The New Hampshire Municipal Energy Assistance Program

Decision Grade Audit Report

Gorham Library
35 Railroad Rd., Gorham NH 03584

Prepared for:

Town of Gorham, NH

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Clean Air Cool Planet

Sustainable Energy Resource Group

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The following report was generated as part of the NH 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 Gorham 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 Gorham.

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Introduction:

MEAP partners are pleased to provide this Decision-Grade Audit Report for the Town of Gorham and the Library building (hereinafter "the building"). This report discusses the findings and subsequent recommendations for energy efficiency and occupant health and safety improvements at the building. Included within this report are details regarding the inspection of the building, and examples that illustrate recommended building alterations and improvements that can reduce energy costs, occupancy health risks, 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 making capital investments, and participating in Federal and State level funding opportunities for municipal energy projects.

Prior to receiving an energy audit, each selected municipality must carry out the MEAP Energy Inventory process. The Energy Inventory, and subsequent energy audit, reports relied on data provided to the MEAP team by municipally appointed /authorized elected officials, employees, or community volunteers. These initial findings, along with a further review by SDES staff, helped determine the most appropriate building to provide an energy audit. The intent of the building selection process is to maximizing the potential energy savings, while at the same time catering to municipal goals and objectives. Any municipally owned building that has received any level energy audit or energy assessment prior to this program will be considered ineligible to receive a MEAP energy audit.

The Audit

It is important to know that there a few types, or levels, of energy audit. This audit, described by SDES Group as a Decision Grade Audit (DGA) is a first step towards making investments in the examined building. It is entrenched within the SDES method to begin with this baseline understanding of "how" and "why" a given building is performing, and state some of the many approaches to reducing energy consumption, while increasing occupancy health and comfort. This, along with the Town's goals, objectives and project funding capabilities are the foundation of sorting through the many available technologies to form a solid Level II audit.

We have found that this approach eliminates wasted time estimating energy savings and project implementation costs for energy efficiency measures and/or alternative energy systems that may never fall within the objectives of the investor. This DGA serves to aid in "deciding," or sorting through, potential projects to be further examined for investment consideration.

Two examples of the many benefits to taking this approach are these: The classic case of a building owner funding a very expensive window replacement project under the mislead assumption that it will save a substantial amount of money in heating costs. The fact is, window replacement projects most often fall quite low on a prioritized list of recommended energy efficiency measures as they usually have high cost and low savings (unfavorable ROI). The benefit in this case is the basic guidance towards long term upgrades with a staged approach. The second example is the time (hourly rate) of an energy auditor to examine the cost benefit of replacing an inefficient oil-fired heating system with *all* the available options. Some of the

options may include (but not limited to) a high-efficiency LP gas boiler or furnace, a geothermal system, a biomass systems (pellet vs. cordwood vs. woodchip) an integrated solar thermal storage system, a cogeneration system of varying fuel types, etc. The distribution system could vary for all of these systems as well. One could provide the "cost/benefit" for burning any of these fuels with a forced air system, a radiant floor system, hydro-air, baseboard radiators, etc. Any of these heating plant, fuel types, and distribution system combinations will have a varying cost in installation, fuel price, efficiency, and maintenance. The benefit here is avoided consulting costs by using the DGA as a tool to hone in, or help define, the objectives needed to carry out intended goals.

A community's goals and objectives may be environmentally or economically based. Regardless of motivation, both goals can be reached in tandem by implementing any set of objectives aimed to reduce energy usage. Given that these are public buildings and facilities, comfort and safety are primary concerns that help guide our analysis and recommendations.

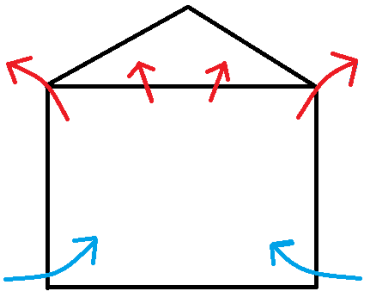
This DGA involves a quantification of energy usage (electrical and heating fuel), a description of existing heating/cooling and distribution systems, thermal barrier inefficiencies, potential electric savings through lighting/appliances upgrades and behavior change, occupancy health and safety concerns, a prioritized list of recommended improvements, and a look at current 15 year projected energy expenses vs. a 30% annual energy usage reduction for the examined building.

Many of any energy auditor's recommendations will be based on their knowledge and experience with particular products, techniques, and technologies. SDES has worked with all major forms of alterative/renewable/conventional high-efficiency heating and cooling systems, has planned for and constructed many types of different high-performance (super-insulated) building envelope systems in an effort to create some of the most healthy, comfortable and efficient private and public spaces in NH. Our prioritized list of recommendations is based on our "what works" experience. Our list will not include detailed "spec" information on how exactly each item should be carried out, nor will it include estimated energy savings. This type of detail would be presented in an IGA (Level II equivalent) in order to receive estimates for the cost of implementation, and return on investment. These details will be needed to participate and many of the State and Federal loan and incentive programs.

Basics of Heat Loss:

Though we are typically used to measuring heat in temperature, it can be measured in a variety of other 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 (BTUs). One BTU is roughly the same amount of heat produced from a kitchen match. Another good reference to have is that there are about 138,500 potential BTUs in 1 gallon of heating oil. During the winter months, we cannot keep BTUs 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.

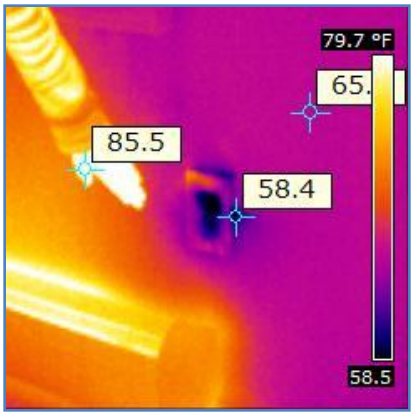
Heat moves through and leaves a building by three different means: *convection, conduction, and radiation*. One way to think of **convective** heat loss is by air movement into and out of a structure. One of the forces causing this to happen is the "stack effect".



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 (heated and/or cooled) 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 also contributes to increased comfort and improved indoor air quality.

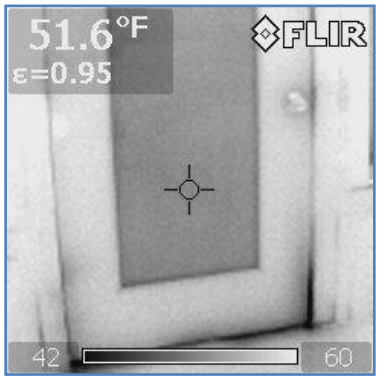
Conduction is the foremost way in which heat travels through a solid building material. R-value is one way to describe a given materials resistance to transfer heat. Materials with a high R-value, such as foams, cellulose, or fiberglass batts are used for insulation. At any location in the building envelope where there is 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 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 any 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 built

environment 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. For example, the heat from a hot copper 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 significant 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 include mold growth, poor indoor air quality, and the early degradation of building materials and equipment. It can also contribute to potentially serious health issues for 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 ways to manage bulk moisture are to keep rain and ground water from entering the building and to quickly fix any water leaks from sources within the building, 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 at 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 system 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 we use these to 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 identify any current moisture problems and address them appropriately. 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 in which moisture can negatively affect the building.

Building Description:

Front

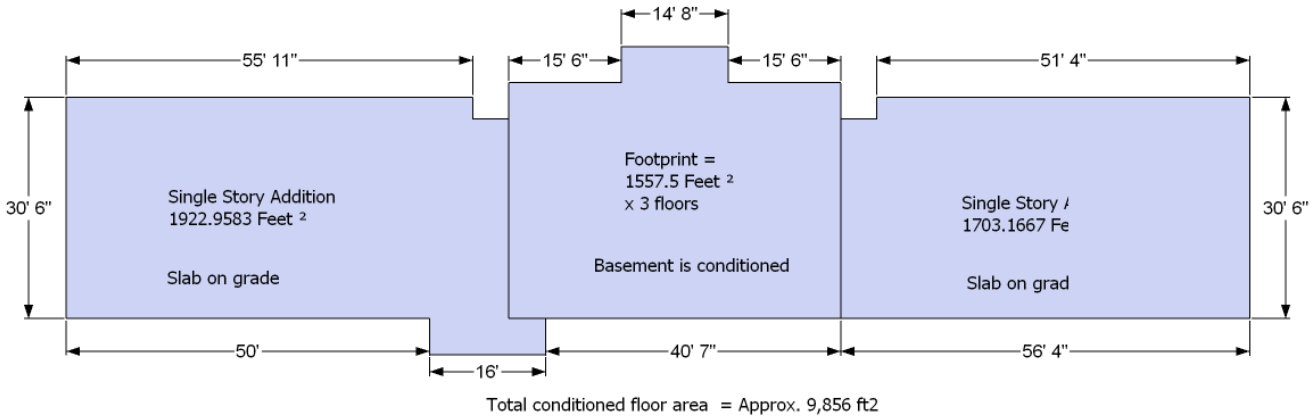
Rear

The original library is the 2 ½ story structure centered in the above photos. Built in 1902 at a different location, this wooded structure was recently moved, and placed on a new full height foundation. Two single story, slab on grade wings were added to either side which now make up the majority of used space.

