



USDA Forest Service
Wood Education and Resource Center
301 Hardwood Lane
Princeton, WV 24740
(304) 487-1510

P R E L I M I N A R Y A N A L Y S I S M E M O R A N D U M

DATE: December 31, 2009
TO: Lew McCreery, WERC
FROM: Tom Wilson, WES; Brandi Johnston, WES
CC: John Tuttle, Missouri Department of Conservation
RE: Mountain View-Birch Tree Liberty Jr/Sr High School; Howell County, Missouri

1.0 MEMORANDUM PURPOSE

The Wood Education and Resource Center (WERC) is providing preliminary analysis of the potential for a wood utilization project at each of the schools responding to the Missouri Fuels For Schools grant opportunity. The preliminary analysis provides the following information for each school:

- A description of the school's heating system, heat distribution system, and controls;
- An estimate of annual fuel usage based on fuel bills and information provided by the school;
- A preliminary design of one potential option for a wood utilization project at the school
 - Recommended biomass heating system sizing, fuel storage sizing, and interconnection and/or modification to the schools internal heating distribution system;
 - An estimate of the annual fuel offset by wood utilization and the associated cost savings; and
 - A site plan showing the wood utilization system, fuel storage, and any distribution piping;
- A conceptual estimate of the costs for installation of the potential biomass system.

The potential option and conceptual costs outlined in this memorandum are based on WERC's initial assessment of the school's opportunity for utilization of wood as a fuel. Modifications to this option or additional options may be developed following additional more detailed evaluation.

2.0 DESCRIPTION OF EXISTING HEATING SYSTEM AND FACILITY

The Mountain View-Birch Tree (MV-BT) site consists of 2 existing buildings: Liberty High School and an adjacent Vo-Ag/Music Building. The High School and Vo-Ag/Music Building are 87,650 and 5,680 square feet, respectively. Additionally, the school district is currently in the process of building a new 56,000 square feet Middle School across the street from the High School. Table 1 provides a summary of the buildings and type of heating systems used in each.

Table 1 - Description of Buildings

| Building/Section | Heat Sources | Year Built | Square Footage | Heat Distribution |
|-------------------------|---------------------|-------------------|-----------------------|--------------------------|
| Liberty High School | fuel oil/ electric | 1971 | 87,650 | central/hot water |
| Vo-Ag/Music | Propane | 1971 | 5,680 | propane hanging |
| New Middle School | electric/propane | 2010 | 56,000 | distributed |

The Jr/Sr high school is served by 4 fuel oil boilers in three separate boiler rooms; each boiler room was the result of an addition to the school. Heat is distributed throughout the school with a 2 pipe hot water system which is interconnected to allow any one of the boilers to supply heat to the entire school. The classrooms generally contain 2 unit ventilators with DX cooling units and hot water coils connected to the two pipe heating system. Boiler room #2 contains one boiler which is 2.5 million BTU/hr based on 17.9 gal/hr of fuel oil (no output or efficiency number was available). The distribution pump is 5 HP, fixed speed. The supply and return pipes are 4 inches with a supply temperature of 180°F and a return temperature 20° lower. Boiler room #1 contains a Bryan Boiler that is the main boiler for the school. It is rated at 4.3 million BTU/hr output with a maximum input of 38 gallons of fuel oil per hour. The circulation pump is 7.5 HP, fixed speed; the hot water distribution supply and return pipes are also 4 inches. This room also contains a 2,000 gallon domestic hot water storage tank with thermostatic controls set at 130°. This tank is heated by the Bryan boiler with water circulated via a small pump.

Boilers 3 and 4 are located in Boiler room #3, measuring 41'-7"x14'-8"x12'-9." Boiler room #3 is a potential location for the new biomass boiler. Boiler 3 supplies 6 rooms and is 327,800 BTU/hr rated output. Boiler #4 services 12 rooms and the office area and is rated at 1.2 million BTU/hr output.

The Vocational-Agricultural building contains 2 LP units. The Middle School Vo-Ag room contains a 75,000 BTU/hr input, ducted propane furnace. The High School Vo-Ag room contains a 250,000 BTU/hr input, propane hanging furnace rated at 81% thermal efficiency.

