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

DOE ZERO ENERGY READY HOME™

U.S. DOE ZERO ENERGY READY HOME 2014 WINNER Housing Innovation Awards

AquaZephyr

Eco-Village Ithaca
Ithaca, NY

BUILDER PROFILE

AquaZephyr, Ithaca, NY
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ecovillageithaca.org
Rater: Steven Winter Associates
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FEATURED HOME/DEVELOPMENT:

Project Data:

- Name: Eco-Village Ithaca
- Location: Ithaca, NY
- Layout: 3 bedrooms, 2 baths, 2 floors
- Conditioned Space: 1,664 ft^2
- Completion: October 2013
- Climate Zone: IECC 6A, cold
- Category: Production

Modeled Performance Data:

- HERS Index: without PV 56, with PV 15
- Builders Added Cost over 2009 IECC Construction: $20,000
- Projected Total Annual Energy Cost Savings (compared to a similar house built to the 2009 IECC): with PV $2,928
- Projected Annual Utility Costs: without PV $1,593, with PV $628
- Annual PV Production Revenue: $965
- Annual Energy Savings: without PV 10,924 kWh; with PV 16,285 kWh

One-foot-thick, double-stud walls helped the Eco-Village Ithaca community achieve certification from the U.S. Department of Energy's Zero Energy Ready Home program. The 17 single-family and four duplex homes are the third, and most efficient, phase of a community of 100 homes that were built for a cooperative living organization called Eco-Village Ithaca, which is part of a loose affiliation of Eco-Village communities around the world. Eco-Village seeks to provide housing that is affordable, durable, sustainable, comfortable, and accessible—values that dovetail nicely with the goals of the DOE Zero Energy Ready Home program.

The homes were built under the guidance of Michael and Kendall Carpenter, who have worked in efficient home construction in the Ithaca area for 25 years. The homes in phase 3 were built to the DOE Zero Energy Ready Home program's aggressive standards, which include meeting all of the requirements of ENERGY STAR Certified Homes Version 3.0, the U.S. Environmental Protection Agency's Indoor airPLUS and WaterSense, and the insulation requirements of the 2012 International Energy Conservation Code. They also met the DOE solar-ready program requirements, which require homes to have solar water heating and solar photovoltaics (PV) either installed or ready to install, with conduit and electrical panel space provided. Eco-Village decided not to install the PV at the time of construction but the project was evaluated for energy performance with and without the PV by the energy rater, Karla Donnelly of Steven Winter Associates, a DOE research partner through its CARB research team. Donnelly noted that, without the PV installed, the homes achieved a Home Energy Rating System (HERS) score of 56. With a 4-kWh PV system installed, the homes would score a HERS 15. A typical home built to code would achieve a HERS score of 100 while a home that produces as much energy as it consumes would achieve a HERS score of 0.

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.

AquaZephyr built the homes at Eco-Village Ithaca to be highly insulated from the ground up. The shallow frost-protected slab foundation included 5.5 inches of polyisocyanurate under the entire slab. Three inches of foil-faced polyisocyanurate covered the outside of the concrete foundation wall to 24 inches below grade, then an additional 3-inch-thick skirt of polyisocyanurate extended down and out 41 inches from the bottom edge of the footing to protect the slab from frost.

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

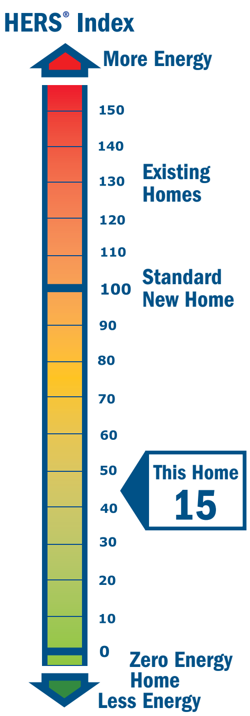
3 **DUCT SYSTEM**
located within the home's thermal boundary

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.



Although not a DOE requirement, the homes are also designed to meet the Passive House Institute Standard U.S. Seven of the homes will seek the Passive House certification; five are already PHIUS certified. These are the first homes in the neighborhood built to the Passive House Standard. This is also the Carpenters' first project built to the DOE Zero Energy Ready Home standard. "It will absolutely be a consideration whenever we build in the future," said Kendall.

