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

DOE ZERO ENERGY READY HOME™

U.S. DOE ZERO ENERGY READY HOME 2016 WINNER Housing Innovation Awards

Knaggs Construction

Minden House
Kearney, NE

BUILDER PROFILE

Knaggs Construction, Kearney, NE
Gene Knaggs, geneknaggs@hotmail.com
308-236-5097, www.knaggsconstruction.com
Rater: American Energy Advisors
Larry Emanuel
inv@aeadvisor.com

FEATURED HOME/DEVELOPMENT:

Project Data:

- Name: Minden House
- Location: Kearney, NE
- Layout: 7 bdrm, 4.5 bath, 1 fl + bsmt, 4,566 ft²
- Climate Zone: IECC 5A, cold
- Completion: May 2016
- Category: custom for buyer

Modeled Performance Data:

- HERS Index: without PV 35
- Projected Annual Energy Costs: without PV $1,545
- Projected Annual Energy Cost Savings (vs home built to 2009 IECC): without PV $1,859
- Projected Annual Energy Savings: without PV 26,073 kWh
- Added Construction Cost: without PV $5,725

Builder Gene Knaggs of Kearney, Nebraska, likes to make each home better than the one before. That philosophy has led him to the U.S. Department of Energy's Zero Energy Ready Home program and a 2016 Housing Innovation Award. The custom home builder began building with his father in 1976 and started Knaggs Construction in 1992. He now has certified three homes through the DOE program and has three more in the works.

The DOE Zero Energy Ready Home program requires homes to meet all of the requirements of ENERGY STAR Certified Homes Version 3.0 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 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 future photovoltaic panel installation.

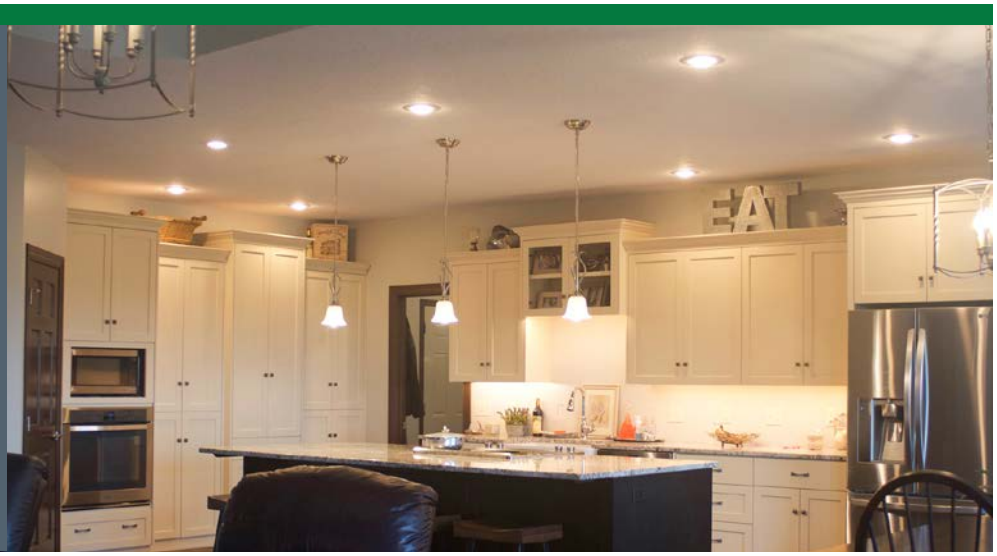
Even without the PV installed, the home achieved a Home Energy Rating System (HERS) score of 35, far below the 80 to 100 of typical new homes. With this performance, the 4,566-ft² 7-bedroom, 4.5-bath, one-story rambler with a full basement located on farm land near Minden, Nebraska, should cost the home owner only about $1,545 in annual energy bills, or about $130 per month.

To achieve this high energy performance, Knaggs constructed the exterior walls with advanced framing techniques that reduce the amount of lumber in the walls and allow more room for insulation. These techniques included 2x6 studs spaced 24 inches on center, 1x6s instead of 2x6s as sheetrock backers at corners and interior-exterior wall junctions, fewer studs around doors and windows, and only one piece of lumber in headers above doors and windows so that insulation can be maximized.

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.

Knaggs Construction built this 4,566-ft² home in Kearney, Nebraska, to the performance criteria of the DOE Zero Energy Ready Home (ZERH) program. ENERGY STAR appliances, 90% LED lighting, low-flow plumbing, and an Internet-controllable thermostat and water heater contribute to energy and water savings. The home also meets EPA Indoor airPLUS requirements including low-VOC paints and carpets.



What makes a home a DOE ZERO ENERGY READY HOME?

