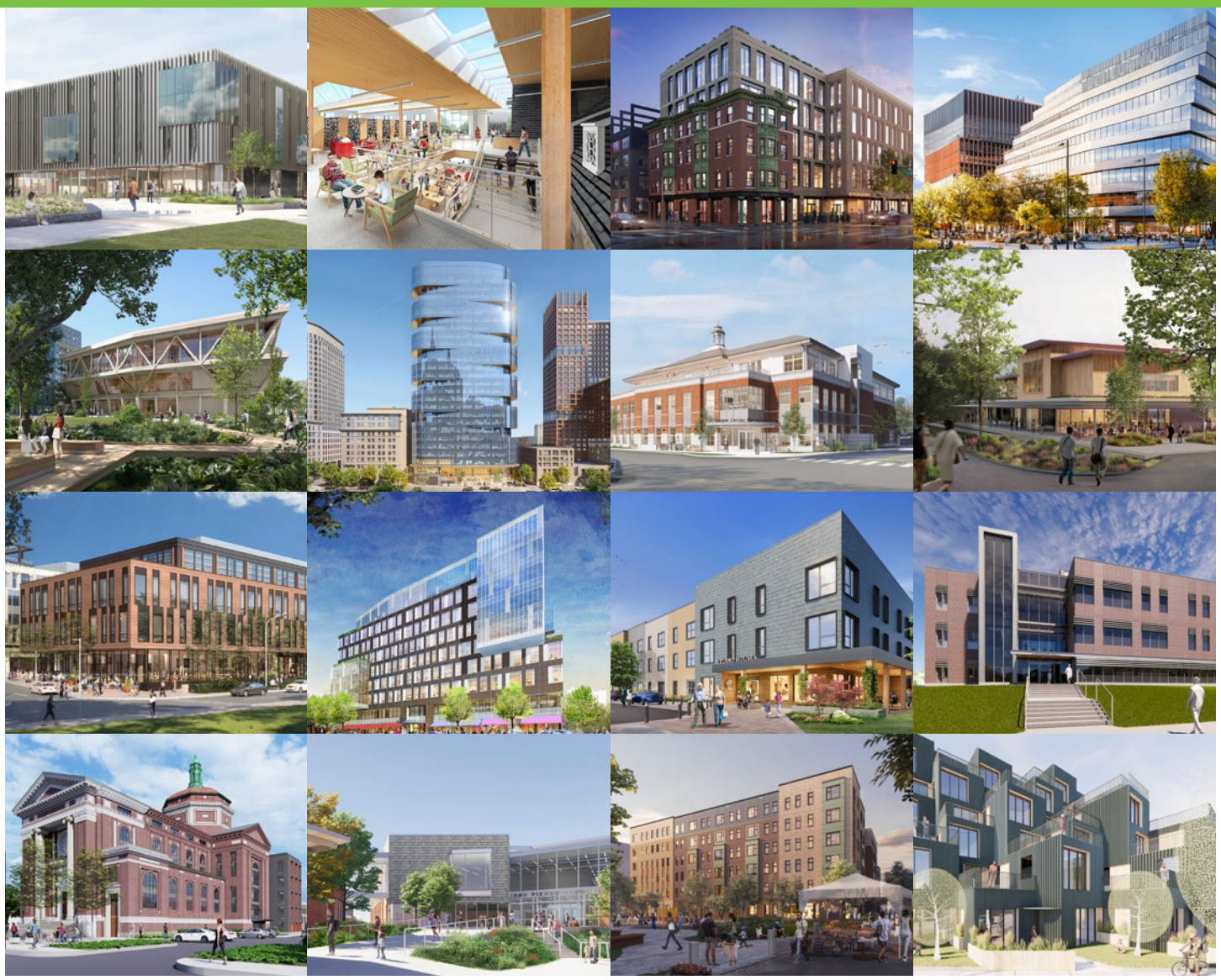
BUILT ENVIRONMENT PLUS

MASSACHUSETTS CLEAN ENERGY CENTER®

EMBODIED CARBON REDUCTION CHALLENGE

16 CASE STUDIES



First-in-the-nation Embodied Carbon Challenge Spurs Action

In March 2023, the Massachusetts Clean Energy Center and Built Environment Plus launched the first-in-the-nation Embodied Carbon Reduction Challenge in order to jump-start the upfront reduction of carbon in building projects across Massachusetts.

16 teams submitted projects performing Whole Building Life Cycle Assessments (WBLCAs), and a total of $380,000 in cash prizes were awarded to 11 lead applicants. A panel of nine judges from across the country made their selections based on embodied carbon reduction, innovation, replicability, and cost effectiveness.

The Challenge equipped a whole new slate of design firms and practitioners with the tools and knowledge they need to take embodied carbon reductions to the next level.

These case studies present all 16 submitting projects in a consistent format. You can explore key results and compare implemented low carbon strategies. Take care drawing conclusions from comparison, as data is not apples-to-apples.

Why Embodied Carbon?

Unlike operational carbon emissions, which can be reduced over time with building energy efficiency renovations and renewable energy, embodied carbon emissions from building materials have irreversibly entered the atmosphere as soon as a building is built.

That means the upfront building material choices are critically impactful. And as new construction operations become more efficient, embodied carbon impacts become even more significant.

Challenge Requirements

Teams had to complete and submit the following:

1. Whole Building Life Cycle Assessment Reports for the baseline and proposed / actual building. Completed in TallyLCA or One Click LCA.
2. Completed Carbon Leadership Forum WBLCA Reporting Templates for baseline and proposed.

**Please see last page for note on data accuracy.*

Projects had to meet the following criteria:

- Be located In Massachusetts.
- Have over 20,000 square feet of floor area.
- Be an actual / real project that will be constructed.
- Have at least started construction documentation by April 3, 2024.
- Have reached substantial construction completion after June 1, 2023.
- Can be new construction or major renovation.
- Must be a whole building.
- There are no limits on project type or construction type.

Sustainable Engineering Laboratories

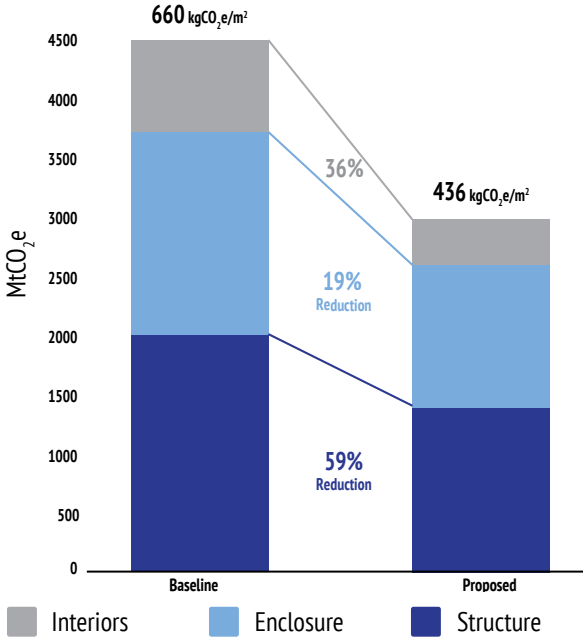
Embodied Carbon Challenge Results

34%
Reduction of Carbon

224 $kgCO_2e$
Reduction per m^2

1,528 $MtCO_2e$
Reduced from Baseline

Space Optimization
Most Impactful Strategy



Client / Owner
UMass Amherst

Competition Participant
Payette

Project Type
Laboratory - New Construction

WBLCA Software
tallyLCA

Anticipated Completion Year
2026

Location
Amherst, MA

Primary Structural System
Mass timber + concrete

Project Overview

Exterior Rendering by Payette

Sustainable Engineering Laboratories (SEL) will function as a living laboratory platform and model for UMass Amherst's College of Engineering to counter the effects of climate change. The project is guided by campus sustainability and carbon neutrality goals, with the building expected to achieve ILFI Zero Carbon and LEED Platinum. SEL makes new ground by incorporating mass timber construction in a program type traditionally averse to it. The program area was also maximized via efficient planning and a 'skip stop' sectional strategy enclosing more program with less facade area and less structure.

