Preliminary Feasibility Report

Sanborn Mills Farm

Wood-Fired Mini-District Heating

Loudon, New Hampshire

Report Prepared for NH WEC by:

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Date of Site Visit: April 30, 2015

Date of Report: June 2, 2015

The NH Wood Energy Council is coordinated by North Country Resource Conservation & Development and funded through a grant from the USDA Forest Service State & Private Forestry. North Country RC&D, coordinator of the NH Wood Energy Council, complies with federal nondiscrimination policy and is an equal opportunity provider.

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I. Executive Summary and Recommendation

The NH Wood Energy Council (www.nhwoodenergycouncil.org - NH WEC), with funding through a grant from the USDA Forest Service, has funded this preliminary feasibility study for Sanborn Mills Farm, located in Loudon, New Hampshire, to determine if switching from fossil fuel to wood fuel for heating is feasible and warranted, and more specifically to study the technical and financial aspects of creating a mini-district heating system to serve four buildings from a central wood heating plant. Tim Maker of Community Biomass Systems, located in Montpelier, Vermont, has been hired by NH WEC to complete this "Coaching" assignment and is the author of this report.

The Sanborn Mills Farm cluster of buildings under consideration will jointly total about 11,400 square feet of heated space:

- Farmhouse 5,200 sq. ft., now heated with a GARN cordwood boiler and an oil boiler
- Wood Shop 1,500 sq. ft., now heated with propane space heaters and a wood stove
- Legion Hall 1,500 sq. ft., not yet moved to the property
- Cattle Barn 3,200 sq. ft., renovation of the lower level in process (now unheated)

These buildings are described in more detail in the body of the report. In addition, a fifth space is expected to be created for dormitory accommodations by demolishing part of a connector between the Farmhouse and the Cattle Barn.

Because much of the space that will eventually be heated is not currently heated, and because three different fuels are currently in use, it is difficult to say with any accuracy what the baseline heating fuel consumption is. Also, the re-purposed lower level of the Cattle Barn will be a dining and kitchen facility, with a significant but unknown domestic hot water (DHW) load. We have calculated the estimated oil equivalent annual gallons for the buildings as follows:

- Farmhouse 3,380 gal oil/yr
- Wood Shop 525 gal oil/yr
- Legion Hall 750 gal oil/yr
- Cattle Barn 1,920 gal oil/yr

Total: 6,575 gal oil/yr

Based on an on-site review of the facility on April 30, 2015, we have determined that:

The overall mini-district heating project is ready for starting the reconfiguration of equipment in the existing boiler house, including the installation of an inside pellet storage bin and installing the first of two wood pellet boilers. We recommend that a qualified engineer be engaged to review and advise on some design elements before hiring an installer. A list of installers, including design/build contractors, is in the Appendix.

A specific wood fuel heating system is not specified in this pre-feasibility report but it is estimated that the total two-phase project cost for installing two pellet boilers and connecting the buildings with buried piping will cost approximately $225,000, depending on a number of factors.

A heat load calculation was made based on the existing fuel use and it has been determined that the four-building peak heat load may be approximately 500,000 Btu/hr (150 KW). Farm Manager Tim Huppe expects the district heat project to get built in two phases over approximately three years. We recommend installing an approximately 250,000 Btu/hr (75 KW) pellet boiler in Phase I. The sizing of the second pellet boiler could be determined once there is experience with the system and the build-out of the heat load. We recommend that thermal storage tank (buffer tank) be installed as part of Phase I.

A preliminary financial analysis has estimated the following:

Project cost (2-phase installation)		$225,000
Anticipated PUC rebate		$ 50,000
Owner cash input		$175,000
Year 1 cash flow	positive	$ 12,700
Year 15 cumulative cash flow	positive	$ 240,000
20-year net present value (NPV)		$ 49,000
Internal rate of return (IRR)		6.9%

Financing options available to Sanborn Mills Farm include:

- NH Public Utilities Commission (PUC) Commercial Wood Pellet Boiler Rebate
- USDA REAP (available only to ag/forestry producers and rural small businesses, generally not to non-profits)
- N.H. T-RECs Enterprise Fund that pre-buys thermal renewable energy certificates (however, this project may be too small to take advantage of it).

It is important to note that the owners of Sanborn Mills Farm have already decided that they want to get off fossil fuels and to convert fully to wood. The 350 acres of Sanborn Mills Farm are largely forested and the intent is to use wood from the farm property to heat the buildings, sourced either directly (as wood chips produced on-site from wood harvested on the farm) or indirectly (as pellets, made by a NH pellet mill which would purchase feedstock wood from the Farm). The main purpose of this report is to assist the owners and staff in decision making about how best to configure the mini-district system to heat existing buildings and those that will be added to the Farm over the next few years.

II. Introduction

Opportunities to use wood energy to replace fossil fuels can provide increased economic benefits to all residents and businesses in New Hampshire and move the state towards the State's goal of using 25% Renewable Energy by 2025.

Nationally, the U.S. Department of Agriculture has directed the U.S. Forest Service to increase its wood to energy efforts as part of that Agency's continuing focus on building a forest restoration economy connected to the management of all lands. By placing a strong emphasis on developing renewable wood energy while restoring the nation's forests, USDA strives to create and retain sustainable rural jobs, conserve forests, and address societal needs.

For these reasons the NH State Forester and the U.S. Forest Service created the NH Wood Energy Council. This team of people includes individuals, organizations, NH businesses, industry associations and non-profits interested in the sustainable use of forest resources, development of renewable energy alternatives - from regional and community agencies sustaining local economies and meeting social needs, and from State and Federal agencies interested in maintaining and expanding the economic benefits from the state's forest resources.

The NH Wood Energy Council serves as a national pilot, testing and refining tools to encourage more use of wood for energy and methods.

The USDA Forest Service has provided financial and technical resources to support the work of the NH Wood Energy Council. The North Country Resource Conservation and Development (RC&D) Area Council facilitates the organization and initial work of the Council.

A key component of the NH Wood Energy Council's work is to provide direct technical assistance to public, institutional and private facility managers to encourage switching to modern, efficient wood fueled heating systems. This preliminary feasibility study is a key method to deliver those technical services where needed.

After an application for assistance was submitted by Sanborn Mills Farm, the mini-district system project was selected by the Council as a site for this preliminary feasibility study conducted to assess the potential to convert from a fossil-fuel based heating system to a wood biomass based heating system.