The second and third floors of the original structure are only used as storage space, and though they are not intentionally conditioned, should be considered within the building envelope.

The basement has dirt floors, and is not used for storage. However, this space is being intentionally heated with two large radiators, and is therefore considered to be part of the total square footage of conditioned space.

Conditioned space, for the purpose of measuring energy usage or creating energy models of a building, should be measured from exterior points in order to include the thermal envelope.

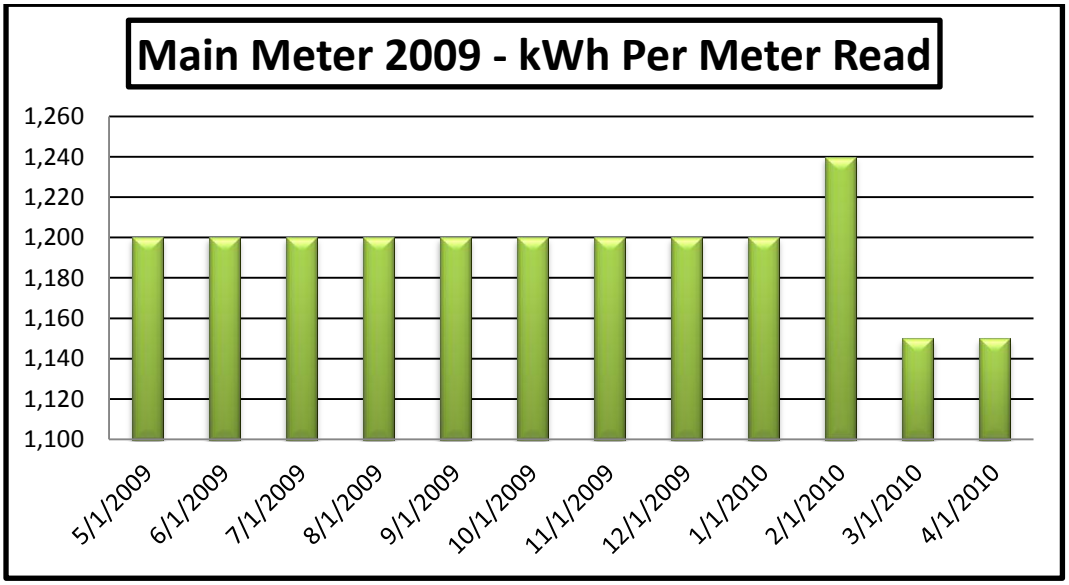


Energy Data Collection:

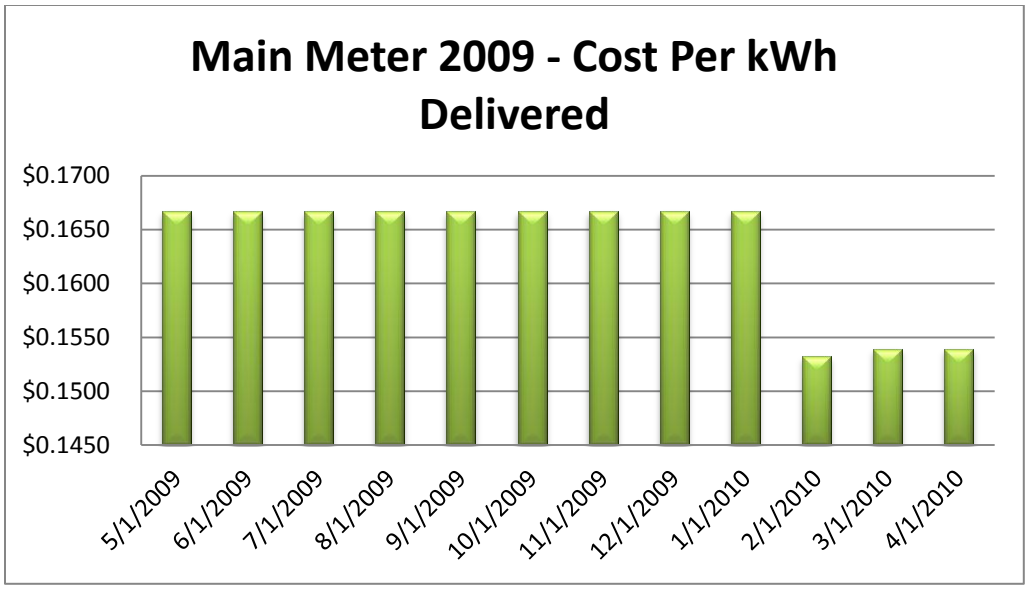
Actual bills were not available, the figures belows are assumed to be correct. Monthly consumption is designated low to high, red being the lowest and green being the highest consumption months in the table below.

Utility			
Date	**KWH**	**Total $/mo**	**Cost Per kWh**
4/1/2010	1,150	$177.00	$0.1539
3/1/2010	1,150	$177.00	$0.1539
2/1/2010	1,240	$190.00	$0.1532
1/1/2010	1,200	$200.00	$0.1667
12/1/2009	1,200	$200.00	$0.1667
11/1/2009	1,200	$200.00	$0.1667
10/1/2009	1,200	$200.00	$0.1667
9/1/2009	1,200	$200.00	$0.1667
8/1/2009	1,200	$200.00	$0.1667
7/1/2009	1,200	$200.00	$0.1667
6/1/2009	1,200	$200.00	$0.1667
5/1/2009	1,200	$200.00	$0.1667

Average $/kWh: $0.1634
Total kWh: 14,340



Annual electricity consumption for Gorham Library



Cost of delivered electricity for Gorham Library

Heat Source 1 - Oil Boiler			
No. 2 Oil			
Date	Fuel Units	$	Cost Per Unit
12/1/2009	377	$719.00	$1.907
11/1/2009	196	$374.00	$1.908
10/1/2009	206	$394.00	$1.913
9/1/2009	1	$3.00	$3.000
8/1/2009	87	$204.00	$2.345
5/1/2009	144	$488.00	$3.389
4/1/2009	312	$1,056.00	$3.385
3/1/2009	391	$1,303.00	$3.332
2/1/2009	627	$2,121.00	$3.383
1/1/2009	427	$1,447.00	$3.389

Total Units Used =	**2768**
Total Paid For Year =	**$ 8,109.00**
Ave Cost Per Gal =	**$ 2.93**

NH Average By Date - 1.31.2011	$ Per Unit =	$3.463
Yearly cost based on the above price +		$9,585.58

Blower Door Test Results:

A blower door test was not performed on this building because of one or more of the following reasons.

- Hazardous building materials were found on site. SDES staff did not want to risk disturbing this material and potentially spreading it to occupied areas of the building.
- Mold was discovered in the building. SDES staff did not want to risk disturbing the mold or spreading spores to occupied areas of the building.
- Though lead paint tests were not performed, SDES felt there may be a threat of disturbing lead paint dust with the potential of spreading it to occupied areas of the building.
- Excessive amounts of bat and/or rodent droppings were discovered. SDES staff did not want to encourage the migration of hazardous gases and associated diseases to occupied areas of the building.
- The risk of spreading materials which are not considered to be hazardous such as fiberglass insulation, dust, etc., was too high. Exposure to such materials can cause respiratory, skin, eye and other irritations to individuals working in or conducting business in this building.
- For security purposes, it was logistically not possible during our building inspection to open all interior doors of the building in order to get accurate test readings.
- Business hours at this building conflicted with the scheduled SDES building inspection, rendering it not possible to keep exterior doors closed during the test.
- It was not possible to shut down heating equipment during the SDES building inspection.

