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

DOE ZERO ENERGY READY HOME™

U.S. DOE ZERO ENERGY READY HOME 2016 WINNER *Housing Innovation Awards*

Revival Homes

Perkins Road House
Litchfield, CT

BUILDER PROFILE

Revival Homes, New Hartford, CT
David Jones, david@revivalhomes.net
860-307-1794, www.revivalhomes.net
Rater: Steven Winter Associates
Matt Slattery
mslattery@swinter.com

FEATURED HOME/DEVELOPMENT:

Project Data:

- Name: Perkins Road House
- Location: Litchfield, CT
- Layout: 3 bdrm, 2 bath, 2 fl, 1,379 ft²
- Climate Zone: IECC 5A, cold
- Completion: December 2015
- Category: affordable

Modeled Performance Data:

- HERS Index: without PV 41, with PV -12
- Projected Annual Energy Costs: without PV $1,492, with PV -$443
- Projected Annual Energy Cost Savings (vs home built to 2009 IECC): without PV $1,926, with PV $3,862
- Projected Annual Energy Savings: without PV 9,634 kWh, with PV 19,308 kWh
- Added Construction Cost: without PV $6,200

Focusing on total cost of ownership helped builder David Jones earn his first ever Housing Innovation Award from the U.S. Department of Energy for a home he constructed in Litchfield, Connecticut. The 1,380 ft² home was Jones' first to be certified to the DOE Zero Energy Ready Home program. And it was the first home that could be classified as "affordable" for the west Connecticut custom home builder whose company, Revival Homes, has built a solid reputation over 30 years of constructing high-efficiency luxury custom and antique reproduction homes.

"There is a perception that "green" or high-performance homes are something that only the wealthy can afford. We wanted to design a house that would shatter that perception, both when considering the initial cost of construction and even more importantly when considering the total cost of ownership, which we defined as initial construction costs plus energy costs plus maintenance costs," said Jones.

They chose to build the home to the criteria of the DOE Zero Energy Ready Home program. Every DOE ZERH certified home must meet the requirements of ENERGY STAR Certified Homes Version 3.0 and the U.S. Environmental Protection Agency's Indoor airPLUS program, 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 solar electric panels installed or have the conduit and electrical panel space in place for it.

Jones joined forces with architect Kate Briggs Johnson of Responsive Designs and the DOE Building America research team led by Steven Winter Associates to come up with an affordable high-efficiency design for the Connecticut climate that met the DOE program requirements. The home owners were enthusiastic about the approach as their primary design goal was also to minimize the total cost of ownership.

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.

Revival Homes of New Hartford, Connecticut, built this 1,379-ft² home to the high performance requirements of the U.S. Department of Energy Zero Energy Ready Home program. The home has ENERGY STAR-rated appliances, a ventless heat pump clothes dryer, and LED lighting. The home's triple-paned, vinyl-framed, low-e windows have EDPM gaskets and PVC pan flashing for durability. Solar-powered skylights flood the upstairs with natural light and can be programmed to open for night cooling. Sensors trigger them to close if it starts to rain.

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

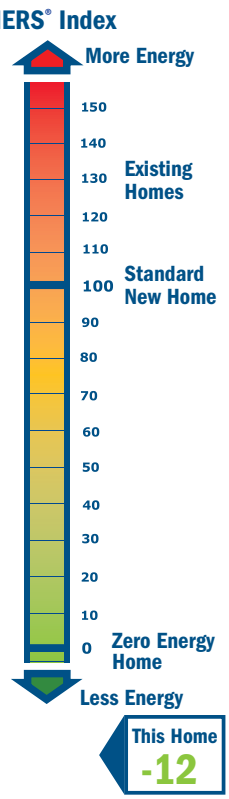
3 **DUCT SYSTEM**
located within the home's thermal boundary

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.



Jones and his team were so successful with the home's compact design and highly efficient shell that, with the addition of a 7.6-kW solar photovoltaic system, the home achieved a Home Energy Rating System (HERS) score of -12. In other words, the home will produce more power than it uses in a year. The home owners should have $0 electric utility bills and should have enough surplus to power an electric car as well. Even without PV, the home would achieve a HERS score of 41, well below the 80 to 100 typical of new code-built construction. Jones achieved all of this at a cost of about $135/ft² including the PV.

