U.S. DOE CHALLENGE HOME 2013 WINNER Housing Innovation Awards

DOE CHALLENGE HOME CASE STUDY

Transformations, Inc.

Production House
Devens, MA

BUILDER PROFILE

Transformations, Inc.
Townsend, MA
R. Carter Scott
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FEATURED HOME/DEVELOPMENT:

Project Data:

- Name: MassDevelopment Devens Green Zero-Energy Community
- Location: Devens, MA
- Layout: 3 bedroom, plus bonus room
- Conditioned Space: 2,508 ft² w/bsmnt
- Completion: 2012
- Climate Zone: 5, Cold
- Category: Production

Performance Data:

- HERS Index without solar PV: 35
- HERS Index with solar PV: -37
- Projected annual utility costs (without solar): $1,334
- Projected annual utility costs (with solar): $-1,602 (credit)
- Projected annual energy cost savings (over a home built to 2006 IECC): without solar $1,377; with solar $4,361
- Annual PV production revenue: $2,936
- Builder's added first cost over standard construction: $9,145 (not counting PV)
- Annual energy savings: without solar 44.5 MMBtus; with solar 114.6 MMBtus

The eight homes built by Transformations, Inc., in a subdivision in Devens, MA, not only produce more energy than they consume, they are affordable for middle-class buyers.

"We have been working for years to drive down the cost of high-performance homes," said company president Carter Scott. "It costs about $100 a square foot to build a code house here; our high-performance homes are only $1.43 above this [yes, that's about a dollar and a half], including the land and driveway." As a result, the first home was built and sold within 6 months, and the others were all sold or under agreement within a year of the first.

Since 2009, Scott has teamed with building scientists from Building Science Corporation through the U.S. Department of Energy's (DOE's) Building America Program to test and apply ways to increase energy efficiency, bring down costs, and improve the aesthetics of the homes. "Working with Building Science Corporation has been wonderful," said Scott. "We have learned that building high-performance homes is not that hard. You need to focus on the building shell and simplify the mechanicals."

One result of their collaboration has been a Transformation home that won a DOE Challenge Home Housing Innovation Award in 2013—a 2,508-ft² home built on speculation in the Devens, MA, subdivision.

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. The space between the walls is filled with low-density (open-cell) spray foam for an insulation value of R-45.6.

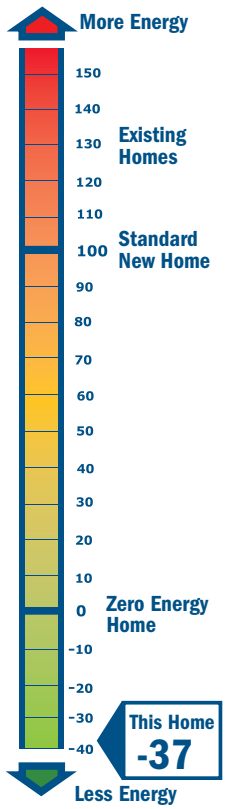
U.S. DEPARTMENT OF ENERGY CHALLENGE HOME

DOE Challenge Home builders are in the top 1% of builders in the country meeting the extraordinary levels of excellence and quality specified by the U.S. Department of Energy. Every DOE Challenge Home starts with ENERGY STAR for Homes Version 3 for an energy-efficient home built on a solid foundation of building science research. Then, even more advanced technologies are designed in for a home that goes above and beyond current code to give you the superior quality construction, HVAC, appliances, indoor air quality, safety, durability, comfort, and solar-ready components along with ultra-low or no utility bills. This provides homeowners with a quality home that will last for generations to come.

Massachusetts builder Transformations, Inc., built eight zero-energy homes in this Boston suburb that are equipped with enough solar to produce more energy than they consume and are affordable for middle-class buyers.

CHALLENGE 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.



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.

As Scott explains, this wall is so effective that when a December ice storm caused a power outage, while temperatures outside hovered in the low 20s, data loggers in one of the homes showed that inside temperatures dropped only 3.6°F over an 8-hour period. With a passion to continually improve, Scott continues working with Building Science Corporation to monitor the long-term performance of this wall configuration. Technical results are available in the recently published DOE report, *Transformations, Inc.: Partnering to Build Net-Zero Energy Houses in Massachusetts* (August 2013, available at http://www.transformations-inc.com/about/buildingscience/Building_Science_Corporation_TR_NREL.pdf).

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 a fully adhering ice- and water-shield membrane from the drip edge to 3 feet up, then topped with 30-year architectural style shingles. Transformations attached a polyethylene vapor barrier to the underside of the attic rafters, taped the seams, and finished the ceiling with blueboard and plaster. All penetrations through the ceiling were carefully air sealed. Above 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.

Based on analysis by Building Science Corporation and their recommendation to keep the basement within the thermal shell, Transformations chose to insulate the floor and walls of the basement rather than insulating the underside of the first floor. Under the four-inch-thick basement slab is a 2-inch layer of XPS rigid foam that extends up the sides of the slab and provides an R-10 insulation value. A 6-mil layer of polyethylene sheeting separates the rigid foam from the slab and provides a vapor barrier. This assembly sits on a layer of crushed stone. 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. The walls were framed and sheetrocked to meet the fire rating and finish the basement. 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 68 240-watt solar panels (16.31-kW system) on the south-facing back roof of this production home helped the home achieve a HERS score of -37 and produce more than enough power for this tightly air-sealed (1.26 ACH 50), highly insulated (R-67 attic, R-46 double-wall construction) home.

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.

Air leakage testing was conducted and showed that the home had a very air-tight shell at 1.26 air changes per hour at 50 pascals pressure, well below the 7 ACH50 required by the 2009 IECC.

