Buildings of Excellence: Driving Resilient, Low-Carbon Multifamily Housing Across New York State

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ABSTRACT

The New York State Energy Research and Development Authority's (NYSERDA) $58M Buildings of Excellence (BOE) Competition rewards the design, construction, and operation of clean, resilient, and carbon-neutral multifamily buildings. Previous reporting summarized planning and design approaches, measure specifications, building operations, non-energy benefits, and the designed cost, energy use, and carbon emissions. This paper focuses on resiliency strategies, embodied carbon, and early measured performance for the first two rounds of the competition.

The BOE awardees enhanced resiliency through high-performance and passive envelopes, support during grid outages, and stormwater management. The awardees lowered embodied carbon through material selection by incorporating new concrete mixes, reducing volume of concrete, minimizing use or volume of foam insulation, selecting low global warming potential (GWP) refrigerants, managing waste during the construction phase, and using reused/recycled or locally sourced materials. Finally, the paper documents early measured performance for buildings with a year of measured data and operational areas for improvement.

Introduction

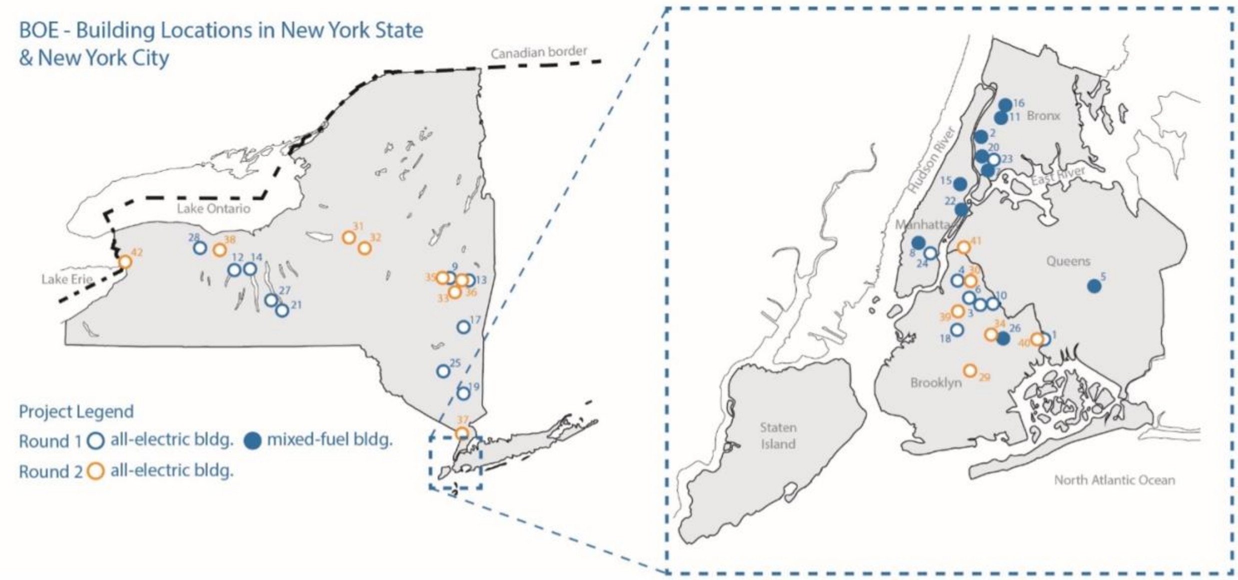

Figure 1. BOE Round 1 and 2 winner locations.

NYSERDA's BOE competition rewards the design, construction, and operation of clean, resilient, and carbon-neutral multifamily buildings by limiting or eliminating the use of fossil fuels in the buildings' operation. Initiated in 2019, this $58M competition is now in its fourth round. This paper will focus on data from the first two rounds of the competition. The 42 Round 1 and 2 awardees ranged from 2 to 52 stories and include both market rate and low-to-moderate (LMI) income demographics. As shown in Figure 1, winners are located across New York State's three climate zones.

Methodology

NYSERDA and its contractors have gathered a rich set of data on the BOE awardees. Using this data, NYSERDA has been conducting an ongoing BOE Trend Analysis to highlight lessons learned on the design, construction, and operation of clean, resilient, and carbon-neutral multifamily buildings. The analysis tracks application packets, deliverable documentation, building cost data, energy models, and post-occupancy data as it becomes available. To increase the impact of driving change in the buildings sector, detailed project information is available on NYSERDA's website,[1] including case studies, cost data, and other presentations. The BOE Trend Analysis (which is expected to be released later this year) includes qualitative analysis on planning and design approaches, clean and resilient design packages, building operations, and non-energy benefits. In parallel, a quantitative analysis summarizes energy use, emissions, and economic performance.

