ANALYZING YOUR ENERGY CONSUMPTION

The first challenge you face in setting goals for reducing your energy consumption is to understand your current energy usage. With this knowledge in hand, you'll be prepared to analyze the potential savings you can reap from your home improvement efforts. You'll also be able to estimate your emissions of carbon dioxide and other pollutants.

The best way to analyze your consumption is by reviewing your utility bills. The utility bill analysis we describe in *Analyzing Your Utility Bill* on page 8 will take an hour or two, but will be well worth your time. You could complete all of the tasks described in this book without performing that analysis, but your work will be more successful if you know where to apply your efforts. If you choose to skip this procedure for now, be sure to review *Ten Sure-Fire Ways to Improve Your Home's Efficiency* on page 16, near the end of this chapter.

You may receive one utility bill that includes both gas and electric accounts, or you may receive separate bills for each of these types of energy. If you live within reach of the nationwide grid of underground gas lines, you probably use natural gas in your home. If you live in a rural area, you may use propane instead (propane is a type of liquefied petroleum gas, or LPG). In some regions, fuel oil is still widely used for heating. And some all-electric homes use electricity for both heat and appliances.

Go to the next page.

Measuring Electrical Consumption

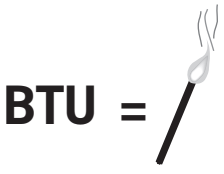
Electrical energy is measured in kilowatt-hours (kWh). One kilowatt-hour is the amount of electricity consumed by a 100-watt bulb in 10 hours of operation.

- If you inspect your electric bill, you may see this unit of measurement written variously as kilowatt hour, kilowatt-hour, kWh, or kwh. These terms all refer to the same measurement.
- The cost to the consumer of a kilowatt-hour of electricity typically ranges from 10 to 20 cents (2008).
- The average family in the U.S. uses about 11,000 kWh of electricity per year. Those with electric heat use more, those with gas or oil heat use less.

We refer to electric consumption in kilowatt hours throughout this book. Though your rate will vary depending upon your region, time of year, and in some cases time of day, we have chosen to use an average current electrical rate of 15 cents per kilowatt-hour (2008).

Measuring Natural Gas Consumption

All measurements of heating fuels — natural gas, propane, and fuel oil — are ultimately based upon the British thermal unit (BTU). A BTU is a measure of heat, and is approximately equal to the heat released when burning a common stick match.



There are several different quantities of BTUs used by utility companies. Inspect your gas bill to see which is used by yours.

- The most common units for measuring natural gas are *therms* (100,000 BTUs) and *decatherms* (1,000,000 BTUs, abbreviated dkt). Some utility companies also use the designation MMBTU (a thousand thousand, or 1,000,000 BTUs, the same as a decatherm).
- Many utilities sell natural gas by the cubic foot. This the unit of volume actually measured by your gas meter. These bills don't show BTUs or therms, but rather 100s of cubic feet (100 cubic feet is abbreviated CCF). Since 100 cubic feet of natural gas produces approximately 100,000 BTUs when burned, 100 CCF equals 1 therm.
- The cost of a therm of energy to a North American consumer usually ranges, with a few exceptions, from $1.00 to $1.80 (2008).
- The average household in the U.S. uses about 920 therms of gas per year. Those who live in cold regions use the most.

Units of Measurement for Natural Gas

1 therm
100 cubic feet (ccf) — 100,000 BTUs

1 cubic foot of natural gas = 1000 BTUs (approximately)

1 decatherm (dkt)
1000 cubic feet (mcf) — 1,000,000 BTUs
1 MMBTU

Your natural gas consumption is billed in one of the quantities shown on the left. Throughout this book we refer to gas consumption in *therms*.

Though the rate you pay for natural gas will vary depending upon your region and the time of year, we have chosen to use a average natural gas rate of $1.50 per therm when we do calculations or make comparisons in this book (2008).

If your gas bill is stated in therms or CCF (shown in the top of the chart above), our measurements are parallel and can be compared directly. If your bill is in decatherms or MMBTU (shown in the bottom of the chart), you'll need to multiply our measurements by 10 to draw comparisons to your utility bill. When we refer to the average price of natural gas at $1.50 per therm, for example, the equivalent price would be $15.00 per decatherm or MMBTU.

Measuring Propane and Oil Consumption

The costs of propane and fuel oil are more volatile than natural gas because they are refined from crude oil and so are more vulnerable to supply disruptions.

