Does Fiberglass Insulation Still Make Sense?

Maybe, but other types offer installation advantages that make them more reliable

BY SCOTT GIBSON

Jim Remick gave up on those familiar rolls of fiberglass insulation years ago. The Portsmouth, N.H., insulation contractor has built three specialized trucks at $100,000 a pop to apply sprayed-in foam insulation, and he dabbles with blown-in fiberglass and cellulose. In Remick's opinion, batts are probably the least efficient thermal insulation a homeowner can choose. "We stay away from them," he says. "We just don't believe in the product."

Representing roughly three-quarters of all residential insulation, fiberglass batts are easy to install, are good thermal insulators, don't burn (although their facings do), and are widely available. They're also relatively cheap, and nagging health questions are being put to rest.

So what's the problem? In a nutshell, airflow. Scientists who study how heat, air, and moisture behave inside buildings say insulation plays a major role in keeping a building dry and its occupants healthy. Batt insulation doesn't do its job when installed wrong. And batt insulation is easy to install wrong. Many insulation contractors make a tidy living from retrofits, fixing houses not properly insulated in the first place.

Alternatives vary in cost and efficiency

With as much as 70% of residential energy consumption spent on heating and cooling, insulation choice can have huge financial implications. It's not merely a question of cost for installation, but how much money insulation can save through lower energy bills.

Insulation can be divided into four families: batts, blown-in varieties, sprayed-in foam, and rigid panels. Installed costs range from less than 50¢ to more than $2.50 per sq. ft. R-values, the standard measure of thermal efficiency, range from about 2.3 to 7 per in. But factors beyond thermal efficiency and cost are worth weighing: Is the insulation an effective air barrier? Does it block water

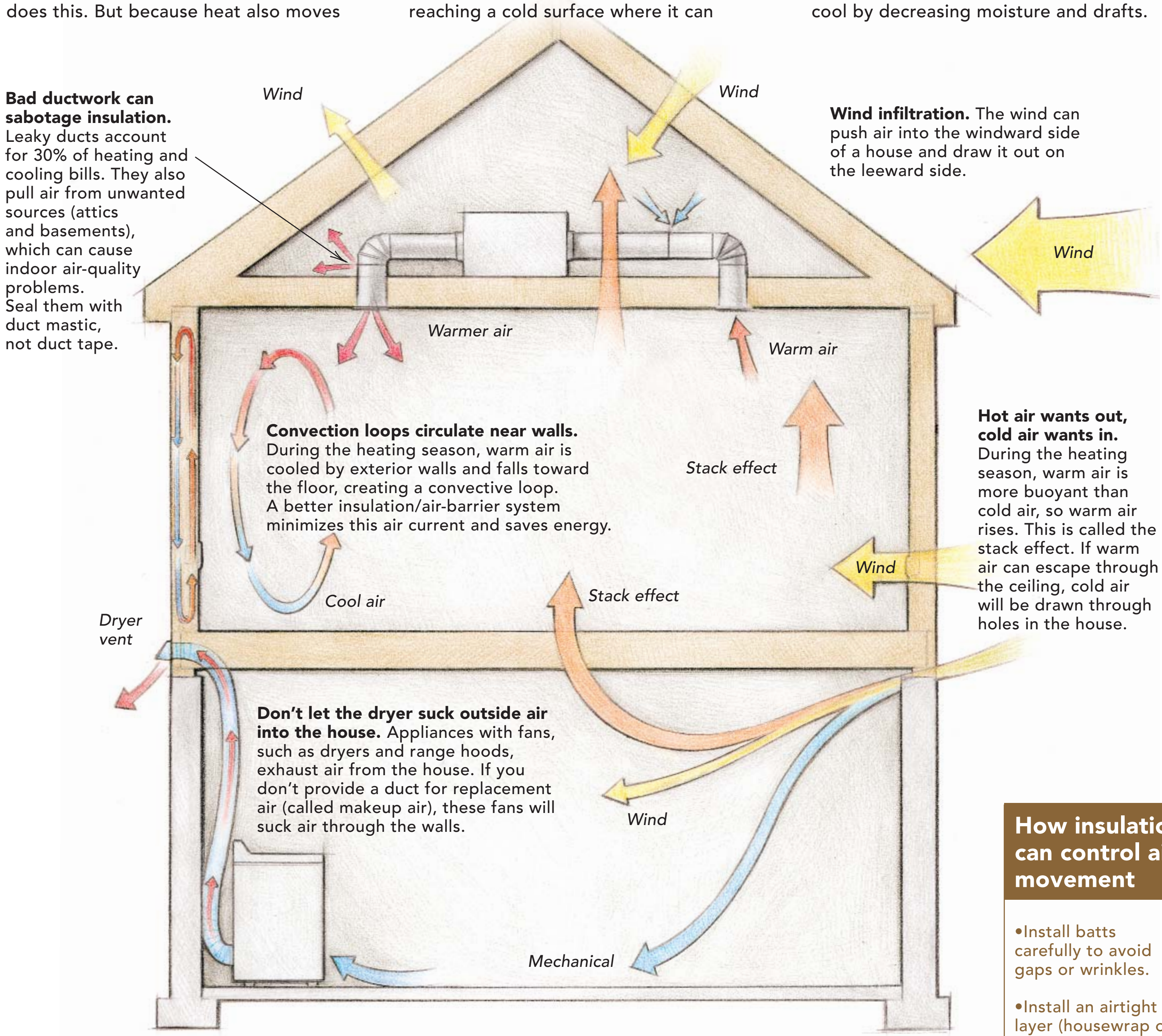
"Batt insulation doesn't do its job when installed wrong. And batt insulation is easy to install wrong."