III. Analysis Assumptions

The district heating approach to wood heating for the buildings of the Farm cluster were studied using Life-Cycle Cost analysis. The assumptions used for in this analysis and in fuel use calculation are:

Oil price		$3.00/gal
Propane price		$2.50/gal
Wood pellet price		$230/ton
Dry Woodchip price		$120/ton
Cordwood cost (assuming owner-produced)		$175/cord
Pellet system cost		$125,000
Total mini-DH system project cost		$225,000
System sizing	Phase I pellet boiler	250,000 Btu/hr
	Phase II pellet boiler	250,000 Btu/hr
Loan interest rate		5%
Loan term		10 years
Seasonal combustion efficiency	Oil boiler	75%
	Propane space heater	85%
	Cordwood (stove)	60%
	GARN boiler	unknown
	Pellet boiler	80%
	Dry woodchip boiler	75%
Grant assistance potential		
NH PUC biomass rebate		$50,000
USDA REAP grant	(non-profits generally ineligible)	

IV. Existing Facility and Heating System Description and Review

Sanborn Mills Farm is a private non-profit working farm that teaches and showcases traditional agriculture, woods work and historic ways of living from the land. The Farmhouse, or Main House, built in 1875, house the offices and will become a bed-and-breakfast and teaching center. Traditional ways of woodworking are taught and used in the Wood Shop, or Old Horse Barn, across the narrow dirt road from the Farmhouse. The ground floor of the impressive Cattle Barn, with its massive granite foundation stones, will be renovated as a dining hall and kitchen. The historic Legion Hall, which has been purchased by the Farm, will be moved to a site just uphill from the Cattle Barn. The owners and staff of the farm are committed to making the buildings as energy efficient as they can, as they are being renovated. An open barn, at ground level, that connects the Farmhouse and the Cattle Barn, will be demolished to make way for the construction of dormitory space.

Sanborn Mills Farm

Farmhouse (3 chimneys), boiler house (to left) and Cattle Barn (background)

The other building that will be part of the mini-district heating system is the existing boiler house. It currently houses a hand-fired cordwood GARN boiler which last winter heated the adjacent part of the Farmhouse. The intent is to remove and sell the GARN (which has not performed satisfactorily – see discussion below) to make space for the installation of modern efficient wood boilers, fueled either with pellets or dry woodchips. The space is also adequate for hot water storage tank(s) and an inside pellet silo.

Cattle Barn

Showing Farmhouse (left), Cattle Barn (right) and connecting barn (between)

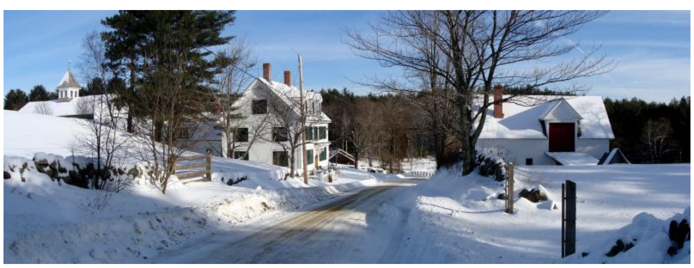
Farmhouse

The Farmhouse has been renovated to increase its energy efficiency and make it useable for the purposes of the Farm operation. It has a conference room attached to the back, with radiant floor hot water heating that is sourced from the boiler plant a short distance behind the building. Currently about 50% of the heat and DHW is supplied by the GARN boiler and 50% by an oil boiler.

Cattle Barn, showing upper level – dining facility to be built in lower level – upper level of boiler house show on farm right

Wood Shop

The Wood Shop is heated with two thermostatically controlled propane space heaters. During the day, when the building is in use in the winter, the work space is heated with a wood stove. The intent is to connect this building to the central boiler plant by burying pre-insulated PEX pipe across the road, possibly coming from the front of the basement of the Farmhouse, or under the side driveway. The hot water from the plant will be used to run a "Modine" style fan/coil unit to heat the work space and displace the propane (and woodstove).



Showing Farmhouse (left) and Wood Shop (on right, across the road)

The Farmhouse and the Wood Shop are the only two buildings of the Farm cluster that are currently heated.

Boiler House and GARN Boiler

The Boiler House, which is located just behind and to the side of the Farmhouse, is an attractive farm out-building. It currently houses a GARN cordwood boiler with 1,500 gallons of hot water storage, and ample space to store cordwood. In addition, there is a large overhead storage room accessed from the uphill (back) side of the building.

The GARN has been a disappointment to farm staff. Last winter it burned 23 cords of firewood to heat about half of the 5,200 square foot Farmhouse. From the Coach's experience, I would not expect it to take more than 8 cords to heat half of the Farmhouse, using woodstoves or an efficient cordwood boiler. It is a mystery where all the heat goes. The staff says that the GARN was heavily and effectively site-insulated, so there should be little heat loss out of the storage tank. That means that either the heat is being bled out of the tank, constantly, up the stack, or somehow it is not making it the short distance to the Farmhouse, or somehow the slab floor of the Farmhouse is leaking heat down to the ground. The high labor requirements to feed the GARN have been a real burden to staff, and there have been other operating problems as well.

While the GARN has the advantage of being able to be sourced from the Farm's own woodlands, the convenience of an automated system will reduce the staff workload significantly (cutting logs to length, splitting stacking, hand-feeding the boiler).

V. Fossil Fuel Use Assumptions including inflation

Data was available on fossil fuel use at the facility for the years 2013 and 2014. The table on the next page summarizes the fossil fuel use. Please note that the fossil fuel use record covers approximately one third of the future heat load of the system envisioned. The annual usage below is the average of the two years' consumption.

See the next page for annual fossil fuel usage.

Fossil Fuel Usage at Sanborn Mills Farm – 2013 & 2014

Year and building	Fuel Oil/Propane Usage (Gallons)	Average Cost/Gallon	Total Expenditures
Farmhouse – Oil			
2013	2,068	$3.70	$7,654
2014	1,292	$3.71	$4,790
Average	1,680	$3.70	$6,222
Wood Shop - LP			
2013	640	$3.33	$2,134
2014	472	$2.27	$2,017
Average	556	$2.80	$2,076
TOTAL both buildings (annual average, oil gal equivalent)	**2,097**	**$3.96**	**$8,298**

According to staff estimates, the **Farmhouse** gets about half its heat from the oil boiler and half from the remote GARN cordwood boiler. An additional half cord of firewood is used in a wood stove. Because of the apparent inefficiency of the heat distribution from the GARN boiler, it is impossible to say what the actual heat load of the building is. The **Wood Shop** uses about 550 gallons per year of propane in two space heaters, for its baseline heat. In addition about 1.5 cords of firewood is used in a wood stove when the building is occupied in daytimes.

The following chart shows our calculated estimates of the expected annual oil equivalents of each of the four buildings when they are connected into a mini-DH system, along with the additional load associated with heat loss (estimated at 10%) from the buried piping. Existing fuel use was documented and then checked against estimates of the per square foot oil usage of each building, as might be expected based on its age, condition and status of renovation.

