# Demonstrating

## A designer-turned-contractor showcases the systems and assemblies of a small, all-electric, healthful home

BY AMBER WESTERMAN

As soon as my contractor's license came in the mail, I broke ground on a superinsulated, all-electric, net-zero house—my personal first, and the first one in my village of Spring Green, Wis. (population 1641; climate zone 6).

I was confident in my plan, but nervous about my ability to vet and supervise the subcontractors I would need to execute it. I had spent the last 35 years behind a drafting board; my job-site experience was limited to quick dashes to meet with clients and check on progress. I had designed hundreds of custom homes, made valuable contacts with people in the renewable-energy and natural-building communities, and had expanded my knowledge of products, materials, and energy-smart construction details by reading articles in *Fine Homebuilding, The Journal of Light Construction,* and Green Building Advisor, and by attending the annual Midwest Renewable Energy Association Energy Fair. But I needed the right building team on board.

The house would be a demonstration home showing how to build with more sustainable, healthful materials; how to reduce waste; and how to maximize space in a modest footprint. It would be affordable and replicable. The informal open floor plan and modern sensibility, combined with rustic good looks and easy access to outdoor living, would appeal to retirees and young families alike.

### Transitioning to innovative building

Showing the house would help me walk the walk, not just continue to talk the talk, as I tried to steer my business away from conventional construction and outdated design solutions and toward everything I believed in (but that wasn't yet popular among most building professionals). If nothing else came of it, at least I'd have a cool place to live and work. I called my new side hustle Poem Homes.

The connection between home design and the impact it has on the environment was made clear to me on the first-ever Earth Day in 1970, when we learned at school that a brick placed in a toilet tank would save water. A few years later, I joined the back-to-the-land movement and got to see—and live in—some of the earliest experiments in earth-sheltered and passive solar designs. For someone whose furthest horizons had been peddling around the cul-de-sacs of suburbia, this was heady stuff.

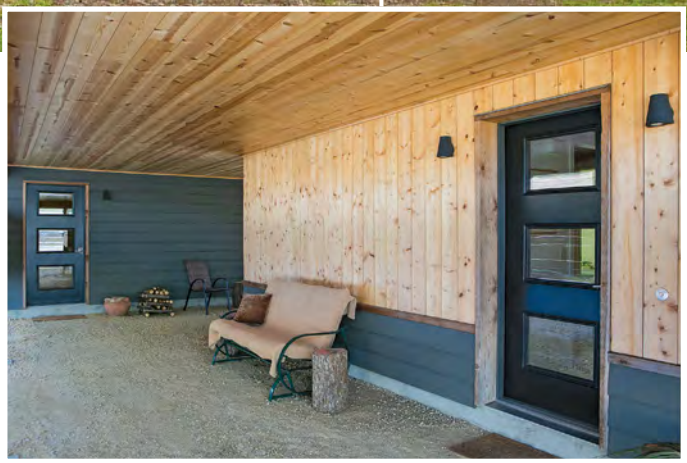
By the time I took my first drafting class, I could hit a 16d nail home in three strokes, cut a straight line with a circular saw, lay down a smooth coat of drywall compound, and in other ways make myself useful around a construction site. But with a growing family, an office job made more sense. After completing a two-year degree in architectural technology, I drafted for several architecture offices and then got my first real education by running estimates, placing orders, and working at my local lumberyard sketching out solutions to tricky problems for builders. After 10 years, I was ready to start my own design business, Amber Westerman Building Design, with a focus on custom homes and remodels for the delightful mix of farmers, artists, and transplants who make up my corner of southwest Wisconsin's Driftless Area.

