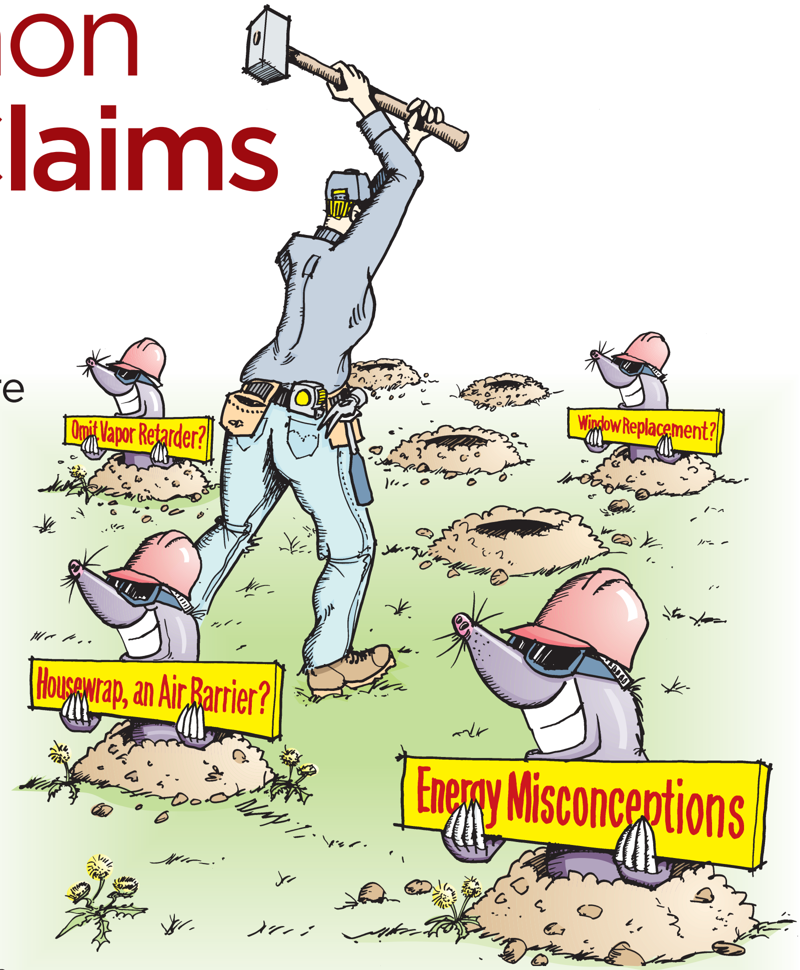
by Martin Holladay

A Close Look at Common **Energy Claims**

Understanding energy consumption and moisture movement in the homes we build is hard enough; rampant half-truths and misconceptions only make it harder



You can't gauge the truth of an opinion by the frequency of its repetition. Exhibit A: Builders' opinions concerning energy, insulation, heating, and cooling. A fair percentage of these beliefs — derived in part from product marketing, obsolete recommendations from "experts," and oft-repeated tales heard at lumberyards — prove upon examination to be half-truths or outright misconceptions. But like Whac-a-Mole pests, they just keep popping up.

To set the record straight, this article will strive to clobber the pesky moles one more time.

"Window replacement is a cost-effective way to save energy."

Replacing old single-pane windows with new double-pane low-e units certainly saves energy. But the cost is so high — and the amount of energy saved is so low — that window replacement is almost never cost-effective. Depending on the climate and the window cost, the payback period for replacement windows can be as long as 20 or 30 years.

According to calculations posted on an Energy Star program Web site, installing new double-pane low-e windows in a typical 2,000-square-foot single-story house that previously had single-pane units will result in annual energy savings of $125 (in a mild climate like California's) to $340 (in a severe climate like New England's). If the old windows had storms, the savings drop to $20 to $70 per year. Exact mileage may vary, but anyone who expects that window replacement will have an energy payback needs to be prepared for a very long wait.

The most cost-effective window retrofit measure is the installation of low-e storm windows. Although many storm-window suppliers are unfamiliar with the product, low-e storms can be ordered. Suitable glass with a pyrolitic (hard-coat) low-e coating is available from most glass distributors. According to a recent study, the payback period for installing low-e storm windows on older houses in Chicago averaged just 4.3 years.

"Housewrap is an air barrier."

When housewrap was first marketed to builders in the 1980s, manufacturers touted its benefits as an air barrier. The marketing campaigns were so successful some builders still believe that "housewrap" and "air barrier" are synonyms.

In fact, the most important function of housewrap is as a water-resistive barrier (WRB). Installed between siding and sheathing, a WRB is designed to stop rain that sneaks past the siding.

Housewrap can reduce air leakage between sheathing panel edges somewhat, especially if the housewrap seams are taped. But the cracks between wall sheathing panels don't account for much of the air leakage in a typical home; the big air leaks are elsewhere.

