ASSESSING YOUR HOME'S ENERGY FITNESS

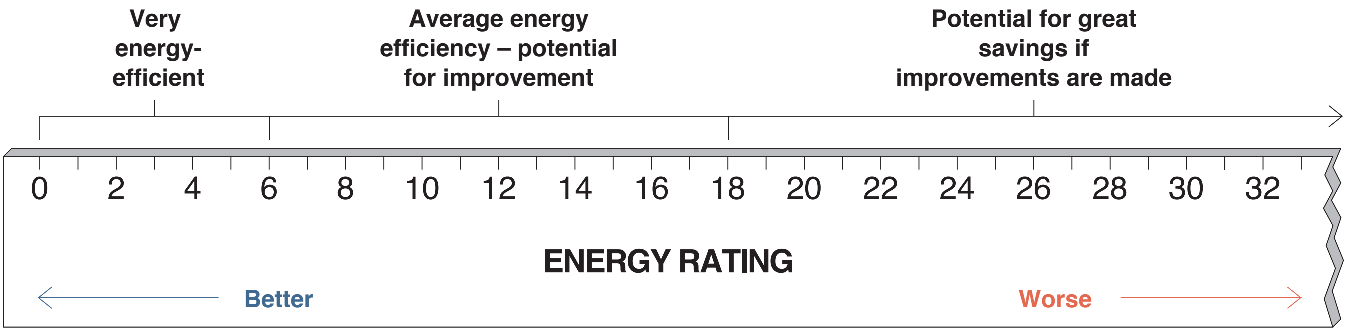

Figure 1-1 - Home Energy Rating Yardstick

Is your home as energy-efficient as it could be? If not, then how can it be improved? This chapter describes a step-by-step process to answer both these questions. It begins with a simple way to rate your home's energy efficiency using past fuel bills, followed by a home inspection procedure to identify major opportunities for reducing energy costs through improved efficiency.

You may find that you already lead an energy-efficient life and that there aren't many improvements to be made. If so, then congratulations. Nonetheless, we suggest that before relegating this book to the top shelf, you at least skim through the rest of the chapters. Chances are there are some useful and practical recommendations that can help you improve home comfort and health, and possibly further improve energy efficiency.

Your House as a System

Before you begin the process of evaluating your home's energy efficiency or have a professional energy audit performed, it is important to understand that your house operates as a system. Your house is a system comprised of many different interactive components that must work together in order for your home to perform properly. A house system has three main parts: the shell of the house, the mechanical equipment, and the people who live inside the house. The shell of the house keeps cold air out and warm air from escaping in the winter. It does the opposite in the summer - hot air out and cool air in. The mechanical equipment consists of machines that control the indoor environment (furnaces, air conditioners, fans, etc.) plus machines that perform other necessary tasks (refrigerators, stoves, computers, etc.). The people control the shell and the equipment through their behavior and activity.

Because your house is a system, you and other occupants must engage in systems thinking and understand that your actions control the movement of heat, air, and moisture. Your lifestyle and decisions, your maintenance of the shell and operation of mechanical equipment, will impact each component and effect the energy performance of the house. For instance, if you increase the level of insulation in your attic it will make your home warmer and your utility bill lower but (if you do not seal thermal bypasses) may create moisture problems in the attic. If you install low-flow showerheads but people in the home still take 20-minute showers, energy use for heating water will still be high. If you install energy efficient windows but leave the windows open when the heat is on, your heating bills will still be high. Your home is a system. Be a systems thinker, use good common sense, and operate your home with the knowledge that the components of your house are interactive and must work together to achieve real energy efficiency.

How Does Your Home Rate?

Even if you are able to obtain the services of a professional energy auditor and/or contractor it is still very important that you perform your own energy examination of the home. The best way to assess your home's overall energy efficiency is to calculate the amount of energy consumed over an average year and then compare your energy usage with similar homes. Using past fuel bills, you

Home Energy Rating Form

Column 1 Fuel Type	Column 2 Total Annual Consumption		Column 3 Conversion Factor		Column 4 Total (in million Btus)
Electricity	kWh	x	0.003413	=	
Natural gas	ccf	x	0.1	=	
Propane	gal.	x	0.096	=	
#2 Fuel oil	gal.	x	0.139	=	
Kerosene	gal.	x	0.135	=	
Wood (Hardwood)	cords	x	24	=	
Coal	tons	x	26	=	

+

Box A: ______ Million BTU

1st Floor Area ______ + 2nd Floor Area ______ + Other Heated Area ______ = Box B: ______ Square Feet

BOX A ÷ BOX B = Box C: ______ MBTU/Square Foot

Box C ÷ Box D (Climate Factor) x 1,000,000 = Box E: ______ Home Energy Rating

Table 1-1-Climate Factors

	With A.C.	Without A.C.
Norfolk	4904	3446
Richmond	5296	3960
Washington – Dulles	5974	5004
Roanoke	5400	4315
Blacksburg	6092	5507
Danville	5240	3856
Average	5484	4348

can use the following simple procedure to calculate your "Home Energy Rating."

The "Home Energy Rating" is a measure of how efficiently your home operates. The lower the Home Energy Rating, the better. If your rating is less than 6, your home ranks among the best new "super-insulated" homes and there is probably little that can be done to significantly improve energy efficiency. Between 6 and 18 is an "average" rating. If your rating is in that range, there are most likely a number of energy-saving improvements that you should consider. If your Home Energy Rating is above 18, there are definitely numerous improvements that you can

Home Energy Rating Form - **SAMPLE**

Column 1 Fuel Type	Column 2 Total Annual Consumption		Column 3 Conversion Factor		Column 4 Total (in million Btus)
Electricity	**6000 kWh**	x	0.003413	=	**20.478**
Natural gas	ccf	x	0.1	=	
Propane	gal.	x	0.096	=	
#2 Fuel oil	**750 gal.**	x	0.139	=	**104.25**
Kerosene	gal.	x	0.135	=	
Wood (Hardwood)	cords	x	24	=	
Coal	tons	x	26	=	

+ Box A **124.728** Million BTU

1st Floor Area **960** + 2nd Floor Area + Other Heated Area = Box B **960** Square Feet

BOX A ÷ BOX B = Box C **.129925** MBTU/Square Foot

Box C **.129925** MBTU/Square Foot / Box D **5296** Climate Factor x 1,000,000 = Box E **24.5** Home Energy Rating

Table 1-1- Climate Factors

	With A.C.	Without A.C.
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Average	5484	4348

make to achieve energy efficiency and significantly reduce your annual energy costs.

Calculating Your Home Energy Rating

To calculate your Home Energy Rating, you will need one full year of past bills for each type of fuel used in your home. The quantity purchased should be clearly marked on each bill. For electricity, it will be listed in kilowatt hours (kWh); for natural gas, it will be in ccf or therms; fuel oil, kerosene and propane will be in gallons; and wood will be listed in cords.

