U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

DOE ZERO ENERGY READY HOME™

U.S. DOE ZERO ENERGY READY HOME 2014 WINNER Housing Innovation Awards

TC Legend Homes

Cedarwood
Bellingham, WA

BUILDER PROFILE

TC Legend Homes, Bellingham, WA
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FEATURED HOME/DEVELOPMENT:

Project Data:

- Name: Cedarwood
- Location: Bellingham, WA
- Layout: 1 bedroom, 1 bath, 2 floors
- Conditioned Space: 1,055 ft^2
- Climate Zone: IECC 4C, marine
- Completion: June 2014
- Category: Affordable

Modeled Performance Data:

- HERS Index: without PV 43, with PV 13
- Projected Annual Utility Costs: without PV $604, with PV $283
- Projected Annual Energy Cost Savings (compared to a home built to the 2009 IECC): without PV $216, with PV $556
- PV Production Revenue: $340
- Annual Energy Savings: without PV 4,240 kWh, with PV 9,009 kWh

Some say high-performance will cost you. How about $144 per square foot? That's the move-in price for a zero energy home built in Bellingham, Washington, by Ted Clifton Jr. of TC Legend Homes. The home is Clifton's third true zero energy home and his lowest cost per square foot yet. The 1,055-ft^2 home sports high-efficiency appliances, a balcony, a greenhouse, a patio, a loft, tongue-and-groove pine ceilings, and solar photovoltaic panels—all for $151,908 or $144 per square foot (not counting the land). A 3.2-kW PV system is all it takes to power the home, thanks to a highly insulated building envelope and high-performance equipment, which helped earn the home a certification from the U.S. Department of Energy's Zero Energy Ready Home program.

To be certified as a DOE Zero Energy Ready Home, the builder must meet the requirements of ENERGY STAR Certified Homes Version 3.0, the U.S. Environmental Protection Agency's Indoor airPLUS requirements, the hot water distribution requirements of the EPA WaterSense program, the insulation requirements of the 2012 International Energy Conservation Code, additional DOE Zero Energy Ready Home efficiency requirements, and have renewables or "renewable-ready" measures installed that ensure the home is ready for solar photovoltaic and panels when the homeowner is ready to purchase them.

This is the second home Clifton has certified to the DOE program. He hopes to certify every home that he has assessed for a Home Energy Rating System (HERS) score by a HERS rater. The Bellingham home was calculated to have a HERS score of 43 when the PV power production is not included, or HERS 13 when the PV is included. A typical existing home would have a HERS score well over 120. Clifton said the home is actually performing at a HERS 0 or below, producing more power than it uses, and the homeowner's bills have been about $8 a month.

ZERO ENERGY READY HOME U.S. DEPARTMENT OF ENERGY

The U.S. Department of Energy invites home builders across the country to meet the extraordinary levels of excellence and quality specified in DOE's Zero Energy Ready Home program (formerly known as Challenge Home). Every DOE Zero Energy Ready Home starts with ENERGY STAR Certified Homes Version 3.0 for an energy-efficient home built on a solid foundation of building science research. Advanced technologies are designed in to give you superior construction, durability, and comfort; healthy indoor air; high-performance HVAC, lighting, and appliances; and solar-ready components for low or no utility bills in a quality home that will last for generations to come.

TC Legend Homes built the Bellingham zero energy home with an ICF stem wall. The concrete-filled foam blocks provided a solid R-28 insulated edge for the poured concrete slab foundation, while an additional R-20 of rigid foam provided an insulating layer separating the slab from the ground.

What Makes a home a DOE ZERO ENERGY READY HOME?

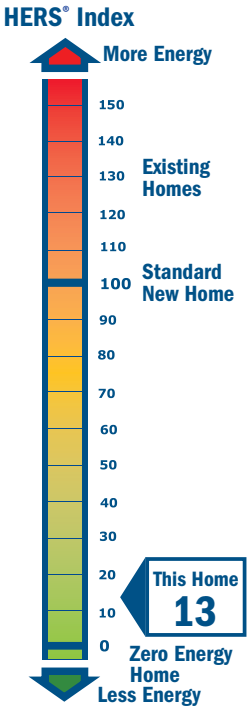
1 **BASELINE**
ENERGY STAR Certified Homes Version 3.0

2 **ENVELOPE**
meets or exceeds 2012 IECC levels

3 **DUCT SYSTEM**
located within the home's thermal boundary

4 **WATER EFFICIENCY**
meets or exceeds the EPA WaterSense Section 3.3 specs

5 **LIGHTING AND APPLIANCES**
ENERGY STAR qualified



6 **INDOOR AIR QUALITY**
meets or exceeds the EPA Indoor airPLUS Verification Checklist

7 **RENEWABLE READY**
meets EPA Renewable Energy-Ready Home.

