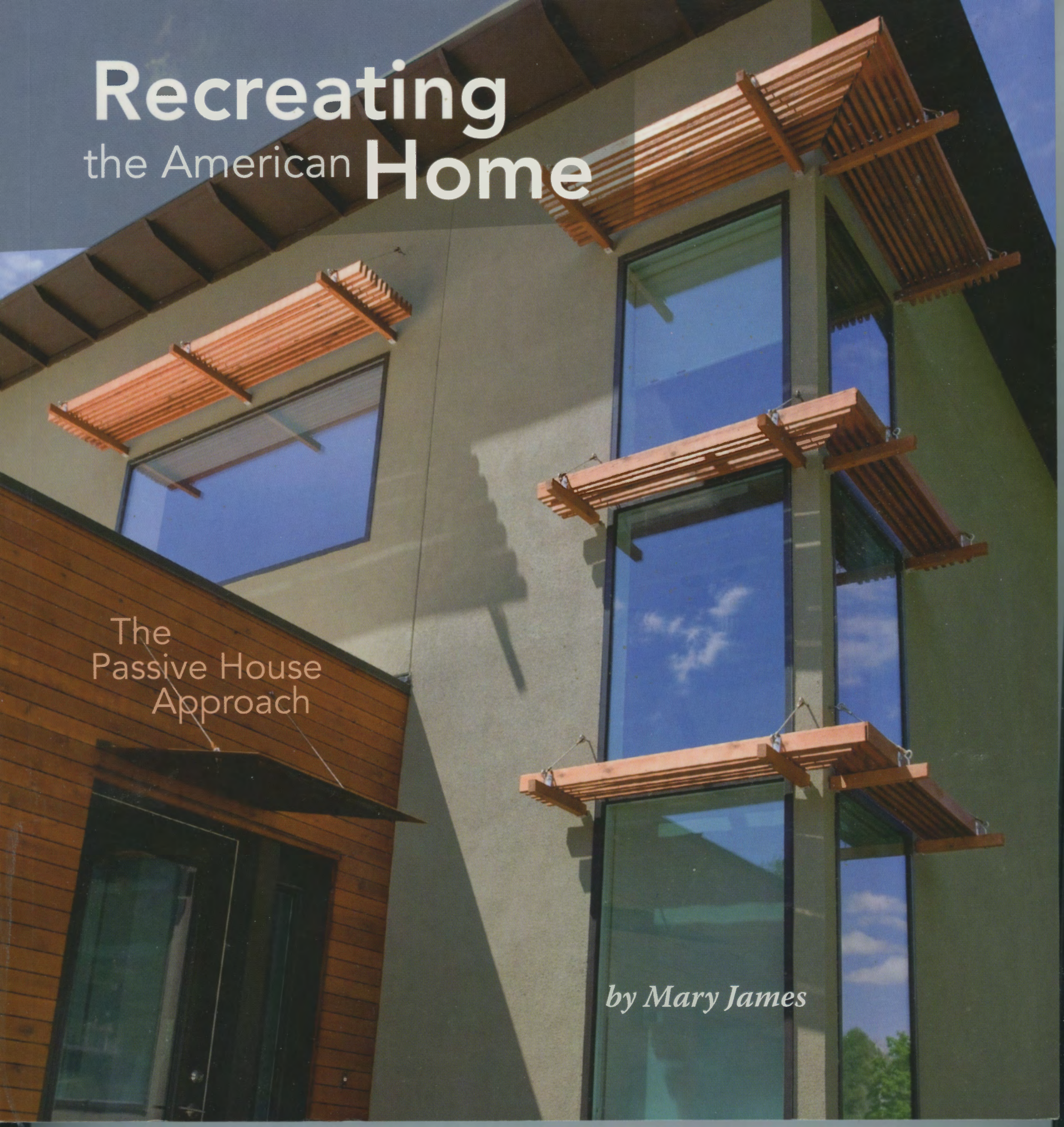

Recreating
the American Home
The Passive House Approach
by Mary James

CHAPTER 11

The First **Modular** Passive House

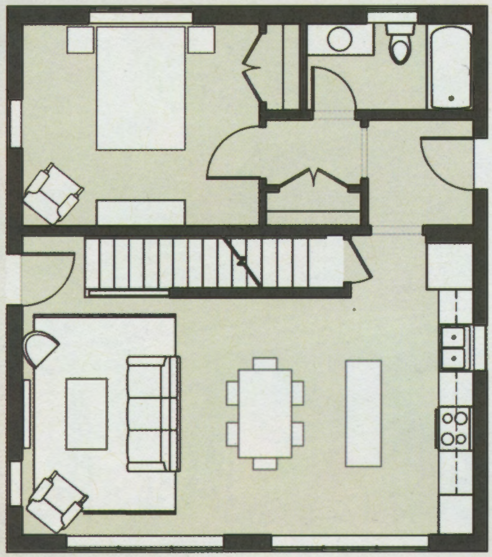
Charlotte, Vermont

A sketch created during a conference session seems an unlikely candidate for the birth of a small revolution—the first modular Passive House in North America—but no matter what its origins, it's a birth that deserves celebration. Architect J.B. Clancy and Peter Schneider, project manager and energy analyst with Vermont Energy Investment Corporation—both are also PH consultants—were conferring at the 2009 North American Passive House Conference. Schneider had heard that Habitat for Humanity was planning to build three homes on a $^{1}/_{2}$-acre section of a 50-acre parcel in his hometown of Charlotte, Vermont.

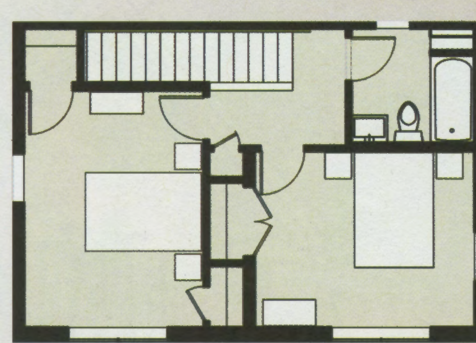
He knew that Habitat was becoming increasingly interested in energy efficiency, and that for this project the organization was planning to add donated rigid foam to the outside of the building shell. He figured pushing Habitat's design to meet the PH standard wouldn't be too difficult or too expensive. When he approached the executive director of Habitat's local chapter, Green Mountain Habitat, with this suggestion, it was welcomed enthusiastically. But the original design—a traditional Cape-style home—was overcomplicated and would need to be modified. That's where Clancy came in.