The following procedure converts each quantity of fuel into Btu's, the standard unit of energy, (see sidebar "Know your Btu's" on page 16 for definition), and then adjusts for house size and climate to calculate your Home Energy Rating.

Use the Home Energy Rating form to do the following calculations. A sample form is provided to help you with this process.

Step 1 - Add up the total annual quantity for each fuel type. Write down the totals in Column 2.

Step 2 - Multiply each number in Column 2 by the "conversion factors" in Column 3. Write your answers in Column 4. This step converts from common fuel units to million Btu's.

Step 3 - Add up the values in Column 4 and write your total in Box A. This is your total energy consumption, measured in "million Btu's."

Step 4 - Estimate the total floor area of your home. Include all floors, but don't include unheated basements or attics. Write the total floor area, in square feet, in Box B.

Step 5 - Divide your total annual energy use (Box A) by the total floor area of your home (Box B) and write the answer in Box C. This is your total energy use per square foot (MBtu/Square foot).

Step 6 - Find the "Climate Factor" for your geographic region in Table 1-1. If your home is air conditioned, select the climate factor in the middle column (with A/C). If you don't have air conditioning, select the climate factor in the right column (without A/C). Write your climate factor in Box D.

Step 7 - Finally divide the figure in Box C by your climate factor (Box D), multiply by 1,000,000, and write the answer in Box E. This is your "Home Energy Rating". That's it. To assess your home's energy efficiency and potential for improvement, find where your Home Energy Rating falls on the Yardstick in Figure 1-1 on page 1.

The home energy rating form only checks the amount of energy used by your home - it doesn't consider how expensive that energy is. The same amount of energy could cost very little if coming from wood, more if coming from natural gas, and still more if coming from electricity. (See "Know your Btu's" (page 16) and the fuel prices in Table 5-2 (page 72).) In some cases, you can save money not only by increasing your home's energy efficiency but by changing to a less expensive energy source.

Inspecting For Flaws

If your Home Energy Rating is above 15, there are probably improvements that can be made either to the house or the way that you are operating it. The next section describes a brief inspection process to identify the major energy conservation opportunities in your home. It consists of a series of questions that you should answer about your attic, windows, heating system, etc. If the answer to any of these questions is "yes", then you may be able to make improvements. The text outlines some specific actions you can take, and refers you to the appropriate chapters for more information. You can use the checklist provided on the following page to record your observations.

Up into the attic

The attic is often the most important part of a home energy inspection. Because it is outside of the conditioned space, any heat that leaks into the attic is lost from the house. This is created by the stack effect, which is the tendency for warm buoyant air to rise and leak out of the top of the house and be replaced by colder outside air entering from the bottom of the house. This happens because of pressure differences that occur in the house and represents a very basic and fundamental reason for heat loss and air leakage in the home.

To inspect the attic thoroughly, you should have a pair of gloves, a ruler, a flashlight, and a dust mask.

Are there any pathways where air could leak up from the living space or basement?

One of the major heat loss pathways in a house is air leakage through the attic floor. Finding and sealing attic floor air leakage is often a challenge, but it typically is one of the most cost-effective energy improvements one can make. A major source of air leakage can occur in one and a half story homes that contain knee walls that separate the attic from the living space. Be sure that the joint at the base of the knee wall - where the floor of the conditioned space meets the unconditioned area - is sealed with a rigid air barrier.

Home Inspection Checklist

	QUESTIONS	NO	YES – Refer to CHAPTER 2	3	4	5	6
ATTIC	Are there any pathways where air could leak up from the living space?						
	Are there any chimney chases?						
	Are exterior and/or interior walls open at the top?						
	Is there enough insulation?						
LIVING SPACE	Do you have drafty spots?						
	Are there any single-glazed windows without storm windows?						
	Do the windows have any cracked or broken glass?						
	Do the windows have cracked or missing putty?						
	Do the windows rattle?						
	Are there any visible gaps around window frames?						
	Is there moisture condensation on windows in winter?						
	Are the doors leaky?						
	Do the walls need insulation?						
BASEMENT OR CRAWL SPACE	Are the walls insulated?						
	Does the crawl space need to be insulated?						
	Is there air leakage at the top of the basement wall?						
	Are there any cracks or gaps in the basement walls and floor that would allow air leakage?						
HEATING AND COOLING SYSTEMS	Do ducts leak air?						
	Is your furnace filter dirty?						
	Is your system due for maintenance or a tune-up?						
	Is your chimney lined according to code requirements?						
	Are your chimney and vent pipes clean and unobstructed?						
	Do you use any unvented gas or oil heating appliances?						
	Is the outdoor unit of your air conditioner or heat pump in direct sunlight or blocked from freely circulating air?						
	Do you have UL-rated smoke and carbon monoxide detectors installed?						
WATER HEATER	Does the water heater tank need to be insulated?						
	Is the water temperature too high?						
	Do your water pipes need to be insulated?						
	Could your plumbing fixtures be more water-efficient?						
	Are any faucets in the house leaking?						

Sometimes referred to as "bypasses" because they bypass the insulation, attic air leakage spots are often difficult to find because they are underneath the insulation (refer to Thermal Bypasses - Chapter 2). One particularly common site for air leakage is through wiring and plumbing holes at the top of interior walls. Move the insulation aside to expose the attic floor just above the interior walls. Check for gaps around any wiring or plumbing penetrations.

One trick for spotting air leakage is to look for its tracks. Look for moisture stains on wood framing. Any moisture in the attic was probably carried there by air leakage. If there are batts on the floor, check their underside for dust marks -- another sign of air leakage from below.

Action : If you find air leakage pathways, they should be sealed. See Chapter 2.

Are exterior walls open at the top?

Many older homes were built with a framing technique called "balloon framing" in which the walls are left open at the top in the attic (as opposed to modern "platform framing" in which the walls are capped with "top plates"). Thus heat from all over the house enters the walls

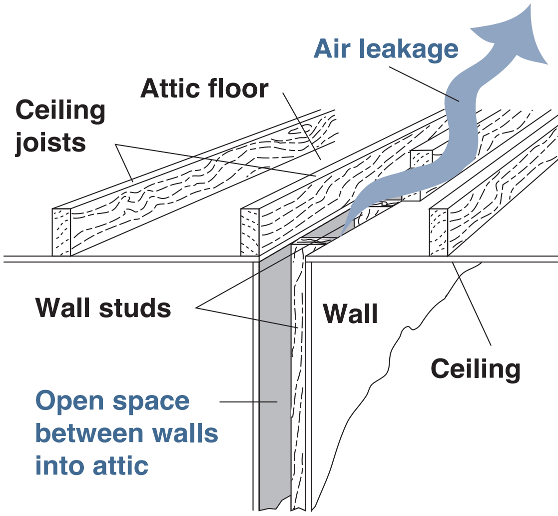


Figure 1-3 - With "balloon framing," open wall cavities allow air and heat to flow up into the attic.

and is dumped into the attic through the open tops. This is particularly problematic if the walls are hollow -- that is, un-insulated -- because the heat is able to move through the walls more easily.

