Preliminary Feasibility Report

Biomass Heating Analysis for Perry County School District

Perryville, MO

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Table of Contents

EXECUTIVE SUMMARY ........................................................................................................... 2
INTRODUCTION ......................................................................................................................... 4
ANALYSIS .................................................................................................................................. 5
  LIFE CYCLE COST METHODOLOGY ....................................................................................... 5
  DESCRIPTION OF EXISTING HEATING SYSTEMS ................................................................. 6
  CAPITAL COST ASSUMPTIONS FOR WOODCHIP SCENARIO .............................................. 6
  NATURAL GAS COST ASSUMPTIONS ..................................................................................... 8
  WOODCHIP FUEL COST ASSUMPTIONS .............................................................................. 9
  INFLATION ASSUMPTIONS .................................................................................................... 9
  OPERATION AND MAINTENANCE ASSUMPTIONS ............................................................... 10
  FINANCING ASSUMPTIONS .................................................................................................... 11

BIOMASS SCENARIO ANALYSIS RESULTS .......................................................................... 12
ADDITIONAL ISSUES TO CONSIDER ...................................................................................... 15
  ENERGY MANAGEMENT ........................................................................................................ 15
  ENERGY EFFICIENCY ............................................................................................................ 15
  INDOOR AIR QUALITY .......................................................................................................... 15
  CAPITAL PLANNING AND A SCHOOL ENERGY INITIATIVE ............................................... 16

PROJECT FUNDING POSSIBILITIES ..................................................................................... 17
  USDA FUNDING OPPORTUNITIES ......................................................................................... 17
  QUALIFIED SCHOOL CONSTRUCTION BOND .................................................................... 18
  ENERGY REVOLVING FUND ................................................................................................ 18

PERMITTING ........................................................................................................................... 19

CONCLUSIONS AND RECOMMENDATIONS .................................................................... 21
WHO WE ARE .......................................................................................................................... 22
APPENDICES ........................................................................................................................... 23
  DISCUSSION OF BIOMASS FUELS .................................................................................... 23
  BIOMASS ENERGY VENDORS ............................................................................................ 27
  POTENTIAL BIOMASS FUEL SUPPLIERS ........................................................................ 28
List of Figures

Figure 1 Suggested Biomass Boiler Location (Image Courtesy of Wilson Engineering Services) ........................................ - 7 -
Figure 2 Williamstown, VT High School Woodchip Boiler Plant ........................................................................................................... - 8 -
Figure 3 Underground Insulated District Energy Piping ......................................................................................................................... - 8 -
Figure 4 Woodchip and Fossil Fuel Inflation ........................................................................................................................................ - 9 -
Figure 5 Annual Cash Flow Graph for Woodchip Scenario .................................................................................................................... - 13 -
Figure 6 Map Showing Potential Fuel Suppliers in Relationship to Perry County School District ..................................................... - 28 -

List of Tables

Table 1 Woodchip Scenario Analysis Assumptions ................................................................................................................................................... - 12 -
Table 2 30-Year Cash Flow Spreadsheet for Woodchip Scenario ................................................................................................................ - 14 -
Table 3 Comparison of Boiler Emissions Fired by Woodchips and Distillate Oil ...................................................................................... - 19 -
Table 4 Particulate Emissions .................................................................................................................................................................... - 20 -
EXECUTIVE SUMMARY

This preliminary feasibility study was prepared by Yellow Wood Associates in collaboration with Richmond Energy Associates with support from Wilson Engineering Services for the Missouri Department of Conservation. Both Yellow Wood and Richmond Energy have extensive community economic development experience and Richmond Energy specializes in biomass energy projects for public buildings. This study was funded by the Wood Education and Resource Center, Northeastern Area State and Private Forestry, U.S. Department of Agriculture.

Perry County School District is located in Perryville, Missouri. The main campus has six buildings with approximately 350,000 square feet of conditioned building space. The biomass scenario analyzed for this report envisions building a stand-alone woodchip boiler house and chip storage facility located to the south of the Old Vocational school and piping hot water to the Senior High School, Old High School and Old Vocational school via underground insulated piping. The existing HVAC allows for easy connection to the proposed biomass system.

These three buildings (Senior High School, Old High School and Old Vocational School) consume about 4,090 Dekatherms (Dtherms) of Natural Gas for heat and hot water each year on average. At the average price of 13.65/Dtherm paid for Natural Gas by the Perry County School district last year the district can expect to pay more than $55,000 next year to heat these three buildings.

The analysis indicates that Perry County School District would need to spend approximately $976,000 for a woodchip boiler plant and connection to the existing heat distribution systems. The Perry County School District has been awarded $970,000 towards this project through the Missouri Fuels for Schools program. Preliminary estimates show that if Perry County School District accepts the Missouri Fuels for Schools Grant, it would cover all but $6,000 of the cost of installing this biomass heating system. If the district makes this investment it could save nearly $1.1 million in operating costs over 30 years in today’s dollars even including the cost of financing equipment and installation. The analysis shows $30,000 in fuel savings in the first year alone.
The woodchip biomass scenario evaluated for this report is cost effective and Yellow Wood recommends moving forward with a project. We recommend Perry County School District take the following steps to investigate this opportunity further:

1. Hire an architectural and/or engineering firm to help refine the project concept and to obtain firm local estimates on project costs. The preliminary conceptual cost estimate should be refined through further investigation and scoping of the proposed biomass project before a decision is made to move forward. The design team should evaluate whether it would be cost effective to add other buildings on the campus to a central biomass boiler system, particularly the Elementary School. The team should also evaluate how much additional savings may be gained by adding a high efficiency central chiller. The US Forest Service may be able to provide some technical assistance to the design team on biomass energy technologies and design suggestions for wood chip fuel storage and boiler house layouts.

