Roofing and Siding Rehabs Get an Energy Fix

by Paul Fisette

When it's time to replace worn siding and roof coverings, recognize the opportunity to upgrade energy performance. Here are several options for incorporating energy retrofits into roof and wood siding rehabs.

The old adage says, "Within every problem lies an opportunity." This is certainly the case when it comes to residing or reroofing a home. Replacing roofing and siding is expensive, so it's often a catastrophic event, like water dripping from the ceiling, that launches the project into motion. But there is much to be gained beyond fixing leaks and worn-out siding. A well-designed exterior retrofit will lower energy bills, improve comfort, and redefine a home's level of performance.

Roofing

Roof shingles wear out and need replacing about every 20 years. Builders in the mid-70s devoted very little attention to insulation and airtightness in the design of their building envelopes. So it's safe to assume that if a home needs a new roof, it also needs new, or at least better, insulation. High energy bills, drafty or sweltering indoor climates, and the formation of ice dams on roofs are all costly symptoms of poor energy design (see "Out, Out Dammed Ice," p. 21). In hot climates, reflective roofing materials can help keep the heat at bay (see "White Roofs for Cool Homes"). Insulation and air sealing are appropriate in all climates, but they are essential in very cold areas subject to ice dams.

In some ceilings, an energy retrofit is easy. Climb into the attic, block all air leaks connecting the living space to the attic space, and increase the thickness of insulation on the attic floor. However, in some homes—those with shallow-pitched rafters or sloped or cathedral ceilings—this plan is not so easy to follow. Reroofing provides an opportunity to gain access to these tight spaces.

Shallow Rafter Pitch

It is difficult to tighten and insulate ceilings in homes with shallow-pitched rafters. Near the eaves, the space between the bottom of the roof rafters and the top of the ceiling joists is just too narrow for workers to access. Also, there isn't room for proper insulation. Twelve inches of fiberglass or cellulose insulation is needed to deliver the R-38 values recommended in much of the United States. Even if you shoot for 9 inches (R-30) of insulation, a roof with a 4/12 pitch does not have the required 10½ inches of clearance (9 inches of insulation plus 1½ inches for roof venting space) until you get in more than 2 feet from the building's edge.

When blowing in cellulose and fiberglass, insulation retention baffles must be positioned over the outside walls at the eaves to prevent the insulation from blocking soffit vents. The narrow space at the eaves makes proper installation of retention baffles difficult or impossible.

Reroofing makes insulating under a shallow-pitched roof easy. Strip the roof covering and sheathing from the lower edge of the roof. If the roof is sheathed with plywood, remove the first row of plywood from the bottom edge of the roof. If the roof is covered with boards, remove them for the first 3 or 4 feet. Carefully remove the sheathing and save it for reuse. The difficult-to-reach section of the ceiling now lies exposed and can easily be worked on.

First, seal any air leaks in the ceiling. Use a can of foam to seal wire penetrations, cracks, or spaces that connect the attic to the living space below. Next, provide adequate levels of insulation. Since space is restricted at the roof edge, use an insulation material that has a high R-value per inch of thickness (see "*Home Energy's* Consumer Guide to Insulation," *HE* Sept/Oct '96, p. 21). Polyisocyanurate foam board, such as Thermax, is rated R-7 per inch. Cut the insulation into strips and stack layers of these strips

