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

DOE ZERO ENERGY READY HOME™

U.S. DOE ZERO ENERGY READY HOME 2024 WINNER Housing Innovation Awards

Daniel Colombini

Spring Valley Passive House Ossining, NY

BUILDER PROFILE

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FEATURED HOME/DEVELOPMENT:

Project Data:

- **Project name:** Spring Valley Passive House
- **Location:** Ossining, NY
- **Layout:** 3 bdrm, 4 bath, 2 fl + bsmt, 3,585 ft²
- **Climate:** IECC 4A, mixed-humid
- **Completed:** June 2023
- **Category:** Custom

Modeled Performance Data:

- **HERS Index:** without PV 30; with PV -9
- **Annual Energy Costs:** without PV $2,200; with PV $200
- **Annual Energy Cost Savings:** (vs typical new homes) without PV $6,300; with PV $8,950
- **Annual Energy Savings:** without PV 28,550 kWh; with PV 44,360 kWh
- **Savings in the First 30 Years:** without PV $262,900; with PV $373,950

"I'm a mechanical engineer and mechanical engineers love to engineer their way out of problems with mechanical engineering solutions," said homeowner and builder Daniel Colombini. But Colombini had to admit that better mechanicals alone were not going to be enough to make the drafty old 1930s home he had bought in Ossining, New York, a comfortable place for his family. Some research into energy-efficient homes sparked an interest in Passive Houses and convinced him that, for a truly comfortable, long-lasting home, the best option was to start over with a highly insulated building envelope.

Colombini's research led him to the U.S. Department of Energy's Zero Energy Ready Home program. The end result was a new 3,585-ft² two-story home with basement built on the foundations of the old home that achieved DOE Zero Energy Ready Home certification and received a DOE Housing Innovation Grand Award. His home was also the first project to achieve both LEED Platinum and Passive House certification in Westchester County, and one of the first in New York State. The home achieved a HERS score of -9, providing enough electricity to power the home and an electric car, thanks to the 13.2 kW of roof-mounted photovoltaic panels and two 16-kWh batteries.

"We learned a lot about construction," said Colombini, who added that for him the important takeaway was that "to do Zero Energy Ready Home-level construction is not a big budget spend; these kinds of improvements should be done by everyone." Colombini said total project costs were less than 10% over standard construction for a similar sized home and that much of that added cost came from the Passive House-qualifying windows and doors, which were imported from Poland. To achieve DOE Zero Energy Ready Home certification alone would have added less than 5% over standard construction, Colombini estimated.

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 3.2 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.

Daniel Colombini constructed this 3,585-ft² home in Ossining, NY, to the high performance criteria of the DOE Zero Energy Ready Home (ZERH) program. The home is equipped with 13.2 kW of photovoltaic panels and 32 kWhs of battery storage, enough electricity to power the home and an electric vehicle or two. The home is so energy efficient, it is expected to save its homeowners more than $6,000 per year in energy costs compared to a home built to code, or almost $9,000 per year if the photovoltaics are included.

What makes a home a DOE ZERO ENERGY READY HOME?

1 **BASELINE**
ENERGY STAR Certified Homes Version 3.0/3.1

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

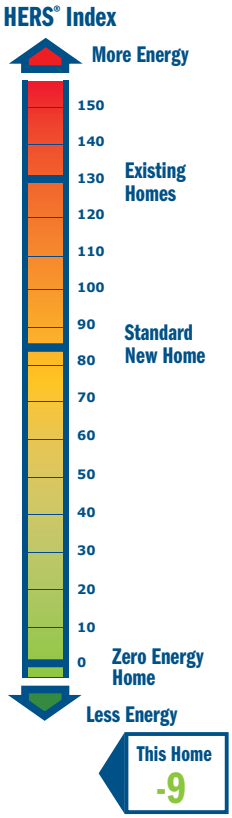
3 **DUCT SYSTEM**
located within the home's thermal boundary

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.



The DOE program has ENERGY STAR and Indoor AirPlus home certifications and the latest energy codes as its baseline so every home provides its home buyers with the health, resiliency, and utility bill savings these programs offer. Other Zero Energy Ready Home requirements help ensure water savings; HVAC and water heating efficiencies; and third party-verified air sealing to minimize drafts and keep out bugs, dust, smoke, and pollens. While homes aren't required to have solar electric panels, this voluntary program specifies installation of the electrical infrastructure and space in the home for future installation of PV, as well as electric vehicle chargers, heat pumps, and heat pump water heaters, offering homeowners the option and ease of future installation should they choose it.