The new Middle School is designed with individual room ventilators with heat pump units and propane for supplemental heating. In addition, rooftop air handling units, which serve larger spaces and internal rooms and offices, supply heat and cooling with heat pumps and supplemental propane. Because of the overall efficiency of the heat pumps and difficulty of interconnecting the biomass system, it is not practical to include this building in the biomass project.

3.0 CURRENT FUEL USAGE AND COST

Mountain View-Birch Tree Liberty Jr/Sr High School uses fuel oil as the main fuel for heating and propane for cooking and heating the Vo-Ag/Music building. Table 2 provides a summary of the annual fuel and energy usage and the estimated current annual cost for each fuel type. Propane usage was estimated, as the delivery timing and additional usage made numbers reported inconsistent with expected heat use per square foot for the type of building. The total average annual energy output of the heating units is estimated to be 2,136 mmBtu.

Table 2 – Annual Heating Energy Usage and Costs

| Building/Section | Square Footage | Heat Input per year, mmBtu | Fuel oil/propane, gal | Annual Cost | Estimated Electric, kWh | Energy output, mmBtu |
|--------------------------|----------------|----------------------------|-----------------------|-----------------|-------------------------|----------------------|
| Liberty High School | 87,650 | 2,396 | 13,567 | \$33,918 | 153,609 | 1,928 |
| Vo-Ag/Music ¹ | 5,680 | 278 | 3,000 | \$6,000 | 0 | 208 |
| Electric heating cost | | | | \$11,213 | | |
| Totals | 93,330 | 2,674 | 16,567 | \$51,131 | | 2,136 |

Note: 1 – Propane use is estimated.

Fuel unit cost assumptions used for this analysis is summarized in Table 3. This does not reflect the actual cost for propane and fuel oil as prices varied widely from year to year and location to location. To allow uniform comparison of projects a value of \$2.50 for fuel oil and \$2.00 per gallon of propane to estimated costs and savings. The electricity costs represent actual prices paid.

Table 3 - Fuel Heating Values and Unit Costs

| Fuel, Unit | Heating Value, Btu/unit | Unit Cost, \$/unit |
|---------------|-------------------------|--------------------|
| Fuel oil | 138,000 | \$2.50 |
| Propane | 92,500 | \$2.00 |
| Electric, kWh | 3,412 | \$0.07 |
| Wood, ton | 10,000,000 | \$40.00 |

4.0 PROPOSED WOOD UTILIZATION PROJECT

The proposed biomass project would serve Liberty High School and the adjacent Vo-Ag/Music Building. It is not practical to interconnect the new Middle School due to the distance from the proposed biomass facility location, complexity of connecting the distributed systems, and low additional heat load required by the individual heat pumps. The biomass boiler room location selected is to the rear of the High School near Boiler Room #1 at the rear of the parking lot.

4.1 Wood System Sizing

Weather data for Southern Missouri shows that the month of January contains on average 25% – 30% of the heating degree days using 55°F as the base point below which schools need to be heated due to internal heat load. Using 25%, an average hourly energy output for the month of January is approximately 0.75 mmBtu/hr. Solid fuel combustion units to operate efficiently and to improve responsiveness need to have thermal storage added and should be sized for base loads and not peak loads. They can effectively operate between 100% and 25% of their rated capacity. Backup fossil fuel systems need to remain in place for peak load and shoulder months when minimal heating is required.

For this study it is estimated a 1.2 mmBtu unit is required. If this project moves forward, more detailed monitoring of loads and efficiencies and modeling of energy demand is needed to size the system.

4.2 Boiler Housing and Chip Storage

The design described by this memorandum is for a wood chip boiler room (720 ft²) with 150 cubic yard chip storage attached. Access for chip delivery is via current driveway and parking lot. Timing of chip delivery will need to be when the school is not in session to allow room for the trucks to maneuver in the parking lot. There are several other options for sites however this location offers easy access to the main boiler room and minimizes site development costs (Attachment A). While there is room for a wood chip boiler in Boiler Room 3, direct access for chip delivery and storage makes this site not as attractive as the site chosen. If this project moves forward, a review of potential sites is recommended.

