Preliminary Feasibility Report

Report Prepared for NH WEC by:

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Hollis Town Schools Cluster

Wood Heating Study

Hollis, New Hampshire

Date of Site Visit: January 15, 2015

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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 the Town of Hollis to determine if switching from fossil fuel to wood fuel for heating at the three buildings of the Hollis Town Schools Cluster is feasible and warranted. Timothy Maker of Community Biomass Systems has been hired by NH WEC to complete this "Coaching" assignment and is the author of this report.

This study looks at three buildings – Hollis Primary School, Hollis Upper Elementary School and the SAU 41 Administration Building – to determine the cost-effectiveness of converting each to a wood heating system and to compare with connecting all three in a mini-district heating cluster served by a central wood heating plant.

- The 46,918 square foot **Hollis Primary School** is heated with oil, approximately 19,000 gallons per year, from two boiler rooms, one with a single boiler and one with two boilers, at a cost of approximately $57,000 annually.
- The 96,528 square foot **Hollis Upper Elementary School** is heated with oil, approximately 23,000 gallons per year, from a single boiler room with ten small modular oil boilers, at a cost of approximately $68,000 annually.
- The 8,096 square foot **SAU 41 Administration Building** is heated with a single high-performance oil boiler in the basement, using approximately 1,600 gallons of oil annually at a cost of approximately $4,800.


Hollis Primary

Hollis Upper Elementary


SAU 41 Administration

Based on an on-site review of the facility on January 15, 2015, we determined that:

1. *All three individual-building projects, all based on pellet boiler systems, are sufficiently well understood that they are ready to move to design and implementation. The two schools, if pursued independently, require decision-making around how to handle design and implementation. The SAU 41 Building project could be implemented immediately on a design/build basis.*

2. *The district heating system, which ties together all three buildings to a single central woodchip plant located between the two schools, has better economics than any of the three individual system approaches, as well as better than doing all three of those projects as one combined project that creates three new pellet boiler plants.*

3. *Overall decision making is required at this point, considering the follow courses of action:*

    - Pursue one or more of the individual building projects independently
    - Pursue the creation of a new woodchip-fueled district heating system (which would also involve consideration of the future creation of a larger district system to serve other public and private buildings in Hollis).

A heat load calculation was made based on the existing fossil fuel use at each of the three buildings:

Primary School	1.28 MMBH (million Btu/hour)
Upper Elementary School	1.54 MMBH
SAU 41 Administrative Building	113,000 Btu/hour

It has been determined that the heat load for each individual building could most cost-effectively be met with a pellet boiler system. If the three buildings were clustered into a district heat mini-system, an approximately 3.0 MMBH woodchip boiler would be required to meet the full heat load. However, to qualify for Thermal Renewable Energy Credits, we recommend installing a 2.3 MMBH woodchip boiler and using the existing heating plants for peak load coverage (thus avoiding the cost of an Electrostatic Precipitator, or ESP, which would be needed to meet the emissions standards to qualify for credits for the larger 3.0 MMBH system). See page 19.

For the single-building pellet boiler systems, a thermal storage tank might or might not be recommended, depending on the make of pellet boilers used and the design of the system. For the woodchip district heating system, a thermal storage tank (aka "buffer tank") is recommended as part of the system. As a conservative approach, buffer tanks were sized (using the USDA Forest Service recommended methodology), costed out and added to the budget for each of the four projects.

A Life-Cycle Cost Analysis (LCCA) has determined the following financial performance for each of the three buildings and the district heating system, as summarized below.

Life-Cycle Cost Analysis Summary

	Option 1	Option 2	Option 3	Combined 1, 2 & 3	Option 4
	Pellet Boiler for Primary School	Pellet Boiler for Elementary School	Pellet Boiler for SAU 41 Building	Sum of Metrics for 3 Individual Projects	Woodchip District Heat System for 3-Building Cluster
Project Cost	$530,000	$600,000	$39,000	$1.2 million	$1.5 million
Loan Amount	$480,000	$550,000	$27,000	$1.1 million	$1.1 million
Yr 1 Cash Flow	$3,500	$2,600	-$1,000	$5,100	$11,800
Yr 15 Cumulative Cash Flow	$200,000	$225,000	$25,000	$450,000	$622,000
20-year Net Present Value	$110,000	$135,000	$10,500	$225,000	$410,000
Internal Rate of Return	6.1%	6.2%	6.7%	6.3%	6.4%

Financing options available for the proposed project(s) include:

- NH Public Utilities Commission (PUC) Commercial Wood Pellet Boiler Rebate Program
- NH PUC Commercial/Industrial Grant Program (Renewable Energy Fund)

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 the Town of Hollis and the Hollis Energy Committee, the Hollis Town Schools Cluster was selected by the Council as a site for this preliminary feasibility study conducted to assess the potential to convert from fossil-fuel based heating systems to one or more wood biomass based heating systems.

"Staged" or "Cascaded" Pellet Boilers

Outside Pellet Silo
Harris Center, Hancock, NH

Small Pellet Boilers with Buffer Tank

III. Analysis Assumptions

Approaches to wood heating for the buildings of the cluster were studied using Life-Cycle Cost analysis (see below for descriptions of the four options). The assumptions used for the oil-to-pellet and oil to woodchip analysis are:

Oil price		$3.00/gal
Wood pellet price		$230/ton
Woodchip price		$ 50/ton
Pellet system total cost		
	Primary	$530,000
	Upper Elementary	$600,000
	SAU 41	$ 39,000
Woodchip district heating system (total system capital cost)		$1.5 million
System sizing	Primary School pellet	1.3 MMBH
	Elementary School pellet	1.6 MMBH
	SAU 41 pellet	120,000 Btu/hr
	DH cluster woodchip	2.3 MMBHs
Loan interest rate		5%
Loan term	School and DH systems	20 years
	SAU 41 system	10 years
Seasonal combustion efficiency	Oil (varies by building)	70-78%
	Wood pellet	80%
	Woodchip	75%
Grant assistance potential		
NH PUC biomass rebate	Each school	$50,000
	SAU 41	$12,000
NH PUC grant	DH Cluster	$350,000
USDA REAP grant	ineligible	(all sites are non-profit)

Other assumptions and calculated values can be found in the LCC summary sheet in the Appendix. These sheets include a preliminary line-item project budget for each of the options.

Description of Options

Option 1 Pellet Boiler System for Primary School

This option includes building a new pellet boiler room attached to the back of the school, against an existing building wall, since there is not space inside or connected to the two existing boiler rooms. The chosen location for the new plant is relatively close to the "outside boiler room," which is where the pipe loop from the proposed pellet boiler room would terminate. The pellet project would include supply and return pipes connecting the two existing boiler rooms.

The pellet boiler system modeled in this report includes multiple "staged" or "cascaded" pellet boilers. Depending on the make of pellet boiler selected, there may also be a thermal storage or buffer tank in the new boiler room. Pellet storage could be inside the new pellet boiler room or in an outdoor free-standing pellet silo. The existing oil boilers would be retained as backup.