2. The district should consider other energy efficiency improvements simultaneously with the biomass energy project. The efficiency of the building envelope and ventilation equipment need to be considered when sizing new boiler equipment. The Energy Center at the Missouri Department of Natural Resources provides technical and financial assistance for energy efficiency and renewable energy projects to school districts and other consumers. Through the Energy Revolving Fund, the Energy Center provides low interest loans to public schools, universities, colleges, cities, counties, public hospitals and water treatment plants to help reduce energy costs. The Energy Center should be contacted and engaged regardless of whether or not the school moves ahead with a biomass project at this time. Information on energy efficiency programs and incentives is included in the *Biomass and Green Building Resources* binder accompanying this report.

3. In order to effectively measure progress toward energy efficiency goals historical energy consumption data should be collected and updated frequently. The most effective method is to track individual building energy usage. With this information facility operators can identify which buildings have the most opportunity for energy savings. There are many tools to help the school accomplish this. One such tool is the EPA Energy Star *Portfolio Manager* software. It is free public domain software that helps facility managers track energy and water use. This software can be downloaded at:


4. Concurrent with the design of a biomass project, the school should cultivate potential biomass fuel suppliers. Perry County School District staff should work with the Missouri Department of Conservation staff to identify potential woodchip fuel suppliers and begin discussing fuel pricing. A list of potential woodchip fuel suppliers is included in the appendices at the end of this report.
INTRODUCTION

There is a significant volume of low-grade biomass in the United States that represents a valuable economic and environmental opportunity if that biomass can be constructively used to produce energy. Commercially available biomass heating systems can provide heat cleanly and efficiently in many commercial applications. Biomass heating technologies are being used quite successfully in over 40 public schools in Vermont alone and the concept of heating institutions with wood is catching on in several other areas of the United States and Canada. Good candidate facilities for biomass energy systems include those that have high heating bills, those that have either steam or hot water heating distribution systems and those that have ready access to reasonably priced biomass fuel.

This report is a pre-feasibility assessment specifically tailored to the Perry County School District outlining whether or not biomass heating makes sense for this facility from a practical perspective. In November 2009, staff from Wilson Engineering Services visited Perryville to tour the facility. This assessment includes site specific fuel savings projections based on historic fuel consumption and provides facility decision-makers suggestions and recommendations on next steps to take based on site visits, data collection and interviews with stakeholders.

The study was funded by the Wood Education and Resource Center, U.S. Department of Agriculture.

This preliminary feasibility study was prepared by Yellow Wood Associates and Richmond Energy Associates, LLC with support from Wilson Engineering Services.
ANALYSIS

LIFE CYCLE COST METHODOLOGY

Decision makers need practical methods for evaluating the economic performance of alternative choices for any given purchasing decision. When making a choice between mutually exclusive capital investments, it is prudent to compare all equipment and operating costs spent over the life of the longest lived alternative in order to determine the true least cost choice. The total cost of acquisition, fuel costs, operation and maintenance of an item throughout its useful life is known as its “life cycle cost.” Life cycle costs that should be considered in a life cycle cost analysis include:

- Capital costs for purchasing and installing equipment
- Fuel costs
- Inflation for fuels, operational labor and major repairs
- Annual operation and maintenance costs including scheduled major repairs
- Salvage costs of equipment and buildings at the end of the analysis period

In addition, it is useful for decision makers to consider the impact of debt service if the project is to be financed in order to get a clearer picture of how a project might affect annual budgets. When viewed in this light, equipment with significant capital costs may still be the least-cost alternative. In some cases, a significant capital investment may actually lower annual expenses, if there are sufficient fuel savings to offset debt service and any incremental increases in operation and maintenance costs.

The analysis performed for this facility compares different scenarios over a 30-year horizon and takes into consideration life cycle cost factors. A 30-year time frame is used because it is the expected life of a new boiler. The base case scenario assumes that Perry County School District will continue to use the existing Natural Gas heating system essentially as it is now being used.

The alternative biomass scenario envisions installing a new biomass boiler and fuel storage structure that would serve the Senior High School, the Old High School and the Old Vocational School. The biomass scenario includes all ancillary equipment and interconnection costs. Under the biomass scenario, the existing Natural Gas boilers would still be used to provide supplemental heat during the coldest days of the year if necessary and potentially for the warmer shoulder season months when buildings only require minimal heating during chilly weather.

The analysis then projects current and future annual Natural Gas heating bills and compares that cost against the cost of operating a biomass system. Savings are presented in today’s dollars using a net present value calculation. Net present value (NPV) is defined as the present dollar value of net cash flows over time. It is a standard method for using the time value of money to compare the cost effectiveness of long-term projects.
DESCRIPTION OF EXISTING HEATING SYSTEMS

The Perry County School District is located in Perryville, Missouri. The main campus consists of 6 buildings, the Senior High School, Old Senior High School, Old Vocational School, Middle School, Elementary School and Career Center. The entire campus presently house 2,314 students and 187 faculty. The school system applied to the Missouri Schools for Fuels program to replace the Natural Gas used at the Senior High School (the building with the highest volume heating fuel). The Senior High School is currently heated by two hot water boilers with central hydronic heat distribution. Due to the proximity and ease of connection, this analysis also assumes that the Old High School and the Old Vocation School will be hooked up to the new biomass system. The Old High School is currently heated by a central forced air heating system connected to a Natural Gas boiler. The Old Vocation School utilizes multiple Natural Gas furnaces.