4.3 HVAC Upgrades

Portions of the existing interior supply and return piping will need to be replaced with larger diameter pipe to allow enough heat to be delivered from one boiler room. In addition, the school could consider a concurrent project that would upgrade room unit ventilators, install a central chiller, and create a two pipe heating and cooling system. These measures would require less maintenance and provide greater energy savings than the current individual DX air conditioning units installed in each classroom; the current unit ventilators are nearing the end of their useful life and expanding the scope of the project to include this option will provide additional energy savings and avoid future replacement costs. This would require that all supply and return pipes be well insulated to avoid condensation and that the pipe diameters to each room are large enough to accommodate the volume of water required for cooling. The annual energy savings could be substantial if a new central chiller plant is installed. Financial analysis of this option is beyond the scope of this analysis.

4.4 Potential Energy and Cost Savings

Current annual costs for heating and domestic hot water are about \$51,000 (Table 2). Table 4 shows that the annual fuel costs with the proposed system would be about \$18,000 annually. Thus, the potential annual savings is about \$33,000. Table 4 provides the heating fuel usage and costs associated with the proposed biomass system.

Table 4 - Heating Fuel Usage and Costs for Proposed Biomass System

| Facility | Fuel Oil or Propane, gal | fuel oil or Propane Cost | Electric Usage, kWh | Electric Cost | Wood Tonnage | Wood Cost | Total Fuel Cost |
|---------------------|--------------------------|--------------------------|---------------------|----------------|--------------|-----------------|-----------------|
| Liberty High School | 2,035 | \$5,088 | 23,041 | \$1,682 | 234 | \$9,360 | \$16,130 |
| Vo-Ag/Music | 450 | \$1,125 | 0 | \$0 | 26 | \$1,040 | \$2,165 |
| Totals | | \$6,213 | 23,041 | \$1,682 | 260 | \$10,400 | \$18,295 |

Notes: It is assumed for the purposes of this report that 85% of heating needs are met with the biomass system. An efficiency of 70% is used for the biomass system in order to calculate the wood tonnage needs. This efficiency is assumed to include biomass boiler room and distribution losses between the biomass boiler room and the interconnection to the various heating units/systems.

5.0 CONCEPTUAL COST ESTIMATE

The estimated capital cost to install the biomass system described in Section 4 is about \$840,000. Attachment B provides a breakdown of the conceptual cost estimate for the system. Further investigation and scoping of the proposed biomass project is required to refine this conceptual estimate prior to a decision to move forward with a project.

Table 5 provides a list of metrics by which this project may be compared to other potential projects that are also competing for the Missouri Fuels for Schools grant funding.

