The New Hampshire Municipal Energy Assistance Program

Decision Grade Audit Report

East Park St. Library
9 East Park St., Lebanon, NH 03766

Prepared for:

Town of Lebanon, NH

Prepared by:

SDES Group
Sustainable Development & Energy Systems

2 Washington Street, Suite 206
Dover, NH 03820
www.sdesgroup.com

In cooperation with:

Jeffrey H. Taylor & Associates, Inc.

CLEAN AIR COOL PLANET

Sustainable Energy Resource Group
Efficiency Makes Sense

Vital Communities
engaged citizens ↔ vital communities

Carbon Solutions New England™

This project is made possible with support from the New Hampshire Regional Greenhouse Gas Initiative

3/11/2011

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 Lebanon 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 Lebanon.

For questions regarding this report, please contact:

Tobias Marquette
603.866.1514
tobias.marquette@sdesgroup.com

SDES Group, LLC
2 Washington St., Ste. 206
Dover, NH 03820
P: 603.617.3767
F: 603.947.2114
Email: info@sdesgroup.com
www.sdesgroup.com

Table of Contents

Introduction: 4
The Audit 4
Basics of Heat Loss: 6
Basics of Moisture Control: 7
Building Description: 9
Energy Data Collection: 11
Blower Door Test Results: 13
Foundations, Floors, Crawl Spaces, and/or Basements: 14
Exterior Walls: 18
Ceilings and Attic: 24
Doors and Windows: 26
Mechanical: 29
Electrical: 33
Health, Safety and Comfort: 35
Recommendations: 37
Financial Considerations and Options: 40
Potential for Savings: 48
Conclusion: 50

Introduction:

MEAP partners are pleased to provide this Decision-Grade Audit Report for the Town of Lebanon and the East Park St. Library (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. A cost:benefit ratio can be determined for burning any of these fuels with a forced air system, a radiant floor system, hydro-air, baseboard radiators or various other heating systems. Any of these heating plants, 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.

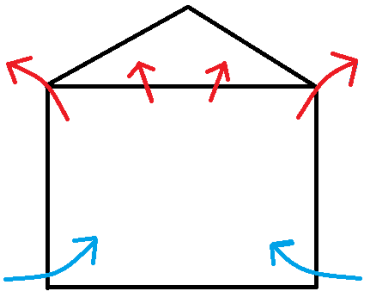
This DGA involves a quantification of energy consumption (electrical and heating fuel), a description of existing heating/cooling and distribution systems, thermal barrier inefficiencies, potential electric savings through lighting/appliances upgrades and behavior change, occupancy health and safety 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 an 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 conventional, alternative and renewable high-efficiency heating and cooling systems, has designed 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 specification 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.

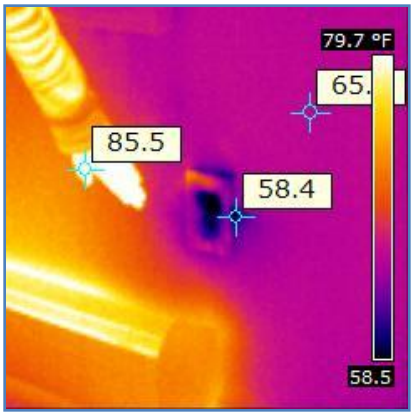
Heat moves through and leaves a building by three different means: *convection, conduction, and radiation*. One way to think of **convective** heat loss is by air movement into and out of a structure. One of the forces causing this to happen is the "stack effect".



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.

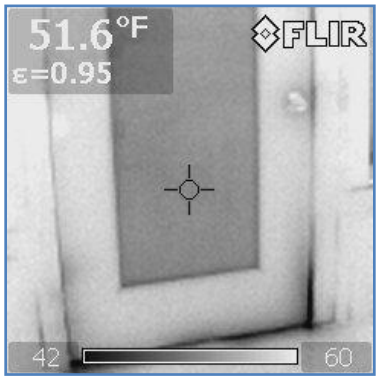
Conduction is the foremost way in which heat travels through a solid building material. R-value is one way to describe a given materials resistance to transfer heat. Materials with a high R-value, such as foams, cellulose, or fiberglass batts are used for insulation. At any location in the building envelope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

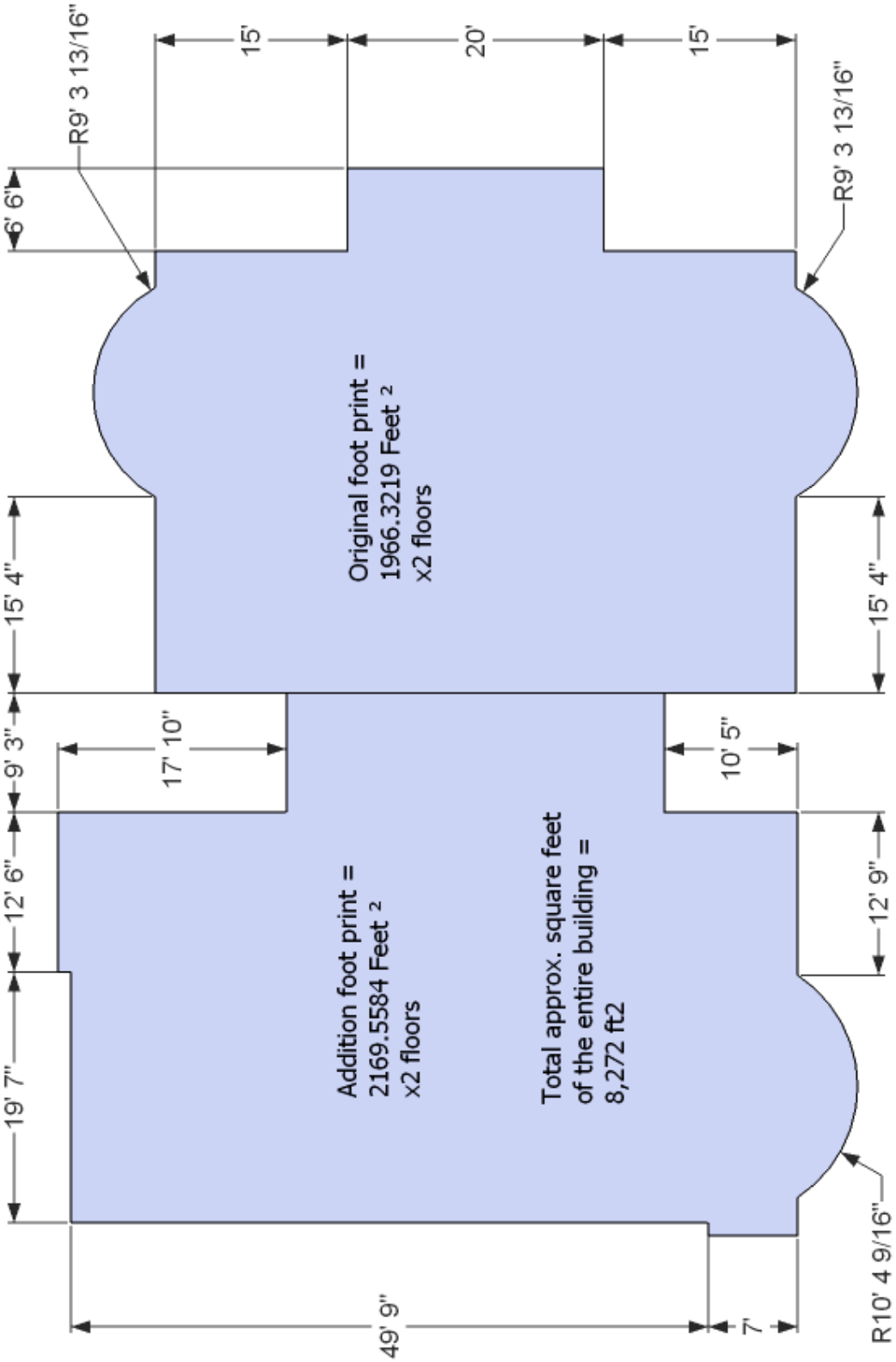
Just as BTUs conduct through solid materials, water vapor diffuses through solid materials. Some materials are more resistant to vapor diffusion, such as polyethylene, and we use these to form a vapor barrier on the inside of the thermal boundary in an attempt to slow the amount of vapor diffusion. Small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

The original section of the Lebanon Public Library was built in 1904 with granite and earth tone bricks. The details on the first floor of this well-constructed building have likely not changed at all since it was built, though the basement has been renovated and now contains a children's room, conference room, a break room for staff, and the motor room for the elevator now found in the new addition.

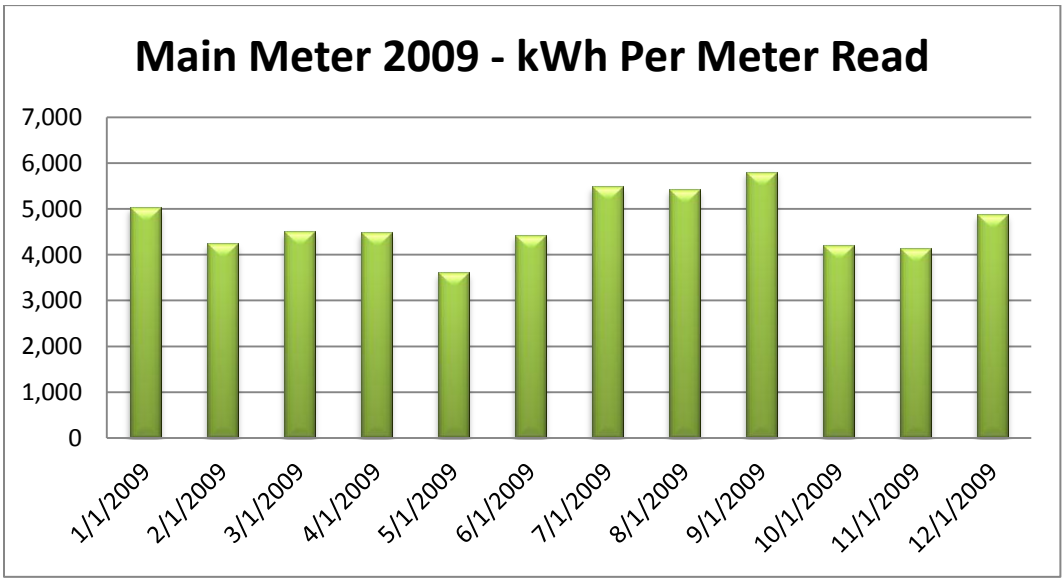
The somewhat recently added addition was constructed with concrete block, some granite details, and a similar earth tone brick venire. The two story addition has a well-integrated modern look that contains more energy efficient construction details such as rigid foam in its wall and roof systems. Fittingly, the addition houses the majority of the Library's computer systems, and was even designed with passive solar wall panels on its south side.