The wall's full of insulation, so what's the problem? *Stuffing batts behind wires and into undersize stud cavities creates channels next to the studs for convective air currents (drawing facing page). Convective air currents negate R-value.*

Photo this page: Joseph Lstiburek

HOW AIR MOVES THROUGH A HOUSE

For any type of insulation to work, it needs to be part of an effective system. Insulation should block conductive heat flow (through materials in contact with each other), and R-value is a measure of how well insulation does this. But because heat also moves through convection (air currents), air movement needs to be controlled with an air-barrier system. Additionally, water vapor rides on convective air currents, and tight insulation prevents this vapor from reaching a cold surface where it can condense, leading to mold and rot. Air moves through a house due to a variety of natural and man-made forces. Controlling air movement makes a house more comfortable and less expensive to heat and cool by decreasing moisture and drafts.



vapor? Will it support the growth of mold, or become a mouse or ant hotel? Does it trap water or allow walls to dry?

Batts: Easy installation, one big weakness

Although fiberglass is by far the dominant player in the batt market, there are other choices: recycled cotton, wool, and mineral (or rock) wool. Fiberglass batts are available in a variety of thicknesses and in precut widths to fit different kinds of framing. Manufacturers offer different densities, with resulting R-values from about 2.9 to 4.3 per in. High-density batts do a better job of restricting airflow in walls, ceilings, and floors.

Putting in batt insulation seems simple. All you need to do is cut the batt to the right length and fit it by stapling the foil, plastic, or kraft-paper flanges to the framing. But there's the rub: The right length is tricky to achieve, and the flanges need to be continuous along the face of the framing. According to research done for the American

How insulation can control air movement

- Install batts carefully to avoid gaps or wrinkles.
- Install an airtight layer (housewrap or rigid foam) behind siding.
- For rigid-foam insulation, use multiple layers with staggered seams.
- Resist air movement by packing wall cavities with cellulose or sprayed-in foams.

Drawings: Bob La Pointe

Batt insulation

Unfaced batts don't provide moisture control.

Kraft-faced batts retard moisture, allow drying.

