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

DOE ZERO ENERGY READY HOME™

U.S. DOE ZERO ENERGY READY HOME 2020 WINNER Housing Innovation Awards

Hartford Area Habitat for Humanity

Roosevelt Zero Energy Home Hartford, CT

BUILDER PROFILE

Hartford Area Habitat for Humanity
Hartford, Connecticut; hartfordhabitat.org
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FEATURED HOME/DEVELOPMENT:

Project Data:

- Name: Hartford Area Habitat for Humanity
- Location: Hartford, CT
- Layout: 3 bdrm, 1.5 bath, 2 fls, 1,280 ft²
- Climate: IECC 5A, cold
- Completed: May 2019
- Category: Affordable

Modeled Performance Data:

- HERS Index: without PV 34; with PV -7
- Annual Energy Costs: without PV $1,500; with PV $150
- Annual Energy Cost Savings: (vs typical new homes) without PV $2,300; with PV $4,000
- Annual Energy Savings: without PV 10,600 kWh; with PV 18,600 kWh
- Savings in the First 30 Years: without PV $97,300; with PV $167,000

Hartford Habitat for Humanity knocked it out of the park with their first zero energy home, scoring a seven below and earning the home a grand award from the U.S. Department of Energy Zero Energy Ready Home program's Housing Innovation Awards. That's a Home Energy Rating System (HERS) score of -7, well below the net zero HERS score which indicates a home that produces as much energy as it uses over the course of a year. This low score translates into low energy bills, a true benefit for the low-income home owners.

Utility bills should be about $12 per month. Even without the PV panels included, the home achieved a low HERS score of 34, low enough to earn it the Connecticut Zero Energy Challenge Award for Lowest HERS Rating before Renewables. The affiliate also received a "Residential Award of Honor" from the Connecticut Green Building Council.

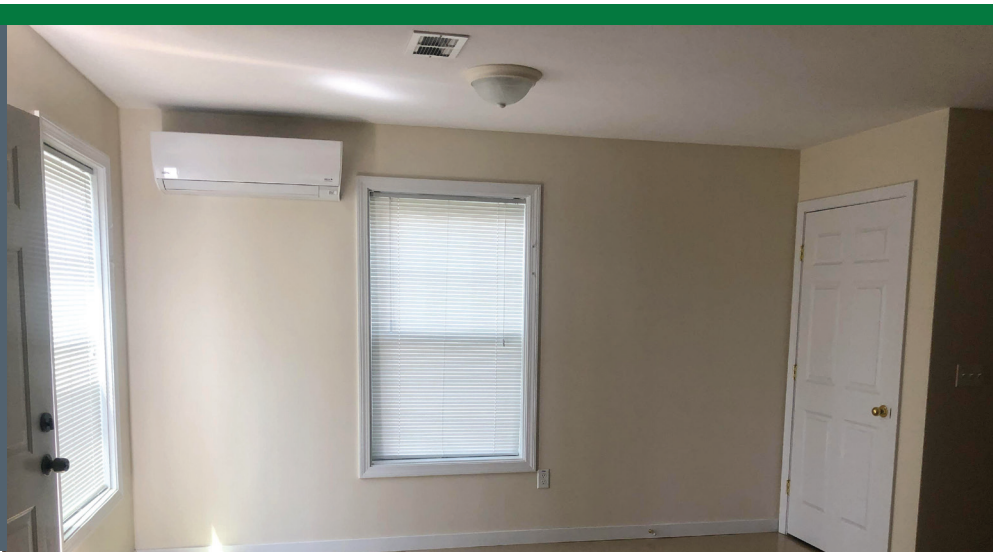
The home was built to the high performance requirements of DOE Zero Energy Ready Home, a voluntary program that earns the home a certification from DOE and incorporates other high-performance certifications as well. Every DOE ZERH home must meet the requirements of the ENERGY STAR Certified Homes checklists. Homes must also be certified to the U.S. Environmental Protection Agency's Indoor airPLUS criteria. All DOE ZERH homes are required to meet the hot water distribution requirements of the EPA's WaterSense program. Hartford Habitat for Humanity went beyond this requirement to fully meet WaterSense certification in the home. Homes must also meet above-code insulation requirements, be blower door tested for air sealing, comply with moisture management guidelines, have ducts inside conditioned space, and use ENERGY STAR labeled windows, lighting, and appliances. Homes must also have solar electric panels installed or have the conduit and electrical panel space in place for future installation of solar panels.

All of these requirements contribute to a home that is energy efficient, durable, and comfortable, with higher indoor air quality, and lower risk of mold and moisture

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. Every DOE Zero Energy Ready Home starts with ENERGY STAR Certified Homes Version 3.0/3.1/3.2 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.

Hartford Area Habitat for Humanity built this 1,280-ft² two-story home in Hartford, Connecticut, to the high performance requirements of the U.S. Department of Energy's Zero Energy Ready Home program. ENERGY STAR certified appliances, as well as no-VOC products and a 7.75-kW PV system bring this home to an impressive Home Energy Rating System (HERS) score of -7.