- Propane and fuel oil are sold by the gallon. A gallon of fuel oil or propane produces 130,000 to 140,000 BTUs when burned.
- The current cost of propane and fuel oil ranges from $1.50 to $3.00 per gallon (2008).

Comparing Heating Energy Sources

A furnace or boiler burns fossil fuels, such as natural gas, propane, and oil fuel, to heat your home. A combustion water heater burns fossil fuel to heat domestic hot water. Burning these fuels inevitably wastes some of the heat of combustion. Some heat escapes up the chimney and some through the cabinet of the appliance. Older furnaces or boilers may operate at only 65 percent efficiency, while modern high-efficiency appliances operate at 90 percent efficiency or higher.

Electricity can also be used as a home heating energy source. But it's always more expensive as a heat source than combustion heating fuels because its production has such a poor efficiency. The primary losses occur at electrical generating plants where coal or oil is burned to make steam that spins turbines which drive electrical generators. Just like a home furnace, a large amount of waste heat is released up the smoke stack of these facilities. Large electrical losses are also incurred at transformers and in electrical transmission lines. By the time electrical energy is delivered to your home, the entire process has an efficiency of only about 30 percent, with 70 percent of the original energy being lost.

That's why electricity is not usually an economical heating fuel. There are a few exceptions, though. One is in homes with minimal need for heat. If you live in San Diego, for example, you probably need heat so infrequently that the inefficiency of electric heat doesn't translate into much additional cost. The other situation in which electric heat can be an economical choice is when it is provided to one room at a time, and it is operated instead of central heat. In some climates, there may be times of the year, for example, when you could get by using only a small electric heater (either built-in or portable) in your kitchen each morning. If you can do so without operating your central gas-fired furnace, you may actually incur less expense since you aren't heating your entire home.

The table *Cost Comparison Among Heating Sources* shows how the cost of energy purchased is not the same as energy delivered to your home.

ANALYZING YOUR UTILITY BILL

It's worth spending a few minutes to learn how to read the utility bills for your home. Gather a set of bills, a calculator, and a pencil. A single month's bill is a good place to start, but a year's worth of bills allows you to perform a more useful analysis. Some utility companies include a recap of the previous twelve months' consumption in each bill—this simplifies your task. If you don't have a complete set of utility bills, call your utility company and ask them to send you a year's worth of records.

When analyzing your home's energy consumption, it's helpful to divide your energy use into two broad categories: seasonal consumption and baseload consumption. This is true of both electric and gas consumption.

Your seasonal consumption includes the energy used for heating and cooling. Consumption may vary dramatically from season to season, and is largely dependent on the outdoor temperature. Your baseload consumption includes the energy used by appliances operated throughout the year: your water heater, refrigerator, stove, washer and dryer, computer, television, lighting, and various small appliances.

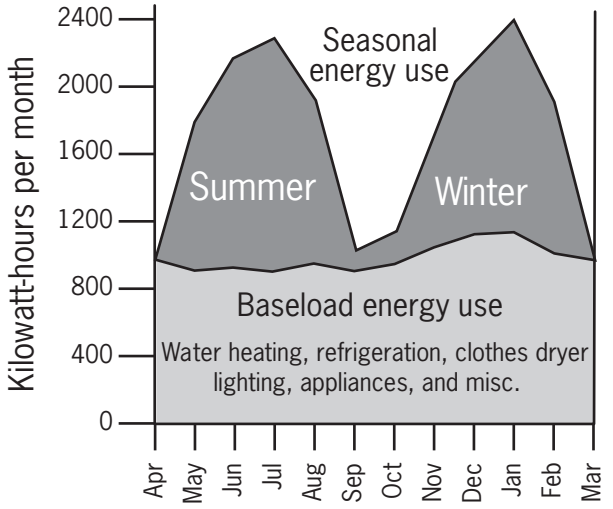
The dollar figures you derive here will help you evaluate the cost effectiveness of proposed home improvement measures. If, for example, your heating bills are three times greater than your cooling bills, you will likely see a greater benefit from adding wall insulation than you would from installing awnings on your south-facing windows. But if you live in a mild climate and your baseload consumption accounts for three-quarters of your total utility cost, you may get the most benefit from retrofits to your lighting and water-heating systems.

Cost Comparison Among Heating Sources

Energy type and how purchased	Cost per unit of purchased energy	Cost per therm of delivered heat
Natural gas	$1.50/therm	$2.14
Propane	$2.10/gallon	$3.00
Fuel oil	$2.70/gallon	$3.86
Electricity	$0.15/kWh	$4.35

The third column shows the cost of delivered heat for typical home heating systems with efficiencies of 70% for gas, oil, and propane. Electricity has a delivery efficiency of 100% within your home. Costs are averages for U.S. and Canada. (2008).

