Carbon Source To Carbon Sink


T3, Minneapolis, MN
Photo credit: Ema Peter

Redesigning the Built Environment for Climate Change

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Climate change demands dramatic shifts in how we design and construct our buildings. At the same time, the urgent need for housing and supportive infrastructure continues to surge at record rates. One important part of the solution? Convert the built environment from a carbon source to a carbon sink.

The urgent need to lower building carbon footprints.

The built environment is growing at a record pace in the United States. It is estimated that 2.5 million new housing units are needed to make up for the nation's housing shortage.

Buildings and their construction account for 39% of global carbon dioxide emissions; 28% of those emissions come from operational carbon—the energy used to power, heat, and cool a building. Buildings' operational carbon can be reduced through energy efficiency measures and policymakers, architects, developers, and engineers have made significant advances in this arena. The remaining 11% of carbon emissions are generated from building materials and construction. This "embodied carbon" can account for half of the total carbon footprint over the lifetime of the building.

To reduce the GHG emissions associated with construction, specifiers, and stakeholders need to act now to create embodied carbon strategies that reduce environmental impacts from buildings we'll use well into the future. The costs of delaying any longer are too high. Greenhouse gas emissions have increased by 90% since 1970. A 1.5% increase in global warming will have catastrophic results for ecosystems and people around the world, including the United States.

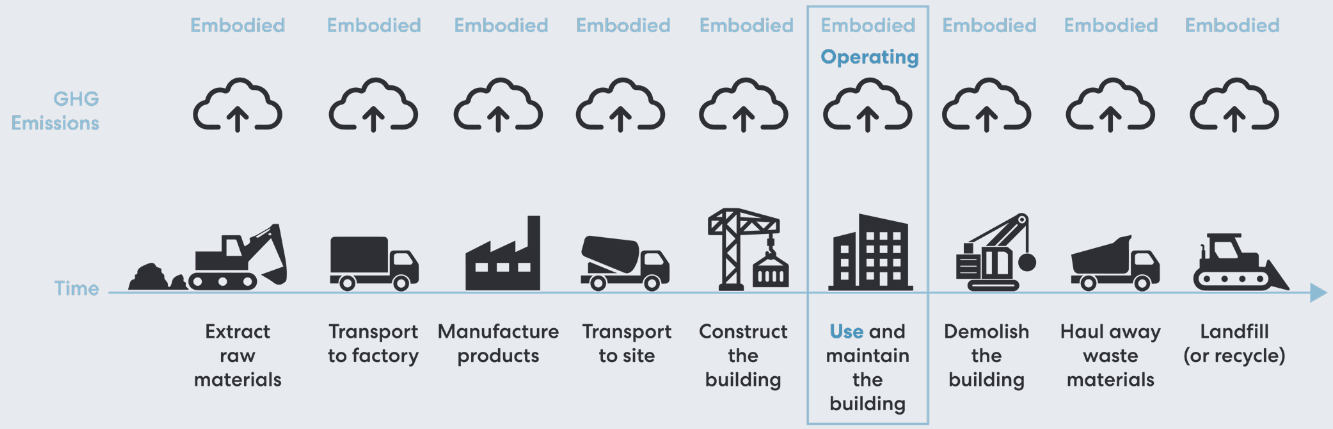
Platte Fifteen, Denver, CO
Photo credit: JC Buck

Embodied Carbon in a Building's Lifecycle

Embodied carbon is a priority for many environmental, architecture, and urban planning organizations including C40 Cities, Architecture 2030, Urban Land Institute, and the World Green Building Council. Many experts believe addressing embodied carbon for buildings and building materials is critical to achieve the goals of the Intergovernmental Panel on Climate Change (IPCC) and the 2016 Paris Climate Agreement.

Embodied carbon is determined by conducting a life cycle assessment (LCA) of a product, assembly, or the building over declared life cycle stages. An LCA study returns results for a number of environmental metrics, including the potential to impact climate or "global warming potential" (GWP). Embodied carbon is the GWP result. Embodied carbon is measured for each stage of the product's life cycle, allowing comparisons across any combination of stages. As buildings become more energy efficient, the upfront embodied carbon from materials begins to account for a higher proportion of a building's carbon footprint. Very soon, embodied carbon is likely to become the dominant source of building emissions.

Embodied carbon varies dramatically between concrete, steel, and wood, making product decisions key in achieving lower carbon buildings. Manufacturing wood products requires less total energy, and in particular less fossil energy, than manufacturing most alternative materials including metals, concrete, or bricks.



Embedded carbon in wood products.