Primary School – Proposed Pellet Boiler Room Location
Open wall on left
(also showing red door to "outside boiler room")

Option II Pellet Boiler System for Upper Elementary School

This option includes building a new stand-alone pellet boiler plant in back of the school, since there is no room inside the school and no outside space adjacent to the existing oil boiler room. The new plant building would include multiple "staged" or "cascaded" pellet boilers. Depending on the make of pellet boiler selected, there may also be a thermal storage or buffer tank in the new boiler room. Pellet storage could be inside the new pellet boiler plant building or in an outdoor free-standing pellet silo next to it. Buried, insulated hot water supply and return pipes would connect the new plant with the existing oil boiler room. Cost estimates assume the use of buried pre-insulated plastic PEX piping for the connection. The existing oil boilers would be retained as backup.

Proposed Pellet Boiler Plant Location

Elementary School Oil Boiler Room & Pipe Entry from Proposed Pellet Plant

Option III Pellet Boiler for SAU 41 Administration Building

This option includes installing a single pellet boiler, and possibly a buffer tank, in the basement of the building, next to the existing oil boiler, which would be retained for backup. Pellet storage would likely be in the basement, although a free-standing outside pellet silo could also be used. Because the building is tall and the availability and usability of any existing chimney are not known, venting the new pellet boiler may be somewhat challenging, perhaps necessitating a tall stack up the outside of the building to roof level.

Modern Pellet Boiler

Option IV Woodchip District Heat System for 3-Building Cluster

This option includes the construction of a new woodchip heating plant located on land owned by the SAU 41 School District between the Primary and Upper Elementary Schools. The location we found most promising is in a wooded area just in back of the playground of the Elementary School, accessed by Drury Lane (which goes to the Elementary School). The new boiler plant would produce woodchip-fired hot water which would circulate via buried pre-insulated PEX piping to the Primary School in one direction and to the Elementary School in the other direction. The Primary School loop would connect under the pavement in back of the school and into the “inside boiler room.” The Elementary School loop would come out to Drury Lane and then follow along the buried municipal domestic water line right-of-way toward the Elementary School. It would be buried under the sidewalk or the driveway in front of the school, extending to the school’s boiler room. The SAU 41 Building would be accessed by smaller diameter buried PEX pipe from the closest part of the Primary School, running in the right-of-way of Silver Lake Road (to simplify the crossing of a small stream) and entering the basement of the SAU 41 Building on the corner of the building closest to Silver Lake Road, next to the oil

Proposed DH Plant Location – Behind Primary School

Proposed Pipe Route To Upper Elementary School

fill pipe.

The boiler plant building would include a boiler room and a below-ground chip storage bin. The boiler room would include a single woodchip boiler with a multi-cyclone for particulate emission control, and a free-standing insulated stack. A highly-insulated buffer tank would be installed either inside the boiler room or directly outside. The boiler room would also house all required ancillary mechanical equipment and the controls for both the boiler system itself and also for its connection to the automated controls systems in the two schools.

3 MMBH Woodchip Boiler Plant –
Same Capacity as Proposed for Hollis Schools Cluster
Architect's Model – Goddard College Wood Heating System

As discussed below, there are different options for the ownership and operation of the district heating system and its boiler plant – including ownership by the school district – which need to be carefully considered in the context of a district heating system that might later be expanded to serve other public and private buildings in town.

Outside Wall of Primary School "Indoor Boiler Room"
Proposed Entry Location for Pipes from DH Plant

IV. Existing Facility and Heating System(s) Description and Review

The two schools and the SAU 41 Building are publicly owned buildings. The two schools are fairly typical for their age. The SAU 41 Building is a converted, modernized farm house.

The buildings were built in the following years, according to energy audits carried out for the Town of Hollis by Acadia Engineers and Constructors in 2012:

Primary School	1952, with additions in 1967 and 1978
Upper Elementary School	1980, with additions in 1997
SAU 41 Administrative Building	1900, renovated in the 1970s

The ***Primary School***, located on Silver Lake Road (NH Route 122) north of the village area of Hollis, is of slab-on-grade construction with concrete masonry unit (CMU) walls, having R-values between

3.6 and 14.0 depending on date of construction. The flat roof system, according to the audit report, has R-values of 8.9 and 20.3 in the two major sections. The building has two oil boiler rooms, referred to as the “outside boiler room” (accessed via a door on the outside of the building) and the “inside boiler room” (accessed via an inside door off the one of the main entrance hallways at the rear of the school). The “outside boiler room” has two equal-sized oil boilers, one new and one old, and very little spare space. The “inside boiler room” has one older oil boiler, and is somewhat more spacious than the other boiler room. The two boiler rooms heat different parts of the school building.

The ***Elementary School***, located on Drury Lane, behind the Primary School, is of slab-on-grade construction with concrete masonry unit (CMU) walls, having R-values between 9.0 and 16.40 depending on date of construction. The flat roof system, according to the audit report, has R-values of 13.5 and 16.2 in the two major sections. The school has a single, small, extremely crowded boiler room with 10 modular oil boilers, of two different makes and vintages.

The ***SAU 41Building***, located on Silver Lake Road just north of the Primary School, has a stone foundation and frame walls with fiberglass batt insulation for a composite R-value of 11.9. The attic has a combination of batt and blown cellulose insulation with an R-value, according to the energy audit, of 14.4. The modern, efficient hot water boiler is located in the spacious, open basement area under the main part of the building.

The two schools have buried oil tanks, located under the driveway in the back of the Primary School and adjacent to the boiler room at the Elementary School. The SAU 41 Building has oil tanks in the basement. Volumes and ages of the oil tanks are unknown.

The three school boiler rooms have masonry chimneys, adequate for use with the oil boilers but not appropriate for a wood burning appliance. The SAU 41 Building has a brick chimney, also insufficient for pellet boiler venting, although there may be a second chimney that could be used.

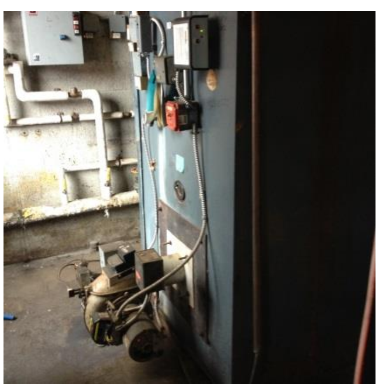
Table 1 Summary of Existing Heating Systems – 3 Buildings

Existing Thermal System in Hollis Primary School	
Distribution System Type	hot water hydronic with air handlers
Domestic Hot Water	1 electric water heater & 1 oil-fired water heater – minimal DHW load
Thermal System Type and Manufacturer	2 Weil McLain oil boilers (one is one year old and one 20 years old) and 1 HB Smith oil boiler (20 years old), in 2 boiler rooms
Nameplate Capacity	1.58 MMBH, 1.58 MMBH and 1.48 MMBH = 4.64 MMBH total
Type of Fuel Used	#2 heating oil
System Efficiency	Unknown
System Emissions (g PM2.5/hr)	Unknown
Warranty End Date	1 new, warranty ends at end of 2015, 2 old (beyond warranty)
Building Annual Heating Fuel Consumption	approximately 19,000 gallons/year

