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

Greenhill Contracting

The Preserve
New Paltz, NY

BUILDER PROFILE

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FEATURED HOME/DEVELOPMENT:

Project Data:

- Name: The Preserve
- Location: New Paltz, NY
- Layout: 3 bedrooms, 2 baths, 2 floors
- Conditioned Space: 2,288 ft^2
- Climate Zone: IECC 6A, cold
- Completion: July 2014
- Category: Custom

Modeled Performance Data:

- HERS Index: without PV 37, with PV 7
- Projected Annual Utility Costs: without PV $1,664; with PV $508
- Projected Annual Energy Cost Savings (compared to a home built to the 2009 IECC): without PV $1,921; with PV $3,077
- Annual Energy Savings: without PV 14,774 kWh; with PV 23,666 kWh

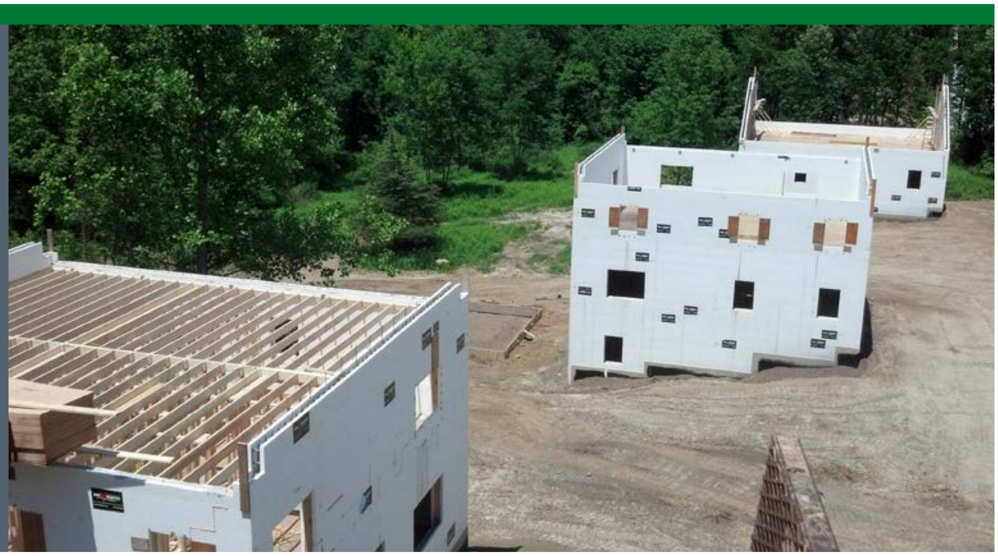
Anthony Aebi has been a custom home builder in New York state since 1995, but it wasn't until he built his own home in 2006 that he had the epiphany that led him to high-performance construction.

"My home was the last crappy house I built," said Aebi. As he was getting ready to enclose the walls of the stick-framed home, Aebi could see that some of the studs already had mold on them that would eventually cause rot in humid upstate New York. "I was so disgusted I wanted to quit building right there, but I had investors and properties I needed to work on." So Aebi, whose family is from Switerzerland, started looking at European construction practices where, as he put it, homes are built to last hundreds of years. First, he investigated reinforced concrete, but there were complexities to the construction process that he didn't like. Then he looked at insulated concrete forms (ICFs). Aebi liked what he saw. Hollow, rigid foam blocks stack to form walls that are filled with steel-reinforced concrete to make a solid, sound-proof, air-tight, highly insulated structure that is nearly impervious to earthquakes, tornadoes, hurricanes, and forest fires.

Aebi's first ICF house, completed in 2007, achieved a Home Energy Rating System (HERS) score of -1. Aebi certified the house to DOE's Builders Challenge (a precursor to the DOE Zero Energy Ready Home program). Aebi's home held the lowest HERS score in New York and in the whole Northeast for the entire 2007-2013 run of the Builders Challenge program. Aebi has built 20 ICF homes since, perfecting the technique as he goes, and putting solar photovoltaic panels on every home. In February 2014, Greenhill Contracting was recognized by the New York State Energy Research and Development Authority (NYSERDA) for being the lowest HERS Index Builder in the state for 2012-2013.

While Aebi typically does custom homes, he just finished a nine-home development called the Preserve in New Paltz, New York, and every home was

All of Greenhill Contracting's homes are constructed with insulated concrete forms (ICFs). The ICFs consist of two pieces of rigid foam held together with plastic spacers to form hollow rectangular blocks roughly 16 in. high by 48 in. long by 11.25 in. wide. The blocks are stacked like bricks to form a hollow wall extending from the footing to the roof line. Steel rebar is inserted in the wall vertically and horizontally and held in place by the spacers. Then the hollow wall is filled with concrete, which hardens in place to form a solid, sound-proof, air-tight, highly insulated wall.



What makes a home a DOE ZERO ENERGY READY HOME?