Air leaks occur in many locations, from the basement to the attic. For example, leaks are common between the top of a concrete foundation and the sill plates, between the subfloor and bottom plates, and around attic access hatches. Significant amounts of air can also leave a house through electrical boxes in partition walls, by traveling up the stud bays and into the attic through cracks between the drywall and the partition top plate. All of these leaks — and many others — need to be addressed before a builder can brag about the tightness of a home's air barrier.

"Interior vapor retarders are a good way to prevent wet-wall problems."

Northern builders tend to overestimate the importance of vapor retarders. Worries about vapor-retarder placement are often misguided, since wet-wall problems are usually caused by wind-driven rain or deficient air barriers, not vapor diffusion. Most of these baseless worries concern either the foam sheathing (sometimes vilified as a "wrong-side vapor retarder") or the lack of an interior vapor retarder.

By keeping wall cavities warm, properly specified and installed foam sheathing actually reduces the chance of condensation inside a wall. And interior polyethylene can be safely omitted from walls — even in cold regions of the country — as long as kraft-faced insulation is used. Almost all walls are free of vapor diffusion problems, in part because even painted drywall provides a fair amount of resistance.

According to the 2007 Supplement to the International Energy Conservation Code, polyethylene vapor retarders are not required in any location in the U.S. In northern climates (Marine Zone 4, as well as Zones 5 through 8), the code requires that walls include an interior vapor retarder; either kraft facing or polyethylene is acceptable.

"It's good to omit vapor retarders in ceilings, to provide a way for moisture to leave the building."

Some cold-climate builders believe that, while vapor retarders are useful on walls, they should never be installed on ceilings "because you have to let the ceiling breathe, so that moisture can get out of the house." This interesting misconception contains several wrong-headed notions wrapped up in a single idea.

Most attics include ventilation. In theory (although not always in practice), attic ventilation can help remove high levels of humidity that might otherwise condense on the cold roof sheathing. However, attic moisture problems usually indicate the existence of two flaws: a wet basement or crawlspace, and a ceiling with air leaks.

Ceilings were never intended to be "moisture-relief valves" for homes. Ideally, a ceiling should be as airtight as possible, to keep warm, humid indoor air from reaching the attic. In cold climates, the ceiling should include a vapor retarder (for example, kraft facing or vapor-retarder paint) on the warm-in-winter side, to limit vapor diffusion through the ceiling.

High indoor humidity during the winter — usually indicated by condensation on windows — is rare in most homes. When it occurs, the solution is to increase the rate of mechanical ventilation. If the home lacks a whole-house ventilation system, a simple remedy for dripping windows is to leave bath exhaust fans on for 24 hours a day until the moisture problems go away.

"In-floor radiant heating systems save energy."

Proponents of in-floor radiant heating systems often claim that such systems save energy compared with conventional heating systems. The idea is that people living in homes with warm floors are so comfortable they voluntarily lower their thermostats, thereby saving energy.

The only problem with the theory is that no reputable study has ever shown it to be true, while at least one study has disproved it. Canadian researchers visited 75 homes during the winter to note where the homeowners set their thermostats. The 50 houses with in-floor radiant heating systems had thermostats set at an average of 68.7°. This was actually a little bit higher than the thermostats at the 25 homes with other types of heat delivery (either forced air or hydronic baseboard), which averaged 67.6°F (see *Notebook,* 12/01). The researchers concluded, "There will generally be no energy savings due to lower thermostat settings with in-floor heating systems."

Other radiant-floor proponents have suggested that homes with radiant floors have lower boiler temperatures compared with homes with baseboard units. This factor, however, would be responsible for only very minor energy savings, if any. It has also been suggested that homes with radiant floors might have reduced infiltration compared with homes with forced-air heat. While this is certainly possible, high infiltration rates are best solved by addressing air-barrier problems at the time of construction.

Radiant floors, like baseboard radiators, are heat-distribution systems. When it comes to heat distribution, a Btu is a Btu. The overall efficiency of a hydronic heating system is basically governed by the boiler; the distribution equipment plays only a minor role in system efficiency.

Finally, it should be noted that a home with a slab-on-grade radiant floor heating system may lose more heat to the ground than a home with a forced-air heating system would — a factor that might lower the radiant heating system's overall efficiency. The best way to counteract this problem would be to increase the thickness of insulation under the slab.

"Caulking the exterior of a house reduces air leakage."

Newspaper columnists often suggest that leaky walls can be improved by filling cracks on the exterior of a house with caulk. This is bad advice, for two reasons: First, most significant air leaks are located elsewhere; and second, exterior caulk can do more harm than good.

A caulk gun in the hands of an overenthusiastic builder can be a dangerous weapon. It's not unusual to see caulk where it doesn't belong — for example, blocking drainage at the horizontal crack between courses of wood lap siding, or blocking weep holes in windows.

