Deep Energy Retrofit
Part 1: Air-sealing

BY PHILIP ARMAND

"And one more thing, Phil ..."—the building inspector, who is a khaki-colored trench coat away from being a clone of my favorite TV super-sleuth, has a habit of dropping a request bomb as he heads toward the exit—"... You need to get a HERS rating for this renovation. Have a nice afternoon." I am stunned. A HERS rating on a partial renovation of a poorly maintained wreck of a house? I take a breath, look around, and feel a giddiness begin to stir inside.

HERS stands for Home Energy Rating System, a nationally recognized system for rating the energy efficiency of a home. The only way to pass is to meet standards that are dramatically more stringent than this 1977 colonial would ever meet. In my area, this rating is not required for renovations—except at the discretion of the building inspector. In a typical renovation where a sizable portion of the house is untouched (about 20% of the interior was not gutted on this home), the chance of meeting the HERS standard is near zero. R-values of existing insulation are incalculable, and the required blower-door test would reveal dramatic breaches in the air barrier. This colonial was a sieve—not a premium, fine-mesh sieve, but a hole-ridden shell; critters and creepy-crawlers had set up shop in the attic, basement, crawlspace, and wall cavities.

However, this was not a typical renovation. Part of the budget had been directed at a deep energy retrofit. We were contracted to move insulation from ceiling joists to roof rafters and add a sweater of continuous exterior insulation with high-performance windows and doors and extended eaves. The job also included ventilation systems, pressure-balanced rainscreens, air-sealing, air-sealing, and more air-sealing. My growing giddiness at the inspector's request came from being able to justify the cost of a blower-door test; I was itching to confirm how well we had sealed this 1977, hilltop sieve.

All the extensive and expensive details that a deep energy retrofit entailed were easily sold to my clients partway through the renovation. After discovering extensive rot, thriving infestations of bugs and four-legged critters, and massive insulation voids in the building

Photos by Philip Armand

envelope, we had a meeting. The husband, an accountant who understands return on investment, saw the value of the work I proposed. His wife agreed, focusing on the immediate and permanent eviction of all uninvited four- (and more-) legged tenants. I did my best deadpan nod at my new directive and walked off, seemingly cool and collected while my internal building-science nerd did a happy dance and rubbed his hands together, with a stupid smile plastered across his face. We were ready to tackle an amazing challenge.

LIST OF PRIORITIES

I usually approach a deep energy retrofit using the following order of priorities (not of process) that I establish with clients to decide where to allocate funds until we run out of budget:

1. Air-sealing
2. High-performance insulation
3. High-performance doors and windows
4. Thermal decoupling
5. Recovery ventilation
6. Efficient heating and cooling distribution and equipment

I aim to execute each of these impeccably, but since open-wallet clients don't seem to have my phone number yet, I pick my battles. Air-sealing is always nonnegotiable, and that's where I'll start for this article. Later in this series, I will cover the negotiable items and share more about the order of priorities, as well as what I have discovered gives the best bang for the buck.

In theory, air-sealing is quite simple: Keep the air in and out of your building. In practice, you have irregular-shaped geometry at a large scale, with a wide variety of penetrations: outlets and other wires, plumbing, vents, windows, doors, chimneys, access hatches, random holes made by negligence or beast, and the gap under the sill plate that is often as accessible as a popcorn hull between molars. In the field, the tools, materials, and methods are mostly simple to use; the tricky part comes in maintaining a high degree of impeccability and exercising patience.

AIR-SEALING TOOLS

The tools we always depend on for air-sealing work include:

■ **Good caulking gun,** preferably one with an adjustable thrust ratio. The 24:1 to 12:1 settings are great for acoustical sealants that are very thick and heavy, while the lower setting of 12:1 is great for nearly any caulking job.

■ **20-ounce sausage gun.** We also use a 12:1-thrust-ratio caulk gun that takes large caulk sausages. Many professional sealants are sold in this format. Buy several extra tips as they may dry out between uses and need to be replaced.

■ **Caulk sealing caps.** Basically, a latex glove for your caulk tip. These make it easy to switch from one sealant to the next, while keeping sealants fresh the next time they're needed.

■ **Putty knives and scrapers.** I like plastic body filler spreaders and a variety of metal putty knives. The most common sizes of putty knives we use are 1 inch and 1 1/2 inches wide, though occasionally we pull out the 3-inch.

■ **Spray-foam sealant gun.** A pro gun allows you to buy the pro-sized cans and not worry about the product drying up by the end of the day. I recommend buying a stock of plastic gun tips; they protect the gun and allow easy access to small gaps and cracks. Foam-gun cleaner is available in the same format as the foam; keep the gun clean between uses, and it will last for several jobs.

■ **Tape roller.** Pressure-sensitive tapes and peel-and-stick weather resistive barriers have revolutionized the industry. Having a set of small to large rollers is a must.

■ **Rubber gloves and eye protection.** On two occasions—once when a spray-foam can exploded and once when cleaner shot onto my assistant's face—severe eye damage was averted by eye protection. In the case of the cleaner, the caustic material destroyed his plastic eyeglass lenses immediately. It was a good reminder to always proceed with caution.

