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

DOE ZERO ENERGY READY HOME™

U.S. DOE ZERO ENERGY READY HOME 2017 WINNER Housing Innovation Awards

Alliance Green Builders

Casa Aguila
Ramona, CA

BUILDER PROFILE

Alliance Green Builders, Ramona, CA
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FEATURED HOME/DEVELOPMENT:

Project Data:

- Name: Casa Aguila
- Location: Ramona, CA
- Layout: 4 bdrm, 5 bath, 1 fl, no bsmt, 3,129 ft^2
- Climate Zone: IECC 3B, hot-dry
- Completion: April 2016
- Category: custom for buyer

Modeled Performance Data:

- CA Energy Design Rating: without PV 43 CA EDR, with PV and batteries -92 CA EDR
- Projected Annual Energy Costs: without PV $1,000, with PV $-9,900
- Projected Annual Energy Cost Savings (vs typical new homes): without PV $1,400, with PV $11,700
- Projected Annual Energy Savings: without PV 9,800 kWh, with PV 64,500 kWh
- Added Construction Cost: without PV $150,000, with PV $319,000

They say every man's home is his castle. The elegant single-story stucco-and-glass house atop a hill above Ramona, California's San Pasqual Valley may not look very castle-like, but the home was built with a host of features that make it a veritable fortress against wildfires, the common enemy of southern California home owners.

When the Witch Creek fire took their previous home in 2007, along with 1,000 other homes in the neighborhood, Pete and Amy determined that one day they would build a home that could resist the fires and have the energy and water self-sufficiency to hold out through the multi-day power outages that often accompany wildfire season in the southern California hills.

Stucco and concrete walls, stone and tile ground covering, metal roofing and posts, high-impact windows, energy-efficient construction, on-site wind and solar power generation and storage, and on-site water collection and recycling systems are among the many fire- and outage-resistant features Alliance Green Builders incorporated into the project. For energy efficiency, the builders certified the home to the U.S. Department of Energy's Zero Energy Ready Home criteria.

This uber-efficient home also achieved a LEED platinum certification from the U.S. Green Building Council and was the first home in San Diego County to be certified by the Passive House Institute US. In its pursuit of water and energy self-sufficiency the project team received the County's first onsite wastewater treatment permit. They also designed a rainwater collection system to supply all indoor water uses. With the solar PV tracking system, solar thermal water heating, 45-foot wind turbine, and battery storage, the home owners are well on their way to achieving grid independence.

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 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.

Alliance Green Builders built this 3,129-ft² home in the hills above Ramona, California, to the high performance criteria of the DOE Zero Energy Ready Home (ZERH) program. The home should perform far better than net zero thanks to a super-efficient building shell, a wind turbine, three sun-tracking solar photovoltaic arrays, and solar thermal water heating. The water-efficient structure also has four 10,000-gallon storage tanks for rain water harvesting and three 10,000-gallon tanks for storm water collection and grey water storage.

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

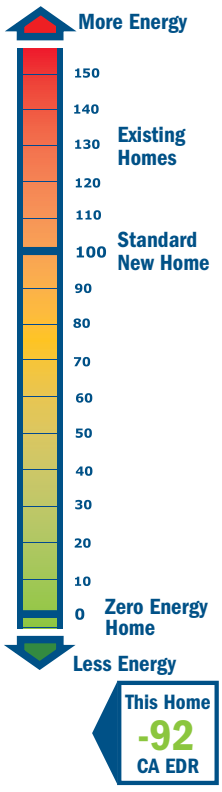
3 **DUCT SYSTEM**
located within the home's thermal boundary

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.



Even with large solar capacity, energy self-sufficiency would be hard to achieve without first constructing a very energy-efficient shell. For this the builder turned to the DOE Zero Energy Ready Home program. This home labeling program requires certification to ENERGY STAR Certified Homes Version 3.0 and the U.S. Environmental Protection Agency's Indoor airPLUS. Each home must also meet the hot water distribution requirements of the EPA WaterSense program and the insulation requirements of the 2012 International Energy Conservation Code. In addition, homes must have solar electric panels installed or be "solar ready" with conduit and electrical panel space for future panels.