Baseload Versus Seasonal Energy Consumption



The home profiled here uses about 1000 kilowatt-hours monthly for baseload uses. It shows a winter peak for heating, and a summer peak for cooling. During the months of March, April, and September, the home uses little energy for heating or cooling. This home uses electricity only, but you can perform a similar analysis for a home that uses both gas and electric by totaling both bills for each month.

BASELOAD VERSUS SEASONAL CONSUMPTION

Refer to the chart *Analyzing Your Utility Bill* on page 11 to follow the case study we describe here. We first profile a cold-climate home, with its large heating load and no cooling load. But the process will be the same wherever you live.

- **Monthly baseload gas cost.** Note that the gas consumption for the sample home is lowest in June ($48), July ($48), August ($42). These months are composed of mostly baseload uses, when no heat was used. In this home, the baseload uses include a gas water heater and a gas clothes dryer. If a furnace had been the only gas equipment in this home, the baseload might have been near-zero for these months. In this case, we've identified three baseload-only months, so we calculate an average cost for those months.

  $48 + $48 + $42 = $138 for three months
  $138 ÷ 3 = $46 average monthly gas baseload

- **Annual baseload gas cost.** To calculate your annual baseload gas cost, multiply your estimated monthly baseload consumption by 12.

  $46 x 12 = $552 annual gas baseload

- **Total annual gas cost.** To calculate your *total* annual gas cost, add the gas bills from all 12 months.

  276 + 266 + 170 + 75 + 68 + 48 + 48 + 42 + 56 + 172 + 276 + 305 = $1802 annual gas cost

- **Seasonal gas cost (heating).** Finally, to calculate your annual gas consumption for heating, subtract your annual baseload gas cost from your total annual gas cost.

  $1802 - 552 = $1250 seasonal gas cost (heating)

Next we run a similar calculation for electric consumption to determine how much electrical energy is consumed by the heating system. If you have electric heat and no gas heating, this will be your primary heating expense. If you have a gas-fired furnace or boiler, you'll still have some small electrical expense for operating the system's fans or pumps. Once you perform a similar calculation for electric consumption, you can add the two up to determine the total cost of heating your home. Here we summarize the electrical consumption for the same cold-climate home. This procedure is identical to the one for gas consumption.

- **Monthly electric baseload cost.** The electric consumption is lowest in May ($86), June ($86), and July ($100). The electric baseload that is reflected here is lighting, a refrigerator and freezer, a kitchen range, a clothes washer (for the pump and motor—the hot water is gas heated), a dryer (for the motor—the heat is provided by gas), and miscellaneous appliances. In this case, we've identified three baseload-only months, so we calculate an average cost for those months.

$86 + $86 + $100 = $272 for three months

$272 ÷ 3 = $91 average monthly gas baseload

- **Annual electric baseload cost.** To calculate your annual baseload electrical cost, multiply your estimated monthly baseload consumption by 12.

$91 x 12 = $1092 annual electric baseload

- **Total annual electric cost.** To calculate your total annual electric cost, add the electric bills from all 12 months.

115 + 96 + 110 + 105 + 86 + 86 + 100 + 119 + 126 + 122 + 118 + 128 = $1311 annual electric cost

- **Seasonal electric cost (heating and other winter uses).** To calculate your annual electric consumption for heating, subtract your annual baseload electric cost from your total annual electric cost.

