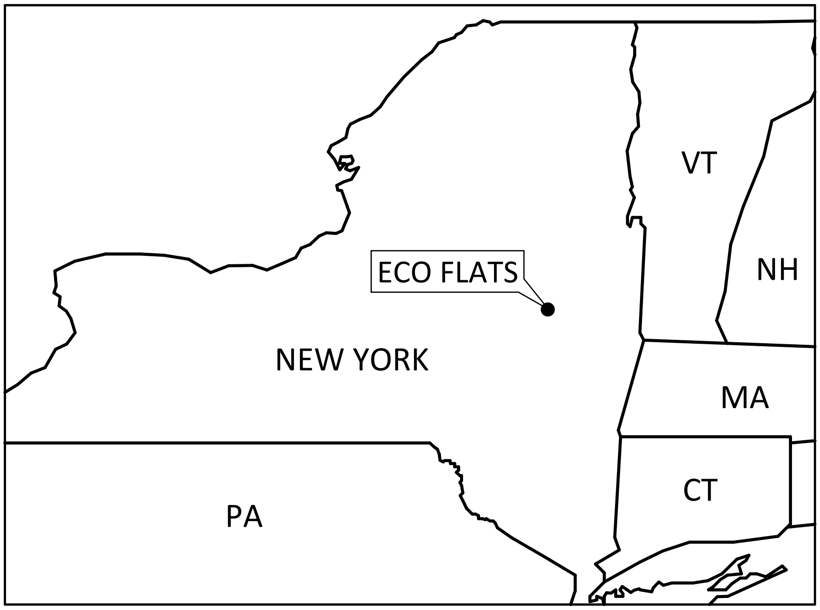
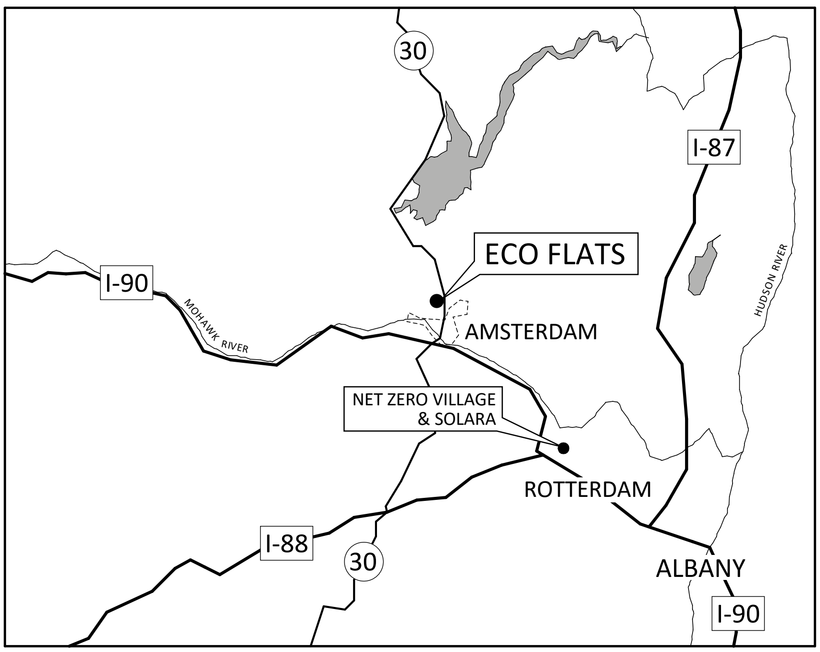
EcoFlats at Log City

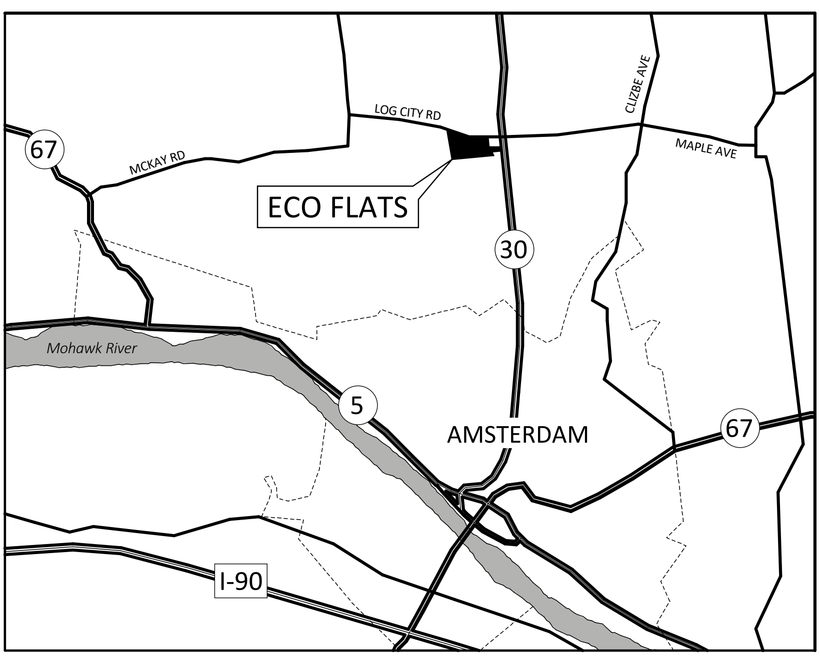
Buildings of Excellence Early Design Support Award
Project Report | April 2025

EcoFlats Typical 12-Unit Building | Black Mountain Architecture

BLACK MOUNTAIN ARCHITECTURE







Vicinity Maps (Not to Scale)

CONTENTS

EcoFlats *...at a glance*

LOCATION

147 Log City Road Ext., Amsterdam, NY 12010 | Climate Zone 6

TIMELINE

January 2023 | *Design kick-off*
May 2024 | *Construction Documents issued*
December 2024 | *Construction kick-off*

OVERVIEW

168-unit Net Zero, Passive House, market-rate housing development

- (11) 12-unit buildings and (2) 18-unit buildings
- 3-story buildings with central stair/mechanical cores

AWARDS & TARGET CERTIFICATIONS

- Net Zero
- ENERGY STAR® for Homes
- Buildings of Excellence Demonstration Project winner (Round 3)
- Buildings of Excellence Early Design Support winner (Round 3)
- Passive House Zero Certification (goal)

Concept Site Plan (not to scale) | Black Mountain Architecture

EXECUTIVE SUMMARY

Achieving Net Zero and Phius Passive House performance in market-rate multifamily projects while maintaining a strong return on investment is not only possible, but replicable. Developer David Bruns of Bruns Realty Group, along with Black Mountain Architecture, Ballston Mourningkill Associates, and other collaborators, have proven this to be true. Over the past decade, this team has successfully applied a collaborative, experience-driven approach to projects like Net Zero Village, Solara Phase I & II, and Solara Phase III, demonstrating that high-performance goals and strong economic returns are not mutually exclusive. The team's approach is replicable and this report shares the strategies behind their success, highlighting key findings from NYSERDA Early Design Support research and lessons learned over a decade-long collaborative relationship on multiple projects.

The EcoFlats at Log City project is the latest and most expansive of these efforts. The team set ambitious goals: meet the rigorous Phius Zero 2021 standard, achieve true Net Zero energy, minimize embodied carbon, and specify low-maintenance systems-- all within the budget of a typical market-rate development. Pursuing Phius Zero certification for the first time, they meticulously addressed envelope thermal performance, air tightness, and component selection, all of which also contribute to co-benefits including occupant health and comfort and building resiliency. Embodied carbon reduction was tackled through assembly and component analysis and the specification of low-carbon materials. HVAC systems were configured to maximize efficiency within Passive House parameters.

The EcoFlats team is a testament to the power of collaboration. Working together, the core team has spent a decade refining their approach, with additional members adding fresh expertise along the way. Their iterative design process encourages open communication, creative problem-solving, and a holistic perspective. From optimizing foundation design and roof slope to carefully selecting windows, each decision supports the greater project performance goals. Doing this work up front during the design process saves countless hours, dollars, and frustration during construction and occupancy.

Financial viability is paramount. Bruns' proforma centers around Net Zero energy as a requirement, not an add-on. This approach generates savings that offset the upfront costs. Tax credits, incentives, and awards further bolster the project's financial success. The strategies outlined in this report prove that Net Zero, Passive House multifamily developments can be built at market rate with returns that equal those of conventional projects.

The successes of Net Zero Village, Solara, and now EcoFlats demonstrate a replicable model for achieving high-performance multifamily housing within market-rate constraints. By building a collaborative team, leveraging experience, and making integrated design decisions, developers can meet rigorous green building standards, cut embodied carbon, and boost return on investment. The detailed strategies and findings shared in this report provide a roadmap for others to follow in their own pursuit of Net Zero, Passive House multifamily projects that benefit both the environment and the bottom line.

THE BUILDING

Passive House | Embodied Carbon | Building Systems

Typical Building Entry & South-Facing Facade | Black Mountain Architecture

BLACK MOUNTAIN ARCHITECTURE

PASSIVE HOUSE

WHAT IS PASSIVE HOUSE?

Passive House for this project refers to the building energy standard developed by the Passive House Institute US, or Phius. The Phius Standard sets location-specific limits on the energy a building can use for heating and cooling in both peak and annual conditions, as well as the minimum building airtightness and maximum overall energy use.

PHIUS AND NET ZERO AT ECOFLATS

This project team has already designed and constructed several other multifamily developments that will be discussed in more detail later in this report (see "Building a Team" and "Project Evolution"). While the previous projects achieved high energy performance, the ambitious target of Passive House certification was a new challenge for EcoFlats. Besides environmental benefits of Phius certification like energy efficiency and renewable energy sources, owner/developer Dave Bruns points to additional benefits including the "fun technical challenge", market differentiation, increased value over time, and demographic preferences. Setting the goal of Phius certification also helped the project gain additional incentive funding (see "Net Zero Proforma").

EcoFlats is designed to be Net Zero, meaning it will produce through on-site photovoltaics (PV), as much energy as it uses over the course of a year. As such, the project is pursuing certification under the Phius Zero program, which incorporates on-site renewable energy generation into the overall energy use equation such that 100% of the on site energy is covered by on-site energy production on an annual basis. Limits on heating and cooling energy need remain a strategy to alleviate strain on the electrical grid during times of peak use and minimal production or peak production and minimal demand.

Although the overall building energy use is not limited as long as the project generates the same amount of energy on site, the project design is still meeting the overall energy use limitations as if there were no on-site PV generation. This is illustrated in Figure 1 below.

HIGH PERFORMING BUILDING ENVELOPE

The building envelope has been designed and dialed in relative to thermal and airtight performance to meet the Phius criteria for heating and cooling energy. EcoFlats' envelope is largely informed by past experience, as this project team has studied and experimented with various high performance wall, roof, and foundation assemblies on previous projects. While previous projects were not pursuing Phius certification, the team still engaged in rigorous energy modeling and embodied carbon analysis from the beginning to enable informed decision-making. The resulting assemblies at EcoFlats achieve high thermal performance and simple details that keep costs down.

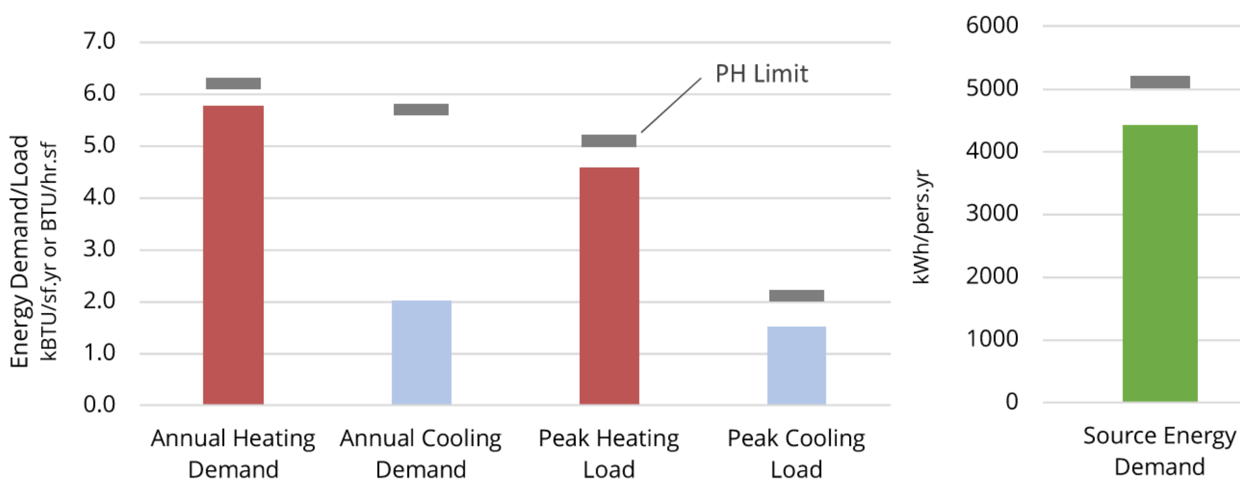


Figure 1: Predicted & Target Energy Use for the Worst-case 12-Unit Building (Cultivate, Inc.)

