The New Hampshire Municipal Energy Assistance Program

Decision Grade Audit Report

Cornish Town Offices
108 South Cornish Road, Center Cornish NH 03225

Prepared for:

Town of Cornish, NH

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CLEAN AIR COOL PLANET

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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 Cornish 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 Cornish.

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Introduction:

MEAP partners are pleased to provide this Decision-Grade Audit Report for the Town of Cornish and the Town Offices (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.

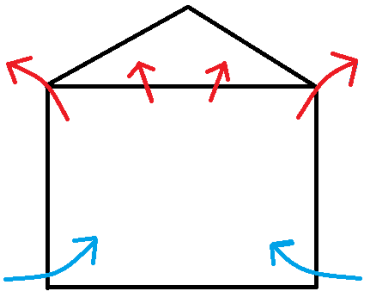
This DGA involves a quantification of energy usage (electrical and heating fuel), a description of existing heating/cooling and distribution systems, thermal barrier inefficiencies, potential electric savings through lighting/appliances upgrades and behavior change, occupancy health and safety concerns, 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. This savings estimate is not based on a specific set of projects instead of a reasonable average goal for work and is used to illustrate the effectiveness of upgrades.

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.

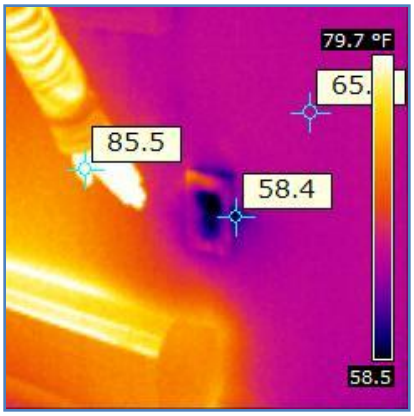
Heat moves through and leaves a building by three different means: *convection, conduction, and radiation*. One way to think of **convective** heat loss is by air movement into and out of a structure. One of the forces causing this to happen is the "stack effect".



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.

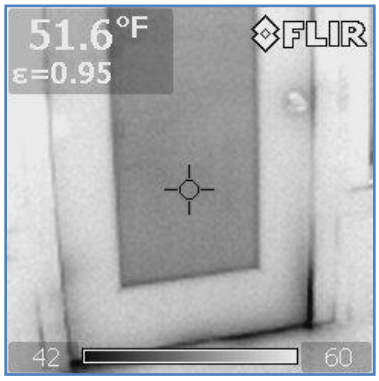
Conduction is the foremost way in which heat travels through a solid building material. R-value is one way to describe a given materials resistance to transfer heat. Materials with a high R-value, such as foams, cellulose, or fiberglass batts are used for insulation. At any location in the building envelope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

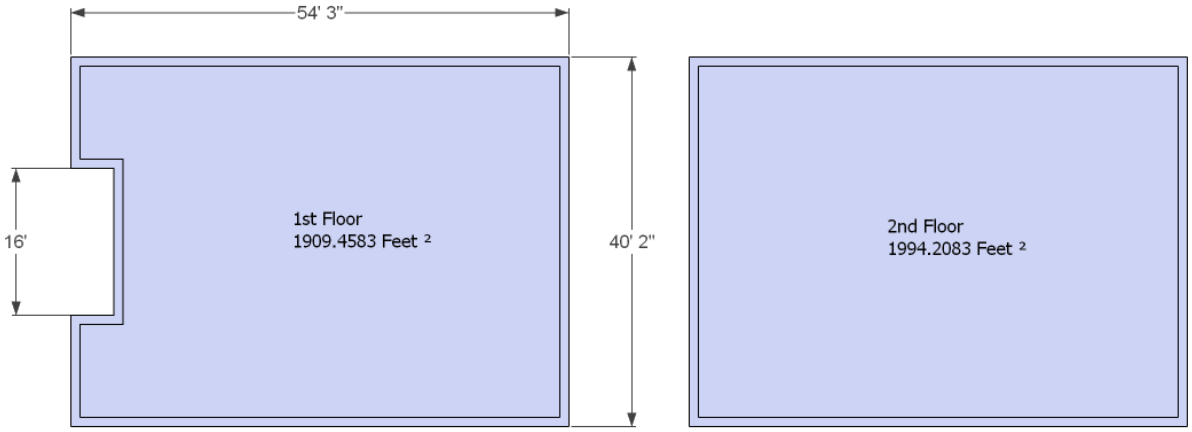
Just as BTUs conduct through solid materials, water vapor diffuses through solid materials. Some materials are more resistant to vapor diffusion, such as polyethylene, and we use these to form a vapor barrier on the inside of the thermal boundary in an attempt to slow the amount of vapor diffusion. Small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

This building, now serving as the town offices, was originally a single story meeting hall with very tall ceilings. The height of the interior was divided into two stories, with all Town office space on the first floor, and a meeting hall on the second floor. The area beneath the first floor is an unusable crawl 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.



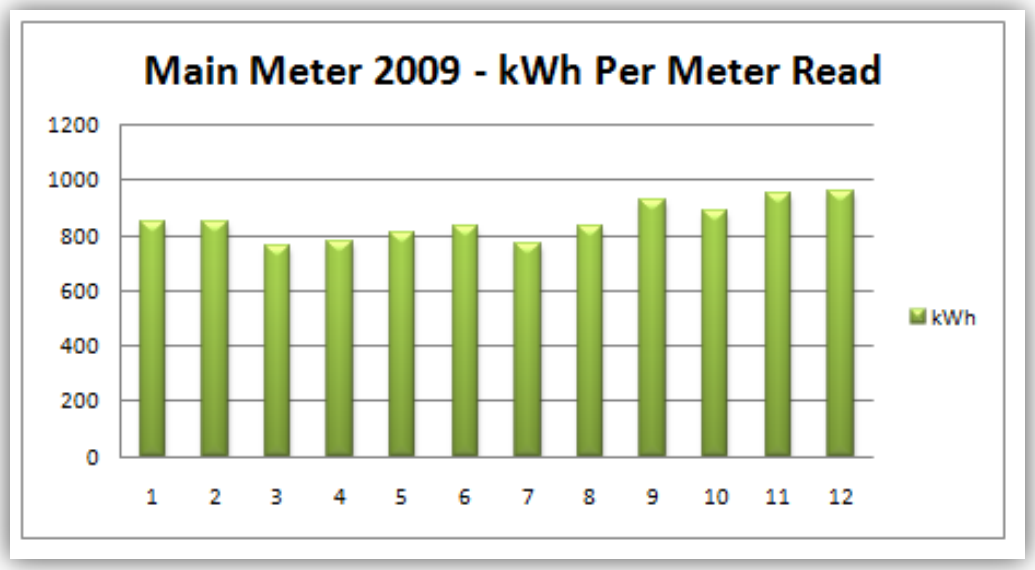
Total Condotioned Space = 3,903.65 ft2

Energy Data Collection:

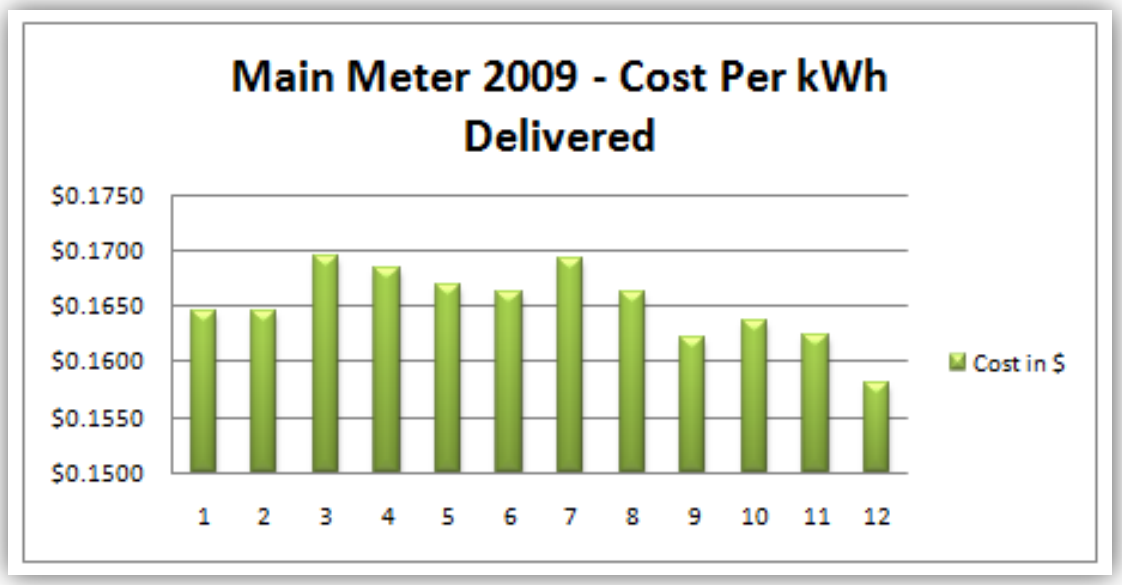
Electric -Main Meter -2009			
PSNH			
Date	KWH	Total $/mo	Cost Per kWh
12/1/2009	850	$139.89	$0.1646
11/1/2009	850	$139.89	$0.1646
10/1/2009	760	$128.88	$0.1696
9/1/2009	780	$131.30	$0.1683
8/1/2009	810	$135.21	$0.1669
7/1/2009	830	$138.00	$0.1663
6/1/2009	770	$130.32	$0.1692
5/1/2009	830	$138.00	$0.1663
4/1/2009	930	$150.76	$0.1621
3/1/2009	890	$145.66	$0.1637
2/1/2009	950	$154.25	$0.1624
1/1/2009	960	$151.71	$0.1580

Total kWh This Year +	10210
Total Piad For Year=	$1,683.87
Ave Cost Per kWh =	$0.1652

Table 1



Graph 1



Graph 2

Heat Source 1 - 2009			
Propane			
Date	Fuel Units	$	Cost Per Unit
2009	1156	$ 2,078.75	$1.798
	Total Units Used =		1156
	Total Paid For Year =		$ 2,078.75
	Ave Cost Per Gal =		$ 1.80
NH Average By Date -	Jan. 31, 2010		$3.549 $ Per Unit
Cost of current usage at this price =			$4,102.64

Table 2

Blower Door Test Results:

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

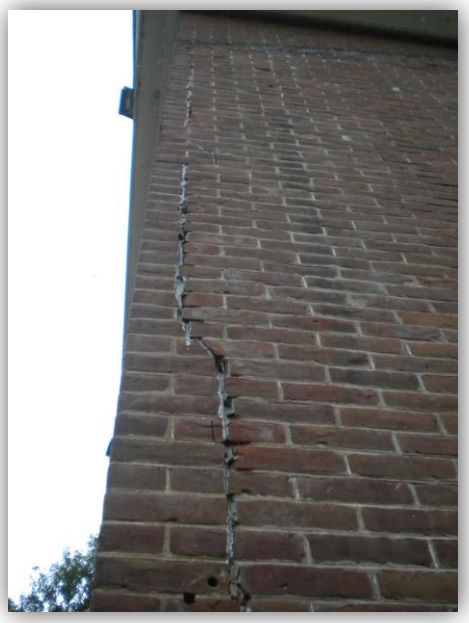
- Hazardous building materials were found on site. SDES staff did not want to risk disturbing this material and potentially spreading it to occupied areas of the building.
- Mold was discovered in the building. SDES staff did not want to risk disturbing the mold or spreading spores to occupied areas 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:

This section of the report describes a serious structural concern of this building. We would like to note that this issue has been a concern for many months prior to our site visit and that an engineer has been hired by the Town to help address this issue. In this section, we will offer insight on potential contributing factors that were observed during the inspection of this building and information gathered through the interviewing of Town officials. The Town should only rely on their engineer for a set of trusted conclusions explaining the cause of and remedy to this problem.

This building sits on a granite foundation that consists of some large slabs of granite in the upper sections, though in many areas below ground level much smaller pieces of granite were used.

The cracks seen in the image to the right are of great concern. We were told during our building inspection that these began to form within the past 5 to 10 years and have gradually gotten worse over time. The Town has hired an engineer to monitor the rate at which these cracks are widening in an effort to fully understand the cause of this problem and to develop a plan for fixing them. This image shows a two-part sliding rule, which has been adhered to either side of one of the many major cracks. It was noted that some of these had separated from what appeared to be equally substantial vertical movement as well as horizontal.



This image demonstrates how this chain reaction, beginning at the foundation, is affecting the entire structure. A major crack like the one in corner of the building is of particular concern as it simultaneously weakens the structural integrity of two walls at once.

A septic system was installed several years ago. Through our interviews with town officials, it seems as though the issue of foundation movement may have started around the same time. The image to the right shows the back door of the building and some grade characteristics that may have changed since the structure was built.
Seen in this image is a type of drain. Built with concrete walls and pressure treated 1 ½ inch boards, this drain channels water into the crawl space beneath the building.