Foundations, Floors, Crawl Spaces, and/or Basements:

When this building was moved from its original location, it was placed on top of a new full height concrete foundation. The foundation walls have not been insulated. Currently, there is vapor barrier on the dirt floor and it is intentionally heated with radiators. There is also an air infiltration coming from around the band joist, and with exception to a very poorly insulated area underneath the front office, the floor has not been insulated. It is important to note that this space is not used for storage and is responsible for a large percentage of the building convective and conductive heat loss.

The amount of moisture coming from the walls and dirt floor of this space is substantial. For the purpose of saving energy, the walls and floor of this space should be well insulated. Furthermore, in order to maintain the durability of the building and to promote the the long term preservation of the books in the library, the insulation of this space should include a well-sealed vapor barrier. A dry insulate basement would also make this space usable for storage purposes. There are many ways to do this, which can be explained during the presentation of this report.

There are many penetrations from the basement into the building above. This serves to aid the stack effect and overall convective heat loss by allowing the upwards movement of air—this puts the space under negative pressure, which, in turn, draws more air in from around the band joist.

This space is currently being heated with the two radiators as seen in the accompanying photo. If the walls and floor of this space were to be well insulated, then the temperature would likely remain at the same temperatures that the radiators are currently maintaining—but without the radiators.

The two additions on either side of the original structure sit on slab on-grade foundations that we suspect to be uninsulated. Not only is there likely a great deal of heat loss coming from the concrete, but this photos shows amble opportunity for air to infiltrate the building envelope. Insulating the foundations of the additions would need to be done with 2 inch extruded polystyrene foam board, which should run a minimum of 2 feet below grade, although 4 feet would be preferred in this climate. The insulation would have to be protected from the elements and from pests. Sealing the foam board where it meets the frame of the building would also be necessary and could be done in such a way as to eliminate the possibility of air infiltrating the building envelope.

This image shows the edge of the flooring in one of the two additions where it meets the sheetrock of an exterior wall. This is an area of a building that is almost never air sealed; usually it is just covered with baseboard trim, which is also not air sealed and can be a substantial source of air infiltration from weaknesses in the building envelope, as described in the previous paragraph.

Exterior Walls:

The exterior walls of the two additions were constructed with 2x6 inch studs and insulated with R-19 fiberglass batts. These walls could be super-insulated by removing the siding and wrapping the entirety of the exterior walls with 2 inches or more of foam board. Though this would have long term benefits, there are much higher priority items; therefore, this is not recommended to be done at this time.
The exterior walls of the original building, seen in the image to the right were found to be mostly uninsulated. These walls could be filled with cellulose insulation. Much of this work could be done from the third floor of the building, though it would also be necessary in many areas to temporarily remove sections of siding in order to reach all wall cavities.

Ceilings and Attic:

The ceilings of the two additions do have vapor barriers in place and have been insulated with R-30 fiberglass batts. The section of this ceiling in the photo to the right is above a small computer room that has a suspended ceiling. This is one of the few areas of these ceilings that was not finished with sheetrock. It was a hot and humid day when we inspected this building, which is evident by the condensation on the roof side of this polyethylene sheeting. Given the limited space between the ceilings of the additions and their roof structures, it would extremely difficult to improve the R-value in these areas. The best option for this may be to wait until the roofs of the additions need to be replaced, and, at that time, add rigid insulation to the roof before reapplying the new roof. This would create what is known as a "cold roof." By the time the current roof is needed to be replaced, the cost to heat these spaces will likely necessitate this action.

Some rooms of 2nd floor of the original building are being used for storage, and the 3rd floor is completely empty. Though these spaces are not intentionally heated, they are considered to be within the thermal envelope of the building. A combination of the main stairwell being open to the 2nd floor and large air passageways in the 2nd floor ceiling, like that seen in the photo to the right, are clear indications of how easily conditioned air can leave the first floor of the library. However, these are not the only ways that air can move upward in this building.

This is a picture of the 1st floor fire place, which is no longer in use. Though the hearth has been filled in with brick, the cracks in the trim around all sides of this chimney are pulling air in—even during the warmer months.

This photo shows just how large the space around the chimney is. This picture was taken from the stairwell between the 2nd and 3rd floor and gives an idea of easily conditioned air can be pulled in from the basement, 1st, and 2nd floors and dumped into the very drafty and poorly insulated 3rd floor.

Other interior chase ways, like the one in this photo to the right, can run all the way from the basement and 1st floor to the 3rd floor. All chase ways would need to be carefully sealed to take full advantage of this savings opportunity.

When the conditioned air of this building completes its nearly unobstructed passage to the 3rd floor, this antiquated/deteriorated 1 inch thick insulation is the only thing between the 3rd floor space and the building exterior.

Doors and Windows:

This photo shows an example of the windows of the additions. These are fairly efficient units, and their replacement would not be recommended at this time. Making sure that they provide a good air seal when closed is important. Also, it is likely that the spaces between the window frames and the wall framing were only stuffed with fiberglass insulation. If this is true, it would be beneficial to temporarily remove the trim and the fiberglass and fill these spaces with spray foam insulation.

The windows in the main section of the building appear to be the original windows of this building, though the glass is not. The original single panes of glass have been replaced with the thermal panes, visible in the photo to the left. Because of this, these windows are likely performing very similarly to the new wooden windows of the addition. The same recommendations can be given. The other only other beneficial recommendation would be to replace the current storm windows with modern high efficiency unit that have a low-e coating.

This image shows that the windows on the 2nd floor have not had the glass replaced nor have the windows on the 3rd floor. It would also be quite beneficial to replace the storm windows with new high efficiency storms.

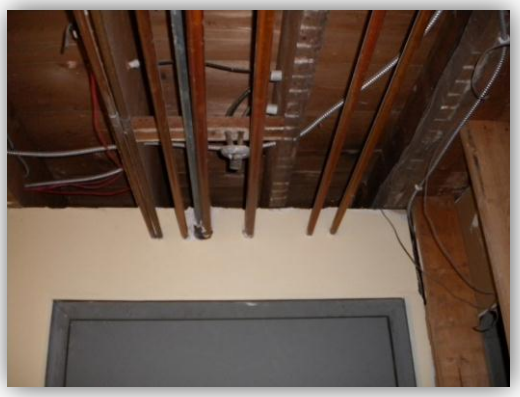
The final concern with the windows regards the 3rd floor windows. These are original windows with original glass and currently have now storm window units. Moreover, the window in this photo does not even close properly. This may be due to movement in the building frame when the structure was being relocated. Regardless, the 3rd floor windows should also have high efficiency storm windows installed.

Mechanical:

This building is heated with a single oil fired boiler seen in this photo. The service tags for this unit indicate that the combustion efficiency is currently around 79% to 80%. This boiler and burner may be capable of combusting oil more efficiently, and it is recommended that an inquiry be placed with the service technician about making appropriate adjustments to nozzle size, oil pressure, and combustion air in order to help to achieve this.

There are many options for replacing this unit with systems that would reduce the cost of heating this structure. However, this unit may still have several more years of useful life; therefore, higher priority investments in this building should come first. More information about system replacement options can be given during the presentation of this report.

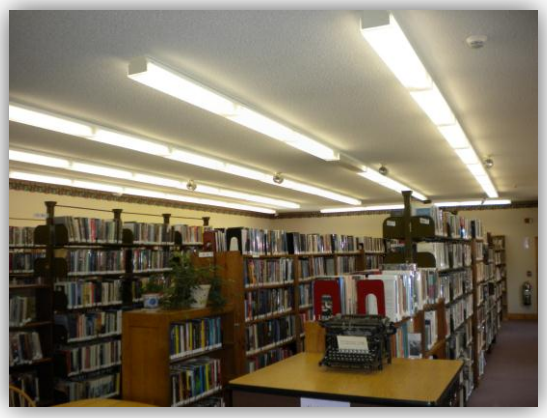
Certain control technologies are available for this boiler that will help it operate more efficiently. For example, an outdoor reset, or modulating aquastat, functions by monitoring the outdoor temperatures and automatically adjusts the temperature set points of a boiler. For example, on the coldest days of a NH winter, the temperature of the water sent to baseboard radiators will most often not need to be greater than 180°F. If the outdoor temperature is only 50°F, the boiler may only have to send 160°F water to the baseboard. Many types can also stage multiple boilers and help reduce short cycling. Outdoor Resets, in conjunction with an indirect hot water heater, can reduce fuel usage by 10%-20% on a yearly basis.



