

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



Project Details

Location:

Newburgh, New York

Project Area:

3,972 sq.ft.

Number of Buildings:

1

**Number of Stories
Per Building:**

3

Number of Units:

3

Project Cost:

\$452,607

Cost per Gross Square Foot:

\$113.95

Market Sector:

LMI

Construction Type:

Gut Rehab

Construction Start Date:

2017

Completion Date:

June 2020

REDC Region:

Mid-Hudson

Developer:

Stephen Taya Property
Management

Architect & Design Team Lead:

The Figure Ground Studio &
Northeast Projects, LLC

Technologies Used:

Fully electrified with ASHP for
HVAC and DHW, ERV, smart
building controls

All-electric, passive house retrofit

Background

North Miller is a three-unit retrofit of a vacant masonry building in Newburgh, NY. The design includes passive strategies that reduce energy use, such as high-efficiency windows that retain heat, reducing heating loads in the winter, and exterior shading that blocks the sun, limiting solar heat gain and reducing cooling loads in the summer. The development team's business case includes the current scarcity of affordable housing, low-property costs, and an owner-paid utility model that allows the project to turn utility savings into income. The design team learned many lessons through this retrofit process, such as the effect of existing brick properties on air barrier selection and energy modeling, that the airtight layer installation process can be simplified by bringing it to the interior of the assembly, and that high-performance window selection can be challenging when meeting historic designation aesthetic requirements.

Key Project Features

The project is designed to meet Passive House Institute U.S. Plus (PHIUS+) 2018 certification standards, as well as the requirements for International Energy Conservation Code (IECC), ENERGY STAR®, U.S. Department of Energy's (DOE) Zero Energy Ready Homes, Environmental Protection Agency (EPA) Indoor Air, and EPA WaterSense. North Miller utilizes all-electric equipment, such as:

- ✓ **HVAC:** Minisplit—Mitsubishi air source heat pump (ASHP), energy recovery ventilation (ERV).
- ✓ **Water Heating:** Sanden CO₂ ASHP + demand recirculation.
- ✓ **Envelope:** Historic preservation with continuous insulation.
- ✓ **Passive:** PHIUS+ 2018 certification.
- ✓ **Lighting:** Light emitting diode (LED) with controls.
- ✓ **Appliances:** Electric dryers and stoves.
- ✓ **Renewables:** Onsite and offsite solar photovoltaic (PV).
- ✓ **Resilience strategies:** Passive survivability.

Predicted Site Energy Use Intensity (EUI): 12.4 kBtu/SF/yr

Net Site Energy Use Intensity (EUI): 1.6 kBtu/SF/yr

Predicted Renewable Production Intensity (RPI): 10.7 kBtu/SF/yr

**Energy Code Baseline: 2019 NYS Energy Conservation
Construction Code (ECCC)**

Performance Path: PHIUS+ 2018

Certification: PHIUS+ Source Zero

Planning and Design Approach

Project Goals

North Miller honors Newburgh’s existing historic townhouses while delivering high-performance benefits of comfort, indoor air quality, and durability. It will serve as a replicable project model for other developers and lenders to retrofit the many vacant masonry multifamily buildings in Newburgh and other financially distressed areas in New York State. The project’s business case includes scarcity of affordable housing, negligible property costs and low-capital requirements, and an owner-paid utility model which allows the project to turn utility savings into income.

The project was designed to meet the standards of PHIUS+ 2018 certification. By implementing the energy-efficient technologies, materials, and techniques outlined in the Passive House guidelines, as well as using an “all in” owner-paid utilities model, the development team will relieve the pressure of high energy bills common in the area, while generating owner income through savings.

