Preliminary Feasibility Report

Town of Madison

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Report Prepared for NH WEC by:

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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 (NH WEC) www.nhwoodenergycouncil.org with funding through a grant from the USDA Forest Service has funded this assessment study for the Town of Madison, New Hampshire. Rick Handley of Rick Handley & Associates has been hired by NH WEC to complete this “Coaching” assignment and is the author of this report.

The Town of Madison Energy Committee is interested in evaluating a mini district heating application for the elementary school and near-by highway garage. Based on the information provided by the Town and an on-site review of the facilities on March 28, 2016, our findings are that, while a mini district heating application is technically feasible, the type, location, and final economics are to be determined.

Our analysis started with the lowest base cost option for a mini-district heating system which we feel is a pellet boiler located near the highway garage. That option would be a portable containerized pellet boiler solution with a pellet storage silo. This option would result in a twenty year net loss of $283,400 at current oil prices. The key economic impacts for this option are an estimated $100,000 for 600 feet of underground hot water piping, the current low cost of oil, and cost for wood pellets.

Since the school is the Town’s primary energy consumer it provides the greatest potential for savings through a conversion to wood heating. We have evaluated three additional options for the Town to better assess its options for wood heating. These additional options are intended to take advantage of the potential for focusing on the largest and best opportunity in the Town, to evaluate the potential for the emerging production of semi-dry wood chips, and the option to defer installation of underground piping to a later date. We have also included the economics of each option using today’s fuel oil cost and a potential future cost of $3.15 per gallon to show the sensitivity to oil cost on all options. The 4 options for the Town include:

- **Option 1 Mini district wood pellet boiler located at highway garage**
- **Option 2 Pellet boiler located at school serving school only**
- **Option 3 Mini district flex fuel boiler located at highway garage**
- **Option 4 Flex fuel boiler located at school serving school only**

We have used the Innovative Natural Resource Solutions - Biomass Thermal Project Calculator to calculate the life-cycle cost (LCC) to compare the options.

Our findings are that a flex-fuel pellet / semi-dry wood chip boiler located at the elementary school, heating only the school, (option 4) is currently the better economic option. Option 4 has the least risk if oil prices remain low, (minimal twenty year loss of only $34,000), and the best “upside” of a twenty year savings of over $600,000 if oil prices increase. In addition, Option 4 could accommodate the addition of the highway garage at lower cost in the future if the situation with respect to high oil costs or self-install of underground piping is considered.

Although important and real, our life cycle analysis does not include the local economic and job creation benefits of using a local fuel vs. the outflow of dollars from the area for imported oil.

Should the Town and school move forward with a new wood boiler, it should be designed and configured to work in tandem with the oil fired boiler to ensure it meets peak capacity requirements and to provide back up for the wood boiler. Given the potential for limited use of the oil boiler, a smaller oil storage tank could replace the larger below ground tank(s).

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 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 restoring the nation’s forests, USDA strives to create and retain sustainable rural jobs, conserve forests, and address societal needs.

For these reasons the State Forester and the U.S. Forest Service created the New Hampshire Wood Energy Council. The NH Wood Energy Council includes individuals, organizations, NH businesses, industry associations and non-profits interested in the sustainable use of 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.

The Town of Madison selectmen formed a Town Energy Committee and charged the committee with reviewing current energy consumption, evaluating alternatives and cost benefits, and make recommendations to the Town on near and longer term energy saving investments in the Town's municipal buildings. The Energy Committee established several guiding principles to guide its review and evaluation including recognition of the volatility of fossil energy prices and the long-term benefits of renewable energy. One of the potential opportunities being evaluated is creating a central boiler/ district heat system for the Town. The vision of a Town-wide district heat system has been placed on the "back-burner" due to the concern that the distance between the Town buildings; library, Town Hall, fire house, garage 1 and the elementary school and Town garage 2, may impact the overall cost benefit of a single Town-wide system. As an alternative the Town Energy Committee recommended that a pre-feasibility study be done to assess the potential for a single biomass heat system that would serve both the elementary school and nearby highway garage.

The focus of this study/report for the Town is to assess the potential for a biomass heating system that would serve the Madison Elementary School and the nearby Madison highway garage. The Town's initial thought is that the new biomass heating system would likely be located near the highway garage and supply hot water to the boiler room of the elementary school via underground insulated piping. The benefit of assessing these two buildings separately vs. a Town-wide system is the close proximity of the two buildings, and the elementary being the largest energy user among the municipal buildings. A successful project could guide a second combined heating system for the other cluster of municipal buildings later.

The challenge in a new biomass heating system is primarily economic, not technical. The economics that impact this project are: how fast and by how much will fossil fuel energy prices increase, the additional capital cost of long-run underground piping to connect the multiple locations to a single biomass boiler, and what if any replacement or avoided costs can be factored into the life-cycle assessment.