Embedded carbon is the storage of carbon for long periods of time. Wood products are approximately 50% carbon by dry weight. The use of wood products in buildings provides an additional environmental benefit by storing carbon removed from the atmosphere. This ability to sequester, or "embed", carbon makes wood an ideal product for buildings, which are designed for long service lives. Essentially, a wood building is a large carbon sink. This storage of carbon is a unique environmental attribute that does not exist in other structural products.

Timber as a tactic for curbing climate change is backed by a growing body of research and advancements in calculating the carbon footprint of building materials. In a recent paper published in the journal *Nature Sustainability,* experts at the Potsdam Institute for Climate Impact Research in Germany delved into four possible scenarios of timber use in buildings over the next 30 years. In the first case, "business as usual," 0.5% of buildings are made with wood while the vast majority remain constructed of concrete and steel. There's a 10% timber building scenario; a 50% timber building scenario; and a fourth in which the vast majority—90% of new construction—is made with wood. Their findings suggest that the lowest scenario could result in 10 million tons of carbon stored per year and in the highest, nearly 700 million tons. "Buildings, which are designed to stay for decades," researchers write in the paper, "are an overlooked opportunity for a long-term storage of carbon, because most-widely used construction materials such as steel and concrete hardly store any carbon."

While the research is limited to European wood construction, the authors of the study see global potential. "This is the first time that the carbon storage potential of wooden building construction has been evaluated on the European level, in different scenarios," said Ali Amiri, one of the researchers of the study. "We hope that our model could be used as a roadmap to increase wooden construction."

More Timber Demands Sustainable Forest Practices

Researchers and practitioners emphasize that building more and taller with wood hinges on well-managed and sustainable forest practices. "Protecting forests from unsustainable logging and a wide range of other threats is key if timber use [is]to be substantially increased," says co-author Christopher Reyer from PIK. Sustainable forest practices are well established in North America. Forest management in the U.S. and Canada operates under federal, state, provincial, and local regulations to protect water quality, wildlife habitat, soil, and other natural resources. Deforestation in North America is among the lowest globally, and forest growth has outpaced harvesting for many decades.

Case studies on carbon and climate.

Design professionals across the country and around the world are increasingly constructing buildings using light-frame and mass timber structures in a commitment to combat climate change. Not only does wood continue to store carbon, its insulative thermal properties lend well to energy efficient solutions like Passive House.

CLT Passive House Demonstration Project

A Boston-based CLT Passive House Demonstration Project is a mass timber, mid-rise, multifamily, and certified Passive House building that shows how cross-laminated timber systems can meet complex design and sustainability goals. It's the brainchild of MIT start-up Generate and design-build firm Placetailor.

The five-story mixed-use demonstration project is Boston's first full cross-laminated timber (CLT) building, housing fourteen residential units and a ground floor coworking space. The project was designed to operate at net-zero carbon, which is achieved by calculating both the building's embodied energy and its operational energy, and offsetting any annual excess energy use through carbon offset purchases. The building is Passive House certified and meets the Boston Department of Neighborhood Development's Zero Emission Standards. It is scheduled to begin construction in spring 2021.

> **"Mass timber buildings, like Model-C, have the ability to tackle climate change [and] are accommodate urban density. "**
>
> JOHN KLEIN
> CEO AT GENERATE TECHNOLOGIES

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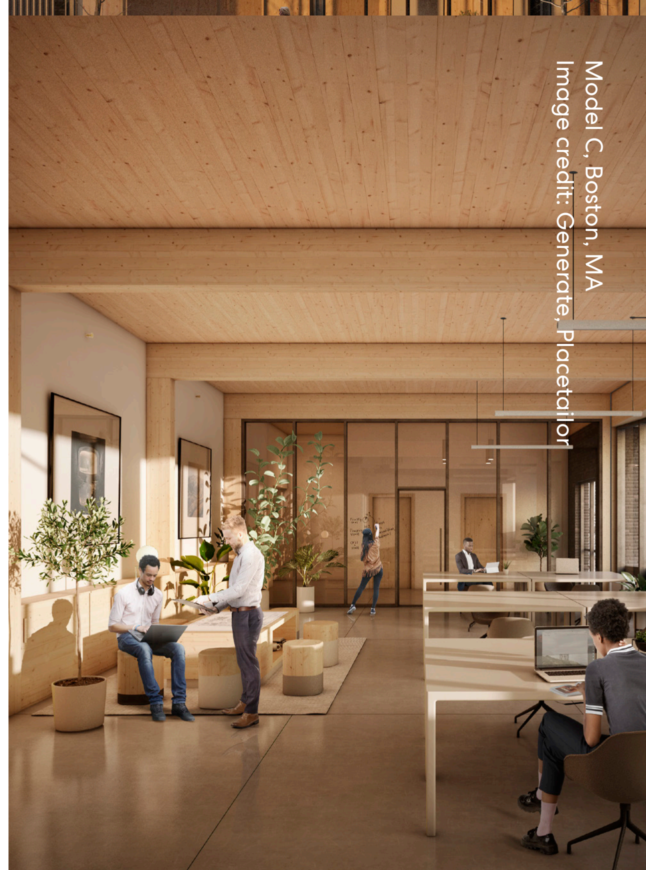
Model C, Boston, MA
Image credit: Generate, Placetailor