R9' 3 13/16"
6' 6"
15' 4"
9' 3"
12' 6"
19' 7"
15'
20'
15'
R9' 3 13/16"
Original foot print =
1966.3219 Feet ²
x2 floors
17' 10"
10' 5"
15' 4"
12' 9"
Addition foot print =
2169.5584 Feet ²
x2 floors
Total approx. square feet
of the entire building =
8,272 ft2
49' 9"
7'
R10' 4 9/16"

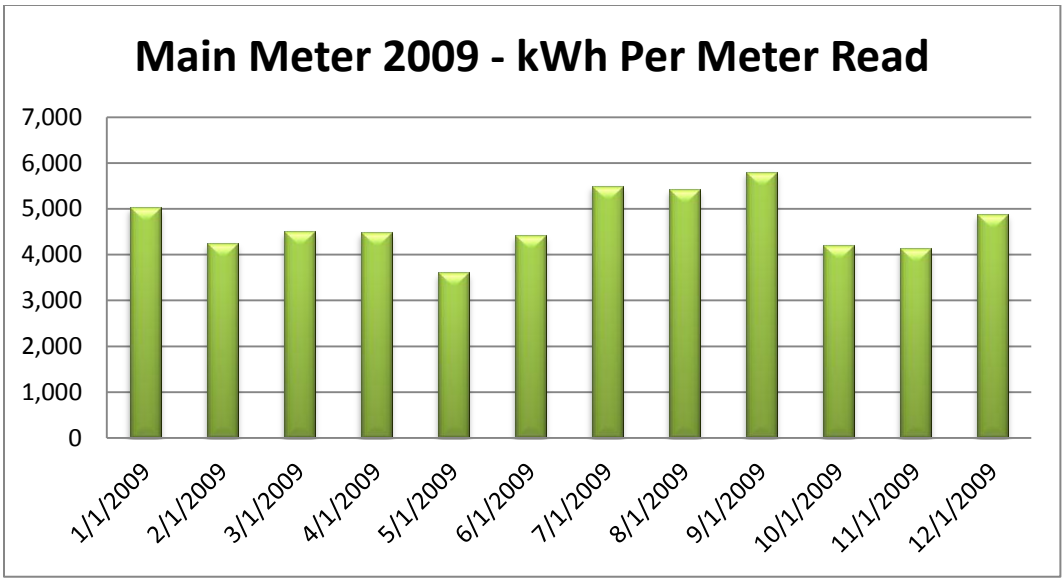
Energy Data Collection:
Analysis from provided utility bills for 2009 produces the following snapshot in electricity consumption. Monthly consumption is designated low to high, red being the lowest and green being the highest consumption months in the table below.

Electric -Main Meter			
GSEC			
Date	**KWH**	**Total $/mo**	**Cost Per kWh**
12/1/2009	4,878	$977.69	$0.2004
11/1/2009	4,142	$843.25	$0.2036
10/1/2009	4,214	$856.39	$0.2032
9/1/2009	5,803	$1,160.60	$0.2000
8/1/2009	5,426	$1,077.07	$0.1985
7/1/2009	5,496	$1,089.21	$0.1982
6/1/2009	4,419	$837.99	$0.1896
5/1/2009	3,610	$745.13	$0.2064
4/1/2009	4,490	$905.68	$0.2017
3/1/2009	4,512	$909.68	$0.2016
2/1/2009	4,242	$860.43	$0.2028
1/1/2009	5,037	$989.84	$0.1965

Average $/kWh: $0.2002
Total kWh: 59,269
Total Cost in 2009: $11,252.96



Annual electricity consumption for Lebanon Town Library



Cost of delivered electricity for Lebanon Town Library

Heat Source 1			
No. 2 Oil			
Date	**Fuel Units**	**$**	**Cost Per Unit**
2009	2,357	$7,143.85	$3.031
	Total Units Used =		**2357**
	Total Paid For Year =		**$ 7,143.85**
	Ave Cost Per Gal =		**$ 3.03**
NH Average By Date - 1.31.2011		Click Here $ Per Unit =	$3.463
Yearly cost based on the above price =			**$8,162.29**

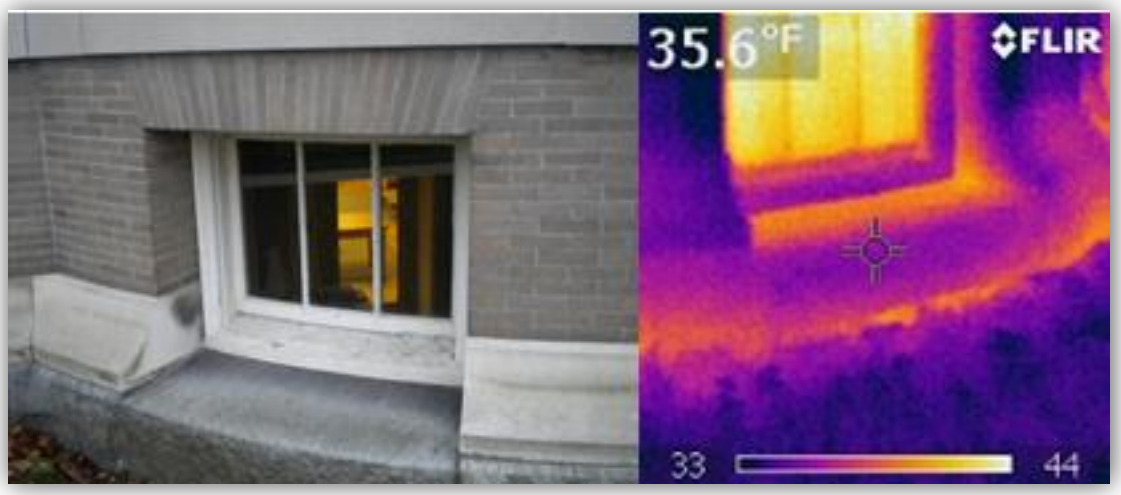
Blower Door Test Results:

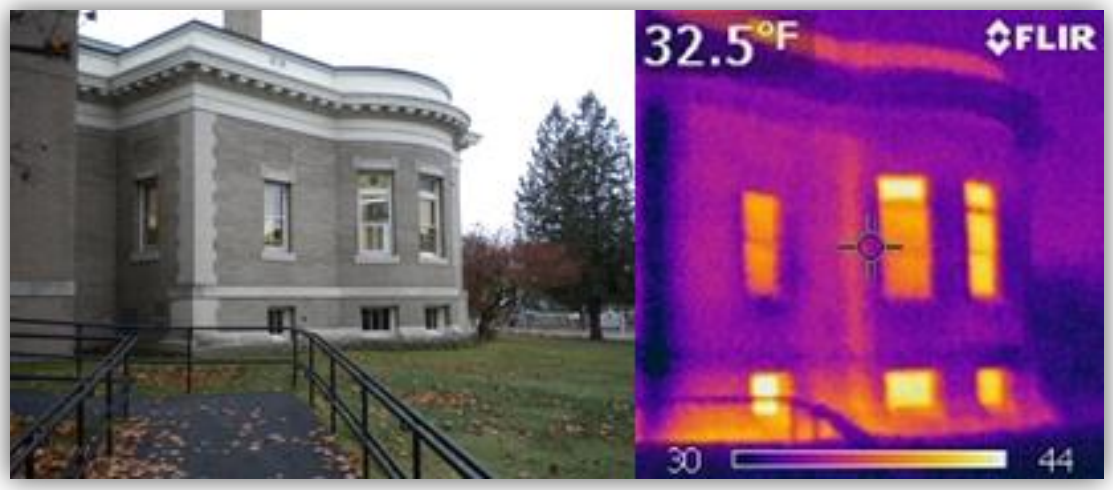
A blower door test was not performed on this building because of one or more of the following reasons.

- 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:

The basement of the original building is, for the most part, a finished/usable space. There is a conference room, children's room, break room, boiler/furnace room, mechanical room for the elevator, and some storage closets.
As with many different types of buildings, much of the heat loss from this building is coming from the bottom and the top of the building. In the original section of the building, the basement walls do not have the same kind of finished surfaces as the walls in the floors above. The walls of the 1st floor have a type of stud wall that supports lath and plaster. Though there is no insulation material behind the lath and plaster, the air gap does offer some insulative value.





The basement of the original building is also a large source of water vapor. High humidity levels can lead to the early deterioration of a building, and the consequent mold and mildew damage may also be harmful to occupants.

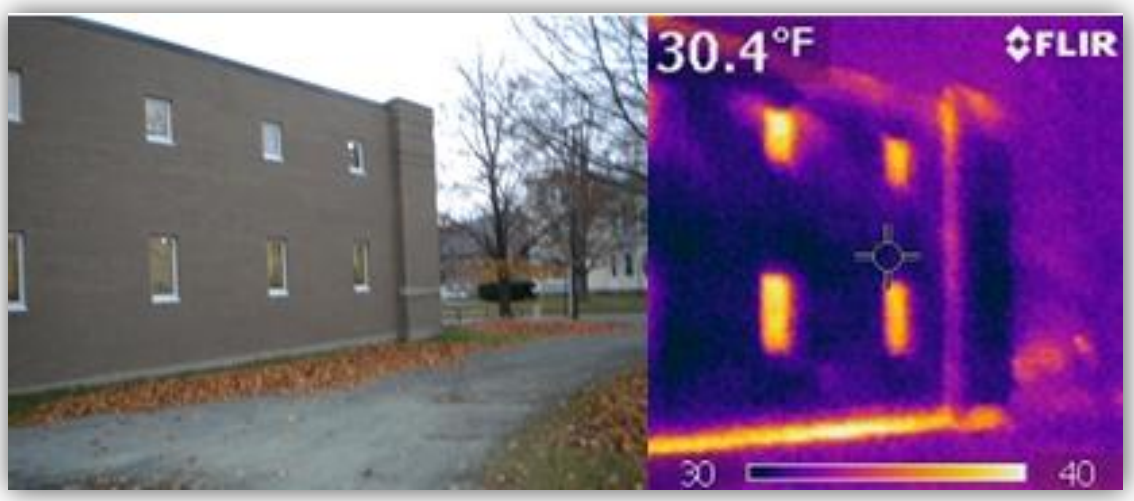
We did not find many direct concerns in terms of moisture damage, which is in part owing to a dehumidifier located in the conference room. This dehumidifier, seen in the photo to the right, is an important tool for expelling some of the excess moisture, but it is important to note that it does not deal with the source of moisture and may add substantially to the building's electric costs. Making sure that a strict schedule for cleaning its filter will help ensure that it is operating as efficiently as possible.

When considering the prospect of insulating the basement walls, there is a common concern to take into account. Because there is such high moisture content in the walls of the foundation, keeping it warm helps prevent the moisture in and around the wall from freezing, expanding, and putting pressure on the joints of the granite.

The two photos below show the moisture level results using a very basic moisture meter. What we noticed was that the moisture levels seemed to be relatively low at the bottom of the wall and gradually increased when approaching exterior ground level (grade), then lowered again when the meter was place against the wall above grade. What this may suggest is that a drainage plan for the top of the foundation, which is also a more accessible area of the foundation, could have a large impact on overall moisture levels in the basement.

Keeping water vapor from entering this space all together would be ideal but may be very difficult to achieve; however, putting an advanced drainage system in place around the perimeter of the foundation would be a great starting point. With the perimeter exposed, there would also be opportunity to lay down sheets of rigid foam board insulation—sealed tightly against the foundation. This foam board could be the beginning point of moving rain water and snow melt away from the foundation—adding a thermal barrier to help retain heat will also reduce the amount of heat loss from the foundation.

The same weak points are found with the new addition as seen in the images below. Most of the floor area of the 1st floor is a concrete slab. Some of the plans for this building did indicate that this foundation should be insulated with rigid foam board, but that is not necessarily what was done, and, as these images prove, there is a substantial amount of heat radiating from the slab. One factor contributing to this is that there are large, round PVC pipes in the slab that serve as air ducts, thus directly heating the slab. For this reason, it is all the more important to ensure that this slab is as insulated as possible. This could be done in an effective manner, which may also add an aesthetically pleasing detail to these walls.



The areas of foundation level air infiltration are limited to the original building. Removing or covering window AC units and making sure that windows are well-sealed will lessen this source of convective heat loss.

