Ten Tough Energy Questions

Expert advice on the tough calls faced by energy-minded builders

Energy-minded builders face a number of tough decisions about materials and techniques. Yet good advice is often lacking and, in many cases, the experts disagree among themselves. Often builders and designers are told they'll have to wait for answers until more research is completed. People in the field, however, can't afford to wait. They have to choose between building system A and B for the project they are starting next week.

With that in mind, we asked a group of building energy experts to provide short, practical answers to ten of the most frequently asked building energy questions. Each warned us that his answers were provisional, not conclusive, and subject to change as more research is completed. With those qualifications, here's the best advice we could pull together for you on the most puzzling energy issues builders face today.

1 What R-value should I seek in basements, ceilings, walls, and windows?

Michael Holtz responds: Designing the most cost-effective building envelope requires analyzing the entire house as an energy system and making tradeoffs between insulation levels, glazing type and area, and mechanical equipment efficiency. The various energy components in a house should be balanced (*optimized*) to get the maximum savings for the money invested in energy improvements.

To determine how far to go with energy conservation, you need to evaluate how much energy each measure will save and what it will cost. Only then can you decide whether the additional expense is justified. For example, let's look at a 1,500-square-foot, single-story, wood-frame ranch house built on a slab foundation. The base design has R-11 walls, R-19 ceilings, no slab insulation, a 0.6 air changes per hour (ach) infiltration rate, a window area equal to 10% of the floor area equally distributed on all walls, double glazing, and a furnace seasonal efficiency (AFUE) of 65%. The "Annual Heating Energy Use" table at right shows the heating consumption for the base design in three climates: cold/cloudy (Concord, N.H.); cold/ sunny (Denver, Colo.); and warm/ sunny (Atlanta, Ga.).

The first package of envelope improvements (Design 1 in the "Energy Conservation" chart) reduces heating costs by about 30% in all locations (based on our company's REM/Design energy software). The second package (Design 2) reduces costs further, but by a smaller increment. Simply increasing the furnace AFUE from 65% to 95% (Design 3), on the other hand, reduces heating costs by roughly 35% compared to the base case —yielding greater savings than Design 1 in all three climates. Similar relationships will exist if we analyze two-story houses or houses with basements or crawlspaces.

In general, you should offer reasonably high insulation levels, such as those in Design 2, as a standard package. Even if such levels cannot yield a fast payback based on today's energy costs, they offer your client insurance against future hikes in energy costs. To help you decide which specific combination of energy improvements to include in a building, a user-friendly computerized design tool is indispensable.

Michael J. Holtz is president of Architectural Energy Corporation (AEC), in Boulder, Colo., and the former head of building systems research at the Solar Energy Research Institute. AEC has developed software called REM/Design to help builders and designers analyze residential energy use.

Energy Conservation Levels

	Base Case	Design 1	Design 2	Design 3
Walls	R-11	R-19	R-24	R-11
Ceiling	R-19	R-30	R-38	R-19
Slab	no insulation	R-5	R-10	R-5
Glazing	double	double/low-e	double/low-e/gas	double
Air infiltration	0.6 ach	0.5 ach	.35 ach	0.6 ach
Furnace AFUE	.65	.65	.65	.95

Annual Heating Energy Use (in thousands of Btus)

	Denver, Colo.	Concord, N.H.	Atlanta, Ga.
Base	86.9 MBtu	117 MBtu	44 MBtu
Design 1	58.8	81.8	29.3
Design 2	42.8	61.1	20.6
Design 3	56.9	76.9	29

Attic insulation should be balanced with wall and basement insulation, glazing type, and heating system efficiency to maximize energy savings.

2 Can exterior foam sheathing cause moisture problems?

Ned Nisson responds: Exterior rigid foam sheathing is basically a high R-value vapor retarder on the outside of a wood-framed wall. Theoretically, it can cause two types of moisture-related problems: wet walls and wood siding failures.

In nearly 20 years' experience, however, there have been no documented cases in which exterior foam sheathing was solely responsible for damage due to moisture accumulation within walls — whether in warm or cold climates. In fact, a controlled experiment at the U.S. Forest Products Laboratory, in Madison, Wis., showed that walls insulated with foam sheathing had *less* moisture accumulation than similar walls sheathed with plywood. Evidently, the high R-value foam reduces the condensation potential by keeping the stud cavity warm. With R-11 batts in the wall, use a minimum of 1 inch of foam in cold climates; two inches is safer. Combined with proper air and vapor barriers, foam sheathing actually appears to be effective in controlling condensation.