A previous paper summarized planning and design approaches, measure specifications, building operations, non-energy benefits, and the designed cost, energy use, and carbon emissions (Brown et al 2024). A few key items to note from the previous paper:

- All 14 Round 2 awardees are all-electric and all upstate project designs across both rounds are all-electric; any use of natural gas is limited to domestic hot water (DHW) production in Round 1 mid- and high-rise projects in New York City (NYC).
- All awardees have designs with all-electric heating, ventilation, and air conditioning (HVAC) systems with energy recovery ventilation (ERV), selecting either an air source heat pump (ASHP) or a ground source heat pump (GSHP). More than half of the project designs also have variable refrigerant flow (VRF).
- The 31 awardees with electrified DHW designs all use heat pump water heaters (HPWH) in some form.
- The biggest barrier for achieving full electrification of larger multifamily buildings is the DHW system. However, the Round 2 high-rise designs have selected all-electric DHW systems with newly available central HPWH options and creative design solutions that can serve as examples for new construction going forward.
- 39 of the 42 awardees include photovoltaics (PV) in their designs to reduce the building's overall carbon emissions; 37 of the PV systems are onsite. The five project designs that do not include onsite PV are all in NYC. For those projects, when teams balanced the system cost and overall emissions, they determined that onsite PV systems were not the best use of their investment given the limited roof space.
- Modeling revealed that space conditioning end uses represent less than 20% of the annual energy use, while unregulated loads such as appliances and other plug loads represent a

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[1] See: https://www.nyserda.ny.gov/All-Programs/Multifamily-Buildings-of-Excellence/Winners/Resources

significant portion of total site EUI. The share of site energy used for DHW is heavily dependent on whether the system is fueled with electricity or natural gas.

- All of the awardees that selected the ASHRAE 90.1 certification pathway had higher design energy use intensities (EUI) as compared to the awardees that selected the Passive House Institute (PHI) certification pathway. This may be due to a difference in modeling assumptions, which is described in more detail below.

This paper will focus on resiliency, embodied carbon, and early measured performance for the first two rounds of the competition. It should be noted that the majority of the awardees are still in the design or construction phase. As of the writing of this paper, 13 of the 42 projects are complete, so some of the illustrative examples are from projects that are still in the design phase. Post-occupancy evaluation is required as part of the competition and NYSERDA will continue to document measured versus predicted performance after projects have been occupied for a year.

Results

Resiliency

Designing buildings to be carbon-neutral is crucial to help avoid the worst impacts of climate change. Since these buildings are built for many decades of occupancy, they also need to provide safe and comfortable shelter through the storms and power failures of the next century. Resiliency is a key focus of the BOE competition and a major priority for NYSERDA in general. According to the New York State Climate Impacts Assessment, New York State has experienced increases in average and maximum temperatures, total precipitation and heavy precipitation events, and the frequency and severity of extreme weather-related events (Lamie 2024). Such changes increase risks and stresses on New York State’s population and building stock. Resiliency strategies help mitigate the risks associated with climate change and related hazards.

Recent NYS Extreme Events. Several recent events demonstrate some of the risks New York will likely face in the future. In December 2022, the City of Buffalo and Western New York experienced a “once in a generation” four-day blizzard that brought a bomb cyclone with top wind speeds of 79 miles per hour, power outages for over 100,000 residents, halted emergency services, and resulted in 47 fatalities (Cappella 2023). Only a few months later in June, New York State, along with much of the Eastern United States, experienced severe drops in air quality due to the Canadian Wildfires, where the Air Quality Index reached unhealthy levels for several days (Fadulu 2023), showing that the impacts of wildfires are not just a risk in the Western states. In the same year, a major heatwave hit in September. As students were beginning to return to school, New York (along with much of the Northeast) experienced temperatures that were 20 degrees higher than usual. This made it challenging for many schools, which traditionally lack air conditioning, to provide healthy and comfortable learning environments.

Common Resiliency Strategies. The awardees incorporate many different aspects of resiliency, with a general focus on keeping internal temperatures stable in extreme weather, planning for electrical power outages by implementing tight envelopes and installing onsite electricity generation and storage, providing continuous access to clean water, and integrating the building into surrounding public transportation networks. The most common resiliency measures are shown in Figure 2.

All of the BOE awardees focused on high-performance envelopes. In extreme weather events or extended grid outages, high-performance envelopes minimize indoor temperature swings to maintain safe interior temperatures. During normal operation, the envelope design, paired with high-performance HVAC systems, provides occupants with enhanced thermal comfort and indoor air quality.

Awardees planned for electrical power outages by installing onsite generation and storage, providing continuous access to clean water, supporting critical equipment (e.g., surge suppression and uninterruptible power supply), providing areas of refuge, and integrating the building into surrounding public transportation networks. Other resiliency features include mold reduction strategies, pest management, stormwater management, placing critical systems above the flood plain, and urban heat island reduction (e.g., low albedo roof).

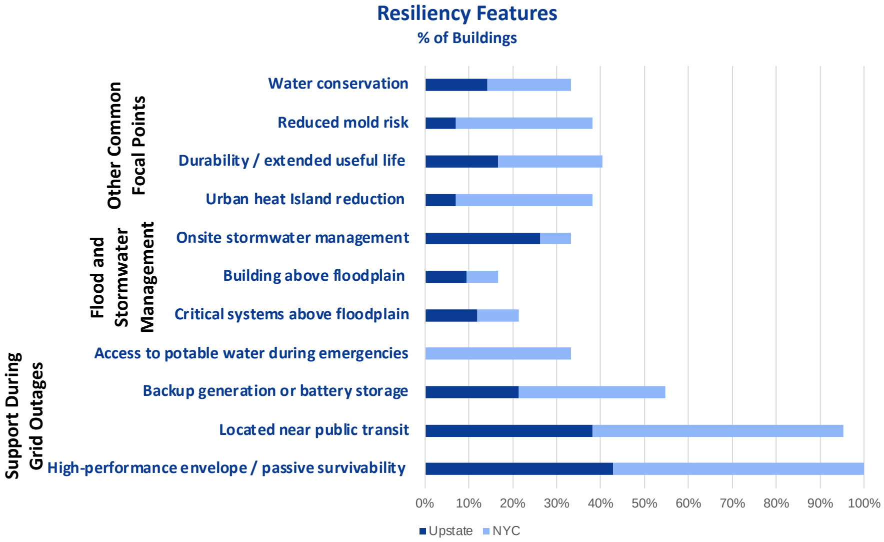

Figure 2. Resiliency feature prevalence.