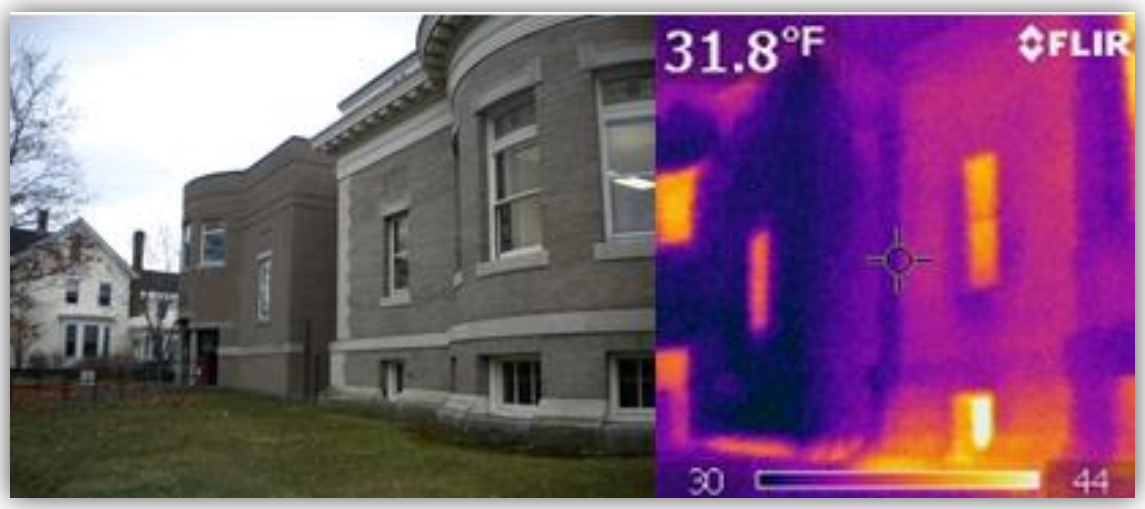
Much of the ceiling area in the basement has three levels: the two tallest being older ceilings. Mechanically, this space is very useful, though the lack of a good air barrier may make it challenging to keep produced heat in its intended location.

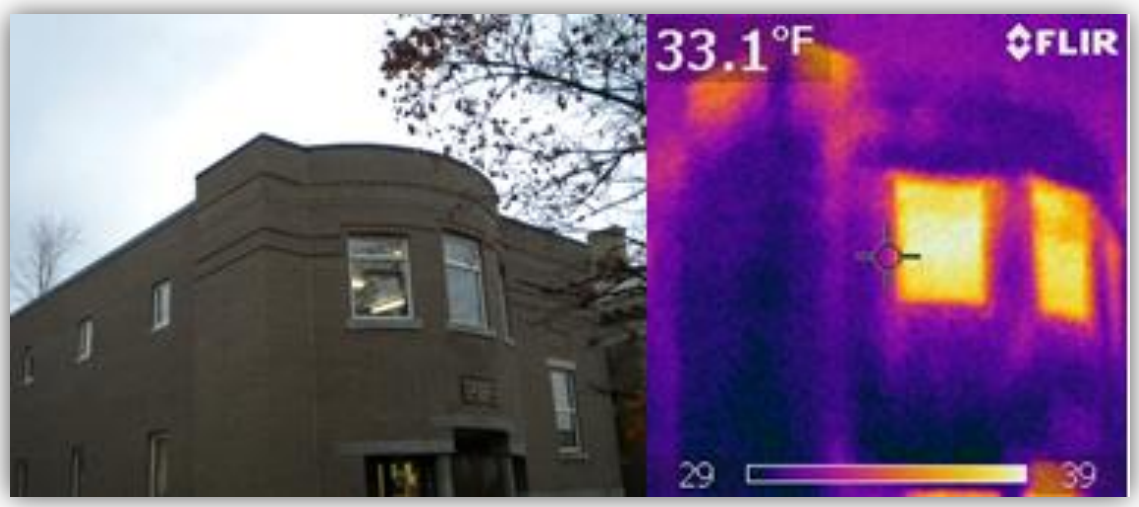
In fact, a great deal of heat dispersed to this space was found coming from the radiator located between two sections of ceiling.

Exterior Walls:

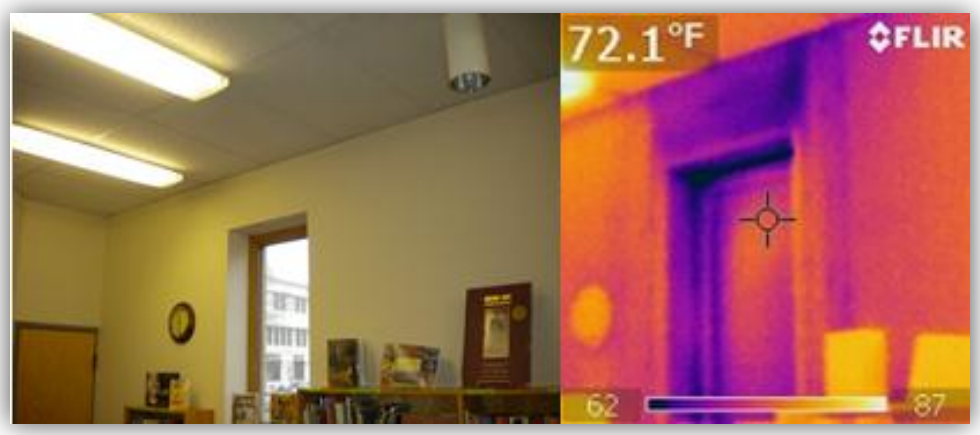
With buildings of this type, there are few options for improving the insulative value of the exterior walls. This is due to a combination of the limited ways to retroactively insulate masonry walls (moisture concerns) and the inability to disturb the history value of the building. There is still much debate in building science on appropriate ways, if any, to insulate a masonry building from the interior. One sure method is to wrap the entire structure in foam board insulation from the exterior and finish with stucco type material. This is known as an Exterior Insulation and Finish System (EIFS). Given that this is not a likely option for this building, making less significant/effective improvements will have to suffice.

Note the sections of the addition that are visible in the images below. This newer method of constructing masonry buildings has used concrete block on the interior (structural wall), foam board insulation, air gap, and then the brick face. The advent of foam board insulation certainly has created a more effective means of slowing heat loss, but as these IR images prove, this wall system too has its weak points.

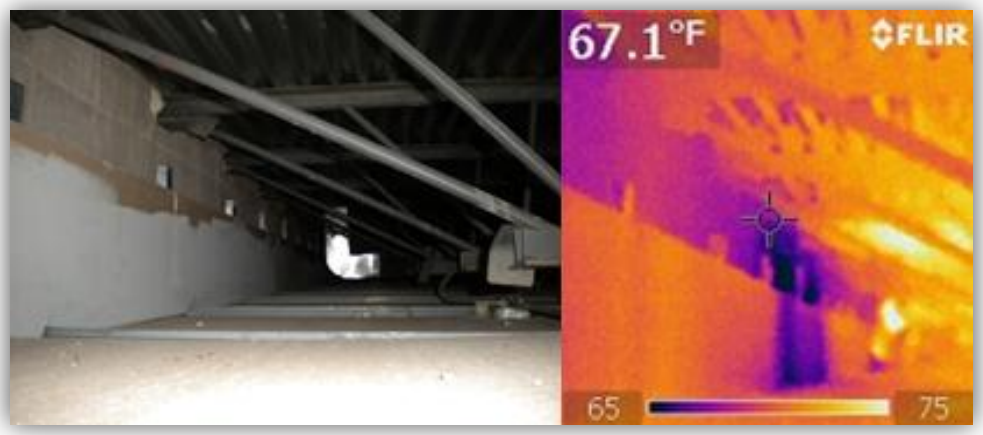




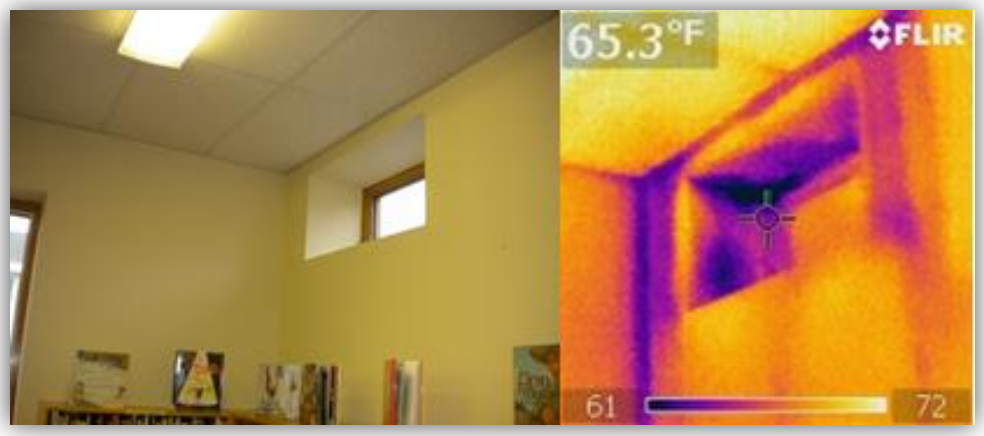
One of the first weak areas we noticed in the addition is the wall area round the windows. As the images below show, the combination of air infiltration and low insulative value is apparent in the purple areas of the IR images.



These images were taken of the same window but from above the suspended ceiling. Each of these window openings was performing in the same way.



The same remained true for these transom windows.



In this next section, we will discuss how the loss of heat may be occurring from the tops of the addition walls. This is only an effort to try and understand why the apparent amount of heat loss is coming from the tops of these walls in order to aid in the development of a potential energy savings opportunity.

This image was taken from above the suspended ceilings on the 2nd floor of the addition (above the front entrance). Note the cold spots between the thick areas of foam and the temperature of the block compared to other surfaces.

The block walls on the interior were finished by fastening metal strapping to the blocks. Then sheetrock was fastened to the strapping. What this does is it creates an air gap that is exposed to areas above the suspended ceiling. Heat delivered to the room conducts through the sheetrock. The air in the gap is heated and creates an upward current. There were some areas where the gaps at the top of the sheetrock had been filled with spray foam but only in a few sections.
The heat that does not rise upward is radiating across this space and heating the block. The foam on the outside of the concrete blocks then slows the heat conduction and radiation processes. However, if the cavities of the concrete blocks are empty, the air inside would be heated and begin to rise towards the roof.

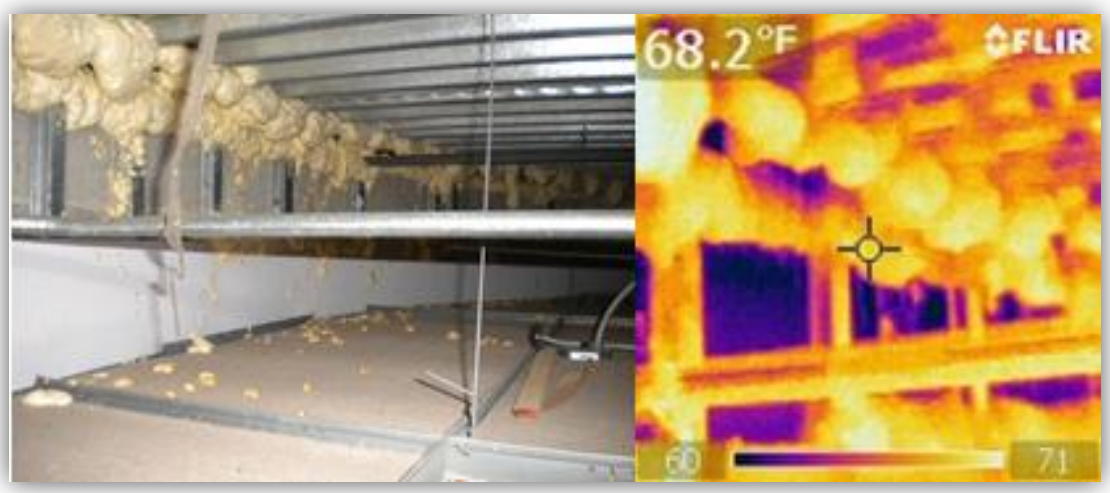


Figure 1 and 2 on the next page show two ways in which the tops of the walls could have been constructed. It may also be that both methods were employed in different areas. Neither could be confirmed during our inspection of the building. Only someone with deep involvement during the construction process would know this detail without having to dissect part of the roof. What appears to be a similar aspect of both these wall details is that there is a lack of insulation between the foam board on the walls and that of the roof. If either one of these design types were used, it seems that determining a way to air seal and insulate the top two or three rows of block, with spray foam perhaps, could reduce this insulation void and slow the upward movement of heated air.