Wood siding over foam is another issue. There have been plenty of reported failures of wood siding installed over foam, but not much agreement over whether the cause was the non-absorbent foam or poor quality siding. The answer may be both.

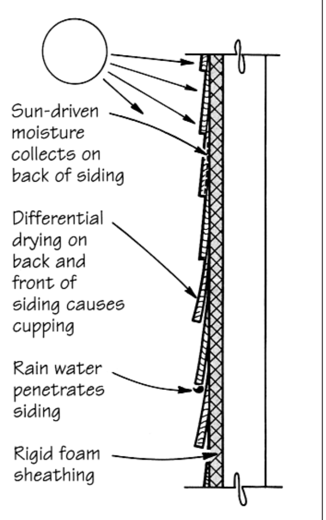
With vertical-grained, all-heartwood siding that is properly preserved and nailed, the sheathing type probably makes no difference. The siding should have little tendency to deform and the nails should resist minor warping force.

But with poor quality, flat-grained siding that is poorly preserved and installed, the situation is different. The siding may have a greater tendency to warp, particularly if up against non-absorbent foam sheathing.

The "official" solution to this issue is to select "good quality" siding (if you can get it) and install it properly. But the unofficial and probably safest recommendation is to install 1x3-inch vertical nailers over the foam at each stud. Not only does this create a 3/4-inch cavity to allow backside drying of the siding, but it also provides a much better nail base.

J. D. Ned Nisson is editor of Energy Design Update *of Arlington, Mass., a monthly technical newsletter on energy-efficient building design and construction.*

Wood Siding Over Foam



Rainwater is drawn up behind lap siding by capillary action and driven through by the sun. Being non-absorbent, the foam sheathing keeps the back face of the siding wet. With poor quality, flat-grained siding, this can result in cupping and nail popping. One solution is to add 1x3 nailers under the siding.

3 What kind of foam plastic insulation should be used on exterior foundation walls?

DOW CHEMICAL

A variety of products can work below grade, but extruded polystyrene, such as Styrofoam, consistently performs well in this application.

Bruce Nelson responds: We have found that many different materials can work, but that some require more expensive installation than others to give equal performance. There's still much we don't know, but our investigation of 59 foundations in Minnesota and discussions with others in the field suggest the following:

- Extruded polystyrene (Amofoam, Certifoam, Foamular, and Styrofoam) always works well.
- Although only two specimens of *expanded* polystyrene (EPS) were observed in our study, we feel EPS can be used successfully. However, use only the higher density products below grade, not the typical one-pound-per-cubic-foot variety found in most lumberyards.
- If you use polyisocyanurate or spray urethane, include a protective coating below grade that is long-lasting and strong enough to avoid puncture from backfill. In some cases we observed higher water absorption, which may have been caused by damage to the below-grade protective coating.

Also, foam plastic is not your only option. Consider high-density fiberglass board for sites where foundation-wall drainage is a must. This material is available as a commercial roof insulation from Owens Corning. It is only available for residential use in Canada, as BaseClad (Fiberglas Canada, 4100 Yonge St., Suite 600, Willowdale, ONT, Canada; 416/733-1600). This product must always be installed with exterior perimeter drains.

No matter what type of material you use, two elements are essential to prevent moisture absorption and deterioration. First, insulate to the top of the foundation wall, making sure to leave no gap where the insulation meets the siding. Use mechanical fasteners or adhesive to prevent the insulation from slipping down the wall.

Second, protect the insulation above grade from physical abuse and sunlight. Since many of the installations we have seen have missing or damaged coatings, we recommend an above-grade covering material at least as durable as the siding. Examples include 1/2-inch pressure-treated plywood, high-quality stucco, and fiberglass panels.

Bruce Nelson is a senior engineer for the Minnesota Department of Public Service

4 Should attics and cathedral ceilings have ventilation and vapor barriers?

Bill Rose responds: We're conducting research at the University of Illinois to answer these questions. The advice below is based on recent literature and my experience in a temperate climate (hot summers and cold winters).

Vents do keep attics and cathedral ceilings cooler. With the sun shining, the air temperature in a vented attic may be 10˚F to 15˚F cooler than in an unvented attic. So the temperature argument for ventilation holds in most of the U.S.