Existing Thermal System in Hollis Upper Elementary School	
Distribution System Type	hot water hydronic with air handlers
Domestic Hot Water	3 electric water heaters – minimal DHW load
Thermal System Type and Manufacturer	6 Hydro-Therm (35 years old) and 4 Weil-McLain oil boilers (18 years old), in one boiler room
Nameplate Capacity	6 at 263,000 Btu/hr each, 4 at 184,000 Btu/hr each; total 2.32 MMBH
Type of Fuel Used	#2 heating oil
System Efficiency	Unknown
System Emissions (g PM2.5/hr)	Unknown
Warranty End Date	past warranty
Building Annual Heating Fuel Consumption	approximately 23,000 gallons/year

Existing Thermal System in SAU 41 Administrative Building	
Distribution System Type	hot water hydronic, with cast iron radiators and baseboard hot water radiation
Domestic Hot Water	indirect tank water heater off the oil boiler
Thermal System Type and Manufacturer	Buderus oil boiler, 2010
Nameplate Capacity	180,000 Btu/hr
Type of Fuel Used	#2 heating oil
System Efficiency	Unknown
System Emissions (g PM2.5/hr)	Unknown
Warranty End Date	past warranty
Building Annual Heating Fuel Consumption	approximately 1,600 gallons/year

Figure 3 Existing heating system



Old Boiler

Primary School "Outside Boiler Room"

New Boiler

Primary School "Inside Boiler Room"

Elementary School Staged Oil Boilers

V. Fossil Fuel Use Assumptions including inflation

Data was available on fossil fuel use at the facility for the years 2010/2011 and 2011/2012, from the 2012 audit reports' monthly usage data for each of the buildings. (Note: the oil consumption figures in the NH WEC application were significantly lower than those in the audit.) We elected to use the higher figures as a conservative approach, since our sizing methodology was based on annual gallons and also because the 2013/2014 year was a much colder winter than those of the data years. Table 2 summarizes the fossil fuel use.

Table 2 Annual Oil Usage at 3 Buildings for 2010-2012

Year and building	Fuel Oil Usage (Gallons)	Average Cost/Gallon	Total Expenditures
Primary School			
Year 2010/2011	18,027	$2.10	$37,853
Year 2011/2012	19,720	$2.66	$52,403
Average	18,874		
Upper Elementary School			
Year 2010/2011	24,301	$2.12	$51,573
Year 2011/2012	20,957	$2.70	$56,488
Average	22,630		
SAU 41			
Year 2011/2012	1,620	$3.00	$4,864
3 Building Totals (averaged)	43,124		

Note that the 2014/2015 price for oil paid by the schools is $3.00 per gallon. At this current price the oil costs for the buildings are:

Primary School	$ 56,622
Upper Elementary School	$ 67,890
SAU 41	$ 4,864
Three-building Total	$129,372

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, although we feel that this is an overly conservative assumption, particularly for the long-term future, considering the rate of oil price escalation over the last 20 years.

NH Office of Energy and Planning data on residential fossil fuel prices as of mid-2014 are shown in Table 3.

Table 3 NH Office of State Planning heating fuel prices

Fuel Type	Price/Unit	Heat Content Per Unit (BTU)	Price Per Million BTU (See Note 1)
Fuel Oil (#2)	$3.547/Gallon	138,690	$25.57
Propane	$3.113/Gallon	91,333	$34.08
Kerosene	$4.149/Gallon	135,000	$30.73
Natural Gas 1st Tier (<100 Therms)	$0.848/Therm	100,000	$8.48
Natural Gas 2nd Tier (>100 Therms)	$0.800/Therm	100,000	$8.00
Wood (Bulk Delivered Pellets) (See Note 2)	$245.97/Ton	16,500,000	$14.91
Wood (Cord) (See Note 3)	$310/Cord	20,000,000	$15.15
Electricity	$0.1535/kwh	3,412	$45.00

At this writing (late February 2015) the site lists oil at $2.78/gal and pellets at $246/ton. In this report we used current oil pricing paid by the schools of $3.00/gal and the current delivered pellet price in southern New Hampshire of approximately $230/ton.

VI. Heat Load

To determine proper sizing for each of the proposed wood biomass heating systems 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 loads of the three buildings are:

Primary School	1.28 MMBH (million Btu/hr)
Upper Elementary School	1.54 MMBH
SAU 41	113,000 Btu/hr

Based on these numbers, we preliminarily recommend that the biomass boiler systems be sized at or just above the peak load, so that biomass will be able to provide all the heat at the coldest time of year. Generally, we recommend multi-boiler pellet systems where the staged boilers have a total combined capacity above the peak load of the facility.

Our preliminary sizing is:

Primary School (multi-boiler pellet)	1.3 MMBH
Upper Elementary School (multi-boiler pellet)	1.6 MMBH
SAU 41 Building (single pellet boiler)	120,000 Btu/hr
District Heat Cluster (single woodchip boiler)	3.0 MMBH

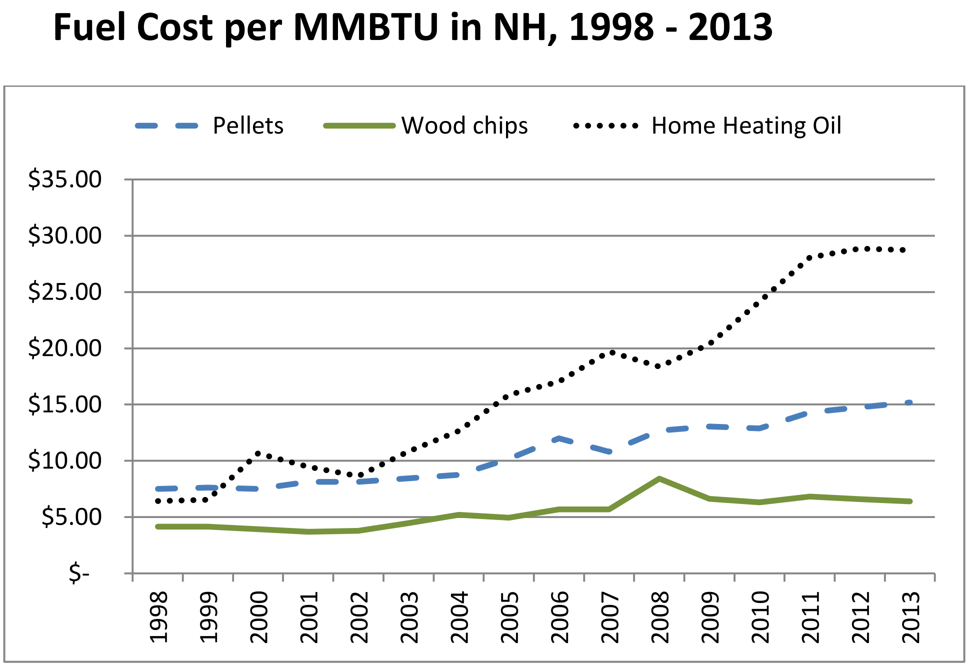
VII. Wood Pellet/Chip Cost Assumptions including inflation

The NH Office of Energy and Planning maintains an up-to-date data set on cost of heating fuels in New Hampshire. Table 3 above shows the table from mid-summer of 2014 and we have modified those data points as described above with more current data. This NH OEP source includes residential wood pellets and firewood (cordwood) but not wood chips. In New Hampshire, wood chip delivered prices (full tractor trailer loads) for community and institutional-scale thermal users in live-bottom trailers ranges from $45-55/green ton. A new semi-dry micro-woodchip product ("dry chips") for boilers that can handle this fuel is starting to become available. Dry chips currently cost $110-125 per ton in southern NH, between the price of pellets and conventional "green" woodchips and less expensive than wood pellets on a BTU basis.