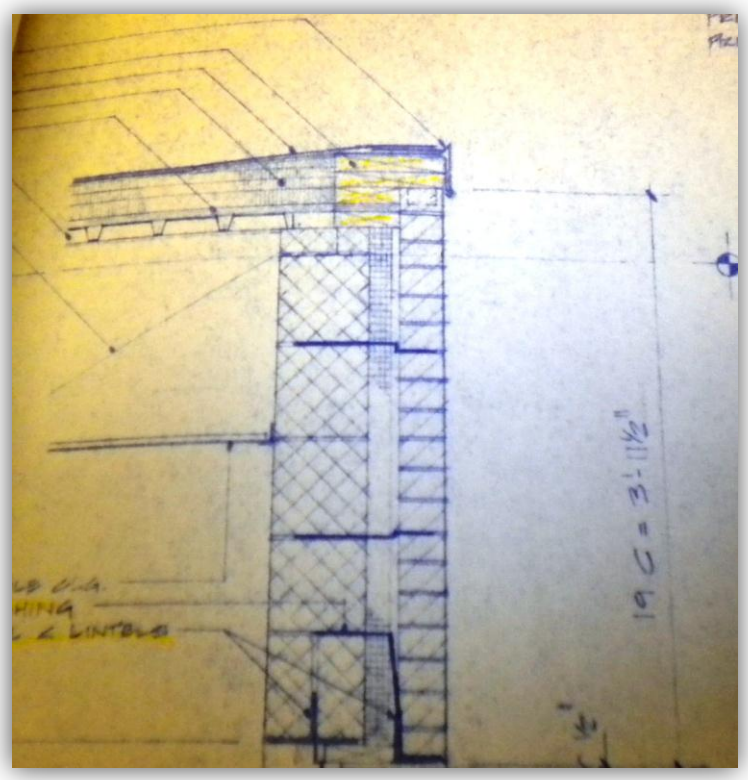


Figure 1

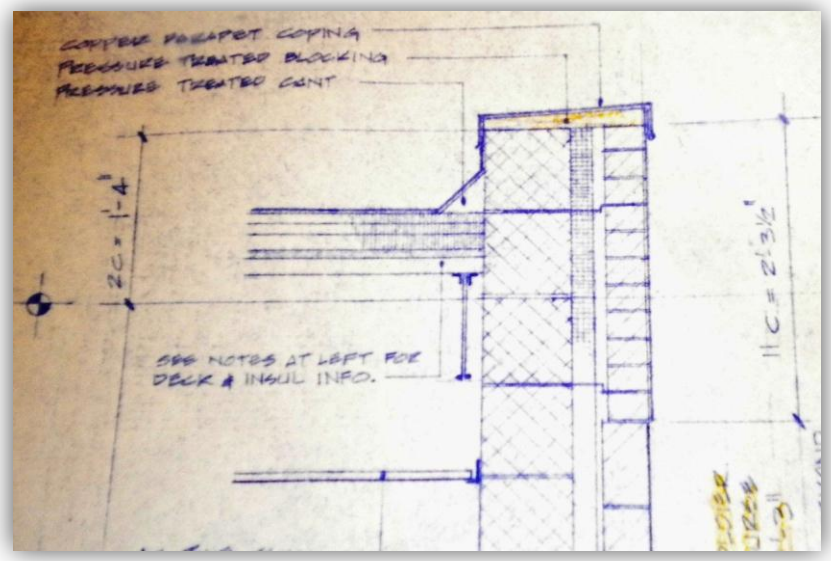
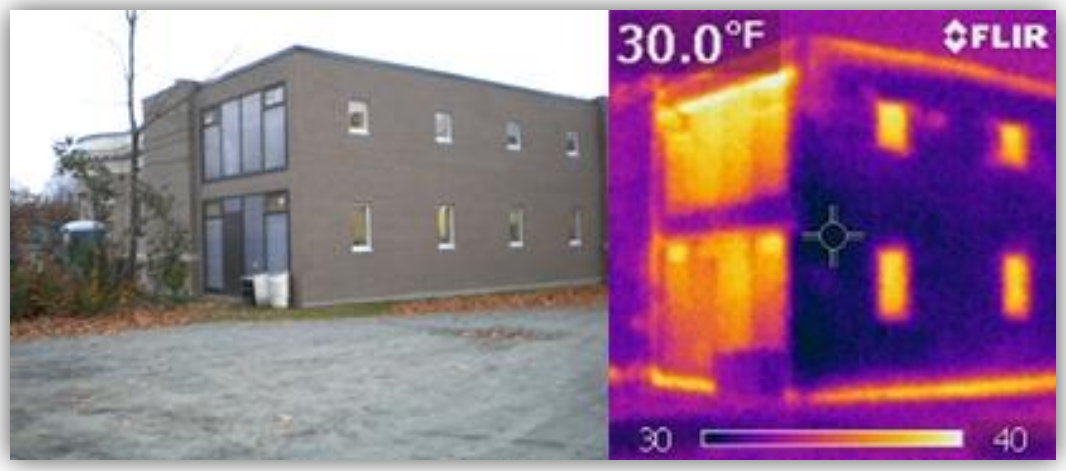
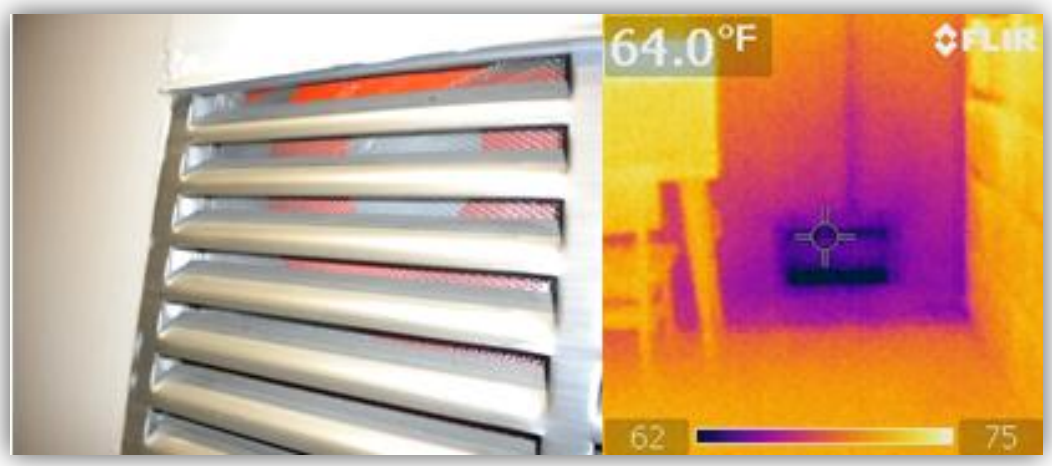


Figure 2

The images below were taken of the south side of the addition and show what appear to be solar heat collectors. These panels are clearly radiating a great deal of heat. If properly insulated (rigid insulation board between these panel and the interior space), then it would be safe to assume that this is not heat loss from the building but rather solar radiation collected by these units.

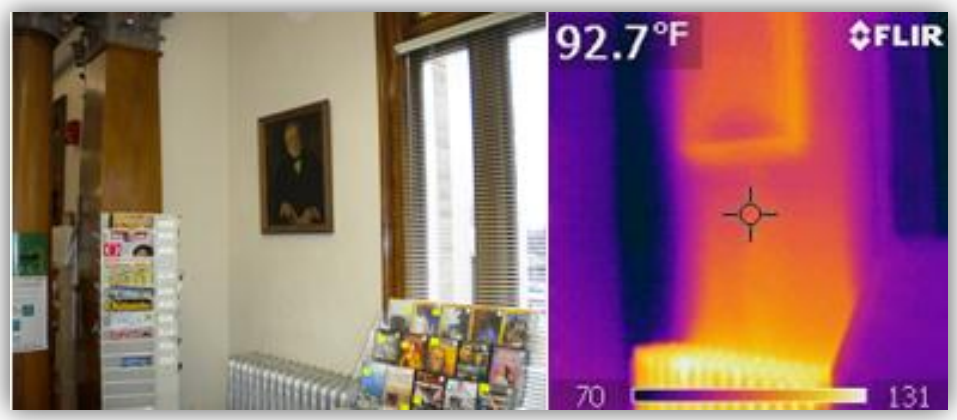


This image shows that that the vents on the 2nd floor have been blocked with rigid insulation. We would like to take the opportunity during the presentation of this report to find out more information about these panels—whether or not they are functioning well, and if not, discuss ways in which this system might be improved in order to take advantage of this potentially great asset.



A radiant barrier is not typically thought of as an aesthetically pleasing finish surface; therefore, we seldom see just how effective they are at reducing both heat loss in the winter and heat gain in the summer. One Library employee put this piece of sheet metal to great use in the confines of their office. To the IR camera, which reads heat waves not light, the sheet metal creates a mirror image of the radiator. Not only does this save money by slowing heat loss but produces greater comfort within the room.

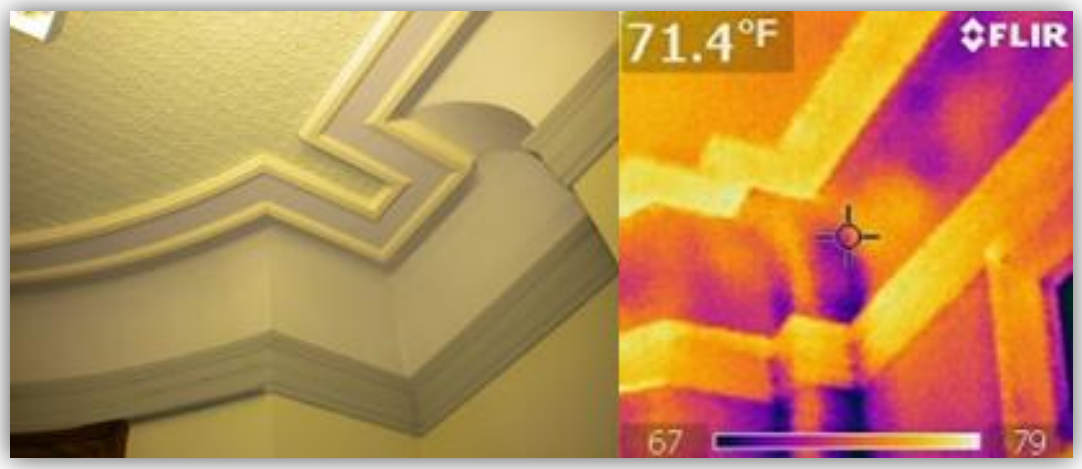
These images below show a wall and radiator without a radiant barrier and serves to illustrate how much heat is normally directed to the exterior wall.



