

Price king. TC Legend Homes specializes in houses that are affordable and high performing in terms of affordable energy and HVAC usage. How does TCL do it? By using the same construction methods from home to home, which lowers construction costs.

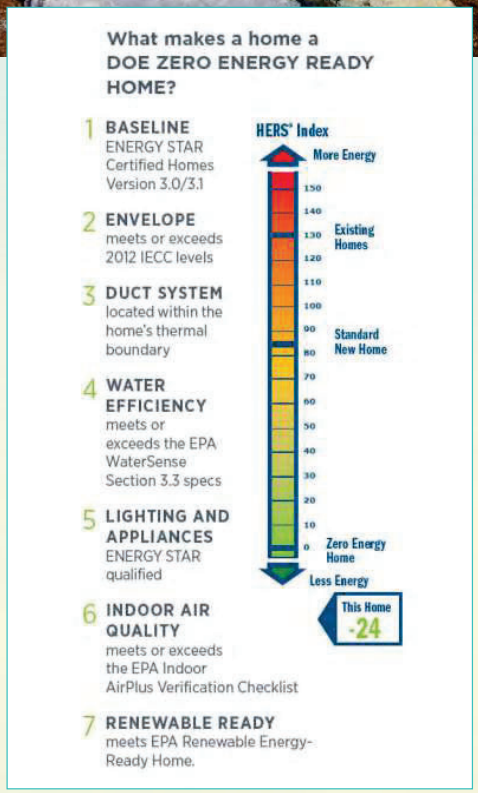
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Project Info

PROJECT NAME: Lynden Powerhouse, Lynden, California

BUILDER: TC Legend Homes, Bellingham, Washington, tclegendhomes.com

COMPLETED: September 2023





A Certified Champion

Affordable, efficient and award winning. What's not to like?

It seems that the more innovative TC Legend Homes becomes, the more the company values simplicity. Simplicity of design has been a key to success for this 12-time winner and now 6-time grand winner in the U.S. Department of Energy (DOE)'s Zero Energy Ready Home (ZERH) Innovation Awards competition, according to company founder and president Ted Clifton. "It's what enables us to make homes that are affordable and incredibly high performing," he says.

While the going rate for custom homes in the Bellingham, Washington, market is $350-$550 per square foot, Clifton is building for $300 per square foot. Clifton achieves this low cost with a tried-and-true building envelope and consistent HVAC package that also meets the criteria of the DOE ZERH certification. The criteria also provides homeowners with net zero power bills through a combination of solar panels and battery storage that can power the home and an electric vehicle or two.

The Bellingham custom home builder has been constructing houses in the northwest corner of Washington state since 1991, honing construction methods he learned from his father, Ted Clifton of Clifton View Homes in Coupeville, Washington. Like his father, Clifton has sought to achieve DOE ZERH certification on every home he builds since founding TC Legend Homes in 2015.

PIECING THINGS TOGETHER

One way Clifton simplifies construction is to use the same construction methods from home to home. Every house is constructed with a structural insulated panel (SIP) wall and roof assembly, and an insulated concrete form (ICF) foundation.

The walls consist of 6.5-inch-thick SIP panels (two half-inch layers of OSB sandwiching a fully adhered 5.5-inch layer of graphite-enhanced expanded polystyrene [GPS]) that provides a wall with an R-29 insulation value, and exceptional wind and seismic resistance. Some builders use dimensional lumber to connect their SIP panels; Clifton uses insulated splines which, together with the continuous layer of GPS in the panels, provide a wall with almost no thermal bridging or transfer of heat between the inside and outside of the home.

Clifton did install a plastic mesh rainscreen product on this home at the homeowner's request. His preferred method of water management is a carefully applied draining house wrap with taped seams, and correctly installed siding over flanged, caulked windows with no window or corner trim. "With all that trim, you just have more seams to caulk," says Clifton. "We design in big eaves and keep it simple."

Thicker 10.25-inch R-48 SIPs are used to construct the roof. The panels are covered with a fully adhered membrane underlayment that prevents air and water leakage but is highly vapor permeable to reduce condensation in this otherwise unvented roof assembly. The locally made 24-gauge standing-seam metal roof has a lifetime warranty and allows for simple photovoltaic panel installation with very few roof penetrations.