For the purposes of this study, we are assuming a current baseline price for wood pellets delivered in bulk form at $230/ton and wood chips at $50/ton. There is enough historical data available on wood pellets to suggest an annual inflation rate for bulk wood pellets at 4%. We use the same figure for wood chips.

Figure 4 (next page) shows historical data for pricing of wood pellets and heating fuel oil.

Figure 4 NH prices for wood pellets and heating oil



Source: NH OEP, Innovative Natural Resource Solutions, LLC

VIII. Life cycle Cost Analysis

A Life Cycle Cost (LCC) analysis was conducted using Community Biomass Systems' proprietary copyrighted spreadsheet-based financial model. The results show the following:

- ***All four options have positive 20-year Net Present Value, meaning that all four projects are financially positive and financially worth carrying out.***
- ***The woodchip district heat option, which replaces the other three project concepts, is the most costly to build but has greater savings and better financial performance compared to the combination of doing the buildings as three separate pellet system projects, based on all the financial metrics: Net Present Value, Rate of Return, first year cash flow savings, and simple payback.***
- ***None of the four wood heat options have O&M costs (non-fuel operation and maintenance) more expensive than the oil systems they would replace.***

- ***The primary reason why the district system is the most attractive financially is because it replaces expensive oil with the most inexpensive of the fuels, green wood chips. The Year 1 fuel cost savings of the district system (including backup fuel cost) is 61%, compared to 30-40% for the pellet options.***

A Life Cycle Cost Analysis evaluates the economic performance of alternative choices or a particular choice. 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 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.

The analysis performed for the Hollis Town Schools Cluster compares different scenarios over a 20-year horizon and takes into consideration life cycle cost factors. The wood pellet and woodchip boiler life is expected to exceed this timeframe.

In the Community Biomass Systems Life Cycle Cost Analysis tool, each scenario was 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. The estimated cost of installing new oil boilers when the current oil boilers reach the end of their service lives was included in the analysis for the oil-to-biomass options – 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, the Year 1 cash flow savings simple payback period, showing net positive cash flows that 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 the various heating projects based on detailed engineering and vendor analysis.

However, we are confident that the primary findings of the analysis will hold true after more detailed analysis is carried out as the projects move to implementation. The capital costs used for the scenarios were provided as estimates by qualified vendors and from the long-term wood heating project experience of Community Biomass Systems. Should the Hollis Town Schools, the Town of Hollis and/or the SAU 41 School District decide to move forward with any of the biomass heating projects, we recommend that they engage one or more experienced professional biomass heating consultants or engineers to assist in project development and implementation and to develop more in-depth analysis and cost estimation as the basis for a competitive bid process involving multiple vendors of pellet or woodchip heating equipment. If the district heating option is selected, we recommend that the project management or design team include a specialist in district heat system design.

Table 4 Life Cycle Cost Analysis Summary

Project Alternative	**Option 1 Pellet Boiler for Primary School**	**Option 2 Pellet Boiler for Elementary School**	**Option 3 Pellet Boiler for SAU 41 Building**	**Option 4 Woodchip District Heat System for 3-Building Cluster**
Capital Cost of Boiler, Fuel Storage, Related Construction	$530,000	$600,000	$39,000	$1.5 million
Additional Capital Cost (if any)	(included above)	(included above)	(included above)	(included above)
Estimated TOTAL CAPITAL COST	$530,000	$600,000	$39,000	$1.5 million
Grant(s)*	$50,000	$50,000	$12,000	$350,000
Amount to be Financed	$480,000	$550,000	$27,000	$1.1 million
Sizing of Pellet/chip Boilers Relative to Base Thermal Load	100%	100%	100%	75%
Estimated fuel usage (including oil back-up)	153 tons pellets 945 gallons oil	171 tons pellets 1133 gallons oil	13 tons pellets 80 gallons oil	498 tons chips 8630 gallons oil
Reduction in heating oil consumption	**18,000 gallons oil**	**21,500 gallons oil**	**1,500 gallons oil**	**34,500 gallons oil**
Reduction in total fuel cost	**33%**	**37%**	**30%**	**61%**
Net Annual O&M cost savings over oil system	**$4,900**	**$600**	**$0**	**$100**
Internal Rate of Return	**6.1%**	**6.2%**	**6.7%**	**6.4%**

20-Year Net Present Value (@ 2.5% discount rate)	**$110,000**	**$135,000**	**$10,500**	**$410,000**
First year cash flow	**$3,500 positive**	**$2,600 positive**	**$1,000 negative**	**$11,800 positive**
Payback period – including grants/rebates	**15.0 years**	**15.3 years**	**16.0 years**	**14.8 years**
Finance payments - 5% interest	**$2,700 /month**	**$3,100/month**	**$300/month**	**$7,600/month**

* see grant options in section XVI.

It is assumed that wood pellet boilers have a service life of 20 years and woodchip boilers of 30 years.

District Heat Option – Qualifying for Thermal Renewable Energy Credits

The Life-Cycle Cost Analysis demonstrates the importance of Thermal Renewable Energy Credits (T-RECs) for the financial viability of the woodchip district heating option. In Year 1, without revenue from the sale of T-RECs, the Option 4 cash flow would go from positive $11,800 to negative $8,400. Woodchip systems with a fuel input rate of 3.0 MMBH or more have to meet stringent particulate matter emissions standards, while those below 3.0 MMBH do not. The preliminary sizing for the District Heat option is 3.0 MMBH output, which translates to approximately 3.8 MMBH input. For a system above this threshold an expensive emissions control device called an electrostatic precipitator (ESP), costing over $200,000, would be needed. For a system below the threshold, no additional emissions control would be required.

This analysis led us to the conclusion that the best financial performance would be derived from putting in a smaller, 2.3 MMBH woodchip boiler (output), to keep it under the size threshold and allowing the system to earn T-RECs without incurring the cost of an ESP . This is not an ideal conclusion, because the smaller woodchip system would require more backup oil use (and cost) in the existing boilers: while woodchips would supply an estimated 80% of the heat to the system, the backup oil would cost almost the same as the woodchips.

If the District Heat project moves to design, the questions of the optimal sizing and type of emissions control needs to be carefully studied.

Dry Wood Chip Fuel Option

We carried out a preliminary LCC analysis for using dry wood chips instead of pellets for Option I, at the Primary School, using price data from Froling Energy, who supplies both dry chip boiler systems and also produces dry chip fuel. That analysis showed significantly better financials for a dry chip system. The Net Present Value of the dry chip system was almost three times better than for pellets, and the Year 1 cash flow was $10,000 better.

A more detailed analysis of the dry chip option is beyond the scope of this study. However, when any biomass project option is developed, it makes sense to see if the SAU 41 School District and the Town of Hollis find that the risk associated with using a new fuel to the market, supplied by limited vendor options for this specialty fuel, outweighs the apparently better financial performance of a dry chip system.

IX. Operation and maintenance

Wood pellet and chip 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 wood pellet or chip boiler will take more time to maintain and operate than a traditional gas, oil, or electric heating system, although it may take less time and cost when a single biomass boiler plant replaces a number of fossil systems in multiple buildings . 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 and chip systems are listed on the following page.