This image shows how moisture is negatively affecting the brick of this wall. The source of this moisture could be coming in the form of rain run-off from this newly paved area, snow positioned directly against the brick in the winter, and certainly from water dripping off the eve and splashing against the brick as a similar negative effect is noticed in the grassed area on the other side of the drain.

In this image, one sees how the water from the drain at the back entrance is emptying into the crawl space beneath the building. Maintaining a dry basement or crawl space is important to the health of any structure and a challenge not always easy to address. This is certainly one of the largest sources of moisture in this crawl space and one that needs to be eliminated.

Concrete footings have been poured in the crawl space and addition support posts and beams have been put in place to help handle the load of the building. This image also shows small pegs that were set into the beams to help mitigate the negative effects of excess moisture and possibly to help prevent infestation. This is a classic example of dealing with the negative effects of a moisture issue and not the source of moisture itself.

The source of moisture in this crawl space is not only from the drain at the back entrance but also from the foundation walls and from the dirt floor. It is important to remember that even if a dirt or concrete floor appears to be dry, without an adequate vapor barrier there is almost always moisture rising up from the earth.

The exact reason for the movement of the foundation and the cracking of the brick walls will be for the engineer to determine. What seems apparent from our building inspection was that this is a new problem with the building, and that there have only been a few changes since the construction of this building that may hold weight in determining the cause. They are as follows: There is likely more moisture in and around the foundation now than before, potentially causing greater heaving than in the past. The building is now being kept at warmer temperatures during winter months than in the past, causing the excess moisture to go through more freeze and thaw periods throughout the winter. There may be more weight placed on the foundation now owing to the new interior framing, office space, and associated furniture and equipment.

Regardless of the exact cause, any well planned solution to this issue can and should incorporate not only structural remedies but also moisture control and energy efficient aspects into a single plan. There is a great deal of heat loss from the uninsulated floors and foundation walls. If done well, the money saved in energy costs would eventually cover the cost to address the structural concerns.

Exterior Walls:

Most of the exterior walls have been finished on the interior with a gap between finished wall and the brick. The image to the right was taken from a document storage room at the back of the building where the moisture issues seem to be greatest. This dehumidifier is charged with the task of gathering this non-stop migration of moisture. As wet always goes to dry, the humidity levels in this room are likely always lower than the crawl space and building exterior, thereby drawing moisture into this space and using a great deal of electricity as a result. As the inside surface of the bricks dry, they begin to crumble into a dust. This is another great example of dealing with the effects of moisture and not the source.

Buildings with brick walls are somewhat limited in options for making the exterior walls more insulated. There is still much debate in building science on what the best solution is, which would no doubt change depending on any particular set of existing conditions. This challenge of working with brick walls, combined with the historic nature of the building and current structural issues, creates even more limitations.

Given the moisture and other air quality issues currently in this building, air sealing the building envelope is not advised at this time. Allowing for a high rate of natural air exchanges per hour will help to exhaust water vapor and other potential air borne pollutants.

Once the moisture problems are addressed, air sealing the building from the inside would be a viable option for reducing heating costs. The two images below show cracks in the exterior wall finishes, which are currently contributing to the stack effect and overall convective heat loss. Sealing the interior finish surfaces will dramatically reduce the upward movement of conditioned air.

Ceilings and Attic:

This picture, taken from the second floor, shows how the large windows extend from the 1st floor into this space. This is mentioned in this section because the 2nd floor space is not used very often and therefore can be kept at lower temperatures. Insulating the floor between the two spaces would be costly, and would not necessarily be a wise use of financial resources. Attempting to slow the rate of air flow from the 1st floor to the 2nd floor would prove to be a much more affordable project and would greatly help to keep heat in the offices below, thus lowering fuel usage. Dividing these windows between the two floors with an effective air seal would be a major step in this process.

The attic space has polyethylene sheeting, which was, at some point, laid out over the top of the joists before about 3-4 inches of loose-fill cellulose was blown on top.

The duct work seen in this photo comes from a large exhaust fan in the ceiling of the second floor used to help keep the space cooler in the summer months.

Doors and Windows:

The two pictures below show two of the four exterior doors. The door to the left is one of two identical front doors which are of historic nature. The door to the right is on the back side of the building and is no longer in use. Replacing any of the doors would not have a substantial effect on energy savings relative to larger opportunities at this building. However, making sure that all doors provide a good air seal when closed is a cost effective way to ensure that these historic door are performing as well as they can.

This building has large, operable, single pane windows with aluminum storm windows fastened to the exterior trim.
Replacing these windows may not be an option owing to their historic nature; therefore, it is very important to make sure that they provide a good air seal when closed. Much of this may be accomplish by focusing on sealing the storm windows or even replacing these with newer more efficient units. High efficiency replacements for the storm windows would offer a superior air seal and can be ordered with low-e coatings to help reflect heat back into the building.

As seen in this photo, the window and door trim needs to be re-sealed where it comes in contact with the brick.

Mechanical:

This building is heated with an open combustion propane boiler that supplies hot water to baseboard radiators. This boiler has a combustion efficiency of around 82%. A new modulating, condensing boiler could be 95%-97% efficient, which would greatly reduce the amount of propane need to create the same amount of heat.

Hot water for this building is supplied by this on demand electric hot water heater. If a high efficiency boiler was installed and if this electric water heater was replaced with an indirect water heater (piped to the new boiler), this would be a more efficient way to meet the potable water needs of this building.

Much of the distribution system for the heating system is located between the 1st and 2nd floor above the suspended ceiling. Any pipes associated with the heating system should be insulated, including those found in the boiler room.

The picture to the left shows how portions of the 2nd floor radiators are placed directly in front of the windows. This is a great inefficiency and can be helped without the cost of moving them. Replacing these with modern panel radiators against the walls of this space could be a great option and would allow for the use of lower temperature water for much of the heating season.

Shown to the right is a picture of the ductwork associated with the ceiling fan on the 2nd floor. This may be an effective way to keep summer time temperatures at acceptable levels, but it is important to understand that the use of this fan puts the building under negative pressure and can draw unhealthy air from the crawl space beneath the first floor. Addressing air quality concerns while replacing this system with a balanced ventilation system would be a preferred approach to providing fresh air to

the building. It is also important to remember that by making improvements to the insulation levels in the attic, the second floor space with stay cooler.

