BY INDIGO RUTH-DAVIS

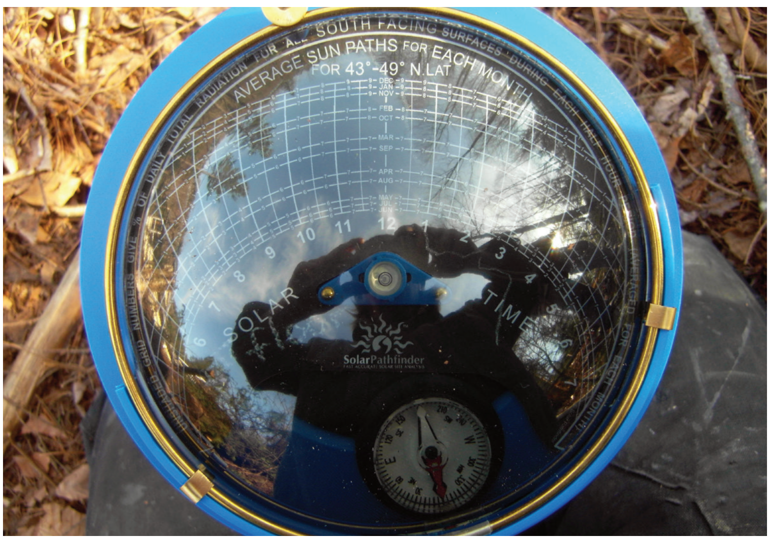
A Passive House Consultant's Toolkit

I'm a carpenter first and a Passive House Consultant second. My builder's approach extends to my consulting work, where my goal is to simplify the design process of Passive House construction. I'm one of a growing group of professionals with the designation of Certified Passive House Consultant, or CPHC, who are refining their methods for achieving the Passive House standard in the U.S.

The perceived complexity and additional cost of Passive House construction has come under much scrutiny since it arrived in the U.S., with little understanding of what it actually takes to design and build a Passive House. The tools that a CPHC uses aren't terribly difficult to master and were designed, in fact, to simplify energy-efficient construction.

At the heart of Passive House design is the building's projected energy use, which is determined early in the design phase by the CPHC. My approach to this is barebones, and my toolkit consists of just these four items:

1. Passive House Planning Package, or PHPP, an energy-modeling spreadsheet developed by the Passivhaus Institute ($215)
2. Solar Pathfinder shading analysis tool ($260)
3. WUFI-ORNL hygrothermal analysis program (free)
4. THERM thermal bridge analysis program (free)



Harvesting heat from the sun is serious business in a Passive House, so the shading analysis must be accurate. The author relies on a Solar Pathfinder to determine shading conditions for the building site.

Photo, graphs, images: Indigo Ruth-Davis

This inexpensive toolkit and the proper CPHC training are all one needs to design a Passive House. I'll use our most recent Passive House project in Vermont to demonstrate how they are used. This design/build project was a collaboration of myself (the CPHC) and Chris Miksic, both of Montpelier Construction (Passive House Institute US–Certified Passive House Builders), and the homeowner and designer, Greg Whitchurch.

ENERGY MODELING

The first step for the consultant is to do a feasibility energy model. I use the PHPP because it's the cheapest energy-modeling tool available that is approved for Passive House certification. It was developed to simplify the energy balance calculations that are necessary to accurately predict energy performance for buildings with low heating demands. Building areas, R-values, window specifications, shading conditions, and information about the mechanical systems are entered into the program. The PHPP combines that data with local climate data and calculates the energy use.

In our case, the Passive House energy demand criteria of 4.75 kBtu per square foot per year required that we use R-56 walls and an R-77 roof. For a Passive House this size (1,400 square feet), the heating load is equivalent to fifteen 100-watt light bulbs. After seeing the feasibility PHPP, our client was 100% committed to building a Passive House and in fact showed a distinct interest in exceeding the standard.

SHADING ANALYSIS

The next step is to analyze the site's shading conditions. Harvesting heat from the sun is serious business in a Passive House, so accuracy in the shading analysis is key. Passive Houses in northern climates are often forced to rely heavily on solar gain through south-facing windows. For complex shading conditions, such as in mountainous or forested locations, I use a Solar Pathfinder—a clear plastic dome that projects shading objects from the site onto a sun path

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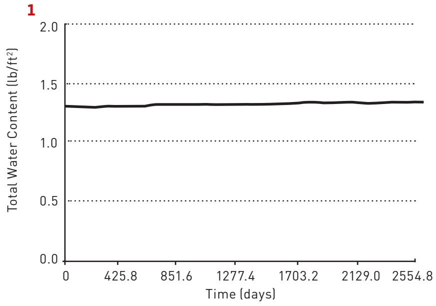

