An Assessment of Arizona's Wood-to-Energy Thermal Biomass Potential

Coordinated by:

The Little Colorado River Plateau Resources, Conservation & Development Area Inc.

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Introduction

In August, 2007, the USFS Technology Marketing Unit announced that Arizona was one of 14 states to receive funding for a “jump start” grant, the goal of which was “to provide financial assistance that will accelerate the adoption of woody biomass as a renewable, domestic energy source while maintaining or restoring forest health”.

The Little Colorado River Plateau Resources, Conservation & Development Area, Inc accepted the challenge and submitted a grant request aimed at ascertaining “the merits of embracing a statewide biomass thermal heating component for public buildings and school facilities by conducting a feasibility assessment at four selected locations in Northern Arizona. When completed, these assessments will enable administrators to make informed decisions about installation of biomass thermal heating systems.”

A team of investigators and nationally recognized biomass experts was formed and began compiling information to support the assessment process. In October, 2007, the team attended a national workshop in Missoula, Montana to learn the latest biomass boiler technology and biomass system implementation tactics. In March, team members traveled as a group to the four selected sites, conducting interviews and assessing the merits of those sites embracing wood to provide thermal heat in the buildings. The team concluded their evaluations during the summer of 2008. In November, team members Nick Salmon and Dusty Moller presented the assessment findings to the Governor’s Forest Health Council and to attendees at the Southwest Sustainable Forests Partnership Fall Conference, both held in Flagstaff. The publishing of a formal report completes this project. The power point brief is available at http://www.littlecolorado.net/SWSFP/Arizona_Pre-Feasibility_ Biomass_Heat_ Assessments.ppt.

The four sites chosen in Northern Arizona were selected based on them serving as appropriate markers for similar public facilities throughout the state. After the site visits and engineering evaluations, a series of installation “principles” began to take shape. In short, the assessment process determined that the amount of investment available to convert from natural gas or propane to biomass was in direct proportion to the annual cost of that fuel; that the conversion costs were dictated by the engineering and construction effort necessary to replace or augment the existing heating system; that the larger buildings or boiler systems or districts generally provided greater return on investment; and, that the success of statewide biomass heating effort depended both on the availability and quality of the fuel stocks and the ability to merge biomass heating into future public buildings, making them “fuel flexible” for conversion when conditions and technology warrant.

Terms and Values

Woody Biomass: Small trees, tree limbs, tops, needles, and other woody plants that are by-products of forest improvements, ecological restoration, and hazardous fuel reduction treatment activities. (Recycled or "repurposed" wood fiber can also be included in this mix. "C&D" waste (construction and destruction) waste from the housing industry and recycled wood packaging or pallets could also be used in wood fired heating systems.) More information can be found in Appendix 1.

BTU: A BTU is defined as the amount of heat required to raise the temperature of one pound of liquid water by one degree from 60° to 61°Fahrenheit at a constant pressure of one atmosphere. Throughout this report, the term "BTU" is used to describe the heat value (energy content) of fuels, and also to describe the power of heating and cooling systems, such as furnaces, stoves, barbecue grills, and air conditioners.

Fuel Value Comparison: The USFS has developed a Fuel Value Calculator as a convienient tool to show how wood can be a competitive alternative to fossil fuels. Based on typical boiler efficiencies for the fuel type, if the target fuel costs $15 per million BTU, then you can pay $86.10 for a ton of green wood, $12.30 for 1000 cubic feet of natural gas and 5 cents per kilowatt hour.

$15/million Btu

1. **Green wood (50% MC):** 5.74 million Btu/ton

$$\frac{\$15}{\text{million Btu}} \times \frac{5.74 \text{ million Btu}}{\text{ton}} = \$86.10/\text{ton}$$

2. **Natural gas:** 0.820 million Btu/1000 ft^3

$$\frac{\$15}{\text{million Btu}} \times \frac{820{,}000 \text{ Btu}}{1000\ ft^3} = \$12.30/1000\ ft^3$$

3. **Electricity:** 3,340 Btu/kWh

$$\frac{\$15}{\text{million Btu}} \times \frac{3{,}340 \text{ Btu}}{\text{kWh}} = \$0.050/\text{kWh}$$

This chart shows other fuel types that will deliver similar amounts of energy. The point to be made here is that the "science" involved in comparing fuel types is solid and can be used with confidence to compute the fuel cost component of a heating system. The other cost components—system cost, installation cost, operation cost, et. al.—will need to be accurately determined to complete the comparison process.

