The New Hampshire Municipal Energy Assistance Program

Decision Grade Audit Report

Gilmanton Iron Works Fire Department
1824 New Hampshire Rte. 140, Gilmanton, NH 03237

Prepared for:

Town of Gilmanton, NH

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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 Gilmanton 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 Gilmanton.

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Table of Contents

Introduction: 4
The Audit 4
Basics of Heat Loss: 6
Basics of Moisture Control: 7
Building Description: 9
Energy Data Collection: 10
Blower Door Test Results: 12
Foundation and Slab: 13
Exterior Walls: 14
Ceilings and Attic: 17
Doors and Windows: 19
Mechanical: 21
Electrical: 23
Health, Safety and Comfort: 24
Recommendations: 27
Financial Considerations and Options: 29
Potential for Savings: 37
Conclusion: 39

Introduction:

MEAP partners are pleased to provide this Decision-Grade Audit Report for the Town of Gilmanton and the Iron Works Fire Department (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.

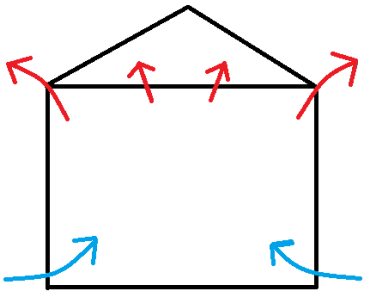
This DGA involves a quantification of energy consumption (electrical and heating fuel), a description of existing heating/cooling and distribution systems, thermal barrier inefficiencies, potential electric savings through lighting/appliances upgrades and behavior change, occupancy health and safety 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.

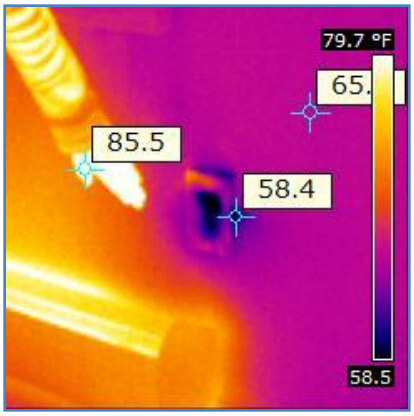
Heat moves through and leaves a building by three different means: *convection, conduction, and radiation*. One way to think of convective heat loss is by air movement into and out of a structure. One of the forces causing this to happen is the "stack effect".



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.

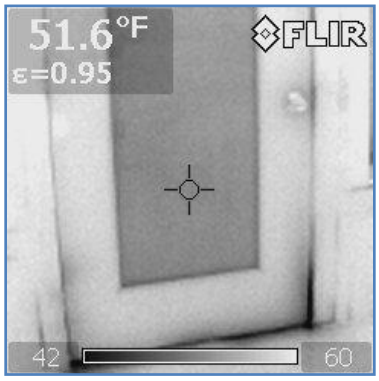
Conduction is the foremost way in which heat travels through a solid building material. R-value is one way to describe a given materials resistance to transfer heat. Materials with a high R-value, such as foams, cellulose, or fiberglass batts are used for insulation. At any location in the building envelope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



Basics of Moisture Control:

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.

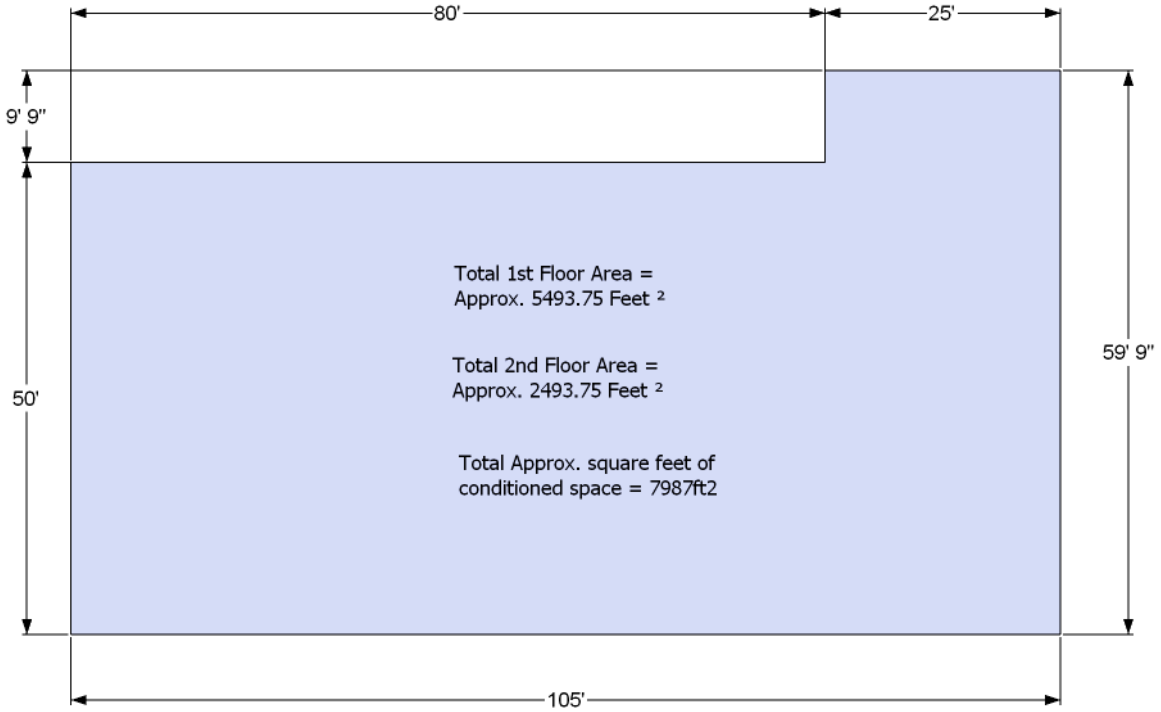
In the winter, there will always be some level of moisture in a heated and occupied space. We want this moisture, or water vapor, to stay within the occupied space for many reasons. Two of the most important reasons are to help occupants feel more comfortable and to keep the water vapor from causing 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 building was constructed in 1973 which included a garage area, as well as a two story office area. At some point, likely in the past decade, a two story addition was constructed on the back side of the building. This has expanded the amount of space for offices, conference room, break rooms, sleeping quarters, etc.

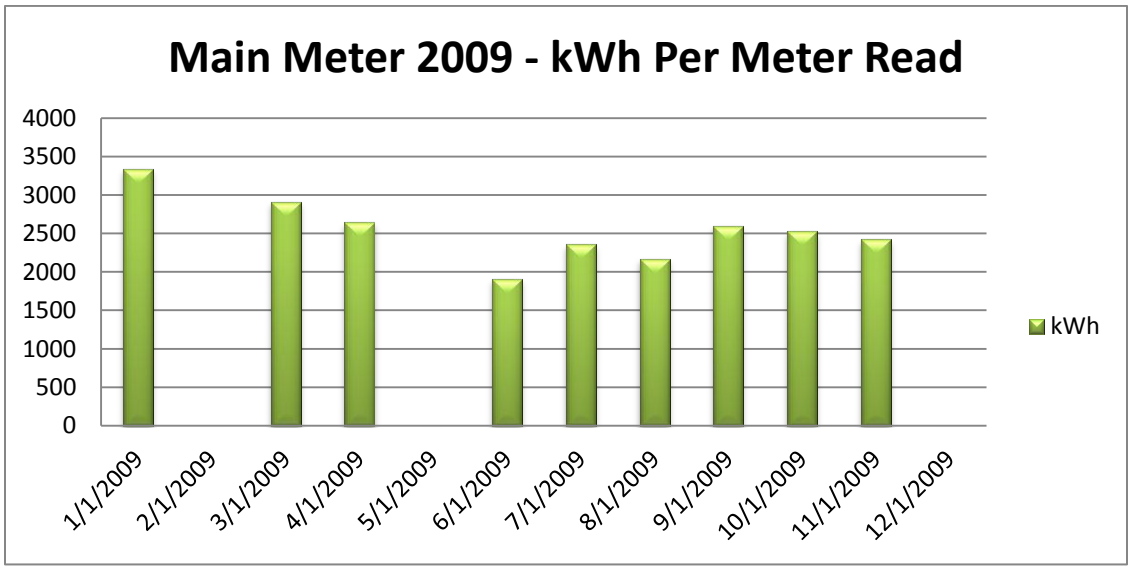


Energy Data Collection:

