Financing Woody Biomass Clusters: *Barriers, Opportunities and Potential Models for the Western U.S.*

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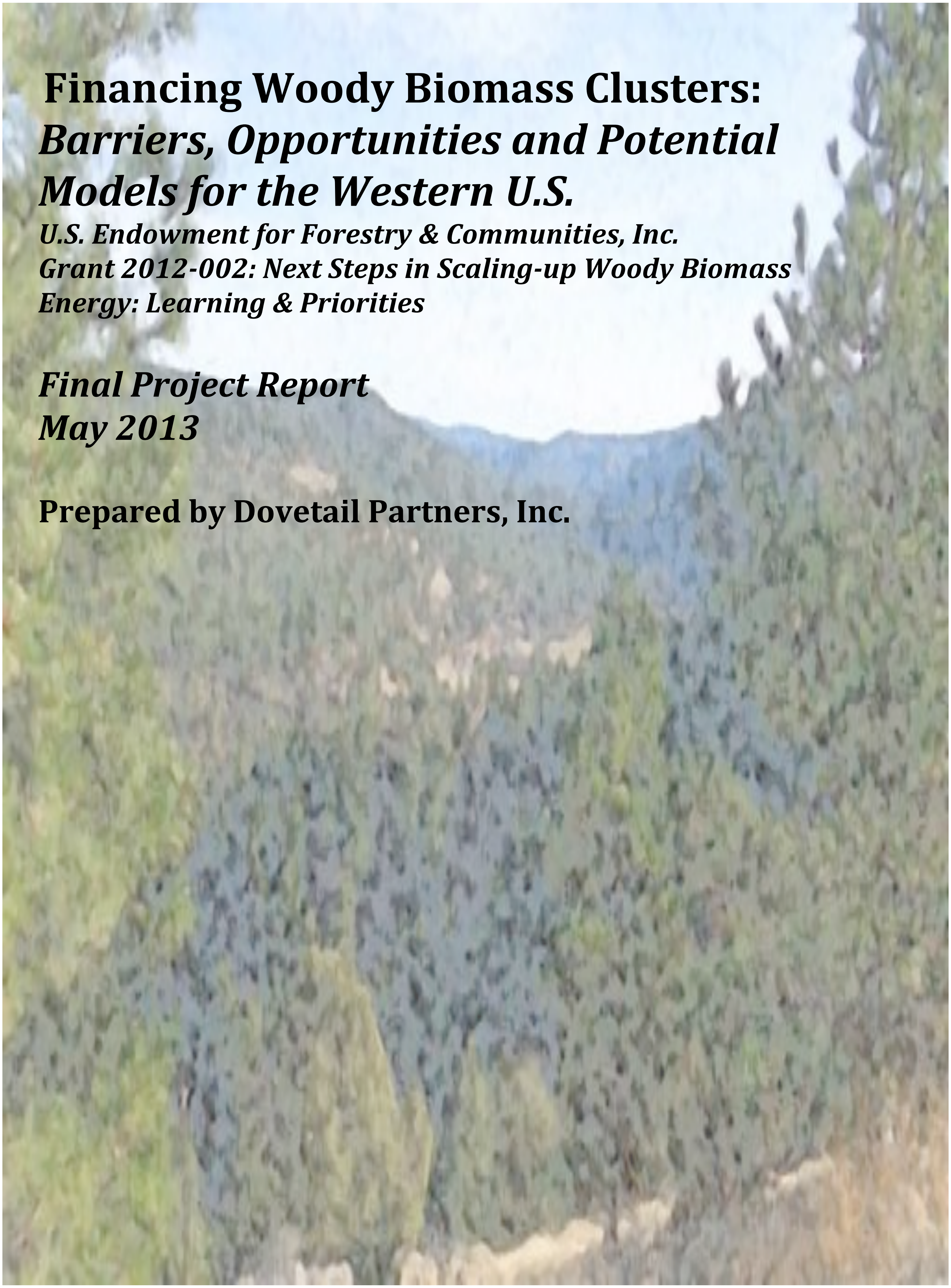
Final Project Report
May 2013

Prepared by Dovetail Partners, Inc.



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Final Project Report

Table of Contents

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EXECUTIVE SUMMARY

Globally, wood and charcoal are the main energy sources for more than two billion people.[1] Production of energy using a renewable material such as wood can have positive impacts on the environment and the economy. It can also contribute to the nation's energy security in a significant way by reducing dependence on imported fossil fuels. Despite these positive impacts and abundant, in some cases overstocked, forest resources, woody biomass makes up only about 2% of primary energy production in the United States.[2]

To better understand how biomass energy could be more widely adopted in the U.S., this project focused on identification of factors contributing to success or failure of biomass energy projects. The findings were used to identify barriers to and opportunities for achieving more extensive use of such systems. This project focused on addressing four primary questions.

- What are the opportunities and barriers to wood-to-energy facilities?
- What are the lessons learned from existing projects?
- What are the potential impacts of non-traditional revenue sources (e.g., payments for environmental services)?
- What models could be economically viable for development of wood-to-energy facilities in a western public lands environment?

To address these questions, the project included a number of components that are summarized in this report and the appendices (see sidebar).

Project and Report Components

Appendix A: Interview Results
- Summary of interviews with 16 biomass experts representing various fields and located throughout the U.S.
- Identification of primary gaps and barriers to bioenergy growth
- Focus on economic factors, collaborative approaches, critical errors, and lessons learned

Appendix B: Survey Results
- Survey of 81 biomass operations, including 73 biomass energy facilities and 8 fuel producers/distributors
- Identification of key opportunities, barriers and lessons learned of current operations

Appendix C: Site Visit Report
- Visits to 15 biomass facilities located in New Hampshire, Maine, Vermont, and Oregon
- Collection of detailed information about specific operations to support case study development, financial analysis and model design

Appendix D: Non-Traditional Revenue Sources
- Summary of potential non-traditional revenues to support biomass energy development

Appendix E: Case Studies
- Case studies for 3 clusters located in Oregon and Maine
- Detailed information used to support financial analysis and model development

A first step of the project was to interview biomass experts representing various fields and located in different geographical regions of the U.S. Next, an extensive survey tool was developed to explore opportunities, barriers, and the financial conditions necessary to support wood-to-energy development. Survey data was gathered from 81 biomass energy

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[1] Source: http://www.fao.org/sd/ruralradio/common/ecg/24516_en_factsheet3_1.pdf

[2] U.S. Department of Energy. 2012. Energy Information Administration. Energy Perspectives 1969-2011. (http://www.eia.gov/totalenergy/data/annual/perspectives.cfm)

operations (73 biomass energy facilities and 8 biomass fuel producers/distributors) across the northern region of the United States.

- Facilities surveyed represented over 2 Million tons of biomass fuel usage annually and ranged in size from 12 to 500,000 tons annually; the median consumption for the survey group was 367 tons annually
- Included were 5 Combined Heat and Power (CHP) facilities, 3 electricity-only facilities, and the balance were thermal facilities
- Fuel costs ranged from $140-189/ton for pellets and from $18/ton to $86/ton for non-pelletized biomass, depending on moisture content, size sort, and other factors
- Total project costs ranged from $36,000 to $80 million, with a median of $550,000

The results of the interviews and surveys aided in the identification of key opportunities, barriers, and lessons learned from current operations as summarized on the following pages (also see Appendices A and B). The primary drivers in wood energy investments were also explored (see sidebar).

Primary Drivers of Wood Energy Investments

Heating cost savings
- Savings versus heating oil, propane, electricity
- Reduced fuel cost variability
- Reduced disposal costs (e.g., utilization of waste wood for energy)

Renewable and local
- Reduced fossil-fuel dependence
- Local economic development opportunities
- Producing environmentally-preferable materials

Productive use of woody biomass
- Wildfire mitigation
- Lower carbon and air emissions
- Forest health improvements

For many facilities, funding is a primary roadblock. Biomass energy systems may provide significant annual heating cost savings, but potential investors may desire a shorter payback than is realistic without low interest financing. Biomass energy systems may also be more capital intensive than alternatives. In many instances, there is broad recognition of the potential environmental and socio-economic benefits of adopting a biomass energy system, but the system still needs to make financial sense as an investment.

Following completion of the interviews and surveys, site visits were conducted at fifteen (15) biomass facilities located in New England and Oregon.

Site Visit Locations

- New Hampshire
  - Concord Steam
  - Crotched Mountain
  - New England Wood Pellet
  - Schiller Station
- Vermont
  - Camel's Hump School
  - McNeil Generating Station
  - A. Johnson Company
- Maine
  - Maine Energy Systems
  - Regional School Unit 74
  - Regional School Unit 18
- Oregon
  - Malheur Lumber Company
  - Grant County Regional Airport
  - Blue Mountain Hospital
  - Grant Union School
  - Oregon National Guard

A primary purpose of these visits was to gather additional and more detailed information about unique experiences related to project finance, clustered development, and best practices to inform the development of a model for wood-to-energy facilities and the writing of case studies (see Appendix C for the Site Visit Report). Case studies were developed for 3 clusters (15 facilities) located in Oregon and Maine. The case studies provide detailed information about four biomass projects in John Day, Oregon, seven sites that are part of the Oregon Army National Guard, and four retrofitted schools that are part of Maine's Regional School Unit 74. These case studies provide detailed examples and lessons learned that can be applied to other locations and used to assist in efforts to scale-up community-based biomass energy (see Appendix E for the case studies).

As a result of the interviews, surveys, site visits, case study development and other research, the following key barriers and opportunities related to the wider use of biomass energy systems were identified.

Barriers to widespread adoption of biomass energy systems:

- High upfront capital costs of biomass systems
- Lack of profitability among many biomass energy fuel producers
- Seasonality of heat demand
- Commodity nature of energy production (high competition/low margin)
- High biomass transportation costs
- End-user issues and customer concerns (e.g., Compared to fossil fuel systems, biomass energy systems are viewed as complex technology requiring large facility space, long lead times on supply, bulk delivery, and complex material handling.)
- Unreliable biomass fuel sources and variability in fuel quality
- Lack of harvesting/processing/transportation infrastructure and value-added industries in the Western U.S. compared to the Northeastern U.S.
- Risk averse operations in the forest products sector and/or interest in maintaining existing methods and technologies
- Uneven playing field in terms of energy policy incentives
- Underdeveloped non-traditional revenues to support biomass energy (e.g., payments for environmental services)

Opportunities for achieving wider use of biomass energy systems:

Address producer needs:

- Replicate models that combine biomass energy production with a sawmill or similar production facilities as a way to improve profitability (e.g., in regions with significant heating seasons, wood products demand in summer may be countercyclical to energy demand in winter)
- Foster further innovation in biomass energy fuel production within traditional lumber facilities, including the rethinking of how, why, and to what end wood products are produced. A new model of softwood lumber production may result that better addresses customer expectations of wood as a source of materials and "fuel" (e.g., modified handing and delivery systems, consistency, maintenance services, etc.).

- Support the continuation and expansion of collaborative planning processes, especially in regards to the western public lands setting, as an essential means of facilitating access to a sustainable biomass supply

Address customer and biomass facility needs:

- Improve how wood energy fuels are transported, delivered and stored. Current systems create significant costs to customers in terms of required storage space and material handling. Innovations in wood energy technologies, including advancements in wood torrefaction and liquid biofuels development, represent a long-term trend to create a more consistent primary combustion material that can be marketed for multiple uses.

Address environmental risks:

- Address regional wildfire risks and other forest health issues. The utilization of woody biomass can help in these efforts. Current approaches to forest fire mitigation and wildlife habitat enhancement activities on public lands in the Western U.S. are expensive. The woody biomass generated by restoration activities is often burned on site with significant environmental costs and without energy recovery. Diverting a portion of current dollars spent in forest fire mitigation and wildlife habitat restoration to biomass energy development could significantly reduce financial barriers to project development. Similar opportunities to connect forest health improvements with biomass energy investments also exist for other public lands as well as private land ownerships.

Financial Analysis, Model Development, and Non-Traditional Revenue Impacts

A key component of the project was to apply the lessons learned from the evaluation of existing facilities to develop a potential model for economically viable wood-to-energy facilities in a western public lands environment. The primary purpose was to gain an understanding of the financial performance of various systems and to identify opportunities to optimize investment potentials.

To support development of a model, a financial analysis was carried out focusing on the information provided by the fifteen facilities included in the case studies. Information about non-traditional revenue sources was included in the analysis to understand how they can impact wood energy investments.

Traditional financial analysis metrics were utilized to determine which sites represented favorable (or unfavorable) investments and to identify the factors that can make projects more (or less) financially attractive. The metrics in the analysis provide information that can be used by facility owners and potential wood energy investors to make biomass energy project decisions (see sidebar).

Financial Analysis Metrics

Facility owner perspective

- Internal rate of return
- Simple payback
- Cash flow analysis

Investor perspective

- Return on investment
- Annualized rate of return
- Sensitivity analysis of annualized rate of return

The results of the financial analysis led to development of an additional metric that can assist in an economic assessment of a bioenergy project's potential – the **Biomass Investment Multiplier (BIM).** Generally, the purchase of a biomass energy system involves a comparative analysis of forecast expenses to determine net benefit (savings). The BIM concept (see textbox) derives from the fact that there is an inherent relationship between the displaced energy in million Btu's (MMBTUs)[3] and the cost of investment (e.g., $). This relationship is fairly direct and inverse and is expressed as the Biomass Investment Multiplier (BIM). The lower the BIM ($/MMBTU), the better the investment. Through this analysis a suggested range for BIMs was developed that can act as a guide both to entities seeking to implement biomass energy systems and to investors attempting to define practical investment options. It should be noted that the BIM is just one tool to add to the financial evaluation toolbox, and one that can serve as a "rule of thumb" to guide discussion. A key value of the BIM lies in the fact that investors can develop a target BIM (or range of acceptable BIM values) based on their own expected returns. The BIM target(s) can be used to calculate capital budgets using displaced (replacement) or competing (new construction) fuel estimates.

The Biomass Investment Multiplier (BIM)

BIM = ($ Total project investment)/(Units of Displaced Fuel x Conversion Factor in Btu/unit) x 1 million)

BIM is expressed in $/MMBtu.

Example Calculation:
($1 million investment)/(44,000 gal of fuel oil x 138,000 Btu/gal) x 1,000,000 = $165/MMBtu

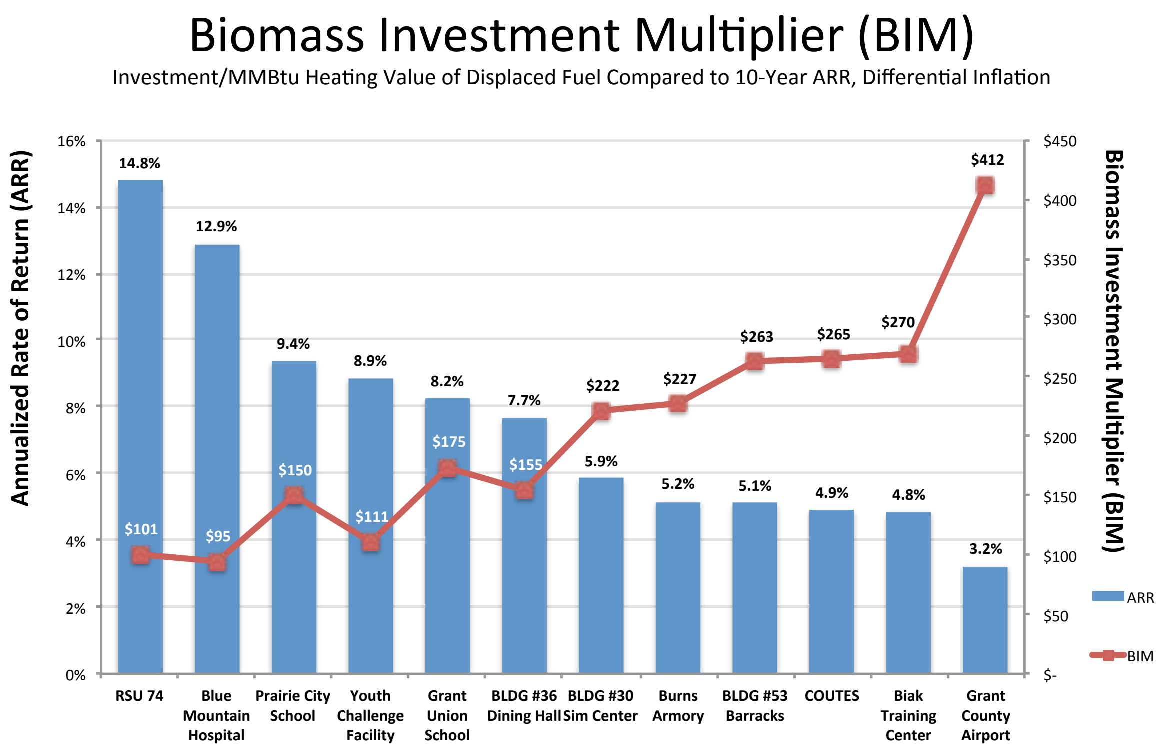
The BIM is calculated by dividing the actual Total Investment in dollars by the actual Current Cost for energy, normalized for energy source by converting to BTUs. The BIM ratio thus represents dollars invested per million BTUs displaced. By selecting a multiplier based on expected return, an investor (including operator) could calculate an acceptable investment amount for a project(s). This also allows an owner-operator to budget a project.

The graph on the next page (Figure 1) suggests that a BIM of $200 per MMBTU (hereafter BIM of 200) of displaced energy will likely provide a 10-year ARR of greater than 5 percent, assuming that inflation varies by source of energy. In this analysis, inflation rates of 1.5 percent for wood, 5.5 percent for oil, and 5.6 percent for propane and 2.0 percent for electricity were used to calculate long-term impacts on costs.[4]

[3] Displaced energy is calculated using previous or recent year's actual volume of energy source used (e.g. oil or propane) converted to MMBTUs.

[4] U.S. Energy Information Administration for all inflation estimates except wood. Wood inflation estimate used for Oregon was provided by local expert Andrew Haden (www.Wisewood.US) and for Maine was provided by the Forest Service (D. Atkins).

Figure 1. Biomass Investment Multiplier (BIM)



Of the 15 facilities subjected to in-depth analysis, 9 were found to have a maximum BIM of 200 (Note: RSU 74 data in Figure 1 is for a cluster of 4 schools). In addition, our analysis suggests that five other facilities would likely meet this threshold with grants (or other forms of financial support) of about 20 percent of the investment costs.

Also evident in Figure 1 is that there are two major groupings based on investment potential. Tier one investments would be those with a BIM of 175 or less (anticipated return > 7%), and tier two would have a BIM of 275 or less (anticipated return > 4%).

In general, based on both this and previous studies, facilities seeking funds for the development of woody biomass energy systems with a BIM less than 100 need the least additional support in terms of grants and nontraditional revenues and are most likely to appeal to traditional financing methods (e.g., banks). Facilities with a BIM greater than 200 will likely need support in an amount greater than 10% of initial investment costs to be economically viable and attractive to funders. Facilities with BIMs between 100 and 200 likely represent the most attractive option for pooling (e.g., cluster development) and where additional relatively minor levels of support can make a big difference between success and failure.

The BIM metric was incorporated into the further development and evaluation of a potential model for wood-to-energy development. The base model of a potential wood-to-energy facility included the following assumptions:

- $25 million investment (for a single facility, group of sites, or bundled projects)
- 10% ($2.5 million) supporting grants, subsidies or other incentives, for a net cost of $22.5 million
- Wood pellets cost assumed at $165/ton current market
- Fuel oil costs were calculated at current cost of $3.36/gal and propane at $2.25/gal
- These alternative fuels (fuel oil and propane) were selected as the most common replacement or competitive option in rural areas of the Western U.S.

The financial performance of the model was evaluated using various BIM levels (see Table 1 below and additional tables in the report). An evaluation was also done that included a hypothetical scenario of a project receiving non-traditional sources of revenue (e.g., payments for environmental services).

Table 1. Summary of Financial Performance of Western U.S Biomass Energy Production with $25 Million Initial Investment Under Three Scenarios of Fuel Displacement (Oil, Propane, Hybrid) Using a BIM of 175 or 200 ($/MMBTU)

Summary Table 1 Wood Pellets	Oil-200	Prop-200	Hybrid-200	Oil-175	Prop-175	Hybrid-175
Displaced energy MMBTU	112,500	112,500	112,500	128,571	128,571	128,571
BIM ($/MMBTU)	200	200	200	175	175	175
Payback (Years)	11	11	11	10	10	10
Years to Positive Cash Flow	4	4	4	3	2	3
IRR 25 yrs. (%)	12.4%	12.6%	12.5%	13.8%	14.1%	14.0%
IRR 15 yrs. (%)	7.9%	8.2%	8.1%	9.8%	10.1%	10.0%
IRR 10 yrs. (%)	0.9%	1.1%	1.0%	3.2%	3.5%	3.4%
ARR 10 yrs. (%)	7.5%	7.5%	7.5%	8.2%	8.3%	8.3%
ARR 15 yrs. (%)	7.4%	7.5%	7.5%	8.1%	8.2%	8.2%
ARR 10 yr. 5% Disc rate	-2.3%	-2.2%	-2.2%	-1.0%	-0.8%	-0.9%
ARR 15 yr. 5% Disc rate	1.5%	1.6%	1.6%	2.4%	2.6%	2.5%

Overall, the results illustrate the potential to design biomass energy systems to fit desired financial performance targets. For example, calculated values in Table 1 show that, biomass energy is likely a good investment for owner/operators as compared against both propane and oil, assuming a BIM of less than 200. These projects can become an attractive investment for a broader pool of investors by combining nontraditional income sources (e.g., payments for environmental services) and cost reduction activities (e.g., forest restoration or wildfire risk reduction) to enhance the financial performance. In addition, clusters of projects can be identified that address the specific risk/reward parameters of funders or investors.

Findings and Recommendations

There are critical strategic, organizational, and financial issues that need to be addressed in order to realize the considerable potential of biomass energy. First and foremost, biomass energy needs to become an attractive and financially viable investment alternative. The following list of recommendations should be considered when seeking to optimize the investment value of a biomass energy project.

1. **Finance -** The era of biomass energy needing incentives via grants is waning and there is an opportunity to move toward market-based tools. Creative, non-grant financing methods such as long-term, low interest loans covering the upfront capital cost of projects can help take the risk out of biomass conversions and increase adoption.
   - For example, *Qualified Zone Academy Bonds* and *Qualified School Construction Bonds* have been effective in helping finance public school conversion projects.
2. **Project Development -** There are a number of best practices among the sample group that may increase efficiencies and minimize the costs of biomass projects in other locations.[5] They include:
   - Minimize capital costs and demand load by implementing energy efficiency improvements
   - Apply the 90/50 Rule for boiler sizing[6]
   - Utilize a modular design
   - Implement a collaborative, multi-site approach that includes standardized design and material reuse
   - Coordinate engineering and integrate work flow between multiple projects
3. **Aggregated and Clustered Development Practices -** There are advantages to utilizing a geographically clustered model *(where biomass fuel manufacturers and markets to utilize biomass are in close proximity to one another)* or a project aggregation approach *(where multiple biomass projects are carried out under the same financial bundle).*
   - Geographic and regional biomass clusters can improve delivery efficiencies by minimizing fuel transportation distances.
   - Project aggregation of multiple smaller biomass projects under the same financial bundle can lead to lower transaction costs associated with financing, achieve economies of scale, and increase attractiveness of biomass projects to lenders when compared to financing individual projects.
4. **Biomass Technology -** Investment to facilitate development of new, lower-cost, standardized biomass energy systems should be a priority, as the current capital costs can be very high as compared to competing systems. There is a need to provide lower costs along with the convenience of traditional fuel heating systems.

[5] For more detailed information about each of these strategies, see the RSU 74 case study, Appendix E.

[6] This guideline suggests that by designing the system to only meet 50% of peak load the system will likely be sufficient to address 90% of annual demand. The 90/50 rule is most applicable to retro-fit conversions where an old system can serve as the back-up for meeting peak load. Thermal storage systems can also be installed as an alternative to having to maintain two systems and may be more appropriate for new construction.

    - Investment in biomass system development could be guided by following best practices used in the design of European biomass system technology and examining why customers choose to import European systems (e.g., identify the weaknesses and examine how they could be cost effectively addressed to better meet consumer needs). Improvements to automation, efficiency, and user-friendliness are key.
5. **Fuel Competitiveness -** Biomass project investments should focus on regions and locations that are dependent on propane, electricity, and heating oil.
6. **Fuel Supply -** Collaborations centered on National Forest restoration activities represent a best practice most relevant to public lands in the Western U.S. and can help provide access to a sustainable biomass fuel supply for users. One of the major benefits of National Forest collaborations, like the one centered on the Malheur National Forest, is that they can help prevent litigation that can hinder forest management activities.
    - There is a need to sufficiently fund and build the capacity of collaborative groups in the West so that they can continue their work and help make bioenergy fuel access self-sustaining. There also may be opportunities for biomass projects to benefit from collaborations that address other public and private lands.
7. **Fuel Delivery -** There is a need for new fuel distribution methods/models that are more customer-oriented (e.g., selling convenience) while also being profitable for distributors.
    - For example, biomass fuel distributors could learn from the experience of U.S. heating oil and propane distributors and/or from the European/Austrian model of delivery for successful best practices and models that could be emulated.
8. **Co-Benefits and Non-Traditional Revenue Sources -** There are significant co-benefits associated with biomass beyond simply using it to produce energy.
    - Creating value and demand for biomass products can lead to economic benefits in timber-reliant communities (job creation and local spending) in addition to diverse environmental benefits (reductions in wildfire threat, watershed improvements, air pollution reductions, improvements in forest health, and utilization of harvested forest residuals that would otherwise be left unused or burned in piles).
    - Some of the environmental co-benefits have existing or emerging markets associated with them (e.g., carbon offset markets) and incorporating these non-traditional revenue sources into project design can positively impact the financial performance of a biomass investment.
9. **Policy –** Policymakers in the U.S. should investigate and consider the biomass policies and incentives that have been adopted in several European nations.
10. **Regional Differences -** The regional issues associated with private land prominence in the Northeast versus public land dominance in the Western U.S. are very important (especially in regards to access to long-term, sustainable biomass supply).
    - Harvesting activities on private forestlands tend to shift according to markets. When markets drop off, private landowners are more reluctant to sell and activity declines. Whereas, activity on National Forests (and other public lands) tends to be more consistent from year to year. However, public lands management can be contested, which can significantly hinder harvesting activities.

SUMMARY

Based on interviews, survey results, site visits, case study development, and a financial analysis that involved biomass energy facilities across the United States, a number of barriers to wider adoption of biomass energy production in the U.S. were identified. Recognition that economic factors and financial concerns on the part of potential purchasers and investors are critical elements in biomass energy adoption and long-term success led to close examination of the economics of biomass energy production. The result was the development of the Biomass Investment Multiplier (BIM) as an additional tool for use in economic assessment of bioenergy project potential. This, in turn, was used to evaluate a number of model scenarios in which biomass energy was compared with more traditional energy sources. This evaluation illustrated how biomass energy investments compare with alternatives and opportunities to design financially competitive biomass energy systems. The availability of payments for environmental services can contribute to improving the financial performance of associated biomass energy systems. Applying biomass energy development as a more economically efficient wildfire risk reduction activity could provide opportunities to access non-traditional revenue sources.

The production of energy using a renewable material such as wood can have positive impacts on all three legs of the sustainability stool - society, the economy, and the environment. Biomass energy development has the potential to foster economic development, address wildfires and associated risks and costs, and reduce dependence on fossil fuels. There are critical strategic, organizational, and financial issues that need to be addressed in order to realize the considerable potential of biomass energy. First and foremost, biomass energy needs to become an attractive and financially viable investment alternative. This can be aided by strategically applying a wide array of market-based, as well as incentive and grant-based financial tools.

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BACKGROUND

There are three primary purposes behind the promotion of renewable energy in the United States: to reduce the nation's dependence on foreign oil, to promote more sustainable, environmentally friendly sources of energy, and to provide needed markets for low-value and/or domestically-produced materials. Biomass energy addresses each of these purposes. The responsible management of forest resources to support biomass energy systems offers the opportunity to benefit from the energy potential of these resources while improving forest health and enhancing forest values. We can also reduce the negative impacts and risks associated with wildfire and other severe disturbances by using woody biomass from forests to produce energy. In some regions of the U.S today there are significant forest health concerns and associated elevated wildfire risks. For these regions, the question needs to be asked: where, when, and how will the trees burn? There are significant environmental, economic and social differences to trees burning in the forest as part of a catastrophic wildfire versus in a controlled environment where the energy can be captured and pollution controls can be applied. Understanding the relationships between trees and fire is a first step to understanding opportunities for biomass energy.

Trees, like all plants, are formed through the process of photosynthesis. Specifically, in the presence of sunlight, carbon dioxide is removed from the air and combined with water dominantly from the ground to form cellulose and other complex hydrocarbons (that collectively comprise wood) and release oxygen back into the air. With *complete combustion* of woody biomass the reverse is also true. That is, cellulose and other complex hydrocarbons are converted back into carbon dioxide and water vapor, releasing the captured solar energy in the form of heat. About 0.2 percent ash results from the process.

Complete combustion requires excess oxygen and "the three T's of Time, Temperature, and Turbulence[7]." When heated to temperatures between 500-600 degrees Fahrenheit wood undergoes pyrolysis, which liberates organic gases and leaves behind carbon-rich charcoal. Pyrolysis is exothermic and self-sustaining once started. Primary combustion is the burning of the solid material, in this case charcoal, and secondary combustion is the burning of the gases that are produced.

Forest fires are a common form of forest disturbance and can occur naturally, but these fires are often characterized by *incomplete combustion*. The result of incomplete combustion is significant releases of particulate matter, carbon monoxide, methane and other volatile organic compounds, and even dioxins. Although the research is incomplete, the EPA reports[8] that preliminary studies indicate forest fires may be one of the major

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[7] Curkeet, R. 2011. Wood Combustion Basics, Presentation at EPA Workshop March 2, 2011.
[8] U.S. EPA (2006) An inventory of sources and environmental releases of dioxin-like compounds in the United States for the years 1987, 1995, and 2000. NCEA, Washington, DC; EPA/600/P-03/002F.

producers of toxic dioxins. Burning of brush in forest restoration is thought to have similar impacts. There is the potential to reduce wildfire risks and avoid the associated negative impacts through the responsible development of biomass energy systems in conjunction with forest restoration programs.

Utilizing woody biomass for energy, rather than disposing of it through open pile burning or wildfire events, can lead to significant air pollutant reductions, such as:

- 98% reduction (6 kg PM/BDT biomass) in *Particulate Matter* (PM)
- 54% reduction (1.6 kg NO_x/BDT) in *Nitrogen Oxides* (NO_x)
- 99% reduction (4.7 kg NMOCs/BDT) in *Non-Methane Organic Compounds* (NMOCs)
- 97% reduction (58 kg CO/BDT) in *Carbon Monoxide* (CO)
- 17% reduction (0.38 t CO_2e/BDT) in *Carbon Dioxide equivalents* (CO_2e)[9]

The opportunity to reduce the occurrence of incomplete combustion and increase the application of complete combustion is an important potential benefit of biomass energy development and use of wood as a fuel. In addition to producing largely carbon dioxide and water, complete combustion of woody biomass releases the full heating potential of the fuel. However, there are still challenges to the effective use of wood as a fuel source. Natural wood is hygroscopic, meaning that it absorbs and desorbs moisture constantly depending on temperature and relative humidity. The presence of moisture in wood can have a significant impact on the ability to completely combust wood fuel and on the technology required to achieve efficient burning. *Today, energy systems that are designed to handle woody biomass and burn it efficiently are complex and relatively expensive. Presently, this expense is being dominantly borne by the end consumer, an approach that is a major barrier to wide biomass energy adoption.* Despite the significant technological and financial barriers, the benefits of woody biomass use in the U.S. are significant enough to outweigh these challenges in many situations. To the extent that new and expanded financial and technological tools can reduce existing barriers, it is likely that the use of biomass energy has the potential to increase significantly.

THE RESOURCE

The United States has a significant forestland base, and the volume of wood on that land has been increasing over the past 70 years. Growth has exceeded harvest in all regions for at least fifty years. In 2006, growth exceeded removals in every region of the country, with the Rocky Mountain and Pacific Northwest regions the highest at more than 200 percent greater growth than removals and the South the lowest with 36 percent growth over removals. In the past twenty years removals on federal lands in the Pacific Northwest region have declined markedly, with a large share of removals shifting to the South. National Forest timber harvest levels overall declined by 77% between 1985 and 2012[10].

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[9] Storey, Brett, et al. "Emission Reductions from Woody Biomass Waste for Energy as an Alternative to Open Burning." Journal of the Air & Waste Management Association, 61 (Jan. 2011): 63-68

[10] http://www.fs.fed.us/forestmanagement/documents/sold-harvest/documents/1905-2012_Natl_Summary_Graph.pdf <http://www.fs.fed.us/forestmanagement/documents/sold-harvest/documents/1905-2012_Natl_Summary_Graph.pdf

This pattern of growth greatly exceeding removal rates has resulted in overstocked woodlands in some regions and increasing issues with forest fires and tree mortality. The challenges associated with overstocked woodlands are common throughout much of the West where federal ownership dominates.

The U.S. government owns approximately 67 percent of the forestland in Washington, Oregon, and Idaho (WA 47%, OR 61%, and ID 92%) in contrast to only one percent in Maine. In general, a vast majority of federally owned forestland is in the West, with a smaller amount in the upper Midwest. From a total landscape perspective there is very little federally owned forestland in the East. There is a significant volume of woody biomass available, particularly in the West that can be used to support biomass energy projects. The use of woody biomass as a fuel resource for thermal and electric energy generation offers a means to reduce forest overstocking and can aid in forest restoration efforts. Using biomass for energy may also help reduce costs associated with fire suppression efforts.

Activities in Oregon illustrate the potential for biomass energy to align with goals for forest restoration and wildfire risk reduction. During the period 2007-2011, large fires in Oregon (those greater than 100 acres in size) cost an average of $43.6 million per year, which was equivalent to $780 per acre. Over that same period the U.S. Forest Service spent an average of $40.7 million per year to accomplish forest restoration treatments on 129,000 acres (approximately $316 in costs per acre).[11] Therefore, to the extent that restoration activities can reduce wildfire risk, there is an opportunity to reduce costs by about 60%. Furthermore, if the biomass removed in the process is used to produce energy, there is the opportunity to create local jobs and economic opportunity while providing renewable energy.

Promoting hazardous fuels reduction through mechanical treatment and biomass utilization has been found to be cost-effective in many situations. For instance, in Wallowa County, Oregon, mechanical treatment with biomass removal for energy production via the Reservoir Biomass project cost $296/acre in 2012. In comparison, hand thinning, piling, and burning on-site cost between $300-900/acre.[12] Other benefits of biomass utilization include fewer equipment entries, the opportunity to use low-impact machines, and economically beneficial use of the material by local businesses and communities.

