Energy Audit Report
68 Magoun Avenue, Medford, MA

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1 Introduction

Energy Efficiency Associates provides investigative, consulting, training and review services to address issues related to comfort and energy efficiency in the home.

Energy Efficiency Associates is a third party, independent consulting service.

Energy Efficiency Associates does not provide air sealing, insulation, HVAC or other contractor services.

This Energy Audit Report is a summary of the on-site investigation conducted on December, 17, 2008.

1.1 Energy Auditor

This audit was conducted by Mike Duclos:

- An ITC Certified Building Science Infrared Thermographer, ITC #19880
- A Certified Home Energy Rating System (HERS) Rater, # EAM-111,
- BS Electrical Engineering, University of Massachusetts, Lowell
- A member Institute of Electronic and Electrical Engineers, IEEE, # 06689541

1.2 Method of Investigation

Energy Efficiency Associates **Energy Audit** for this particular building, client interests and goals is a process comprised of the following steps:

Utility Bill Analysis – Represents the basis for scheduling the energy audit, by calculating the thousands of British Thermal Units per Square Foot (KBTU/SF), a rough 'rule of thumb' for building energy use. Unfortunately, complete heating fuel use data was not available for this building, so this analysis was not possible.

Infrared Camera Scan – An assessment of conductive heat loss in the building envelope, and insulation and air sealing quality due to stack effect only.

Blower Door Infiltration Test – An objective measurement of impact of air infiltration on building heating costs and air quality

Infrared Camera Scan In Combination with Blower Door Infiltration Diagnostic – Comparative analysis of IR scan with blower door to pre-blower door IR scan facilitates visualization of new point sources of cooling, i.e. air infiltration caused by the Blower Door. This process facilitates 'scanning' of large areas to locate points of air infiltration.

Written Report – This documents findings, relative importance, proposed strategies to address issues, and an approximate monetization of improvements.

Consulting Services – The Energy Audit only has value if recommendations are actually implemented which make the building more comfortable and save energy.

An additional hour of consulting time is included as part of this Audit Package to assist the homeowner in selecting improvement measures appropriate to their home and situation, and to assist the homeowner in working with contractors, etc., to achieve the goals of increased comfort and reduced energy costs.

2 Executive Summary

2.1 Key Homeowner Articulated Issues

Reduce energy bills and have greater energy efficiency.

Better control of heating in individual rooms.

Poor or missing insulation is suspected

2.2 Summary of Key Findings

2.2.1 Air Infiltration

Air infiltration in this building was measured with a blower door and extrapolated to approximately 7900 CFM50.

Two rooms had doors shut during the test because keys were not available, so the blower door number is likely higher. This is a large amount of air infiltration for this size of building.

Air infiltration has a very large impact on both energy use and occupant comfort in this building.

This single largest loss of heating energy in this building is very likely air infiltration.

See **General Air Infiltration Discussion** section below for a description of air infiltration.

See the **Suggested Improvements** section below.

2.2.2 Heating Fuel and Boiler

The choice of fuel oil rather than natural gas for a space heating fuel has limited the efficiency of the relatively new boiler, and has potentially caused a significant air infiltration path to remain.

There is natural gas in use in the building, there is a 100 gallon Domestic Hot Water (DHW) heater.

Natural gas boilers are available with Annual Fuel Utilization Efficiency (AFUE) greater than 95% AFUE, while oil fired boilers are commonly limited to about 85% AFUE. This single factor is estimated to have an impact of approximately 10% on annual fuel use.

In addition, high AFUE natural gas boilers are closed systems which use external air for combustion and exhausting combustion by products. This system virtually eliminates air infiltration caused by conventional combustion technologies which use air from inside the building for combustion, and often draw air from the location of the boiler up the chimney via a damper.

However, the use of an Outdoor Reset control on the existing boiler is expected to significantly improve the performance of this system.

See the **Suggested Improvements** section below.

2.2.3 Missing & Poorly Performing Insulation

Infrared scanning revealed areas of either missing, or very poorly performing insulation.

Cellulose insulation in the floorboards of the third floor does not appear to be ‘dense packed, so it is not as effective at stopping air infiltration (see above) as true ‘dense pack’ cellulose at a packing density of 3.5 lbs per cubic foot.

The thermal boundary is not well defined or executed on the third floor level.

See the **Suggested Improvements** section below.

2.2.4 Heat Distribution System

The original, two pipe steam heat distribution system has been modified for forced hot water heating.

At least one room has been partitioned into two sections with an imbalance between heat distribution radiators and heat loss in the room.

Some radiators are covered with metal covers, cloth, etc. Radiators distribute heat by convection (cool air near the floor rises up through the radiator tubing and is heated as it rises.) Impeding this airflow will reduce the amount of heating the radiator provides to that room.

Manually operated valves are used to regulate the amount of hot water flowing through each radiator. At least one of these cannot be closed sufficiently for occupant comfort, so a window is slightly opened to regulate the temperature.

Because the primary Forced Hot Water (FHW) heating system is not providing sufficient heat in some rooms, additional electrical resistance heating units are in use, which likely significantly impact the electric bill.

Some occupants prefer a much higher than normal room air temperature, 78 degrees was observed. This high temperature both greatly accelerates heat loss and can lead to the use of supplemental electric resistance heating.

See the **Suggested Improvements** section below.

3 Homeowner Interview

A summary of the key points noted during the homeowner interview and subsequent investigation of the home, and follow-up communications are listed here. Helen was interviewed to complete this section.

Year Built – Circa Late 1800's

How Long Owned – Unknown

Number of Occupants – Varies, typically 4-5, but public events are held here also.

Age of Roof – Unknown

Recent and Planned Renovations & Dates – There is a single story addition to the right side of the original building which was built in the 1970's, approximately 2100 sf.

Use of Basement Space – Mainly un-insulated basement used for storage, includes a small office area.

Use of Attic Space – There is a third floor in which an attempt was made to turn into an 'attic' by blowing cellulose under the third floor floorboards. The third floor contains fire protection system plumbing.

Day of Audit Conditions – Weather was light rain and snow, 35 degrees
Start of audit Interior Temperature & Humidity – 63 F,40% RH
End of audit Interior Temperature & Humidity – 58 F,35% RH
Blower door had been used to pressurize building to inspect external wraparound porch area for air leaks from the outside.

Number of Fireplaces – One, which was effectively boarded up

Winter Day/Evening Thermostat Settings
Old building on left: 64 usual, 68 for events
Newer building on right: 63-64 usual, 68-70 for events

Air Conditioning
Three permanently window mounted air conditioners on the new right building, one permanently mounted on the left. One additional unit was installed on the second floor, one or two more units are seasonally installed and removed.

Air conditioner air sealing was fairly effective.

Fuel Consumption History

Unfortunately an incomplete history of fuel oil bills prevented a fuel bill analysis. It was only until the auditor was on site he learned there is in addition a natural gas DHW heater.

Electricity use averages 2 MWHr/month, which is very high compared to a typical private residence.

Estimated Conditioned Space Area

The new, right side of the building is about 2100 sf,
The old, left side first floor is estimated at 1260 sf
The new, left side second floor is estimated at 1288 sf
The total conditioned area is estimated at 4648 sf

3.1 Homeowner Articulated Issues

3.1.1 Space Heating Energy Cost Reduction and Energy Efficiency

This is the primary articulated issue.

The building is variously used by a few individuals, as well as for public events.

3.1.2 Zonal Heating Control Improvement

There is perceived need for **greater zonal heating control** to reduce energy cost, as well as to help correct heating imbalances (rooms too cold or hot).

The thermostat setting does not completely control the air temperature of all rooms.

Some rooms tend to be fairly cold or hot.

For example a larger room on the left side of the first floor was partitioned into two rooms.

The rear most room has a very large radiator, and the hot water supply cannot be reduced sufficiently using the existing valve to prevent overheating, so on the day of the audit a window was opened for temperature regulation.

Some rooms are too cold when the thermostat is set for comfort in other rooms.

In other cases the occupants of the rooms desire a much higher than normal air temperature, in one room the observed temperature was about 78 degrees, and it appeared that this was achieved with the use of supplemental electric resistance heating.

There is a two zone oil fired heating system, one zone for the new, left building and one for the old right building.

3.1.3 Homeowner Articulated Issues Addressed

3.1.4 Space Heating Energy Cost Reduction and Energy Efficiency

Space heating and energy cost reduction are addressed by clearly defining a thermal boundary , air sealing it and then installing insulation in un-insulated cavities and in under insulated cavities.

Locations of large amounts of air infiltration that it may be possible to relatively easily address are described below in the **Suggested Improvements** section.

3.1.5 Zonal Heating Control Improvement

Reasons for better **Zonal Heating Control** include not only the more typical 'heating imbalance' situation, in which two rooms in one zone are not at nearly the same temperature, but some rooms in which a greatly elevated temperature is maintained for occupant comfort, as well as the use of the facility for public events. These are currently addressed by use of two separate zones for the public and residential areas of the building.

The most fundamental things to understand about room temperature control are:

How is the heat being lost ?

How is the heat which is lost being replaced ?

3.1.5.1 How is the heat being lost ?

Rooms which have higher than average air infiltration, rooms which have more than one exterior wall (e.g. a room in a corner of the house), rooms with little or no effective insulation in the walls, rooms with a higher ratio of window to wall area, rooms which have a ceiling that is losing heat to the outside, rooms with very leaky windows and doors, etc. will lose more heat than other rooms.

Where possible, reducing heat loss should be the first step to controlling zone temperatures. This will reduce energy use and cost. Adding additional heat will increase energy use and cost.

There is more on how heat is being lost and on **Suggested Improvements** below.

3.1.5.2 How is the heat being replaced ?

Forced hot water through baseboards and radiators is used to distribute space heating.

A room with a larger radiator than is necessary for the heat loss experienced by that room can have control issues if the value cannot be sufficiently closed.

Conversely, a room which has high heat loss (see section above), or with a radiator that is too small, or with a radiator that is covered, or otherwise has the air convection through the radiator impeded (i.e. it is in a box, in a wall, etc.) may not receive enough heat to be comfortable.

3.1.5.2.1 Heat Distribution Control System

The ‘control system’ that is used to determine when the boiler circulator pump runs is key to maintaining a uniform, acceptable temperature.