The Carpenters have been involved with the Eco-Village community since the 1990s. TREE (which stands for Third Residential Eco-Village Experience) is the most energy-efficient phase to date, but efficiency has been a key principal of the entire village. Like the other two phases, TREE is clustered around an open area with walking paths but no driveways connecting the homes, which are slab-on-grade two-story homes with very simple exterior designs and interior finishes.

The homes start with a foam-encased slab. Under the entire slab, 5.5 inches (R-36) of foil-faced polyisocyanurate rigid foam was laid on the ground over a 6-inch layer of gravel and a 6-mil polyethylene vapor barrier. A passive radon venting pipe was installed in the gravel with a vent stack through the roof. The footings extend down to a depth of 24 inches below grade. Three inches (R-19) of foil-faced polyisocyanurate was installed on the exterior surface of this stem wall. At the bottom of the footing, a 3-inch-thick (R-19) skirt of foil-faced polyisocyanurate extended down and out from the footing wall for 41 inches. Although the frost depth in Ithaca is 48 inches, this shallower skirt technique provides adequate frost protection for the slab footing, at a reduction in excavation costs. Dirt was backfilled over the skirt and packed to slope away from the house.

The homes' exterior walls consist of double walls—two 2x4 16-inch on-center walls built 5 inches apart, creating a 12-inch wall cavity. The walls were built with efficient framing practices including open corners, open interior-to-exterior wall intersections, insulated headers, and 24-inch on-center rafters. The exterior walls were sheathed with an OSB product that takes the place of house wrap to provide a complete air barrier when the seams are sealed with a proprietary tape. The inner surface of the exterior wall was sprayed with 3.5 inches (R-22) of high-density closed-cell spray foam, then the remainder of the cavity was filled with 8.5 inches (R-30) of blown cellulose. On the exterior, pine furring strips were installed over the coated OSB to provide a rain screen and air gap behind the siding, which includes a mix of metal and fiber cement lap siding.

The homes' 12-inch-thick double walls are filled with 3.5-in. (R-22) of closed-cell spray foam and 8.5 in. (R-30) of blown cellulose for a total wall R-value of R-52 with no thermal bridging. The rim joists between the first and second floors are filled with spray foam to insulate and air seal this often leaky space. Open-web floor joists provide space for the ERV ducts.

Although the builder had used double-wall construction before, it was a new technique for the framing contractors. "The learning curve was slow for the framers, then after the first few houses, they got it and rolled through," said Donnelly. "It shows how efficient framing is sometimes just a matter of practice."

Additional coated OSB was installed, skin side down, on the house-facing side of the roof trusses. The seams were taped on the house side and caulked on the attic side to provide a continuous air and moisture barrier. Furring strips of wood 2x4s were attached flat-sided to the underside of this coated sheathing. These 2x4s provided a nailing surface to install the ceiling drywall and they also provided a false ceiling that was just deep enough to run wiring across the ceiling without penetrating the coated OSB air barrier. The asymmetrical roofs were pitched with the longer, lower angled roof surface facing south at an optimal angle for solar panels. Both sides had raised heel trusses to increase the depth of insulation over the top plates. However, the north-facing roof pitch didn't leave enough room for 9 inches of blown insulation over the top plates as required by Passive House. So, baffles were installed at every rafter bay then the eave corners were spray foamed with high-density, higher R-value, closed-cell spray foam to air seal and insulate over the top plates. The baffles served to keep insulation from blocking the soffit vents and to provide a backstop for the spray foam. Then 25 inches of blown cellulose was piled onto the attic floor to provide R-90 of insulation for the vented space. A metal roof was installed directly over the rafters with no roof decking underneath.

To meet the Passive House Standard, the builder installed triple-pane windows with low-emissivity coatings, a U factor of 0.13, and a high solar heat gain coefficient (SHGC) of 0.62. The high SHGC windows allow in beneficial low-angle winter sun, which heats the slab floors to provide passive solar heat in the winter, while roof overhangs keep out high-angle summer sun.