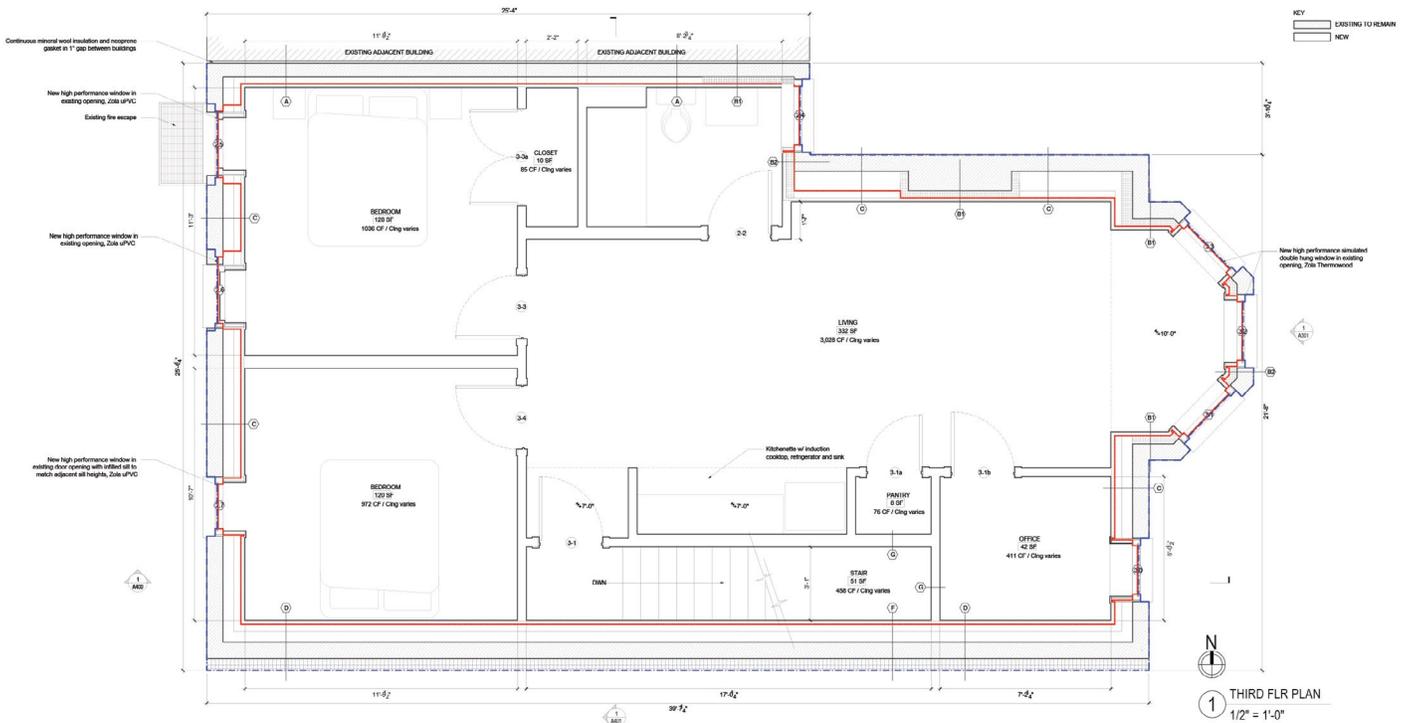
Project Team

The project was developed by Stephen Taya Property Development and designed by John Loercher with Figure Ground Studio. Mechanical engineering services were provided by Baukraft Engineering, and Northeast Projects LLC served as both the energy consultant and the design team lead. Third-party inspections were performed by the PHIUS certified rater, Troy Hodas from Spruce Mountain, Inc., at critical construction points. For example, required site inspections were performed at the pre-installation of the exterior rigid insulation and at 95% installation of the interior air barrier.

Building Design

North Miller’s design blends with Newburgh’s existing historic townhouses. As a previously vacant property, the building sat dormant for the past decade. The upgraded façade details were designed to visually match existing details, such as the double-hung windows, and few changes were made to the historic masonry façade.

The design team implemented passive design strategies to increase interior comfort while reducing the building’s energy use. The building is oriented to capture solar energy, so design upgrades include heat-retaining, high-efficiency windows that reduce winter heating loads. In the warmer months, exterior shading limits heat gain through direct sunlight, reducing summer cooling loads. The south facing wall, which was originally a party wall with the building that once stood next door, could not be equipped for solar heating and cooling since another building could be built in the adjacent vacant lot. The advanced envelope assembly required for a PHIUS certified project ensures stable temperatures for extended periods of time during power outages. The roof-mounted PV system is expected to provide 85% of the renewable energy production needed for net zero qualifications and 79% of the total annual source energy. Off-site PV provides an additional 21% of the annual source energy.