The Middle School and Elementary School were not included in the analysis because each building would require extensive heating distribution retrofits and underground piping costs to connect each of these buildings could be quite high because of their distance from the proposed biomass boiler location. The Career Center was not included because it is being outfitted with a geothermal heat pump.

CAPITAL COST ASSUMPTIONS FOR WOODCHIP SCENARIO

It was not the intent of this project nor was it in the scope of work to develop detailed cost estimates for a biomass boiler facility. It is recommended that for a project of this scale, the school hire a qualified design team to refine the project concept and to develop firm local cost estimates. Therefore the capital costs used for the biomass scenario are generic estimates based on our experience with similar scale projects.

The woodchip scenario envisions building a 1,500 square foot stand-alone boiler house and chip storage facility which would house a 1.75 mmBtu woodchip hot water boiler and woodchip fuel storage and fuel handling equipment to feed the boiler automatically. The scenario assumes the existing Natural Gas units would remain to provide back-up heat for the shoulder seasons and supplemental heat during the coldest nights of the year if necessary. Below is the suggested boiler house location.
Hot water from the woodchip boiler house would be tied into the exiting HVAC systems of the Senior High School, Old High School and Old Vocational School via approximately 650 feet of underground insulated piping. Costs for a tall stack were included to ensure good emissions dispersal. Costs for an underground woodchip storage bin were included, as below grade chip storage bins are less likely to freeze in the coldest winter weather and chip delivery using self unloading trailers into below grade bins is fast and easy. A healthy construction contingency, standard general contractor mark-up and professional design fees were also included. Conceptual costs for the required HVAC upgrades are also included. Below are examples of the type of recommended building and buried insulated piping.
NATURAL GAS COST ASSUMPTIONS

Fuel bills provided by Perry County School District indicate that the school uses an average of 4,090 Dekatherms (Dtherms) of Natural Gas per year to heat the three buildings being considered in this analysis. This is the assumed annual fuel consumption used for the base case in the analysis. Over the past two years, the district has paid an average of $13.65/Dterm for Natural Gas. At that price, the district will spend more than $55,000 to heat these three buildings next year.

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1 Photos excerpted from *Heating Communities with Renewable Fuels* published by Natural Resource Canada.
WOODCHIP FUEL COST ASSUMPTIONS

Frequently, operators of institutional woodchip systems don’t fire up their biomass boilers until there is constant demand for building heat. During the fall and spring, fossil fuel boilers are often used as they are easier to start up and turn down. Woodchip boilers are then typically used in place of fossil fuel boilers for the bulk of the winter heating season. In Vermont where there are over 40 schools that heat with wood, the average annual wood utilization is about 85%. The woodchip scenario in this study assumes the facility will meet 85% of the winter heating needs for the school with woodchips and therefore consume 435 tons of chips per year. The remaining 15% of the heating needs were then assumed to be provided by the existing Natural Gas units consuming about 614 Dtherms of Natural Gas. The costs for Natural Gas and woodchips are then adjusted for inflation each year over the 30-year horizon.

INFLATION ASSUMPTIONS

Estimating future fuel costs over time is difficult at best. Over the past few years it has become even more difficult as fuel prices have fluctuated dramatically. Nevertheless, in order to more accurately reflect future costs in a thirty year analysis, some rate of inflation needs to be applied to future fuel costs.

We looked retrospectively over the last 20 years (1990 – 2009) using US Energy Information Agency data and found that the average annual increase for Natural Gas in Missouri was 5.6% per year. The analysis projects this average inflation rate for Natural Gas forward over the thirty year analysis period.

Figure 4 Woodchip and Fossil Fuel Inflation
The cost of woodchips used for heating fuel tends to increase more slowly and has historically been much more stable in price over the past two decades than fossil fuels. In Vermont for example, the statewide average woodchip fuel price for institutional biomass heating systems rose from $25/ton to $55/ton in the period between 1990 and 2009. The average annual increase during this period was about 3.6% annually\(^2\) with the greatest increases happening recently. Because woodchip fuel is locally produced from what is generally considered a waste product from some other forest product business, it does not have the same geopolitical pressures that fossil fuels have. Over the past twenty years, woodchip fuel costs have been far less volatile than fossil fuels.

After consulting with potential local woodchip fuel providers we are projecting a first year cost of $40 per ton for woodchips which is equivalent to about $4.50 per Dtherm of Natural Gas. For this analysis, $40 per ton was the assumed first-year woodchip fuel cost, and that price was inflated each year at 3.6% annually.

The overall Consumer Price Index for the period between 1988 and 2008, the last year for which data is available, increased an average of 2.9% annually. This is the annual inflation rate that was used in projecting all future labor costs, operations and maintenance costs and scheduled major repair costs for the biomass scenario.