The opportunity for forest restoration, wildfire risk reduction and biomass energy production to work together is further illustrated by the example of Oregon's Malheur National Forest (MNF). The MNF's direct fire suppression costs have averaged $7.6 million annually with some years exceeding $20 million. According to a report from the Southern Blues Restoration Coalition, there have been seventy-one large fires between 1980 and 2010 that have burned over 300,000 acres in the MNF. In 2009, the MNF was awarded a 5-year, $50 million dollar Collaborative Restoration Stewardship contract that includes the

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[11] Krumenauer, Matt, et al. "National Forest Health Restoration." 26 Nov. 2012. http://orsolutions.org/beta/wp-content/uploads/2011/08/OR_Forest_Restoration_Econ_Assessment_Nov_2012.pdf

[12] Davis, Jane, et al. "Forest Restoration and Biomass Utilization for Multiple Benefits: A Case Study from Wallowa County, Oregon." University of Oregon, 2012.

removal of biomass and low value material to reduce wildfire risks and improve forest health and habitat conditions. The value of the materials will return nearly 75% of the cost of the restoration treatments back to the MNF. These returns will be used to accomplish additional restoration work that otherwise may not occur.

The biomass energy cluster in John Day, Oregon receives fuel produced as a result of the stewardship contract on the Malheur National Forest. The four facilities (two schools, a hospital, and an airport) in John Day use about 700 tons of wood pellets annually. Although there are important synergies in this example, it is important to note that the current biomass fuel use in the community is much too small to significantly influence the amount of forest restoration activity that is economically feasible. Based on estimates that one acre of forest restoration yields, on average, the materials needed to produce four tons of dry pellets, it can be suggested that the biomass energy utilization at the four John Day facilities helps support about 175 acres of restoration annually. Given that there are tens of thousands of acres that should be treated each year, it is clear that biomass energy utilization could be occurring at a much larger scale.

In summary, biomass energy projects need to be relatively large to create significant restoration and/or fire mitigation benefits, especially in a western public lands setting. Given the high cost of large wildfires, increasing the scale of treatments for biomass energy utilization could be economically advantageous and provide a productive use for forest residues and small diameter trees that would otherwise be burned in piles on-site after treatments or consumed in wildfires. There are potential net savings to the Forest Service, and direct benefits to the public good, in fostering biomass energy development. Current expenditures could be redirected to realize greater benefit, and financial incentives (e.g., grants or other monetary benefits) can be used to support the implementation of new biomass energy technology. Biomass energy development can also benefit through the expansion of models that include long-term contracts that align with investor expectations. This approach can operate in conjunction with stewardship contracts that include timber removal and where local markets exist for small diameter material. In recent decades, the stewardship contracting authority of the USDA Forest Service has been an important mechanism for accomplishing restoration projects. This authority is currently set to expire at the end of 2013 and should be reconsidered for continuance.

DEVELOPMENT OF THE BIOMASS ENERGY FEASIBILITY MODEL

To better understand how biomass energy could be more widely adopted in the U.S., this project focused on the identification of factors contributing to success or failure of existing biomass energy projects. The project gathered information from 81 biomass energy facilities across the northern region of the United States. In addition, 15 sites were visited for a more in-depth analysis and case studies were developed for 3 clusters totaling 15 facilities in Oregon and Maine (Appendix E). In the latter investigations the primary purpose was to gain an understanding of the financial performance of various systems and to identify opportunities to optimize investment potentials in a model project.

As a result of the interviews, surveys, site visits, case study development and other research, the following key barriers and opportunities related to the wider use of biomass energy systems were identified.

Barriers to widespread adoption of biomass energy systems:

- High upfront capital costs of biomass systems
- Lack of profitability among many biomass energy fuel producers
- Seasonality of heat demand
- Commodity nature of energy production (high competition/low margin)
- High biomass transportation costs
- End-user issues and customer concerns (e.g., Compared to fossil fuel systems, biomass energy systems are viewed as complex technology requiring large facility space, long lead times on supply, bulk delivery, and complex material handling.)
- Unreliable biomass fuel sources and variability in fuel quality
- Lack of harvesting/processing/transportation infrastructure and value-added industries in the Western U.S. compared to the Northeastern U.S.
- Risk adverse operations in the forest products sector and/or interest in maintaining existing methods and technologies
- Uneven playing field in terms of energy policy incentives
- Underdeveloped non-traditional revenues to support biomass energy (e.g., payments for environmental services)

Opportunities for achieving wider use of biomass energy systems:

Address producer needs:

- Replicate models that combine biomass energy production with a sawmill or similar production facilities as a way to improve profitability (e.g., in regions with significant heating seasons, wood products demand in summer may be countercyclical to energy demand in winter)
- Foster further innovation in biomass energy fuel production within traditional lumber facilities, including the rethinking of how, why, and to what end wood products are produced. A new model of softwood lumber production may result that better addresses customer expectations of wood as a source of materials and "fuel" (e.g., modified handing and delivery systems, consistency, maintenance services, etc.).
- Support the continuation and expansion of collaborative planning processes, especially in regards to the western public lands setting, as an essential means of facilitating access to a sustainable biomass supply

Address customer and biomass facility needs:

- Improve how wood energy fuels are transported, delivered and stored. Current systems create significant costs to customers in terms of required storage space and material handling. Innovations in wood energy technologies, including advancements in wood torrefaction and liquid biofuels development, represent a long-term trend to create a more consistent primary combustion material that can be marketed for multiple uses.

Address environmental risks:

- Address regional wildfire risks and other forest health issues. The utilization of woody biomass can help in these efforts. Current approaches to forest fire mitigation and wildlife habitat enhancement activities on public lands in the Western U.S. are expensive. The woody biomass generated by restoration activities is often burned on site with significant environmental costs and without energy recovery. Diverting a portion of current dollars spent in forest fire mitigation and wildlife habitat restoration to biomass energy development could significantly reduce financial barriers to project development. Similar opportunities to connect forest health improvements with biomass energy investments also exist for other public lands as well as private land ownerships.

A key component of the project was to apply the lessons learned from the evaluation of existing facilities to develop a potential model for economically viable wood-to-energy facilities in a western public lands environment. To support development of a model, a financial analysis was carried out focusing on the information provided by the fifteen facilities included in the case studies. Information about non-traditional revenue sources was included in the analysis to understand how they can impact wood energy investments.

Traditional financial analysis metrics were utilized to determine which sites represented favorable (or unfavorable) investments and to identify the factors that can make projects more (or less) financially attractive. The metrics in the analysis provide information that can be used by facility owners and potential wood energy investors to make biomass energy project decisions (see sidebar).

Financial Analysis Metrics

Facility owner perspective

- Internal rate of return
- Simple payback
- Cash flow analysis

Investor perspective

- Return on investment
- Annualized rate of return
- Sensitivity analysis of annualized rate of return

The results of the interviews, site visits and case studies provided insight into the economic factors and financial concerns that are critical to biomass energy adoption and long-term success. The findings illustrated a need to reduce investment uncertainty through the development of additional, practical metrics that analyze the financial viability of biomass projects. As such, one outcome of the analysis was the creation of a tool that can assist in the financial assessment of bioenergy project potential – **the Biomass Investment Multiplier (BIM)**. Because the purchase of a biomass energy system involves a comparative analysis of forecast expenses to determine net benefit (savings), there is an inherent relationship between the displaced energy measured in million British thermal units (MMBTUs)[13] and the economic return on investment by virtually any measure (e.g., annualized rate of return, internal rate of return). This relationship is fairly direct and inverse (see Figure 1, page 23). This relationship is expressed as a ratio comparing dollars

[13] For replacement projects the displaced energy is calculated using previous or recent year's actual volume of energy source used (e.g. oil or propane) converted to MMBTUs. New projects would use volume of the primary competing energy source.

invested to displaced energy and is referred to as the **Biomass Investment Multiplier (BIM)** (see textbox). The lower the BIM ($/MMBTU), the better the investment. Through this analysis a suggested range for BIMs was developed that can act as a guide both to entities seeking to implement biomass energy systems and to investors attempting to define practical investment options. The BIM for a proposed project can be used along with other traditional financial analysis metrics (e.g., IRR or ARR) to inform project investment alternatives. It should be noted that the BIM is just one tool to add to the financial evaluation toolbox, and one that can serve as a good "rule of thumb" to guide discussion.

The Biomass Investment Multiplier (BIM)

BIM = ($ Total project investment)/(Units of Displaced Fuel x Conversion Factor in Btu/unit) x 1 million)

BIM is expressed in $/MMBtu.

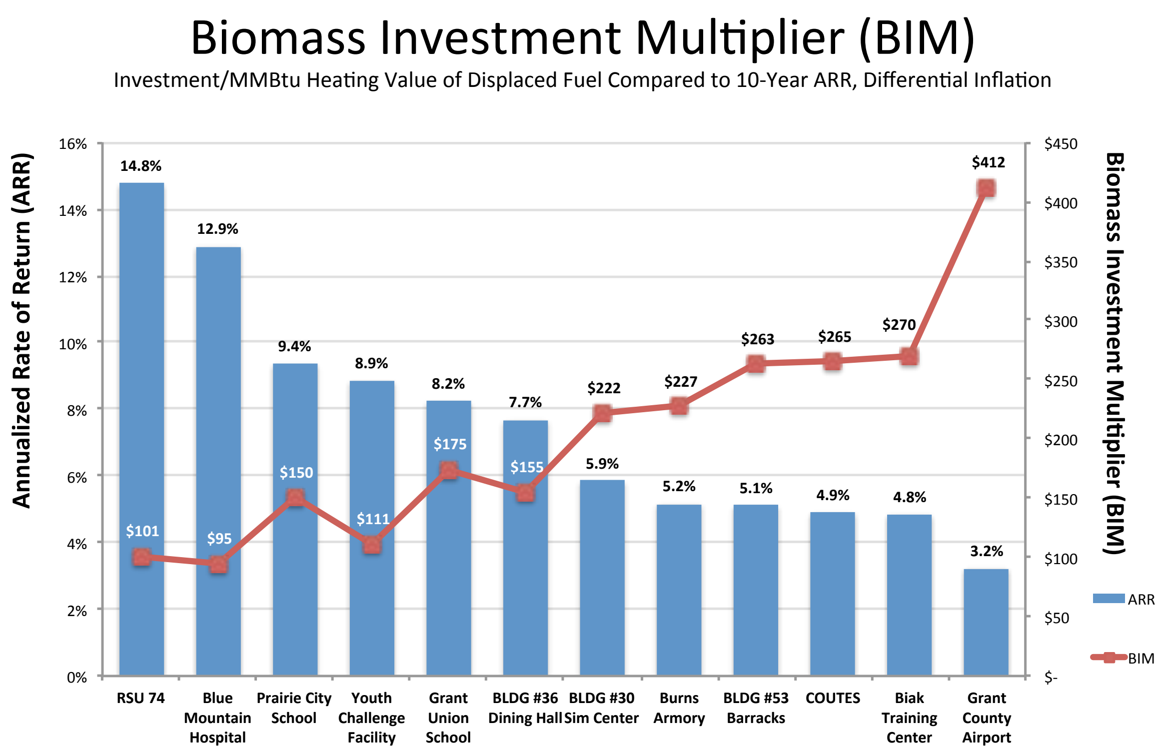
Example Calculation:
($1 million investment)/(44,000 gal of fuel oil x 138,000 Btu/gal) x 1,000,000 = $165/MMBtu

The BIM is calculated by dividing the actual Total Investment in dollars by the actual Current Cost for energy, normalized for energy source by converting to BTUs. The BIM ratio thus represents dollars invested per million BTUs displaced. By selecting a multiplier based on expected return, an investor (including operator) could calculate an acceptable investment amount for a project(s). This also allows an owner-operator to budget a project.

The red line in the graph below (Figure 1) represents the BIM for the facilities analyzed in this project. BIM calculations were also completed for the Maine ARRA study.[14] From the graph below (Figure 1) it can be seen that a BIM of $200 per MMBTU (hereafter BIM of 200) of displaced energy will likely provide a 10-year ARR of greater than 5 percent, assuming that inflation varies by source of energy. In this analysis, inflation rates of 1.5 percent for wood, 5.5 percent for oil, and 5.6 percent for propane and 2.0 percent for electricity were used to calculate long-term impacts on costs.[15]

[14] Data and financial analysis provided by D. Atkins, USDA Forest Service
[15] U.S. Energy Information Administration for all inflation estimates except wood. Wood inflation estimate used for Oregon was provided by local expert Andrew Haden (www.Wisewood.US) and for Maine was provided by the Forest Service (D. Atkins).

Figure 1. Biomass Investment Multiplier (BIM)



Of the 15 facilities subjected to in-depth analysis, 9 were found to have a maximum BIM of 200 (Note: RSU 74 data in Figure 1 is for a cluster of 4 schools). In addition our analysis suggests that with grants (or other forms of financial support) of about 20 percent of the investment costs, five other facilities would also likely meet this threshold. Also evident in Figure 1 is that there are two major groupings of investment potential. Tier one investments would be those with a BIM of 175 or less (anticipated return > 7%), and tier two would have a BIM of 275 or less (anticipated return > 4%).

Using the BIM

Interpretation of the BIM metric is based on certain assumptions of fuel costs, inflation rates and other considerations. If those assumptions change then the interpretation of the BIM must be adjusted as well. In general, based on both this and previous studies, facilities seeking funds for the development of woody biomass energy systems with a BIM less than 100 need the least (if any) additional support in terms of grants and nontraditional revenues and are most likely to appeal to traditional financing methods (e.g., banks). Facilities with a BIM greater than 200 will likely need support in an amount greater than 10% of initial investment costs to be economically viable and attractive to funders. Facilities with BIMs between 100 and 200 likely represent the most attractive option for aggregation and where additional relatively minor levels of support can make a big difference between success and failure.

The BIM can act as a guide to grantors in identifying which projects need the most support (e.g., the $750k project with a BIM of 75 probably doesn't need a $400k grant to get the project financed and the funds may be better used elsewhere). Conversely, outside nontraditional support can play a significant role in bringing BIM values into a viable range. For example, in the Maine ARRA cluster[16] the use of large grants increased the number of facilities with BIMs less than 200 from 10 to 19 (out of 22) making the additional 9 facilities much more viable financial investments and more likely to succeed in the long-term. Some projects in the Western U.S. may warrant large grants and/or creative financing approaches in order to foster the utilization of large volumes of biomass and to economically and environmentally reduce overstocking and the risk of wildfires and other forest health threats.[17]

Discussion of the Model

To evaluate a potential wood-to-energy model three major scenarios were assessed using a baseline set of assumptions (listed below). For each scenario the number of years to positive cash flow was calculated, as were internal rates of return (IRR) at 10, 15, and 25 years. Cash flow for owner/operators was determined by amortizing 4% bond payments over 15 years to generate annual debt expense as a deduction from any savings. Annualized rates of return were also calculated for 10 and 15 years using ROI and 5% discount rate as an indication of attractiveness to investors. Inflation rates of 1.5 percent for wood, 5.5 percent for oil, and 5.6 percent for propane and 2.0 percent electricity were used to calculate long-term impacts on expenses. In this analysis, comparisons were made between biomass versus oil as an energy source, biomass versus propane, and wood versus a hybrid portfolio of 50% propane replacement and 50% oil replacement.

Model Assumptions:

- $25 million investment (for a single facility, group of sites, or bundled projects)
- 10% ($2.5 million) supporting grants, subsidies or other incentives, for a net cost of $22.5 million[18]
- Wood pellets cost assumed at $165/ton current market
- Fuel oil costs were calculated at current cost of $3.36/gal and propane at $2.25/gal
- These alternative fuels (fuel oil and propane) were selected as the most common replacement or competitive option in rural areas of the Western U.S.

Modeled Scenarios:

- BIMs of 200, 175, 150 and 125 (Tables 1, 2);
- Potential impacts of improvements in fuel handling and performance on calculations using the 175 BIM (e.g., adoption of torrefaction or other new technologies) (Table 3); and
- Comparison of the displacement of oil by wood pellets with the inclusion of payments for environmental services (PES) (Table 5).

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[16] American Recovery and Reinvestment Act of 2009 grants supported cluster.

[17] Appendix C includes a description of various creative financing options.

[18] In investment groups or bundles many/most projects will not need support, but the availability of support may make more collaborative efforts possible by allowing inclusion of otherwise low yielding projects.

Results of the Model

Overall, the results of the model and the various scenarios illustrate the potential to design biomass energy systems to fit desired financial performance targets. For example, calculated values in Table 1 show that, biomass energy is likely a good investment for owner/operators as compared against both propane and oil, assuming a BIM of less than 200.

Table 1. Summary of Financial Performance of Western U.S Biomass Energy Production with $25 Million Initial Investment Under Three Scenarios of Fuel Displacement (Oil, Propane, Hybrid) Using a BIM of 175 or 200 ($/MMBTU)

Summary Table 1 Wood Pellets	Oil-200	Prop-200	Hybrid-200	Oil-175	Prop-175	Hybrid-175
Displaced energy MMBTU	112,500	112,500	112,500	128,571	128,571	128,571
BIM ($/MMBTU)	200	200	200	175	175	175
Payback (Years)	11	11	11	10	10	10
Years to Positive Cash Flow	4	4	4	3	2	3
IRR 25 yrs. (%)	12.4%	12.6%	12.5%	13.8%	14.1%	14.0%
IRR 15 yrs. (%)	7.9%	8.2%	8.1%	9.8%	10.1%	10.0%
IRR 10 yrs. (%)	0.9%	1.1%	1.0%	3.2%	3.5%	3.4%
ARR 10 yrs. (%)	7.5%	7.5%	7.5%	8.2%	8.3%	8.3%
ARR 15 yrs. (%)	7.4%	7.5%	7.5%	8.1%	8.2%	8.2%
ARR 10 yr. 5% Disc rate	-2.3%	-2.2%	-2.2%	-1.0%	-0.8%	-0.9%
ARR 15 yr. 5% Disc rate	1.5%	1.6%	1.6%	2.4%	2.6%	2.5%

Table 2 addresses scenarios based on lower BIMs of 150 and 125. Obviously these more restrictive approaches have higher financial returns. At the same time it should be noted that 7 of the 15 facilities included in the case studies would have qualified at the 150 BIM guideline and 6 at a BIM of 125. However, a more restrictive guideline is most likely to eliminate facilities trying to replace, or that are competing against, more competitive fuels. From the evaluation of the first scenario that compares four BIM levels (Tables 1 and 2), it appears that a BIM of 175 on a net investment basis appears to strike a balance between serving the widest number of facilities and still ensuring a fundamentally sound investment.[19] Investment opportunities can also be improved and risks reduced by aggregating a number of projects.

[19] In the Maine ARRA analysis done by D. Atkins 10 facilities would meet the guideline of a BIM of 200 on a total cost basis and 19 on a net owner cost basis. Six facilities based on total cost and 18 on net owner cost would have met the 175 BIM guideline.

Table 2. Summary of Financial Performance of Western U.S Biomass Energy Production with $25 Million Initial Investment Under Three Scenarios of Fuel Displacement (Oil, Propane, Hybrid) Using a BIM of 125 or 150 ($/MMBTU)

Summary Table 2 Wood Pellets	Oil-150	Prop-150	Hybrid-150	Oil-125	Prop-125	Hybrid-125
Displaced energy MMBTU	150,000	150,000	150,000	180,000	180,000	180,000
BIM ($/MMBTU)	150	150	150	125	125	125
Payback (Years)	9	9	9	8	8	8
Years to Positive Cash Flow	1	1	1	1	1	1
IRR 25 yrs. (%)	15.7%	16.0%	15.9%	18.1%	18.4%	18.3%
IRR 15 yrs. (%)	12.1%	12.4%	12.4%	15.1%	15.4%	15.3%
IRR 10 yrs. (%)	6.0%	6.3%	6.2%	9.6%	9.8%	9.8%
ARR 10 yrs. (%)	9.2%	9.3%	9.3%	10.4%	10.5%	10.5%
ARR 15 yrs. (%)	8.9%	9.0%	8.9%	9.8%	9.9%	9.9%
ARR 10 yr. 5% Disc rate	0.5%	0.7%	0.7%	2.4%	2.5%	2.5%
ARR 15 yr. 5% Disc rate	3.5%	3.6%	3.6%	4.7%	4.9%	4.8%

One of the barriers to greater adoption of woody biomass energy is the material capacity and handling systems that are currently required to manage the large volume of woody biomass involved. Also, there are challenges related to the inconsistency of that material (e.g., size, shape, moisture content). Utilizing wood pellets as incorporated here is one of several potential solutions to these challenges. Additionally, wood torrefaction is one of the emerging models growing rapidly in Europe. Wood torrefaction specifically provides at least a partial solution to issues related to material storage and handling as well as concerns about fuel consistency and performance. Wood torrefaction involves the application of heat to produce biomass charcoal in random, pellet, briquette, or similar forms. The torrefied wood is hydrophobic, meaning it doesn't absorb water. It can be transported or stored without being covered and can be used directly for primary combustion. The fuel is also approximately 50% more energy dense than non-torrefied fuels. The use of torrefied wood can significantly increase the consistency and efficiency of biomass energy system, reduce material handling issues and improve planning and design of fuel distribution systems. It is also likely that the cost of production of torrefied wood pellets is competitive with untreated wood pellets. Wood pellets are already being dried and 80% of the heat of torrefaction is recovered heat of drying.[20] Any slight additional costs of processing may be offset by reduced costs of handling and shipping. The use of torrefied wood also increases the potential that distributors will begin to treat the material more as a fuel and less as a commodity wood product.

To the extent that wood energy sources compete with liquid and gas fuel systems (e.g., oil and propane) it is reasonable to anticipate that there will be continued expectations for wood to perform more like these fuels in terms of material handling, storage, energy

[20] Lane, J. 2012. Developing Markets for Wood Pellets and Torrefied Wood, Pt 2. Biofuels Digest, August 13, 2012

production, maintenance and other factors. Although torrefied wood is relatively new in terms of implementation and may or may not turnout to be a significant market trend, it is part of a general trend of moving wood energy utilization along the spectrum from being viewed as a wood product to performing as a biofuel. Perhaps the oldest form of wood energy is firewood or cordwood, and over time wood chips, pellets, torrefied materials, and liquid fuels have been developed to address specific market needs and customer demands.

Torrefied Wood Approach

Torrefied wood offers the opportunity to think about biomass in new ways, namely, more as a fuel and less as a wood product. The potential benefit is that new vendor-customer relationship can be created that are more similar to oil or propane product and service relationships (i.e., just-in-time delivery of fuel rather than bulk delivery, maintenance service contracts, etc). From discussions with current biomass energy system facilities, these changes would likely have a significant impact on material handling and storage costs, an economic factor that was identified as a significant issue for many biomass energy users. Based on these discussions, in the modeling of torrefied wood (Table 3), we assumed a 5% reduction in capital investment, on average, for sites. It is recognized that these benefits and any associated cost savings are likely to be highly variable.

The following comparison (Table 3) looks at the potential for utilizing torrefied wood pellets as feedstock for clusters of biomass energy facilities, as an example of an emerging trend in wood fuel innovation. In current biomass energy systems, facilities using 1 ton per day or less generally have to store two months of material and pay the cost of facility and site work to handle that capacity. Based upon the changes in material handing that could result from the use of torrefied fuels and information about current costs of fuel storage, the model incorporates potential capital cost decreases (herein assumed at 5% per facility) resulting from handling and facility space decreases and increased financial performance due to a more consistent source of energy. It is recognized that this is only a rough estimate of potential savings and that real world impacts could be significantly different and highly variable between sites. As facilities gain more experience with the use of torrefied fuels, it may be possible to more precisely quantify capital cost savings, especially for small or medium sized facilities.

As shown in Table 3, the use of technologies such as torrefied wood that have the potential to reduce capital costs can influence financial performance. The impact is best illustrated by comparing the results shown in Table 1 with Table 3. For example, the estimated 5% reduction in capital costs reduces the number of years to reach positive cash flow from 2 or 3 years down to 1 year.

Table 3. Summary of Financial Performance of Western U.S Biomass Energy Production with $25 Million Initial Investment Under Three Scenarios of Fuel Displacement (Oil, Propane, Hybrid) Using a BIM of 175 ($/MMBTU) and Assuming a 5% Decrease in Capital Costs Due to Handling and Facility Space Efficiencies Associated with Use of Torrefied Wood

Summary Table 3 Torrefied Wood	Oil-175	Prop-175	Hybrid-175
Displaced energy MMBTU	128,571	128,571	128,571
BIM ($/MMBTU)	175	175	175
Payback (Years)	9	9	9
Years to Positive Cash Flow	1	1	1
IRR 25 yrs. (%)	15.5%	15.8%	15.7%
IRR 15 yrs. (%)	12.0%	12.3%	12.2%
IRR 10 yrs. (%)	6.0%	6.3%	6.2%
ARR 10 yrs. (%)	9.2%	9.3%	9.2%
ARR 15 yrs. (%)	8.8%	8.9%	8.8%
ARR 10 yr. 5% Disc rate	0.0%	0.2%	0.1%
ARR 15 yr. 5% Disc rate	3.0%	3.2%	3.1%

The use of torrefied wood (or other new fuel technologies) offers the potential for a producer/distributor to develop more timely (just-in-time) delivery systems and the ability to store torrefied wood in exposed locations without degradation in thermal efficiency due to moisture uptake. Also, the use of torrefied wood potentially increases the "reach" of wood pellet producers by decreasing the BTU cost per mile of transportation. Although this discussion focuses on torrefied wood as a currently emerging technology, it should be noted that many of these additional benefits could be associated with other types of advancements in biofuels production technology.

Modeling Nontraditional Revenue Sources

There are a number of environmental services and co-benefits that can result from the utilization of biomass energy. To the extent that these benefits can be monetized and provide nontraditional revenue sources they can directly affect the value of biomass energy production. Examples of potential benefits and associated economic values are summarized in Table 4 and include carbon benefits, watershed protection and management, wildfire mitigation, and enhanced public health.

Table 4. Summary of Biomass Energy Non-Traditional Revenue Sources and Quantified Potential Impacts

Non-Traditional Revenue Source/Benefit	Quantified Potential Impacts
Employment/Green Jobs	2.13 – 4.9 jobs per MW
General Environmental Services	11.4 ¢/kWh.
General Economic Growth from Biomass Energy Development	$1.50 per dollar spent
General Economic Growth from Forest Restoration	$5.70 per dollar spent.
Reduced Wildfire Risk from Fuel Removals	$600-$1,400 per acre $0.4 million per MW
Reduced Treatment Costs from Biomass Removal *(versus piling and burning)*	$0-600 per acre
Avoided Wildfire Related Costs from Forest Restoration	$1.45 per dollar spent $231 – 481/acre
Avoided Timber Losses due to Fire Risk Reduction	$371-772 per acre
Increased Water Yield value due to Fire Risk Reduction	$83/acre $1.10-$1.50 per dollar spent
Carbon Emission Reductions	$0.01 - $0.26/kWh
Reduced Landfill Waste and Disposal Cost	$66/ton
Tax Base Contribution	$34,900 - $47,200 total tax revenue per year per MW
Pollution/Air Emission Reductions (NOx, SOx)	$0.001-0.02/kWh $14-75/MWh

Data compiled by Dovetail Partners, 2013. For a list of sources, see Appendix D.

In reviewing these potential benefits in the context of arrangements currently in place across the U.S. it appears that payments for benefits associated with watersheds have the greatest potential to positively impact the economics of biomass energy projects. Payments for Environmental Services (PES) for watershed maintenance offer a unique and significant opportunity to foster biomass energy development, reduce restoration costs (e.g., on National Forests), and foster economic development (e.g., jobs) in the western U.S. Today there are roughly 200 cities in 29 countries making payments of over $8 billion annually[21] to ensure healthy watersheds. There are about 67 communities in the United States participating in similar programs, including New York City which pumps over $100 million annually into the Catskills, and Denver, Colorado which has recently partnered with the U.S. Forest Service to fund watershed management in the Rocky Mountains west of the city. These payments can be valued at more than $1,000 per acre annually depending on water rights markets.[22]

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[21] http://www.ecosystemmarketplace.com/pages/dynamic/article.page.php?page_id=9542&section=news_articles&eod=1

[22] Recent data indicates Western water rights markets value an acre-foot at $450 to $650 and these rates have been rising. Investments of $1,000 per acre by the Forest Service or other entities to cut down fire-prone low-quality trees can provide $1,100 to $1,500 worth of increase water yield. See: Poulos, Helen and James Workman. "Our Too Thirsty Forests" Los Angeles Times, 8 May 2012. 29 Jun. 2012 <http://www.latimes.com/news/opinion/commentary/la-oe-workman-kill-trees-save-rivers-20120508,0,7153561.story>.

Another existing market for environmental services is carbon offsets. The impact of carbon offset payments, although beneficial to forest landowners overall, is de minimis when compared to the scale of watershed management payments (<$10/acre for carbon offsets versus $1000 or more per acre for potential watershed payments). In practice, a project may be able to develop multiple nontraditional revenue sources associated with diverse and layered benefits.

The following table (Table 5) shows the results of evaluating a scenario that incorporates Payments for Environmental Services (PES). The modeled scenario assumed 4 tons of wood pellets generated per acre of watershed restoration activities, affecting approximately 1,869 acres annually, and resulting in additional revenues of $1,000 per acre per year, with a 2.3% inflation rate.[23]

The analysis compared:

- Wood used as a replacement for oil with the associated fuel cost savings and using a BIM of 175 (column 1 in Table 5, also included in Table 1 analysis), against
- A financial evaluation of income only using PES funds of $1000 per treated acre without inclusion of annual fuel cost savings (column 2 in Table 5), and to
- The evaluation of a project that receives PES funds (income) of $1000 per treated acre with the inclusion of annual fuel cost savings (column 3 in Table 5)

Table 5. Summary of Financial Performance of a Western U.S Biomass Energy Production with $25 Million Initial Investment Under Three Scenarios: Displacement of Oil, Receipt of PES Funds, and the Combination of the Two, Using a BIM of 175 ($/MMBTU)

Summary Table PES Benefits	Wood vs. Oil-175	PES vs. Oil-175	Both vs. Oil-175
Displaced energy MMBTU	128,571	128,571	128,571
BIM ($/MMBTU)	175	175	175
Payback (Years)	10	25	6
Years to Positive Cash Flow	2	15	1
IRR 25 yrs. (%)	13.8%	0.8%	21.5%
IRR 15 yrs. (%)	9.8%	-6.2%	19.5%
IRR 10 yrs. (%)	3.2%	-15.6%	15.2%
ARR 10 yrs. (%)	8.2%	2.9%	12.1%
ARR 15 yrs. (%)	8.1%	3.0%	10.8%
ARR 10 yr. 5% Disc rate	-1.0%	-12.8%	4.9%
ARR 15 yr. 5% Disc rate	2.4%	-6.4%	6.1%

[23] Assuming net watershed benefit payments increase at a rate consistent with overall inflation of 2.3%.

From Table 5 it can be seen that the addition of payments for environmental services can contribute significantly to the financial attractiveness of a biomass energy investment. In fact, PES funds alone may justify the investment to an owner-operator even if there are no direct savings applied (column 2, Table 5). Although in this analysis the payments are incorporated as a single line item in the model, in reality they could show up dispersed in a number of line items (e.g., direct payments to income, reductions in wood cost, or reduction in other expenses), which would have the same net impact financially. Nontraditional revenue sources could also be applied to reduce initial capital costs. In general, it appears environmental service payments can be a major contributor to the financial viability of a biomass energy project.

Creative Financing Options

In addition to opportunities to incorporate payments for environmental services, existing creative financing options are available that can assist in making biomass energy systems more competitive. These can be divided into some basic categories that differ in terms of the parties involved, qualifications and requirements, and financial structures. A number of examples are summarized below.

Qualified Energy Conservation Bonds (QECBs)[24]

- These are federally subsidized, low interest, long-term qualified tax-credit or direct subsidy bonds (issuers may choose between receiving tax-credits or cash subsidies from US Treasury). These are amongst the lowest cost public financing tools.
- The bonds are available to public entities (local, state government, and tribal governments).
- Private developers do not have access to this financing, but may be able to access these funds through collaboration with a public entity.
- The definition of 'qualified energy conservation projects' is fairly broad, including for example: (1) contains elements relating to energy efficiency capital expenditures in public buildings that reduce energy consumption by at least 20%; (2) green community programs (including loans and grants to implement such programs); (3) renewable energy production; (4) various research and development applications; (5) mass commuting facilities that reduce energy consumption; (6) several types of energy related demonstration projects; and(7) public energy efficiency education campaigns.

Qualified Zone Academy Bonds (QZAB)[25]

- A tax credit bond program providing low or interest-free loans to public schools for building renovations or repairs, equipment purchases, curriculum development, and/or school personnel training.
- Similar to QECBs, rather than receiving interest payments from schools, lenders receive tax credits issued by the federal government.

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[24] "Qualified Energy Conservation Bonds." DSIRE, 2012. <http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US51F>.
[25] "Qualified Zone Academy Bonds." U.S. Department of Education, 2004. <http://www2.ed.gov/programs/qualifiedzone/index.html>.

- There are three criteria that schools must meet to qualify for a QZAB:
    1. "Public schools that are either located in an Empowerment Zone or Enterprise Community or in which at least thirty-five percent of the school's students are eligible for free or reduced-price lunch under the federal lunch program (National School Lunch Act).
    2. Public schools that have an education program designed in cooperation with business and receive a private business contribution that is not less than ten percent of the net present value of the proceeds of the bond.
    3. Public schools that have an education plan that is approved by their school districts and in which students are subject to the same standards and assessments as other students in the district."

Vendor Financed/ Contract Heating[26]

- Cost of equipment is financed through the biomass system vendor either in lease or purchase program (vendor financed)[27]
- Rather than having an owner pay for the large initial capital cost of installing a new heating system, the owner pays for the cost of the "heat" (biomass plus+)
- Contract agreement may be set up to roughly match heating costs (or slightly lower) for other fuels and can be a good option when there is limited access to additional capital or a desire for cost stability. (Basically, you don't save as much in cash flow, but you won't have to lay out the capital)
- Creative approaches include tying payment rates to floating costs of an alternative (generally original) fuel such as oil or propane.
- Prices can be fixed for various terms, e.g. annually or biannually.
- Customer takes ownership of equipment upon complete payoff (e.g., rent to own)

Cooperative Clusters[26]

- Development of a Cooperative business structure where one entity manages the financial arrangements (bonds, financing, expenses, etc) on behalf of the members
- Can create economies of scale and cost savings associated with reduced administration and other redundancies
    - For example, could operate under a district heating co-op concept with a number of smaller buildings concentrated in one area.
    - If a water district or electricity co-op is located in the local area, it might be possible to set up a joint venture with them and utilize their expertise. This would enable, for instance, adaptation of billing systems that they already have in place to the biomass district heating system.

