Adding an Insulated Envelope

An air-tight "puff jacket" achieves near Passive House levels

BY CHRIS CORSON

I've been working on superinsulated houses since the mid-1990s. I designed and built my first Passive House in Knox, Maine, in 2010 and 2011 (see "An Affordable Passive House," May/12 and Jun/12), and since then, I've built six new Passive Houses, designed several more to be built by others, and completed a deep energy retrofit on my own home in Maine that meets the Passive House EnerPHit standard for retrofits.

In recent years I've been approached by a handful of potential clients who have asked me to do EnerPHit retrofits on their existing houses. But in almost all cases, I've declined the work. The sad truth is, it's so expensive to turn a leaky, poorly insulated old house into a Passive House that it's rarely worth the investment. I referred all those clients to a weatherizing contractor who I knew could improve the houses to a moderate degree for a reasonable cost.

But in 2013, I accepted a deep energy retrofit job that, if it doesn't reach EnerPHit levels, will certainly come close. The job won't pay for itself by energy savings, but I decided that it still made sense. By the time the owner, Deb Poor, called me, she was already planning a gut-rehab of the house (to be carried out by another contractor, Tim Andrews of Nobleboro, Maine). Deb had her own reasons to have an energy retrofit done. In particular, she wanted the project to serve as an example to others of what was possible in this community.

Photos: Ted Cushman


1a


1b
ACE
TYPAR


2a


2b
www.proclima.com
pro clima


2c
www.proclima.com
climaDA


3a


3b


3c


3d

1. The general contractor's crew stripped the existing clapboards off the building **(a)**, revealing a mix of building papers installed at various times throughout the building's life **(b)**.

2. The crew pulled the Pro Clima DA membrane tight over the existing sheathing **(a)**, drew layout lines on the fabric at stud locations **(b)**, and stapled the fabric to the wall **(c)**. Air-sealing tape would be applied over the staple lines before wood I-joists were screwed on at the stud locations.

3. Because the existing openings were so out of square, the crew built the window bucks in place using AdvanTech OSB and structural screws **(a)**. Each piece had to be carefully shimmed, plumbed, and leveled to make up for the irregular wall framing **(b)**, and corners were screwed together to make for a strong box **(c)**. After I-joists were installed against the walls, the crew added blocking around the bucks to complete the rough window frame **(d)**.

I think she's making a wise investment, even though a deep energy retrofit is not the most economical way to pursue the goals of Passive House. Her house is in a drop-dead gorgeous waterfront location in Damariscotta, Maine, a popular vacation spot. She's choosing top quality throughout, from frame to finish—it's going to be a showcase project even without the Passive House package. In this case, giving the house the comfort and independence of near Passive House performance is icing on the cake.

Retrofits are a labor of love—it will always be cheaper to start from scratch. There are also practical concerns. The better the bones of the home, the higher the likelihood that it's a good candidate for a deep energy retrofit. If the bones are sound and the basement is sound and dry, then a roof that needs replacing, or siding that's in shambles is something we can work with. In this case, the basics were all in place.

EXISTING CONDITIONS

The original house was a typical Maine hodgepodge. The oldest part of the house was built in 1906, with good solid framing, horizontal sawn-board sheathing, and a sound rubble-stone foundation. A garage addition, which has plywood sheathing, was probably framed in the 1970s.

When Tim Andrews' crew ripped the existing clapboard siding off the house, we found an odd mix of paper underneath **(1)**. The oldest section had asphalt paper as the weather resistive barrier, and the work had been carefully done. The workers had even cut out little squares of paper to back-flash all the clapboard joints. It was nice work for its day.

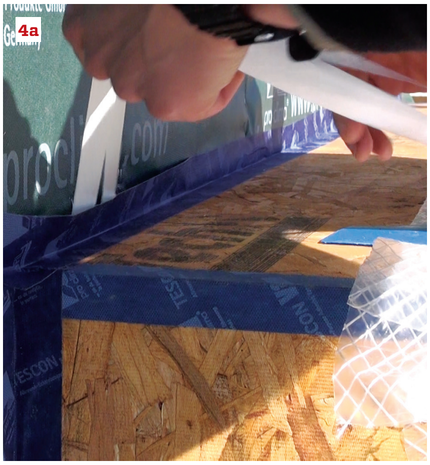
Other parts of the house had Tyvek and Typar housewrap, which had been carelessly applied in the 1980s or 1990s. There wasn't any air space for a drainage plane behind the clapboards, and by this time, the housewrap had badly deteriorated and was rumpled and torn. But whether it was felt paper or housewrap, none of it could make the house anywhere near airtight, so it all went into the Dumpster. We removed the existing windows and started over at the level of the sheathing.