$1311 - 1092 = $219 seasonal electric cost

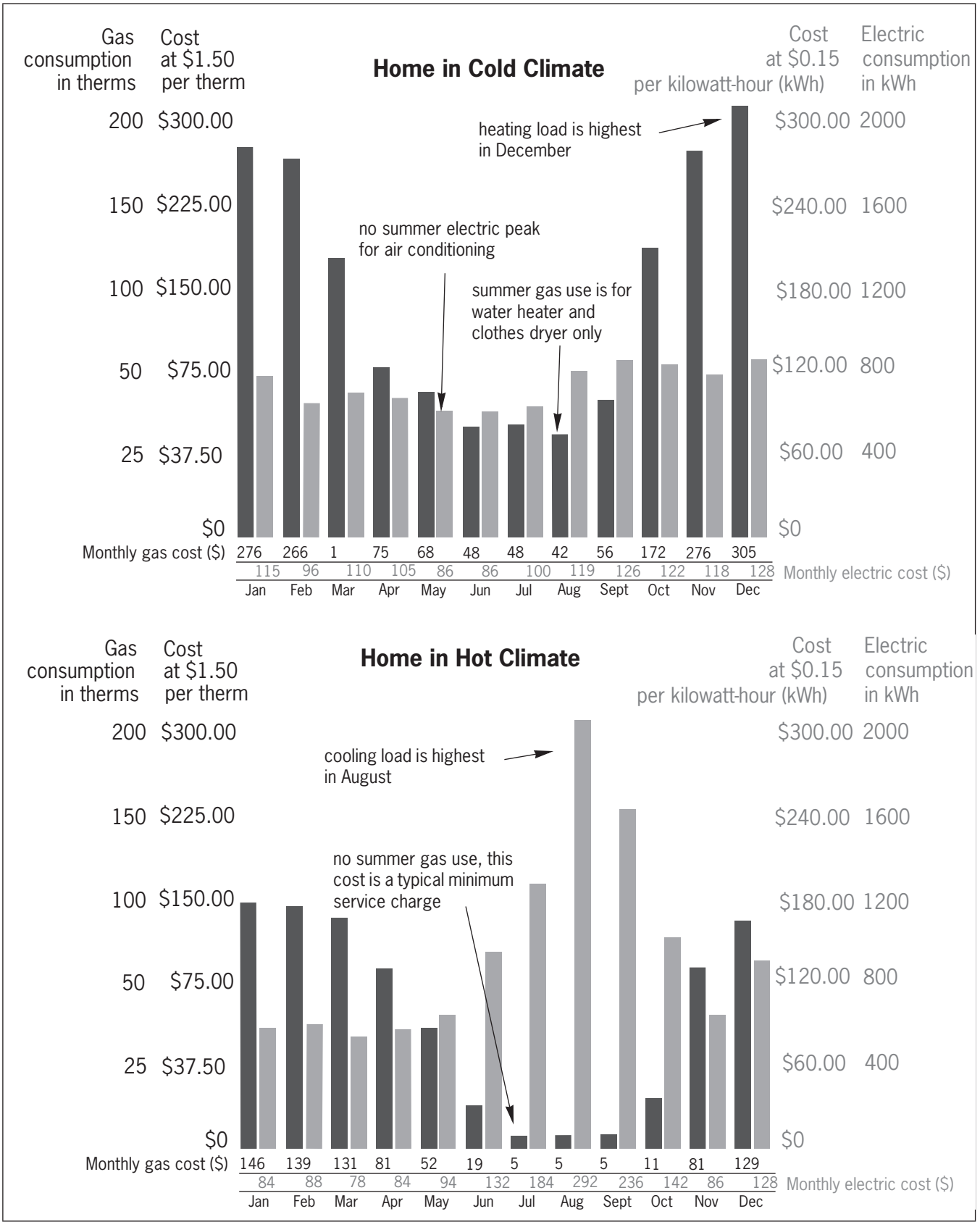
Summary For This Case Study

The annual baseload gas cost for this home is $552 (from the first procedure above). The annual baseload electric cost is $1092 (from the second procedure above). The *total baseload energy cost* of $1644 (total of both) is the cost of operating baseload equipment such as lighting, refrigeration, kitchen range, hot water heater, appliances, and miscellaneous loads. Improvements to these systems, such as installing compact fluorescent lamps, replacing a refrigerator, or insulating a water heater, would reduce this amount.

The annual seasonal gas cost, primarily heating for this home, is $1250 (from the first procedure above). The annual seasonal electric cost is $219 (from the second procedure above). The *total seasonal energy cost* of $1469 (total of both) is the cost of heating the home. This includes both gas and electricity to operate the heating system, and also the slight increase in consumption for lighting and appliances that is typical for most families in winter. You can reduce your seasonal consumption by adding insulation, air sealing your home, or by improving the efficiency of your heating system.

The process for analyzing the utility consumption of any home is the same. In the case of the hot-climate home profiled in the figure, the seasonal consumption shows a winter peak in gas consumption for heating, and a summer peak in electric consumption for cooling.

Analyzing Your Utility Bill



Annual Natural Gas Consumption for U.S. Homes

Use	High	Average	Low
Space Heating	1000	450	100
Water Heating	700	250	100
Clothes Drying	100	60	0
Cooking	50	25	10
Totals	1850	785	210

All measurements in therms (100,000 BTU). To convert to decatherms (dkt), divide by 10. Summary from US EPA and other sources. For U.S. homes.