Shine your flashlight down at the tops of interior and exterior walls. If you can see down into the wall, you have balloon framing.

Action: If your walls are open at the top, they should be sealed, whether or not they are insulated. See

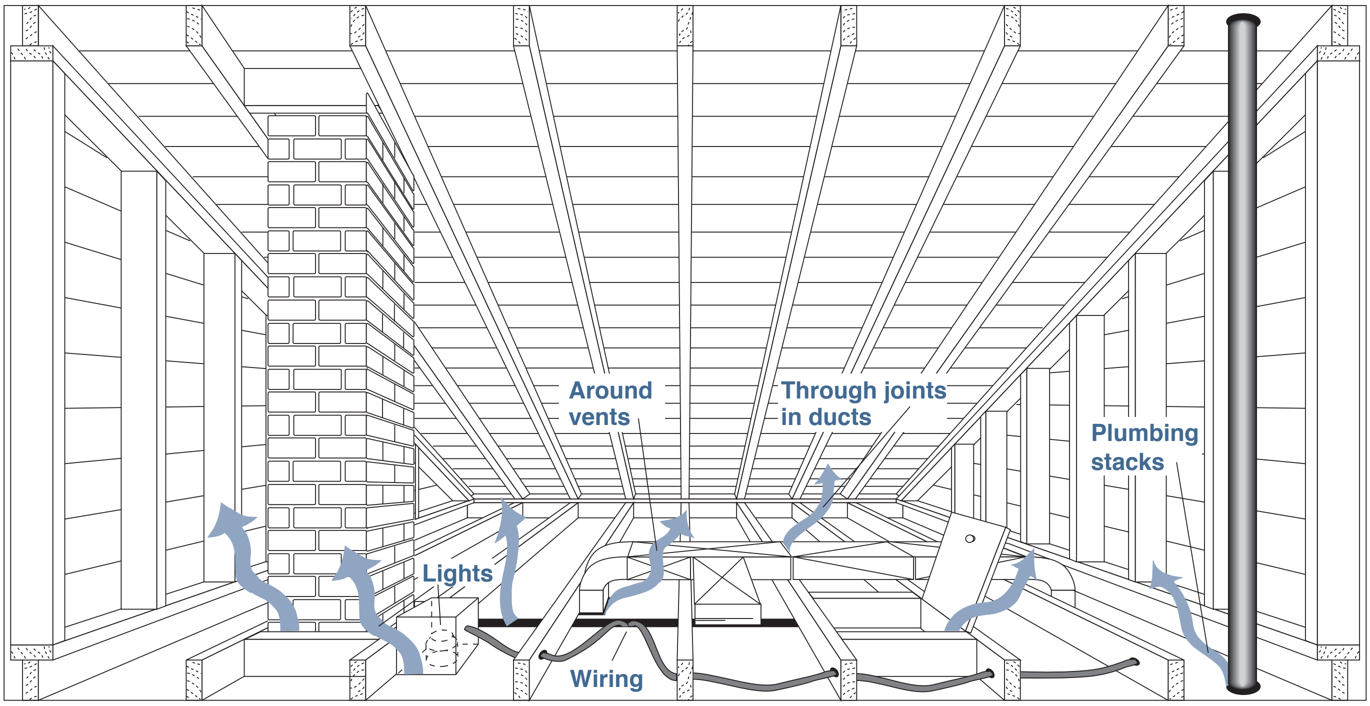


Figure 1-2- Common air leakage pathways through attic floor

Chapter 2.

Is there enough insulation?

Measure the thickness of the insulation in several places -- there should be at least 6 inches. Sometimes a higher minimum level is recommended - check with your local building inspector or insulation contractor to find recommedations for your area. Also make sure that there are no voids or un-insulated areas in the attic. If your attic has a floor installed, you may have to lift up some of the boards.

Action: If you find that the insulation is less than 6 inches thick over a large area, you should add more.

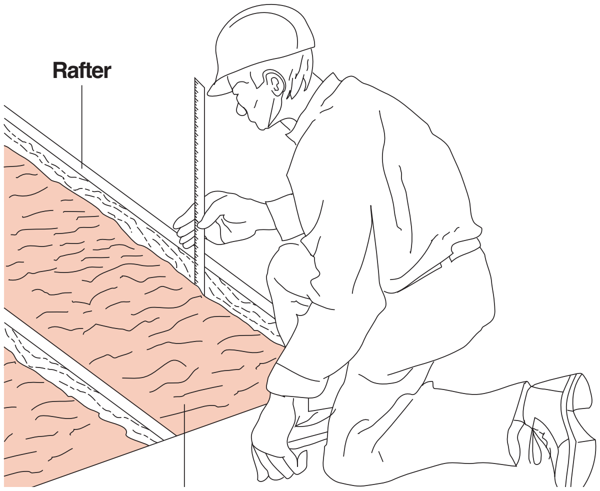


Figure 1-4 - Insulation should be at least six inches thick over entire attic floor.

See Chapter 3.

Into the main living space

The living space part of your inspection begins with an inspection of exterior walls to see whether they need insulation, followed by an evaluation of windows and doors to see if they need repair or replacement.

Do the walls need insulation?

Determining whether your exterior walls are insulated sometimes requires a bit of detective work. One good technique is to remove the cover plate on electrical outlets (turn off the power first) and poke around with a screwdriver or hooked instrument. Using a non-conductive probe, such as a plastic knitting needle, is a safe and effective method as well. Another method of finding wall insulation is to cut a small hole into a closet wall on the exterior of the house. You can then patch the hole and it will never be seen. If you find inadequate insulation it may be possible - depending on the wall construction and the type of existing insulation - to add more by blowing insulation into the walls from the outside or inside. If you are unsure, contact an insulation contractor.

Action: Un-insulated walls should be insulated by a professional contractor. See Chapter 3.

Are there any single-glazed windows without storm windows?

A single-glazed window has only a single pane of glass separating the living space from the outdoors. These windows should have storm windows for winter use. Try to purchase quality storm windows that provide air tightness when installed and insure maximum air leakage benefits. Also look for storm windows with low-e coatings on the glass to improve the energy performance.

Action: Install storm panels on single-glazed windows. See Chapter 4.

Do the windows have any cracked or broken glass?

Broken windows obviously allow a great deal of heat to escape, but even cracked panes of glass allow a significant loss.