An application for assistance from the New Hampshire Wood Energy Council was submitted by Russell Dowd, Co-Chair Madison Energy Advisory Committee for the Town of Madison and Madison Elementary School. The Town of Madison was selected by the NH Wood Energy Council as a site for a preliminary feasibility study conducted to aid the Town and school district in its decision making to convert from a fossil-fuel based heating system to a wood biomass based heating system.

Although we did not review the energy use for all Town buildings it is safe to assume that the elementary school is the largest single energy user of all the six municipal buildings that we saw on the site visit.

The Madison Elementary School includes grades K-6. The two story building has classrooms, offices and a gymnasium/cafeteria with kitchen. The original elementary school was constructed in 1983 with additions in 1990 and 2000. It is important to note that the school is served by a septic system and well water.

The school is located at 2069 Village Rd, Madison, NH. The primary energy requirements for the building are space heating, lighting, and ventilation. A portion of the school is air conditioned. The elementary school purchased an estimated average of 13,000 gallons of fuel oil for the 2013-2014 and 2014-2015 heating seasons. At the state-wide average price of $1.94 the calculated average annual heating costs is estimated to be $25,200. The school spends an estimated $16-17,000 for electricity for a 12 month period.

The Madison Town highway garage is a single story 4000 square foot building that was constructed in 1968. The building is metal skin with insulation of unknown R-value on the walls and ceiling. The high-bay building has installed ceiling fans to help reduce stratification. The building has two large 14x10 overhead doors located at either end of the building. The building is heated by an 180,000 to 200,000 Btu/hr. hot air furnace located in the rear of the building. The furnace is new this spring 2016. There is no duct work in the building and hot air is blown directly from the furnace to heat the space. It was not determined where in the building the thermostat is located.

The Town Energy Committee is seeking an energy audit to assess the lighting at the elementary school and other potential energy conservation and efficiency measures. Our analysis focused on the potential for replacing all or part of the annual heating load / oil use with renewable biomass fuels and did not assess any other energy conservation of efficiency measures. We do recommend that any switch from fossil energy to renewable biomass be coupled with efforts to improve the overall efficiency and conservation of energy.

III. Analysis Assumptions

The following assumptions have been made as part of this pre-feasibility study:

- Price inflation rates for all fuels
- A design build approach would be used
- Costs for size, length, and installing underground piping
- Size and type of wood fuel storage
- Boiler price includes all equipment, installation, commissioning, and training
- Standard warranty
- Operation and maintenance costs
- Finance costs

The details are described in Section VIII Life Cycle Cost Analysis.

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

The Elementary School is heated by two H. B. Smith hot water boilers which were reported to have been installed in 1990, presumably at the time of a major addition to the building. Each boiler is rated at 1 MM Btu/hr. Based on our peak heat load projection of 880,000 Btu/hr., the installed boilers provide for full redundancy for the peak requirements of the building. The system would have been designed based on a heat loss calculation and ventilation rates. It is not clear if the designed ventilation rates are currently being met which could impact our estimates of peak heat load requirements which is based on oil consumption. We recommend that an analysis of the ventilation rates be done to ensure that required ventilation rates are being met. Also we observed that both boilers were operating on a 30 degree day which is unnecessary and can be inefficient; we recommend that the boiler sequence lead/lag controls be reviewed.

The building has some hot water radiators in the hall ways and fan coil units in classroom that presumably heat a mixture of indoor and outdoor air. The gym/cafeteria has a single large fan coil unit that heats this large space. Some of the classrooms have ceiling diffusers and return air ducts that supply hot air from a central unit in the roof. These areas also have air conditioning. The school has recently upgraded its underground oil storage to meet with current DEP regulations.

The Madison highway garage is one of two highway garages operated by the Town. The other is located near the Town Hall, library, and fire station. The highway garage has a single hot air furnace located in the back corner of the building. Heated air is not ducted but blown from the furnace to heat the 4000 square foot garage relying on the blowers and natural circulation to heat the space. The furnace is located away from the main overhead door and could contribute to cold spots in the front of the garage when that door is opened. The garage has installed ceiling fans to help reduce air stratification and promote circulation of the air in the single bay garage.

The Town's vision of a mini district heat system for the two buildings is to locate the boiler behind the highway garage away from the school. This would require trenching and buried underground insulated piping to transport hot and return water between the new biomass boiler and heat distribution system in the existing boiler room. Engineering calculations would need to be made on pipe size and flow rates to ensure that sufficient Btus can be delivered from the boiler plant to school boiler room via the underground piping.

The boiler room at Madison Elementary School is not large enough to accommodate a new biomass boiler and thermal storage tank. However there is space on school property near the boiler room that could be used to place a new boiler and fuel storage if another option is selected.