If rooms have a door closed, and they become cool, that effect is not seen at the thermostat, and so the circulator pump for the zone controlled by that thermostat will not be activated in response.

Installing more circulator pumps and zones can be an expensive proposition.

Other strategies include supplying a thermostatically controlled valve for a single radiator.

This strategy might help for the rooms that are too warm, that is the circulator pump runs for longer than is necessary for those rooms.

However, this will not help if the circulator pump which supplies that zone does not run enough.

Minimizing heat loss from a room is the preferred approach, but failing that, distributing more space heat from the primary system (using a larger radiator, opening the door to allow cool room air to activate the thermostat, etc.) is to be preferred over heat supplied by electrical resistance heating, which is a more costly heat source.

4 Building Inspection

4.1 Exterior

This is a late 1880’s three story home with a basement, to which a much newer, mostly single story addition of about 2100 square feet was added in the 1970s.

The original building has some interesting architectural detail including gables, cantilevered floor, wraparound front porch, cantilevered eave overhangs, a small dormer on the left third floor, significant knee-walls on the third floor, and a relatively complex roof structure consisting of gables, tiered dormers as well as a low pitch roof section.

The newer section is more functionally designed with a flat roof.

4.2 Renewable Energy Assessment

There is little opportunity for roof mounted PV or solar thermal here, there is very little South facing roof area, and the front gabled end is nearly south facing.

5 Infrared Imagery - Overview

Interpretation of building infrared imagery is best left to individuals with an in-depth understanding of building construction, materials, standards and practices of the building industry at various periods in building technology development, proper training, experience and, a conservative approach to the interpretation of these images.

Thermal images are best used as a trigger to further investigation before taking action.

That said, some generalizations can be made that can be used to facilitate understanding, as well as to highlight the locations to address.

The images in this report are mostly black and white, darker colors mean lower temperatures and lighter colors mean higher temperatures (see scale at the right side of the image).

The infrared camera which was used is capable of taking color images, one was included in this report for reference.

However, most professional Building Science Infrared Thermographers prefer to use black and white imagery to facilitate interpretation of the image. Color IR images can have a large emotional impact to those not trained in the use of infrared imagery in Building Science investigations. This impact is inconsistent with a realistic and credible interpretation of the thermal and air flow significance of these images.

When looking at exterior walls from the inside of a building with a lower outside than inside temperature, the studs will (generally) be a darker color than the cavities when there is insulation in the cavities that has thermal resistance significantly greater than the studs.

If the cavity is empty, the studs have a greater resistance to heat transfer than the cavities, and so will (generally) be a lighter color than the cavities.

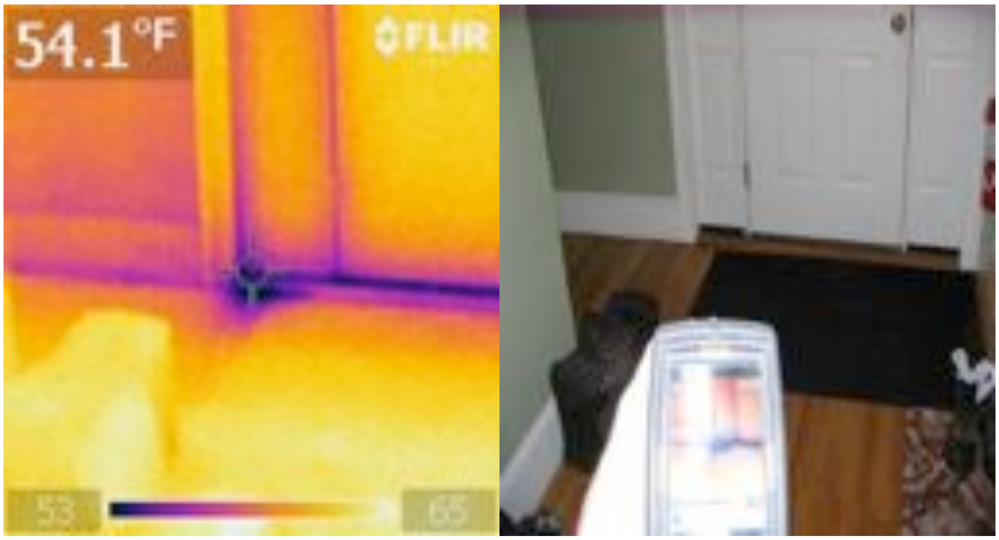
Although papers have been written on the use of infrared imagery to determine the actual R Value of a wall, this is a measurement that is difficult at best to perform accurately, and was not attempted on this building. One such paper is available upon request.

With the above cautions in mind, some images are presented below to illustrate the nature of the anomalies, and their location in the home.

Infrared thermography was impeded in this building by the amount of wall area covered by pictures, cloth, possessions, etc. For this reason, full coverage with the IR scan was not possible. However, adequate open wall area remained to provide a reasonable general assessment of the building.

5.1 Infrared Imagery Without Blower Door Operating

The first image is taken in color to demonstrate the IR camera used (FLIR BCAM SD) is capable of color imagery.



This image is of the front door, and illustrates a small amount of cool air leaking in the left corner of the front door, without the blower door operating, due to the force of stack effect. This airflow was perceptible with the back of the hand.

Dark colors represent cool temperatures, light colors represent higher temperatures (see scale at the bottom of the image).

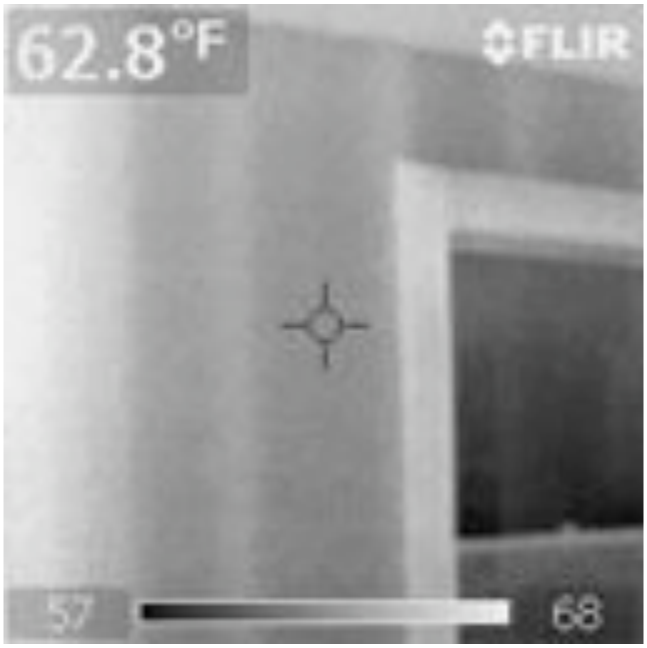
The number in the upper left corner is the approximate, un-calibrated temperature in the circle and cross hairs in the middle of the image.

Building Science Infrared thermography typically uses relative temperature differences, rather than absolute temperature measurements, for interpretation of building phenomena.

For many, this interpretation is facilitated by the use of black and white imagery, which is used for the remainder of this report.

The air leakage above is not very significant in the context of overall building energy use, but could be improved to provide greater occupant comfort.

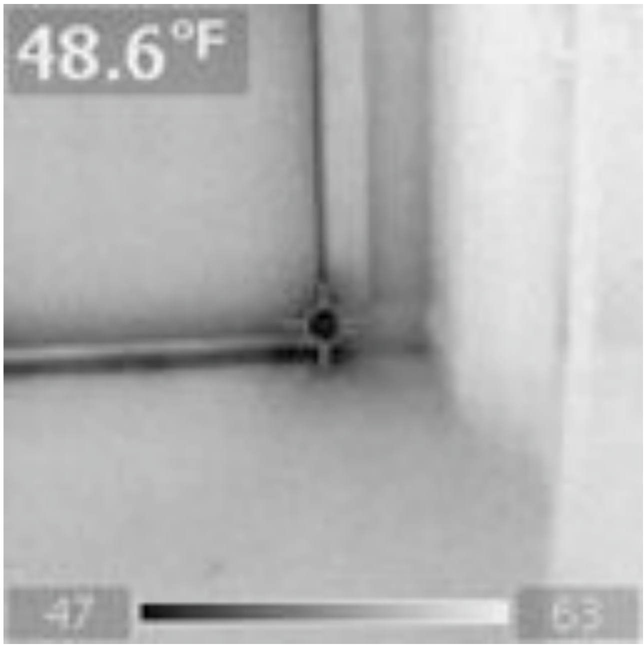
Understanding the value (both economic and user comfort) of making improvements to the building is key to cost effectively addressing energy use reduction and improving occupant comfort. This is a low value improvement, which might be made because the cost is so low, basically just a bit of caulk.



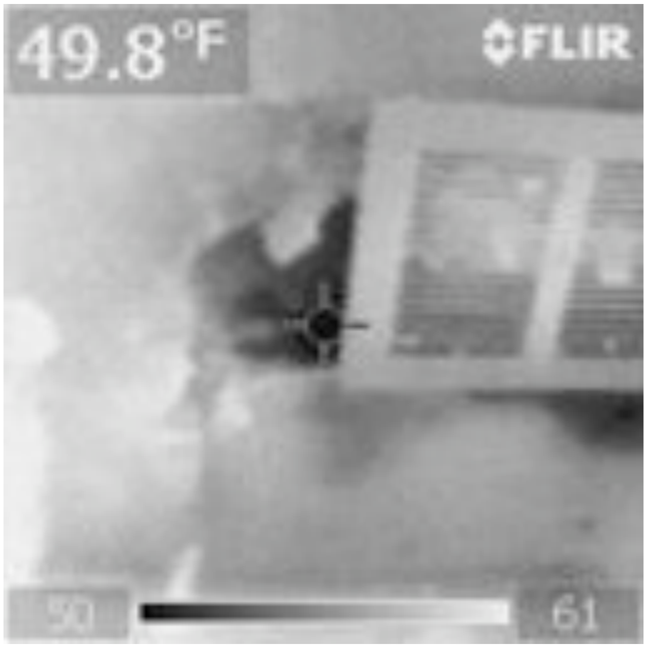
These images illustrate the many areas of un-insulated, or poorly insulated stud cavities.

