The New Hampshire Municipal Energy Assistance Program

Decision Grade Audit Report

Hopkinton Highway Garage
250 Public Works Drive, Hopkinton, NH 03229

Prepared for:

Town of Hopkinton, NH

Prepared by:

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In cooperation with:

Jeffrey H. Taylor & Associates, Inc.

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The following report was generated as part of the Municipal Energy Assistance Program (MEAP). MEAP is made possible through the New Hampshire Public Utilities Commission and the Greenhouse Gas Emissions Reductions Fund. The program is a collaborative effort to carry out a sequence of greenhouse gas emissions inventories and energy audits for between 24 and 48 geographically diverse communities in New Hampshire, setting the stage for these communities to perform renovations to selected buildings that would reduce energy consumption and greenhouse gas emissions. This report has been generated as a result of the Town of Hopkinton being selected to participate in this program.

To follow MEAP updates and activities please visit www.nhenergy.org.

Additionally, this report would not be possible without the assistance and input provided by municipal employees and volunteers. We are grateful for the time provided to us by the Town of Hopkinton.

For questions regarding this report, please contact:

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Introduction:

MEAP partners are pleased to provide this Decision-Grade Audit Report for the Town of Hopkinton and the Highway Garage (hereinafter "the building"). This report discusses the findings and subsequent recommendations for energy efficiency improvements at the building. Included within this report are details regarding the walk-through and exploration conducted in the facility and examples that illustrate recommended building alterations and improvements that can reduce energy costs and the building's natural resource footprint. In this report we will provide a set of options that can help achieve real energy savings and carbon dioxide reductions. These recommendations should be viewed as initial avenues to participating in several State level funding opportunities for municipal energy projects. These funds distributed under the aegis of the ARRA (American Recovery and Reinvestment Act) are targeted specifically to towns and cities.

Prior to the audit process beginning, each selected municipality must carry out the MEAP energy inventory process. The inventory process is required in order to receive an energy audit. This report relied on those initial findings to help determine the most appropriate building to conduct an energy audit for, with the intent of maximizing the potential energy savings.

The Audit

The first stage of any audit process is understanding the nature of the system and the objectives of the audit. The use of the building and the Town's goals and objectives are the foundation of a solid audit. In most cases, these objectives combine environmental and economic goals. In the case of public buildings and facilities, comfort and safety are also primary concerns that help guide our analysis and recommendations.

A decision grade audit involves an inventory of heating systems, quantification of energy usage (electrical and heating fuel), and the process of coordinating this information with the goals and objectives of the Town into a decision tool. Under MEAP we look to provide recommendations that will, if carried out, help the Town achieve at least a 30% reduction in energy consumption. The level of detail provided herein is meant to create the basis upon which investment grade audits and decisions can be made. The decision grade audit is meant to filter options and expectations so that the Town can understand the fundamental building system, how changes to the system can result in economic and environmental benefits and how those changes can interact with other policy and philosophical objectives.

The following information will describe the characteristics witnessed during the walk-through and those areas of the building complex where improvements may be made. The objective of these recommendations is to create a series of options the Town can further explore.

Energy Data Collection:

Name of Building	Fuel Type(s)	Area* (Sq. Ft.)	Energy Use: Electricity (million Btu)	Energy Use: Heating Fuel (million Btu)	Total Building Energy Use (million Btu)	Site energy intensity (kBtu/sq ft)[1]	EPA Average Site kBtu/sq ft for building type	NH Average Site kBtu/sq ft for building type
Highway Garage	#2 Oil	5000	102	359	461	91	77	62

* The above chart was extrapolated from the Lee Municipal Greenhouse Gas and Energy Use Baseline Report.
Energy use data generated by STOCC software; energy intensity data generated by Portfolio Manager software.
*Source- Hopkinton Assessing Records

2007

Meter: Electricity Meter
Building: Highway Crew Shed
May 15, 2010 - 03:09:58 PM

Fuel Type: Electricity, Grid Purchase (kWh (thousand Watt-hours))
Space(s): Entire Facility

Start Date	End Date	Energy Use	Cost - US Dollars
12/17/2007	1/16/2008	2,760.00	$376.00
11/16/2007	12/17/2007	2,664.00	$374.00
10/16/2007	11/16/2007	2,424.00	$330.00
9/17/2007	10/16/2007	1,740.00	$248.00
8/15/2007	9/17/2007	2,112.00	$295.00
7/17/2007	8/15/2007	1,824.00	$265.00
6/15/2007	7/17/2007	1,848.00	$260.00
5/16/2007	6/15/2007	1,860.00	$292.00
4/18/2007	5/16/2007	2,124.00	$312.00
3/15/2007	4/18/2007	3,204.00	$419.00
2/13/2007	3/15/2007	2,904.00	$390.00
1/18/2007	2/13/2007	2,520.00	$343.33

2008

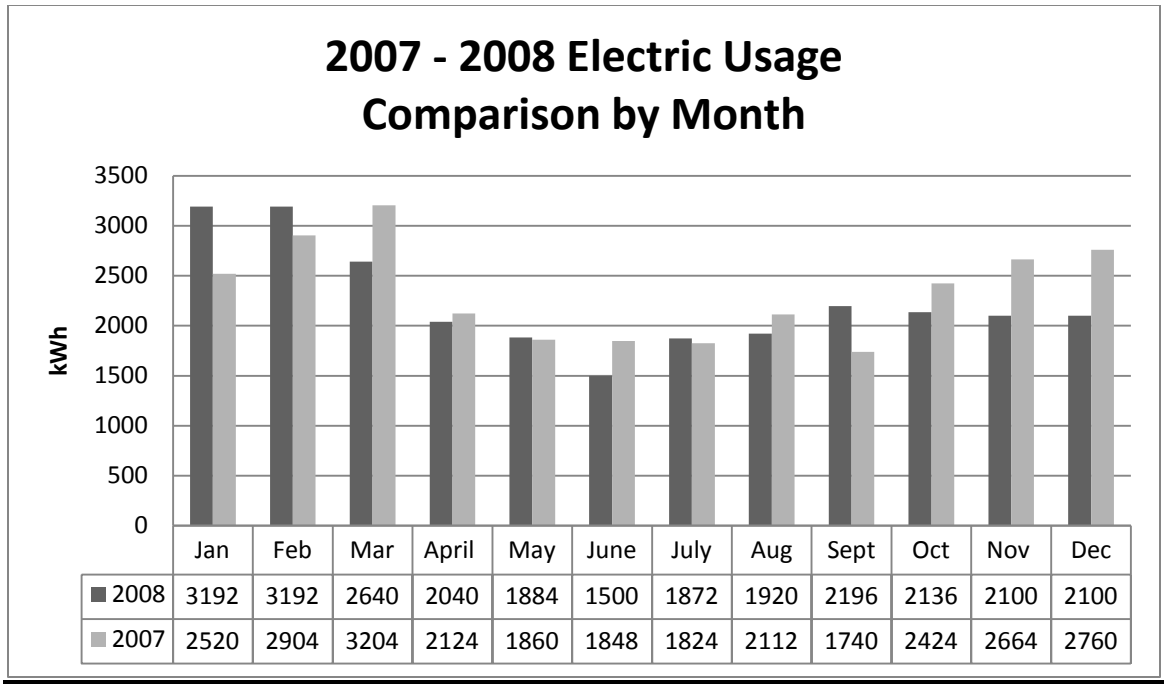
Meter: Electricity Meter
Building: Highway Crew Shed
May 15, 2010 - 03:09:58 PM