Oil Equivalents, by Building and Total

Buildings	sq. ft.	estimated gal/sf	gal/yr
Farmhouse	5,200	0.65	3,380
Wood Shop	1,500	0.35	525
Legion Hal	1,500	0.50	750
Cattle Barn (lower level)	3,200	0.60	1,920
Total	11,400		6,575
Pipe loss	10%		658
Grand Total			7,233

For the purposes of this study, and using data developed by the NH Office of Energy and Planning, we are assuming an annual inflation rate of 5% for fossil fuel costs for all of our analyses in this study.

VI. Wood Fuel and Boiler Selection

The initial concept behind this project was to use logs harvested on the Farm and have them chipped on-site by the contract logger who does harvesting there. It was quickly evident that, given the aggregate square footage of the buildings (about 11,000 square feet) and the projected size of the peak heat load (about 500,000 Btu/hr – see below), a "green chip" boiler system would be very expensive and not cost-effective.

Typical green chip boiler systems start in size around 1.5 million Btu/hr (1.5 MMBH), although it is now becoming rare to see projects using U.S. manufactured chip boilers smaller than 3.0 MMBH. Wood pellet boilers, mostly European, have become the technology of choice for buildings in New Hampshire of less than about 40,000 square feet area of heated space.

Next the Farm staff turned their attention to a "dry chip" approach, which would use the same self-produced chips but dry them on-site to 25% moisture content or less. To take advantage of small European dry chip boilers on the market not only would the chips have to be dried they would also have to be carefully screened to a size smaller than typical commercial chips. These two challenges proved daunting for such a small operation and small annual fuel requirement.

This led staff's thinking to European pellet boilers. Not only are high-efficiency, clean-burning pellet boilers readily available on the market, but the major source for pellets in the area is New England Wood Pellet, located in Jaffrey, NH, about 65 miles away. The idea that wood could be cut at Sanborn Mills Farm and sold to New England Wood Pellet is attractive. The Farm could then buy pellets from New England Wood Pellet, maintaining a virtual scheme of burning its own wood for heating.

Some pellet boilers and some types of pellet storage bins will also work with dry chips, as long as they are manufactured or screened to tight chip size standards.

VII. Heat Load

To determine proper sizing of for each of the proposed wood biomass heating system under consideration, a preliminary heat load calculation was developed.

Using an abbreviated estimation method based on annual fossil fuel consumption to determine heat load and size of the boiler needed, we have estimated that the peak winter heat load of the four buildings, including buried pipe heat loss:

Total 4-building Cluster Peak Heat Loss: 497,000 Btu/hour

This project is anticipated to be built in two phases, two or three years apart. If we take the peak load as 500,000 Btu/hr (150 KW), we could assume for simplicity that the Phase I and Phase II boilers would have equal capacities:

Phase I Boiler Sizing	250,000 Btu/hr (75 KW)
Phase II Boiler Sizing	250,000 Btu/hr (75 KW)

Because there are so many uncertainties about the actual heat load of each of the buildings, it seems that it would be reasonable to install a 250,000 Btu/hr boiler in Phase I and observe its operation closely before making the Phase II boiler sizing decision. Factors to consider will be the boiler run time in peak winter conditions relative to the number of buildings connected to the mini-DH system at that time, and the summer performance under various DHW loads. It will be simple to select either a smaller or larger boiler for Phase II when that decision must be made.

Alternatively, a single 500,000 Btu/hr pellet boiler could be installed from the start. It would be significantly over-sized until all the buildings were connected to it, which might adversely affect its low-load operation. See the discussion below, comparing the pros and cons of one-boiler vs. two-boiler systems.

Pellet boiler (green) with buffer tank (red) for hot water storage

VIII. Fuel Cost Assumptions and Inflation Rates

The table on the next page shows the energy content and fuel price of the fuels under consideration.

Energy Content and Cost, Various Fuels

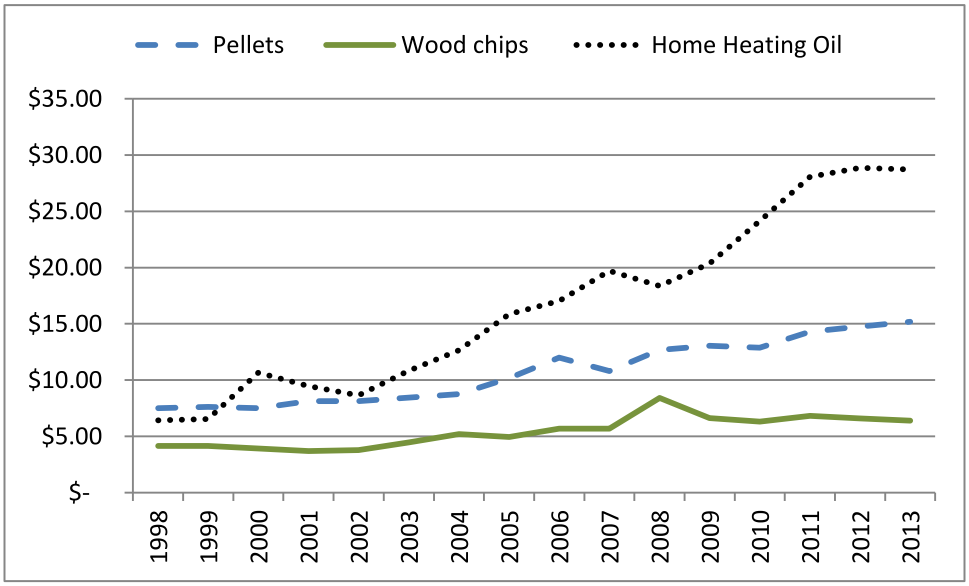
Fuel Type	Unit	Cost per Unit	BTU per Unit (dry)	Moisture Content	MMBtu per Unit	Cost per MMBtu Delivered	Average Seasonal Efficiency	MMBTU per Unit After Combustion	Cost per MMBtu After Combustion
Oil	gallon	$3.00	138,000	0%	0.138	$21.74	75%	0.104	**$28.99**
LP Gas	gallon	$2.25	92,000	0%	0.092	$24.46	70%	0.064	**$34.94**
Wood Pellets	ton	$230	16,500,000	8%	15.2	$15.15	80%	12.1	**$18.94**
Dry Chips	ton	$120	16,500,000	25%	12.4	$9.70	75%	9.3	**$12.93**
Cordwood	cord	$175	22,000,000	25%	16.5	$10.61	60%	9.9	**$17.68**

There is enough historical data available on wood pellets to suggest an annual inflation rate for bulk wood pellets at 4%. For this study, an annual price inflation rate of 5% is assumed for oil and propane.