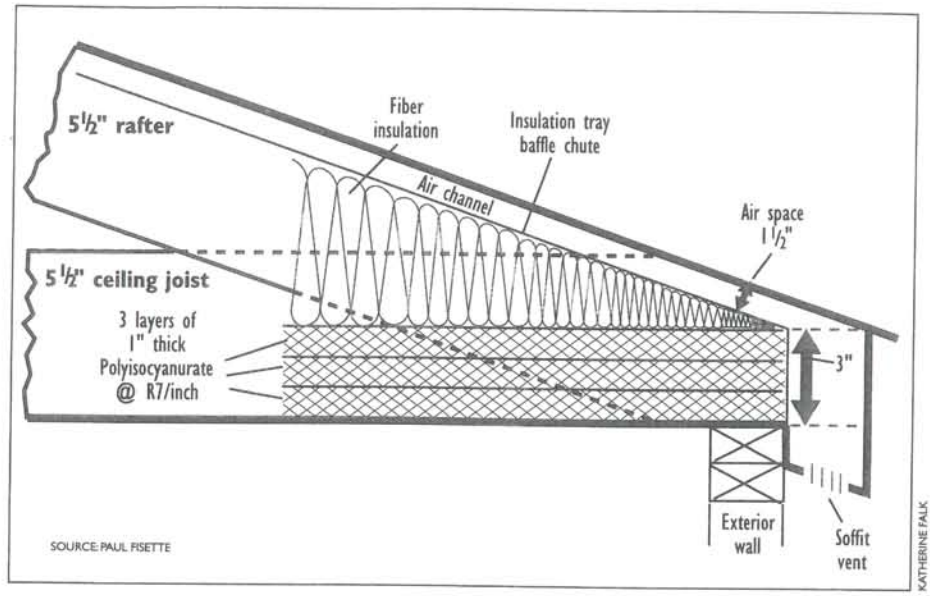
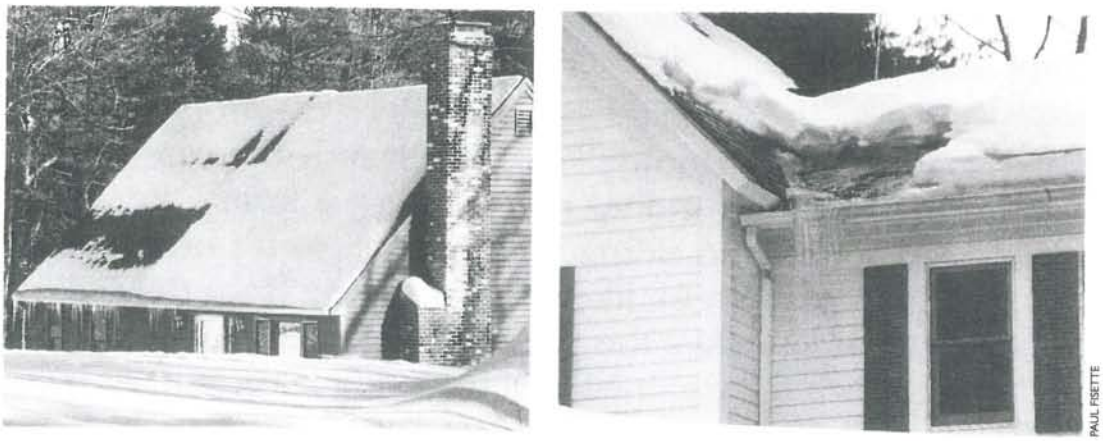


Figure 1. The best method for installing insulation at the edge of a shallow-pitched roof.



Homeowners should plan ahead for the winter months when embarking on a reroofing project. The ice dams on the edges of these roofs, and the bare spot created by leaking heat in the photo on the left, show that additional weatherization is needed. Through adequate insulation, air sealing, and attic ventilation, exisiting homes can be effectively retrofitted.

between the rafters and the ceiling joists directly over the outside wall. Cut the strips so they fit snugly against the framing members of the roof and ceiling. Be sure they extend 2 ft into the attic, and leave 1½ inches above the stack to allow air to pass for soffit-to-ridge venting. Seal the strips to the framing members with canned spray foam to make the connection airtight (see Figure 1).

To finish the job, install insulation retention baffles to hold back loose-fill attic insulation. Reinstall the sheathing and begin the reroofing project. You may not get the full recommended R-value directly over the outside wall, but the airtightness and insulation will be greatly improved.

Cathedral and Sloped Ceilings

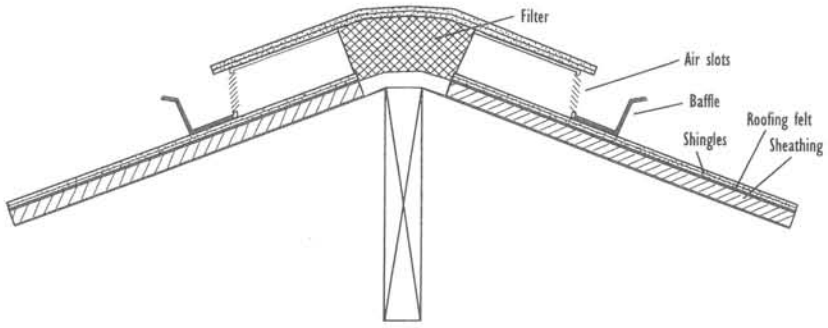
Homes with sloped ceilings (like those found in Cape-style houses) or cathedral ceilings are difficult to retrofit because the rafter cavities are sealed by finished surfaces. Either the exterior surface of the roof or the interior surface of the ceiling must be retrofitted to block the flow of heat. It is painfully expensive to rip apart a new roof or ceiling to add insulation. An energy retrofit becomes more palatable and cost effective when it is combined with a scheduled reroofing project.