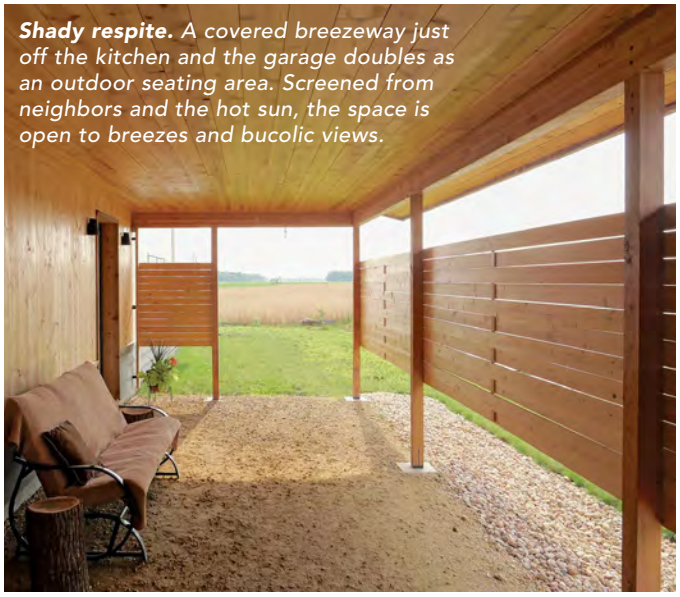
### Sharing the build

If I was going to go through all the trouble and expense of building a demonstration home, I wanted to get as much attention for it as I could during the process, not just when it was done. I wanted people to see the bones and guts and understand the whys and hows of the methods and materials I was using—not just the finish work. The average person has few opportunities to step onto a job site, and I

# High Performance

***Combination siding.*** *The siding was installed on DuPont's DrainWrap and comprises horizontally lapped James Hardie Artisan fiber-cement board with vertical white pine shiplap—both sourced for their biodegradable content.*





***Shady respite.*** *A covered breezeway just off the kitchen and the garage doubles as an outdoor seating area. Screened from neighbors and the hot sun, the space is open to breezes and bucolic views.*

guessed it would interest them—whether they were looking for a new home or not—and if they followed my progress in real time, they might stay more engaged and tell their friends about it.

My marketing strategy was simple and cheap: I crowed about it to everyone I met and held frequent open houses, which I announced on Facebook, in our local monthly, and by pinning up flyers at local businesses. My first open house was on a chilly day in December. The roof sheathing was not on yet. Twenty-five people showed up.

Ultimately, I held 16 open houses and had 520 visitors. In addition, I showed the house privately to dozens more, some of whom became my clients. People asked good questions and each one helped me refine my answers. What they said gave me clues about what caught their eye, what they had concerns about, how much general knowledge they had about construction, and what they were looking for in a new home. I talked about the systems and products I'd spec'd and shared the design thinking behind them. The details that follow were key among my talking points.

## Choosing and installing windows and doors

I chose Marvin Integrity All-Ultrex windows for their rotproof, maintenance-free finish and long-term durability. They are made from pultruded fiberglass and are less expensive than the more common aluminum-clad wood units. I ended up ordering the stock-glazing option after running alternatives through REM/Design energy-modeling software and calculating the payback in energy sav-

***Setting an example.*** *Holding open houses both during and after construction offered a way to share high-performance building information with curious homeowners and potential clients.*

ings. As it turns out, triple-pane windows—when amortized over 30 years—never pay for themselves. Likewise, for high-solar-gain glazing in the south-facing windows, the low-e1 glazing didn't admit enough heat energy over the course of 30 years to make up for the upcharge. The stock option in my region is dual-pane low-e2 glazing, which includes a second layer of low-emissivity metallic coating.

Window and door rough openings were bucked out with ⅝-in. plywood. The patio door is set in from the face of the exterior wall to land over the slab's edge foam for a continuous thermal barrier. The sill is set on a 5-in.-wide length of Conservation Technology's EPDM sill gasket. To accommodate the nailing flange, 2x bucks were added at the jamb and head.

The windows were set flush with the exterior sheathing. Gaps at the rough openings were sealed with a low-pressure polyurethane foam called HandiFoam, chosen for its Greenguard Gold certification for low chemical emissions. I used it with some reservations because I've heard that foam can crack and separate from its wood substrate over time. In any case, the gap is air-sealed by the vapor retarder on the inside and by the sheathing tape on the outside.

I did have condensation problems this past winter, which triple-pane windows may have prevented. The condensation only occurred during severe cold snaps, which we get a few times a winter. My assumption is that the slab and other building components are still drying out, and that this coming winter will be drier. I plan to set the thermostat higher and run the heat-recovery ventilators at top speed if the problem persists.

### The hot-water system

For hot water, I steered clear of on-demand units after hearing about how finicky they are in areas with high levels of lime in the water supply; plumbers around here routinely toss them out after a few years. I looked into heat-pump water heaters, but they are expensive and require a large mechanical room or basement, neither of which I have. What made sense was Rheem's 30-gal. Marathon electric-resistance water heater. The tank is lightweight, insulated with 2½ in. of foam to R-20, and will lose only 5°F in a 24-hour period. Maintenance should be virtually nil, and the unit comes with a lifetime warranty. For plumbing fixtures, I chose EPA WaterSense–labeled products

