

**DOE CHALLENGE HOME
CASE STUDY****e2 Homes**

Winter Park, Florida

**BUILDER PROFILE****e2 Homes**President: Rob Smith
Winter Park, FL**FEATURED HOME/DEVELOPMENT:****Project Data:**

- Name: Wilson Residence
- Location: Winter Park, FL
- Layout: 4 bedrooms, 4 baths
- Conditioned Space: 4,305 ft²
- Completion: May 2012

Performance Data:

- HERS Index without solar PV: 57
- HERS Index with solar PV: -7

Modeled Cost Data:**Standard home, same size/location:**

- Projected annual utility costs: \$3,378

Wilson Residence Challenge Home:

- Projected annual utility costs: \$2,297
- Projected annual energy cost savings (without solar): \$1,081
- PV production revenue: \$2,420
- Projected total annual energy cost (with solar): \$-123

**The Nation's First Certified DOE Challenge Home
Leaves a BIG Impression with a SMALL Footprint**

The first certified DOE Challenge Home—the “Wilson Residence” in Winter Park, Florida—produces more energy than it uses with construction costs one-third less than originally proposed. Completed in May 2012, this 4,305-ft² custom home (with four bedrooms and baths) screams “BIG,” until you hear the “small-footprint” in the energy- and water-efficiency details.

Without solar power, the home scores a HERS 57, which is well below the HERS 100 for a standard home built to code. With its photovoltaic system, the home produces better than zero net-energy performance, with a score of HERS -7. This translates into no electric utility bills and even \$123 annually in the homeowner's pocket from the utility.

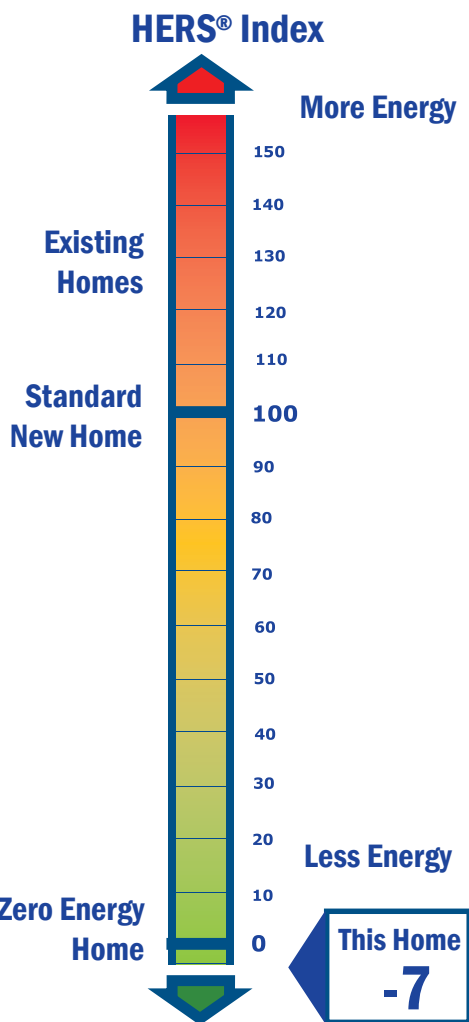
When the homeowner, Mr. Wilson, hired e2 Homes to build his dream home, he gave them several challenges: 1) build at a cost one-third less than another builder bid, 2) make the home as energy- and water-efficient as possible through design and conservation, and 3) build for comfort and durability in a hot and humid climate.

From the start, Rob Smith (the president of e2 Homes) worked with the homeowner, his HERS rater, and his mechanical contractor to come up with a package of measures that meets the energy-efficiency, comfort, and durability requirements of DOE's Challenge Home while taking into account the hot-humid climate and the homeowner's cost constraints. “The DOE Challenge Home is data driven and performance driven, based on all the standards...and it addresses concerns of different climates,” said Smith. The home also meets the requirements of LEED for Homes, the Florida Green Building Coalition, Florida Water Star Gold, and other programs.