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. For a woodchip system it requires about an hour daily.

One of the overlooked issues with pellet systems is the oversight of the volume of pellets in the storage silo. A silo with some type of gauge is 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. For a woodchip system, visually monitoring the level of chips in the bin is part of the regular maintenance routine.

X. Thermal Storage (TS)

A thermal storage tank (buffer tank) or tanks store heat from the boiler(s) in insulated hot water tank(s), from which hot water is then distributed as the building 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.

Some pellet boiler systems, depending on the design of the combustion chamber and the way fuel is fed to the combustion zone, require buffer tanks, while others do not. For woodchip systems, buffer tanks are routinely used in Europe but are still uncommon here.

XI. 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 systems likely to be appropriate for the situation in this facility has been estimated, for each of the three buildings and for the district heat cluster. Because the schools and district heat systems are more complex than a simple pellet system, it was necessary to build a project budget for each option, including fuel storage, boiler room or boiler house construction, engineering costs, etc. These project budgets will be found in the LCC analysis summaries in the Appendix.

It is important to note the significant difference in system cost depending on how a project is structured and implemented. Public schools uniformly use a ***"plan-and-spec"*** approach for biomass systems, in which the school hires an architect to select and manage the design team, as well as to manage the overall project including implementation. This is almost always done for biomass projects that are part of a school modernization or major construction project. If the project is only to convert to a biomass heating system, the school may select and contract with an engineering firm, which would then subcontract an architect to design the space in which the biomass system is housed. Either way, the professional design team takes complete design responsibility, producing plans, specifications and professional-stamped drawings showing exactly how the system will be constructed. A general contractor is hired to construct the entire project as designed by the professional team.

Another approach, common for pellet boiler systems in commercial facilities, is to use a ***"design/build"*** process in which a contractor is competitively selected to be responsible for both the design of the project and its implementation. One advantage of design/build is that there is single-source responsibility for all aspects of the project. If there are problems with the installation, the owner makes one phone call, rather than having to figure out which of the many contracted parties involved in the project is responsible for the problem. Another advantage of design/build is that it can be significantly less expensive, saving one quarter to one third of the project cost, compared to a plan-and-spec project.

In this report, we have analyzed the school pellet projects and the district heat cluster project under the assumption of the plan-and-spec approach – following conventional practice for public schools. For the smaller, simpler SAU 41 project we have assumed that a design/build approach will be used.

XII. Emissions and Permitting

The SAU 41 project will likely require small enough wood pellet boilers that it will not require special permitting in New Hampshire for installation. However, the schools and district heat options may require state environmental agency notification, state air permits, or local and state permits. No federal permits are required at this scale.

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 woodchip and pellet systems burn much cleaner than even 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.

XIII. Wood Ash

One by-product of burning wood pellets or wood chips 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 pellet system manufacturers, the container in which the ash is collected must periodically be emptied and disposed of manually. For woodchip systems of this size, ash needs to be manually shoveled out of the boiler every few days or weekly.

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, and similar for wood chips. A ton of wood pellets burned will produce approximately 20 pounds (about 2 gallons of volume).   A tractor trailer load of woodchips (25-30 tons) produces about a half trash can (40-50 lbs) of ash.

While many wood boiler operators use their ash as fertilizer for lawns, or farm 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, special rules are now in effect that exempt from the requirements of Env-Sw 1700 generators and brokers that distribute 500 tons per year or less of wood ash from the combustion of clean wood for agronomic use (spreading on ag lands). This 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 amount 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

- 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

XIV. Building Envelope and Energy Efficiency

The 2012 audit reports for these three buildings lay out the insulation levels, need for air sealing, efficiency of mechanical systems and other energy-related building details. The reports further lay out the kinds of retrofits required to address the deficiencies. The schools, working with the Hollis Energy Committee, are using the audit reports in annual budgeting, capital budgeting and to schedule energy retrofit work each year going forward.

XV. 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

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

Based on the site review and our analysis, our conclusions are summarized below:

- ***All three individual-building projects, all based on pellet boiler systems, are sufficiently well understood that they are ready to move to design and implementation. The two schools, if pursued independently, require decision-making around how to handle design and implementation, including whether to use pellets or dry woodchips. The SAU 41 Building project could be implemented immediately on a design/build basis.***

- ***The district heating system, which ties together all three buildings to a single central woodchip plant located between the two schools, has better economics than any of the three individual system approaches, as well as better than doing all three of those projects as one combined project that creates three new pellet boiler plants.***

- ***Overall decision making is required at this point, considering the follow courses of action:***
  - Pursue one or more of the individual building projects independently <u>OR</u>
  - Pursue the creation of a new woodchip-fueled district heating system (which would also involve consideration of the future creation of a larger district system to serve other public and private buildings in Hollis).

- ***If the woodchip-fueled district heating option is selected for implementation, the question of how best to qualify for Thermal Renewable Energy Credits should be carefully studied.***

- ***At the next step of project development, the "dry chip" option should be studied in some detail, as an alternative to either pellets or conventional "green" wood chips.***

XVI. 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. It is our understanding that REAP grants, which are available for agricultural and forestry enterprises and rural small businesses, are not available to non-profit and public-sector projects.

No other federal incentives are available at this time.

C. Other/Private

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. An ESCO approach is not realistic for these projects in Hollis, in our opinion, unless packaged as part of a much larger efficiency retrofit project for the whole school district.

The finance approach we have modelled in this analysis is that the majority of project costs for the two school projects would come from municipal bonding – as is common for school capital projects. The cost of the SAU 41 Administrative Building project is low enough that it could be done out of an annual budget appropriation.

Financing for the district heat cluster project is modelled here as a municipal project with bond financing. However, if there is interest in doing the DH project, the ownership options for the new central plant should be closely studied. If a new entity were created to own, operate and finance the district heat system, perhaps with an eye toward a larger town-wide district heating system in the future, that entity might be a private company or a co-op – both of which would have different financial structures that would include consideration of tax impacts and depreciation.

A conventional bank loan might be another way for the school district to finance one or more of the biomass heating projects. Conventional bank financing can be combined with municipal leasing. Municipal and school leasing can be attractive because it is generally not treated as debt and may not need voter approval.

If the School District has a capital fund for eventual removal of buried oil tanks, this fund might be re-purposed as a source of capital toward the cost of a biomass project.