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[26] Information about contract heating was provided by Craig Volz, Tetra Tech in Portland, Oregon.
[27] Information about lender financing was provided by Gerald Brown Assoc., promoting such in Wisconsin. Vendor financing is also a methodology common to solar energy development

New Market Tax Credit (NMTC)[28]

- The NMTC program was created in 2000 "to spur new or increased investments into operating businesses and real estate projects located in low-income communities."
- Can help to attract investment into low-income communities
- Individual and corporate investors receive tax credits in exchange for equity investments in financial institutions (Community Development Entities (CDEs).
- Issued tax credits are equal to thirty-nine percent of the total investment amount.
- The tax credits are claimed over the course of seven years.
- In order to qualify for tax credits under the NMTC program, an organization has to be certified as a CDE by the Fund.[29]

Partnership Flip[30]

- A partnership flip is a creative finance agreement between a renewable energy developer and an investor.
- Goal is to maximize the value of federal tax credits and enhance the economic viability of renewable energy projects.
- Partnership flips first originated in the wind energy industry and were later adapted by solar energy projects.
- They involve partnership between a developer and a tax investor who become co-owners of a project.
- The tax investor makes a large initial investment in the project (e.g. 60-70% of the capital cost) in exchange for a bigger fraction of the income that is generated initially from the project through the federal tax credits or the project's power sales.
- Then, based on an agreement on the rate of return for the tax investor, once a period has passed where all the tax credits and deductions are fully taken, the project's income stream distribution is "flipped" and the developer receives most of the income generated by the project.

FINDINGS AND RECOMMENDATIONS

There is an old saying in the lumber business to the effect that "lumber sales keep the lights on, sawdust makes the profits." The historical interpretation has been that the commodity lumber business is so low margin, that the few dollars the business receives for waste products are critical to profitability. The emerging focus on energy resources and exploration of biomass energy opportunities has the potential to significantly influence this viewpoint. The continued interest in renewable fuels, combined with opportunities for forest restoration and innovations in biofuel technologies (e.g., liquid fuels, torrefied wood, etc.) offer the opportunity for wood products companies to rethink and redesign their

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[28] "New Markets Tax Credit Program." Community Development Financial Institutions Fund, 2013. <http://cdfifund.gov/what_we_do/programs_id.asp?programID=5>.
[29] For more information regarding CDE certification, see: http://cdfifund.gov/what_we_do/programs_id.asp?programID=5
[30] Scharfenberger, Paul. "Developers and Investors Doing "Flips" for Government Tax Incentives: A Discussion of Partnership Flips." NREL, 2010. <https://financere.nrel.gov/finance/content/developers-and-investors-doing-"flips"-government-tax-incentives-discussion-partnership-flip>.

operations to produce new products and serve new markets. There is the potential to foster creative ways of thinking about wood products that can affect profitability and traditional views of commodity-oriented lumbermen. Changes in how wood is viewed as a fuel resource can foster a cash flow, a reduced seasonality, and a new mindset in regard to utilization throughout the product channel that could have broad ramifications for the forest products sector.

A final outcome of the project was the identification of the following major findings and recommendations that can support the further development and performance of biomass fuels and biomass energy facilities. The results are divided into key categories, with discussion of the major challenges and recommendations included for each. Clearly there are situations where challenges and recommendations reach across key categories as well, and these have been identified where appropriate.

Finance Findings

<u>Challenge</u>
Financing the relatively high upfront capital cost of biomass system installations at every scale remains a major barrier to the wider adoption.

<u>Recommendations</u>

1. An era of biomass energy needing incentives via grants is waning and there is an opportunity to move toward full market-based tools. Creative, non-grant financing methods (such as long-term, low interest loans covering the upfront capital cost of projects) can help take the risk out of biomass conversions and increase adoption.
    a. For example, Qualified Zone Academy Bonds (used by some schools in the John Day, Oregon biomass cluster) and Qualified School Construction Bonds (utilized by schools that are part of Maine's Regional School Unit 74) have been effective in helping finance public school conversion projects.
2. Biomass system conversions are more economically viable when facilities have an aging boiler that needs to be replaced. Programs that target these customers have helped increase biomass energy system adoption.
3. It can be more difficult to sell biomass projects to commercial businesses because these private entities may look for shorter payback periods (three to five years); in contrast, public institutions may present a more viable market because they are willing to take on longer financing (ten year paybacks).
    a. Public institutions have also been more successful in getting completed biomass projects versus private entities because they can more easily access bonds financed through taxpayers.
4. More equipment/appliance incentives are needed to increase demand for biomass energy conversions,
    a. The U.S. could follow the European model (e.g. incentives from 25-30% for boiler costs for residential and commercial to spur demand).
5. There is a need to reduce unnecessary and/or redundant feasibility study costs. Key factors such as the cost of alternative fuels (e.g., biomass competes better against propane, oil or electricity than against current natural gas prices), availability of a

local source of biomass fuel, and current heating demands (size of the potential project) are the basic considerations that can determine project feasibility. In many situations, previous investigations have been done that can provide sufficient guidance for a preliminary assessment of feasibility.

Biomass Project Development Practices Findings

Challenge

Many facilities doing replacements work to quickly convert their existing heating systems so they can burn biomass, but they fail to consider and implement other actions concurrently that could help maximize their investment and reduce upfront capital costs.

Recommendations

1. Facilities should consider using a more strategic approach (see textbox) to design and implement biomass energy projects that include consideration of overall energy efficiency improvements.[31]
2. The opportunity to tour and learn from other businesses in similar situations prior to purchasing an energy system is critical to developing customer confidence.

Taking a Strategic Approach to Biomass Energy Projects

- Minimizing capital costs and demand load by implementing energy efficiency improvements.

- Applying the 90/50 Rule for boiler sizing.
This guideline suggests that by designing the system to only meet 50% of peak load the system will likely be sufficient to address 90% of annual demand. *This change in sizing frequently results in being able to use a smaller, less expensive system and operating it more efficiently* (e.g., using more of its operating capacity a greater percentage of the time). The 90/50 rule is most applicable to retro-fit conversions where an old system can serve as the back-up for meeting peak load. Thermal storage systems can also be installed as an alternative to having to maintain two systems and may be more appropriate for new construction. *(Plant, Andrew. "Sizing Your Biomass Boiler to Fit Your Needs." University of Maine, 2010.)*

- Utilizing a modular design.
Using a modular design consisting of numerous smaller units—rather than one large unit—is a design choice that can lead to much higher system efficiencies. By using a modular design, facilities can alter the boiler's demand/capacity based on what is needed at any given time.

- Implementing a collaborative approach across multiple sites and projects that can include standardized design and material reuse. This can also include coordinating engineering and integrating workflows.

[31] For more detailed information about each of these strategies, also see the RSU 74 case study, Appendix E.

Aggregated and Clustered Project Development Findings

Challenge

Many individual biomass energy projects are below the multi-million dollar threshold that private capital investors are looking for, limiting significant investment in bioenergy opportunities.[32]

Recommendations

1. New models for project development, such as project bundling, are needed to reach this investment threshold and help biomass energy come to scale.
2. There are advantages to utilizing a geographically clustered model *(where biomass fuel manufacturers and markets are in close proximity to one another)* or a project aggregation approach *(where multiple biomass projects are carried out under the same financial bundle).*
    a. Project aggregation of multiple smaller biomass projects under the same financial bundle can lower transaction costs associated with financing, achieve economies of scale, and increase attractiveness of biomass projects to lenders when compared to financing individual projects.
    b. Geographical biomass clusters can improve delivery efficiencies by minimizing fuel transportation distances.
    c. Geographic biomass clusters provide opportunities for cooperative agreements (e.g. purchasing), and non-traditional revenue gains.
3. Further reviews of biomass energy cluster opportunities could be constructive and funds or assistance could be targeted to support the early development needs of projects.
    a. The state of Oregon is in the first stages of doing this in cooperation with the USDA Forest Service and the Bureau of Land Management. Oregon recently introduced a grant to support the Wood Energy Cluster Pilot Project in collaboration with the USDA Forest Service to support "small clusters of projects that compliment current forest restoration activities."
    b. Appropriate metrics should be developed and applied to measure the advantages and disadvantages of projects that utilize these new approaches to biomass development.
        i. The biomass investment multiplier outlined in the body of this report can assist in the review and development of clusters.

Biomass Technology Findings

Challenge

The limited range of biomass energy systems available, lack of standardization, lack of comparative data on various biomass systems, and minimal understanding of such systems (as compared to traditional systems) by the design community are limitations with current U.S. biomass technologies, which prevent wider adoption and cause economic opportunities associated with biomass systems to be overlooked.

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[32] For more details regarding biomass project aggregation and clustered development (including benefits and drawbacks), see the RSU 74, John Day, and Oregon National Guard case studies, Appendix D).

Recommendations

1. Investment to facilitate development of new, lower-cost, standardized biomass energy systems should be a priority as the current costs are out of line with the competition. There is a need to provide lower costs along with the convenience of traditional fuel heating systems
    a. Investment in biomass system development could be guided by following best practices used in the design of European biomass system technology and examining why customers choose to import European systems (e.g., identify the weaknesses and examine how they could be cost effectively addressed to better meet consumer needs). Improvements to automation, efficiency, and user-friendliness are key.
2. More attention should be paid to increasing market education about biomass thermal energy systems and their applications, operation, and technical and economic feasibility.
    a. A "Consumer Reports" [33] style guide that compares currently available biomass systems (e.g., repair and maintenance track records, ease of use, features) could help address some consumer uncertainty.
    b. A trade network (providing a listing of qualified biomass system contractors, distributors and other professionals) could be developed and made easily accessible to potential consumers.
    c. Biomass information campaigns could be implemented to help bolster consumer confidence.

Biomass Fuel Competitiveness Findings

Challenge

Biomass is not competitive with some competing fuels, including current natural gas prices.

Recommendations

1. Biomass project investments should focus on areas that are dependent on propane, electricity, and heating oil.
    a. Biomass fuel is currently most likely to provide a cheaper alternative in regions that are dependent on propane, heating oil, or electricity to meet their heating needs.
    b. Biomass can save facilities twenty-five to fifty percent in annual heating costs for those sites that are dependent on heating oil or propane and do not have access to natural gas.
2. There is a strategic opportunity to apply the use of biomass fuels where they offer the greatest benefits, including the potential to reduce consumption and extend supplies of non-renewable energy resources.
    a. For example, using biomass to provide thermal energy creates an opportunity to move people away from fuel oil, freeing up this expensive, non-renewable fuel resource so that it can be refined for other purposes such as transportation.

[33] E.g. www.ConsumerReports.org

Fuel Supply Findings

<u>Challenge</u>

Biomass fuel supply issues are especially prominent in the Western U.S. given the abundance of public lands and the barriers to gaining access to fuel in this environment.

<u>Recommendations</u>

1. For biomass facility conversions to be successful, it is critical that sites have access to biomass supply that is nearby, sustainable, and can meet long-term needs.
2. It is valuable to have multiple sources of biomass fuel to help guard against fuel interruptions.
3. Collaborations centered on National Forests with Stewardship Contracting Authority and restoration activities represent a best practice most relevant to public lands in the Western U.S. and can help provide a sustainable biomass fuel supply for users. One of the major benefits of National Forest collaborations, like the one centered on the Malheur National Forest, is that they can help prevent litigation that can bring forest management activities on federal lands to a standstill.
4. There is a need to build the capacity of collaborative groups in the West so that they can continue their work and help make bioenergy fuel access self-sustaining while addressing forest health and wildfire risk concerns. In Oregon, collaborative groups like Blue Mountain Forest Partners are not well funded, and this is a limiting factor in carrying out forest restoration activities.
5. The Forest Service's funding for restoration activities is lagging behind collaborative proposals, representing another major limiting factor.
6. The Coordinated Resource Offering Protocol (CROP) online mapping tool can be utilized to assess federal forest biomass supply feasibility in Western public forestlands.

Fuel Delivery Findings

<u>Challenge</u>

Current biomass fuel business models are based on commodity forest products models rather than traditional energy service models, and as a result are not customer-oriented and lead to high storage and handling costs on the part of the user.

<u>Recommendations</u>

1. There is a need for new fuel distribution methods/models that are more customer-oriented (e.g., selling convenience) while also being profitable for distributors.
    - For example, biomass fuel distributors could learn from the experience of U.S. heating oil and propane distributors and/or from the European/Austrian model of bulk delivery for successful best practices and models that could be emulated.
2. There are potential significant changes that could be made in the current biomass fuel distribution business models that could result in large savings or greater returns, depending upon the perspective (user versus supplier).
    - For example, a biomass user (e.g., a school) may be willing to pay (or forego fuel cost savings) more per year to reduce risk and increase confidence in the

system with expanded services (quicker response from the supplier, assistance with waste management/ash disposal, routine maintenance oversight or review, etc).

3. The ability to provide more frequent, near "just in time" deliveries of biomass could reduce the capital costs of storage and increase customer satisfaction. More creative, customer-oriented approaches to distribution could increase profitability.
4. Bulk fuel delivery infrastructure represents a challenge and a significant barrier to entry, especially with regards to advanced pneumatic delivery trucks, which have a high capital cost and low/long return on investment. Finding ways to make the delivery cost of pellets competitive with that of an oil or propane delivery process through new equipment/trucks or new methods could help facilitate the transition to bulk delivery.
5. Lack of sufficient bulk fuel customers and low market density create a disincentive for investment in bulk fuel distribution systems as well. At the same time, lack of bulk fuel infrastructure means that the market for biomass systems requiring bulk fuel deliveries cannot be established. Significant growth potential in the bulk delivery industry lies in the central heating business and finding larger, commercial scale customers.
    - Year-round demand for fuel could be achieved if biomass fuel companies could transition into markets with multiple demands for energy including electricity, central heating systems, domestic hot water demand, or markets with large industrial processes.
6. Clustered biomass facilities that are in close proximity to a biomass fuel producer could improve delivery efficiencies by minimizing fuel transportation distances.
7. Aggregating buyers who are located in the same area and charging enough per ton to make deliveries over long distances feasible are two key best practices of successful bulk delivery companies.

Biomass Energy Co-Benefits Findings

<u>Challenge</u>

Upfront capital costs and project financing present significant hurdles to the expansion of biomass energy. There are co-benefits (environmental services and public benefits) associated with biomass energy that are not being captured as part of its overall value.

<u>Recommendations</u>

1. There are significant co-benefits associated with biomass beyond simply using it to produce energy.[34]
    a. Creating value and demand for biomass products can lead to economic benefits in timber-reliant communities (employment creation and local spending) in addition to other environmental benefits (reductions in wildfire threat, air pollution avoidance, improved forest health, and utilization of harvested forest residuals that would otherwise be burned in piles). Some of these benefits have existing or emerging markets associated with them (e.g.,

[34] For a summary of some of the quantified co-benefits of biomass energy, see Table 4.

carbon offset markets) and can impact the financial performance of a biomass investment.

2. More work is needed to quantify, monetize, and receive economic gains from the co-benefits of biomass energy (e.g. carbon offset programs, ecosystem payments, habitat restoration).

Policy Findings

Challenge

Public policies and incentives currently being used for biomass energy development are behind the curve. Currently woody biomass does not receive as much favorable policy support when compared to other renewables like solar and wind. Current policies and incentives do not fully recognize (or match) the technology, capabilities, and opportunities associated with biomass utilization and are driving people to other systems.

Recommendations

1. Public policies and renewable energy incentives should be effectively communicated, lobbied for, and adopted to better internalize the co-benefits of biomass utilization, reflect the total value of biomass energy, help level the playing field with other renewable technologies, and promote its wider adoption.
2. Biomass energy should be elevated to the same tier as solar and wind technologies under state renewable portfolio standards programs
3. Equipment incentives could be used to further spur demand for biomass energy systems and can be informed by successful model incentives, including well-established programs in Europe (e.g., incentives in the form of 25-30% reimbursement for boiler costs in specific types of residential and commercial applications).
4. Thermal renewable energy certificates should be adopted and include recognition for small-scale facilities.
5. Policymakers in the U.S. should investigate and consider the biomass policies and incentives that have been adopted in several European nations, including the Austrian model of biomass development.[35] Austria has provided long-term state policy support (consisting of financial incentives, legislation, and promotional activities) for biomass heating that targets specific market segments.
    - Legal Measures: Emissions and efficiency standardization, fuel requirements, renewable heating mandates, minimum requirements for heating and cooling. These measures have helped facilitate the development of more efficient biomass heating systems.
    - Financial Measures: Investment grants, contracting programs, regional research and development, and demonstration projects have all been used to support biomass energy systems. Investment grants have been used for the purchase of biomass boilers and to connect facilities to district heating systems.

[35] See, "Biomass Heating in Upper Austria", available at: http://www.oec.at/fileadmin/redakteure/ESV/Info_und_Service/Publikationen/Biomass_heating_2010.pdf

- Information and Training: Energy advice; training and education programs; publications, campaigns, and competitions; local energy action plans; and sustainable energy business networks have helped boost consumer confidence in biomass technologies.

6. Biomass fuel standards should be adopted. There is a need to know what feedstocks work for producing biomass fuels and provide a consistently high quality fuel supply. Fuel standards address producer concerns and improve consumer confidence.
7. Allowing biomass project developers to utilize diverse business and profit sharing structures (e.g., Real Estate Investment Trusts (REITs) or Master Limited Partnerships (MLPs)) could make biomass investments more competitive.
8. A more standardized, universal definition of what constitutes "biomass" should be adopted. The lack of standardization has led to a similar lack of consistency in biomass eligibility in policy incentives (e.g., renewable energy portfolios, renewable energy credits, etc) and what sources of material constitute biomass and can be removed from public and private lands.

Noteworthy Regional Differences Findings

<u>Challenge</u>

There are significant regional differences in biomass energy opportunities. In general, the barriers are similar, but they can vary in scope and scale. The available solutions and opportunities also vary in relationship to local capacities and available resources. In many ways biomass energy is "local energy" and system design needs to address local considerations.

<u>Recommendations</u>

1. The regional issues associated with private land prominence in the Northeast versus the issues related to public land dominance in the Western U.S. are very important (especially in regards to access to long-term, sustainable biomass supply).
    a. Harvesting activities on private forestland tend to shift in arcs according to markets. When markets drop off, private landowners are more reluctant to sell and activity decreases. However, so long as markets are sufficient, the mosaic of private landowners in the East can provide a more continuous flow of materials to the marketplace than the situation in the West (For example, there may be dozens of private woodland owners in a supply area and in any given year many of them may be willing to harvest. Whereas in the West, a public agency may represent the vast majority of forestland and if that one land manager is unwilling or unable to harvest, there are no readily available alternative suppliers.)
    b. Activity on National Forests tends to be more consistent where the same harvesting levels are maintained from year to year and more independent of market fluctuations. Public lands can be contested, however, which can bring activities to a complete standstill.

2. A greater capacity of existing infrastructure is already in place for biomass facilities in the Northeast due to the region's reliance on oil and since the region has also historically been dependent on forest-sector activities. This region also has not experienced the same degree of harvesting curtailment and industry declines as the West has in recent decades.
    a. Available harvesting infrastructure and value-added industries to support transportation costs are of key importance in biomass energy's success.
    b. According to one of the biomass experts we interviewed, "A lack of available timber sales, harvesting infrastructure, and a non-existent value-added industry to support the wood energy value chain are the gaps and barriers in the Western U.S."
3. Biomass systems are designed for the specific types of wood and woody materials that are available regionally and issues can arise when the systems are used in another location with different wood characteristics.
4. Wildfire threat, and the role biomass energy can play in mitigating the threat, is much larger in the Western U.S. compared to the Northeast.

SUMMARY

Based on interviews, survey results, site visits, case study development, and a financial analysis that involved biomass energy facilities across the United States, a number of barriers to wider adoption of biomass energy production in the U.S., and in the western U.S. in particular, were identified. Recognition that economic factors and financial concerns on the part of potential purchasers and investors are critical elements in biomass energy adoption and long-term success led to close examination of the economics of biomass energy production. The result was the development of the Biomass Investment Multiplier (BIM) as an additional tool for use in economic assessment of bioenergy project potential. This, in turn, was used to evaluate a number of model scenarios in which biomass energy was compared with more traditional energy sources. This evaluation illustrated how biomass energy investments compare with alternatives and opportunities to design financially competitive biomass energy systems. The availability of payments for environmental services can contribute to improving the financial performance of associated biomass energy systems. Applying biomass energy development as a more economically efficient wildfire risk reduction activity could provide opportunities to access non-traditional revenue sources.

The production of energy using a renewable material such as wood can have positive impacts on all three legs of the sustainability stool - society, the economy, and the environment. Biomass energy development has the potential to foster economic development, address wildfires and associated risks and costs, and reduce dependence on fossil fuels. There are critical strategic, organizational, and financial issues that need to be addressed in order to realize the considerable potential of biomass energy. First and foremost, biomass energy needs to become an attractive and financially viable investment alternative. This can be aided by strategically applying a wide array of market-based, as well as incentive and grant-based financial tools.

Appendix A. Interview Results

Introduction

Opportunities and Barriers Highlighted by Biomass Expert Interviews

During mid-July 2012, Dovetail Partners conducted interviews of biomass experts representing various fields and located in different geographical regions of the U.S. The goal of the interviews was to quickly gather useful information in order to advance the main project goals as follows

- Identify the primary gaps and barriers to larger scale, clustered bioenergy growth.
- Determine economic factors critical to success of biomass projects
- Define public/private collaborative approaches to enhancing viability of biomass projects, and
- Ascertain critical errors that the biomass industry should learn from and avoid. Below is a summary of interview results.

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Primary Gaps and Barriers to Larger-Scale, Clustered Bioenergy Growth

Interview Question: What are the primary gaps/barriers that need to be addressed to help biomass facilities move beyond demonstration projects at institutions and into the scale of operations (i.e., clusters) that address bulk-delivery and production systems that require larger scales?

Overview of Findings

The main barriers and recommended solutions that were most frequently identified by interviewees are related to project financing, policies/incentives, fuel supply, and a lack of understanding regarding biomass and related technology.

Gaps and Barriers: Funding/Financing

- Barrier - For many schools and public institutions, funding is a main roadblock. It is less expensive to put in a propane or oil system.
- Potential Solution - Schools need a revolving fund to pay for biomass project investments to help fund these projects (even if it covers around 50% of the costs).

- Barrier - The comparatively high capital cost of system installations remains the primary hurdle. Bulk fuel delivery infrastructure represents another challenge and a significant barrier to entry–especially for advanced pneumatic delivery trucks (high capital cost and low/long return on investment).
- Potential Solution - Costs will come down as the market scales up, as more vendors get into the market and bring greater competition, and when creative financing options are utilized.

- Barrier - Consumer financing is a major barrier. Resident level, oil boilers cost about $8,000 to install whereas pellet boilers cost around $20,000. Up front capital is a big issue and there is a lack of incentive to help finance this. Finance is not as much an issue in the commercial arena, but perception and a lack of understanding are challenges.

- Barrier - Up-front capitalization presents economic challenges for projects. Biomass energy systems are more capital intensive than traditional fuels (i.e., heating oil and natural gas), and the relatively small market penetration has prevented the industry from achieving economies of scale. Biomass energy systems may have lower annual operating costs which will lead to significant energy savings on an annual basis, but the owners of systems may expect a shorter payback than can be achieved without low interest financing.

- Barrier - Capital costs are the main barrier. How are people going to pay for the big upfront costs despite the long-term gains? There is a lot of uncertainty surrounding the payback periods associated with biomass energy systems. Any time there is uncertainty like this, it becomes more difficult to justify the investment to the public and private interests to install biomass systems.

- Barrier - Finance is a huge issue—especially for small facilities. Large biomass projects never pencil out in the West.
- Potential Solution – A more integrated focus is needed. The focus should be more on facilities that integrate value-added manufacturing and wood products with energy utilization. You need to add value with low value wood. It is important to consider how heat could be utilized with electricity generation.

- Barrier - It is all about the numbers. The cost of a biomass furnace is a barrier for anyone who lives from car lease payment to car lease payment. Biomass has no near-term future anywhere that has close access to natural gas. There are no companies in the biomass energy sphere [that the interviewee can think of] who are making money right now; this is all being developed on a hope and a prayer.
- Potential Solution - When more Americans get in the habit of saving, then biomass heat will be successful at sites that are dependent on fuel oil or electricity for heat. Until that happens, biomass will not experience much growth.

- Barrier - Intermediate financing is a primary challenge (i.e., getting over the "valley of death").

Gaps and Barriers: Policy

- Barrier - Transportation subsidies are not a good pull for building additional capacity because they do not seem to create additional utilization.
- Potential Solution - A lot more attention needs to be paid to where incentives are placed in the supply chain.

- Barrier - At least for the next few years (even if we're talking about something like a carbon tax), the old model of subsidizing or incentivizing renewables with the tens of billions of dollars necessary to make them competitive with fossil fuels is dead.
- Potential Solution - Until there is a national energy policy, there is not going to be much capital flowing in the direction of biomass businesses other than perhaps organizations with the most promising routes to drop-in biofuels.

- Barrier - Existing policies or incentives may drive decision makers to other systems. The U.S. does not have a coherent biomass energy policy and many existing incentives drive projects toward electricity or fuel production. Additionally, the biomass industry is not solidified enough to lobby for a coherent policy. It is difficult for the biomass industry to state that these systems save money and are economical while (at the same time) saying they need additional incentives.

- Barrier - Woody biomass is not treated on par with other renewable energy sources from the standpoint of renewable energy portfolio standards and credits.

- Barrier - Permitting, even on smaller units, can be a barrier. There is a hesitancy to push through permits on newer biomass tech technologies such as torrefaction.

Gaps and Barriers: Fuel Supply

- Barrier - Natural gas accessibility and prices act as barriers to biomass development.
- Potential Solution - Areas with high-heating-need-days and use of propane and oil heating are prime areas for biomass expansion. With clear programmatic support, access to study tours, and technical expertise, these areas could successfully develop biomass energy markets similar to those in Vermont.

- Barrier - A lack of available timber sales, harvesting infrastructure, and a non-existent value-added industry to support the wood energy value chain are primary gaps and barriers in the Western U.S.

- Barrier - In the West, barriers to biomass development include the dominance of federal land and the problem with accessing it. Access to material is a bureaucratic nightmare; getting contracts to access a biomass supply is the biggest issue in the Western U.S.

Gaps and Barriers: Lack of Understanding

- Barrier - There is a lack of understanding regarding biomass energy systems within the design community (i.e., architects, project developers). These people generally are more familiar with traditional energy systems (i.e., heating oil, natural gas, solar) and do not have good information or experience regarding how to carry out biomass projects.

- Barrier - Consumers (residential, building operators, commercial building owners) may not understand biomass systems from an economic or technical perspective and may be intimidated by the operational differences (or perceived differences) of these systems.

- Barrier - There are issues related to public perception and a lack of understanding of biomass technology. Generally, wood is perceived as an old technology, cooling water vapor is mistaken for smoke, and carbon neutrality is debated. Trade barriers have hindered the availability of superior European technology.

- Barrier - There is a basic marketing/public outreach and education challenge with widespread public ignorance about utilizing advanced wood combustion systems as a heating alternative. The biomass industry is still small and not yet in a position to fund comprehensive marketing initiatives.

Gaps and Barriers: Other

- Barrier - There are three primary obstacles to biomass development—particularly for smaller-scale projects at community facilities like schools or hospitals:
    1. Understanding the fuel source: wood supply/availability/reliability, cost, history of cost, etc.
    2. Understanding the technology.
    3. Financing: how to pay for the conversion, what sources of capital are available for conversion, cost-benefit analyses, etc.

- Barrier - There seems to be great concern about competition for wood fiber. For example, paper company representatives express concern about competing for fiber with pellet producers.
- Potential Solution - It comes down to getting comfortable with the technology and fuel source, transaction costs, and the ultimate financial benefit to the facilities. This may not be as much of a problem in the West where overstocked lands are more prevalent.

- Barrier - The range of system sizes and applications currently on the market may not be able to meet all user needs. An increasing number of systems are manufactured in the US or imported from Europe, but the market penetration is minimal.

- Barrier - Risk is a primary barrier.
- Potential Solution - An attempt to mitigate risk could be made through information sharing and public support. Because biomass is heavily used in public institutions, fostering public awareness and growing support of biomass utilization is critical.

Key Economic Factors Determining the Success of Biomass Projects

Interview Question: What do you believe are the critical economic factors determining the success of a woody biomass project?

Overview of Findings

The main economic factors that the interviewees identified are related to fuel supply, alternative energy costs/supply, financing, infrastructure, and policy.

Key Economic Factors: Fuel Supply

- Successful projects need a reliable and consistently high quality fuel supply

- There are a number of key economic factors:
    1. The fuel supply should come from within 30 to 50 miles.
    2. The price for whole tree chips should be between $25 and $35.
    3. The price for bole chips should be between $45 and $65.
    4. Interest rates should be below 6% and/or grants should be made available.

5. Institution scale projects benefit from the existence of a network of larger chip consumers.

- 20,000 tons of fuel annually is the threshold of aggregated demand needed to anchor fuel supply as a primary business.

- Fuel costs and the ability to provide savings or become cost neutral are important. Biomass cannot compete against natural gas at the moment.

- Location is key in terms of the availability of alternative resources and also in regards to having access to an affordable supply of biomass fuels.

- Intermediate to long-term feedstock procurement and off-take agreements are two important economic factors.

- A sufficient supply of wood within a reasonable distance that can be sustainably managed and harvested are important considerations.

Key Economic Factors: Alternative Energy Fuel Costs/Supply

- The type of fuel being replaced is a primary economic consideration.
    - If a facility is using oil or propane, then biomass has a much better chance of succeeding.

- From the standpoint of feasibility, how biomass systems stack up against other fuel options should be examined.
    - If a site has access to natural gas, then biomass probably is not a good option, but much of the NE region is using oil or propane, which is much more viable for biomass utilization.

- Significant operating (heat) cost savings relative to conventional fossil heating fuels is a key factor.

Key Economic Factors: Financing

- Financing the upfront cost of biomass conversions is a key factor, which is true regardless of scale.
    - For institutional projects, upfront financing can be a problem, but public institutions have been more successful because they can easily get access to bonds financed through taxpayers.

- Determining if the project can be done with an acceptable payback or ROI without subsidy is an important consideration.
    - Subsidies would be helpful, but it is easier to sell a project if you can make the case without them.

- Projects need a reasonable investment horizon or payback expectations.

- Having access to capital and a small level of cost share incentive is important.

Key Economic Factors: Infrastructure

- One of the critical factors in the Northeast is that they already have infrastructure in place for biomass facilities since, for better or worse, they have been very dependent for a long time on the forest (surrounded by forest) and wood industry.

- Available harvesting infrastructure, value-added industries to support transportation costs, and high cost fossil fuels compared to delivered woody biomass costs are all key.

Key Economic Factors: Policy

- A more even playing field should be created where environmental benefits of biomass are recognized/internalized versus fossil fuels.
    - Policy drivers and incentives are needed to drive the purchase of renewable energy because people will just go with cheap fossil fuels otherwise.

Key Economic Factors: Other

- The three most important questions determining biomass viability are:
    1. Are you located near a natural gas pipeline? If answered yes, then biomass is not a good option. Biomass cannot compete against cheap, available natural gas. Biomass is just not as competitive alongside other renewables. If a site's next best fuel option is propane, oil, or electricity, then there is a possibility that biomass would be a good option.
    2. Do you have a local source of wood fuel supply? If answered no, then biomass is not a good option.
    3. Is your annual electricity/heating bill greater than roughly $100,000? If answered no, then biomass is not a good option. If your bill is not greater than $100,000, then it generally doesn't make economic sense to install a biomass system because the savings won't be sufficient to offset the costs of installing and operating the system. A building(s) needs to be big enough in scale for biomass to be a good option.

- There needs to be a clear connection between using wood bioenergy and the quality and integrity of forest management necessary to source the fuel in a sustainable manner, with additional clear connections to local jobs and opportunity.

- Should find a project champion and committed project supporters that can shepherd a project through the development and operational phases.

Public/Private Collaborative Approaches to Increase the Viability of Bioenergy Projects

Interview Question: What are some approaches that the private and public sectors could use to collaborate to increase the viability of bioenergy projects (e.g. stewardship projects)?

Overview of Findings

The main approaches that experts suggested that private and public sectors could collaborate on to increase the viability of bioenergy projects are related to aggregated/clustered collaboration, fuel supply collaboration, policy incentives, and consumer education.

Collaborative Approaches: Aggregated/Clustered Development

- Aggregation or bundling of smaller projects may be necessary to attract investors. Larger district heating projects have bigger price tags but often have lower rates of return than smaller heating projects.
  - The majority of projects are below the $25 million threshold that most private capital investors look for.

- Almost all projects have a private/public relationship, but this needs to happen at a bigger/aggregated scale where buildings are combined together in one investment.

- A robust inventory of cluster opportunities should be made and targeted funds or assistance provided in order to help support the early development needs of projects.
  - The state of Oregon is beginning a project to do this in cooperation with the Forest Service and Bureau of Land Management.

- Projects could be aggregated together to lower the transaction costs associated with accessing financing.
  - A larger pool of projects and funds would be more attractive to lenders and would lower the overall risk versus trying to fund single projects one at a time.

- Locate biomass energy facilities at underutilized business/industrial parks or downtown districts to supply electricity, heat, cooling, and process steam (mimic European community heating districts).

- In regards to the utilization and development side of things, county lands could be used as an industrial site for a facility. County level equity could be used for financing opportunities.

- New financial models should be developed rather than using building owner owned and financed or energy savings performance contracting approaches.

    - For example, models could be developed to lease a heating system or purchase biomass energy while a third party owns and operates the system.

Collaborative Approaches: Fuel Supply

- On the harvesting side, perhaps public and private landowners could help by providing longer-term contracts to loggers.
    - This could help loggers invest in the type of equipment required to harvest biomass material.

- Major land managing agencies (e.g. Forest Service, Bureau of Land Management) should commit to a major initiative to replace fossil heating systems with biomass heating systems in their thousands of facilities across the country.
    - In other words, leading by example. The Forest Service could devote more resources within its National Biofuels Strategy to advance demonstration projects throughout Forest Service facilities. The Forest Service's leadership could eventually be extended to all federal agencies with facilities providing heat and power, especially in rural areas with access to biomass feedstocks for fuel.

- On the supply side, if you do not have collaboration through restoration activities, then you do not have supply.

- A system could be developed that matches people who need the heat with people that want to develop systems (i.e. matching people who have technical expertise with people who need to utilize it; like a biomass industry "dating system").

Collaborative Approaches: Policy Incentives

- Public policy can play a critical role.
    - For example, public policy strategies might include: tax credits for purchase of highly efficient boilers or renewable energy more generally; renewable energy credits; use things like PACE loan programs and their other programs to support more efficient energy sources; loan programs (some existing but maybe tailored new ones) to support further development of the entire wood-to-energy value chain; or other tools to support conversion.

- Develop a public awareness/marketing campaign focused on job creation/economic opportunity, local wealth retention and energy security from reduced fossil fuel imports, and connection to forest health and rural communities.

- Support the development of Biomass Renewable Energy Credits.

- Develop financial support systems for wood energy like solar and wind energy systems.

Collaborative Approaches: Consumer Education

- More attention should be paid to increasing consumer education about biomass energy systems and applications, operations, and technical/economic feasibility. A trade network could be developed that is readily available to potential consumers.

Critical Errors that the Biomass Industry Should Learn From and Avoid

Interview Question: What are some critical errors that the biomass industry as a whole can learn from and avoid in the future? Specific cases that could we could look into?

