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

U.S. Endowment for Forestry & Communities, Inc.
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Final Project Report
(without appendices)

May 2013

Prepared by Dovetail Partners, Inc.

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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]

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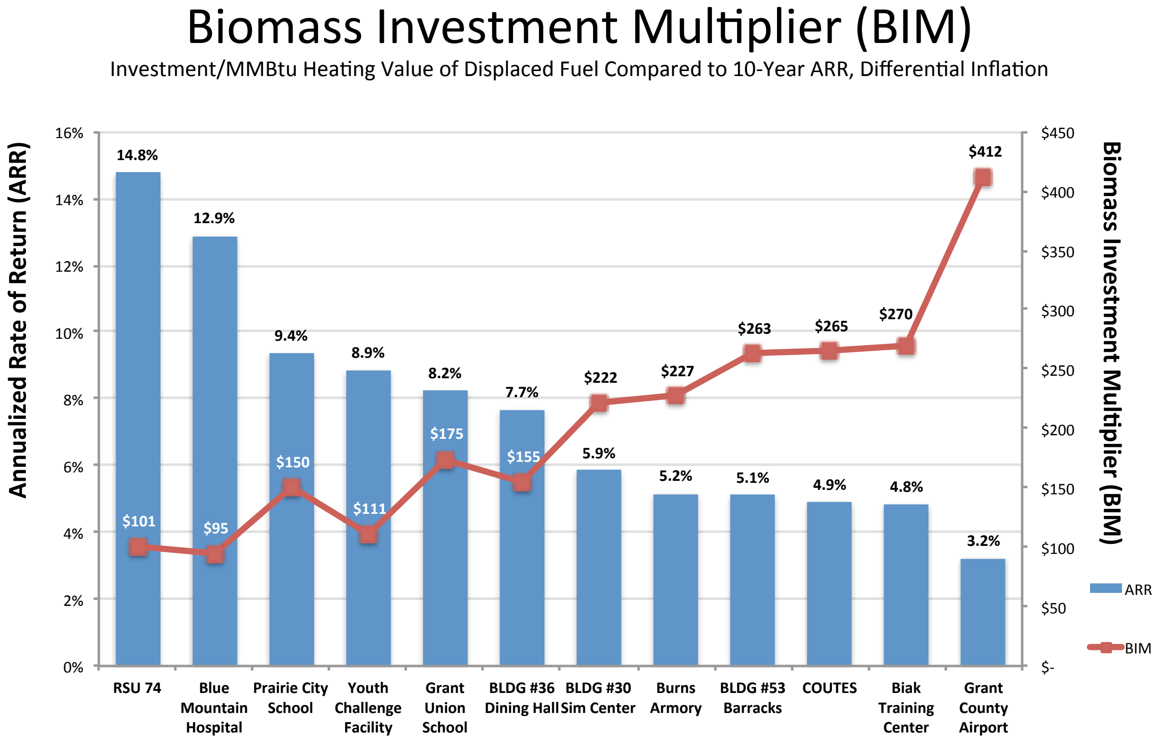
[3] Displaced energy is calculated using previous or recent year's actual volume of energy source used (e.g. oil or propane) converted to MMBTUs.

[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.

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[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

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[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]

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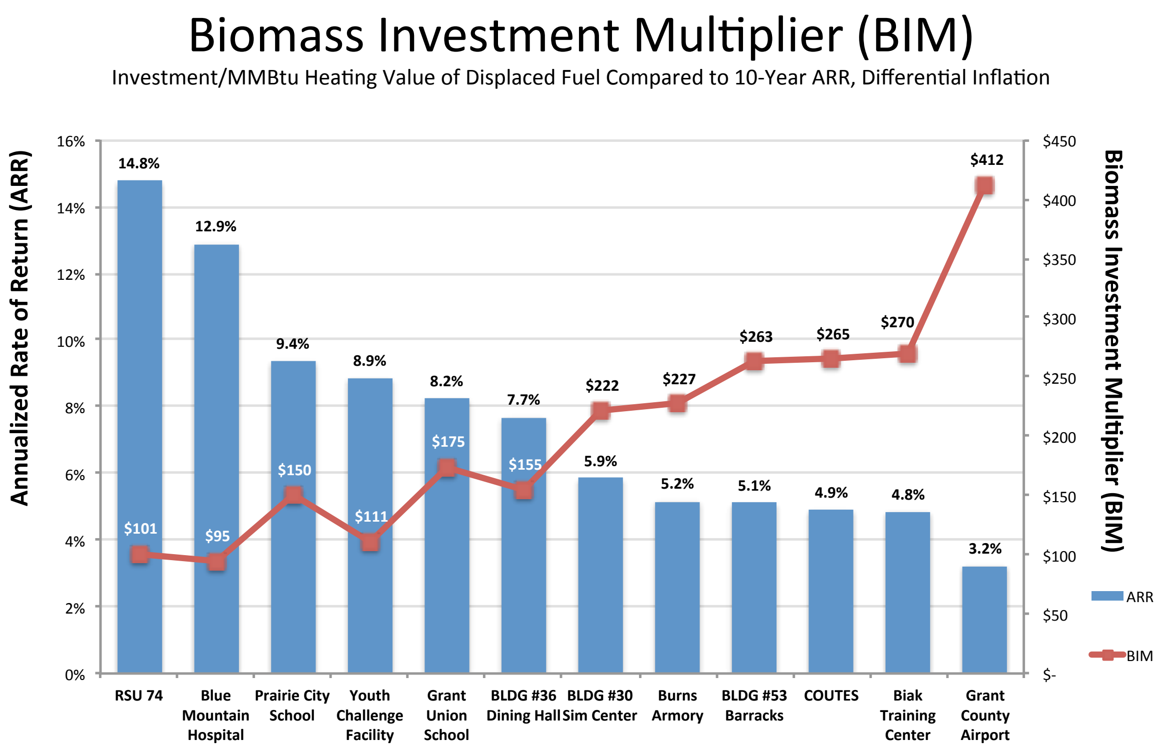
[14] Data and financial analysis provided by D. Atkins, USDA Forest Service

[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.

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[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

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[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%

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[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

Challenge

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

Recommendations

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.

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[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

<u>Challenge</u>

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]

<u>Recommendations</u>

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

<u>Challenge</u>

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.

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

Fuel Supply Findings

Challenge

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.

Recommendations

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

Challenge

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.

Recommendations

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.,

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[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.

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[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

Challenge
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.

Recommendations
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.

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

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