Exterior Walls

EcoFlats' exterior walls consist of 2x10 wood framing filled with dense-packed cellulose insulation, sheathed with Zip Sheathing to the exterior and clad with vinyl clapboard siding, and finished on the interior with a layer of gypsum wallboard and vapor-retarding interior paint. The overall R-value of the exterior wall system is R-31. The airtight layer is the zip sheathing, which has an integrated air barrier. Sheathing joints are sealed with airtight tape.

Windows & Doors

The windows and balcony doors are triple-pane uPVC. Operable windows are either European-style casement or tilt, to increase airtightness from standard American-style double- or single-hung units. Locations for operable units have been optimized to use the minimum amount of operable windows and maximize the higher-performing fixed windows. Doors are all swing type for optimal airtightness. The U-values for fixed and operable window units are 0.15 and 0.19, respectively.

Roof

The roof is built with full-span sloped roof trusses sheathed with Zip roof sheathing and an asphalt shingle roof. The truss space contains 18 inches of blown-in cellulose insulation which is contained with an INTELLO Plus® membrane at the underside of the roof trusses. This membrane also serves as the air barrier in this assembly. Ceilings are built below this barrier with resilient channel and gypsum ceiling board. The overall R-value of the roof assembly is R-64.

Foundation

The building is a concrete slab on grade with EPS insulation underneath the entire slab, including thickened slab areas. Foundations are a shallow frost-protected design which consists of a slab haunch at the exterior wall with continuous insulation underneath the haunch extending horizontally for 49 inches away from the building, per design weigh-in from the structural engineer and ASCE standards. The R-value of the slab assembly is R-10.

See Figure 3 on the following page (Exterior Wall Section) for more information and context regarding EcoFlats' high-performance building envelope.

COST IMPLICATIONS OF PASSIVE HOUSE

While this project team has a history of realizing high-performance buildings in a cost-effective way, pursuing Passive House certification introduced new budgetary considerations. To achieve Phius targets, EcoFlats leveled up from previous projects by upgrading to triple-pane windows and higher-performance ERVs. Switching from double-pane, single-hung windows to the triple-pane windows at EcoFlats boosted the window performance from U-0.24 to U-0.19 (casement units) and U-0.15 (fixed units). Surprisingly, the EcoFlats' triple-pane Intus windows are comparable in price to the double-pane Paradigm windows specified for previous projects.

Unlike the Phius-driven window upgrade, switching to higher-end ERVs does have cost implications; however, taken as a percentage of the overall construction cost, Phius-driven hard costs are negligible. The Broan ERVs installed at Solara cost approximately $800 each, while the more efficient Renewaire units at EcoFlats run about $1,350 each. Even though the Renewaire ERVs are more expensive, EcoFlats maintains the same "off-the-shelf" approach taken at previous projects which keeps equipment costs low, both upfront and ongoing maintenance costs.

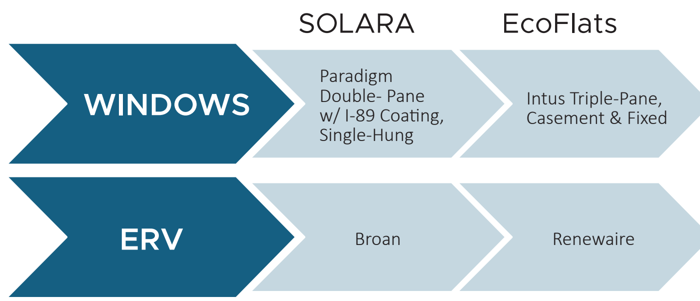
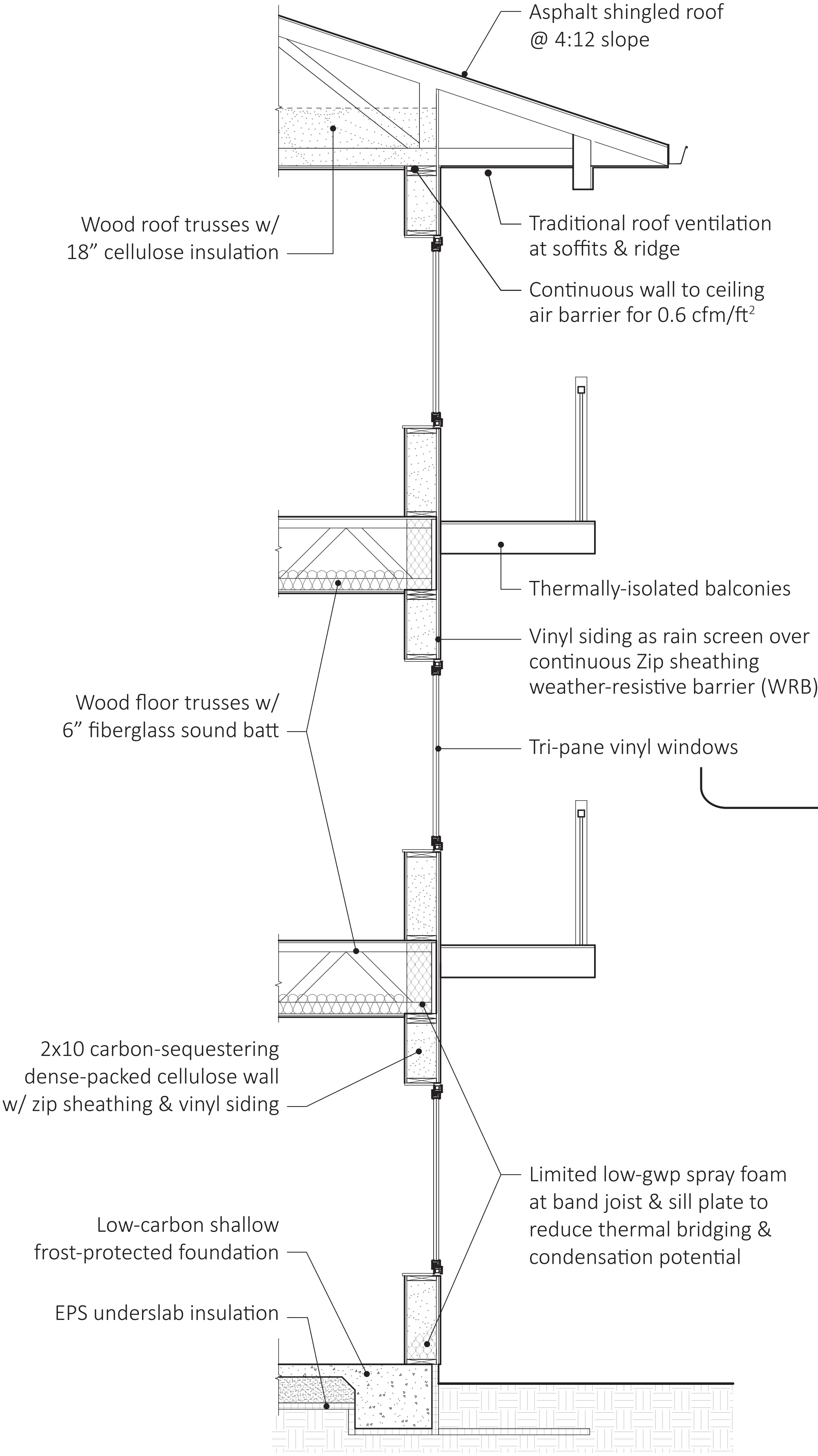


Figure 2: Phius-driven Performance Upgrades

Pursuing Passive House also adds soft costs by requiring a rater, certification fees, and additional architectural coordination. Phius-related soft costs for this project total approximately 1% of the overall construction cost and include the rater (Sustainable Comfort), Phius certification fees, the Phius consultant (Cultivate, Inc.), and related architectural coordination. It should be noted that Phius-related costs will vary from project to project. This team approached their Phius goal from a strong baseline, having already realized several Net Zero projects.

These added soft costs associated with pursuing Phius certification incentivize larger-scale projects like EcoFlats that are based on duplication of a single building because the soft costs increase only marginally for additional buildings with the same design.

NYSERDA's Buildings of Excellence Early Design Support program helped bridge these soft costs by providing $250K of early phase, direct funding to the project. In addition to supporting innovative, low-carbon design at EcoFlats, the positive impact of this funding will be carried forward and applied to future projects.



PERFORMANCE TARGETS

Insulation

Roof: **R-64**
Walls: **R-31**
Slab: **R-10.5**

Air Tightness: **0.06 cfm50/sf**

Windows

U-Value (fixed): **0.15**
$U\text{-Value}_{cog}$ (fixed): **0.12**
U-Value (operable): **0.19**
$U\text{-Value}_{cog}$ (operable): **0.12**
SHGC: **0.3**
VT: **0.64**

Intus Supera Triple-Glazed Window Unit

Figure 3: Exterior Wall Section *(not to scale)*

EMBODIED CARBON

WHAT IS EMBODIED CARBON?

When we talk about carbon - either embodied or operational - we're talking about the release of carbon into the atmosphere. The carbon cycle includes the movement of carbon from its release into the atmosphere to its re-absorption into plants, the earth, and oceans. An imbalance in this cycle has impacts on the atmosphere and the climate which become extremely difficult to reverse or mitigate.

The EPA defines Embodied Carbon as "the amount of GHG [greenhouse gas] emissions associated with upstream - extraction, production, transport, and manufacturing - stages of a product's life." In other words, all of the activities that go into creating a product result in the release of carbon and other greenhouse gases into the atmosphere; these emissions make up the product's overall embodied carbon.

While embodied carbon is extremely difficult to quantify, the Builders for Climate Action BEAM Carbon Estimator[1] is an extremely helpful tool for measuring the carbon impact of various building materials. BEAM calculates the embodied carbon of a building design by applying researched embodied carbon values to project-specific dimensional inputs, providing a complete carbon assessment for the building that's shown on a scale which puts the final quantification in context. The EcoFlats team utilized BEAM throughout the design process to guide environmentally-informed decisions.

EMBODIED CARBON AT ECOFLATS

EcoFlats seeks to utilize low-embodied carbon building materials and components as much as possible in a cost-effective way. This goal highlights the owner's innovative mentality -- when asked about the benefits of ambitious "green" project goals beyond the environment, he points to the "fun technical challenge." Striving for low embodied carbon complements other project goals of Net Zero energy use and Phius Zero Certification which serve to address the building's operational carbon as well. Central to this project is the concept that low-carbon design does not add cost. The low-carbon design features described in this section actually *reduce* construction costs by reducing concrete volume and maintaining simple forms, systems, and details developed through the integrated design process.

Building Materials

The building materials and assemblies make use of natural materials like wood and cellulose insulation to the extent possible, which are known to be low-embodied carbon. Figure 4 illustrates the hypothetical carbon impacts of various wall insulation materials considered at EcoFlats. The team chose cellulose, carrying forward the same exterior wall assembly pioneered for Solara Phase III.

Similarly, Figure 5 on the following page uses BEAM data to compare the carbon impact of steel and wood framing for the exterior and interior walls at EcoFlats. The project is designed with all wood framing, resulting in significant carbon savings compared to light-gauge steel framing and other structural elements.

