Situated for sunlight. *The south wall has the most windows, which enables it to take advantage of free heat during Minnesota's long, cold winters. The roof overhangs were designed to shade the windows during the summer, when the sun is higher in the sky.*

A Rural Electric

A tight building envelope and plenty of insulation mean low energy

House That Works

bills, even for a Minnesota home with electric heat

BY MARTIN HOLLADAY

When I heard that Rachel Wagner, a Minnesota designer known for her efficient homes, had designed a cold-climate house with electric-resistance heat, I was intrigued. After all, homes with electric heat are usually known for their high fuel bills. When I investigated further, I discovered that the house not only is an energy miser but is also very handsome.

Although electric heating systems have a bad reputation, some designers are rethinking their prejudice. A tight, well-insulated house typically has low utility bills even when using an expensive heat source like electricity. Moreover, all-electric homes don't need a chimney or fuel storage, and they don't suffer from fuel fumes or backdrafting. Finally, electric-resistance heaters have few maintenance issues.

Integrated design works well

Wagner's firm designed the all-electric house for Gail Olson and Erik Peterson in Esko, Minn. Olson is the fourth generation of her family to live on the 65-acre farm where the new home was built.

Using an integrated design approach, Wagner pulled together a team that included the homeowners, builder Steve Johnson, and energy consultant Michael LeBeau. The design process emphasized open communication among all the members of the team. The two-story, three-bedroom house that they designed follows classic passive-solar design principles. To keep the space-heat needs as low as possible, Wagner used double-stud walls (R-54), thick attic insulation (R-80), and triple-glazed windows.

At 0.50, the window glazing on the south side of the house has a higher solar heat-gain coefficient (SHGC) than the window glazing on the other three sides of the house, which is 0.31. This approach, called orientation-specific glazing, maximizes solar-heat gain in winter while minimizing it in summer.

It's easy to frame double-stud walls

According to Johnson, the double-stud wall framing—a method that uses two parallel rows of 2x4 studs to frame thick walls—was straightforward. "The window rough openings were lined with boxes made from

Good architects are good listeners

I'm proud of how well the integrated design process went, from the site assessment, to interviewing the clients and understanding their needs, wants, and goals, to incorporating the expertise of the consultants and the contractor, and finally to weaving it all together. The process yielded a result that is pleasing, functional, and really durable.

For the heating system, we weighed the pluses and minuses of all kinds of equipment. The electric boiler was not my first choice, but I've learned from building-performance consultant Mike LeBeau that a hydronic distribution system offers a lot of flexibility in the future. If the homeowners ever want to switch to propane or add a solar-thermal system, they can. Those options wouldn't be available if we had gone with electric-baseboard units or a forced-air system.

The electric boiler has another benefit for low-energy homes that is hard to find in a propane-fired or natural-gas-fired unit: the ability to modulate down to a very low rate. With passive-solar gain, there are times when only the bathroom and northeast bedroom need heat, and the load to distribute heat to just two rooms might be less than 5000 Btu/hour. This is readily achieved with an electric boiler, but it can result in short cycling of a gas-fired boiler. Overall, in the interest of on-site fuel, initial first costs, and matching the plant size and distribution ability to the loads, the electric boiler made sense. If these homeowners later add a photovoltaic system, all the better.

I was happy to agree to the request for a woodstove. I've put woodstoves in more than half a dozen houses testing at less than 1 ACH50. In the houses that also have a range hood, we caution the homeowners to pay attention before turning on the fan. They may need to crack open a window when the woodstove is used at the same time as a range hood or clothes dryer. We've provided dedicated combustion-air routes in a couple of the houses, but not all. It's more about providing makeup air for the exhaust appliances than providing combustion air for the woodstove.