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

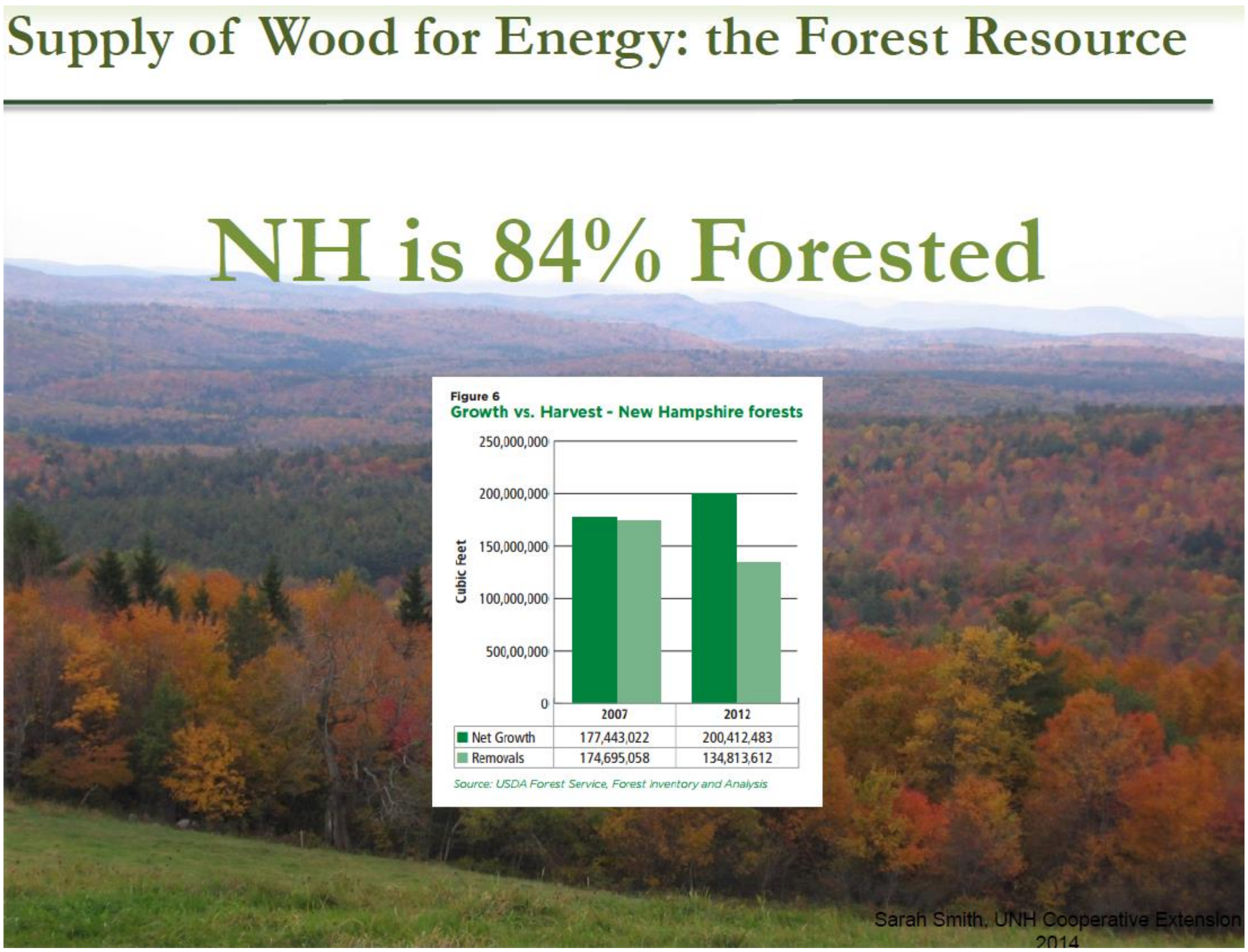
References

- Line-item cost estimates for all four approaches were based on the experience of Community Biomass Systems in both feasibility studies and project implementation.
- A number of line-item cost estimates for the district heat cluster were based on the Goddard College campus biomass district heat project, for which Community Biomass Systems is the contracted project manager. The Goddard woodchip boiler plant is the same size as the proposed district heat cluster woodchip plant for Hollis.
- Pellet boiler system preliminary pricing estimates and the price of "dry chips" were provided by Froling Energy Systems of Peterborough, New Hampshire.
- Ed Hinckley, Building Maintenance Supervisor, provided the O&M cost history for the existing oil systems at the Upper Elementary and Primary Schools.
- Data on the three existing buildings comes from site investigations and the 2012 energy audits performed by Acadia Engineers & Constructors.
- 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). The methodology for sizing buffer tanks is that which is recommended by WERC.
- Site maps in this report were prepared by Pekin Branch Forestry.
- Photograph of the Goddard College district heat woodchip boiler plant provided by the architect, Artichoke Design.

Appendices

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 Sheets

Option I – Hollis Primary School: Pellet Boiler System to Replace Oil

Option II – Hollis Upper Elementary School: Pellet Boiler System to Replace Oil

Option III – SAU 41 Administrative Building: Pellet Boiler System to Replace Oil

Option IV – Central Woodchip DH System to Replace Oil in 3 Buildings

LIFE CYCLE COST ANALYSIS
Biomass Energy System Replacing Fossil Fuel System **SITE:** **Hollis Primary School**
Hollis, New Hampshire

Analysis Date: January 2015

Pellet Boiler System to Replace Oil
Boiler Capacity: **1.3 million Btu/hr peak output**
Biomass Fuel: **Wood Pellets**
Emissions Control: **None**

Assumptions

Project cost	$529,025
Grants & Rebates	$50,000
School equity	$0
School borrowing	$479,025
Interest rate	3.0%
Finance term (years)	20
Current fuel	Oil
Current fuel units	gal
Current fuel price per unit	$3.00
Annual units, current fuel	18,900
Seasonal efficiency, oil	75%
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	$5,500
Boiler replacement cost , Yr 10	$40,000
Ann. wood O&M cost, Yr 1	$600
Major repairs (annualized)	$500
Salvage value (% of original)	25%

Rebate:	PUC	$50,000
Grant:	REAP	$0
	Total	9% of project cost

Calculated values

Annual oil cost, current	$56,700
Thermal load (MMBTU/yr)	1,956
Annual wood use, 100% wood (tons)	161
Wood/oil system:	
Annual wood use (tons)	153
Annual oil use (gal)	945
Annual wood cost	$35,196
Annual oil cost (backup)	$2,835
Total fuel cost, proposed	$38,031
Year 0 fuel cost savings	$18,669
Percent fuel cost savings, year 0	33%
Annual loan payment	$31,880
	$ 2,657 /mo

Financial Performance Summary

20 year net present value of savings		$112,232
Internal rate of return (IRR)		6.1%
Year 1 cash flow	positive	$3,478
Simple payback, years (excluding loan pmts)		15.0

Project Cost

Pellet boiler system (includes stack)		$350,000
Fuel storage (included in system cost)		$0
Buffer tank (included in system cost, if needed)		$0
Building		$20,000
Mechanical/piping (in new boiler room)		$20,000
Interconnection to existing heat distribution		$3,750
Interconnection between boiler rooms		$12,000
Controls interface		$10,000
Btu meter (for REC qualification)		$2,000
Electrical (in new boiler room)		$10,000
Utilities to new boiler room		$15,000
Total capital		$442,750
Contingency	10%	$44,275
Design: engineering & architectural		$30,000
Project management		$10,000
Permitting (allowance)		$2,000
Total		**$529,025**

REC Revenue

Thermal		545	MWH/yr	
Electrical		0	MWH/yr	
Yrs 1-3	$	20.00	per MWH	$10,893 /yr
Yrs 4-6	$	15.00	per MWH	$8,170 /yr

FINANCING

Year	Anuual Loan Payment
1	-$31,880
2	-$31,880
3	-$31,880
4	-$31,880
5	-$31,880
6	-$31,880
7	-$31,880
8	-$31,880
9	-$31,880
10	-$31,880
11	-$31,880
12	-$31,880
13	-$31,880
14	-$31,880
15	-$31,880
16	-$31,880
17	-$31,880
18	-$31,880
19	-$31,880
20	-$31,880
Total Payments:	-$637,599
Interest Paid:	$158,574

