,400 | $17,885 | $4,140 | $2,000 | $1,000 | $49,885 | $19,375 | $279,329 | 14.4 | $922,941 |

| Return on Investment 6.9% |

---

**Table 4: 30-Year Life Cycle Analysis Spreadsheet for Biomass Scenario**
ADDITIONAL ISSUES TO CONSIDER

THERMAL STORAGE

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.

SYSTEM SIZING

It is common for mechanical engineers to size boilers to exceed peak design loads. However, with biomass projects it is better to size a biomass boiler to smaller than 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 approximately 90% of the annual 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.
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, the US Forest Service may be able to provide additional technical assistance from engineers with biomass experience to help with conceptual design.

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 Barnet Elementary 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.

Figure 6: Boiler Sizing¹

Figure 7: Carbon Cycle Illustration²

¹ Graphic courtesy of Joe Kohler, Kohler and Lewis Mechanical Engineers.
² Illustration taken from a handout produced by the Biomass Energy Resource Center
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 Barnet Elementary School can offset approximately 10,800 gallons of fuel oil per year by replacing that heat using biomass. This is equivalent to about 121 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 District 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 the Barnet Elementary School converts to biomass or stays with fuel oil, the facility should use its heating fuel efficiently. The Vermont Superintendents Association offers expert energy efficiency consultation through the School Energy Management Program (SEMP). SEMP offers core services to maximize efficiency, reduce energy budgets and improve the learning environment. For more information on SEMP, contact Norm Etkind, Program Director at semp@vtvs.org. Additional efficiency resources are available through Efficiency Vermont (www.efficiencyvermont.com). If the District decides to move forward with a biomass energy project, it should work with one of these agencies to identify other efficiency projects that could be completed at the same time.

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 Barnet Elementary 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.

EMISSIONS & PERMITTING

There is little emissions data available for pellet boiler systems in North America. Since the EPA regulations are geared toward much bigger systems than what is proposed in this report, permitting should not be difficult. A report released in 2010 (and included in the Biomass and Green Building Resources binder), Emission Controls for Small Wood-Fired Boilers provides a series of Best Management Practices (BMPs) for maximizing energy efficiency and minimizing emissions from wood-fired boilers.
PROJECT FUNDING POSSIBILITIES

EFFICIENCY VERMONT

There are a number of programs available through Efficiency Vermont, an organization created by the legislature and the Vermont Public Service Board to help all Vermonters save energy and reduce energy costs, such as the HVAC Rebate Program which provides rebates for a variety of HVAC equipment and controls, including pellet boilers. The HVAC Rebate Form can be accessed online at; http://www.efficiencyvermont.org/docs/for_my_business/rebate_forms/HVACRebateForm.pdf and is included in the Biomass and Green Building Resources Binder accompanying this report.

USDA COMMUNITY FACILITY GRANTS AND LOANS

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 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.

Montpelier
Karen Lynch
Karen.lynch@vt.usda.gov
(802)828-6044

MUNICIPAL LEASE PURCHASE

As a municipal entity, the Barnet Elementary 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.

**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 2012 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
[mcreery@fs.fed.us](mailto:mcreery@fs.fed.us)
(304) 285–1538
CONCLUSIONS AND RECOMMENDATIONS

The Barnet Elementary School appears to be a good candidate for a wood pellet heating system. We recommend the District take the following steps to further investigate the feasibility of a biomass heating system:

1. Hire an engineering firm to help refine the project concept and to obtain firm local estimates on project costs. An important issue for the project engineers to consider is thermal storage. Biomass heating systems, especially pellet boiler systems, operate significantly more efficiently and effectively (improving cost savings) if thermal storage is designed into the overall system. With thermal storage, a biomass boiler can quickly ramp up to high fire and will shut down when the thermal storage has reached its optimum temperature, this type of system can supply a greater portion of the annual heating load and will therefore provide greater savings. We strongly recommend that any pellet boiler system that is specified for this project include thermal storage as a component of the overall design.

2. If the District moves forward with a biomass project the domestic hot water system should be carefully evaluated to see if it can be incorporated into the biomass project. Adding the domestic hot water load to the project has the potential for greater savings.

