The Evolution of a Pretty Good House

A detailed look at the new low-carbon edition of the grassroots building standard

BY MICHAEL MAINES

Have you heard about the building standard that's completely voluntary and has no set requirements? It's called the Pretty Good House (PGH), and the idea is to use good design and proven building science to reach a practical level of performance in a durable, lovable, net zero energy–ready structure. The PGH was conceived in 2011 at a building science discussion group hosted by Performance Building Supply in Portland, Maine. Dan Kolbert, a builder in Portland and moderator of the discussion group, had grown frustrated with other performance-rating programs for being too restrictive, too resource-intensive, and too hard to convince clients to invest in. We brainstormed about what practical level of performance—and other features—a PGH would include. I wrote a blog post summarizing our discussion on GreenBuildingAdvisor.com (GBA), and the idea took on a life of its own. Recently, we updated the PGH concept to address the urgency of the climate crisis.

Incorporating embodied carbon

The release of the United Nations's 2018 climate-change report highlighted the need to considerably reduce global warming emissions and also made evident the building sector's significant contribution to the problem. Over the last eight years, many of us in the discussion group have developed a deeper understanding of high-performance building, so we decided to review

Photo: Kat Alves

our initial list of PGH attributes. Surprisingly, little had changed—a testament to the practical nature of our original ideas. The most critical addition was the carbon footprint of a house.

"Carbon footprint," or "upfront carbon emissions," can be defined as the sum of carbon emissions over a product's lifetime—from the extracting of raw materials to its processing, shipping, assembly, maintenance, and eventual disposal or recycling. "Carbon emissions" is shorthand for carbon dioxide (CO_2)–equivalent emissions. As a prevalent greenhouse gas, CO_2 is used as a unit of measurement, meaning the effect other greenhouse gasses have on trapping heat are expressed as the equivalent in CO_2. This matters because there is more CO_2 (and other greenhouse gasses) in our atmosphere than there has been for at least 800,000 years. In fact, there is nearly 50% more carbon in the atmosphere now than there was at the start of the Industrial Revolution. Time is running out—if emissions continue at their current rates, temperatures will continue to rise. The U.N.'s team of scientists says we need to reduce emissions by 50% by 2030, and by 100% (net-zero carbon) by 2050. Those ambitious targets don't guarantee a safe future, but they do improve the odds.

An effective forum

No discussion about the PGH is complete without talking about the group process that birthed it. I believe the Portland group was the first of its kind, but there are now several around New England, and they are starting to pop up in other regions too. While online groups, books, webinars, and conferences all have their place, it's easy and fun to get together informally over drinks to talk about building science. For the group I started in central Maine, I chose the name "BS and Beer"—"BS" stands for building science, of course. Others are welcome to use it (but please don't try to copyright it). Get in touch at prettygoodhouse.org so we can add the group to the list. The website includes guideposts to help designers, builders, and current or aspiring homeowners understand and think through all the elements when creating their own PGH.

A final note: *The New Carbon Architecture* by Bruce King is a must-read for anyone who wants to learn about low-carbon building. In a GBA comment, King wrote, "Borrowing from Michael Pollan: Build, but not too big, and mostly with plants. Nuff said." ☐

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WHAT MAKES A HOUSE PRETTY GOOD?

Now is the worst time in human history to dump heavy carbon loads into the atmosphere, but that's exactly the result of many construction practices. Even builders who are concerned with energy efficiency often front-load enormous amounts of carbon-intensive materials with the expectation of savings over the building's life cycle. So, we must ask ourselves: If we have only a decade to mitigate the worst impacts of climate change, what should we do instead? Building Pretty Good Houses is one answer, and they should:

Be part of a **sustainable community.** Plan for access to community solar, jobs and services that minimize driving, and shared infrastructure such as roads, internet service, and the electrical grid. A one-hit wonder in the middle of the woods often comes with a bigger carbon footprint than a community-based home.

Include **photovoltaic panels** or be PV-ready. Panels pay their carbon debt in 2 to 4 years.

Have **good windows and doors.** Even the best of these components perform like an R-10 wall, which is pretty bad, so don't skimp here.