Typical floor plan, provided by The Figure Ground Studio

Energy Modeling

The project team used WUFI Passive 3.2.0.1 as their energy modeling tool, and the project was modeled as a residential retrofit project. Key project features included in the energy model are as follows:

- Windows were modeled with an average solar heat gain coefficient (SGHC) of 0.5 and a U-value of 0.19.
- The average U-values of the exterior walls, basement, and roof were modeled as 0.024, 0.029, and 0.016, respectively.
- No thermal bridges were included in the model.
- The domestic hot water (DHW) system was modeled as Sanden CO₂ heat pump water heater (HPWH)—Gen 3, 119 gallon.
- The heat pump systems were modeled as Mitsubishi MSZ-FH09NA.
- The ventilation systems were modeled as Zehnder Q600.
- The sensible recovery efficiency was modeled as 0.9.
- The model included an efficient electric stove and electric clothes dryer.

In the team's first model, the project had a net source energy of 4,135 kWh/person/year; after improvements made through more efficient systems and added PV generation, the final model showed a net source energy of 592 kWh/person/year, which met the PHIUS 2018+ certification target of 3,840 kWh/person/year.

In addition, the heating demand of 5.7 kBtu/SF/year meets the target of 6.5 kBtu/SF/year; the peak heating load of 5.5 Btu/hr - SF meets the target of 6.2 Btu/hr - SF; the cooling demand of 4.4 kBtu/SF/year meets the target of 6.3 kBtu/SF/year; the peak cooling load of 3.3 Btu/hr - SF meets the target of 3.8 kBtu/hr - SF; air tightness of 0.82 ACH50 meets the target of 1.16 ACH50; and the total sensible recovery efficiency of 89% meets the target of 75%. The state-of-the-art technology and design strategies employed in this retrofit are reflected in the relatively low-site EUI compared to similar buildings.

Energy Efficient, All-Electric Design

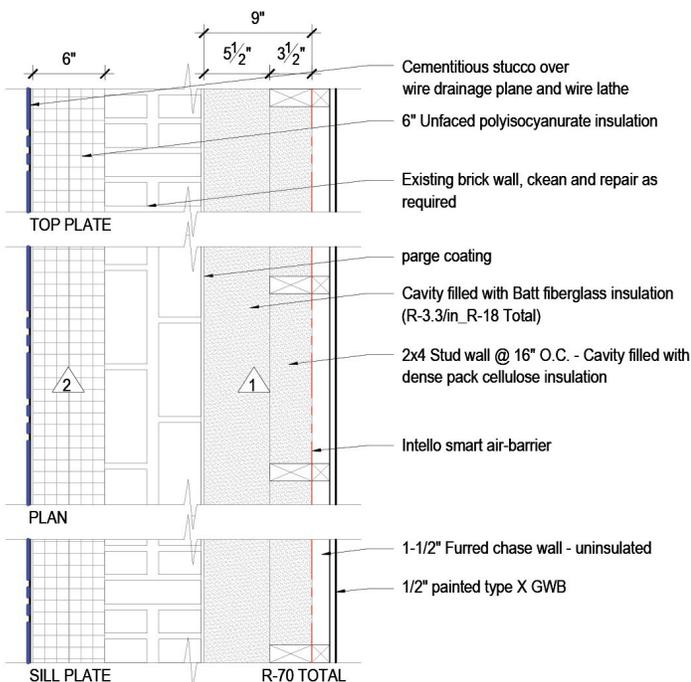
High-Efficiency Lighting Fixtures and Appliances

There is LED lighting throughout the project, and the design optimizes natural daylighting opportunities through high-efficiency windows. North Miller's design and development team incorporated all-electric and efficient equipment throughout the building. The laundry includes an electric dryer and each kitchen includes an electric stove. All appliances, including refrigerators and dishwashers, are ENERGY STAR rated for maximum energy efficiency.

