Solara Apartment Complex

New York State | Buildings of Excellence

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.

nyserda.ny.gov/boe

Project Details

Location:
Rotterdam, New York

Project Area:
340,000 sq. ft.

Number of Buildings:
11

Number of Stories Per Building:
3

Number of Units:
248

Project Cost:
$11,861,426 (Phase III)

Cost per Gross Square Foot:
$128.35

Market Sector:
Market Rate

Construction Type:
New Contruction

Construction Start Date:
2018

Completion Date:
October 2022

REDC Region:
Captial Region

Developer:
Bruns Realty Group LLC

Architect & Design Team Lead:
Harris A. Sanders Architects, P.C. & Black Mountain Architecture

Technologies Used:
PV; solar thermal DHW; ASHP; ERV; HP clothes dryer; EV; advanced controls/monitoring strategy for energy, humidity, and IAQ

Net zero energy, all-electric, market-rate multifamily housing

Background

The Solara Apartment Complex is a three-phase project that serves as an example of how to design and construct cost-effective net zero energy (NZE), market-rate multifamily housing. Phases II and III of the Solara Apartment Complex received BOE awards in Round 1 and Round 2, respectively. According to the project team, Solara will be the largest market-rate NZE complex in the U.S. upon completion. The project utilized an integrated design process, involving all stakeholders early on. This integrated team worked together on netZero Village and through all three phases of Solara's development. Building upon iterations of design from one project or phase to the next allows for progressive increases in efficiency and decarbonization.

Key Project Features

The Solara Apartment Complex is 100% fossil fuel and combustion free, featuring:

- ✓ **HVAC:** Minisplit air source heat pumps (ASHP), energy recovery ventilation (ERV)
- ✓ **Water Heating:** Solar thermal, ASHP electric resistance backup (Air-Water Heat Pump Backup Phase III only)
- ✓ **Envelope:** Closed cell spray foam wall, polyiso roof, dense-pack cellulose wall and loose fill cellulose roof (Phase III only)
- ✓ **Lighting:** Light emitting diode (LED), daylighting
- ✓ **Appliances:** Heat pump clothes dryers, electric range
- ✓ **Renewables:** Onsite solar photovoltaic (PV), solar thermal
- ✓ **Resilience Strategies:** Airtight envelope, passive survivability

Predicted Site Energy Use Intensity (EUI) (kBtu/SF/yr): Phase II 16.9 / Phase III 15.8

Net Site Energy Use Intensity (EUI) (kBtu/SF/yr): Phase II -3.6 / Phase III 0.0

Predicted Renewable Production Intensity (RPI) (kBtu/SF/yr): Phase II 20.5 / Phase III 15.8

Energy Code Baseline – NYS Energy Conservation Construction Code (ECCC): Phase II 2016 ECCC NYS / Phase III 2019 ECCC NYS

Performance Path: ERI – Phase II & III

Planning and Design Approach

Project Goals

Beginning in 2012, Bruns Realty Group worked with Black Mountain Architecture and Ballston Mourningkill Associates to design and construct New York's first ever net zero multifamily development called netZero Village, which was completed in 2016 and located in Rotterdam, NY. The design focused around making net zero buildings possible with common cost-effective construction materials to eliminate the stigma that net zero could not be achieved cost effectively with familiar technologies. With the success of netZero Village, the team set out to replicate this design at a larger scale with the Solara Apartment Complex.

The Solara Apartment Complex is a model for the net zero energy multifamily housing industry, inspiring other clean energy and green development projects. The development and design team is committed to educating other building professionals about high performance projects. The team's mission is to improve energy efficiency and occupant comfort with each new project through advanced design strategies and technologies. Building upon the achievements and efficiencies of Solara Phase I and II, Phase III emphasized embodied carbon reduction, incorporating New York's Climate Leadership and Community Protection Act (The Climate Act) guidelines.