Action: All broken or cracked glass should be replaced. See Chapter 4.

Do the windows have cracked or missing putty?

In most older windows, the panes of glass are held in place with glazing putty on the outside of the sash. From the outside of your house, inspect each window and look for missing or cracked putty.

Action: If you find only small cracks, a good coat of paint might be all you need. But if there are larger cracks or missing putty, your windows may need re-

glazing (new putty added). If the windows are in particularly bad shape, it might make more sense to replace them than to attempt repairs. See Chapter 4.

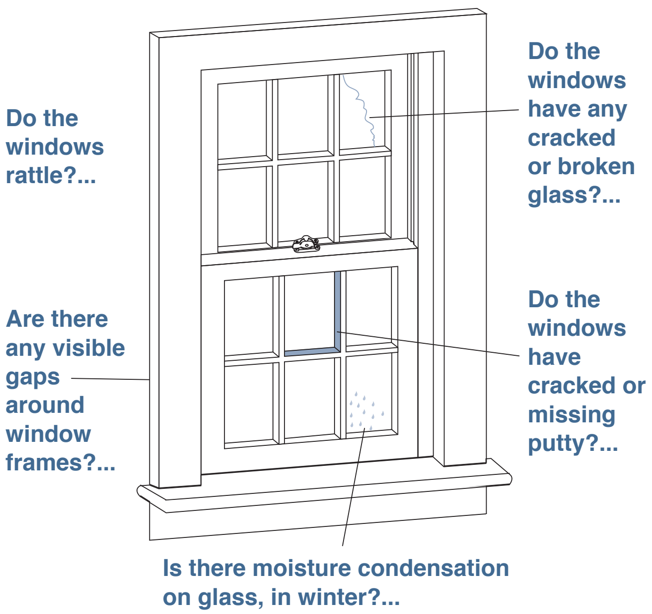


Figure 1-5 - Window flaws

Do the windows rattle?

Loose windows not only lose heat through air leakage, but are also sources of uncomfortable drafts in winter. Check to make sure the window lock is working properly. Also inspect for weatherstripping in the window side channels.

Action: Fix or replace defective lock. Install weatherstripping if necessary. See Chapter 4.

Are there any visible gaps around window frames?

Check for gaps around interior frames. There should be no visible gap between the window frame and wall surface.

Action: Gaps around interior framing should be caulked. You should also caulk exterior cracks to keep rain out of the wall. See Chapter 4.

Is there moisture condensation on windows in winter?

Condensation on the glass or frame during cold weather may simply be caused by excessive indoor humidity, but might also be caused by cold air leakage around the glass.

Action: Check these windows with particular care for the problems mentioned above and make appropriate repairs. See Chapter 4.

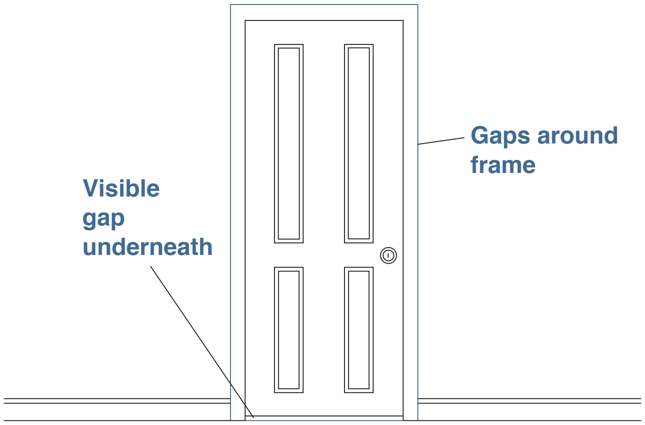


Figure 1-6 - Door checkpoints

Are the doors leaky?

Carefully inspect your exterior doors. Can you detect any air leakage around the edges? Is there a visible gap underneath? Although door air leakage is typically not a major source of heat loss, it does create uncomfortable drafts.

Action: Install door sweep or threshold, if necessary, to make the door bottoms tight. Install weatherstripping around top and sides if needed. See Chapter 4.

Do you have drafty spots?

Have you noticed drafts on windy days -- that cold feeling on the back of your neck while sitting in a reading chair? How about that cold air coming down from the attic door? Even if such drafts do not in themselves account for huge energy losses, they make you uncomfortable, and might even cause you to raise the thermostat.

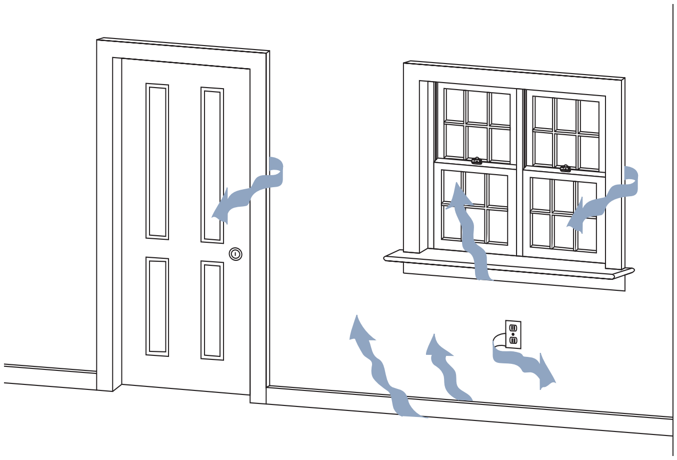


Figure 1-7 - The most common drafty spots in a home are around baseboard moldings, doors, and windows.

Check drafty spots to see if there are any obvious air leaks which could be fixed. Leaks are common around windows, electrical outlets, and in general at any place where a wall meets the floor or ceiling.

Action: Check for leaks. See Chapter 2 for how to seal them.

Down into the basement

Like the rest of your home, the basement loses heat both by conduction through the walls and by air leakage. The relative importance of this loss depends upon whether or not the basement is heated and used as living space. If it is heated, then it should be insulated, particularly if any of the walls are largely above ground. If it isn't heated, you should still check for major sources of air leakage. Insulating an unheated basement (either on the walls or the ceiling) may be worthwhile, particularly if much of the basement is above ground level. If you have a combustion- heating appliance in the basement, be careful not to tighten the basement so much that it may interfere with combustion air requirements.

Is there air leakage at the top of the basement wall?

The most important thing to check in the basement is air leakage at the point where the house sits on its foundation. Try detecting air leakage with a smoke stick or incense. If there is insulation stuffed into the cavities at the end of the floor joists, pull some out and look for dust marks, which would indicate long-term air leakage.

Action: Seal rim-joist area. See Chapter 2.