Each house is built differently. Some have insulation already in the rafter cavities; others are only partially insulated. Some have roof venting in place; others do not. Some are built tight; others are leaky. Peel away the outer skin of the structure to expose the roof cavity and frame. You can see what you are up against once the roof shingles and sheathing are removed. Check for the details listed in Table 1. Rot, degradation, and structural damage can be diagnosed and repaired and the energy envelope improved. Roof ventilation should be provided to help keep the roof sheathing cold (see "Roof Venting"). This is an important detail that helps prevent ice dams and control wayward moisture.

For all sloped-ceiling applications, the insulation process is the same. Carefully remove the roof sheathing using a nail puller and pry bar. Send the old roof shingles to a recycler and save the sheathing for reuse if it is structurally

Roof Venting

Roof vents are required by all building codes. Always vent the air space above the insulation in an attic or a cathedral ceiling. If there is a vapor barrier on the ceiling, a minimum of 1 ft² of net free vent area (NFVA) is required for every 300 ft² of ceiling area below the roof. (NFVA is the total area of air spaces in a vent screen, excluding the screen material.) The minimum requirement jumps to 1 ft² NFVA for every 150 ft² if no vapor barrier is in place.

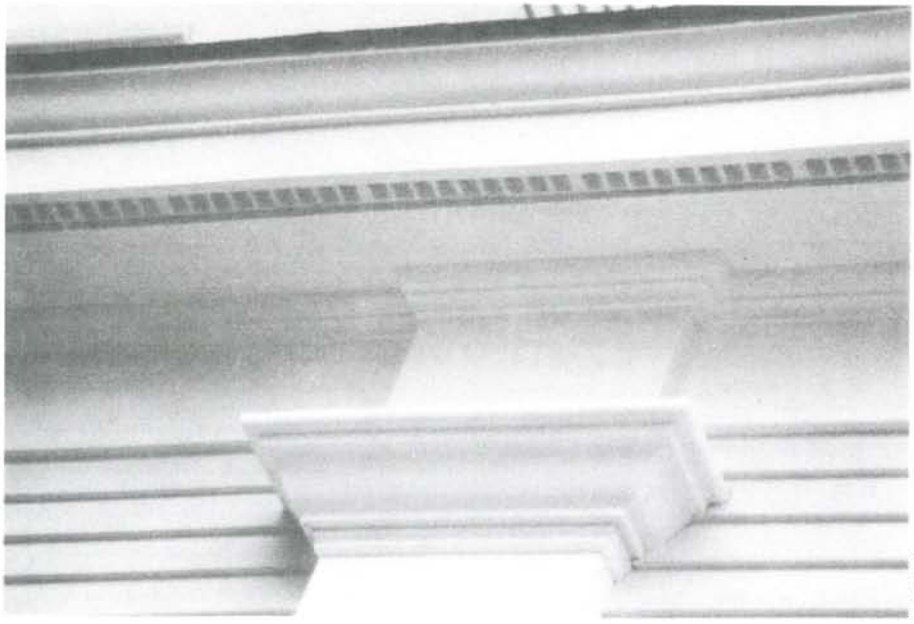


KATHERINE FALK

A baffled ridge vent. These vents create suction regardless of wind direction, and exhaust more reliably than other types, including power vents, turbines, and gable louvers.

The most efficient way to vent a roof is to use continuous soffit and continuous ridge vents. Continuous venting is the only system that moves air uniformly along the underside of the roof from the soffit intake to the ridge exhaust. Roof venting should be balanced: half of the NFVA should be located high, in the ridge, and the other half low, in the soffits, evenly divided between the two soffited sides of the house. Usually, ridge vents have an NFVA of 18 square inches per lineal foot and soffit vents 9 square inches per lineal foot, so they automatically balance.

Ridge vents that have built-in baffles are best. Baffles on ridge vents seem to create suction regardless of wind direction, and they exhaust most reliably.



PAUL FISETTE

Continuous soffit vents form an inlet for attic ventilation, while keeping insects out.