AIR-SEALING MATERIALS

We regularly lean on a cornucopia of reliable materials, including:

■ **Liquid sealants and foam sealants.** On this project, we used six products: On exterior nail holes, between sheet goods, and at wall-to-masonry transitions, we used Zip Liquid Flash, mostly in the 20-ounce sausage format. Around windows and doors, we used Henry Moistop Sealant (also available in the 20-ounce format). On framing penetrations like rafter tails and on interior framing bays and voids, Sashco Big Stretch and Dap Extreme Stretch did the job. For interior pipe and electrical penetrations, we used 3M Fire Barrier Sealant. Under sill plates on newly framed or repaired areas, we used Auralex StopGap Acoustical Sealant. We also leaned on low- and high-expansion foam sealants to fill large gaps before applying a waterproof seal.

■ **Henry Blueskin** VP 100 Self-Adhered Water Resistive Air Barrier Membrane. We used VP100, as it is waterproof and vapor open; much of the home needed to dry to the outside as tile, wallpaper, and millwork covered large portions of the interior. A peel-and-stick WRB, like Henry Blueskin, was ideal for steadfastly bonding irregular surfaces that the old house shell presented, where a staple-up WRB would be sloppy and hard to detail. Another desirable aspect of the Blueskin is the fact that fasteners self-seal when penetrating it. Our rainscreen install did not compromise the air/water-sealing strength of Henry Blueskin. Local availability was another factor: Henry products are a system with components like primer, caulk, and sealing tapes. Being able to dip into local stock is important.

■ **Weather-barrier tapes** including Henry Weather Barrier, Vycor Plus, Zip Tape, and DuPont FlexWrap NF. We found that all these tapes adhered extremely well to the Henry Blueskin. We stayed with Zip Tape on the areas with Zip Sheathing, except the window sill pan—there we used a piece of clapboard siding to induce a slight pitch, over which we used Dupont FlexWrap NF. This is my go-to sill product, and it adhered extremely well to both the Zip and the Henry Blueskin. FlexWrap stays slightly wrinkled, allowing drainage channels under the lower flange of doors and windows.

The photos and captions that follow highlight the critical steps of bringing this home from a leaky sieve to 1.2 ACH50 (code is 3 ACH50). The HERS inspector had never seen a home without an envelope of spray foam do so well. Though I wish we had done a blower door test on the front end of the project and knew the extent of the improvement, it's great that the inspector gave us the imperative to test out, verifying that we had a tight shell in which to build the rest of the systems for this deep energy retrofit.

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We sealed the connection to the sill plate with a site-bent flashing. We added a generous bead of Henry Moistop Sealant to the bottom edge of the sheathing, then set the flashing into that. We topped it all with tape and then Henry Blueskin peel-and-stick WRB **(1)**.

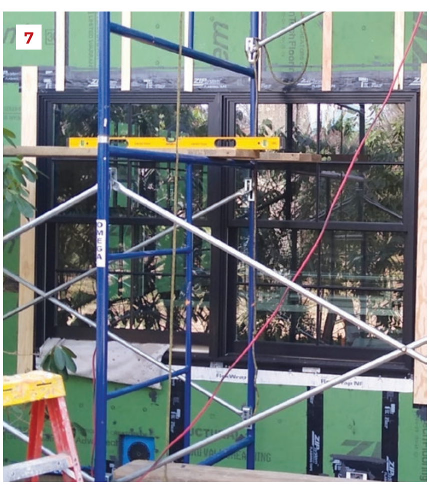
This home had two major renovations in its 46-year existence. We used different approaches to match different circumstances. In this area, a large overhang resulted from adding R-16 to the exterior (the interior of this area remained intact); we air-sealed the overhang with a site-bent flashing and Zip Liquid Flash caulking. Zip Flashing Tape seals the top edge of the flashing and the Zip areas **(2)**.

To maintain a vapor-open ceiling on the cathedral interior, we used Henry Blueskin on the roof, then built a vented overroof. This allows vapor to migrate out and through the structure. We meticulously sealed the existing rafter tails with Henry Moistop Sealant after the WRB was rolled out. We used Henry Blueskin VP100 in these areas, as it is waterproof (this area was left in the rain for several days with no issues) while remaining vapor open. This product is not easy to use; however, the benefits outweigh the steep learning curve **(3)**.

The overroof sits on 2x3 sleepers **(4)** (see also **8**). Air washes into the soffit and behind the siding. A 2x3 rainscreen was added later.

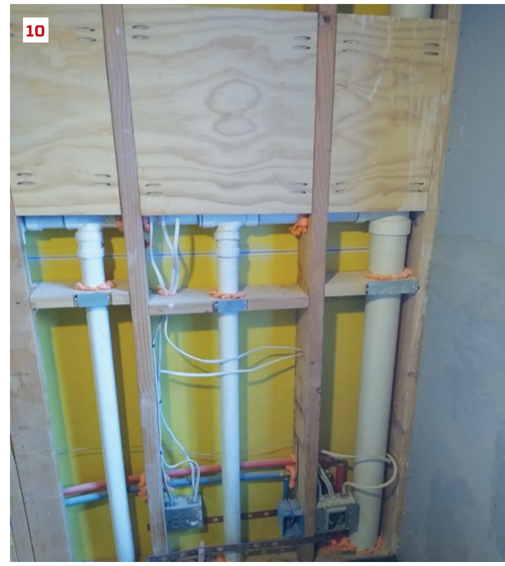
A peek under the Zip sheathing reveals a double layer of 2-inch-thick Rockwool Comfortboard 80, for a total of R-16 **(5)**. We used this strategy in areas we did not have access to from the interior. We used foam sealant in any gaps between the Comfortboards to eliminate interstitial convection within the cavity insulation.