3. 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.

4. A complete mechanical analysis that provides an independent assessment of how to improve efficiencies and the operations and maintenance of boiler equipment, ventilation equipment and controls should be performed before investing in any boiler system. Upgrades could include outdoor temperature reset, DDC controls for unit ventilators and improved boiler controls. A mechanical evaluation will more than likely pay for itself many times over regardless of whether or not the District moves forward with a biomass system.

5. The District 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 District 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. The analysis in this report assumes a 4% 20-year bond for the entire cost of the project. How the project is financed can make a big difference on the potential savings and additional financing options should be investigated. Alternatives may include Municipal Leasing, a commercial loan or even borrowing from available internal funds such as a capital reserve fund. If the district is
earning a minimal return on existing fund balances, then investing money from the fund into a biomass system could provide an opportunity for greater return. Fuel savings from the biomass system could then be used to repay the fund. Yellow Wood can provide alternative analysis based on different financial assumptions upon request.

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 District 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:


8. The District should consider working with other bulk pellet users in the region (such as the Craftsbury School) to identify any opportunities for reducing delivery costs by cooperatively scheduling deliveries. One of the significant cost drivers of using pellet fuel is the cost of transportation. Working with other users in the region to schedule bulk deliveries may significantly reduce per ton costs for pellet fuel.
**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

The following sensitivity analyses show life-cycle costs of the biomass system under varying finance scenarios. Table 5 is a sensitivity analysis comparing annual fuel savings from the installation of a pellet boiler based on varying prices for wood and fuel oil (all of the additional assumptions stated in Table 3 remain the same). For example, if the price for fuel oil goes up to $4.50 per gallon and the price of pellets is $220 per ton, the annual fuel savings will increase to $31,190.

**Table 5: Annual Fuel Savings When Pellet and Fuel Oil Prices Vary**

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<td>$260</td>
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Table 6 is a sensitivity analysis showing the Net Present Value (NPV) of the installation of a pellet system at the Barnet Elementary School based on varying grant funding. In this analysis all of the assumptions presented in Table 3 are held constant with a reduction in the capital cost based on grant funding. For example, if the District was able to obtain a grant for $50,000, the 30-Year NPV for the system would be over $978,000.

**Table 6: 1st Year Cash Flow and 30-Year Net Present Value (NPV) when Grant Funding Is Available**

<table>
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BARNET ELEMENTARY SCHOOL FUEL HISTORY

Fuel oil is the primary heat source for the Barnet Elementary School. The table below summarizes fuel history provided by the Barnet Elementary School as part of the application for a biomass pre-feasibility study.

Table 7: Fuel Oil Usage 2010 - 2012

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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 8 below) but there are also interior pellet storage options (Figure 9).

Figure 8: Outdoor Pellet Storage and Delivery

Figure 9: Indoor Pellet Storage

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. If the District decides to move forward with a wood pellet project they should contact each manufacturer for pricing and delivery information or work with Paul Frederick to gather this information.

Paul E. Frederick
Wood Utilization Forester
VT Department of Forests, Parks & Recreation
5 Perry Street, Suite 20, Barre, VT 05641-4265
(802) 479-7436 FAX: (802) 476-0129
paul.frederick@state.vt.us

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

4 Photo courtesy of A.B.S. Flexible Silos.
The average price paid per ton of pellets in Vermont during the 2011-2012 heating season was $226, however pellet fuel may be available at a lower cost, and the District should check with multiple providers to find the lowest price fuel available.
BIOMASS AND GREEN BUILDING RESOURCES BINDER

TABLE OF CONTENTS

- **Financing Resources**
  - EPA Innovative Financing Solutions
  - **Financing Energy Efficiency Projects** – Zobler & Hatcher, Government Finance Review
  - Financing Energy-Efficient Projects – Municipal Leasing Consultants
  - Efficiency Vermont – Financing Energy Efficiency
  - Efficiency Vermont – HVAC Rebate Form
  - USDA Community Facility Grants
  - USDOE Guide to Financing EnergySmart Schools (ON ENCLOSED CD)