Loading a GARN boiler (not at Sanborn Mills Farm)

The figure below shows historical data for pricing of wood pellets and heating fuel oil.

NH prices for wood pellets and heating oil
Fuel Cost per MMBTU in NH, 1998 - 2013



Source: NH OEP, Innovative Natural Resource Solutions, LLC

IX. Life cycle Cost Analysis

The staff of Sanborn Mills Farm has indicated that the owners are committed to heating the full facility with local wood. The implication was that financial analysis was not really required to make this decision. Nonetheless, a Life Cycle Cost (LCC) analysis was conducted using Community Biomass Systems' proprietary LCCA tool. The results are shown in the table below. A Life Cycle Cost Analysis evaluates the economic performance of alternative choices or a particular choice, compared to a "business as usual" approach – which is generally taken to be heating with conventional fossil fuel: oil or propane. This involves comparing all equipment and operating costs spent over the life of the longest lived alternative in order to determine the true least cost choice. The total cost of acquisition, fuel costs, and life cycle costs that should be considered in a life cycle cost analysis include:

- Capital costs for purchasing and installing equipment
- Fuel costs
- Inflation for fuels, operational and maintenance expenses
- Annual operation and maintenance costs including scheduled major repairs.

If a capital project is to be financed, the impact of debt service must be taken into consideration in order to get a clearer picture of how a project might affect annual budgets. When viewed in this light, equipment with significant capital costs may still be the least-cost alternative. In some cases, a significant debt-financed capital investment may actually lower annual expenses, if there are sufficient fuel savings to offset debt service and any incremental increases in operation and maintenance costs. In this case, however, staff instructed us to assume that the project would be financed with the owners' funds. Since there would be no debt payments, cash flow is positive from the start.

The analysis performed for the Sanborn Mills Farm project compares different scenarios over a 20-year horizon and takes into consideration life cycle cost factors. The wood pellet boiler life is expected to exceed this timeframe.

In the Life Cycle Cost Analysis tool the two scenarios (business as usual, and heating with biomass) were run using common assumptions and data wherever possible. The scenarios include all ancillary equipment and interconnection costs. The analysis projects current and future annual heating bills and compares that cost against the cost of operating a biomass system. An estimated $8,000 cost of installing a new oil boiler in the Farmhouse around the year 2015 to replace the current oil boiler is factored into the analysis as an avoided capital expense. The tool used calculates net present value (NPV), defined as the present dollar value of net cash flows over time. This is a standard method for using the time value of money to compare the cost effectiveness of long-term projects. It also calculates internal rate of return on investment, and payback period where net positive cash flows offset installed capital cost.

It is not the intent of this analysis, nor was it in the scope of work, to develop precise cost estimates for a wood pellet heating project based on detailed engineering and vendor analysis. The capital costs used for the scenarios were provided as estimates by qualified vendors and from the Coach's project and study experience. Should Sanborn Mills Farm decide to move forward with a biomass heating project, we recommend that they engage one or more vendors in providing detailed project quotes, or consider retaining a qualified mechanical engineer to do a more in-depth analysis as the basis for a competitive bid process from multiple vendors.

Table 4 Life Cycle Cost Analysis Summary

Project: Replace Fossil Fuel with Wood	Assume 2-Boiler, 2-Phase Pellet System Installation
Capital Cost of Boiler, Fuel Storage, Related Construction	$120,000
Additional Capital Cost (if any)	$105,000
Estimated TOTAL CAPITAL COST	$225,000
Grant(s)*	$ 50,000
Amount to be Financed (owner funds)	$175,000
Sizing of Pellet/chip Boilers Relative to Base Thermal Load	100%
Estimated fuel usage (including propane back-up)	60 tons pellets
Reduction in heating oil consumption	7,300 gal
Annual operating cost above oil system (if any)	$500
Internal Rate of Return	6.9%
20-Year Net Present Value (@ 2.5% discount rate)	$49,000
Year of First Positive Cash Flow	Year 1

* See grant options in section XVI. A summary of the Life-Cycle Cost Analysis spreadsheet can be found in Appendix C.

It is assumed that wood pellet boilers have a service life of at least 25 years.

X. Operation and maintenance

Wood pellet boilers are relatively simple biomass heating systems. Because wood pellets are generally uniform in size, shape, moisture and energy content, fuel handling is very straightforward. Nevertheless, there are some ongoing maintenance requirements for these systems. A centralized wood pellet boiler system may take the same or more time to maintain and operate than multiple traditional gas or oil boiler systems. At the institutional or commercial scale, however, many of the maintenance activities can be cost-effectively automated by installing off-the-shelf equipment such as soot blowers or automatic ash removal systems. Some of the typical maintenance activities required for wood pellet systems are:

Weekly

- Emptying ash collection containers
- Monitoring control devices to check combustion temperature, stack temperature, fuel consumption, and boiler operation
- Checking boiler settings and alarms, such as those that alert to a problem with soot buildup

Yearly

- Greasing augers, gear boxes, and other moving parts
- Checking for wear on conveyors, augers, motors, or gear boxes

When considered on a daily basis, the total time required for maintaining the wood pellet boiler system equates to roughly 10-20 minutes per day over the entire heating season but maintenance is not required every day during the heating season.

One of the overlooked issues with pellet systems is the oversight of the volume of pellets in the storage silo. Depending on the type of silo, some type of gauge may be required for quick line of sight of the need to order and refill the silo. This will depend on the size of the silo and the use. Pellet deliveries can be simplified and costs reduced in bulk delivery by increasing the size of the delivery.

XI. Thermal Storage (TS)

An insulated thermal storage tank (also called a buffer tank) will store heat from the proposed two pellet boilers, from which hot water is then distributed as the buildings calls for heat. This allows a properly sized biomass boiler to operate in a high fire state at peak efficiency and then be turned off or to go into a stand-by mode where a minimal amount of fuel is being burned. Thermal storage is widely recognized as an important efficiency investment that optimizes system performance and to keep air emissions to a minimum from the system, particularly for district systems serving multiple buildings.

While this project will be carried out in two stages, as different buildings are brought into the district heat distribution system, it makes sense to put in a single storage tank with the capacity based on the full system heat load from all the buildings. We assume a tank capacity of 750-1,000 gallons.

Two pellet boilers (red) with thermal storage (buffer tank, white)

XII. Cost Ranges for Wood Systems

It is not the intention of this analysis to recommend a specific wood fuel heating system in this report. Instead, based on industry standards, vendor calls on likely systems and the author's professional knowledge, the cost of the system(s) likely to be appropriate for the situation in this facility will be estimated.

