



Special Project Report: Town Complex Heating Assessment

Town of Littleton



Report Prepared for NH WEC
by:



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Final

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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 assistance for the Town of Littleton to determine if additions/modifications to its existing pellet heating system are technically feasible and warranted. 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 installed a mini district heating system in 2013 that supplies hot water from two Froling pellet boilers to the fire station and highway garage. A request for technical assistance was made by Fred Moody, Town Manager, for technical support from the NH WEC to assess if the Town’s current installed biomass heating system is large enough to meet future requirements including a new larger highway garage and the potential to add the police department building in the future.

Based on an on-site review of the facilities and meeting with the Town Energy Committee on December 4, 2014, and subsequent review and discussions with the town officials and energy experts It has been determined that:

1. The current pellet heating system is large enough to handle the expected heating requirements for the fire station and new highway garage, but not the police department;
2. Radiant heating should be incorporated into the new highway garage;
3. The current pellet storage silo is sufficient but the thermal storage should be evaluated to ensure that it is working to stratify temperature, and the storage capacity should be increased to ensure meeting the fire station and highway garage demand;
4. The existing vertical fan-coil units in the fire house should be evaluated to determine if new units are required that will operate as designed with water temperature in the 160 -170 degree f range.
5. Interconnection and control sequencing between the pellet system and the fire station boiler should be reevaluated.
6. The new high efficiency propane boiler proposed for the new highway garage should be designed to provide redundancy and backup heat for the entire system and work in tandem with the expanded thermal storage capability. The new heating system could allow for the removal of the oil-fired boiler in the fire house and removal of the existing underground oil storage tank.

II. Introduction

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 Special Project Report is a key method to deliver those technical services where needed.

In 2013, the Town of Littleton installed a wood pellet heating system that services the current highway garage and fire station. The Town is making plans for a new larger highway garage that it will take to voters in 2015. The proposed new construction makes it necessary to assess the current biomass heating system. The Town has requested assistance from the NH WEC to:

- Determine if the two existing pellet boilers can meet the heat load demand of the fire department and a new highway garage recognizing that the two existing boilers have been designed based on meeting 50-60% of peak heat load.
- Evaluate the possible benefits (if any) of integrating radiant heat in the new highway garage to supplement hydronic heaters (which would be relocated to the new garage having just been installed in the current garage).
- If determined that there is sufficient capacity for the fire department and new highway garage, determine if there is any additional available capacity for adding the police department at a later date.
- If added heat load capacity is needed for the new larger highway garage, identify any other likely modifications needed to the existing configuration such as increased pellet storage and/or thermal storage.

Rick Handley (Rick Handley & Associates) was assigned by the New Hampshire Wood Energy Council to provide this assessment. Mr. Handley met with Fred Moody, Town Manager, George McNamara Public Works Director, Joe Mercieri Fire Chief, and other members of the Town's Energy Committee on December 4, 2014. Following a meeting with the Town officials there was a tour of the highway garage, biomass heating plant, and fire station.

Several operational issues were discussed including the tandem operation of the biomass plant with the existing oil-fired boiler in the fire station, the size and operation of the thermal storage tank, and the maximum temperature hot water output of the pellet boilers.

III. Analysis Assumptions

Several assumptions were made from which the recommendations were developed. The new highway garage will have R24 insulation on the walls and R33 ceiling insulation. The building will be slab on grade with no basement. An assumption was made that the new garage will have 7 passive solar overhead doors. The heat loss is based on maintaining 70 degree indoor temperature at -15 outdoor.

The building heat load for the existing garage, fire department, and police station are based on fuel purchases and heating degree days for the 2012-2013 heating season.

Based on discussions with other experts, it was assumed that the maximum water temperature from the Froling boilers to be 176 degrees.