Overview of Findings

The primary critical errors that the experts identified include specific biomass projects examples, large-scale biomass electricity, system planning and design, policy actions, missed collaborative opportunities, and perception molding.

Critical Errors: Specific Biomass Project Errors

- According to the interviewee, the Jemez Mountain School in Galina, New Mexico was a "horrible project" that killed the expansion of wood energy in New Mexico for several years. The project was bad for a number of reasons. The Nederland, Colorado project also comes to mind as a failed project.

- Additional project failures, according to the interviewee, that can be learned from are as follows: First Energy plans to convert a 100 MW power station in southern Ohio from coal to wood. Dominion Energy plans to develop over 263 MW of new power generation capacity in Virginia over the next 5-10 years based on wood costs of $25/green ton. Failure of the University of South Carolina wood energy system installation by Johnson Controls, Inc.

Critical Errors: Large-Scale Biomass Electricity

- Large-scale electricity biomass plants should be avoided.
    - They "scare environmental groups" and can create a downward spiral of publicity/support.

- The idea that people can pursue the stand-alone electrical facilities is false.
    - These facilities do not work in the west/northwest. Should instead promote an integrated system approach to biomass development/expansion.

Critical Errors: System Planning and Design

- Do not cut corners and try to save money on sophisticated machinery and engineering.
    - Spend more capital to build it right the first time in order to save on operating expense down the line. Pay very careful attention regarding safety and quality. There have been some projects that have been oversold or people have been scammed (for example, there was a school that bought a very high quality boiler, but then could not get the necessary biomass supply

with the right moisture content to feed it within a reasonable fuel supply radius).

- Know your market before you build. Do a complete market analysis and know where you are going to sell your product before starting a project.
    - Too many plants have been built and failed because of a lack of viable markets, simply because the project developers (and their financial backers) did not do thorough research regarding the market. Know your wood supply. Too many project developers get into biomass without a clear understanding of the true cost and unique challenges of sourcing woody biomass.

- There is a great need to reduce unnecessary feasibility study costs.
    - There are many projects where it does not make sense to perform a feasibility study, but communities invest in them anyway and waste their money just to have someone say that a project is not feasible. Feasibility studies generally cost around $50,000 to complete.

Critical Errors: Policy

- Do not fight OSHA and air regulators. Accept the stringent expectations of regulators and go the extra mile to comply. You will save money in the long run.

- The debate surrounding the carbon impacts (i.e. the carbon neutrality) of biomass use is damaging.

- While public support is critical to the development of renewable energy resources, the biomass industry has probably relied too heavily on public subsidies when there is probably often a straightforward economic argument.

Critical Errors: Missed Collaborative Opportunities

- Invest as a company in collective efforts to grow the market and the industry. Do not wait for the other guy to do it. Recognize the importance of trade organizations and collaborative problem-solving and market development.

- There is an error on Forest Service's side expecting biomass companies to start up without a guaranteed supply.

- There have been missed opportunities to make a case, raise awareness, and increase public engagement.
    - Many people are just trying to run a pellet plant and not trying to transform the industry or move it forward. All innovation is coming from the public sector and there just isn't that much collaboration or thought going on in the private sector.

Critical Errors: Perception Molding

- Perhaps there have been errors on the side of caution.
    - The pulp and paper industry has operated with limited contracts for biomass—not huge yearly contracts. Banks are only willing to finance biomass with 10-15 year supply contracts. It could be erroneous believing that this is necessary, and if it is not erroneous, it is definitely a big challenge.

- There is no coherent message coming from the industry.
    - In many ways they are stuck in the past and not fully embracing the changes to the economy or emerging opportunities. This is a generality, but there is a lot of complaining coming from the forest products industry and not a lot of vision about what the future looks like and where they fit into it.

- There is a need to key into public perceptions regarding harvesting forest biomass.
    - There is a fundamental difference between solar panel and biomass. There needs to be a better appreciation for public perception regarding large scale biomass use. Answers are needed regarding how much removal is too much and be able to have answers regarding biomass harvesting impacts on environment, habitat, watersheds, etc.

- There should be more of an emphasis on the payback period of biomass versus fossil fuels.

- Learn from the energy efficiency sector.
    - In that sector, people assumed that the benefits would be obvious to consumers; however, until relatively recently, no one was thinking about how to overcome the obstacles for consumers, such as understanding who the good contractors are, how to secure good financing, and so on. This is all laid out in a report from the Lawrence Berkeley Labs at: http://drivingdemand.lbl.gov/

Appendix B. Survey Results

Biomass Survey Results Summary

From late summer to fall 2012, Dovetail Partners developed and applied an extensive survey/interview tool to gather input from biomass facilities. Survey data was collected from eighty-one facilities during this time. The following tables (Tables 1 and 2) provide a summary of the types of facilities that were surveyed and their geographic distribution. The goal and results of the surveys explore opportunities, barriers, and financial conditions necessary to support wood-to-energy development. A companion database[36] summarizes the quantitative information gathered through the surveys, and this narrative report provides a more descriptive summary of the results.

Development of the survey was informed by a review of existing literature and previously conducted interviews with sixteen biomass experts representing various fields and located in different geographical regions of the U.S. The goal of the interviews was to identify the primary gaps and barriers to larger scale, clustered bioenergy growth; identify the critical economic factors determining the success of biomass projects, look at public/private collaborative approaches which increase the viability of biomass projects, and pinpoint critical errors that the biomass industry should learn from and avoid.[37]

Table 1. Distribution of Interviewed/Surveyed Facilities by State and Type

Facilities by State + Type	AK	CO	IN	ME	MN	MT	NE	NH	OR	VA	VT	WI	Total
Airport									1				1
Coast Guard Facility	1												1
College		1					1						2
Conference Center		1											1
Correctional Facility						1							1
District Energy					1								1
District Heating								1					1
Environmental Center		1											1
Fuel Producer/Distributor				2		1		1	2		1	1	8
Hospital				1		2			1				4
Multiple						1						1	2
Multiple Prisons			1										1
Multiple Schools				2		2		1			1	1	7
National Guard Facility									8				8
Office						2							2
Power Plant					1			2			1		4
Prison			2										2
Pulp/Paper					2								2
Rehab Center								1					1
School		1			2	6			5		11	3	28
University				1		1				1			3
Total	**1**	**4**	**3**	**6**	**6**	**16**	**1**	**6**	**17**	**1**	**14**	**6**	**81**

[36] A companion database of the survey results is available separately.

[37] A complete summary report entitled "Biomass Challenges and Opportunities" that resulted from these interviews is available separately.

Table 2. Distribution of Interviewed/Surveyed Facilities by State and U.S. Region

Facilities by State + Region													
Row Labels	AK	CO	IN	ME	MN	MT	NE	NH	OR	VA	VT	WI	Grand Total
Midwest			3		6		1					6	16
Northeast				6				6		1	14		27
Northwest	1					16			17				34
West		4											4
Grand Total	**1**	**4**	**3**	**6**	**6**	**16**	**1**	**6**	**17**	**1**	**14**	**6**	**81**

The information from Tables 1 and 2 may also be viewed via this Google Map: https://maps.google.com/maps/ms?msid=215390583873553688196.0004c9b5863515d417a7c&msa=0

The following list provides a complete summary of the survey participants.

Biomass Survey Participant Reference List

Organization	State	Interviewee	Survey Completion Date
Alaska Coast Guard Projects	AK	Pierre Khalil	9/7/12
Colorado State University Foothills Campus	CO	Carol Dollard	9/4/12
Mountain Park Environmental Center	CO	Dave Van Manen	9/5/12
Park County Re-2 School	CO	Foss Smith	8/12/12
Salvation Army High Peak Camp	CO	Russ Chandler	8/30/12
Indiana Department of Corrections	IN	Michael Callahan	9/14/12
Pendleton Correctional Facility	IN	Keith Butts	8/24/12
Putnamville Correctional Facility	IN	Roger Boillard	8/31/12
Maine Energy Systems	ME	Dutch Dresser	8/29/12
Maine Woods Pellet Company	ME	Scot Linkletter	8/21/12
MSAD/RSU #74	ME	Kenneth L. Coville	8/24/12
Northern Maine Medical Center	ME	Joey Bard	8/7/12
Regional School Unit 18	ME	Gary Smith	8/20/12
University of Maine, Presque Isle	ME	Robert Aughinbaugh	9/9/12
Boise Inc.	MN	Dennis Kennedy	8/1/12
Minnesota Power Hibbard Energy Center	MN	Mike Polzin	8/13/12
Northome School	MN	Jerry Struss	8/14/12
Pine River-Backus Schools	MN	Jolene Bengtson	8/28/12
SAPPI Cloquet	MN	Gary Erikson	8/10/12
St. Paul District Energy	MN	Ken Smith	8/22/12
Marks-Miller Post and Pole Inc	MT	Gary Marks	9/11/12
Clark Fork Valley Hospital	MT	Barry Fowler	8/20/12
Darby Public Schools	MT	Julie Kies	9/21/12
Deer Lodge Central Park Center	MT	Julie Kies	9/21/12
DNRC Anaconda Unit Office	MT	Julie Kies	9/21/12
Eureka Schools	MT	Warren Powell	8/27/12
Glacier High School	MT	Julie Kies	9/21/12
Mineral Community Hospital	MT	Julie Kies	9/21/12
Pfendler Post and Pole Inc.	MT	Roxie Davis	9/18/12
Philipsburg Schools	MT	Julie Kies	9/21/12
Thompson Falls School	MT	Jerry Pauli	8/28/12
Townsend School District	MT	Julie Kies	9/21/12
Treasure State Correctional Training Center	MT	Julie Kies	9/21/12
Troy Public Schools	MT	Julie Kies	9/21/12
University of Montana Western	MT	Jeff J Nelson	9/5/12
Victor Public Schools	MT	Julie Kies	9/21/12
Chadron State College	NE	Dale Grant	8/2/12
Concord Steam	NH	Peter Bloomfield	7/30/12
Crotched Mountain Rehabilitation Center	NH	Terry Webber	9/20/12
New England Wood Pellet	NH	Charles Niebling	8/22/12
Pinetree Power	NH	Russel Dowd	10/10/12
SAU #70	NH	Jonathan Brush	10/3/12

(continued on the following page)

Schiller Station	NH	Richard Despins	8/24/12
Bear Mountain Products	OR	Bob Sourek	8/15/12
Blue Mountain Hospital District	OR	Bob Houser	8/8/12
Estacada High School	OR	Donna Cancio	8/24/12
Grant County Regional Airport	OR	Patrick Bentz	8/9/12
Grant Union School	OR	Mark Witty	8/8/12
Malheur Lumber	OR	John Rowell	7/31/12
Oakridge School District	OR	Dr. Don Kordosky	8/23/12
Oregon National Guard ARMORY	OR	Craig Volz	8/15/12
Oregon National Guard BLDG # 30	OR	Craig Volz	8/15/12
Oregon National Guard BLDG # 36	OR	Craig Volz	8/15/12
Oregon National Guard BLDG # 53	OR	Craig Volz	8/15/12
Oregon National Guard COUTES FMS	OR	Craig Volz	8/15/12
Oregon National Guard BIAK BRETT HALL	OR	Craig Volz	8/15/12
Oregon National Guard READINESS CENTER	OR	Craig Volz	8/15/12
Oregon National Guard YCP	OR	Craig Volz	8/15/12
Prairie City High School	OR	Ryan Gerry	9/7/12
Sisters High School	OR	Leland Bliss	9/5/12
Longwood University	VA	Ben Myers	8/27/12
A Johnson Co	VT	Dave Johnson	8/10/12
Barre City Elementary School	VT	Grant Fleming, John Walker	7/30/12
Barre Town Middle & Elementary School	VT	Steve Murray	8/14/12
Berlin Elementary School	VT	Richard Small	8/17/12
Cabot School	VT	Robinson M. Billings	8/30/12
Camel's Hump Middle School	VT	Mark Adams	8/31/12
Champlain Valley Union H.S.	VT	Kurt Proulx	8/30/12
East Montpelier Elementary	VT	Todd Hill	8/24/12
Grand Isle School	VT	Troy Nolan-Watkins	8/21/12
Harwood Union Middle and High School	VT	Ray Daigle	8/22/12
McNeil Generating Station	VT	John Irving	8/9/12
People's Academy Middle and High School	VT	John Pike	8/21/12
Springfield High School	VT	Tim Bixby	9/4/12
Twinfield Union School	VT	Robinson M. Billings	8/30/12
Barron County Cluster	WI	Monti Hallberg	8/30/12
Great Lakes Renewable Energy	WI	Jerry Brown	9/7/12
Hayward Community Schools	WI	Jim Heinemann	8/20/12
Lake Holcombe School	WI	Tom Goulet	8/26/12
Rice Lake Schools	WI	Steve Lewis	9/5/12
Shell lake School District	WI	Tim Ullom	8/22/12

Survey Results Summarized by Areas of Interest

The goal of the survey was to explore opportunities, barriers, and financial conditions necessary to support wood-to-energy development. The following summary categorizes these results within these areas of interest.

Opportunities for Wood-to-Energy Development

- *Heating cost savings* (based on 9 interviews)
    - Lower cost than alternative fuels like fuel oil and propane
    - Cost savings and waste steam deferment.
    - Saving taxpayer dollars through heating cost reductions; "biomass helps our budget a lot."

- *Environmental benefits* (based on 8 interviews)
    - Carbon offset revenue
    - Lower carbon emissions
    - Forest health improvements
    - Utilization of invasive species fuel supply
    - Supports forest management and agriculture
    - Biomass helps lower the fuel load in nearby forested areas.
    - Benefits to forest health

- *Utilization of operations by-product* (based on 3 interviews)
    - Bark as a byproduct is its only advantage for them using biomass over natural gas.
    - It has been cost effective to consume biomass from mill residue (bark and fine materials). Pulp mills produce a surplus of steam out of the recovery boiler system. Paper machines are large consumers of steam, so it balances out well. Having boilers that are able to burn biomass makes sense and helps you though market cycles when other fuels are more variable in their prices.

- *Renewable and local fuel source* (based on 5 interviews)
    - The company's philosophy is to use local and renewable sources of fuel. Biomass is a good match for this philosophy.
        - "Biomass is an underutilized resource in most areas—especially urban areas where there's an infrastructure that's in place typically to dispose of it. We have become the disposal option and are able to produce energy from it as part of that disposal process."
    - Renewable and local.
    - Using a local, natural grown fuel.
    - "Why should we be shipping oil from other states when can use a renewable source?"

- *Less fuel cost variability* (based on 3 interviews)
    - Better control over fuel costs.
    - Biomass boilers help get you though market cycles when other fuels are more variable in their prices.
    - "The hallmark for our district heating system is fuel flexibility. It is something that has helped keep rates stable and in particular because the wood market doesn't have a bunch of people in hedge funds chasing the latest news related to what's going on in the production of different fuels (e.g. like the petro, coal, and gas markets do). We are more masters of their own destiny with biomass compared to other fuels."

- *Economic benefits* (based on 5 interviews)
    - Growing local biomass market demand.
    - Biomass utilization helps create local jobs.
    - Provides livable wage jobs in essentially rural areas where plants are located.
    - There is a community development aspect of biomass; it creates additional jobs. Rural areas they are in have a much tougher time—especially during this recession—so it's nice to be able to help them.
    - Biomass utilization supports the local economy.
    - Biomass supports the local timber industry.

- *Other opportunities*
    - All of the heat exchange equipment works much more efficiently with the biomass system.
    - They are planning to retire the current plant and build a new combined heat and power facility in town that would primarily provide electricity. They believe that primarily providing electricity would lead to more consistent revenue, as they could be baseloaded most of the time.
    - Converting to biomass provides a way to finance the replacement of aging equipment through annual heating cost savings.
    - Biomass presents an opportunity to benefit the college's public image as an institution that is concerned about the environment and renewable energy.

Challenges for Wood-to-Energy Development

- *Material handling* (based on 9 interviews)
    - The way the auger/conveying system works was the biggest challenge
    - The biggest issues with the system have been related to the conveying system.
    - Had to work a lot with the fuel delivery system. It would work for a day and then break down for a month. Problem was that the wood was too large and as it would get into the auger system, it would bind it up and would not fall through.
    - As a solid fuel, wood requires a fair amount of equipment and handling.
    - Finding the right handling equipment was challenging.
    - There have been interruptions of flow through conveyor systems.

- *Fuel quality* (based on 7 interviews)
    - Hog fuel was causing a lot of problems with the system.
    - Finding consistent fuel quality was a challenge.
    - Dry/uncontaminated fuel supplies were hard to find.
    - Issues caused through wood fuel variability.
    - Convincing the school administration to stop burning inferior quality fuels and to switch to a higher quality feedstock was a challenge.
    - Finding a fuel supply with a consistent mixture and could be processed effectively was difficult.

- *Extra work for staff and staff training needs* (based on 7 interviews)
    - Ash removed every week. Need to time turning off the system right, so staff can get into it and clean the unit.
    - The system needs to be monitored (always attended to during cold months) and loaded often.
    - Variability in the wood fuel means their operators have to stay alert for any issues that can occur.
    - Biomass is more labor intensive than fossil fuels, but operators need to be on shift anyway, so it is not a big issue.
    - Getting everyone up the learning curve for operations.

- *Getting system fine tuned and learning curve* (based on 7 interviews)
    - Learning the best operational procedures to optimize energy efficiency.
    - There has been a big learning curve and hiccups since the system is so new (e.g. with the auger system getting jammed)
    - Overcoming engineering issues and control problems.
    - Learning how to operate the system.
    - Troubleshooting problems and system present a learning curve for maintenance staff.

- *System breakdowns* (based on 4 interviews)
    - Sometimes there are breakdowns that need to be dealt with.
        - In the winter, breakdowns can be more disruptive because they are forced to switch to more expensive backup fuel.
    - If anything goes wrong with the heating system, they have a very small timeframe to get it fixed.
    - It is vital to keep the system running without interruptions because their backup fuel is so expensive.
        - As a solid fuel, nothing happens quickly; when you have to shut it down, it takes quite a few minutes before it drops pressure.
    - Technology changes/replacements can be challenging.
        - Making existing stuff work with the newer technology can be challenging. For example, frequency drives on the motors save energy and cut costs, but if one goes down or needs to be swapped out, it is hard to make existing technology/parts work with the new.
- *Initial capital cost* (based on 5 interviews)

- Initial cost and contemporary metrics concerned with short paybacks present a big challenge.
- Funding the project was hard based on high initial capital cost.
- Financing was the biggest challenge; they were ready to go with the eight years ago had it not been for the financial hurdle.
- Finding the capital funding and justifying it economically.
- Financing was the biggest challenge (needed to find a zero interest loan).

- *Reliable fuel supply* (based on 4 interviews)
  - How to secure a long-term fuel source is a challenge. Concern whether or not they will still have fuel ten years from now.
  - Finding a readily available fuel supply a big challenge.
  - Unable to count on a reliable fuel supply; "living week to week."
  - Where to get the pellets economically and from a reliable supply big challenge.

- *Biomass transportation issues* (based on 3 interviews)
  - Setting up a logistic chain challenging.
  - Biomass is costly to ship because of its low heating value.
  - Biomass is very volume intensive; it takes eleven times as much volume to get the same amount of heat versus coal, which means you need a lot of trucks, trains, and barges to transport the fuel.

- *Difficulty finding expertise in the field* (based on 3 interviews)
  - Almost all of the estimates for every system were inaccurate because they were based on hog fuel.
  - Communication with the building mechanical design consultant was challenging.
  - Finding expertise in the field tough.

- *Policy barriers* (based on 3 interviews)
  - Concern regarding the proposed EPA and the Boiler MACT rules. One facility was frustrated that they were already very efficient, but this was not very recognized by government programs and laws.
  - Regulations and public misconception of biomass utilization.
  - Public policies and incentives currently being used for biomass energy development are behind the curve. The policies do not recognize or match the technology, capabilities, and opportunities associated with biomass utilization—especially for biomass thermal applications

- *Fuel storage* (based on 2 interviews)
  - Making sure to have the right amount of chips on hand to meet weather conditions.
  - Storing the chips.
- *Other challenges*

- Biomass is presently somewhat politically unpopular in certain areas of the country due to recent “junk science studies.”
- Energy market competition when competing against "Megawatt Factories.”
- There is a large wildfire threat near their site, but the Forest Service is not doing many thinning projects.
- Fuel price fluctuations
- Cultural challenge: to do something new, you need a motivation to do it.

Financial Conditions Necessary for Wood-to-Energy Development

<u>Project Performance</u>

- Survey Question JA: “Overall, is your biomass project meeting your expectations (i.e. is it working well, is it paying off)?”
    - 93% (N=37) of the facilities indicated that their biomass systems are working well and paying off.
    - 1 facility (Berlin Elementary School) answered that their system was not working well because they have experienced multiple system failures
    - 33 of the surveyed sites did not respond to this question.

- Survey Question FG: “Are you meeting this expected payback period?”
    - 93% (N=37) sites indicated that they are meeting their expected payback period.
    - 2 facilities answered “No” to this question
    - 33 of the surveyed facilities did not answer the question.

<u>Project Economics</u>

- Survey Question EB: “In seeking funding were you able to identify any non-financial benefits (e.g. emissions improvements, watershed, habitat, etc)?”
    - 59% (N=34) participants answered “Yes.”
    - 41% (N=24) answered “No.”
    - 15 facilities did not respond to the question.

        - Stated environmental benefits or advantages of biomass over previous heating systems include *(benefits/advantages mentioned by multiple sites italicized)*:
            - *Reduced emissions*
            - *Renewable*
            - *Local economic development/employment*
            - *Reduced heating costs*
            - *Reduced wildfire risk*
            - *Forest health improvements*
            - *Locally sourced fuel*
            - *Ash as soil enhancer*
            - Cleaner burning

        - Lower maintenance
        - Green
        - Energy security/fuel price stability
        - More efficient
        - Habitat improvements
        - Land and forest management tool
        - Reduced fuel load in forests
        - Renewable Energy Credit (REC) revenue
        - Carbon offset sales

- Survey Question BB: "Were any phases of the project (e.g. planning, operations, developing a financial model, etc) part of a biomass funding cluster/pooled effort? For example, were any phases of the project part of a wider effort to promote woody biomass utilization for heating/electricity in your area, and/or was the project part of a large collaborative effort?"
    - 61% (N=42) of the surveyed biomass facilities answered "Yes."
    - 39% (N=27) answered "No."
    - 4 facilities did not respond to the question.

        - Advantages of clustered development identified by survey respondents:
            - Shared expenses
            - Reimbursement for project cost
            - Pooled expertise
            - Greater publicity
            - Simplified engineering and reduced design costs
            - Ability to complete a greater amount of work in less time
            - Economies of scale (e.g. from a design perspective have the ability to standardize the design between many facilities)
            - Opportunities for collaboration (e.g. cooperative fuel purchasing agreements)

- Survey Question AE: "What were your main objectives in developing a biomass system?"
    - The most frequently stated reason for switching to a biomass system was to achieve heating cost savings.

        - Other main objectives that survey participants mentioned are listed below *(goals mentioned by multiple participants are italicized)*:
            - *Productive use of materials from thinning projects*
                - Demonstrate a use for beetle-kill trees for the Forest Service
            - *Local economic development*
                - Use of local products
                - Support of local forestry industry
                - Support of local biomass industry

        - *Helping to improve forest health*
        - Adoption of green thinking/green technology
            - Using biomass energy as an educational tool/demonstration of commitment to community/environment.
        - Fuel stability/energy security
            - Reduce imported energy to state/nation thus enhancing national security
        - Carbon and emissions reductions
        - Energy consumption reductions
        - Heating system maintenance/replacement cost reductions.

- Biomass fuel was consistently a cheaper alternative for facilities dependent on propane or heating oil; however, based on the interviews, biomass utilization in smaller scale facilities is not currently competitive against natural gas.

<u>Biomass Fuel</u>

The sourcing and management of the biomass fuel was a significant financial and operational consideration for the surveyed facilities (also see following section addressing lessons learned).

- Survey Question DG: "Is [your storage system] designed to handle bulk deliveries of fuel (i.e. did you purposefully oversize the fuel system so that you could store a large amount of fuel)?"
    - 88% (N=44) facilities answered "Yes."
    - 12% (N=6) answered "No."
    - 23 facilities did not answer the question.

- Survey Question DF1: "Did you develop more storage than you needed so that you could take a full delivery truck?"
    - 64% (N=29) sites answered "Yes."
    - 36% (N=16) answered "No."
    - 28 facilities did not answer the question.

- Many participants expressed interest in cooperative buying schemes that could help lower fuel costs, but there was uncertainty whether these could be realistically implemented.
    - Survey respondents' rational for not favoring fuel cooperatives:
        - Barre City School: "If fifteen guys want some chips, it's hard to get the fuel when you want. Our bin capacity is a little over a truck load (many people have the luxury of two truck loads). We do not want to have a lot of spill over because of the group buying schemes. Our system works well the way it is currently and we not want to go with the deal that some other user already made with the suppliers (i.e., someone else's price and preferences already set through a packaged deal)."

        - Harwood School: “Depends on how it would be managed.”
        - Rice Lake Schools: They said that they are looking for potential schemes, but they do not want to “screw up” the fuel quality that they are purchasing. They worry that getting into a cooperative market would lead to lower quality fuel.

Lessons Learned of Surveyed Biomass Facilities

- *Adequate fuel supply* (based on 9 interviews)
    - Make sure to have a local fuel supply. Do not want to go too far to get fuel.
    - Fuel supply and guaranteed delivery are key.
    - Need access an abundant supply of fuel.
    - Study fuel supply availability.
    - Determine if the supply of fuel is available for long-term usage.
    - Determine if the fuel is accessible during most of the year.
    - Fuel supply is very important because you can have a perfect system but without an economic or reliable fuel supply, you can be very disappointed.
    - Long-term fuel cost/availability.

- *Fuel economics* (based on 8 interviews)
    - Focus on the economic trade-offs and logistical supply.
    - Getting the right price for the fuel is critical.
    - Determine if there is fuel available at a cost that is economically feasible.
    - Conduct a thorough assessment of the cost of the fuel
    - Figure out where local fuel suppliers are.
    - Long-term fuel cost/availability.
    - Should have the fuel ton price point nailed down with suppliers over a period of time.

- *Fuel transportation* (based on 5 interviews)
    - Having nearby trucks to deliver the fuel is critical to the success of a biomass project.
    - Examine the entire fuel supply chain.
    - Become an expert of procurement and understand the logistics of moving large volumes of material in a cost effective way.
        - “This is why you see so many biomass facilities fail. There are a lot of companies that don’t understand the complexities of the forest management side and of procuring the biomass. Biomass works when biomass is the bi-product of a more valuable product.”
    - Facilities cannot be too big so that they have haul fuel over long distances.

        - Interviewee believes that this is a fundamental issue that a majority of biomass electricity producers do not understand and why their projects fail. Can haul coal much longer distances because of its higher BTU content per pound compared to green wood.
    - The amount of fuel needed given the BTU value might surprise people and will prevent some facilities from converting to a biomass system.

- *Fuel storage* (based on 3 interviews)
    - How to store, handle, and move the wood to keep it flowing continuously was the biggest lesson they learned.
    - Determine the adequate fuel storage capacity for a facility's needs.
    - One thing that they would have done differently is installed more storage capacity and also designed their storage area so that trucks could fully back up and dump the fuel.
        - Right now their storage design has a very narrow access and is elevated, making it difficult for fuel deliveries.

- *Fuel quality* (based on 2 interviews)
    - Fuel quality control is very important.
        - The ability to maintain a quality product going into boilers is vital because your efficiency is greatly reduced otherwise.
    - Do not accept lower quality fuels than what the system is intended for.

- *Fuel handling* (based on 2 interviews)
    - Fuel handling was the most important factor when designing the school's biomass system.
    - Fuel handling is critical as well as system controls in maintaining proper combustion.
    - How to store, handle, and move the wood to keep it flowing continuously.

- *Project research/planning* (based on 6 interviews)
    - Research all of the system types out there before you buy one.
    - It is important to share information with other sites that are using similar biomass systems or looking to convert to a biomass system.
    - It is important to look at others who have installed similar systems.
    - Do research and find system designs that are both customized to your facility and represent an integrated comprehensive approach rather than simple fuel source swap.
- *System maintenance* (based on 4 interviews)
    - Need a good support team on hand to troubleshoot system difficulties.
    - Communication between vendors is critical
    - Educating facility personnel about the system is not always simple.

    - Even if you get the right technology, you need to make sure it can be supported. If you get a really sophisticated system, you need to have someone who will be able to support and maintain it.

- *Dealing with unforeseen issues* (based on 3 interviews)
    - Need a lot of patience and perseverance. There are a lot of things to get done, lot of parties interested in it (e.g. with permitting and design), there's a lot of stakeholder, getting it going, getting it tuned.
    - Plan for the worst-case scenario. They went light on some of the equipment and this hurt them in the long run.
    - In retrospect, the school would have gone with below grate chip storage versus above to help with timing of deliveries.

- *All other lessons learned*
    - Biomass is not just a commodity, it is a very complicated business on the logging side, so having a good working relationship with suppliers is key for all of the parties involved.
    - A biomass power plant should be "put where the trees are and not where the people are; a lot easier to transport electrons than it is wood."
    - REC revenue has been critical to many of the biomass power generation facility's financial health and continued operation.
    - Local and public buy-in is important up front.
    - Should know the Btu output difference between biomass hardwood and soft wood
    - If converting to woodchips, do not put a vertical pocket belt elevator as part of the conveying system.
        - They had a bucket elevator that was vertical with pockets that would rapidly bring the fuel up to the next conveyor. They would never use this setup again; the vertical system plugged up all the time.
    - Utilize the biomass system to meet multiple needs (e.g. hot water, heating sidewalks, etc).
    - When putting a boiler in, make sure that everything is conducive and in line.

Appendix C. Site Visit Report

Site Visit Overview

In November 2012, Dovetail Partners carried out site visits to biomass facilities located in New England (New Hampshire, Maine, and Vermont) and Oregon. The goal of the site visits was to collect more detailed information about best practices and lessons learned, clustered or aggregated project development, project finance, and co-benefits of biomass energy that have been quantified or monetized. This information should help illustrate whether or not these projects are meeting expectations, working well, and are paying off.

Site visits during the week of November 12th

New Hampshire

- Concord Steam
- Crotched Mountain
- New England Wood Pellet
- Schiller Station

Vermont

- Camel's Hump School
- McNeil Generating Station
- A. Johnson Company

Maine

- Maine Energy Systems
- Regional School Unit #74
- Regional School Unit #18

Site visits during the week of November 26th

John Day, Oregon

- Malheur Lumber Company
- Grant County Regional Airport
- Blue Mountain Hospital
- Grant Union School
- Met with stakeholders involved with the biomass collaborative

Oregon National Guard

- Oregon National Guard facilities in Eastern and Central Oregon

Case Study Recommendations

Based on what Dovetail Partners has learned about the biomass facilities that were examined, we believe it would be most valuable to develop in depth case studies on the following biomass projects:

- John Day, Oregon Sites: Malheur Lumber, Grant Union School, Grant County regional Airport, and Blue Mountain Hospital.
- Oregon National Guard Sites
- Regional School Unit #74 in Maine: Carrabec High School, Carrabec Community School, Garret Schenck School, Solon Elementary School
- Summary report of the surveyed biomass fuel producers and distributors (if time permits)

Of the facilities we surveyed, these projects most directly related to the main goals of the research project:

- Clustered or aggregated project approaches to biomass development.
- Insights into best practices and lessons learned (i.e. factors associated with success as well as barriers to successful implementation).
- Important lessons related to project financing, capital as a limiting factor to biomass conversions, planning-to-implementation practices, quantification of biomass co-benefits, sustainable biomass supplies in a Western public lands environment.
- Details and strategies that can be translated into applications in other locations.

John Day, Oregon: Malheur Lumber, Grant Union School, Grant County Regional Airport, and Blue Mountain Hospital

The biomass sites in John Day, Oregon are geographically clustered within a high unemployment, rural county. As of October, Grant County had an unemployment rate of eleven percent. John Day is a very timber-reliant town and has experienced a great deal of economic stress because of restricted logging operations and mill closures.

The national forest land surrounding the town is in bad health, and it is believed that increased restoration projects will help improve forest conditions, benefit the local economy, create a sustainable biomass supply, and reduce wildfire threat. As a result, a collaborative has sprung up between the Forest Service, conservation groups, local mills, contractors, and local citizens. It is centered on the Malheur National Forest. The collaboration has been central to the success of the biomass cluster and has allowed generally adverse groups find common ground regarding restoration activities. This has given the Forest Service social license to carry out restoration projects in the national forest without fear of litigation, opening up a larger and more sustainable fuel supply for biomass energy utilization and other activities. During the site visits, the importance and benefits of the collaborative repeatedly came up with one of the interviewees stating, "John Day would be a ghost town with just firefighters and ranchers without the collaborative."

Public land prominence has been a major factor in the cluster being created and sustained over time. Bioenergy development in John Day will highlight the issues and costs of restoration efforts carried out in Western public lands and address the question whether biomass can help address forest management goals. The lessons from the sites, as well as the larger collaboration, could act as a model of sustainable clustered biomass energy development that could be implemented elsewhere.

Oregon National Guard

The Oregon National Guard is designing and installing pellet boilers at eight different National Guard facilities in Eastern and Central Oregon (for more detailed information about this project, please see the "Preliminary Results" report that was sent on 10/31/12). The boilers are not operational yet, but learning about their experience could provide important lessons regarding biomass project aggregation from a design-to-implementation perspective. Craig Volz, the Resource Efficiency Manager of Tetra Tech, has been our main contact regarding the project's progress. This aggregated project should demonstrate the benefits and tradeoffs of implementing multiple projects simultaneously versus individually. Volz has agreed to share detailed financial information regarding the project including detailed lifecycle analysis reports and other documents showing how the projects were looked at. He also shared some interesting suggestions regarding creative financing methods that could help promote biomass energy conversions.

Regional School Unit #74: Carrabec High School, Carrabec Community School, Garret Schenck School, Solon Elementary School

The schools in Maine that are a part of Regional School Unit #74 should help illustrate an aggregated approach to biomass conversion that is well suited to help understand the process of retrofitting existing facilities to biomass systems. The Superintendent of RSU #74 outlined what seems to be an especially systematic approach toward implementing district-wide biomass conversions focusing on minimizing capital costs and demand loads. The district implemented the biomass conversions based on what the Superintendent calls "a dramatic new approach that utilized and integrated multi-facility plan focusing on base-load heating and multiple smaller boiler units, combined with intensive conservation measures to reduce the facility heat load requirements." While the project was designed to be independently viable, it was also designed (where possible) to be compatible with statewide initiatives to promote energy conservation and wood-to-energy conversions.

Fuel Producer and Distributor Summary Report

Lastly, if time permits, it could be beneficial to write a separate summary report focused on the lessons learned, challenges, and opportunities of biomass fuel producers and distributors. Specifically, the report would summarize the lessons learned from eight biomass fuel producers and distributors that we surveyed. Additional detail would be provided for Maine Energy Systems, which seems to be more in line with progressive lessons related to bulk pellet production and distribution and pellet boiler manufacturing and distribution.

