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

DOE ZERO ENERGY READY HOME™

U.S. DOE ZERO ENERGY READY HOME 2024 WINNER Housing Innovation Awards

Howard Building Science

Duke St. Cottage Two-Bedroom Granite Falls, NC

BUILDER PROFILE

Howard Building Science
Granite Falls, NC
howardbuildingscience.com
Rob Howard, 828-217-0506
rob@howardbuildingscience.com

FEATURED HOME/DEVELOPMENT:

Project Data:

- **Project name:** Duke St. Cottage Two-Bedroom
- **Location:** Granite Falls, NC
- **Layout:** 2 bdrm, 1 bath, 1 fl, 800 ft²
- **Climate:** IECC 4A, mixed-humid
- **Completed:** January 2023
- **Category:** Affordable

Modeled Performance Data:

- **HERS INDEX:** without PV 44
- **Annual Energy Costs:** without PV $900
- **Annual Energy Cost Savings:** without PV $600
- **Annual Energy Savings:** without PV 5,800 kWh
- **Savings in the First 30 Years:** without PV $25,650

Builder Rob Howard first heard the term "pocket neighborhoods" in 2018. Now he's close to realizing his dream of building one with completion of the ninth of 11 small homes on a 1.25-acre parcel he dubbed Duke St. Cottages in Granite Falls, North Carolina.

For Howard, pocket neighborhoods are the perfect venue for what he refers to as workforce housing—homes aimed at first-time and low- to middle-income buyers. "Our goal is to provide more housing choices with small homes that anyone can afford, including recent college graduates with student loan debt and retirees on a fixed income," said Howard.

"We are building towards a sustainable future where everyone has a safe, healthy place to call home," said Howard. "We believe that everyone deserves to live in the SHADE: a Sustainable, Healthy, Affordable, Durable, Efficient home.

Howard's roadmap for getting there is the U.S. Department of Energy (DOE)'s Zero Energy Ready Home program. Every one of the 11 Duke St. cottages will be certified to the program's criteria.

Howard achieved a DOE Housing Innovation Award in 2024 for one of the homes, an 800-ft², two-bedroom, one-bath, one-story home in one of two floor plans built to date at Duke St. The compact home epitomizes Howard Building Science's company motto – "Proving that Sustainable is Attainable."

"Every decision we make about construction materials and processes has to pass a cost-effectiveness test," said Howard. "This cost-benefit analysis was burned into my brain from 15 years with Habitat for Humanity. We cannot just throw money at the problem of attainable housing . We have to optimize the material and labor resources to achieve the highest performance for the lowest cost."

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 3.2 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.

The award-winning home is one of eleven homes constructed in one of two cottage-style floor plans with variations in colors and front porches to mimic an older neighborhood street in this rural small town. Underneath the varied exteriors, every home was constructed of sturdy insulated wall panels filled with 3.5 inches (R-26) of closed-cell spray foam and topped with insulated roof panels containing 5.5 inches (R-40) of continuous closed-cell spray foam. The homes sit on unvented crawlspaces lined with 2 inches (R-10) of rigid foam to complete the highly insulated building envelopes.

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

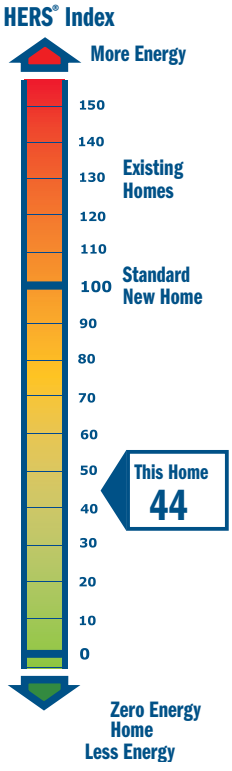
3 **DUCT SYSTEM**
located within the home's thermal boundary

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.