**OPERATION AND MAINTENANCE ASSUMPTIONS**

It is typical for operators of fully automated woodchip heating systems of this size to spend 15-30 minutes per day to clean ashes\(^3\) and to check on pumps, motors and controls. For the woodchip scenario, it was assumed that existing on-site staff would spend on average approximately one half hour per day in addition to their current boiler maintenance for 150 days per year and 20 hours during the summer months for routine maintenance. At a loaded labor rate of $25/hr, this equals $2,375 annually. An additional $2,375 in annual operational costs is assumed for electricity to run pumps and motors.

Another operations and maintenance cost that is included in the analysis is periodic repair or replacement of major items on the boiler such as the furnace refractory. It is reasonable to anticipate these types of costs on a 10-15 year cycle. For this analysis, $15,000 of scheduled maintenance was anticipated in years 10, 20 and 30 and then annualized at $1,500 per year to simulate a sinking fund for major repairs. This $1,500 was then inflated at the general annual inflation rate.

Under any biomass scenario, a case could be made that the existing heating units will require less maintenance and may last longer since they will only be used for a small portion of the heating season.

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\(^2\) Extrapolated from Vermont Superintendent Association School Energy Management Program data. Vermont wood chip price history is used because it is one of the only states that has this historical data.

\(^3\) Wood ash is generally not considered a hazardous material in most states and can be landfilled or land applied as a soil amendment by farmers or on-site maintenance staff.
However, all heating equipment should be serviced at least annually no matter how much it is used. Additionally it is very difficult to estimate how long the replacement of the existing units might be delayed. For these reasons, no additional annual maintenance, scheduled repair or planned replacement costs for the existing Natural Gas boilers were taken into consideration as these are considered costs that the school would have paid anyway. It was assumed that all costs for the operation and maintenance of a biomass boiler are incremental additional costs.

FINANCING ASSUMPTIONS

The Perry County School District has been awarded $970,000 towards this project through the Missouri Fuels for Schools program. Preliminary estimates show that, if the district accepts the Missouri Fuels for Schools Grant, it would cover all but $6,000 of the cost of installing this biomass heating system. Therefore no financing costs have been included in the analysis. However, the fuel cost savings from this project could offset finance costs for a good size project if the district decided to add to the project scope, such as the recommended upgrades to the elementary school. The district has access to assistance for accessing low borrowing cost and favorable borrowing terms through the General Obligation Bond program. There is also access to project funding through a lease/purchase with a 3rd party non-profit and via the Capital Projects Fund (Fund 4). If the school identifies significant energy efficiency opportunities, it may be worthwhile to consider financing some of those improvements and paying the debt service from energy savings.
BIOMASS SCENARIO ANALYSIS RESULTS

The analysis shows that the Perry County School District could save more than $1.1 million in today’s dollars in operating costs over the next 30 years by installing a woodchip heating system. Annual fuel savings alone are projected to be more than $30,000 per year in the first year and will increase over time as Natural Gas prices continue to climb.

Table 1 Woodchip Scenario Analysis Assumptions

<table>
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<tr>
<th>Perry County 32 School District</th>
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<tbody>
<tr>
<td><strong>Capital Cost Assumptions</strong></td>
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<tr>
<td>1,750 mmBtu wood hot water boiler system including installation</td>
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<tr>
<td>Stack and breaching</td>
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<tr>
<td>Biomass boiler house</td>
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<tr>
<td>150 cubic yard chip storage building and chip storage bunker</td>
</tr>
<tr>
<td>Site preparation</td>
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<tr>
<td>Thermal Storage 1,750 gallon</td>
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<td>Biomass boiler room equipment</td>
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<tr>
<td>Pex Pipe (2-3” supply and return)</td>
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<tr>
<td>HVAC Upgrade costs (Old Vocational School)</td>
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<td>Interconnection to 3 existing buildings</td>
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<td>GC markup at 10%</td>
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<td>Construction contingency at 15%</td>
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<td>Design at 12%</td>
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<td><strong>Total estimated project costs</strong></td>
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<td><strong>State Grant</strong></td>
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<td><strong>Fuel Cost Assumptions</strong></td>
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<td>Current annual fuel oil consumption in gallons</td>
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<td>Assumed fuel oil price per gallon</td>
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<td>Projected 1st year wood fuel bill</td>
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<td>Projected 1st year supplemental Natural Gas bill</td>
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<td><strong>Inflation Assumptions</strong></td>
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<td>General inflation rate (twenty year average CPI)</td>
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<td>Natural Gas inflation rate (twenty year average EIA)</td>
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<td>Wood inflation rate (average increase in VT from 1988 - 2008 is 3.6%)</td>
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<td><strong>O&amp;M Assumptions</strong></td>
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<td>Annual Wood O&amp;M cost, including electricity for additional pumps and motors and staff time for daily and yearly maintenance</td>
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<td>Major repairs (annualized)</td>
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<td><strong>Savings</strong></td>
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<td>Net 1st year fuel savings</td>
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<td>Total 30 year NPV cumulative savings</td>
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Figure 5 Annual Cash Flow Graph for Woodchip Scenario
### Perry County School District

#### Preliminary Life Cycle Cost Estimate

**Wood Chip - Heat Only**

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**Total** | $4,145,146 | $4,145,146 | $912,243 | $912,243 | $70,218 | $1,826,591 | $1,826,591 | $2,318,655 |

