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

DOE ZERO ENERGY READY HOME™

U.S. DOE ZERO ENERGY READY HOME 2018 WINNER Housing Innovation Awards

Kalamazoo Valley Habitat for Humanity

Kalamazoo Infill Home
Kalamazoo, MI

BUILDER PROFILE

Kalamazoo Valley Habitat for Humanity
Kalamazoo, MI, HabitatKalamazoo.org
Tom Tishler, ttishler@habitatkalamazoo.org
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Rater: Home Energy Insight, Bob Kildea
rlkildea@sbcglobal.net

FEATURED HOME/DEVELOPMENT:

Project Data:

- Name: Kalamazoo Infill Home
- Location: Kalamazoo, MI
- Layout: 3 bdrm, 1 bath, 1 fl, 1,032 ft²
- Climate: IECC 5A, cold
- Completed: November 2017
- Category: affordable

Modeled Performance Data:

- HERS Index: without PV 46; with PV NA
- Projected Annual Energy Costs: without PV $750; with PV $NA
- Projected Annual Energy Cost Savings: (vs typical new homes) without PV $450; with PV $NA
- Projected Annual Energy Savings: without PV 1,700 kWh, 50 mcf; with PV NA
- Added Construction Cost: without PV $4,000, with PV $NA
- Savings in the First 30 Years: $20,900

If you were to drive down the tree-lined street of tidy 1950's-era single-story bungalows with lap siding and shutter-adorned windows, you'd never know that the blue and white house with the black shutters was built less than a year ago and rivals some of the highest performing new homes in the country. And that is just the way Tom Tishler, director of construction operations for Kalamazoo Valley Habitat for Humanity, wants it. Although the home was built to the high-performance standards of the U.S. Department of Energy's Zero Energy Ready Home program, from outward appearances it fits into the established neighborhood in which it sits. "Our philosophy is to build a home that utilizes the best in building science and quality without standing out as an expensive showpiece. Efficiency can be affordable and blend in," said Tishler.

The home achieved a score of 46 on the Home Energy Rating System index, while typical new code-built homes would score about 80 to 100. The home has the structural support and electrical panel space and conduit in place for the future addition of solar panels and the affiliate calculated that a 7-kWh solar array would enable the home to achieve a HERS 0, meaning the home would have zero energy bills over the course of the year. Even without the solar panels, home owners can expect average energy bills as low as $63 a month.

To achieve those low energy bills, the home was built to the criteria of the DOE Zero Energy Ready Home program. The program requires homes to meet all of the requirements of ENERGY STAR Certified Homes Version 3.0 or 3.1 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 (or 2015) 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 them.

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 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.

Kalamazoo Valley Habitat for Humanity built this 1,032-ft² affordable home in Kalamazoo, Michigan, to the high performance criteria of the U.S. Department of Energy Zero Energy Ready Home (ZERH) program. The home blends in with the 1950s-era bungalows next door but, thanks to advanced zero energy construction techniques like superior insulation, triple-pane low-e windows, and all LED lighting, the home far exceeds even the latest energy conservation code. WUFI software was used to design the walls.

What makes a home a DOE ZERO ENERGY READY HOME?

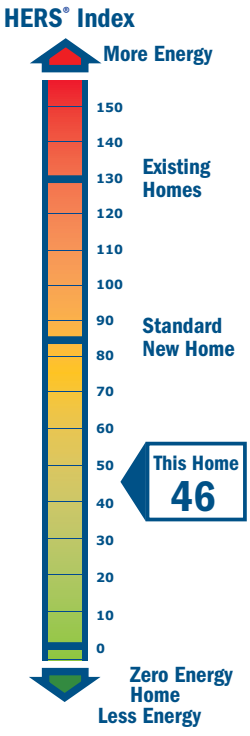
1 **BASELINE**
ENERGY STAR Certified Homes Version 3.0/3.1

