High Style, High Perform

What does it take to build a high-performance home? Determination & attention!

by Ian Woofenden

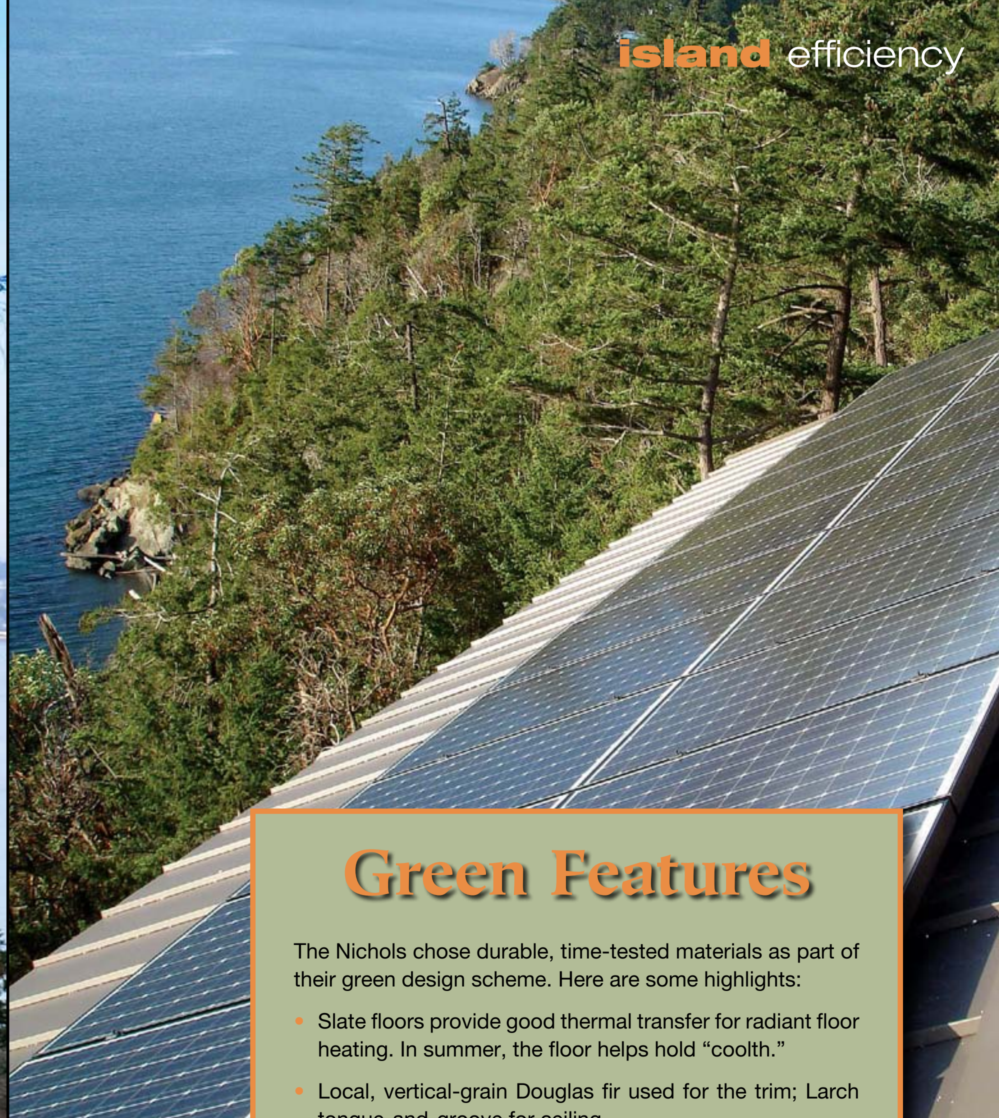
When it comes to building an energy-efficient home, keeping everyone focused on the goal is key. Otherwise, conventional designers and contractors may do what they've always done—build conventionally, and the result will be conventional (mediocre) building performance. But one Northwest couple kept their eyes on the prize, and reaped the rewards.

When Jim and Sue Nichol started planning their new home on Guemes Island, Washington, in August 2008, they were determined to have a fine custom and green home. They wanted to live comfortably as they moved toward retirement, and they wanted to reduce their environmental footprint. A goal was to keep maintenance and utility costs down while enjoying their stunning view. They were stimulated by the challenge of designing their home, and helped by a crew of forward-thinking consultants and contractors.

Their building designer, Art Peterson of Cedar Tree Associates Architects, has been involved in sustainable design for many years, focusing on smaller homes, passive solar design, and green materials. I was a minor part of the design team as well, steering the project toward energy efficiency and renewable energy. Jim and Sue took an active role in the design process, and this was a key factor in the success of the project. With a little direction, the Nichols worked on their goals—by doing research, finding appropriate contractors, and making sure they got what they wanted at each stage of the game.

Jim and Sue ended up with a luxuriously comfortable, high-performance home. In their first year of occupancy, they heated the 2,000-square-foot home for $380 ($1.04 per day), in a neighborhood where other homeowners are paying more than $1,000 per year to heat similarly sized homes.

ance



Jim and Sue Nichol put energy-efficient design first for their Guemes Island, Washington, home. Then they implemented energy-saving systems and appliances, and, finally, renewable energy systems, like this 5.7 kW PV system.