The studs are a lighter color (warmer) than the stud cavities.

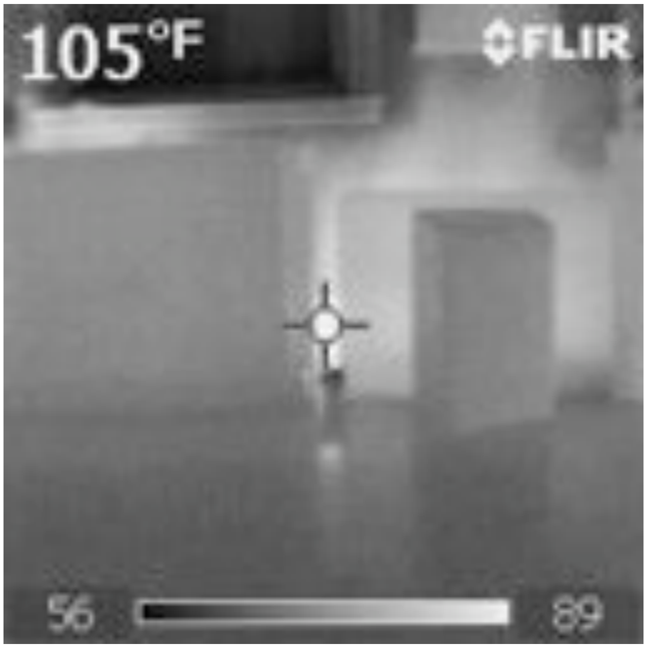
There are more than 75 other pairs of IR and corresponding visible images that are available, these are documented under the heading **Visible and IR Image Pair Correlation** below.



The lower right corner of the door gasket is leaking air, due to stack effect induced pressure .

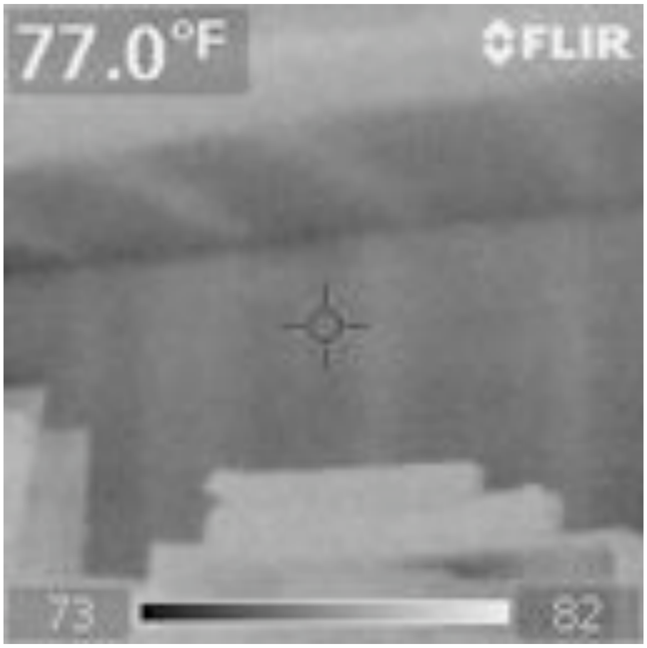


Low temperature air and / or moisture is finding its way into the building, possibly due to the path of the duct connected to this vent. There may also be a correlation to the apparently water induced damage.

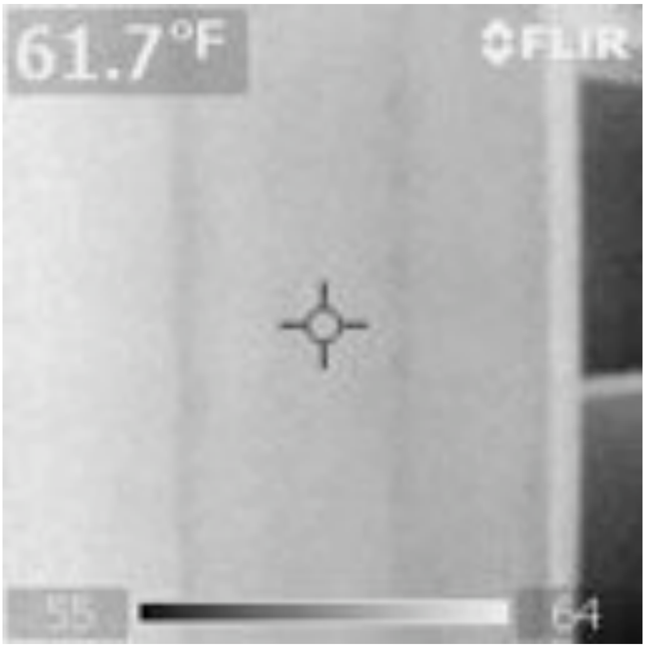


Items blocking baseboards and radiators accelerate heat loss to the outside of the building.

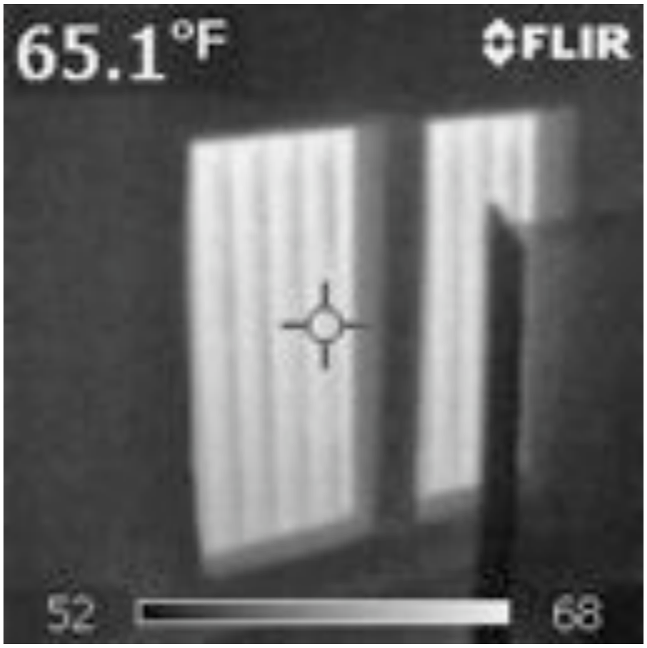
Rather than allowing free air convection to distribute the baseboard heat through the room, these items are blocking the air circulation from the baseboard, heating the wall behind excessively, and so accelerating heat loss through the outside walls. Unblock all radiators and baseboards for most effective heat distribution, room temperature uniformity, and to reduce unnecessary heat loss.



In some areas, both wall and ceiling insulation appears to be missing, or performing poorly.



A few areas were found that appear to have some wall insulation, how effective it may be is unknown.

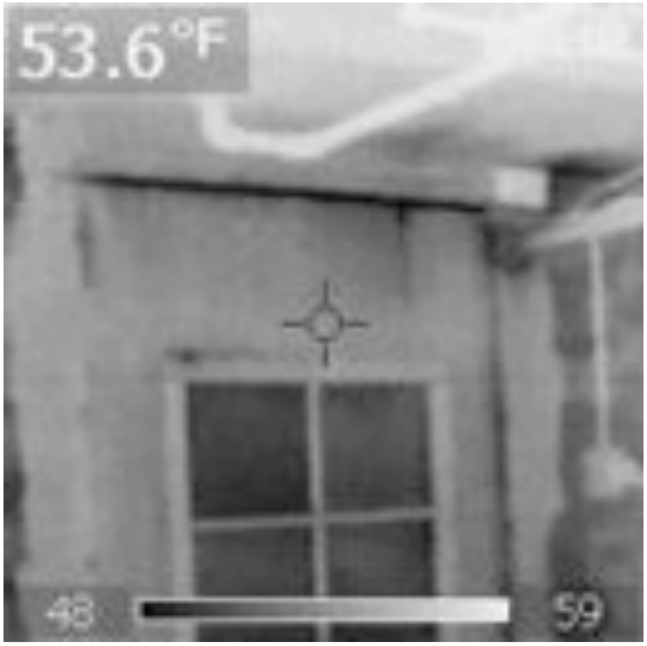


Apparently the heating system is distributing some low grade heat to the third floor.

There is a (possibly water filled) fire suppression system in the third floor eaves.

There is potential for significant water damage should these pipes freeze and burst, or should the sprinkler heads freeze and burst. Should the pipes freeze, the proper operation of the fire suppression system could be impeded.

This sprinkler head is located outside the thermal boundary, in a drafty location behind a knee-wall (Note cobwebs indicating frequent air movement) with very significant potential for freezing.



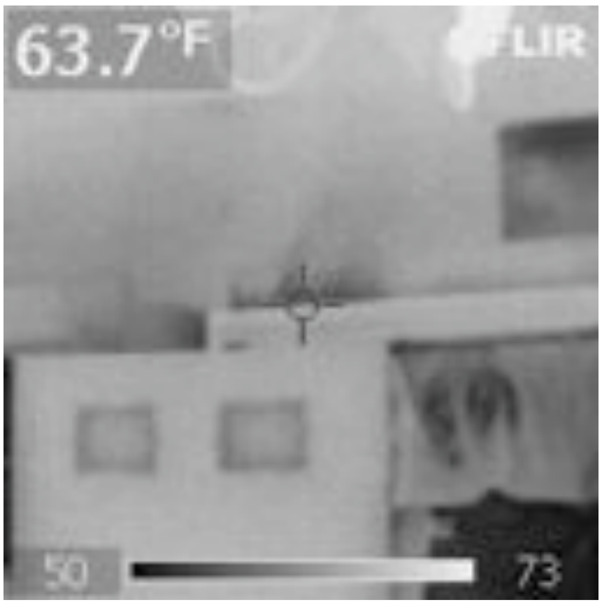
Air leakage around basement door admits a fair amount of cool air into the basement (a high stack pressure area) due to outdoor to indoor temperature driven stack effect.

This air is warmed by the heating system and rises up through the building, escaping at the top of the building carrying with it a great deal of heat, and moisture, dehumidifying the building in the winter.