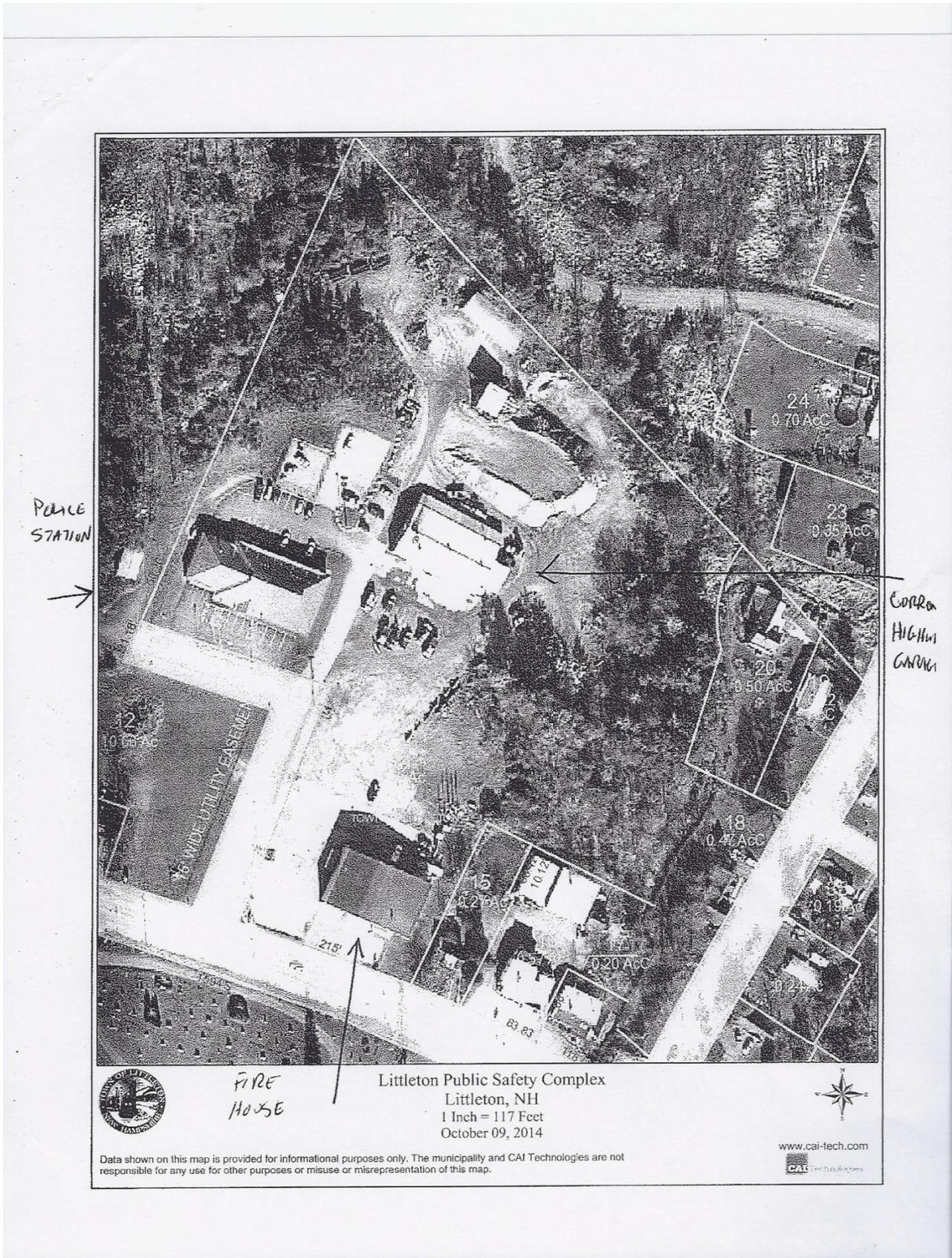
The Modine vertical hydronic heaters in the fire station are assumed to be designed to operate based on receiving 180 degree water.

In order to meet the entire heating requirements of the three buildings with the existing biomass boilers, it is further assumed that the boilers will be maintained and operated according to the manufacture's specs and that the thermal storage is expanded to 800 gallons. In addition, the thermal storage should be operated to ensure the stratification occurs in the tank(s) hottest water on top, coolest at the bottom.

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

The Town of Littleton has a complex of three existing public buildings located at 240 West Main Street in Littleton, NH. The complex includes a public works garage, fire station, and police headquarters.

Figure 1.



