Photo: Farley Pedler

Building a Passive House for the First Time

A builder uses his own house to master the process

BY FARLEY PEDLER

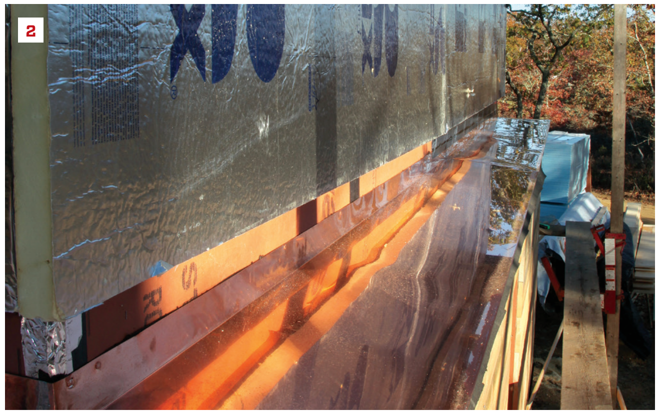
I've been building houses off and on since high school and have always been a conservationist at heart. When I started my own building company on Martha's Vineyard in 2006, my goal was to build houses that were more energy efficient, but it was difficult to find like-minded clients. The first time I built a home using efficient framing techniques and closed-cell foam insulation was in 2009; it was much more energy efficient than most spec houses at the time. My understanding of how to create a truly efficient home was still in the formative stages, though, and I've built eight houses since then, each one better than the last.

For some time, I've been intrigued by the Passive House movement in Europe, as well as in this country, and last year, I began exploring the possibility of building a passive house for myself. Through the Passive House Institute US (PHIUS), I learned of several passive homes on the mainland, which in turn led me to architect Steve Baczek, who has worked on a number of them. Baczek also had the benefit of a building-science background integral to the understanding of complex wall assemblies.

I'd recently purchased a parcel of land in a wooded area of the island, and according to local zoning, I could build a main house and an additional guest cottage of up to 800 square feet. I decided that a cottage would be a perfect starter home for my family. Baczek and I

1

2



5

designed it, giving me the opportunity to build my first passive house without the added pressure of building for a client.

CREATIVE DESIGN APPROACH

As part of my passion for building efficient homes, I push my clients to build "smaller." Building an 800-square-foot home was a very good exercise for me in that regard. But limiting a passive house to that size increased the challenge. To get the high R-values in the walls, passive houses regularly have wall assemblies 18 inches deep or more. Walls that thick would have taken away more than 20% of the space inside the house. So to attain the proper wall thickness, we decided to cantilever the walls outside the perimeter of the foundation, which is exactly 800 square feet. I have read a number of articles describing I-joists being used to create thick walls for passive houses, but Baczek and I were concerned about installing I-joists vertically without them being fully supported on the wall plate. Baczek came up with the brilliant idea of designing a truss that could be fastened to the exterior wall. It could be used vertically and cantilevered—and still maintain full structural integrity. We built 14-inch-deep trusses with a corner notch at the heel, which was sized and oriented to sit perfectly on a 2-by ledger fastened to the sill plate at the base of the walls **(1)**. The trusses were then lagged through the sheathing and into the 2x6 wall framing of the house.

As a design element, the wall trusses cover only the lower 10 feet of the walls. We capped the trusses with a pitched shelf covered with copper flashing. Above the shelf, we wrapped the walls with 4 inches of rigid foam **(2)**. Stepping the upper walls back from the outside makes the house seem less imposing and more cottage-like. Horizontal siding above the trusses also reduces the vertical scale of the house. We added a slight flair to the shingles at the bottom of the trusses to soften the cantilevered effect **(3)**.