NEW AIR BARRIER

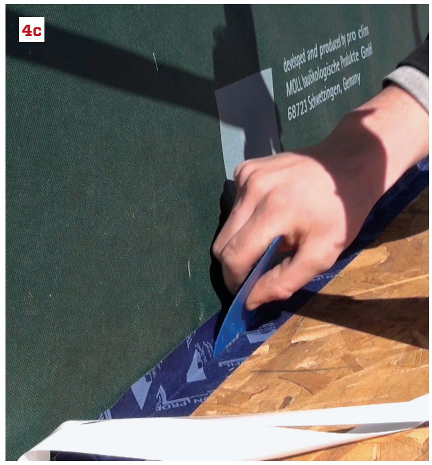
The EnerPHit standard calls for an airtight envelope. In new construction, our high-performance wall system consists of a 2x4 or 2x6 frame sheathed with OSB and taped at the joints so that the layer of OSB forms the airtight control layer for the whole house. Then we apply an outer frame of wood I-joists outboard of this sheathing layer to form a cavity for 12 inches of cellulose insulation. That outer frame is enclosed with vapor-open fabric so that when the cavities are filled with dense-blown cellulose, the assembly can dry to the outside of the building. Everything inboard of the OSB layer is able to dry to the inside.

Our plan was to apply the same I-joist assembly to the outside of the Damariscotta house walls and have it function the same way. Essentially, we'd be wrapping the whole building in a thick jacket of insulation. But we needed something besides the sheathing to form the air barrier under the I-joists. We'd never be able to make the existing board sheathing—or even the existing plywood sheathing on the addition—airtight by using tape. So we chose an airtight vapor barrier fabric from Pro Clima called DA. We applied the fabric over the existing sheathing and taped the fabric joints with Pro Clima Tescon Vana tape **(2)**.

DA is heavier and tougher than typical housewraps. Although it's waterproof, it doesn't form the drainage plane for this job—it's just an air-control layer within the wall. But in retrofits, DA does offer the advantage of temporarily protecting interior framing, insulation, and finishes from rain and wind while


4a


4b
www.proclima.com

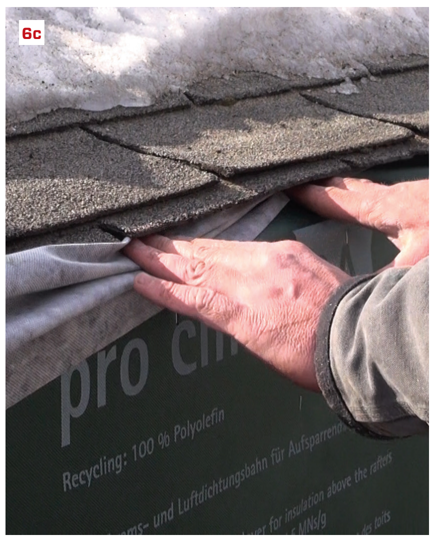

4c


5a


5b


6a


6b


6c
Recycling: 100 % Polyolefin

4. To preserve the air barrier at the windows, the crew applied Tescon Vana tape to the corners of the window bucks **(a)**. While taping the staple lines in the membrane, they also taped the joints where the window bucks meet the membrane on the wall **(b)**. Pressing the tape down with a plastic tool activated the adhesive in the vapor-open tape **(c)**.

5. The crew cut the existing roof eaves back flush to the wall, using a circular saw to cut through the roofing and sheathing **(a)** and a recip saw to cut the rafters flush with the wall sheathing **(b)**.

6. To connect the roof and wall air control layers, the open rafter bays were sheathed over and the DA membrane was extended up past the roof edge **(a)**. At the newly defined roof edge, the shingles were lifted **(b)**, and the DA fabric tucked underneath **(c)**. Later, the roofing crew would seal the DA membrane to the roof while applying Grace Ice & Water Shield self-adhering membrane to the roof.

work on the building exterior is in progress. (In this case, temporary protection didn't matter too much—the whole house was being gutted anyway.)

We rolled the DA out nice and flat and stapled it along the studs with pneumatic staples. We carefully laid out the stud locations before stapling and then taped over the staples with Tescon Vana tape to maintain a perfect air seal. Later, we would attach the I-joists at the same locations, driving structural screws through the flange, through the self-healing tape, and into the studs, so that the air barrier would remain intact. We were shooting for the Passive House airtightness spec of 1.0 ACH50 for retrofits, so we had to be meticulous about avoiding incidental punctures in the air barrier.

