Affordable

The ProHOME team finds a balance between improved performance and construction costs

A "net zero" designation means there is enough on-site renewable energy to offset a house's annual usage. The term could apply as easily to a highly insulated envelope as one built to energy-code minimum. In the custom-house market, the balance between spending on the size of the PV array vs. the building envelope can be influenced by aesthetic concerns, environmental beliefs, and lifestyle decisions. The ProHOME, however, is a spec house built for the affordable market, so there's a laser focus on the marginal costs of improving the envelope relative to the cost savings of an additional kilowatt of solar energy.

Here's a look at how Paul and Tim Biebel designed the foundation and framing to find the sweet spot between material costs and labor costs for the net-zero 2017 ProHOME. □

Sean Groom is a contributing editor.

A SLAB APPEALS TO POTENTIAL BUYERS

To reduce the cost of the building envelope, the ProHOME is built on a slab. This requires less excavation, less formwork, and less concrete, reducing the cost and the duration of the build. The slab is also a plus for the ProHOME's target demographic, since older, downsizing homeowners looking for one-level living aren't interested in a flight of stairs down to subterranean space.

The ProHOME foundation relies on traditional footing and stem-wall construction to reach below the frost line. The inside of the stem walls are insulated with 2 in. of Amvic Envirosheet. In the past, the Biebels have experimented with ICF stem walls, but after factoring in the cost of protecting the foam on the exterior wall, have reverted back to formed stem walls.

ELEVATING THE STANDARD

Amvic SilveRboard insulation

SilveRboard subslab insulation under the ProHOME offers R-5 per in. and a compressive strength of 35 psi. Each face of the EPS foam is laminated with a polypropylene film, adding strength and durability to reduce breakage and cracking during the construction process. The EPS contains no CFCs or HCFCs and is available in four compressive strengths between 12.8 psi and 44.4 psi.

To insulate the slab, they used 4 in. (R-20) of Amvic SilveRboard. Before the slab was poured, Tim's crew rolled out a 15-mil vapor barrier over the insulation. All seams are overlapped and, along with slab penetrations, sealed with tape. At the slab edges, he draped the vapor barrier up the side and over the top of the stem wall and let it run long. After standing the walls, the vapor barrier was taped to the outside face of the wall sheathing.