Photos: 1, Farley Pedler; 2, 5, Roe Osborn

3

4

6

7

Photos: 3, Roe Osborn; 4, 6, 7, Farley Pedler

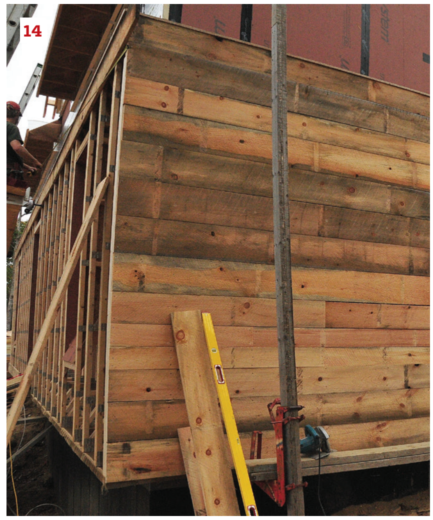
Inside, we kept the floor plan of the cottage simple. One end holds a single bedroom and bath with a loft above; the rest of the house is one big room combining living, dining, and kitchen functions. An island on casters acts as cabinet storage, food-prep surface, and dining table. We platform-framed the bedroom section, but balloon-framed the walls at the other end to get the proper height **(4)**.

Borrowing from a timber-frame aesthetic, the floor of the loft sits on large fir beams, and the 2-inch-thick, tongue-and-groove Douglas fir flooring also serves as the bedroom ceiling. To keep the beams from causing an unwanted thermal break, we inserted pieces of 1-inch rigid foam at the beam ends **(5)**. We framed the roof with raised-heel scissor trusses to give us ample space for insulation, while creating a vaulted ceiling for the spaces below **(6)**. The trusses form a simple gable roof that is broken up with matching conventionally framed dormers front and back.

THE AIR BARRIER

When you're building an extremely energy-efficient house, the most important element is a continuous and unbroken air barrier from the foundation to the peak of the roof on all sides. The goal is to minimize any unregulated air infiltration into the house, and the most problematic areas are framing joints, such as the mudsills and the wall-to-roof transition, as well as the openings for windows and doors. At the earliest design stages, Baczek and I drew a line on the section plans to represent the air barrier, examining every potential problem area and figuring out exactly how each one would be detailed. Then it was up to me and the crew to plan ahead and make sure that the air barrier would be continuous when finished.

Huber Engineered Woods' Zip System wall sheathing applied over the 2x6 framing formed the air barrier for the walls. Before each sheet was nailed on, we applied a healthy bead of Tremco Acoustical Sealant



Photos: 8, 9, 10, 14, Farley Pedler; 13, Roe Osborn

to the framing as well as along the joints of any intersecting sheets **(7)**. This Tremco product doesn't harden or cure, so it remains flexible for the entire lifespan of the wall. After the walls were sheathed and all the excess sealant was scraped off, the joints were also sealed with Zip System tape, rolled for maximum adhesion **(8)**. With the taped joints, the sealant was probably redundant, but I looked at it as cheap insurance.

At the top plate, the air-barrier line shifted inside to the plastered ceiling of the living space. Drywall can make a very good air barrier, especially when skim-coated with plaster. The difficult part was the transition from the exterior wall sheathing to the drywall. Before the roof trusses went on, we wrapped wide Vycor flashing tape from the top of the sheathing over the plate, leaving about 6 inches on the inside with the paper backing still attached **(9)**. After the roof trusses were installed, we ran a 6-inch-wide strip of OSB around the perimeter of the ceiling on the underside of the trusses, with the flap of Vycor in between, adhered to the top of the strips **(10)**. Then we strapped the ceiling in the same plane as the OSB **(11)**. We also sealed the perimeter and joints of the drywall with Tremco.

One of the trickiest areas for detailing the air barrier was the ceiling transition from the scissor trusses to the dormer section and then back again. We solved the problem by framing a flat ceiling in the dormers. This section was detailed like the rest of the ceiling, with OSB strips running around the perimeter **(12)**. Then the triangular cheek walls of the dormers were covered in drywall embedded in Tremco to make the air barrier continuous **(13)**.

BLAST FROM THE PAST

For our wall assembly, the Zip sheathing also functioned as our vapor barrier. I was conscious about making the wall truss system "vapor-open" so that it could dry properly if moisture got in. That meant covering the trusses with a vapor-permeable sheathing to avoid trapping moisture with a second vapor barrier. I first looked

Photos: Roe Osborn

into magnesium-oxide board, which has a high perm rating, but transporting it to the island was prohibitively expensive. Instead, Baczek suggested that we sheath the trusses with rough-sawn pine boards **(14)**, which were affordable, locally available, and vapor open. It was a perfect solution.