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

2 **ENVELOPE**
meets or exceeds 2012 IECC levels

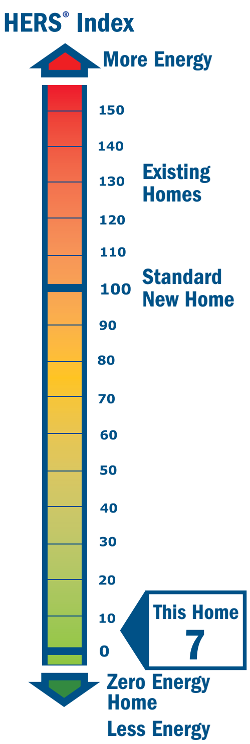
3 **DUCT SYSTEM**
located within the home's thermal boundary

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.



certified to the U.S. Department of Energy's Zero Energy Ready Home program. Aebi's goal in certifying every home was to show that zero energy construction can be done on a production scale. The program requires homes to meet strict energy, health, and durability requirements including ENERGY STAR Certified Homes Version 3.0, the U.S. Environmental Protection Agency's Indoor airPLUS criteria, the hot water distribution requirements of the EPA WaterSense program, and a checklist of "renewable-ready" solar power measures. Aebi's homes also meet the LEED for Homes silver level. "They would meet the gold or platinum level if we filled out the extra paperwork," said Aebi.

The homes in New Paltz earned HERS scores of 7 when the 7.26-kW photovoltaic roof panels were included in the calculations, and without PV they score a 37. In the Northeast, where oil heating is still common, a homeowner with a 2,500 ft^2 home can expect to pay \$5,000 to \$6,000 annually in utility bills. Utility bills for Aebi's homes are expected to be about \$500 per year, with PV, or \$1,660 per year without PV. PV is a standard feature on all of his homes.

The ICF walls are responsible for phenomenal energy performance. Aebi uses 11.25-inch-thick walls, consisting of a 6-inch concrete layer sandwiched between two layers of EPS rigid foam, each 2.63 inches thick, for a total wall R value of R-22. Unlike a stick-built wall (one made of 2x4s or 2x6s with insulation in the wall cavities in between), ICF walls have no thermal bridging because there are no studs to transfer heat through the walls. Instead, there is a continuous layer of insulation from the footing to the roof rafters on the inside of the wall and a second continuous layer on the outside of the wall. The seams of the foam blocks are sealed so the exterior foam layer also serves as a drainage plane. No house wrap is needed, which saves the builder in materials, labor costs, and time. At the window openings, a fluid weather-resistant barrier is applied.

The ICFs are installed below grade from the footing up and can serve as crawl space or basement walls. One problem with ICFs is protecting the below-grade exterior foam surface during construction. Aebi's solution is to install a cement board over the foam from the footing to 8 in. above grade. The cement board is covered with a rubberized tar coating. White metal flashing covers the tar-coated board above grade. Vinyl siding is installed on the wall and comes down to cover the top edge of the flashing.

The concrete slab is poured over a 3-inch-thick bed of closed-cell spray foam and has R-22 insulated ICFs protecting the slab edges to provide a warm, dry floor.

After about four courses of ICF blocks have been laid, Greenhill sprays 3 inches of closed-cell spray foam directly onto the ground creating an R-20 insulating blanket over which the floor slab concrete will be poured. The closed-cell spray foam also serves as an airtight vapor barrier, preventing moisture and soil gases from coming into the home.

Rather than installing insulation on top of the ceiling deck of a vented attic, Aebi chose to spray foam insulation along the underside of the roof deck, providing an unvented, semi-conditioned space that protects the home's HVAC ducts. The HVAC equipment is located in a mechanical room on the first floor (or in the basement for homes that have a basement). Aebi first installed 2 inches of closed-cell spray foam insulation having an R value of R-6.2 per inch, then 10 inches of hybrid open-cell spray foam (which has an R value of R-4.5 per inch). The 12 inches of foam completely fills the roof rafter cavities and ends to provide an insulation value of R-60 and to create a thermal break between the attic and outdoors. A thermal (fire ignition) barrier was sprayed over the foam to allow the attic to be used as a conditioned storage space.

The triple-pane windows provide an insulation value of U-0.20 and a solar heat gain coefficient (SHGC) of 0.23. They are covered with an invisible low-emissivity coating that helps to minimize radiant heat loss, and the space between the panes is filled with an inert argon gas to slow air flow through any cracks.

Thanks to the ICF walls, foam attic, and foundation insulation, the home achieves air tightness of 0.28 air changes per hour at 50 Pascals pressure difference, more than twice as tight as the 0.60 ACH 50 air leakage limit set by the Passive House Standard. Most of the homes at the Preserve had even tighter air leakage rates of 0.14 to 0.16 ACH.