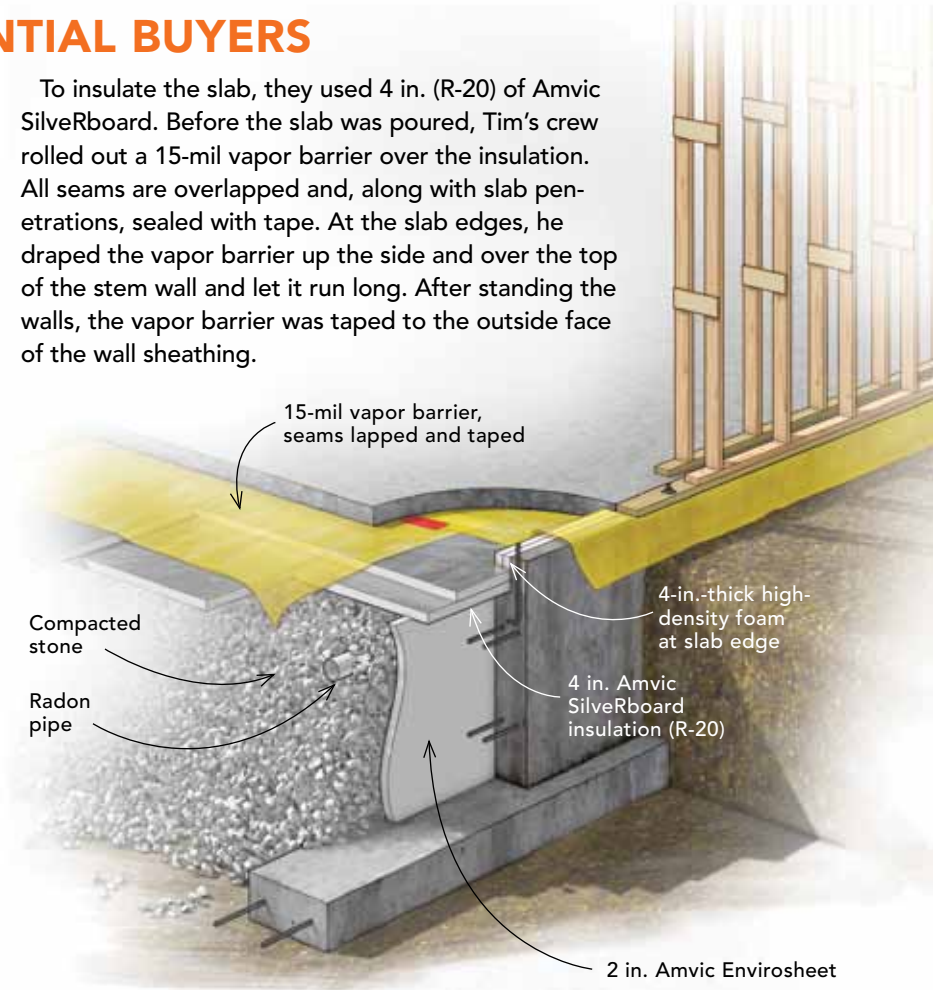
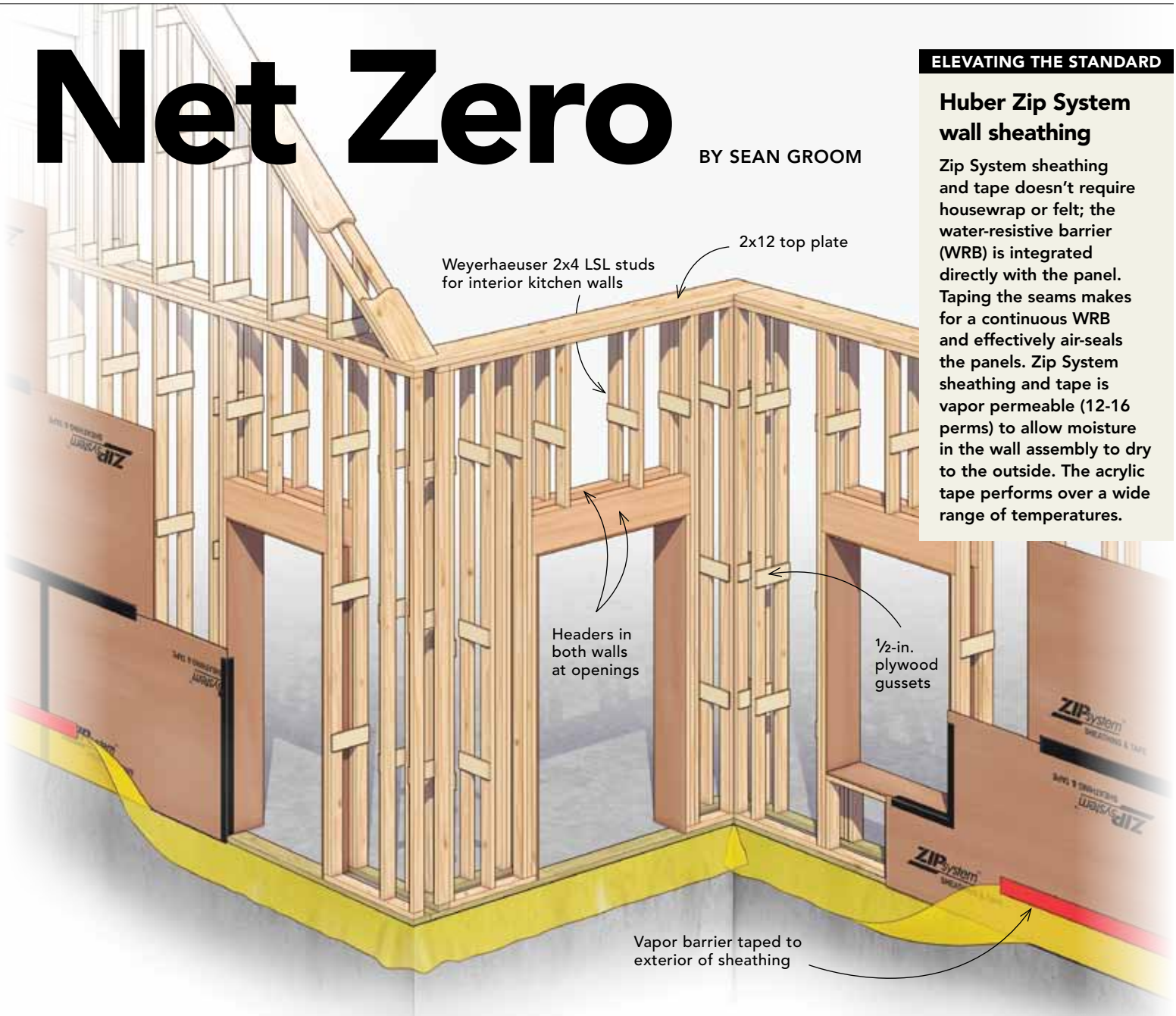


