



**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:** Bill Hart, WES; Dan Wilson, WES  
**CC:** John Tuttle, Missouri Department of Conservation  
**RE:** Eminence R-I Elementary School; Shannon 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 15,726 sf elementary school is serviced by a 1,440,000 Btu/hr LP open combustion boiler. The school has 4 fixed speed recirculation pumps and a central 2-pipe hot water distribution system. The heat in the building is regulated by 4 thermostats that control the 4 recirculation pumps, with no individual room controls. Anecdotal evidence suggests that the school is often simultaneously heating some rooms while opening the windows in others. Cooling is provided by through-the-wall individual air conditioning units. There appear to be no other provisions for air exchange except open windows. Two outbuildings that are each about 1,000 sf and are serviced by 80,000 LP forced air units. An additional outbuilding is about 800 sf and is heated by an electric system. Table 1 presents pertinent information on the three largest buildings.

**Table 1 – Campus Facilities/Buildings**

<b>Building/Section</b>	<b>Heat Sources</b>	<b>Year Built</b>	<b>Square Footage</b>	<b>Heat Distribution</b>
Main Elementary	Propane	50's	15,726	Central
Library	Propane	90's	1,120	Central
Art/Music	Propane	90's	1,120	Central
<b>Total</b>			<b>17,966</b>	

### 3.0 CURRENT FUEL USAGE AND COST

Fuel bills provided by the school show the '07-'08 school year propane usage to be 14,100 gallons for the entire campus, which consists of 3 buildings heated by propane. Anecdotal information indicates that propane was previously stored in about 8 propane tanks ranging from 500 to 1,000 gallons in size. A new 8,000 gallon tank was installed this year. Table 2 shows 14,100 gallons divided among the three buildings. Propane usage is divided between the buildings based on square footage and assessment of the type of construction and anecdotal usage patterns. The electric utilized for the 800 sf additional building is ignored at this level of study.

The Main Elementary shows an annual output per square footage value of 72,595 Btu/sf/yr. This is approximately 3 times higher than would be expected for a school in the geographic region of Eminence R-I Elementary. This high value is likely due to an inefficient propane boiler and to the lack of controls within individual rooms of the building.

**Table 2 – Average Annual Energy Usage and Cost for Heat and Hot Water**

<b>Building/Section</b>	<b>Square Footage</b>	<b>Propane Usage, gal</b>	<b>Propane Cost</b>	<b>Energy Input, mmBtu</b>	<b>Assumed Efficiency</b>	<b>Energy Output, mmBtu</b>
Main Elementary	15,726	13,400	\$26,800	1,340	65%	871
Library	1,120	350	\$700	35	90%	32
Art/Music	1,120	350	\$700	35	90%	32
<b>Totals</b>	<b>17,966</b>	<b>14,100</b>	<b>\$28,200</b>	<b>1,410</b>		<b>934</b>

*Notes: Efficiencies are assumed based on manufacturer ratings where available and past experience where manufacturer ratings are not available.*

The total annual heating costs and energy usage at the Eminence School are estimated to be \$28,000, and 934 mmBtu, respectively. Table 3 provides the heating values and unit costs used in this analysis. The '07-'08 cost for propane was \$1.35/gallon, whereas the '08-'09 cost was \$1.92/gallon. However, for comparison across analyses, a value of \$2.00/gallon is utilized for all calculations performed for this grant opportunity.

**Table 3 – Fuel Heating Values and Unit Costs**

Fuel, Unit	Heating Value, Btu/unit	Unit Cost, \$/unit
Propane, gal	92,500	\$2.00
Wood, cord	18,000,000	\$120.00

Using 55°F as the reference temperature for when heating is required, weather data for this area of Missouri shows that the month of January contains on average 25 – 30% of total, annual heating degree days. Using 25%, average hourly energy output for the month of January comes to about 0.31 mmBtu/hr.

**4.0 PROPOSED WOOD UTILIZATION PROJECT**

A wood utilization project at the school would be able to utilize the existing 2-pipe hot water distribution system within the Main Elementary. However, the project would require installation of new heating units and controls within each of the school rooms. This upgrade to the HVAC system would likely have a significant impact on the annual energy needs for the school. A value of 30,000 Btu/sf/yr as the energy output need for the Main Elementary is used for this level of analysis for the school. This decrease in needed input energy would result from an increase in boiler efficiency and the reduction of loss from heating when some classrooms are using natural ventilation for cooling. The third column in Table 4 shows the estimated energy needed following an upgraded HVAC system for the Main Elementary. It is assumed that a biomass system can replace 85% of the estimated energy usage with energy from biomass.

**Table 4 – Current Cost and Energy to Be Replaced by Biomass (Wood Chips)**

Building	Current Fuel Costs	Current Energy Output, mmBtu	Estimated Output Needed with HVAC Upgrade
Main Elementary	\$26,800	871	472

**4.1 Wood System Sizing**

Using the reduced energy needs with the new HVAC system, the average hourly energy output required from the biomass system for January comes to about 0.14 mmBtu/hr. Thus, it is assumed for this level of study that a wood capacity of 0.25 mmBtu/hr would be appropriate.

The staff at the school has stated that they are amenable to manually loading a cord wood boiler a couple of times daily to provide wood heat. Since the staff is willing to provide a high level of system

maintenance, the level of automation required is reduced. This, in turn, leads to lower capital costs for the boiler system.

