The New Hampshire Municipal Energy Assistance Program

Decision Grade Audit Report

Dunbarton Town Offices
1011 School Street Dunbarton, NH 03046

Prepared for:

Town of Dunbarton, NH

Prepared by:

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Sustainable Energy Resource Group
Vital Communities
Carbon Solutions New England

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5/10/2010

The following report was generated as part of the Municipal Energy Assistance Program (MEAP). MEAP is made possible through the New Hampshire Public Utilities Commission and the Greenhouse Gas Emissions Reductions Fund. The program is a collaborative effort to carry out a sequence of greenhouse gas emissions inventories and energy audits for between 24 and 48 geographically diverse communities in New Hampshire, setting the stage for these communities to perform renovations to selected buildings that would reduce energy consumption and greenhouse gas emissions. This report has been generated as a result of the Town of Dunbarton 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 Dunbarton.

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Introduction:

MEAP partners are pleased to provide this Decision-Grade Audit Report for the Town of Dunbarton and the Town Offices (hereinafter "the building"). This report discusses the findings and subsequent recommendations for energy efficiency improvements at the building. Included within this report are details regarding the site visit and exploration conducted in the facility and examples that illustrate recommended building alterations and improvements that can reduce energy costs and the building's natural resource footprint. In this report we will provide a set of options that can help achieve real energy savings and carbon dioxide reductions. These recommendations should be viewed as initial avenues to participating in several State level funding opportunities for municipal energy projects. These funds distributed under the aegis of the ARRA (American Recovery and Reinvestment Act) are targeted specifically to towns and cities.

Prior to the audit process beginning, each selected municipality must carry out the MEAP energy inventory process. The inventory process is required in order to receive an energy audit. This report relied on those initial findings to help determine the most appropriate building to conduct an energy audit, with the intent of maximizing the potential energy savings.

The Audit

The first stage of any audit process is understanding the characteristics of the building and the objectives of the audit. The use of the building and the Town's goals and objectives are the foundation of a solid audit. In most cases, these objectives combine environmental and economic goals. In the case of public buildings and facilities, comfort and safety are also primary concerns that help guide our analysis and recommendations.

A decision grade audit involves an inventory of heating systems, quantification of energy usage (electrical and heating fuel), and the process of coordinating this information with the goals and objectives of the Town into a decision tool. Under MEAP we look to provide recommendations that will, if carried out, help the Town achieve at least a 30% reduction in energy consumption. The level of detail provided herein is meant to create the basis upon which investment grade audits and decisions can be made. The decision grade audit is meant to filter options and expectations so that the Town can understand the fundamental building system, how changes to the system can result in economic and environmental benefits and how those changes can interact with other policy and philosophical objectives.

The following information will describe the characteristics witnessed during the site visit and those areas of the building complex where improvements may be made. The objective of these recommendations is to create a series of options the Town can further explore.

Energy Data Collection:

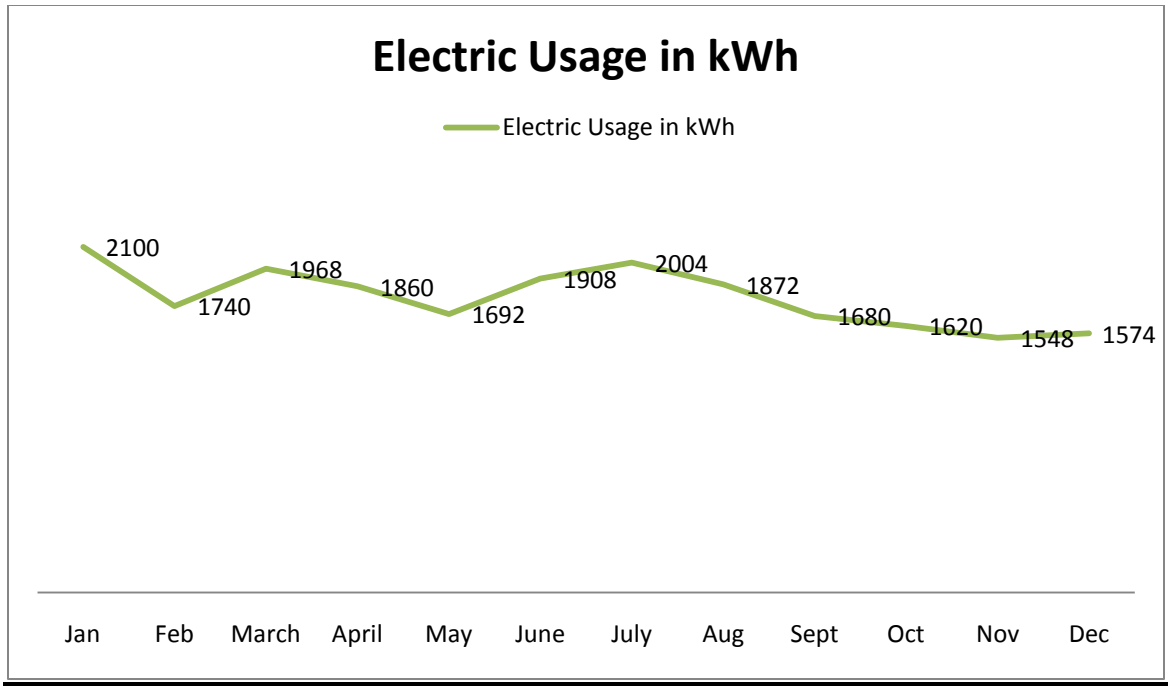
Name of Building	Fuel Type(s)	Area (Sq. Ft.)	Energy Use: Electricity (million Btu)	Energy Use: Heating Fuel (million Btu)	Total Building Energy Use (million Btu)	Site energy intensity (kBtu/sq ft)[1]	EPA Average Site kBtu/sq ft for building type	NH Average Site kBtu/sq ft for building type
Town Office	Elec. & Oil	2,666	73.58	155.46	229.04	75.7	77	70.5

* The above chart was extrapolated from the Dumbarton Municipal Greenhouse Gas and Energy Use Baseline Report.

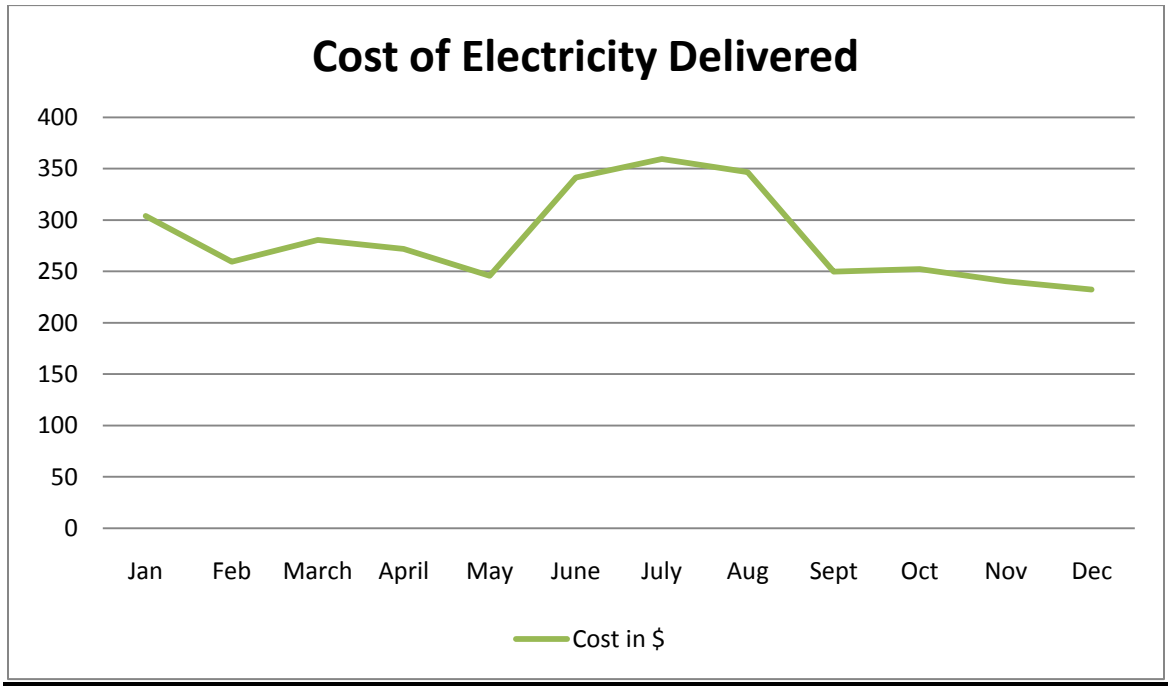
Meter: G82548665			
Building: Dunbarton Town Offices			
April 12, 2010 - 01:02:11 PM			
Fuel Type: Electricity, Grid Purchase (kWh (thousand Watt-hours)) **Space(s):** Entire Facility			
Start Date	**End Date**	**Energy Use**	**Cost - US Dollars**
12/8/2008	1/7/2009	1,574.00	$232.19
11/8/2008	12/7/2008	1,548.00	$240.43
10/8/2008	11/7/2008	1,620.00	$252.13
9/8/2008	10/7/2008	1,680.00	$249.67
8/8/2008	9/7/2008	1,872.00	$346.57
7/8/2008	8/7/2008	2,004.00	$359.40
6/8/2008	7/7/2008	1,908.00	$341.41
5/8/2008	6/7/2008	1,692.00	$245.83
4/8/2008	5/7/2008	1,860.00	$271.96
3/8/2008	4/7/2008	1,968.00	$280.61
2/8/2008	3/7/2008	1,740.00	$259.49
1/8/2008	2/7/2008	2,100.00	$303.89