Photo: Brian McAward; drawings: John Hartman

Net Zero

BY SEAN GROOM



ELEVATING THE STANDARD

Huber Zip System wall sheathing

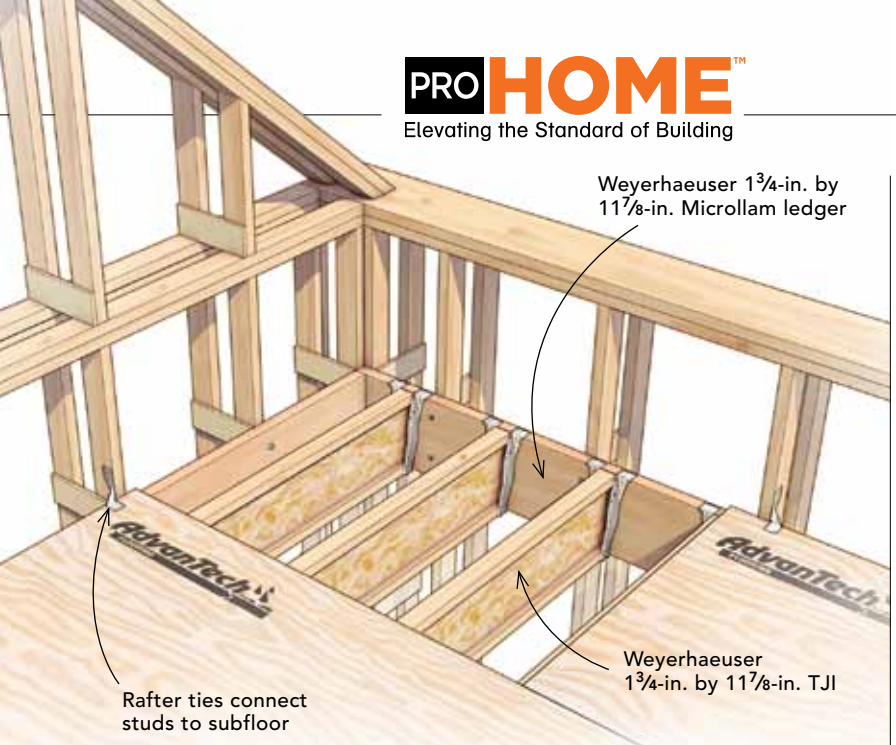
Zip System sheathing and tape doesn't require housewrap or felt; the water-resistive barrier (WRB) is integrated directly with the panel. Taping the seams makes for a continuous WRB and effectively air-seals the panels. Zip System sheathing and tape is vapor permeable (12-16 perms) to allow moisture in the wall assembly to dry to the outside. The acrylic tape performs over a wide range of temperatures.

THICK WALLS ARE FASTER, CHEAPER, AND BETTER INSULATED

The ProHOME's well-sealed and well-insulated envelope adds material and labor costs, but the smaller heating and cooling system has lower purchase and operating costs and requires fewer solar panels to achieve net-zero energy.

Although Vermont's energy code requires R-23 to R-25 walls (depending on the insulation method), Paul and Tim built R-45 walls. Two common ways to a build a well-insulated wall with minimal thermal bridging are to wrap the sheathing of a traditionally framed wall with exterior insulation or to pack thick double-stud walls with cellulose insulation. The decision to use the double-stud wall method for the ProHOME came down to a matter of cost. When they looked at the price of materials and labor, Paul and Tim found that an R-40 2x6 wall insulated with closed-cell spray foam in the cavities and 2 in. of rigid foam on the exterior would be 14% more expensive than their R-45 double-stud wall.