If you want to limit infiltration in a leaky house, put away the caulk gun and ladder. Instead, get a few cans of spray foam and head for the basement or attic.

"Efficiency rating labels on appliances account for all types of energy."

Neither the annual fuel utilization efficiency (AFUE) number on a furnace or boiler label nor the energy factor (EF) used to rate gas water heaters includes any accounting of electrical energy. As a result, an appliance with a high AFUE or EF number may still be an electrical hog.

An appliance's AFUE is a laboratory rating of its efficiency at burning natural gas, propane, or oil. The calculation accounts for typical chimney, jacket, and cycling losses — but not electricity use.

A gas furnace has several electrical components, among them the furnace fan (by far the biggest electrical load), an igniter, a draft inducer, and controls. Oil furnaces include an oil pump, an oil burner motor, perhaps a power vent unit, and a furnace fan. The AFUE gives no clues concerning the power draw required to run these electrical components, which varies from appliance to appliance.

Most furnace fans draw between 500 and 800 watts, with an annual electricity use that averages about 500 kwh per year. Furnace fans account for 80 percent of the electricity used by furnaces, so total furnace electricity use averages about 625 kwh per year. If a homeowner operates the furnace fan continuously — either to improve air mixing or to meet the needs of an electronic air cleaner — annual electricity use is much higher. Since inefficient furnace fans produce waste heat, they are particularly problematic in cooling climates.

To reduce energy consumption, look for a furnace with a blower powered by an electronically commutated motor (ECM). Such motors use significantly less electricity than conventional permanent split capacitor (PSC) motors.

A gas water heater's EF includes thermal standby losses but not electrical power usage. Studies have shown that power-vented water heaters draw between 100 and 200 watts for an average of 84 minutes per day (about 76 kwh per year); high-use families have water-heater run-times of up to 240 minutes per day (about 219 kwh per year).

Although annual electricity use attributable to power-vented water heaters is relatively low, one Canadian researcher concluded that "it appears that the power-vented water heaters deliver very little energy savings when you factor in the use of the power-vent motor" (*Energy Design Update,* January 2004).

"Spray polyurethane foam is a vapor retarder."

This is a half-truth. Closed-cell spray foam — also called "2-pound foam" because it has an average density of 2 pounds per cubic foot — is an effective vapor retarder. Installed at a thickness of 2 1/2 inches, closed-cell spray foam has a permeance of only 0.8 perm.

On the other hand, open-cell spray foam (average density, 1/2 pound per cubic foot) is *not* a vapor retarder. Installed at a thickness of 3 inches, open-cell spray foam has a permeance of about 16 perms, making it fairly permeable to water vapor.

When installed directly against wall or roof sheathing in a cold climate, open-cell spray foam needs to be protected on the interior side with a vapor retarder. In most cases, painted drywall provides enough vapor resistance to avoid problems.

However, when open-cell spray foam is installed in a cold climate between rafters to create a so-called "cathedralized" attic, the roof sheathing can accumulate moisture. Though rare, this problem is most likely to occur in homes with elevated indoor humidity. The solution is to cover the attic side of the insulation with a vapor retarder — vapor-retarder paint, for instance.

"Air-conditioned homes don't need a dehumidifier."

In a hot humid climate, air conditioners make a home more comfortable by lowering the temperature of the air (sensible heat removal) and by dehumidifying the air (latent heat removal). When the thermostat detects that the indoor air temperature is too warm, the air conditioner switches on; when the thermostat is satisfied, the air conditioner switches off. While the equipment is operating, some dehumidification occurs. However, the ratio of latent heat removal to sensible heat removal is a function of equipment design and weather conditions; it is out of the control of the homeowner.

When an air conditioner runs flat out for hours at a time, it's usually pretty good at dehumidification. But in an energy-efficient house with low-solar-gain windows, the typical air conditioner runs for fewer hours. Although the equipment easily cools the house, it may not lower indoor humidity levels to comfortable levels.

As reported in *Energy Design Update* (January 2003), researchers in Houston were called to investigate high levels of indoor humidity plaguing a group of energy-efficient homes participating in the U.S. Department of Energy's Building America program. They discovered that "improvements in window performance and envelope tightness … lowered the buildings' sensible cooling loads to the point that existing air conditioners [were] unable to handle the latent load." The recommended solution: Each house needed a stand-alone dehumidifier in addition to a central air conditioner.

As homes continue to be built to higher energy standards, the need for supplemental dehumidification is likely to increase in hot humid climates along the Gulf Coast and in the Southeast. Stand-alone dehumidifiers are a fairly inexpensive solution to the problem. Unlike an air conditioner, a stand-alone dehumidifier continues to lower indoor humidity until the desired setpoint is reached. The downside: a dehumidifier adds heat to the house. But as long as the house has a properly sized air conditioner, this shouldn't be a problem.