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

[1] Site energy intensity = amount of energy expended per square foot *on site* to heat, cool, and electrify the area. This measure relates to how much is being used on site and fluctuates directly with how much lighting is being used, how thermostats are kept, etc.



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

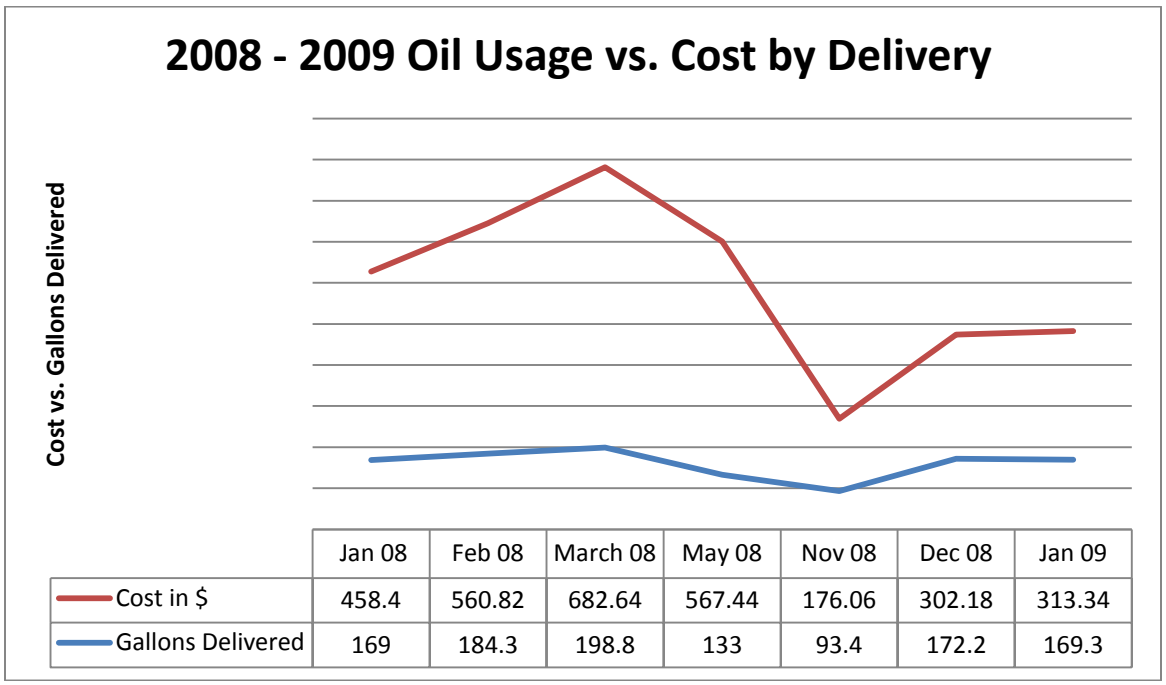


*Graph generated based on data retrieved from the EPA Portfolio Manager account for Dunbarton, NH.

Total kWh used in 2008 - 21,566 kWh
Total Cost of Electricity in 2008 - $3,383.58

Meter: Heating Oil			
Building: Dunbarton Town Offices			
April 12, 2010 - 01:02:55 PM			
Fuel Type: Fuel Oil (No. 2), No fuel generation method associated with fuel type (Gallons) **Space(s):** Entire Facility			
Start Date	**End Date**	**Energy Use**	**Cost - US Dollars**
2/3/2009	3/2/2009	144.2	$262.18
1/12/2009	1/22/2009	169.3	$313.34
12/19/2008	1/11/2009	172.2	$302.18
11/18/2008	12/18/2008	93.4	$176.06
5/27/2008	11/17/2008	133	$567.44
3/24/2008	5/26/2008	198.8	$682.64
2/19/2008	3/23/2008	184.3	$560.82
1/23/2008	2/18/2008	169	$458.40

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



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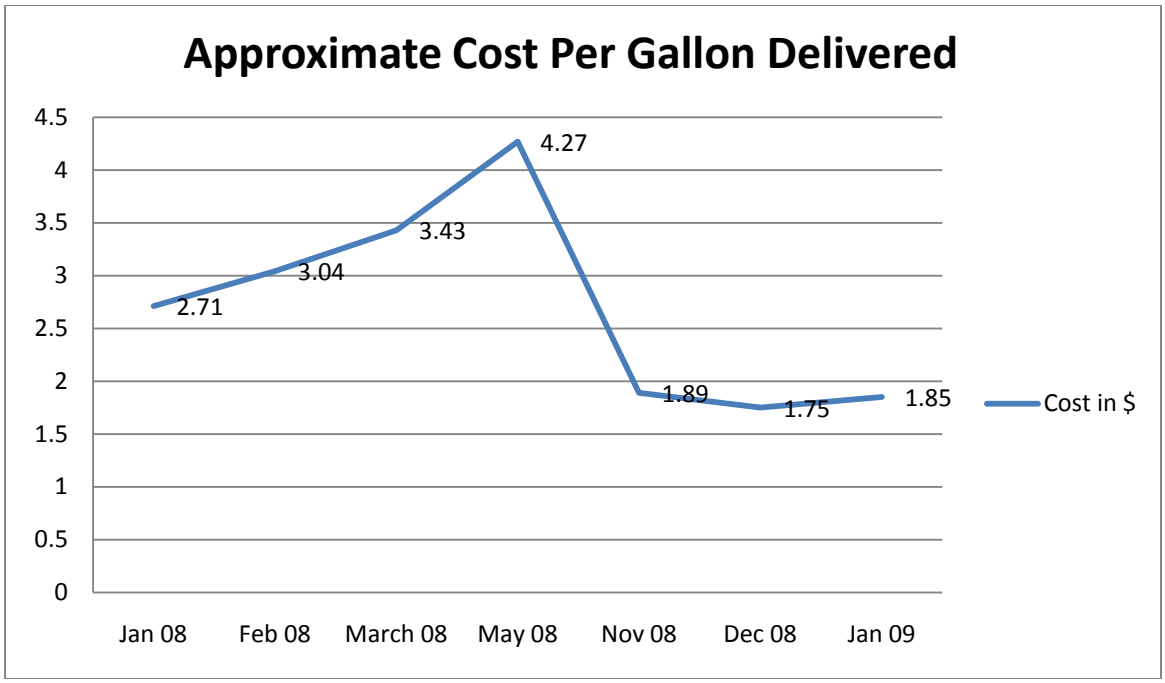


*Graph generated based on data retrieved from the EPA Portfolio Manager account for Dunbarton, NH.