What makes a home a DOE ZERO ENERGY READY HOME?

1 **BASELINE**
ENERGY STAR Certified Homes Version 3.0/3.1

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

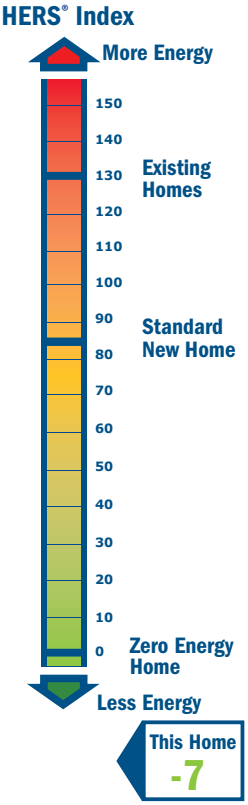
3 **DUCT SYSTEM**
located within the home's thermal boundary

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.



issues. Kris McKelvie, director of construction at Hartford Area Habitat for Humanity appreciates that the program requires every home be blower door tested and HERS rated. "Having all of our homes HERS rated holds us accountable for providing our families with comfortable housing and low energy costs. We use the rating information to educate our homeowners and to document that we are exceeding local building codes," said McKelvie.

The cost for the Habitat affiliate to go above Connecticut's state code, the 2015 International Energy Conservation Code, to the DOE Zero Energy Ready criteria was only $12,300 without PV and about $24,000 with PV. This added cost was kept minimal thanks to the generosity of vendors who provided discounted products and labor. Hartford Habitat's first zero energy home garnered a lot of publicity, including extensive media coverage, home tours, and social media, which brought out dozens of companies and hundreds of volunteers who donated supplies, funds, and hours of volunteer labor. McKelvie also saw this attention as a way to educate the public on zero energy home building. "During construction, we offered house tours to interested organizations to show them what we were doing and to explain what worked or didn't. Upon completion we shared our methods, successes, and failures through online trainings and provided power points to share photos and techniques used in this project."

The Habitat affiliate formed a committee before construction started made up of a HERS rater, a plumbing/heating specialist, an electrician, an insulation contractor, a solar energy consultant, and Habitat staff. As a team, they reviewed house plans, discussed products and materials, and brainstormed concerns relating to cost, installation, longevity, ease of use, and environmental impact. During construction, as issues arose they were addressed by Habitat staff engaging the HERS rater and any contractor related to the concern to help troubleshoot and find solutions that met project goals.

The team chose a narrow two-story, 1,280-ft² house design, with Colonial architectural features to fit within the confines of the narrow lot.

The home is constructed of standard building materials including 2x6, 24-inch on-center stud-framed walls that are filled with 5.5 inches of open-cell spray foam. The walls provide a total insulation value of R-31 thanks to an insulated OSB sheathing product that has an R-6.5 layer of rigid foam adhered to the inside and a weather-resistant coating on the exterior. When the seams are taped, this product can take the place of house wrap to provide an air barrier and drainage plane as well as a weather-resistant barrier. The house has vinyl siding.

The above-grade walls of the home were filled with 5.5 inches of open-cell spray foam and sheathed with an R-6.5 insulated coated OSB sheathing that provides a continuous air barrier, weather-resistant drainage plane, and thermal break over the 2x6 studs. This combination gives the walls a total insulation value of R-31. Triple-pane, argon-filled windows further reduce heat loss and sound transmission.

The vented attic is insulated with 20 inches (R-60) of blown cellulose which extends to the eaves and completely covers the top plates, thanks to the 12-inch raised heel trusses. All penetrations through the ceiling are sealed with canned spray foam. A 4-mil vapor barrier lines the ceiling drywall. The truss gable roof is sheathed with coated OSB and ice-and-water-shield membrane and covered with 30-year asphalt shingles.

The insulated basement is constructed with pre-cast concrete walls that have built-in metal-faced concrete studs. The inside face of the concrete wall panels has an adhered rigid-foam insulation layer. The wall cavities are further insulated with R-21 fiberglass batts.

The home's vinyl-framed double-hung windows are triple-paned providing an insulation value of U=0.19 with an argon fill and low-emissivity coatings for increased resistance to heat transfer. The triple panes both help cut heat loss and reduce condensation in the cold humid climate.

Blower door testing showed the home achieved an excellent air sealing level of 1.12 air changes per hour at 50 Pascals (ACH 50), well below the 3 ACH 50 required by code. In addition to the air-sealing effects of the open-cell spray foam wall cavity insulation, all of the top and bottom plates and sills are sealed and the drywall is sealed to the top plates below the attic.

To help provide ventilation and reduce indoor humidity, the home is equipped with a heat recovery ventilator (HRV). HRVs are ducted to the outside to bring in fresh air that is filtered through a MERV 9 filter then distributed to the home while a second duct collects stale air from the home and exhausts it outside. The two ducts cross in a heat exchanger transferring heat from the warmer air to the cooler air, thus warming incoming air in the winter and cooling incoming air in the summer. This HRV is ducted to pull air from the kitchen and bathrooms and supply fresh air to the bedrooms and living room.