Project Team

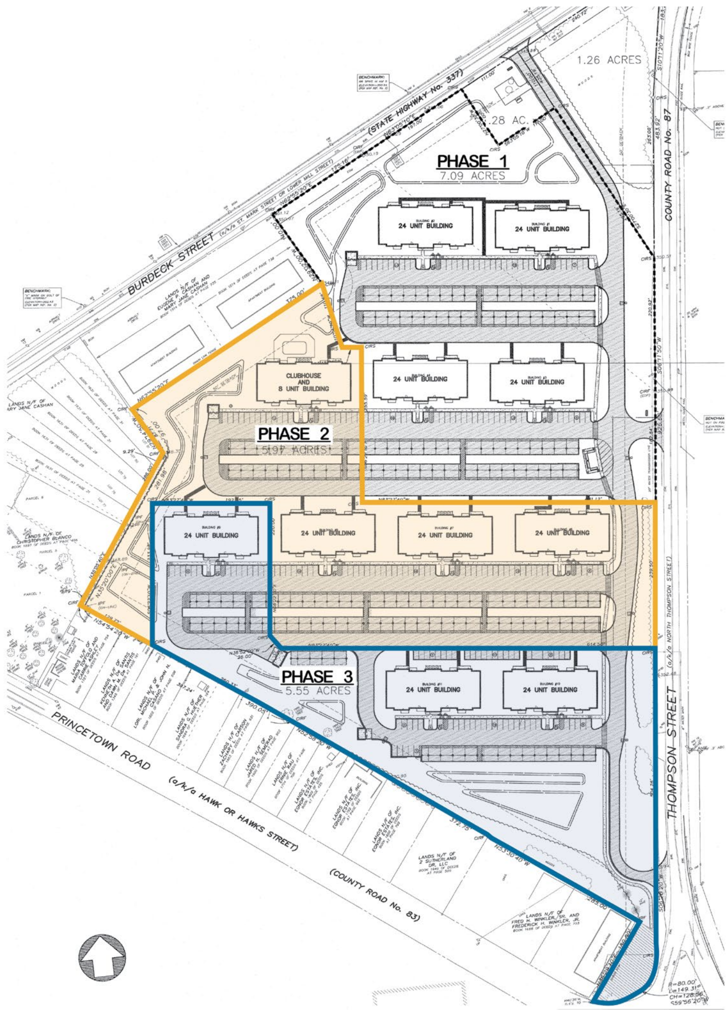
Utilizing an integrated design process, the team and stakeholders were all involved from the beginning, including:

- **Architect:** Harris A. Sanders Architects, P.C.
- **Developer:** Bruns Realty Group
- **Mechanical and Civil Engineers:** ME Engineering and Environmental Design Partnership, LLP
- **Construction Manager:** Ballston Mourningkill Associates
- **Net Zero Energy Consultant and Design Team Lead:** Black Mountain Architecture
- **Home Energy Rating System (HERS) Rater:** En-Tech Associates
- **Solar Thermal Designer:** E2G Solar

The coordination of the different trades was critical to the successful design and construction of a high performance building, particularly with the airtight building envelope. The team met bi-weekly during the design phase and monthly during the construction process.

Building Design

Once complete, the three-phase, eleven-building, and 248-unit state-of-the-art multifamily housing community is anticipated to be the largest market-rate net zero energy apartment complex in the United States, to date. The team was dedicated to creating an easily replicable design that was both high performing and comfortable. The roof and building design were simplified to a flat roof and box shaped massing that used standard construction techniques and commonly available materials. These measures streamlined the construction process, made it easier for the various trades to provide quotes and coordinate installation, and will allow the design and system to be easily repeated.



Site plan by Environmental Design Partnership, LLP (diagrammed by Resource Refocus LLC)

The residential buildings include smart technology, in-unit laundry, bike storage, and covered parking. Dwelling spaces feature individual balconies and 9-foot ceiling heights which enhance interior daylighting. The Solara community has many onsite amenities, including a dog park, a dog wash station, a fitness center, a solar heated pool, and event spaces.

Energy consumption is reduced through extensive air sealing, continuous exterior insulation (Phase I and II only), ASHP for heating/cooling, ERV, advanced windows, and solar water heating. The design team also incorporated passive solar strategies, including an orientation that enhances daylight and winter solar heat gain. In the winter months, low emissivity glazing increases solar heat gain while decreasing thermal losses. When the sun is higher in the sky in the summer months, this solar heat gain is blocked by exterior shading.

Moving from one phase to the next, the development of Solara was an evolution of low-carbon, net zero energy design. The design of Phase III has been optimized through the lessons learned from the design and construction of Phase I and Phase II. Phase III advances the energy-efficient, low-carbon, and high performance design of Phase II to significantly reduce embodied carbon and increase the sequestration of carbon, which is discussed in more detail below.