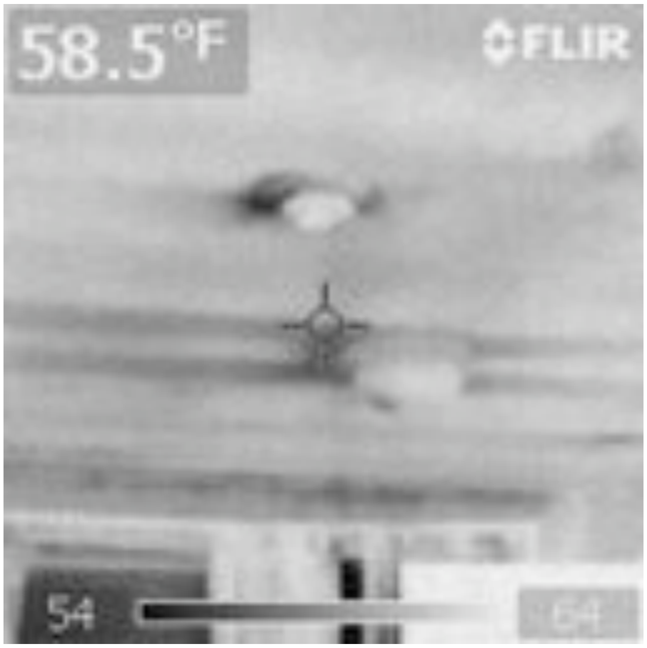
The other basement door in the rear of the building has even greater air infiltration, exterior light is visible around the wooden casement of the door.

5.2 Infrared Imagery With Blower Door Operating

The blower door combined with infrared scan located significant air infiltration in many areas, some examples are given below. Rather than duplicate all the images included above, some are included here for reference, many other images are available upon request.

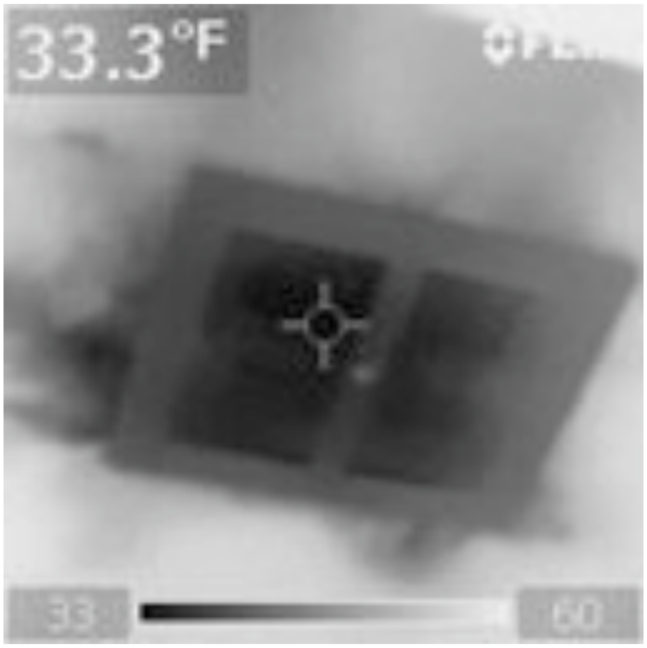


The blower door was installed in the front door. Air leakage (thin, whispy streams of dark cool air) are visible from behind the door above the left side lite trim. This is not a major cause of the high air infiltration, but is very easy to remedy with a bit of caulk.



The ceiling lights exhibit the thin, whispy, patterns characteristic of air infiltration.

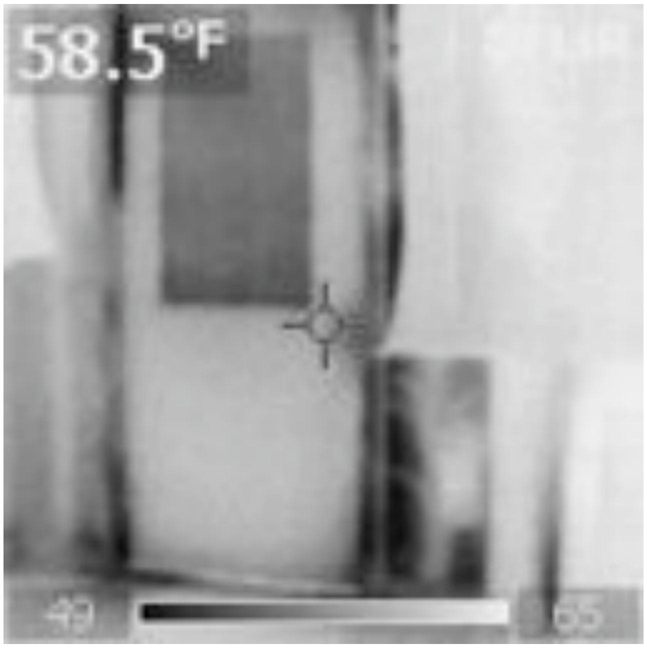
Although not a major loss of energy, this illustrates what is likely poor air sealing in the single story ceiling in this area. This could cause wind washing of fiberous ceiling insulation, reducing the efficacy.

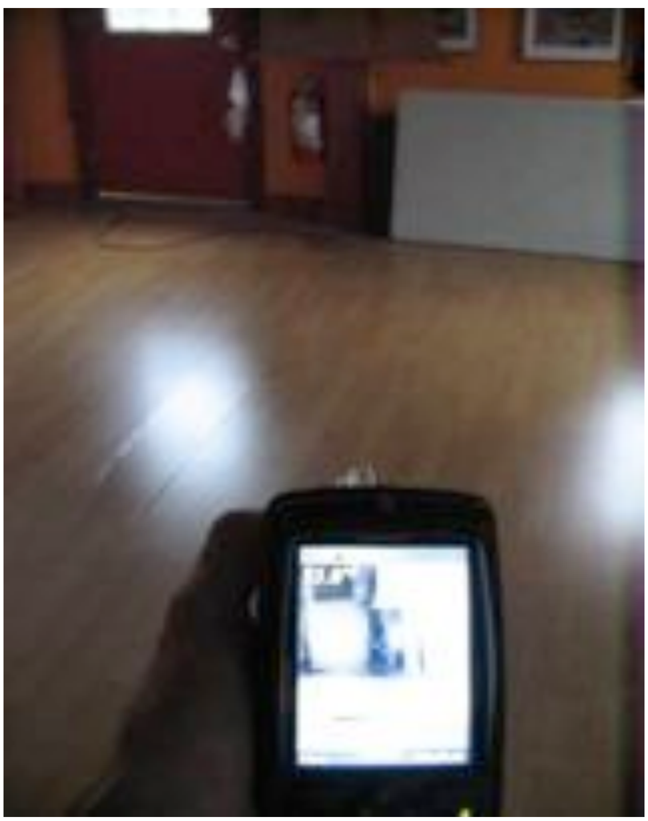


There appears to be no damper in this vent, and so very low (approximate) temperature air enters.

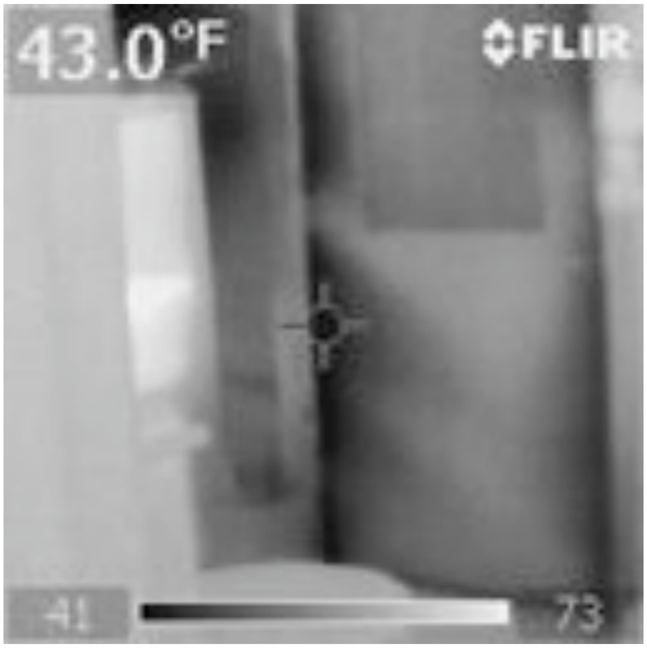
When this area is repaired, proper damper operation should be ensured.

It may be that the damper in this fan is stuck open. This fan appears to be similar to that fan on the left bathroom at the entrance to the large room in the newer, left side of the building. In that left bathroom, if you operate the fan and then turn it off and wait 5 to10 seconds, you can hear the damper close, and this is why that left bathroom vent has much less air infiltration.





Whispy patterns characteristic of air infiltration are apparent at the periphery of the door trim. This is not a very large energy loss factor, but it can be a comfort factor and is easy to fix with caulk and / or paint. Also, as is the case with many of the exterior doors in this building, adjusting the striker place position slightly to compress the door gaskets can greatly reduce the air infiltration.



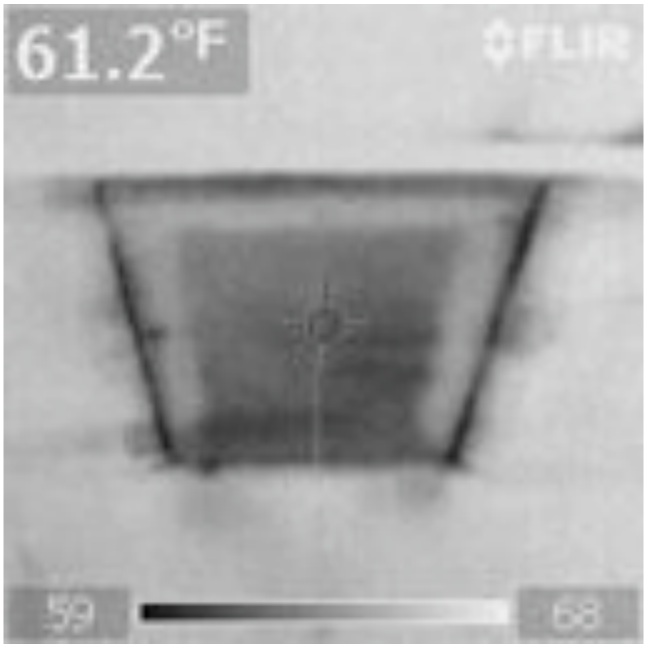
A large amount of air infiltration for an exterior door.

