The New Hampshire Municipal Energy Assistance Program

Decision Grade Audit Report

Town Garage - 602 North Sandwich Road
Sandwich, NH 03227

Prepared for:

Town of Sandwich, NH

Prepared by:

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Clean Air Cool Planet

Sustainable Energy Resource Group
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Carbon Solutions New England™

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6/8/2010

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 Sandwich 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 Sandwich.

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Introduction:

MEAP partners are pleased to provide this Decision-Grade Audit Report for the Town of Sandwich and the Town 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 to understand 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.

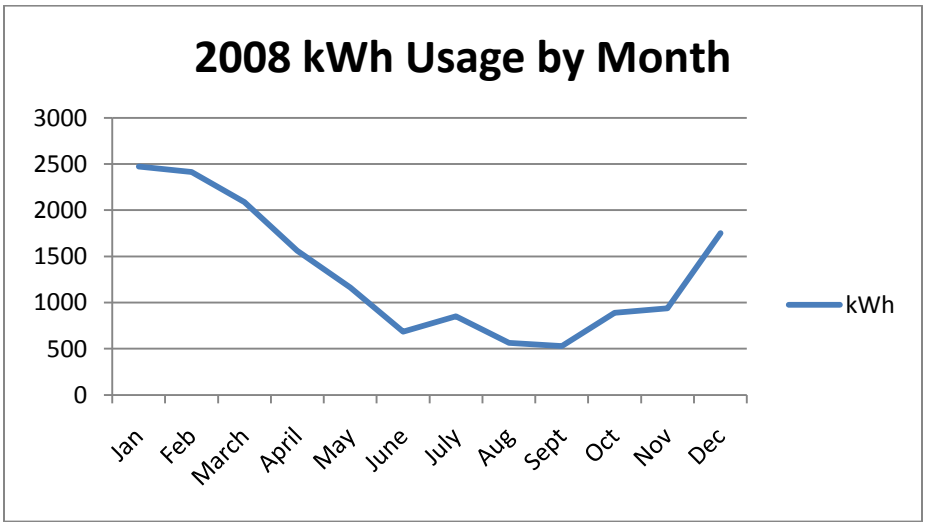
Energy Data Collection:

Table 1

Meter: Town Garage			
Building: Town Garage			
April 19, 2010 - 02:31:14 PM			
Fuel Type: Electricity, Grid Purchase (kWh (thousand Watt-hours)) **Space(s):** Entire Facility			
Start Date	**End Date**	**Energy Use**	**Cost - US Dollars**
12/1/2008	12/31/2008	1,752.00	$294.34
11/1/2008	11/30/2008	936	$175.82
10/1/2008	10/31/2008	888	$174.57
9/1/2008	9/30/2008	528	$105.08
8/1/2008	8/31/2008	564	$125.91
7/1/2008	7/31/2008	852	$159.88
6/1/2008	6/30/2008	684	$133.31
5/1/2008	5/31/2008	1,164.00	$224.18
4/1/2008	4/30/2008	1,560.00	$252.93
3/1/2008	3/31/2008	2,088.00	$317.37
2/1/2008	2/29/2008	2,412.00	$346.73
1/1/2008	1/31/2008	2,472.00	$352.11

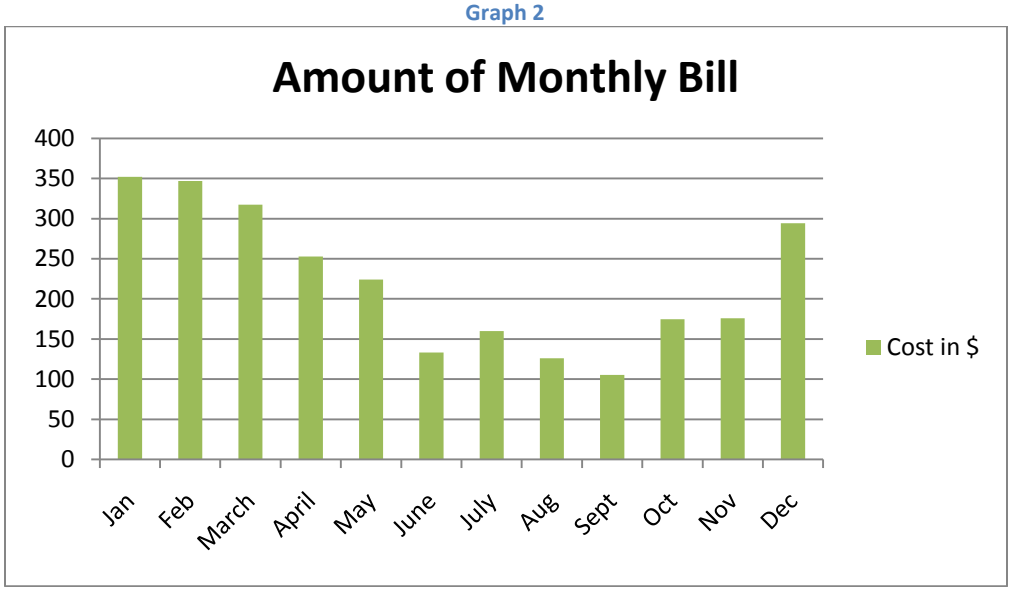
*Note: The presented data was extrapolated from energy information entered into the EPA's Portfolio Manager.

Graph 1



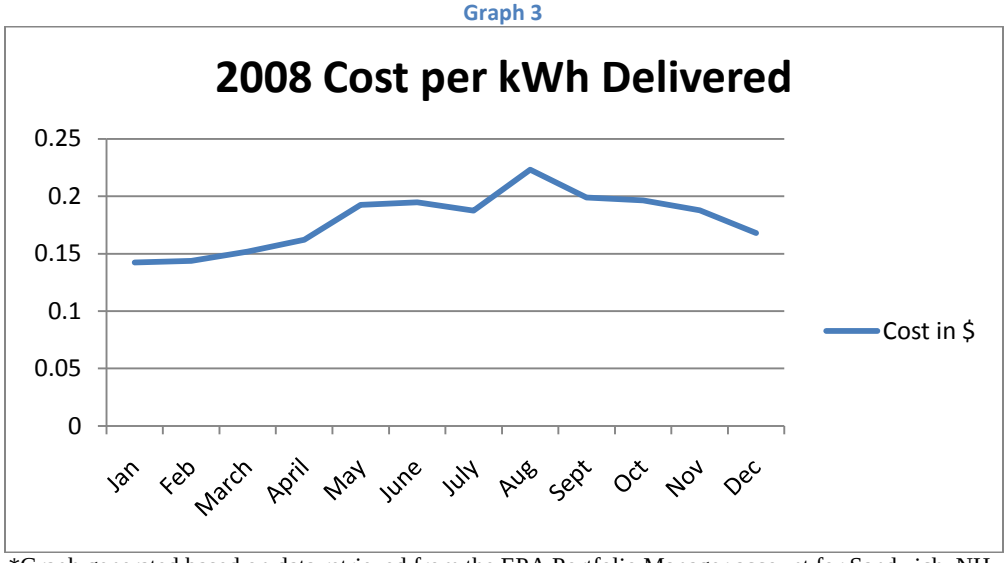
*Graph generated based on data retrieved from the EPA Portfolio Manager account for Sandwich, NH.