Because of the structural strength of the walls and roof, no roof trusses are needed and all interior walls can be non-load bearing, providing for cathedral ceilings and greater design flexibility for interior spaces.

BENEATH THE FEET: A SOLID PLAN

Clifton's signature house assembly also includes a slab-on-grade foundation with an exposed insulated concrete slab floor, wrapped in an ICF stem wall. This foundation assembly encompasses three components that serve multiple functions for simplicity, labor, and cost savings.

Under the 4-inch concrete floor slabs, four inches of high-density expanded polystyrene (EPS) provides R-20 of insulation value, as well as a vapor barrier, eliminating the need for a vapor retarder and capillary break under the slab. The EPS also provides a warm bed for the radiant heating coils that are covered with the poured concrete slab.

The slab is surrounded by 11.23-inch-thick ICFs consisting of two 2.625-inch layers of rigid foam providing an insulation value of R-24 and a stay-in-place form to hold the steel rebar and 6 inches of poured concrete. The foam separates the concrete slab from these concrete stem walls, virtually eliminating heat transfer through the slab edge. The concrete floor slabs themselves are usually sealed, stained, and polished to serve as durable, water-resistant flooring.

The exposed concrete slab also provides thermal mass that absorbs sun through large south-facing windows to provide a passive heating source. Extended roof eaves on the south side of the home allow in low winter sun while keeping out high summer sun.

Reasonably priced vinyl-framed triple-pane windows from a nearby British

Annual Energy Costs	Annual Energy Cost Savings*	Annual Energy Savings	Savings in the first 30 years
$1,100 (without PV)	$1,850 (without PV)	11,650 kWh (without PV)	$77,350 (without PV)
$100 (with PV)	$3,700 (with PV)	31,950 (with PV)	$155,600 (with PV)

* vs typical new homes

Key Features

AIR SEALING: 0.45 ACH50. All SIP panel joints are double-bead mastic sealed. Interior panel seams are taped. Window and door rough openings are foamed. All penetrations are sealed with foam. The whole house is air sealed with aerosolized acrylic.

APPLIANCES AND LIGHTING: LED lighting, ENERGY STAR appliances.

ATTIC: Unvented vaulted ceilings: 10.25-inch R-48 graphite EPS SIP panels.

ENERGY MANAGEMENT SYSTEM: IAQ monitoring. Filter replacement alerts.

HOT WATER: Air-to-water heat pump for combined domestic hot water and space heating, 80 gallon, 4.62 COP. Adaptive recirculation. WaterSense-labeled fixtures.

HVAC: Air-to-water heat pump, radiant floor heating, 3 fan coils, 4.62 COP.

FOUNDATION: Slab on grade with 11.25-inch R-23.6 ICF stem wall. R-20 foam under slab.

ROOF: SIPs gable roof, self-adhering breathable vapor barrier. Metal roofing.

SOLAR: 17-kW PV, 30.7-kWh batteries.

VENTILATION: 3 HRVs, one for each living space, pull from baths and laundry, supply to bedrooms and living areas. HRVs are tied to a CO2 sensor for boost and motion sensors for auto turn off. Kitchen has separate fresh air intake fan balanced to range hood fan mounted outside for quiet operation. All air intakes have HEPA filters.

WALLS: SIPs, R-29 total. 6.5-inch graphite SIPs, self-adhered breathable weather resistant membrane, plastic mesh, fiber cement siding.

WINDOWS: Triple-pane windows, U=0.16, SHGC=0.45, Low e, argon-fill, vinyl-framed. Extended roof and eaves.

OTHER: Two EV chargers and an RV charger. 5,000-gallon rainwater cistern for irrigation.



Net zero accounting. The home's 17 kWs of solar panels and 30 kWh of battery storage should provide the homeowner with $0 electric bills and enough electricity to power the home, two cars, and an RV year round.

