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 this 2,781-ft² 2-story, 4-bedroom home in Bellingham, Washington, to the strict energy-efficiency requirements of the U.S. Department of Energy’s Zero Energy Ready Home program criteria and added enough solar electric panels on the roof to power the house and two electric cars.

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

meet the hot water distribution requirements of the EPA’s WaterSense program and the insulation requirements of the 2012 International Energy Conservation Code. In addition, the homes are required to have solar electric panels installed or have the conduit and electrical panel space in place for them.

Clifton installs solar on nearly all of the homes he builds. Many of his homes are not only net zero but what he refers to as positive-energy. The Bellingham Power House produces enough electricity to power the house, an attached apartment, a shop, and two electric cars, at an initial construction cost of only $150 per square foot. Clifton’s first zero energy house was only $124/ft² (or $114/ft² if you count the rebates and incentives), whereas the average cost for new residential construction in Seattle is more than $200/ft² and that’s for to-code construction, not zero energy construction. Clifton noted there are now other builders in Seattle who are building zero energy homes. “The difference is price; other builders’ net zero homes cost $250-$300/ft². But, it doesn’t have to take much more money to get to a super-efficient home,” said Clifton. Clifton has built more 100% solar-powered homes than any other builder in the area and his company’s mission is to make positive-energy and net-zero-energy homes that are affordable for the average home buyer.

Clifton’s Bellingham Power House achieved a very low Home Energy Rating System (HERS) score of only 34 before the photovoltaics were added. (A typical home built to the 2006 IECC would score about 100.) To achieve the low score, Clifton starts with his standard construction practice—a concrete slab foundation, insulated concrete form (ICF) foundation walls, and structural insulated panel (SIP) above-grade walls and roof. One course of ICF blocks forms the 16-inch-high foundation wall, which provides R-28 of edge insulation for the floor slab. Before pouring the 4-inch slab, a 4-inch-thick (R-20) layer of rigid high-density expanded polystyrene (EPS) foam was laid over the crushed rock base, then covered with 6-mil poly vapor barrier. Then, radiant floor heating loops were laid out over the foam.

Clifton typically does traditional rebar-reinforced concrete slab floors. Because this was his own home, he decided to experiment with some new building materials. One was a micro-rebar product that uses tiny steel pieces 1 inch long and the thickness of pencil lead, instead of long steel rods. The micro-rebar is mixed in to the concrete. Because the microbars are going in every direction, they provide strength in many different directions at once, giving the concrete more
plasticity. The strength of the mixture is based on how many pounds of steel are added. Clifton typically stains and seals the concrete then leaves it exposed as a durable, water-impervious, and economical finished flooring.

The walls consist of 8-inch, R-30 SIPs, and the roof is built from 12-inch R-46 SIPs. The SIPs consist of two OSB panels sandwiching a layer of adhered rigid foam. The home’s exterior walls were covered with house wrap and clad with fiber cement siding. The SIPs provide cathedral ceilings throughout the home. A standing seam metal roof provides a fire-resistant covering. Because the SIPs are solid and the seams are connected with construction adhesive, the SIPs create a very airtight shell around the home. The Power House was third-party tested for airtightness and showed air leakage of only 0.64 air changes per hour at 50 Pascals, about four times as tight as the program requires.

The home was equipped with a high-efficiency, air-to-water heat pump, with a coefficient of performance (COP) of 4.4 that provides warm water for the radiant floor heating as well as hot water for domestic use. Although the heat pump is very efficient, it’s almost more heating than is necessary because Clifton designed the home for passive heating. The home’s south-facing windows allow winter sun to warm the thermal mass floors; the heat is absorbed during the day and released at night. The home’s open, south-facing loft design helps to encourage a convective loop that brings heat up and into second-story rooms while the air-tight thermal-wrapped building envelope helps to prevent temperature fluctuations and extremes.

Clifton also installed a 31-ft² solar collector on the roof for solar water heating. He noted that it really wasn’t needed, but he installed it so he could test its performance.

To provide ventilation for the airtight home, Clifton installed a heat recovery ventilator (HRV). This was the first HRV he had installed and he did so primarily so he could demonstrate and monitor its energy use. Typically, Clifton employs a ventilation strategy he learned from his father Ted Clifton, owner of Clifton View Homes on Whidbey Island and Zero-Energy Home Plans. The strategy employs one or more ENERGY STAR-rated exhaust fans that are installed on a shaded side of the house to direct air into the home. The air flow (cfm) of these fans is matched to the air flow of an exhaust fan set to pull air out of the home from a central location, typically the range hood fan. The fans are electronically controlled to operate together to bring air into the home periodically, and they can be set by timers to come on very early on hot summer days for night ventilation cooling.

HOME CERTIFICATIONS

DOE Zero Energy Ready Home Program, 100% commitment

ENERGY STAR Certified Homes Version 3.0

EPA Indoor airPLUS

Built Green 5-Star
In this home, in addition to the HRV, Clifton also experimented with an earth tube ventilation system. The earth tube is a 4-inch-diameter pipe that passes through the ground to bring outside air into the home after being tempered by the roughly 55-degree ground temperatures. Clifton installed four loops of pipe around the foundation of the home at a depth of 2 feet and a length of 100 feet before he backfilled. One end opens outside of the home and one end opens inside the home. When the range hood fan operates, it passively draws outside air into the home through the tube. Because of the tempering effect of the earth, even if outside temperatures are 20 degrees, the air entering the home will come in at a temperature of about 50 to 55 degrees, said Clifton, who is monitoring the tube’s performance. He added that the cost of the system is about $3,000 for piping, and exhaust fans, and a HEPA filter, which he said compared favorably to an $8,000 HRV, with equal efficiency.

Although the air-to-water heat pump could be set to provide refrigerant cooling, Clifton finds that the highly insulated building stays cool. Deep overhangs help to keep high summer sun out of the home’s interiors and the thermal mass floors act as a heat sink pulling heat out of the air during the day.

Another unique feature of the home is the greenhouse located on the south side of the home by the kitchen. The greenhouse space serves as a mudroom. It is also a great buffer between the kitchen entrance and the outside. In the winter, opening the front door directly to the outside represents a big heat loss; it can exchange all the air in the room with the cold outside air in seconds. Having the greenhouse space stops much of that heat loss. Although it is not conditioned, the greenhouse is enclosed and south-facing so it does warm up. It is separated from the main house by a triple-pane slider door.

Clifton is installing a rainwater collection system for the home that will include two 500-gallon cisterns and one 2,000-gallon cistern, which should cover all of the irrigation needs for the huge vegetable garden he and his wife are planning. Clifton estimates the cost for the system at $3,000 for 3,000 gallons of storage.

The innovative Power House has already been the subject of several tours to high school classes, college classes, and local green aficionados. Clifton is happy that programs like the DOE Zero Energy Ready Home program are promoting the idea of zero energy construction. He is surprised at the number of people he meets who had not even dreamed that zero energy homes were possible. For Clifton, who has been building homes since he was 14, getting to build zero energy homes is more like a dream come true. “Ever since that first net zero home in Seattle in 2011, our team has been hooked. We don’t want to build anything else,” said Clifton.

“Not a lot of technology has been applied to house building. The telephone in your pocket is a million times more technologically advanced than your house.”
—Ted Clifton, owner, TC Legend Homes

**Photos courtesy of TC Legend Homes**