Green Features

The Nichols chose durable, time-tested materials as part of their green design scheme. Here are some highlights:

- Slate floors provide good thermal transfer for radiant floor heating. In summer, the floor helps hold "coolth."
- Local, vertical-grain Douglas fir used for the trim; Larch tongue-and-groove for ceiling.
- Solar tubes (solar skylights) provide natural daylighting to the master bathroom, bedroom, and kitchen.
- Toto Aquia Dual Max toilets reduce water use with two flushing levels—0.9 gallons for liquids; 1.6 gallons for solids.
- Low-flow showerheads.
- A TRD1000 septic treatment system treats the sewage with ultraviolet light and aeration, producing a potable outflow—this was necessary since the home is built on solid bedrock with no place for a septic leach field.
- HardiePlank cement-board siding, which has an expected lifespan of more than 50 years, was used as exterior cladding on the first floor of the house. The siding on the upper floor of the house, which will receive less wear and tear, is prepainted cedar shingles.
- The home's roofing is standing-seam metal, with an expected life of more than 30 years. It provides a collection surface for rainwater to use for plants, car washing, etc. A 1,250-gallon underground storage tank catches rainwater, which can be pumped up to irrigate the living roof and other plants.
- A living roof over the garage—with a 60-mil EPDM liner covered with 6 inches of soil and planted with sod—provides the Nichols with lawn space.

Addressing the Envelope

One of the most important factors in the building design was the choice of building envelope. Jim and Sue decided on structural insulated panels (SIPs)—polystyrene foam sandwiched between two pieces of oriented strand board. The polystyrene provides high insulation value (about R-4 per inch), while the OSB provides structure. Typically manufactured in 4-foot widths, SIPs help minimize thermal bridging through the building's envelope compared to a conventionally constructed, 2-by-4 or 2-by-6 stud-framed home.

Different panel thicknesses are available to meet the design goals for a particular home. The Nichols chose 10-inch panels to provide R-39 for the walls and the cathedral ceiling. This is on the high end of recommendations for the area's climate but maximized energy savings—what Jim and

Sue wanted. The thick SIPs also gave them deep windowsills, which they enjoy.

Over 10 days, two truckloads of SIPs that made up the walls and ceilings of the house and garage were installed. The pieces were lifted by a boom truck and tied together via lapping OSB edges and the 2-by-10 lumber pieces at the edges of the panels. Joints and corners were insulated with expanding spray foam, both during assembly and afterward, to complete the tight building envelope.

The Nichols chose Milgard double-pane, argon gas-filled aluminum windows, with low-E coatings. The exterior doors are insulated fiberglass. All windows and doors were installed with care and edges spray-foamed to minimize air infiltration.

Innovative & Efficient Heating

With a tight and well-insulated building envelope in place, the next area of focus was a high-performance heating system. Though solar methods are great, the cloudy, wet winters in northwest Washington are not very conducive to solar space heating.

My suggestion was to marry an air-source heat pump with a hydronic radiant floor system. Jim connected with Handy's Heating in Mount Vernon, Washington, to install a York Affinity 8T series heat pump and an Aqua Products heat exchanger to move the heat from the heat pump into the hydronic system. While ground-source heat pumps get a lot of press, their air-source cousins are cheaper by a significant margin, and very appropriate in a temperate, maritime climate. We get only a few weeks of freezing weather per year, and the York unit is designed to perform well down to 20°F.

All heat pumps are actually renewable energy collection devices, since they don't make heat, but *move* heat from the air, ground or water. Think of them like your refrigerator, pumping heat out of the fridge box so it stays cold. Heat pumps transfer naturally occurring heat from the air outside your house into your house. One kilowatt-hour of electricity can pump anywhere from 2 to 5 kWh of natural heat.

This trumps traditional boiler or heater efficiency, since it translates to between 200% and 500% efficiency on their scale. The best modern conventional gas and electric heating plants have efficiencies in the mid-90% range.

Marrying an air-source heat pump to a hydronic radiant floor takes an efficient energy-collection system and couples it to an efficient heat-delivery system. Jim and Sue's two-story home has six zones of hydronic tubing in its floors, allowing them to heat only the spaces they need. Radiant floor system owners are almost universally pleased with the thermal comfort of their homes—with warm feet, air temperature needn't be as high as with conventional forced-air systems.

Top: An open kitchen with energy-efficient appliances.

Middle: Durable slate tiles are perfect for radiating the heat from the subfloor hydronic loops.

Bottom: The thick SIP walls make rooms cozy and comfortable.

Structural insulated panels for the exterior walls and roof are not only efficient; they also come pre-cut so the house goes together quickly.

Made of expanded polystyrene and oriented strand board, SIPs are relatively easy to maneuver by hand.

Smart Energy Use

A sensible strategy for an energy-efficient home is to first build a tight envelope; then design and install an efficient heating (and/or cooling) system; and, third, focus on energy-efficient lighting and appliances. After these steps have been met, *then* generating some energy can be considered, evaluating the renewable resources available.

