

Decarbonizing Family Housing CreekView Apartments Phase II

NYSERDA Early-Stage Design Report

CreekView Apartments Phase II
Canandaigua, NY

Owner: Baldwin Real Estate Development Corp

1950 Brighton Henrietta Town Line Road
Rochester, NY 14623

Report By: Sustainable Comfort, Inc.

55 Linden St
Worcester, MA 01609

Report Date: September 11, 2025

Table of Contents

Executive Summary	3
NYSERDA Early-Stage Design Support.....	4
Affordable Family Housing Concept.....	5
About Baldwin Real Estate.....	5
About Sustainable Comfort.....	5
Low Income Housing Tax Credits.....	5
8-Plex Design	6
Why Decarbonization	6
Riverknoll at Radisson	7
CreekView Apartments Phase I	8
CreekView Apartments Phase II	9
Operational Carbon Emissions Reductions.....	10
Measuring Operational Carbon Emissions.....	10
Operational Carbon Emissions	11
Advanced Envelope.....	11
Non-Energy Benefits.....	15
Mechanical System Performance.....	17
Ground Source System Design.....	17
Refrigerant Reduction	17
Demand Reduction.....	18
Energy Reduction.....	19
Maintenance Savings.....	19
Geothermal Heat Pump Incentives and Tax Credits.....	20
45L Energy Efficient Home Federal Tax Credit.....	20
Electrification and Renewable Energy	21
EV charging	21
Solar PV System.....	21
Energy Modeling Review.....	24
WUFI and Ekotrope Energy Modeling Comparison	24
CreekView Phase I Utility Cost Comparison.....	24
Embodied Carbon	27
Measuring Embodied Carbon via BEAM.....	27
Short Cycle Carbon Storage	28
Carbon Storage in Bio Based Materials.....	30
Bio-Based Material Alternatives	30
Total Net Emissions per Scenario.....	31
Embodied Carbon Summary	37
Appendix	38
Case Study Tear Sheet	38
Beam Embodied Carbon Results – CreekView Phase II.....	43
Beam Embodied Carbon Results – Low Embodied Carbon Option.....	45
Beam Embodied Carbon Results – Bio-Based Materials Option.....	47

Executive Summary

CreekView Apartments Phase II is the continuation of the development of a high-performance passive house community in Canandaigua. CreekView Phase II is striving to lower overall carbon emissions and achieve near Net-Zero energy performance while driving down the cost of high-performance building.

The NYSERDA Early-Stage Design Funding was utilized to quantify the deep carbon reductions compared to past projects of this type in the Baldwin Real Estate portfolio, which consists of:

- Riverknoll III: Completed in 2016, LEED Silver with Energy Star level insulation, gas fired heating and hot water, and traditional construction methods.
- CreekView Phase I: Completed in 2019, Certified to Phius 2015 demonstrated the viability of passive construction.
- CreekView Phase II: Currently in construction, this 72-unit project includes Phius-level insulation and air sealing with ground source heat pump mechanical systems, shared ERV's, and roof mounted PV systems to reduce overall carbon emissions.

Using carbon emissions modeling in Ekotrope for operational carbon and BEAM for embodied carbon, the 3 projects have been compared for their overall carbon impact over a 10-year period. Additionally, we explored what a theoretical future project could achieve with a focus on lowering up-front embodied carbon with a shift toward bio-based carbon storing materials to turn the entire project toward net carbon storage through sequestration of bio-based waste materials.

The portfolio of 8-plex projects has shown a dramatic decrease in carbon emissions from Riverknoll to CreekView Phase II design. The study will highlight each project performance and walk through the decarbonization features that lead to the continued reduction in carbon emissions, and end with an exploration of what it might mean to continue to regenerative bio-based design in the future.

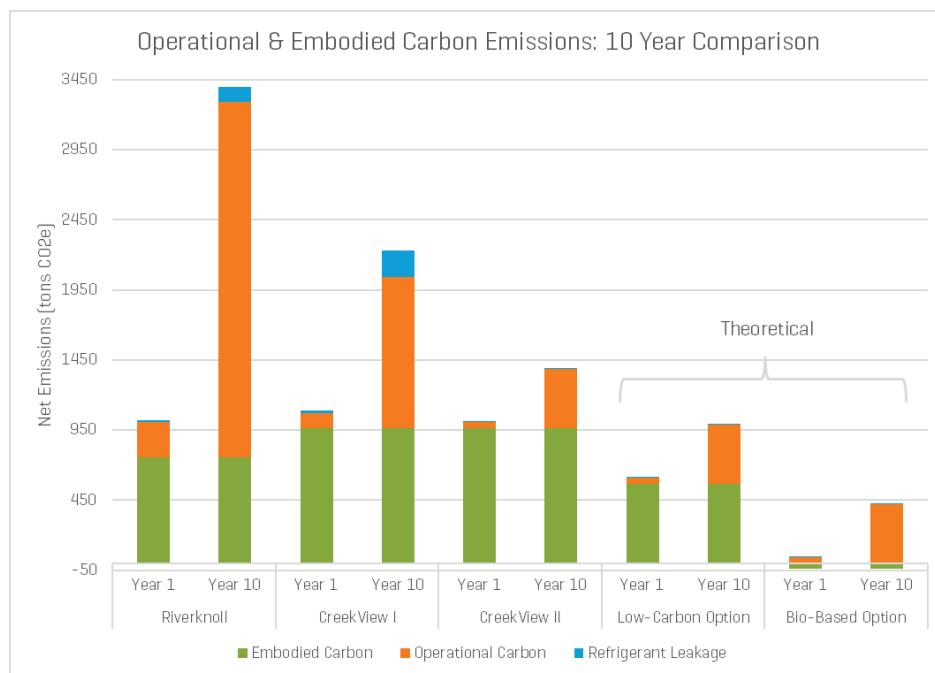


Figure 1: Carbon Emissions by Project

Figure 1 summarizes the results of the study of carbon emissions between the three study projects, and theoretical projects where embodied carbon reductions were the focus. The study shows a steady reduction in operational carbon emissions over the past decade between the projects. The operational carbon reduction between Riverknoll and CreekView Phase I was a result of the Passive House envelope and air tightness leading to a reduction in overall heating and cooling loads. The additional reduction between CreekView Phase I and CreekView Phase II is a result of the swap from individual Air Source Heat Pump systems to a centralized Ground Source Heat Pump with on-site solar PV systems for electricity generation. This has the added benefits of reducing carbon emissions due to refrigerant leakage.

The final portion of the study shows how a focus on embodied carbon on future projects could impact the overall carbon emissions of housing projects with a study of a low-carbon option which prioritizes material swaps to materials with lower embodied carbon. The bio-based materials option shows how a complete transformation to bio-based waste materials could transition housing to carbon storing in the future.

Figure 2 below shows the comparison between each project’s energy use and projected utility bills showing a steady reduction in overall site EUI and utility bills between each project. The theoretical low carbon and bio-based option use the same energy use as CreekView Phase II.

PROJECT	PROJECT TOTAL ENERGY USE						UTILITY BILL SUMMARY	
	ELECTRIC [KWH/YR]	GAS [THERMS/YR]	SOLAR [KWH/YR]	CARBON [TONS/YR]	SITE EUI [KBTU/SF]	SITE EUI WITH SOLAR [KBTU/SF]	MONTHLY ESTIMATED UTILITY BILLS	YEARLY ESTIMATED UTILITY BILLS
Riverknoll Total	297,850	24,595	-	254	49.6	50	\$ 7,706	\$ 92,472
CreekView I Total	511,800	1,327	-	108	27.0	27	\$ 7,613	\$ 91,351
CreekView II Total	513,072	-	353,808	42	24.6	8	\$ 4,548	\$ 54,572
				US Median EUI	59.6	59.6		
				Architecture 2030 Goal EUI	20-25	0.0		

Figure 2: Energy Modeling and Utility Comparison

NYSERDA Early-Stage Design Support

CreekView Phase II project participated in NYSERDA’s Early-Stage Design Support to move through design decisions to implement passive house design including ground source heat pumps and solar PV. The use of the early-stage design funds was integral to help expedite this design process and complete all third-party certification reviews as well as provide a thorough review of carbon emissions across the Baldwin portfolio of projects to assist future teams in decarbonizing projects. The early-design program funded this report, and also allowed the team to study future impacts of carbon reductions through embodied carbon and materials selections. Additional NYSERDA funding is provided by the NYSERDA Buildings of Excellence Demonstration Award, NYSERDA New Construction – Housing Program, and NY-SUN for solar incentives.

Affordable Family Housing Concept

To provide a context of the overall housing type and comparison we will first review the type of housing being built at CreekView Phase II and the corresponding study projects. CreekView Apartments Phase II is the latest development in the Baldwin Real Estate Portfolio which started construction in 2024 and is expanding on the success of CreekView Phase I completed in 2019. This 72-unit project includes 9 buildings with 1-bedroom, 2-bedroom, and 3-bedroom units featuring near net-zero energy performance, and deep decarbonization efforts.

About Baldwin Real Estate

All 3 housing projects are developed and managed by Baldwin Real Estate and built by DiMarco Constructors. Founded in 1991, Baldwin Real Estate Development specializes in innovative affordable housing development throughout New York State. Baldwin has developed over 1,500 units through new construction, renovation and adaptive re-use of existing buildings. Their vision is to develop, own and manage through a vertically integrated process to ensure high-quality communities that are sustainable for the long term. Their success in providing comfortable, affordable and convenient living can be attributed to a dedicated staff and strong partnerships formed with equity investors, local government, and state/federal agencies.

About Sustainable Comfort

Sustainable Comfort, Inc. (SCI) provides green building and energy efficiency consulting throughout the Northeast with a focus on lowering carbon emissions. SCI served as the Primary Energy Consultant on all 3 of the past projects explored in this study including Riverknoll III, CreekView Phase I, and CreekView Phase II where SCI serves as the Passive House Consultant (CPHC), Phius Verifier, HERS Rater, and NYSERDA Primary Energy Consultant. SCI serves through all stages of the project from early-stage planning and development, to design consulting, and construction inspections and monitoring. SCI was the primary energy consultant for this NYSERDA early-stage design study.

Low Income Housing Tax Credits

The type of financing is important to how these projects are ultimately developed and built. Baldwin Real Estate has a large and varied portfolio with a portion of their projects financed through Low-Income Housing Tax Credits (LIHTC). This federal tax credit is implemented by each state and involves competitive allocation of tax credits to worthy housing projects that are scored relative to their strength of providing needed affordable housing while minimizing first cost and long-term operating costs. The team's partnership with the NYS Housing and Community Renewal (HCR) has been integral to providing stable family housing to the finger lakes while prioritizing decarbonization in their selection criteria. All 3 projects have been primarily funded through the 9% Low Income Housing Tax Credit allocation with CreekView Phase II receiving funding from the HCR 9% Round in Fall 2023. The decarbonization effort has been a primary focus of the project being selected for HCR funding by obtaining points in the green building scoring category by including Passive House Certification and obtaining an additional points for inclusion of site solar PV and geothermal energy.

8-Plex Design

All 3 developments have nearly identical housing layouts making them easily comparable on energy and carbon performance. The 8-plex design allows for exterior entryways for all 8 apartments in the building, with 4 units on the first floor and 4 units above on the second floor. This design allows for both individual entryways, and 2 walls worth of exposure with a porch or balcony for each unit to access the outdoors. These layouts work well for affordable family apartments allowing a mix of bedroom count, and direct access to the outside for each apartment.

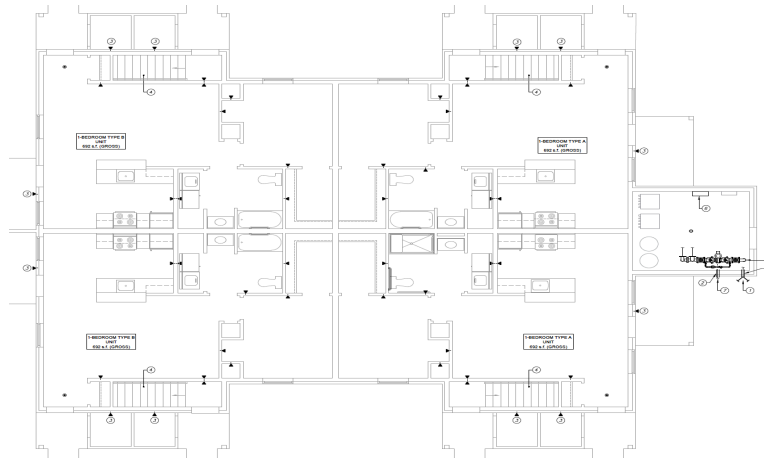


Figure 3: 8-Plex First Floor Plans [Credit: SWBR Architects]

Why Decarbonization

The focus on decarbonization in the past decade and increased adoption has been driven by a few factors, primarily:

1. **Rules/Regulations:** New York State passed the NY Climate Leadership and Community Protection Act (CLCPA) to demonstrate a commitment to decarbonization. This provides a mandate to decarbonize every industry in the state. In affordable housing this has driven a very rapid focus on electrification of housing through policies and rules through all HCR programming, including the release of sustainability design guidelines. These policies pushed each project to include deeper decarbonization measures to obtain project funding.
2. **Access to capital & incentives:** In addition to policy regulations, there are additional funding sources available to capitalize on deeper energy reduction and decarbonization. CreekView Phase II has been able to access additional funds through NYSERDA Buildings of Excellence Demonstration Award, NYSERDA New Construction – Housing, Federal Solar and Geothermal Tax Credits, and state solar (NY-Sun) and geothermal incentives (NY Clean Heat). These programs help offset the additional up-front costs of certain programs.
3. **Lower operating costs and energy use:** Lowering operating costs by decreasing heating and cooling needs is more important as homes are switching to all electric heat pump systems. Due to rising electric prices, electric heat pumps can result in large increases in winter electricity bills without a reduction in heating loads, and additional attention to providing comfortable warm spaces. Reducing maintenance and simplifying systems was a focus of the CreekView Phase II design.

Riverknoll at Radisson



Completed in 2015, Riverknoll at Radisson Phase 3 is an affordable, low-income housing community offering one-, two- and three-bedroom units in Baldwinsville, NY. The project achieved Energy Star Homes V3.0, NYSERDA Low Rise New Construction Program, and LEED for Homes Silver. These homes featured gas furnaces gas hot water, and Energy Star levels of insulation resulting in above-code performance. Assemblies were selected for first cost and Energy Star compliance and represents a typical affordable housing construction project in the region.

Riverknoll Construction

HERS Index	64
Carbon Index	128
Wall	R-21 batt advanced framing
Windows	U-0.3, SHGC-0.26
Air Barrier	Taped Tyvek
Roof	R-38 Batts
Slab	R-10 4' Depth
Heating/Cooling	Gas Furnaces, 14 SEER AC
Ventilation	Exhaust Only
Hot Water	0.67 EF Gas Storage
Appliances	Energy Star Appliances
Lighting	LED/CFL Lighting

Energy and Carbon

Tenants pay their own electric and gas bills at Riverknoll, and all heating and hot water systems are gas-based systems. The project included above code energy performance with an average HERS Index of 64, and ~\$92,000/year operating cost. Note: Energy performance is pro-rated to an equivalently sized 72-unit property to match CreekView Phase II. Riverknoll estimates 254 tons of operational carbon emissions.

UNIT TYPE	AREA	APARTMENT ENERGY USE				UTILITY BILL SUMMARY	
		ELECTRIC [KWH/YR]	GAS [THERMS/YR]	CARBON [TONS/YR]	SITE EUI [KBTU/SF]	MONTHLY ESTIMATED UTILITY BILLS	YEARLY ESTIMATED UTILITY BILLS
Riverknoll 1BR	780	3,517	274	2.8	50.4	\$ 96	\$ 1,147
Riverknoll 2BR	926	4,060	345	3.4	52.3	\$ 106	\$ 1,277
Riverknoll 3BR	1,214	4,834	406	4.4	47.0	\$ 119	\$ 1,429
Riverknoll 72-Unit Total	70,080	297,850	24,595	254	49.6	\$ 7,706	\$ 92,472

Figure 4: Riverknoll Energy and Carbon Performance. Utility costs assume \$0.13/kWh and \$22/month meter fees

CreekView Apartments Phase I



Completed in 2019, CreekView Phase I is the first Phius Certified affordable housing project in Upstate New York. Phius was included to maximize scoring for the HCR 9% round. The design features high performance assemblies including continuous exterior insulation, fluid applied air barrier, and triple pane casement windows. Individual air source heat pumps and energy recovery ventilation are provided for each unit.

CreekView I Construction

HERS Index	46
Carbon Index	51
Wall	R-37 Total: R-21 Cavity + R-19ci
Windows	U-0.15, SHGC-0.33 Casements
Air Barrier	Fluid applied air barriers
Roof	R-59- 78 Blown in
Slab	R-15 continuous under slab
Heating/Cooling	Ductless Mini Splits, 10 HSPF 18 SEER
Ventilation	Unitary Energy Recovery Ventilation
Hot Water	1 BR: Instant Gas, 2-3BR: Electric Resistance
Appliances	Energy Star Appliances
Lighting	LED Lighting

Energy and Carbon

The project features air source heat pumps and heat pump water heaters, with instantaneous gas hot water heaters provided at the 1-bedroom apartments. The impact of super insulation along with electrification resulted in a 57% operational carbon emissions reduction compared to Riverknoll. However, due to rising electric costs, the utility estimates are roughly equivalent at ~\$91,000/year. Note: Energy performance is pro-rated to an equivalently sized 72-unit property to match CreekView Phase II. Phase I estimates 108 tons of operational carbon emissions, a 57% reduction from Riverknoll.

