“Building Envelope Energy Efficiency Analysis”

Doe Residence
123 Energy Efficient Lane
Severna Park, MD 21146

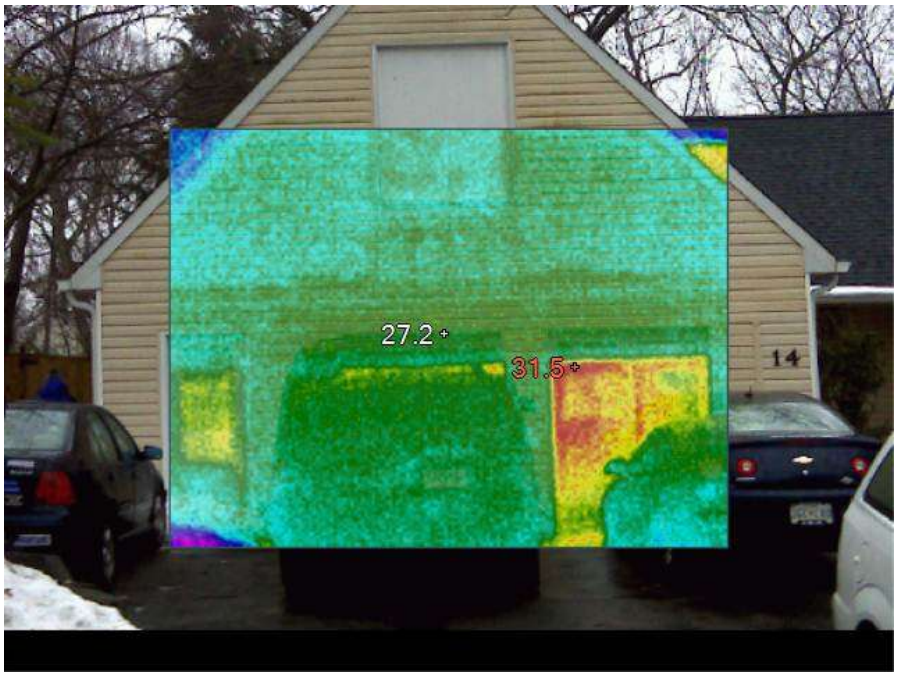
February 17, 2011
Survey #: Z-1108-Doe

Prepared by:

Kurt Pfund
Zerodraft Maryland
113 West Road, Suite 101,
Towson, MD 21204
www.ZerodraftMaryland.com

Contents:

Please do not hesitate to contact us with any questions or comments:
Zerodraft Maryland 410-321-5936 www.ZerodraftMaryland.com



1.) Methodology and Background

a.) Audit Methodology

An investigation of existing conditions was performed to determine the energy performance of the building envelope (air, moisture, and thermal barriers) of the house. Examination of the structure was limited to visual inspection of accessible areas, infrared thermography of accessible areas, and blower door leakage testing.

The primary focus of this inspection was to find areas of wasted energy in the building envelope which lead to unnecessarily high utility bills and reduced homeowner comfort. These areas can include sections of missing, insufficient, or damaged insulation, leaky windows and doors, uncaulked connections at fireplaces and attic hatches, and faulty seals at lighting fixtures or electrical outlets. We also tested all of your combustible appliances for proper drafting and acceptable levels of carbon monoxide (CO) to ensure that any improvements to the building envelope will not heighten any health risks related to combustion gases.

Building Orientation
When describing the names of buildings in your property, we will use the directions “right” and “left” as if we are standing at your front door looking at the house, consistent with the orientation on the cover page.

Limitations
While every effort was made to image every exterior wall surface of the building, full coverage may not have been possible due to factors beyond our control, such as inaccessible areas behind furniture or large appliances.

A serious effort was made to uncover all defects in the building envelope, but hidden or concealed defects are naturally not included in the scope of this report, and a warranty is neither expressed nor implied.

Likewise, while we also make every effort to identify other areas of concern affecting the condition of the house and the health of its occupants, this report should not be mistaken for a full home inspection, as we do not test each of your home's systems.

b.) Building Data

Building Background Data

- building type and floors: 2-story single family
- year built: 1962

- basement: full, unfinished (masonry walls) with utility room and smaller closed crawlspace (3' ceilings)
- ceilings: 8' (with some areas of cathedral ceiling)
- exterior: vinyl siding
- roof type: shingle

- total exterior wall area: 2,880 square feet
- conditioned area (including basement): ~5,280 square feet
- conditioned volume[1]: ~41,000 cubic feet

c.) Atmospheric Conditions

Atmospheric and Internal Conditions

- Climate Zone (U.S. Dept. of Energy): 4

- Starting Time: ~9 am
- Weather Conditions: Overcast with Rain

- Outdoor / Indoor Temperature: 36 / 69° F
  (Indoor-Temperature Δ: +33° F)

[1] Listed area taken from zillow.com; exterior wall area and conditioned area calculated from on-site measurements

2.) Homeowner Utility Data

A utility bill can be broken down into two parts: a baseline load, which includes the cost of lighting, appliances, and water heating and the heating/cooling load, which undergoes far greater seasonal variation.

Heating/Cooling Load

- Approximate annual heating/cooling costs (not including water heating): 53%
- Approximate baseline load (electric appliances, water heating, and A/C): 47%

Currently your heating/cooling load represents over 50**%** of your total utility bill (by comparison, a home of this type and in this area with efficient, modern systems is typically in the 40-50% range). Please see p. 1 of your "BEACON Home Energy Advisor" report for a more detailed breakdown of your measured energy consumption).

3.) General Conclusions and Building Envelope Recommendations

General Findings
Blower door testing helped to determine that the home's air leakage is **230%** of the ideal upper limit for a structure of this type, meaning that a very high portion of conditioned air is passing through the house to the outdoors (please see p. 2 of your "BEACON" report for more detail on this measure).

Three main areas of air leakage were found or confirmed, all of which can be reduced substantially by properly air-sealing and insulating:

1.) Air is entering the home from open gaps behind the porch soffit, which is infiltrating the ceiling above kitchen and downstairs bathroom.
2.) An entire upper wall above the living room-sunroom connection (covered with interior siding) was never properly sealed and insulated and is extremely leaky. There is also substantial leakage into main living spaces through gaps in the floor.
3.) A missing insulation panel in the side attic (adjacent to master bedroom; access through bedroom closet) and air gaps in the attic floor are the source of leakage down through the stairwell.
4.) One other area – under the window above the master bathtub -- was also discovered to be missing insulation.

The basement rim joist is uninsulated and the basement windows are leaky; two other areas of heat loss, including the attic hatch, were noted and photographed, and are included in this report.

Specific Recommendations
For an itemized list of all recommendations, together with their expected cost and cost-savings, please see the attached Energy Retrofitting Estimate. We also indicate which measures Zerodraft is capable of performing and for which utility, state, and federal rebate programs you might be eligible.