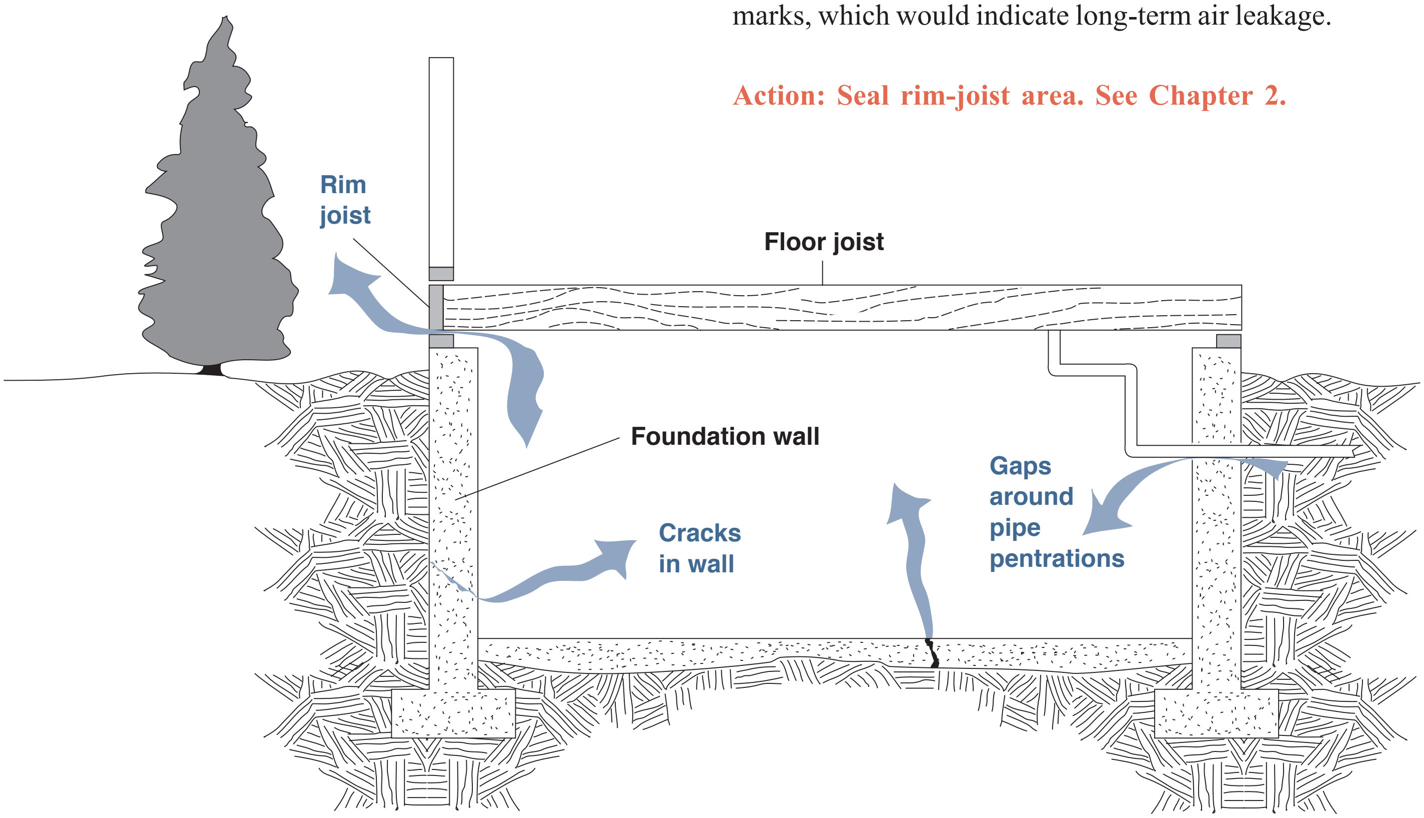


Figure 1-8 - Basement air leakage

Are there cracks or gaps in the basement walls and floor that would allow air leakage?

Cracks in the basement wall or floor or gaps around pipe penetrations can allow air or soil gas to leak into the basement and up into the house. Below ground air leakage not only wastes energy, it also can cause moisture problems and possibly feed radon into the house.

Action: Seal all cracks and gaps in basement floor. See Chapter 2.

Are the walls insulated?

In Virginia, a basement needs insulation only if it is heated. For heated basements, look for wall insulation behind any paneling in the same way that you looked upstairs. If you don't find any insulation inside, check the outside of the foundation wall. Some houses are insulated with rigid foam attached to the wall's outer surface.

Action: If the basement is heated and uninsulated, you should add insulation. If the basement is unheated and uninsulated, adding insulation may still be worthwhile. See Chapter 3.

Crawl spaces

Crawl spaces should always be insulated, particularly if they contain heating ductwork or mechanical equipment. Always install a 6-mil polyethylene ground cover to keep out moisture.

Sometimes it is difficult to inspect crawl spaces because of limited access. Use a flashlight to inspect for the presence of insulation and be prepared to get a bit dirty.

Does the crawl space need to be insulated?

Check the crawl space walls and ceiling for insulation. Also, look for uninsulated ductwork and/or heating or cooling appliances in the crawl space. Finally, see if the crawl space is vented to the outdoors and look for signs of moisture either on the floor or on wood framing.

Action: If the crawl space is uninsulated and unvented, you should install insulation on the walls.

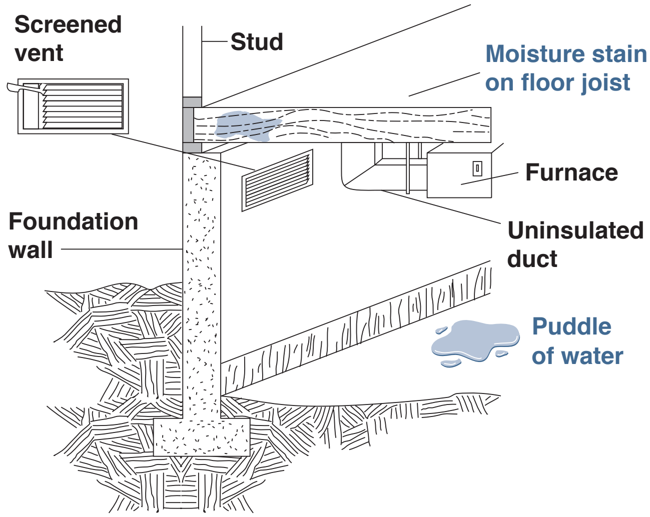


Figure 1-9 - Crawl space

Even if the crawl space is vented, you may be able to block off the vents and insulate the walls. (If this is donethe ground cover must be carefully installed, or moisture problems will result.)

If the crawl space must remain vented, then you should insulate the floor above. In that situation, any ductwork or hot water pipes that pass through the crawl space should be insulated.

If you have any doubts about moisture problems, you should consult a professional contractor. See Chapter 3.