Facings on batts provide three levels of moisture control: none, some, and lots. Batts with barrier facings can cause more harm than good unless detailed properly. Unfaced batts (photo right) are for use in very cold climates where powerful vapor drive warrants plastic vapor barriers.

Encapsulated batts have a plastic vapor barrier.

Foil-faced batts stop moisture, but don't allow drying.

Society for Testing and Materials (ASTM), a gap of even 1 mm can allow substantial convection currents (read: heat loss) within and through a wall assembly.

Even with precut batts of a fixed thickness and width, you still don't get perfection because stud bays and joist cavities often are shaped irregularly. Unless the material is meticulously installed, its actual R-value will be lower than the number printed on the wrapper. That means no gaps, voids, or overstuffing crevices. No shortcuts when fitting the insulation around pipes and wires. And the framing needs to be exact.

Loose fill is blown into attics and walls

The next step up in performance comes from cellulose and fiberglass blown into wall and roof cavities. They readily fill the gaps that are so tough to seal with batts. "The loose-fill products tend to be easier to install, so therefore,

Unfaced batts

everything else being equal, you would expect to get better application out of a loose fill than you would out of batts," says André Desjarlais, program manager for Building Envelope Research at the Oak Ridge National Laboratory. When the entire cavity is filled with insulation, air leaks are fewer, and thermal performance goes up.

In the attic, pile it on

New energy codes typically call for lots of insulation in the attic or roof (R-49 in northern climates like Montana, Minnesota, and Manitoba). According to Desjarlais, a consumer typically gets the most R-value per dollar in an attic when the insulation is applied at the lowest density possible. Lower density is better because it traps more air in the insulation, and trapped air is a good insulator. For fiberglass, that density is about a half-pound per cubic foot, yielding an R-value of 2.5 per in. For cellulose, it's about 1.2 lb. per cu. ft., which yields R-3.5 per in. "Since you've got space, you can keep piling it on," he says. "The application costs are pretty low, so as a consumer, I'm really paying for the weight of the material. … I'm much better off having the products applied at lower densities because for every dollar that comes out of my pocket, I get a lot more R-value."

Although fiberglass and cellulose are close in cost, low-density fiberglass has a problem. When temperatures dip to about 0°F, convection decreases the insulation's efficacy, a fact the cellulose industry takes delight in repeating. As temperatures fall, performance declines—up to 50% at -40°F.

"That's true," says Desjarlais, "but it's reduced by 50% only while it's -40°F outside. It's not like the homeowner is getting only half the R-value all the time; he's getting half the R-value only for that very short period of time." But that can be much of the winter in some places.

In walls, pack it in

Unlike an attic, a wall cavity presents a limited amount of room for blown-in insulation. To achieve higher R-values with loose-fill fiberglass and cellulose, up to about 4 per in., installers squeeze in more insulation, creating a "dense pack."

One big plus for blown-in systems is that they work almost as well in a retrofit as they do in new construction. Reinsulating a house doesn't require invasive surgery. Installers can pop off siding, bore holes in sheathing, and fill wall cavities without disturbing the inside of the house.

In new construction, cellulose can be blown into wall cavities wet or dry with thermal performance similar to that of fiberglass. When installed dry, the material is held in place in a variety of ways: reinforced plastic sheets, netting, drywall, or removable plywood panels with precut holes. Wet application helps cellulose to stick in overhead uses, but if the material goes in too wet, it may take weeks for the insulation to dry. And putting up wallboard before the water completely dissipates or adding vapor barriers can trap moisture inside the wall.