The door gasket is in good condition, the striker plate simply needs adjustment to compress the gasket. Not a very high energy loss area, but a comfort factor for those dining in this area, and easy to repair.

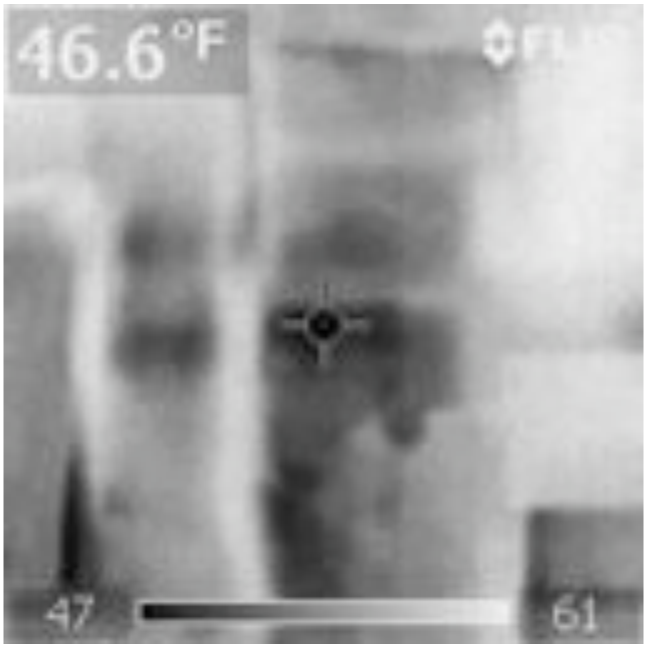
This is a very high air infiltration site.

Typically you may not feel cool air in this location, because warm air typically escapes up the vent. This is a likely a very high heat loss area.

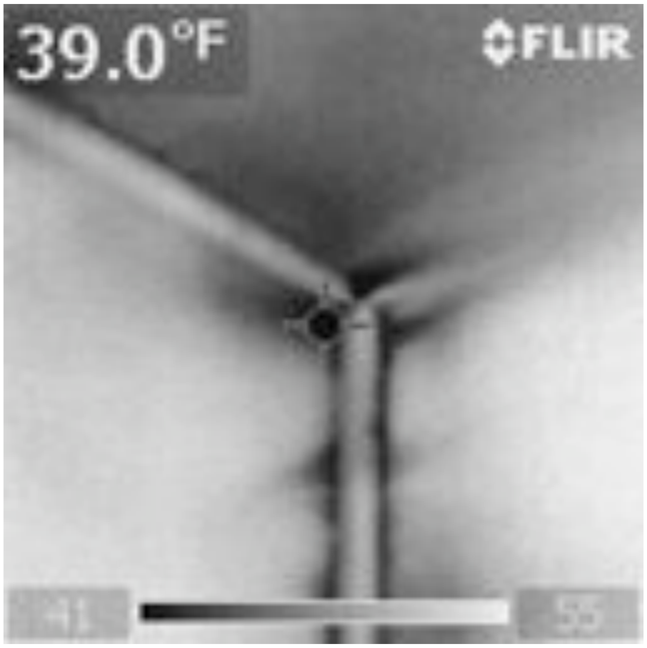
If at all possible according to the local building and plumbing codes, etc., a damper should be installed or repaired to minimize loss of warm air out this vent when it is not in use.



The third floor pull-down stairs demonstrate both air infiltration due to poor air sealing as well as no insulation of the attic stairs. A pliable high quality gasket, and an effective insulating cover are inexpensive and high return on investment improvements in this high stack effect area, if the ceiling of the second floor is to be the uppermost thermal boundary.

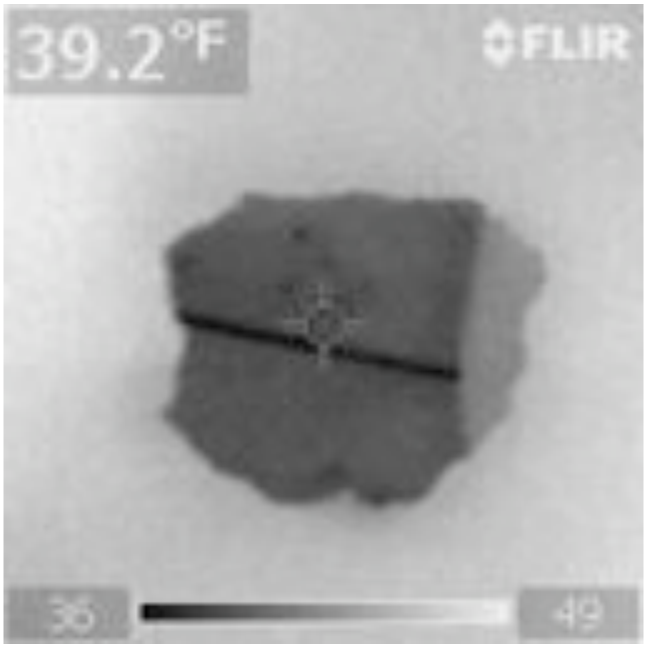


The blower door greatly amplified the heat loss in this area, air infiltration likely the reason, note the low approximate temperature of the interior wall surface. Wall surfaces this cool will make you ‘feel’ colder due to radiant heat loss, in addition to cooling the air in this room.



The right rear corner of the second floor closet over the newer portion of the building exhibited a fair bit of air infiltration that will tend to cool this closet excessively.

Although not a high energy cost item, it is relatively simple to remedy with caulk, paint, or some other air blocker.



The floor of the third floor is not a very effective air barrier, and so holes in the third floor ceiling will make air infiltration worse. In this image the back of the roof sheathing is visible. If the intent is to keep the fire suppression system warm enough to keep the water inside liquid so that the system will function in the event of a fire on a cold night, the pipes must be kept above freezing. Remediation work should consider the impact of all building, plumbing and fire codes, as well as the possible consequences.

The approximate temperature of the air entering this basement window is in the low 30's.

This high stack effect area would benefit from inexpensive caulk.

Although this in itself is not a high energy cost item, it is one of many small things that could be improved which would contribute to savings over time.

Wrap around porches in buildings of this vintage are notorious as a path for air infiltration.

It was not possible to enter the left front bedroom when the blower door was in operation.

An attempt was made to determine if significant air infiltration was occurring in this area by reversing the blower door so that it pressurized the building, thereby expelling heated air from spaces in the building, which might be visible from the exterior.

This experiment did not result in visualization of significant air ex-filtration in the area of the porch to house connection, but that does not mean it does not exist.

It was noted that the underside of the porch 'tongue and groove' ceiling had been painted which would effectively block air infiltration from that path.

Still, a significant amount of air could be entering under the porch shingles, etc.

So this experiment was inconclusive.

During blower door operation, the mechanical room in which the oil boiler is located was examined.

There is a very large amount of air entering this room from this very large external vent.

The need for such a large vent should be investigated in terms of the local plumbing, building and fire safety codes, as well as the boiler manufacturer. It may be possible to introduce a controlled amount of air directly into the boiler in a way which has less impact on the total building air infiltration. See **Suggested Improvements** below.

Interestingly, closing the mechanical room door had very little impact on the air infiltration as measured by the blower door, suggesting that this is could be a very significant source of air infiltration, and therefore heating cost.

However, the reason the closing the mechanical room door did not impact the measured air infiltration is not known.

6 Basement Inspection

6.1 Foundation

The foundation did not exhibit large amounts of air infiltration.

6.2 Rim Joist

The rim joist area could likely benefit from air sealing and insulation. However, most of it is covered by basement ceiling, so how much of an improvement is unknown.

But typically in building like this it is a very significant item, since it is in a high stack effect area.

6.3 Chimney Chases

The chimney chase in the boiler room appeared to be relatively well sealed.

7 Mechanicals

The Weil McLain oil fired boiler appears to be relatively new.

A service tag was not located that indicated the measured combustion efficiency.
Oil boilers should be tuned up annually for optimal performance.

Ideally, select a service company that makes a combustion efficiency measurement and posts it on the service tag.

The indirect hot water tank is an efficient way to make hot water.

The outdoor reset control mechanism is a very good way to increase the effective efficiency of the boiler system.

It is interesting to note that there is an additional, natural gas fired 100 gallon DHW heater, which appears to be older than the boiler / indirect tank setup.

8 Electricity Consumption

Electric utility bill analysis indicates a large electrical consumption for a normal residence of this size. This building also serves for public functions, which will add to the use of electricity. However, there are a number of practices which incur additional electrical use:

8.1 Incandescent Lighting

Some incandescent lighting in the building is on 24 hours per day, 365 days per year.

There are 24 hours in a day, and 365 days per year, for a total of 8760 hours per year.

For the purpose of the following discussion assume electricity is priced at about $0.15 per Killowatt Hour (abbreviated KWHr)

One KWHr is the use of 1000 watts of electrical power for a period of one hour.

To calculate the cost of an electrical load which is on 24 hours per day, 365 days per year, do the following:

Take the number of watts the device uses and divide by 1000 to get Kilowatts,
Multiply by 8760, the number of hours in a year
Multiply by the cost of electricity per KWHr, for example, $0.15 per KWHr

For example, the main assembly room in the rear of the newer section of the building has 42 light bulbs of 5 watts each.

So 42 times 5 = 210 watts
210 watts divided by 1000 = 0.21 KW
0.21 KW times 8760 Hours / year = 1839.6 KWHRs
1839.6 KWHrs times $0.15 per KWHr = $275.94 per year

The use of these lights may be unavoidable. However, this portion of the electrical bill is now explained, so progress is made toward understanding the total electrical use.

There are a number of incandescent light bulbs used in the building. To the extent possible, replacing the ones with a 'high duty cycle' (i.e. that are on for a relatively large number of hours per day) with Compact Fluorescent Lights (CFLs) is a very cost, effective, quick return on investment (typically within one year).