**30 Yr. NPV at** | $2,406,359 | $551,470 | $360,950 | $136,419 | $43,080 | $1,091,923 | $1,091,923 |

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<th>Total Annual Heating Costs</th>
<th>Natural Gas + Woodchips</th>
<th>Woodchip System O&amp;M /Year</th>
<th>Contingency Allowance / Year</th>
<th>Woodchip + Fuel + O&amp;M + Contingency</th>
<th>Annual Fuel Cost Savings</th>
<th>Local Share</th>
<th>Simple Payback (yrs)</th>
<th>30 Yr. NPV Savings</th>
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<td>$6,175</td>
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</table>
ADDITONAL ISSUES TO CONSIDER

ENERGY MANAGEMENT

In order to effectively manage energy use and to identify efficiency opportunities in buildings, it is very important to track energy usage. Unless energy consumption is measured over time, it is difficult or impossible to know the impact of efficiency improvements or renewable energy investments. The US Environmental Protection Agency (EPA) developed a public domain software program called Portfolio Manager that can track and assess energy and water consumption across an entire portfolio of buildings. Portfolio Manager can help building owners set efficiency priorities, identify under-performing buildings, verify efficiency improvements, and receive EPA recognition for superior energy performance. We recommend that the school input several years’ worth of energy and water use data for all of its school buildings into Portfolio Manager as soon as it can. The EPA Portfolio Manager software can be downloaded at the following address:

ENERGY EFFICIENCY

Whether the Perry County School District converts to biomass or stays with Natural Gas, the district should use its heating fuel efficiently. The Energy Center at the Missouri Department of Natural Resources can help identify and prioritize appropriate energy efficiency projects that will improve the school’s infrastructure and save money. Through the Energy Revolving Fund, the Energy Center provides low interest loans to public schools, universities, colleges, cities, counties, public hospitals and water treatment plants to help reduce energy costs. This loan financing may be used for various energy-saving investments, including projects such as upgrading insulation, lighting systems, heating and cooling systems, windows and other items that affect energy use. Loan recipients repay the loan with money saved on energy costs as a result of implementing the energy-efficiency projects. These loans are not defined as debt. Thus, this loan financing does not count against debt limits or require a public vote or bond issuance.

To give an idea of the benefits of energy efficiency in schools, an Energy Efficiency Case Study for the U-32 Junior/Senior High School is included in the Biomass and Green Building Resources binder accompanying this report.

INDOOR AIR QUALITY

Recent studies have shown that poor indoor air quality (IAQ) in schools can lead to a number of health problems, including asthma aggravation, and impact both staff and student performance. The U.S. Environmental Protection Agency has created an Indoor Air Quality Action Kit to help schools understand how IAQ problems develop, the importance of good IAQ and practical actions schools can take to identify and address IAQ issues in their buildings. Appropriately designed HVAC equipment is a key component in creating good indoor air quality. Unit ventilators are one practical approach to
providing necessary fresh air into individual rooms without investing in central air handling systems. Perry County School District would benefit from review of the EPA’s *Indoor Air Quality Tools for Schools Reference Guide Backgrounder* and the EPA *Indoor Air Quality Checklist*, which are included in the *Biomass and Green Building Resources* binder accompanying this report.

**CAPITAL PLANNING AND A SCHOOL ENERGY INITIATIVE**

It is always less expensive to incorporate a biomass energy project into a larger building renovation or new construction project than it is to initiate a project just for building a biomass boiler house and chip storage facility. Design, permitting and general conditions can be spread over a larger project and the logistics of construction can be managed more efficiently.
PROJECT FUNDING POSSIBILITIES

Since the State of Missouri is funding this project through grant funds, the district may not need to fund or finance any part of this project. However, if the school does identify other aspects of the project that may not be eligible for grant funding, they may want to consider using one of the funding mechanisms described below.

USDA FUNDING OPPORTUNITIES

2008 Farm Bill

The 2008 Farm Bill has a number of provisions that may help rural communities consider and implement renewable energy and energy efficiency projects.

❖ **Section 9009** provides grants for the purpose of enabling rural communities to increase their energy self-sufficiency.
❖ **Section 9013** provides grants to state and local governments to acquire wood energy systems.

These grants and loan guarantee programs are competitive. The rules governing the program and the application dates have not yet been released. The state should check with their local USDA office to express interest and to get program roll-out updates.

Rural Community Facilities Grant and Loan Program

The USDA provides grants and loans to assist the development of essential community facilities. Grants can be used to construct, enlarge or improve community facilities for health care, public safety and other community and public services. The amount of grant assistance depends on the medium household income and the population of the community where the project is located.

These grants and loans are also competitive. Highest priority projects are those that serve small communities, those that serve low-income communities and those that are highly leveraged with other loan and grant awards.

For more information about USDA programs and services, contact your local USDA office. Information on programs and contact information is provided in the *Biomass and Green Building Resources* binder.
QUALIFIED SCHOOL CONSTRUCTION BOND

Qualified School Construction Bonds are awarded through the American Recovery and Reinvestment Act. These no-interest loans can be used for taxpayer approved projects to improve school facilities. The Qualified School Construction Bond program absorbs costs that would otherwise be incurred by school districts which have issued voter-approved bonds for construction projects, effectively allowing districts to borrow funds without paying interest. Bondholders are provided with federal tax credits in lieu of the interest that would ordinarily be paid by the school districts which issues them. Through the program, bondholders receive full return on their investment while school districts are able to finance school construction projects less expensively and jobs are created in local communities.

