



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: Perry County School Main Campus; Perry 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 Perry County School Main Campus includes over 350,000 square feet of heated buildings. There are 6 main facilities that make up the Main Campus. Table 1 lists the six and provides a description of the heat sources for each. The Career Center is being outfitted with a geothermal system and is thus excluded from the analysis.

Table 1 – Main Campus Facilities

Facility	Heat Sources	Year Built	Square Footage	Heat Distribution
Senior High School	Gas	60's - 90's	106,978	Central
Old Senior High School	Gas	30's	26,560	Central
Old Vocational	Gas	30's - 60's	19,093	Distributed
Middle School	Gas, Electric	60's - 90's	68,477	Distributed
Elementary School	Gas, Electric	70's - 90's	79,470	Distributed
Career Center	Gas, Electric	80's - 90's	48,220	Central

The Senior High School has a central hydronic distribution system connected to two natural gas boilers and controlled by a Johnson Controls Metasys System. The gas boilers each have input ratings of 2.82 mmBtu/hr and output ratings of 2.35 mmBtu/hr. The Old Senior High School has a central forced air heating system fueled by a natural gas furnace with an input rating ranging from 0.85 – 1.70 mmBtu/hr. The gas furnace is located inside an old coal furnace and utilizes the original fan for air distribution. The Old Vocational building includes the maintenance shop and industrial arts classrooms. The building has multiple natural gas furnaces. The Middle School has a combination of individual and rooftop natural gas forced air units. The Elementary School has three wings that use electric heating provided by individual, through-the-wall units and strip heating. Additionally, the old wing of the Elementary is heated by a central natural gas unit supplied via hydronic distribution system.

3.0 CURRENT FUEL USAGE AND COST

The Main Campus utilizes natural gas and electricity as the energy sources for providing space heating and domestic hot water. Table 2 provides a summary of annual fuel and energy usage. The natural gas values are provided by Johnson Controls and are for the 08-09 school year. The values for the Elementary School (old wing, which is heated by natural gas) and Middle School appear low when evaluated on a square footage basis. The old wing of the Elementary School likely has some electric resistance heating, as does the Middle School. These portions of the school were not toured during the site visit. The electric resistance heating for the old wing of the Elementary School and the Middle School are not considered in this report.

Table 2 – 08-09 School Year Natural Gas Usage for Heat and Hot Water

Facility	Square Footage	Natural Gas Usage, Dtherms	Natural Gas Cost	Energy Input, mmBtu	Assumed Efficiency	Energy Output, mmBtu	Estimated Output, Btu/sf
Senior High School ¹	106,978	2,815	\$38,122	2,815	90%	2,534	23,685
Old Senior High School	26,560	748	\$10,276	748	80%	598	22,530
Old Vocational School	19,093	527	\$7,536	527	85%	448	23,461
Middle School	68,477	810	\$11,430	810	85%	689	10,054
Elementary School ²	37,200	587	\$8,222	587	85%	499	13,413
Totals	258,308	5,487	\$75,586	5,487		4,768	

1 – Includes “Multipurpose Building” energy use.

2 - Does not include portions of Elementary heated by electric resistance heating.

Electric usage values for the portions of the elementary school using resistance heating are estimated using the Btu/sf values for the buildings heated with gas and the square footages provided by Perry School District.

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

Facility ¹	Square Footage	Assumed Output ² , Btu/sf	Energy Input, mmBtu	Electric Usage, kWh	Electric Unit Cost	Electric Cost
Elementary School	42,270	23,456	991	290,588	\$0.11	\$31,965

1 – Old wing of Elementary and Middle School electric usage are not considered in this analysis.

2 – Calculated as the weighted average by square footage of Estimated Output (Table 2) for the Senior High, Old Senior High, and Old Vocational Schools.

The total estimated annual cost and energy output for the portion of the Main Campus considered are estimated to be \$108,000 and 5,750 mmBtu, respectively. This is not including electric costs and energy usage for the Middle School and old portion of the Elementary School. The cost includes about \$76,000 for natural gas and \$32,000 for electric. The Elementary and Senior High School buildings are the users with the highest costs. Table 4 provides the heating values and unit costs used in this analysis. Unit costs are based on 08-09 utility bills for the Main Campus.

Table 4 – Fuel Heating Values and Unit Costs

Fuel, Unit	Heating Value, Btu/unit	Unit Cost, \$/unit
Natural Gas, DTherm	1,000,000	\$13.75
Electric, kWh	3,412	\$0.11
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 1.9 mmBtu/hr.

