Designed for Success

One architect's approach to designing a house to meet the country's most stringent energy requirement

BY STEVE BACZEK

When I'm designing a house to perform at a high level of efficiency, I like to simplify the energy equation to one mind-set: Convert the energy as inexpensively as possible, and then hold on to it as long as possible. The beauty of this approach is that as my energy-conservation efforts increase, my energy needs decrease. As the energy needs decrease, the conversion of that energy becomes more efficient, and so on.

I break the performance of a house into four categories: insulation, windows and doors, air-sealing, and mechanical systems. My goal during the design process is to keep all four categories proportional so that I'm improving the house as a whole, not just a few spots. It doesn't make sense to have R-50 walls and an R-80 ceiling and then to install standard double-glazed windows. This proportional concept is important because it forces me to design the house around the energy goals rather than trying to apply energy efficiency as an afterthought. The success of an energy-efficient house lies in the idea of integration, not application.

Passive Houses can blend right in

For many people, the mention of energy efficiency conjures images of wacky futuristic houses. It's not hard to see why, especially when so many high-performance homes look like oversize toolsheds. I understand that some of the energy requirements lead to certain design requirements—it would be a real trick to build a Passive House without lots of south-facing windows, for example—but the house doesn't have to look wildly different.

The thing to remember is that you can't design along a traditional path—focused on aesthetics, layout, and so on—and then try to apply energy efficiency at the end. The performance needs of a Passive House must be integrated into the design. I try to use these performance requirements as part of the building's aesthetics.

For example, in a 2x6 wall frame, the location of the windows is almost certain to be along the exterior plane of the wall. In a Passive House, where I may be dealing with a 16-in.-thick wall, I now have options for the placement of the windows within the wall that could add some aesthetic value to the project.

I aim to do all of the above while maintaining a level of comfort for the builders and subcontractors. I see lots of designers specifying materials that are costly, hard to acquire, or unfamiliar to the tradespeople who

Photo facing page: Trent Bell

"Tolerances for a Passive House are so low that **flubbing just one of the construction details** can mean the difference between passing and failing."

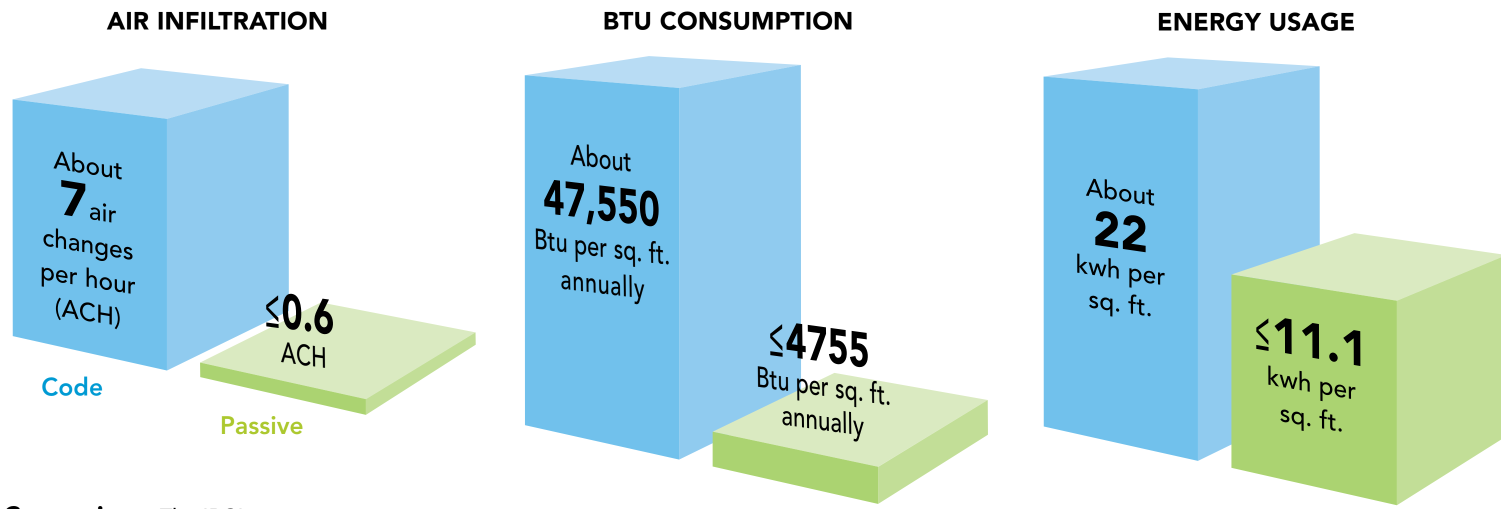
Gears of efficiency

Built to meet the world's most rigorous standard for energy-efficient construction, a Passive House uses about one-tenth the energy of a similarly sized code-built house, a feat accomplished by carefully harmonizing countless design and construction details. At the time of this writing, just 71 houses have earned the Passive House Institute US (PHIUS) certification. Architect Steve Baczek just broke ground on his fourth, and has contracts for a fifth and sixth.