## A LOOK INSIDE THIS ENERGY-SMART ASSEMBLY

### SLAB ON GRADE

The slab rests within a tray of two layers of 2-in. XPS sheet foam (R-20) with staggered joints. Frost protection is a standard 8-in.-thick concrete wall with footings to frostline. A vapor barrier directly under the slab does double duty as an air barrier. It was run long and draped over the frostwall, where it was bedded into a bead of ChemLink's M-1 low-VOC sealant, and later folded up under the mudsills and taped to the wall sheathing for a continuous air barrier. The slab was power-troweled and a day later sawn into 10-ft. by 10-ft. sections to control cracking. It was left to cure for six months, and in the spring when the surface temperature was up to 60°F, it was cleaned and etched with muriatic acid, then coated with an eco-friendly clear sealer. Below the slab is a 6-in.-thick layer of clear stone (no fines) that can be vented to the exterior through a 4-in. PVC pipe should radon be detected in the future.

### DOUBLE-STUD WALL

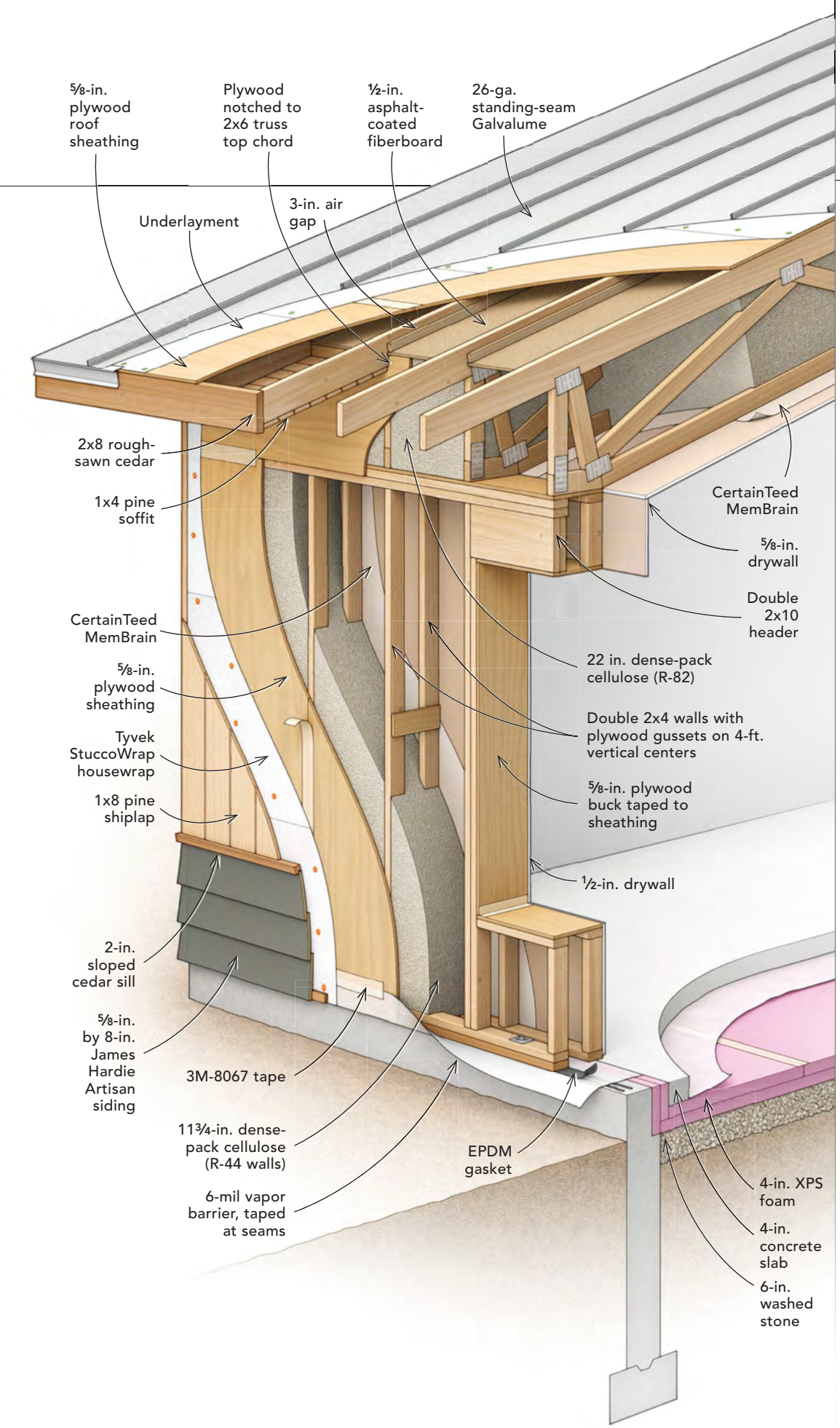
The walls are 11¾ in. thick with an outer 2x4 bearing wall on 24-in. centers married to an inner 2x4 wall by way of plywood gussets at 48-in. vertical centers. The vapor retarder was hung long and the drywall stopped short by 6 in. at the bottom of each window and at the top of each wall section, which provided enough room for the cellulose blower hose to fit into. The vapor retarder was sealed to the framing and at mechanical penetrations with ChemLink's DuraSil, a nontoxic, low-odor silicone adhesive. CertainTeed's MemBrain smart vapor retarder is the interior air barrier. Exterior wall sheathing was upgraded to ⅝-in. plywood, and seams were taped with 3M-8067. The plywood is the exterior air barrier.