UNIT TYPE	APARTMENT ENERGY USE					UTILITY BILL SUMMARY	
	AREA	ELECTRIC (KWH/YR)	GAS (THERMS/YR)	CARBON (TONS/YR)	SITE EUI (KBTU/SF)	MONTHLY ESTIMATED UTILITY BILLS	YEARLY ESTIMATED UTILITY BILLS
Creekview I 1BR 1st	718	4,361	56	1.3	28.5	\$ 89	\$ 1,073
Creekview I 1BR 2nd	840	4,575	55	1.3	25.1	\$ 92	\$ 1,101
CreekView I 2BR 1st	865	7,386	-	1.4	29.1	\$ 102	\$ 1,224
CreekView I 2BR 2nd	966	7,726	-	1.5	27.3	\$ 106	\$ 1,268
CreekView I 3BR 1st	1,150	9,023	-	1.7	26.8	\$ 120	\$ 1,437
CreekView I 3BR 2nd	1,259	9,579	-	1.8	26.0	\$ 126	\$ 1,509
CreekView I 72-Unit Total	69,576	511,800	1,327	108	27.0	\$ 7,613	\$ 91,351

Figure 5: CreekView Phase I Energy and Carbon Performance. Utility costs assume \$0.13/kWh and \$22/month meter fees

CreekView Apartments Phase II



CreekView Apartments Phase II has taken the Plius Certified design from Phase I and has simplified the mechanical approach. The individual mini splits and ERV's from Phase I led to many extra building penetrations, larger refrigerant runs, and higher filter maintenance. Phase II uses ground source heat pumps for heating, cooling, and DHW which increases efficiency, and reduces peak load demand. The central ventilation reduces maintenance and increases accessibility to filter changes.

Energy and Carbon

Phase II estimates 42 tons of operational carbon emissions, a 61% reduction from CreekView Phase I, and an 83% reduction from Riverknoll due to the solar PV system and ground source heat pump system. The roof mounted solar arrays are designed to maximize the solar production and achieve near net-zero performance with an average HERS 11 with estimated utility bills of \$54,572/year.

CreekView II Construction

HERS Index	11
Carbon Index	20
Wall	R-37 Total: R-21 Cavity + R-19ci
Windows	U-0.15, SHGC-0.33 Casements
Air Barrier	Fluid applied air barriers
Roof	R-59- 78 Blown in
Slab	R- 15 continuous under slab
Heating/Cooling	Ground Source Heat Pumps
Ventilation	Central Energy Recovery Ventilation
Hot Water	Ground Source Heat Pumps
Appliances	Energy Star Appliances
Lighting	LED Lighting
Solar	Rooftop PV
EV Charging	EV Charging

UNIT TYPE	AREA	APARTMENT ENERGY USE				UTILITY BILL SUMMARY		
		ELECTRIC [KWH/YR]	CARBON [TONS/YR]	SOLAR KWH PRODUCED	SITE EUI [KBTU/SF]	MONTHLY ESTIMATED UTILITY BILLS	YEARLY ESTIMATED UTILITY BILLS	
Creekview II 1BR 1st	732	5,722	0.5	3,701	9.4	\$ 57	\$ 682	
Creekview II 1BR 2nd	844	6,418	0.6	3,701	11.0	\$ 64	\$ 773	
CreekView II 2BR 1st	883	6,769	0.5	5,213	6.0	\$ 57	\$ 685	
CreekView II 2BR 2nd	992	7,242	0.6	5,213	7.0	\$ 62	\$ 747	
CreekView II 3BR 1st	1,177	7,900	0.6	5,828	6.0	\$ 65	\$ 778	
CreekView II 3BR 2nd	1,295	8,705	0.7	5,828	7.6	\$ 74	\$ 883	
CreekView II 72 Unit Total	71,076	513,072	42	353,808	24.6	\$ 4,548	\$ 54,572	

Figure 6: CreekView Phase II Energy and Carbon Performance. Utility costs assume \$0.13/kWh, \$0.088/kWh solar credit and \$22/month meter fees

Operational Carbon Emissions Reductions

First, to understand and compare projects, we must set a comparison point to use to be able to compare carbon emissions, and then review the features and details taken to reduce carbon emissions through the project design, including envelope approach, mechanical approach, and how each system reduces carbon emissions. To follow, each feature will be reviewed for its carbon reduction and any lessons from CreekView Phase I implemented into the CreekView Phase II design.

Measuring Operational Carbon Emissions

The HERS® Carbon Index provides a more accurate metric to measure emissions, addresses when energy is used in a home, as well as how much can be reduced. A RESNET® accredited HERS software program will take the information entered for a HERS Rating and calculate the Carbon Rating Index Score. The Carbon Rating Index allows a measure of the operational carbon emissions associated with a given home design and considers when the energy is used and overall emissions factors of the energy sources being used.



By focusing on the carbon emissions reductions, you can see below that while the energy use and HERS index has declined from 64 at Riverknoll to 11 at CreekView Phase II, the Carbon Index has dropped from a 128 to a 20 showing additional carbon savings with each subsequent design.

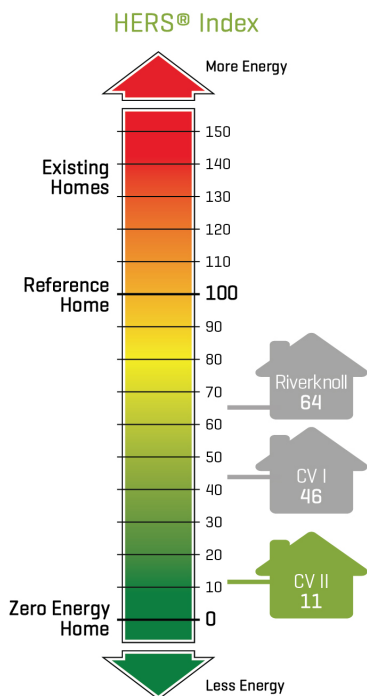


Figure 7: HERS Index

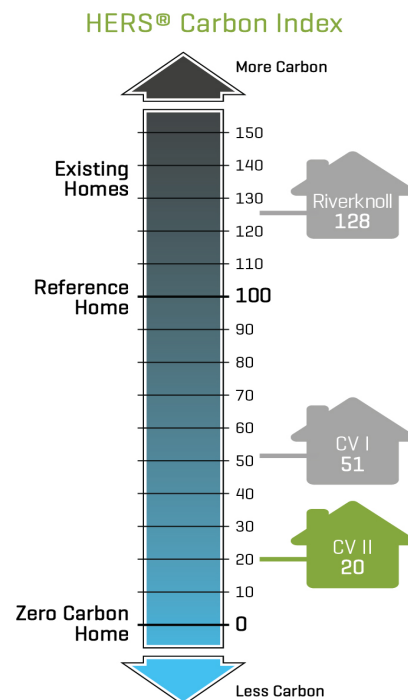


Figure 8: Carbon Index

Operational Carbon Emissions

To compare the overall carbon emissions of the projects, they are compared using carbon emissions at year 1 and 10. Carbon emissions were calculated to show the progression of carbon reductions over time. The operational carbon emissions are shown below at year 1 and year 10 based on the Ekotrope Carbon Rating Index and an estimate of refrigerant leakage assuming 3% annual leakage [described later in the report].

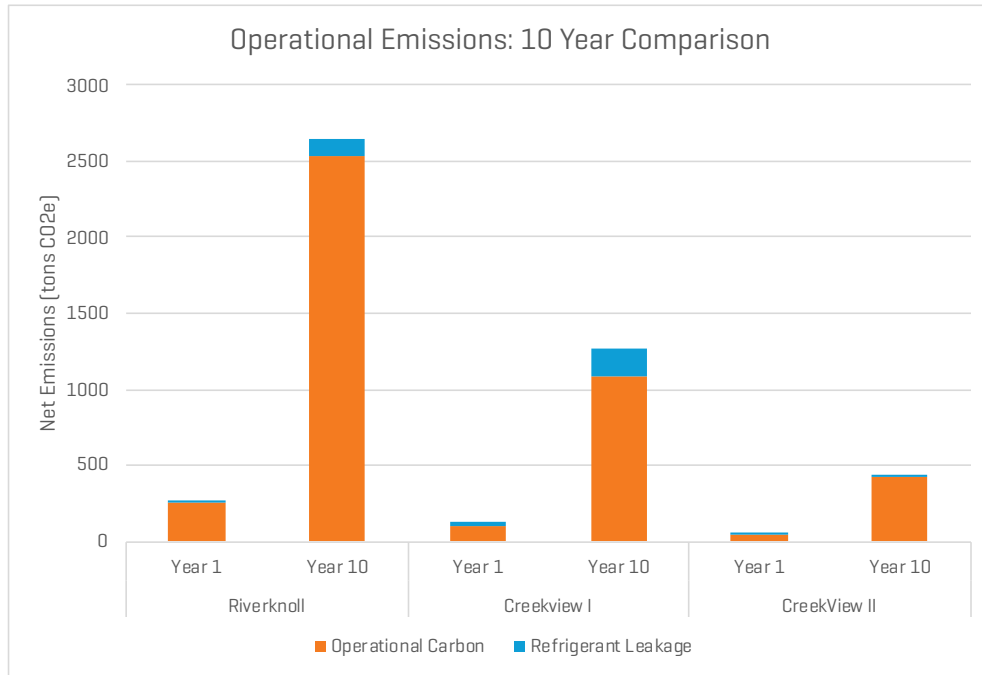


Figure 9: Operational Carbon Emissions

Advanced Envelope

The primary carbon emissions reduction between Riverknoll and Creekevew Phase I was due to the advanced Passive House compliant envelope. To follow is a description of the features of the advanced envelope leading to the carbon reductions. The envelope performance from the Phius Certified Creekevew Phase I was carried over into the design of Phase II, which is summarized below, and highlights any updates from lessons learned on Phase I.

Exterior Walls

The wall design [Figure below] consists of panelized 2x6, 16" oc wood stud walls with OSB sheathing filled with R-21 batt insulation. Following the installation of the wood studs, the exterior is coated with a Prosoco fluid applied air barrier to ensure the air tightness of the building, including at connections to windows. Outside of the wall, a Hunter Panel consisting of 3" polyiso insulation with integral OSB sheathing is applied for the continuous insulation, and the exterior siding is attached to the outside of the panel. Tyvek serves as the drainage plane outside of the Hunter Panel. This design has been proven at Phase I to be effective at achieving the stringent air leakage target of 0.06 CFM50/sf of enclosure. Lessons learned from Phase I include:

- Selecting a fluid applied air barrier that self-seals and provides full coverage.

- Allow for time for preliminary blower door testing prior to drywall and rigid insulation.
- Window bucks may be required either using thermal bucks or blocking; ensure air barrier wraps around window buck to connect to window.
- Interior spray foam did not contribute to air tightness. One building was spray foamed in the interior cavities to see if it provided air sealing benefit and the blower door results showed limited benefits to the interior cavities as any remaining air leakage was occurring at seams between exterior sheathing.
- Door thresholds require extra attention for air sealing.

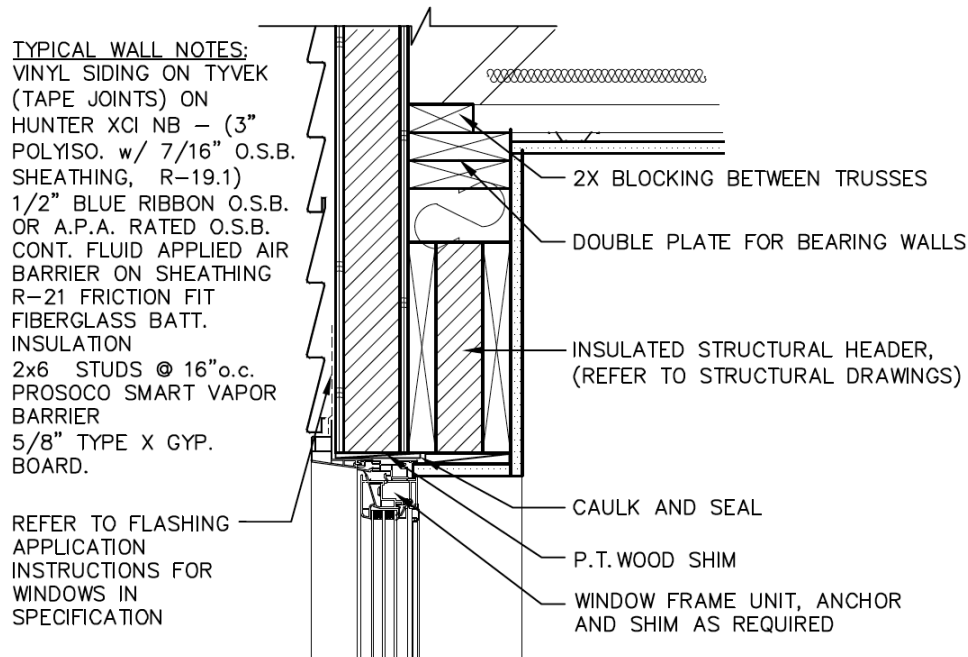


Figure 10: Wall Section [Drawings by SWBR]

Ceilings

Ceilings are insulated with blown in cellulose insulation ranging from R-59 to 78 depending on building type above a continuous air barrier layer. The architect and contractor have worked out 3 possible air sealing strategies to give options to create an air-tight ceiling layer, shown below.

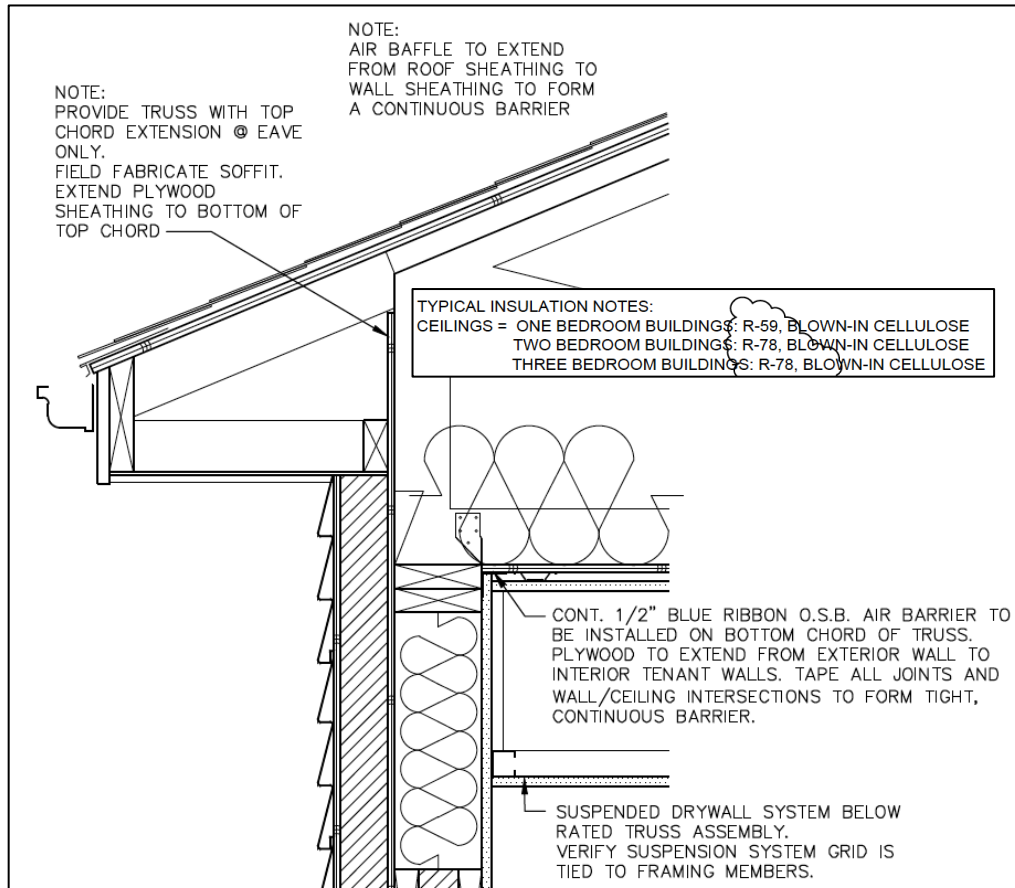


Figure 11: Ceiling detail and insulation levels [Drawings by SWBR]

<p>PRIMARY AIR BARRIER AT SECOND FLOOR CEILING:</p> <p>OPTION #1 - CONT. 1/2" BLUE RIBBON O.S.B. AIR BARRIER TO BE INSTALLED ON BOTTOM CHORD OF TRUSS. O.S.B. TO EXTEND FROM EXTERIOR WALL TO INTERIOR TENANT WALLS. TOUCH AND SEAL/PROSSOCO ALL JOINTS AND WALL/CEILING INTERSECTIONS TO FORM TIGHT, CONTINUOUS BARRIER, 5/8" GYPSUM BOARD, PAINTED</p> <p>OPTION #2 - PROVIDE CERTAINTEED SMART MEMBRAN ABOVE 1/2" BLUE RIBBON O.S.B. AIR BARRIER TO BE INSTALLED ON BOTTOM CHORD OF TRUSS. O.S.B. TO EXTEND FROM EXTERIOR WALL TO INTERIOR TENANT WALLS. TOUCH AND SEAL/PROSOCCO ALL JOINTS AND WALL/CEILING INTERSECTIONS TO FORM TIGHT, CONTINUOUS BARRIER, 5/8" GYPSUM BOARD</p> <p>OPTION #3 - CONT. 1/2" BLUE RIBBON O.S.B. AIR BARRIER TO BE INSTALLED ON BOTTOM CHORD OF TRUSS. O.S.B. TO EXTEND FROM EXTERIOR WALL TO INTERIOR TENANT WALLS. PROVIDE FULL COVERAGE PROSSOCO CONT. AIR BARRIER TOUCH AND SEAL/PROSSOCO TO FORM TIGHT, R, 5/8" GYPSUM BOARD,</p>
--

Figure 12: Ceiling air barrier options [Drawings by SWBR]

Slab Insulation

The slab has been designed to be thermal bridge free using THERM heat loss analysis software. To achieve this, the exterior foundation wall includes continuous rigid insulation connecting and extending down from the continuous exterior wall insulation below grade 4'. On the interior side the R-15 under slab insulation connects to the wall beneath the 2x6 bottom plate via a smaller 4" foundation block and 2" of foam to connect the under-slab insulation to the interior wall. This will reduce all cold

points and condensation potential at the interior of the slab. R-15 insulation included beneath all the slabs to reduce heat flow to the ground.