For a drainage plane under the white-cedar shingles, we covered the pine boards in a double layer of 15-pound felt paper (which has a high perm rating compared with that of OSB sheathing). The first layer of paper went directly over the sheathing. The second layer lapped over the tops of the shingles every five or six courses to allow water to weep to the outside **(15)**. Baczek points out that this detail can be found in architecture manuals dating back to the 1920s.

For the walls above the trusses, the double layer of rigid foam with taped seams created our weather barrier and drainage plane. We ran vertical furring strips over the foam for attaching the horizontal siding boards **(16)**.

To keep bugs and rodents out of the wall trusses, we attached bronze screen to the bottom chord of the trusses from below. We then fastened Trex decking with a ½-inch space between pieces to hold the screen in place and to allow all moisture to drop out **(17)**. Bronze screen might seem extravagant, but I've found it to be the most durable product for the Vineyard's harsh marine environment. We also used bronze screening for our vented soffits. We applied cedar trim over the screen, spaced ½ inch apart to provide ventilation **(18)**.

I wanted the exterior of the house to be as close to zero maintenance as possible, so I looked for rot-resistant wood for the exterior trim. Red cedar is commonly used in this area, but it tends to turn almost black when it weathers. Instead I chose Alaskan yellow cedar, which was readily available from a local supplier. It turns a silvery gray when it weathers. We bought rough-sawn boards and milled them on site. We then cut the boards to whatever size we

needed for all the exterior trim and for the horizontal siding above the trusses **(19)**. The cedar was installed without any finish.

HIGH-TECH WINDOWS

Windows in any house are the weakest point in relation to the overall R-value of the walls. I chose aluminum-clad European "tilt-and-turn" windows equipped with argon-filled triple glazing, which has an R-value of 11.36 and a Visible Light Transmittance (VLT) value of 71%. That combination of high R-value and high VLT is a rare achievement for any window glazing.

Another reason I chose European windows is that the window sizes aren't predetermined but are based on the design of a specific project. (Read more about European windows in *JLC*'s Jun/14 issue.) I was able to order each unit to the exact size requirements of the cottage, including large combination units (fixed and operable) for the first floor. I ordered the aluminum cladding in a deep-blue finish, a color the company had not used before. They created the color and produced the windows with no added time or cost.

Each unit is almost 4 inches thick. Installation required many strong backs to get the window units into position **(20)**. To level them and move them side to side within the opening, we used small flat inflatable bladders that slip between the window and the rough opening. Squeezing a bulb inflates the bladder (similar to a blood-pressure cuff), moving the window units gently and safely into exact position **(21)**. Once positioned, the window is secured to the framing with metal brackets **(22)**. Because windows are also notorious for air leaks, I sealed them in place with spray foam and tape—vapor-open tape on the exterior **(23)** and vapor-closed tape on the interior.

One added benefit of the deep truss walls is shading. I kept the windows in plane with the Zip wall sheathing. In summer, when the sun angle is high and the heating potential is the greatest, the overhangs keep most of the sun off the windows.