One key difference: moisture absorption

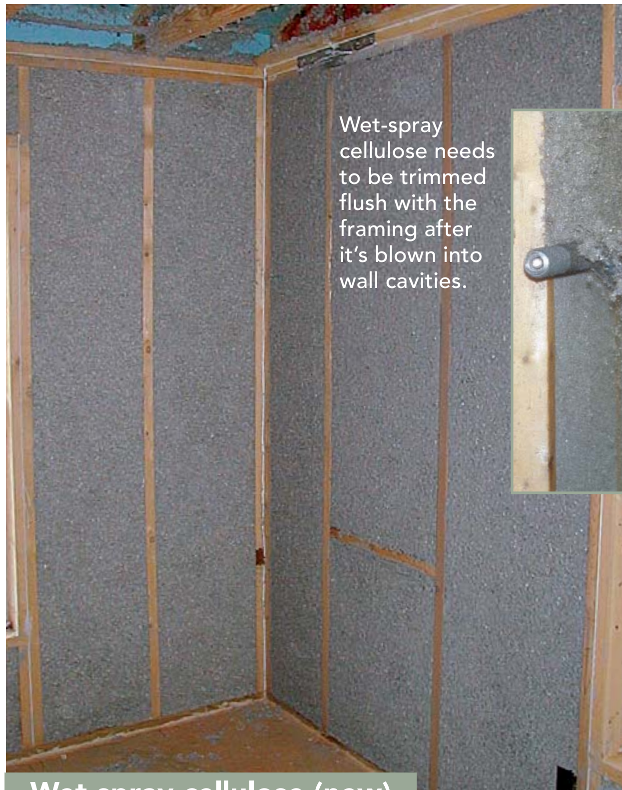
You'll get about the same level of thermal insulation from blown-in cellulose and fiberglass, and costs are competitive. One big difference, however, is how they react to airborne moisture. Cellulose absorbs moisture. Fiberglass does not. Either condition can be good or bad, depending on how you design the wall system.

The cellulose industry says the absorbent quality of its product is a benefit. The insulation holds and evenly distributes moisture driven into the walls and becomes a sort of moisture buffer. This ability to hold and release moisture makes a separate vapor retarder unnecessary in almost all climates, says Dan Lea, executive director of the Cellulose Manufacturers Association. Building scientists concur.

Neither cellulose nor fiberglass fares well when soaked with water. Cellulose doesn't dry quickly, and saturated

Photo right this page: Charles Bickford

Dense-pack cellulose (retrofit)



Wet-spray cellulose needs to be trimmed flush with the framing after it's blown into wall cavities.

Wet-spray cellulose (new)

One big plus for blown-in systems is that they work almost as well in retrofits as they do in new construction.

material should be removed. Fiberglass mats together and loses efficiency because of gaps allowing convection. But if your insulation is becoming soaked, that's the least of your problems. And replacing the insulation probably is going to be the least of your expenses.

Sprayed-in-place foam: Good air barrier at a high initial cost

Foams sprayed into wall and ceiling cavities are the most expensive residential insulation. Like dense-pack fiberglass and cellulose, foams make effective air barriers. Some also offer very high R-values. There are two kinds of foam, open and closed cell. Both are two-part compounds mixed at the nozzle as they are sprayed in place. They expand dramatically as soon as they are applied, and they cure rapidly. Foam seals all the hard-to-reach spots, and the excess is easy to trim off.

Open-cell foam, which expands 100-fold after application, has an R-value of about 3.6 per in. It uses water as the blowing agent to create the foam cells. Closed-cell foam, which uses pentane as a blowing agent, expands about 30-to-1 after application. These foams have an R-value of about 7 per in., although the R-value declines somewhat as the blowing agent dissipates. Estimates for "aged R-value" range as low as 5 per in.

One key difference between open- and closed-cell foams is how easily water vapor passes through the material, a characteristic called permeance. Open-cell foams have high perm ratings, in the range of 9 to 10. Closed-cell foams have a perm rating of less than 1 (anything below 1 is typically considered a vapor retarder). Like absorbency in the loose-fill class, permeance of open- and closed-cell foams should dictate their application. Permeance has nothing to do with their relative utility or value.