Model C, Boston, MA
Image credit: Generate, Placetailor

Yobi Microhousing

Today's wood-frame buildings can offer more affordable housing options. Four to six story-wood-frame structures are a sweet spot for urban infill and neighborhood densification–helping to pencil out housing in bigger cities with rising costs. An excellent example is Seattle-based Yobi Microhousing.

A central strategy in the Yobi project is the creation of shared common space that contributes to an efficient building footprint. Conventional wood-frame construction with dimensional lumber shear walls combined with high insulation levels and sealed openings to create a high-performance exterior envelope for the project with energy use that is 40% lower than current energy code requirements.

"Wood makes it much easier to build an efficient envelope."

DAVID NEIMAN
PRINCIPAL AT NEIMAN TABER ARCHITECTS

The 13,689-sf four-story structure accommodates 40 sleeping units built over a partially-below-grade basement. A ground floor provides common areas including a lounge, community kitchen, laundry area, and media room. Based on energy use per person, Yobi is 70 percent more energy efficient than conventional housing, according to Neiman.

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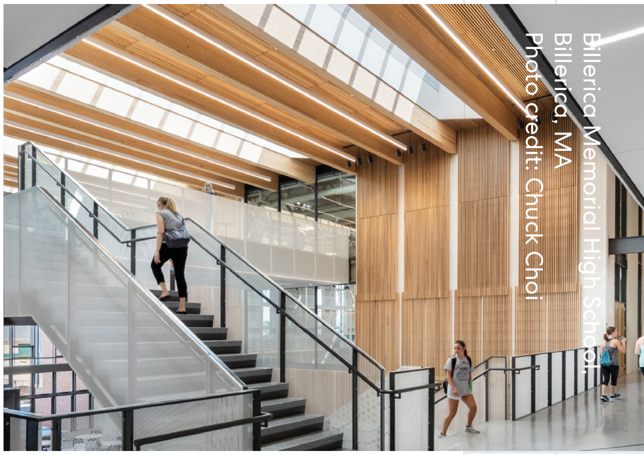
Billerica Memorial High School

Offering lessons in sustainability, more and more of today's education design—from elementary to post-secondary—showcases climate-smart low carbon strategies. At Billerica Memorial High School, timber contributes to the building's carbon-conscious design. Embodied carbon in the sustainably certified spruce timber structure offsets the equivalent of a typical school bus traveling over 460,000 miles.

The 30,000-sf Billerica, Massachusetts-based facility, designed by Perkins&Will, elegantly combines wood, steel, and glass, to give a modernist nod to its neighboring neoclassical civic buildings, while delivering a high tech future-ready educational environment.



Billerica Memorial High School
Billerica, MA
Photo credit: Chuck Choi

T3

Standing at seven stories tall, T3 (Timber, Transit, Technology) was the first commercial property in the U.S. to use timber for its structure and interior finishing. It demonstrates how large timber projects can lower the carbon footprint of the built environment, while providing a warm and innovative commercial space.

The 220,000-square-foot building was constructed with 8-foot-by-20-foot panels of wood that were stacked across beams of glued, laminated timber. The panels themselves were constructed using dimension lumber. Approximately 2.2 million board feet were used in the structure, which will sequester about 700 tons of carbon for the life of the building. It was also built in significantly less time than conventional steel-framed or concrete buildings, completed in just two and a half months at an average of nine days per floor. Given timber's light weight, lower production time and costs, T3 developer Hines has replicated this building prototype in Atlanta, with plans to expand to other markets including Chicago, Denver, Toronto, and Melbourne.

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T3, Minneapolis, MN
Photo credit: Ema Peter

Carbon Conclusions:

Future Outlook

Cutting carbon emissions and finding advanced ways to store carbon in our buildings requires a full court press by the architecture, engineering, and construction sector. And industry leaders are stepping up with substantial commitments—from conducting leading research on carbon and climate to erecting important demonstration projects. Building with structural timber is one way to sequester embodied carbon and reduce the footprint of new construction.

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