Innovation and Replicability

Reductions were primarily driven by highly replicable design-based decisions and further material optimizations were cost neutral. Innovative strategies include a cost per carbon method, timber mullions, a matrix of structural systems, and the use of Dowel Laminated Timber (DLT) with acoustic treatment instead of CLT.

Low Carbon Strategies

In order to achieve a 34% reduction, six of the common low carbon strategies were incorporated. Additionally, they had a number of unique strategies, which set this project apart, such as:

- Creating a "cost per carbon reduction method" model in order to make informed decisions that were cost effective and low carbon
- Reduced floor to floor heights and structural grid optimization
- Specifying Polyiso instead of XPS for the roof assembly
- Mechanical relocation from the basement to ground level and roof to reduce excavation and foundation work

Reuse & Rehabilitation	Space Optimization	Interior Efficiencies	Lightweight Design	Timber Structure	Low Carbon Concrete	Low Carbon Insulation	
	✓	✓	✓	✓	✓	✓	SIX

BUILT ENVIRONMENT PLUS · MASSACHUSETTS CLEAN ENERGY CENTER · EMBODIED CARBON REDUCTION CHALLENGE

Jones Library

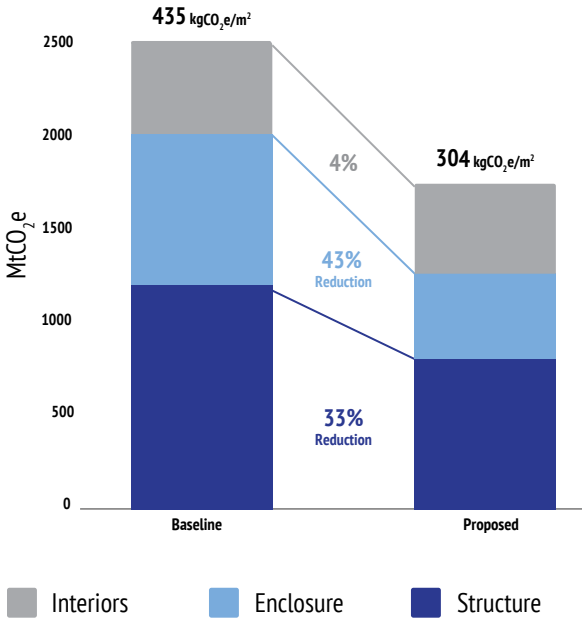
Embodied Carbon Challenge Results

30%
Reduction of Carbon

131 $kgCO_2e$
Reduction per m^2

744 $MtCO_2e$
Reduced from Baseline

Reuse & Rehab
Most Impactful Strategy



Client / Owner
Trustees of the Jones Library

Competition Participant
Finegold Alexander Architects

Project Type
Public Assembly - Major Renovation

WBLCA Software
tallyLCA

Anticipated Completion Year
2026

Location
Amherst, MA

Primary Structural System
Mass timber + concrete

Project Overview

Interior Rendering by Finegold Alexander

The Jones Library project is a renovation and expansion project with the goals of improving safety, user-friendliness, and efficiency of the library. The library renovation also aims to honor the historical facade of the building while also reducing the embodied carbon throughout the project. The new construction enables more preservation of the existing building, for example by improving accessibility, and reduces overall carbon and construction by building a flexible and compact new addition to the smallest feasible size.

Innovation and Replicability

The project thoughtfully combines an adaptive reuse approach with carefully selected low carbon materials to meet function. The use of lower carbon gypcrete where topping slabs were needed, and the reduced use of interior materials for visual and carbon benefits, is a replicable strategy.

Low Carbon Strategies

In order to achieve a 30% reduction, Jones Library incorporated 5 of the common low carbon strategies. They also had a number of other notable strategies:

- The restoration and reuse of the structure, the envelope, and much of the interior woodwork of the historic 1920s building
- Interior finishes have long-term durability and clean-ability
- Wood columns and beams were left exposed where possible
- Included future proofing and flexibility in the design.

Reuse & Rehabilitation	Space Optimization	Interior Efficiencies	Lightweight Design	Timber Structure	Low Carbon Concrete	Low Carbon Insulation	
✓	✓	✓		✓	✓		FIVE

80 West Broadway

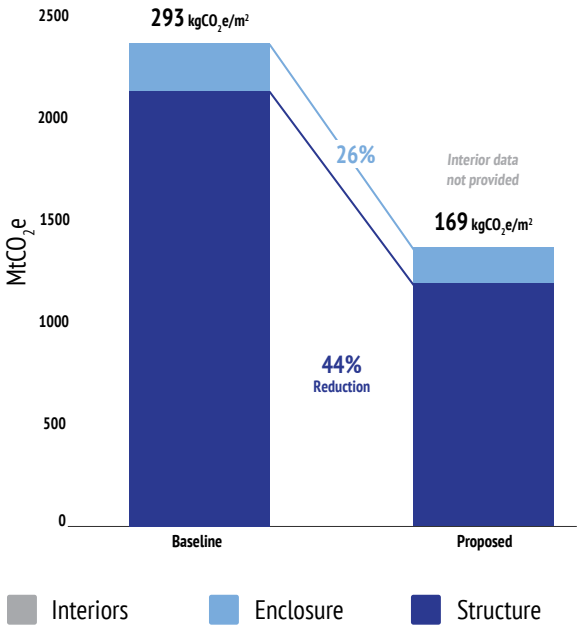
Embodied Carbon Challenge Results

42%
Reduction of Carbon

124 $kgCO_2e$
Reduction per m^2

999 $MtCO_2e$
Reduced from Baseline

Timber Structure
Most Impactful Strategy



Client / Owner
Shorenstein Realty Services

Competition Participant
Stantec Architecture

Project Type
Office - New Construction

WBLCA Software
One Click LCA

Anticipated Completion Year
2026

Location
Boston, MA

Primary Structural System
Mass timber

Project Overview

Exterior Rendering by Stantec

The design for 80 West Broadway has a goal of preserving the Amrheins restaurant building, a 1890 iconic 4-story masonry and copper facade, while also bringing new life into the space. The resulting design maintains the integrity of the previous space, while creating a new mixed-use building that spans four stories, with the restaurant maintained on the ground floor. It is expected to achieve LEED Gold certification.

Innovation and Replicability

Early studies in the design process explored reduction strategies and saved on redesigns. The resulting CLT structure proves replicable with a construction cost savings over a conventional hybrid system. Material selections were considered holistically and using wood construction with thin brick made for a lighter foundation.

