A Cost-Effective Energy Retrofit

With careful air-sealing and the right insulation details, a leaky older home becomes a tight and thrifty one

by Terry Nordbye

Last summer I received a call about renovating a small low-income rental unit in Point Reyes Station, Calif. Its owners, the local community land trust, wanted to replace the foundation, remodel the kitchen, and make some minor upgrades to the interior. They mentioned that the utility bills were extremely high, so they also wanted to add insulation.

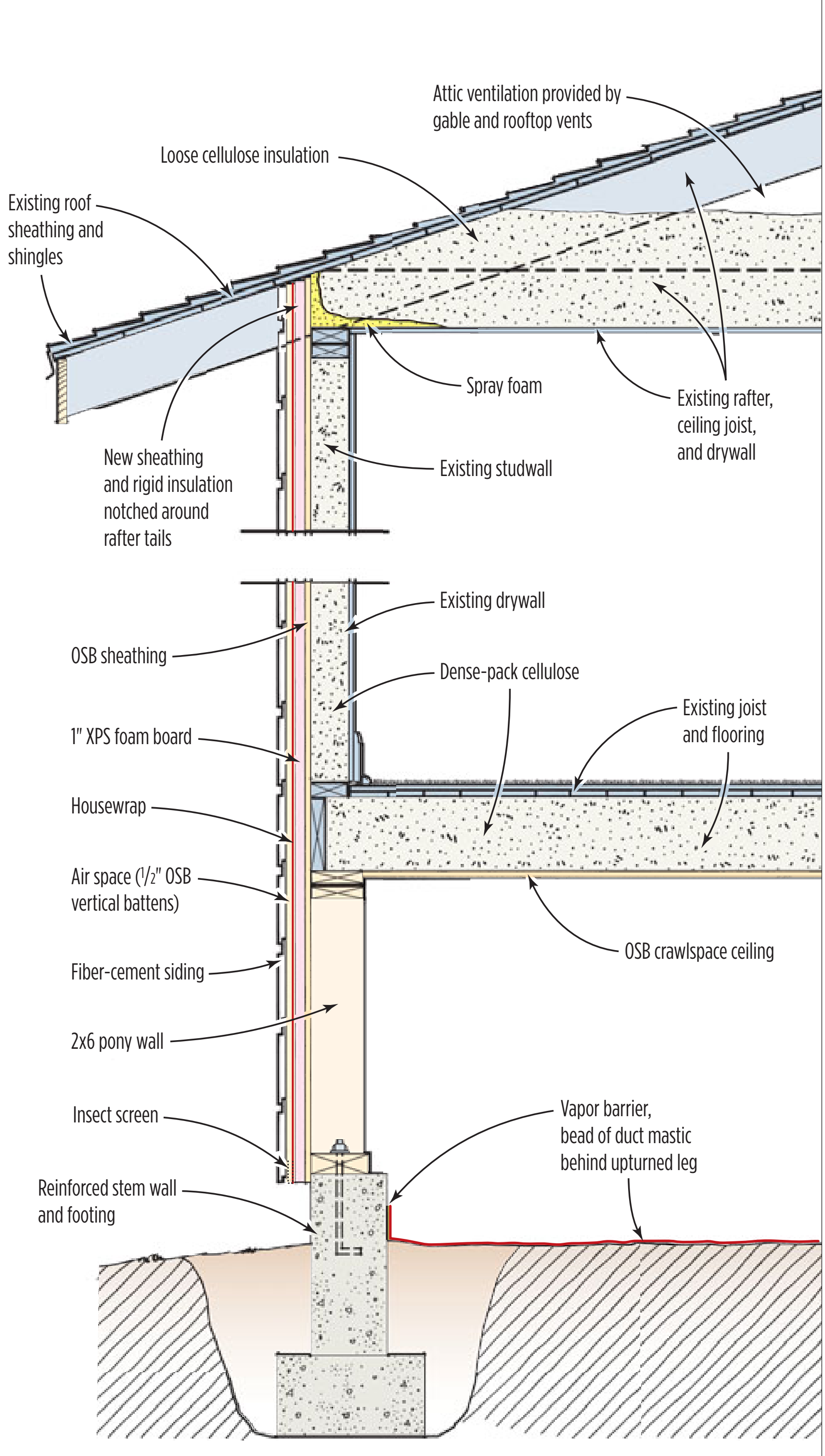
The 80-year-old two-bedroom house didn't look too bad from the outside, but when I inspected the interior I found all kinds of problems. The ceiling was insulated with R-13 fiberglass batts, and several batts installed between the floor joists hung down into the crawlspace. Some portions of the exterior walls had been insulated during an earlier remodel, but others contained no insulation at all.