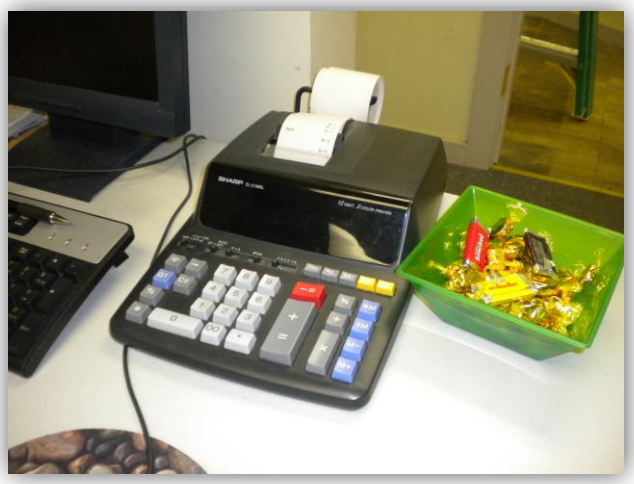
Electrical:

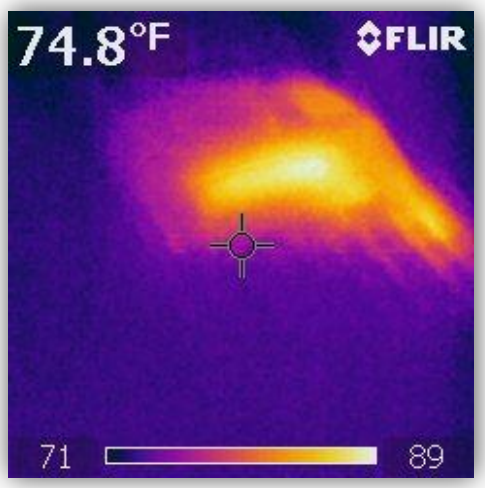
The electric usage of this building stays relatively steady month by month throughout the year. Much of the potential for a reduction in this cost will come from addressing lighting efficiency, buying the most energy efficient office equipment when additions are made or old unit needs to be replaced, and by cutting power to equipment when it is not in use.

The two lights seen below are likely left on throughout the night for safety purposes. Given the long hours of use, these would be great candidates to replace with outdoor LED units that would use a fraction of the electricity currently being used.

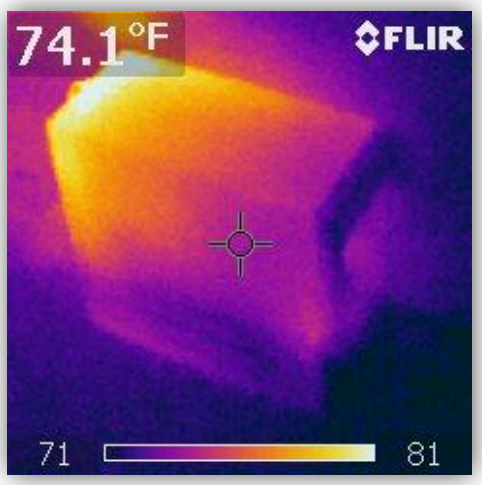
For interior lighting, updating any older florescent tube fixtures while using T8 tubes instead of T12 and replacing any incandescent bulbs with compact florescent (CFL) or LED units would be an appropriate step toward addressing indoor light efficiency.

Most modern electronic equipment draws small amounts of electricity, even when they are turned off. Purchasing smart power strips and cutting power to even small users of electricity is a low cost investment and will lead to a substantial amount of savings over the long term.





Determining which computers in the offices can be completely powered down on nights and weekends could also have a substantial impact on energy savings.

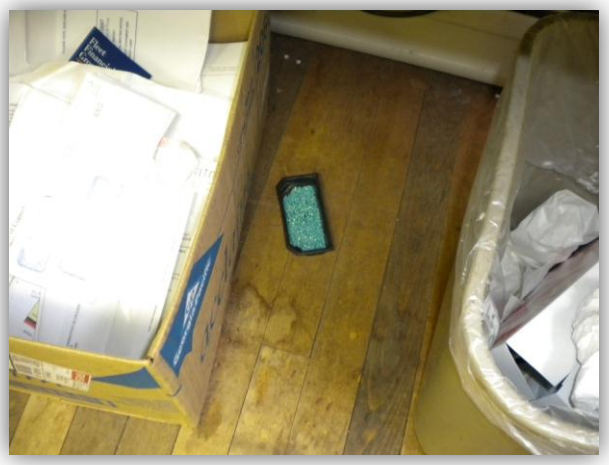


Keeping all equipment free of dust will not only prolong its useful life but may also allow the unit to use less electricity.
Dehumidifiers use a tremendous amount of electricity, even when their filters are not clogged. This air filter on the back of the dehumidifier should be checked and cleaned at least once a week.

Only the highest efficiency Energy Star rated equipment should be purchased. Whether it is a computer monitor, printer, or calculator, the higher upfront cost for more efficient equipment does not take long to earn back in energy savings.

Health, Safety and Comfort:

There were several things noticed in this building that cause concern for indoor air quality and the general health of the building.



The rodent poison seen in this photo is only a small effort to address a much larger problem. As with moisture issues, dealing with pests of any sort should begin with eliminating the source or in this case, access to the interior of the building. If a mouse can fit its head through a small hole, it can squeeze its entire body through. Any hole the diameter of a pencil or greater is an opportunity for rodents and should be sealed. The fumes from rodent urine and droppings, which rise up through the building, are a very unwanted air pollutant.

The attic space has a large amount of bat droppings. Given that this is in the higher area of the building, there is less risk of harmful gases making their way into the occupied areas of the building. Nevertheless, this is still a great health concern to the building as a whole and can affect efficiency by degrading the effectiveness of attic insulation.

These two bats where sleeping between the screen and the window. It was evident that this is a favorite place for them by the amount of droppings on the window sill. Gases from these droppings are likely migrating to the 2nd floor space.

Mice and bats are an important part of our ecosystem. Bats in particular are very beneficial and have been faced with many human-made challenges and their numbers are dwindling as a result. As beneficial as they are, they do not belong in our buildings, which need to be sealed or well screened in order to keep them out. Bat boxes on the property are a great option for keeping these important creatures on the grounds of this building.

Addressing the moisture issue in the crawl space will not only improve structural durability but will help reduce the growth of mold and mildew whose spores will inevitable make their way into occupied areas of the building.

Any building, whether a residence or a place of business, needs to offer 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 1. 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.