Columbia manufacturer complete the high-performance thermal envelope. "The window package only costs us about $5,000 to $10,000 more than double-pane windows but provides a lifetime of energy savings and internal thermal stability," Clifton says. "This is going to make the home more comfortable and reduce mold issues around the window from condensation—a notorious problem in the Pacific Northwest."

INDOOR INNOVATIONS

Three heat recovery ventilators (HRVs) were installed—one for each living area—to enable separate controls when one or more spaces are unoccupied, and to prevent the spread of viruses. Air quality and humidity sensors can boost air flow through the HEPA-filtered HRVs. The kitchen has its own exhaust fan, balanced with a HEPA-filtered fresh air intake powered by a fan located outside. It has a silencer for quiet operation "so it will get used," notes Clifton.

The ventilation system also supports the heating system. The main supply duct for each of the three HRVs contains a coil from the air-to-water heat pump that cools or heats the air before distributing it throughout the home, based on the temperature needs. The air-to-water heat pump is equipped with a variable-speed compressor and provides very efficient heating and cooling (at 4.62 COP) via radiant loops in the floor, fan coil units in each of the main living spaces, and HRV supply ducts to the living areas and bedrooms.

"When paired with the highly insulated envelope and thermal mass floors, the home stays remarkably consistent in temperature, both across the home and throughout the year. There is no need for daytime setbacks. Set your desired temperature once and the home will maintain it round the clock," says Clifton. "This HVAC and envelope design work together to reduce overall energy demands and are easily replicated, creating efficient and comfortable buildings time and again."





"We use the same mechanical closet in every house we build," Clifton says. "I have a cut sheet (layout) so the electrician knows exactly where to put the electrical and the plumber knows exactly where to put the piping. I've gotten the cost down to $35,000 for everything in the mechanical room. That's the same price I paid for a much less efficient system in 2011. Equipment costs have gone up $10,000, but our labor has gone down $10,000. All of the equipment is in the same spot every time. I use the same materials list too. We can do it in a day. On other builders' homes, you'll sometimes see the HVAC guys there for a week."

DONE BY DESIGN

For Clifton, the biggest energy and cost savings come from the design of the building itself. Most of his homes are a basic rectangle. The 2024 award-winning home was essentially three side-by-side rectangles. The homeowners wanted to get two families and their guests under one roof. The house and an ADU are on the main level and three bedrooms, a rec room, and two baths were added above the ADU for visiting family members. "The Lynden house was a fun design challenge," said Clifton. "We tried several designs starting at $2.4 million for construction costs and got it down to $1.2 million."

Simplifying the design often means reducing the number of corners, which reduces costs and energy losses. "Adding a corner can easily add $30,000 to the cost of construction," said Clifton. "You have more air sealing and water management details, more thermal bridging, more exterior wall surface, and more risk of failures."

Clifton also advocates simple roof lines with a monoplane shed roof, a symmetrical gable, or an asymmetrical gable, which enables clerestory windows to bring sunlight into the interior of the home. "You can add details to differentiate the house but add them outside of the thermal envelope, like decks and porches," Clifton says. "I'd rather stick to the rectangle and put a cool timber-framed porch on the outside. Instead of putting our money into complicated wasteful shapes and expensive tricky details, we put our money into PV and EVs."

Clifton is so passionate that he started his own design company, Powerhouse Designs, and now does all of the design work for his custom homes in-house. In typical custom construction, an architect draws up the plans, then hands them to an engineer who specifies materials to meet structural load and then hands the plans and specs to the builder. "The problem is the architect and engineer have no idea how much things cost," Clifton explains. "When we used to build other people's designs, it used to frustrate me so much. The architect or engineer might specify a $2,000 glue-lam beam when $600 worth of lumber could carry the load."

The question: Could reducing the window size 10 percent save a lot without sacrificing view? "We went through one house that had been designed by someone else and specified it as drawn," Clifton says. "We then started making changes and were able to save $50,000 on construction costs by making tradeoffs."

Cost cutting is key, Clifton notes. "We work with our homebuyers and show them the costs of different options so they can see where they can save and choose where they want to spend more money," he says. "And they still get all the performance benefits of a DOE ZERH."