There are 33 school districts in Missouri that are already slated to receive $140 million through the Qualified School Construction Bond program. The Qualified School Construction Bonds Program application, available through the Missouri Department of Elementary and Secondary Education, is included in the Biomass and Green Building Resources binder accompanying this report.

ENERGY REVOLVING FUND

The Division of Energy for the Missouri Department of Natural Resources, through the Energy Revolving Fund, provides low interest loans to public schools, universities, colleges, cities, counties, public hospitals and water treatment plants to help reduce energy costs. This loan financing may be used for various energy-saving investments, including projects such as upgrading insulation, lighting systems, heating and cooling systems, windows and other items that affect energy use. Loan recipients repay the loan with money saved on energy costs as a result of implementing the energy-efficiency projects. These loans are not defined as debt. Thus, this loan financing does not count against debt limits or require a public vote or bond issuance. The Division of Energy approved more than $2.4 million in low-interest loans for the FY2009 round of the Energy Loan Program. Throughout Missouri, six school districts, a community college and three county and city governments will use the loans to make energy-efficiency improvements to save nearly $230,000 annually on their energy costs.

For more information about the Energy Revolving Fund go to: www.dnr.mo.gov/energy.
PERMITTING

Modern biomass boiler technology is both clean and efficient. Controls moderate both the biomass fuel and air to create either a small hot fire or a large hot fire depending on heat demand from the building. Under full load, modern woodchip boilers routinely operate at steady state efficiencies of 70% – 75% efficiencies. Operating temperatures in commercial scale biomass boilers can reach up to 2,000 degrees and more, completely eliminating creosote and the need to clean stacks. The amount of ash produced from a 25 ton tractor trailer load of green hardwood chips can fit in a 25 gallon trash can, is not considered a hazardous waste, and can be used as a soil amendment on lawns, gardens and playing fields.

However, as with any combustion process, there are emissions from biomass boilers. There is no question that natural gas is the cleanest fuel used for heating. However, biomass compares favorably with fuel oil and modern commercial scale biomass boilers with the appropriate pollution control devices can burn very cleanly and efficiently.

Table 3 Comparison of Boiler Emissions Fired by Woodchips and Distillate Oil

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<th>Wood (Pounds per million Btu output)</th>
<th>Distillate Oil (Pounds per million Btu output)</th>
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<td>0.1650</td>
<td>0.1430</td>
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<tr>
<td>CO</td>
<td>0.7300</td>
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<td>0.0039</td>
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<tr>
<td>CO$_{2}$</td>
<td>gross 220 (net 0)</td>
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</tbody>
</table>

As with any combustion process, there are emissions from biomass boilers. The pollutant of greatest concern with biomass is particulates (PM$_{10}$). While biomass compares reasonably well with fuel oil, biomass boilers clearly generate more particulates. That is why it is important to install appropriate pollution control equipment. But the emissions from a modern woodchip boiler are much less than most people think.

One of the most common misconceptions about institutional biomass energy systems comes from the experience people have with residential wood stoves and outdoor wood boilers. In general, an institutional-scale wood energy system emits only one fifteenth (seven percent) the PM$_{10}$ of the average wood stove on a BTU basis. Over the course of a year, a large, woodchip heated school in a climate like Missouri may have the same particulate emissions as four or five houses heated with wood stoves.

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However, in order to install a new woodchip boiler, Perry County School District may still need an air quality permit or an amendment to their existing permit if they have one.

The school can contact Kendall Hale or Kyra Moore (573) 526-3835 at the Missouri Department of Natural Resources for additional information on biomass permitting.

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5 Excerpted from a handout produced by the Biomass Energy Resource Center
CONCLUSIONS AND RECOMMENDATIONS

The woodchip biomass scenario evaluated for this report is cost effective and Yellow Wood recommends moving forward with a project. We recommend Perry County School District take the following steps to investigate this opportunity further:

1. Hire an architectural and/or engineering firm to help refine the project concept and to obtain firm local estimates on project costs. The preliminary conceptual cost estimate should be refined through further investigation and scoping of the proposed biomass project before a decision is made to move forward. The design team should evaluate whether it would be cost effective to add other buildings on the campus to a central biomass boiler system, particularly the Elementary School. The team should also evaluate how much additional savings may be gained by adding a high efficiency central chiller. The US Forest Service may be able to provide some technical assistance to the design team on biomass energy technologies and design suggestions for wood chip fuel storage and boiler house layouts.

2. The district should consider other energy efficiency improvements simultaneously with the biomass energy project. The efficiency of the building envelope and ventilation equipment need to be considered when sizing new boiler equipment. The Energy Center at the Missouri Department of Natural Resources provides technical and financial assistance for energy efficiency and renewable energy projects to school districts and other consumers. Through the Energy Revolving Fund, the Energy Center provides low interest loans to public schools, universities, colleges, cities, counties, public hospitals and water treatment plants to help reduce energy costs. The Energy Center should be contacted and engaged regardless of whether or not the school moves ahead with a biomass project at this time. Information on energy efficiency programs and incentives is included in the Biomass and Green Building Resources binder accompanying this report.

