

As part of the State's effort to achieve a carbon-neutral economy, NYSERDA initiated the Buildings of Excellence (BOE) Competition in early 2019. The competition recognizes and rewards the design, construction, and operation of very low- or zero-carbon emitting multifamily buildings.

[nysersda.ny.gov/boe](http://nysersda.ny.gov/boe)



## Project Details

### Location:

New Paltz, New York

### Project Area:

63,320 sq. ft.

### Number of Buildings:

1

### Number of Stories Per Building:

4

### Number of Units:

46

### Project Cost:

\$10,547,313

### Cost per Gross Square Foot:

\$166.57

### Market Sector:

Market Rate

### Construction Type:

New

### Construction Start Date:

2019

### Completion Date:

January 2022

### REDC Region:

Mid-Hudson

### Developer:

Net-Zero Development, LLC

### Architect & Design Team Lead:

BOLDER Architecture, PLLC,  
Integral Building + Design, Inc.

### Technologies Used:

GSHP for space conditioning and DHW, ERV, PV, ICF high performance wall assemblies, triple-pane fenestration

## Zero carbon, all-electric, mixed-use building in New Paltz, NY

### Background

Zero Place is an ultra-low energy load, carbon neutral, fossil-fuel free, multifamily, mixed-use building that will serve as a model for low-impact, new residential and commercial developments in cold-climate regions. The design team identified three priorities to ensure the project's high efficiency: (1) optimize the energy efficiency of the thermal envelope, (2) select maximum efficiency mechanical systems, and (3) ensure the selected solar photovoltaic (PV) system has the capacity to meet the building's entire energy load. Zero Place utilizes passive survivability strategies through its high-performance building envelope, which can maintain safe temperatures inside during extreme climate events or grid outages. The structural system of the insulated concrete form (ICF) ensures long-term durability and resiliency. A critical aspect of Zero Place's success was having an integrated design team that collectively understood high performance as essential to the project.

### Key Project Features

The design includes three solar PV arrays which cumulatively generate a net surplus of electricity back to the grid in a typical year. The all-electric design includes a ground source heat pump (GSHP) system for space conditioning and domestic hot water (DHW).

- ✓ **HVAC:** Energy recovery ventilation (ERV), demand-controlled ventilation.
- ✓ **Water Heating:** Central ground source heat pump (GSHP).
- ✓ **Envelope:** Insulated concrete form (ICF), Ecospan Structural Floor System.
- ✓ **Lighting:** Light emitting diode (LED), daylighting.
- ✓ **Appliances:** ENERGY STAR appliances, heat pump clothes dryers, induction cooktops.
- ✓ **Renewables:** Onsite solar photovoltaics (PV).
- ✓ **Resilience Strategies:** Long term durability, fire and storm resiliency, backup generator.
- ✓ **Other:** KONE EcoSpace Elevator system.

