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

DOE ZERO ENERGY READY HOME™

U.S. DOE ZERO ENERGY READY HOME 2015 WINNER Housing Innovation Awards

Glastonbury Housesmith

Hickory Drive
South Glastonbury, CT

BUILDER PROFILE

Glastonbury Housesmith, LLC
South Glastonbury, CT
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www.glastonburyhousesmith.com
Rater: Steven Winter Associates
Karla Donnelly, kdonnelly@swinter.com

FEATURED HOME/DEVELOPMENT:

Project Data:

- Name: Hickory Drive
- Location: Glastonbury, CT
- Layout: 4 bedrooms, 4 baths, 2 floors, finished basement
- Conditioned Space: 4,288 ft^2
- Climate Zone: IECC 5A, cold
- Completion: April 2015
- Category: Custom

Modeled Performance Data:

- HERS Index: without PV 29, with PV -23
- Projected Annual Utility Costs: without PV $2,331, with PV $-1,864
- Projected Annual Energy Cost Savings (compared to a home built to the 2009 IECC) without PV $2,763, with PV $6,958
- Builder's Added Cost Over 2009 IECC: without PV $20/ft^2, with PV $38/ft^2
- Annual Energy Savings: without PV 11.1 MMBtu, with PV 90.6 MMBtu

A college summer job renovating old houses taught builder Bob Dykins some important lessons for building new houses. Dykins went to college to study yacht design and mechanical and civil engineering, but it was his summer job working with a remodeler to take apart and restore 300-year-old houses around Newport, Rhode Island, that taught Dykins what works and what fails in house construction over the long term.

Dykins has put those lessons to work in his first home built to the U.S. Department of Energy's Zero Energy Ready Home program criteria, a 2-story plus basement, 4,288-ft^2 colonial style custom home in South Glastonbury, Connecticut. The home was third-party tested by DOE research partner Steven Winter Associates and achieved a remarkably low Home Energy Rating System (HERS) score of 29 without photovoltaics, or -23 when the 13.8-kW solar electric system is included.

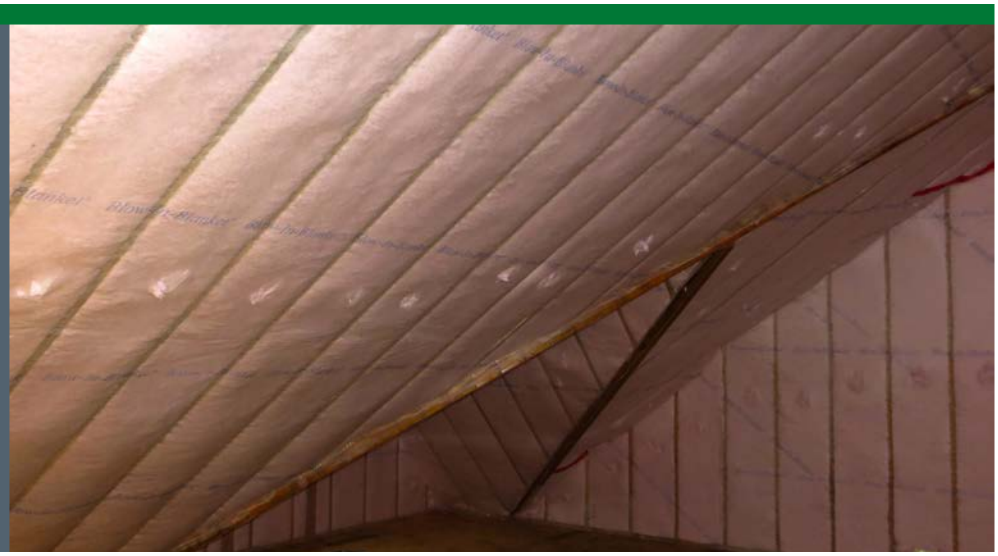
The DOE Zero Energy Ready Home program requires homes to meet all of the requirements of ENERGY STAR Certified Homes Version 3.0 and the U.S. Environmental Protection Agency's Indoor airPLUS, as well as the hot water distribution requirements of the EPA's WaterSense program and the insulation requirements of the 2012 International Energy Conservation Code. In addition, homes are required to have a solar electric system installed or have the conduit and electrical panel space in place for it.