The Littleton Fire Station is a 6000 sq. ft. building built in 1975. The building houses fire trucks and ambulances, the fire station building has offices, meeting rooms, and quarters for firefighters. With the addition of the ambulance service being housed at the station, the building is now occupied 24/7. The building has four heating zones. Three of the zones are supplied by hot water baseboard radiators. The largest zone is the bay area where the fire trucks and ambulances are housed. This area is heated by four ceiling mounted Trane fan coils units. Currently the building is supplied hot water from the two Froling pellet boilers. The existing oil-fired boiler is supposed to be used to supplement the pellet boilers and provide back-up for the pellet boilers. It was reported that following installation of the pellet boilers that the oil-fired boiler was running most of the time supplying heat for the fire department and sending hot water back to the buffer (storage) tank in the pellet boiler house. In addition there still appears to be an issue with the delivered water temperature and the design of the Trane heaters that are reported to require 180 degree water.

Modifications have been made to the plumbing connecting the pellet system with the fire station boiler/distribution system in an attempt to ensure that the oil-fired boiler is not the primary heat source for the fire house. However, full integration of the pellet boilers and the oil-fired boiler still does not appear to be fully resolved. The interconnection between the pellet boilers / thermal storage tank, and the oil fired boiler needs to be reevaluated to ensure that the pellet boiler always serves as the primary heat source. The Trane heaters also need to be reevaluated to determine if they need to be modified or exchanged for units that can work on lower (less than 180 degrees) water temperature.

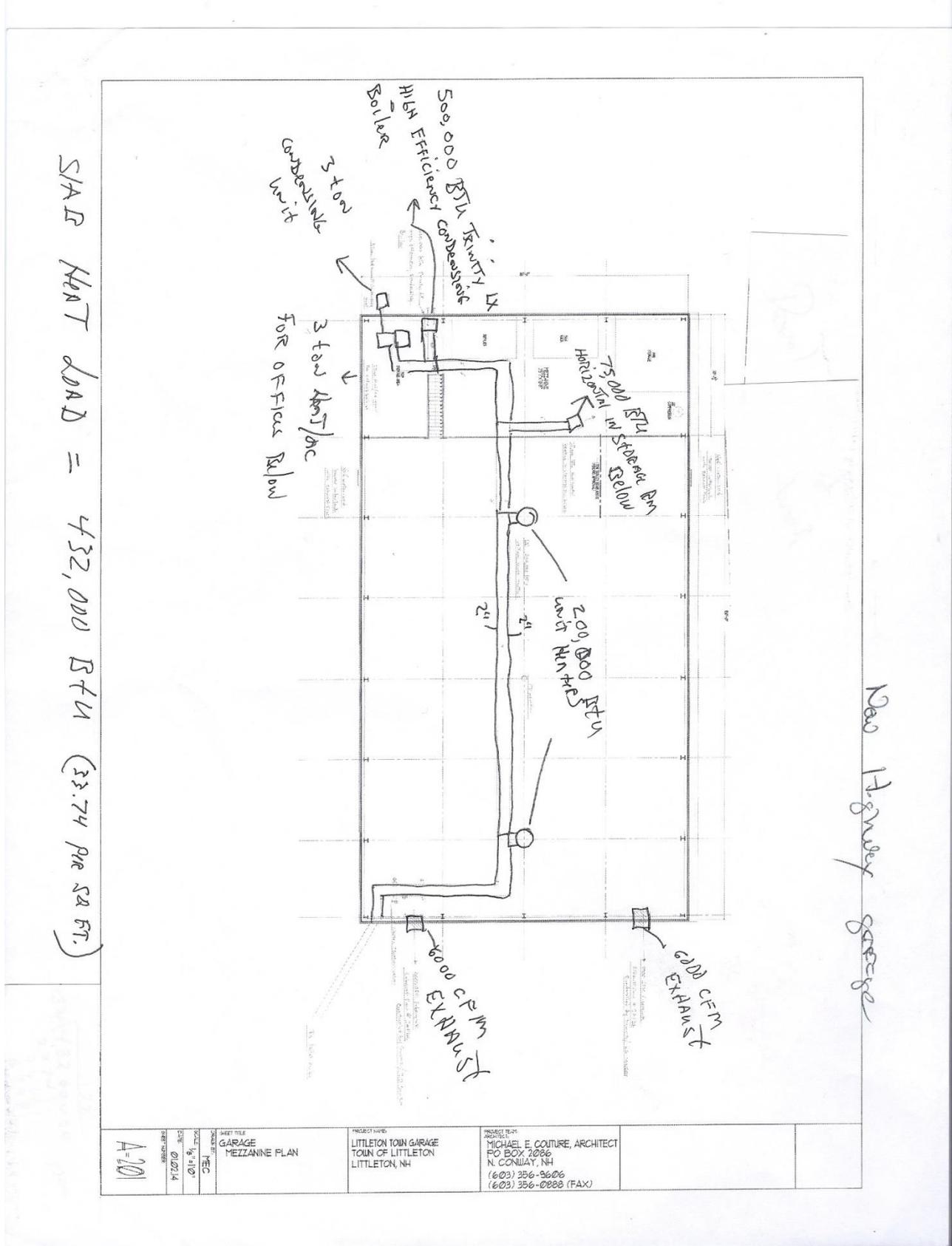
Future additions of new heating equipment, such as the proposed new equipment for the new highway garage, should consider opportunities to abandon in-place, remove, or modify the existing oil fired boiler allowing for removal of the existing 30 year old underground oil storage tank.