Fuel	Net heating value	Cost/unit
Premium wood pellets	13.6 million Btu/ton	$200/ton
Propane	71,000 Btu/gal	$1.10/gal
Fuel oil #2	115,000 Btu/gal	$1.72/gal
Fuel oil #6	124,000 Btu/gal	$1.86/gal
Seasoned firewood	15.3 million Btu/cord	$230/cord
Ovendried switchgrass	14.4 million Btu/ton	$186/ton
Bituminous coal	26 million Btu/ton	$390/ton
Shelled corn @15% MC	314,000 Btu/bushel	$4.70/bushel

(The USFS fuel calculator can be accessed here: http://www.fpl.fs.fed.us/documnts/techline/fuel-value-calculator.pdf)

Assessment Limits

As the site visits unfolded, the team quickly realized that, regardless of what they did, there would be a significant amount that they weren't able to do. The primary target was woody biomass, for example, and no other renewable energy source, say wind or thermal, was considered. Potential energy conservation opportunities, while important, weren't studied.

When "typing" the recommended boiler system, wood chip or wood pellet, no consideration was given to local permit requirements, zoning or other clean air factors. These are important considerations but woody biomass thermal systems are operating successfully throughout the country and siting requirements have been met in a wide range of installations.

Biomass quality availability information was limited. Each site is close to Federal, Tribal and state resources but specific harvest, processing and delivery plans were not developed. These issues are also important. A "Fuels for Schools" project in Nevada, for example, was commissioned and began startup—only to discover that the fuel supply promised in the preliminary engineering, did not materialize and the project has suffered from a shortage of quality fuel ever since.

The financial evaluations developed by the team assumed that the amount of heat energy required could be supplied by "typical" equipment and installation costs. While some of the sites could be called typical, Young School District would require some extremely long buried pipe runs to connect all the buildings to a central boiler. This extra cost was not factored into the payback equation, which, due to low current operating cost, already indicated a challenged project. Additionally, the financial analysis assumed the full cost would be borne by the site; the potential of grant funds was ignored.

One final point--moving forward to quantify the opportunity statewide in Arizona-- was not undertaken. Since the state already has information on the larger and, more importantly, licensed and state-inspected boiler systems within the state, this information is available and a database could be compiled which would be extremely helpful in moving toward a statewide assessment of wood-to-energy biomass potential.

Assessment Site Selection

The assessment team selected the following four sites in Northern Arizona:

Young School District, Young, AZ
Northland Pioneer College, Whiteriver, AZ
Arizona Department of Corrections, Apache Unit, Springerville, AZ
Round Valley Public Library, Eagar, AZ

Each site had unique characteristics that the assessment team felt would be important and applicable to other sites throughout the state. Young School District, for example, was extremely remote and featured several unattached buildings, each having different heating challenges. The Whiteriver Northland Pioneer campus was only a few blocks away from a major sawmill offering a ready supply of wood chips but only used $8,000 worth of propane during the comparison period.

The Round Valley Library was estimated to consume $15,000, nearly twice as much as the several buildings in Whiteriver and had a building "footprint" that promised a reasonable conversion to a small pellet boiler system. The largest installation visited was the Apache Unit of the Arizona Department of Corrections near Springerville, AZ. This prison complex boasted an eye-popping propane bill of nearly $190,000 per year. It's proximity to various chip fuel sources, the pellet fuel plant in Show Low, and the layout of the housing units made for an interesting study.

Assessment Criteria

At the outset of the study, the team adopted the following "protocol" or criteria to apply to each site:

Physical site visit, including plan/blueprint review;

Inspect existing heat/cooling system;

Learn organization infrastructure;

Consider wood chips or pellet options, including availability, processing and delivery issues;

Examine current system fuel records;

Locate potential boiler and fuel storage location(s);

Estimate preliminary system integration costs;

Calculate preliminary financial analysis

Organization infrastructure plays an important role in woody biomass heating systems. These systems are generally not recognized as "plug and play" systems. Irregular material, in the case of chips, by size and moisture content, is difficult to feed into a boiler and plug-ups occur. Someone has to clear them and restart the system.