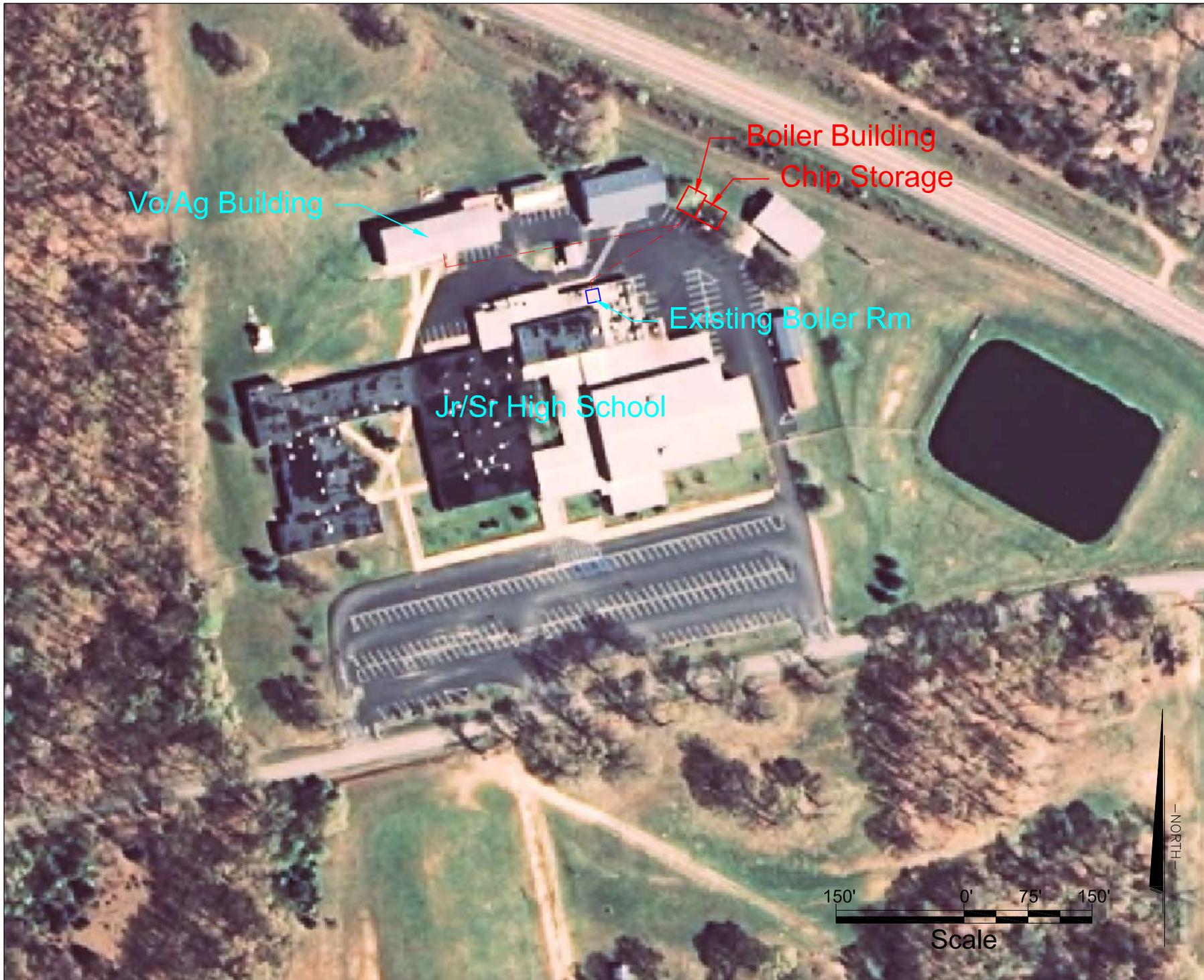
Table 5 - Grant Funding Metrics

| Metric | Value |
|--|-------|
| System cost per annual mmBtu of wood usage (\$/mmBtu) | \$322 |
| System cost per dollar of estimated annual savings (\$/\$ savings) | \$25 |

The grant funding metrics presented above provide a means to compare the ability of the competing projects to leverage grant dollars to utilize low-use wood and realize fuel cost savings.

ATTACHMENT A

Proposed Wood Utilization Project Plan View



| | |
|----------|-----------------------|
| Designed | THW 12-17-09 |
| Drawn | BEJ 12-17-09 |
| Checked | THW 12-17-09 |
| Approved | _____ Date _____ |
| Title | _____ Job Class _____ |

Mountain View-Birch Tree Liberty
 Mountain View, Missouri
Site Plan

WERC
 Wood Education and Resource Center
 United States Forest Service
 United States Department of Agriculture

| REVISIONS | |
|-----------|-------------|
| Date | Description |
| | |
| | |
| | |

Preliminary, Conceptual Cost Estimate

| Line Item | Value | Units | \$/Unit | Cost ¹ |
|--|------------------------------|------------|---------|-------------------|
| 1.25 mmBtu/hr biomass boiler & chip handling system | - | - | - | \$ 240,000 |
| Stack and Breeching | - | - | - | \$ 10,000 |
| Boiler housing | 720 | sf | \$ 50 | \$ 36,000 |
| 150 cy chip storage building and bunker | 720 | sf | \$ 150 | \$ 108,000 |
| Site preparation | - | - | - | \$ 25,000 |
| Thermal storage 1,250 gal | - | - | - | \$ 12,500 |
| Biomass boiler room equipment / installation | - | - | - | \$ 50,000 |
| Pex Pipe (2" & 3" supply and return and blacktop repair) | 445 | lf | \$ 150 | \$ 66,750 |
| Interconnection to 2 buildings | - | - | - | \$ 43,500 |
| Sub-Total | | | | \$ 591,750 |
| | <i>Contractor Profit</i> | <i>10%</i> | | \$ 59,175 |
| Sub-Total | | | | \$ 650,925 |
| | <i>Contingency</i> | <i>15%</i> | | \$ 97,639 |
| Sub-Total | | | | \$ 748,564 |
| | <i>Professional Services</i> | <i>12%</i> | | \$ 89,828 |
| Total | | | | \$ 838,391 |

Notes:

1 - Overhead and bid bond are factored into the estimated item costs and are not broken out.

2 - All costs are installed costs.

3 - Geotechnical investigations and surveys have not been conducted. Soil and grade dependent items are subject to large changes in cost pending site investigation.