In addition to meeting these DOE standards, the home also achieved a National Association of Home Builders (NAHB) National Green Building Standards emerald level and was selected as a CT Zero Energy Homes Challenge 2014 Grand Winner (the first builder to win in three out of four judging categories in the state- and utility-sponsored competition). He also pursued LEED for Homes at the home owner's request and achieved a platinum level. Dykins constructed the first LEED gold certified home in Connecticut in 2007.

ZERO ENERGY READY HOME U.S. DEPARTMENT OF ENERGY

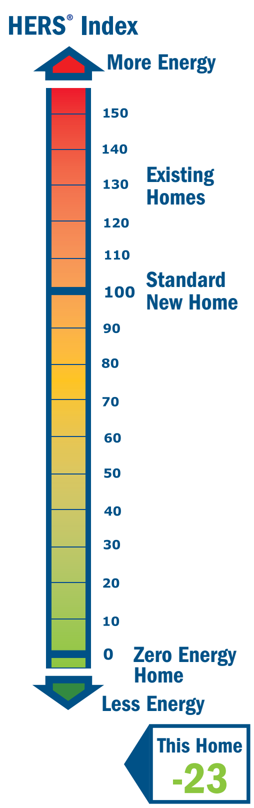
The U.S. Department of Energy invites home builders across the country to meet the extraordinary levels of excellence and quality specified in DOE's Zero Energy Ready Home program (formerly known as Challenge Home). Every DOE Zero Energy Ready Home starts with ENERGY STAR Certified Homes Version 3.0 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.

Glastonbury Housesmith provided extensive insulation and air sealing in the two-story home they built in western Connecticut to the performance criteria of the U.S. Department of Energy's Zero Energy Ready Home program. The builder insulated the underside of the roof decking with 5 inches of closed-cell spray foam plus 6.5 inches of blown fiberglass then spray foamed the rim joists after sealing all wood-to-wood joints with sprayer-applied sealants and installing sealant along top and bottom plates to form a gasket between the plates and the dry wall.



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 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.

The 2x6 walls are filled with 5.5 inches of blown fiberglass, then sheathed with a coated OSB that is taped at all seams to form an air and weather barrier. This is covered with two 1.5-inch layers of mineral wool insulation then 1x3 furring strips to provide an air gap and drainage plane under the lapped fiber cement siding. The wall has a total R-value of R-35.

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.

HOME CERTIFICATIONS

DOE Zero Energy Ready Home Program, 100% commitment

ENERGY STAR Certified Homes Version 3.0

EPA Indoor airPLUS

EPA WaterSense

LEED for Homes, platinum level

National Green Building Standards, emerald level

CT Zero Energy Homes Challenge 2014 Grand Winner

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.

The 14-inch-thick foundation walls include a 4-inch XPS (R-20) rigid foam core, sandwiched between layers of concrete.

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-resistent 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

KEY FEATURES

- **DOE Zero Energy Ready Home Path:** Performance
- **Walls:** Advanced framing; 2x6 24″ on center; open 3-stud corners; right sized headers; ladder blocking at intersecting walls; 5.5″ blown-in fiberglass cavity insulation; taped coated sheathing; 2.75″ rigid mineral wool; .75″ vertical furring drainage plane; fiber cement siding; spray foam from sill to floor joists. Total wall R-35.
- **Roof:** Breathable waterproof underlayment; taped coated sheathing; metal roofing.
- **Attic:** Sealed and conditioned attic; 5″ closed-cell spray foam (R-35); 6.5″ blown-in fiberglass (R-58); insulated on underside of roof.
- **Foundation:** 10″ concrete basement walls; 4″ XPS foam (R-20); rigid fiberglass on slab edge (R-20), rigid fiberglass under slab (R-17).
- **Windows:** Triple-pane; argon-filled; aluminum-clad wood frame; low-e; U=0.23-0.26.
- **Air Sealing:** 0.57 ACH 50.
- **Ventilation:** ERV; MERV 13 filters.
- **HVAC:** Geothermal heat pump; COP 4.4; EER 29.5.
- **Hot Water:** Heat pump water heater; desuperheater.
- **Lighting:** 100% LED.
- **Appliances:** ENERGY STAR-rated refrigerator, clothes washer, dishwasher, heat pump dryer, induction cooktop, and ceiling fans.
- **Solar:** 13.8 kW; rotates on pole.
- **Water Conservation:** All EPA WaterSense-rated fixtures.
- **Other:** Electric charging stations; storm shelter; gravity-fed rainwater irrigation.

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