LESSONS LEARNED

The January electric bill (one of our sunniest winter months) is higher than I expected. Part of me is wondering whether the house should be getting more solar gain. I adhered to the usual formula, making the south glazing equal to 8% to 9% of the floor area, but the house has an unusual layout, with the living room in the northwest corner. Because of that, I think I could have pushed a little harder on the south-facing glazing in the southern spaces across from the living room and increased the total first-floor ratio to maybe 10% or 11% of the floor area.

—Rachel Wagner

½-in. OSB," Johnson says. "The top plates were tied together by one layer of ¾-in. plywood."

Johnson is a fan of double-stud walls. "This was the first double-wall house that I had built," he says. "I think one of the things that impressed me was how simple it was. What we need is better building and less technology. It was really just a matter of building another wall inside the outside one."

The walls were insulated with dense-pack cellulose. "The insulation contractor had insulated double-stud walls before and is very good at it," says Johnson. "The fire code requires that double-stud walls be divided into compartments with drywall or plywood every 10 ft. of linear wall, so we sectioned off the walls, and that helped the insulation crew." Like many builders in Minnesota and Canada, Johnson uses interior plastic as a vapor retarder. "We used Tu-Tuf, which is a high-quality poly, as the air barrier and the vapor retarder," he says. "Adhesives and tapes stick really well to the Tu-Tuf. All the poly seams are lapped at a stud and taped with 3M tape. We used Tremco acoustical sealant between the bottom plate and the subfloor."

Insulating the rim joists with cellulose

The integrated design process allowed Johnson to provide input on air-sealing details. "The rim-joist area was tricky, especially because we used floor trusses," he says. "This was an example of why it was nice to work with Rachel. She brought me in early in the design process, and I made some suggestions. We wanted to end up with a con-

Photo left, this page: courtesy of Rachel Wagner. Drawing facing page: John Hartman.

Kitchens are for morning sun. *From the southeast corner, the sun peeks in as soon as it rises. French doors allow light to enter from two directions, and the deep windowsills, a result of the extrathick walls, are a natural plant shelf.*

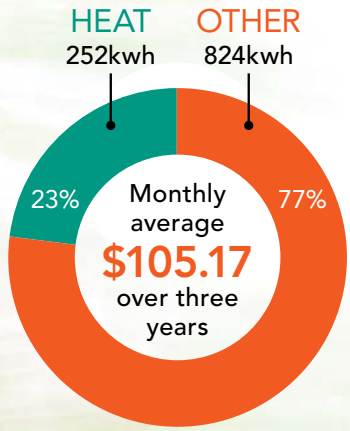
The electric bill is a little over $100 per month