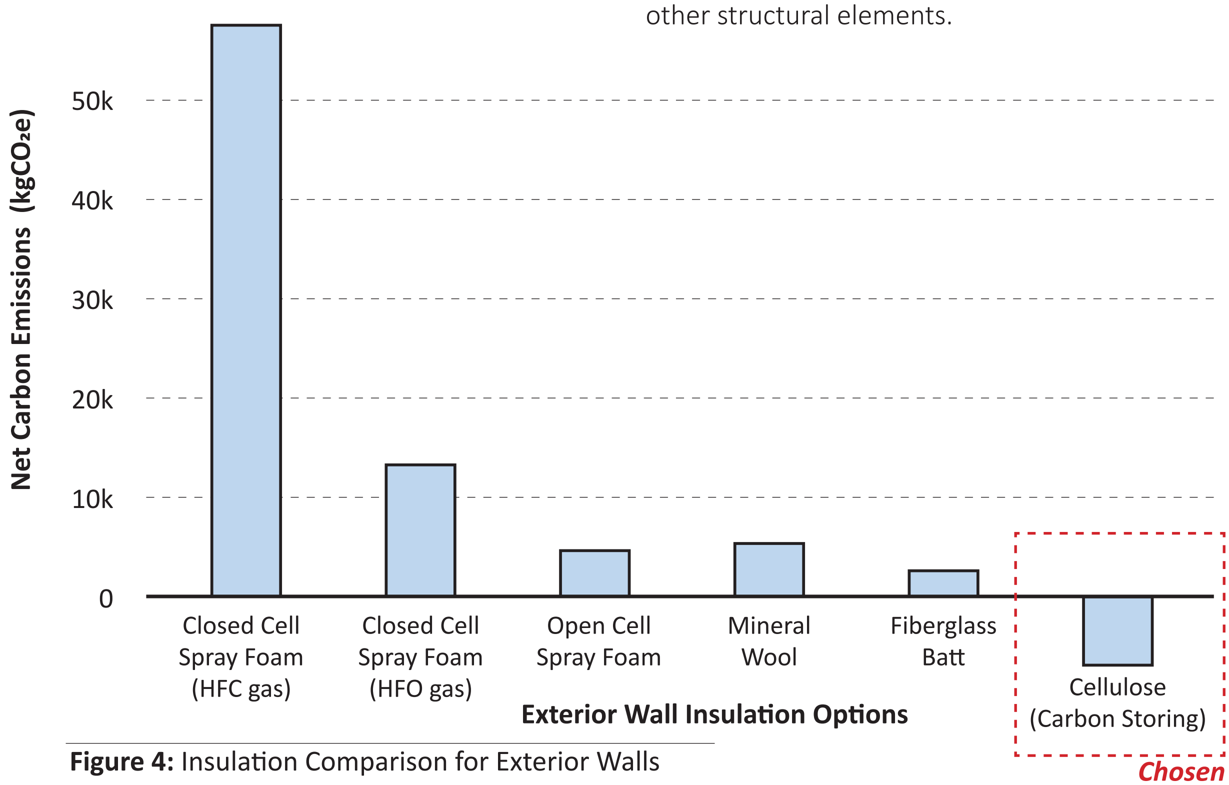


Figure 4: Insulation Comparison for Exterior Walls

[1] https://www.buildersforclimateaction.org/beam-estimator.html

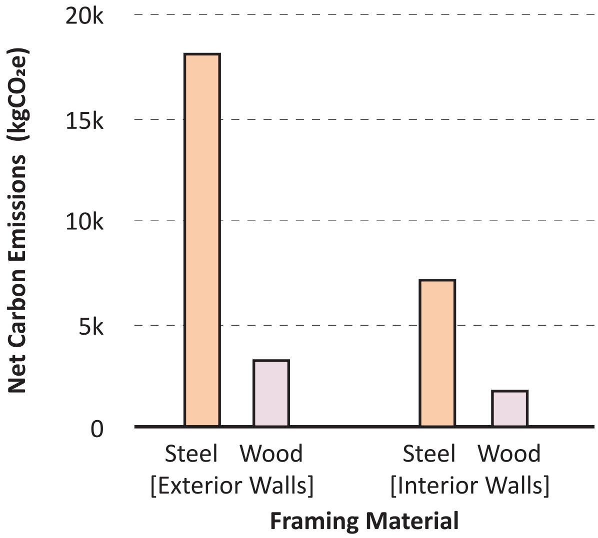


Figure 5: Framing Comparison

The team employed a holistic optimization process of looking at both embodied carbon and cost of various materials. While significant concrete, foam, and steel was eliminated from the project, vinyl siding and flooring remain because there were not good cost-effective alternatives. The BEAM summary and material comparisons on the following pages further describe how materials were considered and selected by the team to optimize both carbon and costs.

Concrete, which is inherently a high-carbon material, can be made with additives, including fly ash, which replace Portland cement and reduce the overall embodied carbon of the concrete. The BEAM carbon calculator highlights the carbon impact of various percentages of fly ash in the EcoFlats slab concrete mix:

- Standard Mix: 15,443 kgCO2e
- 20-29% Fly Ash: 13,251 “
- 30-39% Fly Ash: 12,022 “
- 40-49% Fly Ash: 10,824 “
- >50% Fly Ash: 9,610 “

In addition to the materials themselves, the project team used BEAM to evaluate different configurations of structural elements to achieve a low-embodied-carbon result. One example on this project is the evaluation and ultimate selection of a shallow frost-protected foundation condition, detailed in Figure 6.

Building Form

Another key strategy for reducing embodied carbon is to keep the building massing simple. EcoFlats’ simple, rectilinear massing and efficient floor plan minimize the total required materials and allow for cost-efficient, uncomplicated detailing. Deviations from the simple rectilinear footprint were incorporated mindfully to add visual interest without over-complicating the overall massing. The 4:12 hipped roof allows for both low construction cost and carbon-storing cellulose roof insulation. The simple building massing and floor plan also prioritizes functional, naturally daylighted, high-ceiling spaces inside the apartments. EcoFlats’ simple building form is illustrated in the concept floor plans in the appendix.

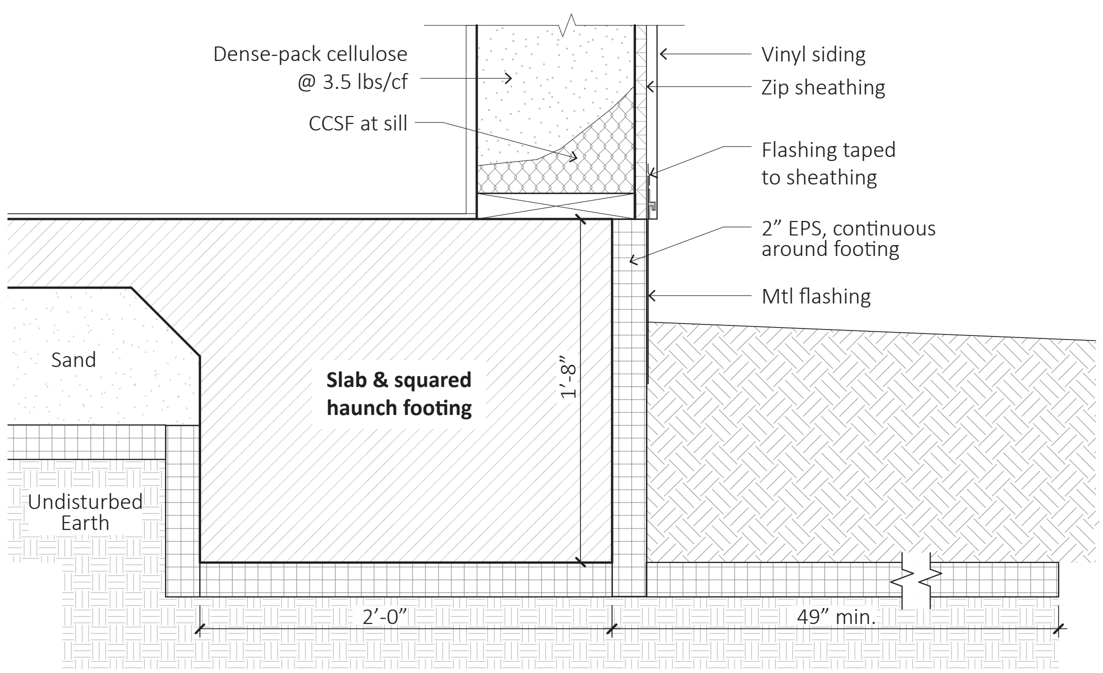


Figure 6: Foundation Detail *(Not to Scale)*

1 https://www.buildersforclimateaction.org/beam-estimator.html

BEAM SUMMARY

Figure 7 below summarizes the material carbon emissions for a typical 12-unit building at EcoFlats. While these results do not capture every detail, trim piece, and fixture in the building, they provide a good understanding of overall carbon impact of the listed sections and allow for apples-to-apples comparison of different material options. This material comparison capacity is paramount in making informed design choices.

As highlighted by the summary below, the primary driver of carbon emissions in this project is the concrete footings & slabs. The shallow frost-protected foundation design allows for complete elimination of foundation walls, which typically carry significant carbon emissions. The project also completely avoids the use of steel structure, which also packs a high carbon impact. The relatively low carbon emissions associated with "Structural Elements" is based on LVL beams around the stair openings.

Floors consist of the second-highest carbon emissions category. The primary source of flooring emissions is luxury vinyl flooring (LVT) throughout the units. According to BEAM estimates, switching to carbon-storing linoleum flooring would reduce flooring emissions by ~60%. While the team would prefer a lower-carbon product, the project also balances goals of providing market-rate housing and a healthy ROI for the developer. As such, some materials decisions are not optimal from a purely embodied carbon perspective. However, these decisions are made with full knowledge of their implications, which enables us to request alternative products from our vendor partners in meaningful ways.

Emissions associated with the exterior walls are almost entirely offset by the carbon-storing capacity of dense-packed cellulose insulation. Similarly, emissions associated with the roof (including asphalt shingling, sheathing, and wood trusses) are largely offset by loose-fill cellulose insulation within the roof trusses. In addition to the BEAM summary in Figure 7 illustrating the carbon impact of overall building sections, the individual building materials with the highest and lowest carbon impact are listed below.

Highest Emitting Materials ($kgCO_2e$)	
Concrete Slab:	13,251
Windows:	12,541
LVT Flooring:	10,956
Sheetrock:	9,393
Concrete Footings:	8,998

Carbon-Storing Materials ($kgCO_2e$)	
Wall Insulation:	-10,330
Roof Insulation:	-3,407

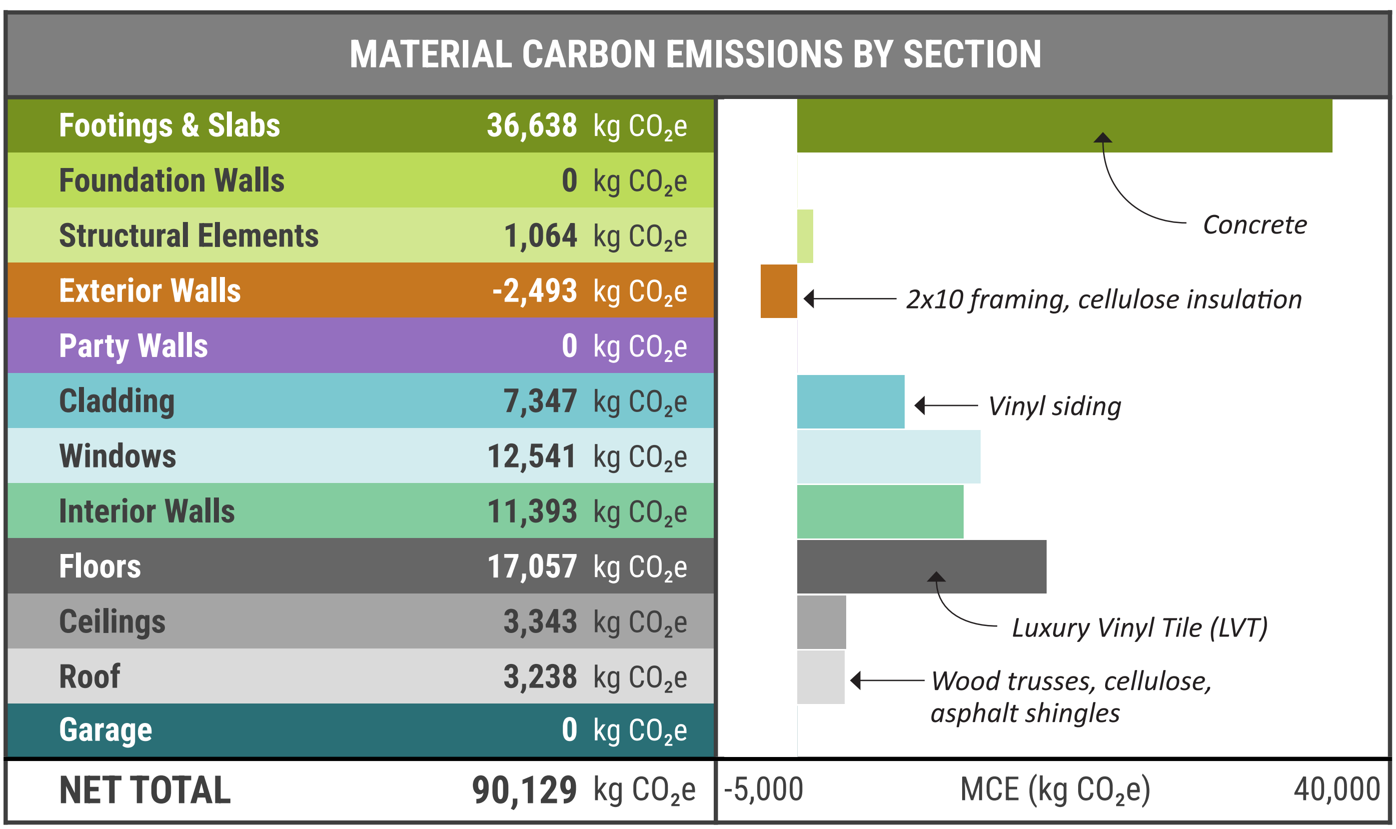


Figure 7: BEAM carbon emissions summary for a typical 12-unit building at EcoFlats

BEAM COMPARISONS

The studies below provide a glimpse into how the team incorporated embodied carbon data from BEAM into informed design choices. Design features from EcoFlats are compared to standard baseline scenarios. It's important to note that these studies are estimating the embodied carbon associated with a single 12-unit building. Carbon savings are exponentially increased when the numbers are multiplied by 13 buildings across the site.

Carbon savings are further increased when these low-carbon design features are applied to other projects. Black Mountain Architecture has integrated many of these features as their design standard for both residential and light commercial projects, including reduced-concrete foundation design, low-carbon concrete specification, and 2x10 exterior walls with dense-packed cellulose.

FOUNDATION DESIGN

BASELINE | Frost Wall Foundation

This baseline scenario assumes a 24"W x 12"H strip footing and 8"W x 48"H frost walls around the perimeter of the building. Concrete associated with the frost walls greatly increases embodied carbon compared to the EcoFlats foundation design.

(***Total: 43,386*** *kg CO_2e)*

ECOFLATS | Shallow, Frost-Protected Foundation

EcoFlats' shallow, frost-protected foundation design is a win-win for cost and carbon, greatly reducing excavation and material costs along with concrete volume.

(***Total: 36,638*** *kg CO_2e)*

Carbon associated with concrete foundation walls is eliminated.