Uninsulated pipes offer a great opportunity for saving money on fuel costs without a large initial investment. Also, unless any major changes need to happen to this distribution system, this investment will stay with the system, even if the boiler is replaced. Often when pipes are insulated, the pipes directly around the boiler are neglected. Insulating these pipes becomes very important during warmer months if a boiler is also producing potable water. In this case, the boiler is always maintaining its core temperature, even when no water is being used. Insulating pipes directly around the boiler then reduces standby losses.

Maintaining an appropriate heat schedule that coincides with hours of operation is another great way to produce measurable savings without a large initial investment. This can be done by replacing the thermostats in this building with digital/programmable units.

Electrical:



Actual kWh usage amounts for each month were not available, which makes it difficult evaluate the difference between baseline and seasonal.

Some of the easiest ways to reduce electric costs do not involve initial investment and include making sure lights are out in spaces not being used and keeping as many lights out as possible if there are employees in the building an hour before and after times of business: Eliminating one hour of electric usage at either end of each day for an entire year may amount to substantial savings.

Also, invest in outdoor LED options for safety lights that are left on during the night year round. The more a light is used, the more important it is to use the most efficient source available. CFL's use a fraction of the amount of electricity than that of incandescent and halogen lights, and LED lights use just a fraction of CFL's.

Modern electronic equipment often draws a small amount of electricity even when powered down, which can equal a sizable amount in cost at the end of the year. Using power strips and fully cutting the power to electronics will reduce this unintended electric usage.

Health, Safety and Comfort:

Any building, whether a residence or a place of business, needs to offer regular fresh air to the people living and working in these structures. The standards for how much fresh air to introduce vary depending on the use, size, and number of occupants in the structure. In some cases, this means introducing a continuous amount of air measured in cubic feet per minute (CFM). Other cases require a measured number of times per hour that the total volume of air is changed. If air-sealing and insulation work is completed on an existing building, it may leave the building providing inadequate amounts of fresh air. If an existing fresh air supply system was designed and installed well, meeting the requirements for the particular building based on square feet, use type, and number of occupants, than air-sealing projects should only serve to eliminate excessive ventilation. A blower door test would determine how tight the building is as a result of the efficiency upgrades, if there is a need for additional fresh air, and how much air to introduce.

Whether installing a fresh air supply system for the first time in a building, or wanting to make an existing system more energy efficient, the most effective way to provide fresh air in either case would be with a heat recovery ventilator (HRV) or an energy recovery ventilator (ERV). These units can be installed in a few different ways which vary where they pull stale air from, and where the fresh air is introduced to. In the case of integrating HRVs or ERVs into an existing forced-air distribution system, they will function by removing a percentage of the stale air from the return plenum, and then introducing charged, fresh air to the return plenum right before the air-handler. In the winter, warm/stale air being removed from the building will charge the incoming fresh air with a heat exchanger located inside the device. Conversely, in the summer months the exhausted cool/stale air from the interior will cool down the hot/humid air from the exterior before entering the air-handler. An ERV has a desiccant wheel as well. This allows for the transfer of moisture and recovery of some of the latent energy otherwise lost by expelling the moisture in the air. In the winter months, some of the moisture in the exhaust air will be transferred to the incoming dry air to help maintain occupancy comfort. In the summer, dry/conditioned air from the interior will remove, at least a portion of, the moisture from the humid incoming air - see Figure 27. Typically, the benefits of an ERV are best realized in areas of high summertime humidity such as in the Southern and Southeastern regions of the US. Subsequently, HRVs are usually installed in the Northeast where humidity levels are generally lower. There are however conditions that may warrant an ERV such as in cold climates if there are few occupants (sources of humidity) in a large drafty building. The ERV may help to maintain more comfortable humidity levels.

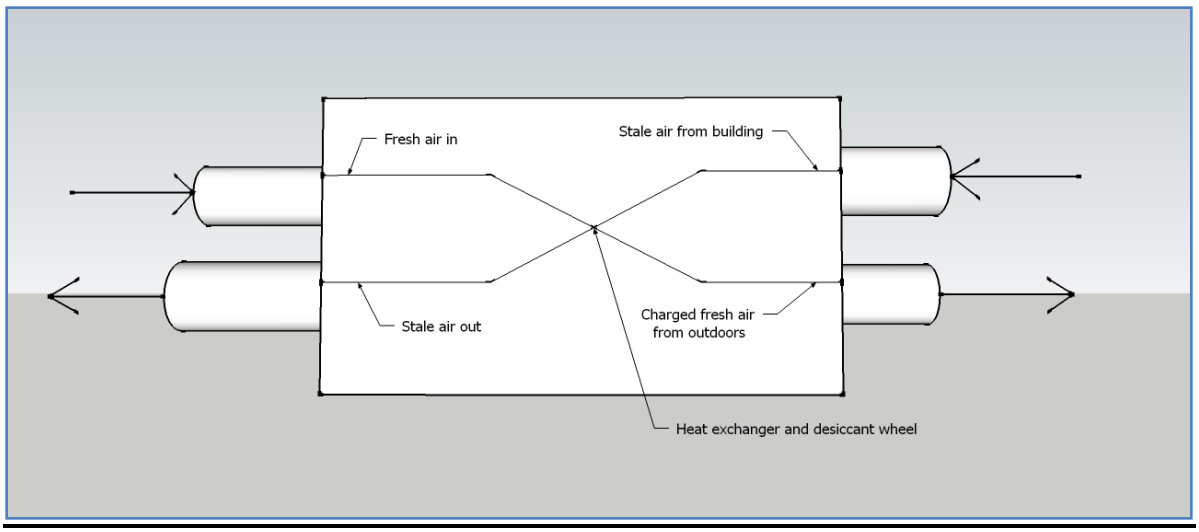


Figure 1

Recommendations:

The following list of recommendations will include steps for improving the performance of this building. Though further analysis is needed to give reasonable estimates of the effectiveness for the energy improvement recommendations, the health and safety concerns should be addressed regardless of whether or not they will reduce energy consumption. Some may in fact increase energy consumption.

This list will focus on each part of the building. Some sections may list the highest impact items first (large initial investment/large energy savings), others may be lower impact improvements that have a low implementation cost (may only require behavior change). These lists will be well explained during the presentation of this report.

Our prioritization is based on our "what works" experience. This list will not include detailed "spec" information on how exactly each item should be carried out. This type of detail would be presented in an IGA (Level II equivalent) in order to receive estimates for the cost of implementation, and return on investment.

Foundations and Slabs:

- At a minimum, eliminate air infiltration from the basement by air sealing the band joist around the entire perimeter of the building with closed cell spray foam.
- Cover the entire basement floor with a durable vapor barrier, making sure that it runs up the foundation walls and that all seams are sealed.
- For greater long term savings, continue the closed-cell foam down the interior of the foundation, applying at an average thickness of 2 inches.

- Confirm with the builder and/or architect whether or not the concrete slabs of the building were insulated. Insulate the perimeter of the slabs/foundations if this has not been done.
- Air seal where the foundation meets the frame and siding of the wood framed walls.

Exterior Walls:

- Air seal all of the exterior walls from the inside of the building. This work should begin where the floor meets the wall and then continue to the ceiling.
- Blow loose-fill cellulose into any empty wall cavities.

Ceilings and Attic:

- Seal any mechanical penetrations and chase ways between the basement 1st, 2nd, and 3rd floors.
- Develop a means of sealing off the top of the stairs from the 1st floor to the 2nd in order to slow the upward movement of conditioned air.
- Spray the entire underside of the original building's roof with closed-cell spray foam insulation, making sure to cover all wooded structural components and to run down the short sections of exterior wall where they extend into the 3rd floor.

Doors and Windows:

- Make sure that all doors and windows provide a good air seal when closed.
- Replace old storm windows with high efficiency units. Order units with a low-e coating for added insulative value.
- Air seal and insulate any gaps between window and door frames and the surrounding wall framing with spray foam. This may not be possible with some of the older windows that operate using window weights. These windows could be retrofitted with systems that would allow the window weights to be removed, leaving the windows still operable.
- Air seal any gaps or cracks between the window /door trim and the finished wall surfaces.
- Make good use of window shades for insulation purposes in the winter and to help reduce cooling loads in the summer.

