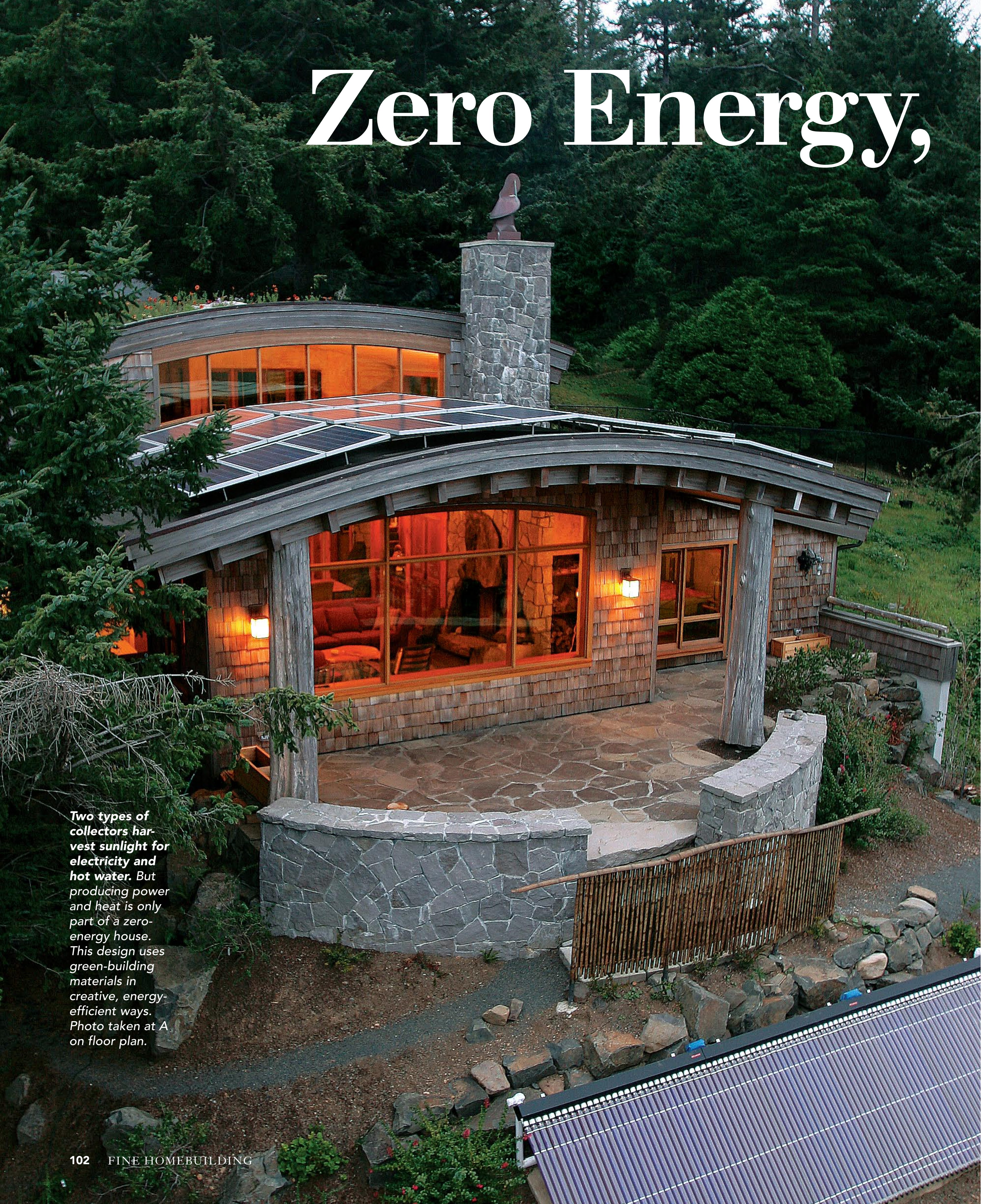
Zero Energy,



Two types of collectors harvest sunlight for electricity and hot water. *But producing power and heat is only part of a zero-energy house. This design uses green-building materials in creative, energy-efficient ways. Photo taken at A on floor plan.*

Infinite Appeal

Winner of a national green-building award, this low-maintenance house should produce as much energy as it uses. And it's built to last for generations.

