



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: Tom Wilson, WES; Brandi Johnston, WES
CC: John Tuttle, Missouri Department of Conservation
RE: Steelville Elementary and Middle School; Crawford 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

There are 3 separate buildings on the Steelville campus, and all are heated with individual, central hot water boiler plants. Both hot water and chilled water are distributed in a two pipe system in the Elementary and New Middle Schools. The hot or chilled water is then piped to heat exchangers in air handling systems and distributed with forced air. In the New Middle School, electric resistance heat is used in shoulder months (boilers had not been turned on as of our visit), which is also connected to the forced air system. Table 1 summarizes the heating units for each of the major building sections in the

schools. In the New Middle School the water for heating and cooling is distributed by VFD, 10 Hp pumps.

Table 1 – Heating Units

| Building Section | Type of Unit | Square Footage Heated | Input, mmBtu | Assumed Efficiency | Output, mmBtu |
|----------------------|-------------------------------------|-----------------------|--------------|--------------------|---------------|
| Old Middle School | Propane, hot water boiler | 44,000 | 2.50 | 70% | 1.75 |
| Elementary | Propane, hot water boiler (primary) | 36,000 | 1.50 | 80% | 1.2 |
| | Propane, hot water boiler (back-up) | 2,000 | 0.75 | 80% | 0.60 |
| Elementary Cafeteria | Propane forced air furnace | - | 0.125 | 75% | 0.094 |
| | Propane forced air furnace | - | 0.125 | 75% | 0.094 |
| New Middle School | Boiler 1- hot water boiler | 43,200 | 0.50 | 84% | 0.42 |
| | Boiler 2- hot water boiler | | 0.50 | 84% | 0.42 |
| Total | | 125,200 | 6.0 | | 4.6 |

There are hanging LP gas burners with fans and conventional forced air heaters located in the media room, art room, cafeteria and the old gymnasium attached to the Old Middle School. These rooms are in an addition between the Old Middle School and the Elementary. The Old Middle School is currently used only for storage but still heated. It has an old, coal fired steam radiator system converted to a LP gas boiler with hot water pumped to the old radiators. No central cooling system is installed. The plan for this building is renovation and conversion to multi-purpose classrooms, community meeting rooms, and offices for the administration. When the Old Middle School is renovated, it may be a good time to expand the central heating system to pick-up the LP Gas fired forced air units. If the Old Middle School is not renovated, then fan coil units can be connected from the hot water distribution system in the Old Middle School to tie these rooms into the main biomass boiler system.

Across the state highway from the campus is a newer, administration/early childhood 1 story building heated with 3 forced air furnaces fired with LP gas. These same units have cooling coils tied to DX units for air conditioning. As the load is small for this facility, the cost of laying pipe under a major highway would make interconnecting this facility impractical.

3.0 CURRENT FUEL USAGE AND COST

The Elementary and New Middle School are heated and cooled by a 2 pipe system with propane as the main fuel for heating. Both the Elementary and New Middle Schools use electric during the shoulder months while the Old Middle School is heated with a propane fired hot water boiler.

Table 2 – Current Average Annual Fuel Usage for Heat and Hot Water

| Facility | Square Footage | Propane Usage, gal | Propane Cost | *Electric for DHW & heat kWh/year | Electric cost for heating | Total Energy output Btu | Total Cost |
|-------------------|----------------|--------------------|-----------------|-----------------------------------|---------------------------|-------------------------|-----------------|
| Elementary School | 38,000 | 6,000 | \$12,000 | 100,234 | \$11,026 | 786 | \$23,026 |
| Old Middle School | 44,000 | 7,500 | \$15,000 | 0 | \$0 | 486 | \$15,000 |
| New Middle School | 43,200 | 5,000 | \$10,000 | 126,612 | \$13,927 | 848 | \$23,927 |
| Totals | 125,200 | 18,500 | \$37,000 | 226,846 | \$24,953 | 2,120 | \$61,953 |

**Electric is estimated based on building construction and expected energy use per square foot per year.*

Using the assumed efficiencies provided in Table 1, the total average annual energy output of the heating units is estimated to be 2,120 mmBtu/yr. Table 3 provides the assumed unit costs and heating values for the fuels in this report.