The introduction of the smaller 4" foundation block and 2" foam under the bottom plate was driven by the Passive House requirement to conduct thermal bridge modeling to reduce potential for condensation at slab edges and minimize energy use.

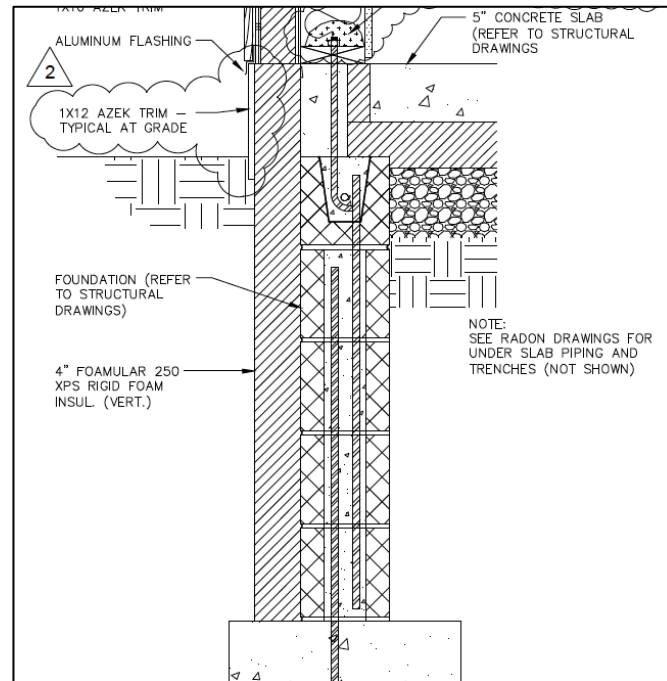


Figure 13: Slab and foundation detail [Drawings by SWBR]

Windows/Doors

The project will use Kohltech triple-pane windows with operable casement windows above fixed windows and passive house doors. This product was used in Phase I and selected based on regional availability in Upstate New York and was an affordable triple pane option. The project will use doors that meet the ADA accessibility guidelines, which do not always allow for the same level of air tightness as a higher threshold. The contractor was able to demonstrate during Phase I the low threshold doors can be successfully installed and achieve the air tightness target of 0.06 CFM50/sf of enclosure.

The design of the windows was selected to provide maximum views from the interior, minimize air leakage, and meet accessibility requirements. The lower fixed window provides fall protection with only the upper part of the window operable using air-tight casement openings.

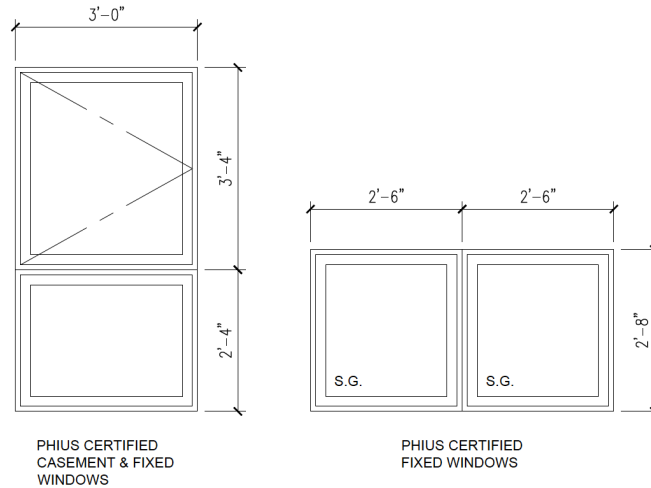


Figure 14: Window Layout, operable casement over fixed, and fixed windows in select areas [Drawings by SWBR]

Non-Energy Benefits

There are additional benefits to the Phius-certified and fully electrified approach to construction employed at CreekView Phase II. The following are some features of highly insulated Passive House projects.

Resiliency and Passive Survivability

The advanced envelope and air tightness support a resilient building design which will retain heat during power outages and require less heating and cooling. Compared to the envelope design at Riverknoll, the CreekView Phase II design uses 63% less energy for heating [Figure below] and will result in more internal comfort due to the reduced air infiltration, triple pane windows, and energy recovery ventilation system. This reduces the utility burden at the property.

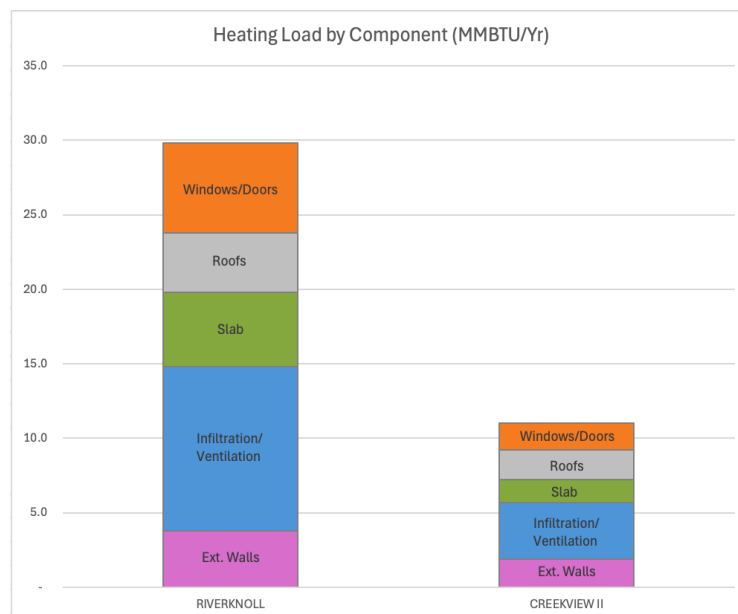


Figure 15: Component heating loads from Ekotrope for a 2-bedroom unit with Passive House infiltration

Noise Reduction

CreekView is located within 1 mile of the Canandaigua Motorsports Park which hosts a variety of dirt track racing car events throughout the year. Affordable housing properties are many times located near noisy locations such as train lines and highways that contribute higher sound and therefore require measures to dampen and reduce sound transfer. At CreekView Phase II the highly insulated envelope and triple pane windows contribute to a lower sound transfer with filtered fresh air allowing for less times where windows would need to be opened.

Healthy Indoor Air Quality

No fossil fuel burning equipment in the unit or on the property contributes to less chance of carbon monoxide exposure, and greater internal air quality. The ERV's on site provide filtration and distribution of fresh air to all areas of the apartments contributing to healthier indoor air quality.

Low Emitting Materials

The EPA Indoor AirPLUS program is a requirement of the Phius program and is being pursued on this project to reduce the emissions of the materials selected. These requirements extend to indoor paints, adhesives, and sealants as well as flooring, and composite wood products. Since this require was also in CreekView Phase I, the selection of finishes and products has remained similar between CreekView Phase I and Phase II.

Mechanical System Performance

CreekView Phase II uses all electric systems via ground source heat pumps. This decision was made with several factors in mind, including:

- Maintenance Savings: The individual mini split heads in Phase I results in distributed heads in each room, which require regular filter cleaning at each head and maintenance of individual exterior condensers for each unit. This led to difficulties to the on-site maintenance team to maintain the systems, and a recommendation to simplify the mechanical systems.
- Energy Savings and Demand Reduction: The stable ground temperatures create more uniform heat pump efficiencies.
- Local Contractor Network: The installing contractor of the Air Source Heat Pumps [ASHP] for Phase I recommended the ground source heat pump systems to simplify installation. Having a local vendor who understands soil conditions in the area and can properly price and communicate system benefits is critical to adoption to overcome the early skepticism that can occur with ground source systems.

Ground Source System Design

The ground source heat pump system uses the Enertech NV060 to provide 100% of each building's heating/cooling and domestic hot water needs. These buildings are cooling dominant as determined by the load sizing calculations which allows for a ground loop to be sized to handle the load of the buildings while taking the extra energy generated in cooling to produce 100% of the units' domestic hot water. This application also limits the variability of the ground loop entering water temperature [EWT]. Ultimately, the building ends up with a balanced load between heating/cooling and DHW.

The project's geothermal well field was designed and based on square feet per ton of base heating and cooling load in a residential setting. Building type, A, for the 1-bedroom units, has a field size of 3 by 400', which is slightly oversized. Building types B & C, for the 2- and 3-bedroom units respectively, a 4 by 400' is slightly oversized, as well. The same geothermal contractor worked on CreekView Apartments Phase I, so the design was informed by the contractor's familiarity with the building's operational performance once the occupants moved in. The design is utilizing 1 borehole per building, which acts as, essentially, a buffer for the domestic hot water system.

Refrigerant Reduction

CreekView Phase II results in a 97% reduction in predicted emissions per year due to minimized impacts of refrigerant leakage of <1 ton of CO2 equivalent emissions compared to 18 tons of CO2 equivalent at CreekView Phase I assuming 3% annual leakage. This is provided by reducing the overall refrigerant amount used, and swapping to R-454B with a lower Global Warming Potential [GWP].

CreekView Phase II includes two factory charged water-to-water heat pumps in each 1- and 2-bedroom building and three heat pumps in the 3-bedroom building. Assuming a charge of 5.5 pounds of R-454B refrigerant with a GWP of 466. These heat pumps include 115lbs of refrigerant across the entire project. Assuming a 1-3% leakage rate per year results in 0.27 Ton to 0.8 Tons CO2 equivalent attributed to refrigerant leakage per year. A study released by Efficiency Maine in March 2022 on Refrigerant Leakage Assessment found a 1-3% annual leakage rate for central AC systems.

CreekView Phase I included a separate mini split heat pump for each apartment with R-410A refrigerant lines running to each individual indoor head from the outdoor condenser. The field connections lead to a higher risk of leakage compared to factory charged equipment. The R-410A has a Global Warming Potential [GWP] of 2,088. The total CreekView Phase I Project is estimated to leak 6.2 - 18.7 Tons/year CO2 equivalent. A breakdown of estimated refrigerant usage for the Samsung AJ020MCS3 equipment which came factory charged with 7.3lbs plus 0.22oz/ft over 131 ft of refrigerant piping:

- 1 Bedroom: 175 lbs. for all 1BR results in 1.8 Tons – 5.4 Tons CO2 equivalent leakage per year
- 2 Bedroom: 200 lbs. for all 2BR results in 2.1 – 6.3 Tons CO2 equivalent leakage per year
- 3 Bedroom: 225 lbs. for all 3BR results in 2.3 – 7.0 Tons CO2 equivalent leakage per year

Riverknoll III included individual AC condensers for each unit factory charged with 4.8lbs of R-410A resulting in 3.6 - 10.8 Tons CO2 equivalent leakage per year at a 1-3% leakage rate.

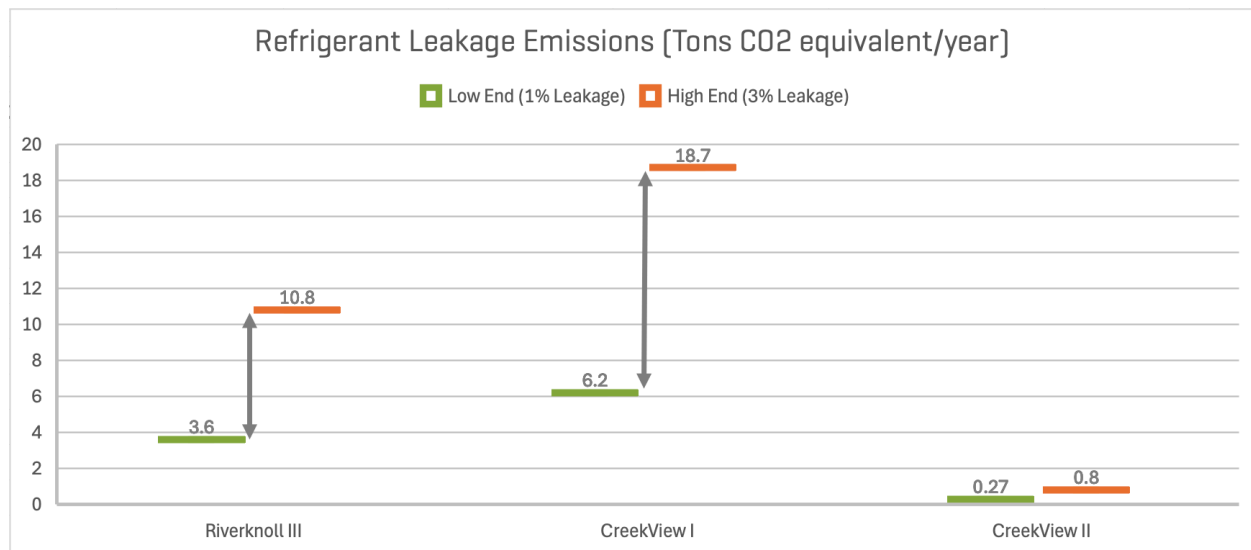


Figure 16: Refrigerant leakage emissions assuming 1-3% annual leakage

Demand Reduction

The design between CreekView Phase I and CreekView Phase II served to reduce the peak demand on the grid using ground source heat pump system for heating, cooling, and hot water. Phase I used air source heat pumps and electric resistance hot water heating. The Ekotrope energy modeling shows an 18% reduction in peak demand [kW] between Phase I and II. The peak for both situations occurs in the winter months. The summer peak is lower than the winter peak.

Peak load reduction is an important consideration for utility companies and communities by:

- Reducing overall load to the site and reducing infrastructure costs
- Reducing fees and costs for utility interconnection. Large electric projects have seen significant fees to interconnect when their loads are too high.
- Reducing operating costs when on demand rates such as commercial meters for residential common areas or master metering.

UNIT TYPE	PEAK ELECTRIC DEMAND [KW]		
	CREEKVIEW I DEMAND [KW]	CREEKVIEW II DEMAND [KW]	SAVINGS
2 Bedroom 1st Fl	1.41	1.17	17%
2 Bedroom 2nd Fl	1.51	1.24	18%
3 Bedroom 1st Fl	1.70	1.39	18%
3 Bedroom 2nd Fl	1.87	1.53	18%

Figure 17: Peak Demand Reduction. 1 Bedroom units excluded due to the use of gas DHW in Phase I

Energy Reduction

The total electrical use for the units is reduced due to the use of the ground source heat pump system by an average of 9% compared to CreekView Phase I. Below is the total electrical usage for each unit type. The 1-bedroom units are excluded due to the use of gas hot water in Phase I.

The energy use reduction directly translates into lower utilities for the project. The average monthly cost for each apartment type is also shown, the cost of CreekView Phase II also benefits from the solar PV to reduce operating costs.

UNIT TYPE	TOTAL ELECTRIC USAGE & UTILITY COST				
	CREEKVIEW I [KWh/Yr]	CREEKVIEW II [KWh/Yr]	ENERGY SAVINGS	CREEKVIEW I [\$ /Month]	CREEKVIEW II [\$ /Month]
2 Bedroom 1st Fl	7,386	6,769	8%	\$ 102	\$ 57
2 Bedroom 2nd Fl	7,726	7,242	6%	\$ 106	\$ 62
3 Bedroom 1st Fl	9,023	7,900	12%	\$ 120	\$ 65
3 Bedroom 2nd Fl	9,579	8,705	9%	\$ 126	\$ 74

Figure 18: Electric use reduction. 1 Bedroom units excluded due to the use of gas DHW in Phase I. Utility costs assume \$0.13/kWh, \$0.088/kWh solar credits and \$22/month meter fees

Maintenance Savings

There are anticipated maintenance savings in the CreekView Phase II design. The individual mini split heads in CreekView Phase I require 216 blower heads that need to be cleaned monthly in every room of every dwelling. CreekView Phase II has ERV filter changes needed every 3-6 months in the exterior mechanical room which is easily accessible by the maintenance staff.

CreekView Phase II also moved toward a central Energy Recovery Ventilation (ERV) system compared to CreekView Phase I where individual ERV's were installed in each unit. The installation costs of central vs. individual ERV's was comparable, with reduced maintenance costs the primary decision to swap to central in Phase II.