Low Carbon Strategies

In order to achieve a 42% reduction, the 80 West Broadway project team incorporated six of the common low carbon strategies. They also had a number of other notable strategies:

- A thermally efficient rain screen system: mineral wool board insulation, thin brick, and thermal-bridging isolation clips
- Project specified electric furnace fabricated steel
- An efficient roof layout of equipment and solar PV to locate heavy-load roof framing
- Implemented car-parking stackers, helping to maximize the efficiency of the space

Reuse & Rehabilitation	Space Optimization	Interior Efficiencies	Lightweight Design	Timber Structure	Low Carbon Concrete	Low Carbon Insulation	
✓	✓	✓	✓	✓	✓		SIX

EMBODIED CARBON REDUCTION CHALLENGE

One Milestone

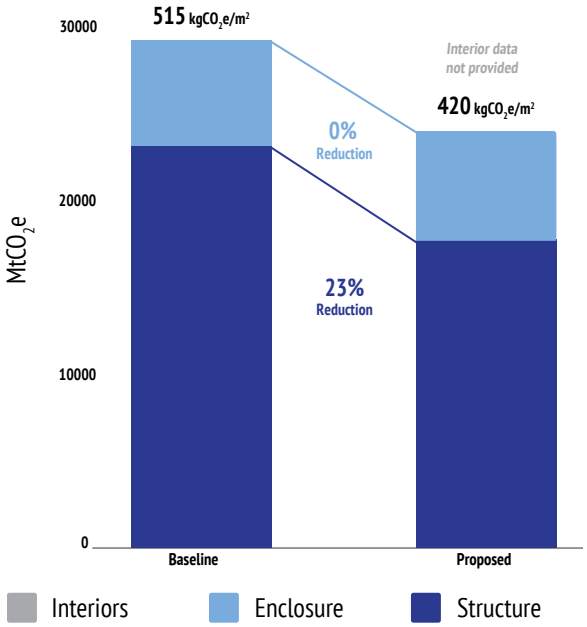
Embodied Carbon Challenge Results

18%
Reduction of Carbon

94 $kgCO_2e$
Reduction per m^2

5,367 $MtCO_2e$
Reduced from Baseline

Space Optimization
Most Impactful Strategy



Client / Owner
Tishman Speyer, Breakthrough Properties

Competition Participant
Arrowstreet Inc

Project Type
Other - New Construction

WBLCA Software
One Click LCA

Anticipated Completion Year
2025

Location
Boston, MA

Primary Structural System
Steel

Project Overview

Exterior Rendering by Arrowstreet

One Milestone is a mixed-use building containing lab and office spaces, located in lower Allston withing the Enterprise Research Campus. It will contain over 2 acres of green space for those occupying the space to enjoy. The project focused on reducing embodied carbon by first optimizing form and structure, and then ensured less materials were used and appropriate lower carbon alternatives were studied and selected. In specifying a reduction of materials, the project also realized lower construction costs.

Innovation and Replicability

The model for engagement on carbon throughout the process is highly replicable. This included the early design analysis using upfront massing and structural studies as well as the project team's collaboration with ready mix suppliers to achieve concrete goals. This type of engagement and commissioning are integral to success.

Low Carbon Strategies

One Milestone reduced 18% of the embodied carbon in the design by implementing four of the common low carbon strategies. They also had a number of other notable strategies:

- Used concrete masonry units with carbon capture technology
- Interior quantities were reduced by utilizing structure as finish with exposed ceilings and polished concrete floors
- Low-carbon site improvements including site/roof pavers with ground glass pozzolan for cement replacement, FSC certified non-tropical benches, and low-carbon site concrete
- Hosted Sublime System's first ever field validation pour

Reuse & Rehabilitation	Space Optimization	Interior Efficiencies	Lightweight Design	Timber Structure	Low Carbon Concrete	Low Carbon Insulation	
	✓	✓			✓	✓	FOUR

BUILT ENVIRONMENT PLUS · MASSACHUSETTS CLEAN ENERGY CENTER

EMBODIED CARBON REDUCTION CHALLENGE

David Rubenstein Treehouse Conference Center

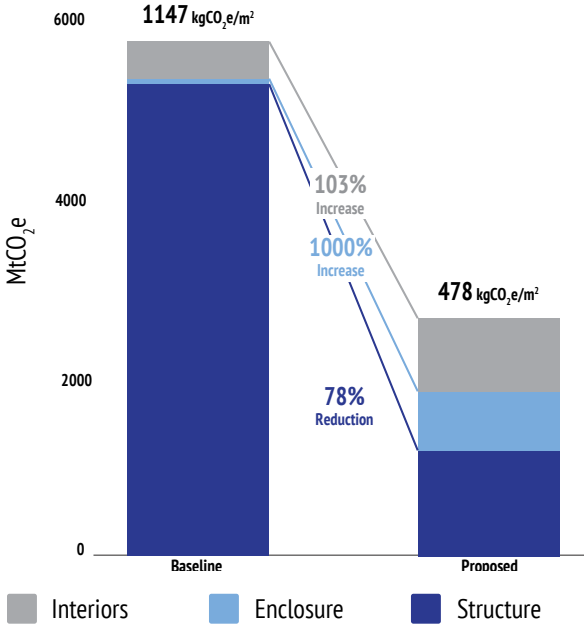
Embodied Carbon Challenge Results

58%
Reduction of Carbon

669 $kgCO_2e$
Reduction per m^2

3,357 $MtCO_2e$
Reduced from Baseline

Timber Structure
Most Impactful Strategy



Client / Owner
Harvard University

Competition Participant
Harvard University Office for Sustainability

Project Type
Public Assembly - New Construction

WBLCA Software
tallyLCA

Anticipated Completion Year
2026

Location
Boston, MA

Primary Structural System
Mass timber

Project Overview

Exterior Rendering via Harvard University

The David Rubenstein Treehouse Conference Center in lower Allston is being constructed as Harvard's first University-wide conference center. The project has a strong focus on sustainability with goals that target climate, health, and equity. The building will function for numerous group activities, including for international summits, alumni gatherings, conference receptions, and workforce recruiting activities. The conference center follows Harvard's Healthier Building standards and the University's Sustainability Plan, while also being all-electric.

Innovation and Replicability

The team found a cost benefit to mass timber with reduced concrete for foundations. They emphasized the importance of early collaboration to reduce cost, perceived risks, and schedule impacts. The project innovates in material use by supporting new markets for timber products and ground glass pozzolan cement replacement.