Engineer Joseph Lstiburek suggests that if you're spraying foam inside your basement walls, a high perm rating is better if the walls need to be allowed to dry (poor exterior damp-proofing details). If the basement is protected on the exterior with a waterproofing membrane and a good drainage system, low-perm foam is better. For roofs, climate dictates which is preferable: The underside of a roof deck in a cold climate should have low-perm foam applied; in a hot climate, high-perm foams are better. Because the foams are such effective air barriers, manufacturers say whole-house ventilation systems are a must.

While disposable kits are available to homeowners who want to spray their own foam insulation, they're expensive. And insulating with foams shouldn't be a do-it-yourself job. Trained crews apply the insulation with special equipment. A precise mix is essential to achieve the

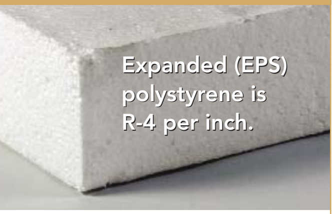
Blown-in insulation

Densely packed blown-in insulation stops convection currents. Cellulose and fiberglass can be blown into wall cavities to insulate and to provide a backup air barrier, but they can't stop pressurized air movement. Cellulose also acts as a moisture buffer because it can absorb, distribute, and release moisture. For the attic, blown-in insulation is most effective at very low densities to provide even better R-values. But blown-in fiberglass can allow convection, and it loses efficiency at colder temperatures.

Cellulose is made from recycled paper.

Photos (left to right): John Curtis, Joseph Lstiburek, Green-Stone Industries

Rigid panels and sprayed foams



Expanded (EPS) polystyrene is R-4 per inch.

Extruded (XPS) polystyrene is R-5 per inch.

Rigid panels are versatile. All are good for walls and roofs, but XPS is the best for insulating foundations. EPS and polyisocyanurate are less resistant to water, but come with a variety of facings to lessen the effect. EPS is used in structural insulated panels and insulating concrete forms as well as coffee cups and coolers. Polyiso is commonly used as an exterior-wall sheathing insulation. Spraying foam into stud, joist, and rafter cavities from the inside provides an effective air barrier in addition to insulation (right).

Polyisocyanurate is R-6.5 per inch.

best results. If you're going to spend the money, you should strive for excellence.

On a per-R installed cost, open- and closed-cell foams cost about the same, but wall thickness can be an issue. Open-cell foam in a conventional 2x4 wall would get a thermal rating of about R-12 or R-13, not enough to meet energy guidelines in many parts of the country. It would have to be augmented by insulated sheathing.

Insulation in board form

Rigid insulation is useful in places where batts, loose fill, and sprayed-in foams are not. Rigid insulation is a great choice in two places in particular: under concrete slabs and as nonstructural sheathing to increase the thermal performance of walls and roofs. It's especially useful in buildings with metal framing where thermal bridging at the studs can be extreme. Three kinds of rigid-foam boards typically are used in residential construction: expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate (polyiso).

Sprayed foam

Expanded polystyrene is least expensive

EPS has the lowest R-value, about 4 per in., and is the least expensive, about 15¢ a sq. ft. for a 1-in.-thick panel. The material is made by expanding polystyrene beads in a mold with pressurized steam. The closed-cell foam can be manufactured in different densities with a compressive strength of up to 60 lb. per sq. in. (psi).

EPS, typically white in color, is used as insulated sheathing, in insulated concrete forms (ICFs) and structural insulated panels (SIPs), and as roof and foundation insulation. Some EPS panels are treated with borates to discourage insects from tunneling or nesting in below-grade applications. A drawback is that the material usually is unfaced and is easily damaged on the job site.

Extruded polystyrene: a better insulator

With an R-value of about 5 per in., XPS is a better insulator than EPS. This closed-cell foam is available in either faced or unfaced panels that are pink, green, or blue, depending on who makes it. XPS can be faced with polyethylene or another film to increase toughness, and it can be made with a compressive strength of up to 60 psi for underslab applications. XPS, which costs about 32¢ a sq. ft., has good water resistance. It's used as insulated sheathing in walls and roofs, and in below-grade applications.