The savings for the system are anticipated in reduced maintenance. There is projected to be about half the amount of ERV filter changes between Phase I and II. A highlight of the central ERV design in Phase II is that filter replacement happens within a central mechanical room. With the individual ERV design in Phase I, filter replacement is done with the dwelling units. The ability for maintenance staff to access the equipment within a common room is much preferred and simpler. Maintenance plans for

monthly filter changes and a core change every 8-10 years. This service is required for both phases; however, Phase II will have less equipment to be maintained.

Geothermal Heat Pump Incentives and Tax Credits

There are several options when evaluating the economic impact of installing ground source/geothermal heat pumps. These options include a 30% Federal Tax Credit [refundable to Not-For-Profit entities, under 1MW HP capacity], up to a 10% Federal Tax Credit [Domestic content]. Due to recent changes to federal policy, future projects should review tax credit availability for each project. There are also custom incentives from New York State Clean Heat program, which are estimated at around \$80 per MMBtu saved versus a baseline approach. The total incentive is still being investigated with the clean heat team.

45L Energy Efficient Home Federal Tax Credit

The 45L Energy Efficient Home tax credit has been available for projects certifying to Energy Star and DOE Zero Energy Ready Homes and the CreekView Phase II may be eligible for \$1,000/unit tax credit. Due to recent federal legislation, these credits are set to expire in 2026 and should be reviewed for any specific project for availability.

Electrification and Renewable Energy

In addition to the all-electric building design, CreekView Phase II supports a holistic electrification approach by utilizing on site Solar PV to fill the available roof space, and EV charging stations to encourage convenient vehicle electrification in the future.

EV charging

Six [6] functioning EV charging stations are being installed at the clubhouse building as a central location for existing Phase I and future Phase II residents. In addition, there are thirty-six [36] EV-capable parking spots to allow for future expansion. Four [4] EV-capable spaces are in front of each of the nine [9] proposed buildings to distribute future EV charging stations equitably throughout Phase II. The EV capable charging spaces are driven by the Plius requirements to provide future opportunity for providing EV charging easily once there is more demand for EV charging.

Solar PV System

The Solar PV design was taken to maximize the solar production from the project. This included deciding to locate all buildings along an East/West orientation to allow panels on both sides of the roof to produce energy and maximize the overall PV production from the project site. The respective building solar designs are shown below:

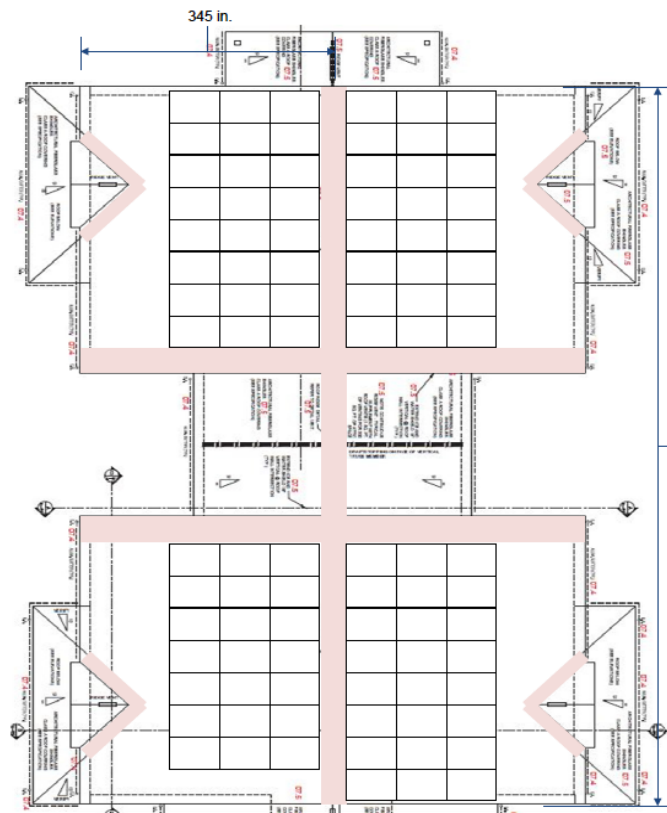


Figure 19: Two Bedroom Building - 39.9 kW Solar

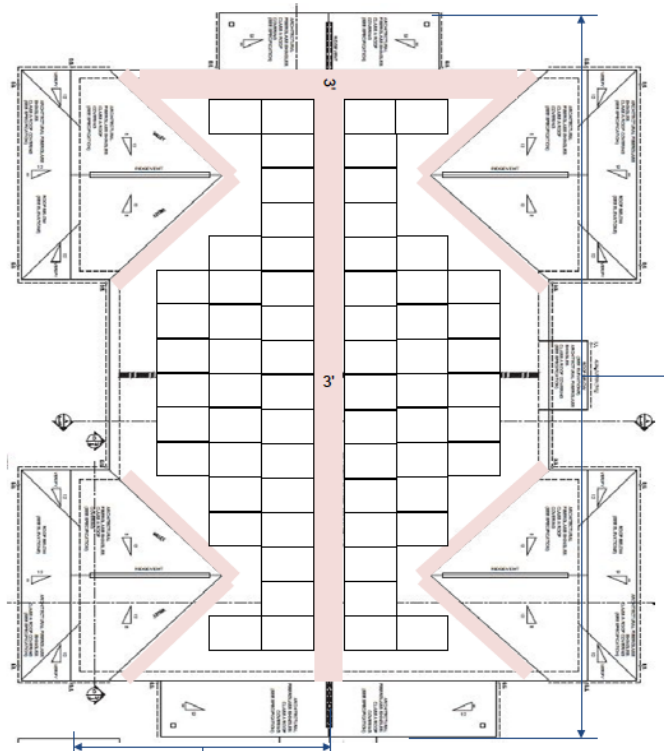


Figure 20: One Bedroom Building - 28.38 kW Solar

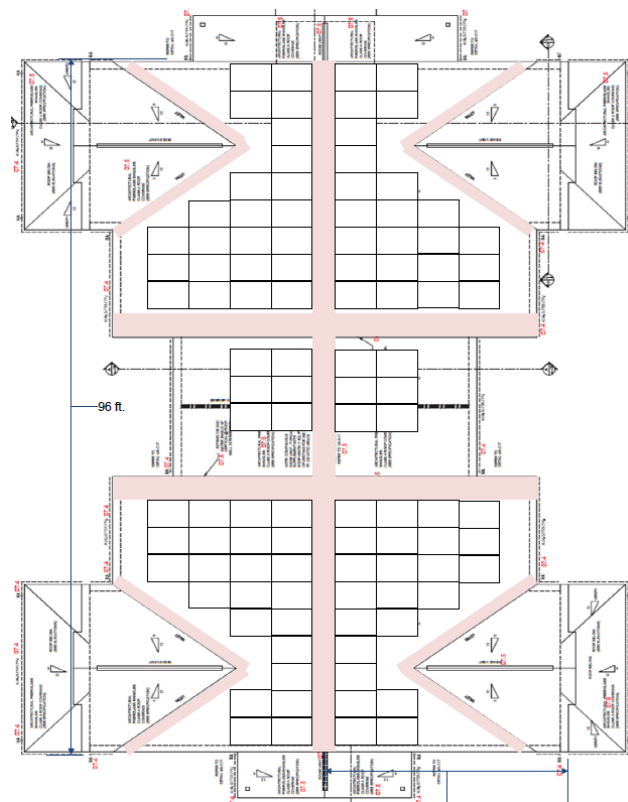


Figure 21: Three Bedroom Building - 44.7 kW Solar

Solar PV incentives

NYSERDA NY-Sun program currently offers a \$0.25/watt rebate off the contract price of a solar PV system. That rebate is paid directly to the contractor who has removed it from the out-of-pocket contract price. The federal Investment Tax Credit also provides a minimum of 30% tax credit for solar systems depending on start of construction and completion of the project. Due to 2025 Congressional updates, the federal tax credit for solar may no longer be available depending on time of construction on future projects.

Energy Modeling Review

This section will review the energy modeling completed on the project and review how the energy modeling performs against each other and against the reality of the project once operating.

WUFI and Ekotrope Energy Modeling Comparison

To study the energy performance and achieve compliance with Passive House Institute US (Phius) and Energy Star Multifamily New Construction Program, there are two energy modeling software’s used on the project for compliance. The first are individual Ekotrope energy models created for each unit type following the RESNET HERS Rating procedures. The Ekotrope modeling has been used throughout this report due to its ability to compare outcomes between Riverknoll, CreekView Phase I, and CreekView Phase II.

The Phius compliance is calculated using WUFI Passive energy modeling which uses different protocols for calculating energy use. We have done a comparison of the outcomes between the two modeling outcomes. The Ekotrope modeling results in a total project usage of 513,072 kWh/yr and the WUFI modeling results in a total project usage of 328,230kWh/yr which is 36% lower. SCI tends to find the WUFI models under-estimate energy usage, and we would suggest using the higher value when estimating actual usage. Other projects have seen 20-30% higher usage than the WUFI model suggests.

The solar provided has maximized the solar production from the available roof area and results in a production of 353,808 kWh/yr. This makes the project eligible to receive the Phius Source Zero badge for a net-zero energy property, however the team is not fully committing to the net zero operation due to the potential for higher energy use based on the results of the Ekotrope modeling.

	ELECTRIC USAGE	
UNIT TYPE	Ekotrope [kWh/yr]	WUFI Model [kWh/yr]
Creekview II 1BR Building	48,560	29,628
CreekView II 2BR Building	56,044	36,649
CreekView II 3BR Building	66,420	43,133
CreekView II Total	513,072	328,230
Difference	36%	

Figure 22: Electric use comparison of Ekotrope vs. WUFI

CreekView Phase I Utility Cost Comparison

As a part of the regulatory agreement for low-income housing tax credit projects, each year the project must develop specific utility allowances for each unit which involves collecting utility history on a sample of units to show the actual utility costs. We were able to collect the information from the most recent utility allowance comparison and compare to the WUFI and Ekotrope energy modeling. We selected sample apartments and compared the actual energy usage with the energy modeling, and aggregated those out to show what the whole property spent.

Utility Allowance Comparison			
	2024 Actual Utility Allowances	Ekotrope Model	WUFI Model
1 Bedroom [\$/Unit/Month]	\$ 71	\$ 91	\$ 76
2 Bedroom [\$/Unit/Month]	\$ 97	\$ 104	\$ 83
3 Bedroom [\$/Unit/Month]	\$ 146	\$ 123	\$ 106
Total Property [\$/Year]	\$ 90,562	\$ 91,584	\$ 76,278
Difference		1%	-16%

Figure 23: CreekView Phase I Utility Cost Comparison

The Ekotrope modeling overall performed better at estimating actual energy usage and cost for the property, within 1% of the overall energy spend. However, there were some differences with specifics such as over-estimating the cost of the 1-bedroom units and underestimating the cost of the 3-bedroom units. Based on this review, the 1 Bedroom utility cost allowances may not be inclusive of all cost as the energy usage in kWh was higher than the energy modeling, but overall cost was lower.

Digging further into the actual energy consumption, we selected 3 sample units and extrapolated those units to the entire property. In this case those units are using more energy than the predicted modeling by roughly 20% in the case of the Ekotrope modeling and 38% in the case of the WUFI modeling. This may be the result of a small sample size, and due to occupant behavior.

Electric Energy Use Comparison			
	Actual kWh	Ekotrope Model kWh	WUFI Model kWh
Unit 113 - 1 Bedroom	5,959	4,468	3,196
Unit 52 - 2 Bedroom	9,610	7,556	5,629
Unit 45 - 3 Bedroom	11,171	9,301	7,748
Total Property [kWh/Year]	7,700,832	6,141,600	4,773,132
Difference		-20%	-38%

Figure 24: Electric Usage Review of Select Units

There was also a large variation in utility costs for various unit types, showing the large differential in how occupancy and actual usage patterns can impact the actual energy usage. There was no noticeable difference in usage between top floor and bottom floor units, likely indicating the heating and cooling load was not a primary factor in the increase or decrease in energy usage between unit types. This is reinforced with the Ekotrope modeling which showed a very small difference in energy use estimates between top floor and bottom floor units. However, the impact of occupancy seems to be a much higher impact with the 3-bedroom units using significantly more energy than the 1 or 2-bedroom units which could be due to higher miscellaneous electrical usage such as plug loads in larger units where larger families typically live.

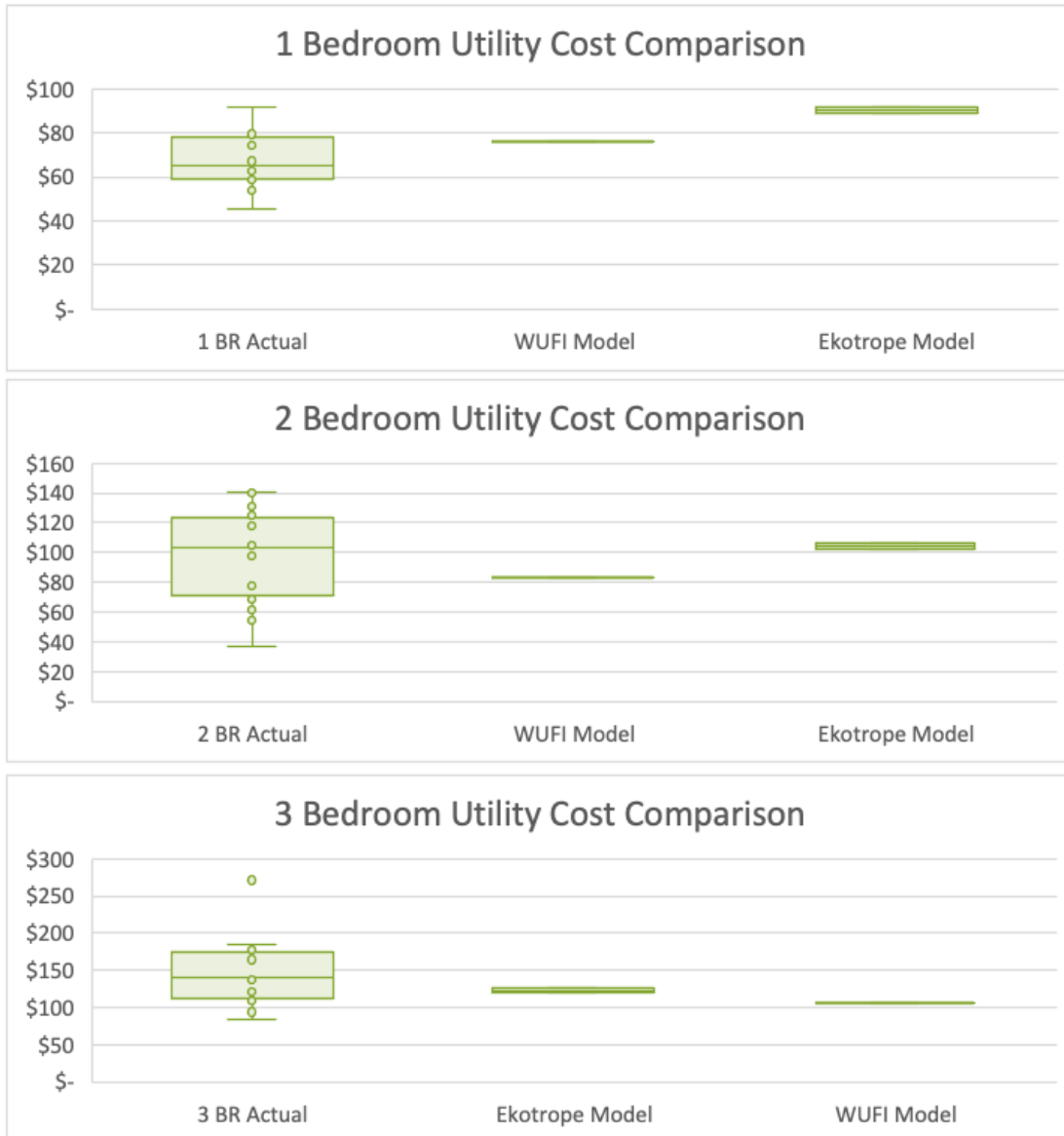


Figure 25: Utility Allowance Comparison to Energy Modeling

Embodied Carbon

The project team has maintained a strong commitment to operational carbon reduction through Phius-certified design, advanced ground source heat pumps, and photovoltaics. However embodied carbon was not a major focus of CreekView Phase II decision making. This study was carried out to inform the team for future decision making of projects of this type, and encourage the market to consider alternative options with low embodied carbon. The embodied carbon of each of the last 3 projects was also analyzed and compared against the operational carbon to quantify the impact of embodied carbon on the total emissions of the project.

Measuring Embodied Carbon via BEAM

Embodied Carbon refers to the greenhouse gas (GHG) emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of building and infrastructure materials. Most embodied emissions are generated before the building is constructed during the raw material and manufacturing stages of the products’ life cycles. These Material Carbon Emissions (MCE) are quantified by manufacturers in Environmental Product Declarations (EPDs) that are third party verified and enable comparisons between products. BEAM is the “Building Emissions Accounting for Materials” estimating tool. It was developed to assess the carbon footprint of the building materials on projects using data from EPDs to understand the best ways to reduce climate impact in materials selection.

BEAM uses material quantities from area-based takeoffs and information from the bill of materials combined with Global Warming Potential (GWP) emission factor data to determine the product emissions for a project. It does not capture the full climate impact of a building; it analyzes the product stage carbon footprint for the structure, enclosure, partitions, primary finishes, etc. BEAM does not currently include mechanical, electrical and plumbing materials, paint and surface finishes, fixtures, appliances, millwork, stairs, cabinetry, trim, or site work. For the purposes of this paper, the “total” is limited to the total embodied carbon captured in a BEAM analysis. These calculations are an estimate with at least a +/- 10% margin of error. BEAM was selected for its high level of specificity in selection products to compare outcomes.