WINDOW BUCKS

Our outer I-joist frame was going to add 12 inches to the wall thickness, so we needed to frame openings for the windows that would extend out just as far. Our solution was to build window bucks into the existing openings using Huber Engineered Woods' AdvanTech OSB sheathing **(3)**. Because we were installing new windows into an old wall that was badly out of plumb in some spots, our first day on the job I had a carpenter measure each existing opening and check it for plumb and square. I'm glad I did, because when we found out how out of whack some of the openings were, I immediately canceled my lumberyard order for ¾-inch AdvanTech for the window bucks, and changed it to ⅝ inch material. The inch we saved overall gave us just a little more leeway when the windows arrived.

Because the window openings varied so much, the easiest way to sequence this part of the work was to cut the DA membrane out of the window openings and build the window bucks in place. Each one had to be carefully measured, shimmed, plumbed, and squared as the pieces were assembled and attached to the studs using structural screws.

To ensure that the window bucks didn't interrupt the air barrier for the building, we carefully taped the corner joints on the window bucks themselves, then taped all the joints where the window bucks met the membrane on the walls **(4)**. The continuous tape seal perfects the air barrier in the wall center, and brings the air barrier to the outer wall plane around the window openings.

WALL-TO-ROOF JOINT

To meet the EnerPHit standard, the whole house has to be airtight. That means the wall and roof systems can't just be airtight on their own; any joints where the wall and roof meet must also be air-sealed. That's impossibly complicated if you have to work around existing eaves details, so we cut the eaves off the building using a circular saw and a Sawzall **(5)**. (I like to use a chain saw, but my crew prefers to stick with carpentry tools.)

Once the eaves were cut flush to the wall edge, we installed sheathing over the openings between the rafters, then ran the DA membrane up to the level of the roof sheathing **(6)**. We loosened the existing asphalt shingles and removed enough nails so that we could tuck the DA up underneath and tack it in place. Later, the roofing crew would strip the shingles and apply peel-and-stick membrane over the whole roof, lapping it over the DA membrane at the eaves. At that point, the wall air barrier and the roof air barrier became connected into one continuous airtight control layer.

INSTALLING WOOD I-JOISTS

With the air barrier complete, we built a framework of I-joists run vertically over the entire wall. One man on the ground cut the roof angle into the top end of each I-joist, then passed the piece up to the crew on the scaffolding **(7)**. The


7a


7b
www.proclima.com
www.proclima.com


7c


8a


8b


8c
www.proclima.com


9a


9b


9c

7. The crew used a radial arm saw to cut wood I-joists to match the roof angle **(a)**, then screwed the I-joists to the wall at stud locations **(b, c)**.

8. After rolling out Pro Clima Solitex Mento membrane directly over the I-joists, the crew stretched the fabric tight **(a)** and stapled it to the I-joists **(b)**. Laps and staple lines were sealed with Pro Clima Tescon Vana tape **(c)**.

9. The crew applied horizontal strapping over the Solitex Mento fabric **(a)**, then applied vertical strapping over that **(b)** to provide nailing for clapboard siding. The strapping secured the fabric to the wall, enabling the crew to blow the I-joist cavities with dense-blown cellulose insulation **(c)**.

I-joists were screwed through the Pro Clima tape into the main wall framing using structural screws.

VAPOR-OPEN MEMBRANE

Once the I-joists were attached, the crew ran an outer membrane layer of Pro Clima Solitex Mento Plus, which serves as a drainage plane, or weather-resistive barrier, under the wood siding (there is no OSB or other wood sheathing on the outboard edge of the I-joists). We rolled the membrane out, pulled it as tight as possible, and attached it with pneumatic staples **(8)**.

As we have learned, it's best to use a lot of staples when fastening the Solitex. When we started to insulate the building, the crew sometimes found that where we had not used enough staples, the air pressure from the powerful insulation blower would blow the membrane off the joists and let insulation leak into the next bay.

Although Solitex is non-porous and is completely watertight and airtight, it has a very high perm rating of 38, which enables the insulated cavity to dry freely to the outdoors.

We taped the Solitex seams using Tescon Vana tape, which is vapor-open and uses a VOC-free adhesive. The adhesive is pressure-sensitive and time-sensitive: You must apply pressure to it to activate the bond. Once activated, the bond grows stronger over time.

As we applied the tape, we pressed down on it with a plastic tool called a Pressfix, supplied by Pro Clima. Over the years, we've used everything from $250 rollers to cheap plastic knives from The Home Depot for pressing down tape, but the Pressfix is our favorite tool for taping. It slides easily, and it's firm enough to stick the tape down but flexible enough not to hurt your fingers. You can tape all day long without getting fatigued.