Mechanical:

- Insulate all of the piping in the building.
- Replace thermostats with new digital/programmable units. Appropriate time and temperature settings can be discussed during the presentation of this report.
- Install an outdoor reset on the boiler to control temperature output.
- Talk with the service technician about options to increase the combustion efficiency of the current boiler.
- Install a solar domestic hot water system, and turn off the boiler during none heating months.

Electrical:

- Make use of smart power strips, and be sure to cut the power to any equipment when it is not in use.

- Replace any incandescent bulbs with either CFL or LED units. Be sure to focus any investment in LED lights to those lights that are used the most.
- Be sure to invest in the highest efficiency, Energy Star rated equipment when buying new items or replacing the old. Pay special attention to the highest energy users like air conditioning units and refrigerators.
- After efficiency matters have been addressed, install a photovoltaic solar system to provide onsite generation of electricity in order to supplement or eliminate what electric needs remain.

Health and Safety:

- Take all necessary steps to reduce the source of indoor air pollutants. Major steps will include moisture and pest control.
- Consult with a ventilation specialist on the most energy efficient means for meeting the ventilation requirements of this building. This might be able to be done by installing a series of residentially sized HRV's.

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.

New Hampshire Energy Technical Assistance and Planning (ETAP):

ETAP is a NH specific program funded by the American Recovery and Reinvestment Act (ARRA). This federally funded program is being administered by the NH Office of Energy and Planning, and is designed specifically to aid NH municipalities as they plan for and implement measures to reduce municipal energy costs.

The highly experienced ETAP team is eager to provide this assistance to your community, but you must sign into the program before mid-2012. Your community will not be required to write a proposal, and there are not charges for these services. It is important to remember that participating in any program will require time from municipal staff. The hours needed would likely run parallel to the size and complexity of the project your community wants to endeavor.

For inquiries on how your community can receive assistance from this valuable program, you will need to contact the ETAP Technical Assistance Coordinator, Eric Halter, at 603.225.3060. You can also get started by directly contacting the North Country Council:

North Country Council - 603.444.6303

NH Community Development Finance Authority (CDFA) – Municipal Energy Reduction Fund:

The NH CDFA was awarded $1.5 million through the Regional Greenhouse Gas Initiative (RGGI) to establish a revolving loan program in order to aid NH municipalities wishing to make their building stock more energy efficient. These loans are structured based on the amount of energy a given project will reduce, and terms/rates are flexible.

Municipalities can register and apply online at:
www.nhcdfa.org/web/erp/merf/merf_overview.html

For questions regarding this program, contact Cassandra Bradley at 603.717.9114 – cbradley@nhcdfa.org

NH PUC – Commercial and Industrial Renewable Energy Rebate Program:

The NH Public Utilities Commission has created a rebate program for renewable energy systems that is available to Local Governments. Participants will need to have a “Level II” audit

performed, and some of the energy efficiency measures implemented prior to being eligible for receiving the final rebate. This is a great opportunity for municipalities who are interested in installing a renewable energy system to receive a similar type of aid previously only available in residential and commercial applications.

There is a maximum incentive, and funding is limited, which means that municipalities will have to carry much of the cost. Participants need to fully understand and follow the project guidelines.

For questions regarding this program contact:
Kate Epsen
NH PUC
603.271.2431
kate.epsen@puc.nh.gov

More information can be found online at:
http://www.puc.nh.gov/Sustainable%20Energy/RenewableEnergyRebates-CI.html

Utility Programs:

Many utilities provide technical and financial assistance for various types of efficiency measures that can be carried out at a municipal facility. Some programs offer 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. Contact your utility provider to discover ways in which they can assist your municipality in reaching its energy efficiency goals.

For PSNH Customers - contact the PSNH representative for your region:

- Seacoast/Northern Region, Kathleen Lewis, 603.436.7708 ext. 5628 lewiskx@nu.com
- Southern Region, Elizabeth Larocca, 603.634.2380 larocel@nu.com
- Western/Central Region, Sue Blothenburg, 603.357.7309 ext. 5115 blothse@nu.com
- Visit - http://www.psnh.com/SaveEnergyMoney/For-Business/Municipal-Smart-Start-Program.aspx

Additionally, a terrific resource for monitoring and 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.

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 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.

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.

The follow Table and three Graphs were retrieved from the U.S Energy Information Administration website, were included in the 2010 Annual Energy Outlook, and are a clear indications of the fact that energy costs will continue to rise over the long term. It is extremely difficult to predict how quickly the cost of energy will escalate as there are too many economic, political, resources, etc. variables that influence these prices. Some years energy cost may be much lower than predicted, and some years may be much higher. The one thing that appears to be certain is that the cost of energy in the decades to come will pose great financial burdens on NH municipalities and their tax payers if no steps are taken to prepare for this forecast.

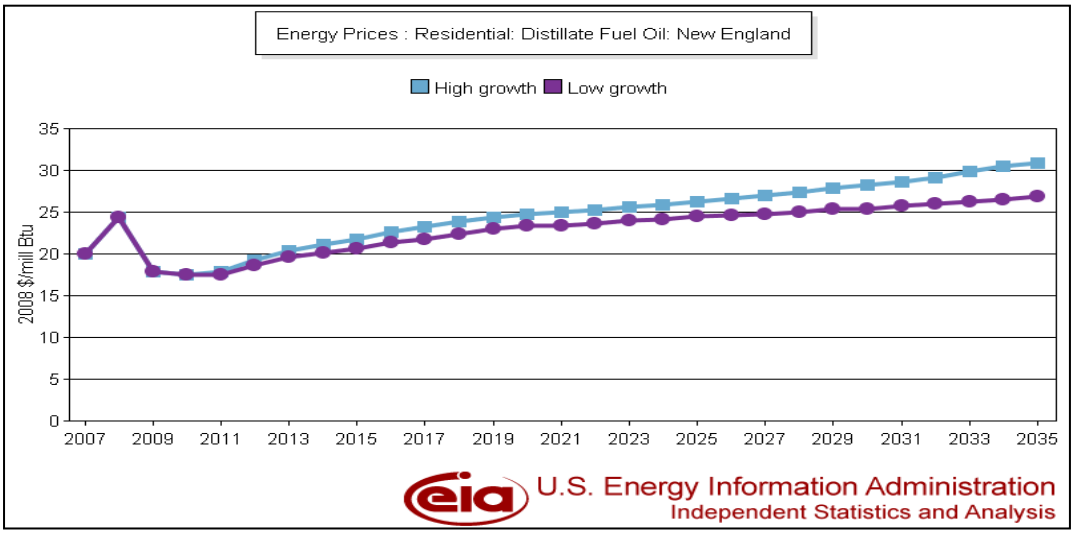
For more information on the history of energy prices and how energy cost projections are calculated, please visit: http://www.eia.doe.gov/analysis/

Price Summary

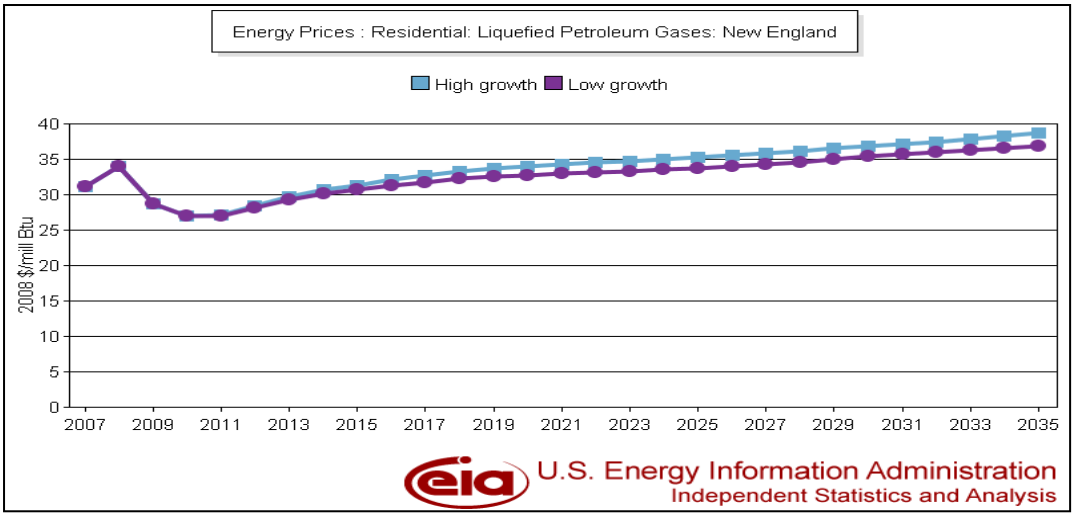
	Year				Percent Change		
	2009	2010	2011	2012	09-10	10-11	11-12
WTI Crude[a] ($/barrel)	61.65	79.40	93.26	97.50	28.8	17.5	4.5
Gasoline[b] ($/gal)	2.35	2.78	3.15	3.30	18.4	13.4	4.8
Diesel[c] ($/gal)	2.46	2.99	3.43	3.51	21.5	14.7	2.4
Heating Oil[d] ($/gal)	2.52	2.97	3.41	3.55	17.5	14.8	4.3
Natural Gas[d] ($/mcf)	12.12	11.17	11.29	12.01	-7.8	1.1	6.3
Electricity[d] (cents/kwh)	11.51	11.58	11.65	11.74	0.7	0.6	0.7

[a] West Texas Intermediate. [b] Average regular pump price.
[c] On-highway retail. [d] U.S. Residential average.