Graph 2



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

Graph 3



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

Total Electric Use: **15,900 kWh**

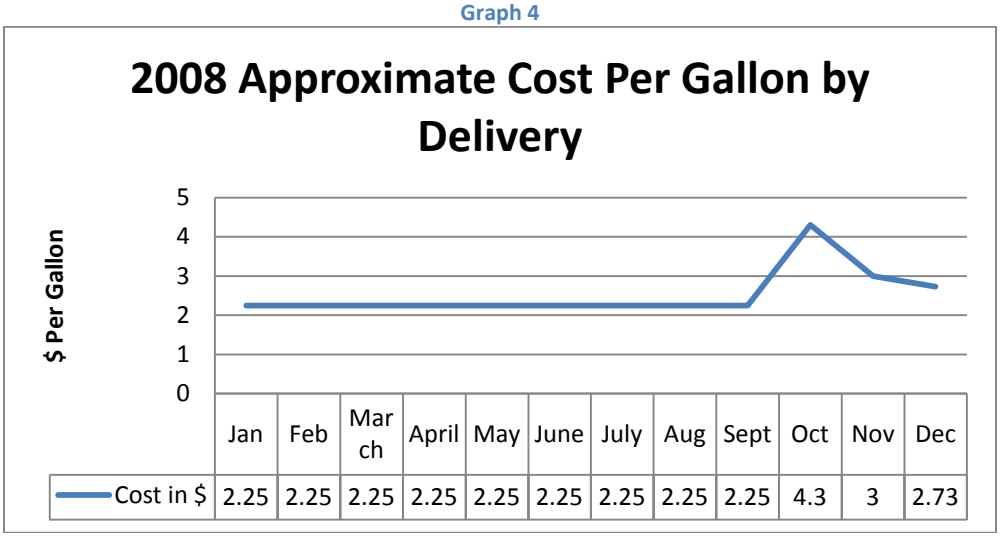
Total Cost of Electricity Used: **$2,662.26**

Table 2

Meter: Town Garage Heating Oil			
Building: Town Garage			
April 19, 2010 - 02:31:46 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	362.2	$989.07
11/1/2008	11/30/2008	48.8	$146.35
10/1/2008	10/31/2008	14	$60.14
9/1/2008	9/30/2008	17.4	$39.06
8/1/2008	8/31/2008	85.6	$192.17
7/1/2008	7/31/2008	83.4	$187.23
6/1/2008	6/30/2008	161.7	$363.02
5/1/2008	5/31/2008	147.8	$331.81
4/1/2008	4/30/2008	248.8	$558.56
3/1/2008	3/31/2008	235.9	$529.60
2/1/2008	2/29/2008	394.8	$886.33
1/1/2008	1/31/2008	426.4	$957.27

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

Graph 4



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

Total gallons Delivered: **2,226.8**

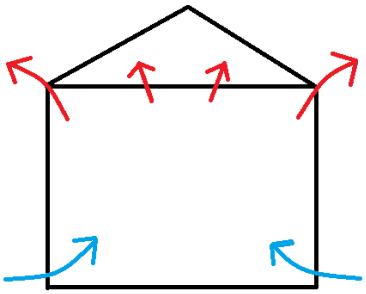
Total cost of oil: **$5,240.61**

12 Cords Wood: **Cost associated with employee hours collecting, processing the cordwood.**

Basics of Heat Loss:

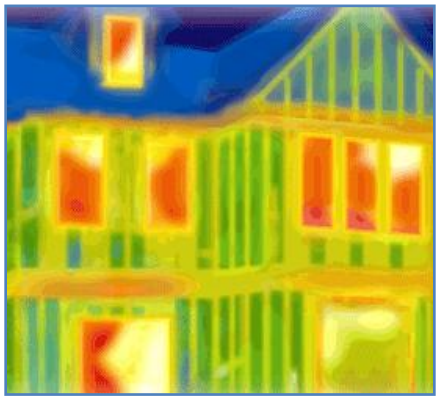
Though we are typically used to measuring heat in temperature, it can be measured in a variety of units. For the purpose of measuring how much heat is produced to condition a space, and how we measure the rate at which heat leaves a structure, we measure in British Thermal Units (BTU's). One BTU is about 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.

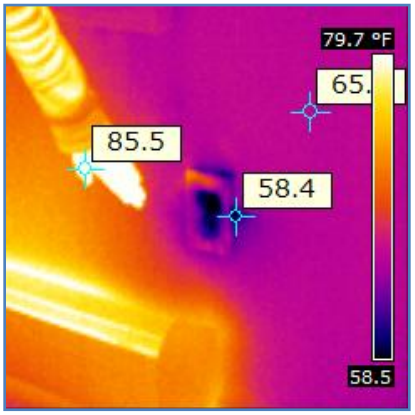
Heat moves through and leaves a building by three different means; *convection, conduction, and radiation*. One way to think of **convective** heat loss is by air movement into and out of a structure. One of the forces causing this to happen is the "stack effect."



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.

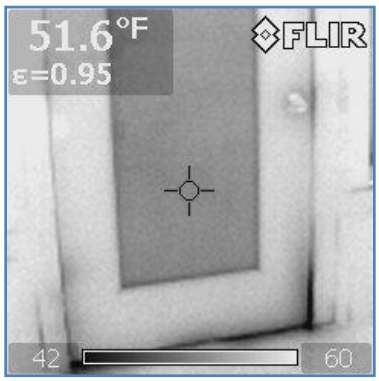
Conduction is the foremost way in which heat travels through a solid building material. At any point in the building envelope where there is a solid building material and no insulation "**thermal bridging**" will occur. For example, a 2x6 inch wood stud in an exterior wall has an R-value, or insulative value, of about R-7, while the 5-½ inch thick 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.