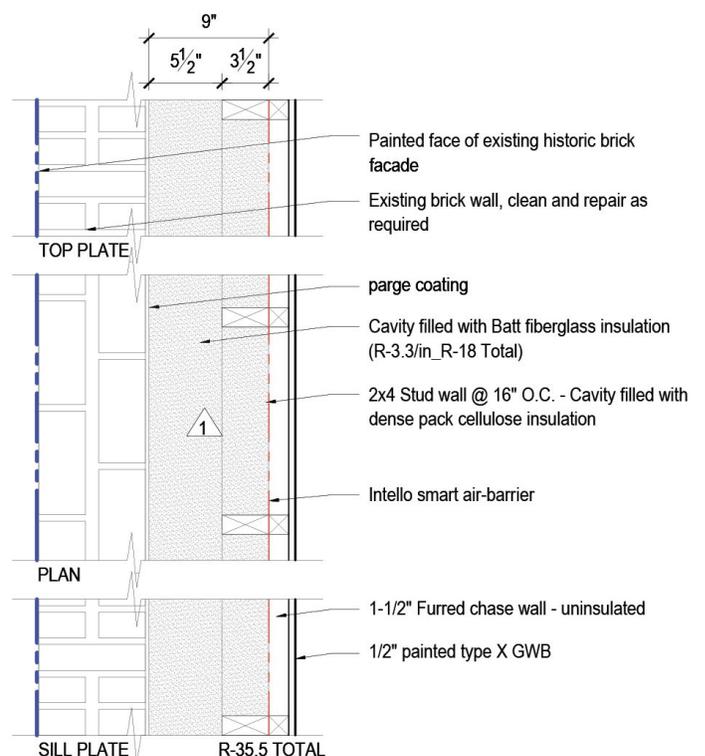
Building Envelope

Designed to Passive House standards, North Miller's envelope is highly efficient and draft free. As a retrofit project, all faces, except the southern, have additional materials and insulation added to the interior to preserve the historic brick façades.

South Wall • R-70



Typical Wall • R-35



Wall detail sections, provided by The Figure Ground Studio

This includes a parge coating, polyisocyanurate or Batt rock wool insulation, stud walls with cellulose insulation infill, and an Intello air barrier, resulting in R-13.5 to R-35.5 walls. The south face was previously a party wall to the now demolished adjacent building, and, as a new building could be built in the empty lot in the future, the wall could not be utilized for solar heating and cooling. Therefore, additional insulation was added to the exterior of that elevation, resulting in an R-70 wall. The R-64 roof is built up from the bitumen roofing, polyisocyanurate insulation, existing sheathing layer, existing rafters with closed cell foam and dense packing (DP) cellulose insulation, and an Intello air barrier.

The design team upgraded the windows to Zola Thermowood windows that tilt and turn on the rear elevation. From the exterior, they look like double-hung windows, which conforms to historic district standards. The frames have a U-value of 0.16, the glass has a U-value of 0.101, and the window units have a SHGC of 0.53.

All-Electric Systems

North Miller is a fully electrified project. HVAC is provided through Mitsubishi Minisplit—ASHP and Zehnder ERV systems, while DHW is provided through a Sanden CO₂ ASHP water heater with demand recirculation. The use of heat pumps lowers the project's energy use by almost 10,000 kWh per year. All three living units are tied to a central ERV unit. The design team chose this method because it minimizes energy losses from the ventilation process, simplifies maintenance, and reduces operating costs. The design also includes electric dryers and stoves.

Renewable Energy

North Miller owns both on-site and remote solar electric PV arrays to achieve a net annual electric demand of 1,903 kWh. The remote solar PV system produces 3,094 site kWh/year, which translates to 9% of the total annual source energy. The on-site system is a 9 kW roof mounted solar array that produces 11,234 site kWh/year, which translates to 79% of the total annual source energy.

Energy Consumption Feedback and Smart Building Technologies

A SiteSage Energy Management System is used to monitor the energy performance of the whole building, end uses, and PV, analyzing occupant energy consumption and identifying any mechanical or electrical system issues. The monitored information for North Miller's units is collected and shared back with the tenants to encourage a reduction in energy use and with the design team as feedback for future design iterations.

Occupancy sensors are utilized in all common spaces within North Miller, such as circulation spaces, the laundry area, and storage areas. All exterior lighting fixtures are equipped with time of day sensors. HOBO temperature loggers and relative humidity sensors are embedded in five locations throughout the building to ensure maximum occupant comfort. The apartments' HVAC setpoints are set to the Passive House standards of 68°F for heating and 77°F for cooling. The DHW system's recirculation loop pump is activated by a control located in each apartment so hot water can be provided on command within EPA WaterSense delivery criteria.