There was also clearly a lot of air leakage. Fifty years of electrical and plumbing additions had left the house riddled with holes, and the siding was nailed directly to the studs with no sheathing or air barrier behind it. I told the owners that unless we air-sealed the building, adding insulation would do little to lower the heating bills.

Developing a Plan

The good news was that the house had a floor area of less than 850 square feet and 8-foot ceilings, so the amount of air-sealing needed was relatively small.

Insulation Details



We decided to try to make the house as tight as possible within the budget we had to work with, which wouldn't allow us to replace doors and windows. We also needed to preserve the interior finishes, so the stud bays would have to be accessed from the exterior.

The primary insulation in the walls and floor would be dense-pack cellulose, with blown loose-fill in the attic. A new layer of OSB sheathing would be followed by an inch of rigid foam and housewrap, with an exterior finish of fiber-cement siding applied over a vented air space (see illustration, left).

Cool and breezy. To measure our ability to eliminate leaks, we did blower-door tests at the beginning and end of the job. The initial test showed there to be 1,330 cfm of leakage at 50 pascals, or a very porous 11.9 air changes per hour (1,330 cfm x 60 minutes / 840 sq.ft. x 8 ft. = 11.9 ACH). When we saw those numbers, we weren't surprised that the previous tenants had complained about heating costs.

Preliminary Work

We began the project by replacing the foundation — a common repair in this area. After a house mover lifted the building onto cribbing, we removed the rotted pony walls and crumbling grade beams and poured reinforced concrete footings and stem walls capped by new pony walls (**see Figure 1, next page**).