Guide to Recommendations

Ideally, all of the problems documented in this report should be further tested and then rectified to achieve maximum energy efficiency of your building envelope. But because of time and budget constraints, we have attempted to help prioritize the defects in thermal, air, and moisture barriers according to a four-fold scale:

- Urgent: defects in the building envelope which are in immediate danger of compromising the safety of inhabitants or the structural integrity of the building. Elements which may present a safety danger have been marked with a sign.
- High: defects which lead to a high degree of wasted energy, will over time deteriorate the building if left unchecked, and/or almost certainly cause a degree of discomfort to inhabitants
- Medium: defects which lead to some degree of wasted energy and/or may cause some discomfort to inhabitants; and
- Low: defects which are undesirable but affect the energy performance of the building less significantly

Likewise, we have grouped the projected cost of retrofits into three main categories. The costs of individual energy retrofit projects are, of course, relative to a building's size and type, and for your building type, we are using the following approximations for the combined costs of energy retrofit labor and materials. Naturally, you can save costs by performing labor yourself on jobs you are capable of performing:

- High ($$$): over $1000
- Moderate ($$): $100-1000; and
- Low ($): $100

Please do not hesitate to contact us with any questions or comments:
Zerodraft Maryland 410-321-5936 www.ZerodraftMaryland.com

4.) Detailed Documentation of Findings with Specific Recommendations

a.) Health, Safety and Building Maintenance Concerns

The inspection conducted on your home was not primarily targeted towards finding safety concerns, but we nevertheless consider it our duty to alert you to any problems in this area that we may have found. Please consult specialists (electricians, plumbers, etc.) for more detailed diagnosis and rectification of these problems:

Drainage Issues

While your downspouts appear to be intact and fully functional, they drain very close to the house and we recommend installing 4" downspout extenders to drain water further away from basement and alleviate moisture concerns.

You can also reduce the possibility of moisture and debris infiltrating your basement windows by installing window box covers.

We also recommend thoroughly cleaning leaf debris out of gutters and roof valleys to reduce the chance of snow/ice damage and moisture buildup.

Indoor Air Quality Issues

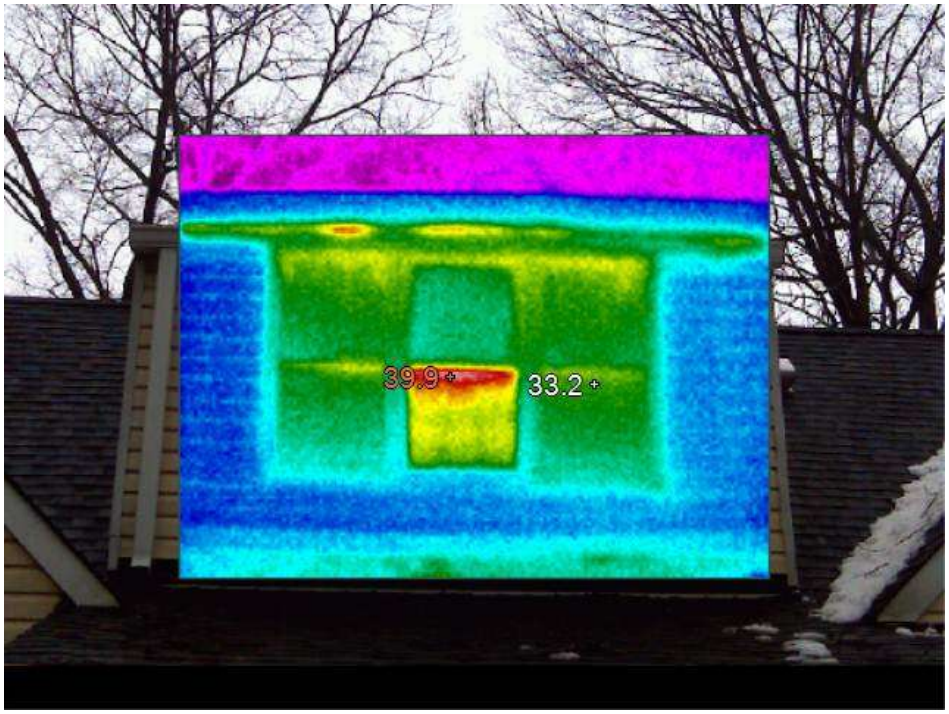
Zerodraft Maryland recommends replacing your return air filter monthly during the heating/cooling seasons (or as recommended by manufacturer) to ensure that the system can run as efficiently as possible and your indoor air is as clean as possible.

General Maintenance Issues

#1 – wood trim around studio door jamb should be sealed to prevent further rot

#2 – settlement cracks in basement concrete foundation should be inspected, filled and sealed

#3 – check to make sure that all storm windows are completely sealed to prevent air infiltration and debris/insect collection between windows.

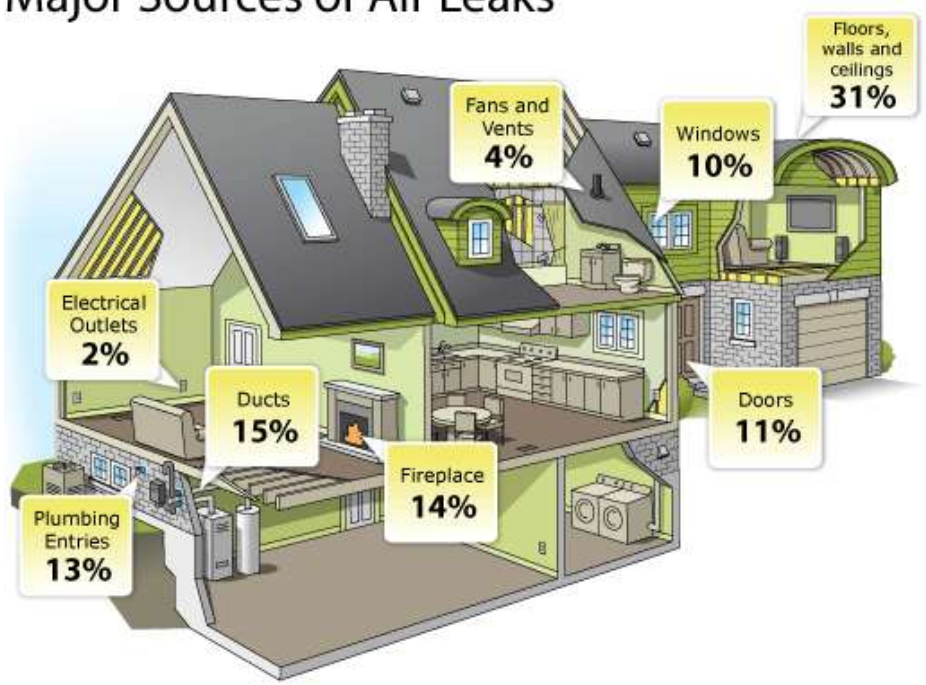


#4 – caulk at outdoor windows should be renewed to keep out water, insects, and debris (for more information, see “Windows and Doors” section)

#5 – lastly, cover outdoor A/C units with a durable fit tarp through the winter to prevent rust and extend life.

b.) Air Leakage

Although every home needs to have some air exchange with the outside in order to maintain a safe and healthy indoor air quality (IAQ), most older homes have far more air exchange than is necessary or desirable. All other factors being equal, a leaky home will always have higher heating and cooling bills than a tighter home of the same size. Excessive air exchange may also lead to problems with moisture, mold, insects, and contaminants, since moisture and particles can also travel through air gaps. The chart below shows typical levels of air leaks in a typical American home.



Data Source: U.S. Department of Energy Savers - Stopping Air Leaks
Image source: InsulationSmart.com

Blower Door Testing Results

Blower door testing was conducted on your house to establish how much air leakage your house has compared to a widely established ventilation standard (ASHRAE 62-89), which takes into consideration your home's volume, number of stories, and climate. The numbers on the left-hand side of the measuring stick indicate cubic feet of air loss, per minute, at a depressurization of -50 Pascals (pa). If your home's measured air loss is above the "Upper Leakage Limit," this indicates that your home is wasting energy through excess leakiness. Please note that your home should not be tightened below the "Lower Leakage Limit" for health reasons. Please also note that you should not enact any air tightening measures without first checking any combustion appliances for backdrafting of harmful combustion gases.