White Roofs for Cool Homes

If a building is too warm in the summer or uses too much air conditioning energy, then the occupants are probably considering options to reduce air conditioning energy use and improve comfort. Reroofing is a good time to add more ceiling insulation, radiant barriers in the attic, and attic venting. Another option is to install reflective roofing materials.

In the summer, the roof receives strong radiant energy from the sun. If this energy is absorbed into the attic, insulation and ventilation can reduce its penetration into the living space. But a dark roof can reach temperatures of 180°F on a sunny, windless day, and some of the heat from the roof inevitably makes it into the building. A reflective roofing material can reject this heat before it has a chance to penetrate indoors.

Look for a material with a high solar reflectance (sometimes called albedo). High solar reflectance is usually accompanied by a bright or white appearance. The best commercially available materials are usually smooth and white. There are, for example, white roof coatings that can be applied over asphalt shingles and most other roofing substrates (see Table 1). When first applied, these can provide a solar reflectance of up to 80%, which means that only 20% of the sun's energy is being absorbed as heat. White roof coatings do weather and get dirty, however. After several years they may reflect only about 50% of the incoming solar flux. This is still a significant benefit, but the degradation is worth keeping in mind if the payback is long.

Some coatings, termed ceramic by manufacturers, contain microscopic glass spheres. Reflectance tests show that these materials perform similarly to other white coatings, with reflectances above 80%. Other coatings are described as elastomeric, referring to their ability to stretch rather than break.

Conventional "white" asphalt shingles, in contrast, typically reflect only about 25% of sunlight, because of their low brightness—they are actually gray—along with their rough texture and black substrate. Premium white asphalt shingles use a whiter white granule, providing a reflectance of up to 35% (see Table 2).

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White roof coatings with high solar reflectance can be applied over asphalt shingles and most other roofing materials.

Solar reflectance isn't the only property to look for in a roofing material. It should also have a high infrared emittance to help the roof shed heat by reradiation. Most materials do—with the notable exception of aluminum roof coatings. Aluminum will stay warmer at night, while a white roof coating will radiate more of its stored heat back to the sky. For this reason aluminum will not perform quite as well as a white material with similar solar reflectance.

Regardless of reflectance, the material from which the roof is constructed also affects how well it sheds heat. For instance, curved tile roofs and wood roofs usually allow air to circulate through them, helping to remove solar heat.

—Paul Berdahl

Paul Berdahl is a physicist with Lawrence Berkeley National Laboratory.

Table 1. Reflective Materials for Sloping and Low-Slope Roofs

Material	Solar Reflectance	Peak Temperature Rise over Ambient Air (°F)*
Bright white roof coating on smooth substrate (including so-called elastomeric, ceramic, mastic, and other coatings)	0.8	15
White roof membranes	0.7–0.8	15–25
White metal roof	0.6–0.7	25–36
Cementitious white coating over tar and gravel (estimate for rough surface)	0.6	36
Bright aluminum roof coating	0.55	51
Dark red roofing tile	0.18–0.33	62–77
Black materials	0.05	90

*In full sun on a windless day.

Source: Based on research at Oak Ridge National Laboratory, Lawrence Berkeley National Laboratory, and the Florida Solar Energy Center.

Table 2. Reflectance of Asphalt Shingles

Shingle Type	Solar Reflectance	Peak Temperature Rise over Ambient Air (°F)*
White shingle with premium white granules (e.g., ISP Minerals K-711)	0.35	60
Generic white	0.25	70
Light brown, light gray	0.2	75
Dark colors	0.08–0.19	76–87
Black	0.05	90

*In full sun on a windless day.

Source: Based on research at Oak Ridge National Laboratory, Lawrence Berkeley National Laboratory, and the Florida Solar Energy Center.

sound. Once the rafter bays lie open and exposed, decide whether to remove the existing insulation or add to it. Keep in mind that the goal is to increase conductive resistance and to block air leaks. Since the homeowner has invested considerable time and money to this point, removing the existing insulation and doing a little airsealing work will make sense in most cases.

Approaches that work well for insulating sloped ceilings involve filling the cavity with foam insulation, fiber insulation, or a mix of the two.

Foam-filled cavity. Filling the cavity with foam may be a good (although pricey) choice for existing roofs where the framing members are shallow in depth. In the Northeast, we need a minimum roof value of R-38. It is difficult to achieve the required minimum R-value when an existing older house is framed with 2 x 6 or 2 x 8 rafters. And you can bet that fussy air sealing was not part of the original design.

