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*

One Sky Homes

Cottle Zero Net Energy Home San Jose, CA

BUILDER PROFILE

One Sky Homes, San Jose, CA
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FEATURED HOME/DEVELOPMENT:

Project Data:

- Name: Cottle Zero Net Energy Home
- Location: San Jose, CA
- Layout: 5 bedrooms, 3.5 baths, 2 floors
- Conditioned Space: 3,198 ft^2
- Climate Zone: IECC 3C, marine
- Completion: April 2012
- Category: Custom

Modeled Performance Data:

- HERS Index: without PV 69 (California HERS), with PV -1
- Projected Annual Utility Costs: without PV $1,972, with PV $0
- Projected Annual Energy Cost Savings (compared to a home built to the 2008 California Title 24 Energy Code): without PV $1,095, with PV $2,900
- Builder's Added Cost Over California Code: without PV $50,000, with PV $65,000
- Annual Energy Savings: without PV 3,661 kWh, 193 therms, with PV 9,156 kWh, 293 therms

In a state that leads the union for its commitment to residential energy efficiency, being recognized as the state's first net zero energy new home is an honor indeed. For the design-build team of Allen Gilliland and Bronwyn Barry of One Sky Homes in San Jose, California, the designation is one of many firsts on the project. The home is the builder's first home certified to the Passive House Institute standard and their first certified to the high energy performance standards of the U.S. Department of Energy's Zero Energy Ready Home program.

To meet the DOE Zero Energy Ready Home criteria, the home had to be ENERGY STAR Version 3.0 certified and meet the insulation requirements of the 2012 International Energy Conservation Code. The DOE program also requires that homes be certified to the air quality requirements of the U.S. Environmental Protection Agency's Indoor airPLUS program. In addition, the builder chose to pursue LEED for Homes and achieved platinum certification on the home.

The project could be thought of as a building science test bed. The 3,198 ft^2, two-story spec home took four years to design and build, more than twice the builder's typical construction cycle for a custom home, because Gilliland wanted to test several new construction techniques.

"It was our intention to take a real building science approach. We wanted to measure this building in every way possible, to learn from it and share what we learned. To everyone's credit, we were very successful. The data verified that we were plus site energy. (The home's 6.4-kW photovoltaic system produces enough electricity to power both the home for a year and an electric car for thousands of miles of charge.) And we're providing the homeowner with a vastly better living experience," said Gilliland.

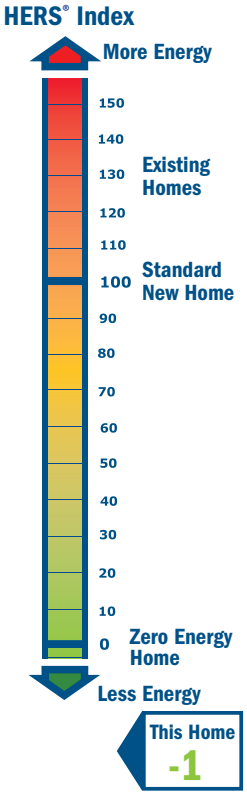
ZERO ENERGY READY HOME U.S. DEPARTMENT OF ENERGY

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.

One Sky Homes of San Jose, California, used insulated concrete form (ICF) blocks to create the insulated crawlspace foundation for its first DOE Zero Energy Ready Home, the first net zero energy new home certified in the state of California. The 48x12x8-inch foam blocks stack up to form a hollow wall that is reinforced with steel rebar and filled with poured concrete, to create a sturdy structure insulated inside and out.

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.



One Sky Homes collaborated with Davis Energy Group, a research partner in DOE's Building America program. Davis Energy Group helped the builder meet the DOE Zero Energy Ready Home criteria while testing several advanced building technologies, including a night ventilation cooling system that cut cooling costs by 98%.

High efficiency starts at the ground level where Gilliland used R-22 insulated concrete form (ICF) blocks to create a 3-foot-high foundation wall that formed the insulated sides of the unvented crawl space. Gilliland covered the crawl space floor with 4 inches of ¾-inch aggregate, a heavy-gauge polyethylene vapor barrier, 3-inch-thick 2-pound rigid expanded polystyrene foam (EPS) foam (R-14), then a 3-inch concrete crawl space slab. A floor decking of 9.5-inch engineered I joists was installed over the crawl space.