→ **9640 CFM_{50}** **Your Home's Measured Air Loss**

→ **4313 CFM_{50}** **"Optimal" Leakage Limit for your Home**

- The house's calculated air leakage value means that the house has 233% of the air leakage of the ideal upper limit for a house of this size and type.
- Stated differently, the house should become about 55% tighter to bring it into line with accepted ventilation standards.

A typical household can save approximately $50-100/month in utility bills for every 1,000 CFM of air leakage reduced, and your comfort will continuously improve until you reach the ideal upper limit for air leakage. The average air sealing job will lower your CFM_{50} score by 20-25%. Naturally, results depend on a variety of factors and will differ from house to house.

Air Leaks at Ceilings, Floors, and Walls
(Average US Home: 31% of Total Air Leakage)[2]

The following sections detail and explain some of the most pressing envelope efficiency issues. We do not report on every room or every area of leakage, only the most apparent opportunities for saving energy. Naturally, these recommendations are not intended as criticism of the building or even of its workmanship, but simply as professional assessments of the conditions we found.

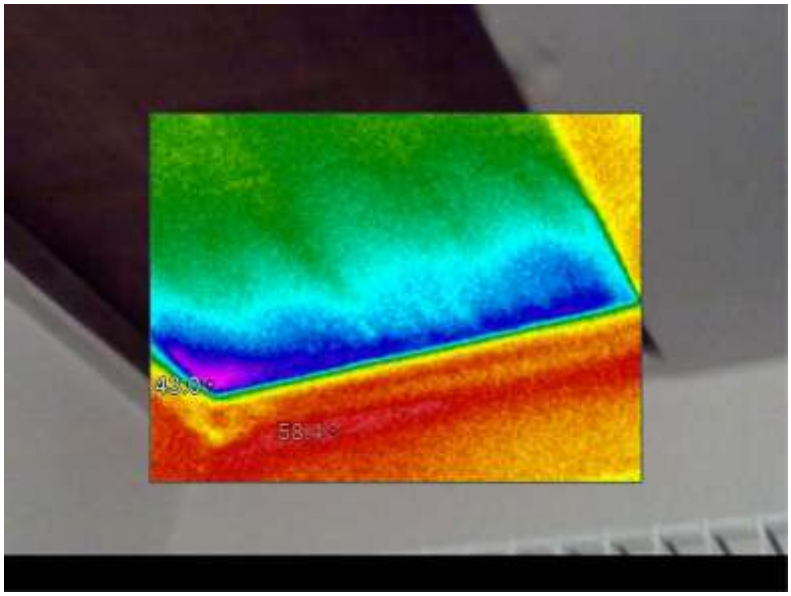
[2] Source: Department of Energy at http://www1.eere.energy.gov/consumer/tips/air_leaks.html

Ceilings

Issue #1: Uninsulated (Dropdown) Attic Hatch

Location/Description: Substantial leakage through attic hatches in master closet and studio.

Below: purple areas show cold air entering closet through gaps in attic hatch.



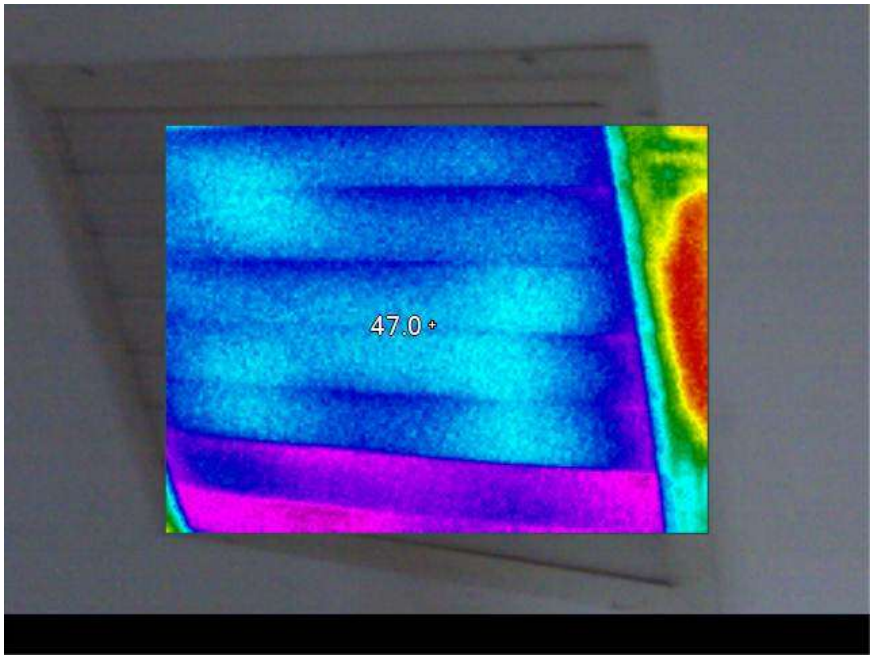
Recommendation: Insulate using custom-fit rigid board and fiberglass and gaskets as

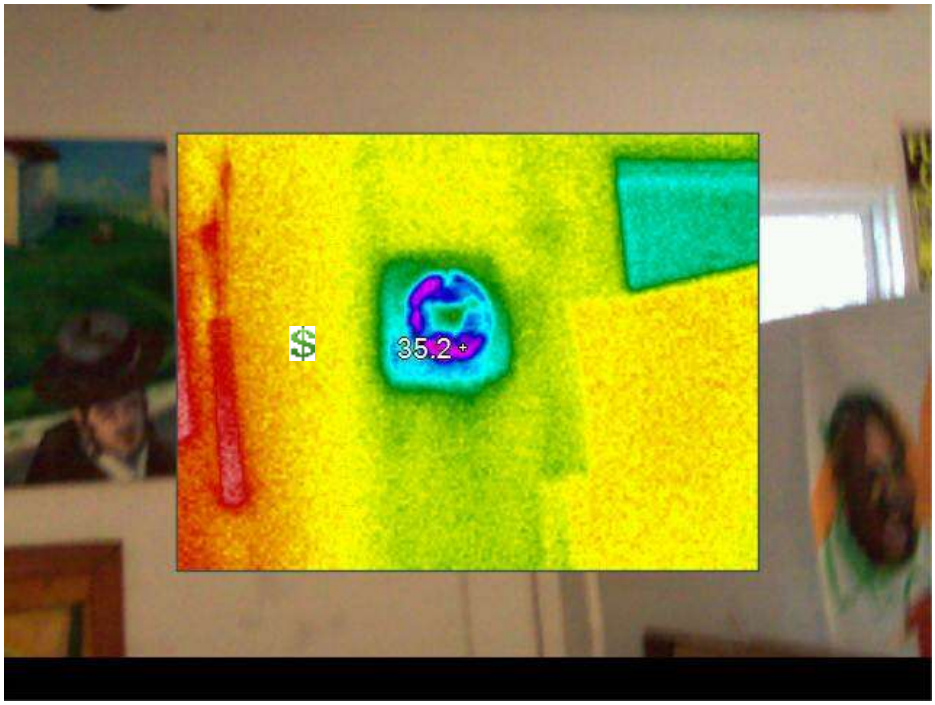
part of overall attic insulation job. Also consider installing an Attic Tent™ for the best quality long-term solution (a zip-up insulated canvas cover).

Priority: Moderate. *Cost:* $ to $$ if Attic Tent installed

Issue #2: Summer Vents

Location/Description: All fan openings should be covered in winter with reusable seals to prevent cold air infiltration into living spaces.