Fuel Type: Electricity, Grid Purchase (kWh (thousand Watt-hours))
Space(s): Entire Facility

Start Date	End Date	Energy Use	Cost - US Dollars
11/18/2008	12/31/2008	4,200.00	$623.00
10/18/2008	11/17/2008	2,136.00	$338.00
9/18/2008	10/17/2008	2,196.00	$323.00
8/18/2008	9/17/2008	1,920.00	$295.00
7/18/2008	8/17/2008	1,872.00	$298.00
6/18/2008	7/17/2008	1,500.00	$246.00
5/18/2008	6/17/2008	1,884.00	$303.00
4/18/2008	5/17/2008	2,040.00	$305.00
3/18/2008	4/17/2008	2,640.00	$375.00
2/15/2008	3/17/2008	3,192.00	$437.00
1/16/2008	2/15/2008	3,192.00	$460.00

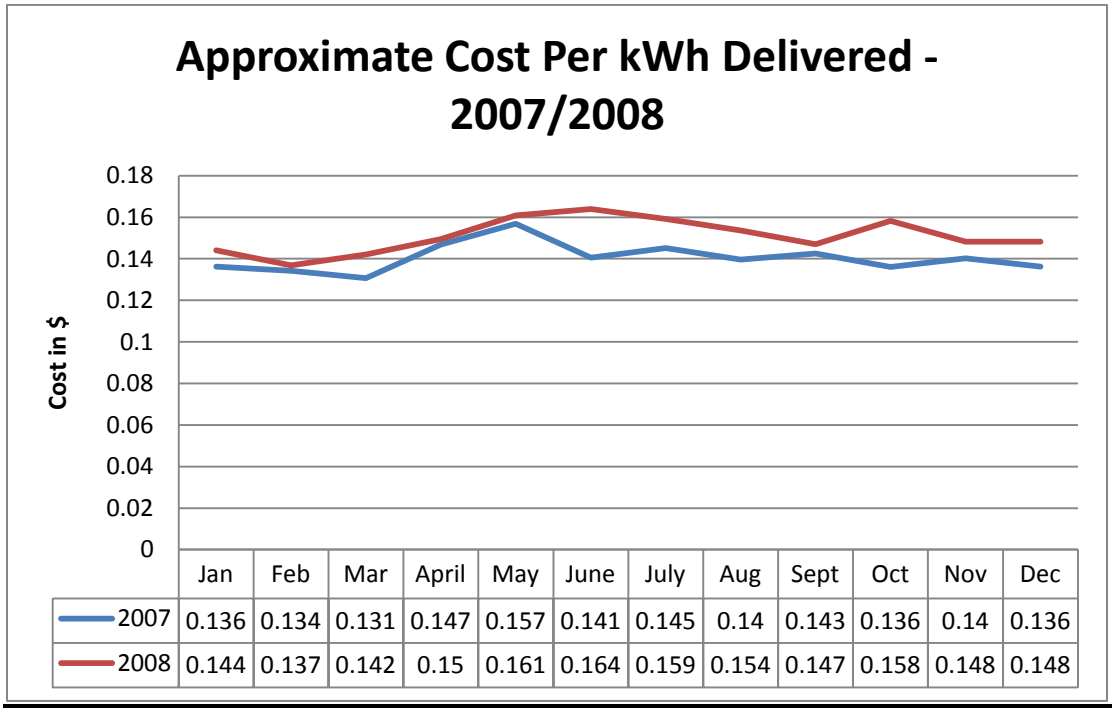
*Note: The presented data was extrapolated from energy information entered into the EPA's Portfolio Manager.

[1] Site energy intensity = amount of energy expended per square foot *on site* to heat, cool, and electrify the area. This measure relates to
how much is being used on site and fluctuates directly with how much lighting is being used, how thermostats are kept, etc.



	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2008	3192	3192	2640	2040	1884	1500	1872	1920	2196	2136	2100	2100
2007	2520	2904	3204	2124	1860	1848	1824	2112	1740	2424	2664	2760

*Graph generated based on data retrieved from the EPA Portfolio Manager account for Hopkinton, NH.



	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2007	0.136	0.134	0.131	0.147	0.157	0.141	0.145	0.14	0.143	0.136	0.14	0.136
2008	0.144	0.137	0.142	0.15	0.161	0.164	0.159	0.154	0.147	0.158	0.148	0.148

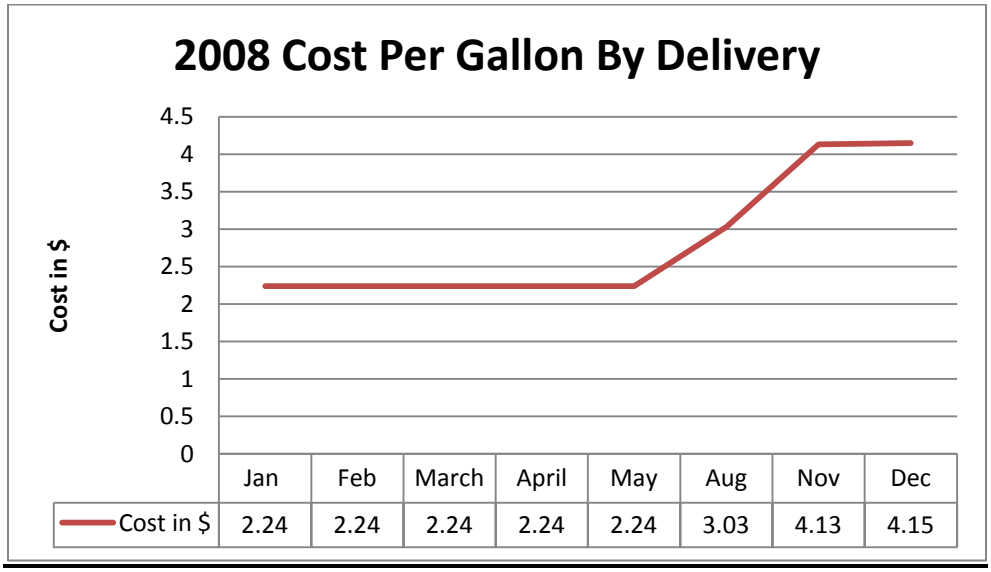
*Graph generated based on data retrieved from the EPA Portfolio Manager account for Hopkinton, NH.