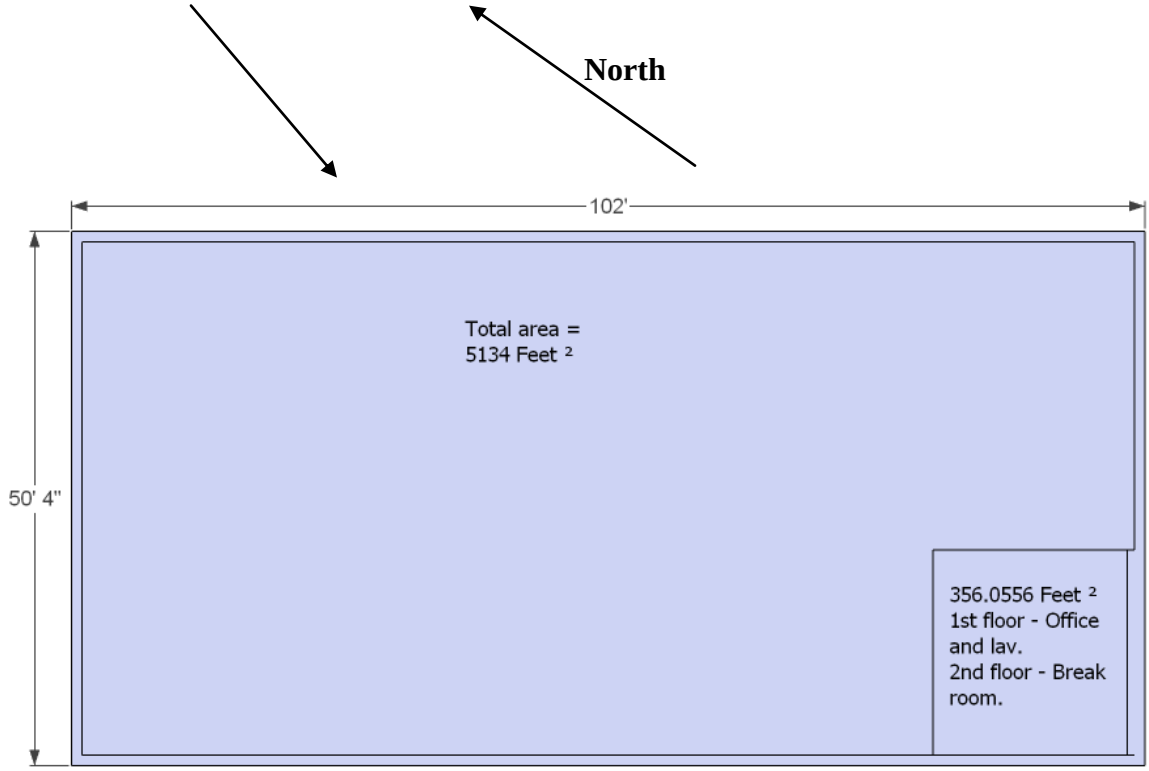
Just as BTUs conduct through solid materials, water vapor diffuses through solid materials. Some materials are more resistant to vapor diffusion, such as polyethylene, and so we use these to try and form a vapor barrier on the inside of the thermal boundary in an attempt to slow the amount of vapor diffusion. 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:

This is a steel frame building with a corrugated metal roof and siding built in 1970. There are five garage bays, with one corner of the building sectioned off providing for two stories with an office, lavatory, and break room.

Front of Building



Foundation:

The building sits on a concrete foundation with about 4 feet of uninsulated foundation wall above grade. This above grade section, though part of the foundation, can also be considered exterior wall area, and makes up about 20% of the exterior wall surface. We believe that the slab, which makes up the entire floor area of this building, is uninsulated. A great deal of heat generated in the building is being lost through the foundation wall area and from the perimeter of the slab. Experts say that insulating around a slab can save 10%-20% on heating cost. One can see in Figure 1 how cold the concrete wall is in comparison to the wall above that has been insulated with a fiberglass blanket. This is because the concrete has almost no insulative value.

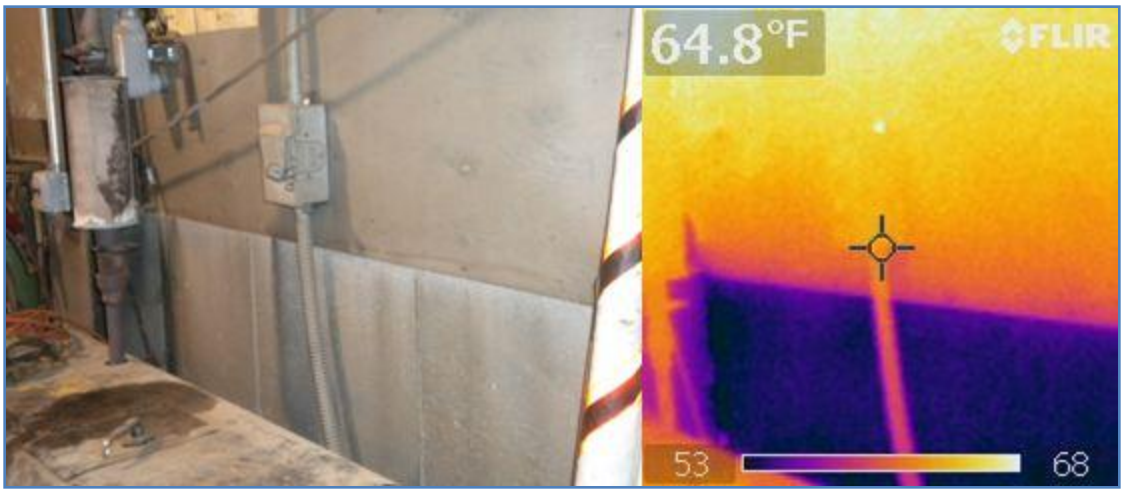


Figure 1

Slowing this heat loss could be done in several ways. One method could involve insulating from the top of the concrete wall, to 4 feet below grade. This would require digging a 4-foot deep trench alongside the building and applying 2 inches of foam board from the bottom of the trench up to the metal siding. In fact, it would be best to cut the metal siding up past the top of the concrete wall a few inches. This would ensure that there would be no break in the thermal boundary between the top of the foam board and where the insulated portion of the exterior wall begins. See Figure 2 for a basic visual explanation. Because the metal siding is fastened at the bottom of the vertical sheets, cutting the metal may entail installing a new nailing strip located a few inches higher on the wall in order to fasten the bottom of the siding. It would be important to make sure that when cutting the metal, the structural integrity of the steel frame will not be compromised. A durable exterior finish would have to be applied to the foam board in order to protect it from sunlight, weather and infestation. A drip cap, sealed to the top of the foam board, and tucked/sealed behind the metal siding would protect the top of this insulation. This method, with the insulation on the exterior, would allow the concrete to serve as a thermal mass (heat storage), as it would to some degree retain heat.

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 utilized, and where the protective barrier on the face of the foam board was ineffective, 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 could be an ideal solution to this potential problem.