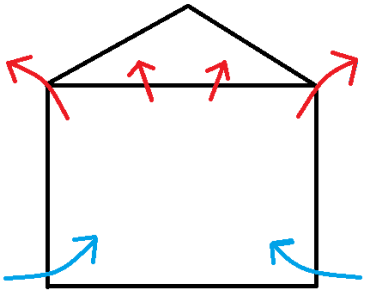
Total Gallons of oil Purchased - 1,120 gallons

Cost of Gallons Delivered - $3,060.88

Basics of Heat Loss:

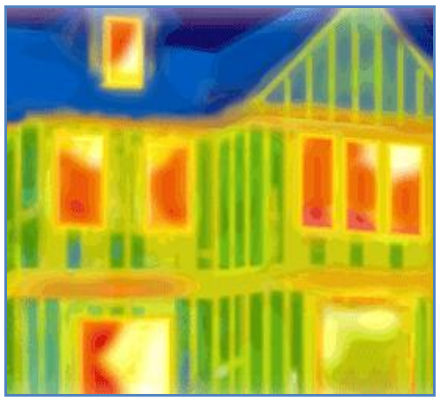
Though we are typically used to measuring heat in temperature, it can be measured in a variety of units. For the purpose of measuring how much heat is produced to condition a space, and how we measure the rate at which heat leaves a structure, we measure in British Thermal Units (BTU's). One BTU is about the same amount of heat produced from a kitchen match. Another good reference to have is that there are about 138,500 potential BTU's in 1 gallon of heating oil. During the winter months, we cannot keep BTU's from leaving our buildings. Hot always goes to cold, or, areas of high pressure are always trying to go to areas of low pressure. What we can do is try to slow the process. We do this by using an **air barrier** and **insulation** at the building envelope to create a thermal barrier.

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

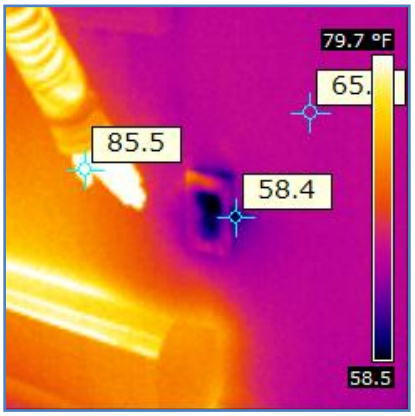


The stack effect describes, on a macro level, the natural way in which air moves through a building. As warmed air leaves through the upper levels of a building, cold air infiltrates through the lower sections. In most cases, this pulls air from less than desirable areas of a building, such as basements, crawl spaces and mechanical rooms, which are often damp and unmaintained. These spaces can be the source of exhaust fumes from heating equipment, mold and mildew, as well as a number of other air contaminants such as radon. Without an effective air barrier between the conditioned space and the attic, warm air will exit the building. For every 1 cubic foot of air that leaves a building, 1 cubic foot of air will infiltrate at a different location. Gaining control of the air movement through a building not only has a positive effect on efficiency, but contributes to increased comfort and improved indoor air quality.

Conduction is the foremost way in which heat travels through a solid building material. At any point in the building envelope where there is a solid building material and no insulation, what is known as "**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 5.5 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 all of the doors and windows, means that a significant percentage of the building envelope has an R-value of less than 10. Even a wall with a high R-value cavity insulation such as spray foam is subject to these weak points in the thermal boundary. Employing methods to reduce or eliminate thermal bridging in our new and existing buildings will dramatically reduce energy costs and emissions over the

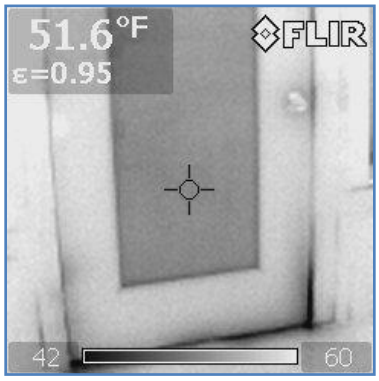


long term as we move towards a new generation of energy and environmental challenges.



Radiant heat loss describes how heat waves, or infrared radiation, pass through space from one surface to another within its view. For example, the heat from a hot cooper pipe will radiate towards cooler surfaces around it, like an exterior wall. The heat can then conduct through building materials to the exterior.

With regards to the building envelope, **gaining control of convective heat loss is the main priority, and usually the easiest to address through air sealing**. After this is done, increasing insulation levels, or R-value, of the building envelope is the next step to gain better control of conductive heat loss. In many cases, a large amount of a structure's radiant heat loss will be addressed with added insulation, either to ceilings, floors, walls, ductwork, or piping. Treating the whole building as a system, and addressing all the issues of heat loss will produce optimum savings and comfort.



<u>Basics of Moisture Control:</u>

The issue of moisture control in buildings is very complex and essential to maintaining structural durability and occupant health. The mismanagement of moisture can lead to a multitude of negative effects. Some of these are mold growth, poor indoor air quality, early materials and equipment degradation, and large negative health impacts on the people who live and work in our buildings.

The two basic forms of moisture in need of managing are bulk moisture (fluid), and water vapor. Two important ways to manage bulk moisture are to keep rain and ground water from entering our buildings, and to quickly fix any water leaks from sources within our buildings such as leaking pipes.

Managing relative humidity and water vapor is a challenge. At some points of the year, occupants want more humidity in the air to maintain comfort, and less in other times. For example, in the winter months we want more humidity indoors because it helps occupants experience greater comfort. In many situations, we increase the relative humidity mechanically with humidifiers. When indoor air is too dry during the winter, we feel colder, develop dry skin, and our upper respiratory can become dry causing discomfort.

Conversely, in the summer we want the air to be dry. Just as hot goes to cold, wet goes to dry. We cool ourselves by perspiring. As we produce this moisture on our skin, it evaporates into the air, drawing heat away from our bodies. The temperature of a room may not be very high, but if the relative humidity is high, we will feel hot because our perspiration is evaporating at a slower

rate. Much of the comfort we achieve from using an air conditioning system (AC) is by removing the moisture from the air, allowing our skin to dry more quickly.

In the winter, there will always be some level of moisture in a heated and occupied space. We want this moisture, or water vapor, to stay within the occupied space for many reasons. Two of the most important reasons are to help occupants feel more comfortable, and to keep the water vapor from causing damage within the building envelope.

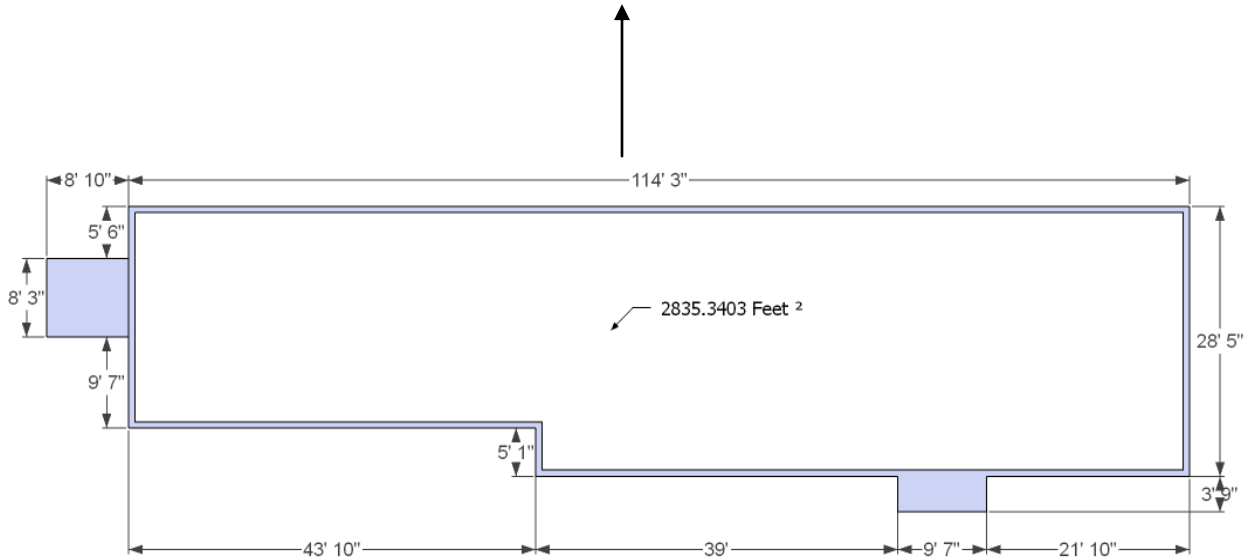
Just as BTU's conduct through solid materials, water vapor diffuses through solid materials. Some materials are more resistant to vapor diffusion, such as polyethylene, and so we use these to try and form a vapor barrier on the inside of the thermal boundary in an attempt to slow the amount of vapor diffusion. Small amounts of vapor traveling through a properly constructed building envelope will diffuse all the way to the exterior, and not cause any damage**. If a large amount of vapor is allowed to enter a wall cavity, the molecules will condense on the nearest cold surface.** When this happens, moisture can build up on the inside of the exterior wall sheathing, or on other surfaces. This will cause a number of problems including long term damage to insulation and structural components, as well as the promotion of mold growth.