Total kWh used in 2007 – 26,160 kWh
Total Cost of Electricity in 2007 - $3,904.33

Total kWh used in 2008 – 26,142 kWh
Total Cost of Electricity in 2008 - $4,003.00

Meter: Heating Oil Meter			
Building: Highway Crew Shed			
May 15, 2010 - 03:11:03 PM			
Fuel Type: Fuel Oil (No. 2), No fuel generation method associated with fuel type (Gallons) **Space(s):** Entire Facility			
Start Date	**End Date**	**Energy Use**	**Cost - US Dollars**
12/1/2008	12/31/2008	271	$1,127.00
11/1/2008	11/30/2008	161	$665.80
10/1/2008	10/31/2008	0	$0.00
9/1/2008	9/30/2008	0	$0.00
8/1/2008	8/31/2008	63.6	$192.80
7/1/2008	7/31/2008	0	$0.00
6/1/2008	6/30/2008	0	$0.00
5/1/2008	5/31/2008	81.2	$182.30
4/1/2008	4/30/2008	259.2	$581.90
3/1/2008	3/31/2008	250.1	$561.50
2/1/2008	2/29/2008	683.4	$1,534.00
1/1/2008	1/31/2008	819.8	$1,840.00

*Note: The presented data was extrapolated from energy information entered into the EPA's Portfolio Manager.



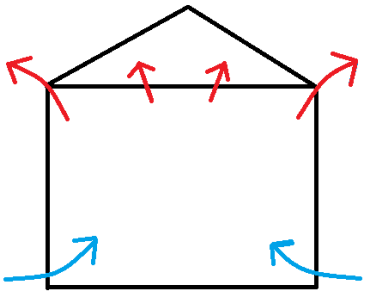
*Graph generated based on data retrieved from the EPA Portfolio Manager account for Hopkinton, NH.

Total Gallons of oil Purchased in 2008 – 2,589.3 gallons
Cost of Gallons Delivered in 2008 - $6,685.30

Basics of Heat Loss:

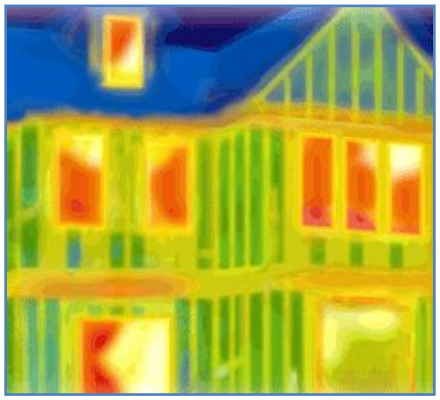
Though we are typically used to measuring heat in temperature, it can be measured in a variety of units. For the purpose of measuring how much heat is produced to condition a space, and how we measure the rate at which heat leaves a structure, we measure in British Thermal Units (BTU's). One BTU is about the same amount of heat produced from a kitchen match. Another good reference to have is that there are about 138,500 potential BTU's in 1 gallon of heating oil. During the winter months, we cannot keep BTU's from leaving our buildings. Hot always goes to cold, or, areas of high pressure are always trying to go to areas of low pressure. What we can do is try to slow the process. We do this by using an **air barrier** and **insulation** at the building envelope to create a thermal barrier.

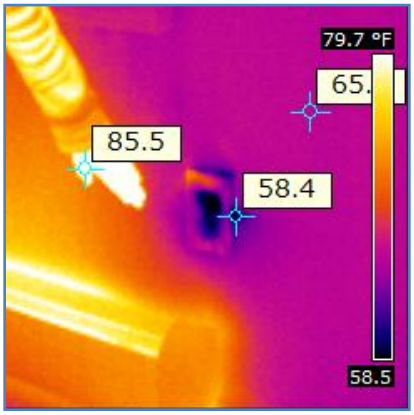
Heat moves through and leaves a building by three different means; *convection, conduction, and radiation*. One way to think of **convective** heat loss is by air movement into and out of a structure. One of the forces causing this to happen is the "stack effect."



The stack effect describes, on a macro level, the natural way in which air moves through a building. As warmed air leaves through the upper levels of a building, cold air infiltrates through the lower sections. In most cases, this pulls air from less than desirable areas of a building, such as basements, crawl spaces and mechanical rooms, which are often damp and unmaintained. These spaces can be the source of exhaust fumes from heating equipment, mold and mildew, as well as a number of other air contaminants such as radon. Without an effective air barrier between the conditioned space and the attic, warm air will exit the building. For every 1 cubic foot of air that leaves a building, 1 cubic foot of air will infiltrate at a different location. Gaining control of the air movement through a building not only has a positive effect on efficiency, but contributes to increased comfort and improved indoor air quality.

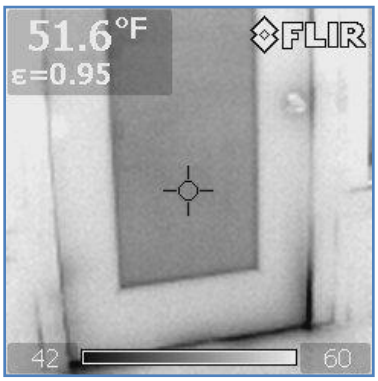
Conduction is the foremost way in which heat travels through a solid building material. At any point in the building envelope where there is a solid building material and no insulation, what is known as "**thermal bridging**" will occur. For example, a 2x6 inch wood stud in an exterior wall has an R-value, or insulative value, of about R-7, while the 5.5 inch fiberglass insulation in the wall cavity is rated at R-19. Solid material in the exterior wall of a typical structure built with 2 inch stock, 16 inches on center (O.C.) will usually make up 20-25% of the wall surface area. This, in combination with all of the doors and windows, means that a significant percentage of the building envelope has an R-value of less than 10. Even a wall with a high R-value cavity insulation such as spray foam is subject to these weak points in the thermal boundary. Employing methods to reduce or eliminate thermal bridging in our new and existing buildings will dramatically reduce energy costs and emissions over the long term as we move towards a new generation of energy and environmental challenges.





Radiant heat loss describes how heat waves, or infrared radiation, pass through space from one surface to another within its view. For example, the heat from a hot cooper pipe will radiate towards cooler surfaces around it, like an exterior wall. The heat can then conduct through building materials to the exterior.

With regards to the building envelope, **gaining control of convective heat loss is the main priority, and usually the easiest to address through air sealing**. After this is done, increasing insulation levels, or R-value, of the building envelope is the next step to gain better control of conductive heat loss. In many cases, a large amount of a structure's radiant heat loss will be addressed with added insulation, either to ceilings, floors, walls, ductwork, or piping. Treating the whole building as a system, and addressing all the issues of heat loss will produce optimum savings and comfort.