The resulting design was a two-story Cape Cod style three-bedroom two-bath home with a simple floorplan and a small footprint. The home's concrete slab floor was poured and finished before any interior walls were added. The house is only 26 feet at its widest point allowing the second-floor joists to be clear-spanning open-web trusses that don't require interior supports. These two features allow interior walls to be moved easily in the future if uses for the rooms change over time. Spare conduits were also installed to accommodate electrical and plumbing for a solar thermal water heating system if one is desired in the future. Jones notes this adaptability is important for a home he expects to last several hundred years.

To achieve the very efficient building enclosure at a low cost, Jones asked his design team to "think outside the box." For the first-floor walls they chose pre-cast structural concrete wall panels, which are usually used for basement walls. The panels are factory-made with an R-12.5 layer of rigid XPS foam insulation adhered to the 2.5-inch-thick layer of concrete and EPS foam wrapping the concrete studs, which are set at 20 inches on center and faced with a steel surface to nail drywall to. The wall cavities are filled with R-23 mineral wool batts then covered with ⅝-inch fire-code drywall and plaster. The unfaced mineral wool batt is fire-, moisture-, and pest-resistant and dense enough to be cut with a saw for a precise fit with RESNET Grade 1 installation quality. All of these components together provide thermal mass walls with an insulation value of R-35.5.

The second floor has walls on the gable ends only. These walls are made with structural insulated panels (SIPs), which consist of two sheets of OSB sandwiching a layer of expanded polystyrene (EPS) rigid foam. The SIPs used on these walls were 10.5 inches thick, providing an R-39 insulation value. A ⅝-inch fire-code drywall was installed over the SIPs and covered with ⅛-inch natural plaster to serve as the inside wall surface while providing additional thermal mass. On the exterior, a dimpled house wrap product covers the SIPs, providing a rainscreen and weather-resistant barrier behind the vinyl shingle siding.

The first-floor walls were made with pre-cast structural concrete wall panels, consisting of R-12.5 of rigid XPS foam adhered to a 2.5-inch layer of concrete. EPS rigid foam wraps the concrete studs which are faced with a steel nailing surface. The structural concrete serves as the exterior wall surface. No additional siding is attached. The durable surface needs no painting and is practically maintenance-free.

The roof is also made of 12.25-inch-thick SIPs that provide R-45 of insulation. Because the building was no more than 26 feet at its widest point, the roof needed no ridge beam or rafters; the SIPs themselves provide all of the structural support, simplifying air sealing and reducing labor and material costs. The entire roof is covered with self-adhered membrane, which provides air sealing as well as a leak barrier should the 130-mph-rated shingles ever blow off in a storm. Jones used large SIP panels (8 feet by 22 feet) which enabled quicker assembly with fewer seams to seal. All SIP joints were sealed with a two-part spray foam injected under pressure to fill the entire joint. Seams were also sealed on the interior side of the house with a very tenacious air sealing tape. These air sealing measures plus the solid panel construction reduced air leakage in the home to 0.76 air changes per hour at 50 Pascals pressure difference, well below the 3 ACH 50 required by the 2015 International Energy Conservation Code.

One of the most unusual features of the home is its foundation, or lack thereof. The concrete first-floor wall panels sit at grade on crushed stone. Before pouring the floor slab, the builder graded the site level, dug 32-inch-deep trenches for the building's perimeter, filled them with crushed stone and continued with 10 inches of crushed stone extending across the entire house site. The concrete walls were then set in place over the trenches. Then three layers of 1-inch rigid XPS were set down within the perimeter of the walls with seams staggered and taped. The builder then stacked 8 inches (R-40) of EPS rigid foam inside the base of the wall cavities to insulate the edges of the 5-inch concrete floor slab. Before pouring the slab, he laid down a thick polyethylene vapor barrier then loops of PEX tubing that could be used for in-floor radiant heat at some future point, although at this point they are being used to pre-warm well water, as much as 10 to 15 degrees said Jones, before it reaches the hot water tank. The concrete slab was sealed and stained to provide the finished flooring for the first floor of the home.

A mini-split heat pump provides heating and cooling. Although the heat pump has only one air handler, located on the first floor, Jones monitored room temperatures over the winter and found temperatures varied less than 4 degrees from the warmest room to the coldest. The home's passive solar orientation with large south-facing windows contributes to beneficial passive solar heat gain, while the home's significant thermal mass and extensive insulation provide a buffer against temperature swings during the day and even over several days. The heating system was turned off for several weeks during the winter and Jones found the house never dropped below 50°F.

