



TC Legend Homes

Neohouse
Bellevue, WA



BUILDER PROFILE

TC Legend Homes
Bellingham, WA; tclegendhomes.com
Ted Clifton, 360-220-2119
Ted@TCLegendHomes.com

FEATURED HOME/DEVELOPMENT:

Project Data:

- Name: Neohouse
- Location: Bellevue, Washington
- Layout: 4 bdrm, 3 bath, 2 fl, 2,614 ft²
- Climate: IECC 4C, marine
- Completed: February 2021
- Category: Custom for Buyer >2,500 ft²

Modeled Performance Data:

- HERS Index: without PV: 35; with PV: -22
- Annual Energy Costs: without PV: \$1,300; with PV: \$0
- Annual Energy Cost Savings: (vs typical new homes) without PV: \$1,500; with PV: \$2,550
- Annual Energy Savings: without PV: 12,100 kWh; with PV: 24,300 kWh
- Savings in the First 30 Years: without PV: \$61,700; with PV: \$103,500

A continuous desire to improve an already incredibly high-performance home led the way for TC Legend Homes of Bellingham, Washington, to achieve its eighth Housing Innovation Award and third Grand Award from the U.S. Department of Energy Zero Energy Ready Home program.

Over the years, this builder of custom homes in the Bellingham-Seattle area of western Washington state has perfected its tried-and-true formula of SIP walls and roof and an ICF stem wall wrapping a slab foundation, but with each home constructed by builder Ted Clifton and crew, they seek ways to reduce waste and improve performance. That penchant for reducing waste has helped the builder trim costs to \$300/square foot, on par with what local just-to-code builders are paying to construct market-rate homes, while TC Legend's homes routinely achieve zero energy performance scores of 10 to 20 below net zero on the Home Energy Rating System (HERS) index. These "positive energy" homes achieve enough energy savings and photovoltaic power production to run the home and an electric car or two.

All TC Legend homes also earn the DOE Zero Energy Ready Home certification, a goal the builder committed to in 2015 and he has thus far seen 20 completed homes certified. This year's award-winning home achieved a HERS score of -22 and should save its homeowners more than \$2,500 per year in utility bills compared to a home built to code, based on 2021 prices. That savings will go up as energy costs increase, noted Clifton.

Meeting the requirements of the DOE Zero Energy Ready Home program means that the home has also been certified to the criteria of ENERGY STAR Certified Homes Version 3.0, 3.1, or 3.2 and the U.S. Environmental Protection Agency's Indoor airPLUS. Builders must also meet other efficiency requirements like the hot water distribution requirements of the EPA's WaterSense program; the insulation



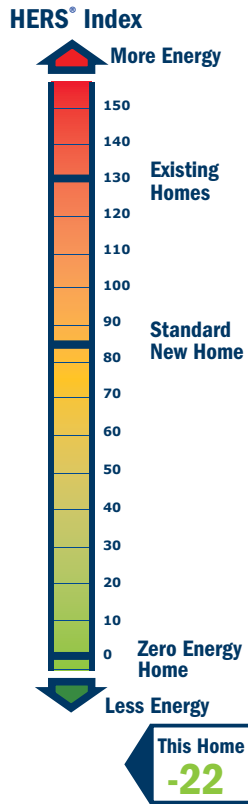
The U.S. Department of Energy invites home builders across the country to meet the extraordinary levels of excellence and quality specified in DOE's Zero Energy Ready Home program. Every DOE Zero Energy Ready Home starts with ENERGY STAR Certified Homes Version 3.0/3.1/3.2 for an energy-efficient home 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.

Triple-pane windows and LED lighting provide ample light to the open interiors while a heat recovery ventilator with a HEPA filter and CO₂ sensor helps to keep the indoor air clean.



What makes a home a DOE ZERO ENERGY READY HOME?

- 1 **BASELINE**
ENERGY STAR Certified Homes Version 3.0/3.1
- 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.



requirements of the latest International Energy Conservation Code; HVAC and water heating efficiencies; third-party verified air sealing targets; installation of ENERGY STAR appliances, windows, and lighting; and ducts in conditioned space. In addition, homes are required to have solar electric panels installed or have the conduit and electrical panel space in place for it. Even without the 12.87 kW of PV panels installed on the roof of the winning home, it would achieve a HERS score of 35, well below the HERS 80 to 90 of most just-to-code new homes.