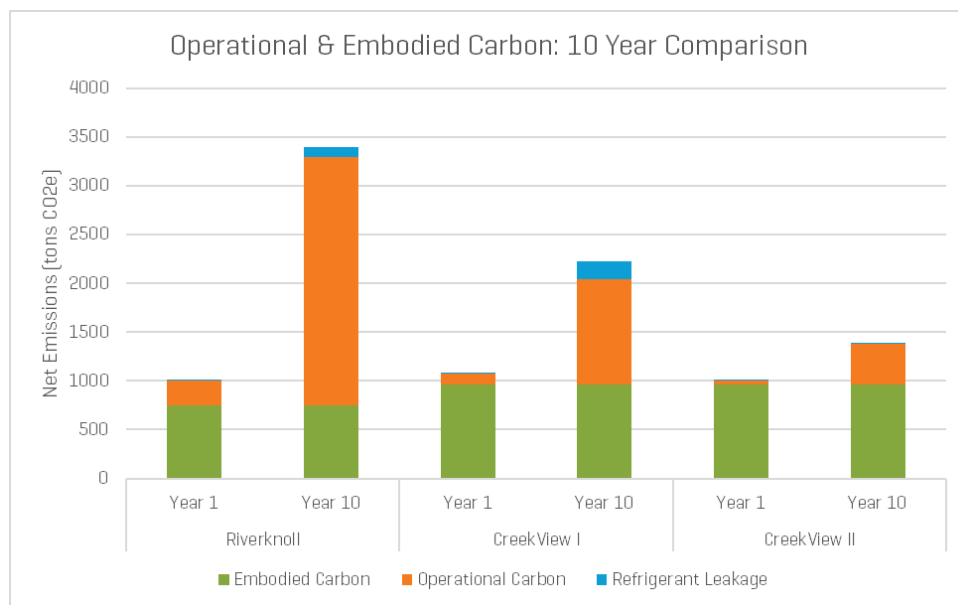


Figure 26: Operational & Embodied Carbon of Riverknoll, CreekView Phase I, and CreekView Phase II over 10 Years

Short Cycle Carbon Storage

BEAM accounts for both gross material emissions and short cycle carbon storage. For some products that contain bio-based materials, the net emissions are the result of carbon emissions minus short cycle carbon storage, which in some cases leads to a negative value. Short cycle carbon is when a plant dies and decays, some of the carbon it was storing is released back into the atmosphere. If the plant resources are harvested and converted into a building product, the carbon is effectively stored for the life of the building. Long cycle carbon are sources such as trees that take a long time to store carbon. Bio-based material usage can make a huge impact on the net embodied carbon of a building.

Big picture, this type of intervention is critical to slowing climate change. Since embodied carbon emissions are released immediately, rather than over the lifetime of the building like operational carbon, the impact of their reduction is immediate as well. For this reason, the short cycle storage potential is included as negative carbon emissions in our analysis. Long cycle storage from materials such as wood from trees was not considered as a part of the net emissions.

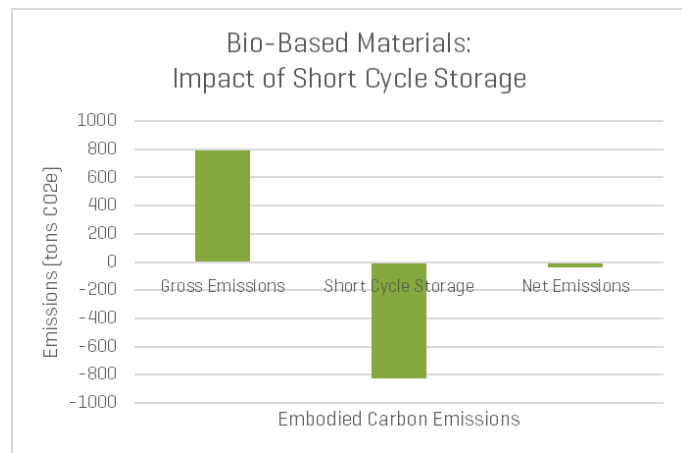


Figure 27: Bio-Based Option Emissions (Gross, Storage, and Net)

Riverknoll III Embodied Carbon

Riverknoll III has an estimated 684 tons of carbon emissions associated with the construction stage using BEAM. Since the Riverknoll project did not pursue Phius certification, it used less insulation materials, which led to less embodied carbon emissions. There was no insulation under the slab, no continuous insulation on the exterior walls, and double-glazed windows rather than triple glazed. This resulted in less overall embodied carbon in materials; however, the higher heating usage and gas equipment leads to much higher carbon emissions over time.

CreekView Phase I Embodied Carbon

CreekView Phase I has an estimated 876 tons of carbon emissions associated with construction, or 192 tons more than Riverknoll III. CreekView Phase I had almost identical embodied carbon as CreekView Phase II in terms of building materials. The only significant substitution that was quantified in BEAM was the exterior sheathing/insulation, which varied from 3" Durasheath-3 to 3-half" Hunter XCI NB.

There may have been a more significant difference in embodied carbon based on the change in mechanical system, but the BEAM tool does not currently quantify mechanical systems, so this difference was not represented in the data.

CreekView Phase II Embodied Carbon

Like many projects, CreekView Phase II biggest sources of material carbon emissions were the footings and slabs, followed by exterior walls and foundation walls. Primary drivers included standard concrete mixes and high-embodied-carbon insulation. Due to the reduction in operational carbon from high performance design, the embodied carbon emissions represent a much larger percentage of the total emissions than the operational carbon, even after 10 years of use. Overall, the project still does relatively well in comparison to others of a similar size and building type. Shown in the Appendix are the full embodied carbon modeling results.

While embodied carbon reduction was not specifically included in decision making, several factors allow the project to still perform well as a low embodied carbon building including small unit sizes, and certain materials selections such as cellulose insulation in the attic.

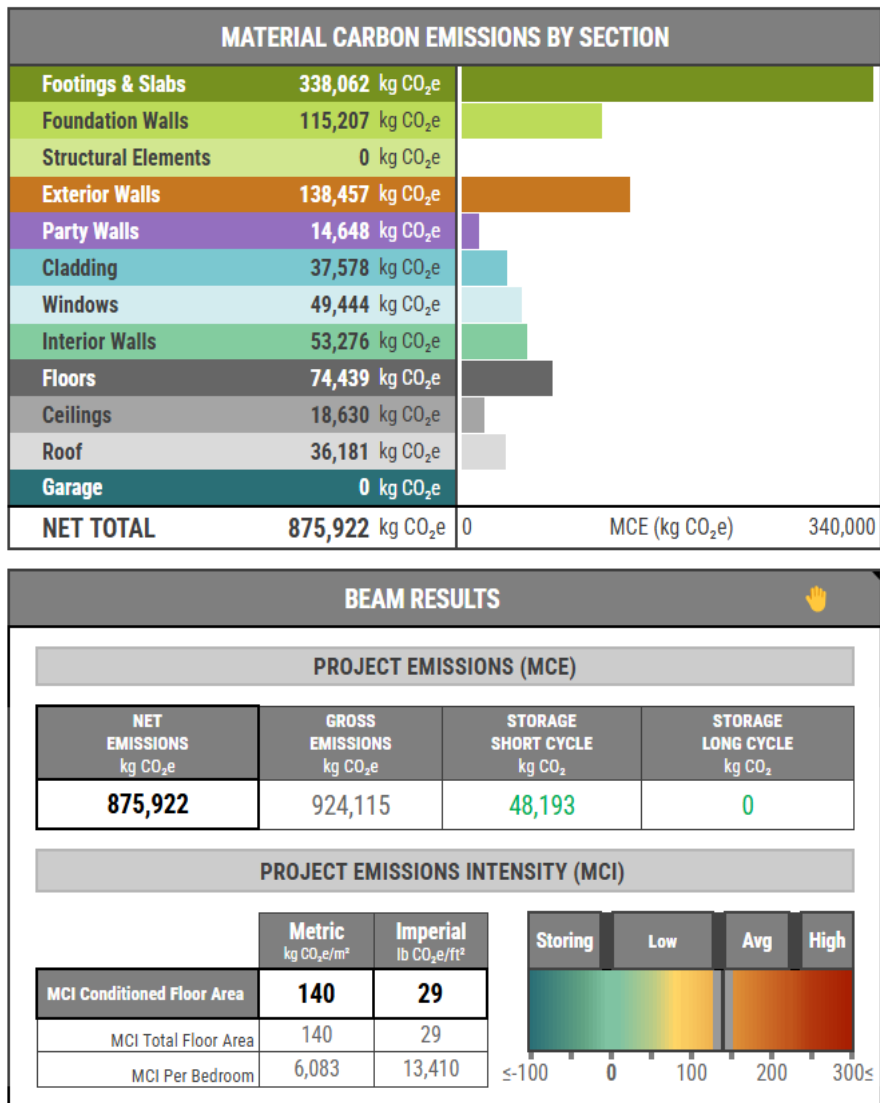


Figure 28: CreekView Phase II BEAM Embodied Carbon Results

Carbon Storage in Bio Based Materials

The objective of this portion of the study was to explore the potential future impact of selections toward bio-based materials and how selecting carbon-storing bio-based materials impacts the potential carbon emissions of similar projects. This portion is purely theoretical and has not been committed to by the project team, which has allowed us to consider the most cutting-edge products and materials available to provide deep embodied carbon reductions. Future projects that put embodied carbon in their decision making would benefit from having these low carbon options more readily available.

For the theoretical scenario, two additional BEAM models were created to represent the same building configuration, but with substitutions to reduce the total embodied carbon.

Better: Low Carbon Option selected materials with a desire for easily available swaps to low carbon materials and away from foams. The desire for creating a more approachable and conventional construction practices were considered in materials selections.

Best: Bio-Based Option selected deeper carbon storage with a priority for products that use existing waste products for agricultural or forestry practices. Selecting these materials keeps the additional carbon emissions out of the atmosphere and stores them in the building.

Note that this section does not provide a thorough architectural, structural, or financial analysis for the materials selected. Each product would take additional detailing; however, each product is currently in use across the region in housing projects.

Bio-Based Material Alternatives

Selecting bio-based materials with short cycle carbon storage not only have the potential to reduce initial carbon emissions in manufacturing, but they can also serve as carbon storage of materials that might otherwise be emitted into the atmosphere. These products can trap carbon from the atmosphere into the building for long periods of time.

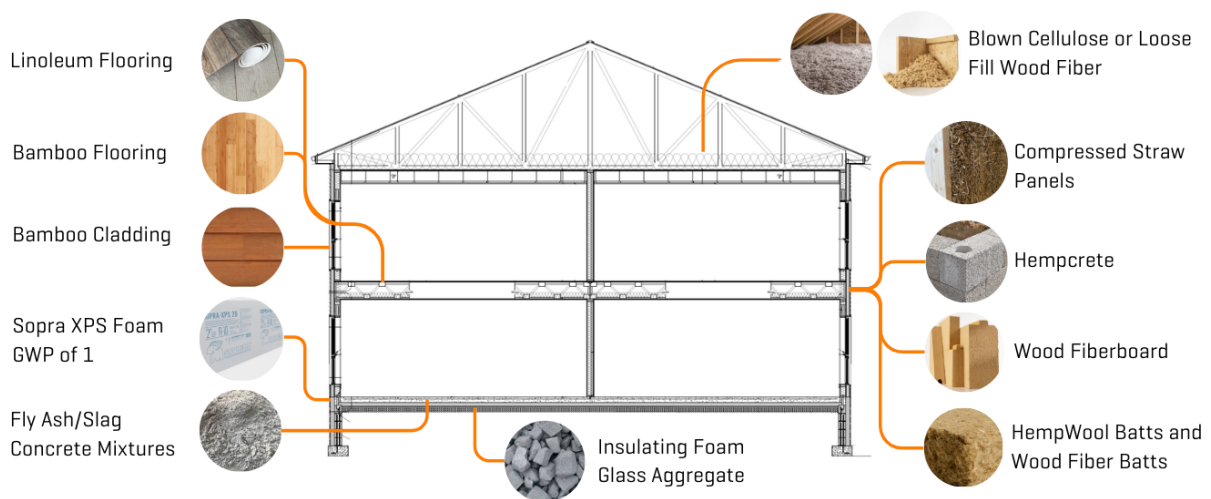


Figure 29: Bio-Based Material Alternatives

Total Net Emissions per Scenario

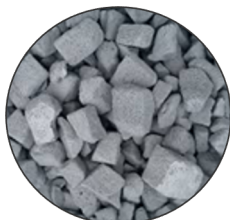
The results from the scenarios show that you can roughly cut the net emissions in half by using low-carbon product replacements. The bio-based option shows you can transform into a carbon storing building with a deeper focus on bio-based materials.

Total Net Emissions			
	CreekView II	Low-Carbon Option	Bio-Based Option
Net Emissions (Tons CO ₂ e)	965	567	-38

The following pages outline a comparison of key material substitutions between CreekView Phase II, the Low Carbon Option, and the Bio-Based Option. While many substitutions are 1:1 product replacement, some are dependent on reduced R-value to accommodate different materials, which may affect the Phius certification and overall performance, thickness of assemblies, etc. All decisions would need to be analyzed more thoroughly to determine their full applicability.

Footings, Slabs, & Foundation			
	CreekView II	Low-Carbon Option	Bio-Based Option
CONCRETE FOOTINGS, SLABS, AND FILL FOR CMU WALL			
Material	Concrete - 3001-4000 psi, Standard mix / NRMCA [Industry Avg US & CA]	Concrete - 3001-4000 psi, 20-29% Fly Ash / NRMCA [Industry Avg US & CA]	Concrete - 2501-3000 psi, >50% SCM mix / NRMCA [Industry Avg US & CA]
Net Emissions (Tons CO ₂ e)	271	233	170
SUB-SLAB INSULATION & AGGREGATE			
Material	XPS foam board / Owens Corning / Foamular NGX 250 / R 5.0/inch, 25 psi Aggregate / NRMCA / US Average [Industry Avg]	Foam glass aggregate / Glasopor AS / R 1.7-inch, 10-60 mm [EU]	Foam glass aggregate / Glasopor AS / R 1.7-inch, 10-60 mm [EU]
Net Emissions (Tons CO ₂ e)	122	8	8
CONTINUOUS INSULATION			
Material	XPS foam board / Owens Corning / Foamular NGX 250 / R 5.0/inch, 25 psi	XPS foam board / SOPREMA / SOPRA-XPS (entire product line) / R 5.0-inch	XPS foam board / SOPREMA / SOPRA-XPS (entire product line) / R 5.0-inch
Net Emissions (Tons CO ₂ e)	30	7	7

Concrete can often be improved through alternative concrete mixes. In this case, a mix with over 50% Supplementary Cementitious Material (SCM) such as fly ash and slag cuts emissions almost in half. To propose an alternative mix, it is recommended to apply a performance-based specification over a prescriptive one and involve the concrete manufacturer in the conversation early to achieve the goals. These newer material industries have cost and availability challenges at the time of specification for the project.



Utilizing foam glass aggregate such as Glasopor, Aero Aggregates, or Glavel can provide insulation and slab stabilization which minimizing steps in the process. In CreekView Phase II, Foamular NGX 250 was selected to wrap the foundation walls and under the slab. There are lower emitting versions of XPS with newer blowing agents such as Sopra-XPS that could be used in select areas such as slab edge and foundation walls. These newer material industries have cost and availability challenges at the time of specification for the project.

Walls			
	CreekView II	Low-Carbon Option	Bio-Based Option
	BARRIERS AND MEMBRANES		
Material	Liquid Applied Barrier / [BEAM Avg]	Ext. Wall barrier, liquid applied / GCP / Perm-a-Barrier VPL 50RS UV stable / 13 Perms, 0.51 mm	Sheet Barrier Moisture-Variable / [BEAM Avg]
Net Emissions (Tons CO ₂ e)	28	8	4
	EXTERIOR WALL: CAVITY INSULATION, FRAMING, & SHEATHING		
Material	Fiberglass batt / NAIMA / R 4.4-inch [Industry Avg N.America]	Fiberglass batt & roll / Owens Corning / Unfaced, PINK Next Gen Fiberglas / R 3.6-inch avg.	Straw Insulated Panels with wood framing (SIP) / EcoCocon / Prefabricated panel, 40 cm / R35 [EU]
	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	Wood / SPF / 2x3 Lumber / AWC & CWC [Industry Avg US & CA]
	OSB sheathing / 7/16" / LP / TopNotch® 350 / 7/16"	OSB sheathing / 7/16" / LP / TopNotch® 350 / 7/16"	Wood / SPF / 2x3 Lumber / AWC & CWC [Industry Avg US & CA]
Net Emissions (Tons CO ₂ e)	48	44	-378
	CONTINUOUS INSULATION		
Material	Polyisocyanurate / Wall Boards / Hunter / Xci / R 6.3-inch, 20 psi	Wood fiber board / GUTEX / Multi-Therm / R 3.6-inch, 40-200 mm [EU]	Wood fiber board / GUTEX / Multi-Therm / R 3.6-inch, 40-200 mm [EU]
Net Emissions (Tons CO ₂ e)	77	-54	-54
	INTERIOR WALL: CAVITY INSULATION		
Material	Fiberglass batt / NAIMA / R 4.4-inch [Industry Avg N.America]	Fiberglass batt & roll / Owens Corning / Unfaced, PINK Next Gen Fiberglas / R 3.6-inch avg.	Hemp fiber batt / NaturFibre / Hemp Wool / R 3.7-inch
Net Emissions (Tons CO ₂ e)	9	6	0

The exterior walls offer ample opportunity for reductions through insulation substitutions. In the low-carbon option the typical fiberglass batt insulation can become wood fiber batt such as Gutex Thermoflex or Steico, which is bio-based and has a similar R3.8/inch. Additionally, the continuous polyiso insulation can become a wood fiber board, such as TimberHP. The wood fiberboard offers a lower R3.8/inch, which requires different thicknesses to meet thermal requirements compared to foam which are R5/inch to R7/inch.