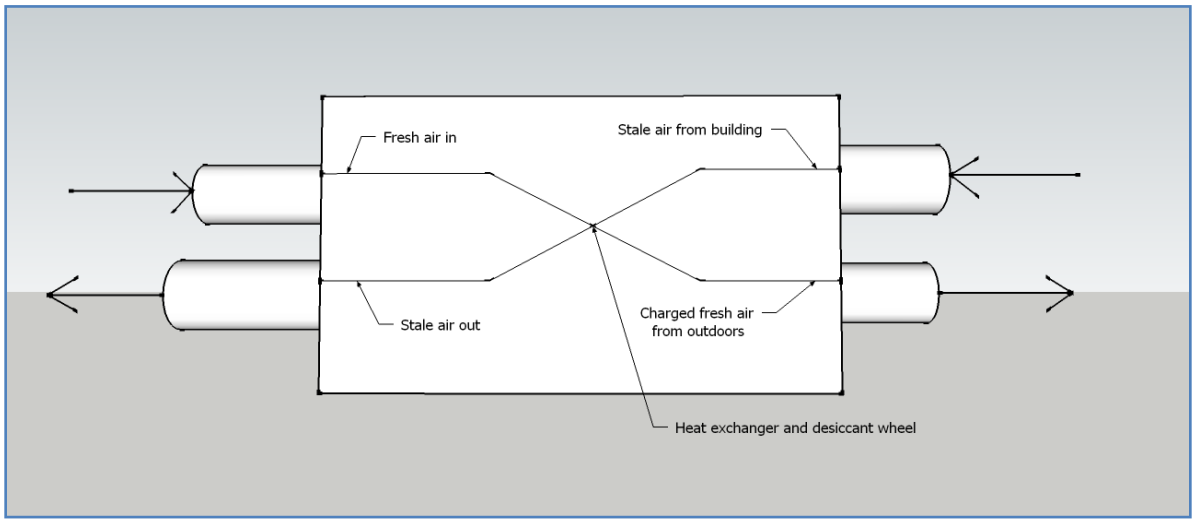


Figure 1

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.

Foundation and Crawl Space:

- When working with the engineer to develop a plan for fixing the foundation issues, be sure to bring the topic of energy efficiency into the discussion. Whether insulating the foundation and crawl space floor or the underside of the framed floor, insulative efforts will reduce the amount of heat loss from this area of the building and will produce long term energy savings.
- Eliminate the drain at the back door or develop a way to ensure that the water is moved away from the building.
- Cut the asphalt away from the back of the building exposing the granite foundation. Put in place a drainage system that will divert water away from the building. Do the same for the grass area on the other side of the rear entrance. Make sure that whatever new surface is abutting the building will not allow for water to splash up against the bricks.
- Eliminate any passage way for rodents to enter the building.
- Cover the entire crawl space floor with a durable vapor barrier, making sure that it runs up the foundation walls and all seams are sealed.

Exterior Walls:

- If water vapor coming from the crawl space is controlled, air seal any cracks in the interior finish on both floors.

Ceilings and Attic:

- Air seal any major paths for conditioned air to rise up to the second floor.
- Air seal any penetrations from the 2nd floor space to the attic above.
- Eliminate any passage ways for bats to enter the attic space. Install bat boxes on the property.
- Remove as much bat droppings as possible and blow 12-16 inches of cellulose insulation evenly over the attic floor.

Doors and Windows:

- Make sure that all doors are well sealed when they are closed.
- Make sure that all storm windows provide a good air seal—consider replacing with new high efficiency, low-e coated units.
- Seal around the trim, inside and out, of all the doors and windows.

Mechanical:

- Replace the current boiler with a high efficiency modulating, condensing gas boiler with a rated efficiency of 95% or greater. Replace the electric hot water heater with an indirect hot water heater. Install an outdoor reset to control the boiler temperature.
- Insulate all piping in the building. Place an insulated radiant barrier between the radiators and the windows on the 2nd floor.
- Provide additional combustion air to the current boiler until it is replaced with a closed combustion unit. This can be a simple vent run from the exterior of the building to the area beside the boiler.

Electric:

- Replace any inefficient lighting systems with CFL, T8, or LED technologies.
- Purchase smart power strips and be sure to cut power to any devices when not in use.
- Check and clean the dehumidifier filter once every week.
- Only purchase the most efficient Energy Star rated equipment when buying new or replacing the old.

Health and Safety:

- Develop a plan to ensure the structural stability of the building.
- Eliminate the possibility for bats and rodents to enter the building.
- Address moisture issues that can lead to mold growth.
- Install an HRV to ensure proper air exchange rates in 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 the Upper Valley Lake Sunapee Regional Planning Commission (RPC). **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:

Cornish is served by both NH Electric Coop and Granite State and a small area of Central Vermont Power. 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

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.

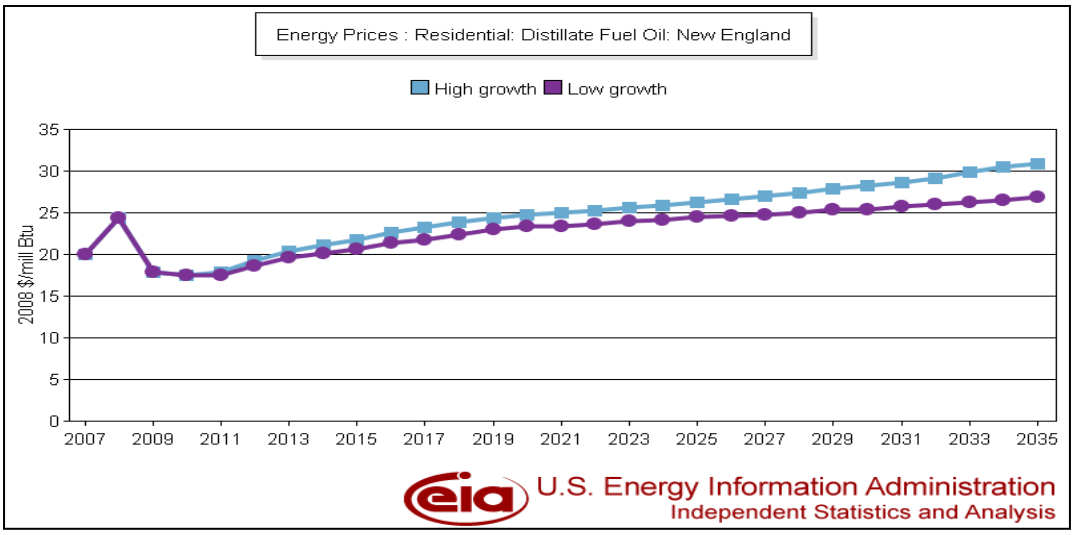
For more information on the history of energy prices and how energy cost projections are calculated, please visit: http://www.eia.doe.gov/analysis/