The Highway garage is a 9,000 square foot facility that houses DPW offices, employee break/lunch room, restrooms, and storage. The facility is a metal skin building with very little insulation. The original heating system consisted of a Thermo Cycle oil-fired hot air furnace with a rated input of 400,000 btu/hr. and a separate Thermo Pride furnace to heat the offices, break/lunchroom, restrooms, and storage. Four Modine fan-coil units were installed when the pellet boilers became operational to replace the Thermo Cycle hot air furnace. A hot water coil was installed to replace the burner in the Thermo Pride furnace which also uses hot water from the pellet boilers. The building also had a small propane heater in an attached structure and waste oil heater. The use and impacts of these two units is believed to be small and they were not considered as part of this assessment.

The Town is considering replacing the current garage with a new 12,000 sq. ft. facility. Plan drawings received from George McNamara showed a 500,000 btu/hr. Trinity LX high efficiency propane condensing boiler that could serve as a supplement and redundant capacity for the pellet

boilers. The Town is also considering radiant floor heating in the new garage. The Town is considering several options/configurations for heating the new highway garage.

Figure 2.



To estimate the heat load for the new highway garage drawings of the proposed new garage and data on the proposed insulation levels and construction provided by George McNamara were used. The calculated heat loads are:

- Fire department 150,000 btu/hr.
- Existing highway garage 290,000 btu/hr.
- Police station 87,000 btu/hr.
- Proposed highway garage 405,000 btu/hr.

One surprise was the heat load for the fire department; another was that the new highway garage's projected heat load is so much higher than the current garage. The new garage, will be 30% larger, will be better constructed and have significantly higher insulation levels. The current garage is likely fairly cool in winter, not 70 degrees as projected in the heat loss calculation for the new garage. The new garage will be able to be kept at more comfortable levels and have more fresh air exchanges than the current garage at this projected heat load.

One explanation for the oversizing of the fire house boiler is that contractors sometimes install what they have on hand or that for little added expense larger boilers are installed vs boilers sized at design load or only slightly over. It is also possible that the heat load calculation is low. That possibility has been allowed for in the report recommendations.

VI. Thermal Storage (TS)

A thermal storage tank stores heat from the boiler(s) in a well-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. There are two items that should be evaluated with regard to thermal storage in Littleton. In the current Littleton system, the thermal storage tank MAY not be stratifying the water in the tank. Through stratification, the hottest water stays at the top of the tank and is delivered to the system. The coolest water (return water) is returned to the tank at the bottom of the tank and is fed to the boiler (or mixed with heated water from the boiler¹) to be reheated in the boiler and returned to the thermal storage tank(s). If the water in the tank is mixing and not stratifying then water is being distributed to the system radiators and fan coil units that is somewhere between the boiler output temperature and the return water temperature and not the hottest water.

¹ The two Froling boilers do not have mixing valves and this boiler design is the reason the max output temperature does not exceed 176 degrees.