- **Efficiency Resources**
  - Making the Grade: A Step-by-Step Guide for School Energy Champions
  - School Energy Management Program
  - Reference Guide for EPA Portfolio Manager software
  - US Department of Energy Reduce Operating Costs with an EnergySmart School Project
  - U-32 Junior Senior High School Energy Efficiency Case Study
  - Commissioning Guide for Better Buildings in Vermont (ON ENCLOSED CD)
  - Collaborative for High Performance Schools and Green Schools Resources (ON ENCLOSED CD)
  - EPA Indoor Air Quality Tools for Schools Reference Guide (ON ENCLOSED CD)

- **Pellet Boiler Manufacturers**
  - ACT Bioenergy
  - New Horizon Corporation
  - Okofen
  - Solagen
  - SWEBO
  - TARM Biomass
  - Viessman / KOB
  - WoodMaster
  - Woodpecker Energy

- **Biomass Energy Resources**
  - Carbon Dioxide and Biomass Energy
  - North America’s Wood Pellet Sector - USDA
  - Pellet Fuel – Pellet Fuels Institute
  - The Wider World of Pellet Fuel – Pellet Fuels Institute
  - Pellet Fuel Standards – Pellet Fuels Institute
  - Demonstration and Public Education at the Wild Center – NYSERDA
  - Commercial-Scale Biomass Boilers Market Growing in the Northeast – David Dungate, Northeast Sun
  - Wood Pellet Heating Guide Book (ON ENCLOSED CD)
  - Emission Controls for Small Wood Fired Boilers (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**

<table>
<thead>
<tr>
<th>Facility name and mailing address</th>
<th>Year of Building Construction (Year)</th>
<th>Years of major renovation(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barnet School</td>
<td>2000</td>
<td>1990</td>
</tr>
<tr>
<td>165 Kidrow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barnet, VT 05821</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Name:** Student Name  
**Title:** Facility Director  
**Phone:** 802-835-1317  
**Fax:** 802-835-4447  
**E-mail address:** student@barnetvt.edu  
**Date form was completed:** 1/15/2012  
**Public or Private:** Public

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.

<table>
<thead>
<tr>
<th>Name of building</th>
<th>Size in square feet</th>
<th>Central boiler?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barnet School</td>
<td>34,000</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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.

**Boiler removal/new installation 2012**

- **Yes**  
- **No**

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 that serve 30% or more of the building(s))
- **Hot water boiler**  
- **Steam boiler**  
- **Hot air furnace**  
- **Electric Baseboard**  
- **Rooftop packaged units**  
- **Heat pumps**

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**Date Printed:** 9/14/2010
List each piece of heating equipment separately below. Include size in boiler horse power or BTU, 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>3.2 MBtu or 200 BHP</td>
<td>Hot water boiler</td>
<td>#2 fuel oil, installed in 1998, poor</td>
</tr>
<tr>
<td>1,000,000BTU</td>
<td>Hot water heater</td>
<td>#2 fuel oil, installed in 1988, poor</td>
</tr>
</tbody>
</table>

If forced 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

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>#2 Fuel Oil</td>
<td>2009</td>
<td>20,000</td>
<td>Gallons</td>
<td>$50,000</td>
<td>100%</td>
</tr>
<tr>
<td>#2 Fuel Oil</td>
<td>2011</td>
<td>12,000</td>
<td>gallons</td>
<td>$30,000.00</td>
<td>100%</td>
</tr>
</tbody>
</table>

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.

Fuel Type | Year | Volume | Units | Cost
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<td>gallons</td>
<td>$30,000.00</td>
</tr>
</tbody>
</table>

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

If so when?

Community/Institution Intentions
Is there an identified community champion for this work? □ Yes □ No
If yes, who is it? Please provide contact information.

Is there a community or institutional policy that supports the use of biomass or its benefits? □ Yes □ No
If yes, please attach.

Are there other institutions/buildings in the vicinity that have expressed interest in participating? □ Yes □ No
If yes, please provide contact information.

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.

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 Date Printed: 9/14/2010
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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