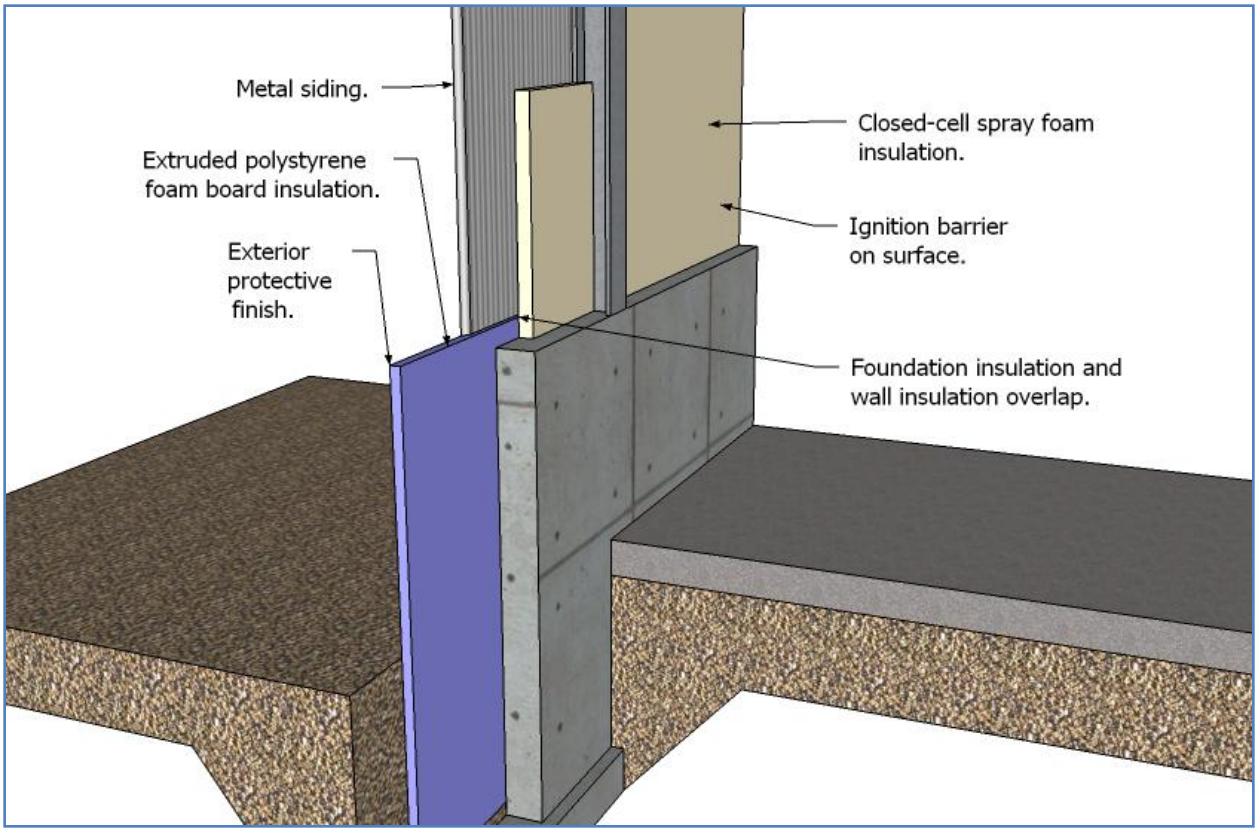


Figure 2

Another method for slowing the rate of this heat loss would be to insulate the top 4 feet of the foundation wall from the interior. This could be done with either foam board adhered to the wall, or closed cell spray foam applied. This method would also reduce heating cost over the long term, but would not be as effective as the external insulation. This is because heat would still be able to conduct beneath the insulation via the concrete slab and be dispersed to the surrounding soil/gravel. This option would also eliminate the benefits of transforming the concrete and the sand/gravel below the slab into a thermal mass.

Recommendations:

- Insulate the foundation from the exterior with extruded polystyrene foam board insulation. This insulation should be buried well below grade, and have a solid/durable exterior protective finish. There should also be a metal drip cap slightly angled from the interior to the exterior.

Exterior Walls:

This is a steel frame building with vertical metal siding. The interior of the walls is lined with foil-faced fiberglass insulation blankets. We were able to look between the blankets and found, in all the examined areas, a space between the fiberglass blanket and the metal siding. Because of all the seams and penetrations in the face of the fiberglass blankets, we would not consider this an effective vapor barrier. We found that there was a great deal of condensation on the inside surface of the siding. This is very typical in a building of this type. Water vapor generated in the building is always trying to find its way to a drier space, which in a cold climate will be the outdoors in the colder months. Often in the winter, there are vehicles that enter the garage with a great deal of snow attached. As the snow melts, it begins to evaporate off of the trucks, and from what small puddles likely form on the floor of the garage. Depending on the situation, this could mean gallons of bulk water turning into the vapor. Because there is not an effective vapor barrier in place, the vapor is able to pass through the thermal boundary (fiberglass blanket) easily, where it meets a cold surface (the metal siding) and condenses.

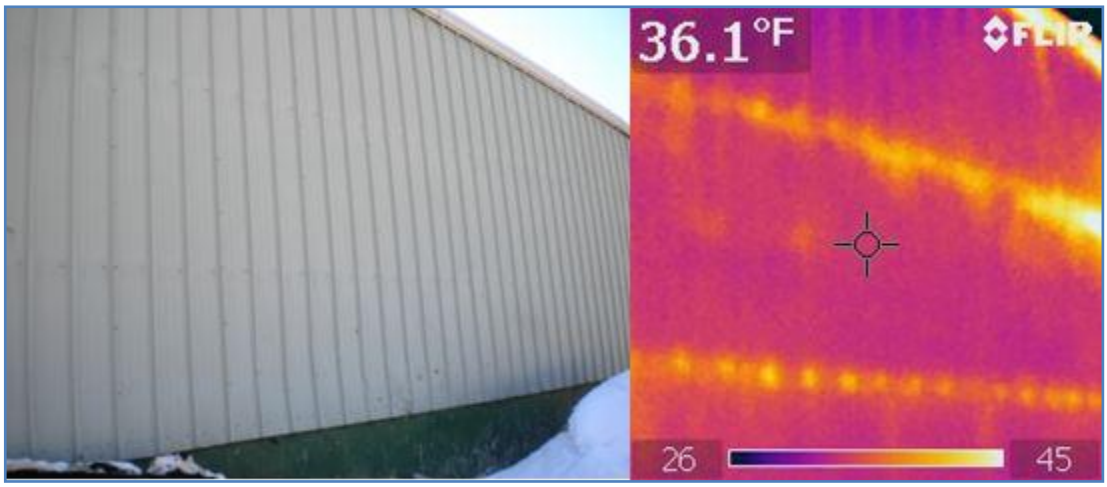


Figure 3

Additional evidence we found depicting how much airflow is occurring from between the conditioned space and the exterior side of the fiberglass insulation was by the amount of soot and other air born particles from the furnaces, vehicle, and other sources that has been caught in the fiberglass. See Figure 4. Fiberglass does very little to inhibit air flow, and acts more like an air filter as is true in this case. Figure 4 is also indicative of the overall air quality in this workspace.

Figure 4

Figure 5 is a view looking from the ground, upward to the gap between the beginning of the metal siding and the top of the foundation wall. This is likely a large source of air infiltration in the building and could easily be sealed with spray foam insulation.