The Bellingham home achieves this performance with a simple plan designed by Clifton to maximize efficiency and minimize cost, with an open two-story layout including a small 630-ft^2 footprint and a 400-ft^2 loft. The home was placed on the lot to maximize passive solar heat gain and avoid shading the PV system, while retaining existing trees.

The slab-on-grade foundation was poured over an R-20 layer of rigid high-density EPS foam. One course of 16-inch-high insulated concrete form (ICF) blocks was set 10 inches in the ground at the perimeter to create the footing wall and to provide R-28 of slab-edge insulation. The concrete slab was stained, sealed, and left exposed as the first floor of the home. Most of the home's triple-pane low U-value, high solar heat gain coefficient windows face south, allowing low winter sun to heat up the concrete slab for passive heating. The green house also warms up in the winter; if additional warmth is desired, this warm air can be brought into the home by opening the sliding door to the kitchen.

The walls and roof of the home were constructed of structural insulated panels (SIPs), which consist of rigid foam sandwiched between two layers of OSB. The foam adheres to the OSB and hardens during the manufacturing process, creating a strong bond and a very sturdy panel. The SIPs are cut to order in the factory, providing straight, clean walls with high shear strength that come to the site ready for quick assembly. No additional insulation is needed. The 6-inch-thick walls provide R-26 of insulation. The 10-inch-thick SIP roof panels provide an R-42 insulation value in the cathedral ceiling.

Attention to detail helps Clifton achieve a very airtight envelope that shows air leakage of only 0.67 air changes per hour at 50 Pascals pressure difference (ACH 50) when tested with a blower door. This is far more airtight than the 7 ACH 50 specified by the 2009 IECC. Where the SIP panels connect to the ICF foundation wall, Clifton uses sill seal plus two beads of SIP mastic under the SIP panel. He also caulks the seam where the SIP panel meets the floor along the inside perimeter of the home, then caulks again along the top and bottom of the baseboard after that is installed. Before drywalling, Clifton's crews also foam the rough openings and caulk around all the windows; foam behind all electric boxes and caulk around them; foam and/or caulk around electric wires and plumbing pipes; and tape and caulk all seams in the SIP panels, in addition to the tape and mudding done by the drywallers.

The walls and roof of the home were made of structural insulated panels consisting of two panels of OSB sandwiching a layer of rigid foam. The panels are precision cut in the factory and come to the site ready for quick assembly into a very sturdy, straight structure. The 6-inch-thick walls have an insulation value of R-26 while the 10-inch-thick roof has an insulation value of R-42.

"Normally the insulation contractors spend about 2 hours air sealing. We spend 20 hours or more on a house, depending on the size of the house. It's a line item in the budget. We may spend $2,000 on air sealing because we caulk everything," said Clifton.

One high-efficiency ductless mini-split heat pump provides heating at a heating season performance factor (HSPF) of 12 and cooling at a seasonal energy efficiency factor (SEER) of 21.5, far higher than the minimum federal standard of 7.7 HSPF and 13 SEER. The unit was located on the first floor under the stairs, to help heat the second-story floor. Despite the high efficiency of the unit, it rarely runs according to the homeowners, because the building shell is so well insulated.