Alternatively, the bio-option explores the impact of a bolder approach involving panelized straw panels such as those from EcoCocoon or New Frameworks, which uses locally sourced bio-based materials. A panelized straw panel could replace both the cavity insulation and exterior insulation, typically with an interior service cavity for MEP.



Cladding			
	CreekView II	Low-Carbon Option	Bio-Based Option
EXTERIOR WALL CLADDING			
Material	Vinyl Siding / Vinyl Siding Institute / 0.040" Double 4.5" [Industry Avg US & CA]	Vinyl Siding / Vinyl Siding Institute / 0.040" Double 4.5" [Industry Avg US & CA]	Bamboo Cladding / Dasso / dassoCTECH outdoor oiled Cladding / Shiplap, 5/8" (18 mm)
Net Emissions (Tons CO ₂ e)	25	25	-41
DRYWALL (WALLS & CEILINGS)			
Material	Drywall 1/2" [BEAM Avg US & CA] Drywall 5/8" Type X / Gypsum Association [Industry Avg US & CA]	Drywall 1/2" [BEAM Avg US & CA] Drywall 5/8" / USG / Sheetrock Brand EcoSmart Firecode X / 5/8"	Drywall 1/2" [BEAM Avg US & CA] Drywall 5/8" / USG / Sheetrock Brand EcoSmart Firecode X / 5/8"
Net Emissions (Tons CO ₂ e)	88	70	70



The vinyl siding at CreekView Phase II measures up well compared to brick, stucco, fiber cement, stone, or metal panel options in terms of embodied carbon. For a bio-based alternative, the vinyl siding could become an engineered wood or even bamboo cladding, but these may not be practical for cost and procurement reasons.

Drywall can be swapped for an alternative product like USG's EcoSmart, though the difference is relatively small compared to other potential swaps.

FLOORING			
	CreekView II	Low-Carbon Option	Bio-Based Option
	Floors		
	FLOOR COVERING		
Material	Carpet / [BEAM Avg]	Carpet / Shaw / Residential Broadloom with ClearTouch Platinum	Carpet / Interface / CQUEST BioX / 1.5 mm Modular tile carpet
Net Emissions (Tons CO ₂ e)	55	33	0
Material	Vinyl flooring / Resilient Floor Covering Institute / Heterogeneous [Industry Avg US & CA]	Linoleum flooring / 4.0 mm [BEAM Avg]	Linoleum flooring / Tarkett / Lino Veneto xf2, Etrusco, Style Elle Emme, Veneto, Originale, LinoRail, Linosport / 2.5 mm sheet style linoleum
Net Emissions (Tons CO ₂ e)	11	2	-1
	FLOOR CAVITY INSULATION		
Material	Fiberglass batt / NAIMA / R 4.4-inch [Industry Avg N.America]	Fiberglass batt & roll / Owens Corning / Unfaced, PINK Next Gen Fiberglas / R 3.6-inch avg.	Hemp fiber batt / NaturFibre / Hemp Wool / R 3.7-inch
Net Emissions (Tons CO ₂ e)	15	9	0.37

For flooring, product emissions can vary a lot based on the manufacturer. In this case, a carpet by Interface fully offsets the embodied carbon, and a linoleum can even store carbon depending on manufacturer. For material choices, the BEAM tool provides several manufacturers to choose from, and project teams can also request EPD's from other manufacturers to get a sense of the embodied carbon emissions. We suggest designers consider using the BEAM tool when deciding on materials to include embodied carbon in the design making process.



Roof			
	CreekView II	Low-Carbon Option	Bio-Based Option
ROOF CAVITY INSULATION			
Material	Cellulose / loose fill / CIMA / R 3.7-inch / [Industry Avg US & CA]	Cellulose / loose fill / CIMA / R 3.7-inch / [Industry Avg US & CA]	Cellulose / loose fill / CIMA / R 3.7-inch / [Industry Avg US & CA]
Net Emissions (Tons CO ₂ e)	-34	-34	-34
Material	Asphalt Shingles / Asphalt Roofing Manufacturers Association / Fiberglass Asphalt Shingles [Industry Avg US & CA]	Asphalt Shingles / Malarkey Roofing / Dura-Seal /	Asphalt Shingles / Malarkey Roofing / Dura-Seal /
Net Emissions (Tons CO ₂ e)	23	12	12

CreekView Phase II used a loose fill, blown-in cellulose for the roof cavity insulation, which is a carbon-storing product. Since this was already an effective bio-based material, cellulose or wood fiber fill are recommended bio-based materials for attic insulation.



All Other Categories			
	CreekView II	Low-Carbon Option	Bio-Based Option
Material	Rebar, Wire Mesh, Underslab Membrane, CMU Walls, Interior Wood Framing, Windows, Trusses, Sheathing, Roof Membrane		
Net Emissions (Tons CO ₂ e)	197	197	197

All other materials were kept consistent through the three options, either because there were no better alternatives available currently on the market, or the project was already including the best available options.

Embodied Carbon Summary

The following graph compares the estimated net embodied carbon for each of the scenarios, including CreekView Phase I and Riverknoll.

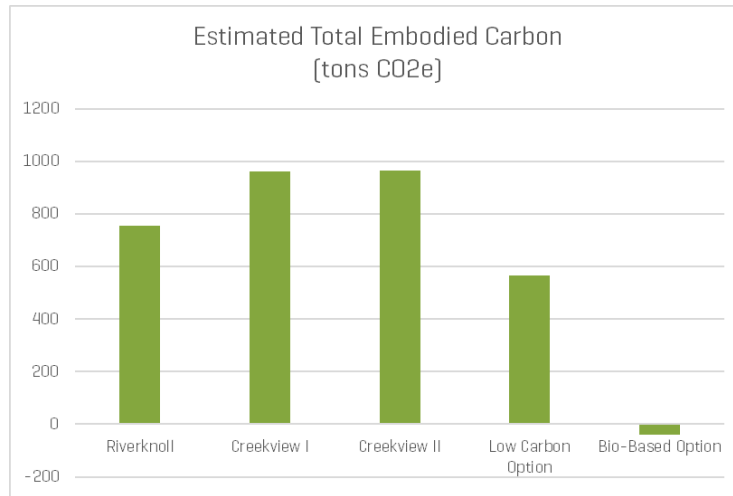


Figure 30: Embodied Carbon Comparison

The chart below represents the overall impact over a 10-year period of the embodied and operational carbon emissions. The relative impact of operational and embodied carbon varies based on the project. This assumes that the operational carbon of the two theoretical scenarios remains similar to the CreekView Phase II scenario, however tradeoffs could be made between embodied carbon materials, and overall insulating value of certain materials to minimize total carbon impact.

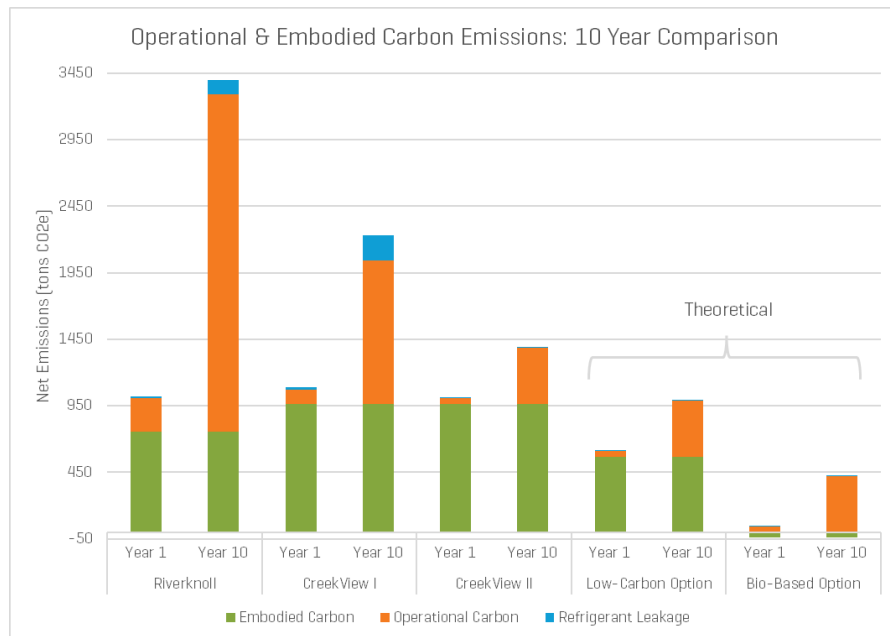


Figure 31: Embodied and Operational Carbon Emission Comparison

Overall, comparing these five scenarios helped to understand the status of carbon emissions for this building type. Operational carbon reduction from high performance design made up for the increased material usage from Riverknoll to CreekView Phase I & II. However once operational carbon is improved, embodied carbon and a focus on carbon storage through bio-based materials becomes a bigger percentage of the addressable carbon emissions.

Simple material swaps to alternative brands can help reduce total embodied carbon, but the impacts are not equally distributed. Focusing on bio-based materials, with insulation substitutions, can provide some of the biggest payoffs to store short cycle carbon emissions. This result should provide strong evidence that a continued focus on embodied carbon in materials is impactful to reduce the overall carbon impact of housing projects.

Even in the low-carbon option some of the materials are not yet widely available and come at a cost premium and an industry wide focus on reducing embodied carbon can drive down the cost of those materials.

Appendix

Additional supplemental materials provided as an appendix.

Case Study Tear Sheet



Owner: Baldwin Real Estate Development Corp | Location: Canandaigua, NY
NYSERDA Buildings of Excellence Early-Design and Demonstration Awardee

How CreekView Apartments is Reducing Carbon Emissions

CreekView Apartments Phase II is a 72 unit housing project in Canandaigua, NY containing a mix of 1-, 2-, and 3-bedroom units. Continuing the Passive House certified Phase I completed in 2019, CreekView Phase II will reach Net-Zero energy utilizing Passive House Standards while reducing carbon emissions. The project is built on a park-like, 30-acre parcel of land in Canandaigua, NY. In addition to access to ample green space, residents benefit from close proximity to child and health care services, grocery stores and retail centers, sports and entertainment options, a community college, and high-quality public schools.

The CreekView Phase II project is developed by Baldwin Real Estate, built by DiMarco Constructors, designed by SWBR, MEP Engineering by EC4B, with Passive House Consulting and Verification by Sustainable Comfort, Inc. CreekView Phase II continues a commitment by Baldwin to reduce carbon emissions throughout their building portfolio. Their design of 8-plex housing style has evolved over the past 10 years from a gas heated LEED project at Riverknoll in 2015, to the Phius Certified CreekView Phase I in 2019, to the innovative Net-Zero energy design of CreekView Phase II.

Eliminating carbon emissions in housing projects is imperative to reduce the impact of climate change. A comprehensive approach to low carbon housing provides:

- Lower environmental impact
- Maximum incentives and tax credits
- Meeting low carbon policies
- Lower operating & maintenance cost
- More comfortable homes
- Healthier indoor air quality
- Lower refrigerant leakage and lower Global Warming Potential (GWP) refrigerants

NYSERDA Support

Through the use of NYSERDA Buildings of Excellence Early Stage Design funds, the project has compared the embodied carbon and operational carbon of the past 3 projects showing a dedicated approach to reducing carbon emissions. NYSERDA awards include:

- Buildings of Excellence Demonstration: \$1,000,000
- Early Design Support: \$100,000
- New Construction-Housing: \$288,000
- NY-Sun: \$84,750 ([\$0.25/W])

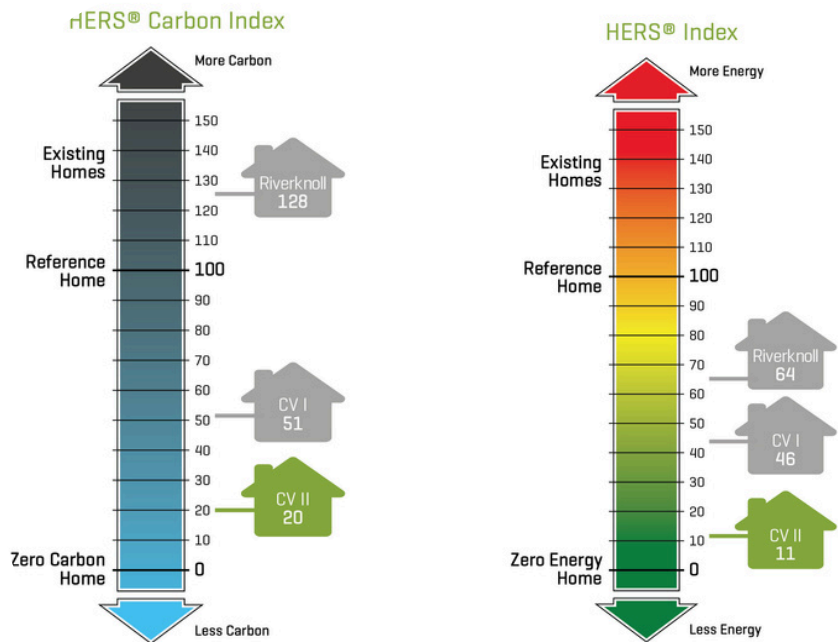


Measuring Carbon Emissions

Carbon emissions were compared and measured over the past three projects using the HERS Carbon Index to measure operational carbon emissions caused by the ongoing energy use and fossil fuel use of the property. At CreekView Phase II, the team has successfully reduced operational carbon emissions by 84% compared to Riverknoll and 66% compared to CreekView Phase I by focusing on Passive House insulation and air tightness, all electric ground source heat pumps, solar PV, and a focus on healthy indoor materials. Embodied carbon was measured for each site using the BEAM embodied carbon estimating tool to show the comparison of embodied vs. operational carbon emissions. Refrigerant leakage emissions are expected to be significantly reduced with CreekView Phase II Ground Source Heat Pump systems compared to Air Source where long refrigerant lines are shown to leak at a rate of 3% per year on average.

Property Features:

Property	Riverknoll	CreekView Phase I	CreekView Phase II
Location	Baldwinsville, NY	Canandaigua, NY	Canadaigua, NY
Year Completed	2015	2019	2026
Wall	R-21 Total: Batt + Advanced Framing	R-37 Total: R-21 Cavity + R-19ci	R-37 Total: R-21 Cavity + R-19ci
Windows	U-0.3, SHGC-0.26 Double Hung	U-0.15, SHGC-0.33 Casements	U-0.15, SHGC-0.33 Casements
Air Barrier	Taped Tyvek	Fluid applied air barriers	Fluid applied air barriers
Roof	R-38 Batts	R-59-78 Blown	R-59-78 Blown Cellulose
Slab	R-10 4' Perimeter	R-20 under slab	R-20 under slab
Heating/Cooling	Gas Furnaces, 14 SEER AC	Ductless Mini Splits, 10 HSPF 18 SEER	GSHP to Ducted Air Handler - 3.3 COP
Ventilation	Exhaust Only	Unitary ERV - 77% Eff	Shared ERV - 77% Eff
Hot Water	0.67 EF Gas Storage	1 BR: Gas, 2-3BR: Electric Resistance	Central GSHP - 3.3 COP
Appliances	Energy Star Appliances	Energy Star Appliances	Energy Star Appliances
Lighting	LED/CFL Lighting	LED Lighting	LED Lighting
Solar	-	-	339 kW Rooftop PV
EV Charging	-	-	[6] EV Stations + [36] EV Capable



Learn more about this comparison study by checking out the full NYSEDA Early Stage Design Report here:

<https://www.nyserda.ny.gov/All-Programs/Multifamily-Buildings-of-Excellence/Early-Design-Support-Program/Creekview-Apartments>

Passive House Building Standard

CreekView Phase II has received Phius 2024 Source Zero Design Certification through Passive House Institute US (Phius). Passive House is the most-rigorous green building standards in the nation and requires superior insulation and energy-efficient HVAC and appliances. Phius-certified buildings typically use 40-60% less energy for heating and cooling than code built homes. The standard also provides a framework for buildings of all types to maximize their efficiency while prioritizing cost effective solutions. The required verification of insulation quality, air tightness, and ventilation effectiveness provides confirmed performance and quality.

To achieve Phius Zero Energy Targets, the CreekView Phase II project is utilizing all electric mechanical systems including ground source heat pumps systems for heating, cooling, and hot water heating, shared Energy Recovery Ventilation (ERV), and a roof mounted solar PV systems on each building.

Compared to the Air Source Heat Pumps at Phase I, the geothermal has lower maintenance cost related to filter changes, and mini split head cleaning. There are also less pieces of equipment prone to failure due to the central mechanical systems. The owner pays all electric utilities on the project to receive the full benefit of the on site solar PV systems.