The above-grade walls consisted of 2x6 studs spaced 24 inches on-center. Advanced framing techniques were used including two-stud rather than three-stud corners, open headers over doors and windows, windows sized to the stud bay openings, and ladder blocking at interior-exterior wall intersections to reduce lumber usage and provide more room in the walls for the R-23 of dense-packed cellulose. "Everything is sized on a 24-inch grid, which makes for faster assembly with less materials waste," said Gilliland. Over the exterior plywood sheathing, a 1-inch layer of EPS foam board was installed. This was covered with house wrap. Then the stucco installers attached a ¼ inch plastic mesh rain screen that served as a drainage plane. Over this they installed wire lathe that was then covered with a traditional three-coat stucco cladding.

Raised-heel trusses provided plenty of room in the attic for the R-51 worth of blown cellulose insulation blanketing the ceiling deck. The roof decking OSB had a foil radiant barrier coating on the underside facing the open attic space. Natural attic ventilation was created with continuous eave and ridge vents. This ventilation, combined with the radiant barrier, kept attic temperatures low. Davis Energy Group monitoring confirmed that interior attic temperatures never climbed more than 20 degrees above exterior ambient temperatures.

All of the home's windows and patio doors were triple-pane glass with the exception of one double-pane window installed for testing purposes. All of the windows were wood-framed with low-emissivity coatings and argon gas fill. Solar heat gain coefficients (SHGC) varied depending on the orientation of the window. Higher SHGC (0.49) windows were installed on the south side to allow beneficial

One Sky Homes used advanced framing techniques like 2x6 studs spaced 24 inches apart, open or insulated headers over doors and windows, two-stud corners, and ladder blocking at intersecting walls to reduce the number of studs in the walls, allowing more space for the dense-packed blown cellulose insulation. An additional 1-inch layer of rigid EPS foam was installed around the exterior of the home to provide a continuous insulation layer and thermal break, preventing thermal bridging or heat transfer through the studs from the inside to the outside of the home. This EPS was covered with house wrap, a plastic mesh rain drainage layer, wire lathe, and three-part stucco.

passive heat gain in the winter. Lower SHGC (0.29) windows were directed toward the west to reduce unwanted late afternoon heat gain. The calculated average "installed" R-value for all of the windows was R-5.

Thanks to rigorous air sealing measures the home was able to meet the very low air leakage minimum allowed by the Passive House Standards of 0.60 air changes per hour at 50 Pascals pressure difference (ACH 50). The home achieved an air leakage of 0.57 ACH 50 when measured with a blower door test.

A typical 3,000 ft^2 home would use about 40,000 kWh of electricity (or natural gas equivalent) annually with half of that consumed by heating and cooling. The One Sky zero energy home uses only 10,000 kWh of energy a year and only 2,000 kWh of that is used for heating and cooling. A split-system central air source heat pump with a cooling efficiency of 21 SEER and a heating efficiency of 10 HSPF is located in an upstairs closet. The system's ducts are located in conditioned space, in the open-web trusses between the first and second floors.

To keep the air healthy in the super airtight home, a heat recovery ventilator (HRV) was installed to draw in fresh air and exhaust stale air. The air passes through a MERV 13 filter then is supplied to the bedrooms and common areas while exhaust air is pulled from the bathrooms and laundry. The HRV uses 3-inch ducts that are completely separate from the heat pump's 8-inch ducts. "With the heat pump, we're moving 100 cfm of air per register. That is an order of magnitude of difference from the 10 cfm of air moving through each HRV duct. It's hard to get 10 cfm of air to move where you want it to in an 8-inch duct," said Gilliland.

The home uses Night Ventilation Cooling, a ventilation system tied to the central air handler that uses temperature sensors, dampers, and electronic controls to draw cool nighttime air from outside through a duct to the return side of the air handler fan when temperature sensors indicate that the outside air is cooler than the inside air and the system is calling for cooling. The technology was initially developed in the late 1990s, in part by Davis Energy Group, and is similar in principal to the economizers used on commercial cooling systems. The system is ideal for climates with dry summers and large day-night summer temperature differences. The Night Ventilation Cooling system's performance was extensively measured and showed dramatic results. It completely eliminated overheating and met 98% of the home's total cooling demand, with a measured coefficient of performance (COP) of 14.

HOME CERTIFICATIONS

DOE Zero Energy Ready Home Program, 100% commitment

ENERGY STAR Certified Homes Version 3.0

EPA Indoor airPLUS

Passive House Institute U.S. Standard (PHIUS+)

LEED for Homes, platinum

Visit One Sky's website to see Gilliland demonstrate how the entire two-story home can be heated with a hair dryer, even on a cold winter night (http://oneskyhomes.com/video/passive-houseproven-hair-dryer-home)

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.