Figure 1 Potential Boiler Location

Figure 2 Aerial View of Madison Elementary School and Town Highway Garage

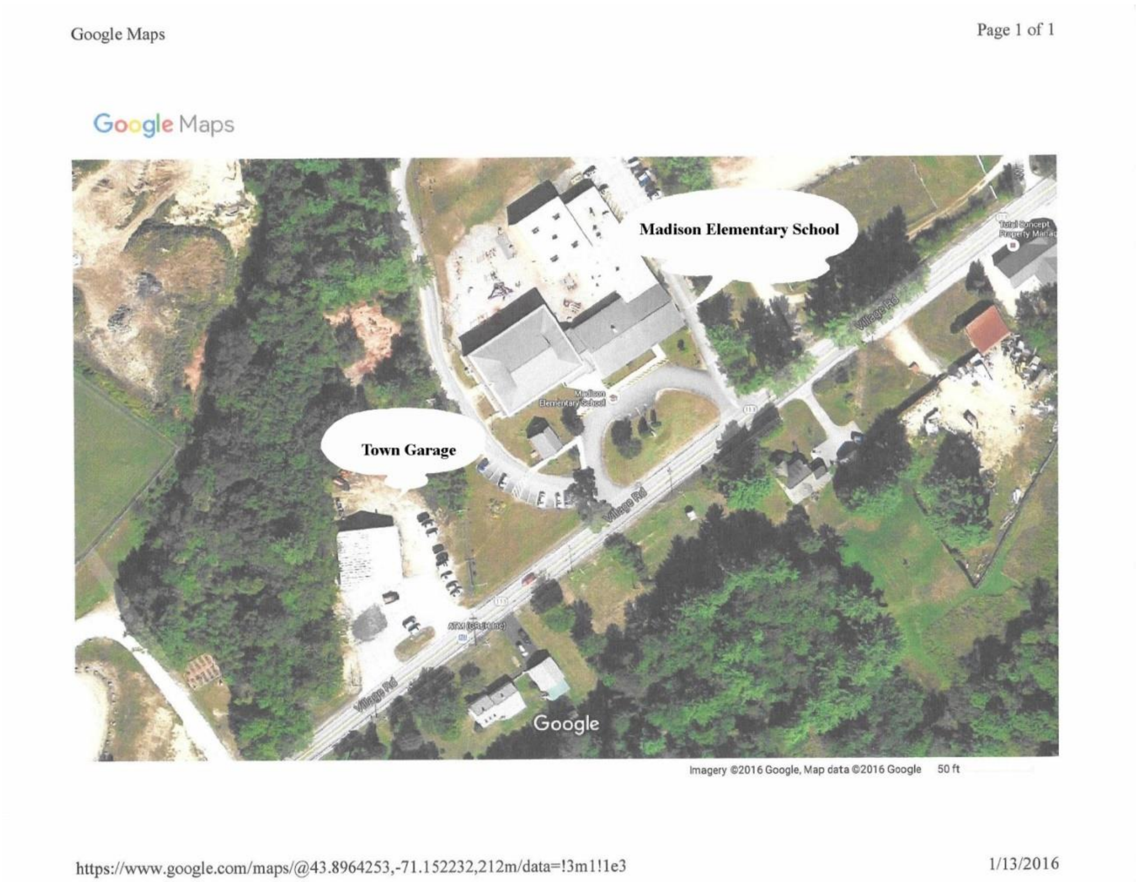


Table 1 Summary of existing heating system at Madison Elementary School and Town of Madison Highway Garage. Data and information supplied by facility, confirmed at site visit, and revised as necessary.

Building	Madison Elementary School	Highway Garage
Distribution System Type	Hot water	Forced air
Thermal System Type and Manufacturer	2 H.B. Smith oil fired boilers	Unknown (new)
Nameplate Capacity	1990 1 MMBtu/hr. 1990 1 MMBtu/hr.	180,000 - 200,000 Btu/hr.
Type of Fuel Used	#2 Heating Oil	#2 Heating oil
System Efficiency	Unknown	Unknown
Warranty End Date	Unknown	New furnace 2016
Estimated average annual fuel Consumption	13,000 gallons	2000 gallons

Figure 3 Existing heating systems

V. Fossil Fuel Use Assumptions including inflation

Fuel oil data was available for the past fuel oil deliveries. Delivery data does account for residual oil in the storage tank, annual use was estimated. Table 2 summarizes the fossil fuel use.

Table 2 Annual fossil fuel usage at Madison School & Highway Garage

Year and building	Estimated Average Annual Fuel Oil (Gallons)	Current Average Cost/Gallon	Estimated Total Expenditures
Madison School	13000	$1.94	$25,220
Madison Garage	2000	$1.94	$3,880

For the purposes of this study, we have used price data provided by the NH Office of Energy and Planning. The prices for #2 fuel oil and pellets are current prices for New Hampshire. We are assuming an annual inflation rate of 4.5% for fossil fuel costs and 3% for wood fuels for all of our life cycle analysis in this study. NH Office of Energy and Planning data on fossil fuel prices for home heating for March 2016 are included in Table 3 below.