**Predicted Site Energy Use Intensity (EUI): 15.9 kBtu/SF/yr**

**Net Site Energy Use Intensity (EUI): 0.1 kBtu/SF/yr**

**Predicted Renewable Production Intensity (RPI): 16.0 kBtu/SF/yr**

**Energy Code Baseline: 2016 NYS Energy Conservation Construction Code (ECCC)**

**Performance Path: Energy Rating Index (ERI)**

**Certification: LEED for Homes Platinum, ENERGY STAR Homes v3.1, DOE Zero Energy Ready, EPA Indoor airPLUS**

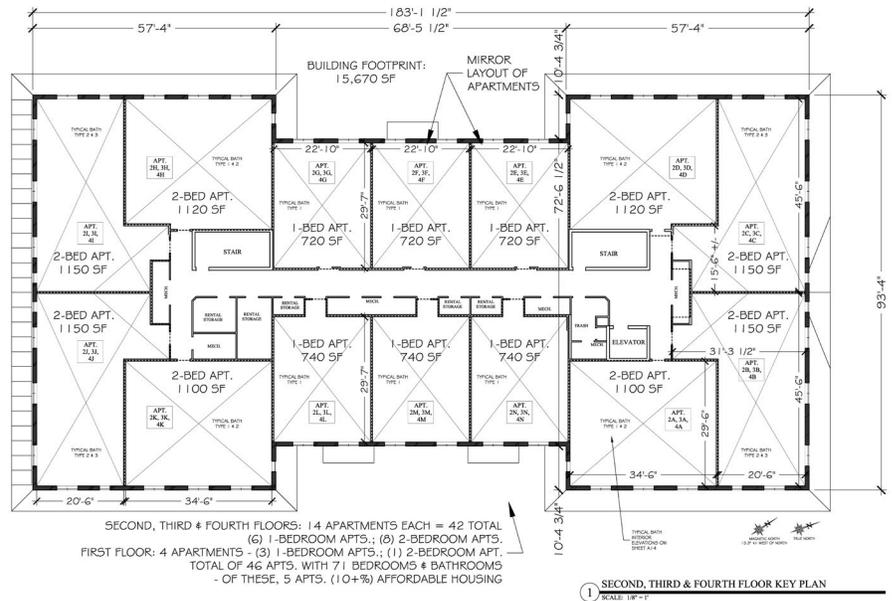
# Planning and Design Approach

## Project Goals

The goal of the development team for Zero Place was to create a replicable and scalable building model that can reduce the environmental impact of new developments in cold-climate regions, such as New York State. By proving the cost effectiveness and efficiency of an ultra-low load, carbon neutral, and fossil-fuel free design, Net-Zero Development hopes to transform the multifamily building industry.

## Project Team

Zero Place was developed by Net-Zero Development, LLC and designed by BOLDER Architecture, PLLC. The project lead, Integral Building + Design, Inc., also served as the energy consultant, energy modeler, and sustainability consultant. The team followed the American Institute of Architects (AIA) Integrated Project Delivery Guide<sup>1</sup>, which helps reduce waste and inefficiencies during the construction process by bringing more building professionals and end users together earlier in the concept and design phases. At the start of the design process, facility managers, end users, and contractors were brought on to the team, including the construction manager, general contractor, and the construction, development, and property management company, Affordable Housing Concepts (AHC), that specializes in energy efficient-multifamily properties. They were able to provide expertise on construction techniques and sequencing, improve the cost and budget management, and anticipate and quickly resolve design related issues. By following this guide, the team ensured that the process was outcome-driven and that decisions were not solely cost-based. Early and open sharing of knowledge streamlined the project communication and goals.



Simplified floor plan by BOLDER Architecture, PLLC.

## Building Design

Centered around the team's three priorities—an efficient thermal envelope, efficient mechanical systems, and meeting the building's load with onsite PV—an integrated design team drove the project to ensure high performance:

- The structural insulated concrete form (ICF) wall system provides two continuous layers of insulation around the entire building.
- Space conditioning and domestic hot water (DHW) are supplied by a ground source heat pump (GSHP) and unitary energy recovery ventilation (ERV) unit with demand-controlled ventilation.
- Photovoltaic (PV) arrays on the roof and south facing solar awnings supply the building with energy.

The additional southern exposure helps the project meet its renewable generation goals; however, the awnings are also a passive solar design feature that integrates with the building's orientation to reduce summer heat gain and the subsequent electrical cooling load, while allowing solar heat gain during winter months when the sun is lower. By focusing on these components throughout the design process, Zero Place developed into a highly efficient, resilient, and durable building with a longer expected life and lower maintenance costs than a typical building.

The Zero Place team is committed to being a leader in sustainability and clean living, from construction through occupancy. They are expecting to achieve Leadership in Energy and Environmental Design (LEED) for the Homes Platinum certification. The project has recycled over 70% of their construction waste, only non-invasive plants are used in landscaping, all concrete and materials are locally sourced, no tropical wood will be used unless it is Forest Stewardship Council (FSC) certified, and water is used efficiently both indoors and outdoors. All on-site stormwater runoff is managed by a combination of below grade retention systems and landscaping details. Water fixtures, such as lavatory faucets, showerheads, and toilets, throughout the interior of the project will meet the Environmental Protection Agency's (EPA) WaterSense standard.

<sup>1</sup>"Integrated Project Delivery: A Guide." AIA, 2007. [https://content.aia.org/sites/default/files/2017-02/Integrated%20Project%20Delivery%20Guide.pdf#q=2\\_265597453.385780313.163457764-1965313330.163457764](https://content.aia.org/sites/default/files/2017-02/Integrated%20Project%20Delivery%20Guide.pdf#q=2_265597453.385780313.163457764-1965313330.163457764)

## Energy Modeling

The team used the REM/Rate software for energy modeling to fulfill the Home Energy Rating System (HERS) requirements. Twelve different units were modeled in REM/Rate—four each on the first, second, and fourth floors. Seven had two bedrooms and five had one. Each unit is modeled with a GSHP with a 3.4 coefficient of performance (COP) and 16.7 energy efficiency ratio (EER) for heating and cooling, an ERV, R-22 walls, R-55 ceilings, windows with a 0.17 U-value and 0.27 solar heat gain coefficient (SHGC), air leakage of 1.0 air changes per hour at 50 pascals (ACH50), 100% LED lighting, and all-electric appliances. The DHW system is a central system consisting of two 5-ton, water-to-water heat pumps (HPs) with four 162-gallon storage tanks utilizing the common ground-loop system. This system is modeled for each unit as an individual 40-gallon heat pump water heater (HPWH) with a 3.0 energy factor (EF), as per the Residential Energy Service Network (RESNET) Multifamily Guidelines.