Clancy and Schneider had met during the PH consultant training in the spring and early summer of 2009. Before that, Clancy had had plenty of experience with green building standards, but he wasn't satisfied with getting points awarded for specifying the installation of bamboo flooring imported from China. How was that really reducing a home's environmental footprint? Dissatisfied and searching for a standard that would focus on energy efficiency, he found the PH consultant training. Several months later, he was happy to apply what he had learned in the classroom to the Habitat project. Then and there, Clancy sketched up a design for a small, cost-effective PH that could be either stick-built or modular housing. That basic design never changed much. As Schneider says, it was an incredibly efficient and buildable design.

Habitat for Humanity builds affordable housing for families who are earning 30% of the area's median income



First Level



Second Level

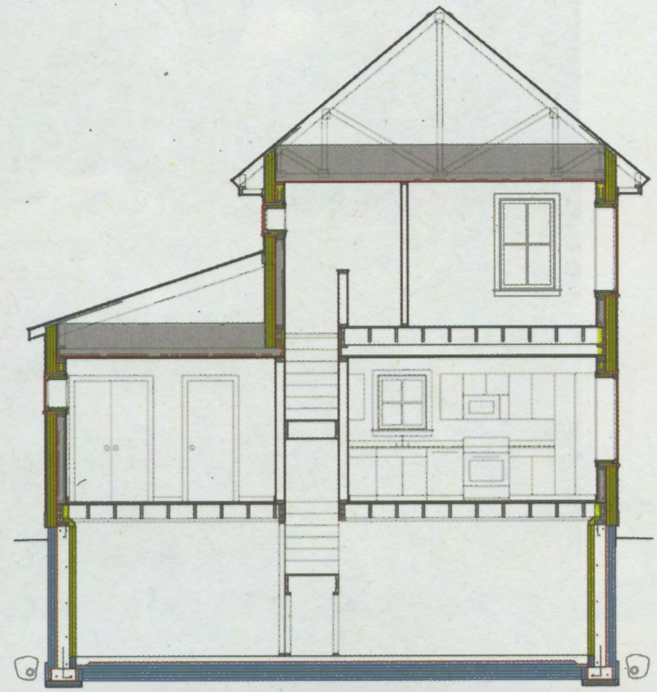
or less and are currently in insufficient housing. It is very competitive to get into one of Habitat's houses, and once in, the families tend to stay for decades. In the Northeast, Habitat understands that affordability doesn't just mean low initial costs or monthly mortgages. Affordability includes life cycle costs, especially energy costs. Being able to control the home's energy costs, and protect the homeowner from future cost increases, is what makes housing affordable in the long term.