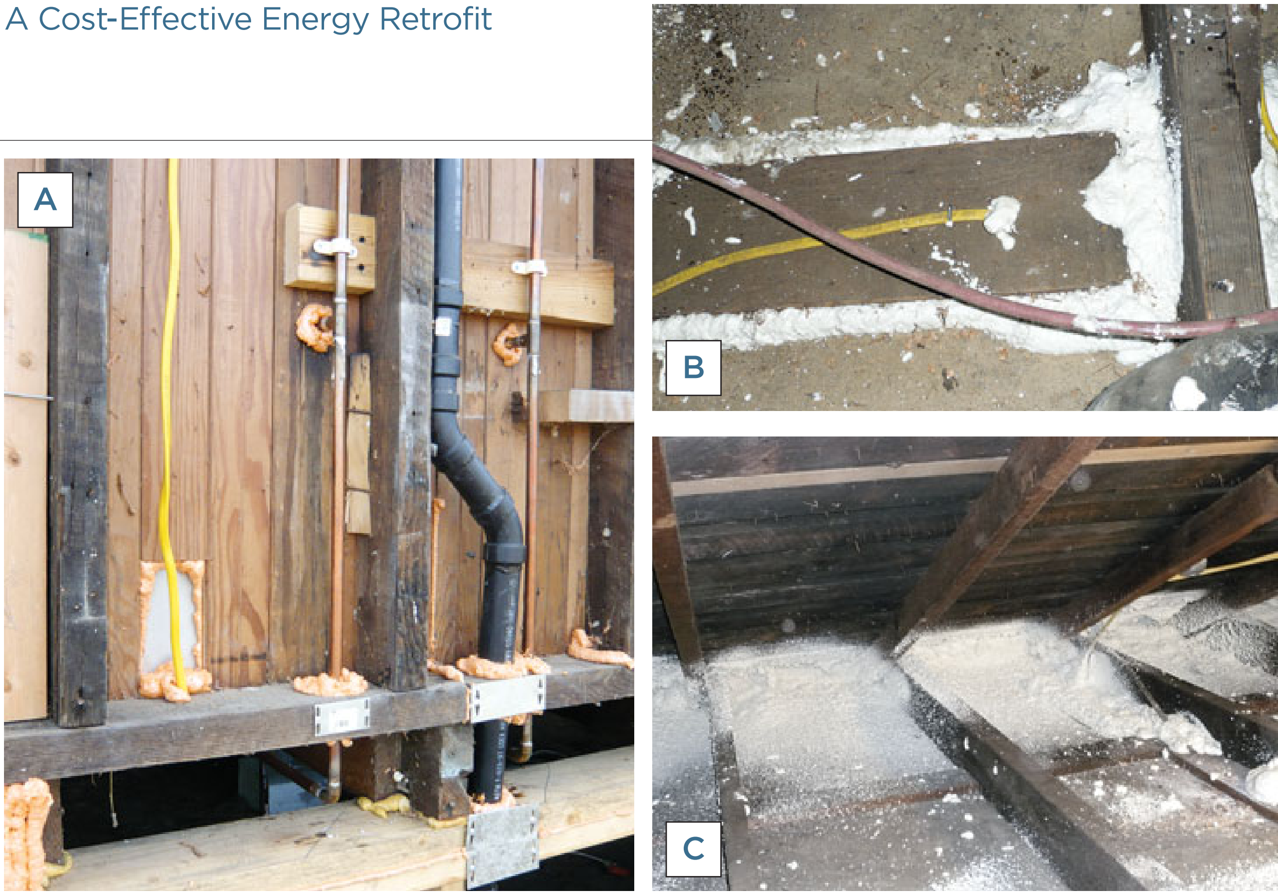
Room to move. Although the building's footprint didn't change, the new foundation raised the structure by 2½ feet. Unlike the original crawlspace, which was only 1 to 2 feet high, the new one was tall enough for our crew and subs to do a good job replumbing, rewiring, and air-sealing from beneath the existing floor.

After the house mover lowered the building onto the new pony walls, we pulled off the old siding and carefully removed the doors and windows so they could be reinstalled later. We made various repairs to the framing, then turned our attention to the small front porch and a shed-roofed laundry room off the back of the house. Although the front porch was in good condition, the laundry room was so infested with termites we had to completely rebuild it. To conserve material and reduce thermal bridging, we framed it using the OVE (optimum value engineering) method (**Figure 2**).

Termite treatment. To prevent future infestations, we sprayed exposed framing with a glycol-borate preservative and termicide called Borrada LP (281/892-2500, controlsolutions.com). According to its maker, the product has low toxicity to humans but kills insects up to 4 inches into the wood. We've since learned that Borrada LP has been discontinued, but similar termicides are still available. Two of the better known glycol-borate products are Bora-Care (800/264-0870, nisuscorp.com) and Bor-ram (919/226-1195, sostram.com).

Figure 1. After placing the house on a new foundation and pony walls (above), the crew removed the siding (left) so they could access the stud bays for air-sealing and then install sheathing.

Figure 2. The back laundry room was rebuilt with optimum value engineering (OVE) framing, a method that reduces thermal bridging and saves material. With OVE framing (left) there is 24-inch stud spacing, a single top plate, two-stud corners, right-size headers, and no jack studs. All of the framing in the house was sprayed (above) with Borrada LP, a low-toxicity glycol-borate preservative that kills termites 4 inches into the wood and prevents new infestations — a task made much easier by the additional crawl-space height provided by the new foundation.



