U.S. DOE ZERO ENERGY READY HOME 2013 WINNER Housing Innovation Awards

DOE ZERO ENERGY READY HOME™ CASE STUDY

Transformations, Inc.

Custom House
Devens, MA

BUILDER PROFILE

Transformations Inc.
Townsend, MA
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FEATURED HOME/DEVELOPMENT:

Project Data:

- Name: MassDevelopment Devens Green Zero-Energy Community Custom Home
- Location: Devens, MA
- Layout: 3 bedroom, 2 bath, 2 floors
- Conditioned Space: 3,168 ft^2 w/bsmnt
- Completion: April 2012
- Climate Zone: 5, Cold
- Category: Custom

Performance Data:

- HERS Index without solar PV: 34
- HERS Index with solar PV: -21
- Projected annual utility costs: without solar $1,499; with solar $-343
- Projected annual energy cost savings (compared to a home built to the 2006 IECC): without solar $1,221; with solar $3,099
- Annual PV production revenue: $1,842
- Annual energy savings: without solar 60 MMBtu; with solar -20.1 MMBtu

When Wes Parlee moved his family of three into their new 1,912-square-foot custom home in April 2012, he knew he'd get lower energy bills but he was still a bit surprised by the $700 check he got from his utility company less than a year later. He was used to paying $467 a month for utilities in his previous similar sized home. In the new home, the family's utilities bills have averaged a credit of $58 per month back to the homeowner. "I know it sounds funny, but it almost feels like stealing," joked Parlee. "It's amazing!"

For builder Carter Scott, "amazing" is the result of over a decade of work to build high-performance homes that achieve net-zero energy usage at prices affordable to middle-class families. Since 2009, Scott has teamed with Building Science Corporation, a research partner with the U.S. Department of Energy's (DOE's) Building America Program, to learn and apply the latest in building science techniques.

The Parlee home was one of eight high-performance homes built by Scott's company, Transformations Inc., in Devens, MA, about 50 miles west of Boston. Two have earned certifications from the U.S. Department of Energy's Zero Energy Ready Home program.

The homeowner worked with Scott on design details for the 3-bedroom, 2-bath home, which sports a New England Saltbox exterior design and a spacious open floor plan inside. The homeowners love the beautiful features like the bamboo flooring and high-end wood laminate cabinets. For the builder, it is what the homeowner can't see that counts.

All of Transformations Inc.'s production and custom homes in the Devens Green Zero-Energy Community start with the same baseline systems.

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 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.

The builder squeezed 78 photovoltaic panels on the roof. At 235 watts each, the system totals 18.33 kW and can produce all the electricity the home can use in a year with enough left over to power an electric car for 30,000 miles.

DOE ZERO ENERGY READY HOME CERTIFIED:

1 **BASELINE**
certified ENERGY STAR for Homes Version 3.0

2 **ENVELOPE**
meets or exceeds 2012 IECC levels

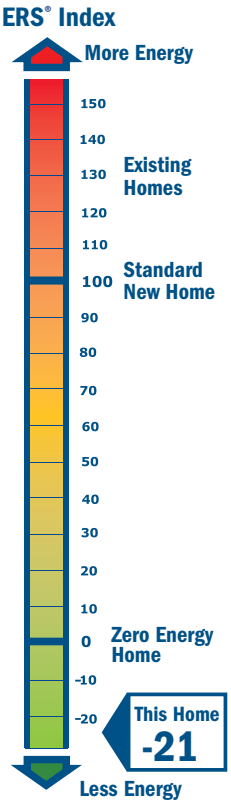
3 **DUCT SYSTEM**
located with the home's thermal boundary

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.