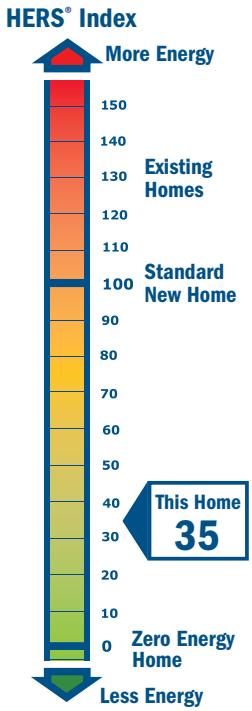
1 **BASELINE**
ENERGY STAR Certified Homes Version 3.0

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.

The OSB sheathing was caulked at all seams and corners and caulked to the top and bottom plates for continuous air sealing then the wall cavities were filled with dense-packed blown fiberglass insulation. A layer of R-3 foam was installed over the double top plate to minimize thermal bridging. Attic knee walls were constructed of 2x4s set 24 inches on center that were insulated with a solid air barrier of R-5 continuous rigid foam insulation that was sealed at the edges with spray foam, then the wall cavities were filled with R-23 of dense-packed fiberglass insulation. The walls were covered with house wrap, which serves as a weather-resistant barrier and drainage plane behind the engineered wood siding.

The house has 8-inch poured-concrete basement walls that are partially exposed on the rear of the house, which sits on a high spot on the site with ground sloping away on all sides, especially at the back of the house. The footings were poured between hollow perforated plastic forms that stay in place to provide a permanent draining system for water and soil gases along the inside and outside of the foundation. The slab was poured over a 6-inch bed of gravel and a 6-mil plastic vapor barrier while 8 inches of gravel plus filter cloth keep silt out of the footing drains. The house site included a sand dune; top soil was brought in and soils around the foundation were mechanically tamped with a jumping jack to minimize the chances of future settling. This soil compaction also helps to maintain the slope around the perimeter of the house to reduce the likelihood of water penetration. Every basement-level window well has a 4-inch drain that leads to the sump pump. The below-grade walls are protected with a sprayer-applied elastomeric emulsion waterproofing membrane. The basement walls were insulated along the interior. First, 2x4 16-inch on-center walls were constructed with a 1.5-inch gap between the stud wall and the concrete wall. This gap and the remainder of the wall cavity were filled with dense-packed fiberglass for a total wall insulation value of about R-22.

The garage walls were framed like the above-grade walls with 2x6s set 24-inches on-center. The wall separating the house from the garage was insulated with R-23 dense-packed fiberglass and covered with fire-rated $\frac{5}{8}$-inch drywall that was spray foamed to the top and bottom plates to help reduce air leakage.

The roof was protected with moisture guard in the valleys, plus synthetic felt rather than tar paper, and composite shingles. The vented attic was insulated with 14 inches (R-44) of blown cellulose. The attic access door was installed in the garage ceiling so that the access is not through conditioned space.

Attic knee walls were insulated with rigid foam insulation and sealed with spray foam to form a continuous thermal blanket and a draft barrier. The engineered trusses were spaced 24 inches on center with an 8-inch raised heel providing space for insulation over the top plates. Baffles made out of scrap OSB were sealed to the top plates to direct air from the soffit vents to the continuous ridge vents. After the blown cellulose was installed, Knaggs constructed a 2x6 bridge across the attic so future installers won't walk on the insulation.

The DOE Zero Energy Ready Home program requires that homes be blower door tested for whole house air leakage. Energy rater testing of the Knaggs house showed air leakage of <1 air changes per hour at 50 Pascals. That's far tighter than required by the newest energy code. (The 2015 International Energy Conservation Code requires 3 ACH 50 or less.) However, blower door testing is nothing new for Knaggs Construction. "We have been experimenting with a blower door on our houses since 2004. Over the years we have been trying different methods of air sealing and finally came up with a very reliable system," said Knaggs. Among the air sealing measures Knaggs employs are gluing and nailing all of the walls to the subfloor deck (which helps to eliminate both air leaks and squeaks); caulking the exterior OSB sheathing to the top plate, inside and outside corners, and all seams; taping all seams and penetrations in the under-slab vapor barrier; caulking the slab edge-to-foundation wall seam; and using latex spray foam to seal the edges of the ceiling drywall to the top plates before installing the wall drywall. After the finishers have taped the ceiling and before the attic insulation is installed, Knaggs uses a blower door to pressurize the house while his air sealing crew is in the attic so they can feel any penetrations and top plates that are leaking and apply spray foam where needed to stop those leaks. According to Knaggs it usually takes about five 12-oz cans of the spray foam and 1.5 to 2 hours of his guys' time. "Our guys would be disappointed if a house leaked more than 1 ACH 50," said Knaggs.