It is important to try and identify any current moisture problems, and address them properly. This is always done by first finding and controlling the source of the moisture. Sometimes it can be quite difficult to see moisture damage, as it may be buried inside of wall cavities. It is also important to know that by making changes to a structure and its envelope, we can change the way, sometimes negatively, in which moisture affects the building.

Building Description:

This is a one story structure that has had two additions added to the original section of the building. The original section of the building was constructed in the mid 1800's. This building houses the Town Clerk, Tax Officer, Town Administration, Code Enforcement, and the Office of the Selectmen.

South/Front of Building



Foundation and Crawl Space:

The original section of the building sits on a granite foundation, while the two additions are set on a concrete block foundation. Both appear to be in good condition.

Figure 1 depicts the amount of heat loss coming from the foundation walls. In the infrared (IR) image to the right, there is a scale at the bottom of the image. The dark blue sections of the image indicate cold areas, or the areas of the least amount of heat loss from the building within the camera's view. Clearly, this image shows a significant amount of heat loss coming from the crawl space.

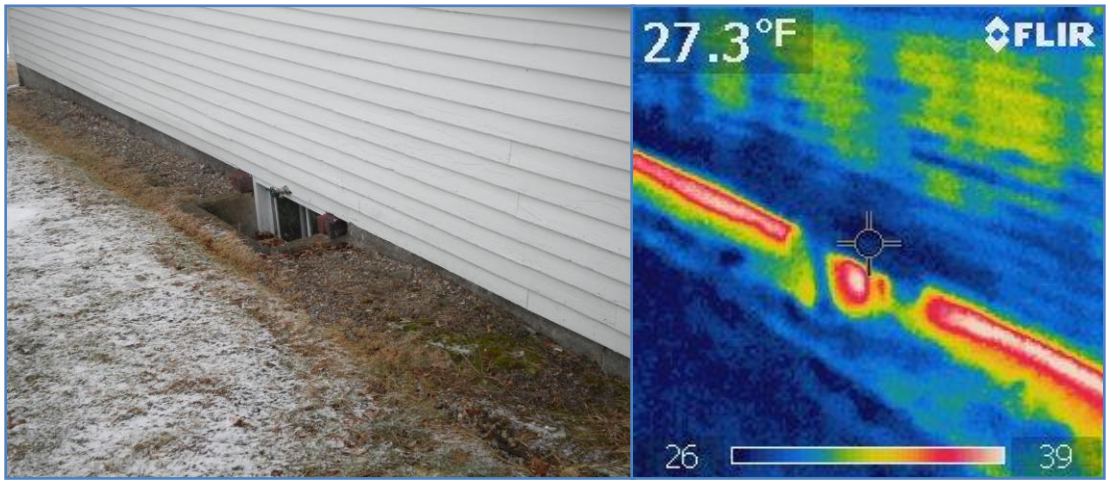


Figure 1

The crawl space underneath the first floor is quite shallow, about 24 inches between the dirt floor and the floor joists. No insulation was found under the first floor or against the inside of the foundation. In addition, we found many penetrations from the crawl space to the first floor which aid to the stack effect of the building. This, in combination with ample penetrations from the conditioned first floor to the attic space, suggests a considerable amount of convective heat-loss. Figure 2 illustrates how heat from the heated first floor radiates down to the crawl space.

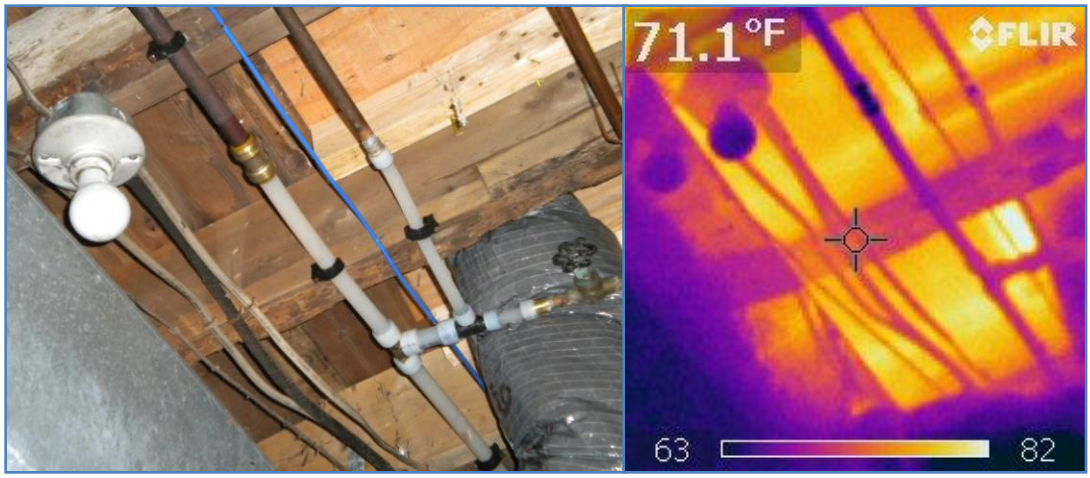


Figure 2

The dark purple seen in Figure 3 shows the foundation as being cold compared to the floor and beams. This is because the foundation has little to no insulative value, and, therefore, loses its heat very quickly. This is why Figure 1 shows heat leaving the foundation at such a high rate.

Controlling moisture levels in this space should also be a priority. Doing so will increase the longevity of the structure and provide for a more healthy working environment. This can be done by putting down a vapor barrier on the dirt floor.

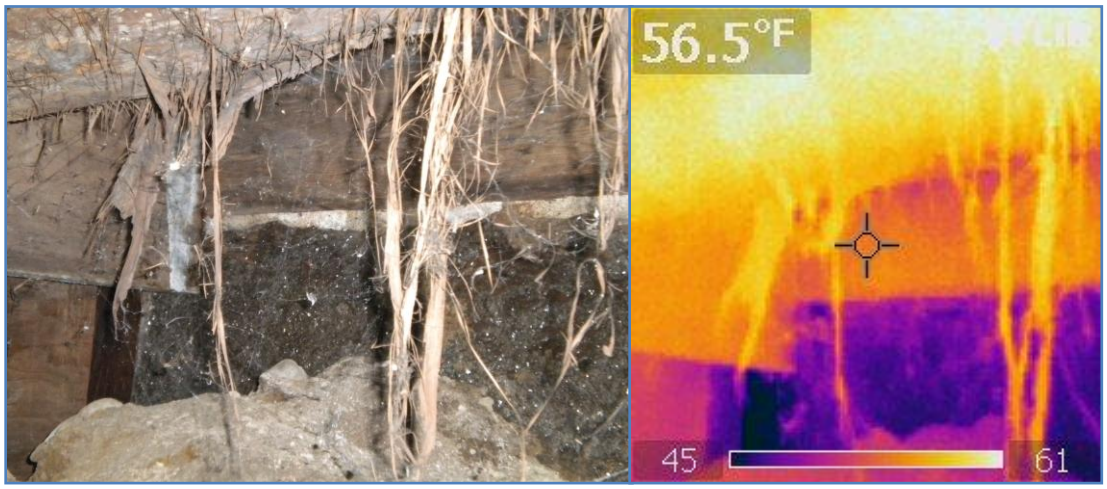


Figure 3

Recommendation:

- Insulate the underside of the first floor with closed cell spray foam insulation. This will both air seal and insulate in one step.
- Put down a vapor barrier on the dirt floor to try and limit the amount of water vapor rising up into the structure.

