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

Promethean Homes

Gross-Shepard Residence
Charlottesville, VA

BUILDER PROFILE

Promethean Homes, LLC, Steeles Tavern, VA
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Rater: Think Little, John Semmelhack
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FEATURED HOME/DEVELOPMENT:

Project Data:

- Name: Gross-Shepard Residence
- Location: Charlottesville, VA
- Layout: 3 bedrooms, 2.5 baths, 2 floors
- Conditioned Space: 2,572 ft²
- Climate Zone: IECC 4A, mixed-humid
- Completion: June 2014
- Category: Custom

Modeled Performance Data:

- HERS Index: without PV 33
- Projected Annual Utility Costs: without PV $1,053
- Projected Annual Energy Cost Savings (compared to a home built to the 2009 IECC): without PV $1,598
- Builder's Added Cost Over 2009 IECC: without PV $28,820 (less than 10%)
- Annual Energy Savings: without PV: 13,315 kWh

Recent retirees Bob and Jean bought a brand new home five years ago from a large production builder in Charlottesville, Virginia. The home was built to code but it was drafty and uncomfortable with uneven temperatures and an HVAC system that blasted hot or cold air on its occupants. So they asked a friend, home energy rater John Semmelhack, to suggest a custom home builder who could build them a more comfortable house. Semmelhack recommended Daniel Ernst, owner of Promethean Homes.

What they got was a home so energy efficient it will reduce their energy bills by an estimated $1,600 per year compared to a code-built home, with indoor comfort and air quality far exceeding even their high hopes. The 2,572-ft² neotraditional home with daylight basement looks ordinary enough on its sloped lot in a 1990s-era development located near the center of town. But inside the structure, the builder has incorporated a host of quality construction and high-performance details that have helped the home earn certification as a U.S. Department of Energy Zero Energy Ready Home, marking it as one of the most energy-efficient new homes in the country.

To be certified as a DOE Zero Energy Ready Home, a home must meet or exceed all of the energy, durability, and HVAC requirements of ENERGY STAR Certified Homes Version 3.0, the insulation requirements of the 2012 International Energy Conservation Code, and the indoor air quality and water saving requirements of the U.S. Environmental Protection Agency's Indoor airPLUS and WaterSense programs. The Charlottesville home has also been certified to the platinum level of the regional Earthcraft Homes program.

"Our energy rater, John Semmelhack, who is a Certified Passive House Consultant and trainer, said the home would almost meet the Passive House Standard, although we didn't go for that certification," said the builder, Daniel Ernst.

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.

Two inches of high-density rigid foam lines the foundation walls. An additional 4 inches of rigid foam covers the aggregate, forming an insulating base for the home's ground-floor slab.

What makes a home a DOE ZERO ENERGY READY HOME?

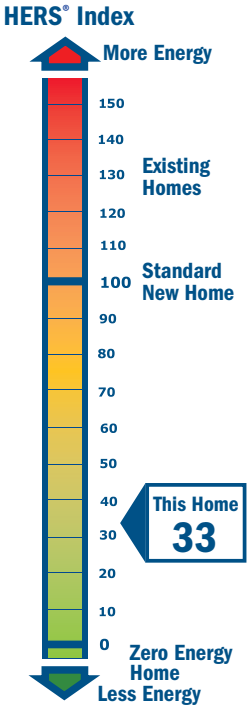
1 **BASELINE**
ENERGY STAR Certified Homes Version 3.0

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.

When Semmelhack put the home through third-party testing, it achieved a Home Energy Rating System (HERS) score of 33 without solar photovoltaic panels included, remarkably low considering the typical average home built to the 2009 International Energy Conservation Code would achieve a HERS score of 85. Ernst noted that a 5-kW PV system on the roof would get the home to a true net zero energy rating, i.e., a home that produces as much power in a year as it consumes.

The DOE Zero Energy Ready Home checklists give builders a game plan to achieve high performance in every aspect of home construction, from site grading to HVAC to roofing. Attention to detail and thoughtful planning helped Ernst to meet the checklist requirements and achieve this remarkable level of performance. "As a design-build firm we were able to take the project from foundation to finish. This ensured that the details were built as drawn. We worked with a limited number of subcontractors and made sure each sub was properly informed about program requirements before starting their work," said Ernst.