Table 3 – 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 | \$0.11 |
| Wood, ton | 10,000,000 | \$40 |

4.0 PROPOSED WOOD UTILIZATION PROJECT

Directly connecting a hot water biomass system to the 3 building campus can be fairly easily accomplished. Remodeling of the Old Middle School at the same time as installing a biomass system would be the best case scenario; however, it is not required. The existing hot water system in this old building can be connected without affecting future changes. If the remodeling project has a reasonable chance of going forward, then connecting the Elementary cafeteria, art room, and media room should wait for that project as it can be accomplished much more efficiently at that time. Connecting the administration building to the biomass system is not cost effective. The biggest question is where to locate the biomass system. There is adequate space in the boiler room of the Old Middle School, but this option would require extensive site work to eliminate the water problem and allow access for chip storage. A seasonal high water table at the site would make it most practical to install a biomass system at grade.

There is no additional funding available from the school district for this project. The administration is very cooperative and has provided an architect as their representative for discussion of potential complications of locating the boiler room in the Old Middle School and then conducting future renovations.

4.1 Wood System Sizing

Weather data for this area of Missouri shows that the month of January contains on average 25 – 30% of annual heating degree days using 55°F as the base point below which heating is required. The estimated average hourly output required for the month of January is 0.70 mmBtu per hour. The goal is to offset the maximum amount of electricity and propane used for heating with the biomass system operating efficiently. It is estimated that 85% of the heating load can be replaced by a 1.0 mmBtu biomass unit with 1,000 gallons of thermal storage to buffer system output and demand. If this project moves forward, further modeling of the system loads is recommended for final system sizing.

4.2 Boiler Housing and Chip Storage

The design described by this memorandum is for a wood chip boiler building and chip storage located on the south side of the grounds, near the propane storage tanks, and very close to the property boundary. This allows easy access for both delivery of wood chips and piping to connect the three facilities. There are no zoning set back requirements from the municipality however the adjacent railroad right of way needs further investigation. The railway was contacted to determine set back requirements but did not return calls. See the proposed location on Attachment A. While there is room in the Old Middle School, unknowns with future plans for the facility and the potential for boiler room flooding due to the seasonal high water table make this location questionable.

4.3 HVAC Upgrades

The existing two pipe distribution system allows for easy interconnection of the biomass system to all three facilities. Due to the convenient location and proximity of the three facilities, consideration should be given to creating one central mechanical room at the new biomass facility to house all heating and chilling equipment, including backup capacity. This will create one central heating and cooling plant for all three facilities, saving labor and maintenance and improving overall system efficiency. It will also avoid future capital costs for replacement of boilers in the elementary school. Connecting the areas served by hanging propane furnaces to the biomass system should be part of renovations to the Old Middle School.

4.4 Potential Energy and Cost Savings

Current annual cost for heating and domestic hot water is about \$62,000 (Table 2). Table 4 provides the heating fuel usage and costs associated with the proposed biomass system. Table 4 shows the annual fuel costs with the proposed system to be about \$21,000, annually. Thus, the potential annual savings is about \$41,000.

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

| Facility | Propane Usage, gal | Propane Gas | Wood Tons | Wood Cost | Electric Costs | Total Fuel Cost |
|-------------------|--------------------|----------------|------------|-----------------|----------------|-----------------|
| Elementary School | 900 | \$1,800 | 105 | \$4,192 | \$1,654 | \$7,646 |
| Old Middle School | 1,125 | \$2,250 | 65 | \$2,590 | \$0 | \$4,840 |
| New Middle School | 750 | \$1,500 | 113 | \$4,524 | \$2,089 | \$8,113 |
| Totals | 2,775 | \$5,550 | 283 | \$11,306 | \$3,743 | \$20,599 |

Note: An efficiency of 65% 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 \$900,000. Attachment B provides a breakdown of the conceptual cost estimate for the system. Further investigation and development of the proposed biomass project is required to refine this conceptual estimate if this project is selected for funding.

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.