Segment of Southern Elevation by Harris A. Sanders Architects, P.C.

Energy Modeling

Solara Phase II and III were modeled in REM/Rate software by a HERS rater, and also modeled by Black Mountain Architecture using the Passive House Planning Package (PHPP), the software used for Passive House certification. Additionally, Phase II was modeled in WUFI to compare the two pathways. The team found that the PHPP model had a slightly lower heating demand and load, and higher cooling demand and load than the WUFI model, but a similar site EUI overall. A lifecycle analysis was completed on top of the energy modeling to show that Phase III had 7% lower operational carbon emissions, 14% lower cradle-to-gate embodied carbon, and 56% higher lifetime sequestered carbon. By creating multiple energy models and performing a lifecycle analysis of both projects, the team ensured that all aspects of the project that would have an impact on carbon emissions were considered.

Energy Model Inputs	Phase II	Phase III
Certification Path	HERS Rating	
Software	REM/Rate v16.0.6, PHPP v9.7	
CFA (% of Gross)	23,121 ft^2 (75%)	
HVAC	Mini-split HPs – SEER 22.5, HSPF 7.4	
ERV	Broan ERV – SHRE of 0.64	
DHW	Solar thermal (46% of load) & HPWH (54%) – 1,200 gal. storage, recirculating	
Windows	U-factor: 0.29	
Walls	R-23	R-29
Slab	R-10	
Roof	R-39	R-65
Thermal Bridges	None	
Additional Loads	Electric range, HP dryer, 100% LED	

Energy Model Results	Phase II	Phase III
Site Energy (kWh/yr)	152,576	142,380
Site EUI (kBtu/ft^2-yr)	16.9	15.8
Renewable Generation (kWh/yr)	185,337	142,380
Air Leakage (ACH at 50 Pa)	0.61	0.61

Energy Efficient, All-Electric Design

High-Efficiency Lighting Fixtures and Appliances

LED lighting is installed throughout the project, and the design maximizes daylighting. Each unit is equipped with a heat pump clothes dryer, an electric cooking range, and low-flow plumbing fixtures. All appliances are ENERGY STAR® certified.

Building Envelope

An airtight and efficient building envelope is critical to the high performance of the project. Throughout the development, the Paradigm double pane windows were single hung with a U-factor of 0.33 and SHGC of 0.52. They have 180 low-e argon glazing with fixed shading on the southern face. Solara participated in a pilot project with Pacific Northwest National Laboratory (PNNL) to test "thin triple" windows in one of the buildings. These test windows have 180 low-e glass with a layer of thin clear glass and krypton fill in between the panes. The slabs are insulated with R-10 expanded polystyrene (EPS) rigid foam insulation and use insulation breaks to isolate the slabs from the stem walls. Interior corridor footings are insulated with EPS below the concrete to reduce the long thermal bridge under each side of the double loaded corridor.

Solara Phase II achieved high levels of energy efficiency through the following envelope components:

- **Above grade walls:** R-23.2 through Zip-R sheathing, with 1 inch of polyisocyanurate rigid insulation, and 3.5-inches of Demilec Solstice closed cell spray foam within 2x6 wood framed walls.
- **Roof:** R-38.6 through 7 inches of polyisocyanurate rigid insulation on top of the sheathing.
- **Sheetrock:** regular gypsum wallboard.

Solara Phase III advanced the techniques used in Phase II to reduce the embodied carbon within the envelope by eliminating the use of continuous foam and using lower carbon concrete mix and sheetrock:

- **Above grade walls:** R-29 (whole wall) through Zip sheathing, 2x10 framed assemblies with dense-pack cellulose insulation within the wall.
- **Roof:** R-64 through 18" of blown in cellulose into a low slope vented "mini-attic".
- **Sheetrock:** low carbon United States Gypsum (USG) Ecosmart wallboard.
- **Concrete:** reduced concrete volume and a mix containing 30% fly ash.

During construction, Black Mountain Architecture and En-Tech Associates periodically visited the site to monitor the construction process and installation quality (e.g. inspecting the envelope insulation before any finishes were applied). A third party contractor was also brought on to conduct blower door tests for each building's envelope after all windows and doors were installed.