The builders exceeded code insulation requirements with double walls consisting of a 2x6 exterior wall and a 2x4 interior wall set 7 inches apart to form a 16-inch cavity stuffed with R-57 of dense-packed cellulose. The inner walls and ceilings are covered with a bio-based phase changing material that helps stabilize temperatures inside the home. The phase change material consists of sheets of plastic containing pockets of a nontoxic gel with a defined melting point; the material cools the room as the wax melts and warms the room as the wax re-solidifies. The sheeting is hidden behind a volatile organic compound (VOC)-absorbing drywall that lines the walls and ceilings. The outer wall is sheathed with 3/8-inch OSB that is coated with a liquid-applied water proofing and air barrier product, which takes the place of house wrap to cover the walls and window and door openings with a seamless layer of protection. The walls are clad with traditional three-coat stucco applied over metal lath and one layer of stucco wrap. The home's wood framing is treated with fire- and termite-resistant borate.

The windows, which are set deep into the 16-inch-thick walls, are a key to the home's fire defense system. It turns out that exterior wood is not the chief source of ignition for house fire damage during wildfires in southern California. Rather, most fires start inside from embers blown through broken windows. The Santa Ana winds that cross California during wildfire season can get whipped up by the fires to such high velocities they can pick up rocks and pelt windows with enough force to shatter glass. To protect against this threat, Alliance installed triple-glazed, tempered glass windows with an outer pane of impact-resistant laminated glass. The R-5 insulated windows also provide year-round energy efficiency with coatings to reduce heat transfer.

The roof consists of 2x8 rafters topped with ½-inch OSB that is coated with the liquid-applied waterproofing membrane that also covers the wall sheathing

A summer kitchen on the patio helps keep heat and humidity out of the home. Solar reflectant metal roofing, SIP roof panels, deep overhangs, and triple-pane Passive House-certified windows with low-emissivity coatings also help to keep out unwanted solar heat gain. Solar thermal panels provide hot water for the pool, spa, domestic hot water, and radiant floor heat. LED lighting, ENERGY STAR ceiling fans, and appliances add to energy savings.

to form a continuous air and water barrier. This is topped with 6-inch-thick structural insulated panels (SIPs) that have a polyurethane core with a higher melting point than most foams. The SIPs are covered with a roofing underlayment and a standing-seam gray metal roof with a solar reflective index of 52 to help resist solar heat gain. Netting is attached to the underside of the roof rafters and the space is filled with blown cellulose. Below that is a 2-inch gap and then 2x6 ceiling rafters that are covered with the phase-change material and drywall. The gap provides more space for insulation above the recessed can lights.

The home's slab-on-grade foundation is wrapped in 1 inch of expanded polystyrene (EPS) insulating foam. Embedded in the concrete is plastic piping for the home's radiant heating and cooling system.

The home actually has several heating and cooling systems. Most of the hot water for the radiant floor heat is provided by nine 4x10 (360 ft²) solar thermal collectors (360 ft²) mounted on the roof. An air-to-water heat pump provides backup water heating and water cooling. Additional water cooling, should it be needed for extremely high summer temperatures, is available via a ducted fan coil system (with cold water from the air-to-water heat pump). Per the owners' request, a third system was installed consisting of a minimally ducted mini-split heat pump with fan coils to provide back-up heating and cooling to the bedrooms.This redundancy may seem excessive for a Passive House, but according to builder Jeff Adams, "the system has been designed for a climate that could be dramatically different in 100 years or more."

The solar thermal system is also the primary source for the home's potable hot water. The air-to-water heat pump and an 80-gallon heat pump water heater provides backup domestic hot water. The hot water distribution system was designed to cut water loss to 1 cup before hot water reaches any bath or kitchen fixture.

The hilltop home is self-sufficient for water. Five 10,000-gallon tanks collect rainwater from the roof to supply 100% of the family's indoor water use. Four more 10,000-gallon tanks collect storm water from the site and one additional 10,000 gallon tank collects greywater (from the shower, baths, sinks, and washing machine). This stormwater and greywater is filtered and used for irrigation and fire suppression. A separate system collects black water from toilets and kitchen sinks in a septic tank; from there, it is aerated and filtered, and the clean water is pumped into another 1,000-gallon holding tank for drip irrigation.

HOME CERTIFICATIONS

DOE Zero Energy Ready Home Program, 100% Commitment

ENERGY STAR Certified Homes Version 3.0

EPA WaterSense

EPA Indoor airPLUS

Passive House Institute US

LEED for Homes, platinum

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 phase-changing material lines the walls and ceiling to help even out day-night temperature swings.