The DOE Zero Energy Ready Home program requires third-party inspection and blower-door testing of the homes. Having a continuously sealed air barrier at the ceiling helped the homes achieve an extremely tight air seal of 0.42 air changes per hour at 50 Pascals pressure difference (ACH 50), beating the very tight Passive House standard of 0.60 ACH 50.

HOME CERTIFICATIONS

- DOE Zero Energy Ready Home Program
- ENERGY STAR Certified Homes Version 3.0
- EPA Indoor airPLUS
- EPA WaterSense
- Passive House Institute U.S.

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 coated OSB sheathes the exterior walls. When the seams are taped, it provides an air-sealed drainage plane and replaces house wrap, saving installation time and costs.

Because the homes are so airtight and so well insulated, the only heating system needed is electric baseboard heaters. Steven Winter Associates raters calculated that annual heating costs would amount to about $275 per home.

To provide much needed ventilation and fresh air in the airtight homes, energy recovery ventilators (ERV) were installed. Each ERV was installed in an upstairs closet with two ducts to the outside, one to bring in fresh air and one to exhaust stale air. The two air streams cross in a heat exchanger that transfers heat from the warmer air stream to the cooler air stream, thus tempering the incoming air. The incoming air passes through a MERV 12 filter and is distributed through 6-inch ducts that run between the first and second floors to supply air to the living room and bedrooms and exhaust air from the bathrooms and kitchen. The ERVs run continuously to meet the ASHRAE 62.2 ventilation standard. Because the homes are so tight, occupant behavior can greatly affect the balance of the ERV. Donnelly recommends testing the system, letting the family move in, testing, then balancing, then testing again.

Solar thermal water heating panels are installed on all of the homes. The solar thermal systems preheat the water which is then directed to an electric storage tank with an energy factor of 0.84.

All of the lighting is energy efficient: 72% of the fixtures are LED based, 28% are CFL based. The homes are equipped with ENERGY STAR-rated refrigerators and dishwashers. All of the homes' plumbing fixtures are EPA WaterSense rated.

Carpenter noted that using very simple designs and working with the sub-contractors to simplify the HVAC, plumbing, and insulation jobs helped to cut costs. Homeowner participation in management of the project was another unique element that also kept costs down. "Flexibility in the building process allowed us to keep the actual cost of building the houses at $100/ft^2. When all the costs of the project are included – land, sewer, water, roads, fire protection, architectural, engineering design – the total cost to the shareholder was about $150/ft^2, compared to the typical market rate of about $200-$300/ft^2," said Kendall.

Photos courtesy of Steven Winter Associates.

KEY FEATURES

- **DOE Zero Energy Ready Home Path**: Performance
- **Walls**: Double 2x4 stud wall with 5-in. gap (total wall depth=12 in.) filled with 3.5-in. (R-22) closed-cell spray foam and 8.5 in. (R-30) cellulose; coated OSB sheathing with taped seams, rain screen furring strips, fiber cement siding
- **Roof:** Metal roof
- **Attic:** 25-in. (R-90) cellulose
- **Foundation:** Slab-on-grade foundation poured on 6-in. gravel bed covered by 6-mil poly vapor barrier and 5.5 inches (R-36) of foil-faced polyisocyanurate rigid foam under entire slab. Stem walls insulated on exterior with 3-in. (R-19.5) rigid polyiso to bottom of footing at 24-in. below grade, then skirt of 3-in. (R-19.5) polyiso extending down and away from footing for 41 in.
- **Windows:** Triple-pane, low-e, U=0.17, SHGC=0.62
- **Air Sealing:** 0.42 ACH 50
- **Ventilation:** ERV with ducts runs continuously to meet ASHRAE 62.2; MERV 12 filter
- **HVAC:** Electric baseboard, passive solar design
- **Hot Water:** Solar thermal preheat with electric storage tank, 0.84 EF
- **Lighting:** 72% LED, 28% CFL; ENERGY STAR ceiling fans
- **Appliances:** ENERGY STAR refrigerator and dishwasher
- **Solar:** 4-kW PV and domestic hot water
- **Water Conservation Features:** All WaterSense fixtures
- **Other:** Sustainable landscaping, semi-permeable stone around house, native wildflowers and grass, retaining walls to prevent erosion; bio-swales, rain garden and retention pond