All-Electric Systems

Solara is a 100% fossil fuel combustion free project. Heating and cooling are provided by minisplit ASHPs, with a single compressor and individual head per apartment. This "one-to-one" solution is an extremely energy efficient configuration that eliminates the need for ductwork. Each apartment is also equipped with its own ERV unit. DHW is provided by solar thermal panels located on the roof of each building and supplemented by air-to-water heat pumps. The distribution system is equipped with a recirculation loop engineered to deliver hot water quickly to each fixture while minimizing energy losses.

Renewable Energy

As a net zero project, onsite renewable energy will generate at least as much energy as the buildings demand over the course of the year, although grid supply will be required at night and in the winter. Located on top of carports, the solar photovoltaic (PV) arrays double as covered parking spaces. The PV array for each 24 unit building is expected to produce 153,000 kWh/yr, 100% of the total annual electric use. An additional solar thermal array is leased to Earth Environmental Group, LLC. Solara Phase III's solar PV arrays are sized to produce 100% of the expected annual electric use, 142,000 kWh/yr. For all phases, solar thermal panels with 1,000 kBtu capacity are located on the residential building roofs to heat the water in the 1,200-gallon hot water storage tanks located within each building for the DHW system.

Exterior photo by Bruns Realty Group LLC

Energy Consumption Feedback and Smart Building Technologies

Touch screens installed in each unit provide the tenants with a 1 day, 7 day, and 30 day summary of historic energy use information, comparing their own usage to their neighbors' anonymized data. This comparison is highlighted through the display of a conspicuous icon that displays the tenant's energy use as "Great", "OK", or "Poor" in comparison to average real-time similar apartment data within the development. Because this feedback is integrated into the thermostat control interface, occupants are able to frequently observe their consumption rates. This is intended to help tenants be conscious of their energy use and encourage energy conservation.

Each unit has a "smart home" hub installed, which enables residents to control locks, lights, and other compatible devices through a phone app. Along with this, the building is equipped with occupancy and daylighting sensor lighting controls. The minisplit system in each apartment is controlled by the tenant through the user-friendly, touch screen interface that is located in each unit's living space. This touch screen is integrated with a centralized building management system.

Building Operations

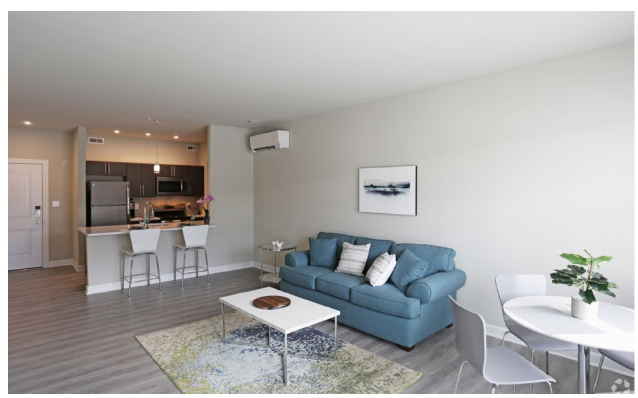
Leasing Structure

Solara is an "all in" market rate rental property with owner paid utilities. The rent includes basic utilities, such as heat, air conditioning (AC), electricity, DHW, water, and sewage, as well as internet, TV service, trash disposal, and snow removal. There are two rental premiums that are included in the rent, beyond market rent, for the net zero concept: a $0.15/month/ft^2 charge for the cost of utilities and a $0.02/month/ft^2 for the "eco-friendly" factor of the apartments.

Cost Reduction

Currently under construction, the project team is encountering Covid-related cost spikes, so the exact cost premiums are still to be determined. For operational costs, producing all of the energy required onsite makes the cost to operate the buildings much more predictable. In addition, since escalating utility rates can be reflected in rent increases, the investment in onsite renewable generation adds increasing value as utility rates rise over time. The cost of energy is built into the rental rates, so the savings will accrue to the building owner and are expected to offset most, if not all, of the cost of efficiency improvements and renewable generation equipment investments.