To reduce heating and cooling loads, TC Legend Homes relies on its tried-and-true base design. A four-inch slab is poured over 4 inches (R-20) of an EPS rigid foam product certified as zero-VOC. The stem walls around the slab are made of insulated concrete form (ICF) blocks consisting of a 6-inch reinforced concrete core wrapped with 2.625 inches of rigid foam on the interior and exterior for an R-23.6 total stem wall. TC Legend often seals the concrete slab to serve as the finished floor of the home because the exposed concrete readily absorbs passive solar heat and also easily transfers warmth from the radiant floor loops. On this home, the buyers requested hardwood flooring.

The home's above-grade walls consist of 6.5-inch (R-29) structural insulated panels (SIPs) that use a graphite-enhanced expanded polystyrene core wrapped with OSB. The walls are finished with house wrap and fiber cement siding. The roof is constructed of 10.25-inch (R-49) graphite-enhanced SIPs, topped with underlayment and asphalt shingles. Clifton notes that choosing a thicker, stronger roof panel allows the builder to use foam inter-panel connection splines in the roof rather than lumber or I-joist splines, which have some inherent thermal bridging heat losses; and the cost of the thicker panels is offset by eliminating the cost of the I-joist splines.

SIP provide seismic category D resistance and are rated to last 100 years. SIPs also make a very airtight structure with very little thermal bridging compared to stick-frame construction. The home is slab on grade, so there is no air leakage from the floor. All SIP panel joints are double-bead mastic sealed and taped at the seams internally with 6-inch SIP tape. Windows are foamed-in and sill plates are also sealed with SIP mastic. After the mechanical trades have completed their work and all windows and doors are sealed, the builder uses a proprietary aerosolized acrylic product that is distributed throughout the home while it is pressurized with a blower door fan to seal any remaining cracks in the building envelope. The final blower door test on this home was 0.47 ACH50.



The home is constructed of structural insulated panels (SIPS) that consist of two sheets of OSB sandwiching a layer of rigid foam, in this case a 5.5-inch layer of graphite-enhanced expanded polystyrene which is sealed at the seams to provide a continuous air and thermal barrier layer around the house.

TC Legend Homes designs their homes with simple rectangular footprints and simple rooflines whenever possible for reduced cost and greater energy efficiency. “The TC shell system is tried and tested, has not changed over the last few years, goes up fast, and works brilliantly. It is designed in-house for easy assembly and great thermal performance,” said Clifton.

The home is designed to take advantage of passive solar heating and shading with a floorplan that is longer in the east-west direction and puts a majority of the windows on the south sides of the house. The triple-pane windows on the south side have a U value of 0.15 and a SHGC (solar heat gain coefficient) of 0.46. In the winter, sunshine can pour in the well-glazed south side of the house and heat up the floors like a thermal battery. In the summer, the 2.5-foot roof overhang upstairs and full-length 3.5 foot covered porch downstairs shield windows from direct summer sun. East-, west-, and north-facing sides of the home have fewer windows. Movable shades on the east and west windows also help prevent heat gain in the summer. Windows and doors are triple-pane glass with three low-emissivity coatings and argon fillings that reduce heat transfer, reaching $U=0.15$ to 0.22 depending on glass type. The home’s windows are supplemented by reflective white paint to take advantage of daylight, and when the sun is down, 100% LED light fixtures illuminate the interior.

The solar panels are also aligned on the south side of the house along the second floor, with space along the porch cover for additional panels. These panels power the all-electric house including the electric vehicle charging station, ENERGY STAR appliances, and air-to-water heat pump for space and water heating.

Mechanical ventilation is a necessity in the super-tight homes. In 2021 after another summer marked by forest fires and days of dangerously bad air quality across the Northwest, TC Legends’ owner Ted Clifton and lead designer Jake Evans decided to tackle air quality issues. The builder was already routinely installing a heat recovery ventilator (HRV) as the standard ventilation system in all of their homes. An HRV brings in outdoor air that is tempered with outgoing stale air in a heat exchanger to warm incoming air in winter and cool incoming air in the summer. They added a HEPA filter unit to the fresh air intake of the HRV that included an inline fan to pull in air that passes through the HEPA filter, which filters out 99.97% of particles down to 0.3 microns. The fan-powered filter unit is operated by the same variable speed switch that controls the home’s powerful range hood fan, so when the range hood fan is on, instead of depressurizing the home or pulling in makeup air through cracks in the building envelope or an imperfect backdraft damper, just the right amount of makeup

HOME CERTIFICATIONS

DOE Zero Energy Ready Home Quality Management Guidelines

DOE Zero Energy Ready Home Program - 100% Commitment

ENERGY STAR Certified Homes Version 3.1

EPA Indoor airPLUS

BuiltGreen 5 Star, Certificate of Merit

“It’s not necessarily that I want to save the world, and it’s not really about the savings, it’s about waste; if there is a better way to do it, then why not?”