Low Carbon Strategies

The project team for the Treehouse Conference Center worked to reduce embodied carbon on this project by utilizing four of the common low carbon strategies. They also had a number of other notable strategies:

- This project considered health aspects in their design, making sure the design decisions that were made were not just more sustainable, but also were beneficial to those using the building.
- 70% cement replacement using ground glass pozzolan and without fly ash
- Wood cladding and making lower-GWP choices for insulation

Reuse & Rehabilitation	Space Optimization	Interior Efficiencies	Lightweight Design	Timber Structure	Low Carbon Concrete	Low Carbon Insulation	
			✓	✓	✓	✓	FOUR

BUILT ENVIRONMENT PLUS · MASSACHUSETTS CLEAN ENERGY CENTER · EMBODIED CARBON REDUCTION CHALLENGE

380 Stuart

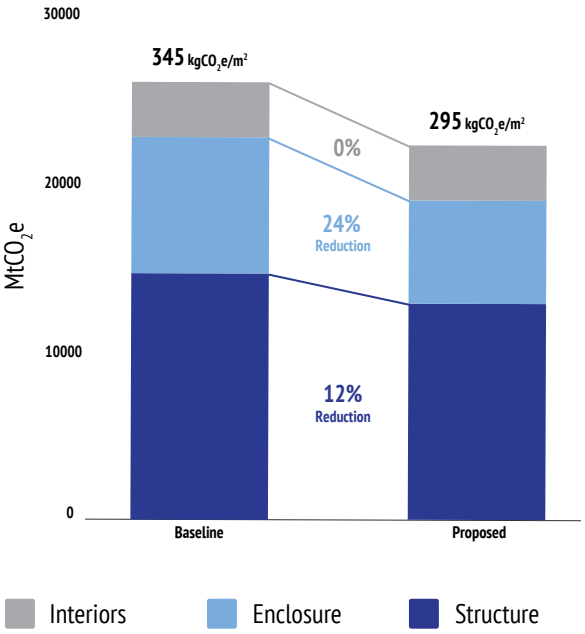
Embodied Carbon Challenge Results

14%
Reduction of Carbon

50 $kgCO_2e$
Reduction per m^2

3,740 $MtCO_2e$
Reduced from Baseline

Lightweight Design
Most Impactful Strategy



Client / Owner
Skanska CDUS

Competition Participant
CBT Architects

Project Type
Office - New Construction

WBLCA Software
One Click LCA

Anticipated Completion Year
TBD

Location
Boston, MA

Primary Structural System
Steel

Project Overview

Exterior Rendering by CBT Architects

Located in Boston's Back Bay, 380 Stuart is a 28-story office tower containing retail and other amenities. The team focused on sustainability goals, accessibility, inclusivity, and tenant health in their design. 380 Stuart was designed with Boston's green building and carbon-neutral goals, and the tower is expected to achieve LEED Gold - with efforts to achieve Platinum in the future. The building is fully electric, eliminating all on-site fossil fuels and has reduced embodied carbon through material selection.

Innovation and Replicability

Their process was both distinct yet repeatable. An early design analysis was important to carbon reductions and then improved with the iterative actions of reviewing the small design changes of the envelope. Beyond just the material swaps, the project implemented facade changes that considered holistic construction impacts.

Low Carbon Strategies

The 380 Stuart project team worked to reduce embodied carbon on this project by utilizing two of the common low carbon strategies. They also had a number of other notable strategies:

- Studied how to reduce the quantity of concrete, designing the concrete core with 3 structural bays where each bay could be replaced with a lighter steel structure
- A curtain wall study reduced the required panels by 528 overall, 22 per floor. They reduced glass use, eliminated aluminum mullions where possible and evaluated connection details on the guardrail, totaling a 27% carbon reduction on the envelope

Reuse & Rehabilitation	Space Optimization	Interior Efficiencies	Lightweight Design	Timber Structure	Low Carbon Concrete	Low Carbon Insulation	
			✓		✓		TWO

Cooper Center for Active Living

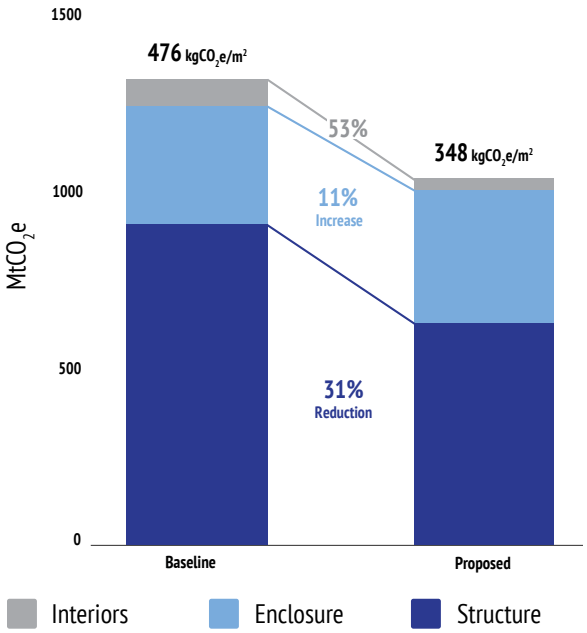
Embodied Carbon Challenge Results

27%
Reduction of Carbon

128 $kgCO_2e$
Reduction per m^2

380 $MtCO_2e$
Reduced from Baseline

Timber Structure
Most Impactful Strategy



Client / Owner
City of Newton

Competition Participant
The Green Engineer

Project Type
Public Assembly - New Construction

WBLCA Software
One Click LCA

Anticipated Completion Year
2025

Location
Newton, MA

Primary Structural System
Mass timber + concrete

Exterior Rendering via The Green Engineer

Project Overview

The Cooper Center for Active Living is a building designed with the goals of creating a comfortable center that meets the needs of older citizens in the Newton Community. The Cooper Center aims to grow a sense of community for this group of residents and improve the quality of life for senior adults in Newton. While designed to meet the needs of seniors, the Center is age friendly and welcoming to everyone, promoting social equality and maximizes access to programs and services to everyone, while also being environmentallyLCA conscious and striving to be carbon neutral.

Innovation and Replicability

The decision to use a hybrid mass timber structure resulted in the lightweight design that allowed for a reduction in size and weight of supporting foundations and footings which ended up being both carbon and cost effective. This project's performance also may not have happened without local legislation and good city planning.

Low Carbon Strategies

In order to achieve a 27% reduction, Cooper Center for Active Living incorporated two of the common low carbon strategies. They also had a number of other notable strategies:

- The need for ground improvement was eliminated, panelization and manufacturing occurred off-site, and the project is expected to be assembled 4 months faster than anticipated.
- The team conducted an early analysis in schematic design to assess the operational and embodied carbon impact of renovating/adding to an existing building or demo/new build.

Reuse & Rehabilitation	Space Optimization	Interior Efficiencies	Lightweight Design	Timber Structure	Low Carbon Concrete	Low Carbon Insulation	
			✓	✓			TWO

BUILT ENVIRONMENT PLUS
MASSACHUSETTS CLEAN ENERGY CENTER
EMBODIED CARBON REDUCTION CHALLENGE

Amherst College Student Center

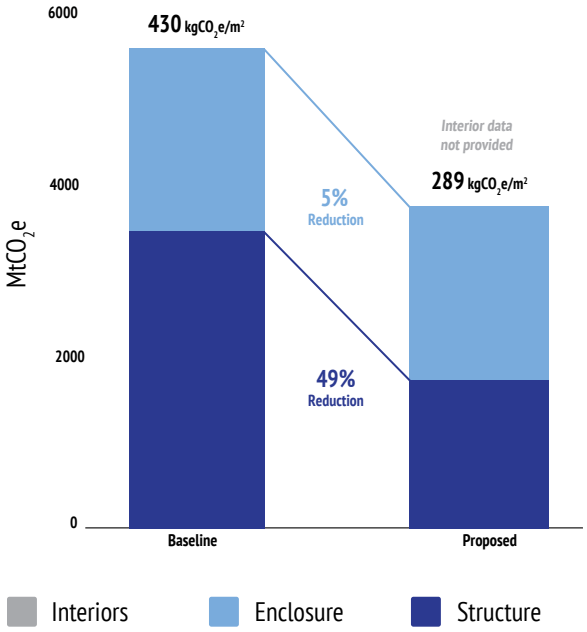
Embodied Carbon Challenge Results

33%
Reduction of Carbon

141 $kgCO_2e$
Reduction per m^2

1,858 $MtCO_2e$
Reduced from Baseline

Timber Structure
Most Impactful Strategy



Client / Owner
Amherst College

Competition Participant
Sasaki

Project Type
Education - New Construction

WBLCA Software
One Click LCA

Anticipated Completion Year
2026

Location
Amherst, MA

Primary Structural System
Mass timber + concrete

Exterior Rendering via Amherst College

Project Overview

Amherst College's new student center will create a multi-functional space for students on campus. The building will provide an additional dining hall, cafe, and lounge spaces, as well as a theater, music rooms, maker spaces, and more to the Amherst College's campus. This project aims to connect the upper and lower campus of the school, providing a central hub for those in the community. The project team is designing with the goal of reducing embodied carbon and aligning to the school's commitment to achieving carbon neutrality by 2030, by utilizing numerous sustainability techniques.