By constructing small, air-tight, super-insulated homes, Scott has been able to reduce the size of the heating and cooling system for cost savings of over $5,000. The builder selected ductless air-source mini-split heat pumps. Thanks to recent efficiency improvements in ductless heat pump technology, the system works effectively even in the cold winters of New England, putting out 92% of its rated heating capacity at temperatures as low as 5°F (-15°C) and still producing at 58% of capacity at temperatures all the way down to -13°F (-25°C). The builders installed two indoor wall-mounted blower units, one on each floor. Copper tubing carries refrigerant from each of these indoor units to their own outdoor compressors. With a seasonal energy efficiency ratio (SEER) rating of 23 for cooling and a heating seasonal performance factor (HSPF) of 10.6 for heating, these units far exceed the minimum heat pump efficiency standards of SEER 13 and HSPF 8.6. Their total cost is approximately $3,000 installed per floor.

The two 23 SEER/10.6 HSPF mini-split ductless air-source heat pumps provide high-performance comfort without the fuss of ducts. ENERGY STAR appliances, 100% CFL lighting, low-flow plumbing fixtures, and a 96% efficient propane-fired instantaneous water heater add to the energy and resource efficiency of the home.

HOME CERTIFICATIONS:

DOE Challenge Home

ENERGY STAR Version 3

EPA Indoor airPLUS

While many builders have been struggling in the recession, Transformations, Inc., has doubled its revenues every year since 2010 by building high-performance, affordable homes that produce more energy than they use.

ENERGY STAR

Building America U.S. Department of Energy

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

ENERGY STAR exhaust fans in two of the three bathrooms run continuously at 30 cfm. Also, for indoor air quality, all of the paints and finishes are certified as containing low or no volatile organic compounds.

Water heating is provided by a 96% energy-efficient, propane-fired instantaneous water heater which is located in the basement. Water conservation measures include dual-flush toilets, low-flow faucets, and native drought-tolerant landscaping.

The high-performance building shell, ENERGY STAR windows, right-sized HVAC mechanicals, and high-efficiency water heater, along with ENERGY STAR lighting and appliances, all contributed to a modeled performance for the home of 35 on the HERS index, which is 65 points more energy efficient than a standard home built to the existing building code without including the energy savings from the solar system.

"We build high-performance homes first. Then, we add solar to get to zero energy," said Scott. This production house has 68 240-watt solar panels on the roof for a 16.31-kW photovoltaic system. At a HERS score of -37, it produces far more power each year than it uses.

Sixty-eight solar panels is a lot of panels for one house, but Scott said the time is right for large residential PV systems, thanks to what he calls the three solar "game changers." First, in 2009 the government removed the $2,000 limit on the 30% tax credit they offer homeowners for the installation costs on a new solar system. So, for example, if a homeowner wants to install a $100,000 solar electric system on their home, instead of a federal income tax credit of $2,000, they'll get $30,000. Second, many states now have solar renewable energy credits (SRECs). In Massachusetts, these credits are offered for the first 10 years of system life. For a 16-kW system they could yield about $30,000 over 10 years. Third is the reduction in the cost of PV panels. In 2008, Scott paid $4.19 per watt for panels. By 2012, the price was $0.80 per watt. "Now, for most homes, it makes economic sense to install big solar systems," said Scott.

Educating appraisers, sales staff, and the public on the value of energy efficiency is an ongoing effort for Scott. He notes he has lost buyers who got nervous when the appraised value of a home was significantly less than the asking price because the appraiser gave zero value for a $45,000 solar PV system.

For builder Carter Scott, reducing the total carbon emissions from buildings is what this is all about, whether it's reducing the heating and cooling load through better insulation and air sealing, using better design to reduce the home's size and materials use, generating more clean power from the sun, or all of the above. He believes in making a difference in carbon emissions one house at a time. "As a society, we have got to solve the carbon issues; if we do not, we will be realizing the negative consequences of climate change. It is just a very important thing. Building affordable homes that can be part of the solution instead of part of the problem—that is the motivating factor for me," said Scott.

KEY FEATURES

- **Path:** prescriptive
- **Above-Grade Walls:** double-stud wall of two 2x4 16-in. o.c. walls; R-46 of open-cell spray foam; coated and taped OSB sheathing; vinyl siding
- **Roof:** 18 inches (R-67) blown cellulose on attic floor, coated and taped OSB roof decking, 3-foot ice and water shield at roof edge and valleys
- **Foundation:** 2 inches (R-10) rigid XPS foam plus 6-mil poly vapor barrier under 4-inch basement slab and at edges between slab and foundation walls. Six inches (R-36) closed-cell spray foam on the rim joists.
- **Below-Grade Walls:** 10-inch poured concrete insulated on inside with 3.5 inches (R-20) of closed-cell high-density spray foam finished with 2x4 framing and drywall; damp proofing on exterior.
- **Windows:** triple-pane, R-5, ENERGY STAR, low-E, krypton-blend-gas-filled, vinyl framed (U=0.21, SHGC=0.19)
- **Air Sealing:** 1.26 ACH50
- **Ventilation:** 57-cfm, 80-watt, ENERGY STAR bath exhaust fans
- **HVAC:** two 23 SEER/10.6 HSPF mini-split ductless air-source heat pumps
- **Water Heating:** 0.96 EF propane-fired instantaneous water heater
- **Lighting:** 100% CFLs
- **Solar:** roof-mounted PV — 68-panels 16.31-kW system
- **Appliances:** ENERGY STAR
- **Water Conservation:** dual-flush toilets and low-flow faucets