Use **air-source heat pumps for heating and cooling.** Minisplits can be efficient to -15°F or below, are affordable (especially for the sizes and number of units needed in a PGH), and are relatively simple to install. In some locations, other systems make more sense, but in most places it's hard to go wrong with a minisplit.

Invest in the envelope and other parts that are hard to change later. **Insulation and air-sealing** should be good enough that active heating and cooling systems can be minimal.

Be **a renovation rather than a new build.** The embodied carbon of an existing house has already been sequestered. When renovating, aim for at least the current International Residential Code performance for new homes.

Have balanced mechanical ventilation with heat recovery for **high indoor-air quality and low energy usage.** Be sure to commission the equipment after installation—it often needs to be adjusted.

Be built with **wood and plant-derived materials.** Ensure wood is sustainably harvested and locally sourced, if possible. Otherwise, healthy forests are better left to remove CO_2 through photosynthesis, sequestering it in the plants and soil. In general, the more that materials are processed, the higher their carbon footprint.

Be **as small as possible**—specifically 1000 sq. ft. for one person, 1500 sq. ft. for two, 1750 sq. ft. for three, and 1875 sq. ft. for four. (Some people find these numbers too low, others say they are too big, but they are Pretty Good targets.)

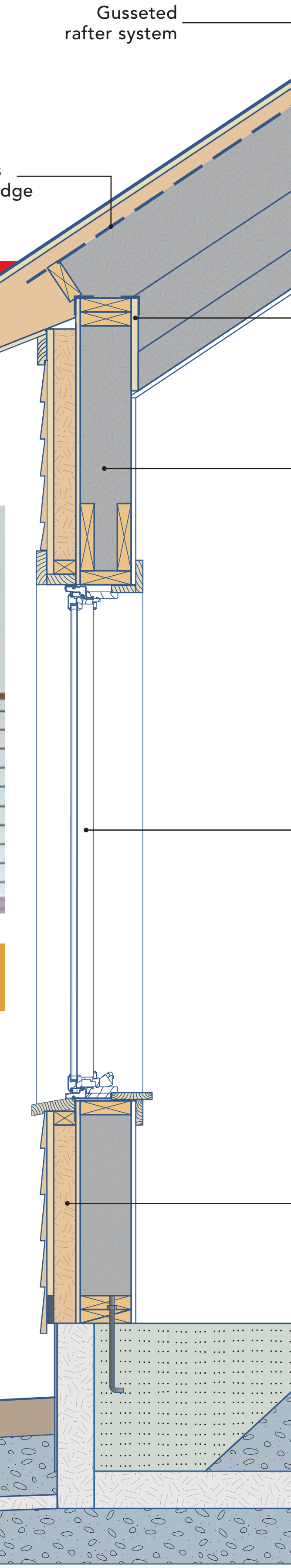
Be **simple and durable.** Simple shapes are easier to air-seal and insulate, they perform better in harsh weather, and they require fewer materials and less maintenance than more-complicated buildings.

Follow our version of the "KISS" principle: Keep It Simple and Safe. A house should be **easy to understand and operate.**

Be **cost-effective**—i.e., make improvements until they stop making financial sense.

PGH 2.0 WHAT MAKES A PRETTY GOOD HOUSE EVEN BETTER?

I've written previously about a few techniques I use when designing high-performance, low-carbon homes, such as building a concrete-free slab foundation (see "Minimizing concrete in a slab-on-grade home," *FHB* #282). In the pages that follow are two concept houses showing examples of how proponents of the original Pretty Good House movement can incorporate low-carbon strategies. While somewhat more complicated and more expensive than code-minimum assemblies, they provide much better comfort and energy savings. They also allow for smaller heating and cooling systems without much increase in embodied carbon or changes to conventional practices.