Resiliency Examples

West Side Homes: People United for Sustainable Housing (PUSH) Buffalo and the Buffalo Neighborhood Stabilization Corporation (BNSC) developed West Side Homes, a series of low-rise multifamily buildings in Buffalo, NY. The project team partnered with the University at Buffalo School of Architecture and Planning’s Resilient Buildings Laboratory to understand the impacts of climate change on buildings and develop strategies for addressing them. The project incorporated many strategies to ensure resiliency for the buildings, residents, and neighborhood, resulting in the following benefits:

- Passive survivability: A strong emphasis on high R-value wall and roof assemblies and low U-value windows increases the project’s ability to maintain safe interior temperatures during grid failures or extreme climate events by improving the thermal resistance to drastic differences in interior and exterior temperatures.

- Green infrastructure and stormwater management: Like many older cities, Buffalo has a combined sewer system that overflows after moderate and extreme precipitation events, including rain and snow melts, which are anticipated to increase in Buffalo's future climate. The project includes both green infrastructure and underground detention systems to manage stormwater on site and prevent overflows. Landscaping at all sites includes rain gardens to help absorb and collect water. Some parts of the development also include an underground piping system to retain water. These efforts comply with the City of Buffalo Green Code and the Buffalo Sewer Authority's Rain Check program. Additionally, BNSC operates an eco-landscaping social enterprise business, PUSH Blue, that installs and maintains green infrastructure systems, ensuring that these resiliency efforts will perform throughout the life of the building.
- Food security: Changing climates will impact secure and safe access to food. To improve residents' food security and resiliency, BNSC currently maintains two large community gardens with a third planned, all nearby the West Side Homes apartments. West Side Homes residents will be prioritized for garden plots and BNSC will explore opportunities to create new garden plots on site or close to the West Side Homes apartments that will be reserved for West Side Homes residents.

The project team also commissioned a feasibility study of battery storage from American Microgrid Solutions to better understand storage options. The study found that given current technology costs and available capital, a PV-only strategy was more financially feasible. As both technology and project financing evolve, the development team will continue to strongly consider incorporating battery storage.

Colonial II is a major retrofit project of an existing LMI multifamily mid-rise building in Rome, New York. The project team paid careful attention to design and material choices to ensure the longevity of the building and the safety of its occupants. The entire building, including the basement, sits outside of both the 100-yr and 500-yr floodplains, minimizing the risk of flood damage. The design includes redundant power supply systems, using a dual fuel back-up system and connections to renewable energy production sources to provide continual power service during prolonged grid failures and power outages. The back-up system provides enough energy to ensure the use of elevators, hallway lighting and plugs, space heating and hot water system, as well as the community room lighting, plugs, and refrigeration of medicine. In line with goals for passive survivability, the improved building envelope increases the duration of comfortable and survivable interior temperatures during extreme weather and/or extended periods without power. To understand the potential range in shelter-in-place durations, the project team is conducting modeling analysis with both typical and future weather data.

Embodied Carbon

Carbon-neutral design should account for whole life carbon, which includes both operational emissions and embodied carbon. Careful selection of building materials and construction methods, in addition to the use of low global warming potential (GWP) refrigerants in mechanical systems, can reduce the building's embodied carbon.

Common Embodied Carbon Reduction Strategies. Almost all of the awardees incorporated design strategies to reduce embodied carbon or minimize construction and material waste. These strategies included the use of local or recycled products, carbon-sequestering materials, and environmentally preferable products. The most common approaches to lower embodied carbon are shown in Figure 3.