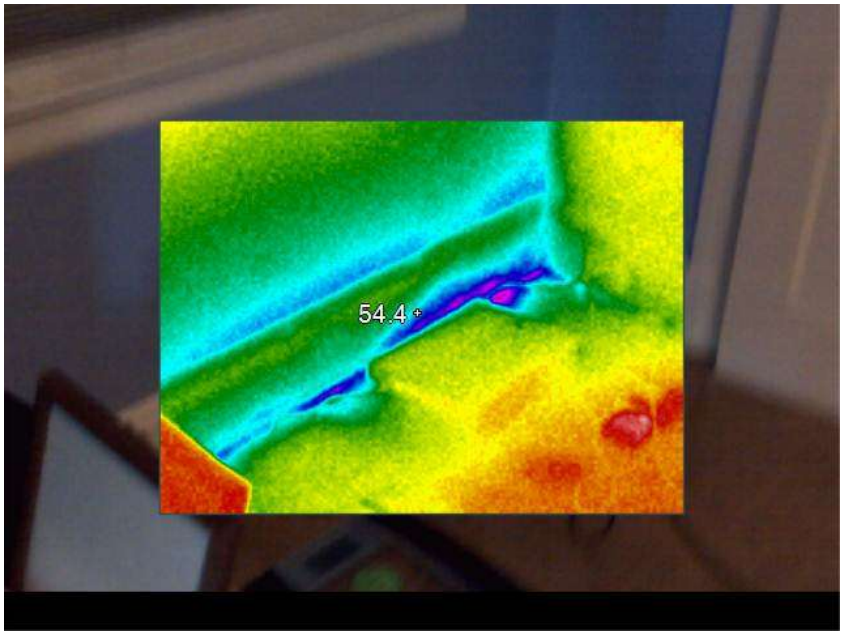




Floors and Walls

Issue #2: Floor Trim/Molding throughout House

Cold air infiltrating perimeter of home through slight gap in floor trim/molding (infrared picture below is from another structure but is meant to be indicative of what we would expect to find in your home).



Recommendation: Caulk all baseboard trim and molding runs throughout perimeter of each level.

Priority: Moderate. *Cost:* $

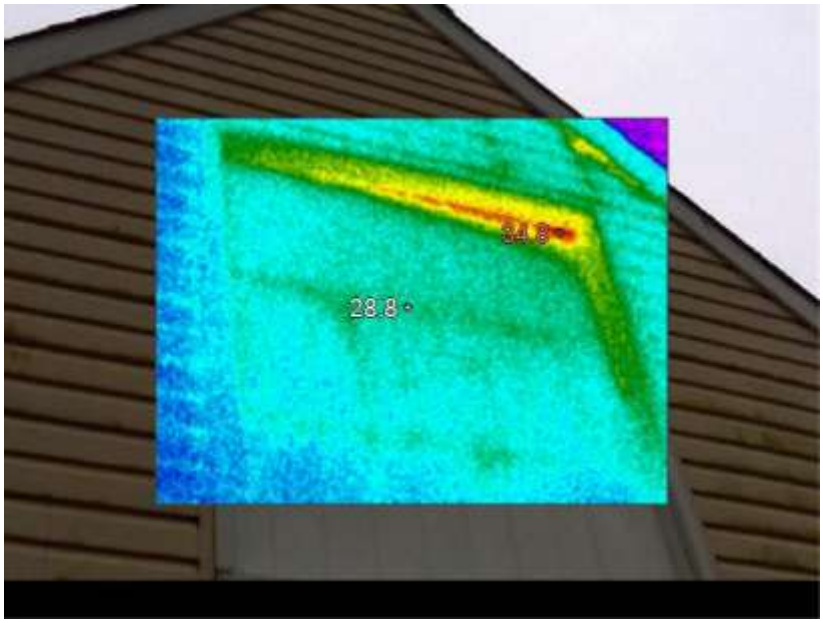
Air Leaks at Doors and Windows
(Average US Home: 21% of Total Air Leakage)

While most of your double-pane windows are fairly tight with the storm windows, special attention should be paid to the basement windows. You may also wish to consider installing storm doors.

Doors

Below: a visible air gap at door is letting out conditioned air

Below: weatherstripping at studio door is deteriorating and could be tightened or replaced.



Above: Gaps in barn door (attic) should be filled with weatherstripping as part of work in attic to achieve more comfortable studio.

<u>Recommendation</u>: Weatherstrip doors with high-quality foam weatherstripping and a 3-fold sweep at door thresholds for a tighter seal.

<u>Priority</u>: Moderate. *<u>Cost</u>:* $

Windows

Above: The basement windows seem to be the leakiest in the entire house and should be given first priority for caulking. The visible air gaps can allow insects (i.e. - stinkbugs) into house.

Thermal insulating blinds will also increase the performance of your windows (see recommendation in section 4e.)

Recommendation: Thorough indoor and outdoor caulking to achieve tighter seal.
Priority: Moderate. *Cost:* $$

Air Leaks at Fireplaces

(Average US Home: 14% of Total Air Leakage)

Above: gap at chimney connection should also be sealed as part of exterior caulking job.

Recommendation:
Your fireplaces themselves were not especially leaky, but to properly seal it when not in.use,,insert a removable "Chimney Balloon" to seal the flue and stop draft in and out of chimney. The chimney-siding connections should be thoroughly caulked as part of exterior sealing job.
Priority: Moderate. *Cost:* $

*Other Specific Air Leaks

(Average US Home: Leaks at Electrical Outlets, Ducts, and Plumbing Penetrations Account for 34% of Total Air Leakage)

Issue #1: Air Infiltration into home through leaks behind front porch soffit

Description: Air is entering the home from open gaps behind the porch soffit, which is infiltrating the ceiling above kitchen and downstairs bathroom.

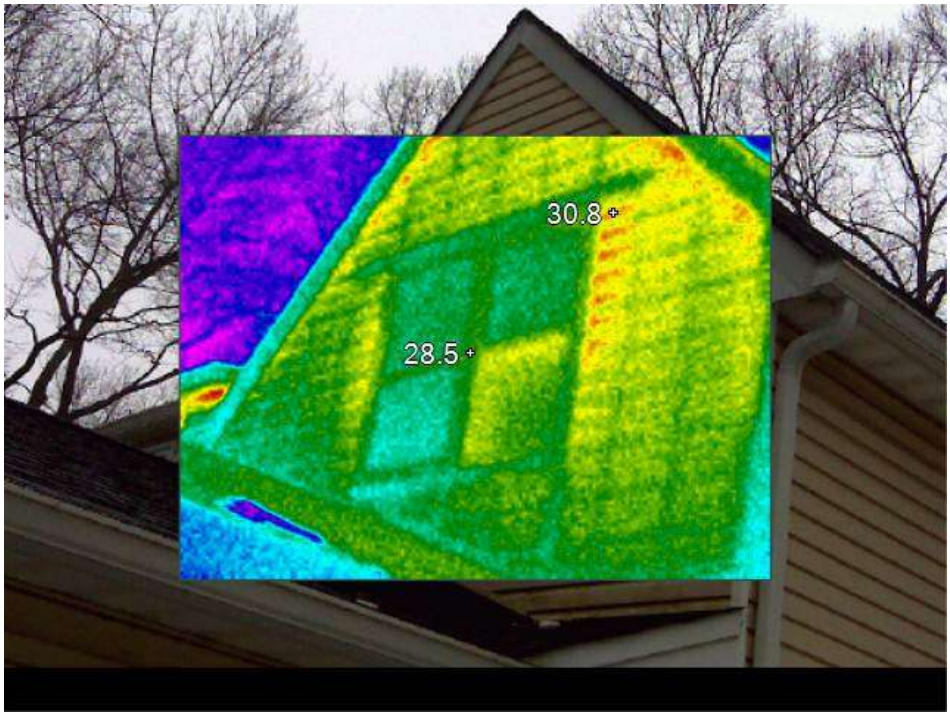
Recommendation: Remove soffits, seal air-gaps using rigid foam board and spray foam, stuff fiberglass batts into open areas, and reattach soffits. Work should also include insulating accessible pipe runs in bathroom (pipe that had frozen).