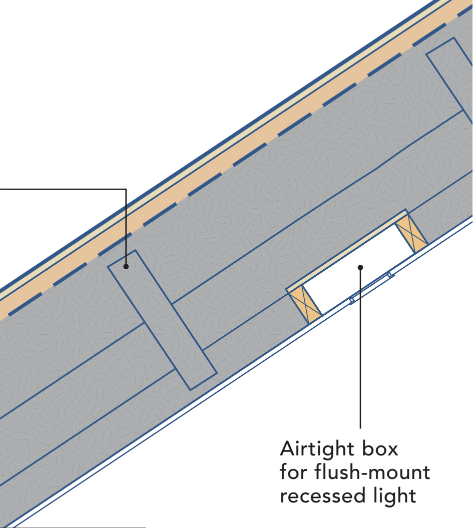
Foundation

Concrete has high embodied carbon, but a slab on grade with sealed concrete as the finished floor is usually the least expensive approach, and up to 50% of the carbon-polluting Portland cement can be replaced with pozzolan admixes. With most slab-on-grade homes that have insulation under the slab, the insulation is located directly below the concrete, but this makes it hard to do a good job with the insulation, and there should be insulation below the turned-down footing anyway. A simple approach is to grade and compact crushed stone, then form the perimeter with foam, add a layer of foam, and top with compactible fill. I spec borate-treated EPS insulation for use below grade; recycled XPS is another option. Don't use polyiso because it absorbs too much water, and don't use new XPS because the energy savings will never make up for the climate impact of its manufacturing process. For the form edges, consider WarmFörm by ByggHouse (photo above). Compact the fill in 6-in. lifts, cover with a heavy-duty vapor retarder, add reinforcing steel where necessary, use a concrete mix with microfibers to reduce fine cracking, and allow the mix to damp-cure slowly to improve the strength—most concrete needs to be kept damp for a week to reach 90% of its design strength. In cold climates, consider adding a frost wing even if it's not required by code—thick insulation under the footing can leave it susceptible to frost heave. The thermal mass of this floor system will help maintain even heat levels. (Don't bother with in-floor heating—in a well-insulated, air-sealed house, you won't get the warm-floor effect.)

Windows

Windows perform best when located near the center of the wall. Shown here are double-glazed, flanged fiberglass windows. In cold climates, triple glazing provides improved comfort and mold resistance—the added cost compared to energy savings depends on the choice of window.

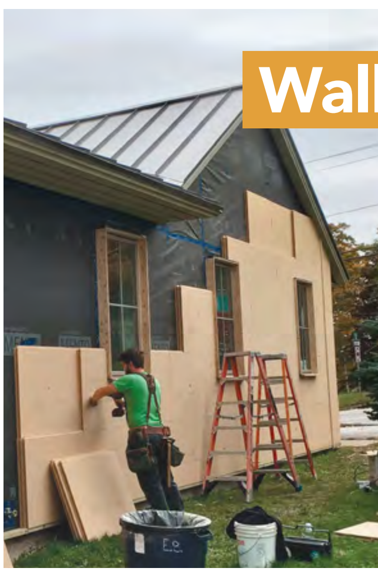
Photos, clockwise from left: courtesy of ByggHouse; Kat Alves; Brian McAward; John Deans, Emerald Builders. Drawing: Michael Maines and Melinda Sonido.



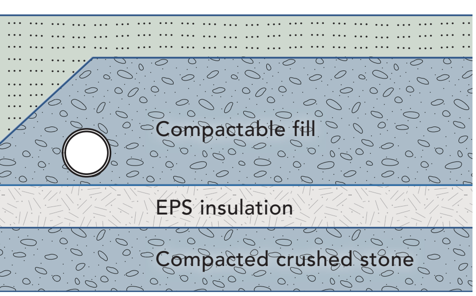
The roof framing is a gusseted rafter system, which is a good way to get decent levels of insulation and ventilation without having to use foam. To maintain ventilation space between the roof deck and the insulation, I spec 1½-in.-thick AccuVent from Brentwood Industries. It is made of 100% recycled PVC. (PVC, an environmentally damaging plastic, should generally be avoided unless the material has been fully recycled). If you can afford the cost of a bit more labor and materials, an even better approach is to make your own insulation baffles from ¼-in. plywood and softwood 1x2s (photo left). Conventional lightweight foam baffles won't stand up to dense-pack cellulose insulation, which is installed here at 16½ in. thick for a total of R-60. Dense-pack fiberglass or wood fiber are other insulation options. At the interior, painted drywall can control air and water-vapor movement, but for safer performance (in Maine's cold climate) I usually spec a variable-permeance membrane. In New England we always fur down ceilings with strapping, but with the gusseted rafter system it's not necessary. (Where there are lights or other penetrations in the ceiling, don't rely on airtight fixtures, which are never truly airtight—instead, make a simple box from 2x4s, plywood, and tape.) For airtightness, it's important to connect the air control layer at the wall—in this case, the sheathing—to the air control layer at the ceiling—in this case, drywall. A continuous plywood ledger provides nailing for the subrafters and code-required fire blocking; when taped to the top plate, it also acts as the air control layer.