The estimated cost of the full, 2-phase installation is approximately $225,000. The project budget is shown in the Life-Cycle Cost Analysis Summary, in the Appendix. Major installed cost categories are:

- 2-boiler pellet system, complete with fuel silo and buffer tank $120,000
- Piping, pumps, electrical and controls in the Boiler House $ 27,000
- Buried piping to three buildings, with building connections $ 53,000
- Engineering $ 5,000
- Contingency $ 20,000

Because of the uncertainty around the actual heat load, the sizing of boilers and the phasing of installation, the preliminary project budget of $225,000 should be considered relatively accurate on a +/- $25,000 basis.

XIII. Emissions and Permitting

This project will likely require small enough wood pellet boilers that it will not require special permitting in New Hampshire for installation.

Emissions such as NOx, SOx and volatile organic compounds from pellet and wood chip burning equipment are, in general, very low in comparison to other forms of combustion heating. Automated, commercial-sized pellet systems burn much cleaner than the most modern home wood or pellet stove.

You should check with local officials to determine if a building permit or other local permitting is required if a wood-fueled system is installed.

XIV. Wood Ash

One by-product of burning wood pellets is ash, a non-combustible residue. While the ash produced by burning wood pellets is automatically removed from the boiler in the systems of many manufacturers, the container in which the ash is collected must periodically be emptied and disposed of manually.

The ash volume produced depends on the fuel burned. Ash content is measured as a percentage of weight and should be at most 1% for wood pellets available for New Hampshire use. A ton of wood pellets burned will produce approximately 20 pounds (about 2 gallons of volume). The likely system for this facility is estimated to use 60 tons of pellets annually and approximately 1,200 pounds of ash will be generated.

While many wood boiler operators use their ash as fertilizer for lawns or athletic fields, there are other useful ways to handle wood ash material, such as composting and amending soil. The ash is not known to adversely affect humans or plant and animal life when dispersed in this way, although, it may over time lead to increased nutrient runoff into streams, rivers, wetlands and other water bodies if not disposed of properly so care is needed in disposal or re-use. This ash can also be disposed of at any state landfill or other permitted solid waste management facility.

There are regulations in NH for wood ash disposal. Historically, all non-household wood ash is captured under Env-Ws 1700 of Solid Waste Rules from the NH Department of Environmental Services (DES), including the large biomass plants and the small and mid-sized commercial boilers. NH-DES does not have staff or resources to implement this regulation for all the new boiler installations.

Effective February 11, 2014, emergency rules are now in effect that exempt from the requirements of Env-Sw 1700 generators and brokers who distribute 500 tons per year or less of wood ash from the combustion of clean wood for agronomic use (spreading on ag lands). This emergency rule has been filed to address the concerns that the Department received at the public hearing and subsequently about the difficulty that the requirements of Env-Sw 1700 has on small boiler operators.

What this means for the ash disposal from this project is that there are no state regulations and oversight for the disposal of the ash from the estimated 60 tons of pellets burned in the proposed biomass system for this project, but it must be actively managed and beneficially used in agricultural applications .

What should a facility do about following rules if exempt? According to DES recommendations, wood ash needs to be managed sustainably:

- Environmentally responsible
- Cost effective
- Socially beneficial

To meet these goals:

-Protect your asset by knowing the quality of the wood ash before distribution
- Develop a program for managing responsibly
- Keep records documenting practices
- Partner with an end user that will benefit
- Educate the public about win-win program

See posting on: http://des.nh.gov/organization/commissioner/legal/rulemaking/index.htm

XV. Building Envelope and Energy Efficiency

We were not able to collect any information about the energy efficiency of the buildings that will be connected to the proposed mini-DH system.

It is very important that heat loads be reduced to the lowest possible level through insulation upgrades and air-sealing, carried out by professionals. This will reduce the size and cost of the boiler system and reduce the fuel requirement.

Please see the discussion below about possible heat loss from the radiant-floor slab of the Farmhouse.

XVI. Project Recommendation

As required by the NH Wood Energy Council, one of the three options for installation of wood heating system is to be made under this review and report activity:

1. *Project should not continue – wood heating not a viable option;*
2. *Project is ready for wood heating system installation (recommend which kind or options including fuel storage)– provide list of design/build contractors;*
3. *Project has potential for wood heating system, but Feasibility level analysis is recommended next step and reason why are outlined.*

   - Option 1 – More analysis is needed and a design engineer and/or design/build contractor could do this work – this work includes…]

   - Option 2 – More analysis is needed, particularly the following… and a full feasibility study is recommended.

Based on the site review and feasibility analysis, it is recommended that this project is ready for Phase I installation. We recommend a design/build approach where the pellet boiler installer has full responsibility for the design and installation of all components of the pellet boiler system: the boilers, the stack, the fuel storage bin, the buffer tank, the controls and all ancillary wiring and plumbing. We strongly recommend that an engineer qualified to provide design of the district heat piping/pumping system be engaged before hiring an installation contractor (see discussion on next page, "Diagnosing the Cordwood Boiler Heat Loss"). Alternatively, the design/build installer may be able to provide the necessary engineering.

In Phase I, the first pellet boiler would be installed, along with the full 2-phase pellet storage silo and hot water storage tank. The system would initially serve the Farmhouse using the existing pumping and buried pipe connections.

To avoid unnecessary cost in Phase II, we recommend that an engineer be engaged to size and lay out the pumping and distribution pipe header in the Boiler House in anticipation of connection of all the buildings. The engineer should evaluate whether the existing buried pipe

connection to the Farmhouse is of sufficient diameter to also serve the Wood Shop across the road. If so, the easiest and least expensive way to run pipe to the Wood Shop would be from the basement of the Farmhouse on the side toward the road. If the existing pipe does not have enough capacity, then a separate pair of supply and return pipes for the Wood Shop would need to be installed from the Boiler House when it is connected, through the basement of the Farmhouse (alternatively, the pipe could be under the driveway on the side of the Farmhouse). The engineer should also determine whether or not the existing hot water distribution pump is of sufficient capacity to handle the full two-phase load.

The engineer would also be responsible for sizing the supply and return pipes to serve the Cattle Barn and Legion Hall, as well as the proposed dormitory. In this way there will be a single coherent design for the entire piping and pumping system established at the outset of the project. The pellet boiler installer will be responsible for the controls that operate the boilers. When each remaining building is connected to the district system, an engineer or a design/build mechanical installer will need to carefully integrate the heating controls of the individual buildings with those of the pellet boiler system.

Backup Heating Systems

We assume that the oil boiler in the Farmhouse will provide backup for that building, and that the propane space heaters in the Wood Shop will provide backup there. As the heating systems for the Cattle Barn and Wood Shop are designed, it will be necessary to decide whether to have backup fossil boilers in those buildings or to install an oil or propane boiler (with fuel storage tank) in the Boiler House.