This series of articles and companion videos focuses on the theory, design, and building of his third Passive House project, located in Falmouth, Mass. Visit FineHomebuilding.com and GreenBuildingAdvisor.com to watch the video series of this Passive House build and to join a conversation with Steve.

WHAT IT TAKES TO BE A **PASSIVE HOUSE**

The Passive House standard aims to maximize passive energy gains while minimizing energy losses. This is achieved with superinsulation, high-performance windows and doors, minimal thermal bridging, strict airtightness of the building envelope, mechanical ventilation, and optimal passive-solar gains. To attain Passive House certification, all of the building components are individually scrutinized in the Passive House Planning Package (PHPP), an elaborate spreadsheet program, before any construction begins. The PHPP predicts the performance of the house before it's built. Once built, the house is tested by a third party to ensure that it has achieved three performance requirements.



Comparison: The IRC's current energy codes require houses to have no more than 7 air changes per hour (ACH) at 50 Pa.

Comparison: That's roughly 90% less heating and cooling than is required in a similarly sized code-built house.

Comparison: This number, which includes heating, cooling, and electricity, is roughly half that of a typical house.

will be installing them. While I'm certainly in favor of developing projects with new materials and methods, I'm conscious of the effort needed to fulfill such requests, and I have to balance that with the expectation that builders will handle their installation or technique with the strictest attention to detail.

Rethinking the construction sequence

The performance tolerances for a Passive House are so low that flubbing just one of the construction details can mean the difference between passing and failing the certification process. An elevated awareness of these stakes is a must. This translates to a drawing set that goes beyond typical, involving larger printouts, more detail, and specific labels. Nothing can be left to guesswork or interpretation.

Once we have the plans in hand, I like to sit down with the builder and all of the carpenters and subcontractors who will be working on the house. We walk through the plans as a group, explain details, ask questions, and reinforce the importance of every step. This sort of pregame meeting isn't common in residential construction, but it's crucial for a project of this complexity. Everybody learns what's at stake and how their part of the build fits into the whole. It's also the chance for us to plan the building sequence, which is often tweaked to help us track air-leakage rates at different stages of the build.

Passive House has a rigorous airtightness requirement, so it's important to use blower-door tests to track airtightness at certain points of the construction process. First, we build and test the primary air barrier, which on the house featured in this series includes the slab, sheathed walls, and drywall ceilings. Only after that assembly passes muster (I aim for no more than 40% of our final allowable air leakage) does our secondary air barrier, a flash coat of spray-foam insulation, get installed. When the second test is complete (ideally, 30% of the overall), I give the green light for the rough openings to be cut and the windows and doors to be installed before again testing the shell of the building.

This compartmentalization not only allows me to understand the air barrier as a whole, but it also provides me with numbers directly tied to the airtightness of each installed component and allows me to correct problems while those components are still accessible.

Is it all worth it?

One of the last hurdles you have to clear when designing a house to this level of energy efficiency is the cost. I always hear, "That level of performance is too expensive" and "You'll never recoup your money."

I can't claim that building a Passive House costs the same as building a code-compliant house of similar size, but I will argue that cost is quite possibly the worst way to measure the merits of a house. It's not that energy-efficient houses cost too much; it's that our idea of a fairly priced new home is based on a history of building houses to meet embarrassingly low performance benchmarks. □

Steve Baczek is an architect in Reading, Mass.

Drawing facing page: John Hartman. Photos facing page: Justin Fink.

