ASSESSING YOUR HOME'S ENERGY FITNESS

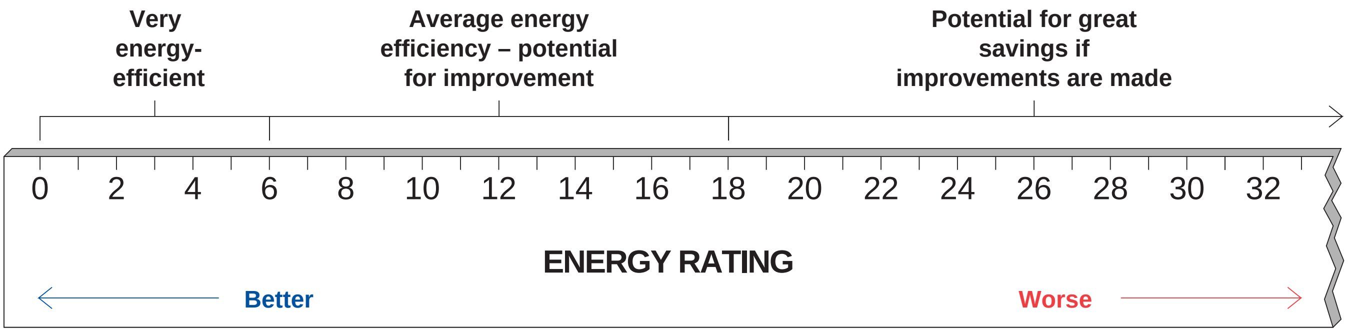

Figure 1-1 - Home Energy Rating Yardstick

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

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

Box D: **5296** Climate Factor

$$\frac{\text{Box C } (.129925)}{\text{Box D } (5296)} \times 1{,}000{,}000 = \text{Box E } (24.5)$$

Box E: **24.5** Home Energy Rating

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Norfolk	4904	3446
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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 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

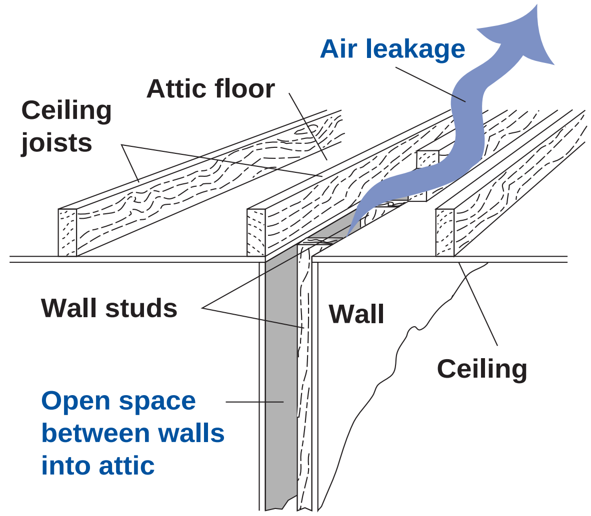

Figure 1-3 - With "balloon framing," open wall cavities allow air and heat to flow up into the attic.