Domestic Hot Water (DHW)

At the outset any significant DHW loads (residential use, showering, domestic and commercial kitchen, etc) should be identified. The engineer or design/build contractor should provide guidance as to how these loads will be served by the pellet boiler system. For incidental DHW in irregularly occupied spaces (such as the Legion Hall), it is unlikely to be cost effective to connect these loads to the mini-DH system. Small electric water heaters are likely a better choice.

Diagnosing the Cordwood Boiler Heat Loss

As discussed above, the amount of wood that is being used by the current cordwood boiler (20-23 cords per year) is troubling. If the problem is somehow related to the GARN itself, and the way it is being fired, then removing it and installing an automated pellet boiler system will solve the problem.

However, there are some other possible explanations that would require additional attention. How well insulated and airtight is the Boiler House? If it is uninsulated and has lots of avenues for cold air to get in, then it will bleed a significant amount of heat and require much more fuel than if it was located in an energy efficient building. Likewise, the pellet boilers should not be installed in a poorly insulated, drafty space. Further, it makes sense to install an inexpensive fan-coil hydronic heater (a "Modine") on a thermostatic control in the Boiler House, so that heat and temperature in this space will be controlled rather than uncontrolled.

Another explanation for the excessive use of cordwood is that there could be a significant loss of heat somewhere outside the Boiler House. It seems unlikely that the buried pipes going to the Farmhouse (supply and return) would be the culprit if they were moderately well insulated. Was insulation placed under the slab of the Farmhouse section with radiant floor heating? How much insulation, of what type, was used under the slab? If it was uninsulated or poorly insulated, a huge amount of heat could be lost to the soil under the slab (probably visible as meltback of snow around the exposed slab perimeter). These problems of lost heat are difficult to diagnose, and may require metering to measure how much heat is actually leaving the Boiler House. Note that the cost of a meter is included in the project budget to be used for verifying biomass heat output to qualify for Thermal RECs payments.

One Pellet Boiler or Two?

It is tempting to install a single pellet boiler at the outset of the project sized to cover the heat load of both the first buildings that will be connected and the heat load of future additions to the system. However, we advise against this because of the uncertainties about the actual heat load and the questions, discussed above, about why the GARN system uses so much wood, we think that installing one boiler at the outset and a second boiler in a few years makes much more sense. That way, all questions about the heat load of current and future buildings can be answered before the second boiler is added to the project.

XVII. Financing Opportunities

Purchase and installation of a wood biomass heating system represents a significant capital cost. The following are potential financial assistance for this expenditure:

A. State

NH Public Utility Commission Competitive Grants – Various competitive grants for wood biomass thermal systems have been available in recent years. Check at http://www.puc.state.nh.us/sustainable%20Energy/RFPs.htm to see current available as these opportunities are changing regularly. In 2014, an RFP due in September allowed for grants of at least $150,000 for qualified projects.

NH Public Utilities Commission Commercial Wood Pellet Boiler Rebate Program – This program offers a rebate payment of 30% of the heating appliance(s) and installation cost, up to a maximum of $50,000, for investments in non-residential bulk-fuel fed wood pellet boilers and furnaces of 2.5 million BTU or less, that become operational, serving designed intent and installer-certified on or after December 18, 2013. Additionally, a rebate of 30% up to $5,000 is available for thermal storage tanks and related components. This program is open to businesses, non-profit organizations, educational institutions, governmental or municipal entities, or multi-family residences of 4 units or greater, that do not qualify for a rebate under the residential wood pellet rebate program. For complete program details, please refer to http://www.puc.state.nh.us/sustainable%20Energy/RenewableEnergyRebates-CI-BFWP.html or contact Barbara Bernstein, barbara.bernstein@puc.nh.gov.

NH Thermal Renewable Energy Certificates – NH has a first-in-the-nation law that allows for generation of Renewable Energy Certificates from wood-fueled thermal projects. For more information go to: http://www.puc.state.nh.us/sustainable%20Energy/Class%20I%20Thermal%20Renewable%20Energy.html.

New Hampshire has adopted ***Property-Assessed Clean Energy (PACE)*** financing programs, whereby municipalities provide financing to commercial entities within their community. Loans are paid back by surcharges on property tax bills. PACE provides tremendous promise for commercial financing of energy efficiency and renewable energy projects. For more information on PACE in New Hampshire contact the Jordan Institute at 603-226-1009.

B. Federal

Federal tax incentives are non-existent for biomass heating projects. Biomass thermal technology does not qualify under the federal section 48 business/industrial renewable energy investment tax credit that provides up to 30% tax credit toward solar, geothermal and wind energy development.

The U.S. Department of Agriculture administers a small number of programs that provide incentives for renewable energy, including the ***Rural Energy for America Program (REAP)***. These are 25% capital grants, up to $500,000, if eligible. Whether Sanborn Mills Farm would qualify for an approximately $55,000 REAP grant will need to be explored. On one hand Sanborn Mills Far is a working farm (so it should qualify). On the other hand it is a non-profit (which would generally not be qualified). The REAP application process is detailed and daunting.

No other federal incentives are available at this time**.**

C. Other/Private

The recently-established ***New Hampshire T-RECs Enterprise Fund*** can provide a source of up-front capital for some biomass projects that qualify for Thermal Renewable Energy Credits (T-RECs). The Credits themselves are a source of revenue for a qualifying project. The Enterprise Fund essentially provides capital for construction in return for ownership of the T-RECs for a defined period of time through pre-purchase of future T-RECs that will be generated by burning wood fuel. The up-side is that some construction capital is made available prior to construction. The down-side is that the owner will not get full benefit of the revenue from the sale of T-RECs. Generally, the Enterprise Fund is set up to assist larger projects. If interested, Sanborn Mills Farm would need to contact the Enterprise Fund to explore participation. See www.t-recsfund.org .

Energy Performance Contracting is a creative approach to financing energy investments whereby a 3rd party energy services contractor (ESCO) provides the upfront capital, which is then paid off from annual energy costs savings over a period of years. During this time the entity is guaranteed a discounted energy cost relative to their current costs. ESCO's have high overhead costs and choose their projects carefully for large cash flows and very attractive returns on investment, which generally means very large projects. It is unlikely that an ESCO would be interested in a project of the size of the Sanborn Mills project.

A ***conventional bank loan*** might be another way for Sanborn Mills Farm to finance a biomass heating project, if financing is required.