CONCRETE SPEC

BASELINE | Standard Concrete Mix

This baseline scenario assumes a standard Portland cement concrete mix spec for all footings and slabs.

ECOFLATS | Concrete Mix with Fly Ash

EcoFlats' concrete spec calls for 25% - 30% fly ash content. Fly ash, a byproduct of the coal industry, is one of many "supplemental cementitious materials" or "SCMs" that can be added to concrete in lieu of Portland cement, which has a very high environmental impact. The builder has confirmed that concrete costs are not significantly different between standard and fly ash mixes.

EXTERIOR WALL ASSEMBLY

BASELINE A | 2X6 Wood Framing with Closed-Cell Spray Foam (HFO Blowing Agent)

This scenario assumes an exterior wall assembly with 2x6 framing filled with closed-cell spray foam insulation with an HFO blowing agent). Stud spacing, sheathing, cladding, and interior gypsum wallboard finish remain constant across the scenarios.

Exterior Walls **14,172** kg CO_2e

BASELINE B | 2X6 Wood Framing with Closed-Cell Spray Foam (HFC Blowing Agent)

This scenario matches Baseline A but assumes an HFC blowing agent instead of HFO. Clearly, HFC blowing agents have major environmental implications and are being phased out of the industry.

Exterior Walls **64,707** kg CO_2e

BASELINE C | Steel Framing with Closed-Cell Spray Foam (HFO Blowing Agent)

This scenario matches Baseline A but assumes 24-gauge metal framing instead of wood framing.

Exterior Walls **30,527** kg CO_2e

ECOFLATS | 2x10 Wood Framing with Dense-Packed Cellulose

EcoFlats' exterior wall assembly, pioneered during the design of Solara Phase III, utilizes 2x10 wood framing filled with dense-packed cellulose. Of the various assemblies studied, this approach was found to be both environmentally friendly and cost effective because it doesn't require specialized framing knowledge. The builder estimates framing costs for this approach to be just $6/sf higher than standard 2x6 wood frame construction.

Exterior Walls **-2,493** kg CO_2e

0

The embodied carbon is negative here because cellulose insulation stores carbon. Wood is also a carbon-storing material although the overall embodied carbon of wood framing is not negative due to emissions associated with harvesting, processing, and transportation.

WINDOWS

BASELINE | Double-Pane Windows

This baseline window assumption is an industry average for double-pane, uPVC frame windows. The frame material and operation are constant between the baseline and EcoFlats scenarios.

Windows **10,434** kg CO_2e

ECOFLATS | Triple-Pane Windows

To achieve its ambitious Passive House target, the windows at EcoFlats are high performance, triple-pane windows. While triple-pane windows carry a higher carbon footprint than double pane windows, the team prioritized energy efficiency in this case. Costs are comparable between the two scenarios.

Windows **12,541** kg CO_2e

BUILDING SYSTEMS

WHY HEAT PUMPS?

EcoFlats at Log City will be a Net Zero energy complex, meaning it will produce all of the energy it consumes over the course of each year on site. The project will generate electricity using photovoltaic panels mounted on the roofs of carport structures and, in some cases, building rooftops. The all-electric building systems and appliances will directly utilize this on-site generated energy. A non-energy co-benefit of all-electric systems is that pollutants associated with combustion are eliminated, leading to improved indoor air quality.

HEAT PUMPS

Heat pumps, very simply, are machines which transfer heat. The most common example is a refrigerator which pulls heat out of the interior of the refrigerator and transfers it to the space outside of the refrigerator. A central air conditioning unit is a heat pump operating in one direction: it transfers heat from the interior of a building to the outside environment. Figure 8 illustrates a conceptual heat pump. At EcoFlats, heating and cooling will be provided by a heat pump which runs in both directions – transferring heat from outside to inside in the winter and from inside to outside in the summer.

Analysis of various mechanical systems was undertaken for previous projects. The cost of drilling wells for a geothermal system was deemed not viable, which is still the case at the time of this report. Heat pumps are compatible with both energy efficiency goals and the project budget.

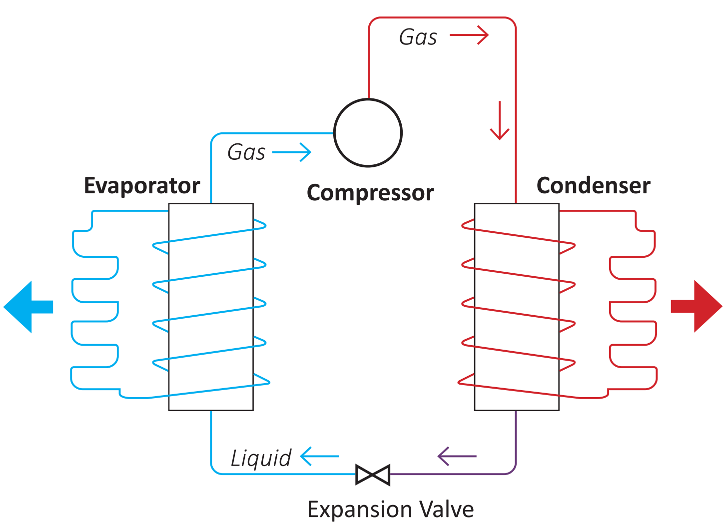


Figure 8: Conceptual Heat Pump

The EcoFlats project utilizes individual minisplit air source heat pumps in a distributed configuration. Each apartment unit contains one centrally located wall-mounted minisplit head adjacent to the open kitchen/dining/living space. Each head connects to its associated outdoor condensing unit at the exterior wall of the mechanical room. This configuration allows for small individual systems providing individualized heating and cooling for each unit and minimizing refrigerant line runs (see Figure 9). The minisplits at EcoFlats are cold climate heat pumps, meaning they operate in cold temperatures where other standard heat pumps might not be able to run.

The building envelope efficiency plays a major role when it comes to the space conditioning system. An efficient building envelope means that the space conditioning system uses less electricity to heat and cool the space, since the envelope keeps heat in (or out depending on the season). When the heating and cooling system can use less electricity, less PV is needed to cover the overall usage. It also means that the system can be smaller and still provide a high level of occupant comfort by utilizing envelope strategies to maintain higher temperatures at exterior surfaces and bring air leakage down to imperceptible levels.

VENTILATION

A critical component of a healthy indoor environment is filtered mechanical ventilation. EcoFlats utilizes individual Energy Recovery Ventilators, or ERVs, for this purpose. An ERV takes air from the outside environment, filters it, exchanges heat with outgoing indoor air before supplying the tempered and filtered fresh air to the interior space and exhausting the stale no-longer-tempered indoor air to the exterior. The transfer of heat from the outgoing indoor air to the incoming fresh air greatly reduces the amount of energy needed to heat or cool the fresh air and maintains more comfortable humidity levels within the building. This improved indoor air quality means building occupants can breathe more fresh, clean air while expending minimal building energy to do so.

At EcoFlats, each apartment unit has an individual ERV. The ERVs are located in a mechanical closet off of each stairwell which allows for easy maintenance access to the equipment while keeping the units close to the exterior wall. The adjacency to the exterior saves energy by limiting the distance the outdoor air needs to travel through the heated and cooled space to supply and exhaust from the ERV.

As with the heating and cooling system, this team's approach to building ventilation has been informed by previous projects. The building layout with units clustered around central mechanical rooms is highly conducive to this individual ERV configuration.

DOMESTIC HOT WATER

The heat pump concept is applied to generating domestic hot water for the project as well. EcoFlats uses air-to-water heat pump water heaters in a semi-decentralized configuration: each heat pump water heater serves the 6 apartment units accessed by a single stair tower. The team chose to locate the water heaters at the second floor level to maintain efficient distances from the heat source to each individual fixture, thereby keeping the time from turning on the tap to hot water delivery as short as possible.

In terms of energy use, the heat pump water heaters are around three times as efficient as standard electric resistance water heaters. This keeps overall energy use low, allows for the PV array to be smaller and reduces construction costs. The higher efficiency of these units will also help to reduce peak electricity demands which, even though the project is Net Zero, makes a difference in overall energy costs through metering charges as well as reducing impacts on the grid due to peak draw and peak generation inconsistencies.

Taking advantage of available incentives for heat pump water heater installation through the NYS Clean Heat program also played a role in domestic hot water decision-making. The installation incentives available for this equipment brought the up front cost closer to that of electric resistance heaters.