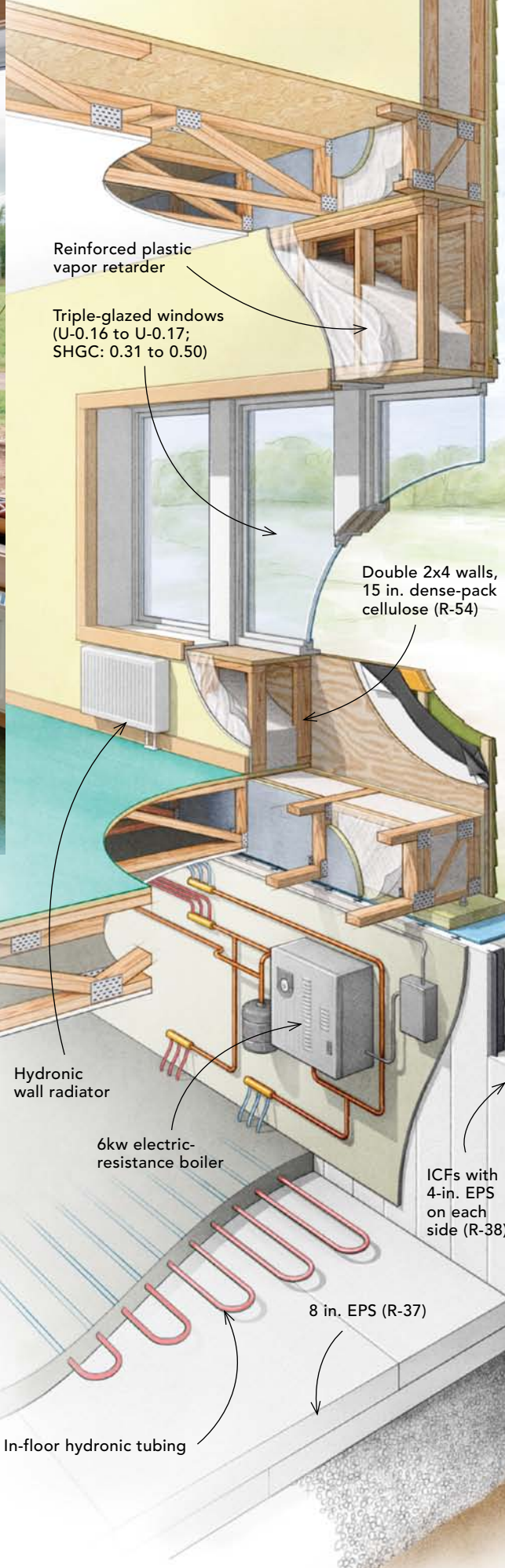
Over the first three years, Olson and Peterson spent $1260 a year on electricity. This figure does not include the 1½ cords of firewood they burned each year. Attention to detail at the connections meant that a tight envelope was easier to achieve.

ENERGY SPECS

Design heating load
15,000 Btu/hour

Air leakage
0.4 ACH50

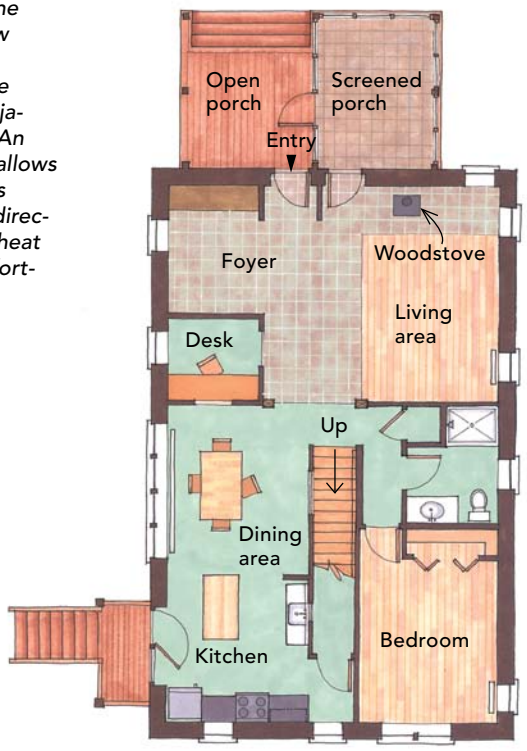




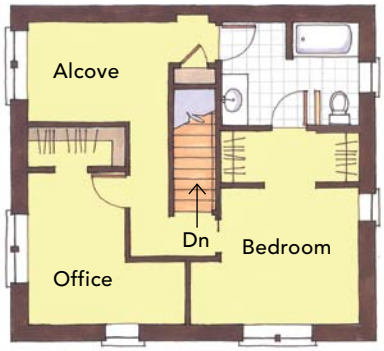
WINDOW PLACEMENT DICTATES ROOM LAYOUT

Houses that take advantage of southern exposure often have many windows on the south wall and few on the north wall. More windows on the south mean more light, so it makes sense to put public spaces where they can take advantage of this sunlight. In winter, when the sun is low in the sky, sunlight pours through the south windows into the public spaces: the kitchen, the dining room, and the downstairs office. An open plan allows sunlight to penetrate deep into the house. Bathrooms are on the north side of the house where windows are few, and bedrooms are in corners where light can enter from two directions.