For the above-grade walls, the super-insulated building shell starts with 12-inch-thick double walls composed of two 2x4 16-inch on-center walls spaced 5 inches apart and filled with low-density (open-cell) spray foam (R-45.6). The outside wall is sheathed with a coated oriented strand board (OSB) product that serves as an air and moisture barrier and rain screen when the joints are sealed with the manufacturer's proprietary tape. This coated sheathing replaces house wrap as the home's weather resistive barrier. Scott chose the same coated OSB product that had been used as the wall sheathing to use as the roof decking. This sheathing was covered with fully adhering ice- and water-shield membrane from the drip edge to 3 feet up, and topped with 30-year architectural style shingles. Transformations attached a polyethylene vapor barrier to the underside of the attic rafters and taped the seams. The ceiling was finished with blueboard and plaster and all penetrations were air sealed. On top of the ceiling deck, 18 inches of cellulose was blown in to provide an insulation value of R-67 on the floor of the vented attic.

Transformations installed 2 inches of extruded polystyrene (XPS) rigid foam under and on the edges of the entire 4-inch-thick basement slab, which is wrapped on the bottom and sides with 6-mil polyethylene sheeting. The foam provides an R-10 insulation value. This assembly sits on a layer of crushed stone that is covered with filter fabric. The 10-inch-thick foundation walls are insulated on the inside surface with 3.5 inches (R-20) of closed-cell (high-density) spray foam. A framed wall is added on the inside and finished with blueboard. Below-grade portions of the basement walls are covered on the exterior side with damp proofing and a capillary break separates the footings from the basement walls.

The carefully flashed triple-pane (R-5) windows are an essential part of the high-performance building shell. These ENERGY STAR-rated, vinyl-framed windows have a krypton-blend gas-fill between the glass layers, which are covered with invisible low-emissivity coatings to reduce unwanted heat loss in winter and heat gain in summer. The windows have U-values of 0.21 and solar heat gain coefficients of 0.19. All exterior doors are insulated vinyl panel doors.

A blower door test was conducted as part of the third-party testing and inspection required for DOE Zero Energy Ready Home certification. The blower door tests whole-house air leakage and gives an indication of how much heated or cooled air is being lost through cracks and crevices in the walls or around the doors and windows. With careful attention to detail, the team achieved a building shell that tests at a very tight 0.92 air changes per hour at 50 pascals (ACH 50); for comparison, the 2009 IECC requires an air leakage of 7 ACH 50 or less.

The simple saltbox design clothes a high-performance thermal envelope that includes 12-inch-thick double walls packed with R-46 of open-cell spray foam, 18 inches of blown cellulose on the ceiling deck for an R-67 attic, and a basement encased in 2 inches (R-10) of XPS foam under the slab, 3.5 inches (R-20) of spray foam on the walls, and 6 inches (R-36) of spray foam at the rim joists connecting the basement to the above-grade walls.

"The house is very comfortable," says homeowner Parlee. "There are no room-to-room temperature differences like you find in a regular stick-built home."

Within the super-tight and highly insulated building shell, heating and cooling were provided by a super-efficient HVAC system consisting of three mini-split ductless air-source heat pumps. The builders installed the heat pump's compressors outside and connected them to three inside wall-mounted air handler units (one in the open living area on the first floor, one in the upstairs hall, and one in the master bedroom on the first floor). The inside units are highly efficient, with a seasonal energy efficiency ratio (SEER) of 23 for cooling and a heating seasonal performance factor (HSPF) of 10.6 for heating. These units put out 92% of their rated capacity at 5°F (-15°C) and 58% at -13°F (-25°C).

"What is really great is that even when it is very hot and humid out, like last year and this year at 95 degrees, I've only had to have the upstairs unit running because the house is so well insulated," said Parlee.

For ventilation, this custom home uses a heat recovery ventilator (HRV) set on a timer to bring in conditioned fresh air at 74 cfm to each of the three bedrooms. Also, for indoor air quality, paints and finishes include low to no volatile organic compounds.

"When we had the other house, we were spending all this money on oil to heat the home in winter," said Parlee. "In this home, we do not have these bills, so in the winter, we keep the house at a very comfortable 71 degrees. The house has a consistent temperature."