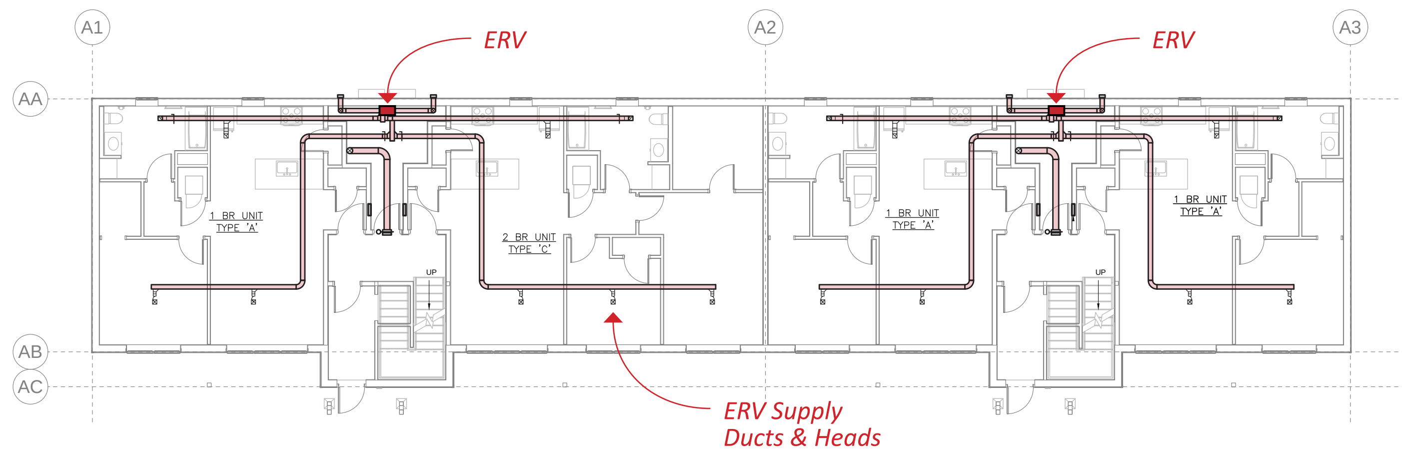


Figure 9: ERV Plan *(not to scale)*

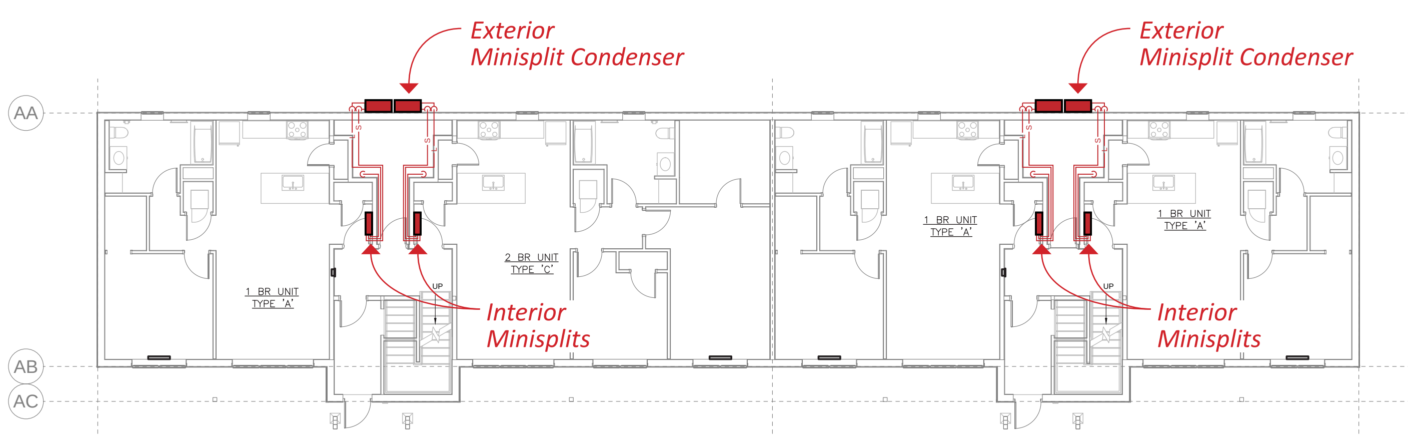
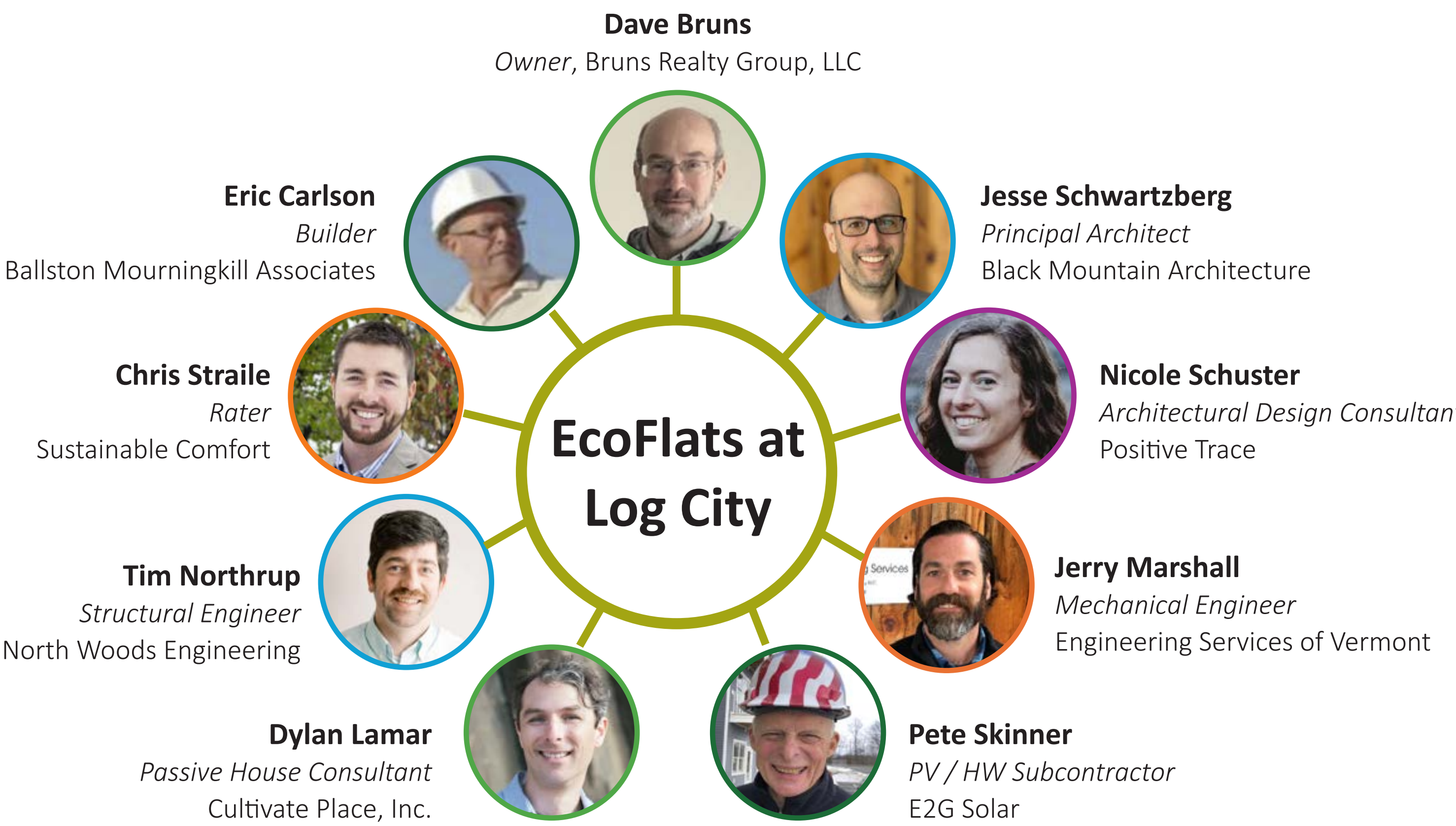


Figure 10: Mechanical Heat Pump Plan *(not to scale)*

THE PEOPLE

Building a Team



BUILDING A TEAM

How They Began

Ten years ago an electrical engineer turned real estate developer named David Bruns got an idea: a Net Zero multifamily housing development which would draw tenants with comfort and convenience and use energy savings to drive the proforma. He knew that he needed the right people working in collaboration to make this idea a reality, so he set out to build a team.

> **"I got this idea, maybe from the internet...a Net Zero concept. I noticed that no one is really doing it in the multifamily world."**
>
> *- Dave Bruns, Owner/Developer*

Dave reached out through connections and previous project experience to find individuals who would be up for such a challenge and who brought the right mix of experience and expertise.

Dave had worked with a contractor named Eric Carlson of Ballston Mourningkill Associates on a previous conventional multifamily project and decided to invite him to be a part of this new endeavor. Through other contacts Dave connected with Harris Sanders Architects who would provide the architectural design services for the project. The contacts at Harris Sanders made a connection with Jesse Schwartzberg of Black Mountain Design Build, which has since become Black Mountain Architecture, who would begin as the Net Zero energy consultant. Jesse in turn brought on Dylan Lamar, then of Green Hammer and now of Cultivate Place, to provide energy modeling and expertise on Passive House principles. Rounding out the initial team were Pete Skinner of E2G Solar who provided design for the domestic hot water system, particularly the solar hot water system, Tom Vitale of Entech Associates for field verification and HERS rating, and Environmental Design Partnership LLP for civil engineering.

Each individual and company brought their own experience and expertise and, most importantly, they all brought an open minded and collaborative approach. Eric was able to contribute input on constructibility to reduce labor and material costs, which were critical components of the overall decision-making. Harris Sanders Architects drew on their experience with multifamily projects to design efficient, functional unit and building layouts. Jesse brought a passion for and expertise in high-performance building design which was one of the most critical components of the project. Dylan's experience with Passive House and building performance energy modeling allowed the team to perform iterative analysis to understand the performance and cost impacts side-by-side for each decision. Pete and E2G Solar are the experts on solar hot water design, having designed, engineered, installed, and measured the performance of their numerous previous systems. Verification of performance and quality at varying stages of construction is crucial to final unit and building performance and Tom's work during construction was vital to the success of the project. EDP's understanding of site conditions and orientation gave the project a strong foundation for high performance. Of course, Dave Bruns imparted the developer's perspective of finding the right balance of cost and quality, and kept the team focused on finding creative solutions.

Changes Over Time

Over the course of the next 10 years and 3 projects, the individual roles, responsibilities, and involvement took on different shapes and forms. Black Mountain Design Build became Black Mountain Architecture and started to take on the Design Lead role, eventually becoming the Architect of Record for the EcoFlats project. Jerry Marshall of Engineering Services of Vermont came on board for the EcoFlats mechanical engineering and plumbing documentation. Pete Skinner transitioned from full system design for solar hot water to general domestic hot water design, as the current project eliminated the solar hot water component (more about "Project Evolution" in the next chapter). Tim Northrup and his team at North Woods Engineering came on to fill the structural engineering role previously performed by Harris Sanders Architects. Dylan has continued to provide energy modeling through his company, Cultivate Place, which has developed into a full Phius Passive House consulting office. Nicole Schuster of Positive Trace joined the team under Black Mountain Architecture, bringing additional multifamily and large scale architectural experience and Passive House expertise. Chris Straile and others with Sustainable Comfort have taken over the verification role, providing full Phius Verifier services for EcoFlats. EDP continues to provide civil engineering services and Eric continues as the tried and true contractor for this important work. Dave continues to drive the team to innovate and tackle new challenges head-on.

THE ECOFLATS TEAM

Figure 11: EcoFlats Team

THE PROCESS

Project Evolution | Design Process | Net Zero Proforma

Typical Building View from Solar Carport | Black Mountain Architecture

BLACK MOUNTAIN ARCHITECTURE

PROJECT EVOLUTION

The History

When Dave Bruns first had the idea to embark on the journey of developing Net Zero multifamily housing, he initiated a lasting, increasingly ambitious effort that continues to push the boundaries of what's possible with market-rate multifamily housing. Together with an aligned design team (see the previous section on "Building a Team") including Black Mountain Architecture and Ballston Mourningkill Associates, they made the original concept a reality. It was just the beginning.

Gen 1: Net Zero Village

This first project, Net Zero Village, is a 14-building market-rate complex. Each building is a three-story walk-up, laid out with individual stair tower cores serving six apartments each (two apartments per floor). As such, each building contained 12 apartments for a total of 168 units. Design began in 2014 and was completed in 2016.

The building layout gives each apartment an exterior wall on both the north and the south, allowing maximum south-facing glazing to take advantage of heat from the sun in winter. Solar shade structures were installed over each window to provide shading and protection from the same solar heat in the summer months. The team reviewed the layout, orientation, glazing and shading using the energy modeling software EC3 to drive design and decision-making.

Various components, systems, and assemblies were analyzed and evaluated throughout the design process. Mechanical system selection was driven by efficiency, comfort, cost, and size based on a high-performance envelope. After discussions with possible providers, ground source heat pumps were determined to be not cost effective. A study was performed to determine that an air source heat pump with a single minisplit head in each apartment unit would provide sufficient thermal comfort. The study indicated that if bedroom doors were left closed during peak heating conditions, electric resistance heaters would be needed for back up heat in the bedrooms. A solar hot water system was chosen because it provided higher temperature incoming water, reducing the load on the electric water heaters. To minimize heating load by recovering heat from ventilation exhaust air, the project used Heat Recovery Ventilators. These subsequently had to have their cores changed out to Energy Recovery Ventilators for optimal humidity control. The windows were single-hung, double-pane, low air infiltration units with an I-89 coating.

The performance of the building envelope was dialed in through cost-benefit analysis. The walls were not insulated beyond code requirements due to the diminishing returns of increased insulation above code minimum. Sub-slab insulation was provided for comfort and durability, as it maintains a higher temperature of the slab which impacts how cold the surface feels to the touch while also making the slab less prone to condensation. Similar to the wall insulation, triple-pane windows were ruled out based on a cost-benefit analysis. Solar PV was incorporated onto the carport structures which provided the double benefit of covered parking and Net Zero energy operation.

Gen 2: Solara Phase I & II

The second generation project, Solara Phase 1 and 2, followed quickly on the heels of Net Zero Village. Design began in 2017 and construction was completed in 2020. Phase 1 and 2 consist of eight three-story buildings, each with 24 apartments for a total of 192 units. Unlike the last project, the design is laid out as double-loaded corridor with apartments on each side, with all units sharing access to the same common stair and elevator. This change was prompted by a tenant desire for elevators, incorporating feedback and market analysis.

Another departure from the Net Zero Village design was the wall assembly. The wall assembly at Solara began as a hybrid assembly with closed cell spray foam and fiberglass in the cavity and a small amount of continuous foam insulation in the form of Zip-R sheathing at R-9. This assembly resulted in observed condensation at the foundation to stud wall junction during construction so the team decided to change course on the remaining buildings and completely fill the cavity with closed cell spray foam, omitting the fiberglass batt insulation. The original assembly on the first buildings performed as expected without issues post construction; it was only during the construction process where condensation risk was increased. The team determined it was not an acceptable risk and made the modifications.

Other than these changes, much stayed the same: minisplit space conditioning, ERVs, solar hot water, double pane windows. Based on the low energy use (both as modeled during design and as measured during construction) and the team's ability to reach their goals within the cost constraints of a typical market-rate multifamily project, Solara Phase 1 and 2 received a Buildings of Excellence, Round 1 Demonstration Project award from NYSERDA.

Gen 3: Solara Phase III

Solara Phase 3 brought the team to the third generation, which took on low embodied carbon materials as an additional goal. This phase consists of three buildings of the same configuration as Phase 1 and 2 for a total of 72 units.

Cellulose replaced the foam insulation in the wall assembly as well as the roof. Because this was a third phase of a single complex, the buildings needed to look similar. This meant the roof needed to be a ventilated flat roof with cellulose insulation. A shallow frost-protected foundation was found not cost effective due to the low cost of excavation at the site so a 6” concrete foundation wall was used to reduce concrete volume and its corresponding embodied carbon.

Achieving the target density of dense-packed cellulose was made more difficult by the increased stud spacing associated with advanced framing. Because the air barrier at the third floor presented a challenge for coordinating light fixtures, the team decided to utilize wall-mounted light fixtures on the third floor instead of ceiling fixtures.

Gen 4: EcoFlats at Log City

The innovation didn’t end there. EcoFlats synthesizes the goals and learnings of the team’s prior experience, targeting Net Zero energy and low embodied carbon while adding Passive House certification as a new goal. This report focuses on EcoFlats as the latest design iteration of a project team that has accumulated invaluable experience and surpassed increasingly ambitious goals over the past decade.

With each generation, lessons learned from the previous were folded into the next. In the case of building layout, EcoFlats exhibits the same configuration as Net Zero Village, with clusters of apartments sharing a stair tower rather than the double loaded corridor used in the Solara projects. Individual unit HVAC equipment (ERVs and wall-mounted minisplits) has endured throughout all of the projects, as well as an off-the-shelf approach to equipment specifications. The simplicity of the mechanical systems has been instrumental for successfully adhering to market-rate budget constraints.

As discussed in the previous “Passive House” section, two key innovations to achieve Passive House at EcoFlats were to upgrade to triple-pane windows and higher-end ERVs.

Industry Evolution

The building industry has undergone significant evolution in parallel with the shifting goals and targets of this team. Architect Jesse Schwartzberg reflects on how the industry has advanced since the pioneering days of Net Zero Village. “The ERV market has gotten a lot more robust over the past ten years.” At the time, high-end ERV systems were beyond the budget for projects like Net Zero Village and Solara. Today, the market has matured, offering more accessible and cost-effective options. Similarly, the cost of high-performance triple-pane windows--once prohibitively expensive--has made EcoFlats’ Passive House goal much more attainable. The team was surprised and delighted to learn that the Intus triple-pane windows specified for EcoFlats come at a comparable cost to the double-pane Paradigm windows previously used at Solara.