Other Information Resources Available

Further listing of additional resources can be found on the NHWEC web site:

http://www.nhwoodenergycouncil.org/other-helpful-links.html

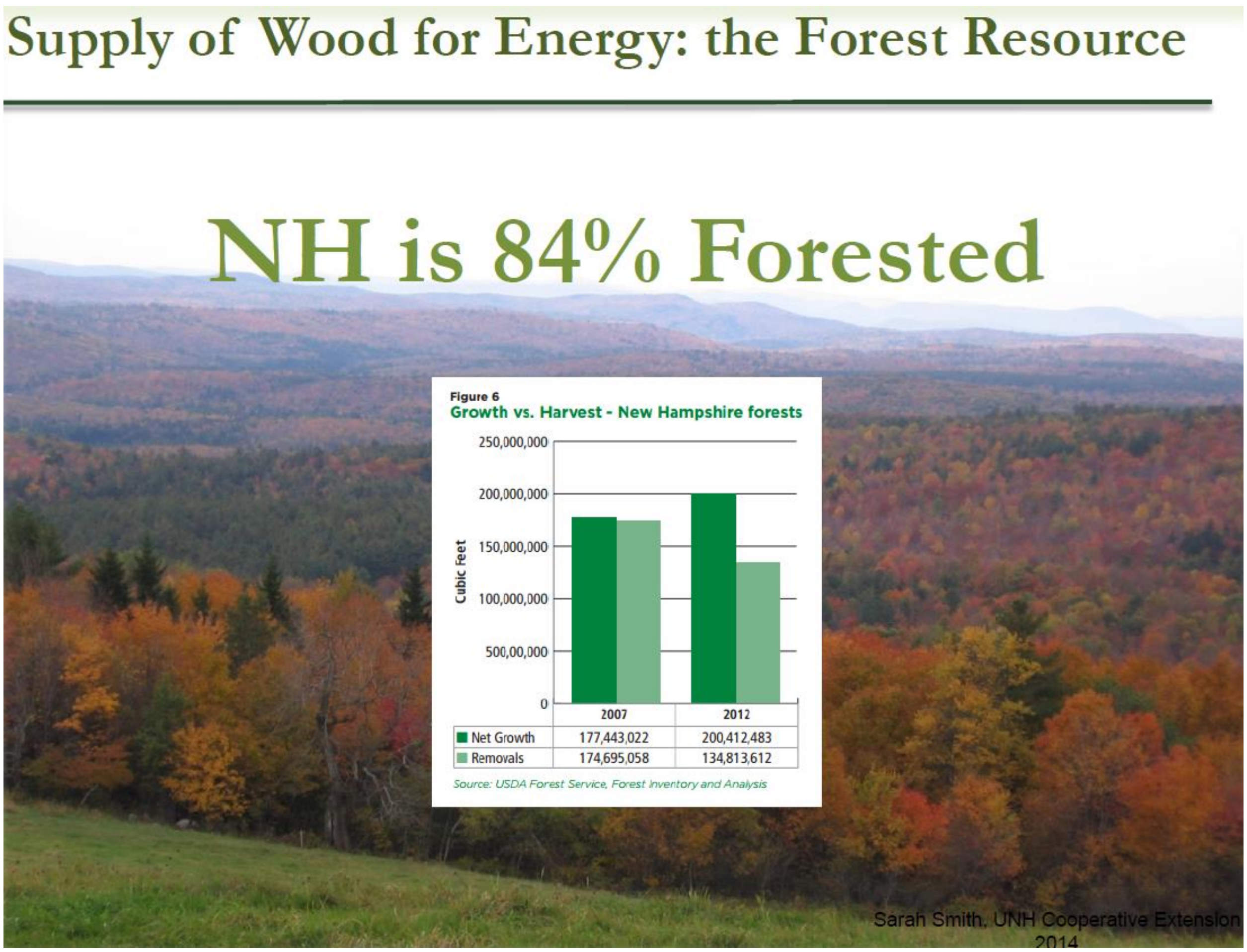
Ash & waste management:
http://des.nh.gov/organization/commissioner/legal/rulemaking/index.htm

References

- Line-item cost estimates for all four approaches were based on the experience of Community Biomass Systems in both feasibility studies and project implementation.
- Pellet boiler system preliminary pricing estimates were provided by Froling Energy Systems of Peterborough, New Hampshire.
- Buffer tank sizing for the mini-DH system was based on recommendations by Froling Energy.
- The methodology for estimating heat load of buildings based on historical fossil fuel consumption was developed by the Biomass Energy Resource Center (BERC), and is similar to that used by the US Forest Service Wood Education and Resource Center (WERC).
- Site maps in this report were prepared by Pekin Branch Forestry.

Appendix A - Wood Fuel Availability and Forest Sustainability Issues

New Hampshire is the second most forested state in the U.S. in terms of percentage of land area (Maine is first). New Hampshire's forests are also adding wood volume every year because wood growth on our trees exceeds the amount harvested for various products plus the volume of trees dying each year. Our forests are in good shape and can easily handle additional wood use for thermal purposes.



Where Does the Wood Come From for Heating?

Wood used to make wood pellets and chips is low-grade material, harvested during forestry operations or produced as a by-product of lumber and wood product manufacturing (e.g., sawdust). Manufacturers of wood pellets often seek sawdust, shavings and other residue from lumber and wood product manufacturing because it is already debarked, sized, and uniform in species. Wood also comes from low-grade wood harvested during logging operations – the relatively low value that wood chip users and wood pellet manufacturers can pay for material means that wood chip use and wood pellet manufacturing does not compete with lumber manufacturing and other higher value uses of wood that is so important to the region's forest economy. In fact, these uses are complimentary to higher value wood uses.

In New England, we are growing significantly more wood than is being used for a range of products, including paper manufacturing, biomass energy, home heating, lumber and other wood products. On private forestland in New England, we currently grow 1.6 times the amount of wood harvested.

Where Are Wood Pellets Made?

Wood pellets are made at dedicated wood pellet mills, which are located to access a sustainable and reliable supply of low-grade wood to use as a feedstock. There is currently one wood pellet manufacturing facility located in New Hampshire, New England Wood Pellet (Jaffrey). The New Hampshire market is also supplied by wood pellet manufacturers in nearby Vermont, Maine, Quebec and New York.

The purchase of wood pellets manufactured in the region helps support the forest economy, keeps dollars spent on heating circulating in New England, and creates jobs for your neighbors in the harvesting, manufacturing and delivery of a locally produced fuel.

Appendix B

Wood Pellet/Chip Boiler Vendors in Northeast U.S.