Exterior Walls:

The exterior walls of the original and mid-sections of the building are constructed with 2x4 inch studs, and appear to have empty cavities. Figures 4 and 5 show two different wall sections with the same symptoms; the studs in the walls appear to be warmer (lighter) than the cooler (darker) wall cavities because the studs are doing a better job retaining heat, or insulating, than the cavities. Normally the opposite is true. The studs in a well insulated wall would appear to be cold next to insulation when viewed from the interior, and would appear as warmer when viewed from the exterior.

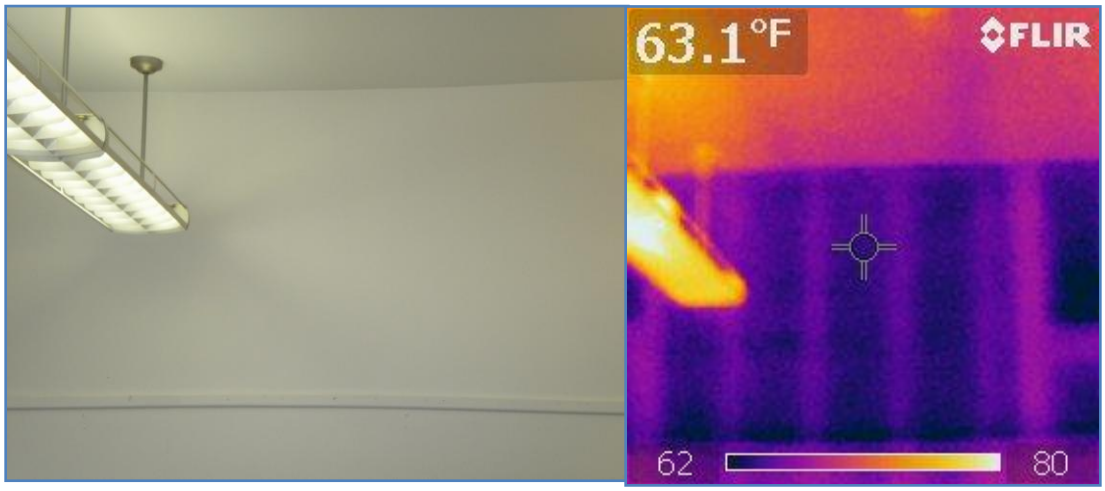


Figure 4

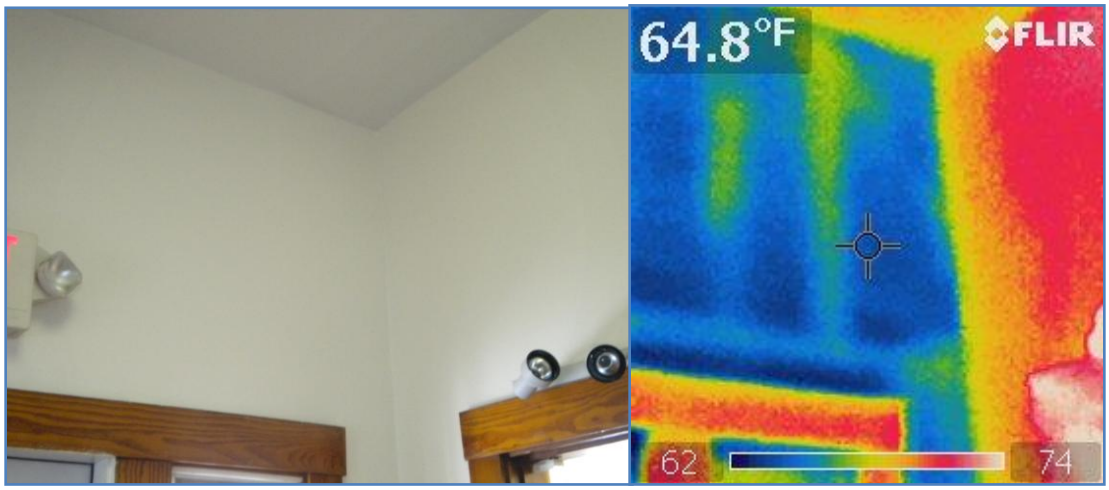


Figure 5

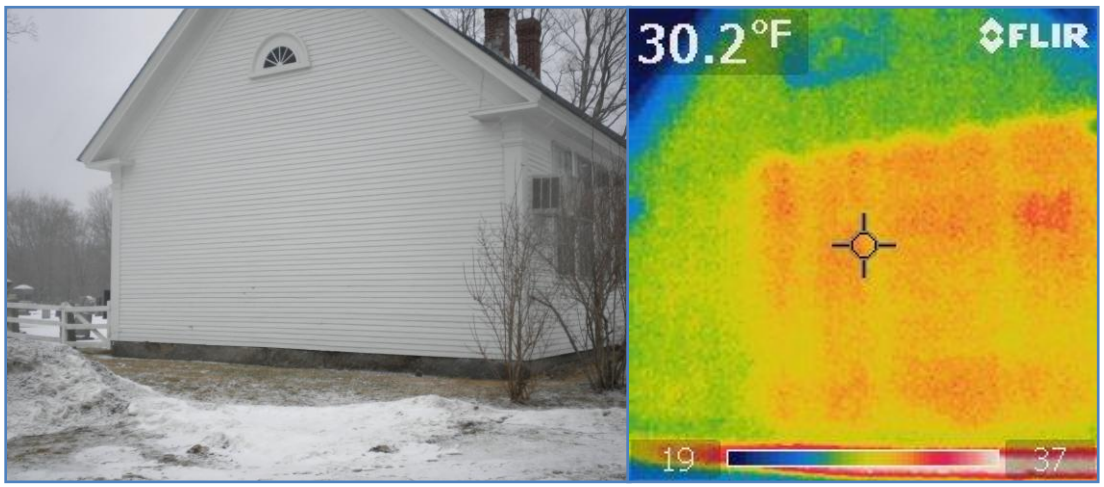


Figure 6

Figure 6 shows the west gable end of the building. It is clear to see where the heated space ends and where the unheated document storage closet is set in the corner towards the north side of the building.

Figure 7

The walls of the newest section of the building are constructed with 2x6 studs. We found rock wool batts that are only about 1 inch thick. See Figure 7.

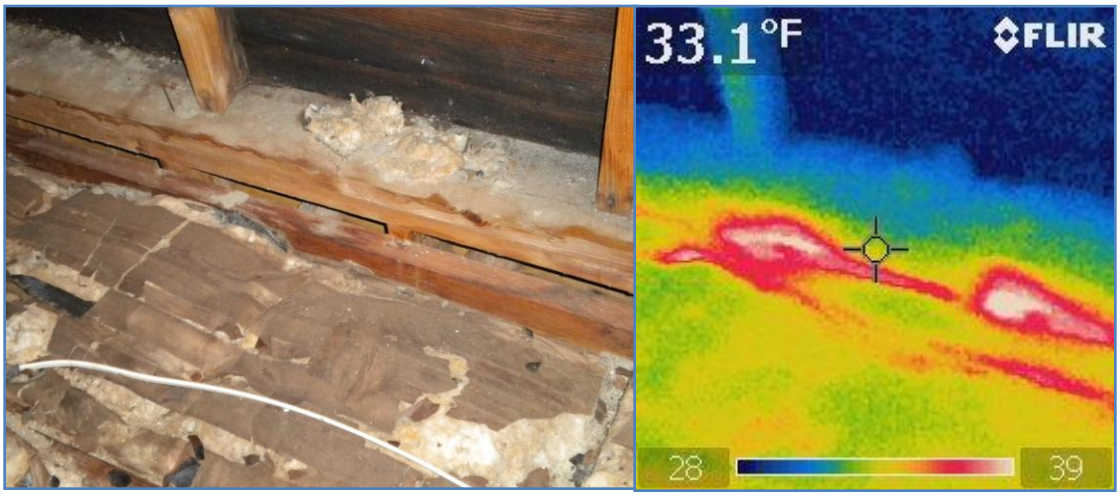


Figure 8

The stud walls are constructed in a type of one story balloon frame manner, in that the studs run from the bottom plate and extend beyond the ceiling joists. See Figure 8. This allows for the wall cavities to be exposed to the attic space. Essentially, they are serving as small chimneys, drawing heat from the conditioned space and depositing much of it into the attic.