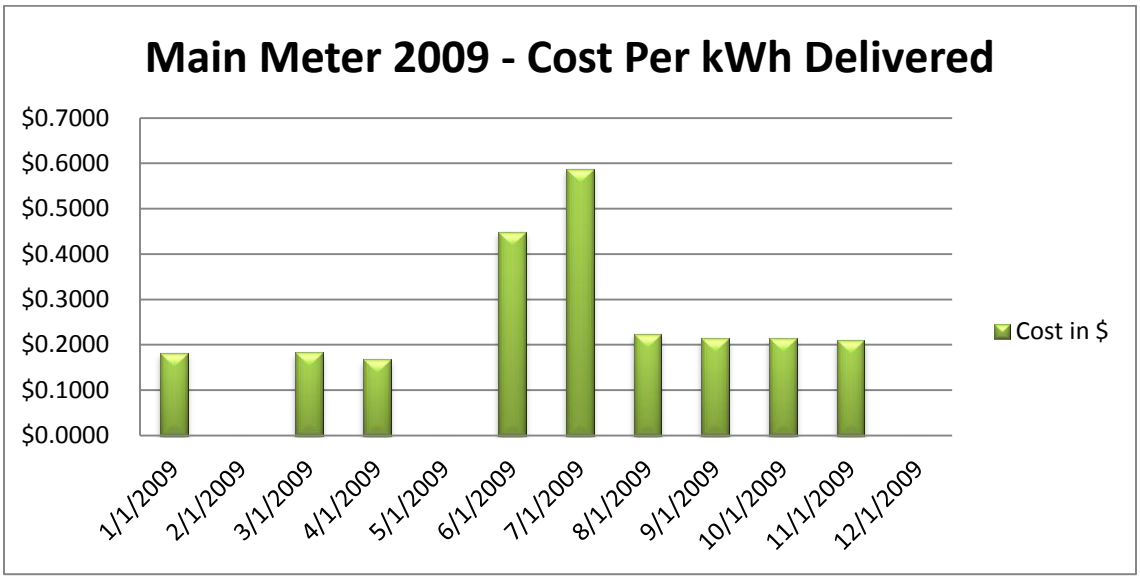
Analysis from provided utility bills for 2009 produces the following snapshot in electricity consumption. Monthly consumption is designated low to high, red being the lowest and green being the highest consumption months in the table below. Clearly, not all data was made available.

Electric -Main Meter			
PSNH			
Date	**KWH**	**Total $/mo**	**Cost Per kWh**
12/1/2009	0	$0.00	#DIV/0!
11/1/2009	2,421	$509.00	$0.2102
10/1/2009	2,525	$542.00	$0.2147
9/1/2009	2,596	$554.72	$0.2137
8/1/2009	2,167	$484.82	$0.2237
7/1/2009	2,353	$1,383.02	$0.5878
6/1/2009	1,904	$855.19	$0.4492
5/1/2009	0	$0.00	#DIV/0!
4/1/2009	2,638	$441.00	$0.1672
3/1/2009	2,909	$531.35	$0.1827
2/1/2009	0	$0.00	#DIV/0!
1/1/2009	3,338	$606.00	$0.1815

Average $/kWh: $0.1907
Total kWh: 43,760
Total Cost in 2009: $5,907.10



Annual electricity consumption for Gilmanton Fire Department



Cost of delivered electricity for Gilmanton Fire Department

Heat Source 1 - Hydro-Air and Baseboard			
NO.2 Oil			
Date	**Fuel Units**	**$**	**Cost Per Unit**
12/1/2009	441	$859.12	1.9481179
11/1/2009	521	$1,016.21	1.950499
10/1/2009	209	$407.92	1.9517703
9/1/2009	77	$149.88	1.9464935
8/1/2009	204	$468.54	2.2967647
	Total Units Used =		**1452**
	Total Paid For Year =		**$ 2,901.67**
	Ave Cost Per Gal =		**$ 2.00**

***It is clear in the electric usage table that there is missing data. Not all of the electric usage was made available.

***What is more difficult to see is the presumed missing oil usage. It is fairly safe to assume that if 1452 gallons of oil were delivered to this facility between August and December of 2009, that there was about this same amount delivered to this facility between January and May 2009. Therefore, we will assume the yearly oil deliveries for 2009 totaled 2904 gallons. This will also be reflected in the "Potential for Savings" section of this report.

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.

Foundation and Slab:

Both the garage and office areas sit on a concrete slab. Concrete has almost no insulative value, and heat loss from concrete slabs and foundations can be substantial.

We performed our inspection of this building during a warm month and were therefore unable to take effective IR images. To help illustrate the amount of heat that is likely occurring from the foundation and slab of this building, we have included a photo and IR image of a slab on grade building in the same climate region as this building, taken during cold weather (see Figure 1). Heat loss from a slab or foundation, showing as orange in this IR image, can account for 20% of a building's total heat load. See Figure 2 for further illustration

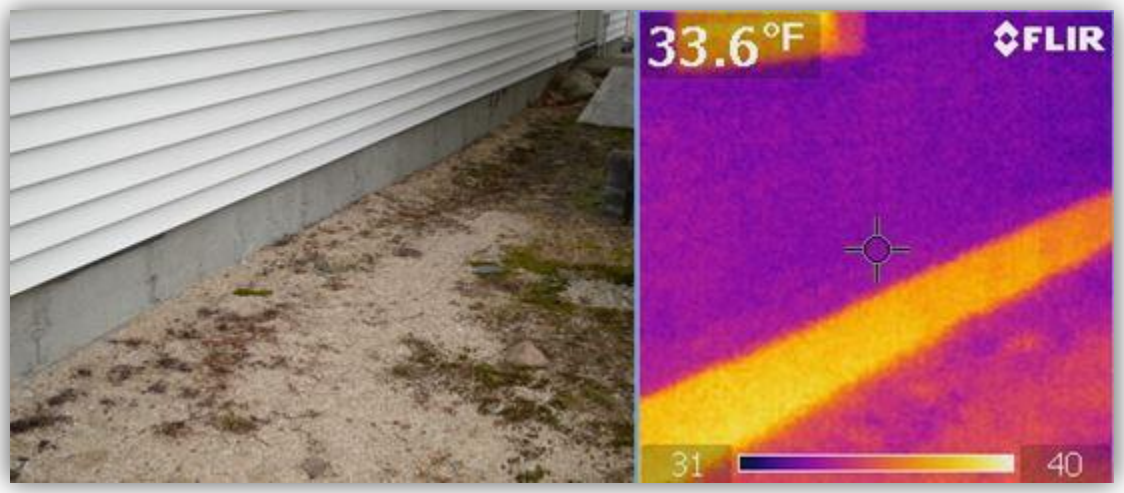


Figure 1

Insulating the foundation would need to be done with 2 inch extruded polystyrene foam board that would run a minimum of 2 feet below grade, though 4 feet would be preferred in this climate. The insulation would have to be protected from the elements and from pests. Sealing the foam board where it meets the frame of the building would also be necessary and could be done in such a way as to eliminate the possibility of air infiltrating the building envelope.