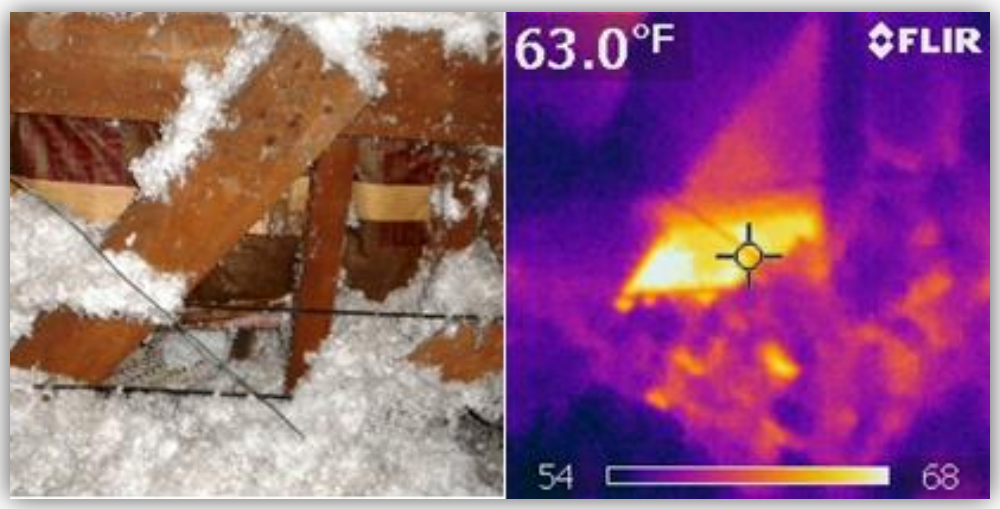
There are many types of radiant barrier materials, some of which allow for the diffusion of water vapor, which can be very helpful in a masonry built structure. Making good use of radiant barriers to reduce energy consumption in this building can be done effectively in areas of the structure that could go unnoticed by visitors.

Ceilings and Attic:

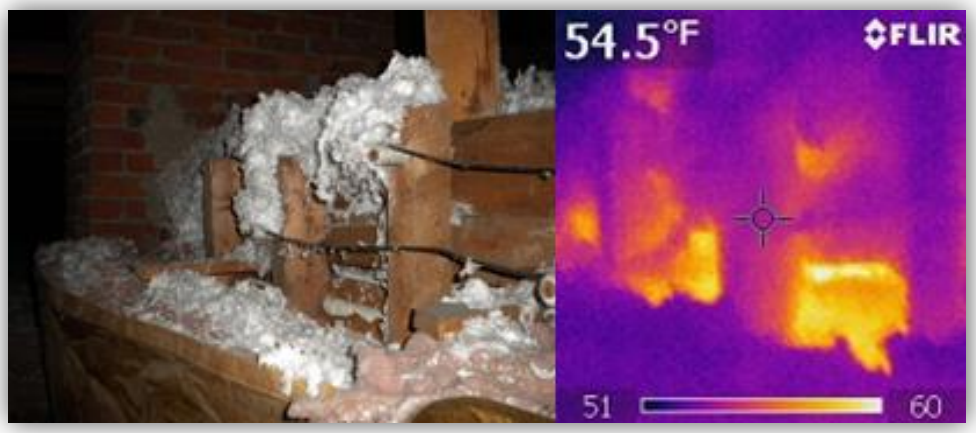
Most of the opportunity for making building envelope improvements to the ceilings may be found in the attic of the original building. The photo below shows a section of the ceiling of the main entry. These ceilings are taller than those on either side and continue at this height all the way to where it meets the new addition. What is clear from looking at this IR image is that insulation here is patchy at best, thus showing an opportunity for improvement.



This image shows an example, from the attic, of weak spots in the ceiling above. Being a vertical surface, it should almost be thought of as an exterior wall, except one that can more easily be addressed than the masonry. As one can see, the fiberglass batts have been compressed, and the craft face is pointing in the wrong direction. The lack of insulation glows orange with heat loss, and the residual orange glow comes from the inadequate amounts of loose-fill fiberglass.

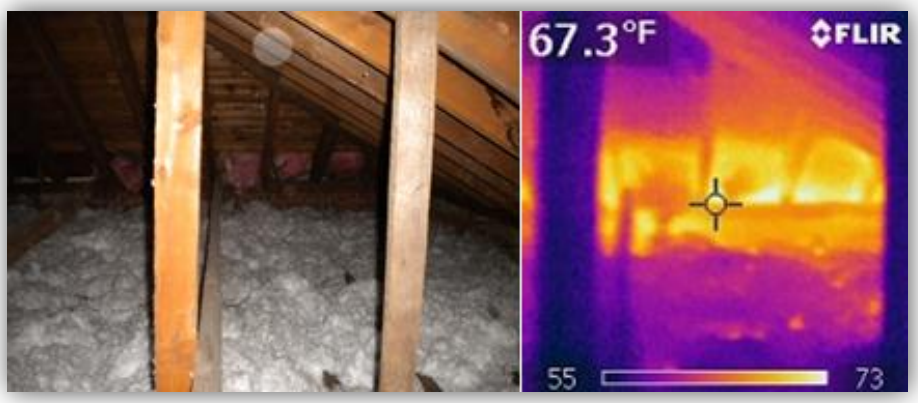


This is another example of where the height of the ceiling is extended, and how the insulation efforts are ineffective. These vertical walls in the attic may be best improved by removing any of the existing insulation and spraying them with 4 inches of closed-cell spray foam insulation.



At the base of the above wall in the attic are the openings from the stud walls. Seen in this photo to the right, the tops of the balloon framed walls, interior and exterior, are usually open to the attic space. All of these wall cavities essentially act as individual chimneys, dumping heat from the conditioned space below into the attic. Not only an inefficiency with respect to heat loss, these unsealed cavities may mean the difference between losing an entire building or not in the unfortunate case of a fire.

Seen in the photo below is fiberglass insulation stuffed between a few sets of rafters. This is where the original building now meets the addition. The heat seen pouring into the attic is coming from the addition.



As the below photos indicate, the heat loss from the previous images is coming from around the elevator shaft. What is also visible is what appears to be a section of ductwork that also appears to be uninsulated. Whether or not it is air sealed is also questionable. The blueprints indicate that this is the location of a section of duct that meets a 14x10" metal to 9" round PVC transition.

Doors and Windows:

Replacing windows in a building usually is fairly low on a prioritized list of energy improvement recommendations, and this holds true for this building. This is because the cost of window replacement projects tend to be substantial, while the amount of energy saved is less significant. The result can be a 20 or more year return on such an investment. The historic value of the current windows may also place limits on this option. However, it is important to make sure that the current windows perform as well as possible. This means making sure that they are well sealed when they are closed. One important measure for accomplishing this is with high efficiency storm windows.

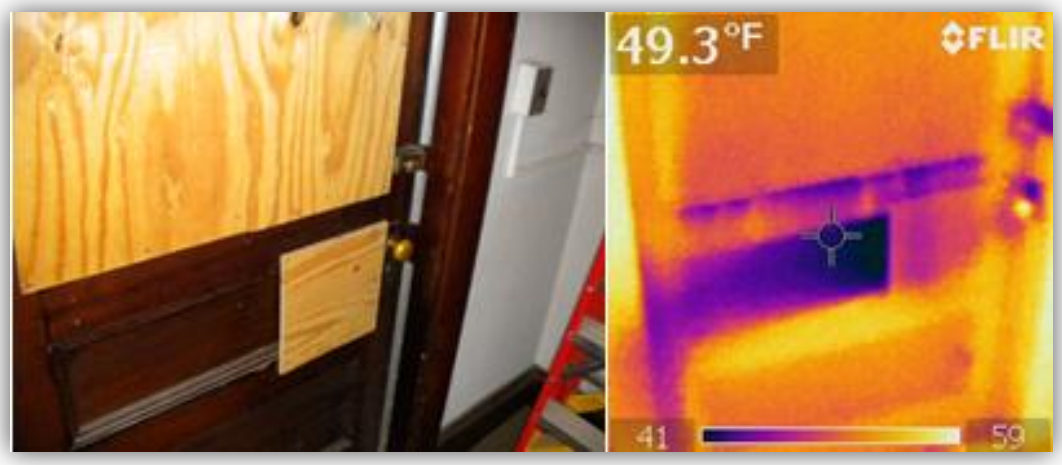
The photo above shows one of the windows that have old aluminum storm windows, though only about half the windows of the original building have these. The efficiency of these older storm

windows is minimal when compared to modern high efficiency storm windows, which allow for minimal amount of air infiltration and can be ordered with a low-e coating to further increase efficiency by reflecting some of the radiant heat loss back into the building. Some high efficiency units will also be certified to use in airport zones for their ability to reduce noise pollution. The windows on the rounded exterior walls would certainly be considered a special order but should be able to be made. Large low-e picture storm windows can be ordered for the two large inoperable windows in the front of the building. Also, for smaller windows that can remain inoperable, like the small stained glass and decorative windows for example, pieces of acrylic glass can be cut to fit and then sealed and fastened in place to eliminate air infiltration.

The effectiveness of any of these solutions will rely largely on how well they are installed. It is important to check from time to time that the caulking of the window trim is maintaining a good air seal. The photo to the right, for example, shows the sides of the panels on the south side of the building. Some types of caulking will last longer than others before it begins to crack, but any type will eventually crack.

The windows installed in the addition are not very efficient windows, relatively speaking. But just as the windows in the original building, replacing them may not prove to show a quick return. Also, because of the direction that the windows open, storm windows are not an option. The greatest efficiency gain with these windows will be to address the amount of air in filtration coming from around the actual units, as described earlier, to make sure that any joints of the wooden frame are sealed with clear caulking, and that the gaps where the sheetrock meets the window frames remains sealed. Also noted in this photo is that the window lock is not latched. Windows, especially this type, are never all the way closed (sealed) until the locking mechanism is fully in place.

Judging by the weather stripping seen in the photo below, some effort has been made to air seal this door that is located at the rear of the original building. As the IR image makes apparent, there is still a large amount of air entering from the edges of the plywood. As this door has been damaged, and is in discrete location, it may be best to consider its replacement with a foam core steel security door.



This window, located in the same stairwell as the above door, should also be made to provide a better air seal. This, and the rest of the windows in the basement, should be treated the same as the 1st floor windows—pieces of acrylic glass sealed and fastened to the outside may be the best option.

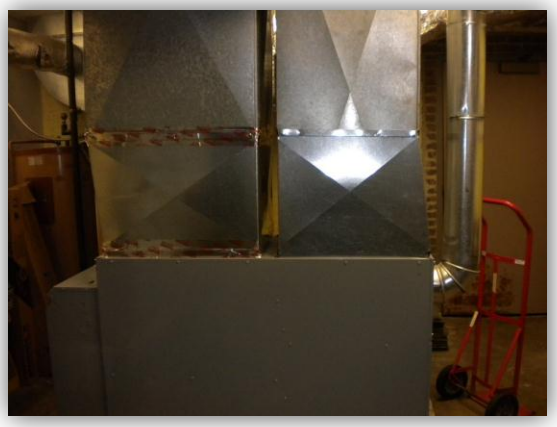
The images below provide a good example of the importance of sealing the trim around all windows. The dark area of the black and white IR image is cold air infiltrating this room.

Mechanical:

In this section we are making some assumptions about the heating and cooling distribution systems. During our inspection of the building, we did make a good effort to follow distribution lines and reviewed the blueprints in order to form an understanding of how the old and new systems were integrated when the addition was built. During the presentation of this report, it would be quite beneficial to have someone present who has an intimate knowledge of this system to help fully understand its workings.

This building has two sources of heat and both burn No.2 heating oil. The first is the steam boiler seen to the right, which according to the State Inspection Certificate, was installed in 1963. Combustion efficiency tests were not performed on this, or the furnace, but it is safe to say that this boiler could be replaced with a more efficient unit.

This boiler is supplying hot water to an air handler located in the boiler room, which we believe supplies supplemental heat to the original building, working in conjunction with the existing radiators. This boiler also supplies hot water to a small fan coil in the children's room and to an air handling unit on the 2nd floor of the addition. Both aforementioned air handlers are associated with two of the three outdoor condensing units. The third outdoor condenser services the ductless split hung from the ceiling of the addition's 1st floor.



Heat for the 1st floor of the addition is provided by the furnace seen in the photo to the left. This unit, rated at 80% combustion efficiency, has metal ductwork that eventually transitions to the round PVC ducts that run through the poured slab under the 1st floor of the addition.