-Home owner



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.



An air-to-water heat pump provides ultra-efficient heating and cooling.

air is brought in through the HEPA filter. The incoming air is tempered through the heat exchanger on the HRV to minimize blasts of cold or hot air from the incoming air.

“After some experimenting with the HEPA fan filter at our test house, I was able to get the indoor air quality down to 54 micrograms/m³, when it was 217 micrograms/m³ outside [an extremely smoky day], and on a typical day, indoor air pollutants were down to 1.5 micrograms/m³. This HEPA filtration unit is easily operated on a variable-speed switch that also controls the range hood. The end user doesn’t have to think about any of that mumbo-jumbo; they can just dial the ventilation up or down as needed, with the added benefit of making their range hood almost twice as effective at eliminating kitchen odors, which is actually the worst source of indoor air pollution for a typical home,” said Clifton.

The HRV is set for continuous operation and has timer-controlled boost settings of 10, 30, and 60 minutes for the bathrooms. There is also a CO₂ sensor in the main living area that will boost the system as needed to keep CO₂ below 500 parts per million.

Although not new with this home, TC Legend also uses a unique heating and hot water system. They’ve installed an air-to-water heat pump that provides domestic hot water with a COP of 3.92 (i.e., the heat pump is 3.92 times as efficient at making hot water as a regular electric water heater.) This is much more efficient than a “heat pump water heater” and has the added benefit that the compressor and fan are located outside, so it is not pulling heat from the air inside the home and it is keeping the fan noise outside as well.

This air-to-water heat pump also provides space heating to the home with a COP of 3.92 for heating, and 6.75 for cooling. “This is the most efficient way to heat and cool a house for our climate, that I have been able to find,” said Clifton. The heat is delivered hydronically via radiant floor loops downstairs and a fan coil unit upstairs, as well as via a heating unit in the supply side of the HRV.

The house is designed for aging-in-place with a bedroom and full bath on the first floor. Doorways on this floor are sized to ADA specifications and an oversized entry and music room can be repurposed as an additional bedroom for potential live-in care.

Overall, the homeowners are amazed. “We are loving our new home. It’s still almost unbelievable to us how air-tight it is in here. It’s so quiet inside, we barely hear any exterior sounds.... We definitely underestimated the amount of light and heat that would come in, both on the west side alone and in the home overall. It is so bright in here. I love it!” said one of the owners.

KEY FEATURES

- **Walls:** SIPs, R-30: 6.5" graphite SIP panel (R-29), house wrap, fiber cement.
- **Roof:** SIP gable roof: 10.25" R-49 graphite-EPS SIPs, asphalt composite roofing.
- **Attic:** No attic, vaulted ceilings.
- **Foundation:** R-23.6 Slab on grade: 11.25" ICF stem walls.
- **Windows:** Triple-pane, argon-filled, low-e3, vinyl frame, U=0.15-0.22, SHGC=0.27-0.46.
- **Air Sealing:** 0.47 ACH50, all SIP joints taped and sealed with double-bead mastic tape. Whole-house aerosol sealant.
- **Ventilation:** HRV, HEPA filter, CO₂ sensor, 88 SRE, 110 CFM, 32 Watts.
- **HVAC:** Air-to-water heat pump with 50% central air handler, 50% radiant, 3.92 COP, AC variable speed compressor, 23.02 EER.
- **Hot Water:** Combi air-to-water heat pump for space and water heating, 50-gal, 3.92 COP, electric tankless back-up water heater.
- **Lighting:** 100% LED.
- **Appliances:** ENERGY STAR refrigerator, dishwasher, clothes washer.
- **Solar:** 12.87 kW, rooftop panels.
- **Water Conservation:** EPA WaterSense fixtures, rainwater collection system.
- **Energy Management System:** PV production and usage monitoring.
- **Other:** EV charging, accessible floorplan, doorways. No-VOC paint, cabinets.

Photos courtesy of TC Legend