That control was what made PH interesting to David Mullin, the executive director of Green Mountain Habitat. The clincher was the cost analysis prepared by Schneider and Clancy. They used the PHPP to chart monthly energy use in their PH design compared to a traditional Cape-style home, and then translated that energy use into monthly energy costs. The increased costs to build the PH, and the resulting higher mortgage bill, were more than offset by the savings in energy costs, even if Habitat had to pay for more insulation and the upgraded windows. If Habitat invested in building a PH now, the new owner would save money immediately.

Charlotte, Vermont, is a small town of roughly 4,000, tucked away in the northwestern corner of Vermont, just 10 miles south of Burlington. Because the Burlington area is extremely cloudy, and because there are a great many heating degree-days per year, this is arguably one of the most challenging climates in the United States in which to build a PH. And yet. And still. Even here, a cost-effective PH is possible.

What's the secret? Schneider cites the simplicity of the design, a modular building approach, utilizing products available in North America, and then stops himself. Most important, he says, is using smart design to decrease the size of the house and still meet all the requirements of an average family. The final design has 1,375 square feet of living space and a very smart floor plan. On the first floor, the kitchen, dining room, and living room flow seamlessly together, occupying one-half of the downstairs. A master bedroom, bath, and mudroom occupy the other half. Upstairs, two more bedrooms share a full bath on a floor that is roughly two-thirds as wide as the first floor. A shaded porch area frames the west-facing front door.

The level of detail that the PHPP requires is what makes this modeling tool particularly practical. Without this tool, says Clancy, what passes for a studied design choice is really just shooting from the hip. Using the PHPP, Clancy was able to design a home in which passive solar is providing two-thirds of the heat load, even though Vermont is the second-cloudiest state in the nation. As Schneider says, it's



The foundation wall is wrapped on the outside with 6 inches of XPS, while the interior of the foundation walls is covered in two 2-inch layers of polyisocyanurate.

pretty remarkable what the sun can provide, even in a poor solar climate.

Habitat's first PH could have been stick-built or modular housing, but Mullin understood that a modular PH could be replicated more easily on the open market. And a model that could be easily replicated would give more families a shot at living in a comfortable, superefficient home. Early in the planning process, after Schneider had given a talk at a building conference about the Habitat project, Dave Stewart and Chet Pasho of Preferred Building Systems (PBS) approached him, proposing to collaborate on the project. PBS is currently a leader in energy-efficient modular homes; this project would be an upgrade from its existing, highly efficient construction practices. Under ordinary market rate conditions, modular homes are less costly to construct than stick-built ones, but Habitat homes are built with volunteer labor—a cost savings that PBS just couldn't match. Instead, it could and did offer to shave its costs as much as possible in order to get this project built. Schneider successfully closed the remaining budget gap with additional fund-raising from local philanthropic organizations.

The exterior wall components, which were built in the PBS factory, are constructed with 2 x 6 engineered studs at 24 inches OC and single top plates, an advanced framing design that reduces the amount of wood used and allows for the installation of relatively more cellulose insulation. Over the framing members, a Huber ZIP System, which consists of structural panels with a built-in water-resistant barrier and a proprietary tape to seal the seams, provides a combined sheathing and air barrier layer. This ZIP system was used to form the exterior walls and the roof sheathing. The roof design, with its 20-inch raised-heel truss, allows for a generously proportioned attic that is filled with 2 feet of cellulose, giving the roof assembly an R-value of approximately 90.

Three 2-inch boards of foil-faced polyisocyanurate rigid foam, layered on with staggered seams, wrap the above-grade walls. That foam is held on with wood strapping. Screws that go all the way back through the foam to the

The modular-home components were built in the Preferred Building Systems factory.