Building Operations

Leasing Structure

North Miller is a three-unit multifamily rental property that serves low- to moderate-income (LMI) occupants, screening applicants for a maximum of 80% area median income (AMI). In NYS, LMI households comprise 59% of multifamily housing units, which highlights the demand to provide housing to this demographic¹. As an "all in" rental model, the cost of energy use is included in the rent amount, with tenants given an "energy budget" of 5,000 kWh per person. This amount was calculated using the national per person averages provided by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). If a tenant goes over the allotted 5,000 kWh, the building manager and owner will help the tenant adjust and resolve the issues of excessive energy use. If the tenant's excess energy use continues, they will be charged the current Central Hudson kWh rates for energy usage over the 5,000 kWh allowance. The rental agreement specifies that owners will supply heat and hot water, electricity, cold water, and sanitation.

Cost Reduction

The construction cost and rent of North Miller are 11% and 20% above comparable structures, respectively. The energy costs per resident are 90% below comparable buildings. The investment into the certified Passive House envelope increased the project cost by roughly 15%. The total investment of retrofitting an existing masonry building is roughly one third that of a comparably sized new construction, which generally average around \$280-\$300/SF in the Hudson Valley.

¹ Cadmus. *Assessment of Energy Efficiency Potential in New York State Multifamily Buildings*. Prepared for NYSERDA June 2021. P. 13.
<https://www.nyserda.ny.gov/About/Publications/Building-Stock-and-Potential-Studies/Assessment-of-Energy-Efficiency-Potential-in-New-York-State-Multifamily-Buildings>

Additional Benefits

Adaptive Reuse

Cities across the United States are struggling with vacant lots. In 2021, there were about 1.3 million vacant residential properties in the United States². In recent years, New York State has passed laws to help local governments reclaim these so called “zombie properties.” North Miller is a successful example of adaptive reuse of such a property, rehabilitating a multifamily building in a historically designated landmark area that had been vacant for the past decade. All but one of the energy renovations occurred on the inside of the existing walls, preserving the majority of the historic brick exterior. The masonry has been sand blasted and treated to both revive its original character and further prolong its life. All of the original architectural detail and trim has been restored and repainted.

Site Context

Newburgh, NY, has a high proportion of residents who are living below the poverty line. Across the country, the low-income population tends to be burdened with high energy costs; over 7% of income goes to utilities for the average low-income household. The typical building stock in the Newburgh area consists of three-story masonry buildings built at least a century ago, often in poor condition with minimal insulation and inefficient heating systems. This leads to high energy costs and exposure to unhealthy conditions for the occupants. Many of these masonry buildings are currently uninhabitable and would need a complete gut rehabilitation. These vacant properties tend to have low property costs, providing a good opportunity for other developers to follow North Miller’s lead in passive and energy efficient housing.

Community Engagement

In February of 2020, Michael Robinson, from Stephen Taya Property Management, presented North Miller to the Newburgh city officials in charge of community building as a way to offer background information on the project’s design and goals, providing an example for other developers to replicate in the community.

Occupant Health, Comfort, and Productivity

Through the dedication to achieving PHIUS+ 2018 certification, the strategies applied to North Miller also allow the project to meet the requirements of the IECC, EPA ENERGY STAR, DOE Zero Energy Ready Homes, EPA Indoor Air for low-volatile organic compound (VOC) content, and EPA WaterSense. The project achieves high levels of indoor comfort and air quality while still prioritizing minimal energy use. The HVAC systems are set to keep the interior air temperatures comfortably within the range of 68°F and 77°F. Occupants can more precisely control their unit’s systems, if needed, as each unit is equipped with a mini-split heat pump. Minimum efficiency reporting value (MERV) 8 and MERV 13 filters are employed to provide a constant supply of fresh filtered air throughout the building. The highly insulated envelope not only reduces heating and cooling loads, but has the additional benefit of providing noise isolation, offering the inhabitants a quiet interior environment.



Diagrammed perspectival section, provided by The Figure Ground Studio

² ATTOM Data Solutions. Fourth-quarter 2021 Vacant Property and Zombie Foreclosure Report.