Figure 5

Figure 6 visually sums up the inefficiencies of the exterior wall system. This rendering is not a completely accurate description of the wall construction, but should be close enough to describe the heat loss process. Air infiltrates from the bottom and seams of the metal siding. Any gaps between the fiberglass and the metal siding effectively form small chimneys as the air is heated forming convection currents upward where the heated air exits. Notice in the IR images of Figures 3 and 7 how much heat loss is visible from the top the exterior walls. Much of this is likely due to convective heat loss (hot air exiting) but a fair portion is also due to thermal bridging. Any heat that comes into contact with the steel-framing members will quickly conduct through the metal and exit to the outdoors. This is also visible where the metal siding has been fastened to the horizontal steel beams.

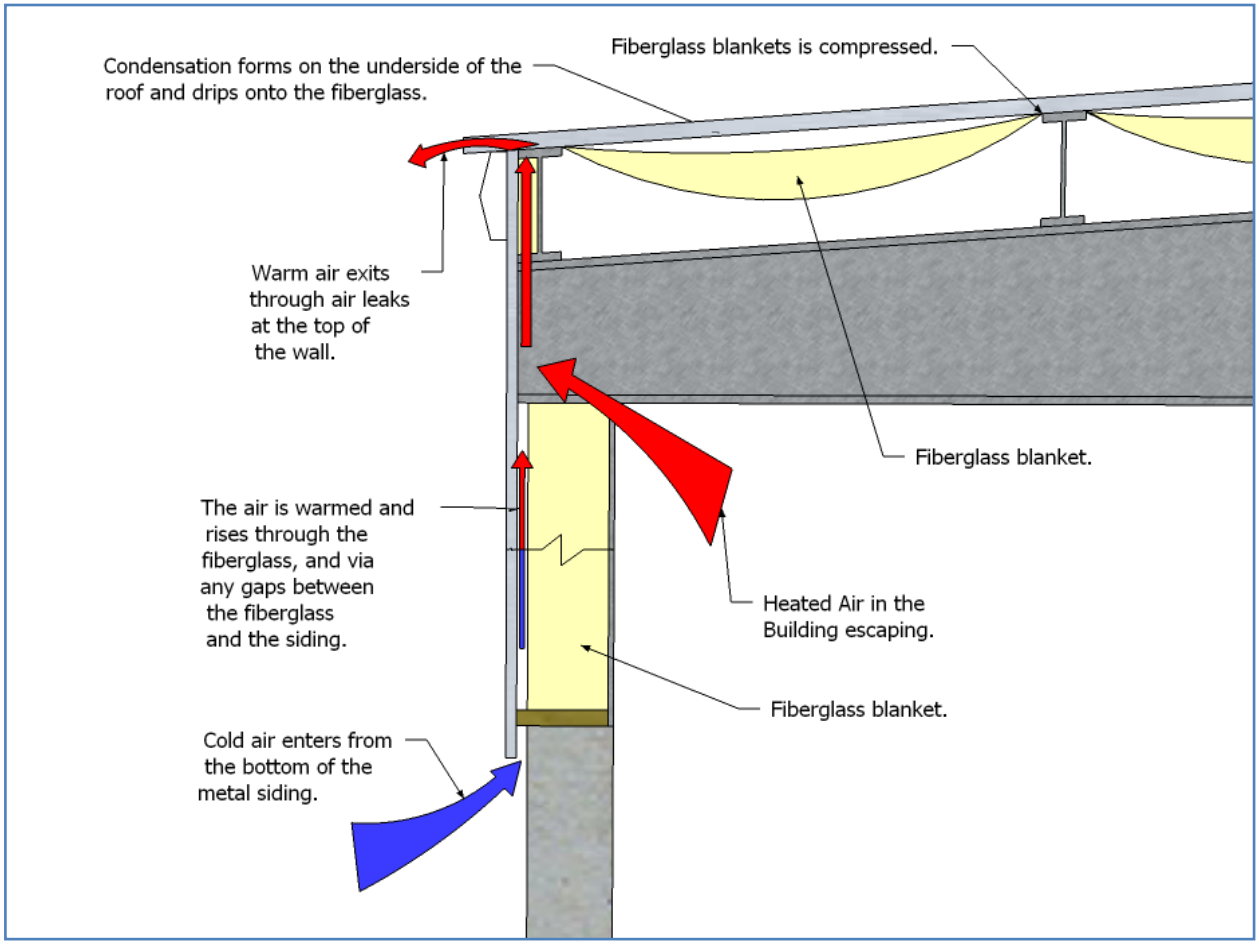


Figure 6

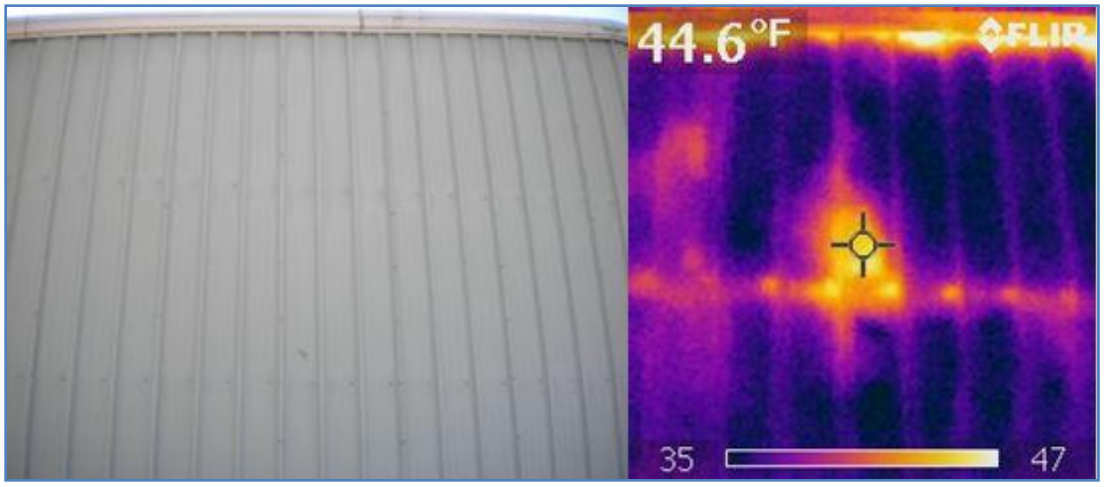


Figure 7

Recommendation:

- Remove the fiberglass blankets from the exterior walls and spray a minimum of 2 inches of closed-cell spray foam against the metal siding. For the best results, the foam would cover any of the steel structural members in order to eliminate thermal bridging. The foam can then be sprayed with ignition barrier paint.

Ceilings:

The ceilings are very similar to the walls in that they are insulated with fiberglass blankets, and there is a space between the fiberglass and the metal roofing. Just like the walls, there is condensation on the underside of the corrugated metal. We noticed water damage to the fiberglass, and many areas where water has clearly been dripping from the ceiling. It is quite possible that there are roof leaks, but dripping condensation could be the sole cause. This is bad for a couple of reasons. First, the water, either from a roof leak or from condensation will cause the metal structure to deteriorate. Second, the fiberglass will also deteriorate, loose its insulative value, and promote mold growth.