### TRUSS ROOF

Parallel chord trusses on 24-in. centers—with a 24-in. energy heel—span the width of the house. A site-built vent chute is open to the eave and rake soffits, which are vented by way of gapped 1x4 boards. MemBrain serves as the interior air barrier and vapor retarder. The fiberboard above and the vapor retarder/drywall below create a 22-in.-deep sealed cavity for dense-pack cellulose (R-82). The roof sheathing was upgraded to ⅝-in. plywood and the nailing pattern was increased from code minimum to 4-in. centers at ends and edges and 6-in. centers in the field for increased wind resistance. (This was done to the wall sheathing too.) Standing-seam galvanized steel roofing pairs well with solar panels—the rack system simply clips onto the standing seams.



Drawing: Christopher MIlls.
Photos: this page, Eric Wallner, courtesy of the author; facing page, courtesy of the author.




## TESTING FOR AIRTIGHTNESS

Blower-door testing was done at the completion of each of three milestones. The goal was 1 ACH50.

**TEST 1**
**2.23**
**ACH50**

The first test was performed after the roof and the windows were installed. The ceiling fiberboard was also in place and caulked to the truss framing.

**TEST 2**
**0.87**
**ACH50**

The second test happened after the ceiling was insulated and drywalled, and the mechanicals were in and air-sealed to the exterior sheathing—but before the walls were insulated and drywalled. Two leaks were identified—one at the perimeter of the fixed-panel sliding glass door and the other at the air-source heat pump, where the line set connecting the outdoor condenser to the indoor-air handler hadn't been air-sealed.

**TEST 3**
**0.38**
**ACH50**

The third test was the final measurement, taken once the entire envelope was insulated and air-sealed to determine how well the HRVs and bath fans were working.

# LOFTY LIVING

The single-story, 1208-sq.-ft. house is long and narrow. The ceiling vaults across the entire length, rising from 8 ft. on the south wall to 13½ ft. on the north wall. Two bedrooms flank the main room, making for a private arrangement. To economize on space, there are no hallways, no formal entry, and no mudroom. A two-car garage attaches to the house by way of an open porch (so fumes don't come inside).

to save on both hot and cold water. The toilet uses just 1.28 gal. per flush.

## HVAC details

Heating and air-conditioning are supplied by a Mitsubishi ductless air-source heat pump. The outside compressor is mounted on brackets on the north wall and the inside air handler is directly above it on the loft wall—this configuration made the line set as short and unobtrusive as possible.

I chose a single-source ductless system for economy and simplicity, knowing that there would be a temperature difference between the main room (where the air handler is located) and the bedrooms at each end of the house. Over the winter, the difference was about 4°F to 7°F, with the bedrooms being cooler, which is acceptable to me. In the summer, I experienced the same differential, only this time the bedrooms were warmer. Like the bedrooms, the loft was off by about 4°F to 7°F—acceptable because it's not often used.

The thick wall-and-ceiling insulation and the thermal mass of the concrete slab keep the house cool in the summer. I only need to run the air-conditioning for a few weeks during the hottest spells. Thinking long-term, I had the electrician install wiring in the bedrooms for electric baseboard heaters should supplemental heat be needed by a future owner; currently, when outside temperatures get below about 10°F, there is frost and ice buildup on the windows. My solution has been to run a floor fan situated in the loft under the minisplit; this eliminates the condensation problem and, as a bonus, evens out the temperature between rooms. I can also run the heat-recovery ventilator (HRV) on high to help eliminate condensation problems, though I find the fan is more effective. Going forward, I'd recommend ceiling fans, which are significantly quieter than floor fans, to help distribute heat. The main advantage of a single-source heating system is initial cost, which is quite low compared to a ducted system.