Knaggs follows the axiom, "build tight, ventilate right." To provide good ventilation for the home, an energy recovery ventilator (ERV) brings in fresh outside air that is filtered through a MERV 12 filter then distributed evenly through the house by the central air handler. The five bathrooms are also equipped with ENERGY STAR rated bath fans and the kitchen has a range hood that vents outside for spot ventilation.

The home is equipped with a multi-stage ground source heat pump that provides heating with a 5.1 coefficient of performance (COP) and cooling with an energy efficiency ratio (EER) of 24. The heat pump's central air handler is equipped with a variable frequency drive for greater energy efficiency. All of the duct work is inside conditioned space and sealed with duct mastic and/or UL-approved 181 AB foil tape. All duct work is pressure tested before the air handler is installed to confirm that the air sealing was done correctly. All supplies and returns are covered during construction to keep out dust and debris.

HOME CERTIFICATIONS

DOE Zero Energy Ready Home Program, 100% commitment

ENERGY STAR Certified Homes Version 3.0

EPA Indoor airPLUS

For Knaggs the biggest challenge is finding appraisers and realtors in Nebraska who understand what a high-performance home is, but Knaggs is working hard to change that. He's given training sessions on building science for appraisers and realtors, community colleges, home builders associations, Habitat for Humanity affiliates, and new state legislators. He chairs the building codes committee for the Nebraska State Home Builders Association. He's spoken at Nebraska legislative hearings, at housing conferences, and at the Nebraska Codes Compliance Collaborative, among other things. "I believe in paying it forward," said Knaggs.

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.

Low-flow toilets and faucets and manifold plumbing with insulated PEX lines that speed water directly to taps from the centrally located heater help to cut water usage.

The ground source heat pump has a desuperheater that preheats the water in a 50-gallon storage tank which feeds the highly efficient 80-gallon heat pump water heater. The heat pump is located in the basement. In the summer it provides some supplemental cooling and dehumidification, which helps to offset the high electric rates due to summer irrigation energy hikes.

Although the home owner chose not to install photovoltaic panels at the time of construction, Knaggs built the house to be PV ready with space in the utility room for the inverter, DC conduit to the roof, and attic access for the PV installer.

For additional resistance to storms, Knaggs incorporated a hip roof design wherever possible because hip roofs are more resistant to wind uplift. He also went beyond code in installing metal straps that attach from the foundation bolts to the outside wall to help hold walls on their foundations. Another unique feature Knaggs incorporated is a sunken floor in the utility room that is 1.5 inches deeper than the rest of the basement floor. "Over the years this sunken floor has saved many home owners from costly cleanups like sewer backup, water softener malfunctions, and fitting leaks," said Knaggs.

Experience has taught Knaggs a few other tricks that prevent hassles later on. He takes photos of all the walls before drywall is hung so he and the home owners will know where wiring and plumbing are located. He sprays lines on the floor by the bottom plate before drywall is installed to show where studs, piping, and electrical are located to assist trades in hitting studs and avoiding accidentally hitting a pipe or wire during the finishing stages. He also performs a duct blaster test on the supply and return ducts before drywall is hung to test for leaks when they can be easily fixed.

Knaggs said he promotes his company's high-performance construction at the local home builders show and parade of homes, and on his website. But his best source of leads is happy home owners who can't help but brag to friends and family about how low their utility bills are and how much they enjoy their new home.

Photos courtesy of Knaggs Construction

KEY FEATURES

- **DOE Zero Energy Ready Home Path:** Performance.
- **Walls:** 2x6, 24 o.c., 5.5″ R-23.5 dense-packed fiberglass, .5″ OSB, house wrap, engineered wood siding.
- **Roof:** Engineered trusses, raised heel, synthetic felt, ridge vents, composite shingles.
- **Attic:** Vented with R-44 14″ blown cellulose, OSB baffles sealed to top plates.
- **Foundation:** Basement with concrete footings poured in stay-in-place plastic drain pipe forms, concrete walls, R-4.5 blown fiberglass behind 2x4 16″ o.c. walls with R-19 cavity insulation.
- **Windows:** Dual-pane, low-e, argon-filled, U=0.27, SHGC=0.21.
- **Air Sealing:** <1 ACH 50.
- **Ventilation:** ERV, MERV 12 filter, bath exhaust fans.
- **HVAC:** Ground source heat pump, 5.1 COP, 24 EER, all ducts inside.
- **Hot Water:** 80-gal heat pump water heater, 2.33 COP.
- **Lighting:** 90% LED, 10% CFL.
- **Appliances:** ENERGY STAR refrigerator, dishwasher, clothes washer and dryer.
- **Solar:** None.
- **Water Conservation:** Water heater centrally located, low-flow fixtures.
- **Energy Management System:** Internet-controlled thermostat and water heater.
- **Other:** Low-VOC paints, CRI green-labeled carpet.

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