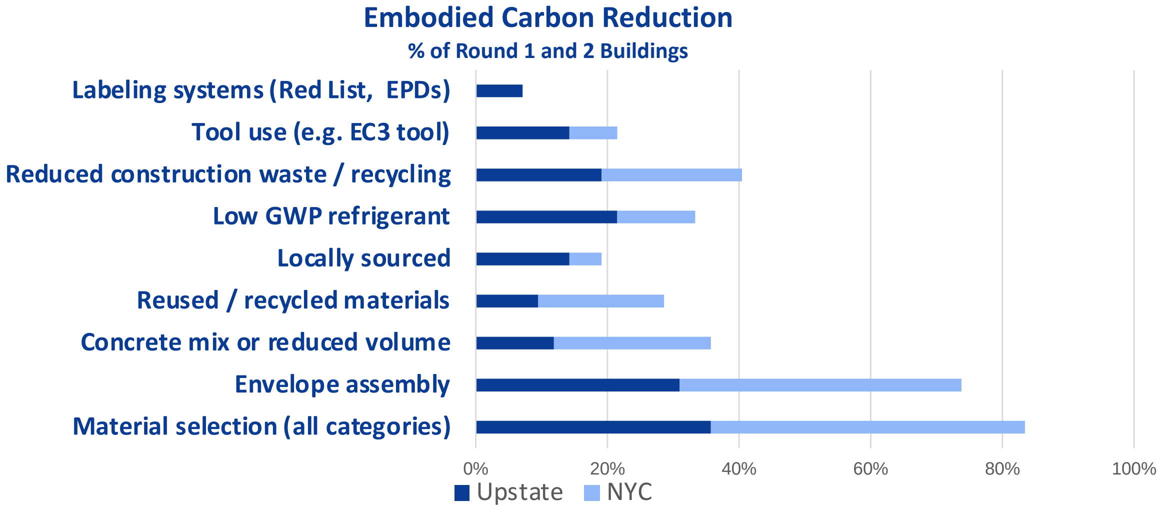

Figure 3. Reduced embodied carbon strategy prevalence.

Material selection and waste management were common strategies used by project teams. This may be due to familiarity with these strategies since these have been encouraged over the past two decades by several rating systems such as Leadership in Energy and Environmental Design (LEED). Thirty-five project designs reduced embodied carbon through material selection of some form. Common focal points were the envelope assembly, concrete, and the use of reused/recycled or locally sourced materials. More than half of the designs incorporated one or more strategies that will at least partially eliminate foam insulation from the building envelope. Alternatives included stone wool and cellulose insulation (both blown-in and dense packed). A third of the designs reduced embodied carbon through either the amount or composition of the concrete (e.g., including fly ash in the concrete mix). Some high-rise designs include autoclaved aerated concrete (AAC) within the structural system which uses about 75% less concrete by volume and requires half the total energy consumption to produce compared to typical concrete (EMR 2023). Other designs lowered the amount of concrete and material used through a COMSLAB® structural system, which uses 60% less rebar, 65% less shoring, and 40% less concrete than conventional concrete slabs (Material Efficiency 2015).

Along with reducing embodied carbon through careful material selection, a third of the designs included heat pumps with CO_2, a low GWP refrigerant, including half of the upstate buildings but only a fifth of the NYC ones. This is likely the result of the wider range of heat pumps available for smaller residential buildings.

The BOE Round 2 application increased the focus on reducing embodied carbon and Round 2 saw an increase in the use of embodied carbon calculation tools. However, it should be noted that environmental production data (EPD) science and reporting methodologies are still in their early stages and assumptions should be carefully vetted.

Embodied Carbon Reduction Examples

Solara: The Solara Apartment Complex is a three-phase low-rise market rate upstate project. Phases II and III were both BOE awardees. Once completed, Solara will be one of the largest market rate net zero complexes in the United States.

The project team has worked together through all three phases of the Solara development (in addition to a previous netZero Village project), allowing for progressive increases in efficiency and decarbonization. While Phase II focused on deep operational emissions reduction, the project team expanded their focus to reduce the buildings' embodied carbon in Phase III.

Figure 4. Solara Apartments, Rotterdam, NY – Imagery Credit: Photo Courtesy of Harris A. Sanders Architects, P.C., and Black Mountain Architecture.

Using the Embodied Carbon in Construction Calculator (EC3) tool, the project team identified three key areas for reduction: the concrete mix, the wall and roof insulation and assemblies, and the gypsum board. Knowing this, the team used strategic materials and methods to reduce the embodied carbon in the building's envelope by 65% while increasing carbon sequestration by 56%. For instance, the volume of overall concrete needed was reduced by optimizing the design of the structural components, using smaller footings and thinner stem walls. The use of spray foam and polyisocyanurate insulation was also largely eliminated by replacing these materials with cellulose insulation in both the wall and the roof assemblies. Careful attention was paid to moisture management within the building assemblies to ensure they could dry out and dew points would not be reached. These strategies will increase the cost by a moderate amount but ensure a low embodied carbon net zero enclosure. Compared to a 2020 Code Scenario, Phase III is expected to have a 50% reduction in total carbon footprint (including operational and embodied carbon).

Baird Road: Baird Road is an affordable senior housing complex located in Fairport, New York. The Baird Road team looked at embodied carbon across multiple systems including envelope, structure, HVAC, and plumbing to address embodied carbon. Three envelope scenarios considered were:

- ENERGY STAR® compliant (baseline): A typical ENERGY STAR wall assembly with R-5 rigid polyisocyanurate insulation, R-19 fiberglass batt cavity insulation, and R-49 fiberglass batt ceiling insulation.
- Super-insulated envelope: Similar wall assembly to the ENERGY STAR scenario but with R-16 rigid polyisocyanurate insulation, R-21 fiberglass cavity insulation, and R-80 fiberglass batt ceiling insulation.
- Phius 2021 (final selection): Includes additional insulation to meet the Phius 2021 requirements, while selecting materials with lower embodied carbon, such as R-9 rigid expanded polystyrene, R-21 mineral wool in the wall cavity, and R-60 blown cellulose in the ceiling.