The progression of project goals (Net Zero to low embodied carbon to Passive House) also mirrors the evolution of the building industry. Jesse notes, “When I think back to Net Zero Village, embodied carbon wasn’t even a vocab word.” At the time, low-carbon materials like lightweight gypsum wallboard were unavailable. Spray foam was the default choice for insulation because embodied carbon simply wasn’t on the radar.

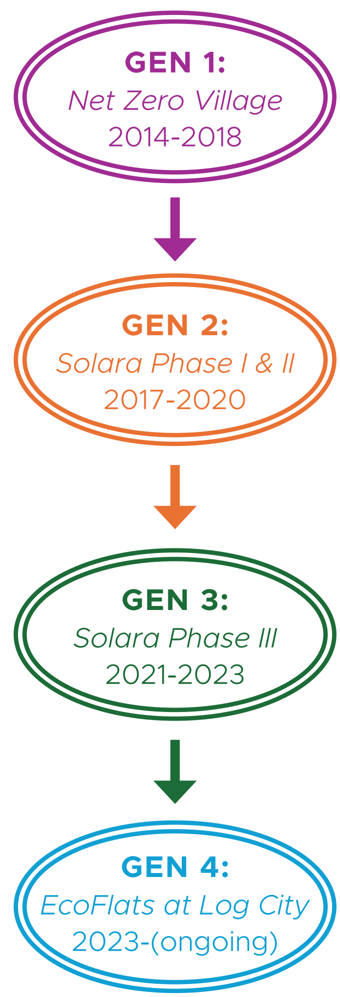


Figure 12: Project Evolution
See following spread for additional detail.

2014-2016
NET ZERO VILLAGE

Rotterdam, NY | 168-units | (14) 3-story buildings

2017-2020
SOLARA PHASE I & II

Rotterdam, NY | 192 units | (8) 3-story buildings

LAYOUT

- Full-depth apartments, central stair/mech cores → Double-loaded corridor, central stair/elevator cores

INSULATION & ASSEMBLY

- 2x6 framing with spray foam insulation → 2x6 framing with spray foam insulation + continuous exterior insulation
- XPS sub-slab insulation
- Flat roof with foam insulation
- Full stem wall foundation
- Double-pane windows with I-89 coating (single-hung)
- Standard concrete mix

MEP

- Solar hot water
- PV carports

CERTIFICATIONS & AWARDS

- Net Zero
Energy Star for Homes → Net Zero
Energy Star for Homes
BOE Demonstration Project Winner (Round 1)

2021-2023
SOLARA PHASE III

Rotterdam, NY | 72 units | (3) 3-story buildings

2023 - (ongoing)
ECOFLATS AT LOG CITY

Amsterdam, NY | 168 units | (13) 3-story buildings

→ Full-depth apartments, central stair/mech cores

→ 2x10 framing with dense-packed cellulose insulation →

→ EPS sub-slab insulation →

→ Vented flat roof with cellulose insulation → Vented hipped roof with cellulose insulation

→ Shallow frost-protected foundation

→ Triple-pane windows (awning & fixed)

→ Low-carbon concrete mix →

→ Heat pump hot water →

Solara Phase III:

Net Zero
Energy Star for Homes
BOE Demonstration Project Winner (Round 2)

EcoFlats at Log City:

Net Zero
Energy Star for Homes
BOE Demonstration Project Winner (Round 3)
BOE Early Design Support Winner
Phius Zero (goal)

DESIGN PROCESS

Integrated Process Overview

What is Integrated Process? It requires the involvement of each project team member from the beginning phase of the project so that the various aspects and decisions can be explored quickly and holistically by incorporating each different perspective simultaneously. To reap the many benefits of this process, it is important for each team member to understand and recognize that every participant in the process is an important and integral part of the whole with valuable input, even on unexpected topics.

Communication between team members is free flowing and frequent, including phone calls, emails, and project team meetings. For this project, the team found that meetings every two weeks throughout the design process was highly effective in keeping everyone on the same page and receiving needed input for required decision-making.

Integrated Problem Solving

There are many people involved in making the EcoFlats project a reality. As with any project, there were a large number of decisions which needed to be made to keep the design process moving. Following are a few examples of key decisions in the EcoFlats Project and how the integrated process allowed for the effective gathering of relevant details and data to inform decision-making in an efficient and cost effective way. These discussion topics highlight the integrated nature of problem solving that took place throughout design.

Foundation Discussion

In contrast to a “this is how we’ve done it” approach, the EcoFlats team took (and continues to take) a critical look at standard configurations and details. One such condition was the foundation wall. The team investigated alternative approaches to the standard frost wall foundation used on previous projects that might prove more efficient and effective for the project. The team weighed several foundation options, including a standard frost-depth foundation wall and footing, a shallow frost-protected stem wall and footing, and a shallow frost-protected haunched slab. Through the integrated process, each team member brought their perspective and expertise to the evaluation of these solutions. The owner contributed a perspective of balancing cost and time efficiency with other project goals. The contractor contributed a perspective of constructibility and provided tangible cost metrics based on the site-specific non-granular soils and subsequent increased excavation costs. The design team, including the structural and geotechnical engineers, contributed a perspective of functional best practices in terms of mitigating thermal and moisture risks and maintaining durability. The architecture team also weighed in with insight into the embodied carbon implications of each option. The structural engineer provided technical expertise on bearing capacity, load transfer of forms, and stability considerations, particularly in relation to the specific soil conditions. Last, but not least, the Phius consultant contributed a perspective of continuous insulation requirements and air barrier and thermal bridge concerns. After collaborative evaluation of these contributing factors and perspectives, the shallow frost-protected haunched slab configuration was selected as the best solution.

Pricing Implications for Foundation Options:

Standard frost wall foundation (full excavation)	$$$
Shallow frost-protected foundation (minimal excavation)	$

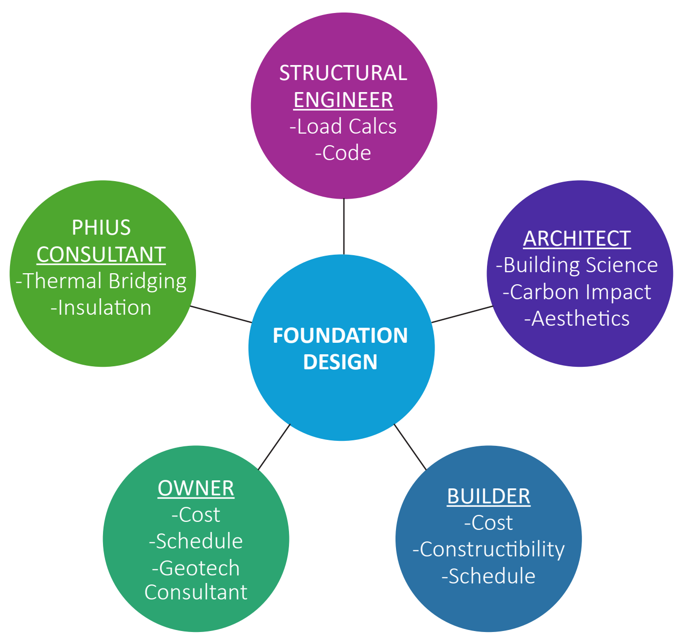


Figure 13: Integrated decision-making for the foundation

Roof Pitch Discussion

The team applied the same approach to the roof slope and assembly, with each team member contributing their perspective in real time. In this case the owner again was checking and balancing cost with other goals. The contractor communicated cost comparisons for the options, which included a flat, vented cellulose-insulated roof (as installed

Figure 14: Contributing factors to the roof design

at Solara Phase III), a steep-slope (10:12) vented cellulose-insulated gabled roof, a shallow-slope (6:12 or less) vented cellulose-insulated gabled roof, and a shallow-slope vented cellulose-insulated hipped roof. The architect investigated and presented the aesthetic implications of each option through 3d modeling studies. The structural engineer calculated and shared structural implications, particularly the impacts to shear and wind load requirements and materials, which then fed back into the contractor's cost implications.

In the end, the team landed on a 4:12 shallow-slope asphalt shingle cellulose-insulated roof that optimizes construction cost and aesthetics. Steeper pitched roofs and low pitched roofs are both more expensive from a labor standpoint, so the 4:12 design was just right. Visually, the hipped roof ensures that the relatively flat gable is not readily visible from the ground.

<u>Pricing Implications for Roof Options:</u>

Shallow Slope (6:12 or less)	$
Steep Slope (> 6:12)	$$
Flat with Vented Attic	$$$

Window Discussion

The team carefully assessed window options to meet the Passive House standards for airtightness and thermal performance while maintaining cost-effectiveness. They considered multiple options and variables: using the high-performing double-glazed, single-hung windows from previous projects, upgrading to triple-glazed windows for improved thermal performance, and exploring alternative window operations like casement or tilt-turn styles for improved airtightness.

The architect analyzed the visual impacts and egress considerations of different window proportions. The Passive House consultant evaluated each option's thermal performance and airtightness in relation to Phius requirements. The contractor acquired pricing from the manufacturers. The structural engineer communicated the design pressure requirements for the windows which had different implications depending on window type and manufacturer.

Although the double-pane, single-hung windows had performed well before, their operation raised airtightness concerns due to the pass-fail nature of Phius requirements. As such, casement or tilt-turn windows became the preferred choice. Triple-pane windows offered better thermal performance, creating a larger energy buffer while also enhancing thermal comfort by reducing the temperature difference between the window surface and the interior space.

After weighing the cost and performance of various options, the team determined that Intus triple-pane casement windows best met the project's needs. They provided the required thermal performance, ensured airtightness, could withstand design pressures without additional structural support, and were comparable in price to the previously specified double-pane windows.

<u>Pricing Implications for Window Options:</u>

Double-Pane w/ I-89 Coating	$
Intus Triple-Pane Package	$
Other Triple-Pane Windows	$$

Process

The team defined the end of the SD phase and the end of the DD phase as two points where more structured cost estimating would be undertaken to check the design against the budget. The contractor's constant real-time cost and constructibility input during the design process made the more comprehensive estimating process more efficient and effective.

In addition to gathering pricing info, the team performed energy modeling at each phase throughout design. Energy models from Cultivate Place enabled the team to understand whether we were on track to achieve Passive House goals.

NET ZERO PROFORMA

Leverage the Value of Saved Utilities

> “ We need Net Zero for the proforma to work. ”
>
> *- Dave Bruns, Owner/Developer*

This is a critical statement for a project: that the Net Zero energy use aspect is non-negotiable and is in fact what makes the project feasible, rather than a nice-to-have add-on feature. The process of forming a proforma with a Net Zero energy basis starts with financing and the concept of leverage.

A Net Zero energy building has reduced operating costs in the form of no energy bills. This reduced operating cost can be translated into direct and quantifiable revenue by charging for a Tenant Utility Package above and beyond the rent for each unit. This package comes at a fixed regular price and provides tenants with electricity and Internet. Because this is an all-electric building, the electricity covers heating, cooling, ventilation, lighting, power, and cooking.

This additional revenue translates into an increase in the total allowable financing that can be obtained for building the project. In other words, more up-front money can be spent building the buildings. This increased up-front financing covers the building energy efficiency measures plus the PV system. There is a balance between energy efficiency and PV depending on the costs of materials, labor, and cost per watt of the PV system.

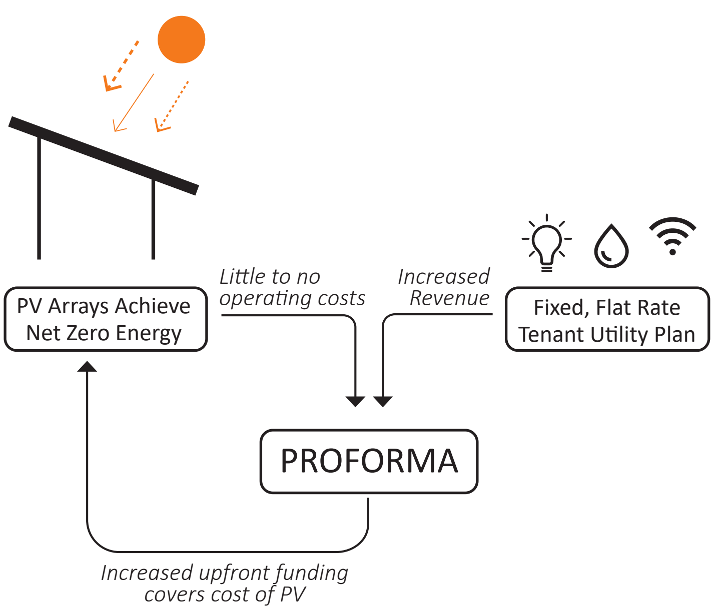


Figure 15: Tenant Utility Plan as Key Factor in Proforma

Incentives

On the other side of the line from demonstrating post-construction revenue is demonstrating other sources of capital and funding outside of direct financing. For Net Zero, low carbon, energy efficient buildings and associated components, these typically take the form of incentives and tax credits. Finding, understanding, and taking advantage of these opportunities is a crucial factor in realizing the project.