The key factors in Solara that ensure high performance, including integrated design, energy consulting, air sealing details, and solar PV carports, are the same factors that most affected the cost of the project. Using an integrated design process was instrumental in reducing costs without sacrificing quality and performance. This included incorporating feedback on constructability and budget from the construction manager, and impact on marketability from the owner throughout the design process. The use of PHPP energy modeling allowed the team to review the potential energy savings of individual building components to inform the decision-making process. Designing a very efficient project meant that the net zero energy goals could be met with a smaller PV system and allowed for the use of smaller, less expensive mechanical systems.



Interior photos by Bruns Realty Group LLC

Energy Management

The buildings at Solara utilize an integrated Building Management System (BMS) with the goal of providing superior indoor air quality while optimizing energy consumption. Each apartment is equipped with an individual ductless minisplit unit and Energy Recovery Ventilation (ERV) to provide individualized heating, cooling, and ventilation. These systems are controlled through the BMS. Color touch screens in the apartment provide a user-friendly interface for the tenant to control the temperature in their apartment. In addition, the touch screen provides conspicuous feedback to the tenant of their energy consumption as described in more detail in a previous section. The touch screen commands are run through the BMS before being sent to the minisplit. This arrangement has several advantages: 1) It prevents occupants from putting the unit in an abnormal operating mode or at extreme temperatures, 2) It provides a less confusing interface than the manufacturer's remote control, 3) It allows the BMS to override inputs if they are out of bounds and/or the unit needs to run in a different mode to control humidity, and 4) It allows maintenance to remotely diagnose issues with the HVAC systems by providing real time data on unit settings and apartment conditions. Individualized ERVs allow the BMS to individually control ventilation rates for each apartment and the unique conditions and behaviors in that apartment.

The BMS reads sensors for temperature, humidity, CO_2, VOCs, and stove operation and regulates the volume of fresh air provided to each apartment. For example, when the kitchen range is in use, the BMS will automatically boost the ERV and redirect the intake to the kitchen to quickly exhaust cooking odors, smoke, or humidity. If occupancy is high and CO_2 levels go above a specified threshold, the BMS will set the ERV into boost mode. If the overall relative humidity inside the apartment is high and the ERV is unable to control it, the BMS will put the mini split air source heat pump into "dry" mode. If it is exceedingly hot and humid or extremely cold outside, the BMS will back off on the ERV ventilation rate. This solution is superior to a fixed ventilation strategy as it custom-tailors ventilation based on exterior conditions, as well as the humidity, temperature, indoor air quality (IAQ), and automatically responds to tenant activities and behavior without relying on tenant input, which is often unpredictable. In addition, this system has other significant advantages such as the ability to continuously monitor and alarm for problems before they become visible.

Additional Benefits

Site Context

The location of the Solara complex is within walking distance to the Mohawk-Hudson Bike Trail and the public bus route. It also provides easy access to I-890, I-90, and I-88, and is near downtown Schenectady.

Community Engagement

As a market rate complex, Solara targets multiple groups as potential tenants, including baby boomers, retirees, downsizers, empty nesters, those interested in net zero with a sense of environmental responsibility, young professionals, and local business employees. The development team is eager to both promote Solara and educate other building professionals. They provide tours, open houses, press conferences, and local presentations. Promotional content that focuses on educating potential renters about low-carbon, net zero housing and energy efficient living is posted to the development company's website and social media pages.

Occupant Health, Comfort, and Productivity

Solara is Environmental Protection Agency (EPA) Indoor airPLUS certified, meaning all materials are low in volatile organic compounds (VOC). The ERV system supplies continuous fresh air to all units and interior spaces. Having an elevator in each building ensures that all units are universally accessible. The combination of high performance building attributes and an airtight envelope result in improved occupant comfort, including quieter rooms, draft-free interior, balanced temperature, humidity control, and ample daylighting.

Resiliency

The development team included many resilient design strategies to further the environmental performance and occupant safety of Solara. Through strategic selection of building materials and assemblies, Solara demonstrates a feasible pathway to housing that has zero onsite carbon emissions, very low embodied carbon, has great market appeal, is easily reproducible, and is capable of withstanding risks from future climate change, all while being profitable for the developer.