Polyisocyanurate has highest performance

Polyiso panels have the highest R-value of the three and cost a bit more than XPS. An industrywide conversion to a new blowing agent at the start of 2003 gave the material less of a thermal edge than it once had, but ozone-depleting chemicals are no longer used. Doug Bibee, a technical manager for Dow (800-441-4369; www.dow.com), says the switch from HCFC 141b to pentane, a hydrocarbon, lowered R-values to between 6 and 6.5 per in. Polyiso panels, Bibee says, have lower compressive strength (about 20 psi) and lower resistance to moisture than XPS and EPS, so they aren't the first choice for use below a concrete slab.

Because of the manufacturing process, polyiso is always made with a facing, and materials range from aluminum to nonwoven fiberglass. Facing materials affect both durability and permeability.

One advantage of polyiso over the two polystyrene panels is higher heat resistance. Where EPS and XPS can start to twist, warp, or expand between 160°F and 170°F, polyiso can handle temperatures of 300°F or more. Because polyiso is a thermoset plastic, it chars in place rather than melts when exposed to very high temperatures.

So what's the best stuff?

Befuddled? Join the club. R-values, perm ratings, and air barriers are as hard to understand as IRS tax forms. For most of us, choosing one type of insulation comes down to a simple question: How do I stay comfortable, winter and summer, without spending more money than I have to?

The drawing on the facing page shows two systems, one good, the other better, that should work anywhere from Austin to Boston. Local costs may give one type of insulation an edge over another. But in the end, even a specialist like Desjarlais has a pretty simple answer:

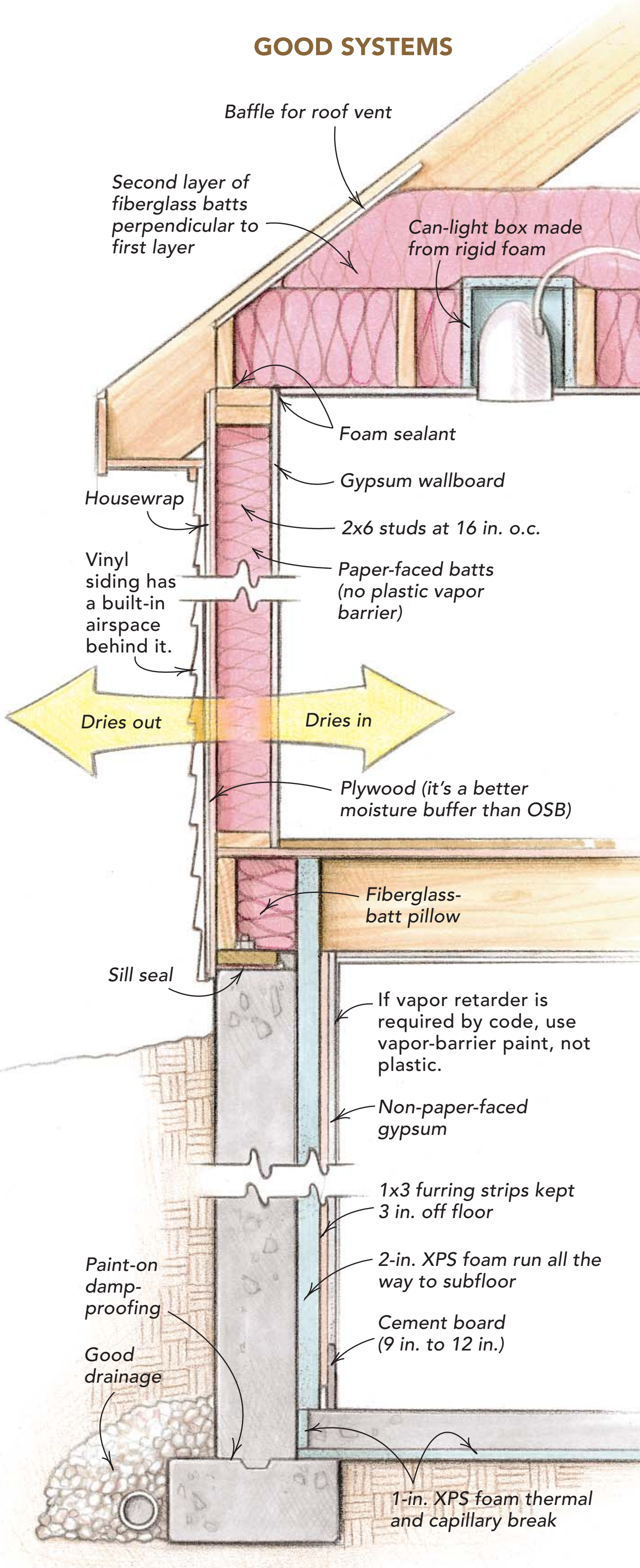
"Forget the product; pick the best contractor. I really think the key is there. If you get someone who's going to install it right, all of these products are going to work; they're all going to save energy. The product you pick, I think, is secondary to the contractor you pick." □