BY NATHAN GOOD

Green building has gone from niche to mainstream over the past 10 years. The grass-roots efforts of architects, builders, and consumers have moved these buzzwords from articles in alternative publications to the front page of *The Wall Street Journal*. With the many local, regional, and national standards out there, though, there's plenty of variety in what defines green building.

Adding bike racks to a commercial building is a green-building component that promotes behavioral changes. Other strategies, like cutting electric-light use by designing spaces with more windows, are basic and obvious design decisions. Even with all the guidelines out there, green building still relies heavily on personal choices and goals. At its core, green building means being resourceful rather than wasteful.

An integrated design team

This house is built in Cannon Beach, Ore., on the site of a cabin that burned down. My clients asked me to design "a small home that would be healthy to live in with a dramatically reduced impact on the environment." They also wanted their new home to express their love of materials and forms found in nature. We discussed the challenges and opportunities, and decided that the costs associated with achieving a green-building certification would be offset by the long-term benefits.

Because we'd be using some unfamiliar materials (Durisol block), some new construction details (a vegetative roof), and a new design philosophy (green, net zero),

SPECS

Bedrooms: 3

Bathrooms: 2½

Size: 2268 sq. ft.

Cost: N/A

Completed: 2005

Location: Cannon Beach, Ore.

Architect: Nathan Good

Builder: Rich Elstrom Construction

Energy consultant: Charlie Stephens, Oregon Department of Energy

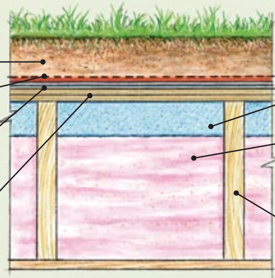
OPEN PLAN WITH LOTS OF LIGHT

A strong east/west alignment is an important element for capturing natural light. A centuries-old Sitka spruce forced some deviation from that ideal, however. The front of the house was brought forward to gain more midday and late-afternoon sunlight. An open plan with few interior walls and a band of clerestory windows allow sunlight to penetrate deeply into the far north end of the house.