3. In order to effectively measure progress toward energy efficiency goals historical energy consumption data should be collected and updated frequently. The most effective method is to track individual building energy usage. With this information facility operators can identify which buildings have the most opportunity for energy savings. There are many tools to help the school accomplish this. One such tool is the EPA Energy Star Portfolio Manager software. It is free public domain software that helps facility managers track energy and water use. This software can be downloaded at: http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager

4. Concurrent with the design of a biomass project, the school should cultivate potential biomass fuel suppliers. Perry County School District staff should work with the Missouri Department of Conservation staff to identify potential woodchip fuel suppliers and begin discussing fuel pricing. A list of potential woodchip fuel suppliers is included in the appendices at the end of this report.
WHO WE ARE

Yellow Wood Associates
Yellow Wood Associates (Yellow Wood) is a woman-owned small business specializing in rural community economic development since 1985. Yellow Wood has experience in green infrastructure, program evaluation, business development, market research, business plans, feasibility studies, and strategic planning for rural communities. Yellow Wood provides a range of services that include measurement training, facilitation, research, and program management.

Richmond Energy Associates
Richmond Energy Associates was created in 1997 to provide consulting services to business and organizations on energy efficiency and renewable energy program design and implementation. Richmond Energy has extensive experience in wood energy systems. Jeff Forward provides analysis and project management on specific biomass projects and works with state, regional and federal agencies to develop initiatives to promote biomass utilization around the country. In addition to his own consulting business, he is also a Senior Associate with Yellow Wood.

Wilson Engineering Services, PC
Wilson Engineering Services (WES) is a multidisciplinary firm providing engineering and consulting services for a wide range of projects and programs. WES combines extensive experience in the following areas to provide clients with sustainable solutions to energy and environmental related issues, including agri-business; application of technology projects related to energy production and distribution, waste handling and environmental remediation; and engineering consulting project and program management.
APPENDICES

DISCUSSION OF BIOMASS FUELS

Purchasing wood fuel is a different exercise than purchasing Natural Gas. While Natural Gas is delivered to the site with little interaction from facility managers, biomass fuel suppliers will need to be cultivated and educated about the type of fuel needed, its characteristics and the frequency of deliveries. Concurrently with designing a wood-energy system, the school should also be cultivating potential biomass fuel suppliers.

Potential wood fuel suppliers include sawmills, loggers, chip brokers and large industrial users such as paper mills or power plants. Many of these forest products producers already make woodchips for pulp and to reduce waste, but may not have much experience dealing with the needs of smaller volume customers. Woodchips produced for institutional biomass boilers have more stringent specifications than those produced for large industrial customers. And woodchip fuel may need to be delivered in different trailers.

When talking to potential woodchip fuel suppliers, it is important to have the wood fuel specification in mind. A one to three inch square chip is ideal. If possible, woodchips for institutional biomass systems will come from logs that are debarked prior to chipping because bark produces more ash which translates into a little more daily maintenance. Pieces or small branches that are six inches or longer can jam augers and conveyors which will interrupt the operation of automated fuel handling equipment. Institutional scale biomass boiler systems in the Northeast are typically designed to operate with wood fuel that is within a 35% to 45% range for moisture content.

Typically institutional biomass systems of this scale have limited chip storage capacity which means they may need deliveries on relatively short notice. Woodchip fuel suppliers will need to be within a 100 to 150 mile radius or so of the user, the closer the better, as transportation costs will affect price. Chip deliveries are typically made in “live bottom” trailers that will self unload into below-grade chip storage bins. Therefore, potential suppliers must have access to a self-unloading trailer for deliveries.

It is possible to design a wood-energy system that uses any one of a variety of biomass fuels, but green hardwood chips make the best fuel. If it is readily available, it should be the fuel of choice. In addition, users should focus on reliability of supply and consistency of the fuel rather than just lowest cost. The goal should be to minimize maintenance and optimize system performance.
Whichever fuel is used, the fuel type needs to be part of the combustion system design process, and the wood system should be operated using the fuel it is set up to use. Ideally, sample fuel chips should be sent to the manufacturer of the biomass heating equipment so that they can design the fuel handling equipment around the type of fuel and calibrate the system properly when setting the system up. No system handles widely varying fuel types at the same time very well. A system can be re-calibrated for a different fuel type, but the most practical approach is to stick with one fuel type, at least for a given heating season. If, for some reason, that fuel type becomes unavailable, the manufacturer of the equipment should be consulted to help reconfigure or retune the system for another fuel.

It is best to try to locate several potential suppliers. By doing so, the school will have the security of knowing there will be back-up in case of an interruption from their primary supplier. This will also generate some competition. A list of relatively local potential fuel suppliers is included in the appendices. For help identifying other potential wood-fuel suppliers, the school may want to contact John Tuttle with the Missouri Department of Conservation. He can be reached at (573) 522-4115. A list of potential wood chip providers is provided in the appendix.

The bottom line is that both the school and fuel suppliers need to clearly understand the characteristics of fuel needed for their particular system. Consistent particle size and moisture content is particularly important for institutional customers, and the school should insist on the quality of the chip. A sample fuel specification is included in the *Biomass and Green Building Resources* binder to give an idea of the types of characteristics to look for in woodchip fuel. Below is a description of the advantages and disadvantages of different types of biomass fuels in order of preference.