Scott Gibson is a contributing editor to *Fine Homebuilding*. Photos by Daniel S. Morrison, except where noted.

Photo right this page: Steve Culpepper

INSULATION SYSTEMS THAT WORK FOR BASEMENTS, WALLS, AND ROOFS

We asked three building-science engineers to choose insulation systems for basements (Bruce Harley), walls (Joseph Lstiburek), and ceilings (André Desjarlais) that will work in a wide range of climates. They chose a good system, which will perform adequately (and which anyone can install), and a better system, which will increase energy efficiency and comfort (but will cost more and may require professional installation). For ZIP code specific insulation advice, visit www.ornl.gov/roofs+walls.



Ceiling systems

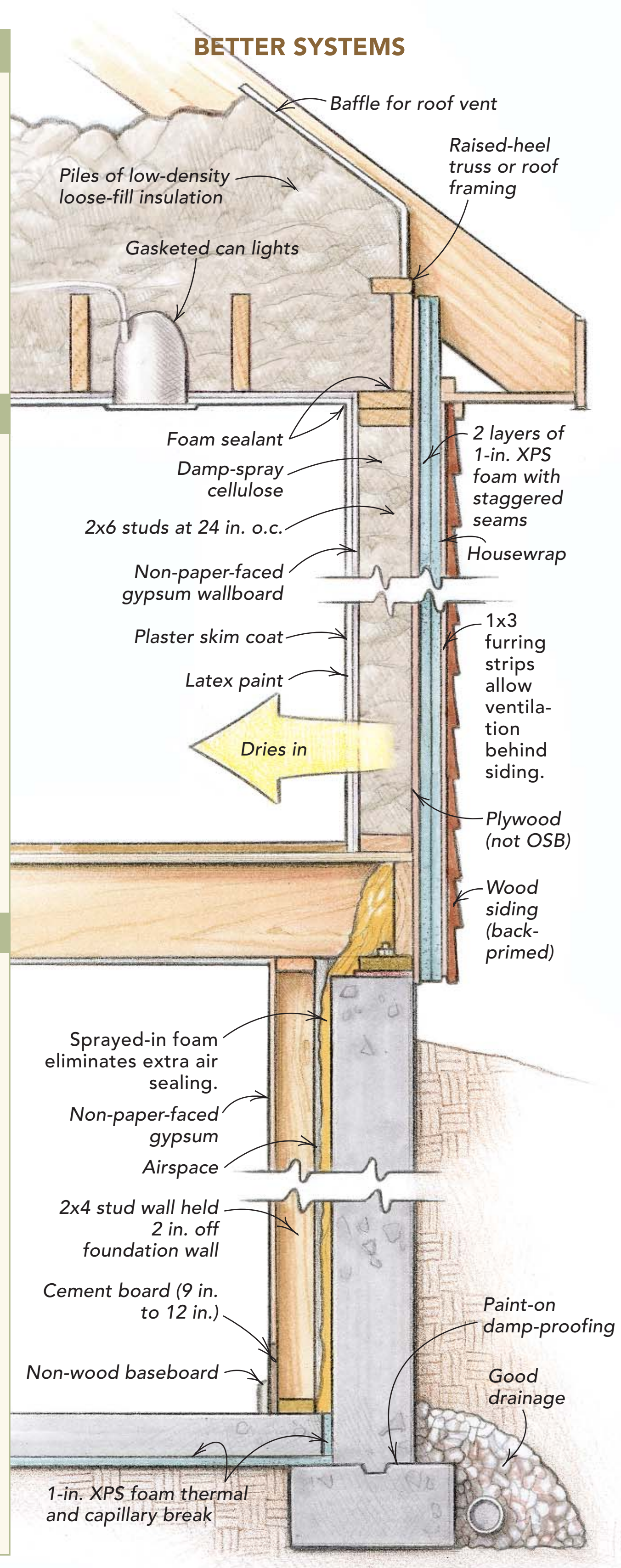
To decrease energy loss due to the stack effect, penetrations in the ceiling should be sealed. In an unfinished attic, a good way to improve batts' efficiency is to add a perpendicular layer. A better system is to blow in piles of loose-fill insulation.