The other main reason to ventilate is to prevent moisture accumulation in the attic or roof system. The jury is still out on how effective that is, but for now the prudent course of action is to ventilate all attics and cathedral ceilings.

What about vapor barriers? Our research shows that in a building with a small moisture load such as a church, you'll never have roof moisture problems. But a house roof must have a continuous ceiling plane. The old way of providing an unbroken plane was to use a poly vapor barrier. The new way focuses on sealing electrical and plumbing chases and holes in the top plates. Holes around ceiling fans and fixtures are the first sites for water spotting on the roof sheathing.

The new way of sealing addresses the fact that most attics are linked to the basement or crawlspace through partition chases. Therefore, a wet basement or crawlspace will likely cause a moisture problem in the attic, and the cure for some attic moisture problems is better gutters, downspouts, and grading around the foundation.

For cathedral ceilings, we've seen both successes and failures with practically every imaginable assembly in every climate. We prefer scissor trusses because the air circulates more freely around the smaller framing members, so they may be less prone to local moisture damage.

But with any roof system, vented or not, you can relax and not worry about moisture if:

- the ceiling plane is tight
- the house is kept reasonably dry

In retrofit work, put your effort into providing good insulation and sealing all holes in the surface where the living space meets the attic.

Bill Rose is researching moisture and roofing systems at the University of Illinois, in Champaign-Urbana, Ill., where he teaches building technology.

5 Do radiant barriers save energy?

Steve Andrews responds: Yes, radiant barriers in vented attics can cut cooling bills by about 10%. They achieve this by reducing heat flow down through the ceiling by 40% or more. But the better question is: Are radiant barriers cost-effective? The answer is also yes, but only in the right climates, only when properly installed, and only at the right price (see map).

Here's a summary of the latest information:

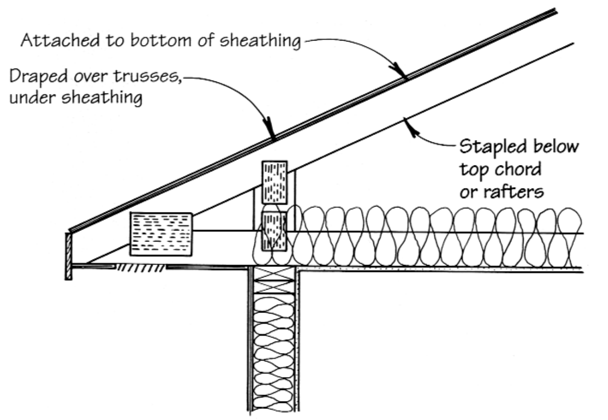
Climate. The NAHB Research Center's study (funded by Eagle Shield) promised to yield good information on radiant barrier performance in cold climates, but it has hit contractual snags. So climate-related advice hasn't changed: Radiant barriers in attics make the most sense in locations where there are 2,000 cooling degree days or more (see map at right). They may also make sense in more moderate climates where annual cooling bills still exceed annual heating bills (excluding mild sections of the West Coast). In cold climates, radiant barriers can make sense in a crawlspace, but this remains unproven for attics.

Properly installed. For attics, staple the barrier beneath the rafters, drape it over the roof trusses before the decking goes on, or staple it directly to the bottom of the roof decking—shiny side down in all cases (see illustration at left). Make sure you vent the attic, since this is the best way to cool this space. Research shows that laying a radiant barrier flat over horizontal attic insulation can cut radiant barrier performance by up to 50% after five years due to dust buildup.

Cost. If you buy material directly from a manufacturer, expect to pay between 7¢ and 15¢ per square foot, depending on the quality of paper backing and fiber mesh reinforcement. These two features can dramatically reduce tearing during installation; test this by ripping up samples before you buy. According to the Florida Solar Energy Center, if a homeowner pays about 20¢ per square foot for the installed barrier, the simple payback will be as little as five years in a cooling climate (based on electricity costs of 8¢ per Kwh). The greater the cooling load and utility costs, the faster the payback will be.