Recommendation:

- Fill the exterior walls with cellulose insulation. Some of this may be done form the attic space and some may have to be done by drilling holes in the exterior of the building and filling the cavities from the exterior. The tops of the wall cavities may have to be sealed off first as to contain the cellulose insulation.

Ceilings and Attic:

Figure 9

As with many older structures, there is not a proper vapor barrier present. Furthermore, the attic is not properly ventilated. One of the results of this was found when examining the roof sheathing boards. As visible in Figure 9, we found frost on the underside of the sheathing boards. This is occurring because water vapor rises into the attic space from the first floor until it hits the cold surface of the roof sheathing where it condenses, melts and turns into liquid again. This is bad for a couple of reasons. The first is that the roof sheathing will decay faster due to its exposure to bulk moisture. The second is that as the vapor turns to water or frost, it saturates the boards and begins to drip down onto the insulation, degrading the material and its effectiveness.

An immediate fix for this is to add ventilation to the attic space. Ventilating the attic space could be done one of several ways, or using any combination of methods. Pulling up the cap shingles, applying an effective ridge vent, then recapping the roof would be one method. This should be done in conjunction with adequate soffit venting and proper vents. Cutting vents into the gable walls in the attic is another option if the ridge and soffit venting proves to be insufficient.

Adding ventilation will certainly address the issue of moisture build up in the attic, and should be done regardless of efficiency measures. However, this alone does not address the source of the problem. Sealing all penetrations and major chase ways from the first floor to the attic will not only help the moisture problems, but will also substantially lower the heating costs of this building. Figure 10 shows how interior partitions can act just like the exterior walls, ushering heat and moisture from the conditioned space below into the attic.

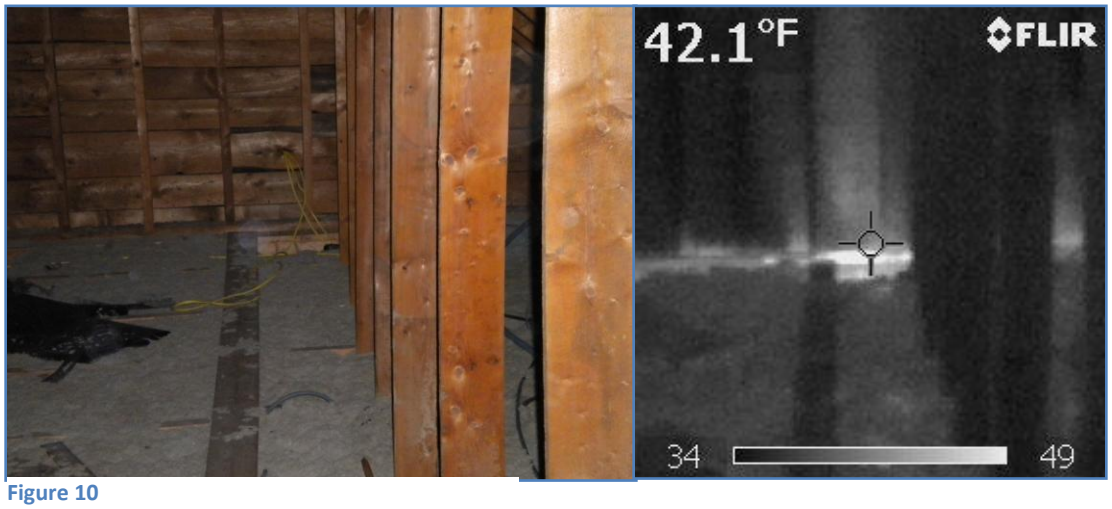


Figure 10

Figure 11 exemplifies how other penetrations also contribute to this problem. A wire here and there does not seem like a lot, but the sum of the total can be significant.

After the air sealing is done, adding loose fill cellulose insulation to increase the R-value of the ceiling would also be quite beneficial. In the east section of the building there are a couple of inches of cellulose with 3 inch fiberglass batts on top. Given the deteriorated condition of the fiber glass, it is recommended to have it removed before adding more insulation.

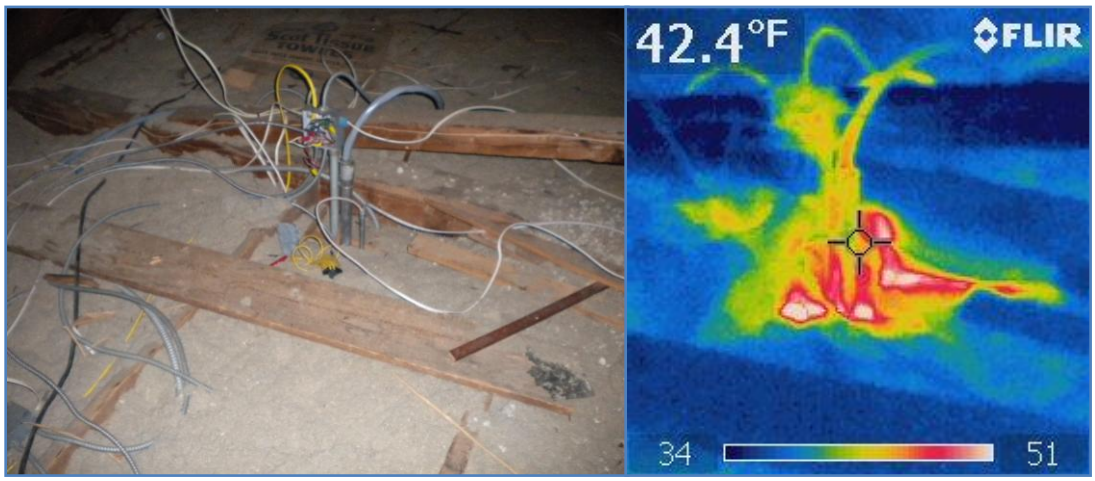


Figure 11

<u>Recommendations:</u>

- Remove the fiberglass insulation from the east side of the attic.
- Seal all penetration from the first floor to the attic. This would include, but not be limited to the tops of the exterior wall cavities, the wall cavities of interior partitions where they rise into the attic, mechanical/electrical penetrations and around the chimneys.
- Blow in loose fill cellulose to achieve between R-38 and R-60. The closer to R-60 the greater the results.

- Insulate the access panel into the attic and apply weather stripping to provide for a good air seal when it is closed.
- Add ventilation to the attic space. Remember, this can be done in ways that do not greatly change the aesthetics of the building, and do not add to the electric bill with AC powered fans.

Doors and Windows:

There are only windows found on the North and the South sides of this building. Most of the windows on the north walls have been replaced with double pane units. Figure 12 shows one replacement window that may not have been sealed properly, while Figure 13 shows a different replacement window that has been sealed with caulking. All of the windows should be well sealed.

Figure 12

Figure 13

Figure 14 shows some window trim boards that have pulled away from each other. The loose fit of the window trim provides a great opportunity to temporarily remove the trim, fill any gaps with spray foam, then reinstall the trim boards.

Figure 14

Figure 15

The windows on the front (south) side of the building are old single pane windows with older aluminum storm windows. The glazing on this side of the building amounts to a large percentage of the square footage of this wall. Last year, the Town had plastic window panes fabricated to be installed on the inside of all the south facing windows. The panes have rubber foam stripping and do an excellent job of air sealing. See Figure 15. Purchasing these was a very smart move on the Town's part, as they are very effective, and the Town claims to be seeing a large decrease in fuel usage already for the winter of 09'-10'.

There are four exterior doors in this building. The two front doors are solid wood, and appear to be sealed fairly well. An emergency exit door in the Selectmen's meeting room is a newer foam core door which is half glazed with double paned glass, and also seems to have a good seal. The forth door leads to an unheated stairwell and emergency exit on the north side of the building. This door is half glazed, single pane and solid wood. Normally, we would suggest replacing this door, but because this door is not in direct contact with ambient conditions, we would not recommend replacing this door at this time. If many of the other higher priority efficiency upgrades are completed, it may be a good time to consider replacing the older doors with newer, more efficient units.