To meet the Passive House criteria, Colombini went well beyond even the high insulation requirements of the 2021 IECC. The home's walls start with a 2x4 16-inch on-center exterior wall that is filled with R-12 mineral wool batts and wrapped with OSB that is sealed and taped at all seams. To the exterior of the sheathing, Larsen trusses were attached through to the studs. The Larsen trusses are factory-made I-joists or site-built trusses consisting of plywood and 2x4s salvaged from the demolition of the old home. The 12-inch-deep trusses were wrapped with a breathable air- and water-control membrane then stuffed with R-42 of dense-packed cellulose. The membrane was held in place with vertical 1x4 furring strips that were topped with hemlock siding.

Lumber salvaged from the original house was used wherever possible on the new construction and 75% of demolition and construction debris was diverted from the landfill. Much of what couldn't be used on site was donated, given away, or sold for re-use on other projects.

The foundation included about 75 linear feet of existing concrete block wall that was retained from the original building and insulated for reuse as part of the basement walls. The basement and crawlspace walls were insulated with R-40 of XPS and 4 inches (R-20) of XPS was installed under the newly poured slabs.

The roof is a simple gable rafter roof constructed of 18-inch Larsen truss rafters at 16-inches on center. The rafters were topped with 5/8-inch OSB sheathing and a vapor-permeable water-resistant 3-ply membrane underlayment under the asphalt shingles. On the south-facing roof where the solar panels were to be installed, this underlayment was topped with 2-inch furring strips installed over the rafters and

The builder, who is also the homeowner, reported that his family is suffering much less from seasonal allergies since moving into the home. This may in part be due to the MERV 13 filters on the separately ducted ERV system and the three indoor air handlers for the heat pump heating system. Like all DOE Zero Energy Ready-certified homes, this home also met the air quality requirements of the EPA's Indoor AirPlus program.

topped with another layer of sheathing to provide an attachment surface for the solar panels while avoiding holes in the primary weather and air barrier.

A smart vapor control membrane was attached to the underside of the rafters and held in place with 2x4s which also provided a service cavity behind the ceiling drywall. The attic is insulated along the underside of the roof line by filling the rafter bays with R-65 of dense-packed cellulose.

"Having the attic as part of the conditioned building envelope simplifies a lot of things. We have a conditioned space for the HVAC. It doesn't really add any heating load and conditioning the attic helps keep it dryer," said Colombini. This was part of a larger lesson he learned while doing repeated WUFI modeling for the Passive House certification. Simplifying the geometry and construction of the envelope is the easiest way to increase energy efficiency and decrease costs.

"It doesn't have to look like a rectangle because you can add details outside of the envelope to make it look interesting. Our house is a great example of that—the covered front porch and back porch, the awnings, the trellis, and the curved balcony—all of that makes the house not look like a rectangle, even though it is just a couple rectangles put together," said Colombini. Mixing up exterior finishes also helps to break up the box. In addition to the painted wood siding, the foundation and chimney are covered with stone and the underside of the eaves is stained wood.

Colombini acknowledges that his architect Christina Griffin and his general contractor Ed Nugent had a lot to do with the success and vision for the project. Griffin is Passive House certified and had designed several previous Passive House buildings including a DOE ZERH 2023 grand award winner. Nugent was also Passive House and LEED certified and had constructed previous homes with Larsen truss walls.

In addition to the team of Daniel, Christina, and Ed, other important contributors were the rater Integral Building + Design and the landscape architect Restaino Design. The landscape architect had worked on the neighboring Teatown Land Reservation and designed a rain garden and adjacent bioswale of native plants for the home site that resolved a long-standing issue with pooling rainwater and runoff. Goldman Copeland Associates, the mechanical and electrical engineering company where Colombini works, designed the HVAC for the project.