#### 4.2 Boiler Housing and Chip Storage

The design described by this memorandum is for a cord wood boiler that is housed adjacent to the existing boiler room on the north side of the school. These systems are hand-loaded with cord wood that is automatically fed into the combustion chamber. An accompanying thermal storage allows the system to operate at peak output with refueling required after several hours during peak demand or a day or more at reduced demand. The boiler housing requires 500 sf of space and cord wood would be stored in a lean-to shed attached to the boiler housing. Hot water from the biomass system would be distributed by 2" (approximate size) dual line insulated pex pipe to the boiler room where interconnection would be made with the existing system. Attachment A provides a plan view of the proposed site.

#### 4.3 HVAC Upgrades

New fan coil units with provisions for economizer cooling and air exchange will be required in each of the individual rooms. The existing distribution piping can be utilized for heat distribution. Modern controls are necessary to allow regulation of heat in each of the rooms. Variable frequency drive pumps will replace the existing hot water recirculation pumps. Attachment C provides a breakdown of the conceptual cost estimate for the proposed HVAC system upgrades.

#### 4.4 Potential Energy and Cost Savings

It is estimated that the new system will reduce the necessary energy output needed at the Eminence Main Elementary from 934 to 472 mmBtu/yr. Additionally, wood can be used to cover about 85% of the 472 mmBtu/yr, with propane covering the rest. Thus, Eminence could see costs go from about \$27,000/yr for propane to \$5,000 for wood and propane, providing a total savings of about \$22,000 annually. Table 5 shows the estimated fuel usages and costs for the proposed biomass system.

**Table 5 – Heating Fuel Usage and Costs for Proposed Biomass System**

Facility	Propane Usage, gal	Propane Cost	Wood Tonnage	Wood Cost	Total Fuel Cost
Main Elementary	765	\$1,530	30	\$3,565	\$5,095

*Note: An efficiency of 75% 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 Main Elementary.*

## 5.0 CONCEPTUAL COST ESTIMATE

The estimated capital cost to install the biomass system described in Section 4 is about \$300,000. 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 the project.

Table 6 provides a list of metrics by which this project may be compared to other potential projects that are competing for the Missouri Fuels for Schools grant funding.

**Table 6 – Grant Funding Metrics**

<b>Metric</b>	<b>Value</b>
System cost per annual wood usage (\$/mmBtu wood)	\$572
System cost per dollar of estimated annual savings (\$/\$ savings)	\$14

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



Boiler Housing

Existing Boiler Room

Scale



Attachment 7

REVISIONS		
Date	Description	Approved

# WERC

Wood Education and Resource Center  
United States Forest Service

## 007 - Eminence Elementary

Eminence, Missouri

Designed DAW 12-09-09

Drawn BEJ 12-09-09

Checked WH 12-09-09

Site Plan

Approved \_\_\_\_\_ Date \_\_\_\_

## Preliminary, Conceptual Cost Estimate

Line Item	Value	Units	\$/Unit	Cost <sup>1</sup>
0.25 mmBtu/hr cord wood boiler(s), storage, controls	-	-	-	\$ 50,000
Stack and breeching	-	-	-	\$ 7,500
Biomass boiler housing	500	sf	\$ 50	\$ 25,000
Site preparation	-	-	-	\$ 5,000
Thermal storage 250 gal	-	-	-	\$ 2,500
Biomass boiler room equipment	-	-	-	\$ 5,000
Pex Pipe (2" supply and return)	20	lf	\$ 150	\$ 3,000
Interconnection to existing boiler room	-	-	-	\$ 15,000
HVAC Upgrades (includes new pumps, controls)	14	rooms	\$ 7,500	\$ 105,000
Sub-Total				\$ 218,000
	<i>Contractor Profit</i>	<i>10%</i>		\$ 21,800
Sub-Total				\$ 239,800
	<i>Contingency</i>	<i>15%</i>		\$ 35,970
Sub-Total				\$ 275,770
	<i>Professional Services</i>	<i>12%</i>		\$ 33,092
<b>Total</b>				<b>\$ 308,862</b>

## Notes:

- 1 - Overhead and bid bond are factored into the estimated item costs and are not broken out.
- 2 - Existing equipment and plumbing have not been evaluated in detail. Cost is preliminary and subject and subject to change pending more detailed analysis.
- 3 - All costs are installed costs.
- 4 - Geotechnical investigations and surveys have not been conducted. Soil and grade dependent items are subject to large changes in cost pending site investigation.



## \*Preliminary, Conceptual Cost Estimate HVAC Upgrades

Line Item	Units	\$/Unit	Cost
Classroom Unit Ventilators with controls	10	\$ 3,600	\$ 36,000
Installation	10	\$ 3,600	\$ 36,000
Fan Coil units with controls for Gym, Kitchen, and offices	6	\$ 1,500	\$ 9,000
Installation fan coil units	6	\$ 1,500	\$ 9,000
New Boiler room plumbing and VFD pumps			\$ 15,000
<b>Total</b>			<b>\$ 105,000</b>

\* Costs have not been quoted for this project. Estimates are based on site visit with cursory investigation into HVAC system needs. Costs are preliminary and subject to change.