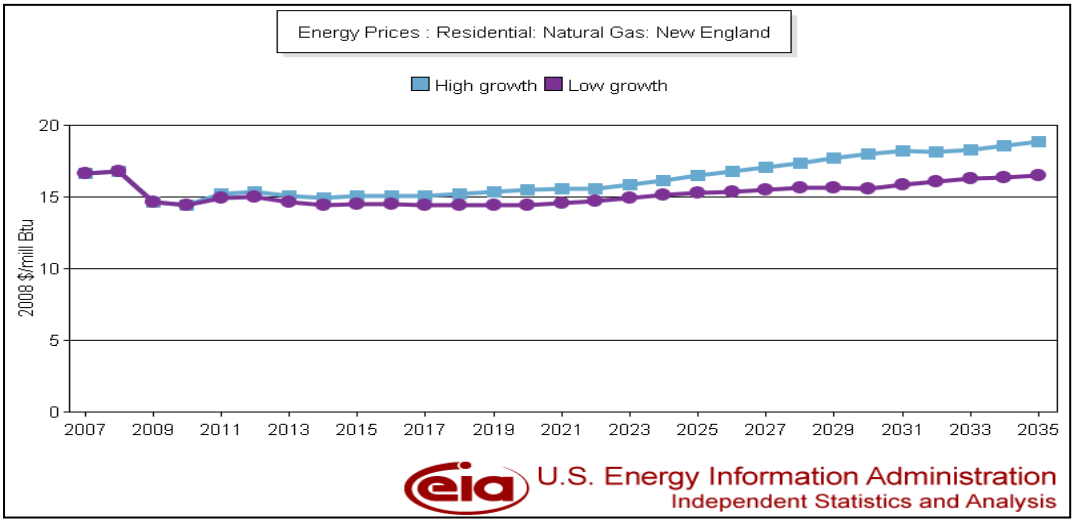
Table 1 – Retrieved from US EIA website



Graph 1 - Retrieved from US EIA website



Graph 2 - Retrieved from US EIA website



Graph 3 - Retrieved from US EIA website

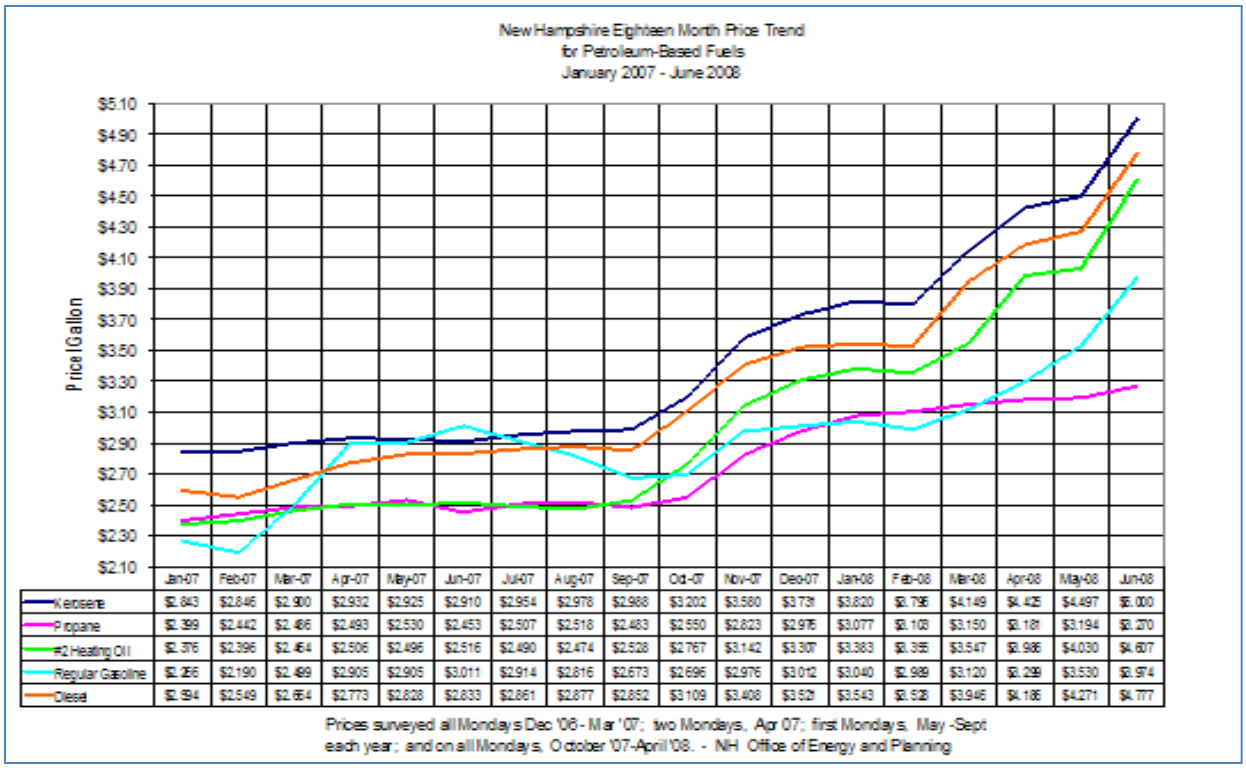
The following three Graphs (retrieved from the NH OEP website) show average prices in NH for liquid fuels beginning in January of 2007 and ending in December 2010. These graphs help to illustrate just how volatile the cost of energy is, and the steady rise of price regardless of occasional "spikes" or "dips" in the market. As unfortunate as the 2008 energy prices were, these types of events only serve to shorted the Return on Investment for those who implemented energy efficiency measure prior to their occurrence.

When considering the type of energy reduction project to implement, it is very important for Local Governments to look far into the future of energy costs, as municipalities will own and operate most of their building stock for as long as they may stand.

Projects such as 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 and a PV system may only last 30 years before it is time to replace them, even with careful