The home owners requested an electric production system that can allow the home to eventually go off-grid. Three large dual-axis solar trackers were installed on a leveled area south of and below the home. Each tracker holds 474 ft² of photovoltaic panels for a total capacity of 21 kW. The panels can rotate in multiple directions; sensors direct them to the brightest point in the sky, even on cloudy days. They can generate power for more than 12 hours/day and are expected to produce about 44,000 kWh per year. A 45-ft-tall helical 3.2-kW wind turbine was installed on the hill just above the home, considered one of the best wind generation sites in San Diego County. The wind turbine is expected to produce 5,000 kWh per year of power. The home now operates off of twenty 12-volt solar batteries but is grid-tied to use the grid for backup power. When more battery storage is added, the home will be able to be completely energy self-sufficient.

Like all DOE Zero Energy Ready Homes, the house was evaluated by an energy rater. California uses the California Energy Design Rating (EDR) rather than the national Home Energy Rating System (HERS) score, for verification to the state's Title 24 energy code. This home scored a very low 43 (EDR) without the renewable energy systems included. With the solar and wind resource included, the home achieved a remarkably low EDR of -92.

The home's performance testing included blower door testing which revealed an extremely tight building envelope with only 0.32 air changes per hour at 50 Pascals pressure difference (ACH50), nearly twice as tight as the 0.6 ACH 50 required by Passive House. To bring fresh air into the home without significant energy loss, Alliance installed a heat recovery ventilator (HRV). The HRV draws in fresh outside air through a filter and ducts the air to bedrooms and living spaces while exhaust ducts pull air from the kitchen and bathrooms. The incoming and outgoing air ducts cross in a heat exchanger which transfers heat from the warmer stream to the cooler stream helping to warm incoming air in the winter and cool incoming air in the summer. Alliance tested a new model of HRV from Italy which also allows for some humidity control. With the filtered ventilation system, and other features like low-VOC finishes, good moisture management, etc., the home met the clean air requirements of the EPA's Indoor airPLUS.

The home owners are happy to share the lessons of their home with others. Alliance Green Builders partners Jeff Adams and Rich Williams, founders of the San Diego chapter of Passive House U.S., have used the home for numerous tours and consider sharing lessons learned the "icing on the cake" for this project. "Designing arguably the most energy and water efficient home in San Diego …is incredibly rewarding," said Adams.

Photos courtesy of Alliance Green Builders

KEY FEATURES

- **DOE Zero Energy Ready Home Path:** Performance.
- **Walls:** 2x6 16″ o.c. double-stud advanced framed walls with R-56 blown cellulose. 3-coat stucco, over liquid-applied weather-resistant barrier. Phase-change material under drywall.
- **Roof:** Synthetic underlayment; standing seam metal roof with 0.52 SRI.
- **Attic:** 2x8 rafters filled with dense-blown cellulose and topped with OSB roof decking, liquid waterproofing, then 6″ SIPs; phase-change material behind dropped ceiling drywall.
- **Foundation:** Slab-on-grade; 1″ R-5 EPS rigid foam and vapor barrier under slab.
- **Windows:** Triple-pane, tilt-and-turn R-5 windows with impact-resistant glass; U=0.20, SHGC=0.30.
- **Air Sealing:** 0.32 ACH 50.
- **Ventilation:** HRV with humidity control.
- **HVAC:** Radiant floor heat; fan coil cooling, ducted mini-split heat pump.
- **Hot Water:** Solar and air-to-water heat pump for space and DHW; backup heat pump WH.
- **Lighting:** 100% LED.
- **Appliances:** ENERGY STAR clothes washer, refrigerator, dishwasher, ceiling fans.
- **Solar:** 22.1-kW PV (three dual-axis trackers); 3.2-kW wind turbine. 40-kW battery storage.
- **Water Conservation:** Four 10,000-gal rainwater cisterns for potable water. Four 10,000-gal storm water tanks + one 10,000-gal grey water tank for irrigation and fire suppression. First residential black water treatment permit in San Diego.
- **Energy Management System:** Tracks energy and water usage and production.
- **Other:** Two electric vehicle charging stations; low-VOC products; VOC-trapping drywall.

PNNL-SA-129485, September 2017