At the Round Valley Library, pellet delivery was viewed as a cinch because the boiler was projected to be located in part of the building that is adjacent to the parking lot

and the pellet storage bin would take up a few parking spaces—easy access for a bulk pellet delivery truck.

At the Springerville unit, the existing heating system is wearing out and has difficult and expensive heat system maintenance issues. The layout of the housing units (cell blocks), among other heat distribution requirements, make the Correction unit a good candidate for a woody biomass heat system. The units are laid out in line and in good position for installing outbound hot water and returning cooled water. Pellet storage is "secure" and the site is just a few miles from the pellet manufacturer. This does not rule out a chip system, however, as the "tenants" at Springerville already provide work crews on forest health projects and woody biomass sources are nearby and plentiful.

Site Evaluation: Round Valley Public Library

(The four sites were individually evaluated and those evaluations along with the "spreadsheets" used to estimate the financial aspects of the project are included as appendices to this report.)

The library was evaluated as a "good" candidate for the use of a woody biomass heating system. While the physical plant was under construction, a review of the building plans showed the building to be 10,000 square feet with a planned heat system using 4 furnaces with a combined capacity of 400,000 BTU/hour.

Wood pellet systems generally make a better fit for projects requiring less than 1,000,000 BTU/hour and the library falls in that category. It's also helped out by the fact that two other buildings in Eagar are already using wood pellets for heat and bulk delivery is available.

This pellet boiler system is operating a few miles from the new library in Eagar and is supplied bulk pellets from the pellet plant in Show Low, about 60 miles away.

While it may not have been planned to have been "fuel flexible" the building design of the library and its placement on the building site—adjacent to the parking lot--make it so. The infrastructure of the town of Eagar is equally important. Town administrators and the community support the wood industry and would work towards completing a successful woody biomass heat

conversion of the new building. What is also important is that this building is one of several new buildings of the same design being completed within the regional library system this year. A successful project in Eagar could lead to several others that could use smaller, wood pellet systems throughout the state. This same issue applies to the Corrections Unit. Several of the other such Corrections units located throughout the state have the same physical layout and offer similar benefits of conversion.

Site Evaluation: Northland Pioneer College

The NPC campus at Whiteriver was judged a challenged site—not recommended for conversion at this time. This site was hindered by having several buildings with an installed capacity of approximately 800,000 BTU/hr. Annual propane costs, judged over the past 5 years, are about $8,000. The capital costs to convert simply cannot be offset by savings in propane over the costs of replacement woody biomass fuel—either pellets or chips.

What the team did remark about NPC was it's proximity to the White Mountain Apache high school and other Tribal administration buildings—just across the highway from the campus. Those buildings are all heated with propane. The tribe operates a large sawmill less than a mile away—a ready source of wood fuel. The community of Whiteriver could form a "heating district" and provide tribal schools, administration—even nearby housing—with woody biomass heat.

Site Evaluation: Young School District

If enthusiasm was a criterion for this study, the Young group would have been awarded "First Place". Take the Maintenance Supervisor, for instance. His "school" day starts about 5:00 a.m., when he opens up the school and turns up the heat in the various buildings. He then starts the school bus and rounds up the children, returning to the school for his regular duties. In the afternoon, he reverses that route. He was supported by school officials, school board members and the potential supplier of wood chips—a local small mill operator. But,

The site visits, like this classroom in Young, included close inspection of existing heat distribution systems.

Young simply does not consume enough propane and is faced with extremely high conversion costs.

Young is not a candidate for conversion. The ratio of high capital cost, exacerbated by long piping runs between the several buildings and relative low propane costs leads to an unacceptable payback. Young does serve, however, as an excellent example of lack of "biomass readiness". Arizona officials planning future public buildings, especially those close to (or in Young's case, surrounded by) woody biomass need to incorporate "flexible fuel" design into future public buildings.

Site Evaluation: Department of Corrections, Apache Unit

Like the Eagar library, this site possesses "natural" physical attributes that help keep retrofit costs lower than, say, the Young School District. The dormitories are lined up, making for straight and short runs between each unit. Heating units are on the top of each building making for easy access. The existing heating system has a high maintenance cost in addition to a significant propane bill for the entire site. Finally, they are close to both green wood chip and wood pellet fuel sources.