LIFE CYCLE COST ANALYSIS
Biomass Energy System Replacing Fossil Fuel System **SITE:** **Hollis Upper Elementary School**
Hollis, New Hampshire

Analysis Date: January 2015

Pellet Boiler System to Replace Oil
Boiler Capacity: **1.5 million Btu/hr Peak Output**
Biomass Fuel: **Wood Pellets**
Emissions Control: **None**

Assumptions

Project cost	$604,100
Grants & Rebates	$50,000
School equity	$0
School borrowing	$554,100
Interest rate	3.0%
Finance term (years)	20
Current fuel	Oil
Current fuel units	gal
Current fuel price per unit	$3.00
Annual units, current fuel	22,650
Seasonal efficiency, oil	70%
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	$1,500
Boiler replacement cost , Yr 10	$50,000
Ann. wood O&M cost, Yr 1	$600
Major repairs (annualized)	$500
Salvage value (% of original)	25%

Rebate:	PUC	$50,000	
Grant:	REAP	$0	
	Total	8%	of project cost

Calculated values

Annual oil cost, current	$67,950
Thermal load (MMBTU/yr)	2,188
Annual wood use, 100% wood (tons)	180
Wood/oil system:	
Annual wood use (tons)	171
Annual oil use (gal)	1,133
Annual wood cost	$39,367
Annual oil cost (backup)	$3,398
Total fuel cost, proposed	$42,765
Year 0 fuel cost savings	$25,185
Percent fuel cost savings, year 0	37%
Annual loan payment	$36,876
	$ 3,073 /mo

Financial Performance Summary

20 year net present value of savings		$134,832
Internal rate of return (IRR)		6.2%
Year 1 cash flow	positive	$2,556
Simple payback, years (excluding loan pmts)		15.3

Project Cost

Pellet boiler system (includes stack)		$400,000
Fuel storage (included in system cost)		$0
Buffer tank (included in system cost, if needed)		$0
Building		$25,000
Mechanical/piping (in boiler room)		$20,000
Interconnection to existing heat distribution		$0
Buried piping from new boiler house		$24,000
Controls interface		$10,000
Btu meter (for REC qualification)		$2,000
Electrical (in new boiler room)		$10,000
Utilities to new boiler room		$20,000
Total capital		$511,000
Contingency	10%	$51,100
Design: engineering & architectural		$30,000
Project management		$10,000
Permitting (allowance)		$2,000
Total		**$604,100**

REC Revenue

Thermal		609	MWH/yr	
Electrical		0	MWH/yr	
Yrs 1-3	$	20.00	per MWH	$12,184 /yr
Yrs 4-6	$	15.00	per MWH	$9,138 /yr

FINANCING

Year	Anuual Loan Payment
1	-$36,876
2	-$36,876
3	-$36,876
4	-$36,876
5	-$36,876
6	-$36,876
7	-$36,876
8	-$36,876
9	-$36,876
10	-$36,876
11	-$36,876
12	-$36,876
13	-$36,876
14	-$36,876
15	-$36,876
16	-$36,876
17	-$36,876
18	-$36,876
19	-$36,876
20	-$36,876
Total Payments:	-$737,526
Interest Paid:	$183,426

LIFE CYCLE COST ANALYSIS
Biomass Energy System Replacing Fossil Fuel System — **SITE:** **SAU 41 Administrative Building, Hollis, New Hampshire**

Analysis Date: January 2015

Pellet Boiler System to Replace Oil

Boiler Capacity:	**120,000 Btu/hr peak output**
Biomass Fuel:	**Wood Pellets**
Emissions Control:	**None**

Assumptions

Project cost	$38,700
Grants & Rebates	$11,610
Owner equity	$0
Owner loan	$27,090
Interest rate	5.0%
Finance term (years)	10
Current fuel	Oil
Current fuel units	gal
Current fuel price per unit	$3.00
Annual units, current fuel	1,600
Seasonal efficiency, oil	78%
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	$250
Boiler replacement cost , Yr 15	$12,000
Ann. wood O&M cost, Yr 1	$250
Major repairs (annualized)	$100
Salvage value (% of original)	25%

Rebate:	PUC	$11,610	
Grant:	REAP	$0	
	Total	30%	of project cost

Calculated values

Annual oil cost, current		$4,800
Thermal load (MMBTU/yr)		172
Annual wood use, 100% wood (tons)		14
Wood/oil system:		
Annual wood use (tons)		13
Annual oil use (gal)		80
Annual wood cost		$3,099
Annual oil cost (backup)		$240
Total fuel cost, proposed		$3,339
Year 0 fuel cost savings		$1,461
Percent fuel cost savings, year 0		30%
Annual loan payment		$3,448
	$	287 /mo

Financial Performance Summary

20 year net present value of savings		$10,554
Internal rate of return (IRR)		6.7%
Year 1 cash flow	negative	-$1,026
Simple payback, years (<u>excluding</u> loan pmts)		16.0

Project Cost

Pellet boiler system (includes stack)		$30,000
Fuel storage (included in system cost)		$0
Buffer tank		$1,000
Mechanical/piping (in boiler room) - in price		$0
Controls (in system cost)		$0
Electrical (in system cost)		$0
Btu meter (for REC qualification)		$1,000
Total capital		$32,000
Contingency	10%	$3,200
Engineering (REC qualification)		$2,500
Project management		$0
Permitting (allowance)		$1,000
Total		**$38,700**

REC Revenue

Thermal		48	MWH/yr	
Electrical		0	MWH/yr	
Yrs 1-3	$	20.00	per MWH	$959 /yr
Yrs 4-6	$	15.00	per MWH	$719 /yr

FINANCING

Year	Anuual Loan Payment
1	-$3,448
2	-$3,448
3	-$3,448
4	-$3,448
5	-$3,448
6	-$3,448
7	-$3,448
8	-$3,448
9	-$3,448
10	-$3,448
11	$0
12	$0
13	$0
14	$0
15	$0
16	$0
17	$0
18	$0
19	$0
20	$0
Total Payments:	-$34,480
Interest Paid:	$7,390

LIFE CYCLE COST ANALYSIS
Biomass Energy System Replacing Fossil Fuel System **SITE:** **Hollis Schools District Heating**
Hollis, New Hampshire

Analysis Date: January 2015

Central Woodchip DH System to Replace Oil in 3 Buildings

Boiler Capacity:	**2.3 million Btu/hr peak output**
Biomass Fuel:	**Wood Chips**
Emissions Control:	**Multi-cyclone**

Assumptions

Project cost	$1,519,113
Grants & Rebates	$350,000
Owner equity	$25,000
Owner loan	$1,144,113
Interest rate	5.0%
Finance term (years)	20
Current fuel	Oil
Current fuel units	gal
Current fuel price per unit	$3.00
Annual units, current fuel	43,150
Seasonal efficiency, oil	73%
Btu content (MMBTU/gal)	0.138
Wood price, Yr 1 (per ton)	$50
Wood fraction (ann. heat load)	80%
Seasonal efficiency, wood	70%
Moisture content, wet basis	40%
Btu content (MMBTU/ton)	9.9
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	$7,200
Boiler replacement cost , Yr 15	$40,000
Ann. wood O&M cost, Yr 1	$7,300
Major repairs (annualized)	$500
Salvage value (% of original)	25%