Price Summary

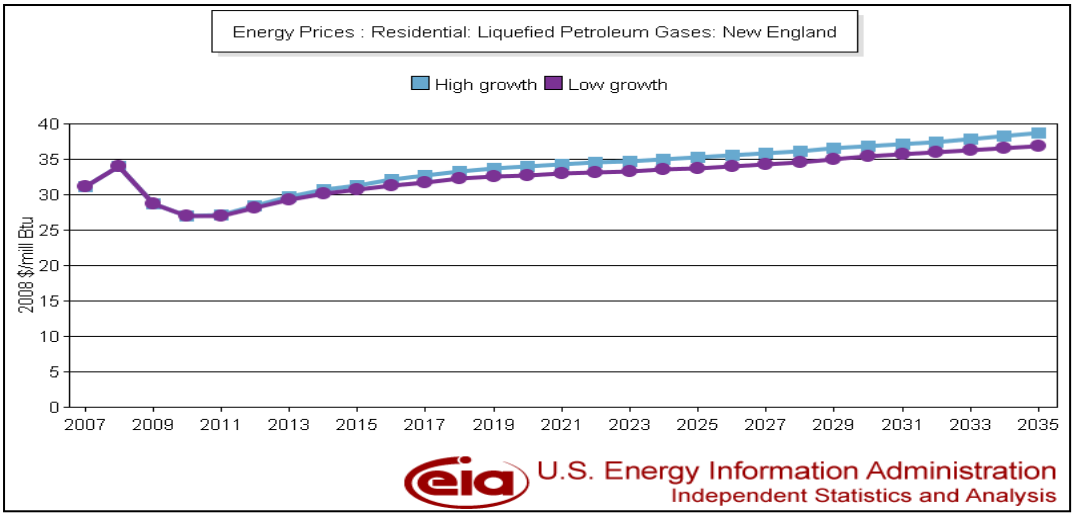
	Year				Percent Change		
	2009	2010	2011	2012	09-10	10-11	11-12
WTI Crude[a] ($/barrel)	61.65	79.40	93.26	97.50	28.8	17.5	4.5
Gasoline[b] ($/gal)	2.35	2.78	3.15	3.30	18.4	13.4	4.8
Diesel[c] ($/gal)	2.46	2.99	3.43	3.51	21.5	14.7	2.4
Heating Oil[d] ($/gal)	2.52	2.97	3.41	3.55	17.5	14.8	4.3
Natural Gas[d]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

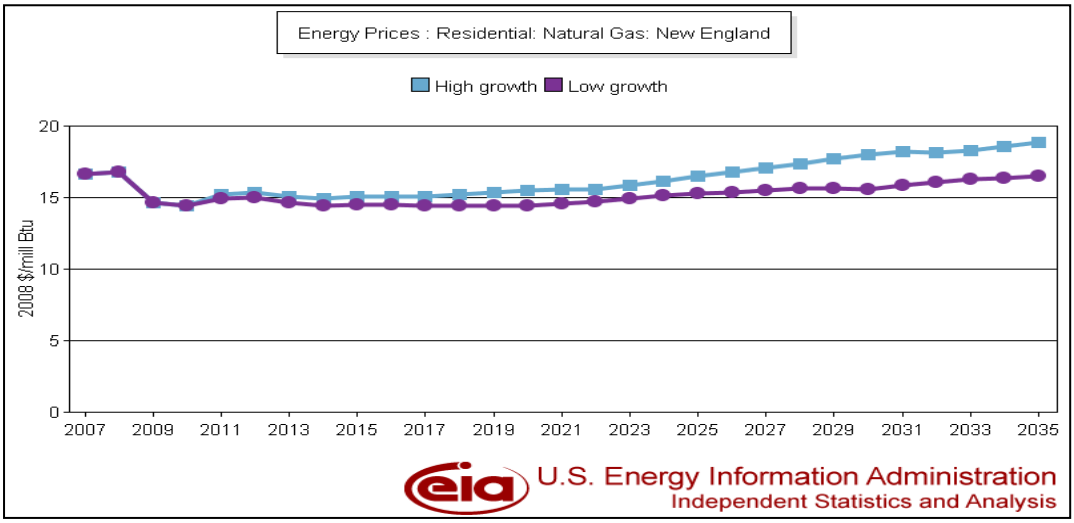
Table 3 – Retrieved from US EIA website



Graph 3 - Retrieved from US EIA website



Graph 4 - Retrieved from US EIA website



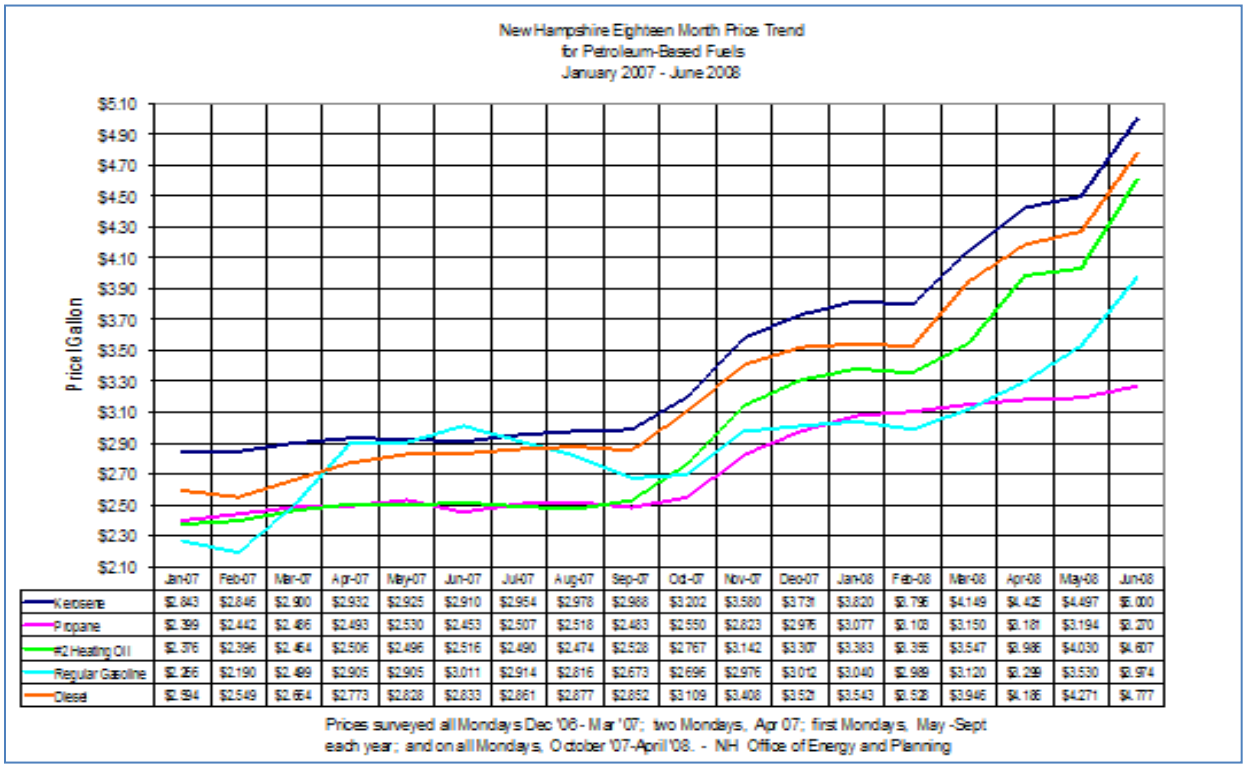
Graph 5 - Retrieved from US EIA website

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.