There are a wide variety of CFLs on the market, some of which have the same form factor as traditional incandescent light bulbs. One source is Energy Federation Inc. in Westboro: www.efi.org

Also see: http://www.energyfederation.org/consumer/default.php See: Lighting Bulbs Click on Standard Bulbs and see Capsules for a form factor very similar to conventional incandescent light bulbs.

CFLs use approximately 1/4th the electrical energy for the same amount of light output, when compared to incandescent lighting.

High CRI (Color Rendition Index) CFLs are now available for more critical applications and users who would choose lighting that more closely match the light spectrum produced by incandescent.

8.2 Electric Resistance Heating

Using a plug in electric resistance heater is an expensive way to heat, or to supplement the heat in a room. To the extent feasible, using the building's oil fired space heating system to serve most of the load is to be much preferred for cost reasons.

Suppose a 1 KW electric resistance heater is on 10% of the time. This is 876 hours per year, and results in a cost of 876 KWHr times $0.15 = $131 per year.

Here is an image of a large space heating system radiator and an electrical resistance heater together:

The items on top of the space heating radiator are blocking some of the convection airflow necessary to maximize the heat transfer from the radiator. Removing these items will result in more heat transfer to the room.

Fixing problems with the building can cost money, but this is a ‘one time’ cost that can avoid the recurring cost of paying for energy every year. It appears that an electric resistance heater might possibly be used to prevent pipes from freezing, refer to the following image:

8.3 Dehumidifier

The source of moisture in the basement should be investigated and eliminated if possible for a number of reasons, which include potential damage to the building, mold, and to reduce or eliminate the expense of dehumidification. Also, stack effect takes basement air and transports it into the living space in the floors above, where it impacts the occupants.

There is a dehumidifier savings calculator on the right side of the following webpage:
http://www.energystar.gov/index.cfm?c=dehumid.pr_dehumidifiers

The calculator estimates the operating cost of a typical dehumidifier at $160 per year, minimizing the need for use can make a significant impact in this cost.

Using this calculator to determine life cycle costs quickly makes it apparent that investing in an efficient unit and using it sparingly are effective strategies.

Fixing problems with the building can cost money, but is a 'one time' cost that can avoid the recurring cost of paying for energy every year.

8.4 Air Conditioning

Air Conditioning can be a significant use of electricity in a building. To the extent inefficient lighting exists, this contributes to the thermal load that must be serviced by the air conditioner, and so further exacerbates the problem. There is a savings calculator at:

http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerRoomAC.xls

The calculator estimates the operating cost of a low SEER dehumidifier at $300 per year,. So minimizing the need for use (good air sealing and insulation, ventilation strategies, efficient lighting, etc.) can make a significant impact in this cost.

Using this calculator to determine life cycle costs quickly makes it apparent that investing in an efficient unit and using it sparingly are effective strategies.

8.5 Refrigerators

Refrigerators are high 'duty cycle' electricity users since they are required to remain cold 24 hours a day, 365 days per year.

There are a few refrigerator savings calculator available at:
http://www.energystar.gov/index.cfm?c=refrig.pr_refrigerators

One in particular can find the estimated energy use from your model number, typically located on a label inside the refrigerator or freezer compartment.

http://www.energystar.gov/index.cfm?fuseaction=refrig.calculator

For example, the Summit refrigerator model FF106xxx was built in 1999 and is expected to use about 574 KWHr per year, for an operating cost of $0.15 times 574 = $86 per year.

Three refrigerators were examined, the two Summits are the same model, the Maytag MTB1954 does not have a close match in the EnergyStar database.

One strategy would be to try to eliminate one of the three refrigerators (or only turn it on during events, etc. when it is needed).

The cost of operating the Summit in the basement is about $86 per year, over 10 years this is $860.

8.6 Electric Dryer

An electric dryer works by heating air and using it to evaporate moisture from clothing.

Care should be taken to route dryer outlet rigid metal pipe (preferred over flexible hose, and required by code in some areas for fire safety reasons) so that it has no sharp bends, and as few bends as possible, and is as short as possible. Long runs of dryer output air conduit can contribute to the premature failure of the dryer heating element due to excess temperatures. This will use excess electrical energy. The existing situation should be corrected.

8.7 "Phantom Loads"

Frequently, electronic devices are not really 'off' when the 'off button' is pressed.

These devices are said to use 'standby power' sometimes called a 'phantom load' because it is not apparent that they are actually using electricity.

Another example is 'wall warts' the small, typically black, transformers that plug directly into the wall outlet and have a low voltage cord used to charge everything from electric toothbrushes and shavers to portable vacuums, tools, computer peripherals and displays, etc.

These draw power even if there is nothing plugged into them.
When possible, use a 'power strip' with an on / off switch to avoid 'phantom loads'.

TVs, VCR/DVDs, etc. with remote controls all present phantom loads that can be very significant

8.8 Measuring Electricity Use – Kill A Watt

It is easy to calculate the cost of two 60 watt outdoor porch lights left on 24 hours a day, 365 days per year:

There are 24 hours in a day, and 365 days per year, for a total of 8760 hours per year.

Assume electricity is priced at about $0.15 per Kilowatt Hour (abbreviated KWHr)

One KWHr is the use of 1000 watts of electrical power for a period of one hour.

To calculate the cost of an electrical load which is on 24 hours per day, 365 days per year, do the following:

Take the number of watts the device uses and divide by 1000 to get Kilowatts,
Multiply by 8760, the number of hours in a year
Multiply by the cost of electricity per KWHr, for example, $0.15 per KWHr

So for the example of two 60 watt porch light bulbs:

So 2 times 60 watts = 120 watts
120 watts divided by 1000 = 0.12 KW
0.12 KW times 8760 Hours / year = 1051.2 KWHRs
1051.2 KWHrs times $0.15 per KWHr = $157.68 per year

But what can you do about electrical devices that are not on 24 hours a day?

If you know the power that they use when they are on (say a 1000 watt electric heater, which therefore uses 1 KW) you can estimate the percentage of time they are in use, (sometimes called the 'duty cycle') and then multiply that 'duty cycle' by the number of hours per year to get the total number of KWHrs used.

For the case of a 1 KW heater used 10% of the time:

8760 times 1/10 duty cycle = 876 hours per year
876 times 1 KW = 876 KWHrs
876 KWHrs times $0.15 = $131.40 per year

But what about 'wall warts, TVs, computers, etc that are supposed to be 'off' ?

You can purchase an inexpensive device called the Kill A Watt at Amazon.com for $25
http://www.amazon.com/P3-International-P4400-Electricity-Monitor/dp/B00009MDBU/ref=pd_bbs_sr_1?ie=UTF8&s=electronics&qid=1229825143&sr=8-1

You plug the KillAWatt into the wall outlet, then plug the device you want to measure into the KillAWatt.

You could for example monitor air conditioner use, dehumidifier use, electric resistance heat use, etc.

8.8.1 Remote Outlet On – Off Switching

An easy way to switch power to an absolute minimum is with a product called Bye Bye Standby, which plugs into a wall and then you plug the device to be controlled into it.

The remotes use a tiny amount of power compared to the device you are controlling and you don't have to bend over to throw the switch on a power strip. Not yet evaluated, but looks to be an interesting product.

8.9 Computers

Personal computers can use a surprising amount of power when left on.

Put computers into 'sleep mode' or turn them off with a hard (e.g. wall outlet) switch or power strip when possible.

Choose EnergyStar rated computers when possible.

There is a product called "Smart Strip" that is a power strip into which you plug your computer into in one particular outlet.

When that outlet 'senses' the computer has gone to sleep or standby, the 'smart strip' turns off all the other outlets, into which you can plug your peripheral devices like LCD monitors, printers, scanners, fax, PDA power, and all other computer associated 'wall wart' transformer devices, power is removed when the computer is not in use.

9 Suggested Improvements

All building codes, plumbing codes, fire and safety codes and manufacturers recommendations, etc. should be carefully followed when making modifications to the building to insure safety, longevity, low maintenance and occupant comfort.

Air sealing a building with basement moisture issues can make these issues worse.

Addressing basement moisture issues should be a first step in any air sealing program.

9.1 Measuring Energy Use: The First Step

Measuring the use of energy in a building is fundamental to:

- Understanding the magnitude of energy use
- Developing cost effective improvement strategies to address use
- ‘Selling’ improvement strategies to the decision maker(s)
- Motivating occupants to change energy use behavior
- Motivating occupants to suggest ways energy use can be reduced

The **Electricity Consumption** section above explains how electrical use is measured and monetized, and offer some specific suggestions as to how to minimize energy costs.

9.1.1 Monitor Heating Fuel Use

By knowing the use patterns, more effective management strategies can be developed.

By knowing energy costs, the cost of making an improvement and the expected return on investment can be calculated, so an informed investment decision can be made.

Goals can be set, and progress towards those goals can be measured.

9.2 Educate Building Occupants

The behavior of the occupants in a building can have a very large impact on energy use, as much as a factor of two or more.

Additionally occupants are in an excellent position to suggest improvements that can greatly benefit energy use.

Engaged, motivated building occupants can be a powerful force in energy use reduction.

9.3 Building Maintenance

Proper building maintenance is key to good energy efficiency, building longevity and avoiding costly repairs due to damage incurred after years of neglect.

9.3.1 Three Principal Damage Functions

The three principal damage functions in buildings are:

Moisture – Accelerates degradation of building materials, facilitates mold growth, etc.

Heat – Excessive heat accelerates damage of building materials

UltraViolet Radiation – Accelerates damage to many materials

Air infiltration transports heat and moisture, and therefore accelerates their effects.

Controlling moisture and air infiltration into a building is therefore key to controlling their impact on the building. Efforts to reduce air infiltration can have a negative impact on building durability if moisture entering the building is not under good control.

9.3.2 Maintenance Issues Related to Energy Efficiency

The following issues related to energy efficiency were noted. Others such as holes in the roof observed from the third floor, as well as signs of water damage, etc. are not considered in this report on building energy use, but should be addressed.

9.3.2.1 Storm Windows Not Secured/Repaired for Winter

Storm windows help reduce air infiltration, especially with poorly fitting and maintained wooden windows.

These should all be properly closed for the winter, including those on the third floor.