Table 3. Current Heating Fuel Prices

Current Heating Fuel Values March 29, 2016			
Fuel Type	**Price/Unit**	**Heat Content Per Unit (BTU)**	**Price Per Million BTU)**
Fuel Oil (#2)	$1.94/Gallon	138,690	$13.98
Pellets (Bulk Delivery)	$254/Ton	16,500,000	$15.39
Semi-dry small woodchips[1]	$125/Ton	12,000,000	$10.41

For additional and up-to-date statewide fuel price for New Hampshire go to:

http://www.nh.gov/oep/energy/energy-nh/fuel-prices/index.htm

VI. Heat Load

To estimate proper sizing of any proposed wood biomass heating system, a preliminary heat load was calculated. We have used an abbreviated estimation method to estimate the boiler size. The method used is "A Simplified Procedure for Sizing a Wood Energy System" developed for the U.S.D. A. Forest Service. The Forest Service's method provides a reasonable first estimate for sizing the boiler.

A heat load calculation was made based on the fossil fuel use and degree data for the period November 2014 – October 2015. The weather station at the Fryeburg Eastern Slopes Regional Airport Fryeburg, Maine was used for degree days. The peak heating requirement for the school has been estimated at 880,000 Btu/hr. Without any modifications to improve heat retention, changes in ventilation rates, or building expansion, 880,000 Btu/hr. is presumed to be an effective peak heat load for the building. The nameplate output capacity for each of the existing oil boilers

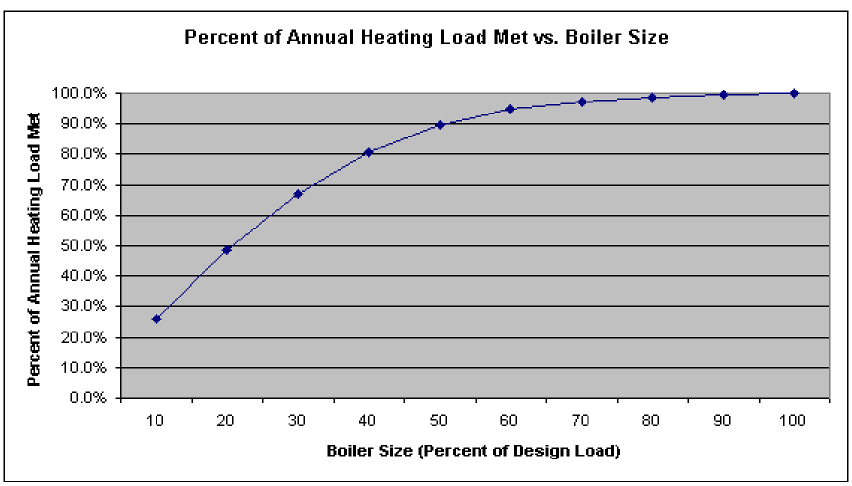
[1] There are currently only two vendors of semi-dry woodchips in New Hampshire and their products differ. The price above is included as a reference for comparison and may not be an actual delivered price.

is 1MMBtu/hr. A similar heat load was done for the Madison Garage. The peak heating requirement for the garage has been estimated at 160,000 Btu/hr.

Biomass boilers are not sized the same as fossil fueled boilers. Biomass boilers, because of the nature of the fuel and their operation, need to be sized to consistently operate within their most efficient operating range. This range is typically 50-100% of their rated capacity. Proper sizing of a biomass boiler should result in longer run-times vs. fossil fuel boilers. In order to meet these conditions, current best practice in the industry is to install two or more smaller biomass boilers to equal the peak day load requirements, or a single biomass boiler with thermal storage and/or fossil fuel backup. Thermal storage should be incorporated to help reduce short cycling and provide for short term peaks in demand. Proper sizing and thermal storage improve overall performance and efficiency.

When using a fossil fuel boiler for peak loads and backup, the biomass boiler can be sized using the “50/90” rule. The rule is a general guiding principle based upon peak versus annual heating loads. Data has shown that sizing boilers to 50 percent of the peak heating load needs results in meeting 90 percent of the annual heating needs (see figure below). The final 10 percent of the annual heat load can be met by the existing fossil fuel boiler. This configuration can also provide the added benefit of providing redundant boiler capacity that can be used in the unlikely event of an outage of the biomass boiler system.

Figure 4 Heat load vs. boiler size



Wood Boiler Sizing – Partial Bin Analysis, Adam Kohler, E.I.T.

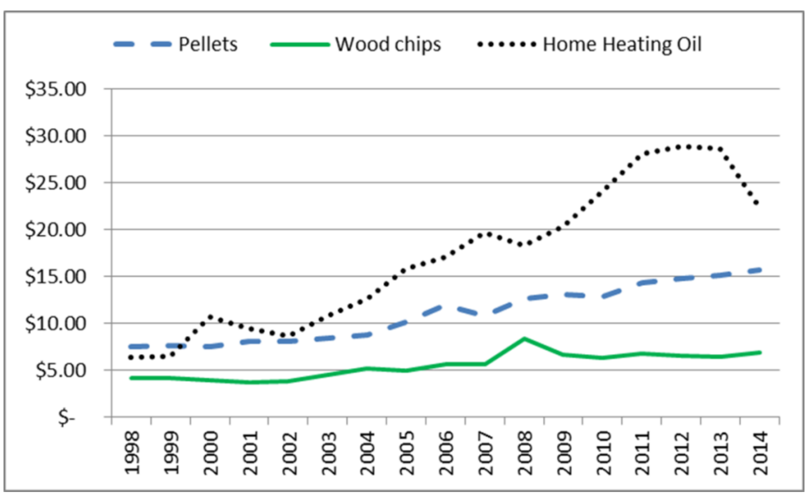
VII. Wood Pellet/Chip Cost Assumptions including inflation