Exterior Walls:

The exterior walls of the original building are lined with insulated panels. It is important to note the water stains coming from the ceiling in the image to the right.

As seen in this photo, the panels have a relatively thin layer of expanded polystyrene insulation. This panel is located in the attic area of the addition. Now exposed, the rust stains on the exterior face of the foam are a clear indication of the condensation occurring on the panels during the winter months.

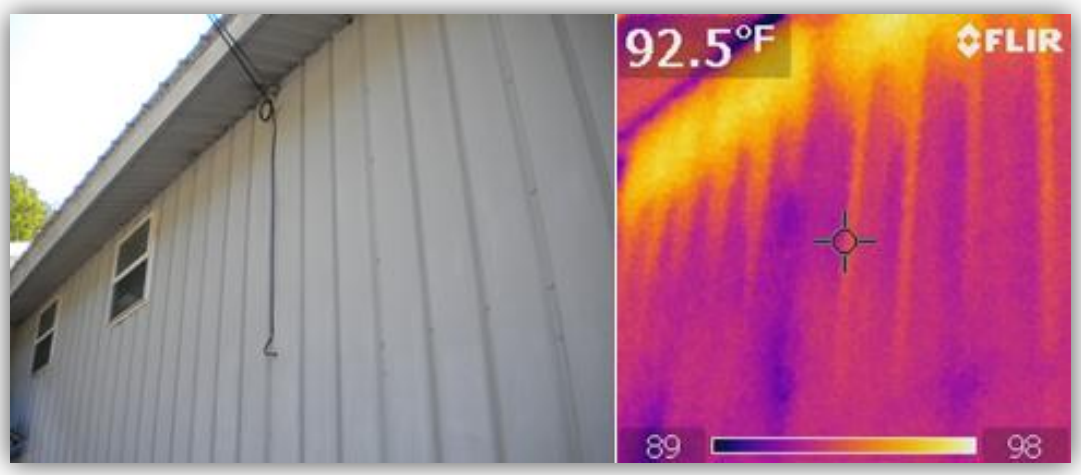
The walls of the addition are lined with vinyl-faced fiberglass blankets. What is visible in this photo is that the walls of the addition are framed with a sheetrock finish. Because there is such a large air space between the finished walls and the fiberglass blankets, heat from the space can easily rise up into the attic space.

This picture looks above the suspended ceiling of the 1st floor. Neither the suspended ceiling or the fiberglass insulation between the floor joists constitutes as an air barrier. This allows the conditioned air to easily pass from the office spaces into these exterior wall cavities.

The same is true for this interior partition between the original building and the addition.

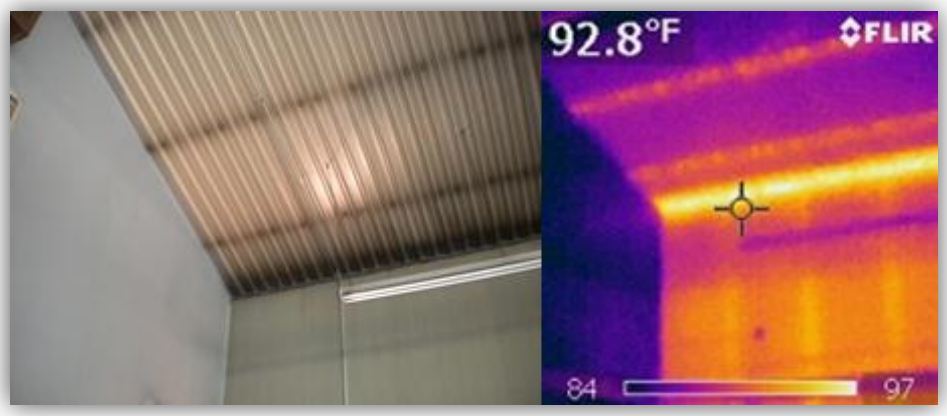
The photo and IR image below, captured on a warm day, indicate heat gain for the exterior walls from light purple to orange. This same wall during cold months would look just the opposite. The studs would appear more orange because they would be holding some heat, while the empty cavities would show as cold (purple), largely because of the rate that the heat can rise away from this space.

This photo and IR image would likely not change much if taken during the colder months as the attic walls and roof are likely be the greatest area of heat loss. On this hot day, much heat is concentrated in the attic as the AC units try to keep the offices and break rooms cool.



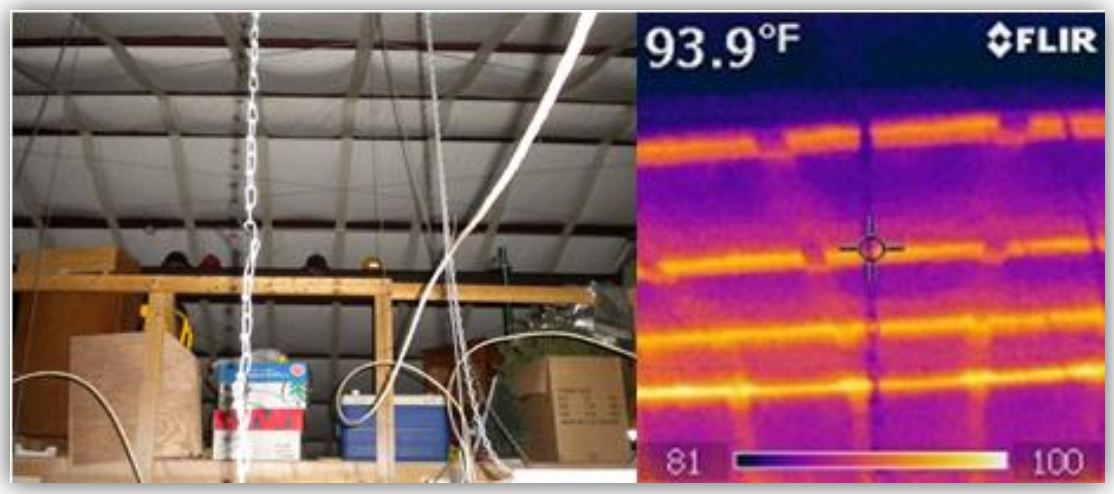
Ceilings and Attic:

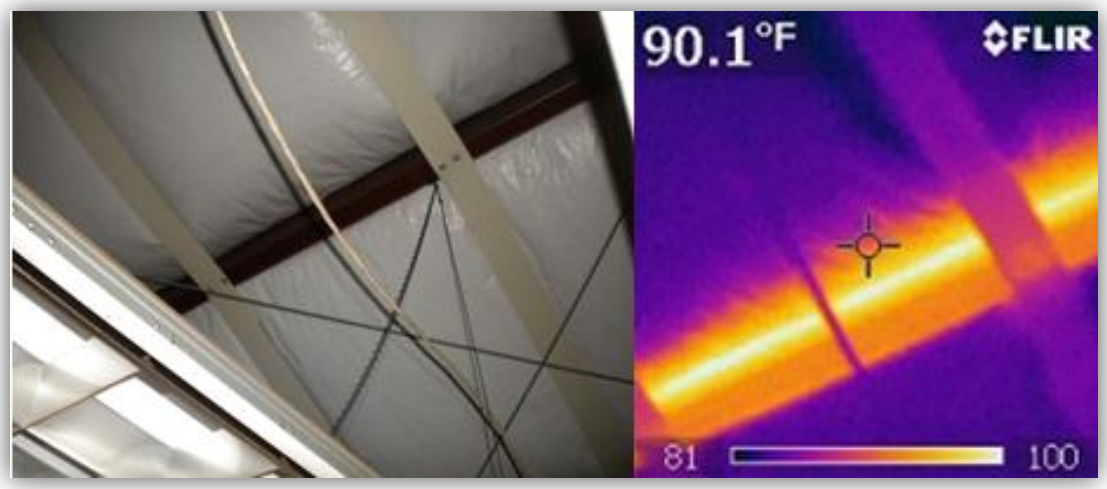
There are three surfaces seen in the photo and IR image below. To the left is the wall separating the garage from the 2nd floor conference room, which is being air conditioned on this summer day. One can also see the amount of heat radiating in from the wall panels in the garage as well as the roof. Note the dark areas on the ceiling around the fasteners and along the eves. Some of this may be particulate matter build-up due to air leakage, though this discoloration is most likely caused from condensation and the resulting degradation of the material.



The two photos below were taken from the attic space of the addition and show the composition of the original building's roof. There are two layers of corrugated metal, between which is fiberglass insulation. The photo to the right is a section that extends beyond the exterior wall on the back end of the building. Notice how clean the insulation appears compared to the photo to the left. The more degraded insulation is not only being exposed to heat from within the building (and consequently condensation) but is also serving to filter particulate matter that escaped along with conditioned air from seams in the metal.

The next two photo/IR images show the underside of the addition roof. The warmer (orange) areas of the IR images indicate solar heat gain as the fiberglass blankets are compressed between the steel purlins and the corrugated roof. At these points there is little to no insulative value and is thereby a large source of heat loss in the winter.



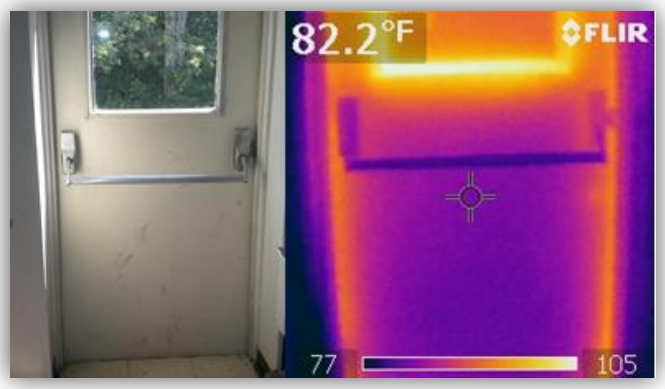


Doors and Windows:

The windows of the original building are metal framed, single pane windows. These should be replaced with new more efficient units.

The windows of the addition are relatively efficient and should not be replaced at this time. However, these and any other windows and door should be well sealed between their frames and the metal siding and interior finish.

Any of the hollow core doors of the original building should be replaced with high efficiency foam core units. The doors of the addition that do have a foam core, like the one seen below, should not be replaced at this time, but all doors should have proper weather stripping to ensure that they are performing as well as they can.



The following solutions can be done to increase the efficiency of these doors: First, repair the weather stripping around the edges—it has fallen off in some areas, and it appears as though it was never installed along the tops of the doors. The photo to the left shows a large gap, which is present at the top of every door. Second, line the inside of these doors with foil-faced bubble wrap insulation. There are three benefits to using this type of insulation: It adds some R-value to the door; it is flexible so that it could possibly overlap where the individual panels meet (the weak points), and it gives the doors a radiant barrier to help reflect some of the heat back into the space. Figure 2 demonstrates just how effective a well-placed radiant barrier can be.

Figure 2

Mechanical:

Heat for this building is provided by the oil-fired boiler seen to the right. We did not find service tags for this boiler nor did we perform a combustion efficiency test, but it is safe to assume that this boiler is combusting fuel at about 84% efficiency. This is a relatively efficient boiler and burner, and if oil will continue to be the main fuel source, we do not recommend replacing this unit at this time. We do recommend that combustion analysis receipts are requested to be left by this boiler.

The boiler does deliver heat to some baseboard heaters but also to two air handling units seen in the two photos below. Other items to note in these photos are the open combustion LP gas water heater, unsealed/insulated ductwork, and uninsulated piping.

It is very important to note 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.

All of the ductwork in the building should be air sealed and, at a minimum, wrapped in foil-faced bubble wrap insulation—air sealing the ductwork in the boiler is of the highest importance. 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 handlers 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 for both open combustion appliance.

We did not perform a worst case CAZ test (combustion appliance zone) during our inspection of this building, but one should certainly be done here. Most HVAC technicians do not perform this test. We recommend contacting an area energy auditor for this. With the combination of two open combustion appliances, unsealed return duct, a clothes dryer, and a return grill directly outside this room, there is certainly cause for caution. The results will likely warrant bringing in additional combustion air.

The potable water for this building is provided by this stand-alone, open combustion LP gas water heater. This unit could certainly be replaced with a number of systems that would save a great deal of energy but would also eliminate the safety concerns associated with the operation of this unit. More about safety concerns will be discussed in the "Health and Safety" portion of this report.

LP gas usage was not included in the "Energy Data Collection" section of this report. The main reason for this is that there is a gas fired generator onsite that likely test fires every week. Given that there is not a meter for both lines, it would be very difficult to assume an amount of LP used with this water heater.

Electrical:

Updating florescent tube fixtures while using T8 tubes instead of T12, and replacing any incandescent bulbs with compact florescent (CFL) or LED units is a great first step toward addressing electric tied to lighting needs. Also, invest in outdoor LED options for safety lights that are left on during the night year round. The more a light is used, the more important it is to use the most efficient source available.

The lights, seen in the photo to the right, could be replaced with high-bay LED options. This would be a substantial initial investment, but the long term savings potential would be equally significant. Not only do LED's use much less electricity, but they have a much longer life; they turn on to full brightness almost immediately, allowing them to be turned on and off more readily, which results in even further savings. Outdoor security lights are another great option for LED's as they are likely kept on all night throughout the year. The more a light is used, the more important it is to use the most efficient source.

There are several small air conditioning units in the office areas of this building. Turning these units off at night, keeping them at reasonable temperatures, keeping them clean, and replacing them with the highest efficiency units available when need be are the first measures for reducing this electric usage.

It is also important to remember that there are two forms of heat that these units work to expel, internal and external heat gains, and how making improvements to other aspects of the building helps to lighten both loads.

Most people think of external heat gains when thinking about air conditioning. This can be hot/humid air infiltrating the building, the heat from the building shell conducting towards the interior (opposite of winter), or even strong sun light radiating in through the windows. Making improvements to the building shell will not only reduce the heating bill but the cost of cooling as well.

Some Internal gains come from the occupants of a space, while other sources of heat are lighting, computers, appliances, and so forth. The more efficient these sources are, the less heat they emit, thus reducing the cost to keep a space cool.

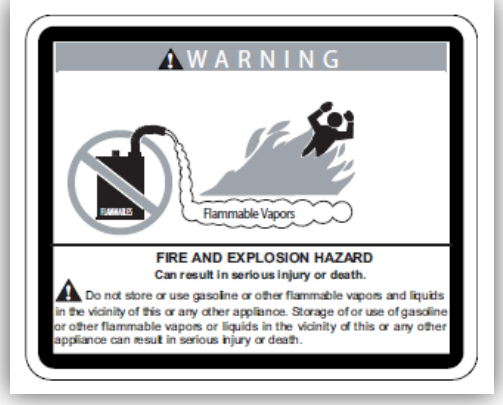
Modern electronic equipment often draws a small amount of electricity even when powered down, which can equal a sizable amount in cost at the end of the year. Using power strips and fully cutting the power to electronics will reduce this unintended electric usage.