<u>Basics of Moisture Control:</u>

The issue of moisture control in buildings is very complex and essential to maintaining structural durability and occupant health. The mismanagement of moisture can lead to a multitude of negative effects. Some of these are mold growth, poor indoor air quality, early materials and equipment degradation, and large negative health impacts on the people who live and work in our buildings.

The two basic forms of moisture in need of managing are bulk moisture (fluid), and water vapor. Two important ways to manage bulk moisture are to keep rain and ground water from entering our buildings, and to quickly fix any water leaks from sources within our buildings such as leaking pipes.

Managing relative humidity and water vapor is a challenge. At some points of the year, occupants want more humidity in the air to maintain comfort, and less in other times. For example, in the winter months we want more humidity indoors because it helps occupants experience greater comfort. In many situations, we increase the relative humidity mechanically with humidifiers. When indoor air is too dry during the winter, we feel colder, develop dry skin, and our upper respiratory can become dry causing discomfort.

Conversely, in the summer we want the air to be dry. Just as hot goes to cold, wet goes to dry. We cool ourselves by perspiring. As we produce this moisture on our skin, it evaporates into the air, drawing heat away from our bodies. The temperature of a room may not be very high, but if the relative humidity is high, we will feel hot because our perspiration is evaporating at a slower

rate. Much of the comfort we achieve from using an air conditioning system (AC) is by removing the moisture from the air, allowing our skin to dry more quickly.

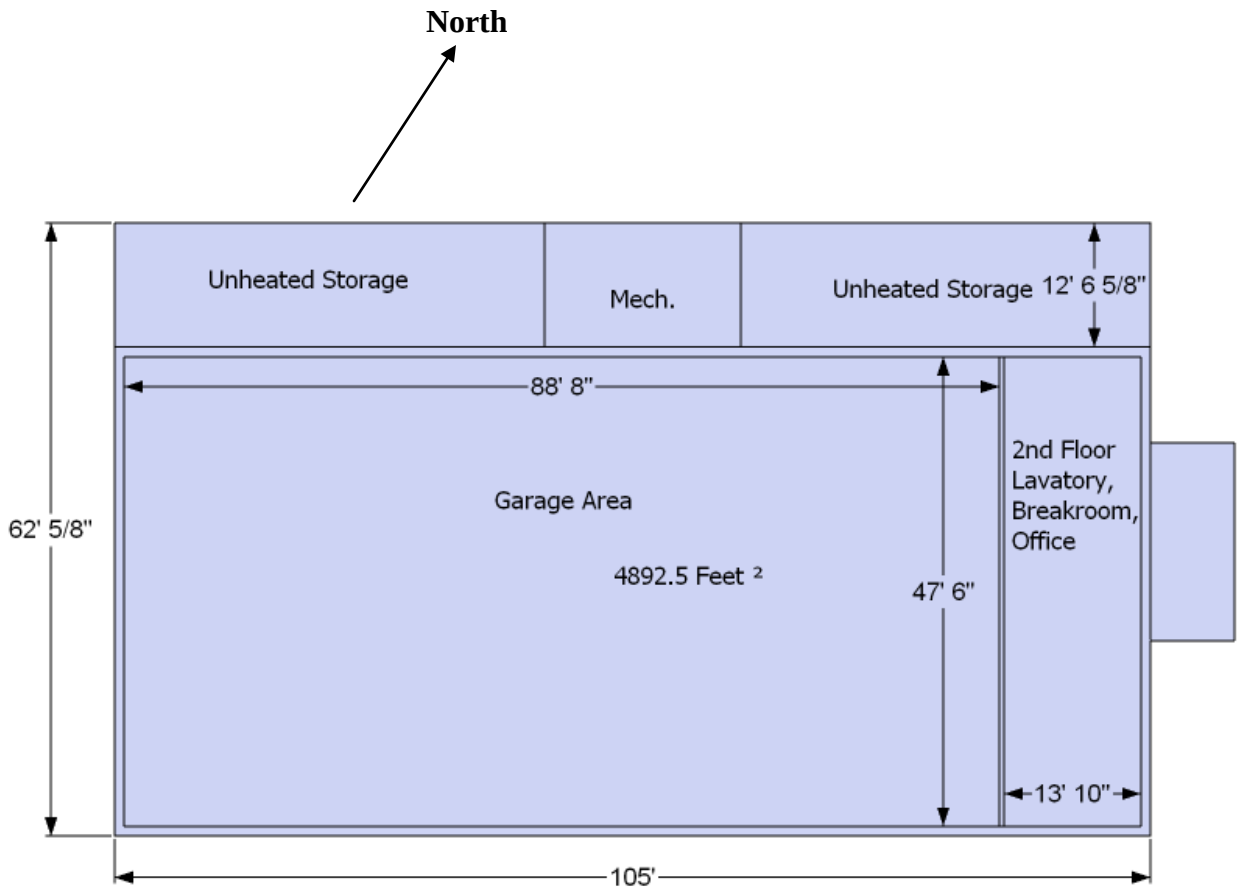
In the winter, there will always be some level of moisture in a heated and occupied space. We want this moisture, or water vapor, to stay within the occupied space for many reasons. Two of the most important reasons are to help occupants feel more comfortable, and to keep the water vapor from causing damage within the building envelope.

Just as BTUs conduct through solid materials, water vapor diffuses through solid materials. Some materials are more resistant to vapor diffusion, such as polyethylene, and so we use these to try and form a vapor barrier on the inside of the thermal boundary in an attempt to slow the amount of vapor diffusion. Small amounts of vapor traveling through a properly constructed building envelope will diffuse all the way to the exterior, and not cause any damage**. If a large amount of vapor is allowed to enter a wall cavity, the molecules will condense on the nearest cold surface.** When this happens, moisture can build up on the inside of the exterior wall sheathing, or on other surfaces. This will cause a number of problems including long term damage to insulation and structural components, as well as the promotion of mold growth.

It is important to try and identify any current moisture problems, and address them properly. This is always done by first finding and controlling the source of the moisture. Sometimes it can be quite difficult to see moisture damage, as it may be buried inside of wall cavities. It is also important to know that by making changes to a structure and its envelope, we can change the way, sometimes negatively, in which moisture affects the building.

Building Description:

The Hopkinton Highway Garage was built in 1986. It is an approximately 5000ft² wooden structure with five large garage bay doors. The building serves as a home base for the management of the Town's roads, and service station for the Town's vehicle fleet. There is a large unheated shed that runs the entire length of the north side of the structure, and a second floor lavatory, break room, and office on the east end.