Wall systems

Walls need to be able to dry when they get wet. Venting the siding allows a wall to dry to the outside, and not using a plastic vapor barrier allows a wall to dry to the inside. A good system uses housewrap and plywood as an air barrier and allows drying behind vinyl siding (which is inherently ventilated). A better system replaces batts with cellulose and adds foam sheathing outside the wall.

Basement systems

Moisture is the biggest threat to a basement or crawlspace. Insulation can eliminate condensation problems, but all basements must have proper drainage detailing to control liquid water. A good system is rigid foam on the inside with furring strips for ventilation and fastening wallboard. A better system, sprayed-in foam, is more reliable because it eliminates the extra air-sealing details. A 2x4 stud wall is easier to build than fastening furring strips and provides space for plumbing and wiring.



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Reader Response

Good article on insulation, but ...

I want to congratulate you on a great insulation article in the last issue (*FHB* #160, pp. 50-55), though I'm sure you must be getting some hate mail from the fiberglass industry by now. I think you did a good job overall with one of the most difficult and unintuitive systems that we use in the construction industry (second only to vapor control).

Of course, there are some finer details I could quibble about—most notably, the idea that spraying foam in cavities inherently makes a house tight (remember, there are some types of leaks that don't happen in the cavities)—but I do have to point out a couple of things.

First, the caption on p. 52 for the photo of encapsulated batts is misleading. The pink wrapping on three sides is *not* a vapor barrier; it's there only to keep weekend warriors from getting itchy (and in the process making the batt even more difficult to install correctly). Only the side with the printing is a vapor barrier, and it's important that this be installed to the warm side.

Second, I disagree with the caption, also on p. 52, that asserts unfaced batts would be used only in places where a poly vapor barrier is needed. I tend to agree with Joe Lstiburek that poly is needed only in extreme cold, but there are other very good uses for unfaced batts, including hot, humid climates, or atypical wall assemblies (like in an R-11 wall with R-10 or more of rigid foam on the exterior in a mixed-to-cold climate).

And finally, EPS is fine for below-grade applications. There was a good article in the August 1999 *Energy Design Update* that featured research showing that EPS is just as durable below grade in long-term tests as XPS. I still wouldn't use it under a slab because of the lower compressive strength, but because of the lower cost and much smaller environmental impact (and the option for borate treatments), I'm liking it more and more for most other applications.

—BRUCE HARLEY Stamford, Vt.