Gilliland is looking forward to the day when smart heat pumps will integrate all of the HVAC functions—heating, cooling, HRV balanced ventilation, and night cooling—into one system with one controller for the home owner. He noted the 2013 California Energy Code, which went into effect July 1, 2014, makes mechanical night ventilation prescriptive in some climate zones in California and gives credit for it in other locations in the state.

The home has three roof-mounted solar thermal panels that send heated water to a storage tank, which the auxiliary gas-fired 96% efficient storage water heater draws from to supply hot water. To reduce water use, plumbing fixtures are water conserving and hot water fixtures are equipped with a recirculation pump that is button- or motion sensor-activated to speed hot water to the fixture.

Another unique feature of the home is the grey water recycling system. During the irrigation season, grey water from the home's sinks and showers goes to an underground 50-gallon tank, from which it is pumped to several irrigation zones around the yard. During the rainy season, the grey water goes directly to the sewer. The grey water system meets 80% of the home's landscape irrigation needs, with below-grade drip irrigation.

The 6.4-kW PV system (28 x 230-W panels) produced 11,000 kWh/year in 2013 to meet 113% of domestic demand; the extra power was used for charging the homeowners' electric car. One electric car charging station is installed in the garage and wiring is in place to install a second one. The solar PV system is grid-tied, but could be upgraded with an inverter that will support independent operation in case of grid failure. Without the PV system, the energy efficiency upgrades would save a homeowner a calculated $1,095 compared to a home built to the 2009 IECC. With the PV system, homeowners are expected to save about $2,900 a year compared to owners of a code-built home.

All of the home's appliances, including the clothes washer, dishwasher, and refrigerator, are ENERGY STAR rated. The home's lighting includes 40% CFL, 40% LED, and 20% halogen kitchen task and accent lights. Vacancy sensor controls were installed in all rooms. Closet lights, heat lamps, and other utility lighting were installed with count-down timer controls. All exterior lighting is ENERGY STAR rated and is on timers with photocell shut offs.

Gilliland said One Sky has enjoyed the experience of learning from this project and is committed to zero energy construction. His only concern is motivating buyers to seek it out. "Once people experience it, they want it. Our customers will tell you, you just can't believe it. It's so much better living in these homes. People just haven't heard enough about it yet."

That may change soon, in California anyway. The California Public Utilities Commission and the California Energy Commission have adopted as a goal that all new residential construction will be zero net energy by 2020.

Photos courtesy of One Sky Homes.

KEY FEATURES

- **DOE Zero Energy Ready Home Path:** Performance
- **Walls:** 2x6 24 in. o.c. advanced framed, R-23 dense pack cellulose cavity insulation, plus 1-in. EPS over plywood sheathing; ¼-in. plastic mesh ventilated rain screen; house wrap, wire lathe; traditional 3-coat stucco cladding
- **Roof:** R-51 blown cellulose; raised heel trusses; foil-faced radiant barrier sheathing; asphalt shingles; continuous eave and ridge vents
- **Foundation:** ICF crawl space walls, 4-in. aggregate, vapor barrier, 3-in. EPS foam, crawlspace concrete slab
- **Windows:** Triple-pane, low-e, wood-framed, argon fill, SHGC=0.49 on south facing and SHGC =0.29 on N/E/W facing windows; U=0.2 (installed)
- **Air Sealing:** 0.57 ACH 50
- **Ventilation:** HRV with MERV 13 filters, 84% sensible heat recovery efficiency. Night Ventilation (economizer) with MERV 13 filters
- **HVAC:** Split-system air-source heat pump SEER 21, HSPF 10; air handler in upstairs closet; all supply ducts in open-web trusses between first and second floors; short return duct buried in attic insulation.
- **Hot water:** 3 solar thermal panels with separate pre-heat tank. Gas-fired, 96% efficient condensing back up storage water heater. On demand hot water recirculation with push button or occupancy sensor controls
- **Lighting:** 40% CFL, 40% LED and 20% halogen; vacancy sensors in all rooms. Closets, bath heaters, and utility lighting on count-down timers. All exterior lighting ENERGY STAR rated and on timers with photocell shut off
- **Appliances:** ENERGY STAR clothes washer, dishwasher, refrigerator/freezer
- **Solar:** 6.4 kW of PV (28 x 230-W panels)
- **Water Conservation:** Low-flow fixtures; grey water system captures drainage from showers, vanity sinks, and clothes washer to provide 80% of landscape irrigation.
- **Other:** Energy management system. Electric vehicle charging station with pre-wiring for a second charger

PNNL-SA-105478, September 2014, Rev. May 2015