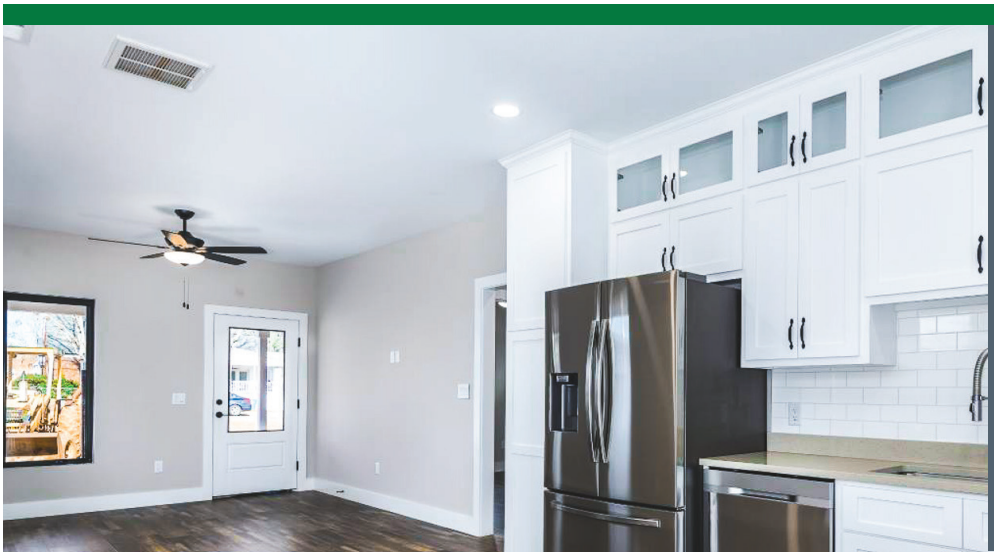


The Duke St. cottages may be small in volume but they are big on performance. The DOE program has ENERGY STAR and EPA Indoor AirPlus home certification and the latest energy codes as its baseline so every certified home provides its home buyers with the health, resiliency, and utility bill savings these programs offer. Other DOE Zero Energy Ready Home requirements help ensure water savings; HVAC and water heating efficiencies; and third party-verified air sealing to minimize drafts and keep out bugs, dust, smoke, and pollens. While homes aren't required to have solar electric panels, this voluntary program specifies installation of the electrical infrastructure and space in the home for future installation of PV, as well as electric vehicle chargers, heat pumps, and heat pump water heaters, offering homeowners the option and ease of future installation of these technologies should they choose to add them.

The DOE program offers multiple performance paths and builders are free to choose what building assembly methods and tradeoffs they will use to meet their performance targets. For the first nine homes, Howard chose a panelized wall assembly. The panel product for this home consists of a 3.5-inch-thick closed-cell polyurethane foam core adhered to an inside-facing layer of OSB and an exterior layer of OSB with a coating that serves as a water-resistant air control layer. The panels came to the site precision cut to the dimensions of the home's design. This particular product uses inter-locking cam-locks that provide for fast, foolproof connection of the panels. Spray foam was applied at the panel edges before connecting for air-tight joints. Factory-formed corners provide for a complete air seal and continuous insulation at this otherwise-hard-to-detail juncture. Pre-framed openings added to the fast assembly, even with unskilled labor. "With a small crew made up of two skilled carpenters and three college students, we were able to set the wall and roof panels in three days," said Howard. Howard added 1x4 furring strips to the exterior of the SIPs to create a drainage plane and nail base for the engineered wood siding.

The same panel product was used to provide the roof, although the panels were thicker with a 5.5-inch core of closed-cell spray foam providing an R-40 roof in a simple gable design that was topped with asphalt shingles.

The home sits on an unvented crawlspace constructed of concrete masonry unit (CMU) blocks, insulated on the interior with R-10 rigid insulation; the ground is lined with a 10-mil vapor barrier. A dehumidifier is installed in the crawlspace to control relative humidity and prevent mold growth. Temperature and humidity sensors are also placed in the crawlspace to monitor conditions and send alerts remotely to homeowner's mobile phones. The foundation is one place where Howard has been able to optimize costs. "We considered using precast insulated concrete wall panels



The kitchen opens to a great room giving a sense of space to this compact, 800-ft² home built by Howard Building Science in Granite Falls, North Carolina, and certified to the criteria of the DOE Zero Energy Ready Home program. Efficient windows let in light but keep out the heat, while ENERGY STAR lighting and appliances reduce energy consumption.

or ICFs for the foundation walls but determined that we could achieve the same performance at a much lower cost by using a combination of CMU and rigid foam insulation. We hired subcontractors to do our first crawlspace encapsulation, but quickly realized that we could buy the materials and install them ourselves for a lot less money," said Howard.

The double-pane windows provide an insulation value of U-0.25 and have a low solar heat gain coefficient of 0.19 to minimize solar heat gain in this mixed-humid IECC 4A climate zone.

Howard took several steps to minimize drafts and air leakage in the building envelope, including taping the seams of the coated OSB, using a closed-cell foam sill gasket under the bottom plates, applying spray foam at the panel joints and around the windows and doors, installing stretch tape and liquid flash around the windows and doors, and sealing all penetrations in the building envelope with spray foam and liquid flash. Blower door testing is required on every ZERH-certified home and this home tested at 2.76 air changes per hour at 50 Pascals pressure differential.

An energy recovery (ERV) was installed to provide fresh air to the tight home while exhausting stale air. The ERV uses a heat exchanger to warm or cool the incoming air, which passes through a MERV 13 filter. Room sensors continually monitor humidity, VOCs, smoke, carbon dioxide, and PM2.5 and can increase ventilation rates if sensors detect high levels of these air quality factors. A smart switch in the bathroom monitors relative humidity and automatically controls the bath exhaust fan. The ERV also helps to distribute conditioned air from the home's single ductless mini-split heat pump which is installed in the living room/dining room. The high-performance heat pump has a cooling efficiency of 26.3 SEER2 and a heating efficiency of 11.1 HSPF2 and performs well even at cold outdoor temperatures.

