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.
The home owner will be a winner for the long term as well. Projected annual utility savings are $2,763 not counting the solar electric system, or $6,958 when the solar system is included.

One reason for the exceptional performance is the high level of air sealing Dykins was able to implement. The house achieved a whole-house air tightness of 0.57 air changes per hour at 50 Pascals of pressure difference (ACH 50).

Dykins constructed a 2x6 16-inch on-center advanced framed home with open, three-stud corners, ladder blocking at intersecting walls, and fewer studs around the windows. Before the exterior sheathing was installed, Dykins applied a gasket around the floor framing just above the foundation. Then he applied a continuous bed of construction adhesive between the subfloor and the bottom wall plate. Sprayer-applied sealant was used anywhere two studs came together, between the top and bottom plates and studs, and along the top and bottom plate to form a gasket when the drywall was installed so the whole wall assembly was air sealed from the inside. On the exterior, Dykins taped the coated sheathing to the foundation with a proprietary air sealing tape.

The wall cavities were filled with 5.5 inches of blown-in fiberglass (R-4.4/inch or R-24 total). The walls were wrapped in a coated sheathing with taped seams over which was installed two 1.5-inch layers of rigid mineral wool. This mineral wool keeps the dew point temperature outside of the sheathing. The mineral wool insulation repels water but is vapor permeable so it won't trap moisture. Vertical strapping was installed over this insulation to form a drainage plane under the fiber cement siding. The total insulation value for the wall assembly is R-35. The sill plate up to the bottom of the subfloor was insulated with 2-pound spray foam insulation. The window sills were pitched to drain out. “Everything needs to flow out. The biggest causes of building failure today are relying on caulk and not understanding that water runs down hill,” said Dykins.

Dykins uses a metal aluminum roofing with an estimated life of 75+ years that is able to withstand 120-mph wind, is made in the USA of 95% recycled content, and is 100% recyclable. Under the roofing, he installs a breathable, waterproof underlayment that allows any condensation on the sheathing to evaporate. A third water control layer is provided by the taped, coated sheathing.
Another framing enhancement that Dykins installs is to put floor joists above the second floor then install a rim joist over that, then another set of floor joists (almost like a third floor. The rafters are 1.5 feet above the second floor, then insulation is added between them. This helps stop ice dam formation.

Dykins insulated along the underside of the roof deck with 5 inches of 2-pound closed-cell spray foam in the vaulted roofs and 6.5 inches of blown fiberglass for a total R-value of R-58. The attic is all in the heated space of the house. Above the attic areas, 7 inches of 2-pound spray foam was blown into the 12-inch roof rafters then the rafters were filled with an additional 5 inches of blown in fiberglass for the rest of the 12 inches. Then the whole attic was sheet rocked on the underside of the roof line for a fire break. The insulated attic provides a conditioned space for mechanical systems and ductwork.

The home’s full basement is 80% below grade and is constructed of 14-inch-thick foundation walls that are insulated in the center of the concrete with 4 inches of XPS (R-5 per inch or R-20 total) between an exterior 6-inch thick concrete bearing wall and an interior 4-inch concrete thermal mass wall. The basement slab sits on R-17 of rigid fiberglass foam insulation consisting of a 3-inch layer and a 2-inch layer (5 inches total, at R-3.4/inch). Dykins describes the fiberglass foam as non-degrading and impervious to insects and fire. The foam sits on 10 inches of crushed gravel with a passive radon system including vent pipe that goes through the conditioned space and vents through the roof. A 20-mil vapor barrier sits on top of the insulation, laps up the sides, and is taped to the foundation walls.

The home exceeds 2012 International Residential Code requirements for wind loads. Steel rods in the foundation wall tie from the footing through the foundation walls to the rafters. The house is locked down safe from high winds, with four rods on every long wall where rafters sit and a few rods in other walls (20 rods total).

A ground source heat pump provides high-efficiency heating and cooling with a COP of 4.40 and an EER of 29.5. The system includes two vertical wells with 635 feet of total length that circulate fluid through the ground, providing a means to absorb heat from the soil in winter or discharge heat to the soil in summer. The ground source heat pump is used to heat air that is distributed via a central air handler and all ducts are in conditioned space.
The ground source heat pump’s central air handler circulates fresh incoming air that is brought into the home by an energy recovery ventilator. The ERV pulls air separately from the bathrooms and exhausts it outside, recovering heat from the exhausted air with a 52% total recovery efficiency. The ERV is equipped with a MERV 13 filter.

A desuperheater on the ground source heat pump provides all of the hot water the home needs when operating to cool the house during the summer. In the winter, the desuperheater pre-heats water and a heat pump hot water heater finishes heating the water to full temperature. Factory-insulated PEX tubing is used to distribute the hot water directly to uses for reduced heat loss. An on-demand hot water recirculation system is integrated into the plumbing to stop warm water from being wasted when waiting for hot water to arrive at the faucet. All of the home’s plumbing fixtures are EPA WaterSense labeled.

The home has several disaster-resistant features including the steel tie downs in the exterior walls, fire-resistant metal roofing, cement siding, and moisture-resistant mineral wool insulation. The homeowner requested some above-code disaster-resistance features: a storm shelter constructed to FEMA standards has been constructed in the basement and all windows use tempered glass for forest-fire resistance.

The 13.8-kW solar photovoltaic (PV) array is not roof mounted but is mounted on a steel pole with dual-axis rotation to follow the sun for 73% more electrical power generation than a fixed system. Each garage parking bay is equipped with an electric car charging station. The home owner is producing six times more power than he is using. The homeowner, an electrical engineer who works in the power transmission industry, hopes to take advantage of Connecticut’s deregulated electric utility industry to start selling power to other users on the grid as an energy provider.

Even without the solar power, the homeowner is expected to enjoy low utility bills, considering the size of the house and the cold climate location. For Dykins, this proves his philosophy that “you don’t have to go crazy installing expensive equipment to build a better house, you just have to understand a few key concepts and do the details right.”

Photos courtesy of Glastonbury Housesmith