As the electrical grid becomes cleaner, embodied carbon has an especially significant role in decarbonizing buildings. Comparing the operational and embodied carbon for the three scenarios at years 1, 10, and 20, the team found that purely adding insulation to a building does not result in the lowest carbon intensity of the building over time. The super-insulated envelope's embodied carbon was about 1.6 times higher than the ENERGY STAR design, but had the lowest operational energy of the three. It would take about 15 years for the additional insulation to pay itself back in reduced operating energy as compared to the ENERGY STAR design. However, the Phius 2021 compliant assembly had the lowest total carbon for the entire 20 year analysis. At 20 years, the total carbon of the ENERGY STAR and super-insulated assemblies were about 2 and 1.8 times higher than the Phius 2021 assembly, respectively.

The team estimated that the final wall assembly will reduce the embodied carbon by 30 tons of $C0_2$ as compared to the ENERGY STAR assembly. For comparison, the average gas-powered car produces 5 tons of CO_2 per year, so the materials selection is the equivalent of the elimination of 6 cars worth of annual CO_2 production just for the insulation materials.

Embodied carbon was further reduced in the design of the foundation and the mechanical systems. The team used a shallow frost-protected foundation system (in lieu of a more typical foundation wall and footer) to decrease the concrete in the design, resulting in an additional 55 tons of $C0_2$ savings. Refrigerant leaks contribute to GHG emissions, so the team made conscious design decisions to minimize the risk of refrigerant leaks throughout the ASHP and HPHW systems. For example, a single indoor ASHP serves multiple rooms within each apartment and only requires one refrigerant line. Similarly, HPHWs are strategically located to allow a single water heater to serve four apartments. The team also included equipment with refrigerant leak detection to provide early warning of any malfunctions.

Modeled Versus Measured Performance

Building performance simulation is an essential part of integrated design, allowing teams to iteratively collaborate on a design that balances occupant comfort, performance, and cost-effectiveness. However, while simulations are a valuable tool to compare prospective designs, there are often significant differences between the predicted modeled energy use and the actual measured energy use once buildings are operational. There is a large body of literature that explores the "building energy performance gap" (Cozza et al. 2021, De Wilde 2014, Zuo et al 2018). Commonly cited causes of this performance gap span the design, construction, and operational phases. An energy model may have inaccurate assumptions (e.g., occupant behavior, weather), building components may be incorrectly installed (e.g., insulation installation quality), or the installed equipment may have operational issues. Miscellaneous loads are particularly difficult to predict, as they depend heavily on assumptions about occupant use patterns. Many of the BOE projects have enacted measures to reduce miscellaneous loads, including installing efficient appliances and providing occupants with resources to encourage energy conservation.

BOE awardees are required to submit operational data. As of June 2024, six projects have submitted at least a year's worth of energy data**,** five of which included monthly data. The most recent energy model for each design was compared to weather normalized measured consumption. A summary of results for three of these projects is included below.

Certification Pathway. BOE projects use one of four energy modeling pathways for certification: Residential Energy Services Network (RESNET), Passive House Institute US (Phius), Passive House Institute (PHI), and ASHRAE 90.1. A previous NYSERDA study compared ASHRAE 90.1 Appendix G, Phius, and PHI paths for different building packages against a standard baseline and found that PHI-based calculations predicted the lowest consumption while Appendix G predicted the highest energy usage for all cases. This is due in part to PHI's lower assumptions for lighting and plug loads and hot water usage than Phius+ or ASHARAE (Karpman 2018, Brown et al).

As described in our previous paper, all of the low-rise buildings selected RESNET or Phius, while all of the high-rise buildings opted for PHI or ASHRAE, as shown in Figure 5. Phius was the most common certification path and the only type to cover low-, mid-, and high-rise buildings. Figure 6 shows the modeled site EUI end use breakdown by compliance path. There is a notable difference between the PHI and ASHRAE EUIs, which were both a combination of mid- and high-rise buildings. Comparing the ten PHI to the nine ASHRAE examples, all of the ASHRAE modeled end use EUIs were larger (Brown et al). Future BOE analyses will carefully explore the predicted vs measured performance for each of these categories as more measured performance data becomes available.

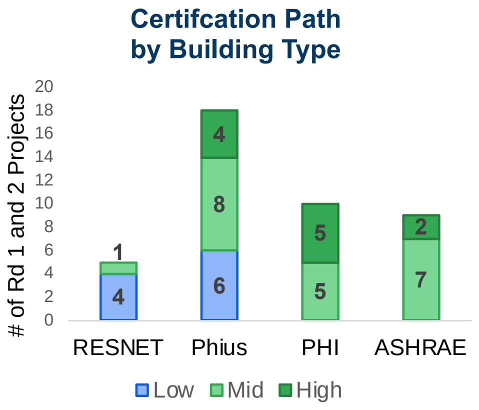

Figure 5. Certification path by building height.

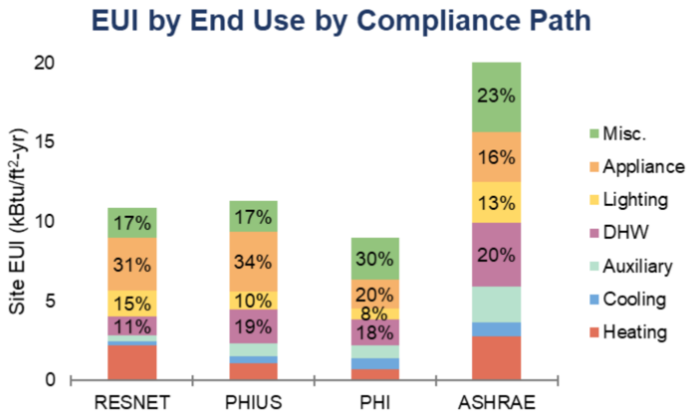

Figure 6. Modeled EUI breakdown by compliance path.