Roof

Walls



Continuous exterior insulation essentially eliminates thermal bridging and keeps the sheathing warm and dry. Rigid foam is the typical choice, and recycled foam of any type can work; new foam comes with relatively high embodied carbon. Rigid wood-fiber insulation, such as Gutex (photo left) or Steico, is a great choice. Even after shipping from Europe, the carbon footprint is smaller than alternatives, and it's easy and safe to work with. Its price tag is on the high side, but GO Lab is gearing up to start producing wood-fiber insulation in Maine, with plans for an affordable price point. Siding is real wood over a ventilated rainscreen, which greatly extends the lifespan of the wood and any coatings. Framing is 2x6 with dense-pack cellulose in the bays. Cellulose has the lowest upfront carbon emissions of any commonly available insulation, and it has several performance and safety advantages. GO Lab also has plans to produce a wood-fiber product that will compete with cellulose. Another option is to fill the bays with fiberglass. Although many environmentally minded designers and builders prefer mineral wool to fiberglass, mineral wool has much higher upfront carbon emissions. Fiberglass installed tightly in a fully airtight cavity, with exterior insulation, performs as advertised. With acrylic tape sealing the joints, the sheathing doubles as the air control layer.



Suggested benchmarks

The original PGH had simple rules, borrowed from Dr. Joseph Lstiburek of Building Science Corporation. In a Green Building Advisor comment, reader Doug McEvers suggests using the advice of Harold Orr, a mechanical engineer and pioneer of high-performance building, whose research led to the creation of the Passive House standard. For superinsulated buildings, Orr advises dividing the location's heating degree days (HDDs) by 180 to get the R-value for a wall, and by 120 for a roof (this is close in line with Lstiburek's advice).

In a cold climate, such as International Energy Conservation Code (IECC) climate zones 5 and 6, use:

R-10 SUBSLAB insulation (expanded polystyrene, mineral wool, or recycled XPS)

R-20 FOUNDATION WALL, frost wall, or slab-perimeter insulation (or build on piers)