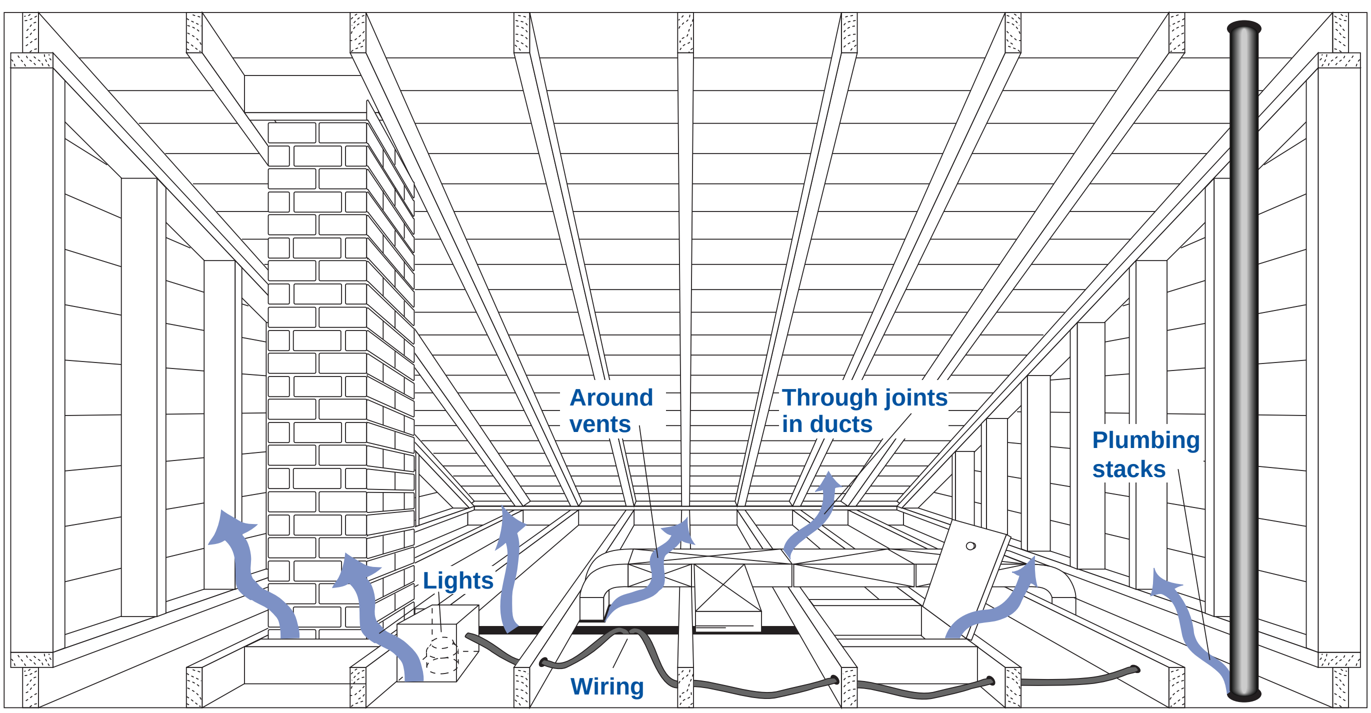

Figure 1-2- Common air leakage pathways through attic floor

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.

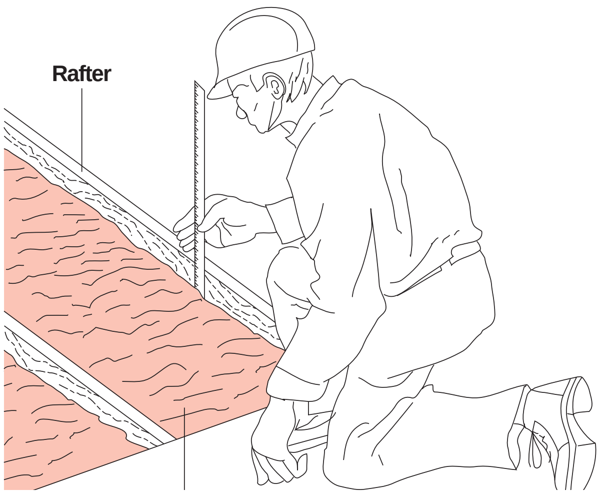

Figure 1-4 - Insulation should be at least six inches thick over entire attic floor.

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.

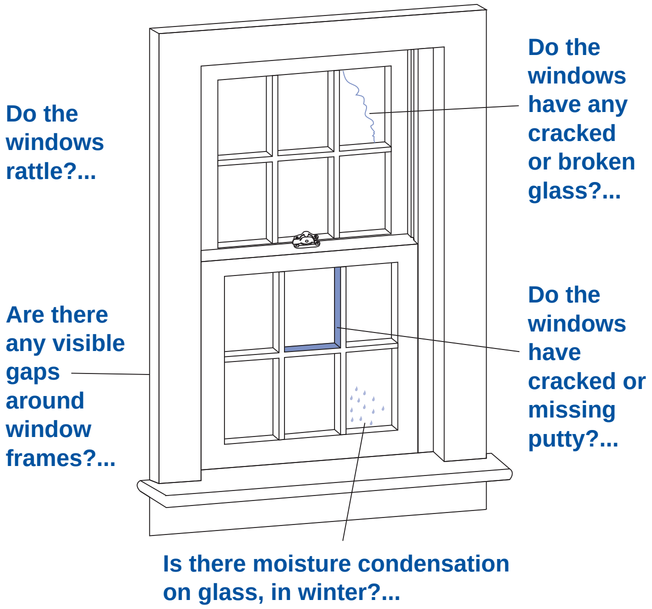

Figure 1-5 - Window flaws

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.

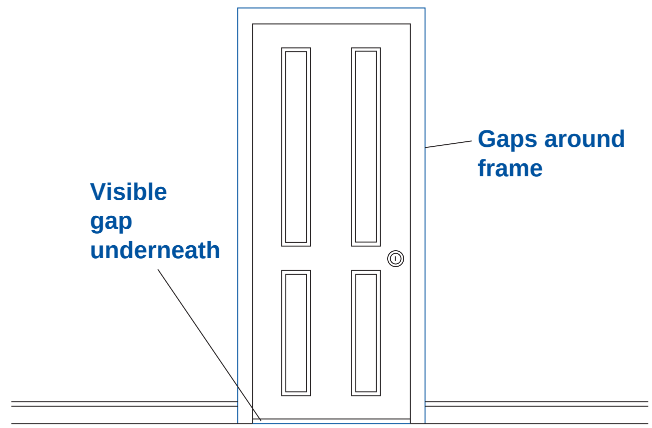

Figure 1-6 - Door checkpoints

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.

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.)	$0.752/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.