A quiet, high-efficiency 30-cfm exhaust fan located in the bathroom runs continuously to meet the ASHRAE 62.2 required ventilation rate. To bring fresh air into the super-tight structure, an earth tube was installed. The earth tube is a 100-foot-long, 6-inch-diameter PVC duct that was buried 2 feet underground along the inside perimeter of the home during construction of the foundation. The outside end comes up near the back corner of the house, extending 2 feet up from the ground. The end of the pipe is bent down to keep out rainwater and is covered with a screen to keep out bugs. The inside end of the pipe is in the utility area near the heat pump. Clifton determined no in-line fan was needed; the duct allows air to be drawn in passively at a rate adequate to balance air pressure in the home with the exhaust fan, which runs continuously at 20 cfm. The incoming air is tempered by the ground as it travels the 100-foot underground distance to reach the inside of the home. Exhaust fans in the utility area and kitchen provide additional spot ventilation. The home's upstairs windows with two south-facing sliding doors, and south-facing French doors also open to provide ventilation. Air distribution is facilitated by the open floor plan including the open second-story loft.

A wall-mounted, instantaneous, tankless, gas-fired water heater takes up very little space while providing hot water. The home's compact layout allowed the builder to meet the strict WaterSense requirement for low wait times for hot water distribution. High-efficiency appliances including a non-vented electric washer-dryer combination unit and low-flow plumbing fixtures further reduce water use.

HOME CERTIFICATIONS

DOE Zero Energy Ready Home Program

ENERGY STAR Certified Homes Version 3.0

EPA Indoor airPLUS

Every DOE Zero Energy Ready Home combines a building science baseline specified by ENERGY STAR Certified Homes with advanced technologies and practices from DOE's Building America research program.

Passive solar heat radiating from the bare concrete floors provides most of the heat for the home's open, compact interior. One mini-split heat pump covers cooling and additional heat when needed.

The home's standing seam metal roof simplified installation of the 3.2-kW grid-tied PV system. The homeowners Kristina and Mike Heintz were so interested in the installation of the solar panels that Kristina took on the task of locating the best solar value possible and ordering the panels. She has since joined TC Legend's staff to handle solar panel purchases for other clients. Although the solar panels for the Bellingham home were purchased from an out-of-state manufacturer, Clifton said Kristina is now helping homeowners purchase solar panels made in Washington because of the state's generous offer to buy back surplus power at a subsidized rate of 54 cents per kW, if the panels are Washington-made.

Clifton noted that while the 3.2-kW system meets all the home's power needs, there is room on the roof to add enough PV to power an electric car as well.

"The Heintz house exemplifies what we want to do in our company. This couple is about to retire. They wanted an affordable home with zero energy bills and we were able to achieve that," said Clifton.

The 38-year old started building when he was 14, working for his father Ted Clifton Sr. who designs and builds DOE Zero Energy Ready Homes on Whidbey Island in Washington. Clifton said he's been improving his understanding of energy-efficient construction ever since. "I thought we were building the most energy-efficient house possible when I built my own home 7 years ago. But my first true net zero energy home last year (his first DOE Zero Energy Ready Home) was a breakthrough in my understanding of real energy efficiency."

Clifton's goal now is to build every home as a zero energy home with enough PV to power the house and the car. And he's hoping to do it for under $120 per square foot.

Photos courtesy of TC Legend Homes.

KEY FEATURES

- **DOE Zero Energy Ready Home Path:** Performance
- **Walls:** 6 in. SIPs R-26; pre-finished fiber cement siding; house wrap
- **Roof:** 10 in. SIPs R-42; metal standing seam roof
- **Foundation:** ICF foundation R-28; R-20 rigid high-density EPS foam board under slab
- **Windows:** Triple-paned vinyl-frame, U=0.20, SHGC=0.45
- **Air Sealing:** 0.67 ACH 50
- **Ventilation:** 30 cfm, 2.7-Watt continuous exhaust fan in bathroom balanced by earth tube that brings in filterered, tempered outside air passively via 100-ft, 6-inch-diameter pipe buried 2 feet below ground inside foundation footing. Spot ventilation fans in kitchen and utility closet
- **HVAC:** One ductless heat pump 12 HSPF, 21.5 SEER
- **Hot Water:** Instant tankless condensing gas-fired water heater; 0.96 EF
- **Lighting:** 100% LED for all fixed lights, 100% CFL for lamps
- **Appliances:** High-efficiency electric washer-dryer combo
- **Solar:** 3.2-kW PV
- **Water Conservation:** Low-flow faucets, shower head
- **Other** Low- to no-VOC glues, adhesives, and paints; water-based sealer on concrete floors

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