SWEATING THE DETAILS

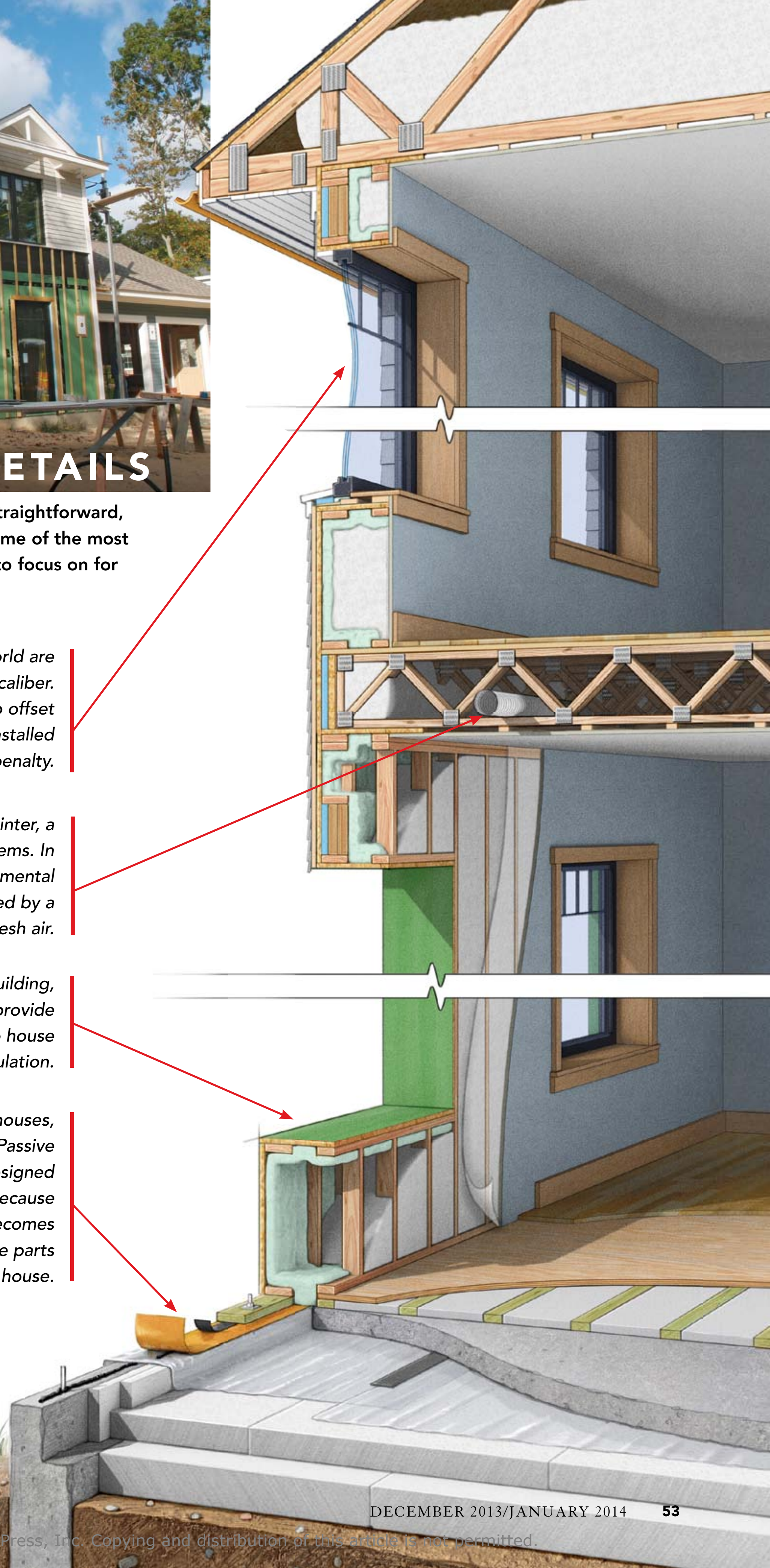
Passive House performance requirements are straightforward, but their execution is complex. Here are just some of the most critical areas that Baczek and the builders had to focus on for the Falmouth project.

Even the best windows and doors in the world are still the weakest point in a house of this caliber. They must be located precisely in order to offset their thermal weakness, and they must be installed impeccably to minimize their air-leakage penalty.

Although largely heated by the sun in the winter, a Passive House still relies on mechanical systems. In this case, a 1-ton minisplit provides supplemental heating and cooling, which is distributed by a recovery ventilator that also provides fresh air.

Making up the largest surface area of a building, the sheathed double-stud walls need to provide not only redundant air barriers, but also house an immense amount of thermal insulation.

A weak spot in the performance of many houses, the sill plate has even higher stakes in a Passive House. This component must be designed critically and executed perfectly, because after the framing is complete, it becomes one of the least accessible parts of the finished house.



Next in the series
How to create an airtight mudsill