The Town should also investigate with Froling Energy (system installer) adding additional capacity for thermal storage. Adding an additional 400 gallons of storage may have the effect of simulating additional boiler capacity with the potential for the system to deliver up to 480,000 btu/hr. for a short duration during extremely cold weather.

VII. Radiant Floor Heating

A radiant heating system is the best option for the new highway garage. Radiant heating will deliver energy as well as worker comfort. The primary benefit of a radiant heating system will be the increased comfort for the employees and the ability to warm vehicles for snow removal and the radiant heating system will also be quieter than a forced air or fan-coil hydronic heaters. Energy savings may occur vs. a 100% hydronic heating system using the fan-coil units because the radiant system will help to reduce stratification of the heated air, lower thermostat settings, potential for lower boiler water settings, and reduced air infiltration. While the radiant floor heat is being recommended to be installed in the new highway garage, there are a several things to consider when designing and installing the new radiant heating in the new public works garage.

The proposed insulation levels for the new garage are fairly high for a building of this type and use and may approach or meet green building standards, which is laudable. Some experts have argued that using radiant floor heating in buildings with high levels of insulation and at least some passive solar gain decreases the economics of the system. The Town will need to be careful and work with an experienced radiant heating contractor to properly size the system and incorporate flexibility in the system so that it can be operated economically as a system with the other buildings.

The time lag of heat movement through concrete must also be able to be controlled; not being able to adjust slab heating with outside temperature, particularly if there are other sources of heat being delivered to the space such as passive solar, can cause overheating of the space.

With slab-on-grade radiant-floor heating systems, there is potential for significant heat loss into the ground. According to the National Renewable Energy Laboratory, even with insulation under the slab, 20% of the heat entering the slab can be lost into the ground. Three to four inches of under slab insulation is recommended in cold climates.

Design of radiant-floor heating systems is quite complex and should be done by someone with adequate training or experience to avoid mistakes and maximize benefits.

VIII. Project Recommendation

- The current pellet heating system, with increased storage, should provide up to 480,000 btu/hr. for short duration heating such as morning warmups and 320,000 btu/hr. constant

output. Given that the maximum heat load for the new garage and fire station is estimated to be 550,000 to 600,000 btu/hr., the biomass system more than meets the “50/90²” rule. The addition of the police department could increase the maximum heat load for all three buildings to over 700,000 btu/hr. and therefore would not meet the “50/90” rule. It is possible that the new highway garage will not be as large a load as projected or that providing less than 90% of the annual heating with biomass is acceptable. If so, then the police department could be added at some point.

- The use of radiant heating for the new highway garage is endorsed provided that the Town contracts with an experienced designer to size and layout the system.
- The current pellet storage silo is sufficient.
- The thermal storage should be evaluated to ensure that it is properly stratifying hot water stored in the tank. The Town should strongly consider replacing the existing storage tank with a larger tank (800 gallons) or adding an additional 400 gallon storage tank.
- The existing vertical Trane fan-coil units in the fire house should be evaluated to determine if new units are required that will operate as designed with water temperature in the 160 - 170 degree f range.
- Evaluate if the interconnect and control sequencing are correct between the pellet boiler system and the fire station boiler, or other supplemental hot water source (see recommendation below). The control sequencing should always use hot water from the pellet boiler system unless that system is unable to deliver hot water or hot water at the appropriate temperature.
- The new 500,000btu/hr. Trinity LX high efficiency condensing propane boiler proposed for the new highway garage should be designed to provide redundancy and backup heat for the entire system and work in tandem with the expanded thermal storage capability. The Town should explore the potential of linking the new propane boiler to the mini district heating system to supply supplemental heat for the coldest days and to serve a redundant back-up for the pellet heating system. Having the redundant capacity could allow for the removal of the oil-fired boiler in the fire house and removal of the existing underground oil storage tank.

² The “50/90” rule states that sizing a boiler at 50% of the maximum heat load for a building will supply 90% of the annual heating requirements for that building.