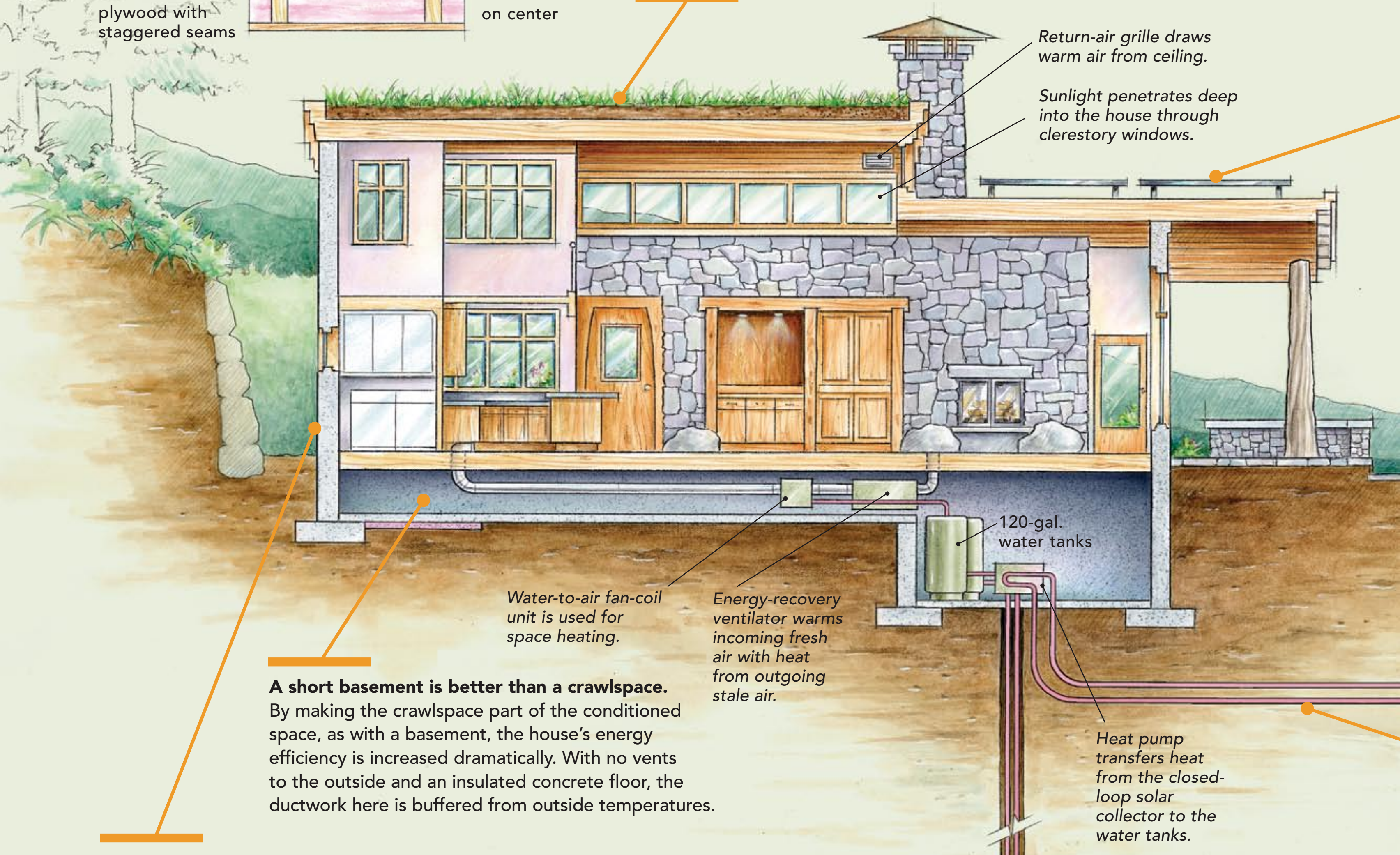
Drawings: Don Mannes

Cool roof, hot rocks, clean air, and free energy:

Here's how it works To achieve net-zero energy consumption, you have to do more than throw some solar panels on the roof. Everything has to work together as a finely tuned system. This home incorporates a number of basic technologies in innovative ways to produce heat, hot water, and electricity.



Vegetative roof keeps the house cool. It's also fire resistant, offers a nice view for the uphill neighbors, and cuts storm-water runoff. But when a roof collects rather than sheds water, it needs to be extremely tight (section drawing, left). Typical plants include perennials such as sedum, wild strawberry, and pennisetum. For more information, see www.greeninggotham.org.
Cost: $9.25 per sq. ft. (soil, drain mat, roof membrane)

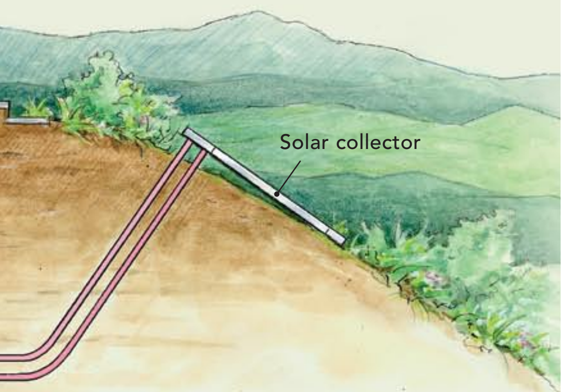


A short basement is better than a crawlspace. By making the crawlspace part of the conditioned space, as with a basement, the house's energy efficiency is increased dramatically. With no vents to the outside and an insulated concrete floor, the ductwork here is buffered from outside temperatures.