In areas where we did have access from inside, we insulated and air-sealed the rim-joist sill first with Sashco Big Stretch to seal all connections to the sill plate and rim joist. Prior to spray-foaming, we added 2-inch blocks of Rockwool Comfortboard over the rim joist. This vapor-open buffer zone allows moisture to dissipate into neighboring materials and dry into the building **(6)**.



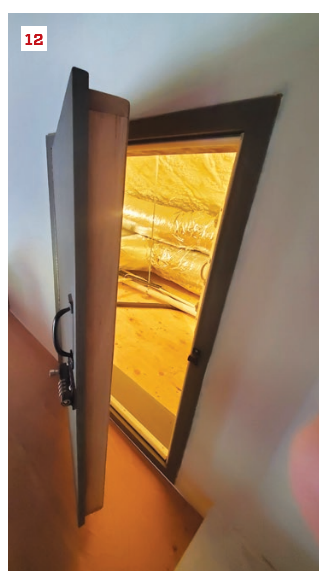
At the bottom of this image **(7)**, a blue Quickflash panel is visible. We detailed most of our electrical, HVAC, and water penetrations with gaskets like Quickflash.

For optimal water and air detailing, we apply Zip Liquid Flash over all nail holes, loose tape, or scratches in the green Zip WRB. In this area, we built the soffit over the Zip R-3 **(8)**. The sheathing connects to the air-sealing layer that travels 1 inch below the roof sheathing. This allows an overroof for airflow.



On this bedroom wall, which extends to the kitchen below, we used CertainTeed's MemBrain, a material that allows water vapor to pass through when humidity levels are high while stopping airflow **(9)**. The membrane worked well to reduce the amount of cooking odors that permeated into the bedroom.

Air-sealing is not relegated to one phase of construction. Throughout the entire build, we continually seal anywhere air can penetrate or convect, as seen in this interior plumbing wall after the shell was sealed **(10)**. Reducing air movement in walls is also important for improving fire safety, deadening sound (sound travels through air), and reducing unwanted moisture movement. In this case, these walls will be tiled on both sides.



Access hatches from the exterior into a crawlspace **(11)** and from the interior into a knee-wall attic area **(12, 13)** are often leaky. For each one, we took care to build insulated access hatches with Zip System sheathing and foam-rubber gaskets.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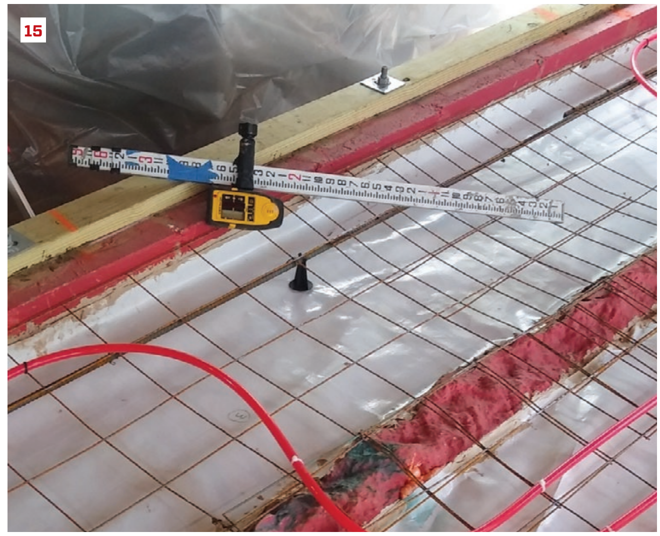
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There are three separate attics with three separate access points. This one was the smallest **(14)**. The air-barrier here consists of $1\frac{1}{2}$-inch XPS foam that we cut into the rafter bays to create a 1-inch ventilation space below the roof sheathing. We do not rely on the closed-cell foam as a singular air barrier.

We used the trick of drawing a line around the structure on plan sections to see where the discontinuities of the control layers were (see "Air Barrier Basics," by Steve Bazcek, Jan/19). In this area, we had to remove an existing slab to create continuity from slab to foundation to sill. The vapor-barrier is sealed to the foundation where a liquid-applied barrier continues to the sill plate. The sill plate is gasketed and caulk-sealed to the foundation **(15)**.


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We added a small roof over a sliding door, and to avoid penetrating the exterior shell with framing to support this projection, I had brackets fabricated that we bolted through the header **(16, 17)**. Small holes for the bolts are much easier to seal than large framing components. And even though steel conducts heat better than framing lumber, this approach still minimizes thermal bridging **(18)**.