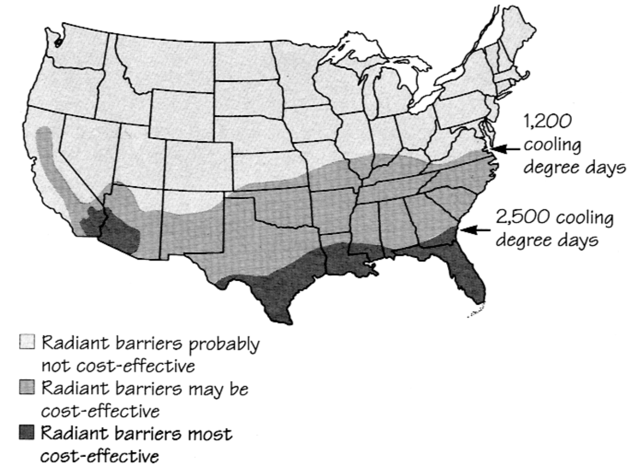
Steve Andrews is a residential energy consultant and freelance writer in Denver, Colo.

Possible Radiant Barrier Locations



In attics, staple the radiant barrier beneath the rafters, drape it over the roof trusses, or staple it to the bottom of roof decking. In all cases, install the foil shiny side down and vent the roof.

Where Radiant Barriers Make Sense



Radiant barriers make the most economic sense in the deep South.

6 Are outside air barriers needed when there is a tight interior vapor barrier?

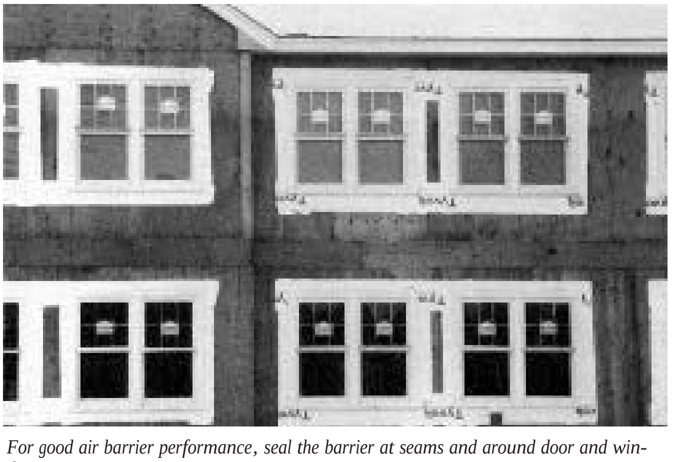
Alex Wilson responds: With plywood or foam sheathing on the exterior and a properly installed vapor barrier on the interior (all seams taped or caulked), an outside air barrier is not strictly required and will probably not be cost-effective. However, if the vapor barrier is typically installed — with unsealed seams and full of holes — an exterior air barrier is a good idea.

The research on this issue is scanty. Manufacturers have commissioned studies comparing different brands of air barriers and comparing taped to untaped installations. But no objective, third-party tests evaluate air barriers when the interior vapor barrier is properly installed.

One series of tests that sheds some light on this question was conducted in September 1987, by Architectural Testing Inc., in York, Pa., under the supervision of the NAHB Research Center, for Dupont. Some of the tests were conducted on walls with taped drywall on the interior, kraft-faced fiberglass, and polyethylene taped over outlets and windows — approximating a tight interior vapor barrier. Under those conditions, properly installed Tyvek (taped at the windows and at the top and bottom of the walls) reduced air leakage by 36% under the equivalent of a 14-mph wind. How this relates to energy savings in a real home, however, is unclear.

So should you use an air barrier? I recommend one in almost all situations as an insurance policy. If the vapor barrier is poorly installed or if it breaks down, the air barrier will be there to keep infiltration down. At an average cost of about 12¢ per square foot, it is just slightly more expensive than conventional building paper. An air barrier will also keep the shell much tighter until the windows are in, which can make a big difference in cold-weather construction.

If installing an air barrier, spend the extra few hours necessary to tape the seams and seal around windows. With clad windows, tape the flanges to the air barrier. With wood windows, caulk the exterior casing to the air barrier, or apply a bead of caulk before setting the window in place. Finally, apply a bead of foam sealant between the jamb and framing to provide a second, more dependable seal.



For good air barrier performance, seal the barrier at seams and around door and window openings.

Alex Wilson is the editor and publisher of Environmental Building News, *a bimonthly newsletter on environmentally sustainable design and construction.*

7 Is it necessary to make the vapor barrier and insulation continuous at the band joist?

Chuck Silver responds: This detail has confounded builders since the dawn of energy-efficient construction.