The ProHOME's double-stud walls are framed with 2x4s with a 4¼-in. gap between them, connected by 5-in.-wide, ½-in.-thick plywood gussets fastened 32 in. on center. These gussets—½-in. plywood bucks that line each window and door opening—and the 2x12 top plate are the only thermal bridges in the wall framing. Energy-conscious builders have long been constructing double-stud walls in this fashion, but a few years ago Paul added his own twist. He balloon-frames the walls, using continuous studs from the bottom plate of the first floor to the top plate of the second floor. This was a common technique



a hundred years ago, and Paul does it today to remove the floor joists from the wall cavity. Instead of setting the second-floor joists on the top plate of the first-floor walls, the joists are hung from a ledger fastened to the inside wall. This allows the full 11¼-in. depth of insulation to run continuously behind the floor joists. If Paul were platform-framing 2x6 walls, he'd have less insulation where the floor system attaches, as the top and bottom plates, rim joist, and floor joist all meet in the wall cavity.

ELEVATING THE STANDARD

Huber AdvanTech subflooring

AdvanTech subflooring is engineered to exceed the strength of plywood and OSB panels and to be highly water resistant. Coating each wood strand in a moisture-resistant resin and sealing the edges prevents edge swelling so effectively that Huber guarantees AdvanTech subflooring won't have to be sanded even with 500 days of weather exposure.

The exterior double-stud wall assembly is the load-bearing wall because the bottom plate of the inner wall lands on the slab. Accordingly, structural headers are used in the outer wall. However, to simplify and speed up framing, every opening in each wall is framed with a header. Tim finds that building every opening the same way saves enough time to offset the small additional lumber cost.

The house is sheathed with Zip System sheathing and tape. The taped seams and surface treatment of the panels function as an air barrier. On this house, they are a secondary air barrier, as the continuous barrier from wall to second-floor ceiling will run on the interior. The Zip System panels, however, are a water-resistive barrier that eliminate the need to install housewrap. Huber claims that the bumpy exterior face creates enough continuous space behind the siding to serve as a drainage plane. This water path meets the siding manufacturer's requirement for a drainable housewrap, so there is no need to apply a secondary wrap or attach strapping to create space behind the siding.