Water heating is provided by a 96% energy-efficient, propane-fired instantaneous water heater located in the basement. "This is another cost savings," said Parlee. "We use propane for this and for the stovetop in the kitchen. I have a 14-year-old daughter who plays sports so she takes two showers a day. My propane usage is still under 300 gallons for the year." Parlee and Scott considered a solar hot water heater but the purchase cost versus the return on investment did not pencil out at this time. Parlee's overall assessment of the on-demand water system is that "it has a little lag time starting the hot water, about 60 seconds, but aside from this, we have plenty of hot water for two showers and other things. It works well."

HOME CERTIFICATIONS:

DOE Zero Energy Ready Home

ENERGY STAR Version 3

EPA Indoor airPLUS

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.

Modeling of the house without solar photovoltaics showed it achieved a Home Energy Rating System (HERS) score of 34. However, Scott planned to include solar from the start. The home is oriented on the lot so that a large portion of the roof faces south. Scott was able to fit 78 235-watt photovoltaic panels on the roof for a total system size of 18.33 kW and a HERS rating of a -21. The home is projected to produce about 10,200 kilowatt hours more than it consumes over a 12-month period. "This is enough electricity to power an electric car for 30,000 miles, year after year," said Scott.

The homeowner appreciates the return on investment. "This home is about $40,000 more compared to other [similar sized] homes around here. However, I am saving $5,000 a year in utility bills, compared to my old home, and even receiving a check each year for my home's energy production," said Parlee.

Three high-performance (23 SEER; 10.6 HSPF) ductless mini-split heat pump systems with indoor air handlers and outdoor condensers keep the entire house heated and cooled. An HRV helps distribute the conditioned air while continually refreshing the indoor air with clean filtered outdoor air.

Parlee believes it is important to educate the public, appraisers, and realtors about the value of owning a solar home. He shared a story about a realtor who was selling Transformation's zero-energy production homes. "The realtor would take the perspective buyer on a house tour, and the buyer would say, 'where is the oil tank? Is it propane?' And the realtor would reply, 'It is electric.' To which the buyer would say, 'Now that is expensive.' It takes time and education for market transformation."

Wes Parlee is such a believer in his high-performance home that he convinced his retired neighbor from his previous neighborhood to move into one of the production homes in Devens, MA. "My neighbor is more energy efficient than we are, so he is predicting a check for $1,200 to $1,300 a year. This will cover his utilities except for television and internet. He has it made," said Parlee.

KEY FEATURES

- **Path:** prescriptive
- **Above-Grade Walls:** double wall (two 2x4 16-in. o.c.) with 12 inches (R-46) of open-cell spray foam, vinyl siding
- **Roof:** vented attic, 18 inches (R-67) blown cellulose on attic floor; coated and taped roof sheathing, 3-foot ice and water shield at roof edge and valleys
- **Foundation:** 2 inches (R-10) XPS foam under 4-inch basement slab. 10-inch poured concrete basement walls insulated on inside with 3.5 inches (R-20) closed-cell spray foam; fire-retardant paint (R-6 per inch); 6 inches (R-36) closed-cell spray foam on rim joists.
- **Windows:** triple-pane, R-5, ENERGY STAR, low-E, krypton-blend-gas-filled, vinyl-framed (U=0.2, SHGC=0.19)
- **Air Sealing:** 0.92 ACH 50
- **Ventilation:** HRV
- **HVAC:** Three mini-splits systems; 23 SEER; 10.6 HSPF; 92% efficient at 5°F
- **Water Heating:** 0.96 EF propane-fired instantaneous water heater
- **Lighting:** 100% CFLs
- **Solar:** roof-mounted PV; 78 235-Watt panels for an 18.33-kW system
- **Appliances:** ENERGY STAR
- **Water Conservation:** dual-flush toilets and low-flow faucets