The buildings are effectively air-tight through the use of exterior fluid applied air barrier over a consistent sheathing, with advanced insulation including 3.5" exterior rigid insulation and blown in cellulose attic insulation. The envelope is completed with continuous under slab insulation and triple pane casement windows over fixed windows to provide air tight windows. The efficient envelope and mechanical systems allows the building energy demand to be offset by the roof mounted solar PV system.

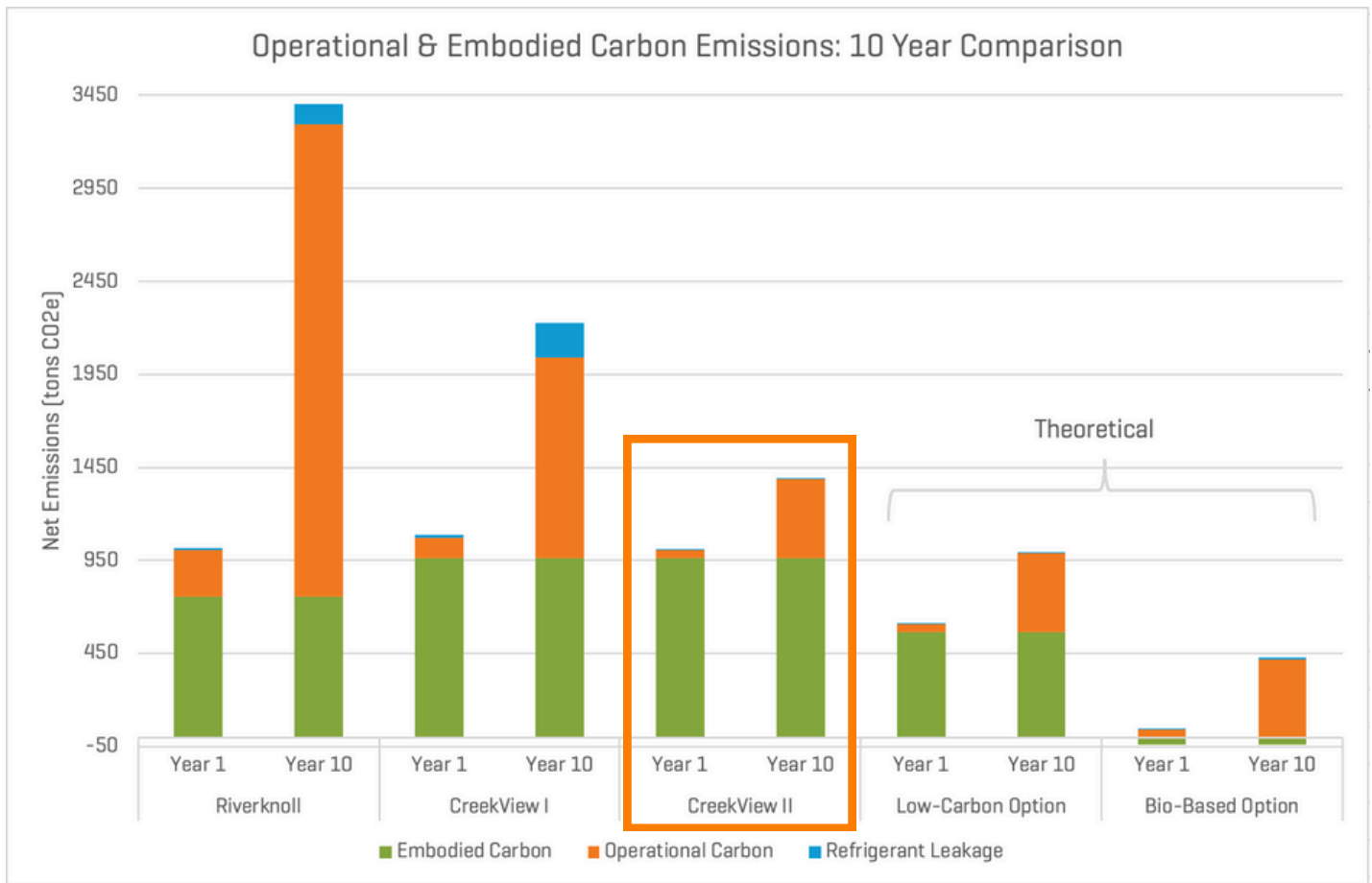


Fig: 10 Year emissions performance of similar 72 unit projects at Riverknoll, CreekView I, and CreekViewII, plus 2 theoretical projects with low embodied carbon discussed on the next page

CreekView II Embodied Carbon

The embodied carbon was calculated for CreekView Phase II using the Building Emissions Accounting for Materials (BEAM) tool which shows low embodied carbon emissions compared to similar projects based on structure, enclosure, insulation, and finish selection.

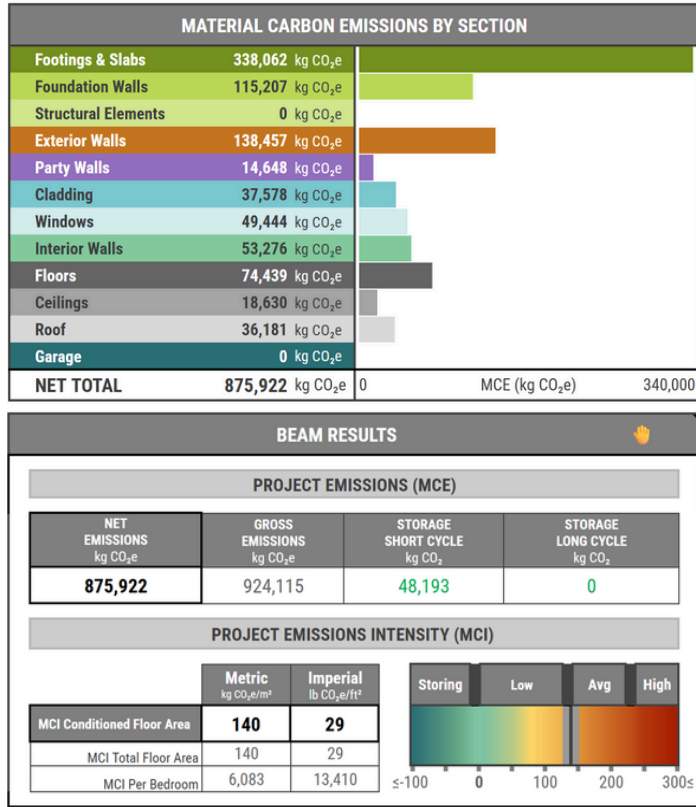


Fig: CreekView II Beam Results

The Future of Bio-Based Materials

For future developments, the use of low carbon materials can serve to reduce the initial embodied carbon. A Low-Carbon Option was explored with readily available product replacements such as:

- Swapping slab insulation to foam glass aggregate
- Swapping exterior polyiso to wood fiberboard
- Upgrading concrete mixtures to include >20% SCM
- Swapping batt insulation for wood fiber batts
- Using XPS with low GWP blowing agents

There are also several innovative techniques being developed to allow for deeper carbon storage using locally sourced bio-based alternatives that allow storage of carbon in building assemblies. The Bio-Based Option explored the use of materials such as manufactured insulated straw panels, which utilize agricultural waste products to store atmospheric carbon into the buildings for a long period of time.

The impact of steel and concrete on building sector emissions is also very large. On this building type, using Supplementary Cementitious Materials (SCM's) such as fly ash and slag can greatly reduce emissions. Designing to remove concrete podiums, or use mass timber frames instead of steel and concrete greatly reduce overall emissions on larger building projects.

Bio-Based Option - Potential Product Types

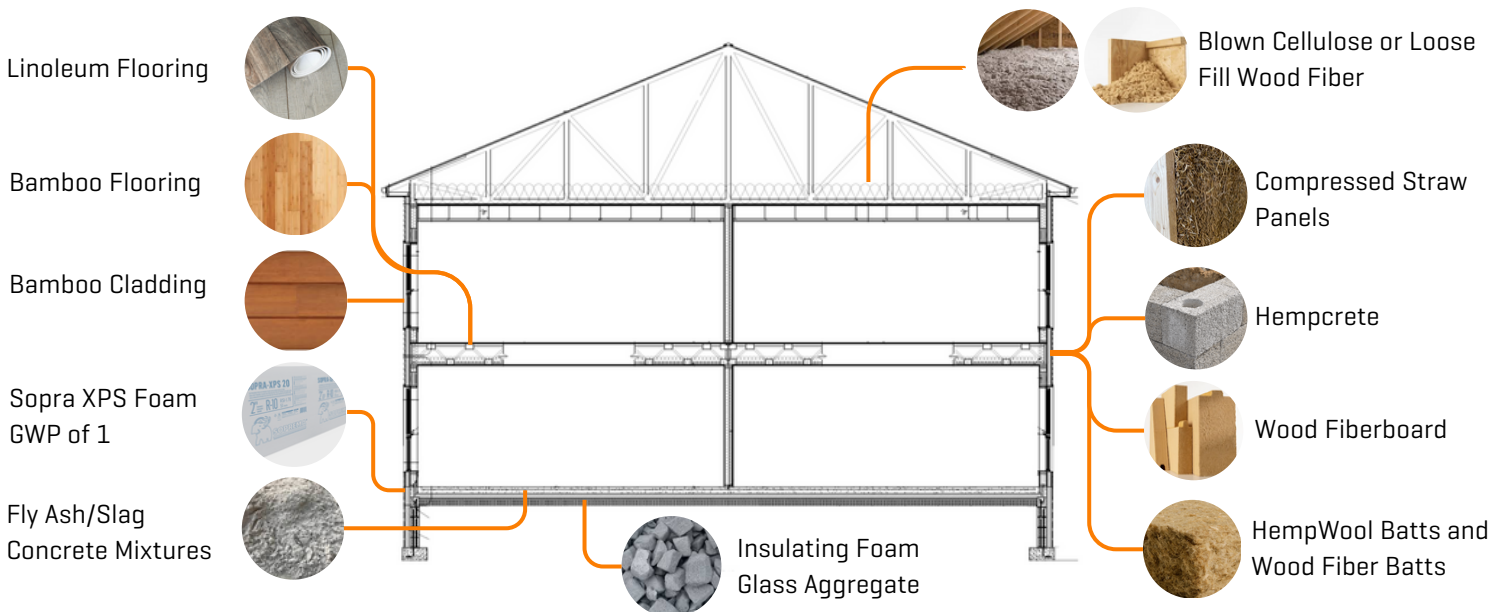


Fig: Available bio-based materials to provide carbon storage on future projects

Beam Embodied Carbon Results – CreekView Phase II



PROJECT NAME:
Creekview II
SCENARIO: Baseline
BEAM VERSION: V1.1


SELECTED PROJECT MATERIALS REVIEW

875,922
924,115
48,193

SECTION	CATEGORY	MATERIAL	NET EMISSIONS kg CO ₂ e	GROSS EMISSIONS kg CO ₂ e	STORAGE Short Cycle kg CO ₂	QTY
Footings & Slabs	CONTINUOUS CONCRETE FOOTINGS	Concrete - 3001-4000 psi, Standard mix / NRMCA [Industry Avg US & CA]	44,576	44,576	0	152 yd ³
Footings & Slabs	CONCRETE SLABS	Concrete - 2501-3000 psi, Standard mix / NRMCA [Industry Avg US & CA]	135,904	135,904	0	36991 ft ²
Footings & Slabs	REBAR FOR CONTINUOUS FOOTINGS	Rebar / Concrete Reinforcing Steel Institute / 98% recycled, EAF / [Industry Avg N.America] / #5	2,393	2,393	0	5909.3 ft
Footings & Slabs	REBAR FOR SLABS	Rebar / Concrete Reinforcing Steel Institute / 98% recycled, EAF / [Industry Avg N.America] / #4	137	137	0	528 ft
Footings & Slabs	REINFORCING MESH FOR SLAB	Welded wire reinforcement / Insteel Industries / 6" x 6" x 6/6g [US & CA]	12,188	12,188	0	36991 ft ²
Footings & Slabs	SUB-SLAB INSULATION	XPS foam board / Owens Corning / Foamular NGX 250 / R 5.0/inch, 25 psi	102,407	102,407	0	36991 ft ²
Footings & Slabs	BARRIERS AND MEMBRANES	Barrier, sheet / Polyethylene sheet / 10 mil	2,096	2,096	0	36991 ft ²
Footings & Slabs	BASEMENT FLOORING	Carpet / [BEAM Avg]	24,409	24,409	0	21825 ft ²
Footings & Slabs	BASEMENT FLOORING	Vinyl flooring / Resilient Floor Covering Institute / Heterogeneous [Industry Avg US & CA]	5,564	5,564	0	8507.9 ft ²
Footings & Slabs	AGGREGATE BASE	Aggregate / NRMCA / US Average [Industry Avg]	8,386	8,386	0	36991 ft ²
Foundation Walls	REBAR FOR FOUNDATION WALLS	Rebar / Concrete Reinforcing Steel Institute / 98% recycled, EAF / [Industry Avg N.America] / #5	2,369	2,369	0	5850.2 ft
Foundation Walls	REBAR FOR FOUNDATION WALLS	Rebar / Concrete Reinforcing Steel Institute / 98% recycled, EAF / [Industry Avg N.America] / #4	781	781	0	3013.8 ft
Foundation Walls	CONCRETE MASONRY UNIT (CMU) WALLS	CMU - Normal weight / 8" Normal weight blocks / 15 MPa, 390 x 190 x 190 mm / CCMPA East Region [Industry Avg CA]	19,151	19,151	0	9839.1 ft ²
Foundation Walls	CONCRETE FILL FOR CMU WALL	Concrete - 3001-4000 psi, Standard mix / NRMCA [Industry Avg US & CA]	65,666	65,666	0	223.9 yd ³
Foundation Walls	CONTINUOUS INSULATION	XPS foam board / Owens Corning / Foamular NGX 250 / R 5.0/inch, 25 psi	27,239	27,239	0	9839.1 ft ²
Exterior Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	10,770	10,770	0	52588 ft ²
Exterior Walls	STRUCTURAL SHEATHING	OSB sheathing / 7/16" / LP / TopNotch® 350 / 7/16"	14,361	14,361	0	52588 ft ²
Exterior Walls	BARRIERS AND MEMBRANES	Liquid Applied Barrier / [BEAM Avg]	25,230	25,230	0	52588 ft ²
Exterior Walls	CAVITY INSULATION	Fiberglass batt / NAIMA / R 4.4-inch [Industry Avg N.America]	18,250	18,250	0	52588 ft ²
Exterior Walls	CONTINUOUS INSULATION	Polyisocyanurate / Wall Boards / Hunter / Xci / R 6.3-inch, 20 psi	69,846	69,846	0	52588 ft ²

Party Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	2,126	2,126	0	16316 ft ²
Party Walls	CAVITY INSULATION	Fiberglass batt / NAIMA / R4.4-inch [Industry Avg N.America]	5,662	5,662	0	16316 ft ²
Party Walls	INTERIOR CLADDING FOR PARTY WALLS	Drywall 1/2" [BEAM Avg US & CA]	2,340	2,340	0	8158 ft ²
Party Walls	INTERIOR CLADDING FOR PARTY WALLS	Drywall 5/8" Type X / Gypsum Association [Industry Avg US & CA]	4,520	4,520	0	16316 ft ²
Cladding	EXTERIOR WALL CLADDING	Vinyl Siding / Vinyl Siding Institute / 0.040" Double 4.5" [Industry Avg US & CA]	23,011	23,011	0	52588 ft ²
Cladding	INTERIOR CLADDING FOR EXTERIOR WALLS	Drywall 5/8" Type X / Gypsum Association [Industry Avg US & CA]	14,567	14,567	0	52588 ft ²
Windows	WINDOWS – TRIPLE-GLAZED	Window - triple pane / Vinyl frame / BfCA Study [US & CA]	49,444	49,444	0	5375.9 ft ²
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	4,301	4,301	0	21001 ft ²
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	6,701	6,701	0	51416 ft ²
Interior Walls	CLADDING FOR INTERIOR WALLS	Drywall 5/8" Type X / Gypsum Association [Industry Avg US & CA]	40,120	40,120	0	72417 ft ²
Interior Walls	CAVITY INSULATION	Fiberglass batt / NAIMA / R4.4-inch [Industry Avg N.America]	2,154	2,154	0	8690 ft ²
Floors	LIGHT WOOD FLOOR FRAMING	Wood floor truss / Common (Warren, 45 deg) web pattern / Top chord bearing, variable depth / QWEB [Industry Avg CA]	9,506	9,506	0	30262 ft ²
Floors	SUB FLOORING	OSB sheathing / 3/4" / AWC & CWC [Industry Avg US & CA]	12,992	12,992	0	30262 ft ²
Floors	SUB FLOORING	OSB sheathing / 1/2" / AWC & CWC [Industry Avg US & CA]	8,661	8,661	0	30262 ft ²
Floors	FLOORING	Carpet / [BEAM Avg]	25,723	25,723	0	22999 ft ²
Floors	FLOORING	Vinyl flooring / Resilient Floor Covering Institute / Heterogeneous [Industry Avg US & CA]	4,354	4,354	0	6657.7 ft ²
Floors	FLOOR CAVITY INSULATION	Fiberglass batt / NAIMA / R4.4-inch [Industry Avg N.America]	13,203	13,203	0	30262 ft ²
Ceilings	CEILING FINISHES	Drywall 5/8" Type X / Gypsum Association [Industry Avg US & CA]	18,630	18,630	0	67253 ft ²
Roof	WOOD ROOF FRAMING	Wood roof truss / Gable Roof, Double Howe, 2x6 Chords, 2x4 Webs, 4:12 Pitch / QWEB [Industry Avg CA]	19,915	19,915	0	51700 ft ²
Roof	ROOF DECKING	OSB sheathing / 5/8" / AWC & CWC [Industry Avg US & CA]	18,502	18,502	0	51700 ft ²
Roof	ROOFING	Asphalt Shingles / Asphalt Roofing Manufacturers Association / Fiberglass Asphalt Shingles [Industry Avg US & CA]	21,037	21,037	0	51700 ft ²
Roof	ROOF CAVITY INSULATION	Cellulose / loose fill / CIMA / R 3.7-inch / [Industry Avg US & CA]	-30,802	17,390	48,193	36991 ft ²
Roof	BARRIERS AND MEMBRANES	Roof Deck Sheet Barrier / [BEAM Avg]	7,528	7,528	0	103399 ft ²