Recommendations:

- Seal around all of the replacement windows on the north side of the building.
- Remove the face trim from around the windows and seal/insulate between the jamb extensions and the jacks/studs, then reinstall the trim. Though doing this by itself would yield some savings, it would be most effective if done in conjunction with an exterior wall insulation project.
- Make good use of the shades on the south side of the building during the summer months. Allow for natural light to enter the space and turn off interior lights if the natural light is sufficient. Remember that these windows offer positive solar gain (heat) during the winter, but also produce a lot of heat during the summer months when occupants are trying to stay cool. Finding a good balance may help reduce lighting and air conditioning costs.

Envelope Efficiency:

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

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

Air sealing/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 ensure that new and efficient heating and cooling equipment will provide the most savings.

If the recommended air-seal and insulation work is completed with care, it will be necessary to provide fresh air to the building. A blower door test would determine how tight the building is as a result of the efficiency upgrades, and help ensure that the ventilation system upholds to ASHREA standards for ventilation.

The most energy efficient way to provide fresh air in this case would be with an energy recovery ventilator (ERV). An ERV functions by removing a percentage of the stale air from the return plenum, and then introduces 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 ERV. 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. In the winter months, 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 16.

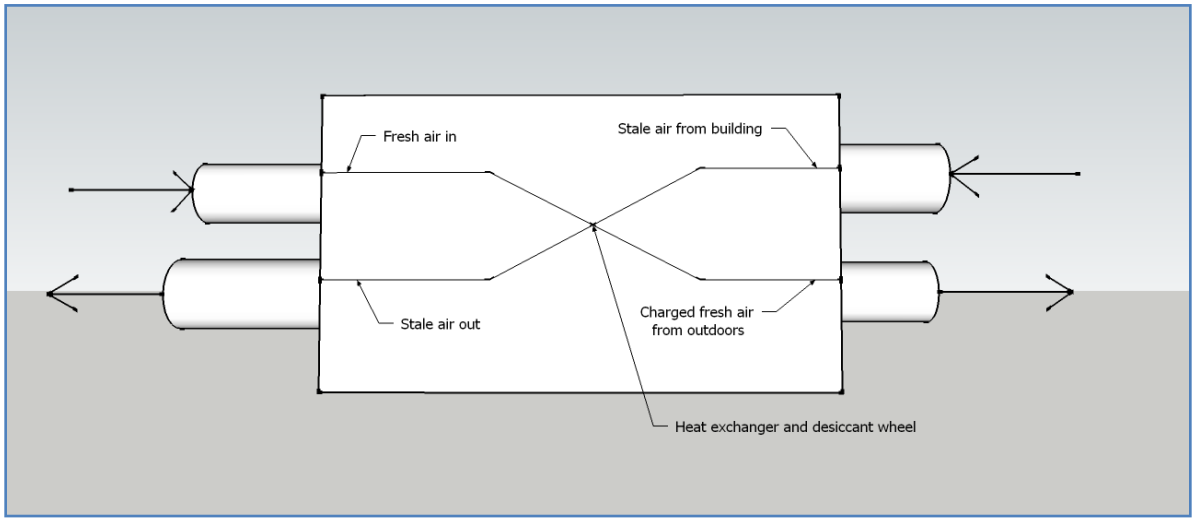


Figure 16

Mechanical:

The building is heated with an oil-fired furnace which is located in a small, mechanical section of the crawl space. This is a horizontal unit and likely has a combustion efficiency of between 80% and 84%. See Figure 17.

Figure 17

Supply and return ducts handle the two zones in the building, one on the east side of the building and one on the west. None of the duct work is sealed or insulated. This is bad for several reasons. On the supply side of this distribution system, because the ducts are not sealed, hot air produced by the furnace leaks into the crawl space. In addition, as the metal of the ductwork is heated, it begins to radiate to cold surfaces due to the lack of insulation. See Figure 18.

Figure 18

Figure 19

Figure 19 shows a return duct that has rusted over the years and has a large hole in it. The return duct has a floor grill and, as employees and visitors of the building walk over or step on it, they deposit water and salt causing its deterioration. This, along with all of the unsealed seams of the return ductwork are pulling air in from the crawl space, passing it through the furnace and delivering it to the offices above. The air quality in the crawl space is very poor and is not suitable for the occupants above.

There are two sinks in the building, with two separate electric hot water heaters. One sink is located in the Code Enforcement office. This small water heater is on a switch and is apparently not used.

The other sink is located in the lavatory and is supplied hot water from a large, potentially over sized electric hot water heater located in the mechanical area below. This unit is keeping relatively large amounts of water hot year round. Replacing this unit with a smaller electric hot water heater, installing a small solar hot water system with an electric backup component or even a point of use water heater would prove to be much more economical over the long term. Additionally, the hot water pipes are not insulated and could be with minimal cost and effort.

Figure 20 reveals the PVC drain from the sink in above lavatory. It has been cut in half and is leaking water into the mechanical area. This is not good for the health of the equipment, the building or its occupants. This is also a quick fix.

Figure 20

Recommendations:

- Repair the damaged return duct seen in Figure 19.
- Repair the cut PVC sink drain. This should be done with a coupling PVC socket fitting and proper adhesives.
- Air-seal all of the duct work with mastic.
- Insulate all of the duct work. This should be done with a minimum of R-8 foil-faced duct insulation.
- Insulate all of the domestic hot water pipes.
- Replace the hot water heater with one of the aforementioned systems.

Electrical:

This is a typical office space with a standard number of computers, printers, copy machines, fax machines, etc. Some older pieces of electronics were found which could be replaced with more efficient models. An LED computer monitor, for example, draws a substantially smaller amount of electricity than the computer monitor seen in Figure 21.

Figure 21

There are three wall mounted AC units. One of the three was covered and somewhat air sealed for the winter, so we were not able to get an idea of its age. The two larger units on the south side of the building appear to be relatively old.

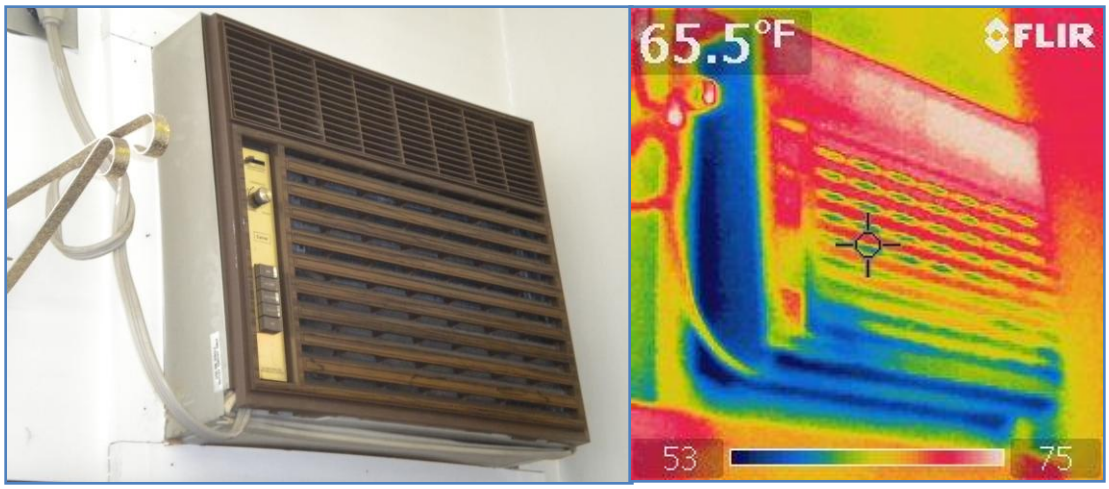


Figure 22

There is ample opportunity in this building for a lighting upgrade. There are about 84, 4ft, T12 florescent tubes and 6 – 8ft, T12 florescent tubes in this building. Upgrading to all electric ballast with at least T8 tubes will produce significant savings.