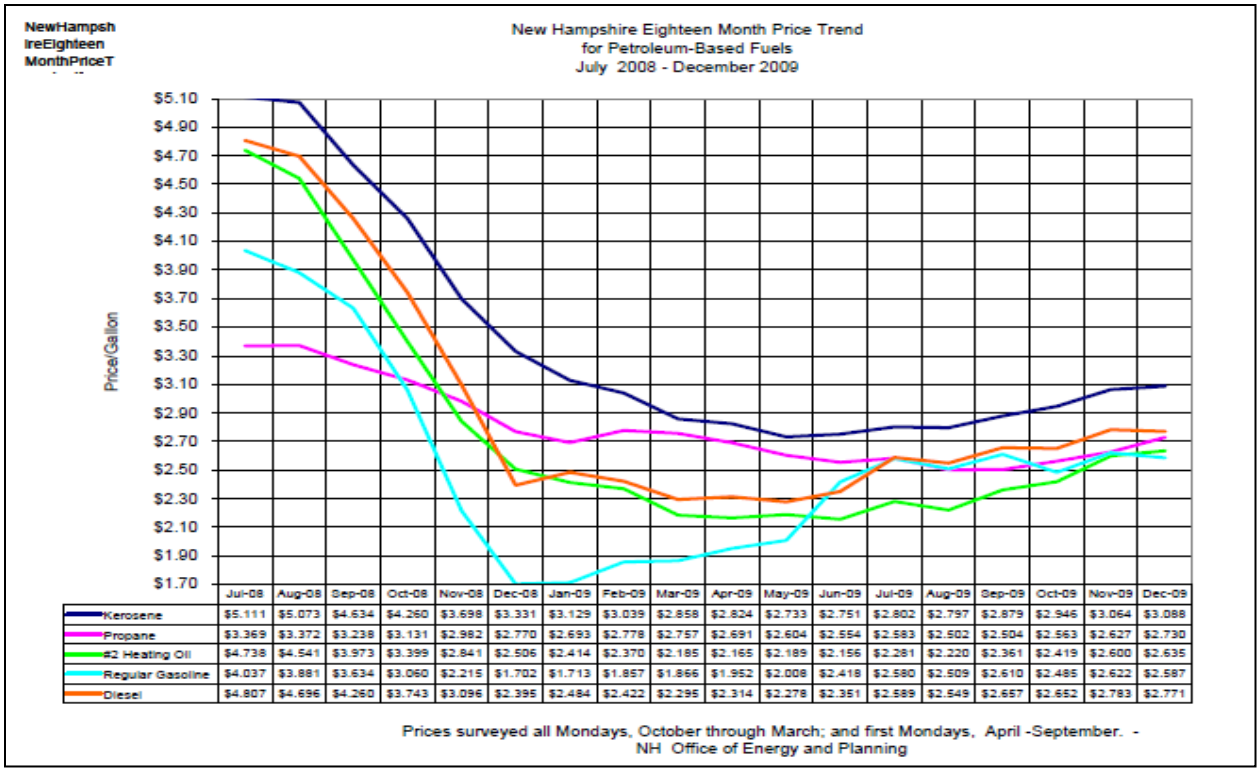
Projects such as air-sealing and insulating can be thought of as a different species of project and investment when compared to items like heat systems, appliances, and alternative energy systems. In the case of the latter, these types of energy investments have a shelf life. A boiler and a PV system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



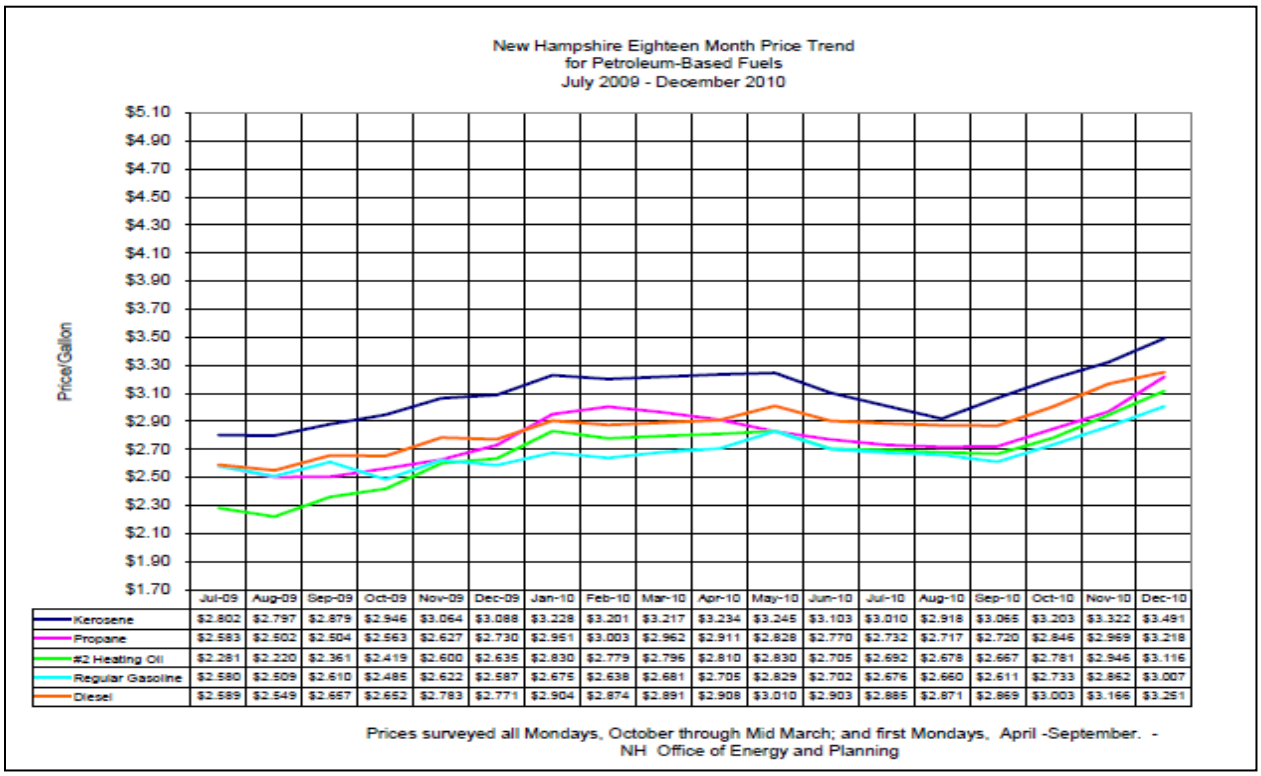
	Jan-07	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08
Kerosene	$2.843	$2.846	$2.900	$2.932	$2.925	$2.910	$2.954	$2.978	$2.988	$3.202	$3.580	$3.731	$3.820	$3.796	$4.149	$4.425	$4.497	$5.000
Propane	$2.399	$2.442	$2.466	$2.493	$2.530	$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	$3.363	$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 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 6 – 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 7 – 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.