Foundation:

The building sits on a concrete slab foundation. There is one section of the slab that has radiant heat, and it is unknown to us whether this or any other section of this slab has any insulation beneath.

Experts say that insulating around a slab can save 10%-20% on heating cost. Insulating the slab would require digging a 4-foot deep trench alongside the building and applying 2 inches of foam board with an exterior finish. This is an effective way in which to slow the heat loss from around the perimeter of the slab, though somewhat controversial. In some cases where this insulation method has been used, pests, such as ants, have found their way into the foam board and made nests. Given this, it is very important to create a strong barrier between the foam and any potential infestation. A thick cement scratch coat with a lime based plaster applied the entire depth of the foam is an ideal solution to this potential problem.

Recommendations:

- Insulate around the exterior perimeter of the concrete slab. This should only be done after all the higher priority recommendations have been carried out.

Exterior Walls:

The exterior stud wall appears to have been constructed with 2x8 inch stock. The exterior has plywood panel siding. The interior has a poly vapor barrier with ½-inch OSB, sometimes called wafer board, fastened to the inside of the studs. The wall cavities have been insulted with fiberglass batt insulation, though it is uncertain what thickness fiberglass was used. With a stud depth of 7.25 inches, the best fit for fiberglass insulation would have been an 8-inch roll, giving the cavity an R-value of 25 if it was installed well. If fiberglass rolls of a greater thickness were used, the rated R-value would decrease, as the fiberglass would be compressed. A 6-inch roll would leave air gaps either in the interior, or most likely, on the exterior of the wall. This would be unfavorable as this could lead to a host of problems, including possible moisture condensation on the inside of the board siding.

Figure 1 shows an example of how the tops of the walls have been finished. This gap is allowing air and vapor to move into the top of the walls and the attic space. Sealing these gaps will not only positively affect the thermal performance of the building, but also promote structural durability.

Figure 1

Recommendations:

- Seal any penetrations that may have punctured the vapor barrier in the main fields of the exterior walls.
- Seal along the top and bottom of the exterior walls where they meet the metal ceiling and slab.

Ceilings:

This building has a truss rafter system with a metal roof. The ceiling above the conditioned space was constructed with the same kind of metal roofing material. On top of the metal roof, in the attic, are 3½-inch fiberglass rolls, with several inches of loose fill fiberglass blown on top.

All along the perimeter, the fiberglass rolls are out of place, and the blown insulation stops well short of the edge, as seen in Figure 2. Figure 3 shows how the metal has been darkened around the edges of the ceiling where there is little or no insulation above. Though we inspected this building on a warm day, we believe this darkening is occurring in the cold months as a result of condensation due to the lack of insulation.

Figure 2

Figure 3

We pulled the fiberglass away in many locations to examine conditions underneath. What we found throughout the entire attic was soot mixed in with the fiberglass. See Figure 4. This is most likely coming from the vehicle exhaust. Sheet metal serves as a great air and vapor barrier. The problem here is that none of the seams of the metal roofing have been sealed where they overlap. Fiberglass insulation does little to impede airflow. Many would describe fiberglass insulation as a glorified air filter, and in fact, that is just what it is serving as here.

Figure 4

There are water stains throughout on the wooden truss system seen here in Figure 5. One or two issues are causing this. Either the roof is leaking at the fasteners, which, by the visual inspection of the roof from the exterior, we believe could be possible. Or, the amount of heat and water vapor passing between the seams of the metal ceiling is too much to be easily vented before condensing on the inside of the metal roof. There is likely a great deal of moisture introduced to the garage bays during the winter months, as snow covered trucks enter and melt onto the floor. After the snow melts, it evaporates into the air, and will try to escape the building wherever it can. A great deal of the water vapor will inevitably make its way through the seams of the metal sections.

Figure 5

Figure 6

However it is happening, it is clear how the moisture on the underside of the metal roof flows towards the eaves, hits the 2x4 strapping, and then drips onto the loose fill fiberglass. It is evident by the neat grooves in the loose fill fiberglass running directly beneath each of the strapping rows seen in Figure 6. This will lead to the early deterioration of the wooden trusses, and it also reduces the effectiveness of the insulation below.

The benefit of air sealing the metal ceiling would be two fold. It would control the amount of heated air escaping into the attic, but it would also control the amount of water vapor movement to the attic.

There are two attic vents at either gable end of the building. One of the vents was installed upside down, and is allowing for rain to enter the attic. This is causing damage to the plywood sheathing. It is also degrading the fiberglass insulation around this vent, saturating it over and over again, compressing it, and rendering it ineffective. There is also the large possibility that this bulk moisture has leaked into the wall cavity below. See Figures 7 and 8.

Figure 8

Figure 7

Recommendations:

- Correct the attic vent on the south gable. It should be turned 180° so that the slats will shed water. Be sure that this vent is properly flashed to keep water from intruding around the edges.
- Air seal all of the seams of the metal ceiling. This should be done with a durable caulking that will adhere well to the metal, and not soon dry and crack.
- Insulate the back of the attic access board with at least 4 inches of rigid foam boar insulation. Create an insulation dam to accommodate an addition amount of loose fill fiberglass, and be sure that the attic hatch provides a good air seal when closed.
- Determine a good method of venting along the eves of the roof. In most cases this is done with "Proper Vent", which is usually stapled to the underside of roof sheathing. Because there is only exposed metal roofing, a different method will have to be developed. It is important to seal between the top of the wall and the vent system.
- Achieve an R-60 with additional inches of loose fill fiberglass. We would almost always suggest using blown cellulose as it performs more efficiently from a thermal performance standpoint. In this case, there is remaining concern about moisture dripping from the underside of the roof, and fiberglass will be more resistant to this potentially ongoing issue.

Doors and Windows:

There are very few windows in this building. We would not recommend replacing any of the windows, though it is important that the windows shut well to provide a good air seal, and that there is no air infiltration coming from around the window frames/trim.

There are five large garage bay doors. There is one insulated bay door on the west side of the building, and four translucent panel bay doors on the south side. There are pros and cons to these four doors. Below is a comparison of the basic positive and negative effects from having translucent panel bay doors vs. foam core bay doors. Determining which doors would be better would require a combined heat loss, heat gain, and lighting study. For the time being, we recommend not replacing the doors, but taking steps to ensure that they are sealed as best as possible without negatively affecting their operability.

Translucent Bay Doors	**Winter**	**Summer**
Day	• Reduce the need for interior lighting (positive). • Offer beneficial heat gain from solar radiation (positive).	• Reduce the need for interior lighting (positive). • Offer heat gain from solar radiation (negative).
Night	• Have much less R-value compared to a foam core door (negative).	• No strong negative or positive effect.