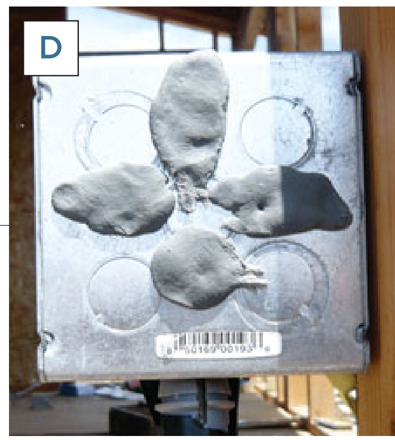


Figure 3. The author used one-component canned spray foam to seal plumbing and electrical penetrations through the walls (A), floor, and attic (B). To seal leaks at the eaves and provide added R-value in an area where insulation depth was limited, a thicker buildup of two-component foam was applied at the intersection of rafters and top plates (C). The holes through existing electrical boxes were plugged with a nonhardening putty (D) designed for sealing ducts.

Air-Sealing

We began air-sealing by spraying canned polyurethane foam into the gaps surrounding pipes, wires, and electrical boxes where they penetrated framing and drywall (**Figure 3**). In the attic, we used two-component spray-foam kits from Touch 'n Seal at the eaves (800/325-6180, touch-n-seal.com). The kits come in several sizes; we used two of the largest, each of which yields about 600 board feet (50 cubic feet) of foam. In addition to sealing the penetrations, going with foam here increased R-value in an area where the low angle of the roof limited the amount of insulation that would fit.

We filled the holes in the backs of existing electrical boxes by plugging them with Arlington Industries' Duct Seal Compound (800/233-4717, aifittings.com), a soft putty that does not harden over time.

After sealing every crack and penetration we could find, we sheathed the exterior walls and crawlspace ceiling with OSB, having already removed the original fiberglass batts from the framing cavities to make room for the dense-pack cellulose that would be blown in later. To further cut back on air leaks, we installed the wall sheathing over freshly applied beads of canned one-component spray foam, which expanded to fill the gaps between sheets (**Figure 4, next page**). There was no edge-blocking in the crawlspace ceiling, so we sealed the joints not backed by framing members with paper drywall tape embedded in a coating of DP 1010 duct mastic (800/641-0808, designpoly.com). The gap at the perimeter of the ceiling was too large for mastic, so we sealed it with more spray foam.

Insulating With Cellulose and Rigid Foam

Dense-pack cellulose insulation is typically blown in from inside, through holes cut in a mesh fabric that has been stapled to open framing. The fabric holds the

Figure 4. The carpenters installed the sheathing over beads of fresh spray foam (above), which expanded to fill any gaps (above right). The seams in the OSB on the underside of the floor joists (right) were sealed with strips of paper drywall tape laid into a coating of duct mastic.

insulation in the cavities, allowing it to be packed to a density of approximately 3.5 pounds per cubic foot. At this density, it has an R-value of about 3.4 per inch. Once the insulation is in, drywall is installed in the usual manner.

Inside out and outside in. Our insulation contractor used that conventional method on the walls and ceiling of the newly framed back porch (**Figure 5**). In areas where the drywall was already up he worked from outside, blowing cellulose through holes drilled in the sheathing. Early in the process, however, we found that the pressure exerted during installation could be enough to push the drywall off the studs. To prevent this from happening, we screwed temporary battens across the inside face of the wall. After the stud bays were filled, we patched the holes in the sheathing by inserting wood plugs and sealing them with duct mastic and mesh drywall tape.

Floor and attic. Instead of blowing insulation through the subfloor or the crawlspace ceiling, the insulation

Figure 5. The insulation contractor used the dense-pack method to insulate the newly framed back porch, blowing cellulose through slits in mesh fabric that had been stapled across the studs (left). Where drywall was already up, he blew insulation through holes in the sheathing (below left). The crew screwed temporary braces (below) across the existing drywall to keep it from popping off while cellulose was being packed into the wall.