Construction started with excavation into the sloped lot to create a daylight basement. The foundation footings and stem walls were poured concrete that was insulated on the interior with 2 inches of high-density EPS rigid foam. Then 4 inches of ¾-inch aggregate was laid down. Over this, 4 inches of high-density EPS rigid foam was laid, then covered with a plastic vapor barrier that extended up the sides of the stem wall. This provided R-16 under-slab insulation and R-8 slab edge insulation for the 5-inch-thick floor slab. On the outside, the concrete wall was treated with a latex-based waterproofing. Rigid mineral wool boards were installed on the lowest and most susceptible parts of the foundation. The boards function as a drainage plane and reduce hydraulic pressure. A 4-in. drain pipe was installed around the perimeter and drained to daylight in the backyard.

The home's above-grade walls were 2x6 stud walls incorporating advanced framing techniques like 24-inch on-center stud spacing, 2-stud rather than 3-stud corners, polyisocyanurate-insulated rather than solid wood headers over doors and windows, single rather than double top plates, and ladder blocking rather than double or triple studs at interior-exterior wall intersections. All of these details reduced the amount of framing in the walls and allowed more room for cavity insulation between the studs. The walls were filled with R-21 of blown cellulose insulation. On the exterior over the plywood sheathing, the builder installed house wrap then 2 inches of rigid mineral wool insulation (R-4 per inch),

Promethean Homes installed rigid mineral wool board insulation over house wrap and plywood on the 2x6 advanced framed walls of its first DOE Zero Energy Ready certified home. Furring strips over the water-resistant, bug-resistant mineral wool boards provide a drainage plane and air gap between the walls and fiber cement cladding.

chosen because it is fireproof, bug resistant, and can dry to the outside. The two insulation types together gave the exterior walls a total nominal R-value of R-29. Over the mineral wool, Ernst installed 1x4 furring strips vertically at 24 inches on center as a drainage gap behind the fiber cement lap siding.

A full 23 inches of blown cellulose was piled onto the ceiling deck of the vented attic for an insulation value of R-70.

To air seal the home, Ernst used the plywood sheathing as the air barrier. Ernst applied an STPE (silyl terminated polyether) sealant to all of the plywood joints and intersections. He installed and sealed plywood on the attic floor to continue the air barrier at the ceiling level. He used a combination of sealant and tape at the joint between the slab and the foundation wall. He used backer rod, spray foam, and tape to seal the rough window openings. Finally, Ernst installed EDPM gaskets on all of the exterior penetrations—plumbing stacks, electrical wiring, HVAC vents, and line sets. These air sealing details helped the builder achieve a remarkably airtight home. Blower door testing showed the home had a whole house air leakage of 0.26 air changes per hour at 50 Pascals pressure difference (ACH 50). For comparison, the 2009 IECC specifies that homes have air leakage of less than 7 ACH 50, which is 25 times leakier than this home.

To help ensure good indoor air quality in the super-tight home, an energy recovery ventilator (ERV) was installed. The ERV has ducts to the outside to bring in fresh air and exhaust stale air. The two air paths cross in a heat exchanger that transfers heat from the warmer path to the cooler path. The incoming air is pulled through a filter with a MERV 12 rating, meaning it can pull pollen, mold, and dust from the outside air. Ernst uses an ERV with a very efficient electronically commutated motor (ECM) to minimize energy use because the ERV is set to run continuously. The ERV supplies fresh air to the bedrooms and pulls stale air from the bathrooms. The kitchen has a separate range hood exhaust fan that exhausts directly outside. The ERV is balanced to itself, i.e., it brings in the same amount of air that it exhausts, but it is not balanced to the 150-cfm range hood. To compensate for that outgoing air, a separate make-up air duct was installed having a barometrically controlled damper that opens to bring in outside air whenever the home gets depressurized.

Ernst likes high-efficiency mini-split heat pumps, but the homeowners did not like the look of the wall-mounted units so Ernst worked with Semmelhack to design

HOME CERTIFICATIONS

DOE Zero Energy Ready Home Program, 100% commitment

ENERGY STAR Certified Homes Version 3.0

EPA Indoor airPLUS

EPA WaterSense

EarthCraft House Virginia, platinum

"Our rater said it's the most airtight home he's ever tested."
—Daniel Ernst, owner, Promethean Homes

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.