HOME CERTIFICATIONS

DOE Zero Energy Ready Home Program, 100% commitment

ENERGY STAR Certified Homes Version 3.0

EPA Indoor airPLUS

EPA WaterSense

"People just don't believe you can build a house like this for about the same cost as any other house."

—David Jones, owner
Revival Homes

ENERGY STAR

Building America
U.S. Department of Energy

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.

A ductless mini-split heat pump with one inside air handler provides all of the home's heating and cooling.

The home's heat pump hot water heater is located next to the bathrooms and laundry helping to reduce wait times at the tap. The kitchen sink is equipped with an on-demand electric hot water heater, which provides nearly instant hot water at the kitchen sink where hot water is often used in short intervals, without the complications and energy requirements of a recirculation system.

At the home owners' request, Jones added aging-in-place features like a first-floor laundry, master bedroom, and full bath with a curbless shower; the first floor is only 6 inches above grade, so its wheel chair accessible with a low ramp.

Jones felt he was also successful in meeting the clients' primary goals: to minimize the total cost of ownership (energy cost plus maintenance cost plus construction cost) and to encourage others to follow a similar path. "When total cost of ownership is considered, this house is incredibly inexpensive," said Jones. Simple finishes, factory-built components, minimal mechanical equipment, and a small footprint helped Jones achieve the low construction costs of $135 per square foot (including the solar PV system, but excluding the site, well, and septic).

"It has zero energy costs and it has extremely low anticipated maintenance costs (over the next 30 years) compared to typical homes and especially most high-performance homes," said Jones. "The ductless mini-split system is far simpler than many heating and cooling systems; it is less likely to fail, but if it were to fail, it is easier and less costly to replace than other systems. The concrete walls can't burn, rot, or support mold, and they never need painting. They will withstand bumps from lawn mowers and storm damage far better than stick-built homes covered in traditional siding. All of the exterior trim is PVC, which won't rot. The concrete floor never needs replacement. The PEX plumbing tubes won't corrode and are unlikely to freeze in the winter. We have seen the house go for weeks without the heat on in winter and not drop below 50°F."

Jones lauds the DOE Zero Energy Ready Home approach for its "comprehensive focus on energy, durability, indoor air quality, and moisture management." "Every home should be DOE Zero Energy Ready," said Jones who has committed to certifying all of his future homes through the program, starting with a cluster of new homes he is constructing with Habitat for Humanity and a local housing trust.

Photos courtesy of Revival Homes

KEY FEATURES

- **DOE Zero Energy Ready Home Path:** Performance.
- **Walls:** First floor R-35.5: pre-cast concrete wall panels with continuous R-12.5 rigid foam plus steel stud interior wall 24″ o.c. with R-23 mineral wool cavity insulation. Second floor R-10.5 SIPs, draining house wrap, vinyl shingle siding.
- **Roof:** Full self-adhered membrane, architectural shingles.
- **Attic:** R-45 12.25″ SIPs.
- **Foundation:** Concrete slab has 8″ R-40 rigid foam at perimeter and R-15 rigid foam under the floor, pre-cast concrete wall panels sit at grade on 3-foot-wide trenches filled with crushed stone and drained to daylight.
- **Windows:** Triple-pane, vinyl-framed, argon-filled, low-e windows; south facing U=0.18, SHGC=0.39, others U=0.17, SHGC=0.2.
- **Air Sealing:** 0.76 ACH 50.
- **Ventilation:** Continuous exhaust fans, auto-open skylights.
- **HVAC:** 18,000-BTU ductless SEER 21, HSPF 12 air source mini-split heat pump with single inside air handler.
- **Hot Water:** Heat pump hot water heater, electric on-demand water heater at kitchen sink.
- **Lighting:** 100% LED. Exterior lights on motion & daylight sensors.
- **Appliances:** Heat pump clothes dryer, ENERGY STAR refrigerator, dishwasher, bath fans.
- **Solar:** 7.6-kW PV.
- **Water Conservation:** EPA WaterSense-certified fixtures.
- **Energy Management System:** Programmable thermostat. Programmable skylights.
- **Other:** Electric car charging station, passive solar water preheating through concrete slab. No-VOC interior paints and finishes. Passive heating and cooling with thermal mass concrete walls and slab and ¾″ drywall. All construction debris recycled. Disaster-resistant concrete and SIP construction.

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