Innovation and Replicability

The team's reuse of an existing two story foundation was carbon smart and wouldn't have been possible without early design analysis. Having a client who owns the site before demolition was helpful to the innovations they accomplished, including a timber transfer plate allowing for a independent upper floor column layout.

Low Carbon Strategies

The Amherst College Student Center aimed to reduce embodied carbon using two of the common low carbon strategies across all projects. They also had a number of other notable strategies:

- The team studied carbon impacts of different building materials in order to make mindful substitutions. This included a facade choice which made a meaningful reduction on the final design, even with all the other reductions.
- Utilizing an integrated team with expertise in early carbon analysis, building reuse, and WBLCA was a winning recipe for big upfront carbon reductions.

Reuse & Rehabilitation	Space Optimization	Interior Efficiencies	Lightweight Design	Timber Structure	Low Carbon Concrete	Low Carbon Insulation	
✓				✓			TWO

EMBODIED CARBON REDUCTION CHALLENGE

Northland Newton Development Building 7

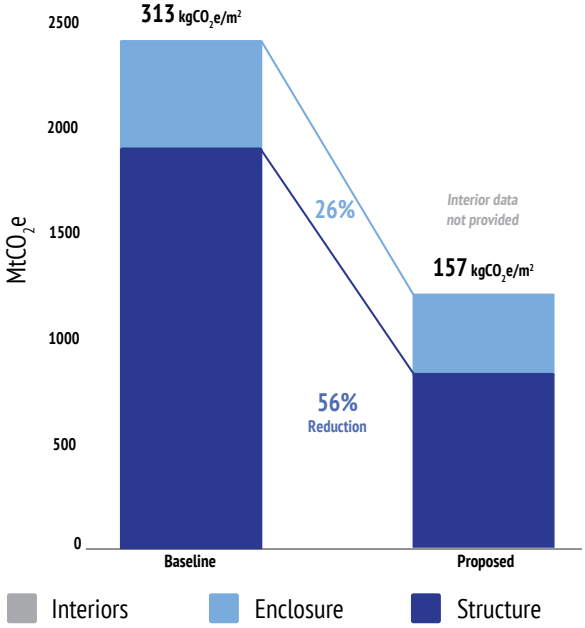
Embodied Carbon Challenge Results

50%
Reduction of Carbon

156 $kgCO_2e$
Reduction per m^2

1206 $MtCO_2e$
Reduced from Baseline

Timber Structure
Most Impactful Strategy



Client / Owner
Northland Newton Investment Corp.

Competition Participant
Steven Winter Associates Inc

Project Type
Residential - New Construction

WBLCA Software
One Click LCA

Anticipated Completion Year
2027

Location
Newton, MA

Primary Structural System
Mass timber

Project Overview

Exterior Rendering by Stantec

The Northland Newton Development is a collection of residential buildings in Newton that are being developed with affordable housing, sustainable, and historic preservation goals in mind. Building 7 is one of many and is an example of how carbon goals are being addressed within the entire project. The total development project will provide 800 apartment units, with 140 being affordable. The space will contain retail and culinary establishments, and green space around the apartments to further encourage the importance of community and create a comfortable environment for residents.

Innovation and Replicability

The early design analysis and collaboration was essential for their results. The team found lower carbon glass and optimized the structural components for a lightweight design with the hybrid structure making efficient use of structural materials. The projects material specs and concrete optimization are easily replicable.

Low Carbon Strategies

Northland Newton Development Building 7 was able to accomplish a 50% reduction through four of the common low carbon strategies across all projects. They also had a number of other notable strategies:

- The project minimized the occurrence of structural transfers, using them only where necessary
- A 12" reinforced concrete structural slab on grade was reduced to a 4" soil supported slab on grade
- Cross laminated timber (CLT) was used as the diaphragm at the roof level, eliminating concrete entirely

Reuse & Rehabilitation	Space Optimization	Interior Efficiencies	Lightweight Design	Timber Structure	Low Carbon Concrete	Low Carbon Insulation	
			✓	✓	✓	✓	FOUR

BUILT ENVIRONMENT PLUS · MASSACHUSETTS CLEAN ENERGY CENTER · EMBODIED CARBON REDUCTION CHALLENGE

80 East Berkeley

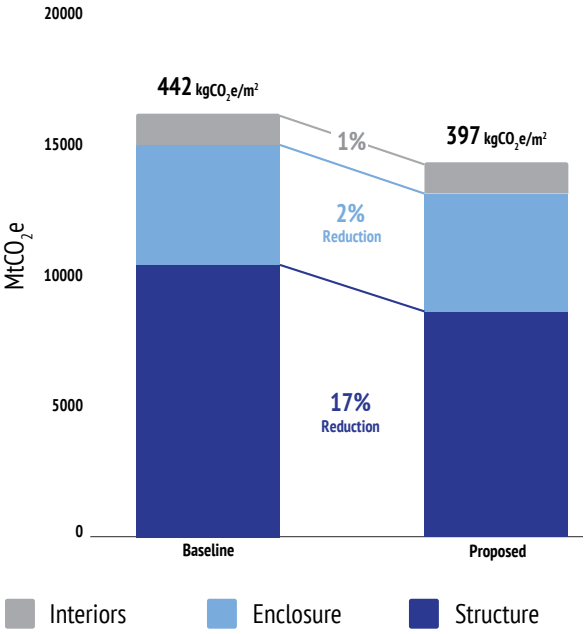
Embodied Carbon Challenge Results

10%
Reduction of Carbon

45 $kgCO_2e$
Reduction per m^2

1,707 $MtCO_2e$
Reduced from Baseline

Low Carbon Concrete
Most Impactful Strategy



Client / Owner
The Drucker Company, Beacon Capital Partners

Competition Participant
Elkus Manfredi Architects

Project Type
Other - New Construction

WBLCA Software
tallyLCA

Anticipated Completion Year
2027

Location
Boston, MA

Primary Structural System
Steel

Exterior Rendering by Elkus Manfredi Architects

Project Overview

80 East Berkeley is designed to be a 10-story mixed-use building with spaces for offices, laboratories, research, retail, and parking This all electric lab/office building shows a 36% site energy savings and 40% GHG emissions reduction against the Stretch Energy Code Baseline. Embodied carbon reduction strategies made on this project occurred on a specification level, with a materials based approach. The project was an adjustment to the architect's firm-wide specifications, and their research will continue to benefit all future projects they work on.