Upgrading the efficiency of both the heating and distribution systems should not be a priority in this case but rather a part of addressing larger concerns relating to health and safety that were found in this mechanical room.

One of the first things noticed is that the ceiling of the room does not provide a fire resistant barrier. Typically, a boiler room is separated from the rest of a building with a minimum of one layer of 5/8" sheetrock that has been first coated with tape and a mixed joint compound. This will not only slow the spread of fire, but provides an air barrier to contain combustion gases and other air pollutants not suitable for occupied areas of the building. Also noted in this photo is the asbestos pipe insulation directly next to air passageways in the ceiling.

Asbestos insulation is a material that is considered not harmful unless it is disturbed and becomes air borne. It is recommended that any asbestos in this building is abated, regardless of whether it is accidentally disturbed.

These two draft dampers are at times working against each other. This is in part due to the combustion supply air being shut off to this space but also likely because these dampers are too close to each other. During our time in this room, the furnace (top damper) was running constantly. The result was air being drawn into this room from the oil boiler's flue damper (below). This occurrence can also be noted by the oil particulate dust on the adjacent pipe insulation. What is of greater concern is the potential for back drafting of combustion gases.

Seen in the photo to the right is the bottom of the combustion supply duct. Not only did the mechanical damper of this, and the adjacent vent, not appear to be functioning (both vents in the closed position) but an attempt was made to seal off the bottom with cardboard and tape. The negative pressure on this space caused by the oil appliances firing was likely enough to pull this cardboard down. The supply air system for this room should be fixed if broken and checked every time these systems are serviced.

Supply ductwork is always under positive pressure, which for efficiency purposes is why it is important to seal and insulate them. Return ductwork is always under negative pressure, and therefore is drawing air into the ducts rather than forcing it out. Some inefficiency can be experienced, but this is mostly a health concern. This is because return ductwork is usually not located in areas of the building that contain healthy air. Given that the filters in the air handler and furnace are meant to protect the equipment from large dust particles and not clean it for suitable breathing, much of what enters the return side of the ductwork will be distributed back to the occupied areas of the building. Furthermore, unsealed return ducts in the combustion appliance zone will only aid in putting the space under negative pressure, further adding to the risk of back drafting. The photo above shows the bottom of the air handler cabinet in the boiler room. As seen in this photo, it has been loosely placed on top of the return plenum, which is lying on the floor. The gap seen here is quite substantial and drawing a lot of air into the system.

The return ducts and plenum of the furnace are also not sealed. Signs of potential combustion gas spillage are seen on the exhaust pipe, which is located directly next to the unsealed return plenum.

We did not have a clear photo to show of the fresh air supply ducts, which are tied into the return side of the two forced air systems. If we had, one would notice that these are also not air sealed. And because they too are under negative pressure, they

show clear signs that they are importing air pollutants from the mechanical room into the air distribution system when there purpose is to be providing fresh air for the occupants of the building.

These examples may not be the only health and safety concerns related to this space, but they are certainly substantial enough to warrant the expense of addressing them.

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.

This fan coil has a very loud motor and/or fan. In order to eliminate noise pollution in this room, this unit should be fixed or replaced. A newer model may also draw less electricity.

Electrical:

These condensing units have a seasonal energy efficiency rating (SEER) of 10. More efficient units could replace these, which would operate at 30% efficiency or more.

The building is currently supplied potable water by this older, stand-alone electric hot water heater. This unit could be replaced with any number of more energy efficient systems; however, this site could be ideal for a solar domestic hot water system. The flat roof of the addition could be a great location for either flat panels or evacuated-tube panels.

Some of the easiest things to do to reduce electric costs do not involve initial investment. One strategy is making sure lights are out in spaces not being used, and if there are employees in the building an hour before or after times of business, keep as many of the lights off as possible. Eliminating one hour of electric usage at either end of each day for an entire year can amount to substantial savings. The bulbs in the spot lighting fixtures seen in this photo could be replaced with warm LED's.

Any outdoor lighting, especially security lights like this one outside of the rear entrance, may spend the majority of yearly hours on and are great candidates for LED replacement.

The elevator in this building is likely a large contributor to the yearly electrical costs and was being used quite a bit during our building inspection. It appeared to be used by some individuals who appeared to be quite capable of using the stairs.

It would be very beneficial to reduce this use to an "only as needed" basis. This, and other energy savings derived from behavior change, could be part of a "Sustainability Campaign" in the library. For example, placing a sign by the elevator that recommends taking the stairs as a way to promote physical and environmental wellness may reduce the overall use of the elevator and lead to other positive changes.

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:

After all known sources of indoor air pollutants have been addressed, the next logical step will be to improve the fresh air system. Installing efficient/balanced ventilation systems will be the best approach. It would also be beneficial to replace the air handler on the 2nd floor of the addition with a cabinet unit installed above the suspended ceiling. Such a unit would have ductwork running to a few registers throughout the space, which could include a small supply air and return to the office seen in the photo to the right. This would allow for the removal of the AC unit seen in the photo and would also allow for an individual ERV or HRV (explained below) to be incorporated into the return side of the duct system. Other ERV or HRV's would need to be installed to provide adequate amounts of fresh air to the other areas of the building as well.

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 3. 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.

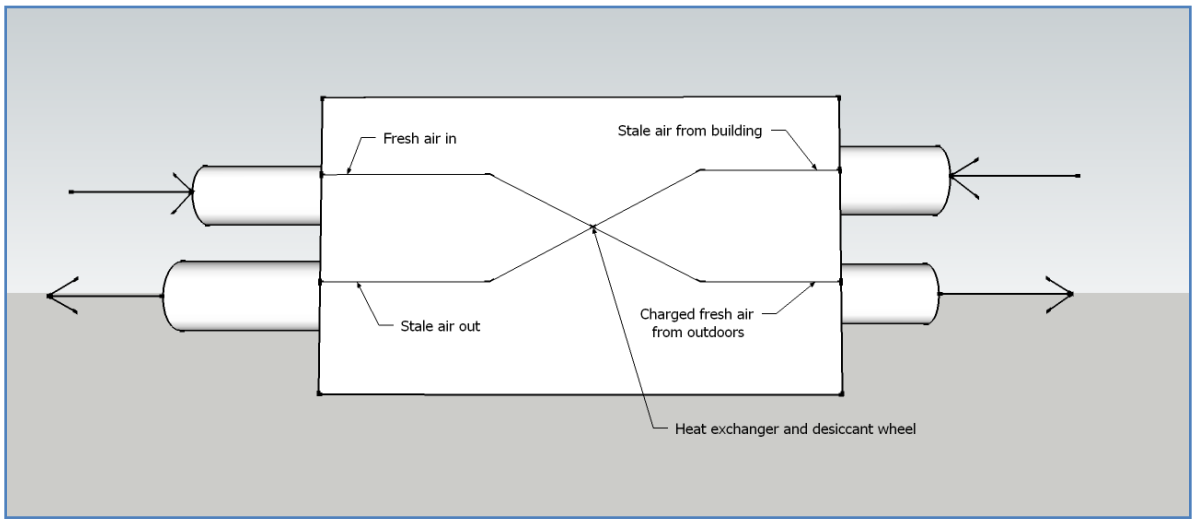


Figure 3

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:

- Consult with a drainage specialist to develop a drainage/insulation plan for the foundation of the original building.
- Insulate the foundation of the addition. This should be done with a minimum of 2inches of extruded polystyrene foam board buried 4ft below grade and should overlap at least the 1st row of brick. Make sure that any finish system covering the foam board is water tight and does not allow for pest intrusion.

Exterior Walls:

- Air seal any penetrations from conditioned space into the wall cavities. This includes foam pads for behind electrical outlet.
- Air seal the tops of framed walls in the original building, both exterior and interior.
- Inject spray foam insulation behind the sheetrock surrounding all the window units in the addition.
- Air seal between the top of the sheetrock and concrete blocks in the addition with spray foam.
- Ask either the architect or the builder (or meet with both) about how the tops of the addition walls were constructed. This would be to determine whether to move ahead with the possibility of injecting spray foam insulation into the block cavities.

Ceilings and Attic:

- Develop a way to completely seal off the mechanical chase abutting the elevator. However this air seal is created, it should be accompanied by high R-value insulation.

- Air seal any penetrations from the conditioned space of the original building into the attic space. It may be best to remove any fiberglass insulation from the vertical walls in the attic, and spray them with closed-cell spray foam insulation. For the flat areas of the attic, add at least 12 inches of loose-fill cellulose insulation.

Doors and Windows:

- Install high efficiency storm windows on all of the original building's windows.
- Make it a part of the building's maintenance plan to check all of the windows and door trim every other year, and reseal with caulking as needed.
- Replace the back door of the original building with an insulated unit.
- Make sure that all doors provide a good air seal when closed. This would include interior doors that separate conditioned entry ways from main conditioned areas of the building.

Mechanical:

- Make any necessary repairs to the combustion supply vents and have their operability checked each time these systems are serviced.
- Clean the fresh air ducts supplying both the furnace and the air handler in the boiler room. After this is done, air seal any seams and connections in the duct work.
- Air seal all of the duct work in the building, most importantly, the return air ducts in and around the boiler room. All duct work should then be insulated with a minimum of foil-faced, bubble wrap insulation.
- Make sure that all wall and ceiling surfaces of the boiler room constitute a fire barrier.
- Move the flue damper of the furnace further away from the boiler flue damper if possible.
- Have any asbestos building materials abated.
- Insulate all hot water supply and return piping.
- Replace thermostats with new digital/programmable units. Appropriate time and temperature settings can be discussed during the presentation of this report.
- Replace the current oil boiler with a high efficiency system. Consider switching to a high efficiency LP, modulating/condensing boiler.
- More system replacement options can be discussed during the presentation of this report.

Electrical:

- Replace the current domestic hot water heater with a solar domestic hot water system.
- Replace the outdoor condensing units with the highest efficiency equipment possible.
- Replace as many lights as possible with LED's.
- Employees and patrons should only use the elevator when necessary.
- Keep as many lights off as possible up until doors are opened for public hours and directly after they are closed.

- Put all electronics on power strips, and cut the power to as much of the equipment as possible outside of hours of operation. When buying new, or replacing old, electronic devices, invest in the highest efficiency Energy Star rated options.
- 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:

- Implement all Mechanical recommendations pertaining to combustion safety and indoor air quality.
- Consult with an ERV/HRV ventilation specialist about integrating such systems to replace the current fresh air strategy. Inquire about the possibility of using smaller residentially sized units, one per air handling unit (section of the building).

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 your Regional Planning Commission (RPC). A full list of NH RPC's is provided below.

Central New Hampshire RPC - 603.226.6020

Lakes RPC - 603.279.8171

Nashua RPC - 603.424.2240

North Country Council - 603.444.6303

Rockingham RPC - 603.778.0885

Southern New Hampshire RPC - 603.669.4664

Southwest RPC - 603.357.0557

Strafford RPC - 603.742.2523

Upper Valley Lake Sunapee RPC - 603.448.1680

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:

Lebanon is served by both NH Electric Coop and National Grid (Granite State). Both NH 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 NH Electric Coop Customers:

- Contact Member Solutions at 1.800.698.2007
- Visit - www.nhec.com/energy_efficiency_programs.php

For National Grid:

- Call - 1.800.843.3636
- Gas - https://www.powerofaction.com/newhampshirecigasnaturalgasheating/
- Electric - https://www.nationalgridus.com/granitestate/business/energyeff/3_small.asp

National Grid - Small Business Program For business customers with an average demand use of 200 kilowatts or less (or 40,300 kilowatt-hours or less) per month, we can help you reduce your company's energy costs by installing energy efficient equipment.