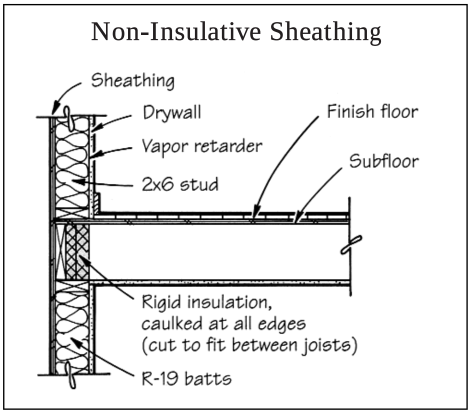
As for insulation, you should protect this area as you would any other section of exterior wall. In fact, this area may be particularly vulnerable to heat loss due to ductwork in the joist system and the fact that the warmest air is likely to lie on the ceiling, which is often penetrated by electrical boxes and recessed lights.

To control water vapor, a continuous air barrier on the warm side of a wall is desirable, since most moisture exits a building with leaking air. The barrier keeps moisture-laden air from getting into wall and ceiling cavities where the moisture can condense on any cold surface. The barrier can be poly, drywall, rigid foam, or any material that will stop airflow.

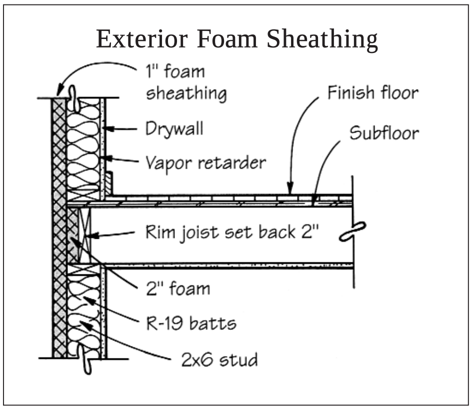
Creating a perfect barrier at the band joist — particularly where it runs perpendicular to the floor joists — is probably impossible. As with the rest of the building shell, it is less critical if excess household moisture is removed by mechanical ventilation. Details that I've used successfully are illustrated below.

Chuck Silver designs energy-efficient homes and conducts training seminars for builders in New Paltz, N.Y.

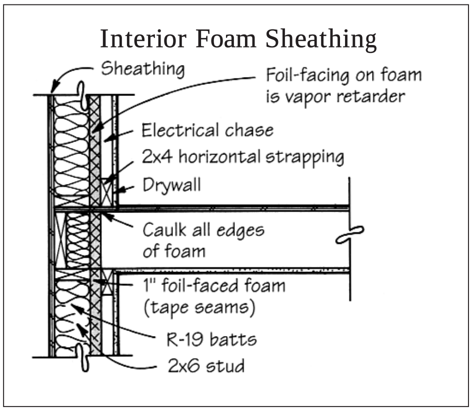
With standard platform framing, cut rigid insulation to fit between the joists and caulk each section in place.



With exterior insulating sheathing, offset the band joist 2 inches and install long strips of foam on the exterior (this keeps the band joist warm enough so that moisture will not condense on it). Some framers, however, find this awkward.



With interior foam sheathing, the foam board can be easily notched and slid up between the joists.



8 Should crawlspaces be ventilated or sealed tight?

Bill Campbell and Charles Jennings respond: Crawlspaces can work well whether vented or not. However, in warm, humid areas such as the Southeast, we wouldn't recommend the non-vented approach unless good construction practices are rigorously followed.

In all cases, you should install a ground cover. With a ground cover, a vented crawlspace should have at least one square foot of free vent area for each 1,500 square feet of ground area. There should be at least four vents well spaced from each other — usually near the corners. Ideally they should be placed with two on the side of the prevailing wind and two on the opposite side to encourage air movement. The insulation goes under the floor above.

The alternative is to place the insulation on the walls (plus the outer 18 inches of earth floor) and close off the vents. This approach typically costs less than installing vents and underfloor insulation. Energy savings are similar and may be better in the sealed approach if the heating system or ductwork is located in the crawlspace.

We have great misgivings, however, about the unvented approach. Having crawled through more swampy, damp, muddy crawlspaces with rotting floor joists and headers than we care to remember, we are reluctant to endorse any technique that could accelerate the growth of damaging fungi. In drier, cooler climates less prone to fungal growth, unvented crawlspaces may be more appropriate.