Foam Core Bay Doors	**Winter**	**Summer**
Day	• Superior insulative value (positive). • Offers no day lighting (negative). • Offers no beneficial solar heat gain (negative).	• Provides shade from the sun (positive). • Do not offer day lighting, but the doors are likely open much of the time anyway. (negative).
Night	• Superior insulative value (positive).	• No strong negative or positive effect.

Recommendations:

- Make sure that all the doors of this building provide as good an air seal as possible without disturbing their operability. This would include the interior doors to the storage sheds.

Mechanical:

Two separate heating plants heat this building. There is an oil-fired furnace (Figure 9), which supplies hot air to the main garage area, and an oil-fired boiler (Figure 10) that supplies hot water to the radiant loop, and to base boards in the office and break room.

Figure 9

Figure 10

Both the furnace and the boiler are older, fairly inefficient units. We did not perform a combustion analysis, though it safe to assume that the boiler has a combustion efficiency of between 85% and 87%, while the furnace is likely burning between 80% and 84%.

None of the hot water pipes from the boiler are insulated. This means that when there is a call for heat from the office/break room, a fair amount of the heat produced from the boiler is lost along the way. If the pipes were insulated, it would help the boiler to run for a lesser amount of time in order to satisfy the heat needs in this section of the building.

None of the ductwork has been sealed or insulated. We would only recommend air sealing and insulating the ductwork within the mechanical room. Normally, we would recommend air sealing and insulating all of the ductwork, even if all of the ductwork were located inside of the thermal boundary. However, because it is supplying air to a single room, and because all of the supply ductwork effectively runs along the floor, we do not see this as a large inefficiency, and would recommend not expending time and monetary resources towards air sealing or insulating all of the ductwork.

Replacing these two heat plants with newer, oil-fired heat plants would not yield a substantial amount of savings. Instead, we would recommend investigating the benefit of replacing the furnace with a biomass hydro/hydro-air system, with a fossil fuel backup system.

An ideal operation scenario for this building could be this; the air handler, baseboard, radiant loop, and domestic use would all pull heat from the storage tank as needed. The biomass boiler would have the job of keeping the storage tank up to temperature. If for any reason the biomass boiler fails to do so - for example, the auger system fails - the fossil fuel boiler would fire to maintain the temperature of the storage tank.

The basic process for switching to a biomass system is roughly outlined below. Also see Figure 11 for a visual explanation:

- Replace the furnace with an air-handling unit.
- Keep or replace the current boiler as a backup heat plant. A heat loss study of the building would determine if the current boiler is large enough to maintain building demand.
- Build a small insulated shed off the north side of the mechanical room, or, section off a portion of one of the storage spaces on either side of the mechanical room.
- A second chimney would be needed.
- Install either a pellet or cordwood boiler that would supply hot water to a heat storage tank located in the boiler room.
- If using a pellet boiler, install a silo on the north side of the building to supply pellets to the boiler via an auger system.

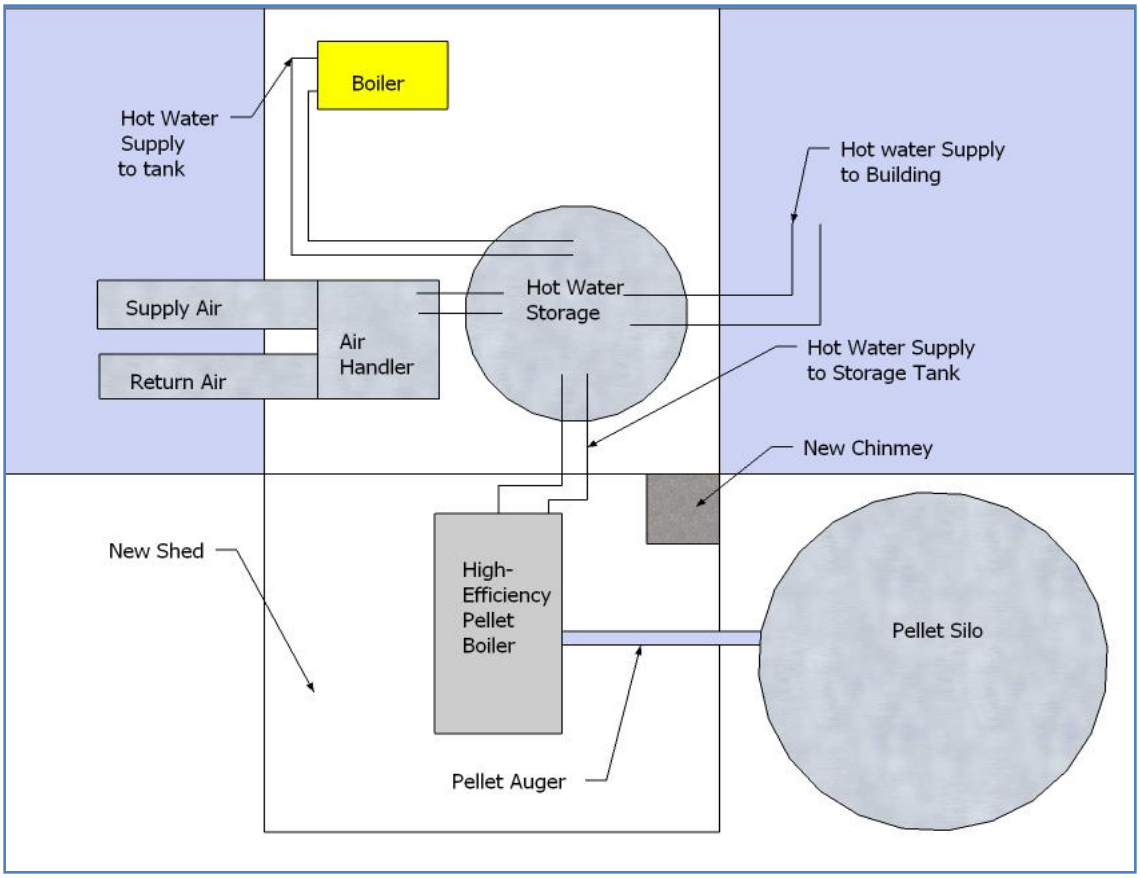


Figure 11

Making a switch from a heating oil system to a wood pellet or cordwood boiler system will not only reduce annual heating cost, but also dramatically reduce the greenhouse gas emissions from facility operations. There are pros and cons to going with either wood pellets or cordwood as a fuel source. It would be important to examine all options to find the most appropriate fit for this particular building. A high efficiency cordwood boiler would produce similar results as a pellet boiler, though a pellet boiler will need much less active maintenance. Be sure to have a full financial analysis done as to thoroughly understand this potential investment and the estimated savings.