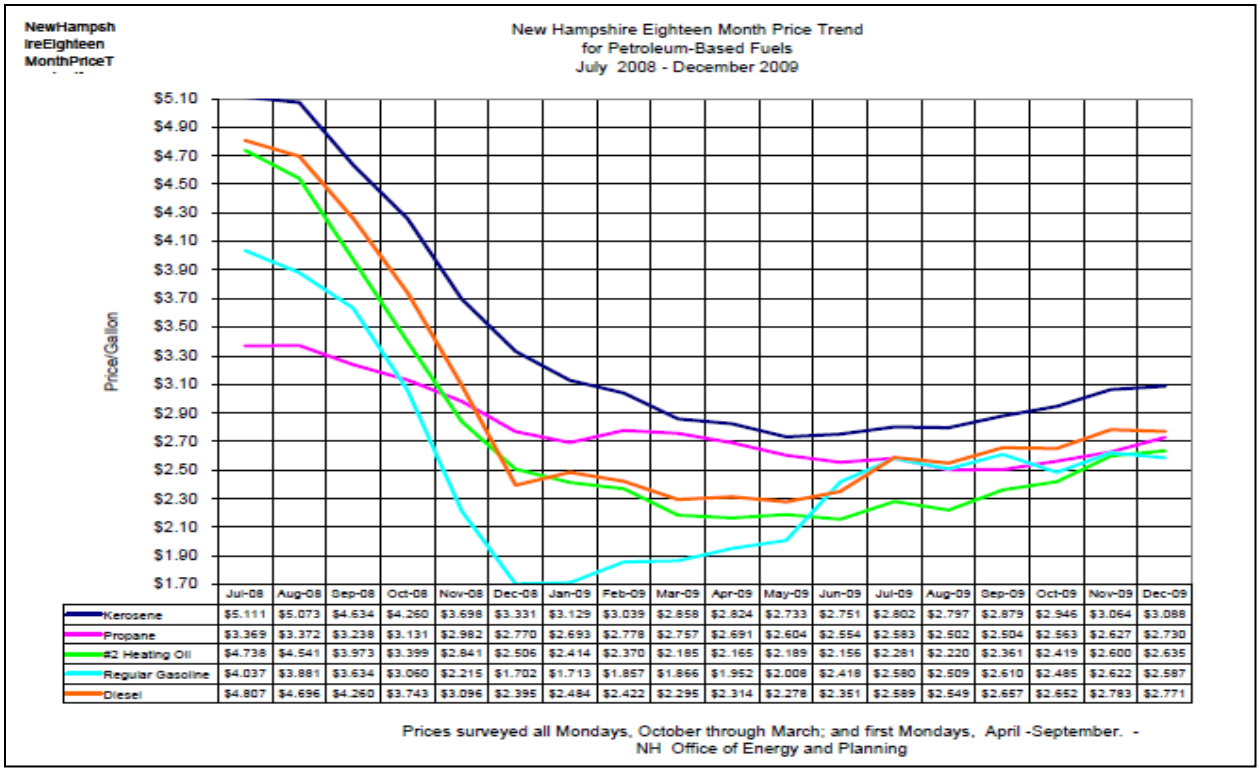
maintenance and care. This is an important consideration when factoring in the true life cycle cost of the implemented solution.

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 is as small as it can be, providing the most savings.



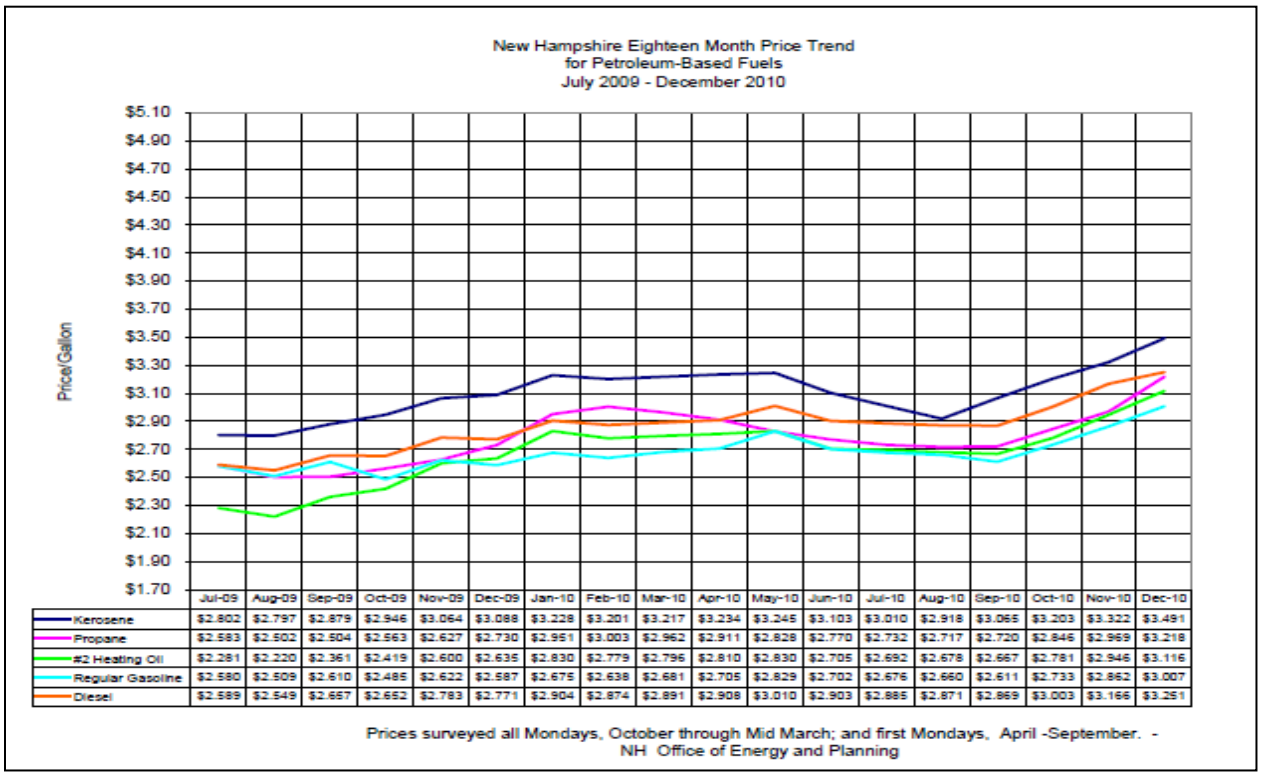
	Jan-07	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08
Kerosene	$2.843	$2.846	$2.900	$2.932	$2.925	$2.910	$2.954	$2.978	$2.988	$3.202	$3.580	$3.731	$3.820	$3.796	$4.149	$4.425	$4.497	$5.000
Propane	$2.399	$2.442	$2.486	$2.493	$2.530	$2.453	$2.507	$2.518	$2.483	$2.550	$2.823	$2.976	$3.077	$3.108	$3.150	$3.181	$3.194	$3.270
#2 Heating Oil	$2.376	$2.396	$2.454	$2.506	$2.496	$2.516	$2.490	$2.474	$2.528	$2.767	$3.142	$3.307	$3.383	$3.355	$3.547	$3.986	$4.030	$4.607
Regular Gasoline	$2.256	$2.190	$2.499	$2.905	$2.905	$3.011	$2.914	$2.816	$2.673	$2.696	$2.976	$3.012	$3.040	$2.989	$3.120	$3.299	$3.530	$3.974
Diesel	$2.594	$2.549	$2.664	$2.773	$2.828	$2.833	$2.861	$2.877	$2.852	$3.109	$3.408	$3.521	$3.543	$3.528	$3.946	$4.186	$4.271	$4.777

Figure 2 - Retrieved from NH OEP website



	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09
Kerosene	$5.111	$5.073	$4.634	$4.260	$3.698	$3.331	$3.129	$3.039	$2.858	$2.824	$2.733	$2.751	$2.802	$2.797	$2.879	$2.946	$3.064	$3.088
Propane	$3.369	$3.372	$3.238	$3.131	$2.982	$2.770	$2.693	$2.778	$2.757	$2.691	$2.604	$2.554	$2.583	$2.502	$2.504	$2.563	$2.627	$2.730
#2 Heating Oil	$4.738	$4.541	$3.973	$3.399	$2.841	$2.506	$2.414	$2.370	$2.185	$2.165	$2.189	$2.156	$2.281	$2.220	$2.361	$2.419	$2.600	$2.635
Regular Gasoline	$4.037	$3.881	$3.634	$3.060	$2.215	$1.702	$1.713	$1.857	$1.866	$1.952	$2.008	$2.418	$2.580	$2.509	$2.610	$2.485	$2.622	$2.587
Diesel	$4.807	$4.696	$4.260	$3.743	$3.096	$2.395	$2.484	$2.422	$2.295	$2.314	$2.278	$2.351	$2.589	$2.549	$2.657	$2.652	$2.783	$2.771

Graph 4 – Retrieved from NH OEP website



	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10
Kerosene	$2.802	$2.797	$2.879	$2.946	$3.064	$3.088	$3.228	$3.201	$3.217	$3.234	$3.245	$3.103	$3.010	$2.918	$3.065	$3.203	$3.322	$3.491
Propane	$2.583	$2.502	$2.504	$2.563	$2.627	$2.730	$2.951	$3.003	$2.962	$2.911	$2.828	$2.770	$2.732	$2.717	$2.720	$2.846	$2.969	$3.218
#2 Heating Oil	$2.281	$2.220	$2.361	$2.419	$2.600	$2.635	$2.830	$2.779	$2.796	$2.810	$2.830	$2.705	$2.692	$2.678	$2.667	$2.781	$2.946	$3.116
Regular Gasoline	$2.580	$2.509	$2.610	$2.485	$2.622	$2.587	$2.675	$2.638	$2.681	$2.705	$2.829	$2.702	$2.676	$2.660	$2.611	$2.733	$2.862	$3.007
Diesel	$2.589	$2.549	$2.657	$2.652	$2.783	$2.771	$2.904	$2.874	$2.891	$2.908	$3.010	$2.903	$2.885	$2.871	$2.869	$3.003	$3.166	$3.251

Graph 5 – Retrieved from NH OEP website

Potential for Savings:

(The following numbers are not meant to be accurate estimates. Such estimates are only provided in an Investment Grade Audit (IGA). Instead, these numbers are only meant to give a rough idea of what potential for savings there may be in regards to the current energy expenditures given a 30% reduction).