Some windows were observed with significant separation from the building, see the image below:

Windows were observed without sash locks, sash locks installed backwards (meaning they could never be used, and sash locks which were not closed, see image below:

This sash lock was installed backwards, it cannot be used.

Old wooden windows leak a fair bit of air. This can impact comfort, and does impact energy use, but the energy use significance is frequently exaggerated by window manufacturers.

New windows are expensive to replace, and may not be all replaced at one time. Window replacement in this building might be preceded by more pressing repairs, and might be done in stages.

In any case, replacing functional single pane windows which have installed reasonable triple track storm windows with new windows that have double pane, LoE, Argon can have an energy pay back longer than the lifetime of the windows.

Approach window replacement cautiously and consider appearance and functionality over claims by window manufacturers of potential energy savings. Sometimes these claims are not only fail to be credible, they can be incredible.

In the meantime, air infiltration can be minimized by use of an inexpensive rope type caulk one such product is Mortite. Windows which are never opened can be easily targeted.

The use of plastic sheeting secured over the interior of windows can be an effective air infiltration barrier, but impacts the seasonal use of the window for ventilation.

If windows are replaced, insist on aggressive air sealing during installation, including completely filling the old sash weight pockets.

Action: Consider window replacements carefully, if replaced, insist on aggressive air sealing and sash weight pocket filling.

Close storm windows for winter.

Action: Temporarily close, secure and/or repair existing windows

9.3.2.2 Basement Moisture

Some reasons to minimize or eliminate basement moisture:

Minimize or eliminate mold growth.
Minimize or eliminate electricity use for dehumidification
Damp, moldy basement air is drawn into the living space above by stack effect.
Air sealing the building could facilitate damage from moisture.

Action: Determine the cause and repair.

9.4 Air Infiltration Reduction

Air infiltration is a powerful force which can a great deal of heat from a building along with moisture, resulting in the low humidity typical of buildings in New England in the winter.

Large air infiltration can be experienced as 'drafts'on a windy day but might better be recognized for the 'stack effect' driven air infiltration. See the description below titled "General Air Infiltration Overview".

A large old building can be a real challenge to air seal, but a detailed, systemic approach can result in impressive savings.

A mockup computer model of a building with an 85% AFUE oil fired boiler distributing heat with forced hot water distribution at a fuel oil cost of $4 per gallon produces a slope of about $350 per 1000 CFM50 of blower door air flow.

Said differently, **each 1000 CFM 50 of blower door reduction results in fuel savings of about $350 per year.**

So if the blower door number could be reduced from 7900 CFM50 to 5900 CFM 50, the fuel savings could be approximately $700 per year.

This is independent of, and in addition to any fuel savings as a result of insulation to reduce conducted heat loss.

9.4.1 Air Infiltration Reduction Strategy

Start with defining the air and thermal boundary (see General Thermal Boundary Overview below).

9.4.1.1 Third Floor Air Sealing and Insulation

Unless the third floor is to be abandoned (which may not be possible due to the need for a functioning fire suppression system, check the local building, fire and plumbing codes), the relatively complex roof structure could become the thermal boundary with an application of polyurethane foam in the rafters, air sealed to the above grade walls to form a continuous air barrier. Given the condition of the third floor walls, a 'gut rehab' approach such as this is very feasible.

Alternatively, installation of a new roof could include rigid foam on the outside which is then air sealed to the above grade walls to form a continuous air barrier, and to improve the conducted thermal performance.

Action: Define and execute plan

9.4.1.2 Kitchen Vent Air Infiltration Improvement

The kitchen cook top vent is a major source of air infiltration.

Action: Remedy this in compliance with all building, plumbing etc. codes.

9.4.1.3 Basement Boiler Air Supply Improvement

The large vent into the boiler room is believed to be a major source of air infiltration, although the mechanism is not well understood.

Action: Investigate this further and if indicated, remedy this in compliance with all building, plumbing etc. codes.

One suggested method (verify building and plumbing code compliance first!):

Some WeilMcLain WTGO boilers are equipped with Beckett burner units, which can use a CAS-2B Field Controls AirBoot tm to introduce outside air directly to the burner air intake.

This unit has a Carlin burner, but a similar product might be available for Carlin. Check with www.oilheatassociates.com for free oil heat consulting on this question.

9.4.1.4 Bathroom Vents Without/With Malfunctioning Dampers

These will cause a substantial amount of air infiltration since there are so numerous.

Action: Investigate those which do not have functioning dampers and repair or replace.

9.4.1.5 Basement Rim Joist Air Sealing and Insulation

If the basement ceiling was not finished, a strong recommendation would likely be made for using two part spray foam to both air seal the foundation to the rim joist and wall sheathing, and to insulate.

There is additional cost to do this, and since the ceiling is in place a complete inspection could not be done. But this should be considered.

Action: Spot check rim joist behind basement ceiling to determine value of this approach.

9.4.1.6 Gasket and Insulate Third Floor Access Stairs

If the third floor is to be outside the thermal boundary, reduce air infiltration at this high stack effect area and insulate this access

Action: Insulate and Weatherize: Third Floor Stairs

9.4.1.7 Adjust Door Striker Plates To Compress Gaskets

Invest a small amount of labor to improve comfort and reduce air infiltration.

Action: Adjust exterior doors.

9.4.1.8 Weather-stripping, Caulking, Crack Sealing, etc.

These activities are most useful in promoting occupant comfort, and do somewhat impact air infiltration. These activities are best done with low or no labor cost (i.e. by the homeowner) for the best return on investment.

Strategic use of these techniques can however be very beneficial for occupant comfort, and incremental benefits to air infiltration result.

For example, a baseboard air leak that allows cool air to enter near the feet while sitting at a desk can be very uncomfortable.

The same is true for drafts in locations where people commonly sit for an extended time, e.g. kitchen table.

Locations to consider include both basement doors, especially the rearmost, through which light can be seen in the area of the rough opening, and all exterior doors.

Rooms in which occupants prefer very high air temperatures could have drafts or air infiltration as the root cause for the discomfort at lower air temperatures. .

Action: Insulate and Weatherize the entire building.

9.4.1.9 Siding Replacement Opportunity

If the siding is to be replaced at some future time, be sure to air seal this large surface area while it is exposed and this is very easily and inexpensively done.

Action: Plan for this opportunity, if done, insist it is done properly.

9.4.2 Un-Insulated or Under-Insulated Wall Strategy

Infrared thermography indicates that a majority of the above grade wall surface area that was examined (a large number of furniture, pictures, decorations, etc. covered a larger than usual amount of the exterior wall surface area preventing a more thorough scan) is un-insulated or under-insulated.

Develop a plan to address this.

A ‘gut rehab’ would allow any good open cavity air sealing and insulating technology to be used.

If the interior of the wall is to remain undisturbed, a ‘closed cavity’ insulating technology which significantly impacts air infiltration should be used, probably from the outside.

Dense pack cellulose is different from ‘blown cellulose’ or ‘claimed to be dense pack cellulose’. These two differ substantially in their ability to reduce air infiltration.

The high air infiltration in this building, strongly suggests true ‘dense pack’ cellulose be used, and the density verified by measurement or material consumption calculations.

The floor of the third floor had cellulose ‘blown in’ which was not densely packed, and so has little air infiltration reduction properties.

True ‘dense pack’ cellulose has a packed material density of 3.5 lbs /cu ft.

Action: If appropriate (see above) obtain an estimate for true ‘dense packing’ the exterior walls. Insist on ‘dense pack’ cellulose and understand the method of ‘dense packing’ verification.

10 General Building Thermal Boundary Overview

The heating and cooling system in a building is intended to condition a 'Building Envelope' or 'Thermal Boundary' which contains the heating and cooling, so as to provide a comfortable environment for the occupants.

A general image of a thermal boundary is provided for the discussion below:

From the **EnergyStar** website: www.energystar.gov

The orange in this image outlines the thermal boundary for a home in which the basement is outside the thermal boundary, that is, there is insulation in the basement ceiling.

The intent for the home under investigation is apparently for the basement to be outside the thermal boundary, since the basement walls are un-insulated.

The case for the third floor is not so clear. The floor boards on the third floor have been drilled in several places, and 'lose pack' cellulose has been installed. The density is not sufficiently high (i.e. this is not 'dense pack' cellulose) to be a significant air barrier.

There is some fiberglass insulation installed in the rafters behind the knee-walls. The attic (3^{rd} floor flat ceiling) is largely un-insulated. There are holes in the roof sheathing through which light is visible. Some areas behind knee-walls are completely un-insulated and have sprinkler pipes near significant air leaks.

For the purpose of this report, the thermal boundary will be called at the second floor ceiling. But this is not really the case, on the date of the audit the outside temperature was approximately 35 degrees, and the third floor was approximately 50 degrees, so a great deal of heat was escaping from the second floor to heat the very leaky third floor to 50 degrees.

For proper building comfort, energy performance, and building durability, the thermal and air boundaries of a building should be coincident and well executed.

The value of insulation is widely appreciated, but the importance of and the reasons for air infiltration control are not so widely understood and valued.

This is discussed next.

11 General Air Infiltration Overview

According to the American Society of Heating and Refrigeration Engineers (ASHRAE), from 20% to 50% of a building's thermal load (the amount of heat that must be supplied to compensate for heat loss) is due to air infiltration.

This building has high air infiltration, as measured by a blower door test number of about 8000 CFM extrapolated to 50 Pascals of air pressure difference. However, two rooms had the doors shut during the test because the keys were not available, so the actual air infiltration of the entire building is likely higher.

Stack effect air infiltration is at work whenever the outside and inside temperatures are significantly different.