Figure 6. The floor was insulated with dense-pack cellulose blown through holes in the joist blocking. To ensure the cavities were completely filled, the insulator connected a PVC pipe to the hose and began blowing from the far end of the bay (left), withdrawing the pipe as he went (below).

Figure 7. A one-inch layer of rigid XPS foam covers the wall sheathing, providing added R-value and a thermal break. Flat roof vents and a pair of gable-end vents supply attic ventilation.

sub worked through holes bored in the blocking that served as a rim joist. To ensure that the cellulose reached the far end of the framing cavity, it was blown in through a long piece of PVC plumbing pipe attached to the end of the hose (**Figure 6**). The insulator started with the pipe all the way in and slowly withdrew it as the joist bay filled with insulation.

The attic was insulated to R-40 with blown-in cellulose. There was no need to install insulation baffles because the existing roof had no ridge or soffit vents. Ventilation was furnished by flat roof vents and a pair of gable vents.

An exterior thermal break. To provide a thermal break and an additional R-5 of insulation value, we covered the wall sheathing with one-inch XPS foam board, which was notched around the rafter tails (**Figure 7**). We cut the front porch free from the building and moved it temporarily away from the wall so the foam could be applied behind it without interruption. In framing the rear laundry room, we cut the rafters flush with the top plate so there would be no breaks through the foam. An overhang with short decorative rafter tails was later fastened to the wall from the outside (**Figure 8, next page**).

Rain-Screen Siding

To increase the durability of the wall assembly, we installed the exterior finish rain-screen style — that is, over a ventilated air space (**Figure 9, page next**). This allows any moisture that gets behind the siding to drain to the bottom of the wall and promotes rapid drying of the back of the siding itself. We began by nailing spacers ripped from scraps of OSB over the foam at the perimeter of the openings and fastening the windows to them. Next, we covered the foam with housewrap, taking care to lap it over the window flanges and spacers. The remaining spacers went on over the housewrap at the stud locations,

Figure 8. To maintain the continuity of the exterior rigid foam, the small front porch — shown here (left) with the siding applied — was cut free of the structure and then reattached after the foam had been slipped behind it. The back laundry room — a former porch — is fully insulated and lies within the building's thermal envelope (right).

with window-screen material stretched across the open ends to keep insects from entering the air space. We completed the exterior by reattaching the front porch and nailing the casings, corner boards, and siding over the spacer strips.

Figure 9. After reinstalling the existing windows, the crew covered the rigid foam with housewrap and vertical battens, which provide an air space and drainage plane behind the siding.

Mechanicals

Before the remodel, the house had an electric water heater and in-wall electric resistance heaters. We kept the existing water heater but replaced the old electric wall heaters with new ones.

A house this tight should be equipped with mechanical ventilation. The budget on this project didn't allow for a fully ducted whole-house HRV, so we put a continuous-duty Panasonic FV-04VE1 in the main living area. This low-cost energy-recovery ventilator sells for about $350 and has a maximum capacity of 40 cfm. Except for the presence of a 4-inch outdoor air intake, it installs in the ceiling in much the same way as a bathroom fan (**Figure 10**).

Improved Performance

Near the end of the job, we performed a second blower-door test. It showed a more-than-tenfold reduction in air leakage — from the original 11.9 ACH to just 0.9. We're confident that the leakage figure would have been even lower if we hadn't been saddled with the existing doors and windows.

The owners have a few utility bills from the previous tenant, and have been tracking electrical use after the renovation. Electrical use this past winter was half what it was during the same time period the year before — down from about 1,250 to 625 kilowatt-hours per month. We suspect that the bulk of current consumption goes to lighting and heating water, and hope to verify this through future monitoring. By my estimate, the air-sealing and extra insulation added about $15,000 to the overall $140,000 cost of the project.

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Figure 10. To improve indoor air quality in the now-tight house, the author installed a Panasonic energy-recovery ventilator in the ceiling of the living area. This small, inexpensive unit installs like a bath fan, except that there are two ducts to the exterior instead of one.