Insulating concrete forms (ICFs) are green and durable. Made with recycled wood chips and portland cement, Durisol blocks integrate rock-wool insulation into the cores, which are filled with concrete. These R-25 walls are fire-, rot-, and termiteproof. The cost is comparable to building walls with Forest Stewardship Council (FSC) certified lumber. **Cost: $13.30 per 8-in. by 12-in. by 24-in. block**

Bottom photo: Nathan Good

Electricity is on the house. Literally. The 5.9kw photovoltaic power plant is connected to the public utility's grid. The electric meter spins backward on many days. **Cost: $29,000**



A heat pump like you've never seen before. The sun heats water for household use and space heating. Energy-recovery ventilators transfer heat from the water to a forced-air system. When the two 120-gal. water tanks in the basement are full and fully heated (165°F), hot water is pumped into 380-ft.-deep cores in the basalt bedrock to store the heat until winter. During cooler months, the heat is recovered for domestic water and space heating. **Cost: $11,000**

Photo bottom right: Nathan Good

we formed an integrated team early in the design process. The owners, architect, landscape architect, interior designer, Oregon Department of Energy (ODE) representative, and contractor all collaborated, with few boundaries between disciplines. This interaction is crucial when building a house with nontraditional materials and construction details. Our builder, Rich Elstrom, gave excellent feedback on design alternatives, costs, life-cycle assessments, ease of construction, and the nuances of durable building in a coastal environment.

Before breaking ground, the design team hosted a daylong training session on green-building philosophy and techniques for local building officials, subcontractors, and other interested individuals. The local building official, Tim Lindsey, was key in the design's development. Tim, Rich, and I met frequently over the course of this project, and Tim's support was paramount to its overall success.

Our integrated design team held a number of meetings, occasionally joined by experts in energy, solar technology, and indoor-air quality. As we progressed from design to construction, Rich and project superintendent Mark Ward continued this collaborative approach, encouraging individual craftspeople to enhance the project with their expertise and creativity. In dozens of instances, we celebrated the creative contributions of the contractors and the craftspeople.

Why is this house green?

When we were designing this house, the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) program for houses still was being developed. Instead, we used the regional Earth Advantage green-building certification program to provide the performance guidelines that we deemed essential (www.earthadvantage.com).

We used FSC (Forest Stewardship Council; www.fscus.org) certified lumber from The Collins Companies (www.collinswood.com) for the concrete formwork, interior-wall framing and roof structure, cabinetry, and incense-cedar columns. Windfallen trees were used for the interior heavy-timber framing, flooring, and stairway to the second floor (photo below). Some of the interior doors and trim were milled from Douglas-fir logs collected from the nearby Columbia River. Other doors were salvaged, along with hardware, appliances, and bath fixtures.

The house is one of the first in the Pacific Northwest to use Durisol insulating concrete forms (ICFs) for exterior walls (www.durisolbuild.com). Durisol blocks are made with recycled wood chips, portland cement, and rock-wool insulation. The hollow cores are filled with concrete to strengthen the wall. To reduce the environmental impact of concrete, we used a high fly-ash mixture (25% in the foundations and 35% in the ICF concrete cores). Fly ash is a waste byproduct from coal-fired power plants and is an effective replacement for portland cement, which requires substantial energy to produce.

We selected interior-finish materials, paints, stains, and sealants that would not

***Functional form.** Douglas-fir stair treads wind around a windfallen incense-cedar trunk. The treads are supported on metal rods sunk into a beech limb that was salvaged from a nearby building project. The large rock was left over from the stone fireplace. Photo taken at B on floor plan.*

Big beams and fine cabinetry. *Windfallen trees yielded the lumber for timber-frame construction. The cherry wood used in the island, the cabinets, and the hutch is from FSC-certified sustainable forests. Photo taken at C on floor plan.*

"We celebrated the creative contributions of

off-gas volatile organic compounds (VOCs) and urea-formaldehyde. The only PVC in the house is the underground conduit and the sheathing of the electrical wiring.

The path to net zero

Most net-zero definitions describe houses that produce as much electricity as they consume, but that thinking doesn't factor in heating oil, natural gas, or propane. We wanted to go a step farther and build a house that is truly net zero: no use of fossil fuels and their associated emissions. I call such a house *carbon neutral*.

Despite the moderate climate along the Oregon coast, our carbon-neutral house required a high-performance building envelope with insulation values substantially higher than the R-21 walls and R-30 roof required by the Oregon Energy Code. The design team tracked down and eliminated energy-wasting details, with Charlie Stephens of the ODE giving us feedback throughout the design and construction processes. Charlie and the ODE plan to produce a detailed case study documenting the house's energy-performance results after its first year of occupancy. The report is scheduled for publication in late summer this year at www.oregon.gov/energy.