Priority: Very *High.* *Cost:* $$

Issue #2: Air Infiltration into living spaces through poorly sealed and insulated side wall over living room (with wood stove)

Description: An entire upper wall above the living room-sunroom connection (covered with interior siding) was never properly sealed and insulated and is extremely leaky. There is also substantial leakage into main living spaces through gaps in the floor.

Leakage from the uninsulated wall in the living room attic, adjacent to sunroom (above), is visible below as heat escaping (red).

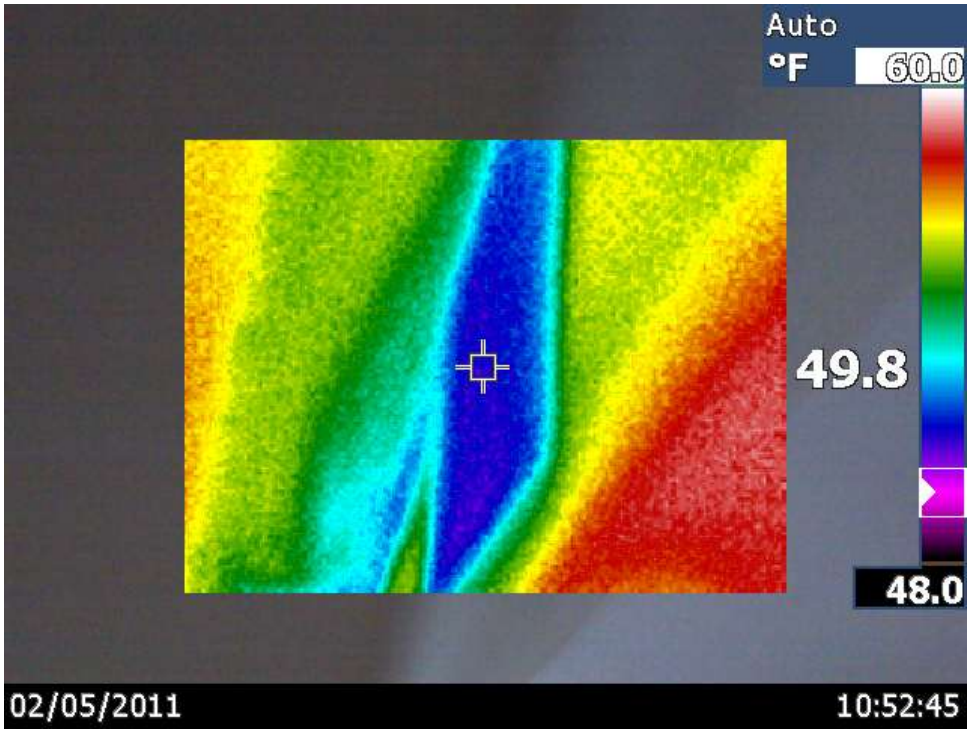


Recommendation: thoroughly seal gaps and cracks in floor using spray foam and properly insulate side wall to min R-19, using fiberglass batts (and spray foam at any gaps and cracks)

Priority: Very *High.* *Cost:* $$$

Issue #3: Air Infiltration into home and stairwell through leaks and missing insulation panel in bedroom closet

Description: A missing insulation panel in the side attic (adjacent to master bedroom; access through bedroom closet) and air gaps in the attic floor are the source of leakage down through the stairwell.



Above: missing panel visible as blue (colder) air leakage in IR picture above.

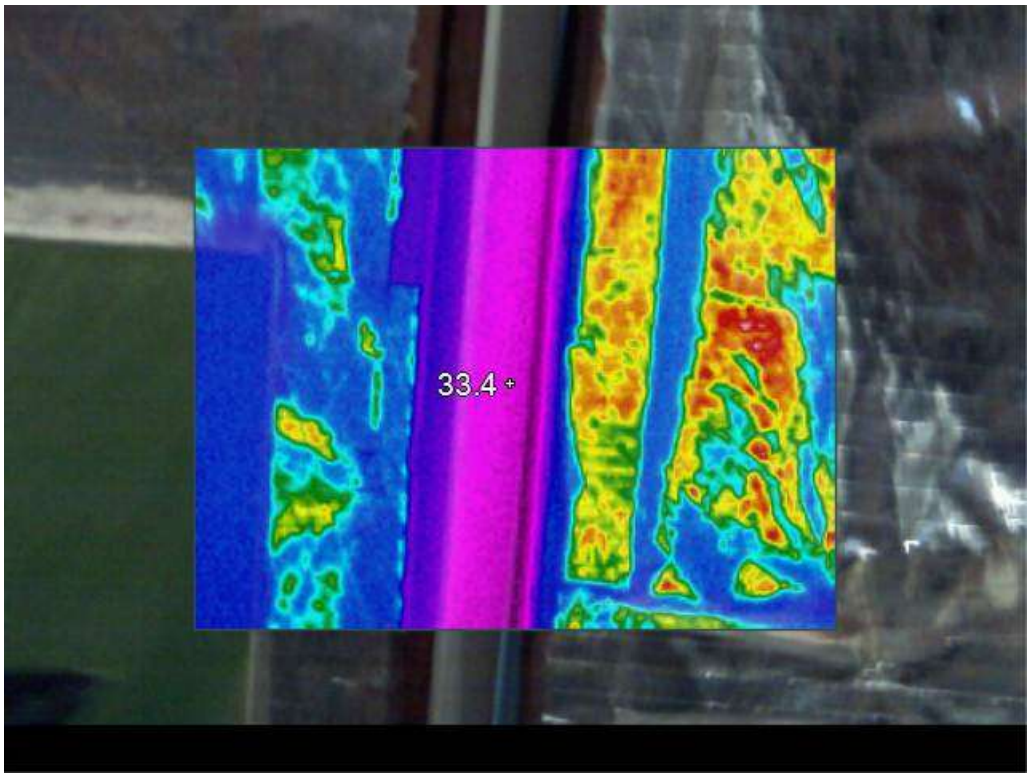
Recommendation: Insulate missing panel using custom-fit rigid board and gaskets; thoroughly seal any air gaps (including the visible gap around plumbing chase in picture above).
Priority: High. *Cost:* $

Issue #4: Air Infiltration into studio through leaks in attic ceiling above studio

Description: Excessive leakage into studio through 3 main gaps: i.) deficient weatherstripping at barn door; ii.) no insulation of drop-down attic hatch; and iii.) air leakage at the studio-living room attic connection.

