
EMBODIED CARBON

in Building Materials for
Real Estate



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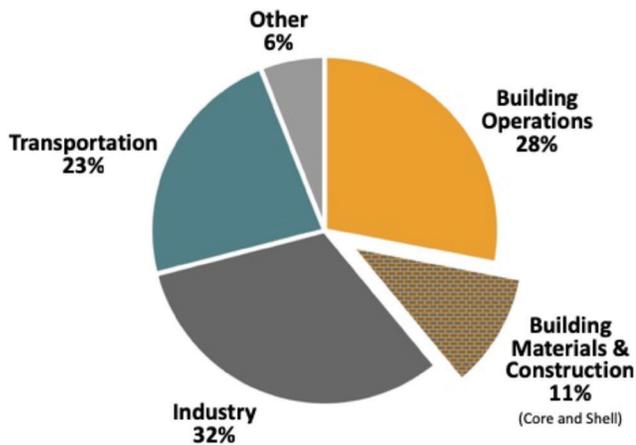
Introduction

In the real estate industry, sustainability has most commonly taken the form of improving operational efficiency in buildings, with the focus on energy use reductions. However the operational emissions of a building are only part of the overall carbon emissions related to the real estate industry.

Embodied carbon is defined as the carbon emissions attributed to manufacturing and transporting construction materials and the process of construction. As shown in the figure, buildings account for 39 percent of global greenhouse gas (GHG) emissions: 28 percent from building operations and 11 percent embodied carbon from building materials and construction. In some cases



Global CO₂ Emissions by Sector



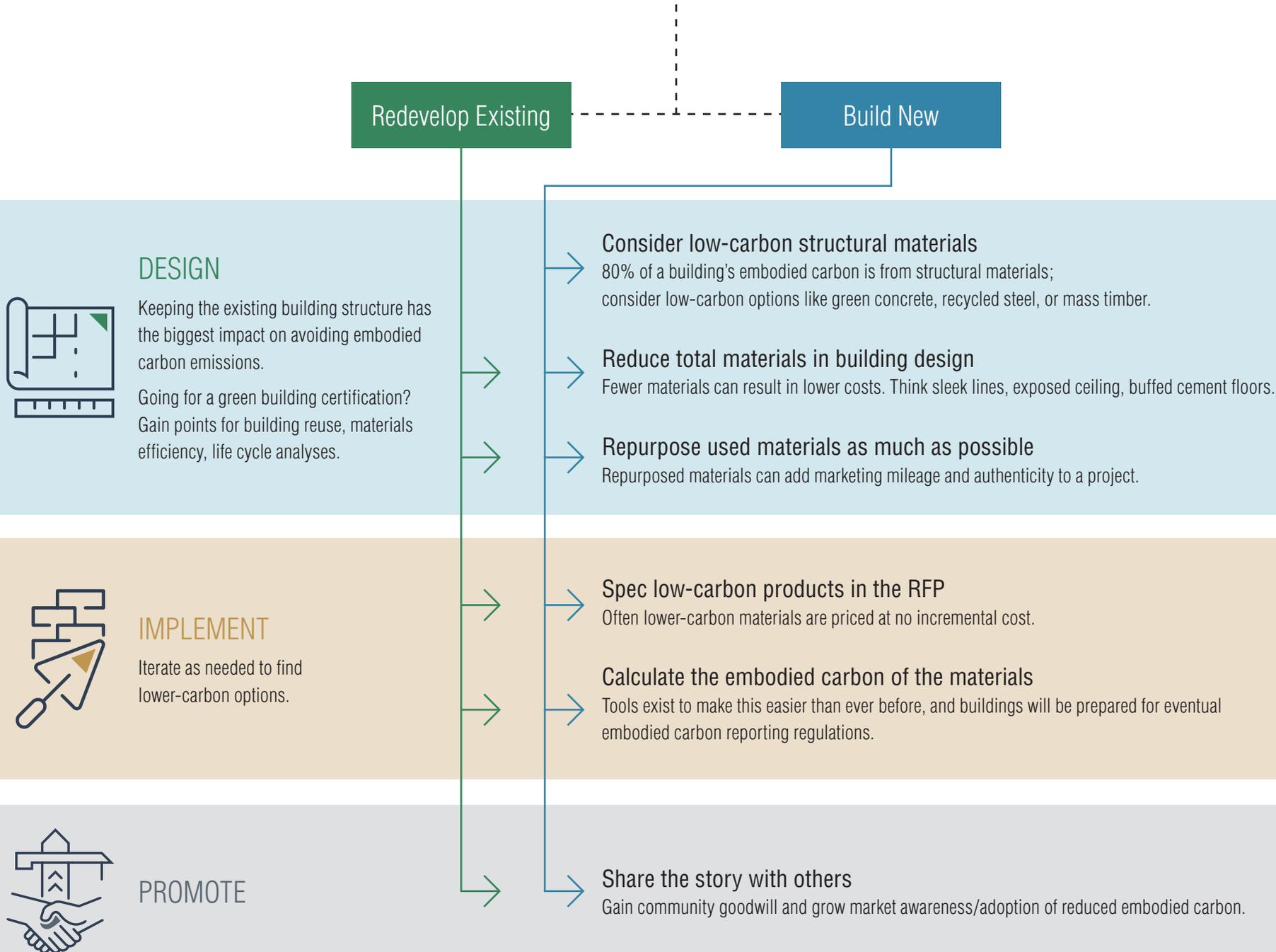
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embodied carbon can account for as much as half of a building's total carbon footprint over its lifetime. This is in large part due to carbon-intensive material manufacturing processes and large quantities of fossil fuels used before materials ever reach the construction site.