Average cost of various energy types in NH
Date - January 31st 2011

Heating Oil, credit	$3.463 per Gallon
Propane, credit	$3.549 per Gallon[1]
Kerosene, credit	$3.841 per Gallon
Electricity	$0.14260 per kilowatt-hour[2]
Natural Gas, first tier	$1.1305 per therm[3]
Natural Gas, second tier	$1.0622 per therm[4]

Figure 3 – Retrieved from NH OEP website

The table below estimates the cost of liquid fuel for this facility over a 15 year period. This is only an estimate, and is based on current yearly usage, NH price averages for January 31st 2011, with a 5% cost increase per year.

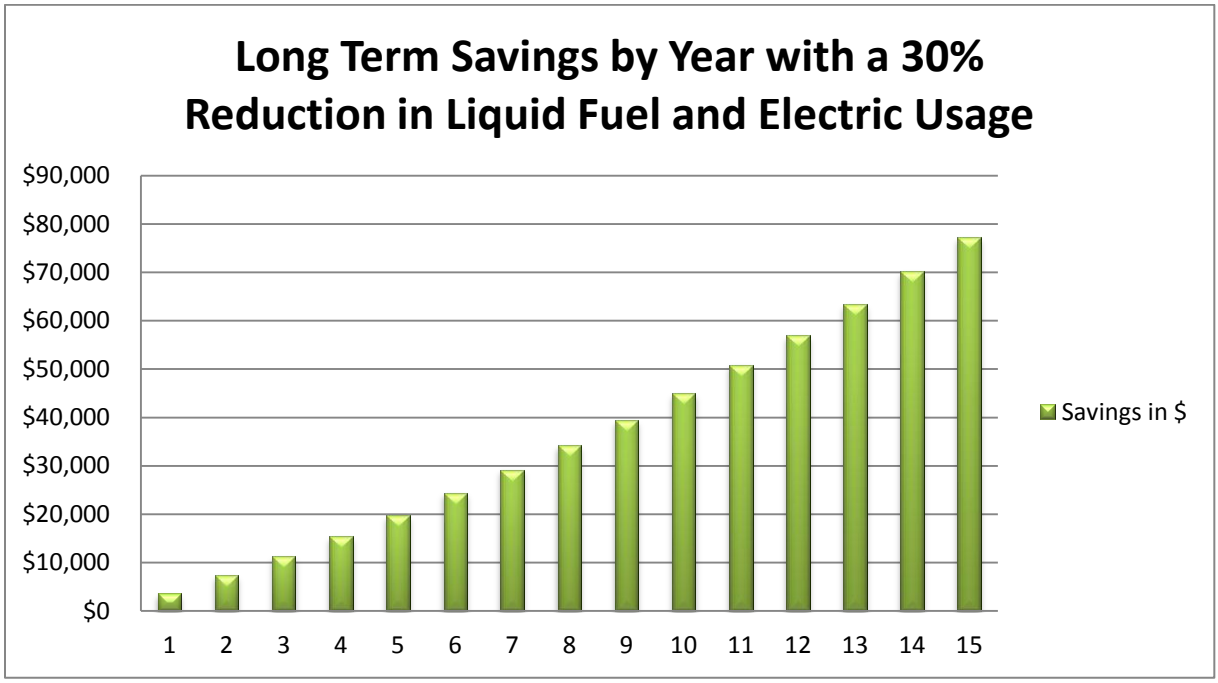
Fuel Usage - Current 15 Year Projection				
Year	Energy Cost By Year	Yearly Increase	Total Accumulated Cost by Year	
		Escalation Rate	5.00%	
Year 1	$9,585.58	$ 479.28		$9,586
Year 2	$10,065	$ 503.24		$19,650
Year 3	$10,568	$ 528.41		$30,219
Year 4	$11,097	$ 554.83		$41,315
Year 5	$11,651	$ 582.57		$52,966
Year 6	$12,234	$ 611.70		$65,200
Year 7	$12,846	$ 642.28		$78,046
Year 8	$13,488	$ 674.39		$91,534
Year 9	$14,162	$ 708.11		$105,696
Year 10	$14,870	$ 743.52		$120,566
Year 11	$15,614	$ 780.70		$136,180
Year 12	$16,395	$ 819.73		$152,575
Year 13	$17,214	$ 860.72		$169,789
Year 14	$18,075	$ 903.75		$187,864
Year 15	$18,979	$ 948.94		**$206,843**

The table below estimates the cost of electricity for this facility over a 15 year period. This is only an estimate, and is based on current yearly usage, NH price averages for January 31st 2011, with a 5% cost increase per year.

Electric Use - Current 15 Year Projection				
Year	**Energy Cost By Year**	**Yearly Increase**	**Total Accumulated Cost by Year**	
		Escalation Rate	**5.00%**	
Year 1	$2,344.00	$ 117.20		$2,344
Year 2	$2,461	$ 123.06		$4,805
Year 3	$2,584	$ 129.21		$7,389
Year 4	$2,713	$ 135.67		$10,103
Year 5	$2,849	$ 142.46		$12,952
Year 6	$2,992	$ 149.58		$15,944
Year 7	$3,141	$ 157.06		$19,085
Year 8	$3,298	$ 164.91		$22,383
Year 9	$3,463	$ 173.16		$25,846
Year 10	$3,636	$ 181.82		$29,483
Year 11	$3,818	$ 190.91		$33,301
Year 12	$4,009	$ 200.45		$37,310
Year 13	$4,209	$ 210.47		$41,519
Year 14	$4,420	$ 221.00		$45,939
Year 15	$4,641	$ 232.05		**$50,580**

The table below and graph are based on the previous two tables, and estimates the savings over a 15 year period if both fuel and electric usage is reduced by 30%.

Long Term Cost Avoidance - Heat and Electric				
Percent of Cost Reduction =			**30.00%**	
Year	**Avoided Cost By Year**	**Savings Gain By Year**	**Total Savings Over 15 Years**	
		Escalation Rate	**5.00%**	
Year 1	**$3,579**	**$ 178.94**		**$3,579**
Year 2	**$3,758**	**$ 187.89**		**$7,337**
Year 3	**$3,946**	**$ 197.29**		**$11,282**
Year 4	**$4,143**	**$ 207.15**		**$15,425**
Year 5	**$4,350**	**$ 217.51**		**$19,776**
Year 6	**$4,568**	**$ 228.38**		**$24,343**
Year 7	**$4,796**	**$ 239.80**		**$29,139**
Year 8	**$5,036**	**$ 251.79**		**$34,175**
Year 9	**$5,288**	**$ 264.38**		**$39,463**
Year 10	**$5,552**	**$ 277.60**		**$45,015**
Year 11	**$5,830**	**$ 291.48**		**$50,844**
Year 12	**$6,121**	**$ 306.05**		**$56,965**
Year 13	**$6,427**	**$ 321.36**		**$63,393**
Year 14	**$6,749**	**$ 337.43**		**$70,141**
Year 15	**$7,086**	**$ 354.30**		**$77,227**



As one can see, the potential savings are significant and can provide supplemental funds to carry out further energy savings within this facility, or another Town facility. While these are assumed savings, current market trends indicate the potential for significantly more savings as a result of the increasing energy costs currently being seen within the region and country as a whole.

Conclusion:

As a result of this audit, the Town has several options available to increase the efficiency of the Library. Achieving 30% savings in energy cost for this building is well within reach, and as the above graph helps to illustrate, the initial investment for energy improvement projects can have an attractive return. Considering that this building will likely be owned and operated by the Town for a period much longer than the next 15 years, we highly encourage that the Town pursue these recommendations described in this report. More detail about our findings and recommendations can be given during the presentation of this report.