Calculating Your Consumption in Kilowatt-Hours and Therms

You may also want to estimate your electrical consumption in kilowatt-hours, or your gas consumption in therms. This can be useful for a few reasons. First, you can compare your consumption over a period of years. Since the cost of utilities typically increases over time, a comparison of cost will be skewed by rate inflation. Once you learn how to analyze your utility bill, you will find it more useful to compare your consumption in kilowatt-hours and therms rather than in dollars. Cost is important to all of us, but its variability makes cost a poor point of comparison at a time when the cost is rising.

The other reason to calculate actual consumption rather than cost is so you can make a comparison among homes that are profiled here or elsewhere in the press. That's why we've provided tables that show typical consumption for U.S. households.

To calculate your actual gas or electric consumption (rather than cost), follow this procedure:

- Compile your utility bills as for the cost analysis procedure above. Separate out the electric and gas accounts.
- Identify the lowest month for each type of energy.
- Multiply the monthly baseload times twelve for each type of energy. This is your annual baseload for each.
- Total up all twelve months for each type of energy. Subtract the baseload calculated above to determine your seasonal consumption for each.

These baseload figures (in kilowatt-hours and therms) will provide insight into your home's equipment. For your gas bill, if you have a gas furnace and gas water heater, your summer gas bills reflect only the cost of water heating. If instead you have gas heating and electric water heating, then you may see a summer baseline gas consumption of zero. For your electric bill, if you have air-conditioning, your highest bills will be in summer; if you have no air conditioning, then your bills show only baseload consumption for several summer months.

Comparing Your Home to Others

You'll find it helpful to know how your home compares to others. The table *Annual Natural Gas Consumption for U.S. Homes* shown here gives a rough idea how much natural gas is consumed in the average North American home. The table *Range of Annual Consumption for All-Electric Homes* on page 13 profiles an all-electric home. For homes that also use gas, fuel oil, or propane, the comparison is more complicated, but the general proportions still hold true.

The tables show a range of consumption that illustrates how little energy is consumed by the most efficient homes. The High Use figures are for large or poorly built homes. The Low Use figures reflect small homes that are built according to reasonably stringent standards. The Passive House standard has been developed in the European markets, and has recently been adopted by a few progressive builders in North America. Homes built to Passive House standards exemplify how well modern homes can perform.

These tables may help you understand how the energy you consume can be separated into specific uses within your home. To estimate how much energy you use in each category, you must analyze your home, your appliances, and your behaviors. We'll discuss this in more depth later.

Range of Annual Consumption for All-Electric Homes

Type of use	High usage	Low usage	Passive House[a]
Heating and ventilation[b]	20,000	4000	3000
Air-conditioning[b]	7000	600	0
Water heating	8000	2400	1000[c]
Refrigeration	2000	600	400
Clothes drying	2000	700	0[d]
Lighting	2000	700	400
Other	3000	2000	1400
Annual totals (kWh)	**44,000**	**11,000**	**6200**
Annual consumption (kWh per square foot)	**26**	**6.4**	**3.6**

a. The Passive House standard establishes guidelines for extremely efficient homes.
b. Highly variable depending on climate, occupants' temperature sensitivity, and personal preferences.
b. Presumed solar hot water system, includes energy for pumping and backup heat.
d. Clothes dried on clothesline.
A kilowatt-hour of electricity in the U.S. and Canada cost between 10 cents and 20 cents (2008). Figures are for an average single-family home of about 1700 square feet.

Estimating Your Carbon Emissions

Most of us use energy that comes from just a few sources. The table *Carbon Emissions Per Unit of Energy and Per Therm* on page 14 shows two ways to measure how much carbon dioxide is emitted by various energy sources:

- How much CO_2 is emitted per unit of fuel consumed.
- How much CO_2 is emitted as a result of generating one therm of energy.

Note that, of all fossil fuels, natural gas creates the smallest CO_2 emissions per therm of heat created. Electricity in general produces the highest CO_2 emissions per therm of heat, though this varies based upon how the electricity is generated. For this reason, electricity is not usually the cheapest energy source for heating, especially if natural gas or other combustion fuels are available. Electricity is best applied to uses for which it is the only choice, such as lighting and appliances.

Carbon Emissions for Typical U.S. Households

Type of energy	Typical use	Typical CO_2 emission
Natural gas	920 therms	11,000 lbs.
Fuel oil	660 gallons	14,500 lbs.
Electricity	10,800 kWh	16,300 lbs

Your household probably uses natural gas or fuel oil, but not both. Virtually all households use electricity. From Energy Information Administration *A Look at Residential Consumption*.