Heating and cooling systems

Your heating and cooling system consists of more than just the furnace and air conditioner. Two other important components are the distribution equipment (air ducts, steam pipes, or hot water pipes), which are usually located in the basement, crawl space, or attic; and the venting system, which includes the chimney and vent pipes. Leaky ducts and uninsulated ducts or pipes can be a major source of energy loss in both summer and winter. Improperly lined or unlined chimneys, improper vent pipe type or installation, and dirty/obstructed chimneys and vent pipes can individually or all together cause furnaces to operate inefficiently and unsafely.

Heating system diagnosis and repair needs to be done by a skilled professional, but there are a few preliminary inspections that you can do yourself.

Is your system due for maintenance or a tune-up?

To maximize your heating and cooling system's life-span and efficiency, you should have it inspected and serviced on an annual basis.

Action: Schedule a maintenance visit and be sure the inspector checks all chimneys and venting. See Chapter 5.

Is your furnace filter dirty?

The filter in your furnace is there to protect the blower motor and other internal components from dust. It should be inspected every few months and changed if dust visibly covers the filter's entire surface.

Action: If the filter is dirty, install a new one. See Chapter 5.

Do ducts leak air?

Ducts located in unheated attics, basements, and crawl spaces should always be insulated and tightly sealed against air leakage. Ducts in heated basements do not need to be insulated, but should be sealed. Be sure the duct leakage is tested by a professional before and after they are sealed.

Figure 1-10 - Furnace filter

Action: Leaky ducts need to be sealed, but it's a job for a pro. Insulating the ducts, on the other hand, is a good do-it-yourself job. See Chapter 5.

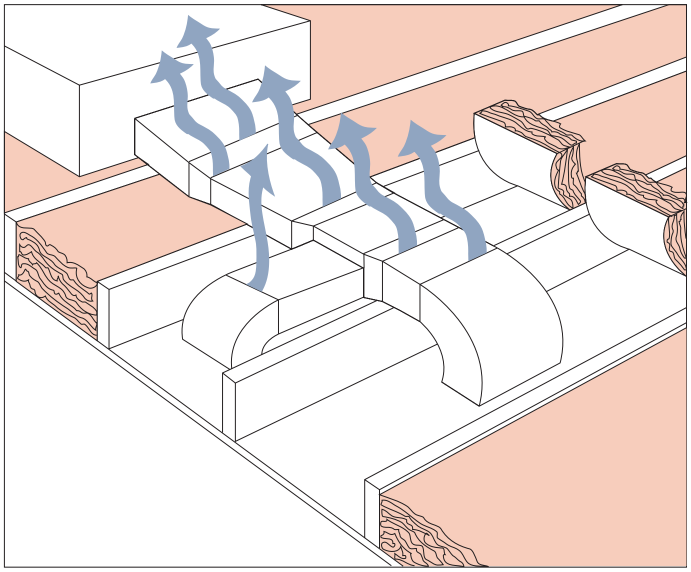


Figure 1-11 - Duct Leakage

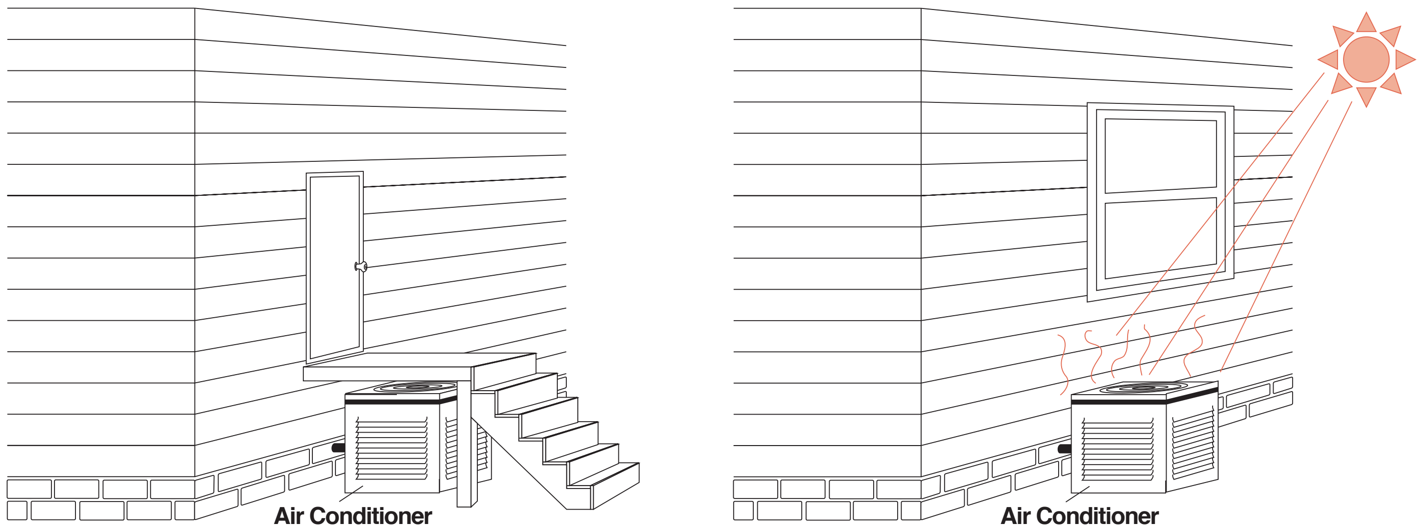
Is the outdoor unit of your air conditioner or heat pump in direct sunlight or blocked from freely circulating air?

The outdoor unit of your air conditioner or heat pump disposes of unwanted heat during the summer. To this end, it should both be shaded from direct sunlight and exposed to freely circulating air. It should not be enclosed to hide it from view. Heat pump outdoor units should be raised at least 3" above the ground (more in some areas) to keep them from becoming clogged with snow. See Figure 1-12 on page 12.

Action: Plant greenery for shade around the outdoor unit. Remove any obstructions that prevent air circulation. Raise unit to protect from snow. See Chapter 5.

The hot water heater

Your water heater is the second or third largest energy user in your home. Whether gas or electric, there may be significant potential to improve its efficiency.



Inadequate ventilation space

Exposure to summer sun

Figure 1-12 - Outdoor unit of central air contitioner

Does the water heater tank need to be insulated?

Almost all older water heaters are inadequately insulated. If your water heater is more than ten years old, it should be covered with an insulation blanket or replaced with an energy efficient model.

Action: Install an insulation blanket if necessary. See Chapter 6.

Is the water temperature too high?

The temperature of your hot water should be about 120°F -- anything more wastes energy. You can measure this temperature directly at a sink. Run the water for a while, and then fill a container and measure the temperature.