Solara Phase II. Solara Phase II, discussed above, is designed to meet the requirements for ENERGY STAR, US Department of Energy's (DOE) Zero Energy Ready Homes, EPA Indoor Air, and EPA WaterSense. The Solara team used Passive House Planning Package (PHPP) and Wärme Und Feuchte Instationär (WUFI) in their analysis, but it should be noted that they intentionally modeled DHW use at twice the rate the PHPP model/standard requires for certification to PHI, since PHI DHW usage assumptions are significantly lower than other certification paths like ASHRAE. They were able to make this change because Solara was ENERGY STAR certified based on a Home Energy Rating System (HERS) Rating, so they were not constrained by PHI and Phius certification modeling requirements.

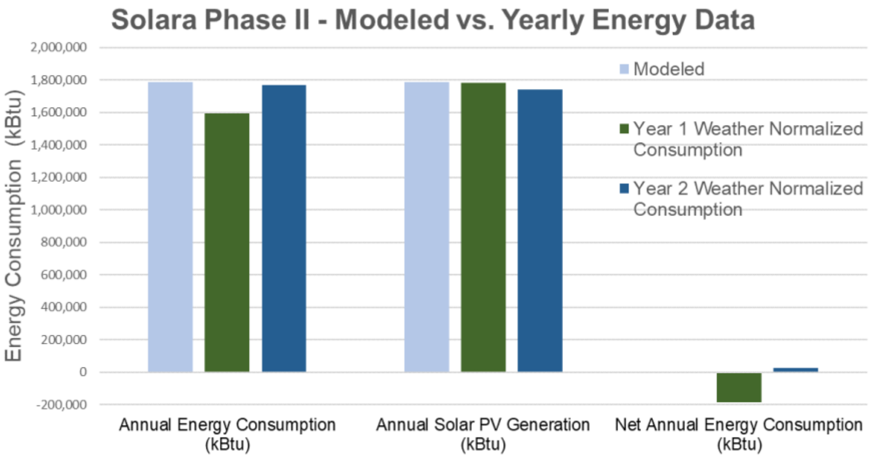

Figure 7: Solara Phase II energy consumption.

The weather normalized annual performance for the first two years (August 2021 through July 2023) closely matched the predicted modeled use, as shown in Figure 7. Solara Phase II had a slightly lower site EUI in the first year (17.2 kBtu/ft^2-yr) and second year (19.1 kBtu/ft-yr) compared to the modeled site EUI before PV (19.3 kBtu/ft-yr). With PV production, it had overall net EUIs of -2.0 kBtu/ft^2 in the first year and 0.3 kBtu/ft^2 in the second. The monthly energy data shown in Figure 8 reveals that there was slightly higher energy consumption in most months of the second year as compared to the first. Lower PV production in June of the second year also contributed to the higher net use in the second year.

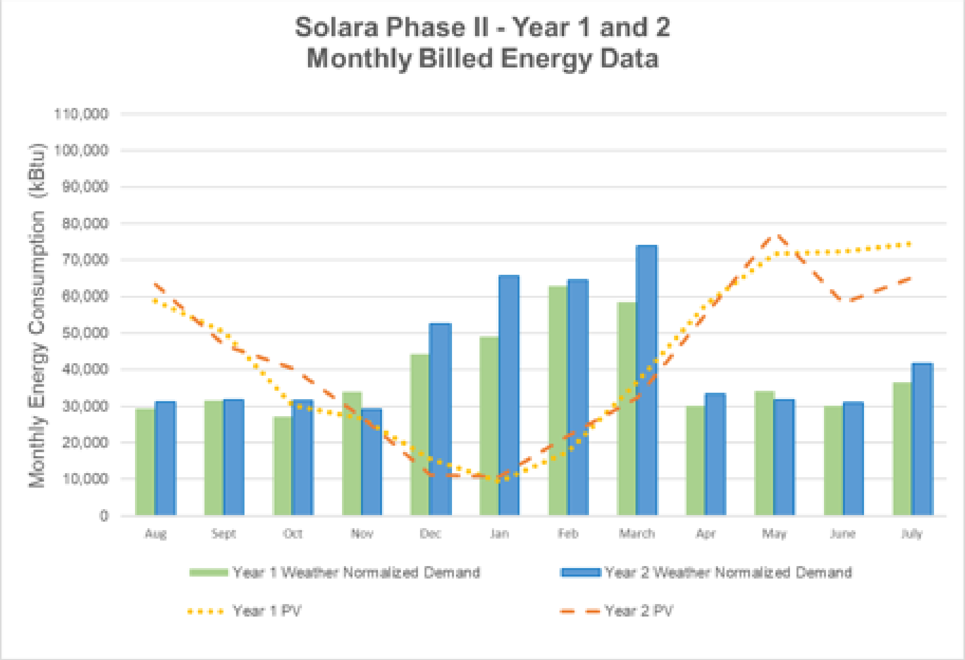

Figure 8: Solara Phase II billed energy consumption and energy production.