- We can provide a free energy audit and report of recommended energy efficiency improvements
- We pay 50% of the cost of the installation of energy efficient equipment and you can finance the remaining 50% interest free for up to 24 months.
- Cost-cutting, energy efficient equipment available through this program include:
- Lighting Upgrades
- Energy Efficient Time Clocks
- Photo Cells For Outdoor Lighting
- Occupancy Sensors
- Programmable Thermostats
- Walk-in Cooler Measures

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.

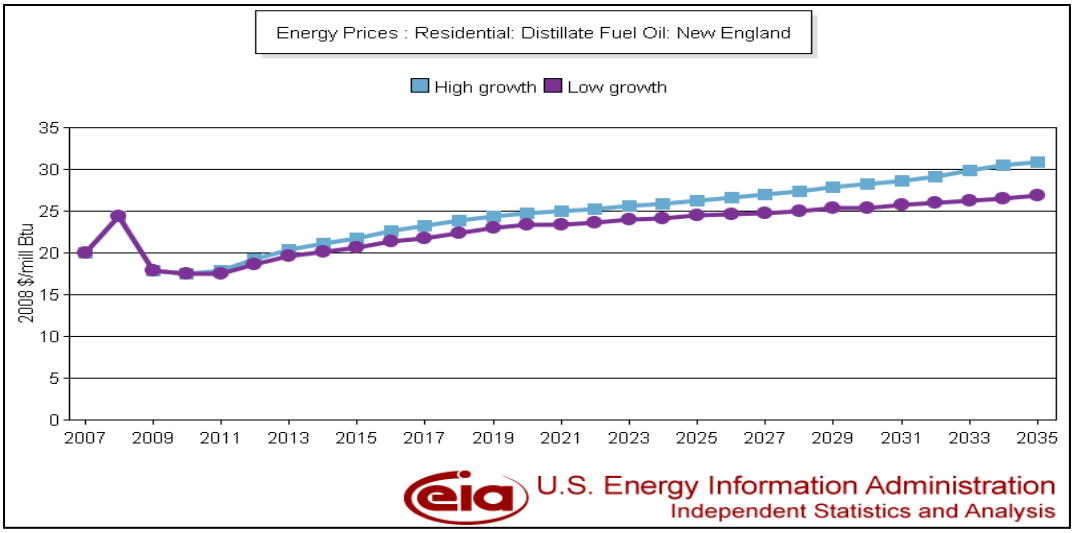
For more information on the history of energy prices and how energy cost projections are calculated, please visit: http://www.eia.doe.gov/analysis/

Price Summary

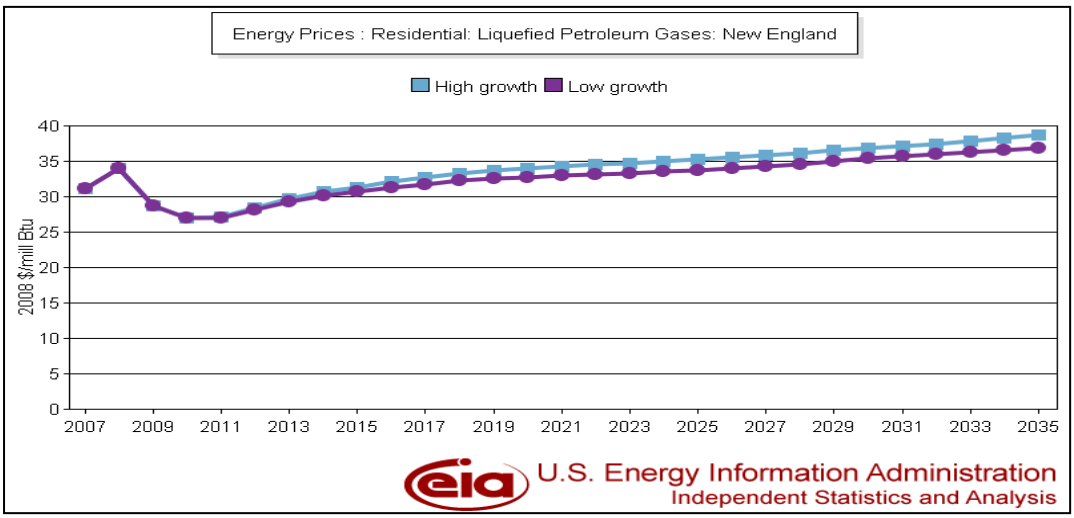
	Year				Percent Change		
	2009	2010	2011	2012	09-10	10-11	11-12
WTI Crude[a] ($/barrel)	61.65	79.40	93.26	97.50	28.8	17.5	4.5
Gasoline[b] ($/gal)	2.35	2.78	3.15	3.30	18.4	13.4	4.8
Diesel[c] ($/gal)	2.46	2.99	3.43	3.51	21.5	14.7	2.4
Heating Oil[d] ($/gal)	2.52	2.97	3.41	3.55	17.5	14.8	4.3
Natural Gas[d] ($/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.

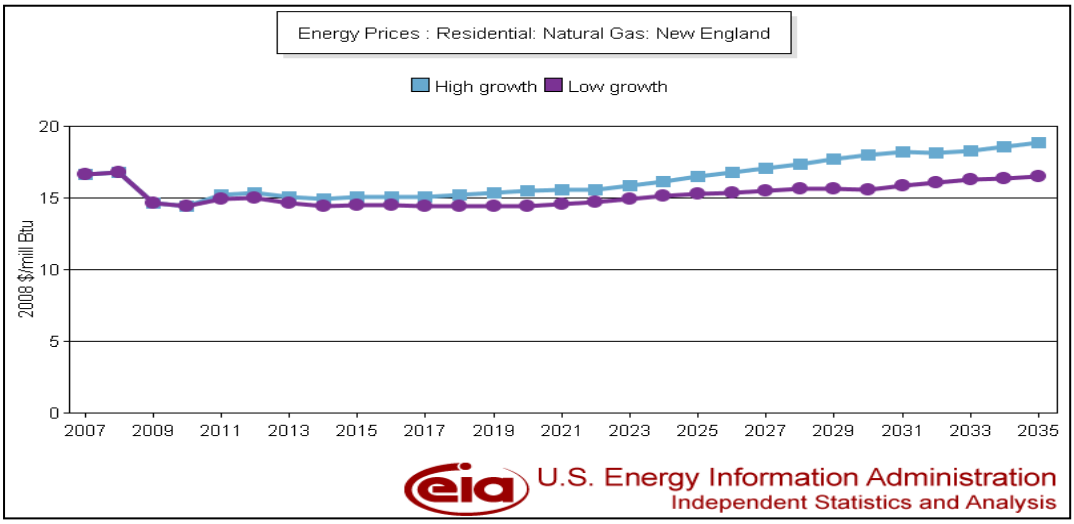
Table 1 – Retrieved from US EIA website



Graph 1 - Retrieved from US EIA website



Graph 2 - Retrieved from US EIA website



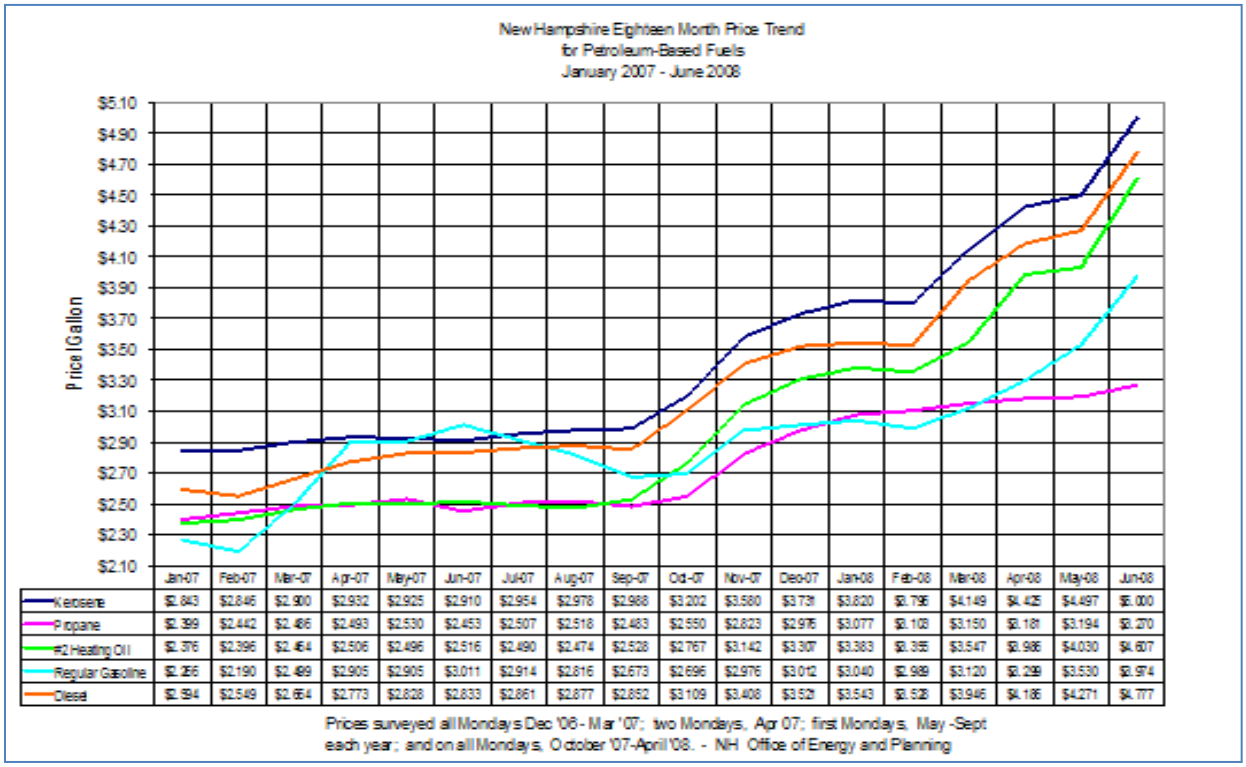
Graph 3 - Retrieved from US EIA website

The following three Graphs (retrieved from the NH OEP website) show average prices in NH for liquid fuels beginning in January of 2007 and end 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.

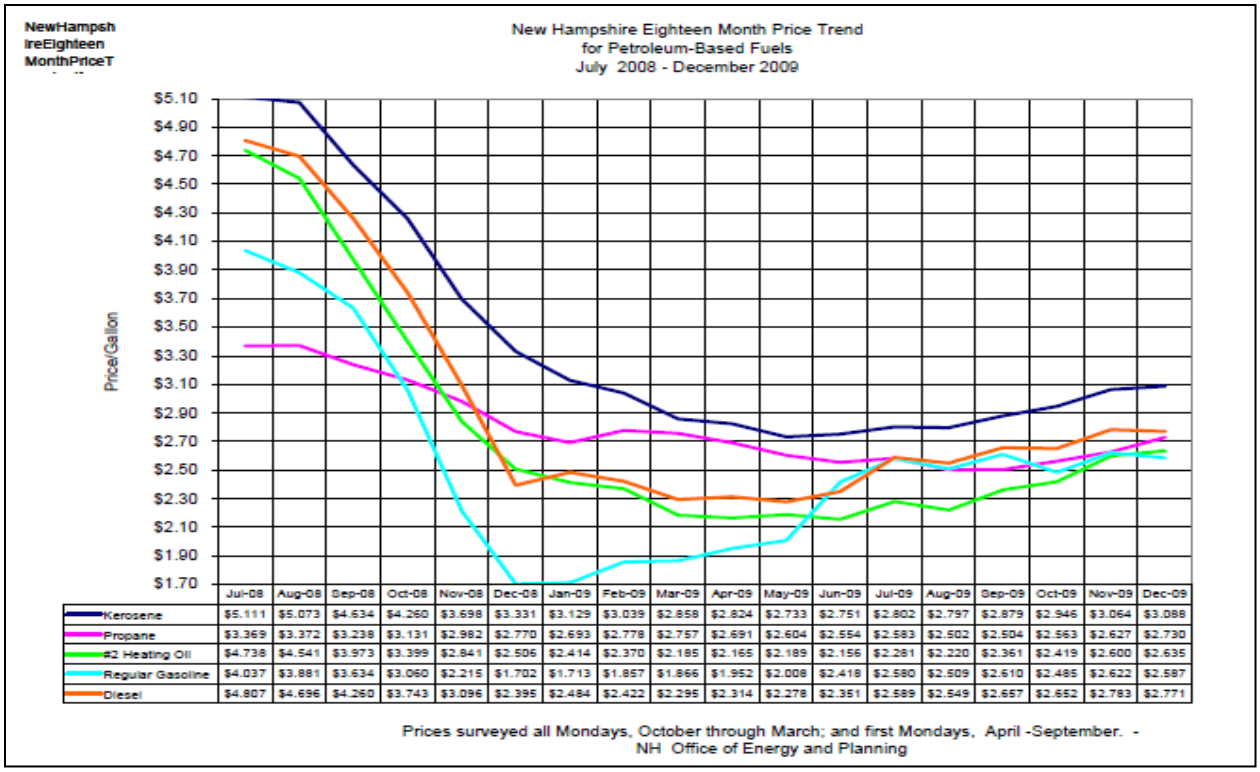
Projects such as air-sealing and insulating can be thought of as a different species of project and investment when compared to items like heat systems, appliances, and alternative energy systems. In the case of the latter, these types of energy investments have a shelf life. A boiler and a PV system 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.