What we would also like to indicate is that the fiberglass blankets are compressed about every 4 feet where the steel beams meet the metal roofing (see Figure 8). This is also visually explained in Figure 6. Fiberglass insulation loses its R-value whenever it is compressed; therefore, these blankets are likely only performing to their rated R-value in a relatively small area, centered between the rafter beams.

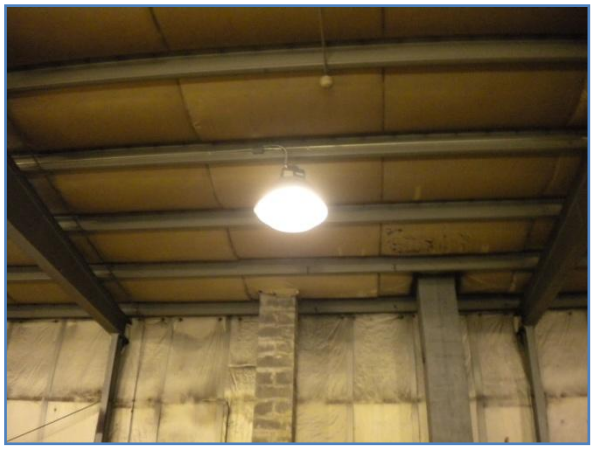


Figure 8

Recommendations:

- Remove the fiberglass blanket insulation from the ceiling and spray 3 to 4 inches of closed-cell spray foam against the metal siding. For the best results, the foam would cover any of the steel structural members in order to eliminate thermal bridging. The foam can then be sprayed with ignition barrier paint.

Envelope Efficiency:

The single largest area for improvement in building efficiency involves the building envelope. The best ways to increase an envelope's performance is to complete air-sealing and insulation work. Although it would be a major undertaking to air-seal and insulate the building, the resulting benefit would be equally significant.

From a building efficiency standpoint, air sealing and insulating can be thought of as a different species of project and investment when compared to items like heat systems, appliances, and alternative energy systems. In the case of the latter, these types of energy investments have a shelf life. A boiler may only last 20 years, or 40 years before possibly needing to replace a PV array, but building envelope efficiency has a lasting positive impact long after equipment need to be replaced. This is an important consideration when factoring in the true life cycle cost of the implemented solution.

Insulation and other building envelope projects are investments that are permanent, require little or no active maintenance, and will stand with the building during its lifetime. These investments secure baseline improvements that in turn provide a foundation for other investments. Lowering the amount of heat needed for a building is the best way to insure that a new and efficient heating plant provides the most savings.

Doors and Windows:

There are only four windows in this structure, and being relatively efficient units, we would not recommend their replacement. These windows are in the break room have good southern exposure. This means that in the winter months, they are allowing for beneficial solar gain during the day. Conversely, this same solar gain in the summer months in unwanted, and will add to the cost of air conditioning the space. We would recommend installing blinds or insulated curtains. During the summer months, keep the blinds closed when the room is not in use to reduce unwanted solar gain. In the winter, close the shades after dark before leaving for the night. This will allow for beneficial solar when the sun is shining, and reduce heat loss over night.

There are five large garage bay doors on the north side of the building. The doors are about 1-½ inches thick and are insulated with expanded polystyrene foam. We estimate the core of these doors to have and R-value of between R-5 and R-6.5. Note that this is just the individual sections, not where there is a break between two sections. There are much more efficient commercial garage doors available on the market. Newer commercial doors can be 2 inches

thick, and are insulated with a 2-inch thick polyurethane foam injected core. The core of a door like this can have a rated R-value of more than 15. Additionally, if newer doors are installed with care, there will be much less air infiltration. Because the garage doors represent such a large percentage of the exterior wall area, it would certainly be beneficial to replace them. A heat loss study would be needed to estimate how new doors would affect the building's energy consumption. Though we feel replacing these doors would produce substantial long-term energy savings, we would recommend implementing the higher priority recommendations in this report first. In the interim, we would recommend taking measures to better air seal the garage doors. Figure 9 exemplifies how well of an air seal these door currently provide. This convective heat loss represents a large portion of the overall inefficiency of these doors.

Figure 9

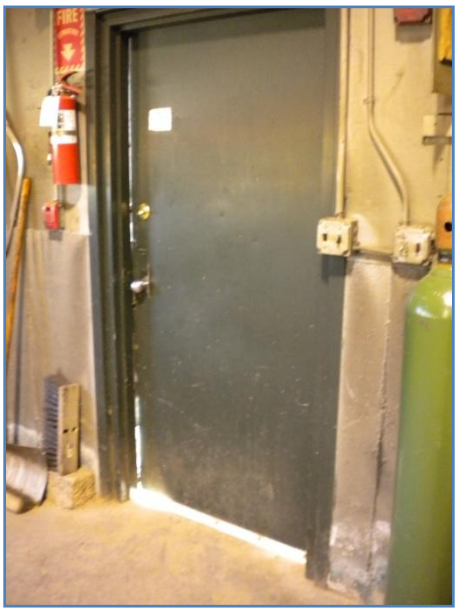


Figure 10

The door in Figure 10 is the only other door in this building. It is clear to see how well this door is performing with amount of daylight coming from around the edges. There are certainly more efficient doors available on the market, and replacing this door would be beneficial, but replacing this door would not fall very high on a list of recommendations. Instead, we recommend air sealing this door by fitting weather stripping around the doorjamb.

Recommendation:

- Replace the garage bay doors with more efficient units. New doors should be 2 inches thick, and be insulated with polyurethane foam. Look for models that have been tested for air tightness, and take great care or oversight of their installation. Getting the most out of new doors will largely depend on how well they are installed.
- If the doors are not to be replaced in the near future, take measures to ensure that all the doors of this building are better air-sealed, without negatively affecting their operability.

Mechanical:

There are four sources of heat in this building. The primary heat source is a very inefficient oil fired furnace seen in Figure 12. The second heat source is a wood fired furnace seen in Figure 11. Though this unit helps reduce the cost of heating the building, and reduces the environmental impact of the facility, it is quite inefficient. Furthermore, it can be dangerous to have an open flame appliance, and in many cases against fire safety codes, in a building of this type. The third source of heat is electric baseboard units in the office, and lavatory. The fourth heat source, seen in Figure 13, is also a cooling source and is known as a Package Terminal Air Conditioner (PTAC). This is powered by electricity and is located in the break room.

Figure 12

Figure 11

As seen in Figures 11 and 12 there is no ductwork associated with either furnace. Both furnaces pull return air in at the unit itself, heat the air, and release the heated supply air from the top of the unit. Because there is no ductwork, there is no distribution loss, but without a distribution system, it would likely take longer for the unit to heat all areas of the garage.