Beam Embodied Carbon Results – Low Embodied Carbon Option

 PROJECT NAME: Creekview II SCENARIO: Scenario 1 BEAM VERSION: V1.1			SELECTED PROJECT MATERIALS REVIEW			514,666	646,911	132,244
SECTION	CATEGORY	MATERIAL	NET EMISSIONS kg CO ₂ e	GROSS EMISSIONS kg CO ₂ e	STORAGE Short Cycle kg CO	QTY		
Footings & Slabs	CONTINUOUS CONCRETE FOOTINGS	Concrete - 3001-4000 psi, 20-29% Fly Ash / NRMCA [Industry Avg US & CA]	38,250	38,250	0	152 yd ³		
Footings & Slabs	CONCRETE SLABS	Concrete - 2501-3000 psi, 20-29% Fly Ash / NRMCA [Industry Avg US & CA]	117,146	117,146	0	36990.9 ft ²		
Footings & Slabs	REBAR FOR CONTINUOUS FOOTINGS	Rebar / Concrete Reinforcing Steel Institute / 98% recycled, EAF / [Industry Avg N.America] / #5	2,393	2,393	0	5909.3 ft		
Footings & Slabs	REBAR FOR SLABS	Rebar / Concrete Reinforcing Steel Institute / 98% recycled, EAF / [Industry Avg N.America] / #4	137	137	0	528 ft		
Footings & Slabs	REINFORCING MESH FOR SLAB	Welded wire reinforcement / Insteel Industries / 6" x 6" x 6/6g [US & CA]	12,188	12,188	0	36990.9 ft ²		
Footings & Slabs	SUB-SLAB INSULATION	Foam glass aggregate / Glasopor AS / R 1.7-inch, 10-60 mm [EU]	7,498	7,498	0	36990.9 ft ²		
Footings & Slabs	BARRIERS AND MEMBRANES	Barrier, sheet / Polyethylene sheet / 10 mil	2,096	2,096	0	36990.9 ft ²		
Footings & Slabs	BASEMENT FLOORING	Carpet / Shaw / Residential Broadloom with ClearTouch Platinum	14,558	14,558	0	21824.7 ft ²		
Footings & Slabs	BASEMENT FLOORING	Linoleum flooring / 4.0 mm [BEAM Avg]	890	5,085	4,195	8507.9 ft ²		
Foundation Walls	REBAR FOR FOUNDATION WALLS	Rebar / Concrete Reinforcing Steel Institute / 98% recycled, EAF / [Industry Avg N.America] / #5	2,369	2,369	0	5850.2 ft		
Foundation Walls	REBAR FOR FOUNDATION WALLS	Rebar / Concrete Reinforcing Steel Institute / 98% recycled, EAF / [Industry Avg N.America] / #4	781	781	0	3013.8 ft		
Foundation Walls	CONCRETE MASONRY UNIT (CMU) WALLS	CMU - Normal weight / 8" Normal weight blocks / 15 MPa, 390 x 190 x 190 mm / CCMPA East Region [Industry Avg CA]	19,151	19,151	0	9839.1 ft ²		
Foundation Walls	CONCRETE FILL FOR CMU WALL	Concrete - 3001-4000 psi, 20-29% Fly Ash / NRMCA [Industry Avg US & CA]	56,347	56,347	0	223.9 yd ³		
Foundation Walls	CONTINUOUS INSULATION	XPS foam board / SOPREMA / SOPRA-XPS (entire product line) / R 5.0-inch	6,201	6,201	0	9839.1 ft ²		
Exterior Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	10,770	10,770	0	52587.7 ft ²		
Exterior Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x3 Lumber / AWC & CWC [Industry Avg US & CA]	2,448	2,448	0	26293.8 ft ²		
Exterior Walls	STRUCTURAL SHEATHING	OSB sheathing / 7/16" / LP / TopNotch® 350 / 7/16"	14,361	14,361	0	52587.7 ft ²		
Exterior Walls	BARRIERS AND MEMBRANES	Ext. Wall barrier, liquid applied / GCP / Perma-Barrier VPL 50RS UV stable / 13 Perms, 0.51 mm	7,475	7,475	0	52587.7 ft ²		
Exterior Walls	CAVITY INSULATION	Fiberglass batt & roll / Owens Corning / Unfaced, PINK Next Gen Fiberglas / R 3.6-inch avg.	11,908	11,908	0	52587.7 ft ²		
Exterior Walls	CONTINUOUS INSULATION	Wood fiber board / GUTEX / Multi-Therm / R 3.6-inch, 40-200 mm [EU]	-48,844	26,685	75,529	52587.7 ft ²		

Party Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	2,126	2,126	0	16315.9 ft²
Party Walls	CAVITY INSULATION	Fiberglass batt & roll / Owens Corning / Unfaced, PINK Next Gen Fiberglas / R 3.6-inch avg.	3,694	3,694	0	16315.9 ft²
Party Walls	INTERIOR CLADDING FOR PARTY WALLS	Drywall 1/2" [BEAM Avg US & CA]	2,340	2,340	0	8158 ft²
Party Walls	INTERIOR CLADDING FOR PARTY WALLS	Drywall 5/8" / USG / Sheetrock Brand EcoSmart Firecode X / 5/8"	3,573	3,573	0	16315.9 ft²
Cladding	EXTERIOR WALL CLADDING	Vinyl Siding / Vinyl Siding Institute / 0.040" Double 4.5" [Industry Avg US & CA]	23,011	23,011	0	52587.7 ft²
Cladding	INTERIOR CLADDING FOR EXTERIOR WALLS	Drywall 5/8" / USG / Sheetrock Brand EcoSmart Firecode X / 5/8"	11,517	11,517	0	52587.7 ft²
Windows	WINDOWS – TRIPLE-GLAZED	Window - triple pane / Vinyl frame / BFC Study [US & CA]	49,444	49,444	0	5375.9 ft²
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	4,301	4,301	0	21000.8 ft²
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	6,701	6,701	0	51415.8 ft²
Interior Walls	CLADDING FOR INTERIOR WALLS	Drywall 5/8" / USG / Sheetrock Brand EcoSmart Firecode X / 5/8"	31,719	31,719	0	72416.6 ft²
Interior Walls	CAVITY INSULATION	Fiberglass batt & roll / Owens Corning / Unfaced, PINK Next Gen Fiberglas / R 3.6-inch avg.	1,405	1,405	0	8690 ft²
Floors	LIGHT WOOD FLOOR FRAMING	Wood floor truss / Common (Warren, 45 deg) web pattern / Top chord bearing, variable depth / QWEB [Industry Avg CA]	9,506	9,506	0	30262.3 ft²
Floors	SUB FLOORING	OSB sheathing / 3/4" / AWC & CWC [Industry Avg US & CA]	12,992	12,992	0	30262.3 ft²
Floors	SUB FLOORING	OSB sheathing / 1/2" / AWC & CWC [Industry Avg US & CA]	8,661	8,661	0	30262.3 ft²
Floors	FLOORING	Carpet / Shaw / Residential Broadloom with ClearTouch Platinum	15,342	15,342	0	22999.3 ft²
Floors	FLOORING	Linoleum flooring / 4.0 mm [BEAM Avg]	918	5,245	4,327	8776.1 ft²
Floors	FLOOR CAVITY INSULATION	Fiberglass batt & roll / Owens Corning / Unfaced, PINK Next Gen Fiberglas / R 3.6-inch avg.	8,614	8,614	0	30262.3 ft²
Ceilings	CEILING FINISHES	Drywall 5/8" / USG / Sheetrock Brand EcoSmart Firecode X / 5/8"	14,729	14,729	0	67253.3 ft²
Roof	WOOD ROOF FRAMING	Wood roof truss / Gable Roof, Double Howe, 2x6 Chords, 2x4 Webs, 4:12 Pitch / QWEB [Industry Avg CA]	19,915	19,915	0	51699.7 ft²
Roof	ROOF DECKING	OSB sheathing / 5/8" / AWC & CWC [Industry Avg US & CA]	18,502	18,502	0	51699.7 ft²
Roof	ROOFING	Asphalt Shingles / Malarkey Roofing / Dura-Seal /	10,807	10,807	0	51699.7 ft²
Roof	ROOF CAVITY INSULATION	Cellulose / loose fill / CIMA / R 3.7-inch / [Industry Avg US & CA]	-30,802	17,390	48,193	36991 ft²
Roof	BARRIERS AND MEMBRANES	Roof Deck Sheet Barrier / [BEAM Avg]	7,528	7,528	0	103399.4 ft²

Beam Embodied Carbon Results – Bio-Based Materials Option



PROJECT NAME: Creekview II
SCENARIO: Scenario 4
BEAM VERSION: V1.1

SELECTED PROJECT MATERIALS REVIEW

-34,699

715,682

750,381

SECTION	CATEGORY	MATERIAL	NET EMISSIONS kg CO ₂ e	GROSS EMISSIONS kg CO ₂ e	STORAGE Short Cycle kg CO ₂	QTY
Footings & Slabs	CONTINUOUS CONCRETE FOOTINGS	Concrete - 3001-4000 psi, >50% SCM mix / NRMCA [Industry Avg] US & CA]	27,739	27,739	0	152 yd ³
Footings & Slabs	CONCRETE SLABS	Concrete - 2501-3000 psi, >50% SCM mix / NRMCA [Industry Avg] US & CA]	86,019	86,019	0	36991 ft ²
Footings & Slabs	REBAR FOR CONTINUOUS FOOTINGS	Rebar / Concrete Reinforcing Steel Institute / 98% recycled, EAF / [Industry Avg] N.America] / #5	2,393	2,393	0	5909.3 ft
Footings & Slabs	REBAR FOR SLABS	Rebar / Concrete Reinforcing Steel Institute / 98% recycled, EAF / [Industry Avg] N.America] / #4	137	137	0	528 ft
Footings & Slabs	REINFORCING MESH FOR SLAB	Welded wire reinforcement / Insteel Industries / 6" x 6" x 6/6g [US & CA]	12,188	12,188	0	36991 ft ²
Footings & Slabs	SUB-SLAB INSULATION	Foam glass aggregate / Glasopor AS / R 1.7-inch, 10-60 mm [EU]	7,498	7,498	0	36991 ft ²
Footings & Slabs	BARRIERS AND MEMBRANES	Barrier, sheet / Polyethylene sheet / 10 mil	2,096	2,096	0	36991 ft ²
Footings & Slabs	BASEMENT FLOORING	Carpet / Interface / CQUEST BioX / 1.5 mm Modular tile carpet	-195	9,274	9,469	21825 ft ²
Footings & Slabs	BASEMENT FLOORING	Linoleum flooring / Tarkett / Veneto Acoustic Cork / 4.4 mm sheet style linoleum with cork backing	-326	4,651	4,977	8507.9 ft ²
Foundation Walls	REBAR FOR FOUNDATION WALLS	Rebar / Concrete Reinforcing Steel Institute / 98% recycled, EAF / [Industry Avg] N.America] / #5	2,369	2,369	0	5850.2 ft
Foundation Walls	REBAR FOR FOUNDATION WALLS	Rebar / Concrete Reinforcing Steel Institute / 98% recycled, EAF / [Industry Avg] N.America] / #4	781	781	0	3013.8 ft
Foundation Walls	CONCRETE MASONRY UNIT (CMU) WALLS	CMU - Normal weight / 8" Normal weight blocks / 15 MPa, 390 x 190 x 190 mm / CCMPA East Region [Industry Avg] CA]	19,151	19,151	0	9839.1 ft ²
Foundation Walls	CONCRETE FILL FOR CMU WALL	Concrete - 3001-4000 psi, >50% SCM mix / NRMCA [Industry Avg] US & CA]	40,863	40,863	0	223.9 yd ³
Foundation Walls	CONTINUOUS INSULATION	XPS foam board / SOPREMA / SOPRA-XPS (entire product line) / R 5.0-inch	6,201	6,201	0	9839.1 ft ²
Exterior Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x3 Lumber / AWC & CWC [Industry Avg] US & CA]	2,448	2,448	0	26294 ft ²
Exterior Walls	BARRIERS AND MEMBRANES	Sheet Barrier Moisture-Variable / [BEAM Avg]	3,492	3,492	0	52588 ft ²
Exterior Walls	CONTINUOUS INSULATION	Wood fiber board / GUTEX / Multi-Therm / R 3.6-inch, 40-200 mm [EU]	-48,844	26,685	75,529	52588 ft ²
Exterior Walls	STRUCTURAL INSULATED PANEL (SIP)	Straw Insulated Panels with wood framing (SIP) / EcoCocon / Prefabricated panel, 40 cm / R35 [EU]	-345,286	69,863	415,150	52588 ft ²

Party Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	2,126	2,126	0	16316 ft ²
Party Walls	CAVITY INSULATION	Hemp fiber batt / NaturFibre / Hemp Wool / R 3.7-inch	146	9,732	9,587	16316 ft ²
Party Walls	INTERIOR CLADDING FOR PARTY WALLS	Drywall 1/2" [BEAM Avg US & CA]	2,340	2,340	0	8158 ft ²
Party Walls	INTERIOR CLADDING FOR PARTY WALLS	Drywall 5/8" / USG / Sheetrock Brand EcoSmart Firecode X / 5/8"	3,573	3,573	0	16316 ft ²
Cladding	EXTERIOR WALL CLADDING	Bamboo Cladding / Dasso / dassoCTECH outdoor oiled Cladding / Shiplap, 5/8" (18 mm)	-36,947	112,014	148,961	52588 ft ²
Cladding	INTERIOR CLADDING FOR EXTERIOR WALLS	Drywall 5/8" / USG / Sheetrock Brand EcoSmart Firecode X / 5/8"	11,517	11,517	0	52588 ft ²
Windows	WINDOWS – TRIPLE-GLAZED	Window - triple pane / Vinyl frame / BfCA Study [US & CA]	49,444	49,444	0	5375.9 ft ²
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	4,301	4,301	0	21001 ft ²
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	6,701	6,701	0	51416 ft ²
Interior Walls	CLADDING FOR INTERIOR WALLS	Drywall 5/8" / USG / Sheetrock Brand EcoSmart Firecode X / 5/8"	31,719	31,719	0	72417 ft ²
Interior Walls	CAVITY INSULATION	Hemp fiber batt / NaturFibre / Hemp Wool / R 3.7-inch	55	3,703	3,647	8690 ft ²
Floors	LIGHT WOOD FLOOR FRAMING	Wood floor truss / Common (Warren, 45 deg) web pattern / Top chord bearing, variable depth / QWEB [Industry Avg CA]	9,506	9,506	0	30262 ft ²
Floors	SUB FLOORING	OSB sheathing / 3/4" / AWC & CWC [Industry Avg US & CA]	12,992	12,992	0	30262 ft ²
Floors	SUB FLOORING	OSB sheathing / 1/2" / AWC & CWC [Industry Avg US & CA]	8,661	8,661	0	30262 ft ²
Floors	FLOORING	Carpet / Interface / CQUEST BioX / 1.5 mm Modular tile carpet	-205	9,773	9,978	22999 ft ²
Floors	FLOORING	Linoleum flooring / Tarkett / Lino Veneto xF2, Etrusco, Style Elle Emme, Veneto, Originale, LinoRail, Linosport / 2.5 mm sheet style linoleum	-371	2,167	2,538	6657.7 ft ²
Floors	FLOOR CAVITY INSULATION	Hemp fiber batt / NaturFibre / Hemp Wool / R 3.7-inch	340	22,693	22,353	30262 ft ²
Ceilings	CEILING FINISHES	Drywall 5/8" / USG / Sheetrock Brand EcoSmart Firecode X / 5/8"	14,729	14,729	0	67253 ft ²
Roof	WOOD ROOF FRAMING	Wood roof truss / Gable Roof, Double Howe, 2x6 Chords, 2x4 Webs, 4:12 Pitch / QWEB [Industry Avg CA]	19,915	19,915	0	51700 ft ²
Roof	ROOF DECKING	OSB sheathing / 5/8" / AWC & CWC [Industry Avg US & CA]	18,502	18,502	0	51700 ft ²
Roof	ROOFING	Asphalt Shingles / Malarkey Roofing / Dura-Seal /	10,807	10,807	0	51700 ft ²
Roof	ROOF CAVITY INSULATION	Cellulose / loose fill / CIMA / R 3.7-inch / [Industry Avg US & CA]	-30,802	17,390	48,193	36991 ft ²
Roof	BARRIERS AND MEMBRANES	Roof Deck Sheet Barrier / [BEAM Avg]	7,528	7,528	0	103399 ft ²