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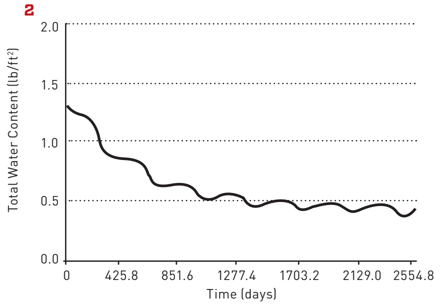

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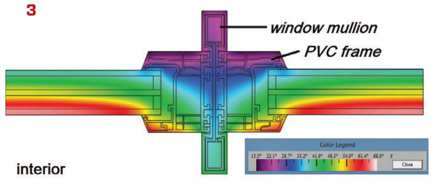

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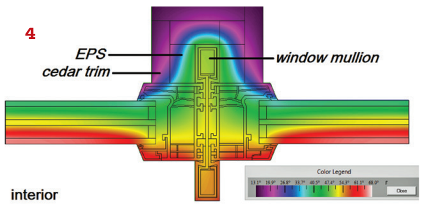

1. This WUFI-ORNL graph suggests that the total water content of an unvented roof assembly could rise if indoor conditions are similar to the base condition that WUFI-ORNL uses in its analysis.
2. Adding 1 ACH in a back-venting plane would give the roof assembly excellent drying potential. Actual venting will vary widely based on roof slope and wind speeds, so this analysis is used only to demonstrate basic hygrothermal principles, not to predict exactly how the roof will perform.
3. A THERM simulation shows that the window's connection mullion is a condensation risk.
4. Wrapping the connection mullion in 1 inch of EPS insulation and cedar trim eliminates the thermal bridge.

chart (see photo, page 45). Shading percentages are tallied and entered into the PHPP.

Our building site was forested with a large hill to the southeast. After a fair number of trees were cleared, the pathfinder showed good solar-gain potential.

MOISTURE ANALYSIS

Before building assemblies are finalized, they must be analyzed for moisture and mold risk. Potential for moisture issues in high-performance building assemblies can be greater than in conventional buildings. I use the program WUFI-ORNL/IBP for this analysis because it's free and is suitable for most non-commercial construction.

In our project, the roof design required special attention for possible moisture risk. When I modeled the proposed unvented dense-pack-cellulose roof with a variety of vapor retarders, WUFI-ORNL predicted in each case that the assembly would not be able to dry. As a result, the moisture content would slowly rise over the seven-year period that I analyzed **(1)**. When I compared this assembly to a back-vented assembly **(2)**, the results were dramatic. With 1 ACH in the venting plane, the roof assembly showed a significant, 66% drop in moisture content over the seven-year period. Based on these results, I recommended a ventilation plane.

THERMAL BRIDGE ANALYSIS

The final step in the design is to look for potential thermal bridges and to either eliminate them or account for them in the PHPP.

Thermal bridges that can't be eliminated need to be modeled separately in two-dimensional heat transfer programs such as THERM, which is a computer program developed by the Lawrence Berkley National Lab to help window manufacturers to accurately determine window performance for NFRC ratings. The PHPP can calculate heat transfer only from point A (inside surface of assembly) to point B (outside surface of assembly), while a program like THERM can calculate the additional thermal transfer that occurs when materials with significantly different R-value interact with each other within the assembly. Areas that typically could benefit from a THERM analysis are window installation details, foundation footing details, and band-joist details.

Our biggest thermal bridge concern was the window connection mullions. To determine if they were a thermal bridge, I first drew them in THERM. (THERM runs a heat-transfer simulation with a mullion and then without one; the difference represents the contribution of the mullion. My THERM analysis of the mullion showed that it was a condensation risk and impacted our heat demand **(3)**. I used THERM again to determine that wrapping the outside of the mullion with a strip of 1 ¼-inch EPS insulation would eliminate this thermal bridge **(4)**.

Although these tools are not the most advanced ones available (compared with BIM software, for instance), their proper use insures a great leap forward in building design and construction. Passive House is at the center of a convergence of energy-efficient technologies. A CPHC's job is simply to promote knowledge about how this technology can be used to improve the way that we build.

Indigo Ruth-Davis is a Passive House Institute U.S. Certified Passive House Consultant based in Calais, Vt. He is a partner at Montpelier Construction, a Certified Passive House Builder and building performance company. To learn more about the project mentioned in this article, see montpelierconstruction.com/passive-house-construction.php.