While Jim and Sue could have taken shortcuts by just writing a check for a big PV system to cover their electrical usage, they instead took a whole-house approach, starting with efficiency first, which results in lower consumption and a smaller RE system. The home was designed with an obstruction- and shade-free roof, facing as close to true south as possible while still preserving views from the house. The roof has a 38° pitch to optimize year-round solar electricity collection.

Since their home is far from the island's underwater electricity cable and critical services, the Nichols had already decided that they wanted generator backup—their neighborhood can experience multiday outages. They chose a 17 kW auto-start propane generator, which can run all of their loads—including the heat pump—during an electrical outage. The 250-gallon propane tank is large enough to provide six days of running time.

With a generator eliminating the need for battery backup, a batteryless solar-electric system was designed and installed by Whidbey Sun & Wind of Coupeville, Washington. The 5.7 kW system uses a 6 kW Sunny Boy inverter and 30 Sanyo 190 W PV modules. The high energy-density Sanyo module line provided the maximum (at the time) output for the square footage available. Because the annual home load was unknown at the time of construction (indeed, until after the house had been lived in for a year), the Nichols chose to invest in a system that would give them significant generation and allow for expansion.

Using less-efficient modules could have given the same performance as the existing system, but would have used

The steep coastal building site lacks yard space, so the Nichols got creative, establishing a living roof—and lawn—above the garage.

Fresh Air in a Tight Home

Building a tight home has many advantages, but at least one disadvantage—lack of fresh air. Tight, well-insulated homes need a mechanical solution for adequate fresh-air exchange. In the Nichols' home, a heat-recovery ventilator (HRV) was installed to avoid mildew and mold buildup and ensure good indoor air quality. The Venmar HEPA 4100 recaptures 80% of the heat in the air being expelled from the building, so that incoming air is preheated—not cold and drafty. The system includes a high-efficiency particulate air (HEPA) filter, removing particles as small as pollen from the air entering the house, something Jim appreciates because he has allergies.

the whole roof instead of only two-thirds of it. Leaving some roof space allows the Nichols to expand the system in the future by adding more modules.

In its first year, the system generated 6,500 kWh, which is about 50% of the building's usage. (Their total usage was about 6,000 kWh for heating and hot water, plus 5,811 for the motor home, lighting, computers, appliances, printers, etc.) Two dedicated kWh meters tracked the electricity usage for space and water heating. For the period of June 2009 through June 2010, the cost of space heating was $1.04 a day; water-heating cost averaged $1.49 a day. A solar water heater and/or on-demand water heater could have reduced that expense significantly, but the Nichols opted to focus on solar electricity, and have no plans to add a SHW system.

Incentives in Puget Sound Energy's service area include the 30% federal tax credit, a sales tax exemption, net metering, and production payments. Net metering means that Jim and Sue are credited (at the retail rate) for every kilowatt-hour their system "sells" back to the utility. Net-metering accounting in Washington zeroes on April 30, when the client pays for any shortfall or gives up any surplus. The total net-metering value of electricity on the Nichols' system for the first year was about $650, which is credited on their bill. In Washington, the production incentive pays 15 cents per kWh to the Nichols, who will receive a check for about $1,000 each year. (The rate is higher if Washington-made components are used.)

Green Payback

Building "green" can be more expensive—Jim guesses that the PV system, coupled with speciality eco-friendly products, added about 30% to the home's construction costs. But he calculates that if they stay in the house 7 to 10 years, they will recoup the additional upfront expense. They also will have the security of long-term fixed costs for a significant portion of their heating and lighting expenses as the cost of energy keeps rising.

Left: An air-to-water heat pump system is more than twice as efficient at heating as conventional space-heating systems.

Right: The PV system's 6 kW SMA America Sunny Boy inverter, AC disconnect, production meter and utility connection.

Jim and Sue Nichol enjoy the view from their comfortable, energy-efficient home.

The Nichols have found a healthy balance between their lifestyle and their environmental goals. And they have used their financial success to promote a model of home design that combines comfort and beauty with environmental awareness. By keeping their focus on their goals, and by assembling a team of people willing to work toward those goals, they have a well-designed and relatively low-impact home they can feel proud of and enjoy in their retirement years.

Access

Home Power senior editor Ian Woofenden (ian.woofenden@homepower.com) enjoys helping people reach their energy goals based on their own motivations. He lives, works, and travels on planet Earth, including Washington's San Juan Islands.

Design & Build Team:

Cedar Tree Associates Architects • Architect

Premier Building Systems • www.pbssips.com • SIP manufacturer

TC Legend Homes • www.tclegendhomes.com • SIP installer

Crater Lake Building Company • General contractor

Handy's Heating • www.handysheating.com • HVAC contractor

Minaugh Excavation • Site prep and septic

Snowy Mountain Excavation • Living roof installation

Whidbey Sun & Wind • www.whidbeysunwind.com • PV system

Components:

Sanyo • www.sanyo.com • PV modules

SMA America • www.sma-america.com • Inverter

Venmar • www.venmar.ca • Heat-recovery ventilator

York UPG • www.yorkupg.com • Air-source heat pump