A semiprivate desk area doesn't interrupt the flow. *The generous window brings in enough light to penetrate deep into the adjacent living area. An interior window allows light to enter this office from two directions and keeps heat at an even, comfortable level.*



First floor



Second floor

SPECS

Bedrooms: 2

Bathrooms: 2

Size: 1950 sq. ft. plus 1200-sq.-ft. basement

Cost: $395,000

Completed: 2009

Location: Esko, Minn.

Designer: Rachel Wagner, Wagner Zaun Architecture

Energy consultant: Michael LeBeau, Conservation Technologies

Builder: Steve Johnson, Two Harbors, Minn.

tinuous air barrier and good R-value at the rim joists. We wanted the rim joists to have the same R-value as the walls."

Wagner and Johnson designed a system on paper, then asked the truss company for extra backing in the floor trusses under the inner plane of the double-stud assembly. "That gave the insulators somewhere to fasten the fabric," explains Johnson. "After the cellulose insulation was installed, we added a layer of rigid foam as blocking. We caulked the rigid foam on all four sides, which was possible only because the backing was there."

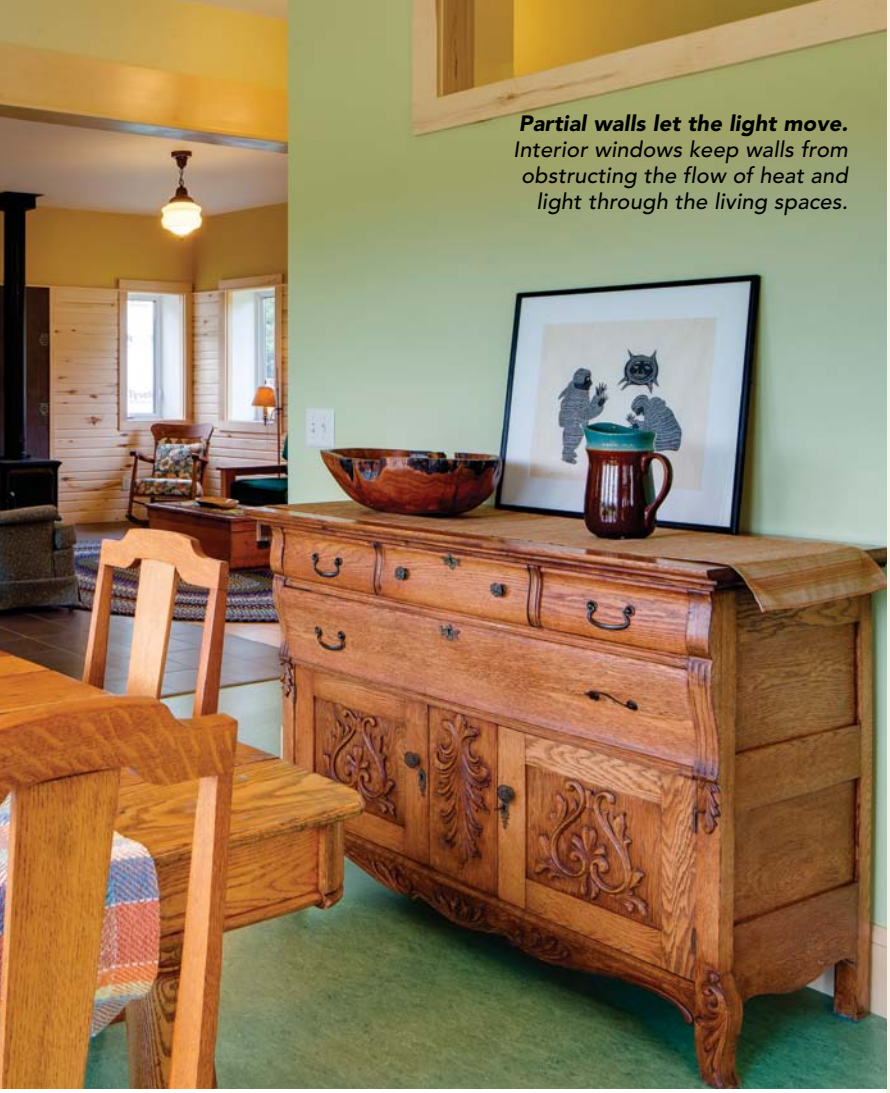
In a climate like Minnesota's, it's impossible to build a low-energy house without paying close attention to airtightness. The excellent blower-door test results for this house—0.4 ACH50—pleased everyone on the team.