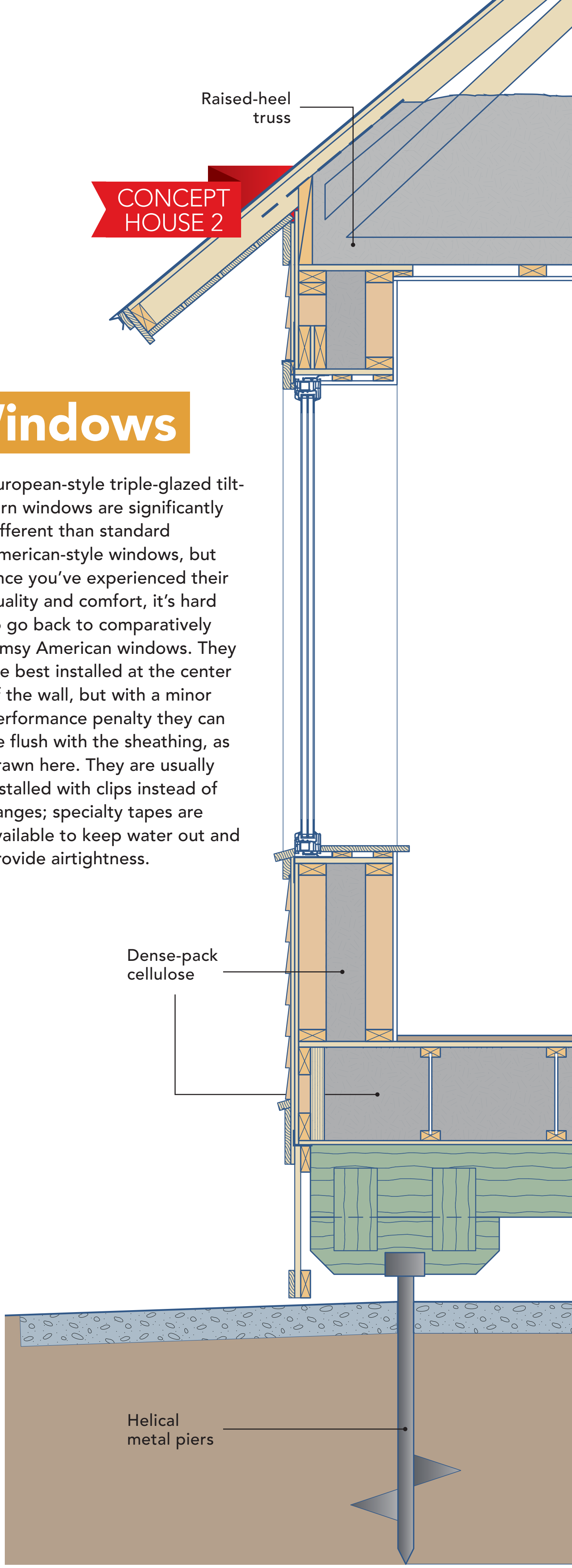
R-60 ROOF

R-40 WALLS

R-5 TO R-8 WINDOWS (U-0.20 to U-0.13). Even the best windows make lousy walls, so don't over-glaze.

1.0 ACH50
That's the maximum air-leakage target many of us are using. Others say 1.5 or 2.0 ACH50 is tight enough. (Tighter than 1.0 ACH50 may not add significantly to the home's performance.)

PGH 2.0 WHAT MAKES A PRETTY GOOD HOUSE EVEN BETTER? CONTINUED



Windows

European-style triple-glazed tilt-turn windows are significantly different than standard American-style windows, but once you've experienced their quality and comfort, it's hard to go back to comparatively flimsy American windows. They are best installed at the center of the wall, but with a minor performance penalty they can be flush with the sheathing, as drawn here. They are usually installed with clips instead of flanges; specialty tapes are available to keep water out and provide airtightness.

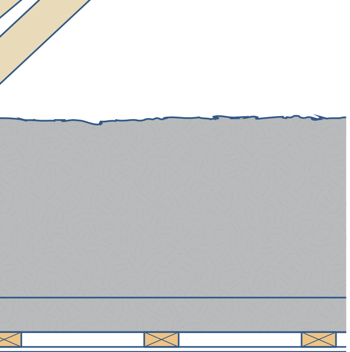
Performance-based approach

An integral part of the PGH is keeping things simple, and you can build a decent house, or even a PGH, without energy modeling. But modeling does have several advantages, and it's not that hard to do once you learn how. It allows you to optimize construction details, especially when it comes to fine-tuning window-performance values. BEopt from the U.S. Department of Energy is a good, simple, free software program. It has an optional feature to automatically determine the most cost-effective path to reaching net-zero operation. Also, you can use it to balance expenditures and gains and to help calculate return on investment. Ekotrope, Wrightsoft, and REM/Design are a few mentionable programs. Some BIM (building information modeling) programs also have energy plug-ins. Passive House practitioners use the PHPP or WUFI Passive energy-modeling programs, which are labor-intensive to use but appropriate for extremely low energy–use homes.

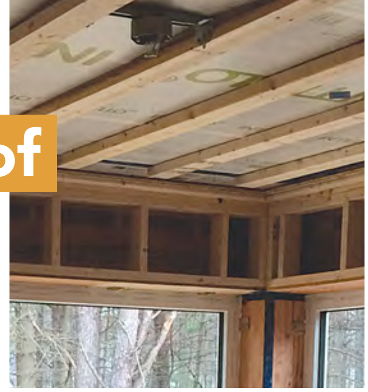
Air Conditioning Contractors of America Manual J calculations are regularly required by newer energy codes to attain heat-loss calculations—they can be done by hand or with a computer program. Supply houses that do them often end up grossly oversizing equipment, leading to inefficient operation.

Additional reasons for using energy modeling include the fact that you can compare the effect that different assemblies will have on a building's energy usage, fine-tune window specifications for the lowest energy use, and determine heating and cooling loads for the house.

Photos, clockwise from left: Matthew Millham, Michael Maines, Brian McAward, Andy Engel.
Drawing: Michael Maines and Melinda Sonido.