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

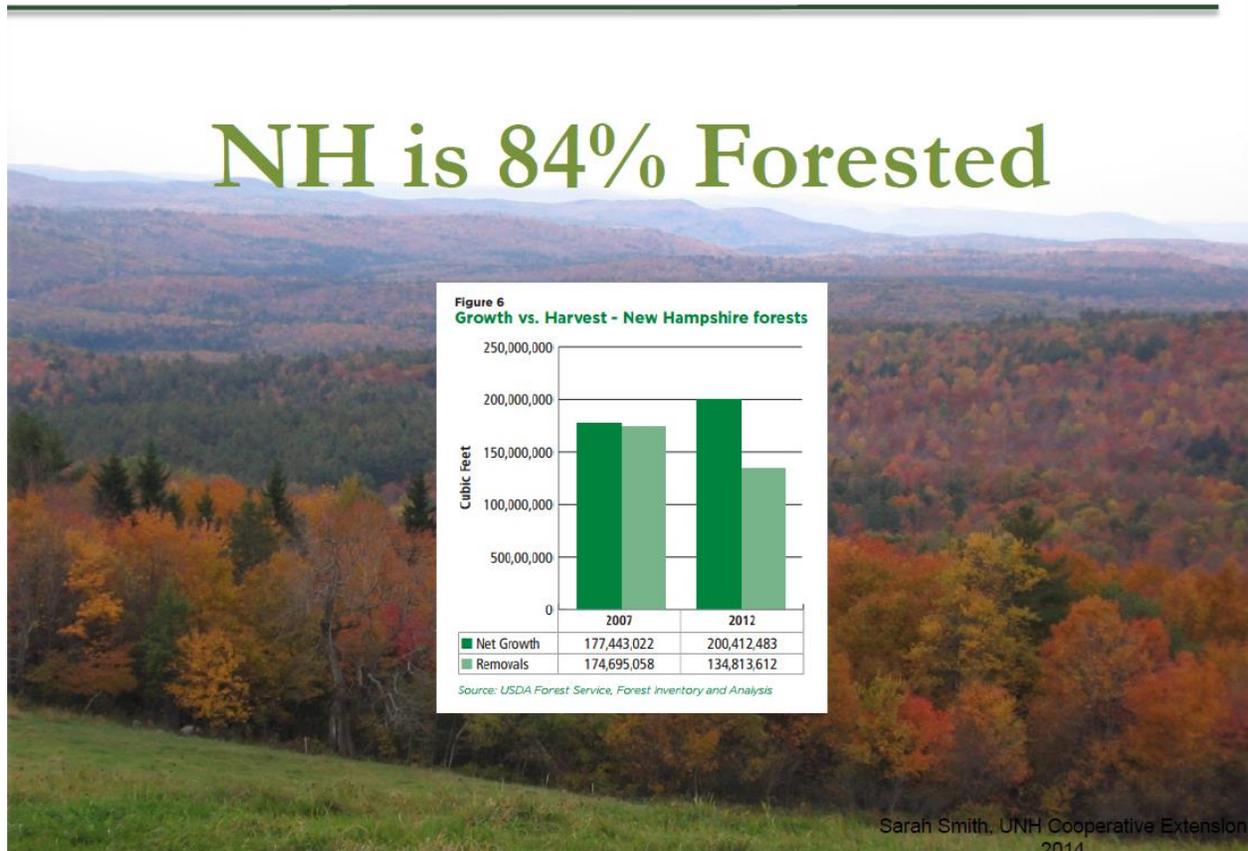
- Memo dated March 18, 2014, from George Brodeur to George McNamara, *Survey of Wood Pellet Boiler Heating Plant Connectivity and Operation Serving the Heating Needs of the Littleton DPW and Fire & Rescue Facilities*
- Line drawing of the proposed heating system for the new highway garage
- Proposed System Details for the Town Garage, Froling Energy
- Drawings of proposed new town garage
- Telephone conversation with Dan Hebert
- Telephone Conversation with Ken Swan, M/E Engineering
- Cut Sheet Insulated wall panels, Nucor Building Systems
- Cut Sheet Passive Solar Energy Overhead Door, R.G. Tombs Door Company
- Article on Radiant Floor Heating, Alex Wilson, Environmental Building News
- Energy Use Data Supplied by the Town of Littleton.

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.

Supply of Wood for Energy: the Forest Resource



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 Dungle
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-converto.com
www.hydro-to-heat-converto.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.com
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 Bjelberg
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