Innovation and Replicability

All reduction strategies on this project occurred at a specification level and were targeted specifically to incur no or minimal cost. The team is implementing these lessons learned firm-wide for ongoing embodied carbon reductions and show clear means for others to replicate the approach using the same accessible tools.

Low Carbon Strategies

80 East Berkeley achieved a reduction of 10% embodied carbon from baseline to proposal by implementing two of the common low carbon strategies across all projects. They also had a number of other notable strategies:

- Optimized use of Mineral Wool board and XPS instead of Polyiso insulation, which gave a 12% reduction for the project
- One of the materials proposed in the optimized LCA model is concrete masonry units with Carbon X technology
- Specified low carbon alternatives for concrete, roofing and gypsum wall board

Reuse & Rehabilitation	Space Optimization	Interior Efficiencies	Lightweight Design	Timber Structure	Low Carbon Concrete	Low Carbon Insulation	
					✓	✓	TWO

Leland House

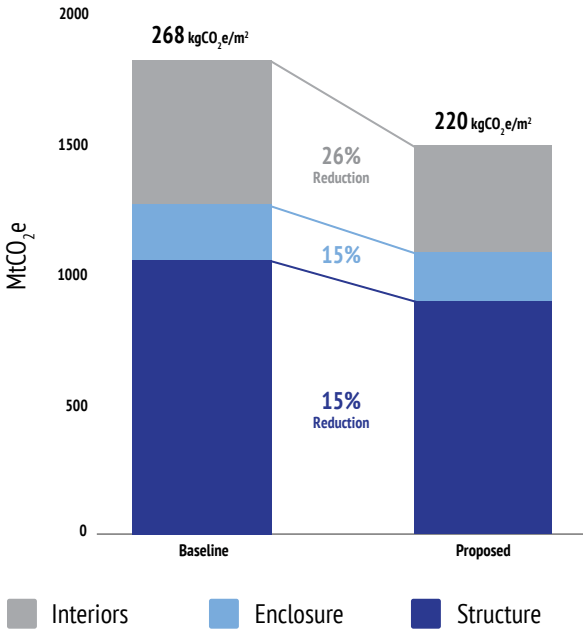
Embodied Carbon Challenge Results

18%
Reduction of Carbon

48 kgCO$_2$e
Reduction per m^2

326 MtCO$_2$e
Reduced from Baseline

Timber Structure
Most Impactful Strategy



Client / Owner
2Life Communities

Competition Participant
Prellwitz Chilinski Associates

Project Type
Residential - New Construction

WBLCA Software
One Click LCA

Anticipated Completion Year
2024

Location
Waltham, MA

Primary Structural System
Wood: Light-frame

Project Overview

Exterior Rendering by PCA

The Leland Home was demolished in August 2023, and Leland House is an affordable housing development for senior adults in Waltham, MA that will replace the former building. The building supports an inclusive community for those living in the home and those visiting. Residents of the building enjoy a Village Center on the first floor with a lobby, reception area, library, lounges, game room, dining area, classroom, and fitness and wellness areas. The design of the building has goals of creating a beautiful but safe and comfortable environment for residents.

Innovation and Replicability

The carbon reductions came through material choice, with market-ready materials that are all replicable. As cellulose insulation is typically cost neutral, it is an ideal swap that comes with a large reduction impact. The team also developed a Lessons Learned 2.0 model that offered further reductions and innovations in design.

Low Carbon Strategies

In order to achieve this reduction, the Leland House project team incorporated four of the common low carbon strategies. They also had a number of other notable strategies:

- Included bio-based materials, including resilient flooring, plant-based acoustic ceiling tiles, and wood veneer ceiling finishes which did not add significant costs to the budget
- Applied a holistic approach that also considered health impacts for interior materials specifying PVC and Red List free finishes
- Studied the total carbon impact of double vs. triple-pane windows

Reuse & Rehabilitation	Space Optimization	Interior Efficiencies	Lightweight Design	Timber Structure	Low Carbon Concrete	Low Carbon Insulation	
			✓	✓	✓	✓	FOUR

BUILT ENVIRONMENT PLUS · MASSACHUSETTS CLEAN ENERGY CENTER · EMBODIED CARBON REDUCTION CHALLENGE

Mass Maritime Lab Modernization

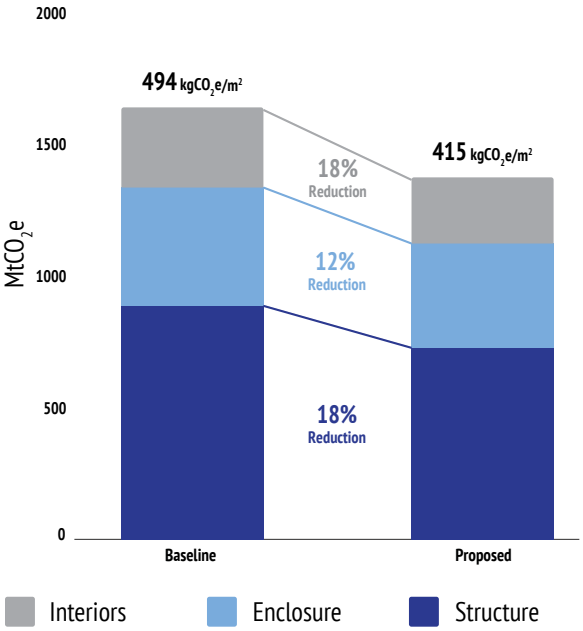
Embodied Carbon Challenge Results

16%
Reduction of Carbon

79 $kgCO_2e$
Reduction per m^2

263 $MtCO_2e$
Reduced from Baseline

Lightweight Design
Most Impactful Strategy



Client / Owner
Massachusetts Maritime Academy, DCAMM

Competition Participant
Ellenzweig

Project Type
Laboratory - New Construction

WBLCA Software
tallyLCA

Anticipated Completion Year
2026

Location
Buzzards Bay, MA

Primary Structural System
Steel + concrete

Exterior Rendering by Ellenzweig

Project Overview

The Mass Maritime Academy, Science, Technology and Engineering Lab Modernization creates a new lab space on campus, replacing existing sheds and works to also renovate existing labs. The project additionally features renovated classrooms. The lab modernization is designed to be all-electric, net zero ready, and contains a number of different operational carbon features such as ground source heat pumps and a efficient fume hood specification. The project also takes resiliency into account by raising the site grade by five feet.

Innovation and Replicability

This project stewarded an approach to optimize space usage and create a lightweight design. The team compared HSS and wide-flange steel, taking into account fireproofing material, something extremely important for laboratory buildings. The HSS reduced the material quantity while retaining the performance requirements.