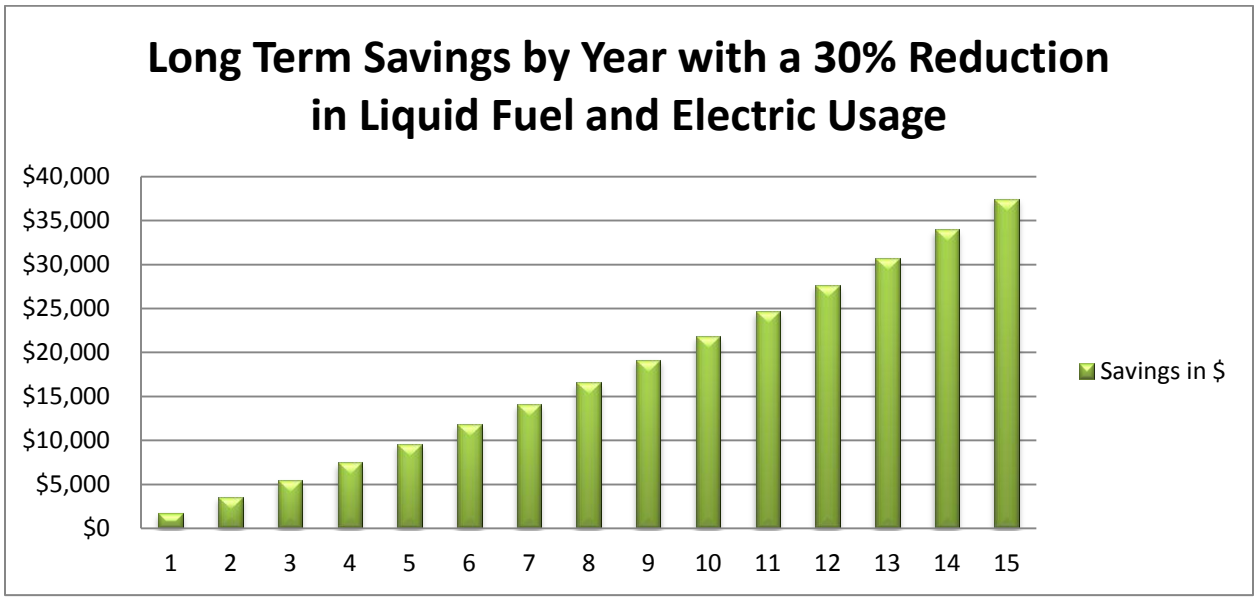
Fuel Usage -15 Year Projection				
Year	Energy Cost By Year	Yearly Increase	Total Accumulated Cost by Year	
		Escalation Rate	5.00%	
Year 1	$4,102.64	$ 205.13		$4,103
Year 2	$4,308	$ 215.39		$8,410
Year 3	$4,523	$ 226.16		$12,934
Year 4	$4,749	$ 237.47		$17,683
Year 5	$4,987	$ 249.34		$22,670
Year 6	$5,236	$ 261.81		$27,906
Year 7	$5,498	$ 274.90		$33,404
Year 8	$5,773	$ 288.64		$39,177
Year 9	$6,061	$ 303.07		$45,238
Year 10	$6,365	$ 318.23		$51,603
Year 11	$6,683	$ 334.14		$58,285
Year 12	$7,017	$ 350.85		$65,302
Year 13	$7,368	$ 368.39		$72,670
Year 14	$7,736	$ 386.81		$80,406
Year 15	$8,123	$ 406.15		**$88,529**

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 - 15 Year Projection				
Year	**Energy Cost By Year**	**Yearly Increase**	**Total Accumulated Cost by Year**	
		Escalation Rate	**5.00%**	
Year 1	$1,683.87	$ 84.19		$1,684
Year 2	$1,768	$ 88.40		$3,452
Year 3	$1,856	$ 92.82		$5,308
Year 4	$1,949	$ 97.46		$7,258
Year 5	$2,047	$ 102.34		$9,304
Year 6	$2,149	$ 107.45		$11,454
Year 7	$2,257	$ 112.83		$13,710
Year 8	$2,369	$ 118.47		$16,079
Year 9	$2,488	$ 124.39		$18,567
Year 10	$2,612	$ 130.61		$21,180
Year 11	$2,743	$ 137.14		$23,922
Year 12	$2,880	$ 144.00		$26,802
Year 13	$3,024	$ 151.20		$29,826
Year 14	$3,175	$ 158.76		$33,002
Year 15	$3,334	$ 166.70		**$36,335**

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 - Fuel and Electricity				
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	$1,736	$ 86.80		$1,736
Year 2	$1,823	$ 91.14		$3,559
Year 3	$1,914	$ 95.69		$5,473
Year 4	$2,010	$ 100.48		$7,482
Year 5	$2,110	$ 105.50		$9,592
Year 6	$2,216	$ 110.78		$11,808
Year 7	$2,326	$ 116.32		$14,134
Year 8	$2,443	$ 122.13		$16,577
Year 9	$2,565	$ 128.24		$19,142
Year 10	$2,693	$ 134.65		$21,835
Year 11	$2,828	$ 141.38		$24,662
Year 12	$2,969	$ 148.45		$27,631
Year 13	$3,118	$ 155.88		$30,749
Year 14	$3,273	$ 163.67		$34,022
Year 15	$3,437	$ 171.85		**$37,459**



Conclusion:

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