Recommendation: Air seal all 3 areas using weatherstripping and spray foam.
Priority: Medium (but direct effect on comfort of studio). *Cost:* $$

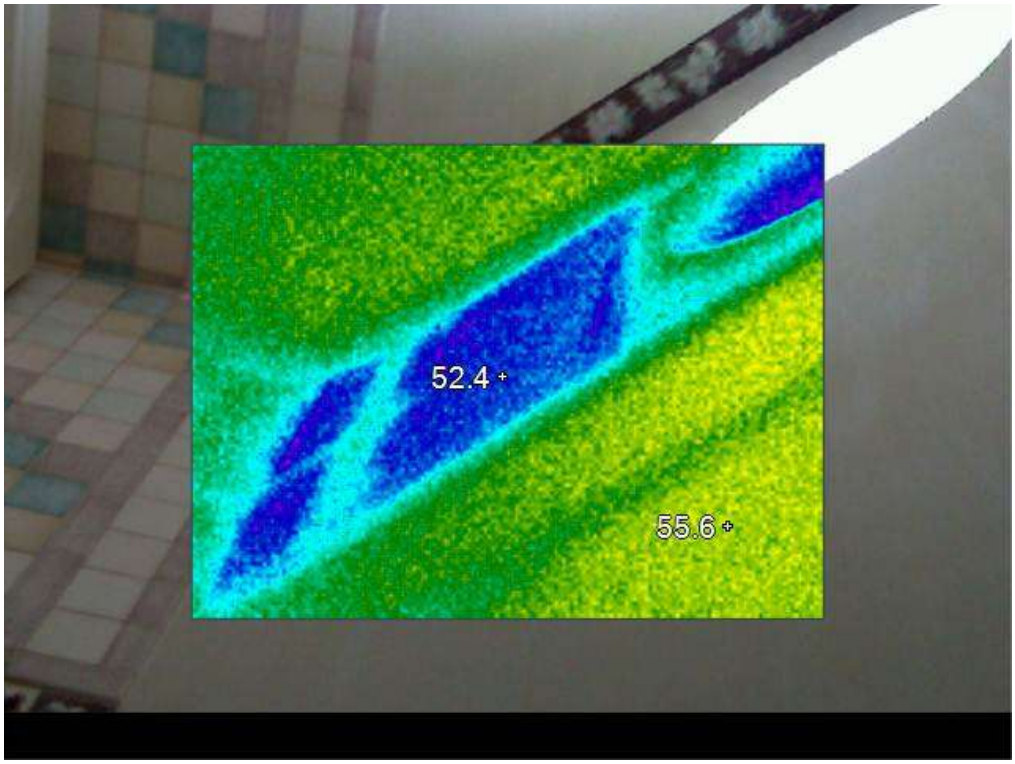
Above and below: cold air entering the perimeter of the attic door above studio; door should be weatherstripped to achieve more constant attic temperatures.



Recommendation: Insulate using custom-fit rigid board and gaskets.
Priority: Low. *Cost:* $

Issue #5: Air Infiltration into bathroom through leak in missing insulation panel over bathtub

Description: One other area – under the window above the master bathtub -- was also discovered to be missing insulation.



<u>Recommendation</u>: Inject spray foam to fill crevice left by missing insulation panel.
<u>Priority</u>: Low. *<u>Cost</u>:* $$

c.) Insulation

Stopping excess air transfer is a vital part of achieving an energy-efficient home, but it is insulation which stops heat transfer between the home and the outdoors. Typically, airsealing measures should be given first priority, but you will obtain a more comfortable home by airsealing in conjunction with insulation work. Some, but not all, types of insulation (i.e. – spray foam) do "double duty" in both airsealing and insulating. Many older homes do not have sufficient insulation to meet modern building envelope efficiency measures, especially since the insulation value of fiberglass (and, to a lesser extent, cellulose) tends to degrade over time.

Attic Insulation

The following graphic is designed to help you measure your attic insulation performance compared to the recommended value for newly constructed homes in Maryland.

→ **R-49** **Recommended minimum insulation level for new construction in Maryland (up to R-60)**
(U.S. Department of Energy)

→ **R-38** **Required insulation level for new construction**
(Maryland building codes)

→ **R-19** **<u>Your Home's Actual Insulation level (both main upper attic and side attic over studio</u>**
(6" fiberglass batts, slumping in areas)

As apparent from the graph above, your attics is somewhat underinsulated. However, access to the upper attic is difficult and airsealing, not adding additional base insulation, will be the more cost-effective way to improve the energy efficiency of your home.

Basement/Rim Joist Insulation

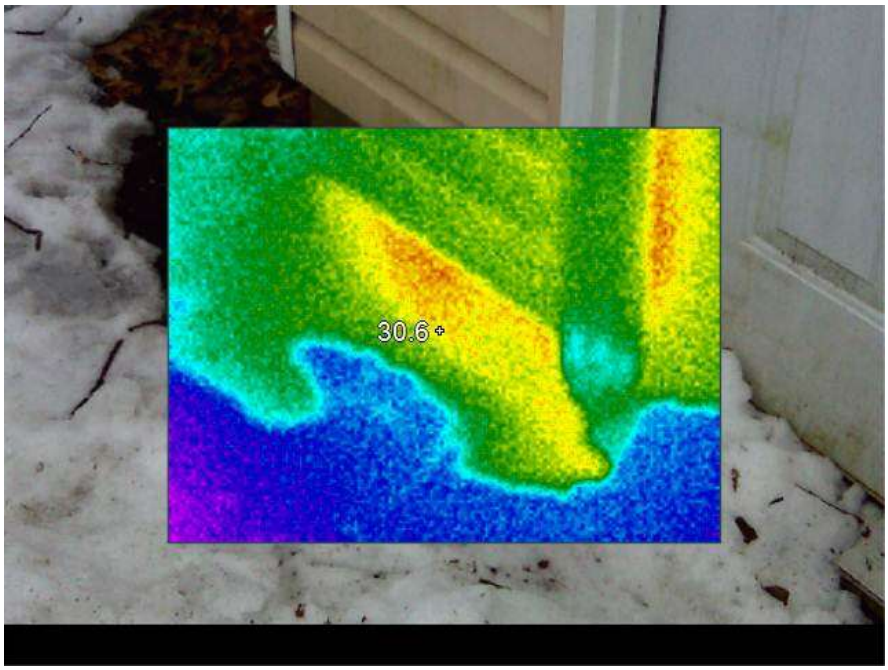
The following graphic is designed to help you measure your basement/rim joist insulation performance compared to the recommended value for newly constructed homes.

→ **R-15** **Recommended Insulation level for new construction**
(U.S. Department of Energy) **And Airsealed**

→ **R-13** **Required Insulation level for new construction**
(Maryland building codes – Basement Walls)

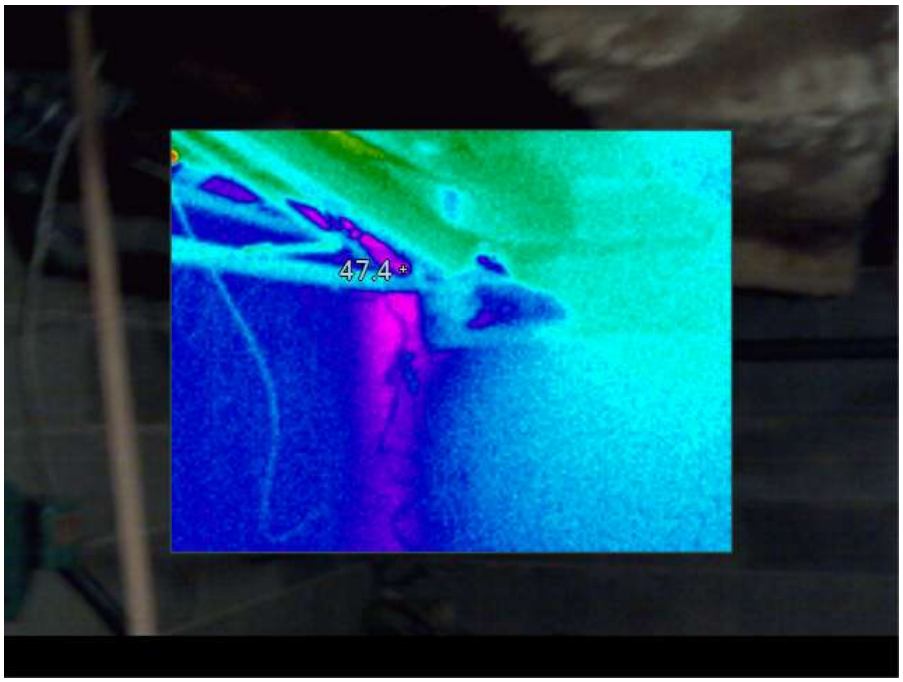
→ **R-1.5** **<u>Your Home's Installed Insulation level</u>**
(solid masonry with major air gaps)
Not Airsealed

Because your basement rim joist is not airsealed, a large amount of unconditioned outside air can easily pass through the wooden beam into the house.