STRAPPING & INSULATING

The Solitex Mento formed the drainage plane behind the building's wood siding. We created an air space for the rainscreen wall by attaching strapping through the fabric into the I-joists **(9)**. For horizontal siding such as the wood

Do Fabric Membranes & Tapes Work?

I've water-tested Solitex Mento by blasting it from short range with a pressure-washer after blowing the cavities with insulation. When we cut the fabric open and inspected the insulation, the cellulose behind the fabric was bone dry. I also have instruments in place on the OSB air-barrier layer of some of the houses we've built this way, and that sheathing has stayed around 8% moisture content through two Maine winters. So I know that the vapor-control strategy and the bulk-water management strategy both work well.

I've also tested the Tescon Vana tape, albeit in an unscientific way: I've used it to mend a down parka. Tescon Vana is designed to adhere to fabric, and it sticks well to clothing. People sometimes use ordinary duct tape to repair their ski jackets, and later you'll see them walking around in their down jackets with a little strip of gray adhesive where the duct tape got brittle and peeled away, and the feathers are coming out again. But I used Tescon Vana to repair the ripped armpit on my parka two winters ago, and I've worn that thing every day, all winter long—skiing, snowboarding, back-country—and the tape is still holding. I have also used Tescon Vana to mend ripped blue jeans, a pair of cycling shoes, the crotch of my snowboarding pants, and the knee of my son's jeans (abrasion testing), and to tape a license plate to one of my job trailers (two years ago!). All are still holding up fine, with the exception of my son's jeans. He just wore another hole through the tape. If you put that tape on clothing, it will never come off.

clapboards on this house, we apply horizontal strapping first, then a layer of vertical strapping; for vertical board siding, we attach the vertical strapping before the horizontal cross-strapping.

Finally, we blew insulation into the cavities, cutting a hole in the Solitex for the blower hose, then repairing the hole again with Tescon Vana tape when the cavity was filled. It's a lot of insulation, and it can literally take days to blow it all.

INSTALLING WINDOWS

The final step in building the envelope was to install the windows, which were supplied by Intus Windows. The units were set in the opening using Intus' system of mounting brackets. I always recommend installing the windows in the center of the wall depth because that minimizes heat flow through the window opening framing. But in this case, the owner insisted on setting the windows all the way to the outside to create a deep bench windowsill on the inside.

To integrate these "outie" windows into the home's drainage plane, we started by placing a ½-inch by 3-inch sill dam on the rough sill. We flashed the dam with 3M All Weather Flashing Tape 8067, then installed the windows, setting the face of each window flush with the Solitex Mento Plus fabric that forms the wall's drainage plane **(10)**. Next we created a dual seal between the windows and the walls: First, we sealed each window to the sill dam with Tescon Vana tape; then we applied a second layer of tape to seal the drainage-plane fabric to the window.

The idea is that if for some reason the window itself springs a leak, the incidental water will puddle on the protected sill inboard of the window, where it can dry to the inside by evaporation. But if water penetrates the exterior trim surround at the base of the window, the water will be directed into the drainage plane air space behind the siding and make its way down and out of the drain-and-dry exterior rainscreen.

WHAT'S NEXT?

Early in the project, the owner had decided to leave the basement out of the conditioned envelope, restricting the deep energy retrofit work to the occupied floors above the cellar. But near the end of the project—after the house was wrapped, the windows were in, and the general contractor's crew was working on exterior and interior finishes—she changed her mind and asked us to dry out and insulate the basement space as well.

I would have done some things differently if this decision had been made in advance. For example, we would not have insulated and air-sealed the floor above the basement as we did.

However, the change in plans has an upside: When it comes to Passive House certification under the EnerPHit protocol, this will change the math because we can now include the basement volume in the calculations. Improving the basement as part of this project puts EnerPHit certification within reach, at least potentially. So after we carry out the basement phase of the job, I'm considering submitting this house for official EnerPHit certification. If we pass, that can only help the house serve as an example, the way the owner intended. But even if we miss the threshold by a little bit, I'm sure that we will have drastically lowered this home's energy consumption and its carbon footprint. And that's a big step in the right direction.

Designer, builder, and certified Passive House consultant Chris Corson owns and manages EcoCor, based in Belfast, Maine.

10. A sill dam nailed to the front edge of the windowsill was flashed with 3M All Weather Flashing Tape 8067 **(a)**. After the Intus window was set into place **(b)**, its edge was sealed to the taped sill dam using Pro Clima Tescon Vana tape to form an inner airtight and watertight seal **(c)**. Finally, the Pro Clima Solitex Mento Plus drainage plane membrane was sealed to the window with Vana tape **(d)**.