For the purposes of this study, we are assuming a current baseline price for wood pellets delivered in bulk form at $254/ton. There is enough historical data available on wood pellets to suggest an annual inflation rate for bulk wood pellets at 3%. Figure 4 shows historical data for pricing of wood pellets and heating fuel oil.

The wood chip information in Figure 4 is for “green” woodchips. There is very little data on semi-dry wood chip sales. Currently we are aware of only two sources for semi-dry wood chips (25% to 30 % moisture) in New Hampshire: Froling Energy and Innovative Wood Fuels, LLC. Froling markets its semi-dried chips as Precision Dry Chips (PDC). Price quotes from Froling for other locations are in the $120 to $125 per ton for full blower truck deliveries within “reasonable” distance to Peterborough, NH. Innovative Wood Fuels, LLC currently supplies semi-dry chips in the central and southwestern NH areas. They provide this product for 20% less than Froling but currently only deliver with live-floor chip trailers which require specialized unloading equipment at the facility like schools currently receiving green chips. We are assuming a base price for delivered semi-dry chips at $125 per ton and a 3% inflation rate.

Figure 5 NH prices for wood pellets and heating oil

Fuel Cost per MMBTU in NH, 1998 – 2014



Source NH OEP, Innovative Natural Resource Solutions, LLC

VIII. Life Cycle Cost Analysis

A Life Cycle Cost (LCC) analysis was conducted using the INRS Biomass Thermal Project Calculator financial model. The results are shown in Table 4. 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 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
- Avoided future capital costs for replacement or overhaul of current system.

The analysis performed for Madison compares four different options over a 20-year horizon and takes into consideration life cycle cost factors. The wood boiler life is expected to meet or exceed this timeframe.

In the Life Cycle Cost Analysis tool, the INRS Biomass Thermal Project Calculator, each option was run using common assumptions and data wherever possible. The options 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.

It is not the intent of this analysis, nor was it in the scope of work, to develop precise cost estimates for a wood heating project based on detailed engineering and vendor analysis. The capital costs used for the scenarios were provided as estimates by qualified vendors and the experience of the “Coach”. Should the Town decide to move forward with a biomass heating project, we recommend that you engage several vendors to obtain a detailed project quote (RFP).

The New Hampshire Wood Energy Council can provide “Coach Plus” services that could assist the Town with soliciting and evaluating actual vendor proposals.

In preparation of this assessment we have made the flowing assumptions:

- The price of heating oil and wood fuels will increase over time. We have included a price escalator of 4.5% for heating oil and 3% for wood pellets and semi-dry woodchips. A temporary or seasonal price increase or decrease may occur but in general we believe historical price trends will continue. General inflation rate is assumed to be 2.5%.

- Typically, larger capital projects include a feasibility study followed by an architect/engineer developing drawings and specifications for the project, and then the project is then put to bid. While this design-bid-build method is typical, it can be costly and may even result in unnecessary equipment or construction costs. Design bid build projects can add 20% to the total coat of the project. Another approach to securing a new biomass system, especially smaller capital projects, is to use a design build approach where the bidders, typically a biomass equipment vendors, provide the full turn-key project from design to final commissioning of the system providing all required design, equipment, and installation for the project. In some cases the bidders can also provide the on-going service and support for the equipment. It can beneficial to use a design build approach especially for smaller systems under 1MMBtu/hr. because the vendor is often more familiar with the unique requirements of biomass systems and has the necessary experience and knowledge of industry best practices. Any design work will be included in the bid price however we feel that because of the dual benefits of lower overall cost and access to the best experience we have assumed a design build approach in our analysis. The capital expense costs include any required engineering and design.

- We have assumed that 600 feet of underground piping would need to be installed to connect the biomass boiler located near the highway garage with the Elementary School boiler room. The piping would need to follow an "inverted V" to avoid the septic and leach field behind the school rising up to the upper parking lot and then back down to the boiler room in the school. In addition, we have assumed a 2.5 to 3 inch pipe diameter would be needed for supply and return lines to provide the necessary volume for the school heating system. This is a significant expense estimated at $100,000. If the Town chooses to locate the mini district boiler at the school vs. the highway garage site we feel there could be significant saving in piping costs due to smaller diameter piping requirements and the potential for the Town doing the installation.

- Base cost for a pellet system is $170,000 and the base cost for a flex-fuel boiler system $200,000.

- We have assumed $20,000 for a 28 ton pellet storage silo and that there would need to be an estimated $10,000 in upgrades to the storage system if a flex-fuel system is selected.