North Miller. North Miller is a three-unit all-electric retrofit of a vacant masonry building in Newburgh, NY that is Phius+2018 Certified. The North Miller project had a pre-PV site EUI of

21 kBtu/ft^2 in the first year of occupation compared to the modeled EUI of 12 kBtu/ft^2 per year, as shown in Figure 9. In the second year, pre-PV site EUI increased to 29.3 12 kBtu/ft^2.

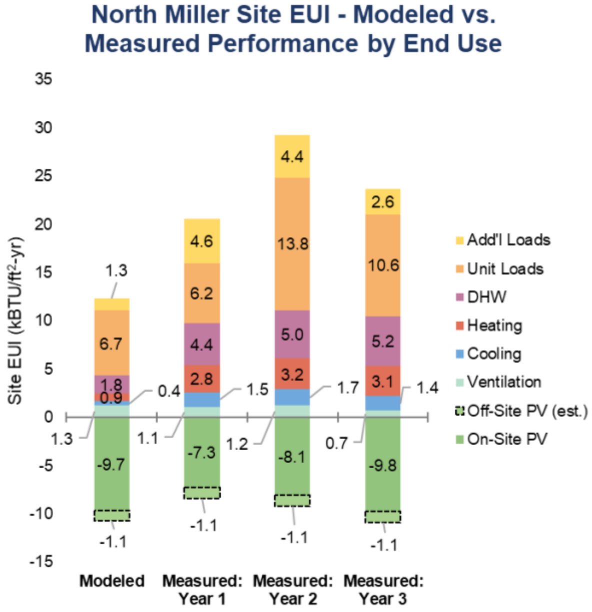

Figure 9. Modeled versus measured EUI at North Miller.

The difference in modeled and measured performance may be partially explained by warmer weather, a change from expected occupancy patterns due to COVID-19, and/or the addition of unmodeled loads, such as exterior or stairway lighting or equipment malfunctions. Of particular note, the measured DHW energy use was around 2.5 times higher than modeled. When exploring possible explanations for differences in DHW performance, the report team learned other teams took more conservative approaches to modeling DHW, such as the Solara project described above.

It is 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. Studies are only just beginning to quantify the expected consumption patterns during this period, but a white paper released by the Northwest Energy Efficiency Alliance described patterns from 200 households in the Pacific Northwest (Clement 2021). 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 (Clement 2021). The largest changes in residential electricity demand in the NEEA study came from end uses including plug loads, kitchen appliances, laundry, and water heaters. North Miller experienced higher-than-modeled DHW and unit load usage in the winter of 2021/2022, although it is likely not exclusively attributable to changed occupancy patterns during the pandemic. The winter and spring unit loads are higher than those during the summer and fall months by about 100% and 50%, respectively, with a small peak around noon and a larger peak closer to 8pm.

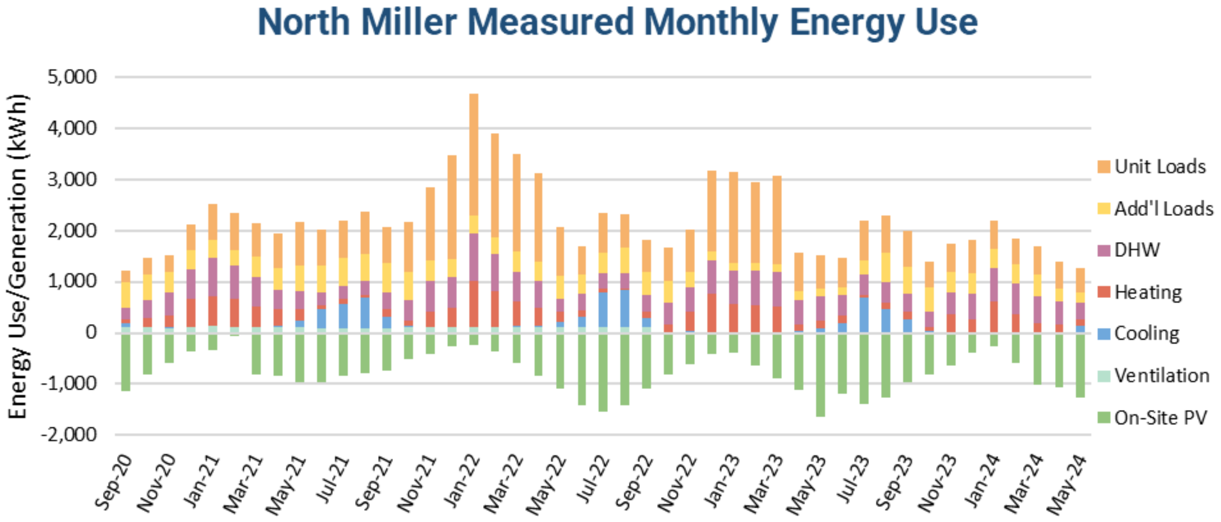

Figure 10: North Miller measured monthly energy use.

The onsite solar generation showed particularly low output in the winter months, as seen in Figure 10, with zero generation measured for multiple days. This is likely 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, North Miller has not performed as well as modeled, in part due to potentially unmodeled loads and COVID-19 occupancy patterns. 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 HPWH heater technology.

