



USDA Forest Service
Wood Education and Resource Center
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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: Ellington Schools; 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 Ellington School campus includes three main buildings totaling about 130,000 square feet of conditioned space:

- Building 1 – Middle/High School (75,373 sf)
- Building 2 – Elementary School (45,797 sf)
- Building 3 – Vocational School (5,437 sf)

Attachment A provides a plan view of the site showing building locations, and Table 1 summarizes the major wings of these buildings. Building 1 consists of three main sections, each controlled by an independent heating system. The two major sections are the Middle and High School wings, which are each heated and cooled by separate two pipe distribution systems. The Middle School, built in 1996, has an 855,000 Btu/hr (950,000 Btu/hr input) propane boiler and a central chiller.

The High school, built in 1977, is heated by an LP boiler with an input range of 900,000 to 2,884,000 Btu/hr. Domestic hot water (DHW) for the high school is provided by a propane hot water heater and 85 gallon storage tank capable of 500,000 Btu/hr output. The old wing of the building consists mainly of a gymnasium that has 4 hanging propane units for heating and no cooling.

Building 2 has two wings. The first, constructed in 1973, underwent renovation in 2009 to replace the original propane/electric package units in each room with new electric package units. The second wing is heated by 74,000 Btu/hr (80,000 Btu/hr input) propane units, with each room having one unit. Electric AC units are located outside, with one unit per two rooms. The new wing of the elementary school has a gable roof, allowing the installation of distribution piping for a central system to be completed cost effectively. Tie-in for the older elementary school portion could be accomplished in one of two ways. The first is to run distribution piping within the building itself, which would result in the pipes being exposed or require the installation of a drop ceiling. Second, piping could be placed on the roof, requiring the utilization of a glycol distribution system.

Building 3 consists of a wood shop and storage area. This building is heated by individual propane units, which recently replaced a 140,000 Btu/hr propane boiler. DHW is provided by an electric water heater with a 40 gallon storage tank. The plumbing for the original propane boiler was left in place when the new, individual propane units were added.

Table 1 – Campus Facilities/Buildings

Building/Section	Heat Sources	Year Built	Square Footage	Heat Distribution
1 - High School	Propane	70's	37,687	Central
1 - Middle School	Propane	90's	30,149	Central
1 - Old Middle School	Propane	60's	7,537	4 hanging units
2 - Old Elementary	Electric (09 install)	70's	25,188	Distributed
2 - New Elementary	Propane	02	20,609	Distributed
3 - Vocational School	Propane	50's	5,437	Distributed
Total			126,607	

3.0 CURRENT FUEL USAGE AND COST

The Ellington Schools use propane as the main fuel for heating. Table 2 provides a summary of the annual propane and energy usage and the estimated current annual cost. The Old Elementary switched from propane to electric for heating in 2009. Table 3 shows the estimated annual electric energy usage for the Old Elementary. Fuel usage data are taken from the October 2006 TAC Energy Solutions Preliminary Energy Analysis Report. Fuel unit cost data (Table 4) are provided by Ellington Schools.

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

Building/Section	Square Footage	Propane Usage ¹ , Therms	Propane Usage, gallons	Propane Cost	Energy Input, mmBtu	Assumed Efficiency ²
1 - High School	39,948	9,750	10,541	\$21,081	975	85%
1 - Middle School	27,134	6,000	6,486	\$12,973	600	90%
1 - Old Middle School	8,291	1,750	1,892	\$3,784	175	80%
2 - New Elementary	20,609	3,600	3,892	\$7,784	360	90%
3 - Vocational School	5,437	980	1,059	\$2,119	98	90%
Totals	101,419	22,080	23,870	\$47,741	2,208	

Notes: 1 – The total annual propane usage is provided by TAC’s report and is 29,080 therms. Individual building usage data are estimated from building area and assumed system efficiencies. Usage total deviates from TAC data due to recent switching of the Old Elementary to electric heating.

2 – Efficiencies are assumed based on manufacturer ratings where available and past experience where manufacturer ratings are not available.

Table 3 – Estimated 08-09 School Year Electric Usage for Heat

Building/Section	Square Footage	¹ Estimated Energy Output Need, mmBtu	Electric Usage, kWh	Electric Unit Cost	Electric Cost
2 - Old Elementary	25,188	595	174,385	\$0.09	\$15,695

Note: 1 – Please refer to Note 1 from Table 2.

Summarizing Tables 2 and 3, total annual cost to the Ellington School is estimated to be \$64,000, and the annual energy output to be met is about 2,500 mmBtu. The annual cost includes about \$48,000 for propane and \$16,000 for electric. Table 4 provides the heating values and unit costs used in this analysis. Unit costs are based on 08-09 utility bills provided by Ellington Schools. The \$2.00 per gallon of propane is a uniform number used in the analyses for the Missouri Fuels for Schools grant.

Table 4 – Fuel Heating Values and Unit Costs

Fuel, Unit	Heating Value, Btu/unit	Unit Cost, \$/unit
Propane, gal	92,500	\$2.00
Electric, kWh	3,412	\$0.09
Wood, ton	10,000,000	\$40.00

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 0.85 mmBtu/hr.