The target energy rating index (ERI) for the 2015 International Energy Conservation Code (IECC) in climate zone 6A is 54, and all units far exceed this with ERIs of 33 to 37 before and -12 to -14 after PV is added. The units also meet the requirements for EPA ENERGY STAR Version 3.1 and exceed the requirements of 2016 Energy Conservation Code of New York State (ECCCNYS) by 34% to 42%.

## Energy-Efficient, All-Electric Design

### High-Efficiency Lighting Fixtures and Appliances

The design and development team incorporated all-electric and efficient equipment throughout the building. The laundry includes a heat pump clothes dryer, which is 40% more efficient than conventional dryers. Each kitchen has an induction cooktop, which heats faster, is easier to clean than a conventional electric cooktop, and significantly decreases the risk of fire hazards. All major appliances, including refrigerators, induction stoves, dishwashers, clothes washers and dryers, are ENERGY STAR rated for maximum energy efficiency. The project includes an energy efficient KONE EcoSpace Elevator. The system utilizes a permanent-magnet and a gearless traction motor. It does not require a separate control room on the roof, as it employs a hoisting motor and control component.

### Building Envelope

Zero Place's high-performance enclosure consists entirely of thermally-isolated ICF exterior walls integrated with an Ecospan Structural Floor System and continuous spray foam at the underside of the roof assembly and slabs. The ICF walls contain expanded polystyrene (EPS) insulation on either side of the structural concrete with a total R-value of 22, providing two layers of continuous insulation around the building. This eliminates thermal bridging and significantly reduces air-leakage. The wall system has an air leakage rate of 1.0 ACH-50, which exceeds 2016 ECCC requirements by 65%. The roof and below grade walls both utilize spray foam insulation and have a R-values of 68 and 28, respectively. All residential windows are triple-paned with a U-factor of 0.17 and a SHGC of 0.27. The commercial portions of the building have high-efficiency, thermally broken storefront glazing.

### All-Electric Systems

The building ventilation is run on unitary ERV systems with demand-controlled ventilation. This innovative system optimizes both energy efficiency and indoor air quality. The demand-control component is activated by carbon-dioxide levels in the apartment, and/or use of the kitchen range to provide additional ventilation. The ERVs will distribute fresh outdoor air to each room through GSHP air-handlers and a duct system. The building includes cooling dominated commercial spaces, and the excess heat extracted from the building can be used for DHW. Space conditioning and DHW are provided by a central GSHP loop with individual heat pumps. This system uses earth's natural temperatures to provide heat; it can operate without electric-resistance backup or any supplemental heat sources, meaning it operates as a 100% site emission-free system. This GSHP system with an integrated common ground exchange loop, high-efficiency variable speed central pump flow station, and an interior loop pipe system—which minimizes pressure drop—is expected to perform at least 15% more efficiently than a conventionally designed GSHP system. Each residential unit is equipped with a high-efficiency, water-to-air heat pump and all ductwork is located within the thermal enclosure.



*Render of southeast corner of project by BOLDER Architecture, PLLC.*

## Renewable Energy

Zero Place includes an on-site PV system with the capacity to generate approximately 295,000 kilowatts per year (kWh/year). In a typical year, the system will send a net surplus of 1,398 kWh/year back to the electric utility grid. The project has three PV arrays: the first is on the main roof, the second is on the penthouse roof, and the third is made up of solar awnings that shade the windows on the south face.

The project includes electrical infrastructure that can allow the integration of an electrical energy storage system in the future. This would help with peak load management and could replace the use of grid-electricity during periods with insufficient solar PV generation.

## Smart Building Technologies and Energy Consumption Feedback

To save energy, lighting in common areas is equipped with occupancy sensors programed to turn off lights when spaces are not in use. Energy use and indoor climate are monitored throughout the building to keep the air quality healthy and occupants comfortable while ensuring efficient building performance. Within the GSHP loop system, the variable-speed central pump is responsive to load demand. The ERV demand-controlled ventilation system optimizes efficiency and indoor air quality, activating in response to fluctuations in CO2 levels and the use of the kitchen range to reduce excess humidity. Public bathrooms have a central exhaust fan with timer controllers. The elevator cab has occupancy sensors that can put the system into idle mode, turning off the lights, ventilation, music, and video screens when unoccupied.

