

DOE ZERO ENERGY READY  
HOME™ CASE STUDY**BPC Green  
Builders**

New Fairfield, CT

**BUILDER PROFILE****BPC Green Builders**

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**FEATURED HOME/DEVELOPMENT:****Project Data:**

- Name: Candlewood Hills Rebuild
- Location: New Fairfield, CT
- Layout: 3 bedrooms, 3 baths, 2 floors
- Conditioned Space: 3,052 ft<sup>2</sup>
- Completion: Dec. 2012
- Climate Zone: 5A
- Category: Custom

**Performance Data:**

- HERS Index without solar PV: 39
- HERS Index with solar PV: NA
- Projected annual utility costs (without solar): \$2,648
- Projected annual energy cost savings (compared to a home built to the 2006 IECC, without solar): \$2,817
- Annual energy savings: 11,700 kWh, 229 gallons propane

A difficult decision to tear down a 60-year old lakeside bungalow led to construction of a U.S. Department of Energy Zero Energy Ready Home-certified, LEED platinum home that takes energy efficiency to new heights in New Fairfield, Connecticut. Owners James Gainfort and Hayden McKay learned the old home's block walls would not support the second-story addition they hoped to add to take advantage of views of Candlewood Lake and to increase storage space in this escape-from-New York weekend retreat that will one day be their year-round retirement home. So the husband and wife architects decided to make the most of the situation, tearing down the old, asbestos-tiled building to the foundation slab, salvaging everything possible, and designing a new, modern two-story home that captures commanding views, lots of daylight, and significant energy savings.

The couple hired local builder BPC Green Builders to construct the home, which was completed in December 2012. When they moved in, they immediately noticed how comfortable and quiet the home is. "We can turn the heat down to 55°F while we are gone during the week and it takes five days to drop from 70 to 62°F," said McKay. The home's double-wall construction and triple-pane glass windows also keep it very quiet inside. "We don't hear anyone's weed whackers or snow blowers."

McKay, who is an architectural lighting designer, was concerned that the triple-pane windows' two layers of low-emissivity coating would block out too much light but she said the coating is barely noticeable to the eye, although it's certainly contributing to the projected \$2,817 in annual utility bill savings.

The home achieved a low Home Energy Rating System (HERS) score of 39 without photovoltaics (PV). The home's flat roof has been structurally reviewed, an inverter location has been identified, and conduit has been installed for the addition of solar panels at some future date. If a 9-kW PV system were added, the solar power production would offset energy use to bring the home very close to net zero with a HERS score of 2.



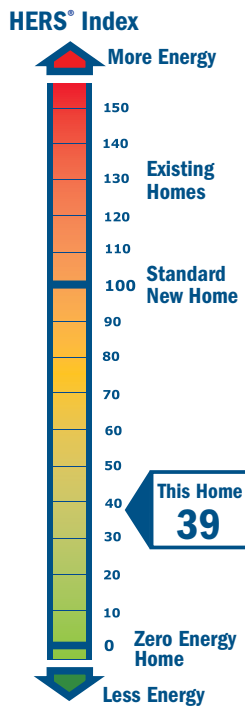
The U.S. Department of Energy invites home builders across the country to meet the extraordinary levels of excellence and quality specified in DOE's Zero Energy Ready Home program (formerly known as Challenge Home). Every DOE Zero Energy Ready Home starts with ENERGY STAR for Homes Version 3 for an energy-efficient 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.

Rigid foam insulation covered the slab foundation, which included some old existing slab plus a new poured slab. The rigid foam also lined the interior and exterior of the foundation walls, providing a snug thermal break and moisture protection for first-floor radiant heating loops, which were set in 2 inches of gypcrete.



**DOE ZERO ENERGY READY HOME CERTIFIED:**

- 1 BASELINE**  
Certified ENERGY STAR home
- 2 ENVELOPE**  
meets or exceeds 2012 IECC levels
- 3 DUCT SYSTEM**  
located with 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 Solar Electric and Thermal Checklists



The highly insulated roof has R-33 of blown cellulose between the ceiling joists, plus R-39 of rigid insulation installed above the roof sheathing for a whopping R-72 insulation value. The isocyanurate foam is protected with an adhered cover board plus a modified bitumen roof membrane. The roof surface is slightly tapered to direct water to two drainage points, where stainless steel piping carries the rainwater to two outdoor cisterns, 1,000 gallon and 750 gallon, for garden irrigation.