Low Carbon Strategies

The Mass Maritime Lab Modernization team worked to reduce embodied carbon on this project by utilizing four of the common low carbon strategies. They also had a number of other notable strategies:

- Conducted a comparative study between aluminum frame triple glazing and fiberglass double glazing, with the latter demonstrating a 25% reduction in embodied carbon
- Incorporated product-specific Environmental Product Declarations (EPDs) for interior products such as gypsum wallboard and flooring finishes

Reuse & Rehabilitation	Space Optimization	Interior Efficiencies	Lightweight Design	Timber Structure	Low Carbon Concrete	Low Carbon Insulation	
	✓		✓		✓	✓	FOUR

EMBODIED CARBON REDUCTION CHALLENGE

Blessed Sacrament Affordable Housing

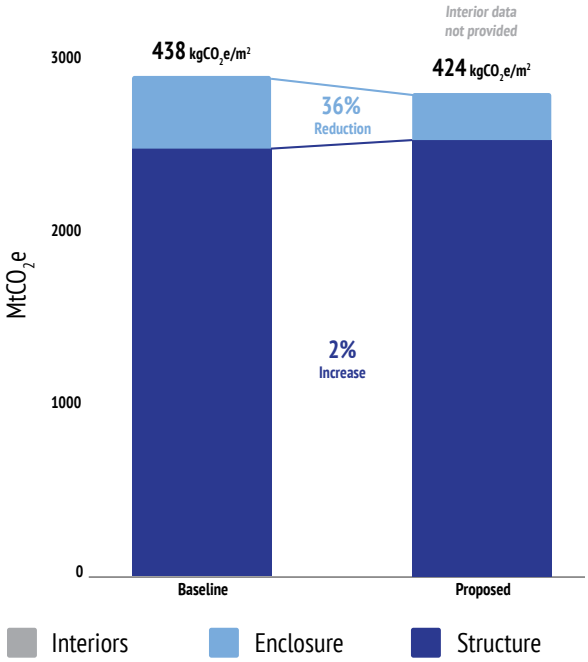
Embodied Carbon Challenge Results

3%
Reduction of Carbon

14 $kgCO_2e$
Reduction per m^2

92 $MtCO_2e$
Reduced from Baseline

Reuse & Rehab
Most Impactful Strategy



Client / Owner
Pennrose

Competition Participant
Innova Services

Project Type
Residential - Major Renovation

WBLCA Software
tallyLCA

Anticipated Completion Year
2025

Location
Jamaica Plain, MA

Primary Structural System
Steel + concrete

Exterior Rendering by Dimella Shaffer

Project Overview

Blessed Sacrament Affordable Housing is a major renovation project that transforms the existing Jamaica Plain church into housing units while still maintaining the integrity of the church. Through close collaboration with the owner, the project will create 55 units of rent controlled housing. Initially closed in 2004, and the team is working to preserve important historic aspects of the building while aiming to create efficient and comfortable living spaces for residents. The building is designed to be net zero ready and was designed with both operational and embodied carbon in mind.

Innovation and Replicability

The team aimed to limit future extensive renovations by preparing the building to be net zero ready, and evaluated both the operational and embodied carbon impact. Durable materials containing recycled content were used for the exterior, roof, and more to ensure long-term value and reduce long-term operational costs.

Low Carbon Strategies

The project is primarily focused on a 60% reuse and rehabilitation of the historic building while reducing its embodied carbon, presenting a challenge with the importance of preserving the building. The team utilized three common strategies in their reduction efforts. They also had a number of other notable strategies:

- Making the historic facade a high-performance envelope with insulation, thermal bridge derating, and replica triple-pane windows.
- Salvaged existing features like lighting and wood details, and specified recycled content in the steel.

Reuse & Rehabilitation	Space Optimization	Interior Efficiencies	Lightweight Design	Timber Structure	Low Carbon Concrete	Low Carbon Insulation	
✓					✓	✓	THREE

EMBODIED CARBON REDUCTION CHALLENGE

The Pierce School

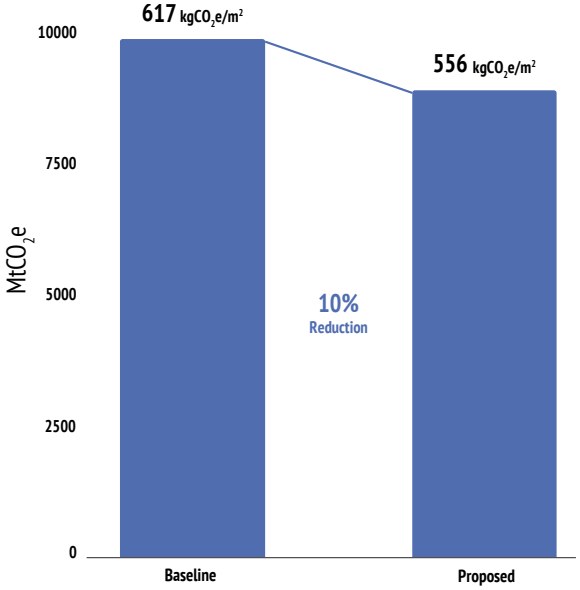
Embodied Carbon Challenge Results

10%
Reduction of Carbon

61 $kgCO_2e$
Reduction per m^2

975 $MtCO_2e$
Reduced from Baseline

Reuse & Rehab
Most Impactful Strategy



Client / Owner
Town of Brookline

Competition Participant
Miller Dyer Spears Architects

Project Type
Education - New Construction

WBLCA Software
tallyLCA

Anticipated Completion Year
2027

Location
Brookline, MA

Primary Structural System
Steel + concrete

Exterior Rendering by MDS Architects

Project Overview

The Pierce School is designed to serve almost 800 Pre-K to 8th grade students in the Brookline area. There were a number of different considerations made in the design process which included reuse instead of a whole new building construction, but in the end, the team felt the best course of action was to demo the majority of the existing complex and replace it with The Pierce School development. The design preserves the underground parking and renovates the historic school building. The development is designed with passive house and net zero design standards in mind.

Innovation and Replicability

The collaboration with the community was an important contributor to the project's design, and augmented the deep analysis work to determine the best reuse and rehabilitation action. Maintaining the existing underground structure provided cost savings and placing studs 24" O.C. is a simple and replicable material efficiency option.

Low Carbon Strategies

The Pierce School project team worked to reduce embodied carbon on this project by utilizing three of the common low carbon strategies. They also had a number of other notable strategies:

- Utilized composite deck at the roof only where equipment is located and metal deck without the topping concrete in other areas.
- The existing historic building is being rehabbed and modernized, including being insulated from the interior and will be served by the project's ground source heat pump system.

Reuse & Rehabilitation	Space Optimization	Interior Efficiencies	Lightweight Design	Timber Structure	Low Carbon Concrete	Low Carbon Insulation	
✓	✓		✓				THREE