Triple-pane windows let in light while retaining heat.

an HVAC layout that used two mini-split slim-duct units. These are similar in efficiency to ductless heat pumps, but are installed in a dropped ceiling or closet and have short duct runs to adjacent rooms. Each inside unit is tied to an outside compressor unit. The units are highly efficient, having a heating efficiency of 12.2 HSPF and a cooling efficiency of 21 SEER. The upstairs unit is installed in a closet above a dropped ceiling and has ducts into the family room and the kitchen. The downstairs unit is located in the utility room with duct runs going to registers in the three bedroom ceilings. Each heat pump has a central return grille with a 2-inch-thick MERV 11 filter. The 12-inch metal trunk ducts and 6- or 8-inch metal branch ducts are mastic-sealed with short (<5 feet) flex duct sections at the ends to connect to the registers to minimize sound and facilitate installation.

A typical 2,600 ft^2 home would have a furnace with an 40,000 to 60,000 Btu/hr capacity, which would be far too much for this highly insulated home. These small heat pumps operate in the 3,000 to 11,000 Btu/hr range. The slim-duct systems have variable compressor speeds, variable refrigerant flow, and variable fan speeds, so they can easily ramp down or up depending on demand, rather than operating full blast whenever they are on.

The home's water heating system is an ENERGY STAR-rated heat pump water heater with an energy factor (EF) rating of 2.3. To further improve energy savings, 85% of the home's lighting is LED, 10% is tube fluorescent, and 5% is incandescent. The home's refrigerator, dishwasher, and washing machine are all ENERGY STAR rated. All of the home's windows are triple-pane, pultruded fiberglass-framed, argon gas fill windows with low-emissivity coatings to reduce heat transfer. The Canadian-made windows have insulating U-values ranging from 0.15 to 0.22 and varying solar heat gain coefficients depending on solar orientation.

Measures like a garage exhaust fan and no-VOC paints ensure good indoor air quality and helped qualify the home for the EPA Indoor airPLUS program, which is a requirement of the DOE Zero Energy Ready Home program.

This is Ernst's first DOE Zero Energy Ready certified home and he plans to do more. "Near-Passive House [Standard] is our core focus. We hope to be zero energy or zero energy ready on everything we build," said Ernst whose next three houses will all be true net zero with PV installed. "Once you've done this type of construction, it's hard to go back to standard construction because you know what is out there. You know what works better."

Photos courtesy of Promethean Homes, LLC.

KEY FEATURES

- **DOE Zero Energy Ready Home Path:** Performance
- **Walls:** 2x6 advanced framed; R-21 cellulose insulation in stud cavity; plywood sheathing, house wrap, 2 inches rigid mineral wool insulation, 1x4 vertical furring strips for ventilation gap, fiber cement siding
- **Roof**: Vented attic with 23 inches (R-70) blown cellulose on ceiling deck; 2x10 rafters; rigid plywood air barrier at attic floor; asphalt shingles; rubber flashing boots around pipes
- **Foundation:** Poured concrete foundation and stem walls; 2 inches (R-8) high-density EPS rigid foam on inside of stem wall; 4 inches aggregate plus 4 inches high-density rigid EPS (R-16) plus plastic vapor barrier under slab
- **Windows:** Triple-pane, pultruded fiberglass frames, argon gas fill; low-e coatings; U=0.15 to 0.22, SHGC=0.24 to 0.42 based on orientation
- **Air Sealing:** 0.26 ACH 50 or 101 cfm 50
- **Ventilation:** ERV with MERV 12 filter, supplies to heat pump air handlers, returns from bathrooms; garage exhaust fan runs continuously
- **HVAC:** 2 slim-duct heat pumps, 21 SEER, 12.2 HSPF, with rigid metal and flex ducts inside conditioned space
- **Hot Water:** ENERGY STAR heat pump water heater, 2.4 EF
- **Lighting:** 85% LED, 10% tube fluorescent, 5% incandescent
- **Appliances:** ENERGY STAR refrigerator, dishwasher, clothes washer
- **Water Conservation:** EPA WaterSense-certified fixtures and homerun manifold plumbing with PEX tubing