Installing a photovoltaic solar system on site, either to meet the needs, or supplement the costs of electricity is always recommended. Options for funding such a project are given in the next section of this report.

Health, Safety and Comfort:

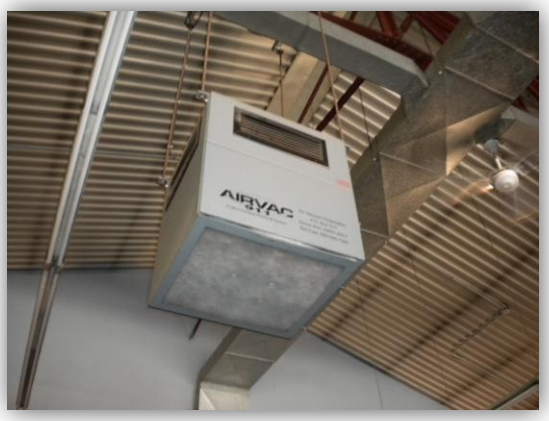
There were no signs of rodents or bats. Such unwanted animals can emit harmful gases from their droppings and are common in a building like this. It is important to address such issues immediately should they arise. The first line of defense is always to eliminate access points into the building.
Though we did not test for mold, there were no obvious signs of mold growth in this building. Any moisture issues that should occur need to be addressed right away—always start by eliminating the source of the moisture.
Make sure that there are an appropriate number of well-place carbon monoxide and smoke alarms placed throughout this building.

The picture below and to the left shows several sources of gas fumes that pose a potential hazard as these are directly outside the mechanical room, which, as discussed earlier, is likely under negative pressure much of the time. Below and to the right is an image captured directly from the website of the same gas hot water heater installed in this adjacent room. A similar illustration and warning is on a sticker directly adhered to the unit. Furthermore, there is a supply air return located on the wall behind this fuel storage area—this is likely drawing in fumes and potentially distributing them to other areas of the building.



There were a couple of safety concerns noticed with the installation of the gas water heater. One of them being the water heater exhaust and the oil boiler exhaust almost directly across from each other. We are not certain if this against code, or even a safety concern, though we do recommend looking at the manufacturer specs and possibly consulting the local code enforcement officer.

There are 4 forms of ventilation found in this building. Natural air infiltration and associated convective loss, bathroom exhaust vents, the air filtration unit, seen in the photo below and to the right, as a form of aid to indoor air quality, and in the photo to the left is a type of ventilation system that helps to create convection currents without the use of electrically powered fans. Even with all of these in place, we would still recommend consulting with a ventilation specialist to find ways to improve the air quality in this building. The potential of air pollutant monitoring systems, exhaust hoses for vehicle mufflers, and heat recovery ventilation should all be considered.



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.

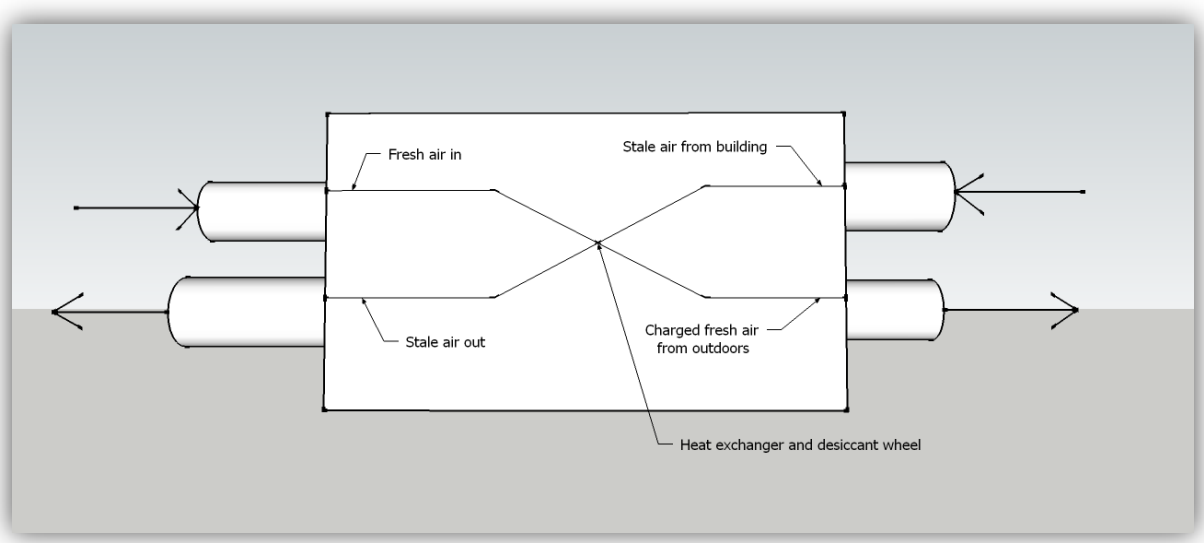


Figure 3

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:

- Insulate the foundations and slabs of this building and its additions. This should be done with 2 inch extruded polystyrene foam board, which should extend below grade 2-4 feet. 4 Feet would be the preferred depth should conditions allow. The foam needs to be protected from the elements and pests with either a durable cement type finish or with coated sheet metal that is well sealed at all seams.

Exterior Walls:

- In the tow story sections of the building, seal off any passage ways from the 1st floor to the 2nd. Do the same from the 2nd floor spaces to the attic areas. Options for improving the insulative value of the two wall systems can be discussed during the presentation of this report.

Ceilings and Attic:

- The roof insulation of both the original building and the addition could be improved to maximize long term savings. More about the various options of doing so can be discussed during the presentation of this report.

Doors and Windows:

- Replace any of the older door and windows with high efficiency units. Make sure that all doors and windows are well-sealed between the frames and the metal siding.

Mechanical:

- Air seal and insulate all of the ductwork in the building.
- Insulate all of the heating and domestic hot water pipes in the building.

- Install an outdoor temperature reset to control boiler temp.
- Replace the current hot water heater with either an on demand LP water heater, or a slor domestic system.
- Supply addition combustion air to the boiler room.
- There are many options for reducing heating costs with full system replacements, including infrared heaters, or a wood pellet system. These options and more can be discussed during the presentation of this report.

Electrical:

- Replace any inefficient lighting systems with either CFL, T8, or LED technologies.
- Make use of smart power strips, and be sure to cut the power to any equipment when it is not in use.
- Be sure to invest in the highest efficiency, Energy Star rated equipment when buying new items or replacing the old. Pay special attention to the highest energy users like air conditioning units and refrigerators.
- After efficiency matters have been addressed, install a photovoltaic solar system to provide onsite generation of electricity in order to supplement or eliminate what electric needs remain.

Health and Safety:

- Install HRV or ERV units to ensure an adequate number of air exchanges per hours for those working or doing business in this building.
- Find a better place to store gas cans and alike. The ideal location would not be in occupied areas 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 Lakes Regional Planning Commission (LRPC) at 279.8171.

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

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

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

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

NH PUC – Commercial and Industrial Renewable Energy Rebate Program:

The NH Public Utilities Commission has created a rebate program for renewable energy systems that is available to Local Governments. Participants will need to have a "Level II" audit performed, and some of the energy efficiency measures implemented prior to being eligible for receiving the final rebate. This is a great opportunity for municipalities who are interested in installing a renewable energy system to receive a similar type of aid previously only available in residential and commercial applications.
There is a maximum incentive, and funding is limited, which means that municipalities will have to carry much of the cost. Participants need to fully understand and follow the project guidelines.