This table allows you to estimate the carbon dioxide emissions you produce with your current energy use:

- Compile your utility bills, and calculate your total annual consumption of heating fuel (in therms or gallons) and electricity (in kilowatt-hours).
- Find your heating fuel in the chart, and multiply your annual consumption in therms by the CO_2 emission per therm of the fuel you use. This product is your annual CO_2 output in pounds for that fuel.
- Multiply your annual consumption of electricity in kilowatt-hours times the appropriate emission per kilowatt-hour. This product is your annual CO_2 output in pounds for electricity.

For example, the average U.S. household uses about 920 therms of natural gas annually. This represents an output of about 11,000 pounds of carbon dioxide. The average U.S. household uses about 11,000 kilowatt-hours of electricity annually, an output of about 16,500 pounds of carbon dioxide.

You may note that the weight of CO_2 produced by the combustion of fuel is greater than the original weight of the fuel itself. That's because atmospheric oxygen combines with fuel in the process of combustion, and so its weight is added to the weight of the carbon dioxide byproduct.

Carbon Emissions Per Unit of Energy and Per Therm

Type of energy	CO_2 per unit	CO_2 per therm
Natural gas	12 lbs./therm	12 lbs.
Propane	13 lbs./gal.	14 lbs.
Fuel oil	26 lbs./gal.	19 lbs.
Wood	5000 lbs./cord	21 lbs.
Electricity from gas	1.3 lbs./kWh	39 lbs.
Electricity from oil	2.2 lbs./kWh	63 lbs.
Electricity from coal	2.4 lbs./kWh	69 lbs.
Electricity: average from all U.S. sources	1.5 lbs./kWh	45 lbs.

From American Council for an Energy-Efficient Economy and Energy Information Administration.

HOME ENERGY AUDITS

Once you've evaluated your energy consumption and costs, you'll have a general idea where to direct your home improvement efforts. But if you'd like to fine-tune your analysis, you should consider hiring a professional to do a home energy audit. Energy audits can take several forms.

Utility Company Audit

Many utility companies offer free energy audits to their customers. This offer may apply to all customers, though it is sometimes reserved for low-income customers. The utility audit usually offers a brief snapshot of the home, with the intention of helping homeowners decide where to apply their conservation efforts. The utility auditor will sometimes install a few measures such as water heater wraps or compact fluorescent lamps. Contact your utility company to schedule this type of simple audit.

Comprehensive Energy Audit

Comprehensive energy audits are usually offered by private consulting firms. The auditor will perform a room-by-room assessment of your home, evaluating insulation, air leakage, heating and cooling equipment, appliances, doors and windows, and other systems. He or she should perform a blower door test to evaluate air leakage, and make recommendations for air sealing. If you have combustion heating or water heating equipment (burning gas, propane, or oil), the auditor should perform a combustion safety evaluation. If you have a forced air heating or cooling system, the auditor should test the duct work for air leakage.

The auditor should evaluate your utility bills, and provide a written report that describes the home's components, and makes recommendations for energy upgrades. This report can serve as a blueprint for your future home improvement projects.

See the *Resources* on page 173 for more information about locating an energy auditor in your area, or contact your State Energy Office.

Home Energy Rating System

The Home Energy Rating System (HERS) provides a standardized method of measuring the energy efficiency of residential structures. HERS ratings can be used in several ways: to help lenders qualify both new and existing homes for Energy Efficiency Mortgages (EEMs), to identify new homes that meet Energy Star standards, to qualify homes for federal tax credits, and to help consumers compare homes that they are considering purchasing. A HERS rating can also be used to evaluate the likely savings from home efficiency upgrades such as those described in this book.

To assign a HERS rating to your home, an energy auditor will visit your home to gather data. He or she will analyze this information with an approved software program, and produce a numerical rating for your home. A lower number is better on this scale. A rating of zero is given to a zero-energy home, one which requires no net use of external energy. A rating of 85 or lower earns the home the ENERGY STAR label for new homes in much of the U.S. A rating of 80 or lower is required for ENERGY STAR homes in the north-central region. A rating of 100 is the basis for the HERS index, and represents a hypothetical home that is built in compliance with the International Energy Conservation Code (IECC). The average home today in the U.S. has a HERS rating of 130.

If you plan to perform major energy retrofits to your home, we recommend that you have a HERS rat-