**Green Hardwood Chips**

A consistent green hardwood chip is the easiest fuel for institutional scale automated biomass heating systems to handle. Rarely will they jam an auger or conveyor. Green chips burn somewhat cooler than most other biomass fuels making it easier to control the combustion. With proper controls, they burn very cleanly with minimal particulate emissions and little ash. They have less dust than other biomass fuels so they are less messy and safer to handle. Ideally moisture content will be between 35% and 45% on a wet basis. Green hardwood chips can come from sawmill residues or timber harvest operations.

**Mill Residues vs. Harvest Residues**

Woodchips can be produced at sawmills or other primary wood products industrial sites as part of their waste wood disposal process. Mill residues are typically the most desirable source of fuel
woodchips. Mills can produce a bark-free chip with few long pieces or branches that can jam augers and fuel conveyors. A mill supplier can easily calculate trucking costs and can negotiate dependable delivery at a consistent price.

Another potential type of wood fuel is whole tree chips which are produced as part of tree harvesting. Whole tree chips tend to be a dirtier fuel than sawmill residues and may contain small branches, bark, twigs and leaves. The longer pieces can jam the relatively small augers of an institutional scale biomass system and can add to the daily maintenance because they produce more ash.

The bole of a tree is the de-limbed trunk or stem. Chips made from boles are in-between the quality of a sawmill chip and a whole tree chip. Bole-tree chips tend to have fewer twigs and long stringers than whole tree chips. Both bole-chips and whole-tree chips can be potentially good sources for biomass fuels, although they have a greater likelihood of including oversized chips and they will produce somewhat more ash, compared to mill residues.

**Softwood Chips**

Green softwood chips will generally have less energy and more water content per truckload, and therefore they will be more expensive to transport than hardwood chips. As long as the combustion and fuel handling equipment is properly calibrated for softwood chips, an automated woodchip heating system can operate satisfactorily with softwood chips. Softwoods tend to have higher moisture contents and can range up to 60% moisture on a wet basis. The best biomass fuel will have less than 50% moisture. One species to avoid altogether is white pine. It has a very high moisture content and therefore relatively low bulk density. The experience in Vermont schools with white pine is that it is a poor biomass fuel for institutional-scale woodchip systems.

**Dry Chips vs. Green Chips**

Dry chips (less than 20% moisture on a wet basis) burn considerably hotter than green chips and typically have more dust. The increased operating temperature can deteriorate furnace refractory faster increasing maintenance costs slightly. The dust can make for a somewhat dirtier boiler room which will be a problem for some maintenance staff. Dry chips are also easier to accidentally ignite in the fuel storage bin or fuel handling system. If dry chips are used, the combustion equipment needs to be carefully calibrated to handle these higher temperatures. Dry chips are not generally recommended for institutional settings.
Bark

Bark has a high energy value, but it also comes with significant maintenance costs. It produces a considerable amount of ash that needs disposal; it can create more smoke than green chips; and it can cause other routine maintenance problems such as frequent jamming of augers from rocks. Bark can be an inexpensive fuel, but the additional maintenance costs make it unattractive for institutional biomass systems.

Sawdust and Shavings

Sawdust and shavings should ordinarily be ruled out for the institutional wood heating market. Dry sawdust can be dusty to handle and raises fire safety and explosion issues. Shavings are also dusty and easily ignited and are difficult to handle by typical fuel handling equipment. This fuel type can work fine in an industrial setting, but institutions typically do not have the maintenance staff that can provide the supervision that these fuels need.

However, one school in Missouri, the Houston High School has a sawdust boiler that they have been using successfully for thirty years. They use green sawdust with as much as a 40% moisture content and have had the same boiler operator since its installation. This school obtains fuel very inexpensively and has learned how to manage the system safely and economically. Any school that might consider using green sawdust should consult with the Houston Building Maintenance Director, Wes Lindaman, (Email: wes@houston.k12.mo.us  417-967-3024 Ext: 446) to get tips and advice on how to operate a sawdust boiler in an institutional setting.
BIOMASS ENERGY VENDORS

This list is for informational purposes only and does not imply a recommendation or endorsement of any manufacturer, nor is this list represented as being a complete list of all companies that may offer these products. When selecting a manufacturer, the customer should perform due diligence by checking references at existing installations and comparing warranties. Features such as the degree of automation, combustion and thermal efficiencies, the ability to handle the fuel source selected and pollution control devices should be compared.

Bio-Fuel Technologies
Bob Rice
PO Box 41
Beaverton, PA 17813
570-658-7491
ricerc@ptd.net

Biomass Combustion Systems
Charlie Carey
16 Merriam Rd
Princeton, MA 01541
508-393-4932
info@biomasscombustion.com

Biomass Energy Concepts/Advanced Recycling
850 Washington Rd
St. Mary's, PA 15857
800-611-6599
areinc@alltel.net

Chiptec
Bob Bender
48 Helen Avenue
So. Burlington, VT 05403
800-244-4146
BobBender@Chiptec.com

Messersmith Manufacturing
Gailyn Messersmith
2612 F Road
Bank River, MI 49807
906-466-9010
messersmith@uplogon.com

Viessmann Manufacturing Company (U.S.) Inc.
Steve David
45 Access Road
Warwick RI 02886
401-732-0667
dav@veissmann.com
## POTENTIAL BIOMASS FUEL SUPPLIERS

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Figure 6  Map Showing Potential Fuel Suppliers in Relationship to Perry County School District