The double-wall construction consists of a 2x6 24-inch on-center outer wall and a 2x4 24-inch on-center inner wall spaced 0.5 inches apart with staggered studs to provide a 9.5-inch cavity that was filled with R-33 of blown cellulose. The outer wall was sheathed with CDX plywood, covered with a layer of vapor-permeable, self-adhered, air- and water-barrier house wrap over which were installed 1x3 furring strips and fiber cement siding.

Some portions of the old slab were removed and replaced with new concrete slab. Then a liquid gypsum material was poured over both the new and old slab to level the surface. This was covered with R-20 (4 inches) of extruded polystyrene (XPS) rigid foam insulation. The radiant floor tubing was installed on the XPS and 2 inches of gypcrete was poured over this as a base for the tile floors. Rigid XPS (R-15) was installed along the foundation walls, 3 inches thick on the exterior and 1.5 inches thick on the interior, before the slab was poured.

The highly insulating envelope was also heavily air sealed with all holes, joints, and cracks caulked or filled with spray foam. The DOE Zero Energy Ready Home program requires that every home be tested for air leakage with a blower-door test. BPC Green Builders achieved a very low score of 0.45 air changes per hour at 50 Pascals pressure.

To ventilate the super-tight structure, an energy recovery ventilator (ERV) was installed that supplies fresh air to the central air handler through a MERV 11-rated media filter. The ERV pulls stale air from the bathrooms. The homeowner noted that the ERV was incorrectly set to run continuously on high when it was initially installed, causing higher than necessary heating bills this past winter. The ERV is now turned off during the week while the homeowners are away.

The 3,000-square-foot home is heated and cooled by an air-source heat pump with a heating efficiency of 9.2 HSPF and a cooling efficiency of 18.8 SEER. Duct leakage to the outside was nearly zero, while total duct leakage was 4 cfm/ft<sup>2</sup> of conditioned living space.

A 90% AFUE propane boiler with a 40-gallon tank provides additional heat to the first floor via radiant heating loops in the floor. The boiler also provides domestic





Nearly every room and closet in the home receives natural light through triple-pane low-emissivity windows or insulated solar tubes. Extra attention to air sealing helped the home achieve a very low air leakage rate of 0.45 ACH 50.

hot water. A compact layout for the plumbing lines and R-4 pipe insulation increase hot water efficiency. Although not yet installed, plans were drawn for a roof-mounted solar thermal water heating system, which may be installed at a future date.

Every room in the home has natural daylighting via windows or solar tubes, including every closet but one—the closet under the stairs. All but one fixture in the home use LED or CFL bulbs; most are screw-based fixtures to accommodate future improvements in light sources. McKay designed the home's lighting plan, which includes 35 different lighting zones. Indirect lighting above built-in shelves is set by timers to consist of brighter lighting in the morning and warmer tones in the evening to encourage the occupants to wake up and feel sleepy at appropriate times. All of the actual dimmers and switches are high up in the closet, but 7-button, 1-gang controllers were installed on the walls to lump controls into fewer switch plates.

Water is a concern on the site, where well water can run low in the summer. The lot also has a small septic system. To reduce water consumption, the home's plumbing system includes central manifold piping, dual-flush toilets, and low-flow bathroom faucets that are fitted with push button-operated hot water recirculation systems. One of the home's two utility rooms houses a 400-gallon water storage tank that is filled with potable water in the spring, in case extra water is needed during the dry summer months.

Native drought-tolerant plants reduce irrigation needs in the summer. All stormwater is collected on site in rainwater cisterns. Overflow is directed to rain gardens on both sides of the house. Other "green" features include the use of low-VOC sealants, caulks, adhesives, primers, and paints. Patio and walkway materials are locally sourced or repurposed from the original structure. Maple flooring, the cast iron whirlpool bathtub, cabinets, sinks, door handles and hardware, and concrete block from the old home were reused on site. Usable doors, windows, skylights, cabinets, and appliances that weren't kept for the new home were donated for reuse in other buildings. Clean debris was separated off site for recycling or disposal and asbestos and lead in the original structure were properly disposed of.

An enclosed, insulated but unheated sun room with double-pane glass windows provides a buffered space for enjoying the views and natural light during the cold-season daylight hours. The space is separated from the home using the same double-thick wall construction as the rest of the home's exterior walls.