- A flex fuel system would require a cyclone at an estimated $10,000.

- A flex fuel system would require a larger "footprint" at $5,000.

- All installation done by successful bidder and is included in the boiler price.

- Pellet systems have proved to be very reliable in part due to the smaller and more uniform size of the fuel. A semi-dry woodchip system should also perform well but the Town should expect to give it a few hours more attention per year vs. a pellet system. In addition the service for the pumps for the piping system will need maintenance. We have provided appropriate estimated labor costs to provide routine service for the respective systems.

Exact pricing for a new combined heating system is difficult for an analysis of this level of detail. Site specific conditions will influence the final costs and even firm estimates from vendors/installers may have a contingency. We believe that the price estimates used for this report are within + or – 20%.

Option 1 Mini district wood pellet boiler located at Highway garage $300,000

- Pellet boiler(s) 500,000 BTU/hr.
- Boiler enclosure
- Suitable concrete pad for boiler enclosure
- ASME rated thermal storage tank(s) 500 gallons
- Pellet storage silo and flex conveyor
- Pellet silo concrete pad
- Balance of System (controls)
- New fan-coil unit heaters (4) for highway garage
- New exhaust stack
- 600 feet insulated underground piping
- Construction/Installation (including trenching and repair of the driveway and parking area).
- Testing start-up commissioning and operator training.

Option 2 Pellet boiler located at school serving school only $190,000

- Pellet boiler 300,000 BTU/hr.
- Boiler enclosure
- Suitable concrete pad for boiler enclosure
- ASME rated thermal storage tank(s) 300 gallons
- Pellet storage silo and flex conveyor
- Pellet silo concrete pad
- Balance of System (controls)
- New exhaust stack
- Construction/Installation
- Testing start-up commissioning and operator training.

Option 3 Mini district flex fuel boiler located at Highway garage $325,000

All the equipment requirements for option 1 plus additional costs for:

- slight increase in boiler cost
- upgraded flex fuel storage
- larger “footprint”

- cyclone emission control.

Option 4 Flex fuel boiler located at school serving school only $225,000

Same equipment as option 3 with no piping costs.

Table 4 Life Cycle Cost Analysis Summary Madison Elementary School and Highway Garage

Project Scenarios	Option 1 Mini district pellet boiler located at Highway garage	Option 2 Pellet boiler located at school serving school only	Option 3 Mini district flex fuel boiler located at Highway garage	Option 4 Flex fuel boiler located at school serving school only
Estimated Total CAPITAL COST Including install	$300,000	$190,000	$325,000	$225,000
Grant(s)*[2]	55,000	55,000	55,000	55,000
Amount to be Financed	245,000	135,000	270,000	170,000
Sizing of Wood Boiler Relative to Peak-Hour Thermal Load	50%	35%	50%	55%
Estimated % of annual heat load covered by biomass boiler[3]	90%	70%	90%	90%
Estimated annual wood fuel use	115 tons pellets	99 tons pellets	175 tons semi-dry chips	150 tons semi-dry chips
Estimated annual supplemental oil use	1500 gallons	3900 gallons	1500 gallons	1300 gallons
Reduction in heating oil consumption	13500	9100	13500	11700
Annual operating cost above oil system	$1000	$500	$2000	$1000
Total CAP EX plus 20 year O&M	$320,100	$175,100	$375,600	229,900
Total fuel cost savings for 20 years @ current oil $1.94	$36,700	($121,900)	$233,800	$195,900
20 year net savings (loss) @ $1.94 oil	($283,400)	($297,000)	($141,800)	($34,000)
Total fuel cost savings for 20 years @oil $3.15	$549,200	$223,500	$746,300	$834,200
20 year net savings (loss) @ $3.15 oil	$229,100	$48,400	$370,700	$604,300

[2] See grant options in section XVI. Grant total is based on 30% NH Public Utilities Commission Commercial Wood Pellet Boiler Rebate, $50,000 max grant plus up to $5000 for thermal storage.
[3] Remainder of annual heating is supplied by existing oil boilers and furnace.

IX. Operation and maintenance

Modern wood heating systems are highly automated. Because wood pellets and semi-dry small wood chips 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 boiler will take more time to maintain and operate than a traditional gas, oil, or electric heating system. 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 boiler 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 as recommended by the manufacturer
- Checking for wear on conveyors, augers, motors, or gear boxes.

When considered on a weekly basis, the total time required for maintaining the wood boiler system equates to roughly 1 – 3 hours per week over the entire heating season but maintenance is not required every day during the heating season. When considering a flex-fuel system the storage system will need additional attention because wood pellets and semi-dry chips have different storage and feed characteristics. In addition the size and type of storage system may require more labor if greater deliveries per year are required. Deliveries can be simplified and costs reduced in bulk delivery by increasing the size of the delivery. In this analysis we have assumed a bin that can accept a full truck load of pellets or semi-dry chips per delivery. The operation of a flex-fuel wood boiler may require more observation and attention to ensure that peak efficiency is being maintained. Semi-dry woodchips will also produce additional ash that needs to be removed vs. pellet systems.