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

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

Utility Programs:

Many utilities provide technical and financial assistance for various types of efficiency measures that can be carried out at a municipal facility. Some programs offer the opportunity for municipalities to go forward with the installation of approved measures at no up front cost to the municipality. A town simply pays for the energy improvements with the savings from reduced energy usage until the project is paid off. Contact your utility provider to discover ways in which they can assist your municipality in reaching its energy efficiency goals.

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

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

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.

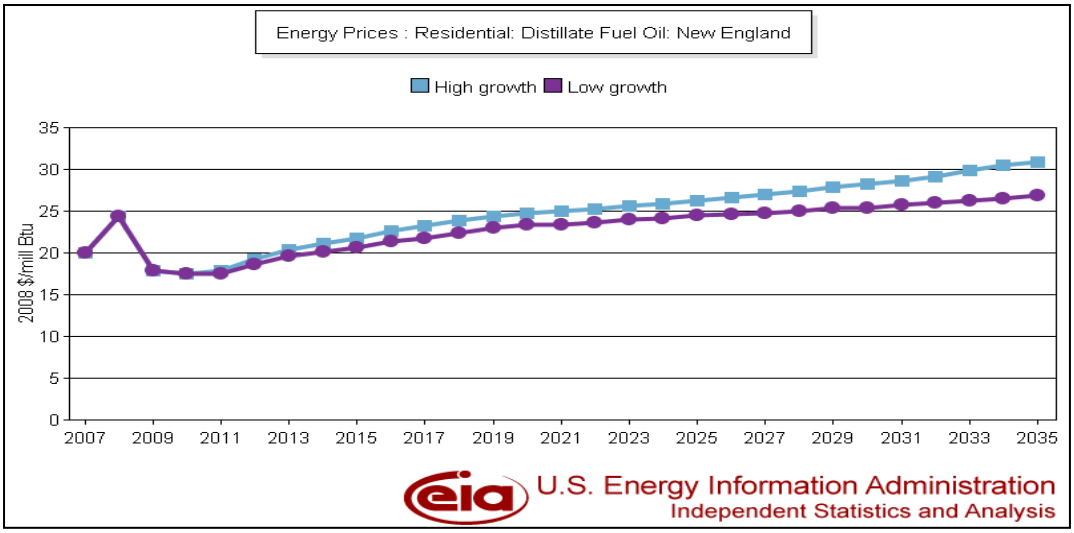
For more information on the history of energy prices and how energy cost projections are calculated, please visit: http://www.eia.doe.gov/analysis/

Price Summary

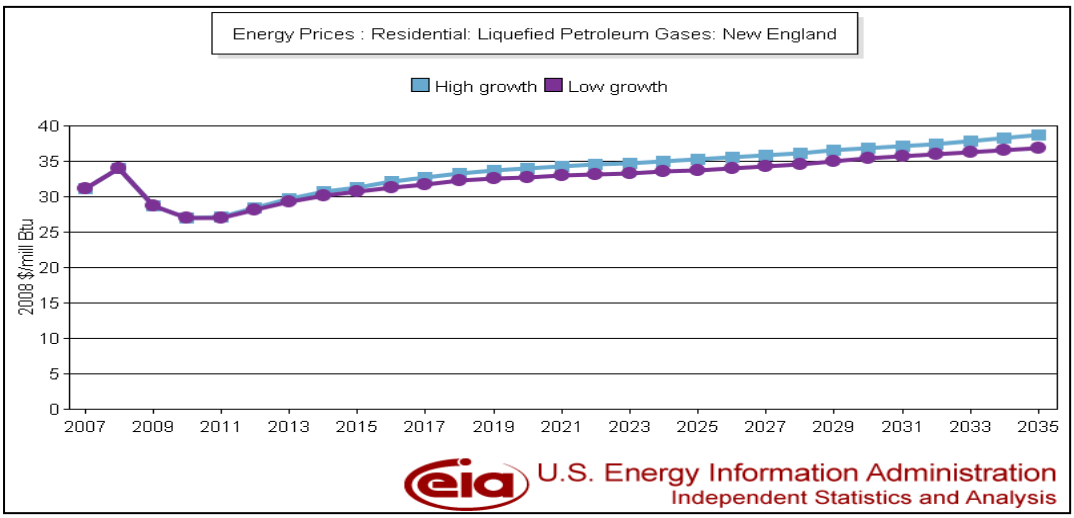
	Year				Percent Change		
	2009	2010	2011	2012	09-10	10-11	11-12
WTI Crude[a] ($/barrel)	61.65	79.40	93.26	97.50	28.8	17.5	4.5
Gasoline[b] ($/gal)	2.35	2.78	3.15	3.30	18.4	13.4	4.8
Diesel[c] ($/gal)	2.46	2.99	3.43	3.51	21.5	14.7	2.4
Heating Oil[d] ($/gal)	2.52	2.97	3.41	3.55	17.5	14.8	4.3
Natural Gas[d]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