Recommendations:

- Bring supply air from the outdoors into the mechanical room. Currently, there is a vent from the garage into the mechanical room above the mechanical room door. This vent, and the door should be sealed. This is best done by attaching ductwork to the wall vent and running the ductwork to about a foot or so off the mechanical room floor.
- Insulate all of the hot water pipes starting at the boiler.
- Replace the two thermostats with 7-day digital programmable thermostats. Having a set-heating schedule should yield real savings at a very low cost.
- Take measures to help the current hot water system to operate more efficiently. Two items that would help substantially would be to install a modulating aquastat (outdoor reset), and to replace the current hot water storage tank with a high-efficiency foam insulated indirect hot water heater.
- We recommend installing a high efficiency pellet or cordwood boiler as the primary heat source for the building.

Electrical:

The majority of the electric use in this building seems to be from the use of power tools, compressors, and lighting. Given the nature of the facility, there is little room for improvement by the tool and compressor usage. One task that could be performed would be to check all the compressor lines for air leaks, including hose and tool fittings. Maintaining air pressure when tools are not in use would be a good way of ensuring that the compressor does not turn on more than needs be.

The lighting in this building is primarily a combination of high intensity discharge (HID) lamps, T12 florescent tubes, and halogen lamps. We would encourage the Town to always be seeking more efficient lighting options, not only in this building, but also in all of the Town's structures.

LED lighting has come a long way in the past several years, and the use of this very efficient light source is becoming more and more popular. Whether for high bay lighting, task lighting, and even flood and parking lot lighting, the LED market is ever expanding to meet all lighting needs. One of the largest deterrents for most potential LED buyers is the high initial cost. Regardless of the high initial cost, there are enormous benefits to choosing this option. Operational costs are decreased due to a much lesser electrical demand of LED lamps. If LED lights are to replace metal halide lamps, not only will they use less electricity, but also the hours of operation can be reduced because LED's do not need warm up time. When the light switch is

turned on, they are emitting full lumen output almost immediately. This would allow for bay lighting to be turned off for smaller segments of time throughout a workday.

LED lamps also last much longer than any other lamp, reducing the cost of purchasing and installing new lamps more frequently, and the cost recycling the old lamps, which contain hazardous materials.

There is some opportunity to save electricity from phantom loads. Phantom loads describe how a piece of equipment will still draw a small amount of electricity even when the unit is turned off. Putting items like computers and printers on a power strip, then cutting the power to the devices will help eliminate waste.

After work has been done to reduce the electric demand of the building, onsite generation of electricity with the use of photovoltaic (PV) panels is always recommended.

Recommendations:

- Put all electronics on power strips and be sure to cut the power to this equipment when they are not in use.
- Check all of the compressor lines and hose/tools fittings for air leaks.
- Consult a lighting specialist to develop a lighting retrofit plan. Look to utilize the excellent day lighting available on this site, and high efficiency LED lighting options.
- Whenever buying new equipment like refrigerators, washing machines, computers, printers, etc. always buy the most energy efficient equipment available. The initial cost for high-efficiency equipment will be a little more, but understand that the long-term savings will render this a more frugal purchase.
- Install a photovoltaic (PV) system on site. Given the orientation of the roof, it may be best to install a ground-mounted system. Figure 12 shows one potential location along the northern tree line.

Potential PV location

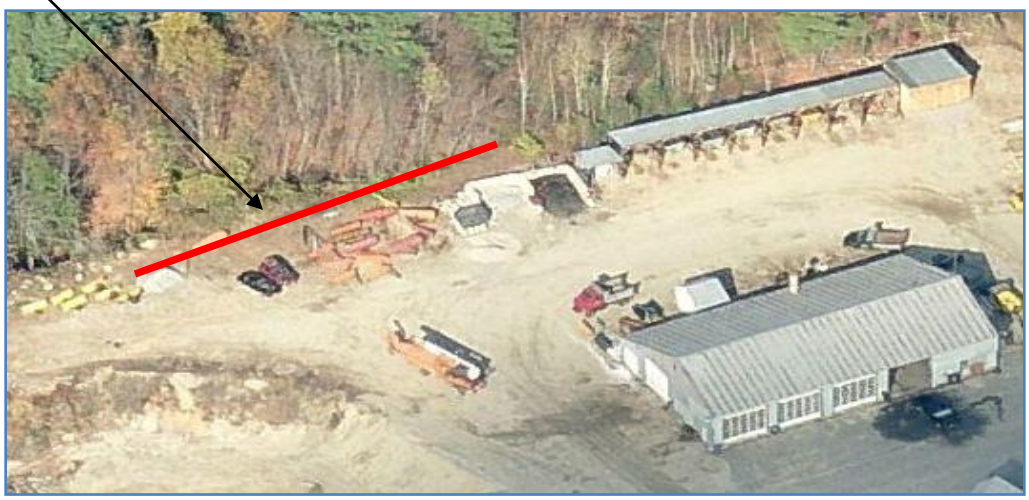


Figure 12. The above photograph was retrieved from Bing™ Maps.

Ventilation:

There is one exhaust fan located on the west gable end of the building. We would recommend that the building and this exhaust system be inspected by a ventilation specialist to verify ventilation adequacy, and, if necessary, to make recommendations as to how to meet ASHRAE standards for a building of this size and use. With vehicles driving in and out of this building, there is potential for dangerous exhaust, gasoline, and other fumes to reach unhealthy levels. Maintaining a healthy work environment for Town employees should be one of the primary goals.

Summary of Recommendations:

- Correct the attic vent on the south gable. It should be turned 180° so that the slats will shed water. Be sure that this vent is properly flashed to keep water from intruding around the edges.
- Bring supply air from the outdoors into the mechanical room. Seal the mechanical room door, and the above vent.
- Air seal all of the seams of the metal ceiling. This should include where the metal ceiling meets exterior walls.
- On a warm rainy day, carefully examine the attic space to see if there are any leaks in the metal roofing. It would be beneficial to know if the water damage is coming from winter time condensation alone, or also from a leaky roof.
- Check all of the compressor lines and hose/tools fittings for air leaks.
- Put all electronics on power strips and be sure to cut the power to this equipment when they are not in use.
- Insulate all of the hot water pipes starting at the boiler. This would include the hot water pipes from the electric hot water heater.
- Replace the two thermostats with 7-day digital programmable thermostats.
- Make sure that all the doors of this building provide as good an air seal as possible without disturbing their operability. This would include the interior doors to the storage sheds.
- Seal any penetrations that may have punctured the vapor barrier in the main fields of the exterior walls.
- Take measures to help the current hot water system to operate more efficiently. Two items that would help substantially would be to install a modulating aquastat (outdoor reset), and to replace the current hot water storage tank with a high-efficiency foam insulated indirect hot water heater.
- Determine a good method of venting along the eaves of the roof.
- Insulate the back of the attic access board with at least 4 inches of rigid foam boar insulation. Create an insulation dam to accommodate an additional amount of loose fill fiberglass, and be sure that the attic hatch provides a good air seal when closed.
- Achieve an R-60 in the attic with additional inches of loose fill fiberglass insulation.
- We recommend installing a high efficiency pellet or cordwood boiler as the primary heat source for the building.