Fresh air is supplied by two pairs of Lunos e2 HRVs—one in each bedroom and two in the main room. Again, the choice of a ductless system was for economy and simplicity. The Lunos system was the only one I found that could be turned on 24/7 without overventilating a small house. I can choose from three settings: 10, 15, or 20 cubic feet per minute (cfm). This matches favorably with industry standards for a two-bedroom home, which range from 33 cfm to 54 cfm. When set at 20 cfm, the two HRV pairs deliver just under 40 cfm. Because the units are ductless and inherently balanced, they lend themselves to DIY installation, which I did with my electrician. The units were easy to install, are visually unobtrusive, and have the best heat-recovery efficiency and noise ratings I could find.

To meet the high cfm ratings required by code for year-round bathroom ventilation, I also installed 80 cfm ultraquiet Panasonic fans above each shower. They are set on a humidistat for automatic operation.

## Healthful finishes

Wherever possible, I chose nontoxic materials and finish products made in America. (This really perked up the ears of some visitors.) None of these products were off the shelf at my local stores—I ordered everything online.



Floor-plan drawing: 07sketches/Bhupeshkumar M. Malviya

The slab is sealed with ECOS Paints Concrete Sealer, a zero-VOC, no-odor, water-based acrylic with a soft sheen. It doesn't look thick or plasticky, and it receives many compliments. It has held up well and is easy to clean. The interior wall, trim, and cabinet paint is also from ECOS Paints. It's nontoxic, biodegradable, low-odor, zero-VOC, and certified Red List Free (that is, free of "worst in class" chemicals prevalent in the building industry). It was easy to use and has proven quite durable.

The kitchen cabinets are from Barker Cabinets—the only company I could find that uses NAUF (no added urea formaldehyde) PureBond plywood produced by Columbia Forest Products. The inset panels on the doors are made from medium-density fiberboard (MDF) that is CARB Phase 2 compliant for reduced formaldehyde emissions. The door frames and drawer fronts are solid wood. The components are prefinished with a low-VOC varnish.

The countertop was custom-made, ordered through my local lumberyard. The supplier was able to meet my specification of GreenGuard Gold–certified Formica and ultralow-emitting formaldehyde particleboard from SkyBlend. The interior doors from Koch Doors have engineered wood cores that are CARB Phase 2 compliant, and the finish is low VOC. The living room rug is natural wool with no backing.

Sharing these details with open-house visitors confirmed for me that my choices were sound. It also felt good to impart, in person, this type of information to people searching for it.

***Dual functions.*** *The loft and vaulted ceiling work together to create a generous yet cozy space. The loft spans the north wall, hiding a mechanical chase, and connects to attic-like rooms above each bathroom that can be used for storage.*

## Assembling the right building team

As I anticipated, putting together the right team took work. I lined up contractors I had confidence in and reached out for recommendations to fill in the gaps. I enlisted a neighbor who runs a remodeling business to be on call should I need a "wingman" (I did). A few subs were willing to give a flat price, but I paid most of them by the hour. We made a great crew but for one: the framing crew I hired cut a lot of corners. I fired them when the roof underlayment they installed leaked like a sieve. Friends with skills stepped in to help, and I patched and pieced in carpenters and got the work done.

A few notes on paying subs by the hour: By-the-hour work is common here for "single-truck" workers, including those in the mechanical trades. I would do it this way again if I were doing it as an owner-builder and were able to be on the job site most of the time to monitor the work. If I were working for a client, I would need to have firm bids from each sub, or an estimate based on an hourly rate with a not-to-exceed number. I tell my clients that experienced general contractors are invaluable because they get competitive bids, keep their subs to a timeline, and are on the lookout for poor-quality work or materials.

I was lucky to be my own boss and to be on the job site almost every day. I didn't have any deadlines, and I enjoyed all aspects of staging the work: ordering, pickups and deliveries, stacking and sorting materials, and deciding what to do with the waste. (For example, drywall cutoffs were tossed along a row of trees and covered with rotten straw; gypsum can improve soil structure.) I kept a daily log, took lots of pictures, and kept up with the bills and my construction blog at poemhomes.org.

## Looking back

In the end, my total cash outlay was $332,000, or $275 per sq. ft. (1208-sq.-ft. house + 400-sq.-ft. breezeway + 440-sq.-ft. two-car garage). I'm proud of the design and the quality of work. My path forward as a general contractor isn't certain, but my plan to build a demonstration house and attract environmentally aware clients to my design business is working. More people are getting the idea that a thoughtfully designed small home built with natural materials and in tune with the rhythms of the day makes for a quiet, comfortable, and serene life. That's what a Poem Home is all about. □

Amber Westerman is founder of Poem Homes in Spring Green, Wis. Photos by Beth Skogen, except where noted.