Resiliency

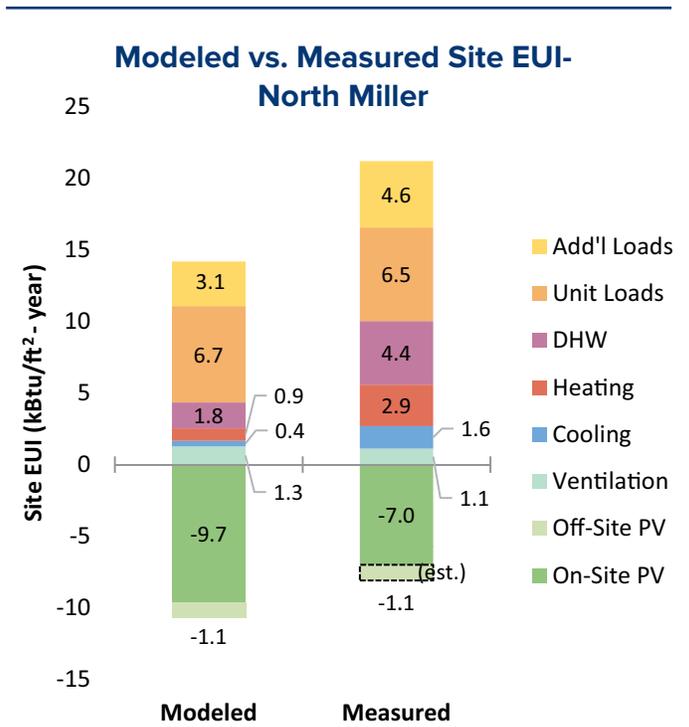
The design team's use of high-performance windows and doors, super insulated wall and roof assemblies, and thermal bridge-free construction ensure that North Miller is airtight and thermally resilient. In historically designated buildings, insulation is often added to the inside of the brick façade to match the existing aesthetic. However, this isolates the brick façade from the interior heating source, putting it at a serious risk for freeze/thaw cycles. Using advanced energy modeling (WUFI Plus), the envelope was designed to direct and remove vapor through the wall assembly, reducing the likelihood of freeze/thaw, mold growth, and other material degradation. This Passive House method protects existing masonry buildings and increases their lifespan while also providing thermal resiliency for its occupants in times of power outages due to storms and other grid failures.

Performance Verification

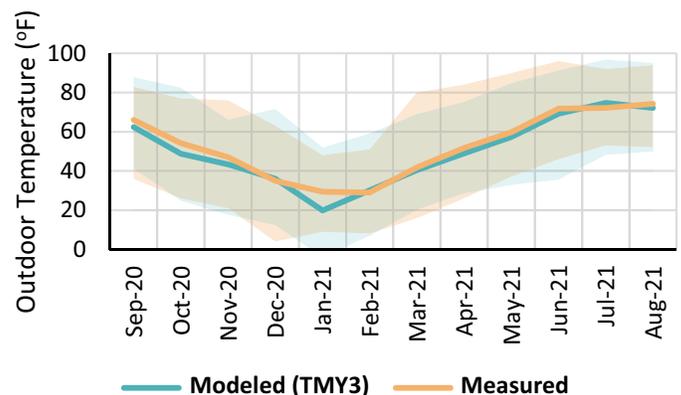
The building was completed and occupied starting in August 2020. With over a year of energy data available from the SiteSage monitoring portal, the building performance can be compared to the energy model created for the building. The model predicted a site EUI of 12.4 kBtu/SF - year before adding 10.7 kBtu/SF - year of solar generation, on- and off-site, for a net site EUI of 1.6 kBtu/SF - year. From September 2020 through August 2021, the measured site EUI was 21.2 kBtu/SF - year with an RPI from on-site solar of 7.0 kBtu/SF - year. There was no measure of the off-site solar production, but it was assumed to perform as modeled. With a total measured RPI of 9.7 kBtu/SF - year, the building has a net site EUI of 11.5 kBtu/SF - year. The pre-PV site EUI is 71% higher than modeled and the RPI was 28% lower than modeled. The figure to the right shows the breakdown by end use as available through SiteSage.