EcoFlats Funding Sources

- NYSERDA Programs
- Utility Incentives & Tax Credits
- Regional Bank Loan
- Cash Equity

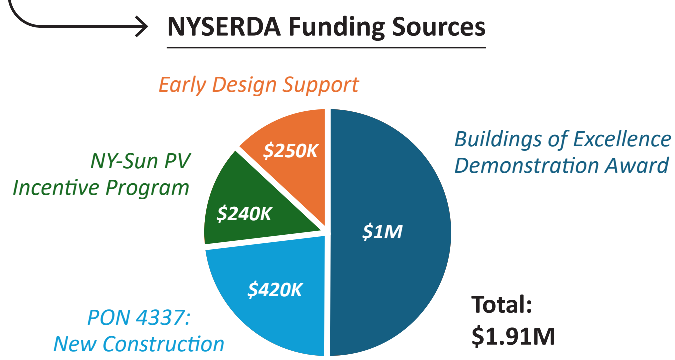


Figure 16: Funding Sources

EcoFlats is a NYSERDA Buildings of Excellence Demonstration Project winner, which is a significant source of additional funding for the developer. The Buildings of Excellence competition provides funding for climate-friendly multifamily projects through two paths: Demonstration Projects and Early Design Support (EDS). The EcoFlats team also participated in the EDS program which provides funding to the design team for projects with ambitious low-carbon goals. The EDS program proved particularly impactful for this project because of its replicable nature. The team leveraged EDS funding to develop one module, then copy/pasted the design across all 13 buildings. The energy-efficient, low embodied carbon, cost effective design features described in this report can also easily be replicated in future projects of this typology.

In addition to NYSERDA funding sources, the project plans to take advantage of utility incentives for heat pump water heaters and tax credits provided by the Inflation Reduction Act and other tax credit programs.

The incentives and credits are as critical as the Net Zero aspect of the project: they're essential for feasibility. The many, varied programs available for this type of project are constantly changing and evolving; as some programs retire, new programs are launched.

Cost Savings Through Integrated Process
The EcoFlats team works closely in collaboration; team members are involved in the process early and often which allows the whole team to move the project towards high value. It's important to understand the balance of energy efficiency measures, their performance impacts, and their associated costs in conjunction with the required quantity of PV to reach Net Zero and the associated cost per watt of the PV system. Achieving this holistic understanding in the most efficient way, minimizing circularity and rework, requires bringing the design team, the developer, and the contractor together regularly to discuss the implications of each team member's area of expertise and experience.

Controls and the Cost of Energy
Net Zero energy use does not always equate to Net Zero energy cost. A Net Zero energy building that is grid tied, as EcoFlats will be, will take energy from the grid when the PV is not supplying energy and will feed energy back into the grid when the PV system is generating more energy than the building is using at that moment in time. The building will be buying energy at a certain cost when it needs more than it makes, and will sell energy to the grid at a certain cost when it makes more than it needs. The cost structures for these conditions can vary.

Specific to EcoFlats, though likely generally applicable to other utilities as well, the cost per unit of energy can change depending on how much energy is being taken from the grid at a particular time. These are called demand charges or demand meter. Once a particular meter is taking a certain amount of energy, the cost per unit of that energy will increase and will stay at that increased rate for a defined period of time, even if the energy use goes back down within that period. This increased cost can significantly impact the balance of the proforma calculation which requires a certain cost balance between energy cost savings and increased up-front expenditure. There are a few ways to address this condition and mitigate the risk of demand charges for energy use:

Separate Meters | Individual apartment unit meters can mitigate demand charges because the usage of each individual apartment is much more likely to stay below the limit that would trigger an energy cost increase than the whole building energy usage would be. Individual meters for clusters of apartment units would have a similar result. The downside of the numerous meters is that each meter would incur a delivery charge.

Demand Control | One way to control peak demand on energy use is to install peak usage equipment, such as hot water systems, which are highly energy efficient. In the case of EcoFlats, the heat pump water heaters serve to help with this condition. Another way to control peak demand is to implement a controls system which can ramp certain equipment up or down at different times of the day depending on peak usage times. This can also help with additional time-of-use charges which incur a higher fee for energy usage at certain times of day regardless of overall energy use at the time.

Energy Storage | Another way to avoid demand charges is to keep the excess generated electricity on site to use as needed when electricity generation is not sufficient, typically through use of batteries. The design team discussed batteries at an early stage and it was determined that implementing a battery solution was not cost effective at the time. It is understood that future incentives may become available which would make this a more feasible strategy, so the team will design the system to allow for the addition of battery storage at a future time.

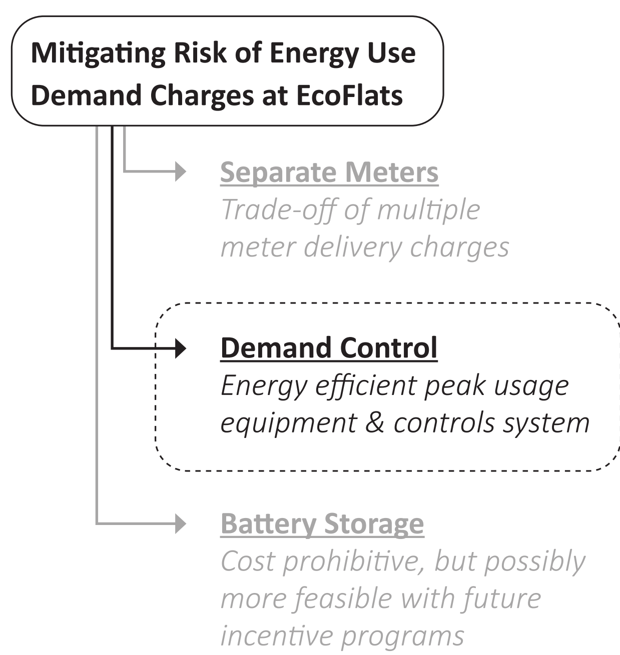


Figure 17: Energy Use Demand Charges

CONCLUSIONS

Rendered Aerial View of EcoFlats Development | Black Mountain Architecture

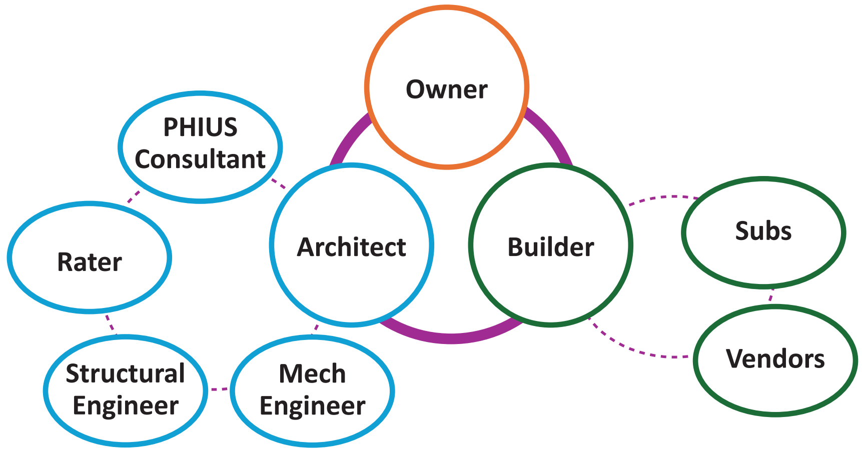
BLACK MOUNTAIN ARCHITECTURE

CONCLUSIONS

While the takeaways from this project and the team's decade-long collaboration are vast and varied, the conclusions below represent a few features that are central to EcoFlats' high-performing and cost-effective design. These strategies are highly replicable across project types, and the project team hopes that sharing these takeaways will push the larger industry toward more Net Zero, low-carbon, Passive House, market-rate projects.

1 | Integrated Project Delivery

As emphasized throughout this report, the integrated team decision-making process is a central pillar of the success of this project and its predecessors. Collaboration between the owner, builder, architect, engineers, and subcontractors throughout the entire design process sets the stage for a high performance project on all fronts.

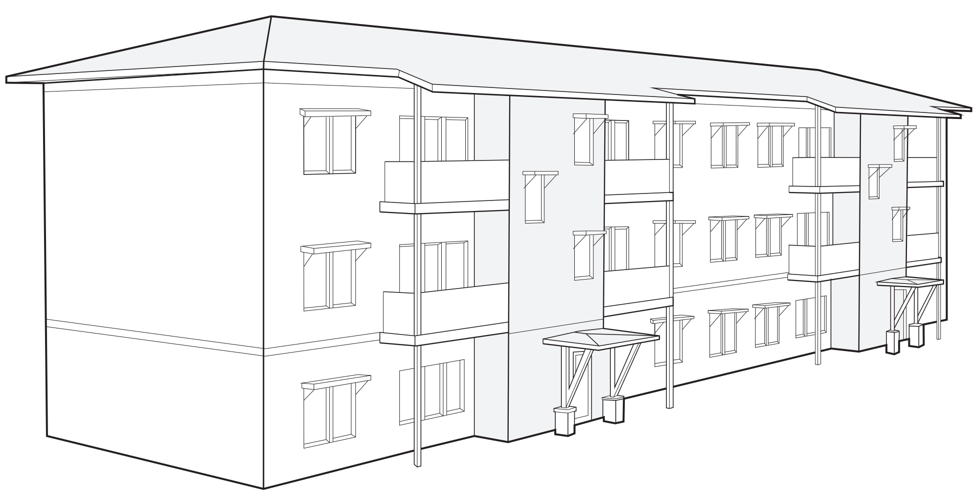


2 | Simplicity at all Scales

The simple, rectangular massing typical of multifamily projects is a win-win for thermal performance and cost effectiveness. Bump-outs help break down the scale visually, but should be deployed thoughtfully as they add complexity and cost. Simplicity at the detail level is also key to any project's performance. Simple air sealing details that don't require specialized products or installation knowledge are key to achieving high performance and cost-effectiveness simultaneously. Additionally, employing off-the-shelf HVAC equipment offers significant cost savings, both up-front and ongoing with maintenance.

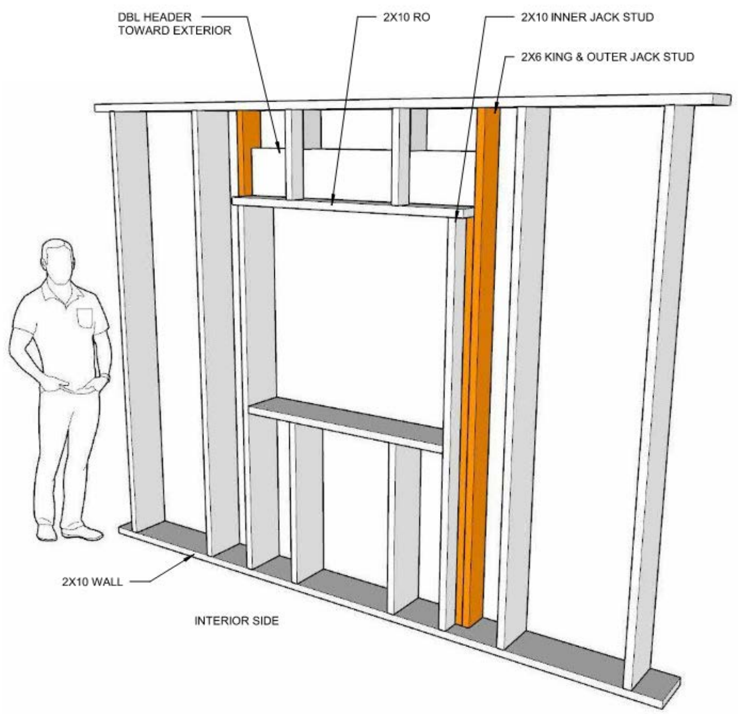
3 | Reduction of High-Carbon Materials

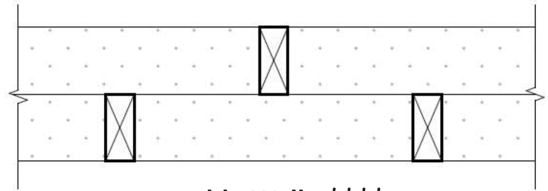
Reducing concrete, steel, and foam insulation from any project can simultaneously reduce costs and embodied carbon. EcoFlats' shallow frost-protected foundation eliminates all cost and carbon associated with concrete foundation walls and, depending on the site soils, also significantly reduces excavation costs. If this approach isn't viable, reducing the size of concrete footers, foundation walls, and slabs from standard dimensions is another path for significant concrete reduction. Similarly, going with wood framing over light-gauge metal framing is beneficial for both the bottom line and carbon footprint. Dense-packed cellulose insulation in the exterior walls and loose-fill cellulose insulation in the roof have proved to be good alternatives to high-carbon, costly spray foam insulation.



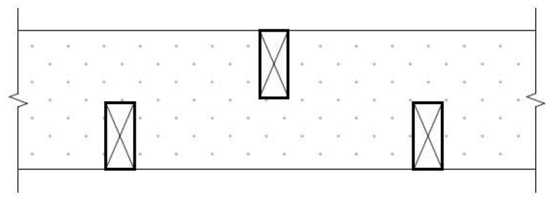
4 | Exterior Wall Assembly (2x10 with Cellulose Insulation)

Early on when exploring various wall assemblies for Net Zero Village, the team identified 2x10 framed walls with dense-packed cellulose cavity insulation as a low carbon and low cost assembly. Labor costs were lower than double wall or staggered stud assemblies because framers can follow their standard framing procedures and the deep studs provide an R-value of R-36. Black Mountain Architecture has adopted this wall assembly as their standard for single-family residential and light commercial projects.