4.0 PROPOSED WOOD UTILIZATION PROJECT

The school district applied with the intent to utilize a biomass system to replace the maximum amount of natural gas used at the Senior High School. The Senior High School is the largest energy user, has a central hydronic distribution system, and would be the primary load on any biomass system at the Main Campus. There are many combinations of additional loads to consider from the remaining buildings. The option analyzed for this preliminary analysis is the installation of a biomass boiler and chip storage to the south of the Old Senior High School. This location allows minimal distribution piping to reach the Senior High School, Old Senior High School, and Industrial Arts Building. Attachment A provides a plan view showing the proposed biomass system. Table 5 lists the buildings included in the proposed biomass system.

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

Facility	Current Natural Gas Cost	Current Energy Output, mmBtu
Senior High School	\$38,122	2,534
Old Senior High School	\$10,276	598
Old Vocational	\$7,536	448
Totals	\$55,934	3,580

Note: The biomass system is assumed to replace 85% of the current fuel usage for the included facilities.

Should a biomass project at the Main Campus move forward, additional studies should evaluate the costs for installation of central hydronic heating and cooling distribution system in the Elementary school where electricity is the heating fuel source. This, in conjunction with the connection of the rest of the Elementary to a biomass system and installation of a high efficiency central chiller, may provide enough additional savings to Perry County School District to justify the additional capital costs. Options

including the Elementary school should include evaluation of utilizing the open space between the Elementary and Senior High schools for installation of the biomass system.

4.1 Wood System Sizing

The estimated annual energy output needed for the three buildings is provided in Table 5. The estimated average hourly output required for the month of January is 1.2 mmBtu/hr. The goal of the biomass system is to replace the maximum amount of natural gas. Existing systems 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 1.75 mmBtu/hr for the purposes of this report, and a thermal storage of 1,750 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 for the biomass system.

4.2 Boiler Housing and Chip Storage

The design described by this memorandum is for a wood chip boiler housed to the south of the Old Vocational School. Housing for the boiler system and storage adequate for housing 1.5 walking floor trailer loads of wood chips require about a total of 1500 sf of space. Hot water from the biomass system would be distributed by 3" (approximate size) insulated pex pipe from the biomass housing to the Senior High School boiler room where interconnection would be made with the existing system. The pipe leading to the Old Senior High School and Industrial Arts Building would be 2" (approximate size) insulated dual pex pipe. Attachment A provides a plan view of the proposed site.

4.3 HVAC Upgrades

The existing distribution systems within the three buildings identified would be utilized. Interconnection to the systems is expected to be straightforward. Some portions of the Old Vocational building may require new internal plumbing and may or may not be chosen for connection to the biomass system.

4.4 Potential Energy and Cost Savings

Current annual cost for heating and domestic hot water for the three buildings is about \$56,000 (Table 5). Table 6 shows that the annual fuel costs with the proposed system would be about \$26,000. Thus, the potential annual savings is about \$30,000. Table 6 provides the heating fuel usage and costs associated with the proposed biomass system.

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

Facility	Natural Gas Usage, Dtherms	Natural Gas Cost	Wood Tonnage	Wood Cost	Total Fuel Cost
Senior High School	422	\$5,807	308	\$12,307	\$18,113
Old Senior High School	112	\$1,543	73	\$2,907	\$4,449
Old Vocational	79	\$1,087	54	\$2,176	\$3,263
Totals	614	\$8,436	435	\$17,389	\$25,825

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 \$975,000. 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 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.