Because the home is so airtight, Aebi installed a heat recovery ventilator (HRV) to pull fresh air into the home through one duct and remove stale air from the home in another. The two air paths cross in a heat exchanger that allows the hotter path to give up heat to the cooler path. So, in winter, outgoing air transfers heat to the incoming air, warming it before it is poured into the living space; in summer, hot incoming air gives up heat to the cooler outgoing air. The HRV is installed in the mechanical room and supplies fresh air to the return of the HVAC system to be distributed to the whole house while pulling stale air from the bathrooms, kitchen, and laundry through separate ducts at a continuous exhaust flow rate of at least 20 cfm, to meet ASHRAE 62.2 2010 ventilation requirements.

The home is equipped with a ground-source heat pump that provides heating and cooling. Unlike an air-source heat pump, the ground-source heat pump draws heat from or discharges heat to the ground via piping loops filled with pure water that circulates through 400-ft closed-loop wells. Because the ground temperature

HOME CERTIFICATIONS

- DOE Zero Energy Ready Home Program, 100% commitment
- ENERGY STAR Certified Homes Version 3.0
- EPA Indoor airPLUS
- EPA WaterSense
- DOE Zero Energy Ready Home Quality Management Guidelines
- LEED for Homes, silver

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 high-efficiency ground-source heat pump provides space heating and cooling and preheats water for the electric tank water heater.

stays an even 50˚F year round, ground-source heat pumps can achieve far greater efficiencies than an air-source heat pump. The 3-ton unit has a modulating condenser and variable speed electrically commutated fan motor for additional efficiency of the system, which has a coefficient of performance (COP) of 5.7 and an energy efficiency ratio (EER) of 44.0. It also has a desuperheater to preheat domestic hot water in a dedicated buffer storage tank. The water then goes to an electric "finishing" water heater to bring the temperature to 120˚F. The homes meet DOE's requirements for efficient plumbing distribution.

Aebi also installed an ENERGY STAR-labeled refrigerator, clothes washer, dishwasher, and microwave oven. The majority of the lighting is LED, and some fixtures are CFL. All plumbing fixtures are water efficient. Furthermore, Aebi met the EPA Indoor airPLUS requirements. Measures included designing the home with a detached garage and not installing any combustion space or water heating equipment inside the home.

Several steps were taken to manage surface water on the site. All homes were constructed at an elevation slightly higher than the road. Over 90% of each lot's surface area was preserved as vegetative land; 100% of the storm water runoff was managed on-site with retention ponds. No invasive plant species were planted. Drought-tolerant turf was selected. No irrigation was added. Local material was used for backfill.

The DOE Zero Energy Ready Home Program requires homes to be solar-ready by installing conduit to the roof for solar electric and water heating lines, by leaving space in the utility room and on the electrical panel for solar equipment, and by orienting homes on the lots and designing roofs for solar panel installation. Aebi went beyond this solar-ready requirement, by installing 7,420 Watt (DC) PV solar panel arrays on every roof.

For the homeowner, the benefits of a high-performance home include healthy air, comfort, energy savings, quality construction, disaster resistance, and durability. But Aebi points out that one of the biggest benefits is protection against rising fuel prices. According to Aebi, when heating oil prices shot up in the spring of 2009 from $2.50 per gallon to $5 a gallon, homeowners all over the Northeast were calling their banks saying their mortgage payments would be late because their oil bill was twice what they expected. Aebi's homeowners have no oil bill and one-tenth of the utility costs. "Banks all over the Northeast should be paying attention to this," said Aebi.

Photos courtesy of Greenhill Contracting, Inc.

KEY FEATURES

- **DOE Zero Energy Ready Home Path:** Performance
- **Walls:** R-22 ICF; EPS foam as drainage plane; vinyl siding
- **Roof:** Roof insulated along underside of roofline with 2 in. closed-cell and 10-in. open-cell spray foam coated with ignition barrier paint; foam covers rafters for thermal break; R-60
- **Foundation:** Slab with R-20 closed-cell spray foam under entire slab; R-22 ICF slab edge insulation
- **Windows:** Triple-pane, argon-filled, vinyl-framed; U=0.20; SHGC=0.23
- **Air Sealing:** 0.28 ACH 50
- **Ventilation:** MERV 11 filter, ducted to air handler; continual HRV bath
- **HVAC:** 3-ton ground-source heat pump (5.7 COP, 44.0 EER) modulating condenser; variable speed ECM blower
- **Hot Water:** 1.20 EF desuperheater from ground source heat pump; 50-gal. tank with electric backup heat source.
- **Lighting:** 80% LED, 20% CFL
- **Appliances:** ENERGY STAR-rated clothes washer, dishwasher, refrigerator, microwave oven
- **Solar:** 7.5-kW solar PV panels installed
- **Water Conservation:** EPA WaterSense-rated showerheads, faucets, toilets; 90% of lot landscaped with drought-tolerant turf and native plants; no irrigation
- **Other:** Detached garage; 49% waste diversion from landfill

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