P – pellet
C – chip
1 – Residential
2 – Commercial/Institutional
3 – Industrial

Maine Energy Systems P - 1, 2
Dr. Harry "Dutch" Dresser
Dutch@maineenergysystems.com
www.maineenergysystems.com
8 Airport Road, P.O. Box 547
Bethel, Maine 04217
Office: 207.824.NRGY (6749)

Pellergy LLC P - 1, 2
Andy Boutin
andy.boutin@pellergy.com
www.pellergy.com
104 East State Street
Montpelier, VT 05602
802-477-3224

Froling Energy Systems P/C - 1, 2, 3
Mark Froling
mark@frolingllc.com
www.frolingenergy.com
19 Grove Street
PO Box 178
Peterborough, NH 03458
603-924-1001

The Sandri Companies P - 1, 2
Jake Goodyear
jgoodyear@sandri.com
http://www.sandri.com/renewable-energy/
400 Chapman Street
Greenfield, MA 01301
413-223-1115
800-628-1900

Tarm Biomass P/C - 1, 2
Scott Nichols
scott@tarmusa.com
www.woodboilers.com

WeBiomass Inc. P – 1,2
16 Washington St.
Rutland, VT 05701
802-772-7563
info@webiomass.com

Interphase Energy
4 Britton Lane
P.O. Box 285
Lyme, NH 03768
800.782.9927

Lyme Green Heat P - 1, 2
Morton Bailey
morton@lymegreenheat.com
www.lymegreenheat.com
302 Orford Road
Lyme, NH 03768
603-353-9404

Bioenergy Project Partners P/C - 2, 3
David Dungate
New York-based
Toll Free: 888-583-5852
Email: info@bioenergybox.com
Web: www.bioenergybox.com

Woodmaster P/C - 1, 2, 3
Gust Freeman
Bowman Stoves
www.woodmaster.com/index.php
1727 US Highway 11
Castle Creek NY 13744
bowmanstoves@gmail.com
607-692-2595

Caluwe Inc./Windhager/Heizomat, P/C - 1, 2
Marc Caluwe
marc@hydro-to-heat-convertor.com
www.hydro-to-heat-convertor.com/pelletboilers.html
83 Alexander Road
Billerica MA 01821
781-308-8583

Viessmann P/C - 2, 3
Bede Wellford
wefb@viessmann.com
www.viessmann.ca
(207) 212-2052

Troy Boiler Works/Evotherm P - 1, 2
Lou Okonski
lokonski@troyboilerworks.com
www.troyboilerworks.coml
2800 7th Ave.
Troy NY 12180
518-274-2650

Thayer Corporation P/C - 2, 3
Dan Thayer
info@thayercorp.com
www.thayercorp.com
1400 Hotel Road
Auburn, ME 04210
207-782-4197

Sunwood Systems P – 1, 2
David Frank
124 Fiddlers Green, Waitsfield, VT 05673
(802) 583-9300

Better World Energy/Messersmith C – 2, 3
Barry Bernstein
1237 Bliss Road
Marshfield VT 05658
802 456 8843 o
802-477-3993 c
bbearvt@myfairpoint.net

Gazogen
Carl Bielenberg
Tel 802-522-8584
GazogenVIP@gmail.com
330 Industrial Drive
P.O. Box 346
Bradford, VT 05033

AFS Energy Systems C – 2, 3
418 Oak Street
P.O. Box 170
Lemoyne, PA 17043
717.763.0286
info@afsenergy.com

Disclaimer: the NH Wood Energy Council provides this list as a guide and not a set of recommendations. NH WEC acknowledges that this is an incomplete list of vendors and encourages those not on the list to contact us – www.nhwoodenergycouncil.org

Appendix C

Life-Cycle Cost Analysis Summary

Appendix D

Aerial Photo

Mini-District Heating Layout

LIFE CYCLE COST ANALYSIS
Biomass Energy System Replacing Fossil Fuel System — **SITE:** **Sanborn Mills Farm, Loudon, New Hampshire**

Analysis Date: May 2015

Central Wood Pellet DH System to Replace Oil in 4 Buildings
Boiler Capacity: **500,000 Btu/hr peak output - 2 boilers, 2 phases**
Biomass Fuel: **Wood Pellets**

Assumptions

Project cost	$224,450
Grants & Rebates	$50,000
Owner equity	$174,450
Owner loan	$0
Interest rate	
Finance term (years)	
Current fuel	Oil
Current fuel units	gal
Current fuel price per unit	$3.00
Annual units, current fuel	7,700
Seasonal efficiency, oil	73%
Btu content (MMBTU/gal)	0.138
Wood price, Yr 1 (per ton)	$230
Wood fraction (ann. heat load)	95%
Seasonal efficiency, wood	80%
Moisture content, wet basis	8%
Btu content (MMBTU/ton)	15.2
General annual inflation rate	2.5%
Discount rate (no genl inflation)	2.5%
Oil inflation (w/ genl inflation)	5.0%
Wood inflation (w/ genl inflation)	4.0%
Annual oil O&M, Yr 1	$500
Oil boiler replacement cost yr 15	$8,000
Ann. wood O&M cost, Yr 1	$200
Major repairs (annualized)	$500
Salvage value (% of original)	25%

Rebate:	PUC	$50,000	
Grant:	REAP	$0	
	Total	22%	of project cost

Calculated values

Annual oil cost, current	$23,100
Thermal load (MMBTU/yr)	770
Annual wood use, 100% wood (tons)	63
Wood/oil system:	
Annual wood use (tons)	60
Annual oil use (gal)	385
Annual wood cost	$13,861
Annual oil cost (backup)	$1,155
Total fuel cost, proposed	$15,016
Year 0 fuel cost savings	$8,084
Percent fuel cost savings, year 0	35%
Annual loan payment	$0

Financial Performance Summary

20 year net present value of savings		$49,133
Internal rate of return (IRR)		6.9%
Year 1 cash flow	positive	$12,712
Simple payback, years (excluding loan pmts)		17.7

Project Cost

Pellet boiler system - 2 boilers		$110,000
Pellet silo -in system cost		$0
Buffer tank		$10,000
Building - existing		$0
Mechanical/piping (in boiler room)		$15,000
Electrical (in boiler room) - in system cost		$0
Utilities to new boiler plant		$0
Buried piping into 3 buildings		$45,000
Connections to boiler rooms in buildings		$7,500
Controls interface with existing controls		$10,000
Btu meter (for REC qualification)		$2,000
Total capital		$199,500
Contingency	10%	$19,950
Design: engineering		$5,000
Project management		$0
Permitting (allowance)		$0
Total		**$224,450**

REC Revenue

Thermal		214	MWH/yr	
Electrical		0	MWH/yr	
Yrs 1-3	$	20.00	per MWH	$4,290 /yr
Yrs 4-6	$	15.00	per MWH	$3,217 /yr

FINANCING

Year	Anuual Loan Payment
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
Total Payments:	$0
Interest Paid:	$0

Community Biomass Systems
INNOVATION FOR A NEW CENTURY

Sanborn Mills Farm
Loudon, NH

Sanborn Mills Farm
Wood-Fired Mini-District Heating

Community Biomass Systems
INNOVATION FOR A NEW CENTURY