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

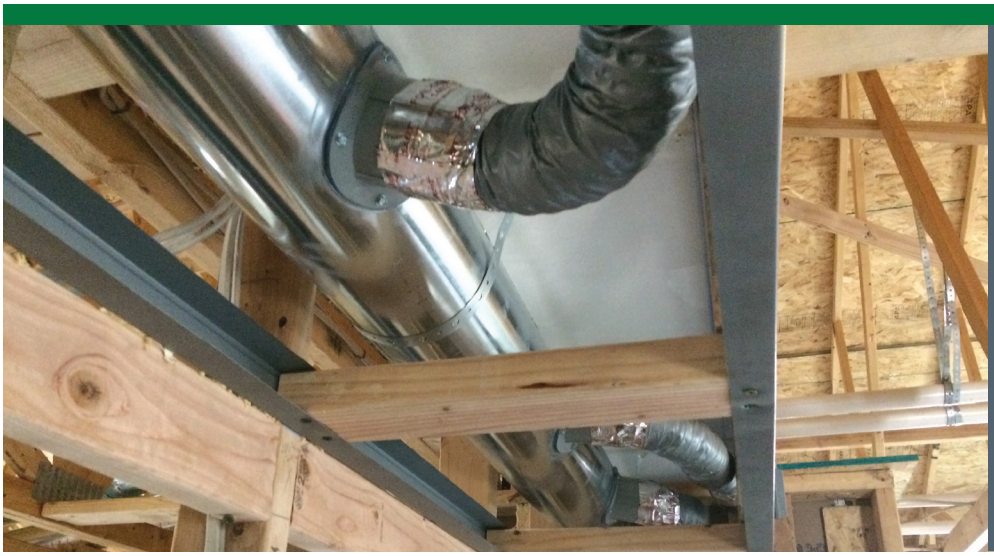
7 **RENEWABLE READY**
meets EPA Renewable Energy-Ready Home.

This is Kalamazoo Valley Habitat for Humanity's third home certified to the DOE program, and the affiliate, which builds about five single-family homes a year, plans to build all future homes to the program criteria and has five in progress now.

To keep costs down (a Habitat mandate), the home uses a simple rectangular structure, which Tishler notes also happens to be the most energy-efficient design because it reduces the surface area of the exterior walls.

Kalamazoo Valley Habitat uses a staggered-stud wall assembly consisting of 2x4s set on a 2x6 plate. In the past when they did staggered-stud walls, the affiliate would set the 2x4s every 12 inches with alternating studs aligned with either the inside or outside edge of the 2x6 plates so there would be a nailing surface every 24 inches on the interior face of the wall and every 24 inches on the exterior face of the wall. The outside wall was then sheathed with 2 inches of rigid foam, which DOW supplied free to all Habitat affiliates. A second panel of foam was cut to fit and installed between the 24-inch-spaced exterior studs before installing the interior studs, then a 22-inch-wide fiberglass batt was pulled behind the interior-facing 2x4 to fill the rest of the wall cavity. Tishler said this worked but it was time-consuming to pull the batts into place centered in the cavity behind each alternating stud and the front studs compressed the batts quite a bit. Then the affiliate hit on the idea that the studs didn't need to be spaced 12 inches apart, as long as they provided a nailing surface every 24 inches on both the interior and exterior face of the walls. So, on this house they set the interior- and exterior-facing studs only 2 inches apart; they still have a nailing surface every 24 inches along the interior and exterior edges of the wall. They still sheath the exterior with rigid foam and do another 2-inch-thick inset of rigid foam between the exterior-facing studs. Then, when they fill the remainder of the cavity with the batt insulation, they only have to tuck one edge about 2 inches behind the interior-facing stud of that stud bay. This results in much faster installation and much less batt compression.

The continuous layer of exterior rigid foam is covered with house wrap and vinyl siding. The foam creates an air-sealed layer exterior of any wires or pipes that will be run by trades. All wall penetrations, framing gaps and cracks, and the edges of the rigid foam in each stud bay are air sealed with elastomeric caulk. All penetrations through the exterior walls (including gas lines, the dryer vent, light fixtures, hose bibs, etc.) are fully flashed using vinyl J-blocks, flashing tape, and overlapping house wrap. All roof-to-wall intersections are flashed with kick-out flashings where required.



Before the rest of the ceiling drywall is installed, the Habitat affiliate's crews installed a sheet of drywall down the compact home's main hallway. Then, a rigid metal trunk duct was installed and short small-diameter 2.5-inch insulated ducts were attached to it to distribute conditioned air from the home's 97% AFUE modulating gas furnace. The duct chase was then framed in and air sealed as a dropped hallway ceiling to be dry-walled along with the rest of the walls and ceilings.