Figure 13

We did not perform a combustion analysis of this equipment, but it is fairly safe to assume that this furnace has a combustion efficiency of between 80% and 84% if it is well maintained. The wood furnace likely burns its fuel somewhere in the realm of 50% to 60% efficient.

We refer to the oil furnace as the primary heat source because it provides the majority of the heat to the building. The potential number of BTUs in 2,226.8 gallons of heating oil is approximately

138,500, meaning that about 308,411,800 potential BTUs of heating oil were delivered to the garage in 2008. The potential BTUs in a cord of wood can vary substantially. Assuming that there are 18,000,000 BTUs per cord, there were only about 216,000,000 potential BTUs of cordwood burned in 2008. This translates to 60% oil and 40% cordwood. Furthermore, if we assume that the oil furnace is burning at 82%, and the wood furnace is at 60% efficiency, the percentage of delivered BTUs to the space becomes approximately 66% oil and 34% cordwood.

In the Energy Data Collection portion of this report, there is no dollar amount associated with cost of cordwood. This is because, according to our understanding, the town employees collect fallen trees and then cut, split and stack the wood. Utilizing the resource of fallen trees and downed limbs is a wise tactic for saving on energy cost, and the Town is commended for doing so. However, when fully analyzing the cost to heat the building, employee hours and wages should be factored into the equation. For example, the cost to heat the building in 2008 was $5,240 for 2,226 gallons of oil, and 12 cords of wood. If efficiency improvements to the building yielded a 20% savings, this would be a savings of $1,048.00 in oil, plus the cost of employee wages to process 2 ½ cords of wood. Depending on how many man-hours it takes to process the wood, and the dollar amount per man-hour, this could substantially increase the overall savings. Including these estimates when trying to determine the "cost benefit" or return on investment (ROI) of implementing an efficiency upgrade is essential. Another factor needed to be included when considering the cost to heat the building is the electrical usage. This will be discussed more in the next section of this report.

<u>Recommendation:</u>

- We recommend removing the cordwood and oil furnaces from the garage, and replacing the system with a higher efficiency, cordwood, hydro-air system. There are many options for accomplishing this, and deciding the most appropriate equipment and heat delivery system will require careful consideration. One method would require building a mechanical shed against the backside of the building and installing a high-efficiency gasification cordwood boiler, with a fossil fuel backup boiler. An ideal scenario will also involve a large heat storage tank. How the system would basically operate is this; when a thermostat located inside the garage calls for heat, it would look to the storage tank to provide it. Pumps would then circulate hot water through well-insulated pipes to either an air-handling unit, or several fan coils suspended from the ceiling. The wood boiler would only concentrate on maintaining the temperature of the storage tank. If the wood boiler could not handle the heat load, (perhaps it's the weekend and no one is there to feed the boiler), the fossil fuel based system would automatically fire to maintain the temperature of the tank. It would also be possible to run a loop to baseboard radiators in the office, lavatory and break room. This would reduce the electric load, thereby providing more efficient, clean heat. The wood boiler could also provide the domestic hot water. Figure 14 gives a basic visual explanation. Though a system like this would mean burning wood more efficiently, it would not necessarily mean burning less wood. Depending on the size of the boiler, it would need to be filled less often than the current wood furnace. In fact, if the thermostats were turned down, and the building shell was more efficient, it is possible that a load of wood could supply enough heat to last through a night or at least during the "shoulder months" where less heat is needed to maintain the

temperature of the building. The idea would be to burn much less, if any, oil. In 2008, the cost of the 2226 gallons of oil was $5,240.00. Though we cannot speculate, the future of energy prices, a typical rate used when calculating a payback period for a project of this type is a 4-5% increase per year. If there was another spike in oil cost, like was seen in the summer and fall of 2008, the cost of the same 2226 gallons could run close to $10,000.00.

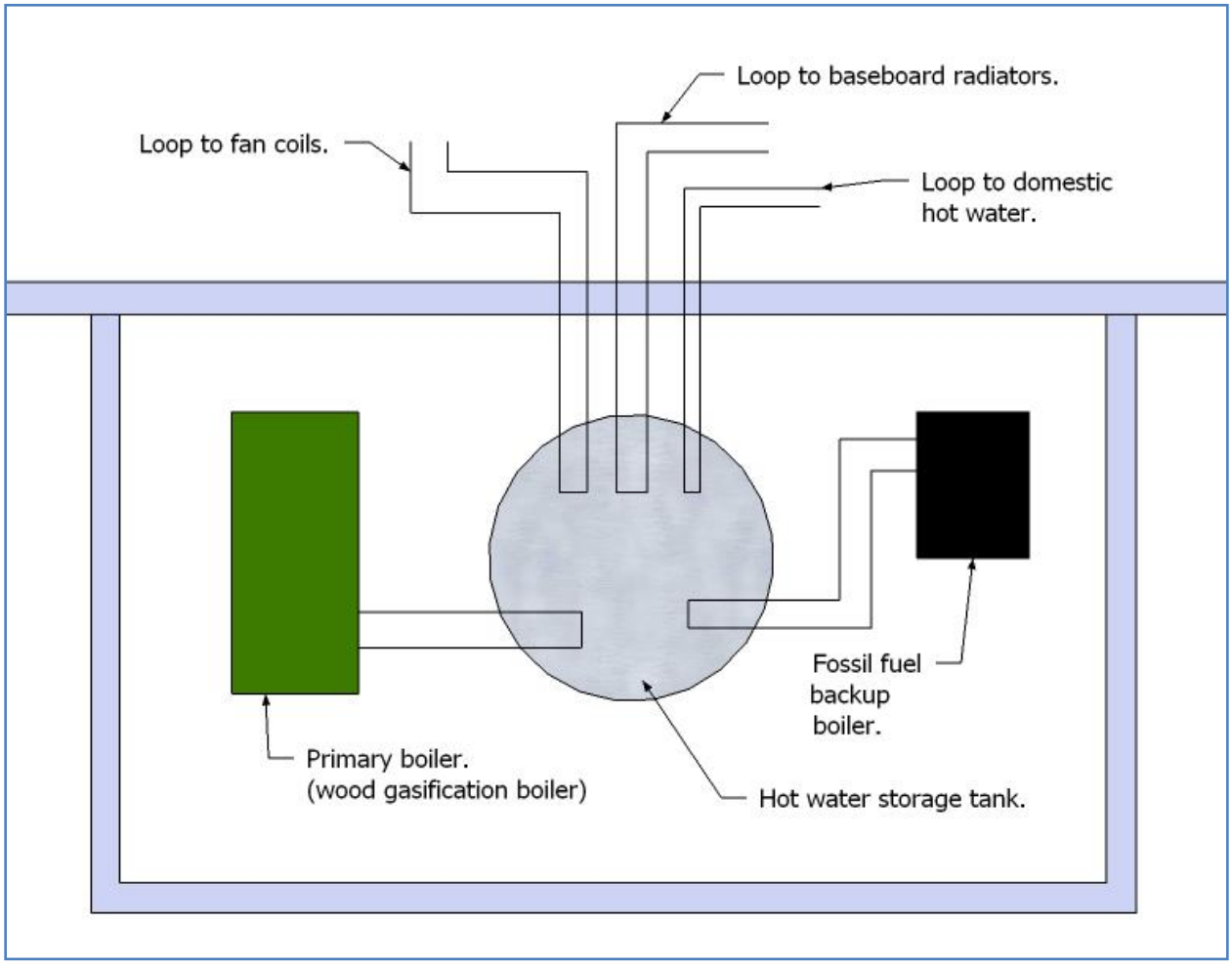


Figure 14

Electrical:

There is a fair amount of the electric usage in this building due the nature of the work being done here with power tools and compressors. Given the use 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.