Unlike operational carbon, embodied carbon cannot be reduced in materials once a building's construction is complete. As buildings continue to improve operational efficiency, embodied carbon will become a larger proportion of the buildings' overall lifetime carbon emissions. Although awareness of this topic is still growing, reckoning with embodied carbon is a necessary step for the real estate industry as it works to mitigate climate change.

If nothing is done to reduce embodied carbon in buildings, it is unlikely that emissions targets necessary to keep global warming within 2 degrees Celsius will be met: to achieve ambitious climate goals, addressing embodied carbon has to be a part of the real estate industry's climate mitigation strategy.

Simple Pathway for a Developer to Reduce Embodied Carbon





The Business Case for Reducing Embodied Carbon in Real Estate

It is not too early for the real estate community to begin reducing embodied carbon in building materials; there is already a strong business case for these actions.

Regulations Are Coming

As more cities commit to decarbonization and because buildings are such a significant contributor to emissions in cities, many in the industry expect climate action plans that limit both operational and embodied carbon. Staying ahead of the policy curve and adopting low-embodied-carbon design practices (now) protects firms from the challenges and costs of transitioning in the future, whether through potential policy fines or the cost of getting up to speed on low-carbon development.

One potential policy that influences real estate decision-making around embodied carbon is the future of carbon pricing. The United States currently has no federally legislated price on carbon, but carbon taxes and pricing regulations are expected to become standard in the near future. In 2019, the Denver City Council proposed a citywide carbon



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We're going to see changes across a [number] of materials, at a faster pace than we've seen in the past. The next two-to-five years will see big innovation, and we're hearing more from municipalities about net zero building policy transitions.”

—STACY SMEDLEY
Director of Sustainability, Skanska

tax with more cities and states, such as Washington state, also looking into it. Once a carbon tax is passed, developers will have a strong financial incentive to take action and reduce embodied carbon. Moreover, development firms that work in progressive markets likely to take on carbon prices in the next 10 years can reap clear benefits by acting now to align to the sustainability policies of cities and by embracing upcoming policy goals.

Making the choice to push progress on embodied carbon reductions and partner with cities also establishes cooperative relationships for future embodied carbon legislation. Early willingness to engage means getting to set the example for policy to build from.

More embodied carbon policies are coming, and soon. Examples of national and local policies driving embodied carbon reductions in real estate include the following:

- **The Netherlands Circularity Goals:** To meet the country's commitment to economic circularity by 2050, the goals set the intention of being 50 percent circular by 2030 and requiring that the building sector reduce its raw materials use by 50 percent by 2030. Since 2013, all new buildings are also required to conduct a whole-building life-cycle analysis.
- **France:** Currently in the pilot stage, the Positive Energy and Carbon Reduction (E+C-)voluntary labeling scheme uses whole-building life cycle assessments (LCAs) to assess performance. The country plans to regulate embodied carbon by 2020. Good performers are eligible for a density bonus.
- **Buy Clean California:** Signed into law by Governor Jerry Brown in 2017, this legislation mandates that all state agencies consider the carbon emissions of the full supply chain when embarking on a new construction or infrastructure project, thus rewarding manufacturers that produce materials with lower embodied-carbon levels. Washington state is currently considering similar legislation.
- **Bay Area Low-Concrete Carbon Codes Project:** Based in Marin County, California, the project works to target local building codes to phase out highly polluting traditional forms of concrete.
- **Vancouver's Zero Emissions Buildings:** Perhaps the most rigorous embodied carbon policy to date, the policy sets the city on track to reduce embodied carbon by 40 percent by 2030.