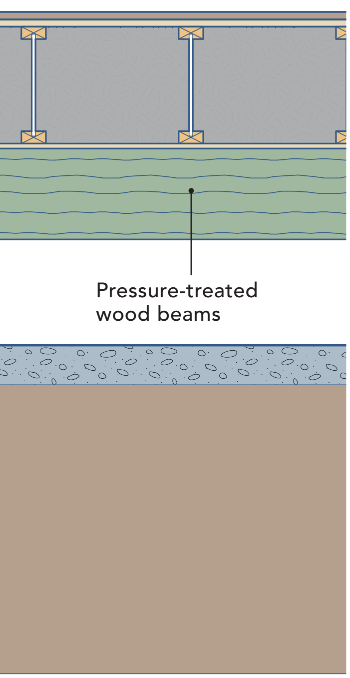
Roof



The least expensive, lowest-carbon way to build and insulate a roof is usually a raised-heel truss with loose-blown insulation. I typically spec R-60 cellulose at 16 in. deep. Raised heels can make walls look tall, so I reduce the insulation depth at the eaves to 10 in. to 12 in. The air control layer is at the ceiling, in the form of a variable-permeance membrane, but taped ½-in. sheathing works too. Inside of that, install furring to create spaces that can be used to install lights and run wires without puncturing the air control layer (photo above).

Walls

Builders have strong feelings about double-stud walls, but they have a long track record in New England, and the builders I work with tend to like them. In a cold climate, they need to have a ventilated rainscreen so they can dry easily to the exterior. In cold climates I am most comfortable when a variable-permeance membrane is used at the interior, though many builders just use painted drywall. With a 12-in. insulation cavity, the wall will perform at about R-40. The sheathing doubles as the air control layer.



Foundation

A pier-and-beam system using helical metal piers (photo right) has much lower upfront carbon emissions than a concrete foundation. Piers are located to carry pressure-treated wood beams to support the floor framing. When the top of the piers are more than a few inches above grade they need bracing, so instead I'm showing a bolster system (see drawing) to create the height needed to allow code-minimum 18-in. clearance from grade to the bottom of the floor system. The beams are inset enough to allow for ventilated skirting. The floor system can be dimensional or engineered lumber; I prefer I-joists because the narrow webs nearly eliminate thermal bridging, allowing for about R-40 for the whole floor system when insulated with dense-pack cellulose, wood fiber, or fiberglass. To keep out air and critters, ½-in. sheathing is installed below the joists and sealed to the beams. (If you're in an earthquake-prone zone, this system may not work for you, but it pairs well with a partial basement that can provide additional lateral support and a place for utilities.)

Products to minimize or avoid

✖ **Concrete**—specifically Portland cement, which contributes over 8% of all global warming emissions. Consider modern additives such as CarbonCure or more traditional pozzolan admixes. Helical metal piers, which are screwed into the soil to support structures, are gaining ground as an alternative foundation to concrete pours. Steel is also carbon-heavy, but emissions from this type of foundation are much lower than from a concrete foundation.

✖ **Foam**, particularly hydrofluorocarbon (HFC)-blown closed-cell spray foam and extruded polystyrene (XPS) rigid insulation. A PGH uses no foam above grade. If you do use it, try to find a source for recycled rigid foam, or use foam with relatively low global warming potential, such as EPS and polyisocyanurate instead of XPS, and spec hydrofluoroolefin (HFO)-blown spray foam rather than HFC-blown.

✖ **Combustion appliances**, especially those that burn fossil fuels. You can have a woodstove in a PGH, but make sure it is EPA-certified and properly installed; and use dry, sustainably harvested firewood.

✖ **Unhealthy materials.** Fortunately asbestos is no longer allowed in homes, but fiberglass fibers have a similar shape, which is not a problem for occupants if the batts are sealed inside a cavity, but can be an issue if air moves through the assembly. Formaldehyde is commonly used as an adhesive in sheet goods such as those in inexpensive cabinets—avoid it. Avoid, also, plasticizers in flexible vinyl products such as shower curtains; choose nylon curtains instead. Carpeting, even with natural fibers, collects detritus, which can affect air quality. In general, natural products are safer than manufactured products.