The existing propane-based heat system at the Apache unit is "high maintenance"—one of many factors favoring conversion to a woody biomass heating system.

This site is a definite candidate for conversion to woody biomass heating. During the "discovery" phase of the site visit, the team learned about other Corrections units constructed along similar profiles which should pique the interest of decision makers who must decide how state monies are invested as the state attempts to meet the current Arizona state renewable energy goals.

The financial analysis for the Apache unit shows some of the best returns among all of the sites visited. The recommended step now is to move to more detailed cost engineering especially given that both chip and pellet fuel sources are close and either type of boiler(s) could be put in place—each with differing operating and maintenance costs.

(A wood energy calculator similar to that used by the team is available here: http://michiganwoodenergy.org/calculator/calculator.php?action=form1)

Summary

Making the decision to convert an existing heating system to a woody biomass fueled system is simplified by applying a few principles of physics, cost engineering and cost accounting. Converting the heat energy supplied by propane or natural gas to that available from woody biomass and calculating the type and size of boiler to generate that equivalent or, as conversion planners recommend, 95% of the equivalent, is straight forward. Installation costs such as piping hot water underground or retrofitting heat exchangers can be confidently estimated. This also goes for operating costs including forecasting for future fuel price increases.

Perhaps the most “iffy” part of the equation are supply side issues—at what cost can the woody biomass system be fueled with the needed quantity and quality of material? A shift in policy by a land manager or any other interruption along the supply chain can reduce or eliminate the savings used to justify the conversion. Changes to the structure of the wood processing industry, sawmills closing down or forest thinning projects going unfunded will directly affect the price and availability of wood-based fuels.

The analytical tools used by the LCRP RC & D team and the engineering and design expertise engaged led the team from initial site visit to preliminary financial analysis quickly and confidently. Of the four sites, the Eagar Library and Apache Correction Units show good promise and are recommended for a detailed analysis. The Young School District and Northland Pioneer College site are not recommended for similar reasons—excessive costs with poor return. But saying that is in itself a positive because future school and other public buildings can be designed for heat “fuel flexibility” as technology and fuel sources meet the challenge to reduce consumption of propane and natural gas for heating purposes.

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A Powerpoint7 presentation, entitled "**An Assessment of Arizona's Wood-to-Energy Thermal Biomass Potential"** is available at the following website: http://www.littlecolorado.net/SWSFP/Arizona_Pre-Feasibility_ Biomass_Heat_ Assessments.ppt.

Appendices

Appendix 1 is Primer on Wood Biomass for Energy by Richard Bergman, Chemical Engineer, and John Zerbe, Wood Technologist, USDA Forest Service, Technology Marketing Unit, Forest Products Laboratory, Madison, Wisconsin, Dated January 2008.

Appendix 2 is an assessment submitted by team member Dan Bihn, Jump Start: Arizona Biomass Assessment Project, A Market Transformation Perspective, Dated March 2008, and the Flexible Energy Communities Initiative concept

Appendix 3 is an assessment submitted by team member Nick Salmon, Pre-Feasibility Assessment for Integration of Biomass Energy Systems for Round Valley Public Library, Eagar, Arizona, dated May 20, 2008.

Appendix 4 is an assessment submitted by team member Nick Salmon, Pre-Feasibility Assessment for Integration of Biomass Energy Systems for Northland Pioneer College, Whiteriver, Arizona, dated May 20, 2008.

Appendix 5 is an assessment submitted by team member Nick Salmon, Pre-Feasibility Assessment for Integration of Biomass Energy Systems for Young School District, Young, Arizona, dated May 20, 2008.

Appendix 6 is an assessment submitted by team member Nick Salmon, Pre-Feasibility Assessment for Integration of Biomass Energy Systems for Arizona Department of Corrections, Apache Unit, Springerville, Arizona, Dated May 20, 2008.

Appendix 7 is an excerpt from the website, Michigan Wood Energy, a Wood Energy Calculator, available at http://michiganwoodenergy.org/calculator/calculator.php?action=form1.

Appendix 8 is a copy of the power point presentation, An Assessment of Arizona's Wood-to-Energy Thermal Biomass Potential, dated August 2008.