Selection of the Sites for Final Case Studies

We wanted to visit a large mixture of sites during the trip to New England and Oregon to determine which sites would make the best case studies for deeper analysis and make the trips as valuable as possible. The visits provided a wide spectrum of biomass applications and it was interesting to learn about the challenges and opportunities that each facility faced. The biomass experts we interviewed previously recommended many of these sites. These experts suggested that these sites are key examples of successful U.S. woody biomass facilities that are operating profitably and/or have successfully overcome major obstacles or other issues.

We gained some valuable insights touring the biomass facilities in New Hampshire and were impressed by the level of success they have achieved. However, while most of these facilities are interesting and provide important lessons, we believe that the sites in Oregon and Maine have unique qualities that differentiate them as doing something new or innovative and demonstrate more valuable lessons learned in regards to biomass conversions. Overall, we feel that while there were many positive aspects about the sites in New Hampshire, the potential case studies in Oregon and Maine seem more related to the main goals of this project and would therefore be better candidates to further develop case studies. At this point, however, we are still open to further discussion, and other recommendations, for the final case study selection.

Discussion of Findings from Other Site Visits

New Hampshire Site Visits

The sites in New Hampshire included a pellet producer and distributor, a rehabilitation center, a district heating plant, and a large power plant.

<u>Concord Steam</u>

Concord Steam is a privately owned district heating facility that provides district heating to about five million square feet of buildings, including 100 customers (200 commercial and institutional buildings) in the town of Concord. The district heating plant has been operating since the 1930s and was retrofitted for wood use in the 1980s. Concord Steam is not currently profitable because its biomass fuel is being out-competed by natural gas and because thermal demand is so seasonal. They are planning to retire the current plant and build a new combined heat and power facility in town that would primarily provide electricity. They believe that primarily providing electricity would lead to more consistent revenue, as they could be base loaded most of the time.

Biggest Lesson Learned: The most important lesson that they learned through utilizing biomass is not related to the mechanics of the equipment, but in understanding the logging industry and wood market. It is not just a commodity. It is a very complicated business on the logging side, so having a good working relationship with suppliers is key to for all of the parties involved.

New England Wood Pellet

This is a biomass fuel producer/distributor with twenty years of experience dealing primarily with bagged pellets (although they do have some bulk delivery). One of the biggest challenges the company has encountered is growing the market demand for their fuel so that they can operate their plants at full capacity and sell their entire product. They invested heavily in new capacity over the years anticipating that market demand would grow rapidly, but it hasn't grown as rapidly as they would have hoped. Unfortunately, the company has not been profitable for the past three years, but they believe they will make a profit this year.

Greatest Opportunity: There is opportunity in providing a fuel that can displace the use of natural gas, propane, or heating oil. In the northeast, heating oil and propane are very expensive to heat with. As consumers understand more about the economics of heating and the options they have, and as the technology becomes more automated and user-friendly, they will hopefully gravitate toward pellet fuel. If New England Wood Pellet could transition from a market that is predominately bagged fuel and pellet stoves to a market that has a higher percentage of central heating using boilers with bulk delivery/storage, they could even things out because they could take delivery in the summer months. If systems also produce domestic hot water, that is another fuel load that would need to be satisfied twelve months of the year. If they can expand the market into industrial processes as well as facilities like hospitals who have huge domestic hot water loads, this would be very helpful because they have twelve month demand curves. He thinks "the real growth potential in their market lies in central heating and not heating living rooms with pellet stoves."

Crotched Mountain Rehabilitation Center

Biomass provides the Center's heat, domestic hot water, and absorption cooling to all of the large buildings on the campus (totaling 365,000 square feet). Many of the facility functions utilize the biomass system (their swimming pool, for example). By utilizing biomass, the

Center has been able to save $500,000 in heating costs per year. There are three interesting features within their system: they have chip storage that utilizes a truck bridge, tandem wood boilers of different sizes with capacity for different burn settings resulting in better efficiency, and a bag house for improved emissions control.

Schiller Station

Schiller Station is a large, fifty-megawatt, regulated utility that burns coal, oil, and wood. They are one of the largest coal-to-biomass plants in the country. The main impetus for the plant's development was to expand their renewable portfolio. To keep biomass fuel economically viable, Schiller Station is relying heavily on renewable energy credits (RECs) as a source of revenue, which it sells to REC markets in Massachusetts, Rhode Island, New Hampshire, and Connecticut. "If not for the RPS and the REC revenue associated with it, we would not have converted the coal/oil unit to wood because it isn't a very efficient fuel." It was a seventy-five million dollar project, so they needed a return to make that investment. If they had relied only on the electricity market to recoup the investment, the biomass project would not have happened.

Biggest Lesson Learned: How to store, handle, and move the wood to keep it flowing continuously was the biggest lesson they learned. The one thing they would tell somebody who is converting to wood chips, is not to put a vertical pocket belt elevator as part of the conveying system. They had a bucket elevator that was vertical with pockets that would rapidly bring the fuel up to the next conveyor. They would never use this setup again. The vertical system plugged up all the time, but they have been able to get the bugs out of the system.

Vermont Site Visits

The Vermont Sites included a biomass fuel producer and distributor, a school, and a large power plant.

A. Johnson Company

This is a hardwood mill that sells bulk wood chips from their mill residue. They are entering their thirteenth year of chip production and supply some of the Fuels for Schools facilities in Vermont. Many of their customers have old systems that require very high quality fuel. They get more revenue from selling to heating customers than to the paper mills because paper mills are concerned with keeping costs down whereas heating customers are willing to pay a higher price when compensated for delivery costs (these heating customers have very high priced alternatives, so they are willing to pay a higher price because they are still saving money).

Challenge: Many of the smaller schools that they deliver to have storage that is too small (some of them that can barely hold a trailer full of chips if they are completely empty) for bulk delivery and scheduling deliveries has been a big issue.

Opportunity: A. Johnson Company is considering producing micro-chips as an alternative to pellets. Value would be added by drying, heat-treating, and producing, well sorted out chips so that they burn consistently and have a simpler combustion process. A. Johnson believes that micro-chips would be a more economical product to deliver over a longer distance because you can get more Btus after getting rid of excess moisture content. They would be marketed to customers with smaller demand (e.g. an apartment complex or a housing authority with interconnected buildings). Chips that are heat-treated with low moisture content are more storable and they would probably utilize a bulk distribution system. However, producing these smaller chips would be difficult because the company would need a much higher grade screening process.

McNeil Generating Station

McNeil is a large-scale, jointly-owned biomass power plant. They first started operating in 1984, and the site is something that other projects look to for guidance and to try to emulate (about 1,000 people come to see McNeil every year). There are 130 employees inside and outside of the plant. They put 300 million dollars into the local economy and power would have to be imported from outside of New England had it not been for McNeil. REC revenue has been critical to the plant's financial health and continued operation, but there is concern that the REC's value is too fickle and could disappear abruptly and for no good reason (e.g. one person making a clerical error). Right now, McNeil trades RECs for $55.00 per MWh and in 2007 RECs traded for $7.00 per MWh.

Biggest Challenge and Lesson Learned: Biomass is very volume intensive; it takes eleven times as much volume to get the same amount of heat versus coal, which means you need a lot of trucks, trains, barges to transport the fuel. McNeil is located right in the middle of the city of Burlington. As such, the city was worried that there would have too much traffic downtown because of McNeil's operations. McNeil had to go to the Vermont Public Service Board to obtain a Certificate of Public Good, which required them to get 75% of the fuel by train if they were to build in the city of Burlington. Unfortunately, this leads to double handling because wood starts off in a truck somewhere and the train requirement adds 20% cost to all fuel transported by train. The biggest lesson they have learned is to "put the plant where the trees are and not where the people are; it is a lot easier to transport electrons than it is wood."

Camel's Hump Middle School

Camel's Hump Middle has used biomass (wood chips) for eighteen years to heat its entire (89,000 square foot) school building. They heat the school for .31 cents per square foot and they save $45,525 in heating costs per year. Overall, the system has worked great over the years and the school has recently added a solar system, which has significantly reduced their electricity costs.

Lesson Learned: Our contact at the school stated that fuel handling is the most important factor when designing a biomass system like the one at Camel's Hump. One thing that they would have done differently is installed more storage capacity and also designed their storage area so that trucks could fully back up and dump the fuel. Right now their storage design has a very narrow access and is elevated, making it difficult for fuel deliveries.

Maine Site Visits

The Maine sites included a biomass producer and distributor and two regional school units that converted multiple schools to biomass systems.

Maine Energy Systems

This is a biomass fuel distributor and producer focusing on bulk delivery. Most of their customers are residential users that have 2-3 ton loads. They also have larger users (schools, municipal offices, commercial buildings) that will take full truckloads at a time (10-14 tons). Maine Energy Systems only does bulk pellet delivery--they don't do anything with bags—and is also the distributor and licensed manufacturer for the German pellet boiler company OkoFEN. The company has highly specialized pellet delivery trucks for delivering pellets. Because of low customer density for pellet fuel, Maine Energy Systems has to deliver the fuel over long distances (300 mile trips in some cases). They try to aggregate buyers who are located in the same areas and the company is still profitable because they charge enough per ton to make deliveries. Maine Energy Systems has been able to make a profit and is on a 2x growth curve. However, according to Dutch Dresser, the Executive Director of Maine Energy Systems, "The U.S. is 15-30 years behind Austria and

Germany in terms of where the industry is at. We've borrowed a lot of ideas from Austria, but U.S. policy related to biomass is still very young."

Dutch believes that more appliance incentives are needed and that the U.S. should follow the European model in tailoring incentives (e.g. incentives from 25-30% for boiler costs, residential and commercial, to force demand).

Regional School Unit #18

Regional School Unit #18 installed one of the largest wood chip heating systems in Maine to heat its three school buildings (the high school, middle school, and elementary school) totaling 240,000 square feet. Their project completed between September 2011 and May 2012 and they are in their first heating season. Based upon their projections, they are expecting to save around $250,000 per year on heating costs. The district has a great bread basket in the area (three different sources of wood supply within around three miles). There has been a big learning curve and hiccups (e.g. the auger system getting jammed) since the system is so new. Overall, they feel like the system is off to a good start, and it will be interesting to see how the system performs in its first heating season.

Appendix D. Non-Traditional Revenue Sources

Table 4. Summary of Biomass Energy Non-Traditional Revenue Sources and Quantified Potential Impacts

Non-Traditional Revenue Source/Benefit	Quantified Potential Impacts
Employment/Green Jobs	2.13[i] – 4.9[ii] jobs per MW
General Environmental Services	11.4 ¢/kWh.[ii]
General Economic Growth from biomass energy development	$1.50 per dollar spent[iii]
General Economic Growth from forest restoration activities	$5.70 per dollar spent. [iv]
Reduced Wildfire Risk from fuel removals	$600-$1,400 per acre[v] $0.4 million per MW[vi]
Reduced Treatment costs from biomass removal *(versus piling and burning)*	$0-600 per acre[vii]
Avoided Wildfire Related Costs from forest restoration	$1.45 per dollar spent[viii] $231 – 481/acre[ix]
Avoided Timber Losses due to fire risk reduction	$371-772 per acre[ix]
Increased Water Yield value due to fire risk reduction	$83/acre[ix] $1.10-$1.50 per dollar spent[x]
Carbon Emission Reductions	$0.01 - $0.26/kWh[xi]
Reduced Landfill waste and disposal cost	$66/ton[xii]
Tax Base Contribution	$34,900 - $47,200 total tax revenue per year per MW[xiii, xiv]
Pollution/Air Emission Reductions (NOx, SOx)	$0.001-0.02/kWh[xv] $14-75/MWh[xvi]

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[i] "Economic Impact of Renewable Energy in Pennsylvania." Black & Veatch Corporation, Mar. 2004.
[ii] Morris, G. "The Value of the Benefits of U.S. Biomass Power." National Renewable Energy Laboratory, 1999.
[iii] Allen, Geoff, et al. "Energy from Forest Biomass Potential Economic Impacts in Massachusetts." Massachusetts Sustainable Forest Bioenergy Initiative, Dec. 2007.
[iv] Krumenauer, Matt, et al. "National Forest Health Restoration." 26 Nov. 2012.
[v] Mason, Larry, et al. "Investments in Fuel Removals to Avoid Forest Fires Result in Substantial Benefits." Journal of Forestry, Feb. 2006.
[vi] "CPUC Feed In Tariff Rulemaking And The Opportunity To Support Community Scale Biopower." Placer County Air Pollution Control District.
[vii] Davis, Jane, et al. "Forest Restoration and Biomass Utilization for Multiple Benefits: A Case Study from Wallowa County, Oregon." University of Oregon, 2012.
[viii] Krumenauer, Matt, et al. "National Forest Health Restoration." 26 Nov. 2012.
[ix] Mason, Larry, et al. "Benefits/Avoided Costs of Reducing Fire Risk on Eastside." Forest Health Strategy Work Group, Jul. 2007.
[x] Poulos, Helen and James Workman. "Our Too Thirsty Forests" Los Angeles Times, 8 May 2012. 29 Jun. 2012 <http://www.latimes.com/news/opinion/commentary/la-oe-workman-kill-trees-save-rivers-20120508,0,7153561.story>.
[xi] Anderson, Roy, et al. "Developing a Business Case for Sustainable Biomass Generation: A Regional Model for Western Montana." NorthWestern Energy, Jun 2010.
[xii] "Biomass Cofiring in Coal-Fired Boilers." DOE, May 2004.
[xiii] Morris, G. "The Value of the Benefits of U.S. Biomass Power." National Renewable Energy Laboratory, 1999.
[xiv] Morris, G. "The Value of the Benefits of U.S. Biomass Power." National Renewable Energy Laboratory, 1999.
[xv] Anderson, Roy, et al. "Developing a Business Case for Sustainable Biomass Generation: A Regional Model for Western Montana." NorthWestern Energy, Jun 2010.
[xvi] Anderson, Roy, et al. "Developing a Business Case for Sustainable Biomass Generation: A Regional Model for Western Montana." NorthWestern Energy, Jun 2010.

Appendix E. Case Studies

Biomass Energy in Grant County, Oregon

Oregon Army National Guard

Regional School Unit 74, Maine

Note: Included in this report are the narrative portions of each case study. The full case studies for the sites in Oregon include extensive appendices and financial analysis data. The full case studies are available separately.

Biomass Energy in Grant County, Oregon

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- Mark Webb, County Judge, Grant County
- Andrew Haden, President, Wisewood Inc.
- Nerissa Lindenfelser, Project Manager, Wisewood Inc.
- Mike Billman, Timber Manager, Malheur Lumber Company
- John Rowell, Plant Manager, Malheur Lumber Company
- Mark Witty, Superintendent, Grant Union School
- Dennis Flippence, Head of Maintenance, Grant Union School
- Bob Houser, CEO, Blue Mountain Hospital
- Steve Hill, Director of Facilities Services, Blue Mountain Hospital
- Patrick Bentz, Airport Manager, Grant County Regional Airport

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Introduction

With a population of just over 1,700 people, John Day is a small rural town located in east-central Oregon that despite its small population provides a successful model for biomass energy projects. The facilities that have converted to biomass systems in John Day (as well as a school located nearby in Prairie City) are geographically clustered within a high unemployment rural county. John Day is a very timber-reliant town and has experienced a great deal of economic stress due to restricted logging operations on federal lands and mill closures. Data from the Oregon Labor Market Information System shows that as of October 2012, Grant County had an unemployment rate of 13.6% percent.[38]

According to the US Forest Service, the National Forest land surrounding the town is in poor health, and it is believed that forest management activities that support increased restoration[39] will help improve forest conditions, benefit the local economy, create a

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[38] Source: "Oregon's Recession Timeline." Oregon Employment Department, Oct. 2012 http://www.qualityinfo.org/olmisj/OlmisZine?zineid=00000011 .

[39] Restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. Ecological restoration focuses on re-establishing the composition, structure, pattern, and

sustainable biomass supply, and reduce wildfire threat. As a result, a broad collaborative effort centered on the Malheur National Forest has arisen and has been key to the success of the biomass cluster.

Biomass clusters, like the one in Grant County, have multiple benefits such as improvements in efficiency by minimizing fuel transportation distances. According to the Oregon Bureau of Land Management, four primary features characterize biomass clusters:

1. A source of woody biomass (forest residue from forest management activities, for example).
2. A biomass manufacturer that produces biomass fuel.
3. A market to utilize the biomass product (schools with biomass boilers, for instance).
4. Close proximity of biomass sources, biomass fuel processors, and customers.[40]

The biomass energy development case studies reported herein summarize the experience of four clustered facilities that converted to biomass pellet systems; the development of a local pellet mill is also chronicled. This report also highlights the issues and cost of restoration efforts carried out in Western public lands and addresses whether the local use of biomass energy systems can help compliment forest management goals. The lessons learned from these sites, as well as the larger collaboration of the Blue Mountain Forest Partners, could act as a model of sustainable, clustered biomass energy development that could be implemented elsewhere in the Western U.S. where public lands are prominent.

Figure 1. John Day, Oregon

ecological processes necessary to facilitate terrestrial and aquatic ecosystem sustainability, resilience, and health under current and future conditions. Source: http://www.fs.fed.us/restoration/

[40] Source: “Biomass Cluster Pilot Project.” Bureau of Land Management, 19 Sep. 2012 http://www.blm.gov/or/resources/forests/files/BiomassClusterFAQ.pdf .

The Collaborative

Coincidental to an economic downturn affecting the town of John Day, the National Forest land surrounding the town is considered to be in poor health. As a result of these adverse conditions, a collaborative (centered on restoration[2] activities carried out on the southern end of the Malheur National Forest) was formed in 2006. The collaborative is known as the Blue Mountain Forest Partners (BMFP), and it includes a wide spectrum of stakeholders such as the Forest Service, conservation groups, local mills, ranchers, contractors, city and county representatives, and local citizens. BMFP has allowed generally adverse groups to find common ground regarding restoration activities and has given the Forest Service social license to carry out restoration projects in the Malheur National Forest without fear of litigation. It is thought that increasing the number and scale of restoration projects in the area will help improve forest conditions, benefit the local economy, reduce wildfire threat, and open up a larger and more sustainable fuel supply for biomass energy utilization and other activities. The importance of the collaborative to the community and to the success of the biomass cluster came up repeatedly during interviews with various local stakeholders. One of the interviewees went so far as to say, "John Day would be a ghost town with just firefighters and ranchers without the collaborative."

In the fall of 2012, Dovetail Partners interviewed some of the major stakeholders involved in BMFP to learn more about its beginnings, lessons learned, and about best practices contributing to its success.

Main Goals and Drivers

According to Mark Webb, a County Judge who has been involved in BMFP, the initial goals of the collaboration were to reduce the risk of unnatural fires and to help support the local community. However, these initial goals evolved over time, with the emphasis now on fostering longer-term environmental resilience and community development. According to Mike Billman, Timber Manager at Malheur Lumber and a co-chair of BMFP, the overarching goal of the collaboration is focused on forest restoration. "Of course, some people feel that the main goal of the collaboration is more economic than environmental," Billman points out, "but the reality is that everything has to be driven by the ecological benefits because this is what keeps the environmental groups at the table." As Webb elaborated, "It increasingly became a desire not just to reduce fire danger and [improve] economic drivers, but to reintroduce or restore complex forest structures that are important for wildlife species, listed species, and species of concern as well as to reorient how commercial harvest looks at things."

For environmental groups, the main interest in the collaboration has been to preserve and protect forest resources such as large, old growth ponderosa pine trees. According to Curt Qual, Partnership Coordinator at USDA Forest Service, the Malheur National Forest is in very poor health. It is overstocked and has a high threat of wildfire stemming from years of fire suppression and reduced management. Insect infestations and various forest health threats are also problematic. Old growth trees in the National Forest, which were logged heavily in the past, are now being lost due to wildfire and pine beetles. According to the "Southern Blues Restoration Coalition" report, despite aggressive fire suppression efforts, there have been seventy-one large fires between 1980 and 2010 that have burned over 300,000 acres in the Malheur National Forest, and over half of the dry forests within the National Forest are overstocked. The report also states that roughly thirty percent of forested stands near the southern end of the Blue Mountain range could potentially lose twenty-five percent of their volume due to insects and disease over ten years.[41] Such conditions led the environmental community to realize that active management and commercial activity were needed to protect these environmental assets.

The interviewees explained that there was a great desire on the industry side to increase commercial activity in the National Forest. As a very timber-dependent town, these activities are strongly tied to the economic wellbeing of John Day. Commercial activity in the National Forest had almost completely dried up in the years prior to development of the cooperative. "Environmental efforts were very successful in shutting down the timber program. Even though greater than sixty percent of our county is Forest Service, we were not getting anywhere near the amount of timber we needed," Billman said.

Overall, it seems clear that the beginnings of the BMFP collaboration was born out of necessity to address the pressing issues that could only be solved if various environmental, community, and industry stakeholders worked together. Billman believes it was the combination of the forest industry losing wood supply and environmental groups losing forest resources through wildfire that pulled these normally adverse groups together. Mark Webb emphasized the symbiotic relationship between the groups, "Environmental groups cannot achieve their goals for ecological restoration short of a viable timber industry. You cannot separate these things on the east side. . . because those parameters are forced on both groups. The timber industry is willing to reach for less than what they want as long as they get a commercially viable product . . . and the environmental community is much more willing to consider and put together projects that have a significant economic component for the sake of supporting the timber industry—as long as the prescriptions are ecologically appropriate."

Benefits

The collaborative has led to a number of important benefits now that it has been operating for about six years. Curt Qual stated that perhaps the most important benefit of BMFP is that forest restoration planning has been able to keep pace with implementation in the Malheur National Forest. He explained that National Forest operations that lack collaborative programs are much smaller and their planning much more expensive because of litigation. Because of BMFP, diverse and adverse stakeholders have been able to come together and hash things out over the course of three to five years to come to an agreement regarding restoration efforts. Before the collaboration, it used to take about two to three years to get one small restoration document prepared just because it had to be ironclad legally so that it could be carried out.

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[41] Source: "Southern Blues Restoration Coalition." USDA Forest Service, 2011. http://www.fs.fed.us/restoration/documents/cflrp/2011Proposals/Region6/Malheur/2011SouthernBluesRestorationCoalitionCFLRPProposal.pdf .

Consequently, the number of National Forest acres on which restoration management activity occurred was very low. According to Mike Billman, the collaboration has opened up a greater supply of biomass and saw logs. The collaborative has been instrumental in helping get projects through the approval system faster. Billman said that project sizes have increased "from under 10,000 acres to now between 20,000-40,000 acres." Furthermore, he explained, a higher percentage of these project acres are being treated where harvesting is included as part of the restoration operations. "It used to be maybe a third of the acres, now we're up to fifty percent. The more acres you treat, the more biomass and saw logs are available," he stated.

Mark Webb also agreed that the collaboration has helped reduce the amount of litigation that used to exist. There appears to be less reason for litigation. The prescriptions that are agreed to in the collaboration are more restoration-oriented and less aggressive commercially than timber harvesting in the past. He pointed out that these restoration activities would not exist without the collaborative. "The collaboration has definitely made a difference in getting large projects on the ground that are successful and that have made a difference to their existing mill," he said. "I think as we get more aggressive with our prescriptions for biomass removal in order to achieve a more resilient situation, we are likely to see some attempts at litigation because some environmental members in the community are not comfortable with any kind of activity on forest land."

Mike Billman also agreed that BMFP has helped avoid litigation and has benefitted both Malheur Lumber and the wider community. Several years ago when the recession first hit and the housing market slowed down, timber industries, including Malheur Lumber in John Day, were among the first to feel the impact. Conditions continued to deteriorate, and in August 2012, mill management announced that by November the sawmill would be closed permanently. However, within only several weeks, there was a huge local effort in the community to save the mill. Billman explained that this effort was not based just around the mill. "In this case, we had been very tight with the collaborative efforts and the collaborative efforts had been very substantial. This was about saving everything that [the collaborative] was doing on the Malheur National Forest," he said. As the last mill in the area that can process logs, Malheur Lumber is an important part of the forest restoration work. Local support pulled together leaders from the environmental sector, timber industry, the U.S. Forest Service, and other citizens in John Day. This effort resulted in the Forest Service agreeing to speed up timber sales and increase restoration projects, which helped save the mill and allowed the collaborative to continue its work. "I believe this is all because of the collaborative," Billman said.

Various reports also highlight the benefits of collaborative forest management activities in Oregon. For instance, a 2011 Forest Service report titled the "Southern Blues Restoration Coalition" estimates that restoration activities centered on the Malheur National Forest would lead to a sustainable supply of biomass and benefit local communities, increasing restoration-related employment by approximately seventy percent (or as many as 154 new jobs).[42] According to the report "National Forest Health Restoration: An Economic Assessment of Forest Restoration on Oregon's Eastside National Forests," for every one million dollars spent on restoration activities in eastern and south central Oregon, $5.7 million are generated in economic returns; furthermore, the report states that for each dollar the Forest Service spends on restoration activities, the agency avoids $1.45 as a potential loss due to wildfire-related costs.[43]

Best Practices and Lessons Learned

The management of Forest Service lands is driven extensively by federal policies, including the National Environmental Policy Act (NEPA).[44] The NEPA process has become integral to federal land management and requires public engagement in management decision-making and planning. Tools like a collaborative can provide a number of benefits, including the direct benefit of addressing the NEPA requirement for stakeholder engagement. According to Mark Webb, "As long as we're going to have NEPA and federal land management, the collaborative is the best way to go because it facilitates local ownership of a public process, where 'local' is understood broadly to include whoever is at the collaborative table, and thereby matures it in a manner that was lacking before, but is essential for moving forward. This collaborative probably has only been successful because so much is at stake for the industry and the environmental community."

It is clear that one of the largest benefits of the collaborative is that it has prevented litigation that used to bring forest management activities to a standstill. "Litigation is not the way forward because it shuts things down. This is where the collaborative is nice because it doesn't shut things down. It filters out the bad and facilitates the good. So, we need a Federal land management approach that is less litigation prone and more [focused on promoting resilience,]" Webb said.

Based on our interviews with stakeholders involved in the collaborative, BMFP, and similar collaborative efforts centered on National Forests, represent a best practice that can be employed to restore whole forests and landscapes rather than small patches of land. Collaboration is the foundation from which forest material [logs, biomass, etc.] is opened up and helps attract industry through a guaranteed sustainable supply.

However, there is a need to build the capacity of collaborative groups (like those involved in BMFP) in the West so that they can continue their work and help make bioenergy fuel access self-sustaining. In Oregon, other collaborative groups similar to BMFP are not well

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[42] Source: "Southern Blues Restoration Coalition." USDA Forest Service, 2011. http://www.fs.fed.us/restoration/documents/cflrp/2011Proposals/Region6/Malheur/2011SouthernBluesRestorationCoalitionCFLRPProposal.pdf .

[43] Source: Krumenauer, Matt, et al. "National Forest Health Restoration." 26 Nov. 2012. http://orsolutions.org/beta/wp-content/uploads/2011/08/OR_Forest_Restoration_Econ_Assessment_Nov_2012.pdf .

[44] NEPA was signed into law January 1, 1970 and establishes goals and a process that promote national environmental protection. Under the Act, federal agencies are required to thoroughly assess the potential environmental impacts of any major federal action that could significantly affect the environment. Citizens and organizations have the ability to sue a federal agency if it fails to enforce NEPA provisions under a proposed action. For more information about NEPA, please visit www.epa.gov/compliance/basics/nepa.html

funded, and this is a limiting factor in carrying out forest restoration activities. Another major limiting factor, according to the interviewees, is that the Forest Service's funding for restoration activities is lagging behind collaborative proposals.

According to the 2011 "Southern Blues Restoration Coalition" report, biomass removal on the Malheur National Forest has been more feasible when both biomass and saw logs are removed at the same time. They have found that restoration treatments are economically viable when the saw log/biomass volume ratio is maintained at about 50/50. According to the same report, the Malheur National Forest has a fifty million dollar, five year "Collaborative Restoration Stewardship" contract that makes it more economically feasible to combine the removal of biomass and low value material: "The value of the products will return nearly 75% of the cost of the restoration thinning back to the Malheur National Forest, which will be used to accomplish additional restoration work that otherwise may not occur." [45]

Approaches to Help Foster Collaboration Around National Forests

Decision-Making Process

Mark Webb emphasized the importance of building a clear decision model. "It's really taken getting clear about common ground, what we are willing to live with and not willing to live with, and you need a pretty mature decision making process exercised by mature people," he said. "Because you're starting to push the edges of what is acceptable to either the timber industry or the environmental community. . . .You're going to be in situations where there will be outliers either with the industry or the environmental community." He pointed out that BMFP would not have been able to make progress if total consensus was required on every project before moving forward. BMFP needed a decision model that respected disagreement and diversity yet still facilitated robust projects. As such, to meet these needs, *the group tries to have representatives from a wide variety of relevant stakeholders and uses a majority rules system.* More specifically, the group adopted a system whereby a majority vote moves a recommendation forward to the Forest Service and requires that the majority recommendation include individuals from every interest group represented in the collaborative. Individuals who support an alternative are encouraged to share and submit their concerns and recommendations to the Forest Service for consideration.

According to Mike Billman, in order to find common ground between the generally adversarial groups, BMFP has relied on *good facilitation* particularly at the onset. The collaborative group was lucky, he explains, to have facilitation through Sustainable Northwest and other groups like the Gifford Pinchot Taskforce. These organizations have been vital in terms of facilitation and organizational leadership.

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[45] Source: "Southern Blues Restoration Coalition." USDA Forest Service, 2011. http://www.fs.fed.us/restoration/documents/cflrp/2011Proposals/Region6/Malheur/2011SouthernBluesRestorationCoalitionCFLRPProposal.pdf .

Field Tours

Another best practice highlighted by Mark Webb has been the *field tours* provided by the Collaborative. They found out that the industry and environmental organizations use very different language to support their perceptions and describe their goals. In a formal setting (like an office or a conference room) it can be much harder to neutralize the rhetoric between interest groups. In contrast, field tours get people on the ground to see firsthand what the landscape looks like before and after a restoration treatment. After the tours, Webb said that the groups involved in BMFP found that despite what often appeared to be deep differences in perception and interests when shared across a table, they were able to come closer to agreement about what is occurring on the ground and began to use common language, which made it easier to communicate more effectively with each other.

The Right Stakeholders

Having the *right mixture of stakeholders* in the Collaborative has also been critical to its success. “You have to have parties that are interested and committed, have no option but to work together, and are solution oriented.” Mark Webb said. To foster fruitful cooperation, it was important that BMFP not just choose representatives from the relevant stakeholders, but select individuals who were able to see things from multiple perspectives, able to consider alternatives, and who could acknowledge when they were wrong. “If a person lacks these character traits, then even if you have the representative groups attending, conversations are probably going to be less than fruitful,” he said.

Access to Local Experienced Biomass Users

Access to a network of experienced clustered biomass users has also been critical to the continued success of the collaborative. Having facilities in the area that are able to utilize biomass for heating purposes creates a market demand for biomass material that is the by-product of the collaboration’s forest management activities. Demand for forest residue means that it can be utilized to manufacture wood pellets rather than left onsite to be burned in piles or accumulating and contributing to a greater wildfire threat.

Biomass Energy Case Studies

The following four case studies describe the experiences of two schools, a hospital, and an airport in converting to biomass energy systems within the Grant County cluster. The development of a local pellet mill is also described.

Grant Union JR/SR High School

Figure 2. Grant Union School

GENERAL INFORMATION	
FACILITY	**Grant Union School**
Building Area (ft^2)	12,000
Experience Total (years)	1
Project Type	Retrofit
EQUIPMENT SPECIFICATIONS	
Boiler Manufacturer	Hurst
Boiler Model	Hurst
Output MMBtu/hr	2.00
Biomass Percent of Building Heating	85%
Backup Unit	Propane
FUEL SPECIFICATIONS	
Composition	Ponderosa Pine wood pellets
Source	Forest stewardship contracts
Supply Radius (miles)	5
Delivery Frequency	Monthly
Quantity Delivered (tons)	20
Cost Per Ton Delivered	$ 165
Moisture Content	≤ 5%
Fuel Storage Capacity (tons)	25
Annual Consumption (tons)	180
Fuel Replaced by Biomass	Heating Oil
Annual Biomass Fuel Cost	$ 29,700
Annual Heating Cost Savings	$ 49,260
PROJECT ECONOMICS	
Project Total Funding	$ 532,000
Quality Zone Academy Bond	$ 500,000
DOE Cool Schools Grant	$ 32,000
Other Non-Project Funding Malheur Lumber Discounted Pellets	$ 50,000
Project Total Cost	$ 532,000
Equipment Cost	$ 235,200
Installation Cost	$ 296,800
Annual O&M Costs	$ 1,200
Financial Analysis	
Annualized Rate of Return (10yr)	8.7%
Internal Rate of Return (25yr)	14.8%
Payback Period (years)	10.8

Project Background

Grant Union JR/SR School is a small 7-12th grade school located near the southern edge of John Day, Oregon. Grant Union School's shift to biomass began abruptly in 2011, when heavy rains and flooding swamped the school campus and forced the school's oil storage tank up and out of the ground. This disaster had a silver lining, however, as it was spring when the boiler was knocked out, so there was still some time to act before the arrival of the winter heating season. Grant Union was able to use this time to research what type of systems would best fit their current and future needs and to come up with funding. First, they used the flood as an opportunity to convert their old oil boiler to propane, which was demonstrated to be a cheaper alternative to replace and operate. Soon after, they began to put together a larger plan to put in a new biomass system.

The main goal of Grant Union School's biomass project was to reduce the yearly cost of heating the building, explained Mark Witty, Superintendent of Grant Union School. Another motivation was to act as a community partner by helping struggling local businesses by purchasing their timber products. Witty noted that helping the local community was important because both the economy and forest were in bad condition.

To determine which biomass model to purchase, the school utilized computer-modeling programs to compare various boiler alternatives. The school contracted with Wisewood, a local engineering firm that specializes in biomass energy, to provide technical recommendations on the project. The school initially calculated that they could cut their heating bill from $78,960 per year using 23,500 gallons of oil at $3.36 per gallon down to roughly $40,000 per year by installing a biomass system. They also contacted other local woody biomass facilities in Grant County such as Blue Mountain Regional Hospital and the Regional Airport to learn about their experiences with biomass systems and to identify how much money they were spending/saving. The staff at Grant Union attended an open house at Blue Mountain Hospital to see their new pellet system first-hand and hear about how it was working.

Ultimately, the school chose to go with a wood pellet boiler. The conversion took a little over a year to complete and the boiler went online March 2012.

System Components

Today, a 2 MMBtu/hr Hurst biomass boiler heats Grant Union's 12,000 square foot seventh-through-twelfth grade school building. The boiler is housed in its own small building directly outside of the school alongside a twenty-five ton pellet storage silo. They generally fire the system up by the middle of October and run it into early May. The pellet boiler is designed to heat the building at around eighty-five to ninety percent capacity, so pellets are not the school's only heating source. The school uses the propane backup system during exceptionally cold periods in the winter or when the building needs to be heated quickly, but they are attempting to minimize its use by carefully tuning the biomass system.