DOE Challenge Home builders are in the top 1% of builders in the country meeting the extraordinary levels of excellence and quality specified by the U.S. Department of Energy. Every DOE Challenge Home starts with ENERGY STAR for Homes Version 3 for an energy-efficient home built on a solid foundation of building science research. Then, even more advanced technologies are designed in for a home that goes above and beyond current code to give you the superior quality construction, HVAC, appliances, indoor air quality, safety, durability, comfort, and solar-ready components along with ultra-low or no utility bills. This provides homeowners with a quality home that will last for generations to come.

All of the 962-ft² porch roof is comprised of solar panels with a 13.4-kW solar array system. The 69 panels don't sit on top of the roof; they are the roof. The completely watertight structure allows about 15% of natural light to filter through the panels, lighting the space below. The panels are dual surface meaning they can produce power from any sunlight reflected up onto their lower surface for up to 30% greater than rated power production. All wiring is hidden within the canopy's aluminum support beams.



As specified in the Challenge Home requirements, the envelope was designed to meet all ENERGY STAR Version 3 requirements and 2012 International Energy Conservation Code (IECC) insulation levels. Final blower door tests confirmed a tight envelope at 1.77 ACH 50.

The exterior walls were constructed of autoclaved aerated concrete (AAC) blocks. “My client wanted AAC to avoid using drywall [in this hot humid climate],” said Smith. Breathable plasters and paints designed for AAC are applied directly to the blocks as finishes. “They have been using it in Europe for about 80 years, and they are about the same price as insulated concrete forms (ICFs),” said Smith. Like concrete block, AAC is mold-resistant, non-combustible, and not penetrable by termites or pests, but the unique foam-like structure of the AAC also results in good insulating performance (R-8 for an 8-inch block), effective sound resistance, light weight (one-fifth the weight of concrete), easy workability since it can be readily sawed or drilled, and excellent structural capabilities (AAC blocks and panels come reinforced with rebar).

CHALLENGE HOME CERTIFIED:

- 1 BASELINE**
certified ENERGY STAR for 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 Solar Electric and Thermal Checklists with PV already installed



The walls are built of 2 ft. x 8 in. x 8 in. Autoclaved Aerated Concrete (AAC) blocks. AAC is made of most of the ingredients found in concrete but in a process something like bread making: sand is ground like flour and mixed with water, cement, and a little bit of aluminum powder. The mixture is poured into railroad car-sized molds and allowed to sit for 4 hours while the aluminum reacts with the cement forming millions of tiny bubbles in the concrete and causing it to rise, more than doubling in size. Rebar is set into the foam-like concrete, which is cut into blocks or slabs that are baked in ovens. The hardened, aerated concrete is then ready to be used to build walls and foundations.

The team analyzed variations of window placements, overhangs, and sizes before construction to determine the most efficient and effective combination for the Central Florida climate and budget. “There are probably 100 emails between me and Steve [the HERS rater] regarding options for windows, sliding doors, and SEER ratings,” said Smith. The window package they ultimately selected is an ENERGY STAR certified, low-E window that blocks 95% of ultraviolet and infrared light with a solar heat gain coefficient of .24.

A light-colored standing-seam metal roof was installed over engineered roof trusses that are spray foamed underneath to R-20. This creates a sealed, conditioned attic with summer temperatures down to 85°F instead of a typical 150°F. The heating and cooling system ducts and air handler are located within this unvented attic to meet the Challenge Home requirements of locating HVAC ducts within conditioned space.

The home is heated and cooled by three systems: conventional heat pumps for the first and second floors (SEER 18, HSPF 9.5 and SEER 16.5, HSPF 9 respectively), and a ducted mini-split heat pump for the master bedroom (SEER 16, HSPF 10).

“[In determining the HVAC system] the biggest, most important thing is coordinating with the mechanical contractor and the energy rater,” said Smith, “The energy rater wants to minimize tonnages; the mechanical contractor who is concerned with comfort may want to increase tonnages, and I am concerned with costs....we have to right size and find the happy medium.”

The team chose a supply-only ventilation system that creates a slight positive pressure in the house to help control infiltration of outdoor humidity. The “low-cost ventilation system” includes a fresh air duct to the outside of the home with an electric damper regulated by the thermostat to meet ASHRAE ventilation standards. If needed, the system can be upgraded to an energy recovery ventilator (ERV) or augmented with a supplemental dehumidification system. The team also followed the EPA Indoor airPLUS Verification Checklist and Construction Specifications as mandated by Challenge Home, with some limited exemptions.