BUILT ENVIRONMENT PLUS
MASSACHUSETTS CLEAN ENERGY CENTER
EMBODIED CARBON REDUCTION CHALLENGE

Bunker Hill Housing - Building M

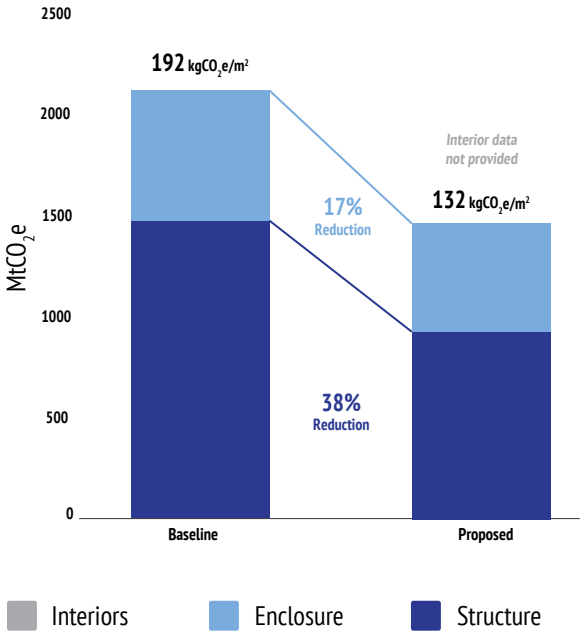
Embodied Carbon Challenge Results

31%
Reduction of Carbon

60 $kgCO_2e$
Reduction per m^2

664 $MtCO_2e$
Reduced from Baseline

Timber Structure
Most Impactful Strategy



Client / Owner
Leggat McCall Properties

Competition Participant
Integrated Eco Strategy

Project Type
Residential - New Construction

WBLCA Software
Athena Impact Estimator for Buildings

Anticipated Completion Year
2024

Location
Boston, MA

Primary Structural System
Mass Timber

Project Overview

Exterior Rendering via Integrated Eco Strategy

Building M - the first of many buildings in Bunker Hill's housing redevelopment project will stand at six stories and contain 102 affordable housing units. The goal of the redevelopment project is to create a mixed-income residential community where residents can enjoy comfort while existing in a highly efficient building. The project is not limited to housing complexes alone, but also contains large green spaces so residents can grow their sense of community and enjoy the outdoors. It has achieved PHIUS/Passive House Design Certification, and is pursuing full Passive House certification.

Innovation and Replicability

The timber structure was chosen as a simplification model across the development. Even though traditional dimensional lumber construction may have sufficed, this multi-building strategy helps reduce holistic development costs and allows greater replicability.

Low Carbon Strategies

Building M was able to accomplish a 31% reduction by utilizing two of the common low carbon techniques. They also had a number of other notable strategies:

- The project team found savings with their use of Cross Laminated Timber (CLT) compared to concrete plank, and this substitution additionally contributed to a shorter construction period, reducing cost of project general conditions
- Precast concrete is used for the stairs and elevator towers, as opposed to traditional concrete masonry units. This provides shear protection and eliminates use of temporary vertical access.

Reuse & Rehabilitation	Space Optimization	Interior Efficiencies	Lightweight Design	Timber Structure	Low Carbon Concrete	Low Carbon Insulation	
				✓	✓		TWO

BUILT ENVIRONMENT PLUS · MASSACHUSETTS CLEAN ENERGY CENTER · EMBODIED CARBON REDUCTION CHALLENGE

2400 Mass Ave

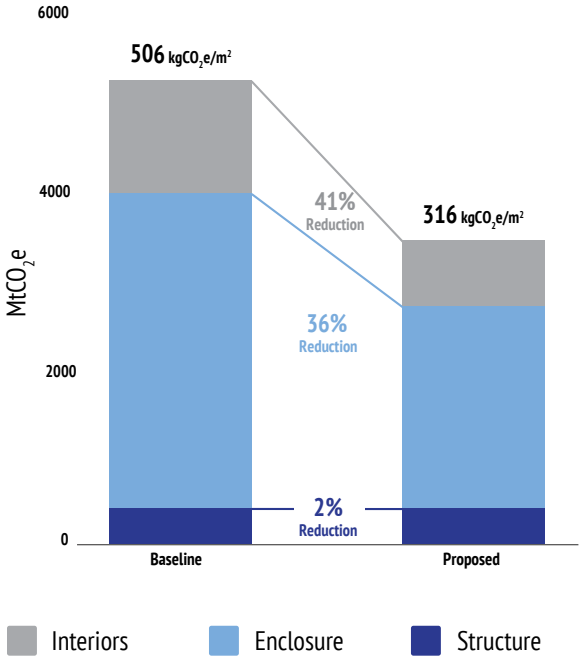
Embodied Carbon Challenge Results

38%
Reduction of Carbon

190 $kgCO_2e$
Reduction per m^2

2,003 $MtCO_2e$
Reduced from Baseline

Material Optimization
Most Impactful Strategy



Client / Owner
North Cambridge Partners

Competition Participant
Linnean Solutions

Project Type
Residential - New Construction

WBLCA Software
One Click LCA

Anticipated Completion Year
2026

Location
Cambridge, MA

Primary Structural System
Mass timber + steel

Exterior Rendering via Linnean Solutions

Project Overview

2400 Mass Ave is a 6-story new construction development in Cambridge that will primarily aim to add 56 residential units to the area. The project is designed as two buildings, joined by the ground floor slab and underground parking garage. In addition, the building will contain retail shops on the primary floor in the "retail canyon" for residents and visitors to enjoy. The project has a focus on outdoor spaces for residents and a tiered geometry to flow visually with its surroundings.

Innovation and Replicability

The CLT assemblies are installed faster than post tensioned concrete, proving the opportunity for a large financial savings, making this technique extremely beneficial from both a carbon and cost perspective. The specification of high-recycled-content aluminum for windows and curtain walls are also replicable improvements.

Low Carbon Strategies

The 2400 Mass Ave project team worked to achieve a 38% reduction in embodied carbon, using two common low carbon strategies. They also had a number of other notable strategies:

- Utilized bio-based materials, notably exchanging Polyiso for TimberHP wood fiberboard as continuous insulation
- The use of CDX plywood instead of Oriented Strand Board (OSB)
- Replacing concrete fiberboard cladding with 70% Corrugated metal and 30% cedar cladding

Reuse & Rehabilitation	Space Optimization	Interior Efficiencies	Lightweight Design	Timber Structure	Low Carbon Concrete	Low Carbon Insulation	
				✓		✓	TWO

Acknowledgments

Our Partners

The Embodied Carbon Challenge Case Studies were created by Built Environment Plus (BE+) using the submitted project and written data provided by the 16 participants, and were made possible by the Massachusetts Clean Energy Center (MassCEC).

Thank you to our partners who offered professional knowledge, resources, and tools to staff and participants.

And an extra special thank you to the competition participants:

- Payette
- Finegold Alexander Architects
- Stantec Architecture
- Arrowstreet
- Harvard University
- CBT Architects
- The Green Engineer
- Sasaki
- Steven Winter Associates
- Elkus Manfredi Architects
- Prellwitz Chilinski Associates
- Ellenzweig
- Innova Services
- Miller Dyer Spears Architects
- Integrated Eco Strategy
- Linnean Solutions

Learn more about the Embodied Carbon Reduction Challenge and access Resources & Tools at:

builtenvironmentplus.org/embodied-carbon-reduction-challenge/

*Note on Submitted Data Accuracy:

The Whole Building Life Cycle Assessments from the projects needed to include the following scope at a minimum:

- Life cycle stages A1-A3, A4, B4, C1-C4. Additional physical scopes or phases of life may be submitted, but are not required.
- Physical Scope: Substructure, Superstructure, Exterior Enclosure
- Environmental Indicators: Global Warming Potential (GWP)
- The baseline and proposed buildings must be of comparable size, function, orientation, and operating energy. The service life must be the same and at least 60 years.
- Use the same assessment software tools and data sets to evaluate both the baseline building and the proposed building. Data sets must be compliant with ISO 14044.

The submitted data is inconsistent across projects and comparison results include an unknown margin of error. This should not discount the reductions each project made, though it does introduce outliers when attempting to compare and rank. Please note the following:

- Submitted projects span the range of development stages, resulting in varying material quantity accuracy and the depth of individual building components included.
- Interior data was included in results data on projects that submitted it.
- Biogenic Carbon was not consistently reported, included, or discluded from the results. This resulted in one greatly exaggerated reduction outcome and disadvantaged other timber structures who do not have the value included in their result calculations.