Figure 3. Dennis Flippence, Head of Maintenance, Next to the Pellet Boiler

Quality Zone Academy Bond
A tax credit bonds program providing interest-free loans to public schools for building renovations or repairs, equipment purchases, curriculum development, and/or school personnel training. Rather than receiving interest payments from schools, lenders receive tax credits issued by the federal government.

The school has not encountered any major frustrations using the new boiler. Currently, the system is not quite tuned correctly to maximize fuel efficiency, and there are continuing efforts to determine the best times to turn the system on and off. Compared to their old boiler, Mark Witty believes that there will be more labor involved with the biomass system, particularly cleaning the ash out, but they have a good delivery system, so this is not a large concern. The system produces very little ash—about a fifty-gallon trashcan per year—and requires very little maintenance, generally about two hours per week.

Project Economics

Much like the rest of John Day, money is tight at Grant Union School, so converting their heating system was no small task. They realized if they found the right funding package, biomass would reduce their heating costs and help the local economy—but it would take the right financial incentives.

After the flood in 2011 that forced the school's oil storage tank out of the ground, Grant Union began to look for funding resources. They were able to identify a Quality Zone Academy Bond (QZAB), which would cover $500,000 of the cost to convert to a biomass system. As part of the QZAB agreement, the school had to get a local company to give ten percent of the bond as a donation. Malheur Lumber stepped up and gave an in-kind donation that provides Grant Union with pellets for a reduced cost (essentially, a $33.00 discount per ton) until $50,000 in value is reached. Under the donation agreement, Malheur Lumber bills Grant Union School for the market value of the pellets ($165.00/ton) and a credit is applied reducing the total fuel cost until the $50,000 donation is reached. The Oregon Department of Energy's Cool Schools program also provided a $32,000 grant for the project. Through the QZAB zero interest loan and the other financial assistance, Grant Union was able to take much of the risk out of the project and get it off the ground.

Figure 4. Rear of the Hurst Pellet Unit

According to Superintendent Witty, financing was of key importance and ended up being the hardest part of getting the project on its way. "A biomass boiler is a much larger outlay of cash on the front end so [you] need to be able to view the savings over the long haul," he said. "We would not have been able to do the project without the incentive of a zero interest loan."

It took a significant amount of time to reach an agreement with Sterling Bank for the QZAB. Getting the QZAB agreement was difficult in part because of requirements like a balloon payment on the loan amount that the school must pay annually (approximately $33,000 per year) and because they had to convince Malheur Lumber to provide $50,000 worth of discounted pellets (which was required to qualify for the QZAB). The school struggled to sell the idea of a biomass system conversion for several months. Local banks in the county helped apply pressure on their district offices to get them to agree to the QZAB project. Ultimately, Sterling Bank took on the QZAB and now receives a tax credit, allowing Grant Union School to pay back the bond at zero percent interest.

Figure 5. Pellet Silo and Boiler Housing Building

In total, the project cost approximately $532,000. Grant Union School expects a savings of roughly $49,260 a year before debt service expenditures (a higher savings than was initially estimated). The school currently estimates that they will still save roughly $15,000 per year after paying off the bond.

There are various methods that can be employed to analyze a project's financial viability. One financial analysis tool is the annualized rate of return (ARR).[46] The purpose of the ARR is to identify the potential rate at which an investment will increase (or decrease) each year. Calculating a ten year ARR is valuable for investors because this timeframe best reflects their shorter term focus. The ARR is calculated using a project's return on investment (ROI), which acts as a multiplier at which an investment is estimated to grow over a set time period.

Another useful financial analysis calculation is the internal rate of return (IRR). The IRR estimates a facility's expected return from an investment over time (a measurement of the efficiency of the investment). The IRR is useful for facility owners and calculating it over a twenty-five year time period coincides with the typical projected life of a wood-energy system (twenty-five to thirty years). It is calculated as comparison of fuel savings for term to total project investment.[47]

A basic financial analysis of Grant Union's biomass project shows that it has a payback period of 10.8 years, a ten year ARR equal to 8.7%, and a twenty-five year IRR of 14.8% (assuming inflation varies by source of energy). In this analysis, inflation rates of 1.5% for wood and 5.5% for heating oil were used.[48] Overall, these calculations indicate that Grant Union's project is favorable from a financial investment perspective (current markets are looking for an ARR between five to ten percent and the project's IRR indicates positive growth). For additional financial analysis details, please see Appendices A and C.

Fuel Supply

Grant Union School's wood pellet fuel is supplied locally by Malheur Lumber Company's pellet and brick plant in John Day. The pellets are made using forestry residuals and small diameter trees that are removed from National Forest lands during stewardship contracting activities. The $50,000 grant from Malheur Lumber provides the school a discount (thirty-three dollars off per ton) on pellets they purchase from Malheur until $50,000 in value is reached. On average, the school burns around 180 tons of pellets when the system is running during the cold months of the year (or about one ton per day), representing an annual fuel cost of approximately $29,700 (without applying the discount). The design of the project was aided by having a supplier that was able to offer a set fuel ton price over a period of time.

The main reasons the school selected pellets, versus an alternative biomass fuel like woodchips, are because they are clean burning, efficient, require minimal maintenance, and are a local product. In addition, the local area does not have access to natural gas, so that was not an option. Malheur Lumber's pellet plant is located four miles from the school. The

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[46] ARR Formula: $((1+ROI)^{1/N})-1$

N = # of years ROI = Return on investment = B – C/P

B – C = Cumulative fuel cost savings added up over a set period of time P = Total project investment.

[47] IRR Formula: $PNW = 0 = F_a/(1 + R)^a$

PNW = Present Net Worth = 0 F = Income Each Year = Fuel Savings Each Year a = Year R = Rate of Return

[48] U.S. Energy Information Administration for all inflation estimates except wood. Wood inflation estimate was provided by local expert Andrew Haden (www.Wisewood.US)

pellets are delivered on a monthly basis when the system is operational starting in October. If a local source of pellets were no longer available, the school could invest $25,000-$30,000 to convert the system to utilize woodchips.

Conclusion

Now that the project is complete and the school has some experience operating the system, they have been very satisfied with the results. “We are one hundred percent satisfied with the system so far,” Witty said. The school likes using a heating source that is clean, less expensive, and locally produced. They are going to visit other school boards in Oregon to share their experience with the system. If things continue to work well over the next couple of years, Witty plans to pursue another QZAB to install another boiler to heat an additional school building.

Blue Mountain Hospital

Figure 6. Blue Mountain Hospital

GENERAL INFORMATION	
FACILITY	Blue Mountain Hospital
Building Area (ft^2)	50,000
Experience Total (years)	2
Project Type	Retrofit
EQUIPMENT SPECIFICATIONS	
Boiler Manufacturer	Viessmann-Köb
Boiler Model	Pyrot 540
Output MMBtu/hr	1.84
Biomass Percent of Building Heating	90%
Backup Unit	Heating Oil
FUEL SPECIFICATIONS	
Composition	Ponderosa Pine wood pellets
Source	Forest stewardship contracts
Supply Radius (miles)	3
Delivery Frequency	Bimonthly/Monthly
Quantity Delivered (tons)	20-25
Cost Per Ton Delivered	$ 165
Moisture Content	$\leq$ 5%
Fuel Storage Capacity (tons)	50
Annual Consumption (tons)	260
Fuel Replaced by Biomass	Crude Oil
Annual Biomass Fuel Cost	$ 42,900
Annual Heating Cost Savings	$ 84,000
PROJECT ECONOMICS	
Project Total Funding	$ 450,000
ARRA Funding	$ 339,923
Bank Loan	$ 110,077
Project Total Cost	$ 450,000
Equipment Cost	$ 234,000
Installation Cost	$ 216,000
Annual O&M Costs	$ 1,200
Financial Analysis	
Annualized Rate of Return (10yr)	13.7%
Internal Rate of Return (25yr)	25.4%
Payback Period (years)	5.4

Project Background

Blue Mountain Hospital is a 50,000 square foot, 25-bed hospital located in John Day, Oregon. Six family practice physicians, a surgeon, and a family nurse practitioner work at the hospital, and residents and interns are also rotated through on a regular basis as part of the Oregon Health Sciences University Family Practice Residency program.

According to Bob Houser, CEO of Blue Mountain Hospital, the hospital began converting to a biomass system in 2009 with the main objectives to save money on oil consumption and help support the local pellet industry in John Day. There were also a number of environmental considerations that led the hospital toward selecting biomass as a fuel source including reduced carbon emissions and reduced fossil fuel dependence by using a locally produced, renewable fuel source.

With these goals in mind, the hospital began to research what type of biomass system would best fit their needs. Blue Mountain needed a constant supply of conditioned air and hot water throughout the year, so it was important to find a system that could meet this requirement. They visited Grant County Regional Airport and another hospital located in Burns, Oregon, to hear about the success they had achieved with their biomass units. Based on the recommendation of Andrew Haden, the lead project engineer and consultant for the hospital's project, the hospital ultimately decided to go with a Viessmann-KOB Pyrot 540 pellet boiler. After determining which type of boiler would best fit their needs, the hospital applied for a state grant, got bids, and broke ground.

The project took about two years to complete, which was a bit longer than anticipated because of a delay in manufacturing the pellet unit. The Viessmann-KOB Pyrot 540 pellet boiler started operating in April 2011, and, to date, it has heated and supplied hot water to the whole hospital complex and clinic space (totaling about 50,000 square feet) for almost two years. Houser said they have been quite pleased with the results thus far and have found biomass to be an alternative that is "cheaper, cleaner, and it supports the local timber industry."

System Components

The following are the major components of Blue Mountain Hospital's biomass system:

- Fifty-ton pellet silo
- 1.844 MMBtu/hr pellet boiler
- 1,500 gallon water/glycol storage tank integrated into the system to even out load conditions and reduce boiler cycling
- Two heating oil backup units

Figure 7. Steve Hill, Director of Facilities Services, Next to the Pellet Boiler

Before making the switch to biomass, Blue Mountain Hospital relied on two bunker fuel boilers along with one #2 heating oil boiler to meet the facility's heating and hot water needs. They replaced one of the hospital's old bunker fuel boilers with the new pellet boiler and decided to convert the remaining bunker fuel boiler to heating oil. They now have two heating oil boilers that act as backups.

The biomass boiler, which is tied into the hospital's existing hydronic heating system, is located directly outside of the hospital, housed in a steel container alongside a fifty-ton wood pellet silo. In total, the 1.844 MMBtu/hr Viessmann-KOB Pyrot 540 boiler provides roughly ninety percent of the hospital's total heat load. The system is operational year-round because it is also used to heat hot water when the building itself does not need to be heated. It is a very automated system that only needs to be checked infrequently by the hospital's maintenance staff. Generally, it takes less than two hours per week on average to maintain the system.

Figure 8. Pellet Silo and Biomass Housing Unit

The biggest challenge the hospital experienced with the system occurred soon after its installation and involved getting the first load of pellets into the storage unit. "[The fuel] was delivered in a regular farm truck and we had to get an elevator to put the pellets in the silo," said Houser. They also had some initial challenges with getting the boiler tuned and with a bad batch of fuel that caused a lot of ash caking. Fortunately, these glitches have been worked out over time and the system now performs very well.

Fuel Supply

Blue Mountain Hospital's wood pellet fuel is supplied locally by Malheur Lumber Company's pellet and brick plant in John Day. The pellets are made using forestry residuals and small diameter trees that are removed from National Forest lands during stewardship contracting activities.

There were numerous reasons why the hospital chose to go with pellet fuel. Possibly the most important factor was the close proximity of a pellet supplier – Malheur Lumber is only several miles away from the hospital. Because of this nearby fuel source, the hospital is able to fill the storage silo on an as-needed basis. Cost, availability, ease of handling, capital cost of fuel storage and conveying relative to the total project cost, and burning characteristics were also important decision factors.

Hospital officials have been very pleased with the pellet quality that Malheur Lumber produces. Originally, the hospital tried using pellets from another vendor in Oregon, but they had higher ash content and caused problems with "clinkers." Since switching to Malheur Lumber, the issues associated with fuel quality have been resolved. The fuel is very clean burning and has produced less than twenty gallons of ash in the past fifteen months of use.

The hospital consumes an average of 260 tons of pellets per year, which, at $165.00 per ton, costs $42,900 annually. Blue Mountain has a year-round need for the pellet system to meet the hospital's hot water and heating demand. Double the amount of pellets are consumed during winter, when there is a significant increase in demand for both building heating and hot water, compared to the summer.

Project Economics

The overall cost of the project was approximately $450,000. This included the cost of the pellet silo, enclosed pellet boiler, the container pad, the interconnections with the existing heating system, and the total installation cost.

To help fund the conversion project and cover some of the large capital costs, the hospital received $339,923 in state and federal stimulus money through the American Recovery and Reinvestment Act. The remaining $110,077 was financed through a loan from the Bank of Eastern Oregon.

Figure 9. Heating Oil Boiler

The biggest funding challenge that Blue Mountain Hospital encountered during the development of the project was in completing all the mandatory documentation. According to Houser, there was a lot of extra documentation that was required in order to qualify for the grant money.

On average, since converting to the pellet system, the hospital has saved $84,000 per year in heating costs. In addition to these financial savings, the hospital has found that using a new energy efficient pellet boiler has helped reduce their carbon emissions versus their old oil fired boilers, which were made in the 1950s prior to emission controls mandated by the Environmental Protection Agency. Also, on average, one to two hours per week are required for maintenance, which is about one third the amount of work required compared to their previous oil boiler.

There are various methods that can be employed to analyze a project's financial viability. One financial analysis tool is the annualized rate of return (ARR). The purpose of the ARR is to identify the potential rate at which an investment will increase (or decrease) each year. Calculating a ten year ARR is valuable for investors because this timeframe best reflects their shorter term focus. The ARR is calculated using a project's return on investment (ROI), which acts as a multiplier at which an investment is estimated to grow over a set time period.[49]

Another useful financial analysis calculation is the internal rate of return (IRR). The IRR estimates a facility's expected return from an investment over time (a measurement of the efficiency of the investment). The IRR is useful for facility owners and calculating it over a twenty-five year time period coincides with the typical projected life of a wood-energy system (twenty-five to thirty years). It is calculated as comparison of fuel savings for term to total project investment.[50]

A basic financial analysis of Blue Mountain Hospital's biomass project shows that it has a payback period of 5.4 years, a ten year ARR equal to 13.7%, and a twenty-five year IRR of 25.4% (assuming inflation varies by source of energy). In this analysis, inflation rates of 1.5% for wood and 5.5% for heating oil were used.[51]

Overall, these calculations indicate that the hospital's project is favorable from a financial investment perspective (current markets are looking for an ARR between five to ten percent and the project's IRR indicates positive growth). Compared to other biomass facilities in John Day that have a seasonal heating demand, the hospital's high year-round (non-seasonal) heating and hot water demand makes the economics of the project especially favorable. Additionally, because fuel oil has been so expensive, the hospital may beat its initial expected payback estimate and could have investment costs paid off in less than five years. It should be noted that these financial calculations do not deduct the cost associated the hospital's choice to convert to a pellet system versus merely replacing their aging oil boilers with similar units. Accounting for these factors would only improve the

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[49] ARR Formula: $((1+ROI)^{1/N})-1$
N = # of years ROI = Return on investment = B – C/P
B – C = Cumulative fuel cost savings added up over a set period of time P = Total project investment.
[50] IRR Formula: $PNW = 0 = F_a/(1 + R)^a$
PNW = Present Net Worth = 0 F = Income Each Year = Fuel Savings Each Year a = Year R = Rate of Return
[51] U.S. Energy Information Administration for all inflation estimates except wood. Wood inflation estimate was provided by local expert Andrew Haden (www.Wisewood.US)

financial viability of the project. For additional financial analysis details, please see Appendices A and B.

Conclusion

Of the four biomass projects in the Grant County cluster, Blue Mountain Hospital's project is the most favorable from a financial investment perspective. In retrospect, now that the boiler has been operational for close to two years, there is not much that the hospital would have done differently in developing the project. So far, it has been "headache-free" and they have not experienced major frustrations using the system. They would have liked to prevent the delay in manufacturing the unit, however. "[We would have] ordered the unit quicker, before the manufacturer got behind, so it could be used sooner," said Houser. Things have gone quite smoothly, and, overall, Houser is very happy with how the system has worked out. "It has exceeded our expectations and is paying for itself. We are continuing to use our unit and have convinced several other businesses in the county to convert as well," he said.

Grant County Regional Airport

Figure 10. Grant County Regional Airport Airbase Building

GENERAL INFORMATION	
FACILITY	Grant County Airport
Building Area (ft^2)	14,000
Experience Total (years)	2
Project Type	New Construction
EQUIPMENT SPECIFICATIONS	
Boiler Manufacturer	Viessmann-Köb
Boiler Model	Pyrot 220
Output MMBtu/hr	0.75
Biomass Percent of Building Heating	50%
Backup Unit	Heat Pumps
FUEL SPECIFICATIONS	
Composition	Ponderosa Pine wood pellets
Source	Forest stewardship contracts
Supply Radius (miles)	6
Delivery Frequency	Seasonally
Quantity Delivered (tons)	20-25
Cost Per Ton Delivered	$ 165
Moisture Content	≤ 5%
Fuel Storage Capacity (tons)	30
Annual Consumption (tons)	32
Fuel Replaced by Biomass	N/A
Annual Biomass Fuel Cost	$ 5,280
Annual Heating Cost Savings	$ 7,520
PROJECT ECONOMICS	
Project Total Funding	$ 325,000
USDA Grant #1 Biomass Project	$ 29,700
USDA Grant #2	$ 147,650
Connect Oregon II Grant	$ 147,650
Project Total Cost	$ 225,000
Equipment Cost	$ 225,000
Installation Cost	$ 100,000
Avoided Capital Cost (Electric)	($ 100,000)
Annual O&M Costs	$ 500
Financial Analysis	
Annualized Rate of Return (10yr)	3.2%
Internal Rate of Return (25yr)	0.8%
Payback Period (years)	29.9

Project Background

Spread over 335 acres in John Day, Grant County Regional Airport, which is owned and operated by the County, houses a dozen general aviation aircraft at its base and serves a diverse cliental including doctors and business people and services such as medevac services, emergency services, and refueling needs. In terms of facilities, there are thirteen private hangars, a county hangar, a terminal building, and a Forest Service Helibase located at the airport. In the past, a flight school was also located at the airport. The airport acts as a hub for people who need to get to places quickly, which is especially important given John Day's remote location.

The airport is another John Day site that recently installed a new wood pellet system to heat its entire terminal building. All in all, the project took about two years to complete from planning to operation with the goals of acting as a demonstration program and providing financial savings on heating costs. As of November 2012, the airport has used the biomass system for a little over two years.

Unlike the other biomass energy projects in John Day, the airport was not a conversion project. The biomass project first originated about five years ago and coincided with the new terminal building construction.

Figure 11. Patrick Bentz, Airport Manager, Next to the Pellet Boiler Container

The old terminal was simply a converted home that badly needed updating. The setup was not at all suitable for their needs, so the county decided to build a new terminal. When the new airbase building was being constructed, they saw that Malheur Lumber, a local sawmill in John Day, was in the process of building a new pellet mill. The pellet mill was in very close proximity to the airport and would be a convenient fuel supplier, so the airport decided to go with a wood pellet biomass system.

The new 14,000 square foot airbase building is divided into three sections: a County side, a Federal side (for the Forest Service), and a common area that anyone is free to use. It is a multipurpose facility that Patrick Bentz, Regional Airport Manager, is trying to run like a business, so that it does not annually cost the county money. He said the new terminal building has hosted city meetings (with state Senators attending) and private celebrations. The Forest Service conducts wildfire-training exercises at the base (such as repel training) and many firefighting personnel are based there throughout the summer. The airbase building also houses Forest Service offices.

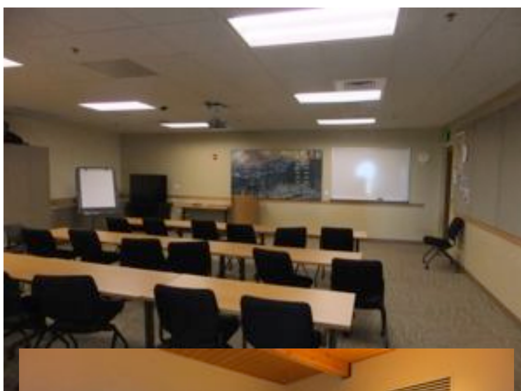
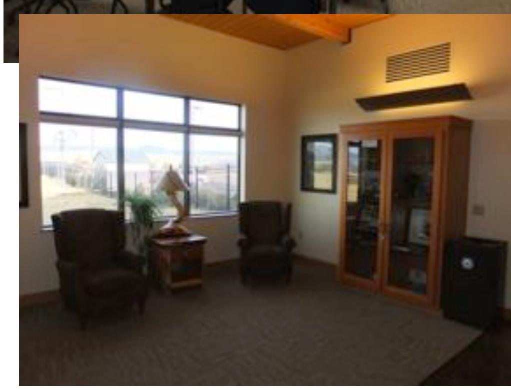
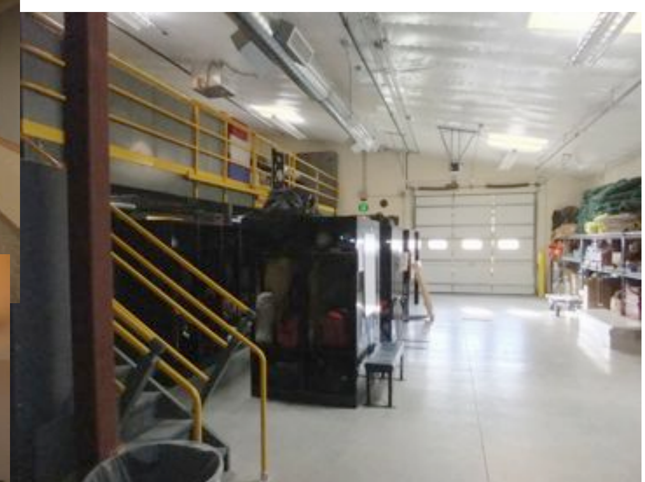

Figure 12. Various Sections of the Airbase

Project Economics

In total, funding for the entire new terminal building project was just over five million dollars, funded through a Connect Oregon II grant and a USDA grant. The biomass heating project ended up costing $325,000 ($225,000 when accounting for the $100,000 avoided cost of not installing a conventional electric boiler that would handle 100 percent of the terminal's heating). The airport received an additional $29,700 USDA grant specifically for the biomass project and the remainder of the project cost was covered by the larger Connect Oregon II and USDA grants. The Forest Service had a very old facility that was barely adequate, so they provided the grant to help remedy this issue. In the end, because of these grants, the project did not cost the county anything. Overall, using a pellet system to meet the building's heating demand saves the airport approximately $7,520 per year in heating costs versus relying on an electric boiler. The project has an expected payback period of close to thirty years.

There are various methods that can be employed to analyze a project's financial viability. One financial analysis tool is the annualized rate of return (ARR). The purpose of the ARR is to identify the potential rate at which an investment will increase (or decrease) each year. Calculating a ten year ARR is valuable for investors because this timeframe best reflects their shorter term focus. The ARR is calculated using a project's return on investment (ROI), which acts as a multiplier at which an investment is estimated to grow over a set time period.[52]

Another useful financial analysis calculation is the internal rate of return (IRR). The IRR estimates a facility's expected return from an investment over time (a measurement of the efficiency of the investment). The IRR is useful for facility owners and calculating it over a twenty-five year time period coincides with the typical projected life of a wood-energy system (twenty-five to thirty years). It is calculated as comparison of fuel savings for term to total project investment.[53]

A basic financial analysis of the Regional Airport's biomass project shows that it has a payback period of 29.9 years, a ten year annualized rate of return equal to 3.2%, and a twenty-five year internal rate of return of 0.8% (assuming inflation varies by source of energy). In this analysis, inflation rates of 1.5% for wood and 2.0% for electricity were used.[54]

Overall, these calculations indicate that the airport's biomass project is not as favorable from a financial investment perspective as the other three biomass projects in the Grant County biomass cluster (current markets are looking for an ARR between five to ten percent and the project's IRR indicates small positive growth). The pellet boiler was designed to meet only fifty percent of the terminal building's heat load, so the airport is not able to achieve large annual heating cost savings from which to pay off its investment. Also, electricity is relatively cheap in Oregon at about 0.08/kwh, and this reduces the fuel cost savings of biomass compared to

Figure 13. Side View of the Pellet Unit

[52] ARR Formula: $((1+ROI)^{1/N})-1$
N = # of years   ROI = Return on investment = B – C/P
B – C = Cumulative fuel cost savings added up over a set period of time   P = Total project investment.
[53] IRR Formula: $PNW = 0 = F_a/(1 + R)^a$
PNW = Present Net Worth = 0   F = Income Each Year = Fuel Savings Each Year   a = Year   R = Rate of Return
[54] U.S. Energy Information Administration for all inflation estimates except wood. Wood inflation estimate was provided by local expert Andrew Haden (www.Wisewood.US)

more expensive alternatives like heating oil or propane. For additional financial analysis details, please see Appendix A.

System Components

The biomass boiler is located directly outside of the terminal building, housed in a steel container alongside a thirty-ton wood pellet storage silo. The airport uses a 0.75 MMBtu/hr Viessmann-KOB Pyrot 220, which provides hot water heating and it can run cold water (using a condenser) to the new 14,000 square foot airbase building. The pellet unit provides fifty percent of the airport's heating demand with the remaining half being met through a series of water source heat pumps that use a common loop operating between 70° and 85°.

As far as challenges are concerned, fine tuning the system and gaining experience in operating the unit under a variety of conditions have been the biggest challenges. Bentz explained that he has been learning the ins and outs of the system since he was hired as the airport's manager. Overall, the system is very automated and computer controls can be used to modulate heating in different sections of the building.

Fuel Supply

The airport's wood pellet fuel is supplied locally by Malheur Lumber Company's pellet and brick plant in John Day. The pellets are made using forestry residuals and small diameter trees that are removed from National Forest lands during stewardship contracting activities.

The airport has a convenient source of pellets with Malheur Lumber just three miles away from their location. There is a level indicator on the fuel storage silo that lets them know when it needs to be refilled. The system is turned on in late October and with three to four months of storage, the pellet silo is filled up once or twice a year. A local rancher delivers the pellets straight from Malheur Lumber to meet the airport's seasonal needs.

The airport consumes roughly thirty-two tons of pellets a year. At $165.00 per ton of pellets, it costs roughly $5,280 per year to heat with pellets.

Conclusion

Overall, Bentz has been happy with how the biomass system is working. He talked about how people in John Day are very dependent on forest activities and how there are a lot of brush piles in the forest that would normally just be burned in piles onsite. He noted that wildfire can be a threat and referred to a large wildfire near the town, which took Forest Service personnel and helicopters about a week to extinguish. He thinks using this biomass to produce pellets is a more productive use of forest treatment material and could help reduce the threat of these unnaturally severe fires.

Figure 14. Forest Service Training Equipment

Prairie City School

The project information and photos for this case study were provided by Wisewood Inc

Figure 15. Prairie City School Staff at the Biomass Project Groundbreaking (photo by Wisewood Inc)

GENERAL INFORMATION	
FACILITY	Prairie City School
Building Area (ft^2)	70,000
Experience Total (years)	< 1
Project Type	Retrofit
EQUIPMENT SPECIFICATIONS	
Boiler Manufacturer	Biomass Combustion Systems
Boiler Model	463
Output MMBtu/hr	2.50
Biomass Percent of Building Heating	90%
Backup Unit	Propane
FUEL SPECIFICATIONS	
Composition	Ponderosa Pine wood pellets
Source	Forest stewardship contracts
Supply Radius (miles)	40
Delivery Frequency	Monthly
Quantity Delivered (tons)	20-25
Cost Per Ton Delivered	$ 160
Moisture Content	≤ 5%
Fuel Storage Capacity (tons)	48
Annual Consumption (tons)	239
Fuel Replaced by Biomass	Propane
Annual Biomass Fuel Cost	$ 38,240
Annual Heating Cost Savings	$ 68,635
PROJECT ECONOMICS	
Project Total Funding	$ 655,000
Quality Zone Academy Bond	$ 655,000
Other Non-Project Funding Malheur Lumber Discounted Pellets	$ 68,000
Project Total Cost	$ 655,000
Equipment Cost	$ 375,000
Installation Cost	$ 280,000
Annual O&M Costs	$ 3,600
Financial Analysis	
Annualized Rate of Return (10yr)	9.5%
Internal Rate of Return (25yr)	16.4%
Payback Period (years)	9.5

Project Background

Located roughly twenty miles east of John Day, the Prairie City School campus has the newest biomass system within the Grant County biomass cluster. A wood pellet system currently provides heating (steam) to the entire main high school, middle school, and connected elementary school (totaling 70,000 square feet). The unit also provides hot water heat to the school's separate gymnasium and cafeteria.

Prairie City School District was in desperate need of a new heating system. Originally, there were a total of five boilers operating in the school buildings, providing adequate redundancy in case one of the boilers went down. However, as these boilers aged, the district began to run into issues maintaining the system. Eventually, the campus had only one boiler that was operational in each of the school buildings, and the boilers that still worked needed constant repair to prevent them from breaking down. All three of the schools were dependent on propane for their heating needs—which was very costly and hurting the district's budget. As a result, the district had two options: continue trying to maintain the remaining boilers with a reduced maintenance staff or replace the boilers.

The school chose the latter option and Dave Kerr, the former superintendent of Prairie School District #4, began researching alternative heating systems that would better fit the school's needs. Biomass seemed like it would be a good match because it would help reduce

the school's heating costs, have improved price stability versus propane, support the local economy, and help continue the development of biomass energy in Grant County.
Kerr contacted Wisewood, Inc. (a Portland-based design/build firm that specializes in biomass energy) to learn more about what it would take for the school to put in a new biomass system. The former superintendent then worked to gain support of the school board for the biomass project. After gaining the board's approval, the school secured funding through a Quality Zone Academy Bond (the same type of bond that Grant Union School used to fund their biomass boiler project). The school then moved on to get the system engineered and they received competitive bids for the construction. Wisewood won the bid for the construction of the project.

When project construction began, Wisewood realized that getting the biomass boiler equipment would involve the longest lead time, so they made sure to order it early on to avoid any delay. Concurrently, Wisewood and its subcontractors focused on putting other infrastructure in place such as the trenching, hot water, steam line installation; building and silo erection; and building connections to existing heat distribution systems in the school and gymnasium. They found it relatively straightforward integrating the system into the existing heat distribution and controls at the school buildings.

Figure 16. Pellet Silo and Boiler Housing Building. (photo by Wisewood Inc)

Once the boiler was installed, Wisewood began work on fine-tuning parts of the system including the fuel settings, controls, and other scheduling. This work has been the most challenging over the course of developing the project. Getting fuel settings optimized to cover three district loads (the school building, gymnasium, and cafeteria) took longer than expected because of a new auto-ignition system and an auto-dialer to alert staff of any alarms triggered in the system.

From development to commissioning, the project took about nine months to complete. The school is still making small adjustments to the unit such as getting the controls dialed in, but it has been fully operational and has been producing heat since late October 2012.

Quality Zone Academy Bond
A tax credit bonds program providing interest-free loans to public schools for building renovations or repairs, equipment purchases, curriculum development, and/or school personnel training.
Rather than receiving interest payments from schools, lenders receive tax credits issued by the federal government

Project Economics

Overall, the total cost of the biomass project was $655,000 and Prairie City School funded the entire project through a Qualified Zone Academy Bond (QZAB), which is a zero percent interest, balloon payment bond. The QZAB account to which annual installment payments are made is administered by a local branch of the Bank of Eastern Oregon. Prairie

City School is able to keep any interest accumulated on the savings account, and this will eventually be used to make a balloon payment by the end of the twenty-year loan in addition to other capital improvements. Because the QZAB funding had been previously utilized by Grant Union School for its biomass project, Prairie City School did not have much difficulty finding a local bank to take on the bond. Given the high up front capital cost of the biomass system, getting the zero percent QZAB loan was critical in financing the project.

Also, like Grant Union School in John Day, Malheur Lumber Company provided a $68,000 grant to Prairie City School, and supplies the pellets to the school at a discounted rate per ton until the grant value is reached. Under the grant agreement, Malheur Lumber bills Prairie City School for the market value of the pellets ($160.00/ton) and a credit is applied reducing the total fuel cost until the $68,000 donation is reached.

Overall, the new pellet system is expected to provide an annual savings of approximately $68,635 over the previous heating system.

There are various methods that can be employed to analyze a project's financial viability. One financial analysis tool is the annualized rate of return (ARR). The purpose of the ARR is to identify the potential rate at which an investment will increase (or decrease) each year. Calculating a ten year ARR is valuable for investors because this timeframe best reflects their shorter term focus. The ARR is calculated using a project's return on investment (ROI), which acts as a multiplier at which an investment is estimated to grow over a set time period.[55]

Another useful financial analysis calculation is the internal rate of return (IRR). The IRR estimates a facility's expected return from an investment over time (a measurement of the efficiency of the investment). The IRR is useful for facility owners and calculating it over a twenty-five year time period coincides with the typical projected life of a wood-energy system (twenty-five to thirty years). It is calculated as comparison of fuel savings for term to total project investment.[56]

A basic financial analysis of Prairie City School's biomass project shows that it has a payback period of nine and a half years, a ten year annualized rate of return equal to 9.5%, and a twenty-five year internal rate of return of 16.4% (assuming inflation varies by source of energy). In this analysis, inflation rates of 1.5% for wood and 5.6% for propane were used.[57]

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[55] ARR Formula: $((1+ROI)^{1/N})-1$
N = # of years ROI = Return on investment = B – C/P
B – C = Cumulative fuel cost savings added up over a set period of time P = Total project investment.
[56] IRR Formula: $PNW = 0 = F_a/(1 + R)^a$
PNW = Present Net Worth = 0 F = Income Each Year = Fuel Savings Each Year a = Year R = Rate of Return
[57] U.S. Energy Information Administration for all inflation estimates except wood. Wood inflation estimate was provided by local expert Andrew Haden (www.Wisewood.US)

Overall, these calculations indicate that the school's project is favorable from a financial investment perspective (current markets are looking for an ARR between five to ten percent and the project's IRR indicates positive growth). It should be noted that these financial calculations do not deduct the costs associated the school's choice to convert to a pellet system versus merely replacing their aging oil boilers with similar units, and accounting for these factors would only improve the financial viability of the project. For additional financial analysis details, please see Appendices A and D.

System Components

There are several components that are part of Prairie City School's biomass system:

- 2.6 MMBtu boiler
- Forty-eight pellet silo and auger
- Heat exchanger
- Pumps
- Steam distribution lines
- Hot water distribution lines
- Existing propane units used as backups

The school benefited from joining the larger biomass cluster in John Day, where three other biomass conversions are located, because the sites were able to share their experiences with one another. Prairie City School looked to the experience of Malheur Lumber's pellet mill and the three other biomass conversions in John Day to learn about how the technology functioned and how savings were being delivered to others in the community.