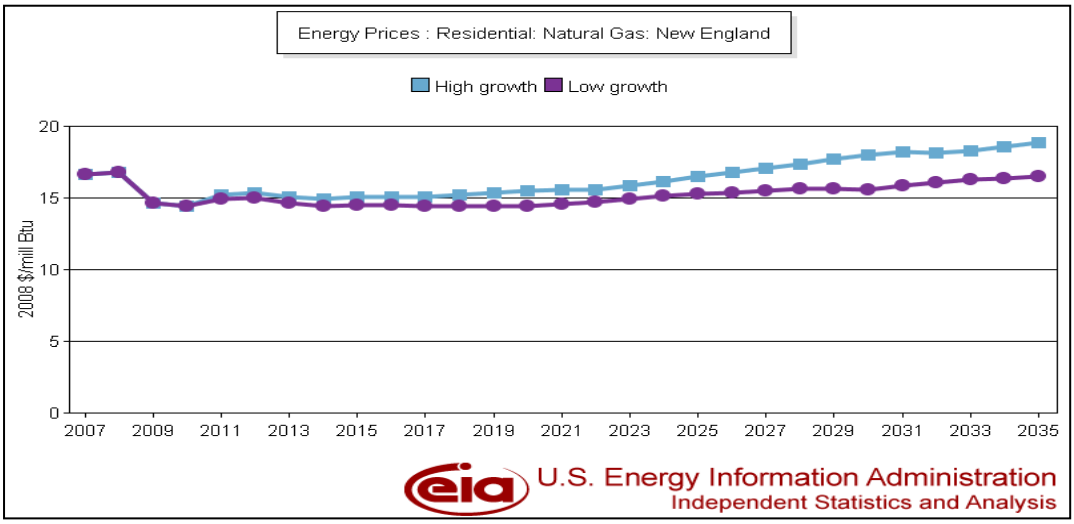
Table 1 – Retrieved from US EIA website



Graph 1 - Retrieved from US EIA website



Graph 2 - Retrieved from US EIA website



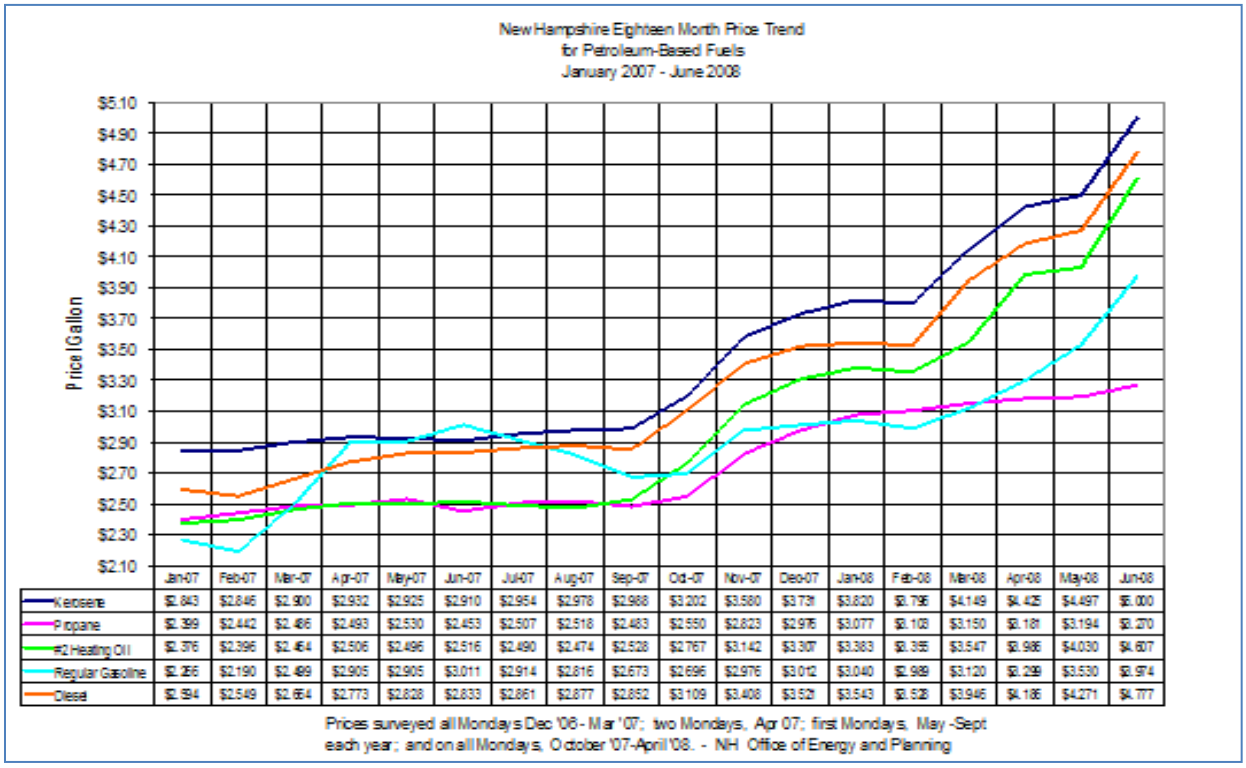
Graph 3 - Retrieved from US EIA website

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.

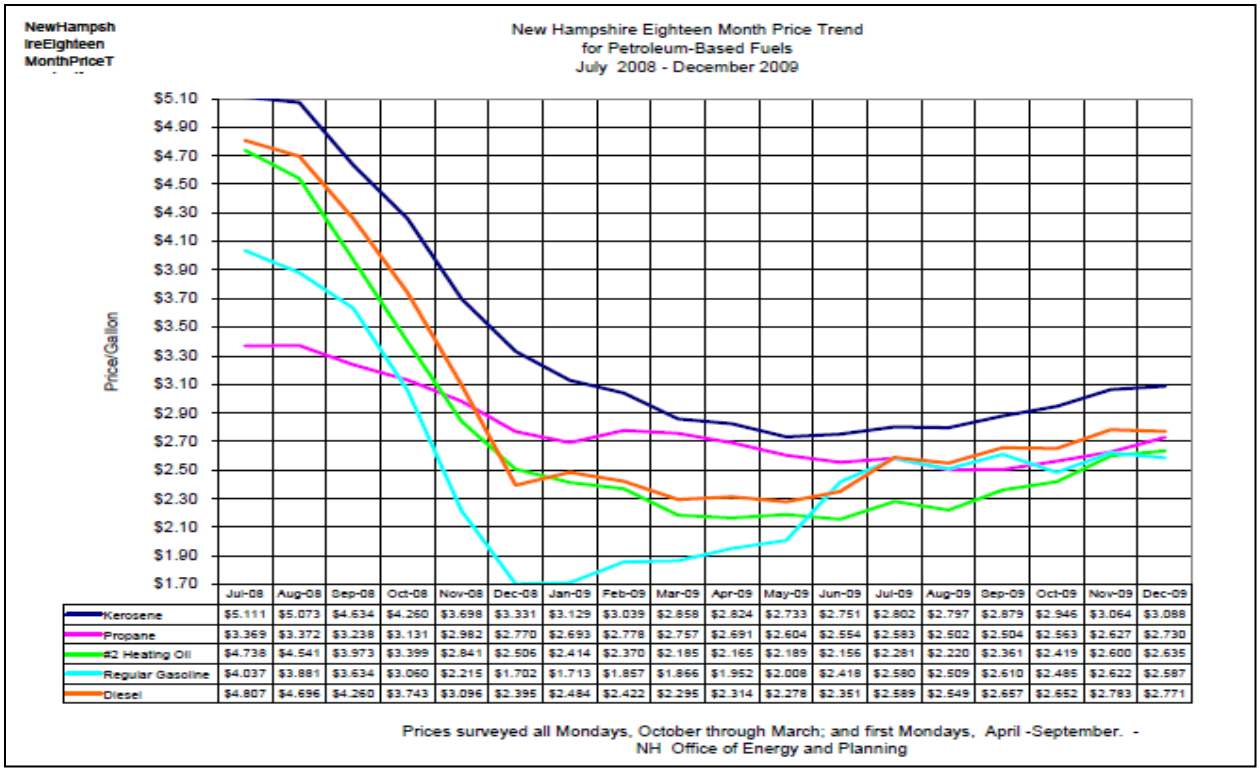
Projects such as air-sealing and insulating can be thought of as a different species of project and investment when compared to items like heat systems, appliances, and alternative energy systems. In the case of the latter, these types of energy investments have a shelf life. A boiler and a PV system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