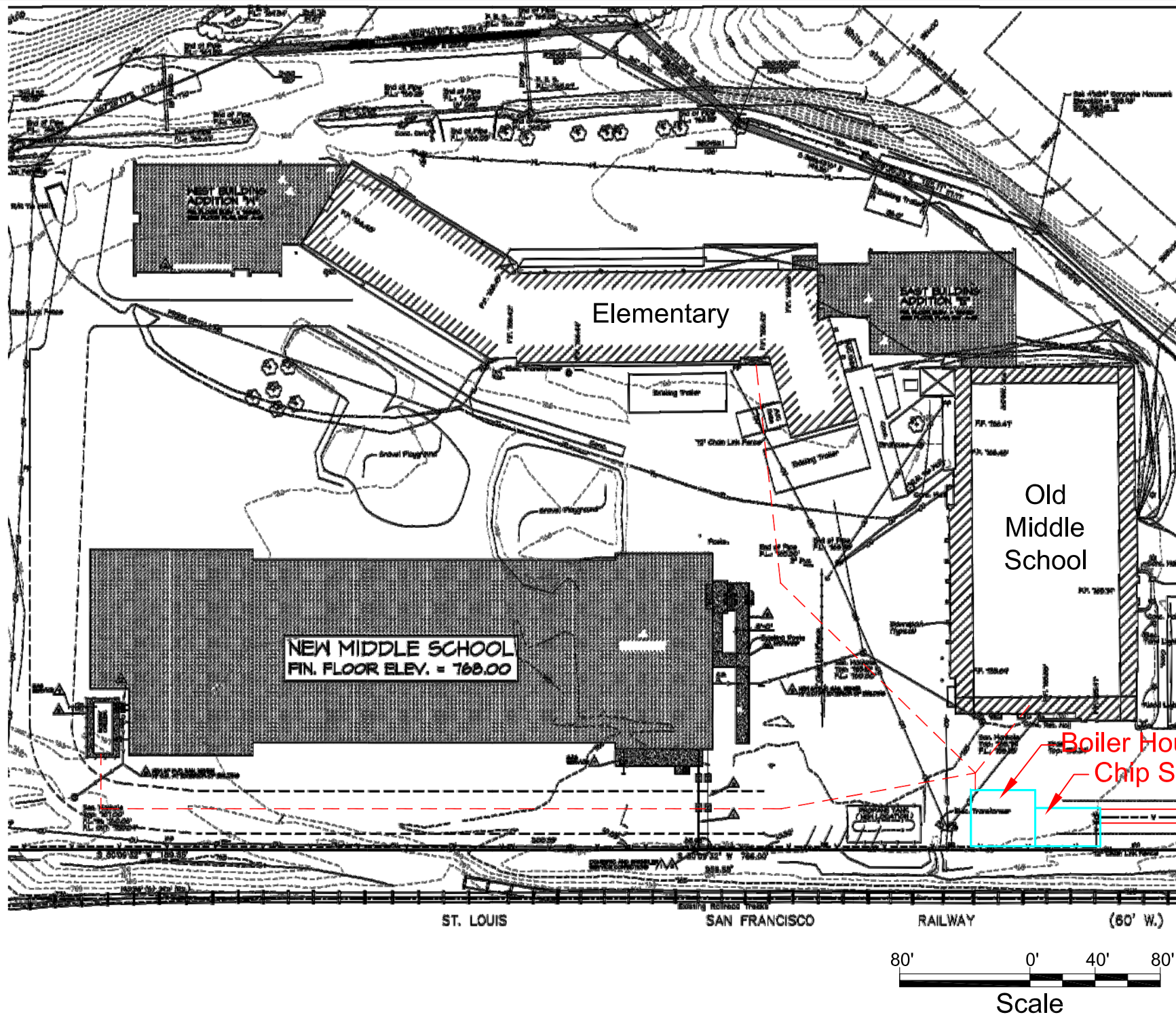
Table 5 - Grant Funding Metrics

| Metric | Value |
|--|-------|
| System cost per annual mmBtu of wood usage (\$/mmBtu) | \$317 |
| System cost per dollar of estimated annual savings (\$/\$ savings) | \$22 |

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 12-15-09
 Drawn BEJ 12-15-09
 Checked THW 12-15-09

Steelville R-3 School District
 Steelville, Missouri
 Site Plan

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

| Date | Description | Approved |
|------|-------------|----------|
| | | |

Approved _____ Date _____
 Title _____ Job Class _____

Preliminary, Conceptual Cost Estimate

| Line Item | Value | Units | \$/Unit | Cost ¹ |
|--|------------------------------|------------|---------|-------------------|
| 1.0 mmBtu/hr biomass boiler & chip handling system | - | - | - | \$ 230,000 |
| 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 1,000 gal | - | - | - | \$ 10,000 |
| Biomass boiler room equipment / installation | - | - | - | \$ 50,000 |
| Pex Pipe (2" supply and return) | 940 | lf | \$ 150 | \$ 141,000 |
| Interconnection to 3 building | - | - | - | \$ 24,000 |
| Sub-Total | | | | \$ 634,000 |
| | <i>Contractor Profit</i> | <i>10%</i> | | \$ 63,400 |
| Sub-Total | | | | \$ 697,400 |
| | <i>Contingency</i> | <i>15%</i> | | \$ 104,610 |
| Sub-Total | | | | \$ 802,010 |
| | <i>Professional Services</i> | <i>12%</i> | | \$ 96,241 |
| Total | | | | \$ 898,251 |

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.