Green Building Certifications and Reporting Structures Increasingly Look at Materials

Over 100 voluntary sustainability certifications already recognize efforts to look at embodied carbon. And with a number of cities now requiring (for example, Denver; Miami; Alexandria, Virginia) or incentivizing (for example, Chicago, Philadelphia, Las Vegas) green building certifications for most new commercial buildings, tracking embodied carbon will become more common across the industry.

Importantly, these certifications emphasize the procurement of environmental product declarations (EPDs), offering credits for LCAs, which assess the whole-life impact of buildings.

In addition, voluntary reporting and disclosure initiatives with substantial real estate participation are starting to request information on embodied carbon, which will help standardize the requested metrics and process of collecting the data. For example, in 2020, CDP—a global disclosure system for investors, companies, cities, states, and regions that serves global investors with more than \$90 trillion

in assets under management—will begin asking for new information from real estate and construction sector participants, including the following:

1. Do you assess embodied carbon for any of your new construction or major renovation projects?
2. Provide further details on how you assess the embodied carbon.
3. Can you disclose the embodied carbon emissions for the new construction/major renovation projects completed in the reporting year?
4. Disclose the embodied carbon emissions of new construction/major renovation projects in the reporting year by property type.

Green Building Certification Schemes That Look at Embodied Carbon

Certification	Location	Embodied Carbon Specifics
Building Research Establishment Environmental Assessment Method (BREEAM)	Global	Performance of a life cycle assessment (LCA) can provide up to 20 credits, includes recognition for use of environmental product declarations (EPDs)
Excellence in Design for Greater Efficiencies (EDGE)	Global, emerging markets	Tracks and awards certifications to projects that show reductions in embodied energy
Positive Energy and Carbon Reduction (E+C-)	France	Includes method to track and report embodied carbon performance
Futurebuilt	Norway	Includes method to reduce embodied carbon by 50%, with third-party verification
Green Star—Green Building Council Australia	Australia	Gives credits for the use of LCA, EPDs, and low-carbon materials choices
LEED v4—U.S. Green Building Council	Global	Awards credits for LCA, EPD procurement, and reuse of existing buildings and materials
Living Building Challenge (LBC) version 3.1—International Living Future Institute (ILFI)	Global	Rewards embodied carbon benchmarking and reduction in the LBC Materials Petal
LBC version 4.0—ILFI	Global	Rewards embodied carbon benchmarking and reduction in the LBC Energy Petal
Zero Carbon—ILFI	Global	Projects must reduce embodied carbon by at least 10% and purchase offsets for the remaining embodied carbon

EPDs Explained

Environmental product declarations (EPDs) are documents provided by the manufacturer as an assessment of the environmental impact of a specific product. This includes emissions assessments of everything from mining and extraction to transport and factory processes. Although not all EPDs are easily comparable, EPDs are becoming more mainstream as institutions like the U.S. Green Building Council and International Living Future Institute (ILFI) push for supply chain transparency and environmental accountability among manufacturers through their certification schemes.