Morris II. Morris II (also known as Park Avenue Green) is a 15-story, 154-unit Passive House certified building in the Bronx. The developer, Omni New York LLC, also constructed a similar 15-story, 176-unit project called Morris I that was code compliant and LEED certified, but not Passive House certified. The projects are nearly identical, except:

- Heating: Morris II uses VRF heat pumps, Morris I has central gas condensing boilers
- Ventilation: Morris II uses in-unit ERVs, Morris I has exhaust-only ventilation system.
- Thermal breaks: Morris II specifically implemented thermal breaks; Morris I did not.

Bright Power was hired to perform energy monitoring and analysis. Their team determined total building carbon emissions for 2020 as shown in Figure 11. Morris II had lower carbon emissions than Morris I in every month, with big discrepancies in winter months due to the lower carbon emissions of heat pump space heating and smaller discrepancies in summer months due to a more thermally isolated envelope.

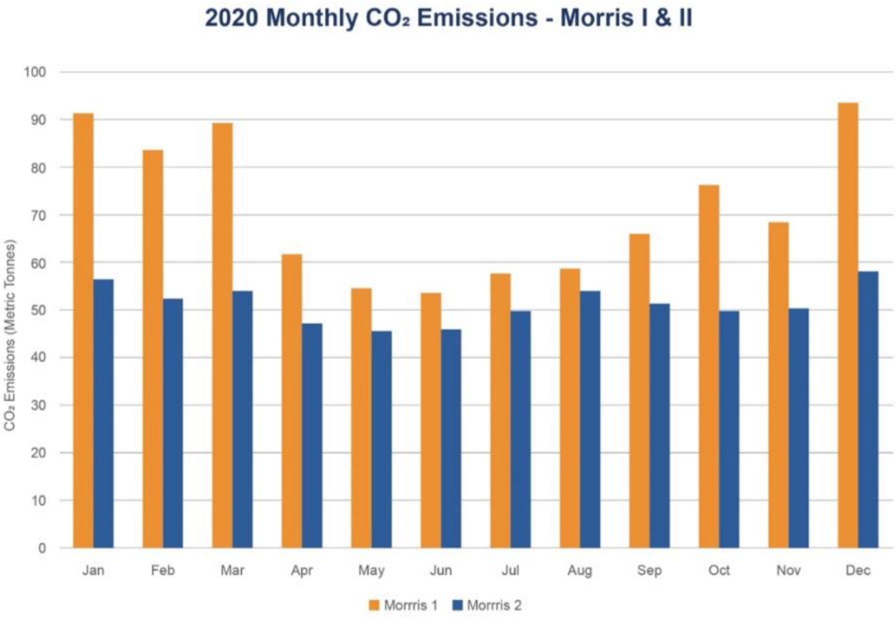

Figure 11: Morris I & II 2020 weather normalized CO_2 emissions (via Bright Power).

The Bright Power team also studied the impact on comfort due to the Passive House envelope and found that Morris II had a tighter temperature range throughout the year on all floors surveyed (66°F to 82°F) compared to Morris I (54°F to 89°F) while using less energy for space conditioning, suggesting that the tight envelope enabled thermal comfort in ways not possible in a building built to minimum code standards.

Figure 12: Morris I & II 2020 owner-paid utility and maintenance costs (via Bright Power).

An area where Morris II does not perform better than Morris I is total electricity cost. Despite Morris II consuming 17% less electricity than Morris I, Figure 12 shows that the Morris II owner paid 2020 electricity bills that were nearly twice Morris I's bills, $43,000 higher. This difference is attributed to peak demand charges—at Morris I, the average monthly peak demand was 39 kW, and at Morris II it was 114 kW. This could be due to heat pump use in the winter at Morris II, but this is not confirmed and requires more investigation. However, this highlights the importance of factoring demand into cost estimates as well as investing in load flattening measures such as smart thermostats with temperature setbacks. Morris II did have lower maintenance costs than Morris I, which was attributed to lower maintenance needs as a results of using heat pumps and ERVs rather than boiler and exhaust fans, respectively.

Conclusions

Resiliency: Passive and carbon-neutral design, resiliency, and passive survivability are naturally aligned through tight, durable envelopes that dampen temperature swings during extreme weather events or extended grid outages and provide increased occupant comfort during normal operation. Using both typical and future climate data sets through energy modeling can better estimate the potential duration of passive survivability under a range of conditions. Including a mix of onsite energy generation, backup generators, and battery storage can maintain critical functions during grid outages. For building in floodplains, it is important to incorporate stormwater management and consider installing building systems on upper levels.

Lowering embodied carbon remains an area for improvement: While almost all of the designs identified at least one method that lowers the design's embodied carbon, there are opportunities to further reduce embodied carbon. For example, it is encouraging that all 42 project designs use heat pump HVAC systems and 31 have electric DHW, but only a third selected low GWP CO_2 refrigerants, so future designs can be improved by selecting better refrigerants for these end uses. Envelope designs can lower whole life carbon by carefully balancing the operational benefits of increased insulation with the level of embodied carbon in the design.

Modeled Versus Measured Performance: There is a notable difference between the PHI and ASHRAE modeled EUIs for the awardees, which were both a combination of mid- and high-rise buildings. Comparing the ten PHI to the nine ASHRAE examples, all of the ASHRAE end use modeled EUIs were larger. The choice of modeling software and assumptions embedded in the software can have a significant impact on predictive performance.

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