For all crawlspaces, we recommend the following:

- Avoid the use of below-grade crawlspaces
- Slope the grade around the house away from the foundation
- Use roof gutters and direct downspout runoff, along with patio and driveway runoff, away from the foundation
- Use foundation drains in areas with high water tables or other drainage problems
- Always use a ground cover. In an unvented crawlspace, carry it up to the top of the walls
- Overlap ground covers a minimum of 4 inches and secure with rocks or pieces of masonry to prevent movement
- Repair and properly drain air conditioner condensate lines
- Remove all wooden debris from the crawlspace and keep the structure at least 18 inches above the ground
- Periodically inspect the crawlspace

Whether vented or unvented, a wet crawlspace can lead to structural decay.

Additionally, in a vented crawlspace, make sure the vents are not below grade or blocked by shrubs. The vents should be open year-round.

Bill Campbell and Charles Jennings have done extensive field research on crawlspaces with the Tennessee Valley Authority in Chattanooga, Tenn.

9 Do tight houses have higher levels of humidity, radon, and indoor air pollution than older, leakier houses?

Terry Brennan responds: With a strong enough contaminant source, any house can have an indoor air quality problem. If contaminants are properly controlled, a tight house can have as clean or cleaner air than a leaky house.

For example, some of the houses with radon problems I've worked on would need 20 to 30 air changes per hour to get them below the recommended levels for indoor radon. This could be done by adding big enough fans, but the house would cost a fortune to heat and you couldn't keep candles lit from the breeze. So the first rule is "No strong sources of air contaminants in the house."

Some sources, however, like moisture and odors from kitchens, laundries, and bathrooms, are unavoidable. These are actually pretty easy to control by locally exhausting these rooms. Local exhaust is better than a general increase in ventilation because it not only brings in outside air to dilute the contaminant, it also keeps it from spreading to the rest of the house. ASHRAE recommends 100 cfm of intermittent exhaust in the kitchen and 50 cfm in each bathroom.

Other unavoidable contaminant sources are scattered throughout the building—notably people. People give off bioeffluent (body odor) as well as carbon dioxide and water vapor from breathing. (With too much CO_2 in the air, you feel drowsy and overheated.) There are also fungi, bacteria, mites, insects, rodents, dogs, and cats — who all give off odors — even in the cleanest of houses. ASHRAE recommends (Standard 62-1989) that residences have .35 air changes per hour of general ventilation air to supply oxygen for breathing and to control contaminants from these sources.

The ventilation system should be designed to control the last category of unavoidable contaminants — soil gases, which include water vapor and occasionally radon and methane. Use the air handling equipment to slightly pressurize the basement or use an exhaust fan to depressurize the subslab drainage layer. Similarly you should design the ventilation system to slightly depressurize the upper parts of the house (in northern climates) to protect the walls and ceilings from moisture condensation.

Terry Brennan is a building researcher in Oriskany, N.Y.

10 Does an oversized heating system waste energy?

Richard Karg responds: Yes, an oversized heating system is wasteful for three reasons: 1) It reduces the annual efficiency of combustion heating systems; 2) it increases the potential for flue condensation in mid-efficiency systems; and 3) it increases the cost of heating systems.

Now for some explanation. First, an oversized combustion heating system will not fire as much as a system that is sized properly. Instead, it will "stand by" more and lose more heat up the flue. The more oversized it is, the greater the stand-by time, and the higher the fuel bill.

Off-cycle losses are greater from a boiler (which heats water) than from a furnace (which heats air) because water stores over 3,000 times more heat energy than air for a given volume. This means that boilers are penalized more than furnaces are for oversizing. Also, note that the higher the efficiency of a combustion heating system, the smaller the penalty for oversizing. (The efficiency of electric heat is not affected by oversizing.)

Second, if a combustion heating system runs less because of oversizing, the flue may not stay warm enough to evaporate flue-gas condensation. This could lead to corrosion of the flue, which is a maintenance problem and could result in flue gases spilling into the house.

Third, the larger the heating system, the more costly it will be to install (for any type of heating system).

Studies indicate that the average combustion heating system in the U.S. is oversized by 2.3 times. Using a conservative estimate of a 5% penalty for oversizing in gas appliances (up to 10% for oil-fired equipment), the savings from accurate sizing is substantial.

Heating systems should be sized for new and existing homes by using design heat load calculations — not rules of thumb or intuitive guesses. ■

Rick Karg is an energy management consultant in Topsham, Maine, and frequently conducts training seminars on sizing heating systems.