## HOME CERTIFICATIONS:

DOE Zero Energy Ready Home

Connecticut Zero Energy Challenge  
Home third-place winner

ENERGY STAR Version 3

EPA Indoor airPLUS

LEED for Homes, Platinum  
(anticipated)



Every DOE Zero Energy Ready Home combines building science specified by ENERGY STAR for Homes and advanced technologies and practices from DOE's Building America research program.



The exterior sheathing of the home was wrapped with a self-adhering vapor-permeable house wrap that serves as a weather-resistant air and water barrier. Furring strips were installed over this barrier allowing it to serve as a drainage plane for any bulk water that manages to get past the fiber cement siding.

We are focused on all of the performance criteria (energy efficiency, indoor air quality, comfort, safety, durability, and reduced maintenance). For us the starting point is always building science. I can't imagine building to anything lower than ENERGY STAR. When you add the cash rebates, it makes even more sense. It ought to be the minimum starting point for any builder."

The Trolles have won several awards from the Home Builders Association of Connecticut, including two best new green home builder awards and one best green renovation award. They've built several LEED homes and are currently working on a home that will meet the Passive House standard.

In addition to certifying as a DOE Zero Energy Ready Home, the house was a third-place winner in the Connecticut Zero Energy Challenge ([http://www.ctzeroenergychallenge.com/participant\\_overview.php?ID=bpcgreenmckay](http://www.ctzeroenergychallenge.com/participant_overview.php?ID=bpcgreenmckay)). Trolle worked with Karla Donnelly of Steven Winter Associates, a Building America research team member, to perform the inspections, testing, and energy modeling and to submit the home for Challenge Home and LEED certifications. Trolle anticipates a LEED platinum rating on the house based on Steven Winter Associates' modeling.

"People have all sorts of misconceptions about the sacrifices they have to make in high-performance homes and it's exactly the opposite. The even temperatures, the lack of drafts, the feelings of warmth and comfort, and the right levels of humidity and fresh air are all unrivaled. The comfort is something you've never experienced properly in a home until you have a high-performance home." said Mike Trolle.

"This will be our retirement house," said McKay. "Our goals were to have the tightest envelope and the most efficient systems we could, for the long run."

Custom builders and remodelers Mike and Chris Trolle were entirely supportive of the homeowners' energy-efficiency goals. Mike Trolle founded BPC Green Builders in 1998 with the goal of doing energy-efficient construction and his brother Chris, an engineer, soon joined him.

"We market ourselves as green builders, with performance as the biggest focus, especially energy efficiency. Different customers are interested in different aspects of green," said Trolle. "Some are concerned about the environment, some are more interested in energy efficiency, some see it as a path to a better quality home, many are concerned about health and worried about chemicals so they think green material selection is important."

## KEY FEATURES

- **Path:** prescriptive
- **Walls:** double-wall construction: 2x6 outer wall, 2x4 inner wall with offset studs; 9.5" (R-33) blown cellulose. CDX plywood sheathing, with self-adhered, vapor-permeable air and water barrier house wrap, 1x3 furring strips, fiber cement siding
- **Roof:** flat roof with R-72 total: R-33 cellulose between ceiling joists, plus R-39 isocyanurate rigid foam insulation over sheathing, covered with modified bitumen membrane above the roof sheathing
- **Foundation:** R-20 (4 inches) XPS rigid foam insulation over existing slab and under new slab. 3 inches (R-15) XPS exterior, plus 1.5 inch (R-7.5) XPS on interior of foundation walls
- **Windows:** triple-pane, argon-filled, low-e coated fiberglass-framed, U=0.20, SHGC=0.31
- **Air Sealing:** 0.45 ACH50
- **Ventilation:** ERV supply connected to HVAC air handler; return from bathrooms. MERV 11 media filter at air handler located between the ERV and the return plenum
- **HVAC:** 9.2 HSPF/18.8 SEER heat pump, plus 90% AFUE propane boiler with 40-gal tank, for first-floor radiant heat and domestic hot water
- **Hot Water:** 90% AFUE propane boiler
- **Lighting:** almost 100% LED and fluorescent; wireless lighting controls
- **Appliances:** ENERGY STAR-rated dishwasher, clothes washer, and refrigerator.
- **Solar:** solar ready with conduit installed; inverter location identified; flat roof with structural review for PV installation
- **Water Conservation:** 1.5-gpm WaterSense faucets, dual-flush toilets, 100% roof rainwater harvesting
- **Other:** 88% recycling of construction debris; reuse or recycle of existing building components; native drought-tolerant plants; locally sourced pavers