Two ductless minisplits heat and cool the entire two-story home. One is centrally located on the first floor to serve the living room and kitchen. The second unit is located upstairs in the hallway. To reduce costs, rather than installing multiple air handler heads in the bedrooms, the affiliate installed small transfer fans in the bedroom walls to pull conditioned air from the hallway into each of the bedrooms when the doors are closed. The minisplit heat pumps provide heating and cooling with efficiencies of 14.2 HSPF for heating and 33 SEER for cooling, 2 to 3 times higher than the minimum federal standards for heating and cooling equipment.

HOME CERTIFICATIONS

DOE Zero Energy Ready Home Program - 100% Commitment

ENERGY STAR Certified Homes Version 3.1

EPA WaterSense

EPA Indoor airPLUS

DOE Zero Energy Ready Home Quality Management Guidelines

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 Heat Recovery Ventilator (HRV) continuously exchanges stale indoor air with fresh, outdoor air, while transferring heat to minimize heating and cooling energy usage.

Hot water is provided by a 50-gallon, heat pump water heater located in the insulated and indirectly conditioned basement. The water heater has a Uniform Energy Factor (UEF) of 3.42.

To further reduce utility costs in the all-electric home, all light fixtures are ENERGY STAR rated with LED bulbs. Exterior fixtures have daylight and motion sensors. The refrigerator, range, dishwasher, clothes washer, and dryer are all ENERGY STAR labeled. Low-flow and WaterSense labeled plumbing fixtures add to water and energy savings.

The home meets all of the indoor air quality measures required by EPA's Indoor airPLUS program including the use of no-VOC paints and flooring and formaldehyde-free cabinets, along with good water management details inside and out like the HRV whole-house ventilation and hard surface flooring in wet areas such as the kitchen, bathrooms, and entry. Outside all of the windows and doors are properly flashed, gutters line the eaves, a vapor barrier was laid on the ground under the slab to keep out moisture and soil gasses, and the lot was built up so the ground slopes away from the home for good site drainage.

Hartford Habitat for Humanity's business model requires homeowners to put in over 150 hours of "sweat equity" in helping to construct their home. McKelvie saw this as an excellent way to educate the homeowners about the home and what made it unique. "We could show them the insulation we used and explain the reason behind certain design choices. At the end of the build we complete a thorough walk-through with the family explaining how to operate their HRV, the mini-splits, all appliances, and the solar PV. We make certain they know the importance of how these systems work together and why. After they have occupied the home for a few months, we checked in to confirm everything is working as designed and to help answer any questions or concerns that have arisen," said McKelvie.

Hartford Habitat for Humanity saw the healthy environment for families and the cost savings over the long run as among the biggest rewards of the project. "As a non-profit, this project was a test run to determine if we would build ZERH at an affordable price. We understood it would cost more than our typical construction, but wanted to determine if the cost was reasonable.…We also wanted to understand the benefits of a ZERH for our homeowners—how this could help them by a providing a more affordable home by limiting utility expenses," said McKelvie.

By all accounts the project was a success. The new homeowners couldn't agree more. When asked about the house, "We love our new home," was the response from both husband and wife, almost in unison.

KEY FEATURES

- **Walls:** 2x6, 24″ o.c., R-31 total: 5.5″ open-cell spray foam in cavity, 1.5″ R-6.5 insulated coated OSB sheathing, vinyl siding.
- **Roof:** Gable truss roof: 0.5″ coated OSB sheathing; ice & water membrane; architectural shingles.
- **Attic:** Vented attic: 20″ R-60 blown-in cellulose above ceiling, 0.5″ drywall, 4-mil poly vapor barrier, air sealed w/foam around light boxes and penetrations. 12″ raised heel trusses.
- **Foundation:** Insulated basement, R-31 total: precast concrete panels with adhered R-10 rigid foam, R-21 fiberglass batt.
- **Windows:** Triple-pane, argon-filled, vinyl double-hung frames, U=0.19, SHGC=0.27.
- **Air Sealing:** 1.12 ACH 50, all plates and sills sealed, dry wall sealed to top plates, all ceiling fixtures foamed.
- **Ventilation:** HRV, exhausts from kitchen and baths, supplies to bedrooms and living room; MERV 9 filter.
- **HVAC:** 2 single-head ductless heat pumps, 14.2 HSPF, 33.0 SEER. In-wall transfer fans.
- **Hot Water:** Heat pump water heater, 3.42 UEF, 50-gal., compact plumbing design, PEX tubing.
- **Lighting:** 100% LED, daylight sensors.
- **Appliances:** ENERGY STAR refrigerator, range, dishwasher, clothes washer, clothes dryer.
- **Solar:** 7.75-kW rooftop panels; 25 310-watt panels.
- **Water Conservation:** EPA WaterSense fixtures, drought-resistant landscaping.
- **Energy Management System:** PV tracking, programmable thermostat.
- **Other:** No-VOC paints and flooring, formaldehyde-free cabinets.

Photos courtesy of Hartford Area Habitat for Humanity

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