Photos: Roe Osborn

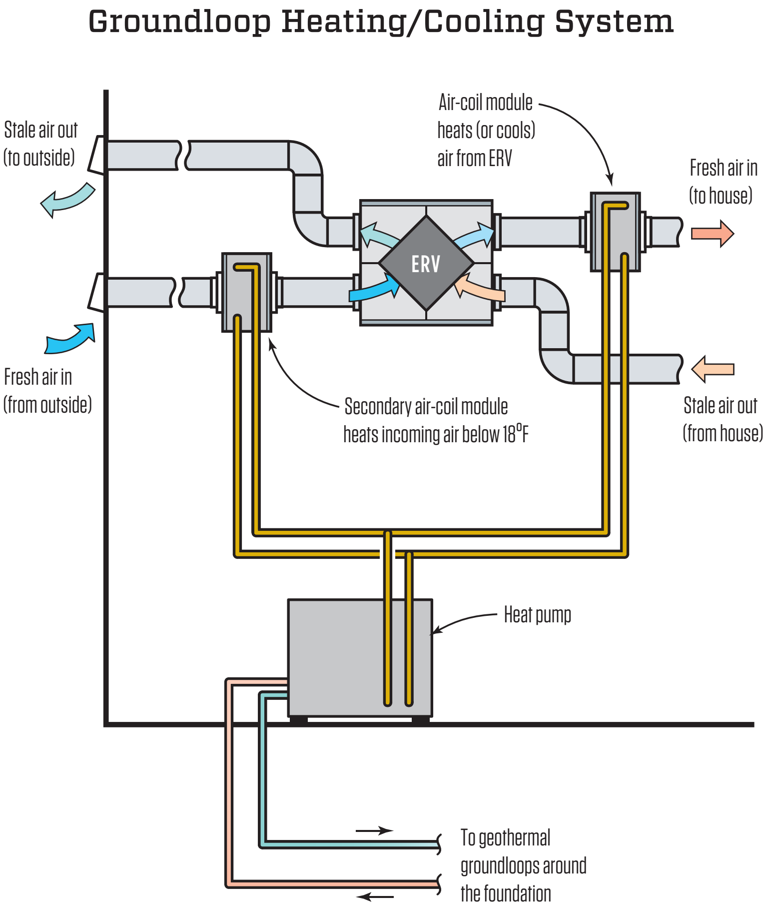
Photos: Roe Osborn

ENVIRONMENTAL SYSTEMS

We needed to use insulation in the wall trusses that wouldn't be affected by moisture, so it had to be inorganic. Roxul, a rockwool product made of fibers that come from molten rock, was the perfect choice. I was concerned about rockwool's high level of embodied energy. However, because of its unique properties, I went with it in the end, using a dense pack in the walls (both in the framing and in the wall trusses) for a total of R-90 **(24)**. When the framing and glazing are added into the equation, we calculate a finished R-value of R-55 for the wall assembly. We insulated the ceiling with loose-fill rockwool for a total of R-96.

To vent the roof, we attached commercially made foam vent channels to the underside of the roof sheathing and spray-foamed them in place to minimize any air wash over the insulation. To create a dam for the rockwool at the heel of the trusses, we installed rigid foam vertically—cutting it to fit around the vent channel—and foamed all the edges. The term "Passive House" is a bit of a misnomer because there is quite a bit of active technology involved in making one function successfully. The whole idea of controlling air infiltration means that a system needs to be in place for heating and cooling as well as for keeping the air in the building fresh and healthy for the inhabitants. For the heating system, I installed a geothermal ground loop around the foundation. When the foundation contractors excavated, I had them overdig the foundation hole by 6 feet on all sides. I then ran eight loops of ¾-inch piping around the outer perimeter of the foundation at two different levels for a total ground-loop of about 1,000 feet **(25)**.

The pipe is filled with a glycol mixture that runs through a water-source heat pump. The heat pump is plumbed to an air-coil module that heats or cools the air on the supply side of an energy recovery ventilator (ERV). The ERV is essentially the lungs of the house, taking in fresh air from the outside, cleaning and conditioning it, and then




25


26

circulating that air throughout the house. At the same time, the ERV pulls stale air from inside the house, removing any moisture and contaminants. In the process, it exchanges heat between incoming and outgoing air.

TESTING PERFORMANCE

Blower-door testing is an essential part of assessing a home's energy performance. And it's particularly important with a Passive House. We tested this home at three stages: first, before windows, doors, and the basement slab were installed **(26)**; then after the windows and slab were installed; and finally after the house was completed. The testing not only gives an overall rating for the house but also pinpoints—with a smoke test—areas of concern in the air barrier.

Testing at various stages also gives you quantifiable figures to mark improvement at each level of completion. Overall, the house performed better than expected, with a final figure of 80 cubic feet per minute at 50 pascal (0.3 air changes per hour), a number even better than the PHIUS minimum standard of 0.6 ach.

When I get asked about building a house to this extreme level, my answer is that it's not difficult, just different. It was imperative to have every member of my crew on board for maintaining the meticulous level of detail in the house, especially when forming the air barrier. For example, one bad squeeze while moving the caulking gun too quickly could result in an air leak that would be very expensive to fix. It's difficult to get production-minded craftsmen to slow down and make sure each step is properly completed. This attention to detail definitely increases the cost. However, that cost is easily recovered during the first few years of ownership. I was lucky to use my own home to learn the techniques for building future passive houses.

Farley Pedler, owns Farley Built, on Martha's Vineyard, Mass.

Photos: 25, Farley Pedler; 26, Roe Osborn