Above: heat loss from the basement foundation is visible to the IR camera from outside the building.

Below: This pattern of cold air infiltration into basement rim joist gaps is typical of most homes constructed without an insulated rim joist or basement walls.
(IR images are from other structures and are only representative).



Above: though the crawlspace is well-insulated, it is important to thoroughly air-seal the perimeter of this space

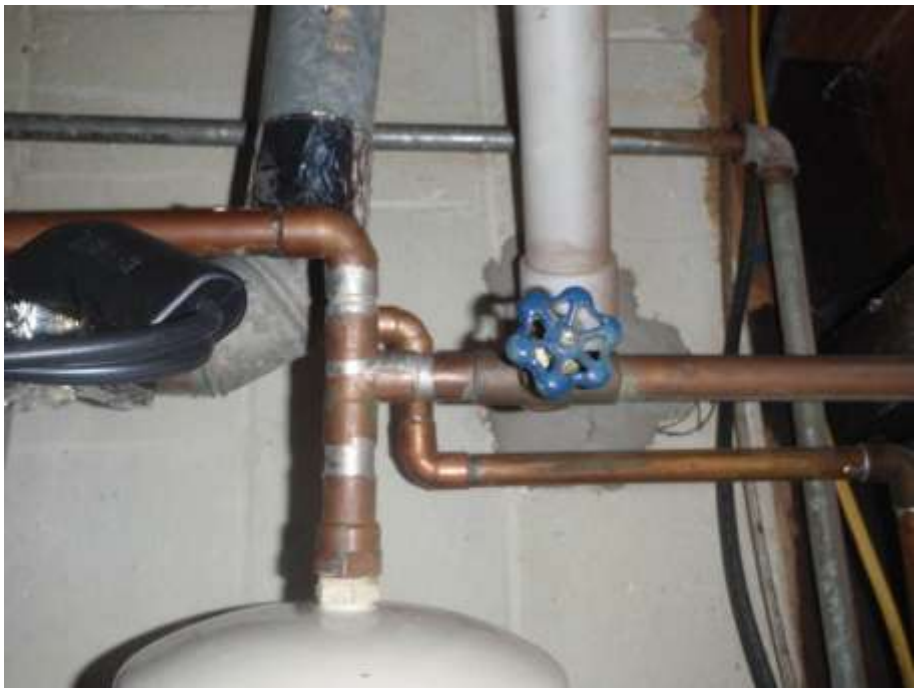
Above: as part of exterior caulking job, this crack in brick, which lets out conditioned air from basement, should be sealed

d.) HVAC Systems

The efficiency of your heat pump and furnace are reasonably high and your energy retrofitting dollars are almost certainly better spent in insulating/tightening your home than in upgrading your system. However, we do recommend cleaning, tuning and servicing your current system to make sure that it is running at peak efficiency. A system tune-up will help your system to perform more efficiently by adjusting your refrigerant charge, insulating refrigerant lines, and cleaning essential parts in the heat pump. The line filter may also need to be changed.

e.) Water Heating and Water Conservation

Savings Opportunity #1: Wrapping your gas hot water heater and wrapping all accessible pipes with insulating wrap (min. R-4) will minimize standby loss and heat your water more efficiently (IR picture below is from another system and is merely representative).

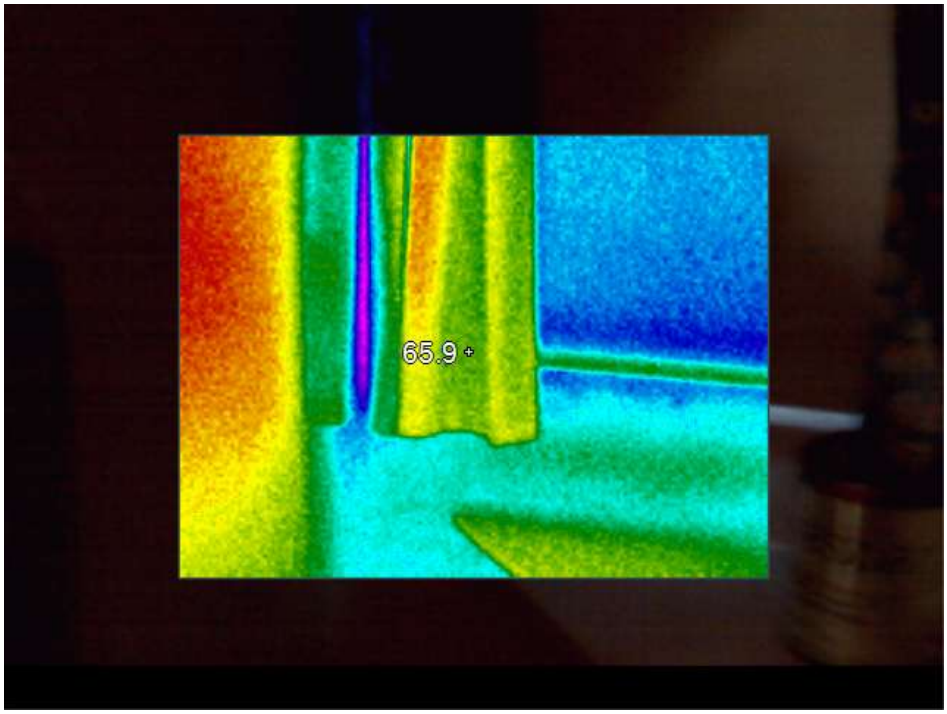


Savings Opportunity #2: Continuing to upgrade to low-flow shower fixtures and faucet aerators can reduce your water consumption and baseload hot water requirements ((IR picture below is from another system and is merely representative).

f.) Other General Baseload Utility Issues

Savings Opportunity #1: You can continue to convert your incandescent bulbs to CFLs (now available in a great variety of shapes and sizes, including dimmable) and even LEDs for improved baseload savings.

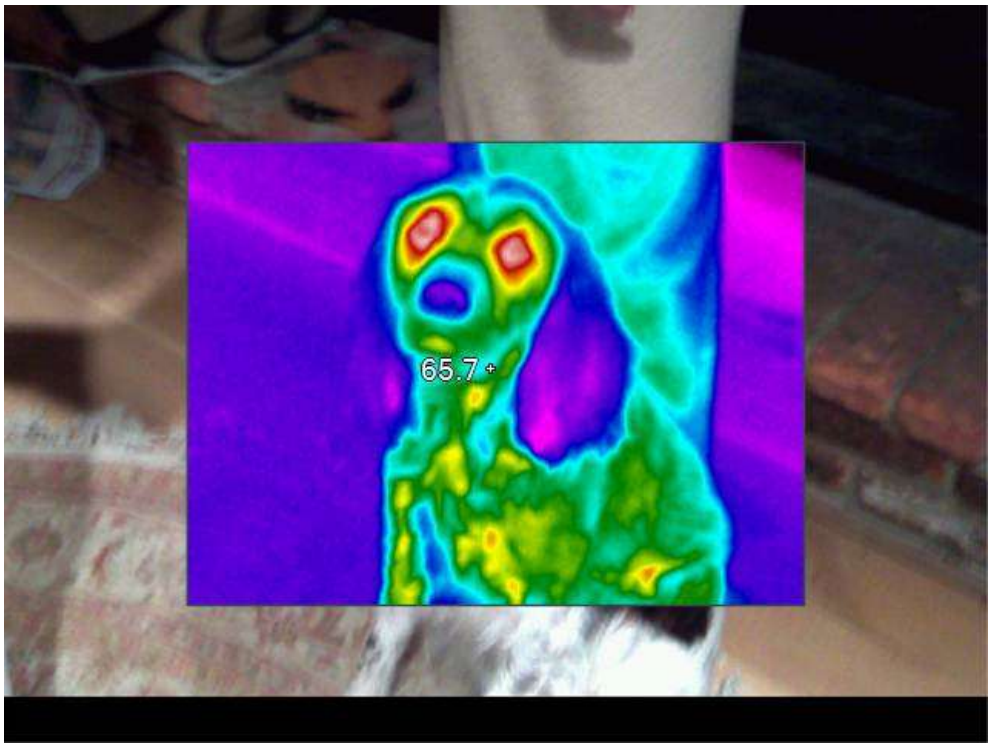
Savings Opportunity #2: You can continue to install thermally efficient blinds at all windows for improved insulation (below you can see a 10 ° surface temperature difference in the curtain and window glass).