Double Wall: $$$$



Staggered Stud Wall: $$

2x10 Wall: $

5 | Low-pitch Roof with Loose Fill Cellulose Insulation

The team has investigated many roof options and EcoFlats' 4:12 hipped roof is a Goldilocks solution that employs cost-effective materials and installation while also utilizing carbon storing cellulose insulation (with sufficient venting). The design team was initially drawn to a 10:12 gabled roof for aesthetic reasons, but the contractor pointed out that slopes steeper than 5:12 increase labor cost because installation requires scaffolding. For Solara Phase III, the team did a flat roof and vented attic. "The vented [flat] roof was a very expensive thing we would never do again," says owner/developer Dave Bruns. "Lots of wailing and gnashing of teeth over that."

6 | All-Electric Systems

Utilizing heat pumps for heating, cooling & hot water is an effective way to lower utility costs. Heat pump options have come a long way over the past ten years and continue to get more sophisticated and affordable.

EcoFlats' solar carports generate enough power to completely offset the project's electric load. This Net Zero synergy between electricity generation on site and all-electric building systems is highly replicable and can be incorporated into other multifamily projects around the country.

Lessons Learned & Takeaway

The conclusions described on the previous spread summarize key, actionable design strategies that can be implemented across a range of project types to support successful delivery of high-performing, cost-effective design.

- Integrated Project Delivery
- Simple Form & Detailing
- Reduction of High-Carbon Materials
- 2x10 Exterior Wall Assembly with Dense-Packed Cellulose
- Low-pitched Roof Assembly with Loose-Fill Cellulose
- All-Electric Systems
    - Heat Pumps for Heating, Cooling & Hot Water
    - PV Carports

These strategies are lessons learned over a decade of innovative exploration of pushing the envelope on what can be done in the realm of market-rate multifamily housing. The work is ongoing. Thanks to NYSERDA's continued incentives for low-carbon, Net Zero design and construction, these high performing, cost-efficient projects can be replicated and further improved.

Typical Building Entry & South Balconies | Black Mountain Architecture

APPENDICES

Abbreviations

Site Plan

Concept Floor Plans

EcoFlats BEAM Summary

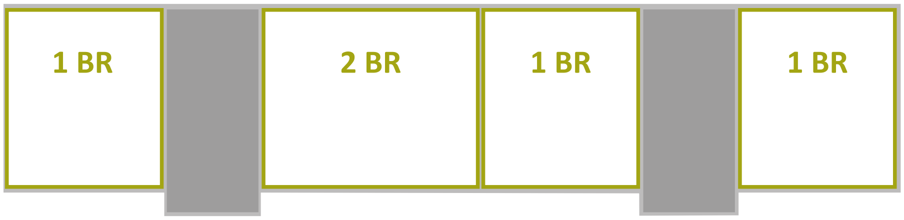
ABBREVIATIONS

ASCE	American Society of Civil Engineers
BEAM	Building Emissions Accounting for Materials
BOE	Buildings of Excellence
CPHC	Certified Passive House Consultant
DHW	Domestic Hot Water
EPS	Expanded Polystyrene (Insulation)
ERV	Energy Recovery Ventilator
GHG	Greenhouse Gases
HVAC	Heating, Ventilation and Air Conditioning
HFC	Hydrofluorocarbon
HFO	Hydrofluoroolefin
IAQ	Indoor Air Quality
IPD	Integrated Project Delivery
LVL	Laminated Veneer Lumber
LVT	Luxury Vinyl Tile
NYSERDA	New York State Energy Research and Development Authority
PHIUS	Passive House Institute of the United States
PV	Photovoltaic
SCM	Supplemental Cementitious Material

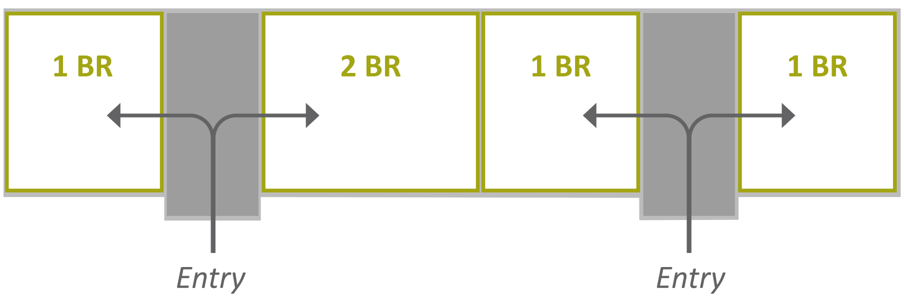
SITE PLAN

Not to Scale

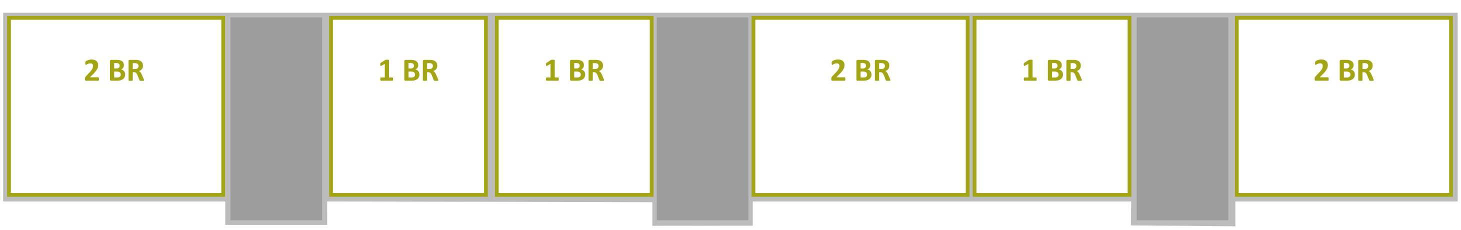
CONCEPT FLOOR PLANS



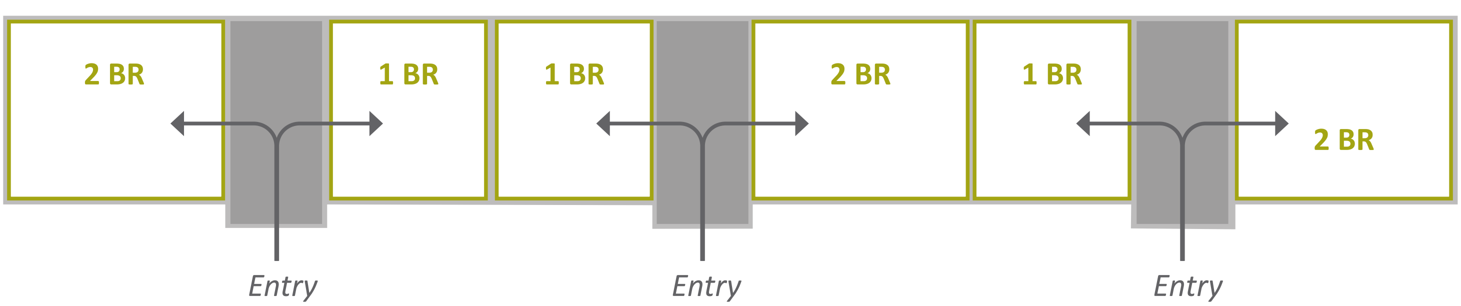
12-UNIT BUILDING | 2ND & 3RD FLOORS



12-UNIT BUILDING | 1ST FLOOR



18-UNIT BUILDING | 2ND & 3RD FLOORS



18-UNIT BUILDING | 1ST FLOOR

MATERIAL CARBON
PROJECT RESULTS

BUILDERS FOR CLIMATE ACTION BEAM

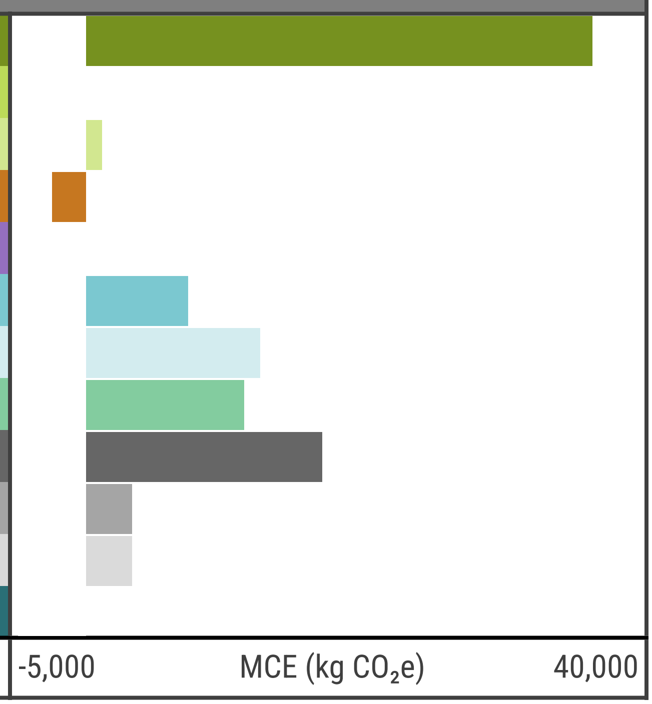
V1.1

PROJECT INFORMATION

Project Name	Eco Flats at Log City	**Construction Year**	2024
Scenario	Baseline	**Stories Above Grade**	3
Beam Version	V1.1	**Number of Bedrooms**	15
Design Firm(s)	Black Mountain Architectu		
Engineering Firm(s)	North Woods Engineering		
Builder / Developer	Ballston Mourningkill Asso	**CONDITIONED AREA**	
Development Project		**Above Grade**	221 ft²
Street Address		**Below Grade**	0 ft²
City	Amsterdam	**Total**	221 ft²
Country	United States		
Province / State	New York	**GROSS AREA**	
Building Type	Apartment (all units)	**Excluding Garage**	13065 ft²
Construction Type	New Construction	**Garage**	0 ft²
Project Stage	Construction Documents	**Total**	13065 ft²

MATERIAL CARBON EMISSIONS BY SECTION

Footings & Slabs	**36,638**	kg CO_2e
Foundation Walls	**0**	kg CO_2e
Structural Elements	**1,064**	kg CO_2e
Exterior Walls	**-2,493**	kg CO_2e
Party Walls	**0**	kg CO_2e
Cladding	**7,347**	kg CO_2e
Windows	**12,541**	kg CO_2e
Interior Walls	**11,393**	kg CO_2e
Floors	**17,057**	kg CO_2e
Ceilings	**3,343**	kg CO_2e
Roof	**3,238**	kg CO_2e
Garage	**0**	kg CO_2e
NET TOTAL	**90,129**	kg CO_2e



BEAM SUMMARY

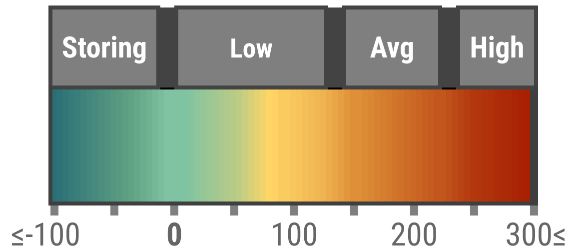
BEAM RESULTS

PROJECT EMISSIONS (MCE)

NET EMISSIONS kg CO_2e	GROSS EMISSIONS kg CO_2e	STORAGE SHORT CYCLE kg CO_2	STORAGE LONG CYCLE kg CO_2
90,129	111,621	21,493	0

PROJECT EMISSIONS INTENSITY (MCI)

	Metric kg CO_2e/m^2	Imperial lb CO_2e/ft^2
MCI Conditioned Floor Area	**4,390**	**899**
MCI Total Floor Area	74	15
MCI Per Bedroom	6,009	13,247



HIGHEST EMITTING MATERIALS

SECTION	kg CO_2e	MATERIAL
Footings & Slabs	13,251	Concrete - 3001-4000 psi, 20-29% Fly Ash / NRM
Windows	12,541	Window, triple-glazed, PVC-U frame, tilt & turn / [
Interior Walls	9,393	Drywall 5/8" Type X / Gypsum Association [Indus
Footings & Slabs	8,998	Concrete - 3001-4000 psi, 20-29% Fly Ash / NRM
Floors	7,561	Luxury Vinyl Tile / Resilient Floor Covering Institu
Cladding	4,499	Vinyl Siding / Vinyl Siding Institute / 0.040" Doub
Exterior Walls	3,993	OSB sheathing & barrier / Huber ZIP System / Ro
Footings & Slabs	3,802	Concrete - 4001-5000 psi, 20-29% Fly Ash / NRM
Footings & Slabs	3,395	Luxury Vinyl Tile / Resilient Floor Covering Institu
Ceilings	3,343	Drywall 5/8" Type X / Gypsum Association [Indus

HIGHEST CARBON-STORING MATERIALS

SECTION	kg CO_2e	MATERIAL
Exterior Walls	-10,330	Cellulose / dense pack / CIMA / R 3.7-inch / [Ind
Roof	-3,407	Cellulose / loose fill / CIMA / R 3.7-inch / [Indust