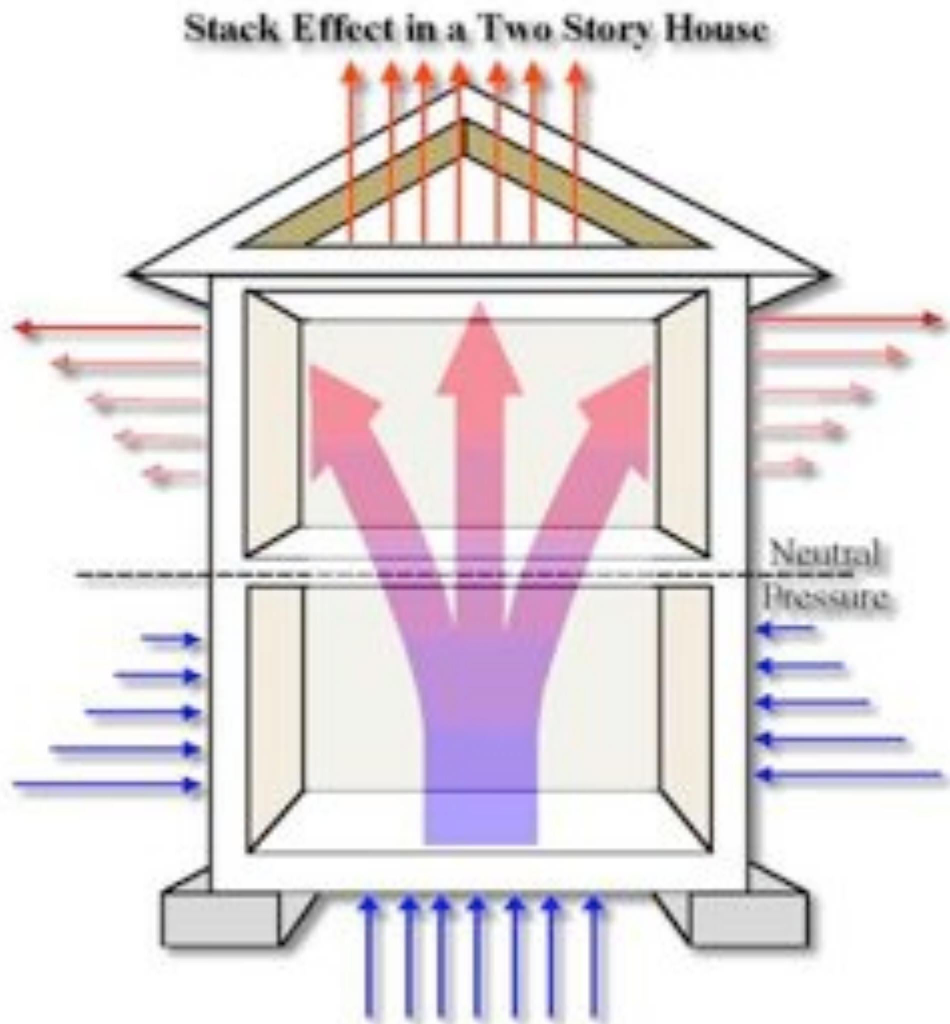
Stack effect causes cold, relatively humid winter air to enter the building where it increases in temperature, and therefore decreases in humidity (Google "Psychrometric Chart" and review the Wikipedia entry for more detail.)

The diagram below is for reference for the following discussion.

From the **EnergyStar** website: www.energystar.gov

Blue arrows indicate cold air entering the building envelope in the lower, negative pressure area of the house. Orange arrows indicate heated air pushing out the upper, positive pressure area of the building envelope, exiting via chimney and plumbing chases, recessed lights, attic hatch, whole house fans, etc. Minimizing air infiltration will reduce drafts and cold wall/ceiling temperatures that are uncomfortable, will reduce heating bills and facilitate wintertime humidity control. Controlling stack effect will also minimize vapor transport and the associated building degradation.

Here is a more ‘abstract’ diagram of ‘stack effect’ which serves to show the areas of highest and lowest stack pressure, as well as their directions.



Note this is a heating season diagram, if the blue arrows indicate the direction and magnitude of the cold air pressure and direction entering the building, and the red arrows indicate the warmed air pressure and direction leaving the building.

The key point to understand from this diagram is that it is important to address the areas with the greatest stack pressure, since these have the greatest value in reducing air infiltration.

These areas are typically the basement and rim joist area (which is often very leaky) as well as the attic ceiling area.

12 Radiant Temperature Overview

Perceived comfort is not entirely defined by air temperature and air motion (e.g. drafts).

Surfaces which are at a lower temperature than the air temperature both cool the air and can (if the temperature difference is great enough, like windows on very cold days) create convection currents that feel like drafts.

But the surfaces which are at a lower temperature also radiate less infrared radiation. So when you are in an environment with an otherwise acceptable air temperature, you may feel uncomfortably cool near a cold wall or window, because that surface emits less infrared radiation to warm you.

13 References

Insulate and Weatherize, Bruce Harley – Excellent overview of all aspects of home energy improvement, written by an experienced professional, with numerous illustrations, many important details. Available from Amazon for about $14

EFI – Energy Federation Inc – A Westborough, MA based company dealing in a wide variety of energy efficiency related products. Source for one and two part air sealing foam, attic hatch covers, an extensive range of Compact Fluorescent Lights (CFLs), QLON weather-stripping, Panasonic Whisper Green bath and ventilation fans, Heat Recovery Ventilators, etc. www.efi.org/

EFI sells two part spray foam in kits of various sizes.

There is an image of a two part kit in use at:
http://www.efi.org/wholesale/p27_high_expansion_foam.pdf

And the packaged product here:
http://www.efi.org/wholesale/p27_high_expansion_foam.pdf

The 15 board foot kit is a bit difficult to use but if you want to experiment with two part foam inexpensively ($30) it is available.

If you are interested in the larger kits, contact me, I've used the small kit and have been with people working with the large kits. There are a few things to be consider, as well as some application tips that are important. An excellent product for rim joist air sealing to the foundation, and insulation.

Psychrometric Chart – Use this to determine the humidity change for a temperature change only, etc. Available free at: http://www.linric.com/free4me.htm

EnergyStar on Air Sealing and Insulation – Numerous resources here including a DIY (Do It Yourself) Gide to Air Sealing and Insulating with EnergyStar
http://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_sealing

Energy Savings Reality Check – Michael Blasnik does statistical analysis of large scale weatherization efforts to discover 'What Works and What Doesn't Work". Learn about the energy savings measures that are effective, and which have little payback.
www.nliec.org/2007%20Conference/Presentations/M**Blasnik**_Energy%20Conservation.pdf

Commonwealth Solar – In Massachusetts significant rebates are available for Photovoltaic arrays, learn how to estimate your costs, benefits and how to apply:

www.masstech.org/SOLAR

OilHeatAssociates.com – Free oil fired mechanicals consulting. Call and ask questions about any oil fired mechanical system questions (tell them I sent you!): www.oilheatassociates.com

AHRI - Air Conditioning, Heating and Refrigeration Institute - Directory of many mechanicals, find input, output, power AFUE, etc. http://www.ahridirectory.org/ahridirectory/pages/home.aspx

EnergyStar Appliance Efficiency Ratings – Look here when purchasing new appliances to determine energy use for all EnergyStar listed appliances. http://www.energystar.gov/index.cfm?c=appliances.pr_appliances

14 Visible and IR Image Pair Correlation

This is a table of visible and IR images that have been correlated for future reference

Visible #	IR #	Comments
8791	2 028	Stud Cavity Insulation ?
92	29	Stud Cavity Insulation ?
94	30	Stud Cavity Insulation ?
95	31	Door sweep leak
99	32	Stud Cavity Insulation ?
8801	33	Bath Fan Leak
02	34	Possible air/water
09	35	Possible air/water
10	36	Blocked convection heating
11	37	
12	38	Unused baseboard heat ?
13	39	Unused baseboard heat next to Radiator in use ?
14	40	Stud Cavity Insulation ?
15	41	Insulation air infiltration issue ?
16	42	
17	43	Cool air from window ?
19	44	Stud Cavity Insulation ?
21	45	Stud Cavity Insulation ?
22	46	Stud Cavity Insulation ?
23	47	Stud Cavity Insulation ?
24	48	Stud Cavity & ceiling Insulation ?
25	49	
26	50	Stud Cavity & ceiling Insulation ?
29	52	Possible air/water leak ?
30	53	Stud Cavity Insulation ?
31	54	Stud Cavity Insulation ?
33	55	Stud Cavity Insulation ?
35	56	Possible air/water leak ?
36	57	Possible insulated wall cavity
38	58	Possible insulated wall cavity
8843	2 059	Stud Cavity & ceiling Insulation ?
8844	NA	Attic Interior. wall Temperaure
45	61	Some heat distribution in attic ?
47	62	Some heat distribution in attic ?
55	63	Stud Cavity & ceiling Insulation ?
56	64	Stud Cavity & ceiling Insulation ?
57	65	Warm air leak from downstairs ?

59	66	Some heat distribution in third floor ?

Visible #	**IR #**	**Comments**
8860	2 067	Fire suppression in third floor
61	68	Attempt at third floor insulation
65	69	Third floor ceiling insulation
8887	2 071	Stack Effect leak in basement
8926	2 074	Stack Effect leak basement door
8988	2 081	Start Blower Door On, door trim air leak
89	82	Suggests air infiltration
90	83	Suggests air infiltration
91	84	Suggests air infiltration
92	NA	Window air leak visualization
95	85	
96	86	Air infiltration from bathroom vent
9001	2 088	Possible pipe or other material in stud cavity
02	89	Air and or insulation displacement
03	90	Air and or insulation displacement
06	91	Air infiltration around door trim
07	93	Air infiltration fire suppression sprinkler
08	94	Effective bathroom vent damper, this bathroom is on the left as you are entering main rear hall area.
09	95	Large amount of door gasket leakage, adjust striker plate
11	96	Kitchen Exhaust Hood - Major air leakage path
18	97	Suggestive of air infiltration amplified loss
19	98	
20	99	Suggestive of air infiltration amplified loss
23	2 100	No gasket, no insulation in this high stack effect area
28	2 101	Suggestive of air infiltration amplified loss
29	02	Suggestive of air infiltration amplified loss
34	03	Suggestive of air infiltration amplified loss
36	04	Suggestive of air infiltration amplified loss
39	NA	Visualization of window air sealing loss
42	05	Suggestive of air infiltration amplified loss
46	06	

9052	2 107	Third floor air infiltration
55	08	Third floor interior wall approximate temperature
58	09	Third floor hole and roof sheathing approximate temperature
59	10	Suggestive of air infiltration amplified loss
61	11	Basement window amplified air loss
	2115	Exterior wrap around porch
	2116	Exterior wrap around porch
	2117	Exterior wrap around porch