Form follows function

The house's simple design is composed of two gently curved overlapping roofs. The upper roof is vegetative, a choice we made for a number of reasons. The lightweight soil and flowering plants help to minimize the impact of 80 in. to 90 in. of annual rainfall on the municipal storm-sewer system. Also, the green roof is fire resistant, is highly insulated, and should last well over 50 years. Additionally, the lush roof softens the uphill neighbor's view.

The lower roof serves as a platform for the 5.9kw photovoltaic (PV) system and creates shelter for the south-facing patio below. Bands of clerestory windows set between the two roofs provide daylight to interior spaces (top photo, facing page). The PV system is connected to the local utility's electrical grid, which means that the electric meter actually can spin backward if the house is generating more electricity than is being used. Energy the contractors and the craftspeople."

Natural daylighting *is accomplished through a band of clerestory windows. A light-colored reflective ceiling and open floor plan allow light to penetrate deep into the house. Photo taken at D on floor plan.*

Trust of Oregon financial incentives and State of Oregon tax incentives enabled us to save approximately 55% on the total installed cost of the PV system.

Windows are a key ingredient

Most of the house's windows face south to capture the spectacular view of the Oregon coastline and to optimize daylight, which reduces the need for electric lighting. The high clerestory windows, interior light shelves, and a raised ceiling in the great room provide excellent natural lighting, even on overcast days. To minimize heat loss through windows, we chose high-performance argon-filled glazing with a low u-factor (less than 0.32). Operable windows placed strategically throughout the house facilitate cross ventilation and improve indoor-air quality.

A short basement can boost energy efficiency

Crawlspaces provide excellent flexibility for electrical wiring, plumbing, and ductwork, but venting them (required by Oregon residential codes) results in significant energy losses. By eliminating vents to the outdoors, installing a concrete floor, and providing a moderate amount of conditioned air, we increased the energy efficiency of the building envelope. The shift in name from *crawlspace* to *short basement* was not just a matter of semantics; it was the difference between vents and no vents.

Because of this house's high-performance thermal envelope, space-heating loads are very low. Energy for the space-heating system and domestic hot water is provided by a combination of solar-thermal collectors, a ground-source heat-pump system, and energy-recovery ventilators (ERVs) (drawing pp. 104-105).

Located on a south-facing slope below the house, the thermal collectors gather solar energy to heat water in a circulating loop. A heat exchanger transfers the heat from the loop to two 120-gal. storage tanks in the basement. These tanks provide hot water for the house. When the water-storage tanks are charged fully, excess heat is stored in the basalt-rock formations under the house for later extraction by a ground-source heat pump. Without the bedrock-storage loop, we could have reduced the solar-thermal system by two-thirds.

Space heat is delivered by a forced-air system using the three ERVs, which retrieve heat from the water tanks. The ERVs are the backbone of an indoor-air-quality strategy.

More than 60 sensors in the house are connected to an automated control system that allows the ODE and Oregon Institute of Technology students to track the house's energy usage remotely.

How green is it?

Of all our green-building goals, the most challenging was our aim for a zero-energy house. We submitted the design to a third-party auditor, who calculated the HERS rating (home energy rating system) to be 94.0. This rating is 58% more efficient than the Oregon Energy Code requires. We also attained Earth Advantage's platinum-level green-building certification and were awarded the National Association of Home Builders' Custom Green Home of the Year award for 2005. Early data suggest that the house is on track to reach its goal of generating more energy than it consumes on an annual basis. During August 2005, the home delivered 173kwh more to its electric-utility provider than it consumed, and for September, the electric bill was less than $10. The design team hopes this project will help to facilitate a new generation of green-built homes. □

Nathan Good lives in Salem, Ore. His Web site is www.nathangoodarchitect.com. Photos by Daniel S. Morrison, except where noted.

Pebble-beach bath. *The interior designer specified two types of flooring, but it was the installer who conceived of integrating the two while watching waves wash over the sand during his lunch break at the beach. Photo taken at E on floor plan.*