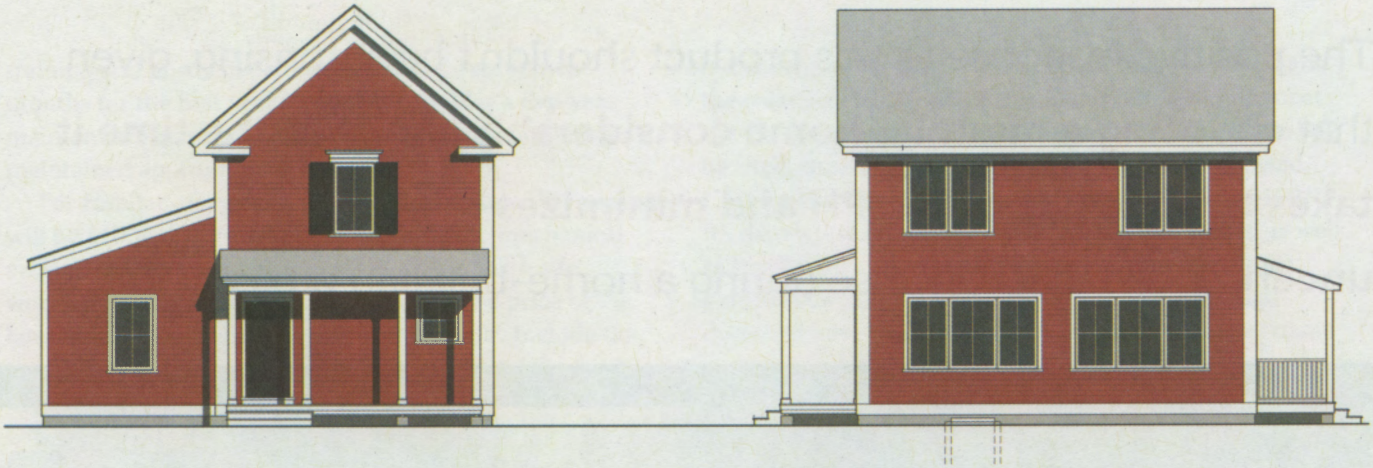
studs hold the strapping in place, and the siding is attached to the strapping. Since Schneider and Clancy are choosing cement board for the siding, and since cement board is heavier than other types of siding and doesn't travel as well, it will be attached on site. The total R-value of the exterior walls is 60.

For the windows, Schneider chose to have PBS install Thermotech 332 Gain+ units, which have a glass and frame U-value of .16 and a spacer U-value of .024. The SHGC is .64, the highest value they could find. They used casements on the east and west sides, and awning-style windows on the north side. On the south side, fixed-pane windows are mulled to casements on both sides. These triple-pane windows come with slim, well-insulated, fiberglass frames.

As this book went to press, Schneider and Clancy were eagerly awaiting the imminent delivery of the modular-home components. All of the site preparation and below-grade construction had been finished. The footings, which extend 4 feet below the frost line, sit on and are wrapped in 4 inches of XPS. The one load-bearing footing in the center of the 4-inch concrete slab is similarly wrapped in foam. Buried beneath the slab are six layers of 2-inch XPS boards with staggered seams, for a total of 12 inches of foam. The foundation wall is wrapped on the outside with 6 inches of XPS, while the interior of the foundation walls is covered in two 2-inch layers of polyisocyanurate.

The modular-home components will be assembled on site by a PBS set crew. The finish details will be completed using an all-volunteer crew, as is true of all Habitat homes. In some locations, an all-volunteer crew can be a mixed blessing, with enthusiastic but unskilled volunteers. That won't be the case in Charlotte, where local carpenters have volunteered to pitch in, trading free labor for the experience of helping to construct a PH.

The volunteers will be responsible for all interior and exterior finishes, including trim, flooring, cabinetry, and siding, and for installing the asphalt shingles on the roof. In addition, although the ducts and rough wiring and plumbing were included in the wall components, the mechanical system will be installed on site.