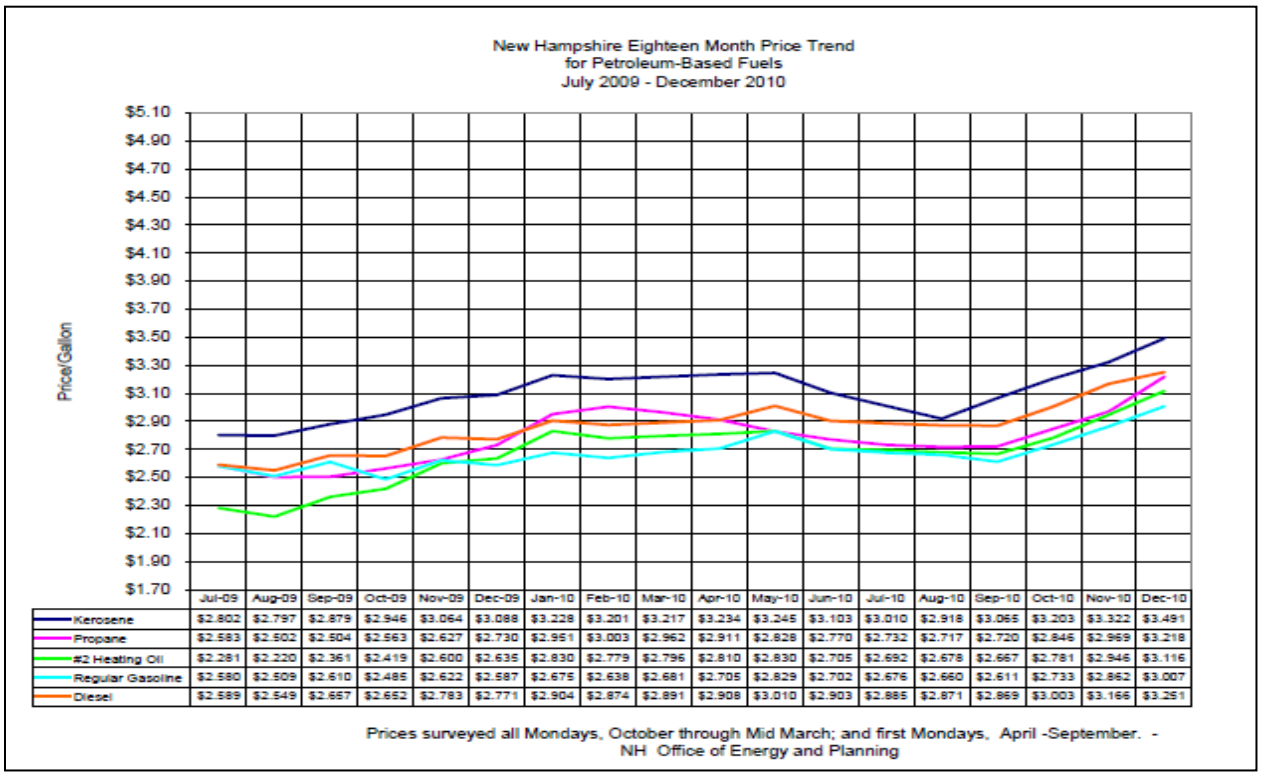
	Jan-07	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08
Kerosene	$2.843	$2.846	$2.900	$2.932	$2.925	$2.910	$2.954	$2.978	$2.988	$3.202	$3.580	$3.731	$3.820	$3.796	$4.149	$4.425	$4.497	$5.000
Propane	$2.399	$2.442	$2.466	$2.493	$2.530	$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 table 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. Also, this is based on an estimated yearly oil usage of 2904 gallons as mentioned on page 11 of this report.

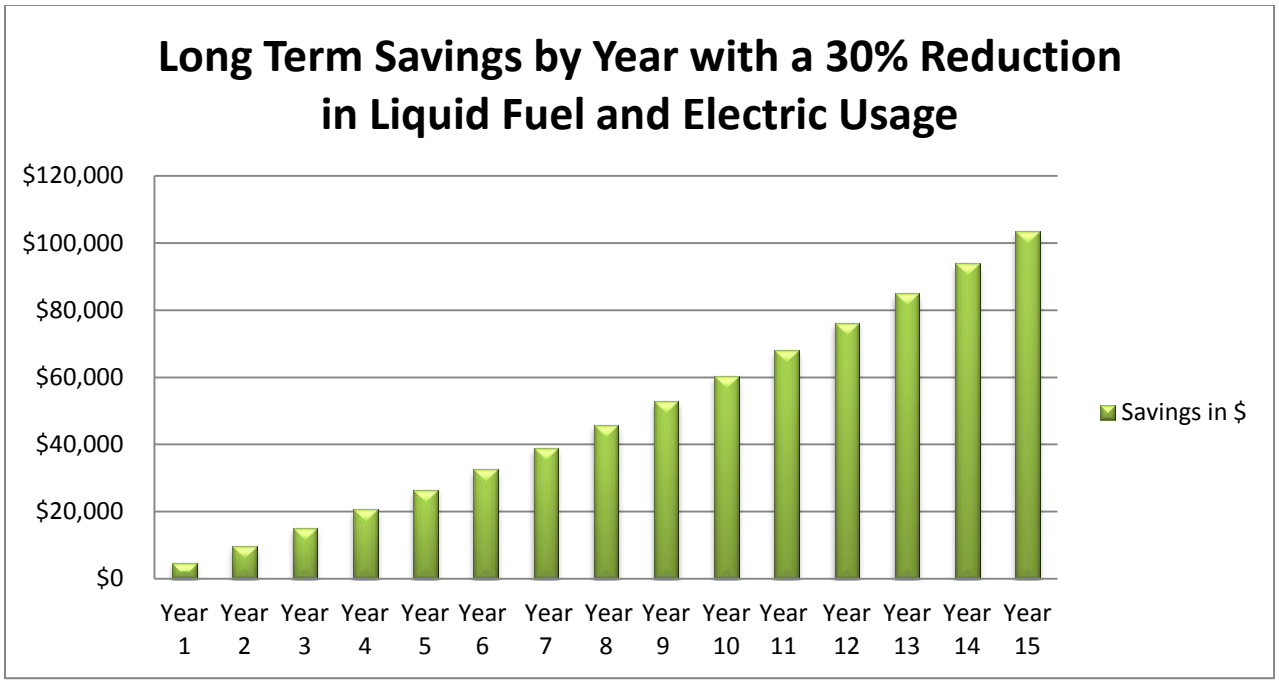
Current Fuel Usage				
Year	**Energy Cost By Year**	**Yearly Increase**	**Total Accumulated Cost by Year**	
		Escalation Rate	**5.00%**	
Year 1	$10,056.55	$502.83		$10,057
Year 2	$10,559	$527.97		$20,616
Year 3	$11,087	$554.37		$31,703
Year 4	$11,642	$582.09		$43,345
Year 5	$12,224	$611.19		$55,569
Year 6	$12,835	$641.75		$68,404
Year 7	$13,477	$673.84		$81,881
Year 8	$14,151	$707.53		$96,031
Year 9	$14,858	$742.91		$110,889
Year 10	$15,601	$780.05		$126,490
Year 11	$16,381	$819.05		$142,871
Year 12	$17,200	$860.01		$160,071
Year 13	$18,060	$903.01		$178,132
Year 14	$18,963	$948.16		$197,095
Year 15	$19,911	$995.56		**$217,006**

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	$5,907.10	$295.36		$5,907
Year 2	$6,202	$310.12		$12,110
Year 3	$6,513	$325.63		$18,622
Year 4	$6,838	$341.91		$25,460
Year 5	$7,180	$359.01		$32,640
Year 6	$7,539	$376.96		$40,180
Year 7	$7,916	$395.80		$48,096
Year 8	$8,312	$415.59		$56,408
Year 9	$8,727	$436.37		$65,135
Year 10	$9,164	$458.19		$74,299
Year 11	$9,622	$481.10		$83,921
Year 12	$10,103	$505.16		$94,024
Year 13	$10,608	$530.42		$104,632
Year 14	$11,139	$556.94		$115,771
Year 15	$11,696	$584.78		**$127,467**

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 - Liquid 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	$4,789	$239.45		$4,789
Year 2	$5,029	$251.43		$9,818
Year 3	$5,280	$264.00		$15,098
Year 4	$5,544	$277.20		$20,642
Year 5	$5,821	$291.06		$26,463
Year 6	$6,112	$305.61		$32,575
Year 7	$6,418	$320.89		$38,993
Year 8	$6,739	$336.94		$45,732
Year 9	$7,076	$353.78		$52,807
Year 10	$7,429	$371.47		$60,237
Year 11	$7,801	$390.05		$68,038
Year 12	$8,191	$409.55		$76,229
Year 13	$8,601	$430.03		$84,829
Year 14	$9,031	$451.53		$93,860
Year 15	$9,482	$474.10		**$103,342**



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 Iron Works Fire Department. 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.