- Consult with a lighting specialist to develop a lighting retrofit plan. Look to utilize the excellent day lighting available on this site, and high efficiency LED lighting options.
- Install a photovoltaic (PV) system on site. Given the orientation of the roof, it may be best to install a ground-mounted system. Figure 12 shows one potential location along the northern tree line.
- Insulate around the exterior perimeter of the concrete slab. This should only be done after all the higher priority recommendations have been carried out.

Financial Considerations and Options:

A common occurrence across many communities within New Hampshire is the challenge of obtaining the necessary capital funds to carry out the recommended retrofits found within the audit. The following information is an attempt to provide some assistance with understanding some concepts and pathways to acquiring public or private funds to carry out an energy efficiency or generation project. Also, portions of the following information have been taken from the New Hampshire Handbook on Energy Efficiency and Climate Change – Volume II.

Life Cycle Costing –

The National Institute of Standards and Technology (NIST) Handbook 135, 1995 edition, defines Life Cycle Cost as "the total discounted dollar cost of owning, operating, maintaining, and disposing of a building or a building system" over a period of time. Life Cycle Cost Analysis is an economic evaluation technique that determines the total cost of owning and operating a facility over period of time.

Since municipal buildings are funded in their initial year through bonds and/or capital outlays, they generally fall victim to an inordinate focus on the bottom line cost of construction instead of the lifetime cost to operate the building. This is a critical misstep in particular with energy concerns for municipal buildings because they are placed in service for a significant period and are subject to extended energy pricing. A more efficient building could save the costs of initial investments several times over during its lifespan.

Energy Price Stability –

The second most important concern about energy costs is the volatility. Municipalities budget on a yearly cycle and must predict energy costs over the year – sometimes over pricing the cost in the case of high lock in prices or subjecting the municipality to risk where a cost (+ some percentage) contract is used for the year. When prices go up budgets go up, when the go down, budgets tend to go down. Changes result is wide variation in predictability and thus lead to fund shortages or balances, and general frustration on all sides of the discussion.

The concept of stability in the context of energy prices is achieved through on-site distributed generation with effective predictive modeling and most importantly, efficiency. The cheapest energy available is the energy you don't need. The less you buy the less amount of appropriations are subject to the price swings.

"Green" Building Cost Myths –

A perception that all energy-efficient construction costs more than conventional construction persists. We have been unable to find valid research that supports this conclusion - especially where choices made about efficiency are evaluated in a realistic context considering the life cycle cost to operate the facility. To the contrary, we have found several sources, from government facility agencies, that show not only that in most cases costs are in fact lower but that any increased cost is almost immediately realized through lower operating expenses.

A terrific resource to understand what type of incentives are available for both energy efficiency and generation is the "Database of State Incentives for Renewables & Efficiency", or DSIRE. This site, funded by the US Department of Energy, provides a list of the potential financial incentives found within New Hampshire and the Federal Government. To see what is available within New Hampshire go to www.dsireusa.org and click on New Hampshire.

Utility Programs:

Many utilities provide rebates for various types of efficiency measures that can be carried out at a municipal facility. PSNH offers the Municipal Smart Start Program. This program offers the opportunity for municipalities to go forward with the installation of approved measures at no up front cost to the municipality. A town simply pays for the energy improvements with the savings from reduced energy usage until the project is paid off.

For more information please contact Sue Blothenburg, (603) 357-7309 ext. 5115, or visit http://www.psnh.com/Business/Efficiency/Paysave.asp

Third-Party Financing Options

The most important part to understanding the potential in third-party is the ability to address up front capital costs and access tax benefits. Additional benefits are potential operations and maintenance savings where the implementation is owned by a third-party. In the three-party model, new businesses create an income stream and take over the insurance, performance assurance, and maintenance of the renewable energy system. New jobs and local investment follow. The business secures stable and long-term funding enabling expansion to other facilities for similar projects.

There are several benefits that appear for the municipality that is considering a third-party financing strategy.

Ability to Monetize Federal Tax Incentives. Federal tax incentives for some projects can equal 30% of the installed capital cost. Under the current law, this 30% is payable in the form of a grant from the Department of Treasury. In addition, businesses can accelerate the depreciation of the cost of a some systems and installations using a five-year schedule. Together, these two incentives can have a tremendous impact on both the cost of and the financial returns on a project. Local governments, however, cannot directly benefit from these incentives. The third-

party ownership model introduces a taxable entity into the structure that can benefit from the federal tax incentives, lowering the overall cost to the non-taxable entity.

*Low/No Up-front Cost*s. Even with programs to provide support to municipalities, such as rebates and grants, the need to reduce this amount, the up-front cost is significant. Given the current economy and budget constraints, a large initial investment is difficult to achieve regardless of the return on the investment. A third-party structure places the responsibility of the increased initial cost on to the investor/developer of the project.

Predetermined Energy Pricing. In a project that involves efficiency or distributed generation, the portion of conservation or generation that is met by the project can be considered "fixed" at a particular price in the terms of the contract. This can be in the form of a fixed-priced power purchase agreement (with a predetermined escalation rate).
This predictability offers stable pricing for the portion of the entity's load served by the project. In most cases, the price of electricity in power purchase agreement is usually set at or below the customer's current retail rate for the first year, and then escalates annually for term of the contract (in a solar PPA, these terms are usually 20 – 25 years). For solar projects, an annual price escalator of 3-3.5% is common.

Operations and Maintenance. Another attractive feature of the third-party ownership structure is the fact that new equipment can result in lower operation and maintenance expenses and in the case of some systems, the entire cost and responsibility can shift to the project developer.

Eventual Ownership. As a final issue, third-party structures can be pre-crafted to permit and even encourage local government buyout provisions. This allows the municipality to consider advanced purchase options if circumstances change in a way that makes this pathway more beneficial. If for instance a grant program becomes available, such funds can be used to accelerate the ownership path and provide for a more immediate "vesting" of full savings opportunities.

Otherwise, these arrangements usually provide for a number of options at the end of the term, the three likely scenarios for the host would be to: 1) extend the arrangement, 2) purchase the facility, or 3) ask that the improvements be removed.

Conclusion:

As a indicated in this audit report, the Town has several options available to increase the efficiency of the Highway Garage. We highly encourage the that the Town pursue these recommendations described in this report and to utilize the further assistance provided under this program to help develop plans for implementation – including possible identification of contractors who will provide the services needed to carry out the recommendations. SDES Group will provide the Town an additional twenty-five hours of Community Energy Advocate service to assist with further efforts under the MEAP program in an effort to bring the recommendations outlined in the report to fruition.