5.) Additional Resources

a.) Just for Fun

The following thermal anomalies were also detected in the course of the inspection.



b.) Understanding Infrared Thermography

The material in the box immediately below, is adapted from the U.S. Department of Energy's "Energy Savers" website and can be accessed at: http://www.energysavers.gov/your_home:

Thermographic Inspections

A thermograpic inspection is a form of nondestructive testing used to measure the heat pattern of a building, boat, person, animal, or just about anything with a temperature above absolute zero. Energy auditors may use thermography—or infrared scanning—to detect thermal defects and air leakage in building envelopes.

How They Work

Thermography measures surface temperatures by using infrared video and still cameras. These tools see light that is in the heat spectrum. Images on the video or film record the temperature variations of the building's skin, ranging from white for warm regions to black for cooler areas. The resulting images help the auditor determine whether insulation is needed. They also serve as a quality control tool, to ensure that insulation has been installed correctly.

A thermographic inspection is either an interior or exterior survey. The energy auditor decides which method would give the best results under certain weather conditions. Interior scans are more common, because warm air escaping from a building does not always move through the walls in a straight line. Heat loss detected in one area of the outside wall might originate at some other location on the inside of the wall. Also, it is harder to detect temperature differences on the outside surface of the building during windy weather. Because of this difficulty, interior surveys are generally more accurate because they benefit from reduced air movement.

Thermographic scans are also commonly used with a blower door test running. The blower door helps exaggerate air leaking through defects in the building shell. Such air leaks appear as black streaks in the infrared camera's viewfinder.

Thermography uses specially designed infrared video or still cameras to make images (called thermograms) that show surface heat variations. This technology has a number of applications. Thermograms of electrical systems can detect abnormally hot electrical connections or components. Thermograms of mechanical systems can detect the heat created by excessive friction. Energy auditors use thermography as a tool to help detect heat losses and air leakage in building envelopes.

Infrared scanning allows energy auditors to check the effectiveness of insulation in a building's construction. The resulting thermograms help auditors determine whether a building needs insulation and where in the building it should go. Because wet insulation conducts heat faster than dry insulation, thermographic scans of roofs can often detect roof leaks.

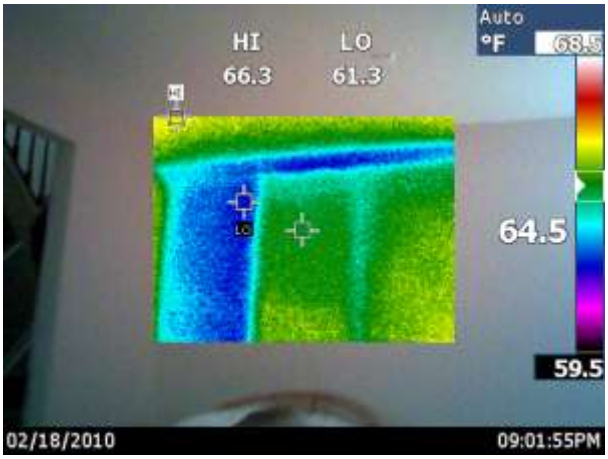
In addition to using thermography during an energy audit, you should have a scan done before purchasing a house; even new houses can have defects in their thermal envelopes. You may wish to include a clause in the contract requiring a thermographic scan of the house. A thermographic scan performed by a certified technician is usually accurate enough to use as documentation in court proceedings.

The energy auditor may use one of several types of infrared sensing devices in an on-site inspection.

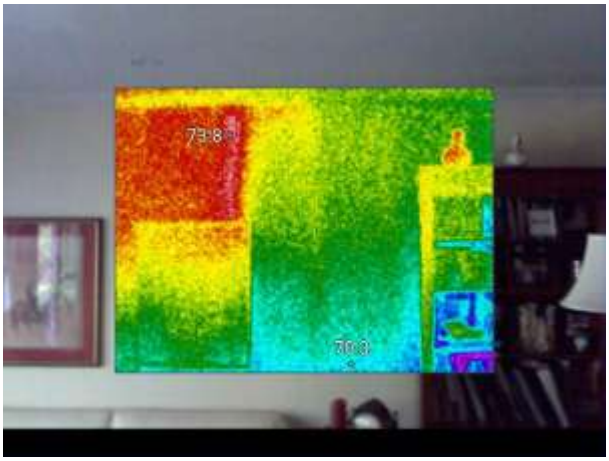
A spot radiometer (also called a point radiometer) is the simplest. It measures radiation one spot at a time, with a simple meter reading showing the temperature of a given spot. The auditor pans the area with the device and notes the differences in temperature. A thermal line scanner shows radiant temperature viewed along a line. The thermogram shows the line scan superimposed over a picture of the panned area. This process shows temperature variations along the line. The most accurate thermographic inspection device is a thermal imaging camera, which produces a 2-dimensional thermal picture of an area showing heat leakage. Spot radiometers and thermal line scanners do not provide the necessary detail for a complete home energy audit. Infrared film used in a conventional camera is not sensitive enough to detect heat loss.

Summer and Winter Infrared Interpretations

Infrared inspections require on a temperature differential (ΔT) between the outdoor and indoor ambient temperatures. Because ΔT tends to be greatest in winter, most of our inspections are done during the cooler months. However, Zerodraft's sensitive IR camera enables us to take inspections in all seasons – one should simply note that summer IR images will tend to look somewhat different than winter IR images.



Typical WINTER IR Image


Typical SUMMER IR Image

In winter, the areas of missing insulation are cooler than the surrounding wall and are translated into cooler colors on our camera (usually blue or purple). Conversely, warmer spots show up as warmer colors (typically red and yellow). In summer, on the other hand, the areas of missing insulation do a poorer job of keeping out the warm outdoor area, are warmer than the surrounding wall, and show up as lighter spots on our camera.

c.) Taking Action

The following guidelines will be helpful in understanding the types of products, applications, and services that are available to mitigate the existing energy deficiencies. We recommend addressing issues in the general order of this report: first safety or building maintenance (including moisture) concerns, then air sealing *before* adding any new insulation. In most cases, this is the most cost-effective solution, in the same way that closing up a partially unzipped down jacket is simpler and cheaper than replacing the down.

ZERODRAFT Maryland, a full-service Energy Efficiency Consultancy, can perform or manage the remedial measures outlined in this report, and, additionally, provide a Master Plan for undertaking successive levels of those measures required to further increase energy savings while promoting the health and comfort of the occupants. Should you desire additional information, please contact us at 410-321-5936.