One difference between modeled and measured performance comes from additional loads not attributed to any unit or end use. These could be loads such as exterior or stairway lighting, which may not have been included in the model. The building also experienced 16% more cooling degree hours and 12% fewer heating degree hours than the typical meteorological year (TMY3) temperatures used in the model; the two climates are shown in the figure to the left, which may explain some of the discrepancies in cooling loads, although it does not help explain the difference in heating or DHW performance. It is also possible that there is a difference in the modeled versus actual occupancy patterns that could explain higher heating use, hot water use, and plug loads.

For example, the monitored period overlapped with Covid-19 shutdowns when many people were working from home. Little research exists to quantify the expected consumption patterns during this period, but a white paper "How COVID-19 Changed Household Electricity Consumption" released by the Northwest Energy Efficiency Alliance (NEEA) described patterns from 200 households in the Pacific Northwest. For this sample population, the average load grew by 6.3% during the day and fell by 3.1% during the evenings, a pattern consistent with more people working and schooling from home. The largest changes in residential electricity demand came from end uses including plug loads, kitchen appliances, laundry, and water heaters. With residents cooking at home more, kitchen appliance use increased across almost all hours, which also created more demand for hot water, especially during mid-day hours. In the study, the largest demand changes occurred in the spring of 2020 and the winter of 2020/2021. This winter period is also when North Miller experienced unexpectedly high DHW usage.



Site EUI by end use for model and measured data

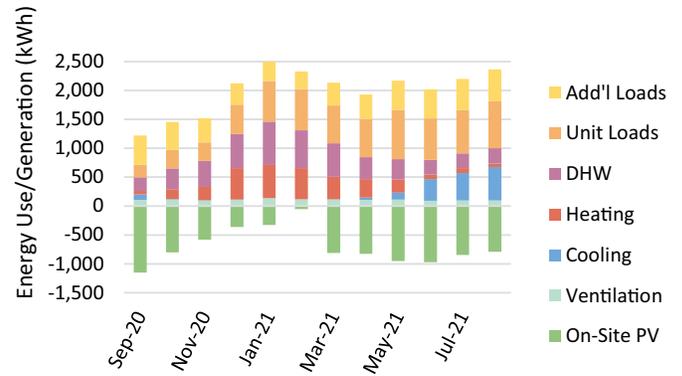


Comparison of daily average, minimum, and maximum outdoor air temperature

The on-site solar generation showed particularly low output in January and February, as seen in the final figure, with zero generation measured for multiple days. It is possible that extreme weather fully cut off solar production, but it is also likely that a maintenance issue caused an outage in the generation or metering, so the measured generation values should continue to be monitored before any additional actions are taken.

Overall, the building has not quite performed as well as designed—in part due to potentially unmodeled loads, differences in weather, and COVID-19 occupancy patterns—but the DHW system’s unexpectedly high-energy consumption, with large peaks in the winter months, merits additional monitoring and analysis for the benefit of future projects using similar heat pump water heater technology.

North Miller Measured Monthly Energy Use



Measured monthly energy use and generation by end use

Lessons Learned

- Reusing wooden pocket beams in an existing masonry building led to complications with air sealing, as each beam passed through the Intello air barrier. This puts the beams at risk of rot and mold if water penetrates the through the exterior. A possible solution would be to remove the existing pocket beam and build a new interior structural wall inside of the existing masonry wall.
- It is crucial to test the properties of the specific type of brick used in the existing masonry walls, such as moisture qualities and adhesion compatibility. The type of brick will impact the adherence of different air barriers, the type of exterior fastener that will work, and the accuracy of the energy model.
- Bringing the primary airtight layer to the interior of the wall assembly, behind the chase wall, simplified the process of covering anomalies and made it easier to work in the tight spaces common in retrofits.
- To attach the Intello air barrier, it must be stapled to the wall framing. Though the product is supposed to “self-seal,” the team found that it became necessary to cover the staples, which created holes, with air sealing tape.
- Due to the building’s historic designation, the replacement windows were required to have the same aesthetic style and placement as the originals, which was challenging and led to higher prices. The windows also needed to be installed in line with the existing brick wall, rather than at the centerline of the entire wall assembly. This placement, required by historical preservation criteria, undermines the thermal resilience of the window and lowers the psi-install value.
- To maintain fire-separation when using a single central energy recovery ventilation (ERV) unit for a multifamily building, fire dampers must be installed between each floor and standard bent metal ductwork must be used. This results in an increase in the complexity of the system installation.

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