To determine which biomass model to purchase, Prairie City School entrusted Wisewood (which also developed the other biomass projects in John Day) to recommend which biomass unit would best meet the school's needs. They saw how well the boiler at Grant Union School was working, and ultimately decided to pursue a similar unit. Prairie City School has also been able to improve its maintenance efficiency by using the same boiler make as Grant Union School. The same maintenance staff splits time between Grant Union School and Prairie City, and having the same type of boiler installed at both of the school has helped reduce the learning curve in terms of knowing how to operate and maintain both the units.

Figure 17. Biomass Combustion Systems Pellet Boiler (photo by Wisewood Inc)

Not everything has run smoothly, however. There have been some frustrations that the school has experienced with the new system. If a steam unit would have been available, one thing that Wisewood would have done differently in the development of the system is to have utilized more compact, efficient, and automated European biomass technology. According to Wisewood, "European biomass technology is two decades ahead of U.S.

biomass technology, but was not yet ASME rated[58] to provide steam heat when this project was conceived, so we used a more basic U.S.-made unit. It is very robust and clean burning, but it doesn't have automatic de-ash, so that has to be performed manually every week."

Perhaps the most important lesson Prairie City learned while developing its biomass project was that the actual construction may not be as straightforward as the biomass technology itself would lead you to believe. For example, trenching and retrofitting older buildings are often required and other unforeseen issues can be encountered along the way.

Fuel Supply

Prairie City School's wood pellet fuel is supplied locally by Malheur Lumber Company's pellet and brick plant in John Day. The pellets are made using forestry residuals and small diameter trees that are removed from National Forest lands during stewardship contracting activities. Compared to using propane and spending money that gets exported out of the state, purchasing biomass fuel means that more money stays within the local economy and benefits the community.

As mentioned earlier, Malheur Lumber Company provided a $68,000 grant to Prairie City School and delivers the pellets at a discounted rate until the grant value is reached. The school consumes 239 tons of pellets per year at $160.00 per ton—representing $38,240 in annual fuel costs (without applying the discount).

Figure 18. Combustion of Pellet Fuel
(photo by Wisewood Inc)

There were a number of reasons the school went with pellets over another biomass feedstock such as woodchips. Most importantly, the school has a local supply of pellet fuel readily available twenty miles away at Malheur Lumber Company; consequently, in addition to providing cost savings on delivery, the school also viewed going with pellets as a way to help benefit the community (local job creation at Malheur Lumber's pellet mill, for example). Additionally, pellets are a cleaner fuel and take up less space compared to wood chips. As a school, it was also important that the system require minimal maintenance, so a pellet system made the most sense. In addition, pellets are very economical versus propane. Lastly, emission reductions were an important consideration as well as the ability to use harvested forest residuals that would otherwise be left unused or burned in piles. According to Wisewood, "In Grant County, there are forest fires every year, which can be seen as a waste of resources. By utilizing forest residuals instead of fossil fuels, we get to capture some of that energy."

[58] The American Society of Mechanical Engineers (ASME) sets the standards for the design and construction of boilers. To sell boilers in the U.S., European companies must first receive ASME certification.

Conclusion

Because Prairie City School's new pellet unit has only been running for a couple of months, it remains to be seen how it will work in the long run. So far, the school is very happy with how the new pellet unit is working. The system is using the amount of fuel that was expected and the school now needs very little propane to heat its campus. Pellets are a much cheaper fuel source versus propane and the system will save the school a significant amount of money in heating costs. Because there are many similarities between the biomass project at Prairie City School and the one at Grant Union School, it is expected that the new system will achieve similar positive results over time.

Looking forward, Prairie City School plans to use the new pellet system for the next thirty or more years. The single pellet boiler does the work of three fossil fuel units, and they expect it will provide significant heating cost savings over time as the cost of propane and oil continue to rise.

Malheur Lumber

Figure 19. Malheur Lumber Yard

GENERAL INFORMATION	
FACILITY	Malheur Lumber
Facility Type	Pellet Mill
Project Total Cost	$6,500,000
ARRA Funding	$5,000,000
Experience Total (years)	2
FUEL SPECIFICATIONS	
Products Sold	Bulk and Bagged Pellets Bundled Fuel Bricks
Pellet Composition	Ponderosa Pine
Pellet Moisture Content	5-6%
PROJECT ECONOMICS	
Raw Material Sources	Stewardship Contracts Timber Sales
Fuel Supply Public/Private	50/50
Raw Material Supply Radius (miles)	100-150
Pellet Delivery Radius (miles)	200-250
Bulk Truck Delivery Capacity (tons)	28
Currently Profitable? (yes/no)	No
Profitability Threshold (tons delivered/month)	750-1000

Pellet Mill Project Overview

Malheur Lumber Company (a wholly-owned subsidiary under Ochoco Lumber Company of Prineville, Oregon) began the construction of its sawmill located in John Day in 1983. The mill employs a total of ninety people both in production and management. Most of their lumber (cut from pine logs) is sent to secondary manufacturers that make housing materials such as doors, windows, moldings, cabinets, and furniture.

Malheur Lumber also has a pellet mill on site and acts as the pellet fuel producer and distributor for all three of the local biomass facilities clustered in John Day (located just a couple of miles away) plus Prairie City School (located about twenty miles from the mill). The construction of the pellet mill began in April 2010, and it was completed in December that same year. This study was conducted the second year that the pellet mill had been in operation. At that time, five people were employed at the mill and thirteen expected to be employed after business expansion. John Rowell, the Plant Manager at Malheur Lumber, expressed hopes to run the pellet mill year-round if fuel demand for the pellets could be increased enough.

Figure 20. Pellet Drying Equipment

Pellet Mill Beginnings

Mike Billman, the Timber Manager at Malheur Lumber, worked as the project manager for the pellet mill project while it was under construction and he summarized the experience. He explained that the project came about during the stimulus money era with American Recovery and Reinvestment Act (ARRA) grants. Proposals were sent by all of the National

Forests requesting ARRA funds to carry out thinning projects and other restoration activities. The Malheur National Forest put in its own proposal, but they also requested money to construct a pellet plant in Grant County or Harney County (the neighboring county). Grant County is quite distant from pulp and paper markets, and it was thought that a pellet plant would help grow the market and the value for fiber in Grant County locally. In the end, Malheur Lumber was selected as the grant recipient and the project went forward. Billman stated that having Malheur Lumber handle the project was based on the Forest Service's desire to create a local market for biomass. They ended up receiving a five million dollar federal recovery grant to build the mill.

Figure 21. Bagged Pellet Fuel

The stimulus money provided the necessary funding to complete the plant. Malheur was awarded the grant in February 2010 and had to have product out the door by December. This accelerated schedule that was part the funding requirements led to some issues in the design and construction of the plant. As a sawmill, Malheur Lumber did not have much experience or knowledge about pellet mills and the design and construction of the plant proved challenging.

Despite the challenges, Malheur Lumber was able to complete the project, installing a new drying system, two fuel brick-making machines, and one pellet-making machine. The mill already had boilers onsite that were upgraded for the pellet mill addition.

The sawmill tries to use every part of a log that they can to minimize wasted material. Malheur Lumber has a biomass boiler onsite which creates the steam that is used to produce and dry the pellets. The boiler burns "stewardship biomass"[59] coming from federal lands as well as mill waste. In the woods, operating on stewardship sales, saw logs are sorted for the sawmill and fiber logs sorted for the production of pellets and fuel bricks.

Fuel Supply and Delivery

Malheur Lumber's harvested fuel comes from stewardship contracts[60] as well as timber sales on federal lands and private timber sales. It depends on where the most competition is (there is more competition in the north, so the radius does not stretch as far north), but generally the company stays within a 100 to 150 mile radius for their fuel supply (which

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[59] Forestry residuals and small diameter trees that are removed from National Forest lands during forest restoration activities as outlined by stewardship contracts. For more information: http://www.fs.fed.us/restoration/documents/stewardship/stewardship_brochure.pdf

[60] Stewardship contracting includes natural resource management practices seeking to promote a closer working relationship with local communities in a broad range of activities that improve land conditions. When using the Integrated Resource Timber Contract (FS-2400-13) for a stewardship contract, the cost of required service type restoration work activities will approximately be equal to the value of the products being removed. For more information: **http://www.fs.usda.gov/detail/malheur/home/?cid=STELPRDB5403809**

comes from a mixture of public and private land). The pellets are made using forestry residuals and small diameter trees that are removed from National Forest lands during timber sales and stewardship contracting activities. Malheur also produces compressed wood bricks, which can be used to replace firewood in a regular wood stove and have benefits including handling, cleanliness, no bugs, and better storage.

Malheur Lumber delivers finished pellets (which are about six percent moisture content) to the ultimate consumers or people come and pick the fuel up. The market is generally within a 200 mile radius, although some material is delivered as far away as 250 miles. To the west sales are limited to a distance of about 150 miles because of more competitors.

Figure 22. Storage Yard

Malheur contracts with several companies to deliver the pellet fuel to biomass boilers (like the ones in John Day), and they also contract with other hauling companies to ship non-bulk products such as bagged pellets and bundled bricks, which are utilized for residential use. One of the bulk delivery trucks delivers other products (such as grain or construction materials) in addition to the pellet fuel. Since Malheur Lumber is located in a rural area, transportation is a big issue and it is important to find trucks that are hauling other products in addition to the pellets because it is not economical to pay for a dedicated haul of the bulk pellet fuel. It has been key to find haulers with the capability, that have other types of deliveries they are performing, and with compatible operations that makes it easy to deliver pellets as an extra product in addition to their other delivery materials. This approach can make transportation much more challenging when confined to a certain delivery area for pellet shipments.

John Rowell said that they would like to own a bulk delivery truck, but that would require a lot more deliveries to make it economical (600 to 1,000 tons monthly during the heating season within a 100 to 150 mile radius). Currently, this does not seem realistic, and contracting with companies that have other deliveries has been a more cost-effective approach.

Marketing

From a market perspective, Billman stated that marketing the products has been somewhat challenging, but overall demand for the fuel has been good. Bulk pellet sales account for around twenty-five percent of Malheur Lumber's total volume. Bagged sales for residential users (while difficult to track and estimate) represent around sixty percent of the total volume (a rough estimate based on the total volume shipped indicates the company has between 1,500 to 2,000 residential users within a 200 mile radius). Net sales are between $650,000 and $1,000,000.


Figure 23. Pellet Processing Equipment

Rowell believes that bulk sales fit nicely into Malheur Lumber's business plan. Selling bulk pellets to facilities in John Day is a big part of the company's business, and with the talk of new local biomass boiler installations, he expects bulk sales to grow. Larger sites like Blue Mountain Hospital with a high year-round demand for bulk pellets are especially attractive customers; however, large industrial applications are limited in the region. To keep expanding their customer base, Malheur Lumber markets its various products using the company's website, advertisements in local magazines and newspapers, direct mailing, word of mouth, and by making cold calls.

There is considerable competition in stores for packaged wood pellet fuel so that market is much tougher to get into and appears less profitable. It is also very difficult to deliver to individual residential users, according to Rowell. A primary barrier to establishing a residential bulk pellet market is that many homes in the U.S. have forced-air systems, electric heating, or pellet stoves. Consequently, many residential heating systems in the U.S. are not candidates for bulk pellet usage. The residential market for bulk pellets is more established in Europe because there are more houses that are central heated with hot water and can utilize pellet boilers to heat the water.

The model Malheur Lumber would like to follow is to find distributors who deliver two to four tons of fuel, per season, to people's homes. Such distributors would likely have to make multiple deliveries to some of these customers. This is already being done to a certain extent, but the hope is to do it at a larger scale.

Malheur Lumber has a storage yard where products are bagged, packed, and shipped to retailers in different states and locations. John Rowell said that the company hopes to expand into strategically located storage sites, like resale facilities, so they would not have to worry about storing fuel onsite.

Challenges

There were a number of challenges that Malheur Lumber ran into delivering pellets to the geographically clustered biomass facilities in John Day and to Prairie City School:

- The person who handles the pellet deliveries likes to deliver twenty-eight tons at a time because it is much more expensive to do partial deliveries to different facilities – the more tonnage per delivery, the less per ton the delivery costs are.
- Fuel storage capacity has been an issue with some of the sites; a couple of the pellet installations in John Day only have around thirty tons of fuel storage.
- Low storage capacity means that pellet deliveries to the facilities need to be timed carefully just before they run out. Sometimes by the time one of the facilities calls, they are getting low on pellets.
- Bigger silos that are forty or fifty tons help avoid delivery issues because it can take more than a week to schedule a delivery.

- John Day's low population density limits Malheur Lumber's bulk pellet sales. It difficult to sell a large volume of pellets in John Day compared to other pellet plants that are located near bigger populations.
- During the summer, very few people purchase pellets. Some facilities like Blue Mountain Hospital require a year-round supply of pellets, but these are rare. The company tries to encourage people to stock fuel and buy year-round by offering discounts during the summer. This helps reduce the demand spike that occurs toward winter when people are rushing to purchase fuel. Additionally, to help encourage bulk fuel purchases and increase demand and efficiency, Malheur Lumber offers a discount to consumers that buy in bulk versus smaller amounts.

Conclusion

Currently, Malheur Lumber is still working on making the pellet portion of its operation profitable. Rowell estimated that it would take 750 to 1,000 tons a month year-round to turn a profit on the pellet fuel); this could be met through bagged or bulk pellet sales as long as the product is priced accordingly (such as adding an additional cost for bagged pellets to cover packaging). Overall, they are happy that they have successfully overcome challenges related to the pellet plant. Rowell is optimistic that the pellet plant will be profitable within another year based on how business has expanded annually. Looking forward, Malheur Lumber is planning to continue developing, building on the infrastructure, becoming more efficient, and growing their customer base.

Oregon Army National Guard

Acknowledgements

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Introduction

This case study highlights seven Oregon Army National Guard biomass energy projects that are in the process of being designed and installed. These projects provide valuable lessons learned and best practices related to project aggregation from a design-to-implementation perspective. This case study describes the benefits (economies of scale, efficiencies, etc.) and drawbacks of carrying out multiple geographically clustered biomass projects under the same financial bundle. It highlights factors associated with successful biomass energy projects as well as best practices that can be translated into applications in other locations.

The Oregon National Guard Biomass Project

The Oregon Army National Guard (ORARNG) is designing seven wood pellet biomass energy systems that will be installed and operational by 2013 at seven National Guard facilities located across central Oregon. The National Guard's project illustrates a large-scale, aggregated approach to biomass conversion as all seven systems are being installed concurrently.

Craig Volz, Resource Efficiency Manager of Tetra Tech, is facilitating the development of the current phase of the ORARNG's biomass energy project. Volz believes the project is a good opportunity for both the National Guard and Forest Service to achieve multiple goals. "There is a nexus between forest health, biomass fuel sources, and also local economics and job creation through having a locally provided fuel source," he said. Converting to biomass presents an opportunity to create a synergy between the National Guard's objectives related to energy security, renewable energy, energy efficiency, and fuel cost savings and the Forest Service's goals in regard to forest health, hazardous fuels reduction, and local economic development. Additionally, as a renewable and locally available fuel source, biomass helps the ORARNG improve its energy security.

The following seven National Guard buildings are involved in this initiative:

- Youth Challenge Facility
- Central Oregon Unit Training and Equipment Site
- Biak Training Center
- Burns Armory
- Umatilla Training Center, Building #30, Simulation Center
- Umatilla Training Center, Building #36, Dining Hall
- Umatilla Training Center, Building #53, Barracks

Pellet Systems and Fuel

Table 1. Estimated Equipment Specifications for the ORARNG Biomass Systems

LOCATION / BUILDING	Bend YOUTH CHALLENGE FACILITY	Redmond COUTES	Powell Butte BIAK TRAINING CENTER	Burns ARMORY	Umatilla BLDG # 30 SIM CENTER	Umatilla BLDG # 36 DINING HALL	Umatilla BLDG # 53 BARRACKS
Manufacturer (basis of design)	Köb	Köb	Köb	Köb	Köb	Köb	Köb
Model	Pyrot	Pyrot	Pyrot	Pyrot	Pyrot	Pyrot	Pyrot
Output kW	540	300	220	220	300	540	220
Output MMBtu/hr	1.84	1.02	0.75	0.75	1.02	1.84	0.75
Efficiency LHV	85.2%	85.2%	85.2%	85.2%	85.2%	85.2%	85.2%
Efficiency HHV	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%
Components	Storage tank Pellet silo Pellet Auger Boiler controls Auto ignition Ash extraction Tube cleaning	Containerized Storage tank Pellet silo Pellet Auger Boiler controls Auto ignition Ash extraction Tube cleaning	Containerized Storage tank Pellet silo Pellet Auger Boiler controls Auto ignition Ash extraction Tube cleaning	Storage tank Pellet silo Pellet Auger Boiler controls Auto ignition Ash extraction Tube cleaning	Containerized Storage tank Pellet silo Pellet Auger Boiler controls Auto ignition Ash extraction Tube cleaning	Containerized Storage tank Pellet silo Pellet Auger Boiler controls Auto ignition Ash extraction Tube cleaning	Containerized Storage tank Pellet silo Pellet Auger Boiler controls Auto ignition Ash extraction Tube cleaning
Biomass Percent of Building Heating & DHW	100%	100%	100%	100%	100%	100%	100%
Backup Unit	Propane	Propane	Propane	Propane	Propane	Propane	Propane

To determine where the biggest energy cost savings could be achieved, Tetra Tech examined the National Guard's sites scattered throughout the state. Biomass fuel turned out to be the most cost effective energy solution for seven of the ORARNG's buildings because they are all dependent on costly propane (with costs at the time of this study at about $20.00/MMBtu) and do not have access to natural gas. Additionally, biomass helps meet the ORARNG's Net Zero Energy Goal renewable energy requirement. The Guard was selected as one of eight US Army Pilot Net Zero Energy Installations given the charge to reduce their energy use by sixty-five percent from a 2003 baseline and achieve the remaining thirty-five percent offset by using renewables.

The existing propane systems in the seven buildings will be replaced with pellet boilers, with a goal of providing one hundred percent of the heat load for the facilities. Tetra Tech outlined a number of reasons why going with pellet systems is the best strategy. The National Guard needs a very automated and reliable system because it operates and maintains a large number of facilities across Oregon and because the state budget and the Guard's maintenance staff are spread thin. Consequently, it would not be economical to install wood chip systems at the seven National Guard

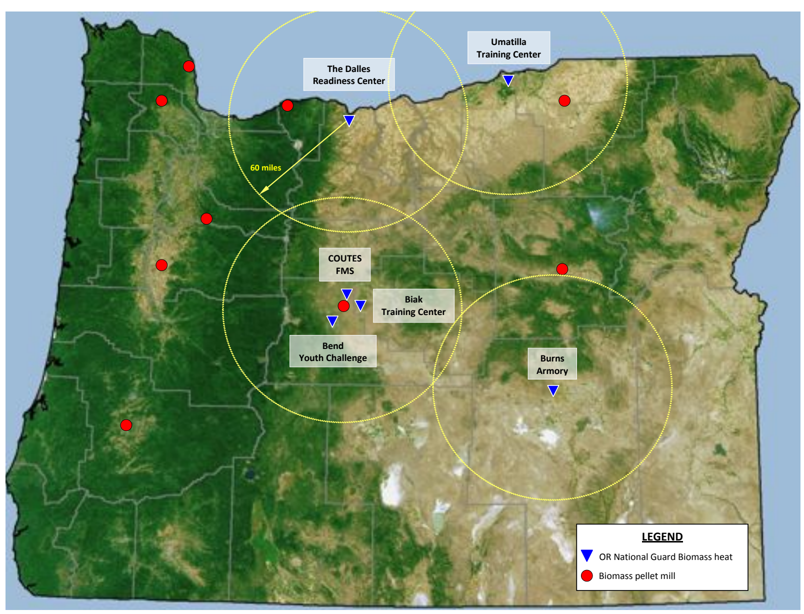

Figure 24. Map of Oregon National Guard Biomass Facilities and Pellet Mills (Tetra Tech)

facilities because of the small scale of the conversions and because wood chip systems are much more hands-on from an operations standpoint (more material handling and higher operation and maintenance costs) than pellet systems.
While there are a number of local biomass boiler manufacturers based in Oregon, the Guard is looking at a Kob/Viessmamn unit that is manufactured in Europe as an initial design. Tetra Tech believes that there are a number of advantages in using imported European biomass boilers versus relying on biomass boilers that are currently manufactured in the U.S. The Kob/ Viessmamn unit they are considering is very automated in terms of ash extraction and tube cleaning, representing a clear advantage from an operational and maintenance standpoint (key advantages in terms of the ORARNG's needs). "The Europeans have been designing and manufacturing biomass systems for decades and you can really see it," said Volz. "In the U.S., manufacturers are smaller . . . and they are more fabricators. While their systems can be robust and heavy duty, they just aren't as sophisticated."

Tetra Tech also recommends consideration of a containerized design (where the boiler is housed in a shipping container outside of the facility rather than stored in a boiler room), which could be beneficial in certain installations. Some of the National Guard's buildings do not have a lot of extra indoor space, and a containerized design would also allow them to easily renovate buildings and relocate the boilers where needed.

Table 2. Estimated Fuel Specifications

LOCATION / BUILDING	Bend YOUTH CHALLENGE FACILITY	Redmond COUTES	Powell Butte BIAK TRAINING CENTER	Burns ARMORY	Umatilla BLDG # 30 SIM CENTER	Umatilla BLDG # 36 DINING HALL	Umatilla BLDG # 53 BARRACKS
Composition	Ponderosa Pine wood pellets	Ponderosa Pine wood pellets	Ponderosa Pine wood pellets	Ponderosa Pine wood pellets	Ponderosa Pine wood pellets	Ponderosa Pine wood pellets	Ponderosa Pine wood pellets
Source	Forest Service stewardship contracts - thinning & fuels reduction	Forest Service stewardship contracts - thinning & fuels reduction	Forest Service stewardship contracts - thinning & fuels reduction	Forest Service stewardship contracts - thinning & fuels reduction	Forest Service stewardship contracts - thinning & fuels reduction	Forest Service stewardship contracts - thinning & fuels reduction	Forest Service stewardship contracts - thinning & fuels reduction
Supply Radius	154	135	129	73	155	155	155
Delivery Frequency Per Year	4	2	0	1	2	4	0
Quantity Delivered (tons)	28	28	28	28	28	28	28
Cost Per Ton (BDT) Delivered	$ 160	$ 160	$ 160	$ 160	$ 160	$ 160	$ 160
Moisture Content	≤ 4%	≤ 4%	≤ 4%	≤ 4%	≤ 4%	≤ 4%	≤ 4%
Fuel Storage Capacity (tons)	50	50	35	35	50	50	35
Annual Consumption (tons)	90	38	24	25	43	85	20
Annual Biomass Fuel Cost	$ 14,400	$ 6,080	$ 3,840	$ 4,000	$ 6,880	$ 13,600	$ 3,200

There are six or seven local pellet fuel manufacturers and distributors clustered in a relatively tight geographical area near the ORARNG sites. To insulate against supply interruptions, the ORARNG intends to maintain two sources of pellet fuel. This diverse fuel supply should help the Guard meet its objective in achieving greater energy security versus remaining dependent on imported propane. "Because woody biomass is plentiful throughout the state, pellets are a good strategy to replace our fossil fuel thermal loads with a renewable source," Volz said.

The Guard expects to pay around $160.00 per ton of pellets, and in total the facilities will consume about 325 tons of pellets annually, representing an annual biomass fuel cost of approximately $52,000 between all of the facilities.

Project Economics

Table 3. Estimated Project Economics[61]

LOCATION / BUILDING	Bend YOUTH CHALLENGE FACILITY	Redmond COUTES	Powell Butte BIAK TRAINING CENTER	Burns ARMORY	Umatilla BLDG # 30 SIM CENTER	Umatilla BLDG # 36 DINING HALL	Umatilla BLDG # 53 BARRACKS
PROJECT FUNDING							
2012 Hazardous Fuels Woody Biomass Utilization Grant (design)	$ 71,863	$ 36,419	$ 33,014	$ 30,097	$ 25,118	$ 30,810	$ 22,679
State Funds	$ 99,369	$ 13,641	$ 12,366	$ 100,456	$ 9,408	$ 11,540	$ 8,494
Federal Funds	$ 298,106	$ 275,466	$ 207,253	$ 100,456	$ 265,607	$ 374,907	$ 144,515
OR Dept Energy Commercial Thermal Incentive	$ 281,293	$ 188,124	$ 148,467	$ 135,711	$ 169,727	$ 235,962	$ 99,352
Total project funding	**$ 750,630**	**$ 513,650**	**$ 401,100**	**$ 366,720**	**$ 469,860**	**$ 653,220**	**$ 275,040**
PROJECT COSTS							
Construction Cost	$ 655,000	$ 448,211	$ 350,000	$ 320,000	$ 410,000	$ 570,000	$ 240,000
SIOH	$ 19,650	$ 13,446	$ 10,500	$ 9,600	$ 12,300	$ 17,100	$ 7,200
Contingencies	$ 32,750	$ 22,411	$ 17,500	$ 16,000	$ 20,500	$ 28,500	$ 12,000
Design	$ 39,300	$ 26,893	$ 21,000	$ 19,200	$ 24,600	$ 34,200	$ 14,400
Commissioning	$ 3,930	$ 2,689	$ 2,100	$ 1,920	$ 2,460	$ 3,420	$ 1,440
Public Utility Company Rebate	($ 463,646)	($ 225,799)	($ 218,314)	($ 204,143)	($ 198,038)	($ 273,518)	($ 123,470)
Total Investment	**$ 286,984**	**$ 287,851**	**$ 182,786**	**$ 162,577**	**$ 271,822**	**$ 379,702**	**$ 151,570**
PROJECT ECONOMICS							
Fuel Replaced by Biomass	Propane	Propane	Propane	Propane	Propane	Propane	Propane
Annual Heating Cost Savings	$ 35,231	$ 16,008	$ 9,995	$ 9,763	$ 18,683	$ 37,343	$ 8,786
Annual O&M Savings	$ 2,782	$ 1,565	$ 1,159	$ 1,159	$ 1,565	$ 2,782	$ 1,159
Savings to Investment Ratio	2.19	1.00	1.00	1.11	1.24	1.75	1.07
Annualized Rate of Return (10yr)	10.4%	5.9%	5.8%	6.2%	6.9%	8.9%	6.0%
Internal Rate of Return (25yr)	18.2%	9.0%	8.9%	9.8%	11.0%	15.1%	9.4%
Simple Payback (years)	**8.1**	**18.0**	**18.3**	**16.7**	**14.5**	**10.2**	**17.3**

To finance the design phase of the seven biomass sites, the ORARNG received a $250,000 Woody Biomass Utilization Grant (WBUG) from the USDA Forest Service, which covers seventy-three percent of the design phase cost for the project. The state is covering the remaining twenty-seven percent ($83,000) of the design cost. The total investment for the project as a whole (including design, construction, SIOH, contingencies, and commissioning) will be around $3,430,220. Overall, the average simple payback for the entire project is equal to 14.7 years. Table 3 highlights additional current project funding and cost estimates for each of the seven ORARNG facilities along with a couple financial analysis figures.

Presently, all of the selected ORARNG sites are dependent on propane for heating, which provided the main financial incentive for converting to pellet boilers. The Guard pays around $20.00 per MMBtu for propane whereas wood pellets should be less than half the cost (roughly $9.30 per MMBtu). Switching from propane to pellet fuel is expected to save the Oregon Army National Guard an average of $19,401 per year (per facility) in heating costs and on average $1,739 annually (per facility) in maintenance costs.

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[61] The simple payback figures included in Table 1 are calculated using the total project investment divided by annual heating cost savings. These payback estimates are greater than the ones included in the more detailed financial analysis section in Appendices A-J, which are based on a different calculation (total investment/first year dollar savings). Please see Appendices A-J for a more detailed financial analysis of each facility.

There are various methods that can be employed to analyze a project's financial viability. One financial analysis tool is the annualized rate of return (ARR). The purpose of the ARR is to identify the potential rate at which an investment will increase (or decrease) each year. Calculating a ten year ARR is valuable for investors because this timeframe best reflects their shorter term focus. The ARR is calculated using a project's return on investment (ROI), which acts as a multiplier at which an investment is estimated to grow over a set time period.[62]

Another useful financial analysis calculation is the internal rate of return (IRR). The IRR estimates a facility's expected return from an investment over time (a measurement of the efficiency of the investment). The IRR is useful for facility owners and calculating it over a twenty-five year time period coincides with the typical projected life of a wood-energy system (twenty-five to thirty years). It is calculated as comparison of fuel savings for term to total project investment.[63]

A basic financial analysis of the National Guard's biomass project shows that the project's average ten year annualized rate of return (ARR) equals 7.2% and its average twenty-five year internal rate of return (IRR) is equal to 11.6%. These figures help indicate that the National Guard's project is financially favorable (current markets look for a range between five to ten percent ARR figures).

The Youth Challenge Program Facility (YCF) is especially financially favorable with a ten year ARR of 10.4%, a twenty-five year IRR of 18.2%, a savings to investment ratio of 2.19, and an expected payback of 8.1 years. In comparison to the rest of the ORARNG sites, the least financially attractive facility appears to be the Biak Training Center with a ten year ARR of 5.8%, a twenty-five year IRR of 8.9%, a savings to investment ratio of one, and a payback period of 18.3 years. In this analysis, inflation rates of 1.5% for wood and 5.6% for propane were used.[64]

Overall, these calculations indicate that the National Guard's project as a whole is favorable from a financial investment perspective. All of the facilities have a calculated ARR greater than five percent, and current markets are looking for an ARR between five to ten percent. Additionally, the project's IRR indicates positive growth across all seven facilities. Please see Appendices A-J for a more detailed financial analysis of each facility.

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[62] ARR Formula: $((1+ROI)^{1/N})-1$
N = # of years ROI = Return on investment = B – C/P
B – C = Cumulative fuel cost savings added up over a set period of time P = Total project investment.
[63] IRR Formula: $PNW = 0 = F_a/(1 + R)^a$
PNW = Present Net Worth = 0 F = Income Each Year = Fuel Savings Each Year a = Year R = Rate of Return
[64] U.S. Energy Information Administration for all inflation estimates except wood. Wood inflation estimate was provided by local expert Andrew Haden (www.Wisewood.US)

According to Tetra Tech, a basic take away lesson comparing the financial viability of the seven ORARNG facilities is the greater their annual energy expenses, the greater the economic benefit because of the relatively high fixed costs for the biomass boiler installations. As required boiler sizes increase, incremental project costs are reduced as project costs increase at a slower rate compared to fuel cost savings. Therefore, the return on investment for the ORARNG's project is primarily driven by the annual heating cost. The greater a facility's energy requirements and change in cost of using biomass versus an alternative fuel, the greater the potential savings will be—compared to the effect of capital construction costs, which are only marginally greater between each of the sites.

Incentives can also significantly affect a project's payback. For example, comparing the Burns Armory's project to YCF's, the armory has a much lower annual heating expense versus YCF. Additionally, the armory's total project cost is close to half of YCF's cost. Nevertheless, because Oregon biomass incentives are calculated as a percentage of project costs, YCF's payback period is reduced significantly more than the armory's. Consequently, projects with a higher total cost like YCF can receive a greater incentive benefit, and combined with greater annual heating cost savings, this can lead to significantly reduced payback periods.

Facility Background

Table 4. General Information for the ORARNG Converted Facilities

LOCATION / BUILDING	Bend YOUTH CHALLENGE FACILITY	Redmond COUTES	Powell Butte BIAK TRAINING CENTER	Burns ARMORY	Umatilla BLDG # 30 SIM CENTER	Umatilla BLDG # 36 DINING HALL	Umatilla BLDG # 53 BARRACKS
Building Area (ft^2)	71,439	10,464	20,560	12,426	15,787	6,920	72,114
Year Built	1984	1989	1984	1954	1942	1943	1942
Project Type	Retrofit	Retrofit	Retrofit	Retrofit	Retrofit	Retrofit	Retrofit

Following are brief descriptions of each of the facilities to be served by biomass heating systems:

Youth Challenge Program Facility

Located in Bend, Oregon, the Youth Challenge Program Facility was built in the early '80s. Originally a night vision testing facility, the building has been repurposed and now acts as an academy for at-risk youth. The building operates continuously for ten months during the academic year and it has very high use from a heating and domestic hot water standpoint. Because of these characteristics, the economics (the ARR, IRR, savings to investment ratio, and payback period) of converting this facility are especially favorable compared to some of their other smaller National Guard facilities without year-round heating demand.

Figure 25. Youth Challenge Program Facility

Central Oregon Unit Training and Equipment Site
Located in Redmond, Oregon, the Central Oregon Unit Training and Equipment Site (COUTES) is a 10,000 square foot metal building that houses a high bay maintenance shop where the ORARNG does military vehicle maintenance along with having some office space. Volz said they are looking into putting in some ceiling radiant panels in the high bay area along with the biomass boiler. He explained that three of the ORARNG sites (the Youth Challenge Facility, Biak Training Center, and Burns Armory) already have hot water boilers installed, which are pretty simple to change out. However, the COUTES site has direct-fired radiant heating and it does not have an existing hydronic boiler system, making things a little more complicated.

Biak Training Center
Nearby the COUTES site and located in Powell Butte is the Biak Training Center. The center supports a wide variety of military branches in addition to other emergency response agencies. The army carries out training exercises on the 22,255 acres of federal land located nearby. The pellet system will heat a simulation center, classroom, and an administrative building, totaling a little over 20,000 square feet for the three facilities.

Burns Armory
The Burns Armory is a typical older armory. It is a 12,000 square foot facility that was built around 1954.


Figure 27. Biak Training Center


Figure 26. Burns Armory

Umatilla Training Center Facilities (Buildings #30, #36, and #53)
There are three different facilities (referred to as Buildings #30, #36, and #53) located at the Umatilla Training Center in Hermiston, Oregon that will be converted to biomass heating systems. Building #30 is a 15,000 square foot metal building that serves as a simulation center for training exercises. The building has a steam boiler that will be converted along with hot water piping. Building #36 is a 7,000 square foot dining hall. Another building, next to the dining hall, Building #53 is a barracks that does not have continuous occupancy but does include an existing steam system.

The Oregon Department of Energy recently awarded a Wood Energy Cluster grant to ORARNG to conduct a biomass district heating feasibility study at the Umatilla Training

Center.[65] Volz explained that Tetra Tech will perform the feasibility study to determine whether installing a biomass district heating network would make more sense from an economic and efficiency standpoint versus replacing individual boilers on a building-by-building basis. Since many of the buildings at the Umatilla Training Center are in close proximity to one another, it could be advantageous to install one or more central heating plants that would serve clusters of buildings.

The Training Center's current building stock, heating systems, and steam piping infrastructure are growing old and will need replacing. In the long-term, there are plans to completely replace buildings constructed during the '40s, and there are near-term plans to renovate and upgrade other existing buildings. Taken together, these development plans provide a good opportunity to examine the feasibility of constructing a biomass district heating system at the site.

Currently, under the Base Realignment and Closure process, the Umatilla site is transferring from the U.S. Army to ORARNG occupancy. The ultimate heating configuration of the site will be determined over the next five to ten years, so Tetra Tech will be proposing "strategies that are flexible, and scalable—allowing us to use a modular approach so we can supply short term needs and expand the system as the site is redeveloped."