The simple gable roof over the flat ceilings is constructed of wood trusses with 16-inch raised energy heels that allow for the full depth of insulation over the exterior walls. Baffles are installed in every rafter bay to provide an air path from the soffit vents to the continuous ridge vent for proper ventilation of the attic space. All penetrations into the attic are fire caulked. After installing the ceiling drywall, any penetrations into the attic, including wires, plumbing, electrical boxes and fixtures, and interior wall top plates were covered with 1 inch of closed-cell spray foam to seal the ceiling. The tops of the exterior walls were also spray foamed and the foam served to seal the baffle-to-top plate junction. Although the HVAC ducts were not installed in the attic, the metal ducts for the HRV were; these were covered with 2 inches (R-14) of closed-cell spray foam. Then, 16 to 18 inches (R-60) of blown cellulose was installed over the entire attic.

The Habitat affiliate has experimented with several different foundation techniques. On this home, volunteer crews constructed homemade insulated concrete forms of 2-inch-thick sheets of rigid XPS, which is held in place by treated wood spacers. The interior foam is 16 inches high and the exterior is 22 inches high. Concrete is poured into the form to create an insulated 16x16-inch combination footer and foundation wall. Then the area within the perimeter of the foundation wall is back filled with sand that is compacted to level with the 16-inch interior edge. The entire area is topped with a horizontal 2-inch layer of rigid foam that extends to meet the outer foam layer. Then the 4-inch concrete floor slab is poured. When the above-grade walls are constructed, the rigid foam sheathing will extend down to touch the slab edge insulation creating a continuous thermal break on the exterior of the walls that extends from the bottom of the footings to the trusses.

To provide heating for the highly efficient home, the Habitat affiliate installed a 97% AFUE natural gas furnace with a modulating ECM motor and a modulating gas burner that can ramp down 5 kBtu to match the heating load required. The furnace has a smart controller that monitors temperature and humidity and calculates the heating requirements to provide a steady temperature in the home for maximum comfort and minimum cost of operation. Instead of 8- or 10-inch ducts, the system uses 2.5-inch-diameter ducts that run off of the 6-inch-round metal trunk line. Total duct leakage was only 6 cfm.

To provide fresh air to the tight home, the affiliate installed a heat recovery ventilator (HRV) that is set to provide an equivalent of 50 cfm of continuous ventilation. The bathroom fan has both motion and dew point sensors to provide ultra-efficient bath ventilation to discourage moisture issues.

HOME CERTIFICATIONS

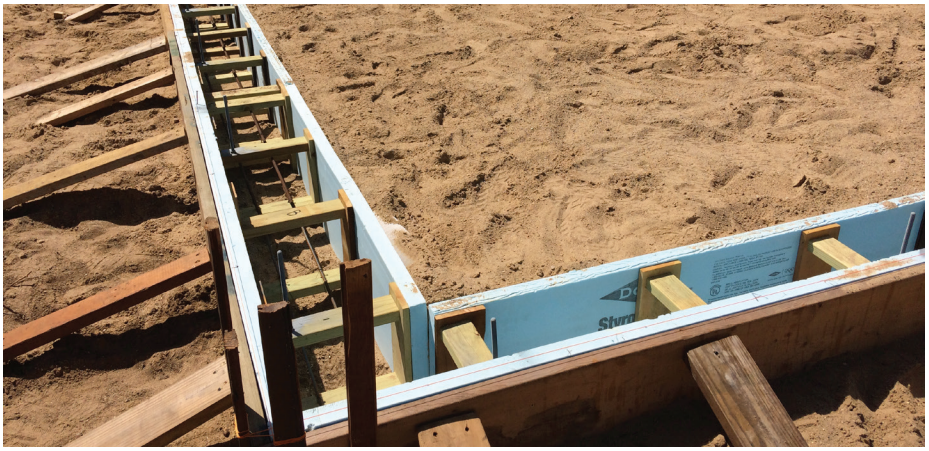
DOE Zero Energy Ready Home Program – 100% Commitment

ENERGY STAR Certified Homes Version 3.0

EPA Indoor airPlus

"As a non-profit builder of high-performance affordable homes, our business metrics relate directly to how we effect the low-income families we serve. Our goal is to lift them out of poverty, keep them healthy, and give them a better life. Many of the families we serve have members with asthma or other respiratory issues, which pushed us to consider and use the Indoor airPLUS certification eight years ago."