To meet the home's heating load and supply fresh air, Schneider opted for an UltimateAir ERV with a rated efficiency of 83%. He also specified installing a water-to-air coil that preheats the incoming air. The liquid in the coil is actually a water-glycol mix that runs through a double loop of standard PEX tubing, which was installed around the home's footing. In Charlotte, the ground temperature below the frost line is typically 50°F. The tubing transfers the earth's heat to the water-glycol mix, boosting the temperature of the outside air when it is 10°F or colder by about 40°F. This preheating also prevents very cold outdoor air from damaging the ERV. This relatively inexpensive system is completely passive, except for a 30W circulator pump tied to a temperature sensor that measures the incoming air. The rest of the heating load will be supplied with a 12,000 Btu air-to-air source heat pump, manufactured by Mitsubishi. This unit provides a 100% output at 5°F and a 75% output at -13°F; and it shuts off at -18°F.

The cooling load—well, that's not really a problem in Vermont. Neither is humidity. While summertime weather rarely amounts to much of a challenge, there are a few weeks when the heat and humidity can get uncomfortable—but that same 50°F liquid is still circulating through the coil. In summer, that liquid can precool the incoming air by condensing out excess moisture, which then gets dumped through a condensate drain. Combine that strategy with night cooling—closing the house during the day and opening it up at night—and those few weeks of summer heat can be enjoyed very comfortably.

Shading is also unnecessary here. According to the PHPP modeling results, even eliminating the overhangs on the south-facing windows will not overheat the house. On peak cooling days, the sun is at a 23° angle, way up in the center of the sky, and the high-performance windows reflect most of the heat. In the late spring and early fall, when it is still, or already, the heating season, the absence of overhangs lets in more solar heat. Averaged over the year, the eyebrowless look lowers energy consumption.

In spite of Vermont's solar limitations, Schneider calculated that a solar water heater should provide 75% of the annual DHW load. He chose to install a flat, black, closed-loop system with a water-glycol mix, and an 80-gallon storage tank. A well-insulated 40-gallon electric water heater will serve as backup.

Schneider and Clancy's goal was to keep the home's systems as simple as possible, and to minimize maintenance for the occupants. Although they generally succeeded, the systems in a PH are often unfamiliar to the homeowner. To ease the transition, Schneider and Clancy plan to conduct training and postoccupancy evaluations every three months for the first year. They will also offer a five-year maintenance contract to make sure everything is being maintained appropriately.

For Habitat, the price to deliver the modular PH package will be $100/ft^2$, but that doesn't include the mechanical system, asphalt roofing, or finish flooring. With site work and a foundation, but not counting the price of the land, this package will cost just over $115/ft^2$. Include the mechanical system and the finish flooring, and the total cost for a complete house would be $130/ft^2$. That price compares amazingly well with what it costs to get a custom house built almost anywhere in the United States, and certainly in Vermont, where labor costs are high. A custom house usually goes for somewhere in the high $100s to $200/ft^2$.

This efficient and buildable design, which has been precertified by PHIUS, is now available as a PH modular home from PBS. PBS can deliver its modular-home components to any site in the New England region. When this modular PH is assembled in a different location, the climate data will have to be updated to reflect that location, but as long as the due south orientation is preserved and the solar access is good, the modular home should meet the PH requirements. Depending on where the home will be sited, the shading system might have to be adjusted. Cost for this modular PH would be from $130 to $150/ft^2$, depending on the choice of finishes and siding, as well as the distance from the PBS factory to the site. Once a contract with PBS is signed and all the final design decisions have been made, it should take no longer than eight weeks to assemble and deliver the home components, according to Stewart.

PBS has already received many inquiries about its new modular PH, and as this book went to press, one new order was already in the works. The positive response to this product shouldn't be surprising, given that choosing a modular home considerably shortens the time it takes to build a certified PH and minimizes the budgetary uncertainties that can arise during a home-building project. Streamlining access to a PH may not be a dramatic revolution, but sharply reducing carbon emissions in the housing industry doesn't call for drama—just action. Innovation doesn't hurt, either.

PASSIVE HOUSE
Verification Summary

Builder	Habitat for Humanity
PH Consultant	Peter Schneider/ J.B. Clancy
Architect	J.B. Clancy
City	Charlotte, Vermont
Year	2010

Specific Space Heat Demand	4.63 kBtu/ft²/yr (1.4 kWh/ft²/yr)
Pressurization Test Result	0.6 ACH_{50}*
Specific Primary Energy Demand (DHW, Heating, Cooling, Auxiliary, and Household Electricity)	36 kBtu/ft²/yr (10.6 kWh/ft²/yr)
Specific Useful Cooling Energy Demand	3 kBtu/ft²/yr (0.9 kWh/ft²/yr)

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