4.0 PROPOSED WOOD UTILIZATION PROJECT

Together, buildings 1 and 2 require more than 95% of the heating energy for the Ellington School campus. Building 1 can be connected to a biomass district energy system fairly simply, with two main points of connection and some internal plumbing to the Old Middle School. The Elementary School will require an overhaul of the internal heat distribution system to allow connection to a biomass district energy system. Only the new elementary is assumed to be included in a biomass system for the purposes of this preliminary memorandum. This is due to the potential for the old elementary to be decommissioned and the high cost for interconnection to a biomass system. Should this project move forward, future plans of the school and estimates of the cost to connect the old elementary should be re-considered. Attachment A provides a plan view showing the proposed biomass system. Table 5 lists the building sections included in the proposed biomass system.

Table 5 – Energy and Costs to Be Replaced by Biomass (Wood Chips)

Building/Section	Current Estimated Fuel Costs¹	Current Energy Output¹, mmBtu
1/All sections	\$37,838	1,509
2/New Elementary School	\$7,784	324
Totals	\$45,622	1,833

1 - Assumes that 85% of the existing fuel usage can be replaced by a biomass system.

Should a biomass project move forward, the potential for installation of a new high efficiency central chilling plant should be pursued. This could provide significant energy and cost savings, particularly if the new internal system is installed in the Elementary building.

4.1 Wood System Sizing

The estimated annual biomass energy output needed for the buildings is provided in Table 5. The estimated average hourly output required for the month of January is 0.6 mmBtu/hr. The goal of the biomass system is to replace the maximum amount of propane and electricity. Existing systems or a new, central propane backup will remain in place to cover low use periods, peak use periods, and down time for the biomass system. The selected output rating for the biomass system is 1.0 mmBtu/hr for the purposes of this report, and a thermal storage of 1,000 gallons is also recommended to regulate modulation of the biomass boiler. Future design and further investigation into load profiles for this project may modify the recommended size of the biomass system.

4.2 Boiler Housing and Chip Storage

The design described by this memorandum is for a wood chip boiler housed north of the High School gym. Housing for the boiler system and storage adequate for housing 1.5 walking floor trailer loads will require a total of about 1500 sf. Hot water from the biomass system would be distributed by 3” (or smaller) insulated pex pipe from the biomass housing to the school buildings. Attachment A provides a plan view of the proposed housing and chip storage site.

4.3 HVAC Upgrades

The existing distribution systems within the Middle/High School buildings would be utilized. Additional internal plumbing would be required to pick up the Old Middle School loads. The Elementary building loads will require new internal distribution piping and interconnection to existing individual forced air systems. New individual forced air distribution may be required in the Old Elementary. Attachment C provides a breakdown of the conceptual cost estimate for the proposed HVAC system upgrades.

4.4 Potential Energy and Cost Savings

Table 6 provides the heating fuel usage and costs associated with the proposed biomass system. Current annual costs for heating and DHW for the three buildings are about \$46,000 (Table 5). Table 6 shows that the annual fuel costs with the proposed system would be about \$16,000. Thus, the potential annual savings are about \$30,000.

Table 6 – Heating Fuel Usage and Costs for Proposed Biomass System

Facility	Propane Usage, gal	Propane Cost	Wood Tonnage	Wood Cost	Total Fuel Cost
1 - Middle/High School	2,838	\$5,676	183	\$7,328	\$13,004
2 - New Elementary School	584	\$1,168	39	\$1,574	\$2,741
Totals	3,422	\$6,843	223	\$8,902	\$15,745

Note: 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 buildings.

5.0 CONCEPTUAL COST ESTIMATE

The estimated capital cost to install the biomass system described in Section 4 is about \$1,050,000. Attachment B provides a breakdown of the conceptual cost estimate for the system. Further investigation and scoping of the proposed biomass project are required to refine this conceptual estimate prior to a decision to move forward with the project.

Table 7 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 7 – Grant Funding Metrics

Metric	Value
System cost per annual wood usage (\$/mmBtu wood)	\$468
System cost per dollar of estimated annual savings (\$/\$ savings)	\$35

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	DAW 12-09-09
Drawn	BEJ 12-09-09
Checked	WH 12-09-09

008 - Ellington Schools
 Ellington, Missouri

Approved _____ Date _____
 Title _____ Job Class _____

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
Biomass boiler housing	720	sf	\$ 50	\$ 36,000
150 cy chip storage building and bunker	720	sf	\$ 150	\$ 108,000
Site preparation	-	-	-	\$ 15,000
Thermal storage 1,250 gal	-	-	-	\$ 12,500
Biomass boiler room equipment	-	-	-	\$ 50,000
Pex Pipe (2 - 3" supply and return)	625	lf	\$ 150	\$ 93,750
Interconnection to Middle/High School boiler room(s)	-	-	-	\$ 70,000
HVAC upgrades for New Elementary ²	-	-	-	\$ 100,750
Sub-Total				\$ 736,000
	<i>Contractor Profit</i>	<i>10%</i>		\$ 73,600
Sub-Total				\$ 809,600
	<i>Contingency</i>	<i>15%</i>		\$ 121,440
Sub-Total				\$ 931,040
	<i>Professional Services</i>	<i>12%</i>		\$ 111,725
Total				\$ 1,042,765

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	Value	Units	\$/Unit	Cost
Plenum heat exchangers	16	na	\$ 250	\$ 4,000
Installation	16	na	\$ 500	\$ 8,000
Main distribution piping	675	ft	\$ 50	\$ 33,750
Runs to individual furnaces	600	ft	\$ 50	\$ 30,000
Plumbing and hook-up in old boiler room				\$ 25,000
Total				\$ 100,750

* 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.