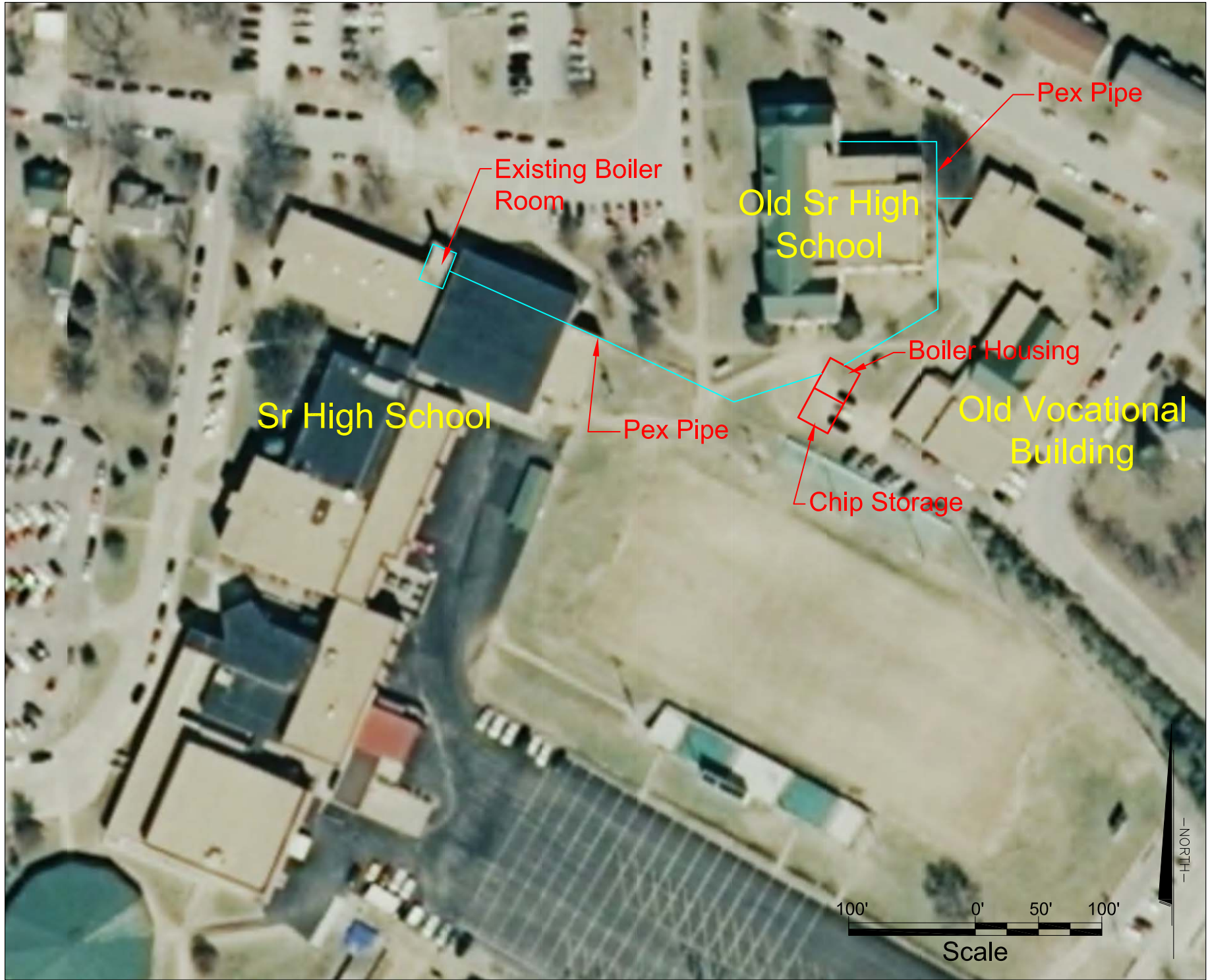
Table 7 – Grant Funding Metrics

Metric	Value
System cost per annual wood usage (\$/mmBtu wood)	\$224
System cost per dollar of estimated annual savings (\$/\$ savings)	\$33

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	12-10-09
Drawn	BEJ	12-10-09
Checked	WH	12-10-09

Perry Co. 32 School District
 Perryville, Missouri

Site Plan

Approved _____ Date _____
 Title _____ Job Class _____

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

REVISIONS	
Date	Description

Attachment A

Preliminary, Conceptual Cost Estimate

Line Item	Value	Units	\$/Unit	Cost ¹
1.75 mmBtu/hr biomass boiler & chip handling system	-	-	-	\$ 260,000
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	-	-	-	\$ 30,000
Thermal storage 1,750 gal	-	-	-	\$ 17,500
Biomass boiler room equipment	-	-	-	\$ 60,000
Pex Pipe (2 - 3" supply and return)	650	lf	\$ 150	\$ 97,500
HVAC upgrade costs (Old Vocational School)	-	-	-	\$ 40,000
Interconnection to 3 existing buildings/systems	-	-	-	\$ 30,000
Sub-Total				\$ 689,000
	<i>Contractor Profit</i>	<i>10%</i>		\$ 68,900
Sub-Total				\$ 757,900
	<i>Contingency</i>	<i>15%</i>		\$ 113,685
Sub-Total				\$ 871,585
	<i>Professional Services</i>	<i>12%</i>		\$ 104,590
Total				\$ 976,175

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.