The home's 50-gallon heat pump water heater provides domestic hot water with an efficiency of 3.75 UEF. A core plumbing design was used to keep hot water distribution as compact as possible. ENERGY STAR-labeled appliances and lighting and a heat pump clothes dryer and induction cooktop add to energy savings.

Howard has been interested in pocket neighborhoods since first hearing the term used by architect Ross Chapin, author of *Pocket Neighborhoods: Creating Small Scale Community in a Large Scale World,* at a conference in 2018. Howard already has plans for two more pocket neighborhoods in the works on property he has acquired.

HOME CERTIFICATIONS

DOE Zero Energy Ready Home Program - 100% Commitment

ENERGY STAR Certified Homes Version 3.2

EPA Indoor AirPlus

PEARL

"We thoroughly enjoy our DOE Zero Energy Ready Home because of the consistent air quality and tremendous energy savings. From designing our home to the installation, everything was a smooth process."
–Homeowner

ENERGY STAR

Building America
U.S. DEPARTMENT OF ENERGY

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.

The roof is constructed of insulated panels which provide both structure and insulation, offering a temperate space for storage and the HVAC ducts.

One neighborhood will be a town-home project in Hickory, North Carolina, that Howard calls the Hickory Grove project. Module will do the design. Green Builder Media will collaborate on it as their next VISION House. The property is 0.9 acres and may have up to 18 townhomes on it. The second parcel is 2.5 acres in nearby Hudson, NC, where Howard plans to build a mix of single-family and townhomes, providing much needed workforce housing for this small town.

But first he wants to finish Duke St. Cottages. Nine of the 11 homes have been built and sold so far. Homes 10 and 11 will be modular construction. "That was not the original plan but I ran into a right-of-way conflict with the railroad that backs up to our property. I had to shrink the footprint of the last two homes down from 24 ft wide to 16 ft wide. I realized you can ship home modules up to 16 ft wide," Howard found a factory partner in South Carolina who would construct the modular homes to the DOE Zero Energy Ready Home standards.

Howard's first foray into pocket neighborhoods has generated a lot of interest. Once he started building the Duke St. Cottages, word got around. "Builders and developers just show up at the site to see what I'm up to. There are a lot of builders who are intrigued by this idea," said Howard. "One morning I came out at 8am and there was someone walking the site. He was in town visiting family. He and his wife are now my business partners."

Although the home does not have solar installed, it is roughed-in for a future solar array on the roof. "We are currently talking to LG about testing their new Home 8 Energy Storage System on one of the homes at Duke St. Cottages. With batteries and an 8-kW PV array, we can achieve net-zero energy with minimal dependence on the grid," said Howard. "Our ultimate goal is for all of our homes to achieve net-zero energy."

Howard's passion for affordable, efficient, resilient construction extends beyond the construction site. In addition to building pocket neighborhoods of DOE Zero Energy Ready Homes, Howard also teaches building science at Appalachian State University, serves on the North Carolina Building Code Council, and serves on the boards of Habitat for Humanity of Catawba Valley and the Watauga Community Housing Trust. He also teaches continuing education workshops for the Appalachian Energy Center on building affordable Zero Energy Ready Homes.

Howard was recently called to testify in front of the House Committee on Energy and Commerce about the additional cost of building to the 2021 IECC. "While NAHB is claiming that it costs $31,000, we have found the additional cost to be closer to the DOE estimate of $7,000 per house," said Howard. Thanks to these lower upfront costs plus lower utilty bills, it sounds like lucky buyers of the Duke St. cottages have got it made in the SHADE.

KEY FEATURES

- **Walls:** Panels, R-26 total: closed-cell spray foam core, exterior face of panel has an integrated coating for rain screen and water control.
- **Roof:** Panels, gable roof: exterior face of panel is coated OSB.
- **Attic:** Unvented, 5.5″ R-40 panels with closed-cell spray foam core. 400 ft² storage space.
- **Foundation:** Unvented crawlspace, concrete masonry unit walls insulated along interior with R-10 rigid foam. 10-mil vapor barrier on ground.
- **Windows:** Double-pane windows, U=0.25, SHGC=0.19.
- **Air Sealing:** 2.76 ACH50; closed-cell foam sill gasket; flashing tape on panel seams; stretch tape and liquid flashing around windows and doors; all penetrations sealed with spray foam and liquid flash.
- **Ventilation:** ERV, distributed system. Sensors to monitor humidity, VOCs, smoke, carbon dioxide, and PM2.5.
- **HVAC:** Ductless mini-split heat pump, 11.1 HSPF, 26.3 SEER. Dehumidifier in enclosed crawlspace.
- **Hot Water:** Heat pump water heater, 50-gal, 3.75 UEF. Core plumbing design.
- **Solar:** None.
- **Energy Management System:** Ventilation system controlled by sensors that monitor humidity, VOCs, smoke, carbon dioxide, and PM2.5.
- **Other:** Electric vehicle charging station.

Photos courtesy of Howard Building Science

PNNL-SA-207044, Dec. 2024