Figure 28. Umatilla Building #30 Simulation Center

Figure 29. Umatilla Site Aerial View

Figure 30. Umatilla Buildings #36 Dining Hall and #53 Barracks

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[65] For more information about the grant, please see http://www.oregon.gov/energy/RENEW/Biomass/Pages/Wood-Energy-Cluster-Pilot-Project.aspx

Readiness Center

The National Guard also evaluated another potential project outside of the WBUG grant at the Readiness Center, a new 60,000 square foot LEED certified building. The goal is for this Center is to be the first completely net zero facility within the ORARNG. The Center is located in The Dalles, Oregon in the northern part of the state along the scenic Columbia Gorge. The facility has a drill hall, assembly area, and administrative offices.

The ORARNG will use a wide variety of technologies to make the building as energy efficient as possible. In contrast to the other seven WBUG facilities, a ground-source heat pump will act as the primary heating source for the Readiness Center. The ground-source heat pump will provide about ninety percent of the site's heat load, along with a condensing high efficiency natural gas boiler for supplemental heating. A dual-fuel biomass pellet boiler was proposed to meet the remaining ten percent of heating demand, but this option was not selected due to project funding constraints. The ground-source heat pump could be augmented with biomass heating, so that all of the thermal loads will be covered one hundred percent using renewables. They are also planning to install a solar PV system to offset the building's electrical usage.

Building Envelope Upgrades

In conjunction with converting existing buildings to biomass systems, the ORARNG is considering some building envelope upgrades. As mentioned earlier, the Guard was selected as one of eight US Army Pilot Net Zero Energy Installations charged with reducing energy use by sixty-five percent from a 2003 baseline and to achieve the remaining thirty-five percent offset by using renewables. The building envelope upgrades will not only help them achieve their goals in terms of utilizing renewable biomass energy, but will also help with energy efficiency improvements. It is fortuitous that the timing of these energy efficiency upgrades coincides with the HVAC conversions. The Guard could potentially gain additional cost reductions by minimizing the design size of their pellet boilers, which could then help offset the cost of the building envelope upgrades. Biomass also helps meet the Net Zero Energy Goal's renewable energy requirement.

Tetra Tech believes that the drive for renewable energy adoption in support of the Net Zero Energy Goal creates a premium incentive over natural gas, making it more feasible to replace aging gas boilers with biomass systems. Currently, a key barrier to wider biomass adoption is cheaper natural gas. Power is generally inexpensive in the Northwest—especially if there is access to natural gas—but Volz thinks that natural gas prices may rapidly accelerate if liquid natural gas is exported to other countries—much faster price increases than biomass—which will make biomass look more advantageous as time goes on.

Project Aggregation and Clustered Facility Efficiencies

The Oregon Army National Guard's seven projects provide valuable lessons from a design-to-implementation perspective related to project aggregation (multiple biomass projects under the same financial bundle) and in terms of the efficiencies that can be achieved through geographically clustered facilities.

According to Tetra Tech, there are many more advantages than disadvantages being part of a larger scale aggregated effort to convert to biomass. For example, carrying out multiple projects simultaneously allows the ORARNG to achieve many *economies of scale* from a design perspective such as the ability to standardize design between many facilities. Given the large number of National Guard buildings, standardization is also important from a maintenance and performance perspective (which are key in terms of meeting the Guard's needs). Additional economies of scale result because the projects are clustered in a compact geographical range. Because the sites are in close proximity to one another, the Guard should be able to obtain a *multi-year contract for fuel pricing*, allowing them to save on fuel costs.

However, there are also a number of potential disadvantages that should be noted with being part of a large-scale, aggregated biomass project. For instance, a higher level of effort is required to develop and implement all of the details and logistics for a project cluster versus a single project. Furthermore, converting seven buildings at once means there is more risk if things are not done correctly the first time. "It is not a rearview mirror look where we've actually designed and built these systems . . . .So, we don't have all of the [hands on] experience, and some of this will be based on estimates," Volz explained. Ideally, there would be a pilot project before implementing a large number of projects, and the pilot would provide a year's worth of experience and lessons learned that could then be applied to a larger number of buildings.

Volz noted that there are existing biomass project installations in their general geographical area and believes that there are *opportunities for collaboration* that would benefit all groups. As Volz points out, there are around twelve to fifteen biomass boiler installations in public buildings nearby (such as the cluster in John Day, Oregon, which is 70-120 miles away from the various ORARNG sites). They are considering collaboration with these sites through things like *cooperative fuel purchasing agreements*:

> "There is a regional airport and a U.S. Forest Service airbase that is close to this area and they have to buy fuel and there are also schools and hospitals in the area that also have to purchase fuel. [Cooperative fuel purchasing agreements] are something that weren't necessarily on our horizon, we probably would have just done a contract on our own, but it's an interesting concept to achieve some economies of scale that would benefit both the state and other public hospitals and schools."

Tetra Tech believes that Malheur Lumber located in John Day, Oregon is a solid option as a fuel supplier for some of their facilities. A lot of Malheur Lumber's fuel supply comes from National Forest land, which matches the restoration goals of the Forest Service included in the WBUG grant.

Quantified Aggregation Benefits[66]

Table 5. Fort Oregon Bundled Project Cost Estimates

EEM	SITE | BUILDING	AREA (ft²)	DESCRIPTION	TOTAL COST
RE-1	COUTES FMS	10,464	Biomass radiant heating system	$ 513,650
RE-2	Biak Brett Hall	20,560	Biomass heating system	$ 401,100
RE-3	Umatilla Simulation Center	15,787	Biomass heating system	$ 469,860
RE-4	Umatilla Dining Hall	6,920	Biomass heating system	$ 653,220
RE-5	Umatilla Billeting	72,114	Biomass heating system	$ 275,040
RE-6	Bend YCF	71,439	Biomass radiant heating system	$ 750,630
RE-7	Burns Armory	17,180	Biomass heating system	$ 366,720
	TOTAL	**214,464**		**$ 3,430,220**

As it turns out, there are also quantifiable benefits from using a project bundling approach versus individual boiler installations. After running the numbers, Tetra Tech estimates that bundling all seven individual biomass pellet boilers into a single design-build procurement package should lead to a cost savings between five to ten percent versus individual procurements using a traditional design-bid-build approach. This represents an estimated savings in the range of $180,000 to $300,000 for the $3,430,220 project. This net overall savings includes volume discounts for major equipment, materials, and labor. The volume discount on major equipment will be a greater percentage (twelve to eighteen percent), but the installation labor accounts for more than half of the overall project cost because there is no corresponding discount on labor.

There could also be significant savings by going with a district heating system at the Umatilla Training Center versus relying on individual boiler installations:

- **34% Capital Expenditure Savings = $990,295**
    - $2,950,395 (eight individual building boilers & fuel silos)
    - $1,960,000 (one district central plant & fuel storage + piping network)
- **63% Operational Expenditure Fuel Savings = $70,000 per year**
    - 700 tons/year biomass pellets at $160 per ton = $112,000 per year
    - 700 tons/year biomass wood chips at $60 per ton = $42,000 per year

[66] Note: The data analysis in the "Quantified Aggregation Benefits" and "Biomass Energy Co-Benefits" sections was provided by Tetra Tech.

Biomass Energy Co-Benefits

According to Tetra Tech, beyond just providing heating cost savings to the Guard, there are additional co-benefits of using biomass systems that the ORARNG's project should provide. Some of these co-benefits are summarized below:

- *Wildfire Cost Reductions:* The average annual U.S. Forest Service fire suppression expenditures nationwide have exceeded $1,000,000,000 per year since 2000. Eighty-five percent of Oregon's large fire costs occur in the east-side region where ORARNG's proposed biomass cluster is located. For FY2002-FY2011 Oregon Department of Forestry spent over $197,000,000 on fire suppression with over $70,000,000 spent in the Central Oregon and Northeast Oregon districts where the ORARNG biomass cluster is located.[67]
- *Energy Security:* On-site biomass fuel storage provides a minimum six-month fuel supply. Existing propane storage tanks currently provide only two weeks to a month of reserve fuel supply.
- *Job Creation:* Individual biomass boiler installations create short-term constructions jobs, long-term service/maintenance jobs, and jobs in the forest products sector for woody biomass harvesting, fuel processing, and delivery. The proposed Fort Oregon Biomass cluster projects are expected to create approximately eighty-nine short-term construction jobs and sustain two long-term forest products jobs.
- *Economic development:* Rural Oregon unemployment in Crook (13.3 percent), Deschutes (10.5 percent), Harney (11.6 percent), and Umatilla (8.0 percent) counties is substantially higher than the state-wide (8.4 percent) and national rates (7.8 percent)[68]. Employment in the forest products industry in Oregon has been in decline for decades. The opportunity to create a local sustainable woody biomass based fuel industry offers a chance to reverse this negative trend. The ORARNG is exploring opportunities at the Umatilla Training Center to work with the Oregon Department of Forestry (ODF), local county development agencies, the Confederated Tribe of the Umatilla Indian Reservation, and forest resource companies to develop a woody biomass fuel infrastructure to supply military, industrial, and community energy needs.

Lessons Learned

Based on the National Guard's experience, Tetra Tech emphasized that there are a number of key factors that facilities should pay attention to when considering converting to a biomass system:

1. *A fuel supply that is both economical and sustainable is of critical importance.* "You can have a perfect system but without an economic or reliable fuel supply, you can be very disappointed," Volz noted.
2. *The type and economics of biomass fuel and the operations and maintenance required.* Both pellets and chips were evaluated for the ORARNG sites. Volz explained that storage, material handling, and operation and maintenance requirements become more onerous with woodchips. Because most the ORARNG's sites are smaller and

[67] Sources: http://www.oregon.gov/odf/fire/fpfc/cliffpres.pdf; http://www.oregon.gov/odf/fire/fpfc/dfc.pdf
[68] Unemployment rates as of 12/01/12

geographically distributed, the economics for woodchips did not look as favorable compared to pellets.

3. *The equipment selection.* There are a lot of biomass equipment manufacturers out there, but many of them are very small outlets. "[The U.S. is] decades behind the technology in Europe. We just have small fabricating systems, so the other challenge is doing your research and finding the right technology."
4. *Equipment support availability.* "Even if you get the right technology, you need to make sure it can be supported. If you get a really sophisticated system, you need to have someone who will be able to support and maintain it."
5. *Look to others who have installed similar biomass systems.* Learning from the success and failures of others will highlight best practices that can help a project succeed as well as point out pitfalls to avoid.

Conclusion

Currently, the next steps in the ORARNG's biomass project are being planned to carry the project forward from design to implementation. In 2013, pellet boiler design and construction are slated to begin at the Biak Training Center and COUTES in addition to conducting feasibility studies for installing a biomass district heating system and combined heat and power plant at the Umatilla Training Center. In 2014, pellet boiler design and construction is planned to begin at the Youth Challenge Program Facility and Burns Armory. Lastly, in 2015, assuming favorable feasibility study results, the current plan is to start Phase 1 design and construction of a biomass wood chip district heating plant at the Umatilla Training Center.

Overall, Tetra Tech believes that the ORARNG's biomass project will provide a wide range of benefits once completed. "We are excited about the biomass grant because there are benefits for the National Guard, for forest health, and for the local economy," he emphasized. However, Volz does not appear to want to stop with just these seven conversions to biomass systems. He is hopeful that the seven conversions are just the beginning of a larger plan to economically convert National Guard sites to biomass. If they can get the design funding, there are additional buildings around the state that the National Guard would like to convert to biomass. If the funding comes through, he said there are an additional five buildings that are good biomass conversion candidates that could be included as part the ORARNG project. As mentioned earlier, the ORARNG is evaluating the feasibility of developing a district-heating system at a 25,000 acre Umatilla Training Center in Umatilla, Oregon. Combined heat and power could be very advantageous because it would have favorable conditions with high demand and load. If approved, this combined heat and power plant could lead to another five buildings being hooked up to biomass at a central location as part of a 2nd phase build.

Lastly, it is worth noting that (from a policy perspective) the National Guard's biomass project highlights the uneven playing field that biomass energy faces within the policy realm. In fact, the major frustrations that Volz has experienced in working on the project are not related to the project design process, but are associated with policy incentives. More specifically, Volz, along with many others connected to the biomass industry, are frustrated that the public policies and incentives currently being used for biomass energy development are behind the curve. “There are federal and state incentive programs for renewable energy that generate power, but there’s a real gap in terms of thermal energy,” Volz said. He explained that they were not able to take advantage of renewable energy incentives for the ORARNG’s project. There was a renewable energy grant through the Oregon Department of Energy, but the National Guard’s project was ineligible because the grant was only for power production, not thermal energy. He went on to point out that the Federal Investment Tax Credit offers a payback for electricity, but again there is nothing for biomass thermal energy. There are Renewable Energy Certificates for renewable power production, but not a good, similar standard for thermal energy credits. “It would helpful if there was a more comprehensive approach on the federal and state basis to recognize the value of thermal energy,” Volz said. Current policies do not recognize or match the technology, capabilities, and opportunities associated with biomass utilization—especially for biomass thermal applications.

As a footnote to this policy conundrum, The Oregon Department of Energy (ODOE) has recognized this gap and is proactively working to help level the playing field for biomass projects. ODOE has issued a new incentive for renewable thermal projects that do not generate electricity, but use renewable resources such as biomass to provide thermal energy. This new funding opportunity is first available beginning in March 2013. ORARNG’s projects could be eligible for an incentive of up to thirty-five percent of the project cost under this new funding opportunity.

Regional School Unit 74, Maine

Figure 1. RSU 74's Four Schools

GENERAL INFORMATION	
FACILITY	**Regional School Unit #74**
Total Building Area (ft^2)*	119,180
Experience Total (years)	1
Project Type	Retrofit
EQUIPMENT SPECIFICATIONS	
Boiler Manufacturer	ÖkoFEN
Boiler Model	PES56
Output MBtu/hr	191 x 8 Boilers
Biomass Percent of Building Heating	> 90%
Backup Unit	Heating Oil
FUEL SPECIFICATIONS	
Fuel Type	Wood Pellets
Supply Radius (miles)	15
Delivery Frequency	Biweekly/Bimonthly
Cost Per Ton Delivered	$ 175
Moisture Content	5%
Fuel Storage Capacity (tons)	11-21
Annual Consumption (tons)	375
Fuel Replaced by Biomass	Heating Oil
Annual Biomass Fuel Cost	$ 65,625
Annual Heating Cost Savings	$ 100,000
PROJECT ECONOMICS	
Project Total Funding	$ 697,000
Qualified School Construction Bond	$ 407,000
USDA Forest Service Grant	$ 250,000
Efficiency Maine Grant	$ 40,000
Project Total Cost	$ 697,000
Equipment Cost	$ 347,000
Installation Cost	$ 350,000
Annual O&M Costs	$ 15,000
Financial Analysis	
Annualized Rate of Return (10 yr)	14.8%
Internal Rate of Return (25 yr)	28.1%
Payback Period (years)**	7

*Building area includes all four schools
** Payback period does not include avoided costs

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Introduction

This case study describes how four schools in Maine (part of Regional School Unit 74) successfully converted to biomass pellet systems, outlining the complex process of retrofitting existing facilities to biomass systems. These schools illustrate a district-wide, aggregated approach to converting to biomass energy systems, and they present an especially systematic approach (emphasizing capital cost and demand load minimization) in the implementation of a biomass conversion project. The five interconnected strategies that the district relied on during the development of the project represent best practices that can help increase efficiencies and minimize the costs for carrying out biomass projects in other locations.

Project Background

Beginning July 2011 and finishing in September that same year, it took Maine's Regional School Unit 74 (RSU 74) only a few months to successfully convert four of its schools to biomass pellet boilers. Much of the success can be attributed to what Ken Coville, the district's superintendent, describes as "a dramatic new approach that utilized and integrated a multi-facility plan." The plan included providing base-load heating through multiple smaller boiler units while also implementing a number of energy conservation measures that helped reduce the overall heat demand.

Around the time of this conversion, prices for heating oil were peaking at nearly $3.70 per gallon, which had a very negative impact on RSU 74's schools. As a result, the district began to research other options with which to heat their facilities. They were very interested in learning about the cost savings and maintenance reductions achieved by a neighboring school that had converted their heating oil-fueled systems to wood pellets. The nearby experience also provided an opportunity to evaluate potential problems associated with different feedstocks.

Figure 31. Operating Pellet Unit

Four years earlier, a neighboring school had decided to install a corn stove to heat their bus garage. After the system was installed, it became quickly apparent that corn was a poor fuel choice for their situation. The corn fuel had very high moisture content and this resulted in inconsistent heat, greater than expected maintenance, and over-reliance on backup oil heating. Rather than continue to deal with the issues using corn, the school decided to switch to wood pellets as a fuel source. After switching to the wood pellet system, the neighboring school did not experience any of the technical issues that had occurred with corn, and they were able to substantially reduce their heating costs. The school's success using wood pellet heating for their bus garage led to the development of additional projects to convert other school buildings to wood pellet boilers. The school was able to obtain USDA and DOE grants that covered eighty percent of the cost for the new pellet boilers.

This success inspired RSU 74 to research what it would take to convert to a similar wood system. In 2010, they learned that it would cost $450,000 to convert one of the four schools, the Carrabec High School, to pellets using the same system design of the neighboring district. Unfortunately, the grants that their neighboring school was able to take advantage of were not available to cover the cost of Carrabec's conversion, and the project's capital cost would offset the cost savings from converting to the lower cost fuel source.


Figure 3. Kenneth Coville by ÖkoFEN Pellet Boilers

Innovative Approach

Not to be deterred, the district decided to continue on without a grant by researching means to lower the capital conversion costs. When RSU 74 began implementing the project in July 2011, their effort to convert the heating systems in the multiple schools was guided by a number of central objectives:

- Reduce heating fuel costs
- Reduce heating system maintenance and replacement costs
- Support the local forestry industry
- Support the local biomass energy industry
- Reduce carbon footprint
- Reduce imported energy and enhance national security

To help achieve these goals, the district carried out the school biomass conversions using a set of five strategies that represent the best practices of the project. Each of the strategies are discussed in more detail below.

Strategy #1: Minimize Capital Costs and Demand Load by Implementing Energy Efficiency Improvements

To provide a better return on investment, the district realized that the best strategy would be to focus on reducing the project's capital costs and their demand load. To achieve this goal, they first carried out energy audits for each school to analyze energy flows and identify where improvements could be made to conserve energy and minimize their heating requirements.

Once the audits were complete, they shifted their focus to making energy efficiency improvements to the schools. They discovered that Solon Elementary School was very energy efficient. The building already had good insulation and benefited from solar passive gain in a tower that also has active heat transfer, so no additional work had to be done. The other schools, however, needed improvements. *Garret Schenck School was able to reduce their heating demand by forty-five percent by upgrading their heating controls with variable speed motors and modernizing the system by correcting design flaws. They used the same approach for the other schools, modernizing their setup and controls, which led to twelve percent reductions in their heat load.*

Figure 4. Pellet System Burner

Strategy #2: Apply the 90/50 Rule for Boiler Sizing

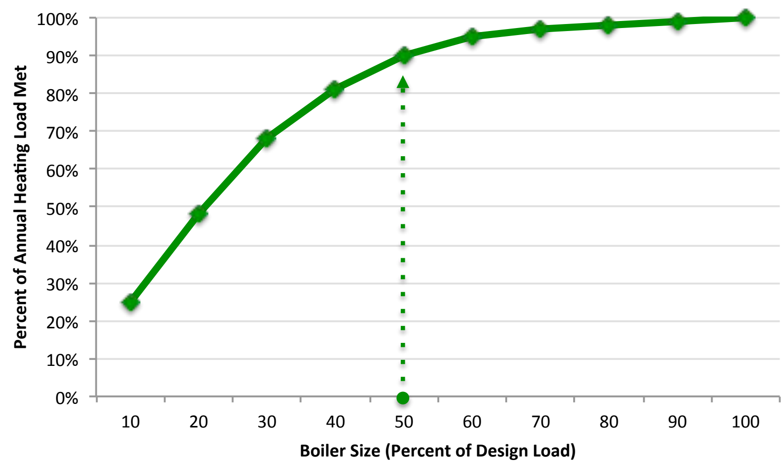

Figure 5. Percent of Annual Heating Load Met vs. Boiler Size

The second major strategy involved closely adhering to the 90/50 rule, which is a boiler sizing best practice that can significantly reduce project costs and the payback period while improving system efficiency. It can be costly and inefficient to size boilers to one hundred percent of peak demand. Instead, many facilities should be able to meet ninety percent of their annual heating demand by sizing a boiler to fifty percent of peak heating load demand and letting a backup system meet peak demand. *This change in sizing frequently results in being able to use a smaller, less expensive system and operating it more efficiently* (e.g., using more of its operating capacity a greater percentage of the time).[69]

RSU 74 found that they could use their existing oil boilers as excess capacity to meet the occasional peak demand of the various school buildings, which meant that the required boiler size of the pellet systems could be reduced, thereby achieving significant capital cost savings. *Critically, because the pellet boilers could be smaller in size, the schools did not have to construct new buildings to house the boilers.* Other costs were also reduced through this approach including lower trenching, piping, mechanical, and stack costs (in one school, they were able to reuse their existing stack).

Overall, these first two strategies resulted in cutting the capital cost of the boiler conversions by an estimated forty percent.

Strategy #3: Utilize a Modular Design

Using a modular design consisting of numerous smaller units—rather than one large unit—was another key design choice that led to much higher system efficiencies. By using a modular design, the schools can alter the pellet boiler's demand/capacity based on what is needed at any given time. Consequently, this has allowed the schools to maximize their efficiency levels by operating fewer units at higher operating levels (and thus high efficiency) during frequent low demand times rather than operating a large unit at very low, and very inefficient, levels during those periods. This approach has led to a reduction in maintenance costs because less material is combusted and the material that is burned is much cleaner.

[69] Plant, Andrew. "Sizing Your Biomass Boiler to Fit Your Needs." University of Maine, 2010.

Counterintuitively, the cost of multiple smaller units (three at one school) was actually lower than the projected cost of purchasing a single larger boiler. This is likely because the units that were selected used standardized assembly production rather than more custom production of larger units. *Also, by placing an order for eight standardized units, the school district received volume discounting on the per-unit cost and significantly reduced delivery costs.*

Figure 6. Interconnected Modular Design

Strategy #4: Implement a Collaborative, District-Wide Approach, That Includes Standardized Design and Material Reuse

Having a district-wide approach for the project was another key strategy wherein each project was carried out simultaneously and with a coordinated workflow. "The project was designed to be viable independent of collaborative efforts," Superintendent Coville said, "but it was also designed where possible to be compatible with state-wide initiatives to promote energy conservation and wood to energy conversions." Consequently, a standardized design for the boiler systems was adopted that could be flexibly adapted to the individual schools.

Relying on a standardized design approach also helped maximize the use of situational opportunities. The school district focused heavily on refitting existing resources in each of the schools to reduce disposal or replacement costs. For instance, they relocated existing oil boilers between the four schools so that they better matched the peak demand of each school. They also had an underground fuel tank that would have had to be removed, but they decided to convert it to a diesel fueling station. This decision has saved 1,000 gallons per year in refueling and between $4,000-$5,000 in fuel-related costs because, previously, the closest place to refuel was thirty miles away. Interestingly, the conversion cost was actually less than the projected removal cost that would have been required by the Maine Department of Environmental Protection. Piping, pumps, and valves from the existing systems were also reutilized when possible, and any new purchases were standardized across the four schools to reduce down stream maintenance costs.

Figure 7. Heating Oil Backup System

Figure 8. Diesel Fueling Station

Strategy #5: Coordinate Engineering and Integrate Work Flow Between Projects

Related to the district's coordinated district-wide approach, Coville emphasized the benefits of relying on in-house engineering for the design of the projects. RSU 74 used one engineering firm to coordinate all of the installations at the various schools. *This approach helped ensure that all of the designs melded together well and a systematic workflow was carefully adhered to so that the work was carried out as efficiently as possible.* The school selected the firm that had completed the facility energy audits to coordinate the project based on their demonstrated competencies, intimate knowledge of the facility systems, and their independence from the other project vendors.

All in all, from the first workday to operational commissioning, RSU 74's biomass project only took three months to complete. Now, Carrabec Community School (45,000 ft^2), Carrabec High School (47,200 ft^2), Solon Elementary School (10,230 ft^2), and Garrett Schenk School (16,750 ft^2) have one full heating season under their belts using ÖkoFEN PES56 wood pellet boilers. The conversion went so smoothly that some people did not believe that anything had changed. As Ken Coville explained, the most common misperception about the systems was when people would ask, "Are you ever going to turn on those wood boilers?" This arose from an expectation of traditional wood smoke exhaust. Some community members had to actually be shown the boilers in operation to believe they were working.

Project Economics

Overall, the total project cost roughly \$697,000: \$172,000 for the eight boilers, \$175,000 for other equipment (including boiler related piping insulation, stacks, heating controls, operation equipment, and diesel pumping station equipment), and \$350,000 for installation, heating system retro-commissioning, and labor and engineering costs.

Because the project's predicted return on investment was very favorable, the school district did not encounter any significant hurdles in obtaining project funding. Additionally, this calculated investment return did not take into account any avoided costs, such as the replacement of aging equipment, which was a further benefit of the conversion. To help fund the project, RSU 74 received a \$250,000 USDA Forest Service grant and a \$40,000 Efficiency Maine Grant. The Forestry Department and Efficiency Maine also provided technical assistance and support. A Qualified School Construction Bond covered the remaining \$407,000 project cost.

Qualified School Construction Bonds Tax credit bonds for public school facilities used for construction, rehabilitation, or repair activities. Rather than receiving interest payments from schools, lenders receive tax credits issued by the federal government.

The schools also took advantage of a number of co-benefits associated with biomass energy that acted as "application enhancers" for the project funding. For instance, full-time employment (created or retained) was an important criterion of the USDA Forest Service grant and a reduction of the schools' base heating demand was key to the Efficiency Maine grant

Maintaining the systems has provided cost savings. The pellet systems require less maintenance time with lower maintenance costs. Total cleaning of the units is only required on an annual basis. These are very automated boilers and on average require no more than an hour of maintenance per week. Gross maintenance for all of RSU 74's pellet systems totals roughly $15,000 per year, which includes the labor for daily checks, ash removal, and so on. This maintenance is carried out by existing in-house staff that received maintenance training as part of the project. As such, while this maintenance is an attributable cost, it is not a net new expense. In fact, overall maintenance has been less expensive with the new pellet units compared to what it previously cost to maintain the school's old heating oil boilers.

In addition to operational cost savings on an annual basis, the conversion allowed RSU 74 to finance the replacement of aging equipment through those same annual savings. Therefore, the avoided costs of not having to replace the existing obsolete systems is an additional uncredited, but significant, savings (at Carrabec High School alone, it would have cost an estimated $250,000 to replace its aging oil boiler).

As mentioned earlier, before converting to biomass pellets, all four of RSU 74's schools depended on expensive heating oil, which was rising in cost during the conversions. Before switching to pellets, oil costs were around $3.50 per gallon and cost $227,000 annually. In total, the district saves around $100,000 annually (including the debt service costs) using pellets versus heating oil, representing a net savings of around forty-four percent.

During the first year of using the new pellet boilers, the school district expected to turn on the oil during the summer, but this did not end up being the case. Because of the modular design, wood pellet heating of summer domestic hot water can now be achieved through efficient burn rates. Now, RSU 74 does not have to purchase imported fuel oil, which helps benefit the local economy (according to the U.S. Energy Information Administration, close to eighty percent of every dollar spent on heating oil in Maine leaves the state).[70]

There are various methods that can be employed to analyze a project's financial viability. One financial analysis tool is the annualized rate of return (ARR). The purpose of the ARR is to identify the potential rate at which an investment will increase (or decrease) each year. Calculating a ten year ARR is valuable for investors because this timeframe best reflects their shorter term focus. The ARR is calculated using a project's return on investment (ROI), which acts as a multiplier at which an investment is estimated to grow over a set time period.[71]

Another useful financial analysis calculation is the internal rate of return (IRR). The IRR estimates a facility's expected return from an investment over time (a measurement of the efficiency of the investment). The IRR is useful for facility owners and calculating it over a twenty-five year time period coincides with the typical projected life of a wood-energy

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[70] "Home Heating Oil Report." EIA, 2010.

[71] ARR Formula: $((1+ROI)^{1/N})-1$

N = # of years   ROI = Return on investment = B – C/P

B – C = Cumulative fuel cost savings added up over a set period of time   P = Total project investment.

system (twenty-five to thirty years). It is calculated as comparison of fuel savings for term to total project investment.[72]

A basic financial analysis of RSU 74's biomass project shows that it has a payback period of 6.9 years, a ten year annualized rate of return equal to 14.8%, and a twenty-five year internal rate of return of 28.1% (assuming inflation varies by source of energy). In this analysis, inflation rates of 3.3% for wood and 10.7% for heating oil were used.[73] Overall, these calculations indicate that RSU 74's project is favorable from a financial investment perspective (current markets are looking for an ARR between five to ten percent and the project's IRR indicates positive growth).

It should be noted that a limitation of these financial calculations is that they do not take into account the avoided costs, such as the replacement of aging equipment, that the district was able to take advantage of. Accounting for the avoided costs would only improve the favorability of these calculations. For example, factoring in these avoided costs, Coville explained that the district initially projected a five-year payback period for the systems. However, they are currently on track to beat this payback period by close to a full year. "At the current rate, we will have return on investment in approximately 4.2 years," Coville said.

System Components

The school district carefully planned out which biomass system manufacturer would best meet their needs. "The key determining factor was the capability of the units to meet or exceed our base load heating requirements with an installation that could be accomplished within existing boiler room facilities," Superintendent Coville said. "The second critical factor was unit capabilities in terms of reliability, self cleaning, auto start, low maintenance requirements, fuel compatibility, integrity of design, etc. The third critical factor was capital cost. Finally, the fourth critical factor was the availability from a Maine supplier. It also didn't hurt that [the boilers] look great and come in our school colors."

All of the pellet boilers ended up being assembled by Maine Energy Systems based on the design of the Swedish pellet boiler company ÖkoFEN. Maine Energy Systems assembles the pellet systems at its headquarters in Bethel, Maine, and acts as the distributor and licensed manufacturer for ÖkoFEN.

The school district has four schools with setups ranging from one to three ÖkoFEN PES56 wood pellet boilers. Solon Elementary School has one 191 MBtu/hr boiler, the other three schools have two to three boilers each. In total, there are eight pellet units and each boiler produces up to 191 MBtu/hr, and together they provide for a range by facility of 191 MBtu/hr-573 MBtu/hr.

The pellet boilers provide the base load heating for all four of the schools and act as their primary heating source throughout the heating season (beginning in late September

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[72] IRR Formula: PNW = 0 = $F_a/(1 + R)^a$
PNW = Present Net Worth = 0   F = Income Each Year = Fuel Savings Each Year   a = Year   R = Rate of Return

[73] Inflation rates based on the Maine ARRA Study, D. Atkins, USDA Forest Service.

through late April or early May). "The multiple boilers are arranged in tandem operation with rotating lead lag to equalize the total burn times between the units," Coville said. The boilers are also very hands free and only require "around ten to fifteen minutes [of maintenance] per school, per day." In combination with other conservation measures, the boilers have eliminated 90-96% of the school district's heating oil consumption.

Figure 9. Fuel Storage Components

The storage systems installed at the different schools include two external silos and two internal flexilo storage systems. Storage capacity varies between eleven and twenty-one tons. Coville explained that the type of storage equipment they installed at each site was based on individual facility features, with internal storage being the preferred setup where possible. The storage units are designed for bulk deliveries and can store up to sixty tons, allowing the schools to arrange to take full truck loads. Coville said that they wanted this large storage capacity to ensure a sufficient on hand supply so facilities could mange through potential fuel delivery interruptions and to provide greater bargaining power in case of fuel quality issues. Fuel delivery frequency is also reduced with bulk delivery and full truckload capability, which helps lower the costs of both the pellets and the handling of fuel deliveries.

Fuel Supply

The district pays $175 per ton of pellets delivered and consumes 375 tons of pellets annually, representing an annual biomass fuel cost of around $65,625 (RSU 74 paid $227,000 in annual fuel costs prior to the conversion).[74] RSU 74 is able to purchase its fuel supply from multiple pellet vendors that are in close proximity to the schools. The district is located halfway between Athens Pellet and Geneva Pellet (which are approximately fifteen miles away in each direction) and both companies are comparable in terms of fuel quality. As such, RSU 74 was able to decide which vendor to go with based mostly on cost. The schools require pellet shipments between a biweekly and bimonthly basis (it depends

[74] As of 8/24/12

on the seasonal demand rate). To make fuel deliveries efficient and reduce fuel costs, they stage refueling so that the pellet company delivers to all four schools at the same run, allowing the truck to unload a full load on each circuit delivery.

Co-Benefits

The benefits of converting from a heating oil system to a wood pellet system have been "huge." Superintendent Coville highlighted benefits such as achieving cost reductions from twenty-five to forty-five percent per building.

Beyond the significant heating cost savings, RSU 74 has also experienced a number of environmental benefits adopting a pellet system. For instance, the schools have a dramatically smaller carbon footprint, with approximately 50,000 gallons of fuel oil displaced and accounting for a reduction of 1,535,800 pounds of CO_2 emissions per year. Furthermore, Coville explained, because the replacement wood pellet fuel comes from certified, sustainable forests, RSU 74's overall heating carbon footprint is virtually zero. Even the approximately 1,750 pounds per year of low metal ash produced by the system is put to productive use as a lime substitute on athletic fields.

Also, Coville stated, because the project was comprehensive and integrated, the facilities' life spans have been extended in this infrastructure area and the quality of life for occupants in terms of heating control and consistency of environment has improved. In addition, the purchase of locally produced renewable wood pellets supports the local economy and reduces foreign oil imports thereby enhancing national security.

Conclusion

Coville does not want to stop with the great success of their pellet boiler conversions. Now, the district is planning to install a transpiring solar collection system at the high school, which would be beneficial in addressing the significant number of air exchanges the school is required to have each day. The schools are now working to integrate transpiring solar collectors into their ventilation systems, which will reduce winter heat load by preheating ventilation air by twenty to forty degrees Fahrenheit. Coville said, "With a time machine, we would go back and include this in the integrated project thereby further downsizing both the boiler capacity needs at one school, [and] the storage capacity and fuel consumption needs at two schools."

The pellet systems are exceeding Coville's expectations—they are working very well and are paying off. He said the most important factors that other facilities should consider when thinking about converting to biomass are, "Situational characteristics of your facility and long term fuel cost/availability. We anticipate wood pellet heating to be our primary low-cost heating option until they get that small scale cold fusion stuff working." Overall, the most important lesson he says was learned through the biomass project is that people should not be limited by the standard vendor designs they see, instead "Do your own research and demand system designs that are both customized to your facility and represent an integrated comprehensive approach rather than simple fuel source swap."

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Financing Woody Biomass Clusters:
Barriers, Opportunities and Potential Models for the Western U.S.

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