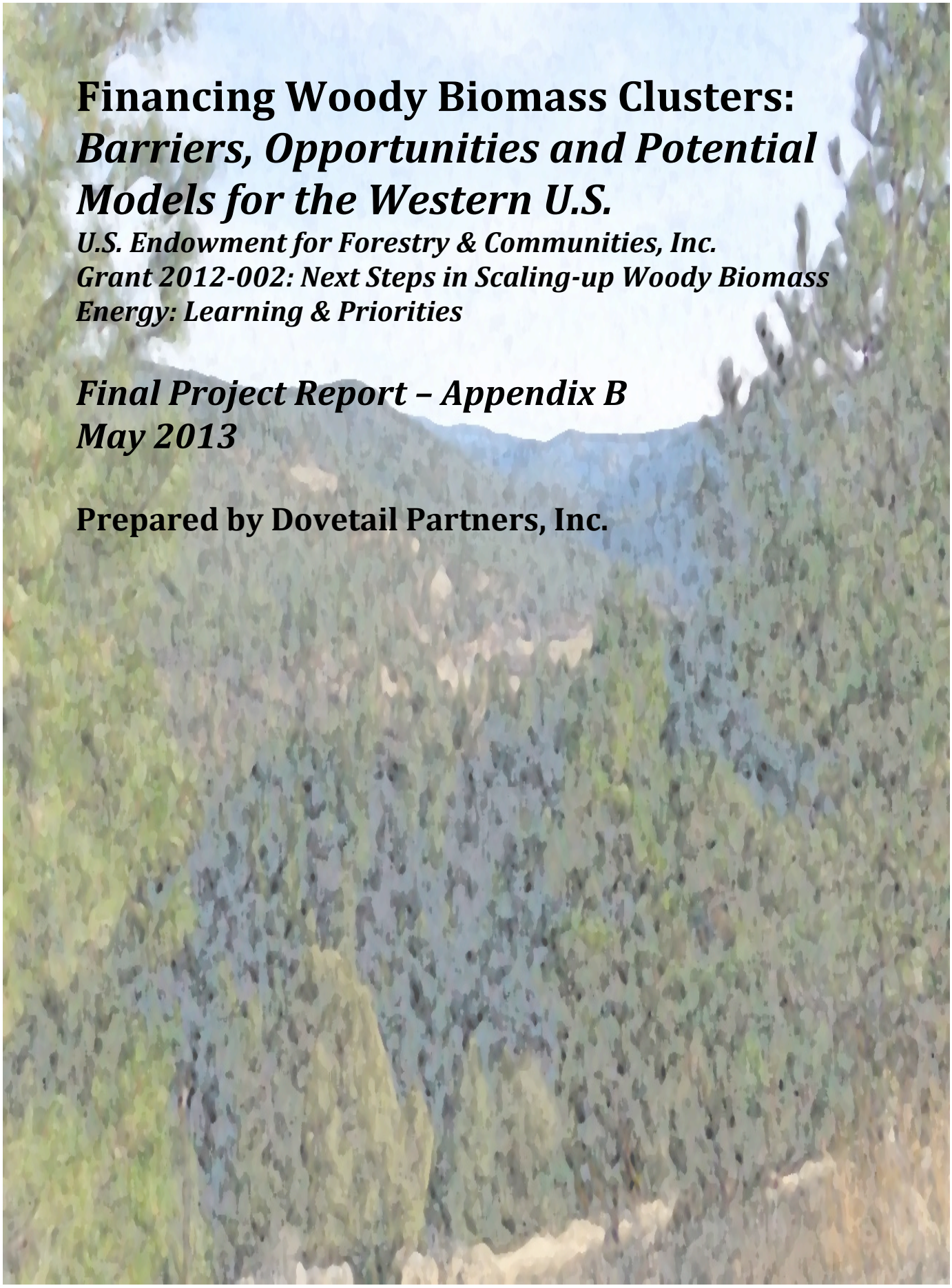

Financing Woody Biomass Clusters: *Barriers, Opportunities and Potential Models for the Western U.S.*

U.S. Endowment for Forestry & Communities, Inc.
Grant 2012-002: Next Steps in Scaling-up Woody Biomass Energy: Learning & Priorities

Final Project Report – Appendix B
May 2013

Prepared by Dovetail Partners, Inc.

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

Final Project Report – Appendix B

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Appendix B. Survey Results

Biomass Survey Results Summary

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

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

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

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

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

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

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

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

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

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

Biomass Survey Participant Reference List

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

(continued on the following page)

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

Survey Results Summarized by Areas of Interest

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

Opportunities for Wood-to-Energy Development

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

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

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

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

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

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

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

Challenges for Wood-to-Energy Development

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

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

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

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

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

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

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

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

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

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

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

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

Financial Conditions Necessary for Wood-to-Energy Development

Project Performance

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

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

Project Economics

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

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

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

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

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

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

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

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

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

<u>Biomass Fuel</u>

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

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

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

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

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

Lessons Learned of Surveyed Biomass Facilities

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

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

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

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

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

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

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

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

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

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

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

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