If you use a dishwasher without a booster heater, you may have to keep the water temperature at 140 degrees. Temperatures above 140°F not only waste energy, but present a hazard of scalding if someone should be exposed to unmixed hot water.

You can also check the temperature setting on the water heater itself by opening the access panel. If you have an electric water heater, turn off the power to the water heater at the circuit breaker or fuse box for safety. Depending on the particular model, the actual temperature setting may be shown, or the dial may only show relative settings: "warm" or "low" (typically 110-120°F), "medium" or "normal" (typically 140°F), and "hot" or "high" (typically 160°F).

Action: If the temperature setting is above 120°F, turn it down. See Chapter 6.

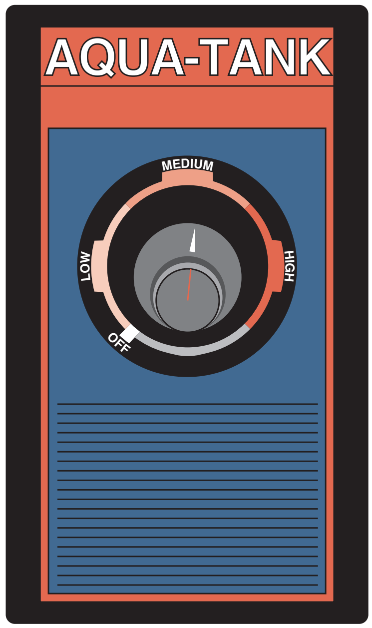


Figure 1-13 - Water heater temperature control

Do your water pipes need to be insulated?

Feel the water pipes leading from your hot water heater to determine which carry hot water and which carry cold water. All exposed hot-water pipes should be insulated. The first three or four feet of the cold-water pipes leading out of the water heater should be insulated as well.

Action: Wrap the pipes in insulation. See Chapter 6.

Could your plumbing fixtures be more water-efficient?

If you are wasting hot water, you are also wasting all of the energy that was used to heat the water. More efficient plumbing fixtures reduce this waste.

Inspect the showerheads and faucets in your bathroom(s). Look for low-flow showerheads and faucet aerators, which reduce water use. If you don't know what these look like, you can measure the actual flow of water to determine if you have them. Cut the top off a plastic gallon jug and measure how long it takes to fill with the shower or faucet on all the way.

Action: If the showerhead uses more than 3 gallons per minute, (20 seconds to fill the jug), you could save water and energy by installing a low-flow showerhead. If the faucet uses more than 1 gallon per minute, you could save by installing a faucet aerator. See Chapter 9.

Are any faucets in the house leaking?

A leaky hot water faucet dripping at a rate of one pint per hour will waste 1,092 gallons per year of water together with the energy used to heat that water.

Action: Fix leaky faucets. See Chapter 9.

Obtaining a Professional Energy Audit

Investing in a professional energy audit is money well spent. A trained energy auditor or home performance contractor uses sophisticated equipment like a blower door (Figures 1-14 and 1-15), heating and cooling efficiency testing equipment, an infrared camera, and often a computerized audit program to help identify problems. These problems may include air leakage, inadequate insulation, inefficient appliances, heating and cooling malfunctions, indoor air quality issues, and duct system inefficiencies. The auditor will identify the most cost effective measures applicable to your home's energy performance and provide you with a list of recommendations.

Obtaining a professional energy audit is certainly an appropriate place to start in determining the energy needs of your household. Some utilities provide basic energy audit services free of charge. Checking the Yellow Pages under "Home Performance Contractors", "House Doctors", "Weatherization Contractors" or "Building Science Services" may help you locate a trained energy auditor. Home Inspectors sometimes provide this service in conjunction with their more traditional home inspections.

Blower Doors and the Weatherization Program

The federally funded Weatherization Assistance Program (WAP) is the largest and oldest residential energy conservation program in America. It serves every

Figure 1-14 - Blower door for testing air leakage.