Grant:	PUC	$350,000	
Grant:	REAP	$0	
	Total	23%	of project cost

Calculated values

Annual oil cost, current	$129,450
Thermal load (MMBTU/yr)	4,317
Annual wood use, 100% wood (tons)	623
Wood/oil system:	
Annual wood use (tons)	498
Annual oil use (gal)	8,630
Annual wood cost	$24,919
Annual oil cost (backup)	$25,890
Total fuel cost, proposed	$50,809
Year 0 fuel cost savings	$78,641
Percent fuel cost savings, year 0	61%
Annual loan payment	$90,608
	$ 7,551 /mo

Financial Performance Summary

20 year net present value of savings		$409,523
Internal rate of return (IRR)		6.4%
Year 1 cash flow	positive	$11,845
Simple payback, years (excluding loan pmts)		14.8

Project Cost

Woodchip boiler system, complete, installed		$378,000
Buffer tank		$30,000
Electrostatic precipitator		$0
Building (incl. plumbing & electrical)		$437,500
Mechanical/piping (in boiler room)		$55,000
Electrical (in boiler room)		$20,000
Utilities to new boiler plant		$40,000
Buried piping into 3 buildings		$213,875
Connections to boiler rooms in buildings		$11,000
Controls interface with existing controls		$30,000
Btu meter (for REC qualification)		$2,000
Total capital		$1,217,375
Contingency	10%	$121,738
Design: engineering & architectural		$120,000
Project management		$50,000
Permitting (allowance)		$10,000
Total		$1,519,113

REC Revenue

Thermal		1,012	MWH/yr	
Electrical		0	MWH/yr	
Yrs 1-3	$	20.00	per MWH	$20,245 /yr
Yrs 4-6	$	15.00	per MWH	$15,183 /yr

FINANCING

Year	Anuual Loan Payment
1	-$90,608
2	-$90,608
3	-$90,608
4	-$90,608
5	-$90,608
6	-$90,608
7	-$90,608
8	-$90,608
9	-$90,608
10	-$90,608
11	-$90,608
12	-$90,608
13	-$90,608
14	-$90,608
15	-$90,608
16	-$90,608
17	-$90,608
18	-$90,608
19	-$90,608
20	-$90,608
Total Payments:	-$1,812,153
Interest Paid:	$668,040

Appendix D.

Maps

Hollis Primary School Map

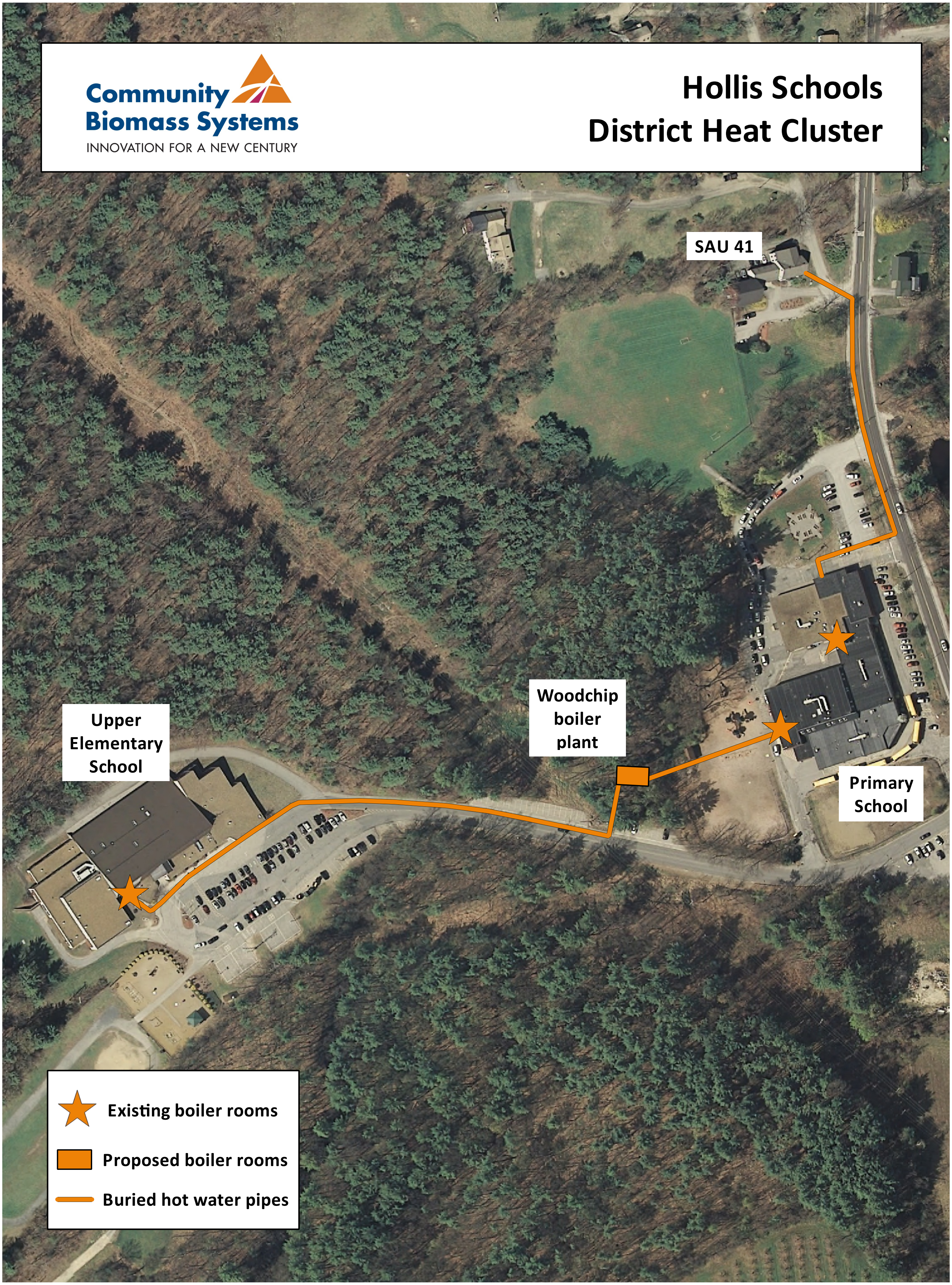
Hollis Upper Elementary School Map

District Heating Cluster Map


Community Biomass Systems
INNOVATION FOR A NEW CENTURY
Hollis Primary School
Existing & Proposed Boiler Locations
"Outdoor" boiler room
Pellet boiler room
"Indoor" boiler room
Existing boiler rooms
Proposed boiler rooms
Buried hot water pipes

Hollis Upper Elementary School
Existing & Proposed Boiler Locations

Community Biomass Systems
INNOVATION FOR A NEW CENTURY


Community Biomass Systems
INNOVATION FOR A NEW CENTURY
Hollis Schools
District Heat Cluster
SAU 41
Woodchip boiler plant
Upper Elementary School
Primary School
Existing boiler rooms
Proposed boiler rooms
Buried hot water pipes