"R-value measures only conductive heat transfer."

Of the three heat-flow mechanisms — conduction, convection, and radiation — radiation is probably least understood by the average builder. Sensing an opportunity, some marketers of radiant barriers, reflective insulations, and "ceramic coatings" take advantage of this common misconception (that R-value is a measure of conductive heat transfer alone) to promote their products. But in fact, R-values include all three heat-transfer mechanisms.

The most common method of testing a material's R-value is ASTM C518, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus. In this test, a technician measures the thermal resistance (resistance to heat flow) of a specimen of insulation placed between a cold plate and a hot plate.

To understand how all three heat-transfer mechanisms are involved, consider the flow of heat across a fiberglass batt. Heat wants to flow from the hot side of the fiberglass batt to the cold side. Where individual glass fibers touch each other, heat is transferred from fiber to fiber by conduction. Where fibers are separated by an air space, heat is transferred from a hot fiber to a cooler one by radiation and by conduction through the air. In ASTM C518 tests of fiberglass insulation, air movement within the fiberglass batt (that is, a convective loop) is rare, although the test captures the phenomenon when it occurs.

Since R-value measures the resistance of a material to all three heat-flow mechanisms, it remains a useful way to compare insulations and to judge the performance of insulation alternatives.

Once insulation is inserted into a wall, however, the performance of the insulation is affected by additional factors that aren't measured by R-value testing. While R-value testing measures the effects — if any — of convective loops with a tested sample, it can't be expected to account for air leakage through a wall caused by wind or other pressure differences acting on a defective air barrier. A leaky wall assembly insulated with fiberglass batts will not perform as well as the same wall assembly insulated with spray foam with the same R-value; but the difference in wall performance is due to the spray foam's ability to reduce air leakage rather than to a difference in R-value between the two materials. The fact that some insulations are more porous than others does not imply that R-value tests are misleading.

To obtain the best performance from fiberglass insulation, the Energy Star Homes program now requires most fiberglass-insulated framing cavities (including knee walls) to be enclosed by air barriers on all six sides. If builders pay attention to airtightness, fiberglass insulation can (at least in theory) meet the performance expectations that the R-value label promises. Nevertheless, in the real world, builders who use fiberglass are unlikely to reduce air leakage enough for a fiberglass-insulated wall to perform as well as a wall insulated with the same R-value of cellulose or spray-foam insulation.

"Radiant heat passes right through conventional insulation."

The idea that conventional (mass) insulation products allow radiant heat to pass right through them — that "mass insulation is transparent to radiant heat" — is a scare tactic used by some marketers of radiant barriers. The misleading claim leads some builders to falsely conclude that radiant heat can travel like radio waves right through a deep layer of attic insulation, with the only solution being a layer of aluminum foil.

Radiant heat travels through air (for example, from an open fire to nearby skin) or a vacuum (for example, from the sun to the earth). It can't travel through a solid material like concrete. If sunlight warms a concrete patio, the heat travels to the ground below not by radiation but by conduction; in other words, the concrete is first warmed by the sun (by radiation), and then the warm concrete gives off some of its heat to the soil below (by conduction). In this example, there is no radiant heat transfer directly from the sun to the soil.

A microscope reveals that most insulation products consist of fibers or pieces of material surrounded by air. If one side of an insulation blanket is exposed to radiant heat energy, most of the radiation ends up hitting a fiber or speck of material in the insulation layer, heating up that fiber. The warm fiber can then reradiate some of the absorbed heat to an adjacent fiber, as long as that adjacent fiber is at a lower temperature.

When radiant heat hits one side of an insulation blanket, only a tiny percentage of that radiant heat is "shine-through" radiation — that is, radiation that manages to miss all of the fibers in the insulation blanket and emerge unscathed on the other side of the blanket. "With insulations like fiberglass or cellulose, radiation can be absorbed by one piece of material and then reradiated," explains David Yarbrough, an insulation expert and research engineer at R&D Services in Cookeville, Tenn. "There is very little shine-through radiation with any of these materials."

The fact that heat flows through a layer of insulation, usually by a combination of two or three heat-transfer mechanisms, does not mean the insulation isn't working. Although insulation doesn't *stop* heat flow, it slows it down considerably; the more insulation, the lower the heat flow.

How much heat flows through an uninsulated ceiling into a 1,000-square-foot 32°F attic? Assuming that a 72°F house has an uninsulated drywall ceiling — that is, a ceiling assembly with an R-value of 2 — the heat flow across the uninsulated ceiling is 20,000 Btu per hour.

If insulation is added until the ceiling assembly has an R-value of 38, the heat flow is reduced by 95 percent, to 1,052 Btu per hour.

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