HOME CERTIFICATIONS:

First DOE Challenge Home certified in the United States

ENERGY STAR Version 3

LEED-H Platinum

NAHB Green - Emerald

Florida Green Building Coalition Platinum

Florida Water Star Gold

Every DOE Challenge Home combines building science specified by ENERGY STAR for Homes and advanced technologies and practices from DOE’s Building America research program.



The home is water efficient in several ways. Two tankless, propane-fired water heaters are located as close to the points of use as possible to minimize water and energy waste (one is near the master bedroom and the other is near the kitchen, laundry room, and other bedrooms). Also, the house is double piped so that a 7,000-gallon cistern collects and supplies rain water to all toilets and urinals. The cistern also supplies water to the homeowner's saltwater aquarium and special collection of plants in the backyard. The front yard includes drought-resistant local shrubs and plants.

To achieve efficient lighting, the team analyzed lighting costs and selected airtight, insulation contact-rated recessed can lights equipped with LED bulbs for most fixtures. In addition, the windows in the home were designed to provide as much natural light as possible without allowing direct solar heat gain from the intense Florida sun to enter the home.

With the home designed for maximum energy efficiency, indoor air quality, and water conservation, the 13.5-kW photovoltaic system is now the appropriate last step for zero net-energy performance. "The key to creating any zero net-energy home while keeping costs down is to focus on energy conservation [in the design]," explains Smith. Rather than mounting the 69 solar panels on the roof, the solar installer fit them together to form a watertight structure that literally is the roof of the home's 962-ft² porch. The 195-Watt solar panels are bifacial, meaning they can generate some electricity from reflected light that hits the bottom side of the panels. The panels also permit about 15% of the daylight to filter through them, lighting the porch area beneath. The hybrid inverter converts the panel-produced direct current power into a utility-compatible alternating current, using a unique technology that overcomes the limitations of traditional central string inverter systems, but at a much lower cost than micro-inverter systems.

"At the end of the day, my message for builders considering [building to] Challenge Home is that this program is very rigorous, so it should help builders stand out from the crowd," said Smith. "If you plan early in the process, there doesn't have to be a cost differential to implement high-performance building."

"The earlier in the process you think about high-performance building, the cheaper it is to implement. Early on, you can do cost-benefit analysis like we did for the windows and for the roof structure with the photovoltaic array. Then, you can make more informed decisions that end up bringing your costs down."

ROB SMITH, *president, e2 Homes*

KEY FEATURES

- **HERS Score** (without solar PV): 57
- **HERS Score** (with solar PV): -7
- **Path:** Performance
- **Walls:** Autoclaved Aerated Concrete blocks (8-inches = R-8) with AAC-approved breathable plasters and paints for finishes
- **Roof:** light-colored standing-seam metal roof over engineered roof trusses with R-20 spray foam at the roof deck for a conditioned attic
- **Foundation:** slab on grade
- **Windows:** ENERGY STAR qualified low-E, double-pane, vinyl, U-factor =.27, solar heat gain coefficient =.24
- **Air Sealing:** 1.77 ACH 50; 1,297 CFM 50
- **Ventilation:** duct with an electronic damper regulated by a thermostat to bring in fresh air (positive-pressure supply ventilation). Can be easily upgraded/converted to an ERV.
- **Heating/Cooling:** 1st floor heat pump (SEER-18, HSPF 9.5), master bedroom ductless mini-split heat pump (SEER 16, HSPF 10), 2nd floor heat pump (SEER 16.5, HSPF 9)
- **Ducts:** Within the conditioned attic
- **Air Handler:** Within the conditioned attic
- **Water Heating:** Two tankless propane-fired water heaters
- **Lighting:** LED bulbs in IC-rated recessed cans
- **Solar:** 13.4-kW PV system
- **Water Conservation:** 7,000-gallon rain water cistern for using reclaimed water for all toilets and drought-tolerant landscaping

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

For more information on the
DOE Challenge Home, go to
www.buildingamerica.gov/challenge

PNNL-SA-93080 January 2013



www.BuildingAmerica.gov