With the changing climate, extreme weather events are expected to happen more frequently, requiring preparation for both winter and summer grid outages. The airtight envelope and continuous insulation allow the building to remain at a stable and safe interior temperature in the event of a prolonged power outage. During heat waves, the white roofing membrane and exterior shading design will passively prevent solar gain. In the winter outages, the envelope provides significant protection against freezing. The solar shades that block summer heat gain, allow for solar gains in the winter when the sun is lower in the sky. The airtight strategy combined with dense-pack cellulose will prevent infiltration of cold air and mitigate against plumbing freezing, generally keeping the building warm for extended periods. The 1,200 gallon solar hot water thermal storage tank can provide hot water for extended outages.

Sensitive components of Solara's electrical infrastructure like the elevator, internet network, EV charging equipment, BMS, etc. are protected with a surge suppression system. The BMS also has a dedicated circuit with an uninterruptible power supply (UPS) to ensure that it remains functional during power surges and outages. All stormwater is managed onsite, reducing runoff and runoff pollution and increasing groundwater infiltration. In both phases, careful attention to the vapor barrier assemblies reduces the risk of moisture and mold growth. This was a critical element that the project team focused on when designing the assemblies and is described in more detail below.

Embodied Carbon

Having deeply addressed the buildings' operational carbon footprint in Phase II, the project team expanded their focus to reduce the buildings' embodied carbon footprint in Phase III. The design specifications of the Phase III building resulted from the team's collaborative review and assessment of the most cost-effective measures to reduce embodied carbon while also improving operational carbon/energy performance.

Using the Embodied Carbon in Construction Calculator (EC3) tool, the project team identified three key areas for reductions: 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 polyiso insulation was also largely eliminated by replacing these materials with cellulose insulation in both the walls and the roof assembly. Careful attention was paid to moisture management within the building assemblies to ensure they could dry out and dew points wouldn't 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 operation and embodied carbon).

Lessons Learned

The design and development team learned many lessons from the netZero Village and Solara Phase I development, which were then used to design a more successful and efficient iteration with Solara Phase II. These included:

- The team culture emphasized an integrated design process—where assumptions were questioned and everyone was open to learning new techniques—that added value to the project early on and generally resulted in better ideas. For example, if a trade identified any design complications, the team worked together to mitigate that complication.
- Both the integrated design process and the use of Passive House Planning Package (PHPP) energy modeling resulted in a more cost-effective, high-performance design. Smaller building loads allowed for both a smaller photovoltaic (PV) system and a smaller, ductless heating, ventilation, and air conditioning (HVAC) system, both of which had significant cost savings for the project.
- Air-sealing: The air-sealing was performed in-house rather than through a contractor as it gave the team greater quality control. The smoke stop locations were aligned with party walls to make air sealing a simpler and easier process.
- Condensation concerns: During the construction process, the team observed moisture issues due primarily to heavy moisture loads associated with a building under construction, which was further exacerbated by heavy rain and the unconditioned interior environment that naturally exists during the construction process. Based on their past moisture analysis, the team was concerned with the interior dew point and drying when using fiberglass batts on the interior face of continuous foam on the exterior wall, so they replaced the fiberglass batts with a full closed cell spray foam assembly on the interior of the Zip-R sheathed wall. During operation, Solara exerts careful control over humidity through a central monitoring and control system that overrides local HVAC controls. If necessary, the team has made a plug-and-play location to install dehumidifiers if any moisture concerns arise.
- The building management system (BMS) was put on its own circuit with an uninterruptible power supply (UPS), ensuring that it remains functional during power surges and outages.
- Energy recovery ventilation (ERV) units were located within utility rooms rather than in hallway drop ceilings to be more accessible.

In Phase III, the team pushed these learnings ever further to significantly reduce embodied carbon in three key areas: the concrete mix, the wall and roof insulation and assemblies, and the gypsum board. Of particular note, Phase III incorporated a new wall assembly that performs better and significantly reduces the embodied carbon in the wall and foundation assembly, while maintaining a similar cost to previous iterations:

- They have eliminated continuous polyiso insulation and closed cell spray foam in the wall assembly by using dense-packed cellulose in 2x10 conventionally framed walls, which has significantly lower embodied carbon.
- Condensation concerns: This new design allows drying to occur in both directions – through the exterior wall sheathing which is covered by vented vinyl siding (and does not have polyiso foam attached) and also partially through the interior drywall which has a Class II vapor retarder primer. Spray foam was applied at the sill plate, the coldest point in the wall assembly, in order to reduce thermal bridging and moisture accumulation risk at this location.

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