HOME CERTIFICATIONS

ENERGY STAR Certified Homes Version 3.1

EPA Indoor AirPlus

PHIUS Passive House

LEED Platinum

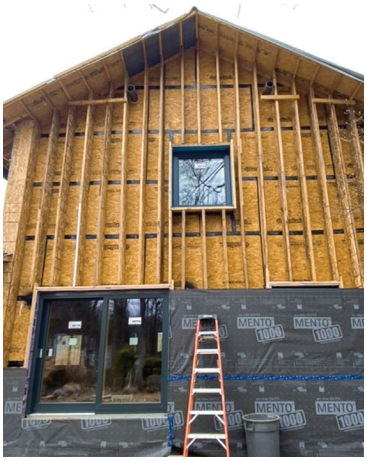
"One of the easiest ways to make zero energy ready home construction more cost effective is to simplify the geometry – build a rectangle with a roof."

—Daniel Colombini, builder and homeowner

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.



Site-built and I-joist Larsen trusses create a 12-inch wall cavity exterior of the sheathing. Together with the 2x4 framing on the interior, they form a wall 16 inches deep that holds R-57 of insulation.

The home is heated and cooled by a variable-refrigerant flow (VRF) heat pump system with a heating efficiency of 9.0 HSPF, a cooling efficiency of 16 SEER, and a capacity of 3 Tons (36,000 Btu/hr). The heat pump serves three indoor evaporator units (one per floor), each equipped with a MERV 13 filter.

A separately ducted energy recovery ventilator (ERV) provides fresh tempered air throughout the home. The outside air intake is filtered with a MERV 13 filter. The ERV operates at three speeds depending on air quality needs in the home. "Providing a ventilation system that is separate from the heating and cooling system allows for simpler ventilation operation that runs constantly, regardless of heating and cooling demand. This works well for a Passive House, which often does not require heating or cooling, but always needs ventilation," said Colombini.

The HVAC was designed to be as simple as possible, using readily available high-efficiency equipment. "Our experience shows that overly complex designs may indicate great efficiency on paper but in practice systems must be easy to operate and maintain by building occupants and service vendors," said Colombini.

Even though the project team sought simplicity on the design side, there were still some implementation issues. Supplies were sometime difficult to get due to the pandemic. Reuse of lumber helped to balance some materials costs spikes and shortages, as did some creative switching of materials like using hemlock siding instead of cedar siding.

Another challenge was finding skilled labor that understood what needed to be done to meet the objectives of the project. "Finding contractors who were able to do this was nearly impossible. Everyone learned a lot on the job," said Colombini. Several training sessions took place on site to teach the subcontractors various envelope assembly details. For example, "extreme care was taken to provide a sealed envelope. This required constant supervision and quality control," said Colombini.

Still Colombini is optimistic "Many of these strategies could be easily implemented by any design and construction team that is educated on their implementation," said Colombini.

"What are the fastest, most cost-effective ways to meet the design criteria that we're trying to hit?" said Colombini. "That's the question we have to keep asking." That perspective has Colombini excited to take what he learned on this house and try another one. "I'd like to do one in Vermont. Going to a colder climate zone, with half the budget is my challenge," said Colombini.

KEY FEATURES

- **Walls:** Larsen trusses and 2x4 16″ o.c., R-57 total: R-12 mineral wool batt, ⅝″ OSB, 12″ Larsen trusses with R-42 dense-pack cellulose, hemlock siding.
- **Roof:** Gable Larsen truss and rafter roof, 16″ o.c., ⅝″ OSB, synthetic underlayment, architectural shingles.
- **Attic:** Unvented attic. Dense-packed cellulose under roof deck.
- **Foundation:** Insulated basement and unvented crawlspace.
- **Windows:** Triple-pane windows, U=0.17, SHGC=0.49, low-e, argon-fill. Roof overhangs.
- **Air Sealing:** 0.64 ACH50; taped and sealed sheathing; blower door testing during construction.
- **Ventilation:** ERV, MERV 13 filters, separate ducts.
- **HVAC:** Central air-source heat pump, 9.0 HSPF, 16.0 SEER. Passive solar design.
- **Hot Water:** Heat pump water heater, 50-gal, 3.88 EEF. Adaptive recirculation.
- **Lighting and Appliances:** ENERGY STAR appliances; induction cooktop.
- **Solar:** 13.2 kW PV, 32 kWh batteries.
- **Energy Management System:** Solar array monitored via an app.
- **Other:** Passive House Zero certified; LEED Platinum.

"This project demonstrates that Zero Energy Ready Home construction can be attained with a modest cost increase given a properly trained design and construction team."

—Daniel Colombini, builder and homeowner

Photos courtesy of Daniel Colombini

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