Table 1 and Graph 1 on page 4 show the 2008 electricity usage trends. What is seen is a large spike in usage during the heating season. Some of this elevated electrical usage could be due in part to lighting, and the shorter days during the winter. However, in a building such as this with little available day lighting, the lighting bills will tend to be more consistent throughout the year. The curve of Graph 1 is more constant with that of heating costs which tend to make a steady rise in the fall, peak in January and February, and make a decline from there to the end of the heating season. The incline and the decline of a heating curve represent the months when less heat is needed to maintain a building's temperature, and are commonly referred to as the "shoulder months."

There are a few items that are associated with electric cost of heating this building. First are the electric radiators in the office and lavatory, and the PTAC unit in the break room. The other major sources are the blower fans from the two furnaces. Even non-electric heating systems have an associated amount of electric usage due to pumps and blowers. The amount of electricity needed to distribute heat throughout a system will depend largely on the distribution design, and the efficiency/correct sizing of the motors associated with pumps and blowers. Installing the biomass hydro-air system illustrated in Figure 14 should prove to substantially reduce the amount of electricity needed during the heating months. An electric load study of the current electric usage, versus the design load of a proposed system, would reveal estimates of this reduction, and could be used in determining the ROI of a heating system replacement. Designing a system with properly sized, high efficiency pump and fan motors would maximize the savings.

Also note that the cost of an electric hot water heater tends to be more in the winter, as the difference in temperature between the water and the tank surroundings is greater, and building occupants tend to use more hot water in the colder months.

The lighting in this building is primarily a combination of high intensity discharge (HID) lamps, T12 florescent tubes, and incandescent bulbs. We would encourage the Town to always seek 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. Despite its 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 LEDs 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, as well as the cost of recycling the old lamps, which can contain hazardous materials.

There is some opportunity to save electricity from phantom loads in this building. 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. At a minimum, look to replace any incandescent bulbs with compact florescent or LED bulbs, and replace any magnetic ballasts and T12 florescent tubes with electrical ballast and T8 florescent tubes. Always consider the LED options for any lighting replacement, including "high bay" LED options.
- Whenever buying new equipment like refrigerators, microwaves, 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. After steps have been taken to reduce the buildings electrical demand, onsite electrical generation is the next step towards reduced electric cost and harmful greenhouse gas emissions.

Ventilation:

There is one exhaust fan located on the SW exterior wall. We would recommend that the 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.

Air sealing and insulating the building could dramatically reduce the amount of natural air changes per hour, making a potentially unhealthy environment worse. Knowing this, we still recommend the air sealing work, but would also recommend having mechanical control of the amount of air changes, rather than assuming the amount of air leakage is sufficient. Mechanical ventilation can have a heat recovery component to minimize the amount of energy needed to heat incoming fresh air. Such a system is known as a Heat Recovery Ventilation system. This would be ideal ventilation in the colder months, and could possibly be turned off during the warmer months with use of natural ventilation (opened garage doors).

If possible, incorporate air quality monitors into the ventilation system. Monitors can be installed to keep track of carbon monoxide (CO), carbon dioxide (CO2), relative humidity (RH), and much more. Such systems are known as Demand Control Ventilation (DCV) systems. These systems are used to ensure fresh air is supplied when it is needed, and to save energy by disabling the ventilation when air quality it is at acceptable conditions. Given the nature of the facility, we would recommend a minimum of installing CO sensors in conjunction with an exhaust fan for safety purposes.

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.

Additionally, 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. New Hampshire Electric Co-op offers the SmartSTART 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 NH Electric Co-op at: 1-800-698-2007, or visit http://www.nhec.com/business_energysolutions_smartstart.php

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.

Summary of Recommendations:

- Hire a ventilation specialist to examine the current ventilation system to determine if it meets current health and safety standards. New ventilation measures should take into account and future building envelope upgrades, as this will likely affect the ventilation design. Install a smart ventilations system with heat recovery capabilities.
- Put all electronics on power strips and be sure to cut the power to this equipment when they are not in use.
- Whenever buying new equipment like refrigerators, microwaves, computers, printers, etc. always buy the most energy efficient equipment available.
- Check all of the compressor lines and hose/tools fittings for air leaks. Repair as needed.
- Install insulated blinds or curtains in the break room windows.

- Take measures to ensure that all the doors of this building are better air-sealed, without negatively affecting their operability.
- We recommend removing the cordwood and oil furnaces from the garage, and replacing the system with a high efficiency, cordwood, hydro-air system. We would also suggest replacing the electric baseboard with hot water baseboard or panel radiators. These should also be installed in the break room.
- Remove the fiberglass blanket insulation from the ceiling and spray 3 to 4 inches of closed-cell spray foam against the metal siding. For the best results, the foam would cover any of the steel structural members in order to eliminate thermal bridging. The foam can then be sprayed with ignition barrier paint.
- Remove the fiberglass blankets from the exterior walls and spray a minimum of 2 inches of closed-cell spray foam against the metal siding. For the best results, the foam would cover any of the steel structural members in order to eliminate thermal bridging. The foam can then be sprayed with ignition barrier paint.
- Replace the garage bay doors with more efficient units. New doors should be 2 inches thick, and be insulated with polyurethane foam. Look for models that have been tested for air tightness, and take great care or oversight of their installation. Getting the most out of new doors will largely depend on how well they are installed.
- Insulate the foundation from the exterior with extruded polystyrene foam board insulation. This insulation should be buried well below grade, and have a solid/durable exterior protective finish. There should also be a metal drip cap slightly angled from the interior to the exterior.
- Consult a lighting specialist to develop a lighting retrofit plan. At a minimum, look to replace any incandescent bulbs with compact florescent or LED bulbs, and replace any magnetic ballasts and T12 florescent tubes with electrical ballast and T8 florescent tubes. Always consider the LED options for any lighting replacement, including “high bay” LED options.
- Install a photovoltaic (PV) system on site. Given the orientation of the roof, it may be best to install a ground-mounted system. After steps have been taken to reduce the buildings electrical demand, onsite electrical generation is the next step towards reduced electric cost and harmful greenhouse gas emissions.

Conclusion:

As a result of this audit, the Town has several options available to increase the efficiency of the Town 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.