Energy, water, and indoor climate are monitored for all apartments, common spaces, and commercial spaces throughout the project. Energy is monitored at the unit level and real-time monitoring is anonymously displayed in the lobby to show energy consumption in relation to generation. This is intended to be used as an educational tool for occupants and visitors. Tenants will be provided individually monitored data, so they can better understand their consumption patterns. The information collected from monitoring energy and water will be used by management to identify opportunities to implement further energy-efficient strategies. Water monitoring also allows management to identify and locate any leaking plumbing fixtures. Sensors integrated into the ERV demand-controlled ventilation system monitor in real time relative CO2 levels, humidity levels, kitchen range activity, and temperature, allowing management to minimize energy costs, identify any areas with air quality issues, and ensure comfortable interior conditions.



*Rendering of southern face of Zero Place, including the pocket park and solar awnings, by BOLDER Architecture, PLLC.*

## Commissioning

Initial testing for air leakage was conducted at the building before drywall was installed to enable low-cost correction of any issues found. To achieve the compartmentalization standard, the construction team sheet-rocked a sample apartment to test air tightness levels prior to sheet-rocking the other apartments in order to identify necessary improvements in the air barriers between dwelling units. When construction was at the 50% completion mark, inspections were completed satisfactorily for the vault bearing walls, foundation walls, the below grade vault slab, the slab on grade, the Penthouse-level walls, and all residential and commercial fenestration. All units were individually tested upon completion of construction. All energy systems and the building envelope are set to be commissioned by a third party. Site inspections were conducted throughout the construction phases. The results of the testing and commissioning were used to create as-built performance measurements, drawing, and energy models.

## Building Operations

### Leasing Structure

Zero Place will function as a mixed-income rental property. Ninety percent of units are market rate, and the remaining 10% are affordable. It will have an “all in” rental model where the owners will pay for utilities, allowing residents to avoid the fluctuating seasonal utility costs. Occupants will pay a single flat rental price that includes the owner paid utilities, internet, and the units’ smart features. Energy savings are intended to flow to both owners, at 60%, and residents, at 40%.

## Cost Reduction

Zero Place's construction costs and rental prices are 35% and 15%, respectively, above similar code-compliant buildings. The team expects that several of the more expensive design decisions will be recouped through their greater efficiencies and reduced need for maintenance. The ICF wall construction increased the project cost by \$275,000; however, 60% of that cost was recouped by not needing to integrate multiple trades and materials used in traditional construction. This cost was also offset by an expected longer lifespan, reduced maintenance, and the lack of exterior wall framing, sheathing, and insulation, elements not necessary in this system. The solar PV system was a \$450,000 investment but has a payback period of just over eight years and an internal rate of return (IRR) of 12%. The GSHP cost approximately \$850,000 with a payback period of five to seven years. This system is significantly more efficient than air source heat pump (ASHP) systems, which are already more efficient than gas alternatives. Additionally, the GSHP system dramatically reduces the peak power demand during extreme hot or cold weather, whereas ASHP systems have excessively high peak demands during extreme weather. And lastly, using the same ground exchange loop for GSHP and DHW offset this cost by 15%. The Eco-Car elevator system cost \$20,000 more than a typical hydraulic lift. The advantages of this over a conventional elevator are that it does not require a rooftop control room, which frees up space for additional solar PV generation. It uses 50–80% less energy than a typical hydraulic system and utilizes regenerative drive systems to recover otherwise wasted energy.

## Occupant Engagement

The management team will create friendly competitions for tenants to incentivize lowering energy usage, with prizes that support local businesses. This will encourage residents to learn about, understand, and participate in carbon reduction strategies. Tenants will be provided with a manual that explains the building's various energy systems and promotes methods of energy conservation. They will also be given an orientation and walk through of the apartment to learn about the zero energy building features included. A novel feature in the fitness center, available to all tenants as an additional amenity included in their rent, allows tenants to generate electricity while using fitness equipment.

## Facility Management and Vendor Training

After the construction of Zero Place was completed, the building manager and maintenance staff were given an overview and operational training of all building systems. Buffalo Geothermal Heating, the GSHP designer, trained the manager and maintenance staff on the proper operation and maintenance of the GSHP system. SunCommon, the solar PV system designer, provided the manager and maintenance staff with solar equipment training, and Integral Building + Design, the energy monitoring installer, trained them on how to use the energy monitoring equipment. The management team was also provided with a manual that explains the energy system operations of all the buildings.