X. Thermal Storage (TS)

A thermal storage tank or tanks is used to store heat from the boiler in an insulated hot water tank, from which hot water is then distributed as the building calls for heat. This allows an appropriately 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 aids in controlling air emissions and environmental conditions. In our analysis we have assumed that with thermal storage options 1, 3, and 4[4] will supply at least 90% of the annual heating requirement for the building. Thermal storage also provides additional benefits including faster response time to calls for heat in the building and greater overall efficiency of the system and increased boiler life. The thermal storage would be located in the external boiler room.

XI. Cost Ranges for Wood Systems

This analysis is not detailed enough to provide exact pricing for a wood pellet or flex-fuel pellet / semi-dry woodchip heating system for Madison but can provide reasonable estimates of cost to aid in decision making. 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 have been estimated. These are preliminary estimates and could vary by as much as + or - 20 %. These costs reflect that a pellet or semi-dry woodchip boiler and woodchip storage at Madison would require additional construction of the outside boiler and storage enclosure and the potential for addition construction.

XII. Emissions and Permitting

Based on current NH air emissions standards and the estimates and assumptions made in this Pre-Feasibility Report this project will not require air emissions 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 woodchip and pellet systems burn much cleaner than even the most modern home wood or pellet stove. The current practice to properly size the biomass boiler with added thermal storage contributes to increased efficiency in the operation of the system and lower emissions. It is recommended that the Town check with local officials to determine what building permits or other local permitting is required if a wood-fueled system is installed.

XIII. Wood Ash

One by-product of burning wood is ash, a non-combustible residue. While the ash produced by burning wood can be automatically removed from the boiler in the systems of many

[4] Option 2 is a low budget option using a smaller less costly wood pellet boiler. We have estimated that even a pellet boiler rated at 35% of peak day load could supply 70% or more of the annual heating load with thermal storage.

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). At an estimated annual use of 100 to 115 tons for pellets ash generated would be about 2000 to 2300 pounds (200 to 230 gallons volume). The ash generated by semi-dry woodchips would be higher estimated at about 2 to 3% by weight or up to an estimated 3 tons annually.

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 an estimated maximum 3 tons generated in the proposed biomass systems for this project, <u>but it must be actively managed and beneficially used in agricultural applications.</u> 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

Our review of the Madison Elementary School and Highway Garage focused on the heating plant; we did not review any other energy using systems in the building. In general we found the boilers to be well maintained and in good working order. We recommend that the Town and school district update / maintain / track its energy use by participating in U.S. EPA Portfolio Manager Program to better track its energy use and aid in identifying changes. A Portfolio Manager account is required for State grant funding. http://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager

XV. Project Recommendation

The goal of this pre-feasibility study was to conduct an assessment as required by the NH Wood Energy Council, and select one of three options with regard to the installation of wood heating system made under this review and report activity:

1. *The Project is not feasible and 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 additional analysis is recommended.*

We find that a mini district heating system for the Madison Elementary School and Highway Garage is technically feasible but additional analysis is recommended. An estimate of the life cycle cost has been made for several options and that all the options are very sensitive to price changes in heating oil. The final economics of the project are to be determined. More information is needed based on budgetary quotes from vendors of a complete biomass mini district heating system as outlined in this report. This additional analysis should include at a minimum:

- Determine if additional ventilation (air exchanges) are required for the school;
- Determine if the location just behind the school is suitable / acceptable for a biomass boiler;
- Determine the cost premium to install a flex-fuel (pellet semi-dry wood chip) boiler, such as the additional equipment such as increased "footprint", a cyclone, and upgraded flex-fuel storage;
- Evaluate if the Town could install underground insulated piping from a boiler located near the school boiler room to the highway garage;

- Evaluate appropriate control logic to ensure that the new biomass boiler, thermal storage, and oil boiler work together with the goal of the biomass system providing 90% of the annual heat load;
- Identify an acceptable service provider for the new biomass system; and
- Identify local wood fuel providers. Currently there are only two suppliers of semi-dry wood chips within New Hampshire. Determine if the Town is able to get a contract for guaranteed supply for semi-dry fuel. Will the vendor provide a firm price over a contracted period? What quality control assurance on chip size and moisture content will the school be able to contract for? If semi-dry chips became unavailable how difficult would it be to move to pellets and what technical issues would be created?

XVI. Financing Opportunities

Purchase and installation of a wood biomass heating system represents a significant capital cost. The following are financial assistance programs that can off-set some of those capital costs. Each of the programs listed below have eligibility requirements and may or may not be available to the District depending on the program requirements.