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.



Do-it-yourself insulated concrete forms create the foundation walls.

Hot water is provided by a condensing tankless gas water heater with an efficiency of 98% AFUE. All of the hot water lines are insulated half-inch PEX tubes that come off a central manifold next to the water heater and go directly to their end uses. The home was designed to have all of the hot water fixtures clustered together for short runs and located, near the water heater, which is in a closet in the laundry room directly adjacent to the kitchen and bath. No lawn sprinkler system was installed.

All caulks, adhesives, cabinets, and finishes are no-VOC, and paint and flooring are low-VOC certified. During construction, all materials on site that could be recycled (metal, glass, plastic, paper, cardboard, etc.) were taken to a recycling facility. The home was designed on a 2-foot grid so that common building material sizes could be used with little or no waste. Even the pitch of the roof and eaves were calculated so that full sheets of OSB were used to sheath the roof with almost no waste. Scrap plywood and OSB were used for drywall nailers and blocking.

The home is also universally designed, with two covered no-step entries into the home from the driveway, 36-inch doors, 42-inch hallways, and a larger adaptable bathroom. Blocking was installed in the walls for future installation of grab bars around the toilet.

"We built the home to be as energy efficient, safe, healthy, comfortable, and durable as possible within our $80,000 budget. Our energy-efficiency goals are based on striving to get energy costs down as far as possible so the family has more money in their pocket—period. The small up-front costs to build a healthy and energy-efficient home versus a code-built home we estimate to be no more than $5,000 per home. Over the course of a 25-year no-interest Habitat mortgage, that adds less than $17 per month. The low energy bills, comfortable living, excellent indoor air quality, adaptability for aging and/or disability, decreased maintenance, and enhanced durability are of value far beyond the inconsequential extra cost. We measure our success by the DOE ZERH certifications and HERS scores we receive on each home, which ensure the homes are built to the highest standards," said Tishler.

Photos provided by Kalamazoo Valley Habitat of Humanity.

KEY FEATURES

- **DOE Zero Energy Ready Home Path:** Performance.
- **Walls:** 2x4 studs 24″ o.c. staggered on 2x6 plates, advanced framed, 2″ R-10 XPS sheathing; in cavity 2″ R-10 XPS plus R-13 fiberglass batt; house wrap, vinyl siding.
- **Roof:** Asphalt shingles; taped ½″ OSB, ice-and-water shield installed over roof edge and subfascia, and 6′ up from eaves.
- **Attic:** Vented attic with 16″ energy heels. Metal HRV ducts in the attic encapsulated in 2″ R-14 closed-cell spray foam and covered with 16-18" R-60 of blown cellulose.
- **Foundation:** 16x16" footing and frost wall grade beam poured into 2" R-10 XPS form, topped with R-10 XPS under slab. R-10 slab edge continuous up exterior walls.
- **Windows:** Triple-pane, low-e, argon-filled, vinyl frames, U=0.22, SHGC=0.25.
- **Air Sealing:** 2.72 ACH 50.
- **Ventilation:** HRV, bath fan with motion and dew point sensors.
- **HVAC:** 97% AFUE furnace with modulating ECM motor and gas burner. Smart controller monitors humidity and temperature. All ducts in conditioned space.
- **Hot Water:** 98% AFUE condensing tankless; insulated hot water lines.
- **Lighting:** 100% LED.
- **Appliances:** ENERGY STAR-rated refrigerator, ENERGY STAR range.
- **Solar:** Solar ready.
- **Water Conservation:** ½″ PEX hot water lines; compact plumbing design.
- **Energy Management System:** Smart thermostat.
- **Other:** No-VOC caulks, adhesives, and finishes; low-VOC paint and flooring; on-site recycling; universal design. WUFI modeled wall design. Extra wall strapping and attic bracing.

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