Remove the existing insulation and completely fill the 2 x 6 rafter cavities with foam-in-place urethane. This will air tighten the ceiling nicely and bring the roof close to the minimum acceptable insulation level. Level the foam, and use 16-penny nails spaced 8 inches on center to attach 2 x 3s to the top of the 2 x 6 rafters to provide a vent space for continuous soffit-to-ridge ventilation. Next, replace the roof sheathing, roof trim, and roof coverings, and install soffit and ridge vents. There is enough room in 2 x 8 construction to provide 6 inches of foam, leaving a 2-inch air space for roof venting.

One word of caution: Plastic foam material, such as urethane or polystyrene, must be protected on the interior (living) side with a minimum covering of ½-inch gypsum wallboard to comply with fire codes. Exposed foam on the back side of an existing wallboard ceiling is no problem. Some products, such as Thermax, a foil-faced polyisocyanurate, are made with a fire retardant and are approved for exposed applications. Check this detail carefully.

Fiber-filled cavity. Where the existing framing members are deep, or fairly low R-values are needed, a good, less expensive insulation method is to fill the cavity with fiber insulation. Remove the existing sheathing and insulation. Then air seal gaps, cracks, and seams in the ceiling with caulk (good) or canned urethane foam (best). Reusing the old insulation after the air sealing operation has been completed is acceptable as long as the insulation is in reasonable condition.

Gauge the depth of fiberglass or cellulose insulation to match the required minimum R-value. A 2 x 10 rafter bay completely filled with fiberglass will have a cavity R-value of about R-31; a 2 x 12, about R-38. Dense fiberglass batts with higher R per inch are available. If the existing rafter cavity is completely filled with insulation, install 2 x 3 spacers on top of the rafters to create a roof ventilation chute.

Next, install a baffle at the bottom of each rafter bay above the exterior wall to keep air away from the insulation. Otherwise, air from the soffit vent can enter the insulation, degrading the effective R-value. Replace the roof sheathing, roof trim, and roof coverings, and install soffit and ridge vents.

While this retrofit works adequately in most cases, there are some trade-offs to consider. Loose-fill cellulose doesn't work well on steep pitches. It settles downward and blocks the ventilation air space, so plastic air chutes (such as Proper Vents) are needed to hold cellulose insulation in place. And call me paranoid, but I don't like installing cellulose in a roof where I can't inspect it regularly. Wet cellulose compacts and loses its effectiveness. It is only a matter of time before the roof leaks, and matted cellulose in a cathedral ceiling is hard to fix. Fiberglass fill is more forgiving in this regard, but it will allow air intrusion from soffit-to-ridge ventilation. If fiberglass is the choice, install plastic chutes to protect its top side.

Foam-fiber hybrid. Another option is to combine the two approaches described above to take advantage of high R-values and good air sealing with moderate cost. Remove the existing insulation and spray urethane foam into the cavities against the back of the ceiling to a depth of 2 inches. This gives good air sealing and a quick R-value jump start. Then fill the rest of the cavity with low-cost fiber. Follow the recommendations outlined above to protect against air intrusion and to provide roof ventilation.

In summary, these are the steps for a sloped ceiling retrofit with foam, fiber, or both:

- Strip roof shingles.
- Remove roof sheathing.
- Remove insulation.
- Air seal.
- Refill rafter cavities.
- Install baffles over exterior walls for fiber fill.
- Install plastic chutes (if using fiber insulation).
- Install 2 x 3 furring over rafters' location.
- Install structural roof sheathing.
- Install trim.
- Install roof venting system (if needed).
- Apply roof covering.

Table 1. Cathedral Ceiling Diagnosis

Detail	Problem	Action
Shallow rafter depths	Low R-value	Improve R/in of thickness
Inadequate soffit-to-ridge ventilation beneath roof sheathing	Low potential to cool sheathing and remove moist air from roof	Install continuous soffit-to-ridge roof ventilation system, keep air channels clear with baffles
Discontinuous air barrier	Allows passage of heat and moisture to attic, roof	Air tighten, seal all penetrations into attic and roof frame
Improper or incomplete insulation of rafter bays	Allows the transfer of heat through conduction	Add proper depths of insulation, protect loose fill over exterior walls with baffles