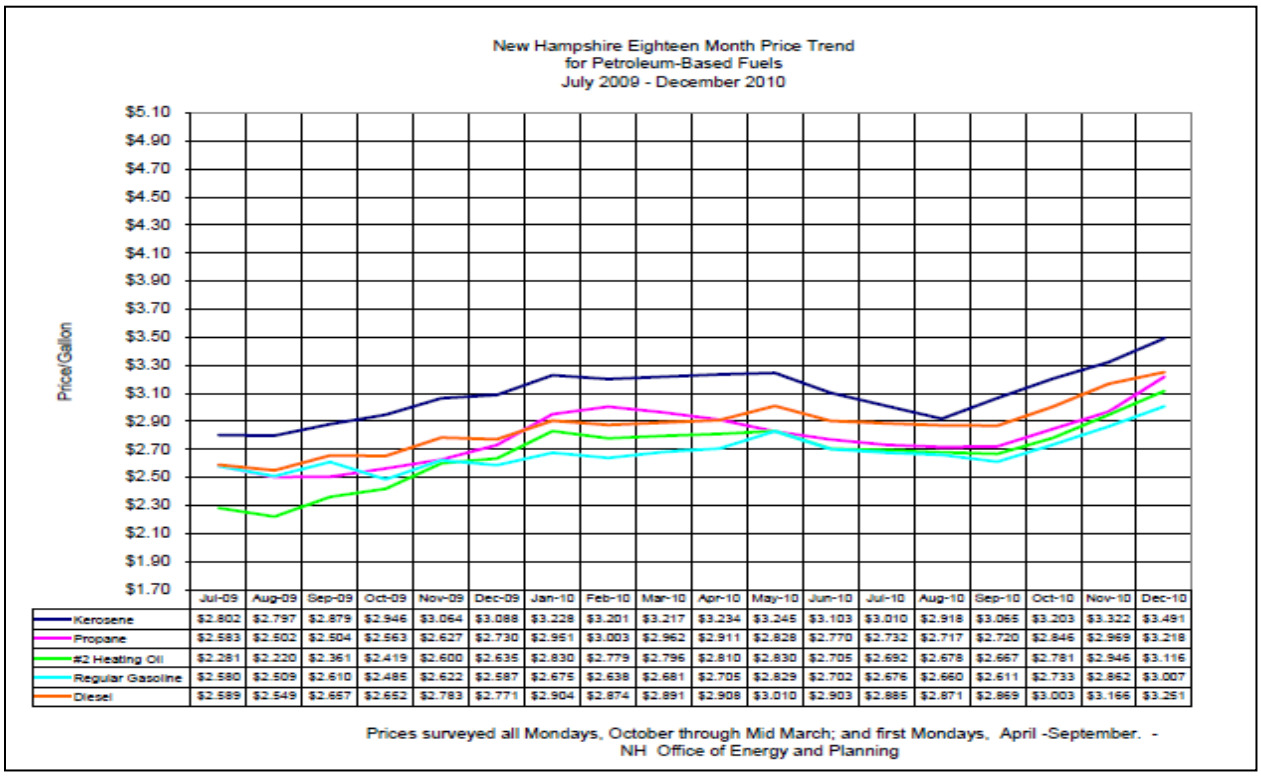
	Jan-07	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08
Kerosene	$2.843	$2.846	$2.900	$2.932	$2.925	$2.910	$2.954	$2.978	$2.988	$3.202	$3.580	$3.731	$3.820	$3.796	$4.149	$4.425	$4.497	$5.000
Propane	$2.399	$2.442	$2.466	$2.493	$2.530	$2.453	$2.507	$2.518	$2.483	$2.550	$2.823	$2.975	$3.077	$3.103	$3.150	$3.181	$3.194	$3.270
#2 Heating Oil	$2.376	$2.396	$2.464	$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	$2.266	$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 4 - 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 tables and graph are provided to illustrate the potential savings for the Town if recommendations are carried out in the near future. The tables provide an assumed fuel escalation rate that is built into the savings model to show a fifteen year potential savings for the 30% reduced energy costs today as compared to the escalation of costs over fifteen years.(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 5 – 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.

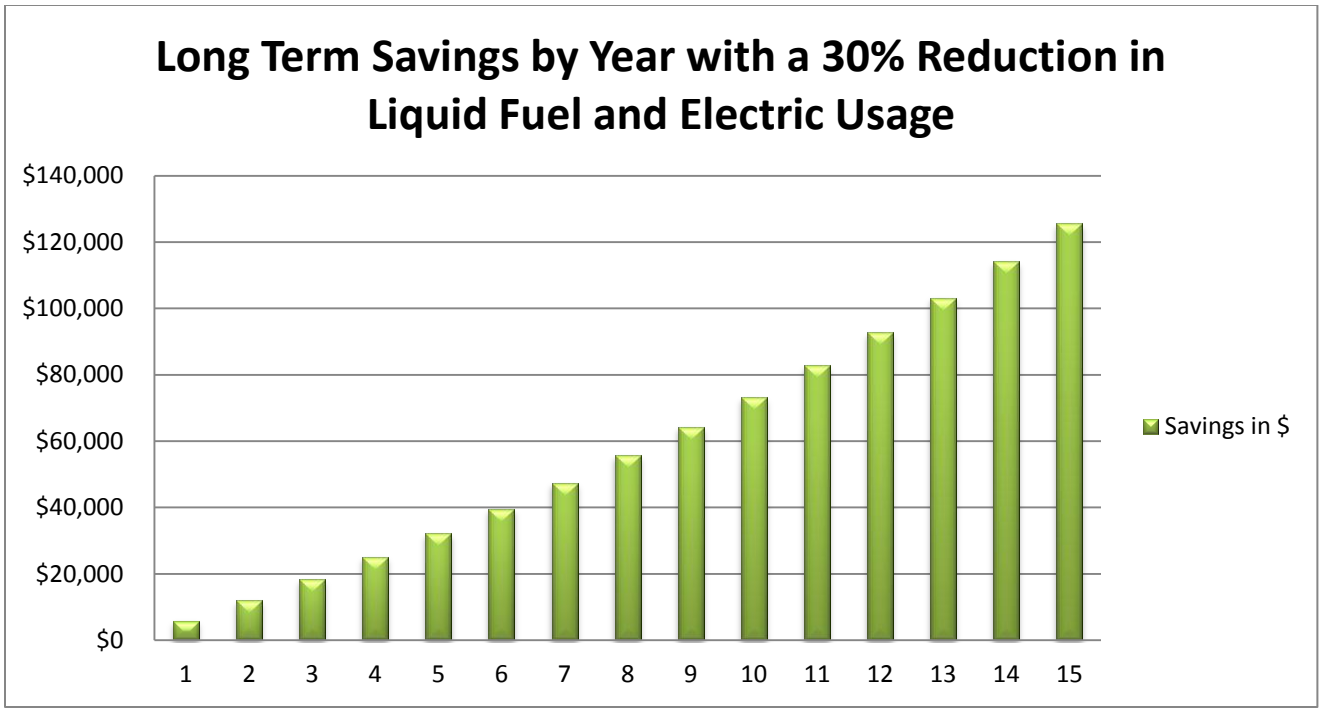
Current Fuel Usage				
Year	Energy Cost By Year	Yearly Increase		Total Accumulated Cost by Year
		Escalation Rate	5.00%	
Year 1	$8,162.29	$ 408.11		$8,162
Year 2	$8,570	$ 428.52		$16,733
Year 3	$8,999	$ 449.95		$25,732
Year 4	$9,449	$ 472.44		$35,180
Year 5	$9,921	$ 496.07		$45,102
Year 6	$10,417	$ 520.87		$55,519
Year 7	$10,938	$ 546.91		$66,457
Year 8	$11,485	$ 574.26		$77,943
Year 9	$12,059	$ 602.97		$90,002
Year 10	$12,662	$ 633.12		$102,664
Year 11	$13,296	$ 664.78		$115,960
Year 12	$13,960	$ 698.01		$129,920
Year 13	$14,658	$ 732.92		$144,579
Year 14	$15,391	$ 769.56		$159,970
Year 15	$16,161	$ 808.04		**$176,131**

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 Usage				
Year	**Energy Cost By Year**	**Yearly Increase**	**Total Accumulated Cost by Year**	
		Escalation Rate	**5.00%**	
Year 1	$11,252.96	$ 562.65		$11,253
Year 2	$11,816	$ 590.78		$23,069
Year 3	$12,406	$ 620.32		$35,475
Year 4	$13,027	$ 651.34		$48,502
Year 5	$13,678	$ 683.90		$62,180
Year 6	$14,362	$ 718.10		$76,542
Year 7	$15,080	$ 754.00		$91,622
Year 8	$15,834	$ 791.70		$107,456
Year 9	$16,626	$ 831.29		$124,081
Year 10	$17,457	$ 872.85		$141,539
Year 11	$18,330	$ 916.49		$159,868
Year 12	$19,246	$ 962.32		$179,115
Year 13	$20,209	$ 1,010.43		$199,323
Year 14	$21,219	$ 1,060.96		$220,543
Year 15	$22,280	$ 1,114.00		**$242,823**

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	**$5,825**	**$ 291.23**		**$5,825**
Year 2	**$6,116**	**$ 305.79**		**$11,940**
Year 3	**$6,422**	**$ 321.08**		**$18,362**
Year 4	**$6,743**	**$ 337.13**		**$25,105**
Year 5	**$7,080**	**$ 353.99**		**$32,184**
Year 6	**$7,434**	**$ 371.69**		**$39,618**
Year 7	**$7,805**	**$ 390.27**		**$47,424**
Year 8	**$8,196**	**$ 409.79**		**$55,620**
Year 9	**$8,606**	**$ 430.28**		**$64,225**
Year 10	**$9,036**	**$ 451.79**		**$73,261**
Year 11	**$9,488**	**$ 474.38**		**$82,749**
Year 12	**$9,962**	**$ 498.10**		**$92,711**
Year 13	**$10,460**	**$ 523.01**		**$103,171**
Year 14	**$10,983**	**$ 549.16**		**$114,154**
Year 15	**$11,532**	**$ 576.61**		**$125,686**



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 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.