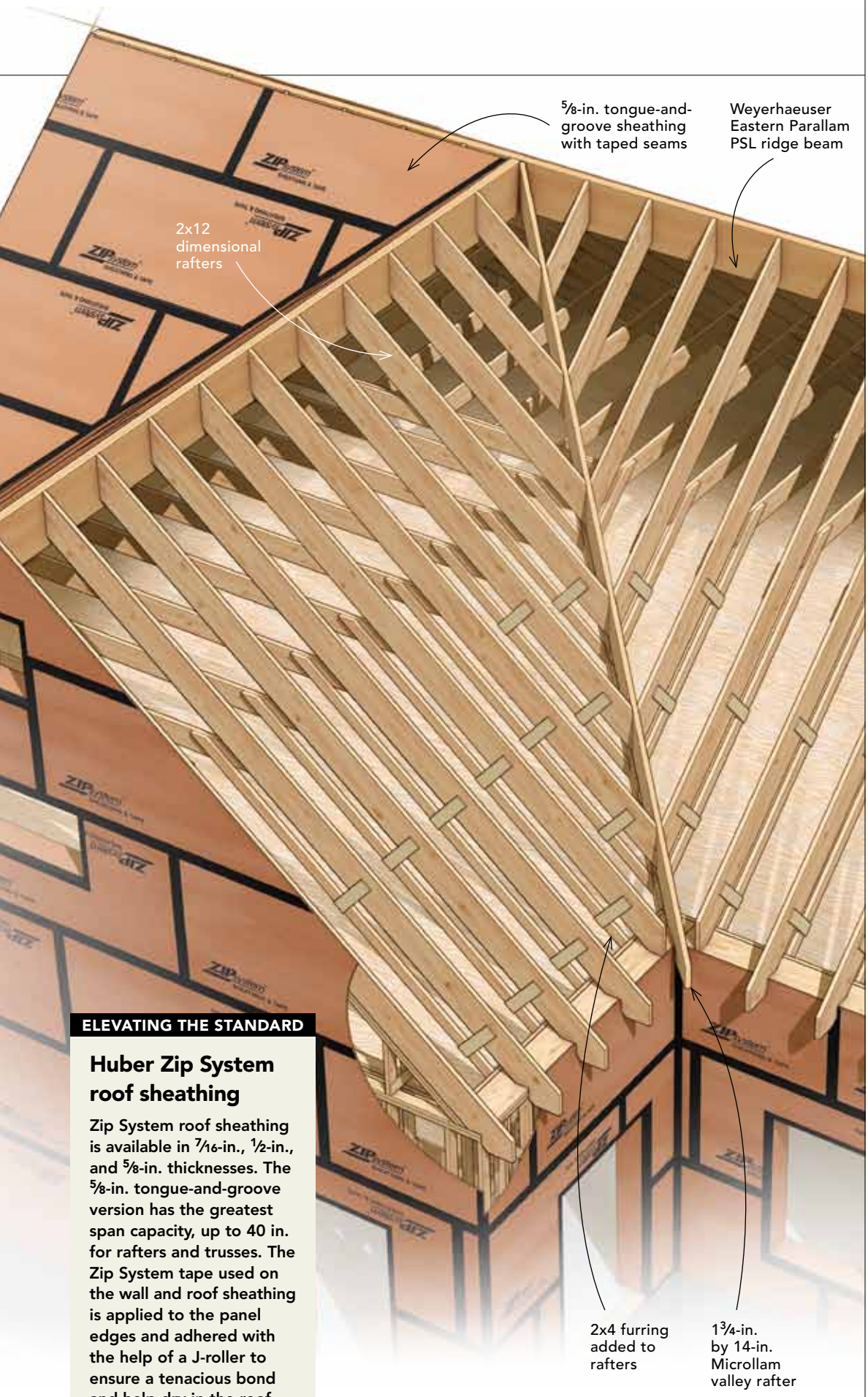
A ROOF FOR INSULATION, SOLAR PANELS, AND BEDROOMS

While many of the potential home buyers for this small development want a floor plan that accommodates single-level living, that was just one of several concerns guiding Paul as he designed the homes for this neighborhood. He wanted the houses to have a visually interesting roof line, and they needed to include bedrooms on the second floor for customers who need more space. They also had to have a large south-facing roof plane to accommodate a PV array.

His solution is a one-and-a-half-story design with intersecting roofs and gable ends. This creates a more interesting roof line than a simple boxlike ranch, and the 10-in-12 pitch on the ProHOME allows for enough usable space on the second level to tuck two bedrooms and a bathroom under the roof. There is also a good deal of conditioned storage space that helps make up for the single-car garage and the lack of a basement. The 40° roof slope is also within the Vermont location's ideal range for maximizing solar production over the course of the year.

Although the gables and valleys were added to create visual interest, the single south-facing roof plane is large enough to accommodate up to 10kw of PV. Based on the Biebel's experience with the first house they built in the development, Tim believes an array of this size should be enough to allow a family of four to reach net zero.

Paul and Tim have used both trusses and stick-framed roofs on their houses, letting cost dictate the choice. The roof shape of the ProHOME added enough complexity to the truss design that stick-framing was the cheaper option. The structural ridge beams are 3½-in. by 18-in. Weyerhaeuser Eastern Parallam PSL beams and smaller 1¾-in. by 14-in. Microllams for the valley rafters. The common rafters are 2x12s. However, they don't provide the depth needed for 16 in. of dense-packed cellulose insulation to achieve R-60 in the lower portion of the ceiling. The solution is to drop the ceiling below the top plate by furring the rafters down with 2x4s. The upper end of each 2x4 is nailed to the collar tie and the lower end toe-nailed to the stud below the top plate with gussets in the middle of the run.



ELEVATING THE STANDARD

Huber Zip System roof sheathing

Zip System roof sheathing is available in 7⁄16-in., ½-in., and 5⁄8-in. thicknesses. The 5⁄8-in. tongue-and-groove version has the greatest span capacity, up to 40 in. for rafters and trusses. The Zip System tape used on the wall and roof sheathing is applied to the panel edges and adhered with the help of a J-roller to ensure a tenacious bond and help dry in the roof.

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