## Additional Benefits

### Site Context

The project team conducted a regional study to create a design that is respectful of the historical context and aesthetic of the nearby community of Huguenot Street. The façade is made of stone and brick, with material variation and trees to break up the size of the building mass. The team hopes that by respecting local architectural vernacular, they can gain public support for the high-performance design.

With a bus stop located on site, Zero Place provides tenants with access to the main route for the Ulster County Area Transit (UCAT) bus and a direct transit option to New York City. The site location also puts residents in close proximity to community recreational resources, a wildlife sanctuary, the historic district, the community center and pool, and the State University of New York at New Paltz. Zero Place sits at the intersection of the historic Walkkill Valley Rail Trail and the new Empire State Trail, a continuous 750-mile route from NYC through the Adirondacks and west to Buffalo. The site includes 50 bike racks and public restrooms, supporting both local and statewide trail hikers and bikers. The project team hopes to help promote the growth and development of the Empire State Trail and accommodates the New York State Department of Transportation through site planning in this effort. Additionally, the development site includes 20 off-street parking locations with electric vehicle (EV) charging stations.



Site plan by BOLDER Architecture, PLLC.

## Community Engagement

As a mixed-use building, the project provides residents and community members with immediate access to local markets and services. Through discussion with the local planning board, the team decided to preserve open space rather than limit their setback from the street. This developed into a pocket park on the south side of the building, which, along with seating on the east side, enriches the street front and provides outdoor space for tenants and community members. As the project offers commercial space to businesses, tenants and community members will have immediate access to local markets and services.

## Occupant Health, Comfort, and Productivity

The geothermal heat pump systems use minimum efficiency reporting value (MERV) 13 filtration to provide tenants with filtered air along with dedicated, balanced ventilation air from the outdoors to each dwelling. Following the EPA's Indoor airPLUS standards, all of the finishes were low- or no-volatile organic compound (VOC) products, which reduces the indoor pollution loads. Triple-pane windows provide enhanced thermal comfort, reduced noise transfer, and condensation control. As an all-electric building, there is no risk of gas or fuel leaks, no back-drafting of flue gases, and a reduced risk of fire. Enhanced compartmentalization and air-sealing strategies maintain the conditioned interior environments.

## Resiliency

Zero Place was designed to achieve Passive Survivability in the case of an extended grid outage during extreme weather conditions. The project can maintain life safety services and a safe indoor temperature during power outages and extreme weather conditions through an enhanced thermal envelope and a back-up generator. As the GSHP is located inside the building, it is not vulnerable to severe storm damage. The ICFs, designed for long-term durability, are rot- and pest-resistant and are considered a hurricane-proof construction component. The concrete and steel floor assemblies also provide additional fire and storm resiliency.

## Lessons Learned

- Having a design team and architect who were adaptable and willing to work on a building with high performance was the most important aspect of the project's success.
- Insulated concrete forms (ICF) at this scale require an experienced crew, and the market does not support the labor associated with ICF work compared to full-poured concrete work. ICF is not cost competitive yet, but it could be in the near future. There is also a lack of skilled labor and market awareness. For the project, the team had to use carpenters who were less costly but less experienced in concrete work. To succeed with ICF cost reduction, the developer would need to bring the ICF team in house.
- The Eco-Span Structural Floor System is intended to work seamlessly with ICF structural walls to create a nearly pre-engineered whole-building structure. However, it must be built to exact specifications and it is critical to maintain the maximum concrete slab depth when placing the concrete floors. Thickness was added to the slab during placement, and the entire building's structural support had to be re-engineered to ensure the integrity of the building design, resulting in a substantial delay and increase in cost. Under ideal conditions, this system saves one third of the cost and 35% on materials, but if the specifications are not followed exactly those savings are reduced.
- Extensive prework enabled the project to run smoothly and efficiently overall. Components were pre-sized and ICF is low waste. The design was efficient but required more skilled trades than a wood frame high-performance project would require.
- The ground source heat pump (GSHP) system designed and installed at Zero Place is an innovative system and the performance results are pending the operation over the course of a full year. Buffalo Geothermal Heating's strategy, along with the tight envelope and high-performing building design, required fewer wells and created a more efficient design compared to other projects.
  - The GSHP strategy and performance in this project is another benefit of integrated design.
  - The teams were generally concerned with long-term durability and the likelihood of increased extreme weather conditions, so the systems are designed with more redundancy than may be necessary.
- Typically, an architect designs the building first, and then the mechanical engineer and energy rater are introduced. In this case, the energy rater and engineer worked with the team and created the energy model before the final design. Utilizing an integrated design process resulted in accurate sizing for equipment.

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