Heating options are limited in rural America

Natural gas is unavailable at the site, and the homeowners and the design team spent some time considering a variety of heating systems. "My sense is that air-source heat pumps aren't efficient in our climate," Olson says. "Some people are installing ground-source heat pumps, but we felt that the payout was not worth the investment for us. Oil isn't a very common option in this area, and I didn't want to have a propane tank in addition to electrical service."

They eventually decided to use electric-resistance heat. Instead of installing electric baseboards, however, they chose an electric boiler; this leaves open the possibility of installing a propane boiler in the

Floor-plan drawings: Martha Garstang Hill. Bottom photo, facing page: courtesy of Erik Peterson.



Partial walls let the light move. *Interior windows keep walls from obstructing the flow of heat and light through the living spaces.*

future if electricity rates rise faster than propane prices. While some energy experts warn against a woodstove in a tight house, Wagner didn't hesitate when asked to recommend one here.

Olson and Peterson chose a Hearthstone Tribute woodstove, and they use it frequently during the winter. "We usually have a fire for two or three hours in the morning if it's 10°F and sunny, say, or 20°F and cloudy," says Olson. "We build another fire in the evening for two or three hours. We burn mainly aspen from the farm along with some birch. If temperatures are below zero and cloudy, I usually keep a fire burning all day. I do need to crack a window in the basement if I am using our electric dryer and have a fire burning in the stove; otherwise, we get a backdraft from the stove. It's convenient for me to do this because there is a basement window close to our dryer."

Solid comfort with no drafts

According to Johnson, the project was a big success. "The homeowners deserve a lot of credit," he says. "They set out to build a really good energy-efficient home. They wanted to see how far they could take this. They went to a local design conference in Duluth, where they met Rachel, which was a good move. The design is not boring, but it has no bump-outs or cantilevers or beams that penetrate the envelope. The design was conducive to achieving these goals." □

Martin Holladay is a senior editor. Photos by Mark Teskey, except where noted.

A woodstove in a tight house? *Wagner has put woodstoves in many ultratight houses with no drafting problems. When using their clothes dryer, though, the homeowners have to crack open a window.*

Good clients do homework

Gail Olson and Erik Peterson wanted the members of their design and construction team to be familiar with energy-efficient building methods. "We feel incredibly lucky to have met an architect and builder who are so committed to building low-energy houses in this challenging climate," says Olson.

Peterson adds, "Rachel created innovative design and energy solutions, Steve focused on the beauty and efficiency of every building detail, and we reclaimed many elements—the cabinetry, light fixtures, and harvested wood—from the farm. I love that we can wear our boots into the house, process 50 lb. of tomatoes in the kitchen, and raise chicks in our mudroom."

Olson, too, is happy. "I like the even heat," she says. "The naturally proportioned rooms connect to the outdoors and feel both spacious and intimate. The passive-solar design is fabulous. The house heats up well in the winter and is shaded in the summertime. I love the deep windowsills—I like the feeling of solidity that comes from these 15-in.-thick walls. I feel good in the house. I grew up in a settler's log cabin, and I've always lived in drafty houses. The soft passive-solar and wood heat feel comforting on a cold winter day. As the fourth-generation owners of the farm, we think we are leaving a good legacy."

LESSONS LEARNED

"We could have made the house smaller, but that only reflects the benefit of good design."