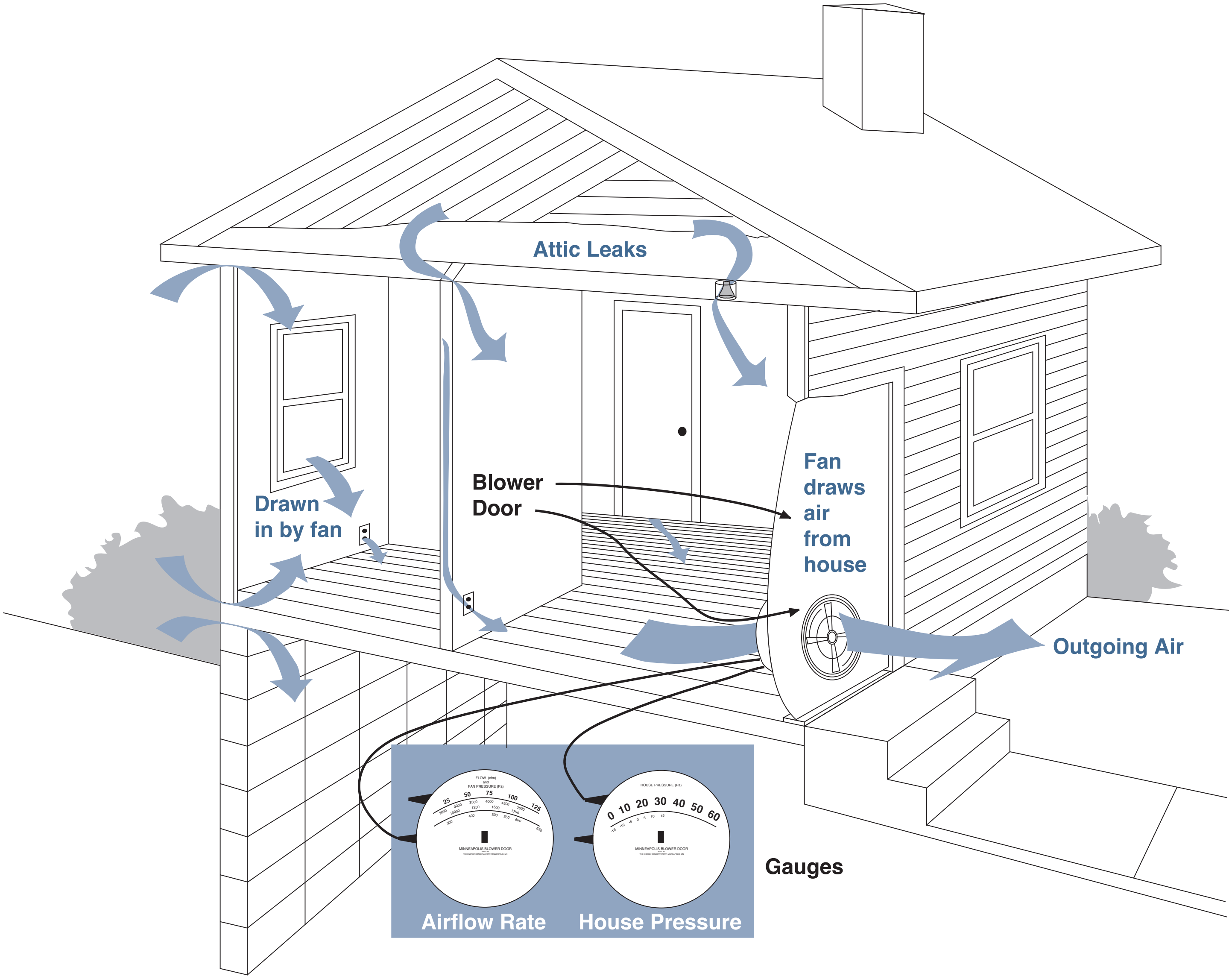


Figure 1-15 - By depressurizing the house, a blower door allows technicians to detect most leakage areas as well as measure total house air leakage.

county and city across the United States and is a program designed to provide energy conservation and efficiency services to eligible low-income families and individuals - particularly the elderly, handicapped, and families with children. Services that are provided include an energy audit, heating and cooling inspection, installation of insulation, air leakage sealing, duct diagnostics and repair, and indoor air quality testing. Weatherization professionals and contractors are trained energy auditors and building scientist who sometimes offer their services to middle and upper income households. The Virginia Weatherization Program has several programs that conduct energy audits and perform blower door tests and charge a fee that is then used to help support their program's efforts on behalf of low-income citizens. Information on how to contact a Weatherization Program in your area is provided in the Appendix.

Weatherization Programs have pioneered the use of the blower door and use it in conducting energy audits on every house that they weatherize. A blower door is a wonderful diagnostic tool that can identify air leakage areas in the home, air leakage in the duct system, help diagnose pressure problems in the house and also determine the air tightness of a home. Sometimes a house is "too tight" and the air exchange in the home is inadequate. A house that is too tight can cause significant indoor air quality problems and create negative pressure situations that may result in chimneys back-drafting.

A blower door consists of a powerful, calibrated fan that, when placed in an exterior doorway, with all the windows shut, pressurizes or depressurizes the house.

Using pressure gauges, the operator can measure exactly how much air leakage there is in your house (Figures 1-14 and 1-15). With the house depressurized, your contractor will then find and seal each major leakage point. After the work is finished, the technician should measure the leakage rate again to verify that the air sealing work was effective and also to be sure that the house has not been tightened too much (Figure 1-15).

Using a blower door not only allows the contractor to find and fix major air leakage spots, it also avoids wasting time on apparent holes that may not actually leak air. The blower door test is so effective, that it is probably the most useful technique developed for weatherization work on homes.

Energy Tips and Recommendations

1. Be a systems thinker and understand that your house is a system comprised of interactive components - the shell, the mechanical equipment, and the people who live in the house - and that all the parts of the system must work together to achieve maximum home energy performance.
2. Perform your own home energy rating by doing some simple calculations and by inspecting for flaws using a home inspection checklist.
   - Check the attic for air leakage and insulation levels.
   - Check the exterior walls of the house for existing insulation.
   - Check all windows and doors for possible air leakage, repair opportunities, and potential replacement needs.
   - Inspect basements and crawlspaces for air leakage and insulation.
   - Check the heating and cooling systems to see if they are on a regular maintenance schedule. Make sure that all chimneys and vent pipe are clean, unobstructed, and properly installed.
   - Inspect the duct system for insulation and leakage. Be sure to have a professional check and test the ducts for air leakage.
   - Examine the water heater for insulation and water temperature setting.
   - Inspect all water lines, faucets and toilets for water leaks. Check to see if showerheads are low-flow and if faucets are using aerators.
3. Make a sound investment in your home by obtaining the services of a professional energy auditor. This means that your home's energy performance will be tested using sophisticated building science equipment and technology. An energy auditor will help you prioritize and select the most cost-effective energy conserving home improvements.

Know your Btu's

In the United States, we measure energy in Btu's or "British Thermal Units." One Btu is a very small quantity of energy, typically described as the amount of energy given off by a wooden kitchen match. More precisely, it is defined as the amount of energy needed to raise the temperature of one pound of water one degree Fahrenheit.

- It takes about 80 Btu's to boil a cup of water.
- A 75 watt light bulb consumes 256 Btu's per hour.
- The average automobile (20 mpg) requires 6,250 Btu's to travel 1 mile.
- On the average, Virginians consume about 325 million Btu's per person per year.
- In 2000, the Commonwealth of Virginia used 2,304 trillion Btu's.

Your home probably consumes between 25 and 100 million Btu's per year. How much you pay for these Btu's depends on how you buy them. One million Btu's worth of electricity costs about $22.04 at today's electric rates. Natural gas costs considerably less -- about $9.64 per million Btu's. Table 1-2 lists typical current costs per million Btu's for each type of fuel.

These costs can of course change as fuel prices rise and fall. For example, Table 1-3 shows the cost per million Btu for natural gas and electricity and natural gas at different base prices.

Comparison of $/Btu for different energy sources makes it clear that all Btu's are not created equal. Some energy sources (such as coal) are more difficult to utilize, so the market drives their $/Btu price down. Others (such as natural gas) are easier to utilize, so the market drives their $/Btu price up. Electric energy is a special case because it must be generated in power plants where approximately 2/3 of the fuel energy is unavoidably lost as waste heat. This makes electric energy much more expensive, per Btu, than energy in the form of fuels. The ease and efficiency with which electric energy can be used, however, makes it the best energy source for many uses.

Table 1-2 - Cost per million Btu's for various types of residential fuels.

Fuel Type	Cost per million Btu's at 2000 prices
Electricity	$22.04
Natural Gas	$9.64
Fuel Oil	$9.47
LPG/Propane	$17.34
Coal	$3.12

Table 1-3 - Cost per million Btu's for natural gas and electricity at various base prices.*

Electricity at	$0.0726/kWh (1990 VA avg.)	$0.0752/kWh (2000 VA avg.)	$0.05/kWh	$0.075/kWh	$0.10/kWh
Cost per million Btu's	$21.24	$22.04	$14.65	$21.98	$29.31
Natural gas at	$0.670/ccf (1990 VA avg.)	$0.998/ccf (2000 VA avg.)	$0.50/ccf	$1.00/ccf	$1.50/ccf
Cost per million Btu's	$6.48	$9.64	$4.83	$9.66	$14.49

* Overall appliance costs are a function of end-use efficiencies and cost of fuel. See Chapter 5 for examples of typical appliance efficiencies. 1990 and 2000 average prices are from the U.S. Energy Information Administration.