For the amount of fixtures in this building, there is very limited control of the lighting. For example, Figure 23 shows a view from the Selectmen's meeting room, looking over the Code Enforcement office. One can see that there is only the ability to turn off the middle row of lights. Though this is helpful, it would be better to separate the lights over the Code Enforcement office, as half of the lights in this picture light a room which is seldom used.

There is a similar situation with the middle section of the building. There is the Tax Collector's office directly beside the Town Clerk's office. The walls do not extend to the ceiling and rows of lights span both offices. As office hours differ between the two, there are times when one of the offices is being unnecessarily lit.

Figure 23

Another factor to consider is the ample amount of day lighting. This is a long narrow building with plenty of windows on the south side, with a very open concept space. If there are three rows of lights running east to west, it is possible that the row of lights closest to the south side of the building could be turned off much of the time. They could also be controlled with light sensors that could be automatically turned down on the more sunny days.

There are several very inefficient outdoors lights that are on all night, year round. There are a number of LED outdoor area and safety lighting options that would be an ideal solution to help reduce this energy use.

Recommendations:

- Consult with a lighting specialist and perform a lighting upgrade, both indoors and out. Look to replace the current outdoor lighting with LED technologies. Develop a good light scheme for the interior. Use electronic ballast and at least T8 Florescent tubes. Develop better control of the interior lighting, separating offices. Make wise use of daylight, having the ability to turn off rows of lights on the south side of the building.
- Replace the old, inefficient air conditioners with the most efficient Energy Star® rated units available.
- When it is time to replace any computers, printers, monitors, etc., purchase the most energy efficient Energy Star® labeled equipment available.
- Keep all electrical equipment on smart power strips and be sure to cut the power to all electronics when not in use. Doing this alone will cost very little money and should produce measurable results.
- Install a grid tied photovoltaic system on the south facing roof. This building is situated almost perfectly for such a system and has plenty of space for a solar array that could handle a large portion of the electric load.

Financial Considerations and Options:

A common occurrence across many communities within New Hampshire is the challenge of obtaining the necessary capital funds to carry out the recommended retrofits found within the audit. The following information is an attempt to provide some assistance with understanding some concepts and pathways to acquiring public or private funds to carry out an energy efficiency or generation project. Also, portions of the following information have been taken from the New Hampshire Handbook on Energy Efficiency and Climate Change – Volume II.

Life Cycle Costing –

The National Institute of Standards and Technology (NIST) Handbook 135, 1995 edition, defines Life Cycle Cost as "the total discounted dollar cost of owning, operating, maintaining, and disposing of a building or a building system" over a period of time. Life Cycle Cost Analysis is an economic evaluation technique that determines the total cost of owning and operating a facility over period of time.

Since municipal buildings are funded in their initial year through bonds and/or capital outlays, they generally fall victim to an inordinate focus on the bottom line cost of construction instead of the lifetime cost to operate the building. This is a critical misstep in particular with energy concerns for municipal buildings because they are placed in service for a significant period and are subject to extended energy pricing. A more efficient building could save the costs of initial investments several times over during its lifespan.

Energy Price Stability –

The second most important concern about energy costs is the volatility. Municipalities budget on a yearly cycle and must predict energy costs over the year – sometimes over pricing the cost in the case of high lock in prices or subjecting the municipality to risk where a cost (+ some percentage) contract is used for the year. When prices go up budgets go up, when the go down, budgets tend to go down. Changes result is wide variation in predictability and thus lead to fund shortages or balances, and general frustration on all sides of the discussion.

The concept of stability in the context of energy prices is achieved through on-site distributed generation with effective predictive modeling and most importantly, efficiency. The cheapest energy available is the energy you don't need. The less you buy the less amount of appropriations are subject to the price swings.

"Green" Building Cost Myths –

A perception that all energy-efficient construction costs more than conventional construction persists. We have been unable to find valid research that supports this conclusion - especially where choices made about efficiency are evaluated in a realistic context considering the life cycle cost to operate the facility. To the contrary, we have found several sources, from

government facility agencies, that show not only that in most cases costs are in fact lower but that any increased cost is almost immediately realized through lower operating expenses.

A terrific resource to understand what type of incentives are available for both energy efficiency and generation is the "Database of State Incentives for Renewables & Efficiency", or DSIRE. This site, funded by the US Department of Energy, provides a list of the potential financial incentives found within New Hampshire and the Federal Government. To see what is available within New Hampshire go to www.dsireusa.org and click on New Hampshire.

Utility Programs:

Many utilities provide rebates for various types of efficiency measures that can be carried out at a municipal facility. PSNH offers the Municipal Smart Start Program. This program offers the opportunity for municipalities to go forward with the installation of approved measures at no up front cost to the municipality. A town simply pays for the energy improvements with the savings from reduced energy usage until the project is paid off.

For more information please contact Elizabeth Larocca, (603) 634-2380, or visit http://www.psnh.com/Business/Efficiency/Paysave.asp

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.

Summary of Recommendations:

- Remove the fiberglass insulation from the east side of the attic.
- Seal all penetration from the first floor to the attic. This would include, but not be limited to the tops of the exterior wall cavities, the wall cavities of interior partitions where they rise into the attic, mechanical/electrical penetrations, and around the chimneys.
- Blow in loose fill cellulose to achieve between R-38 and R-60. The closer to R-60 the better.
- Insulate and seal the access panel into the attic.
- Add ventilation to the attic space. Remember, this can be done in ways that do not greatly change the aesthetics of the building, and do not add to the electric bill with AC powered fans.
- Insulate the underside of the first floor with closed cell spray foam insulation. This will with both air seal and insulate in one step. Note, this should be done in conjunction with air sealing and insulating the duct work, as well as insulating the hot water pipes.
- Install an energy recovery ventilation system.
- Repair the damaged return duct from Figure 19.
- Repair the cut PVC sink drain. This should be done with a coupling PVC socket fitting and proper adhesives.
- Air seal and insulate all of the duct work. Air sealing should be done with either mastic, or a metalized tape, though mastic would be the preferred material.
- Insulate all of the duct work. This should be done with a minimum of R-8 foil-faced duct insulation.
- Insulate all of the domestic hot water pipes.
- Fill the exterior walls with cellulose insulation. Some of this may be done form the attic space, and some may have to be done by drilling holes in the exterior of the building and filling the cavities from the exterior. The tops of the wall cavities may have to be sealed off first as to contain the cellulose insulation.
- Seal around all of the replacement windows on the north side of the building.
- Remove the face window trim and seal/insulate between the window trim and the jacks/studs, then reinstall the trim. Though, doing this by itself would yield some savings, it would be most effective if done in conjunction with an exterior wall insulation project.
- Make good use of the shades on the south side of the building during the summer months. Allow for natural light to enter the space and turn off interior lights if the natural light is sufficient. These windows offer positive solar gain (heat) during the winter, but also produce a lot of heat during the summer months when occupants are trying to stay cool. Finding a good balance may help reduce lighting and air conditioning costs.
- Consult a light specialist and perform a lighting upgrade, both indoors and out. Look to replace the current outdoor lighting with LED technologies. Develop a good light scheme for the interior. Use electronic ballast and at least T8 Florescent tubes. Develop better control of the interior lighting, separating offices. Make wise use of daylight, having the ability to turn off rows of lights on the south side of the building.
- Replace the old inefficient air conditioners with the most efficient Energy Star® rated units available.

- When it is time to replace any computers, printer, monitors or alike, purchase the most energy efficient, Energy Star® labeled equipment available.
- Keep all electrical equipment on smart power strips, and be sure to cut the power to all electronics when not in use. Doing this alone will cost very little money, and should produce measurable results.
- Replace the hot water heater with one of the more efficient system mentioned earlier in this report.
- Install a grid tied photovoltaic system on the south facing roof. This building is situated almost perfectly for such a system, and has plenty of space for a solar system that could handle a large portion of the electric load.

Conclusion:

As a result of this audit, the Town has several options available to increase the efficiency of the Town Offices. We highly encourage the that the Town pursue these recommendations described in this report and to utilize the further assistance provided under this program to help develop plans for implementation – including possible identification of contractors who will provide the services needed to carry out the recommendations. SDES Group will provide the Town an additional twenty-five hours of Community Energy Advocate service to assist with further efforts under the MEAP program in an effort to bring the recommendations outlined in the report to fruition.