A. State

NH Public Utilities Commission Commercial Wood Pellet Boiler Rebate Program[5] – 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. Additionally, a rebate of 30% up to $5,000 is available for thermal storage tanks and related components. This grant was included in the financial assessment contained in this report. 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. It is possible that the NH TRECs Enterprise Fund may provide payments to the District in exchange for the thermal RECs that are generated. The process to generate thermal RECs is new however, and due to the size of the Sanbornton project we feel that the transaction and verification costs may offset any value received and is not calculated for this report. For more information go to: http://www.puc.state.nh.us/sustainable%20Energy/Class%20I%20Thermal%20Renewable%20Energy.html and www.t-recsfund.org.

[5] Grants may not be available for a dual-fuel pellet and woodchip boiler especially if the plan is to use woodchips as the primary fuel.

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 availability as these opportunities are changing regularly.

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.

It does not appear that the Town of Madison is eligible for any federal incentives 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. It is not likely that an ESCO would fund only the installation of a biomass boiler but would look to include a menu of energy measures along with the boiler.

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

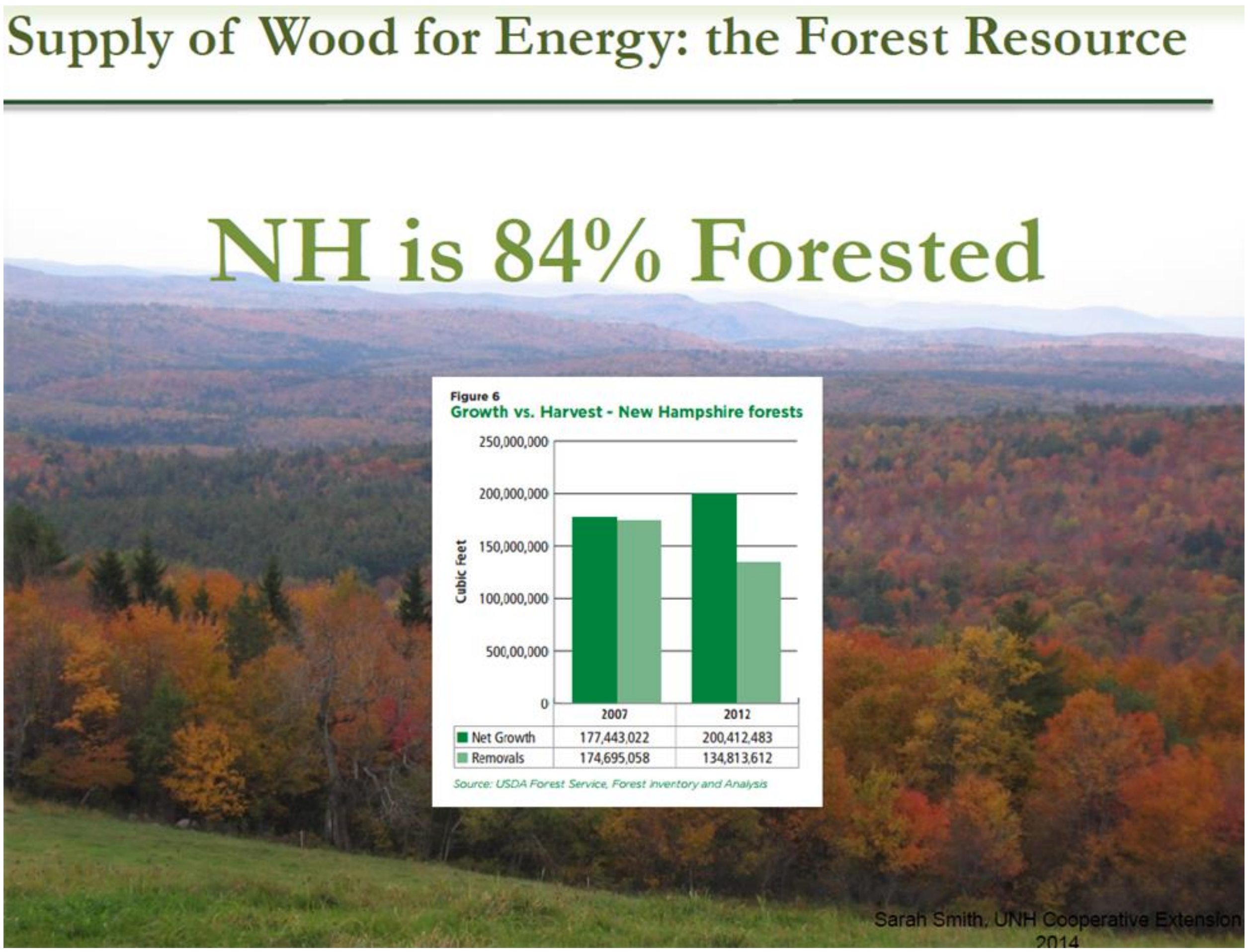
References

- United States Forest Service – Simplified Procedure for Sizing a Wood Energy System
- Innovative Natural Resource Solutions, LLC - Biomass Thermal Project Calculator
- New Hampshire Office of State Planning – Current Heating Fuel Values
- New Hampshire Public Utilities Commission – Non Residential Pellet Boiler Rebate Program

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.

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
802-477-3993
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