LCAs Explained

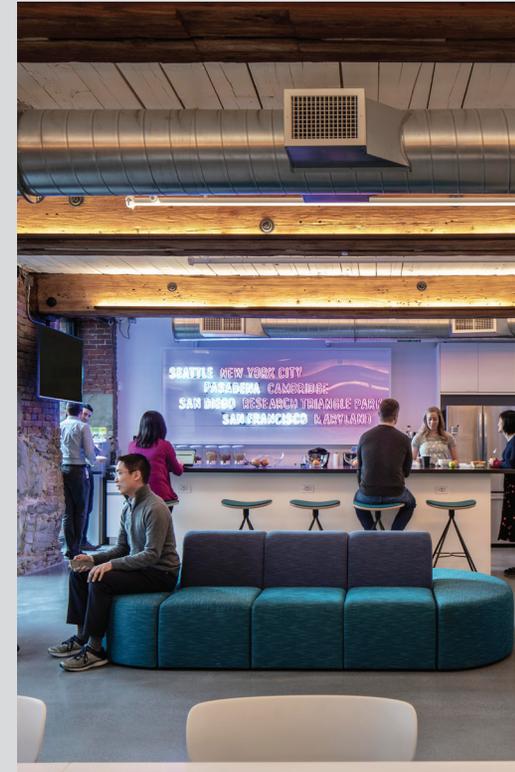
Life cycle assessments (LCAs) are considered the gold standard in tracking and benchmarking the environmental impact of a whole building over the course of its useful life. LCAs are a scientific approach to performing carbon footprint calculations of buildings, using information provided by the building design and databases of EPDs to consolidate and quantify total impact. Many LCA tools and consultants available for use in real estate offer a range of services throughout the design stages of a project.



Project Profile: Alexandria Real Estate Equities

Acknowledging the role that building materials play in driving sustainability and occupant health, Alexandria Real Estate Equities Inc.—a real estate investment trust recognized as the leader in owning, operating, and developing sustainable and collaborative life science, technology, and agtech campuses in key innovation locations in North America—includes guidelines covering EPDs and health product declarations (HPDs) to reduce embodied carbon on construction projects and drive the use of low-emitting materials.

Demonstrating its commitment to supporting high levels of sustainability, health, wellness, and productivity, Alexandria displays its approach at the Alexandria LaunchLabs at the Alexandria Center at One Kendall Square in Cambridge,



Massachusetts. In the interior buildout of the dedicated 20,000-square-foot laboratory space for early-stage life science companies, Alexandria used 14 materials with EPDs, nine materials with HPDs, and over 40 materials that meet Leadership in Energy and Environmental Design version 4.1 (LEED v4.1) requirements for low-emitting materials, all of which helped the project achieve LEED Gold certification and Fitwel 3 Star certification.

Project Profile: NRDC Office Redevelopment, San Francisco

Leased tenant spaces have great potential for reducing embodied carbon during redevelopments. The Natural Resources Defense Council (NRDC) received the Living Building Challenge (LBC) Materials Petal certification for its San Francisco office renovation in February 2016. The office was one of the first tenant-occupied redevelopments in the world to pursue both LEED and LBC Petal certifications. The 16,000-square-foot space pursued the Materials Petal under version 3.1 of the Living Building Challenge, which requires an LCA to measure the embodied carbon footprint of a project and serve as a baseline for embodied carbon reductions and for purchasing offsets. Using the United Kingdom's Environment Agency Carbon Calculator for construction activities, the NRDC team established an embodied carbon footprint of 54.7 tons of carbon dioxide equivalent (CO₂e), which it more than matched by purchasing 63.9 tons of CO₂e of Green-e Climate landfill gas carbon offsets.

Before undertaking this project, NRDC had already completed the materials certification at its Midwest office in Chicago. Although the project team was able to provide a list of low-emissions products, there were still many local conditions, including building condition and manufacturer location, that required additional research and creativity. To reduce

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NRDC fosters a collaborative and inclusive workspace that prioritizes the health of its occupants and the planet. By thoroughly vetting each architectural detail, we are able to reflect the greater mission of NRDC and act as a catalyst for positive change.”

—MARIA MCCAIN

Sustainability Coordinator, Facilities,
Natural Resources Defense Council

the space's embodied carbon and achieve LBC Materials Petal certification, NRDC sourced more than 50 percent of its materials within 621 miles (1,000 km) of the San Francisco office, including the majority of its new lighting fixtures, which were manufactured less than 373 miles (600 km) from the office, thus limiting the carbon emissions associated with transporting both goods and people. When making selections for new materials, NRDC looked first for recycled products, prioritizing products with Declare labels, Forest Stewardship Council–certified wood products, HPDs, and EPDs. The NRDC team also focused on simplifying its design, reducing the need for new or additional materials, a plan which also helped reduce indoor pollutants from building materials. NRDC also reused as many used components as possible, including flooring and doors from the old office space and salvaged timber.



Natural Resources Defense Council



No Incremental Cost Is Necessary for Lower-Carbon Materials

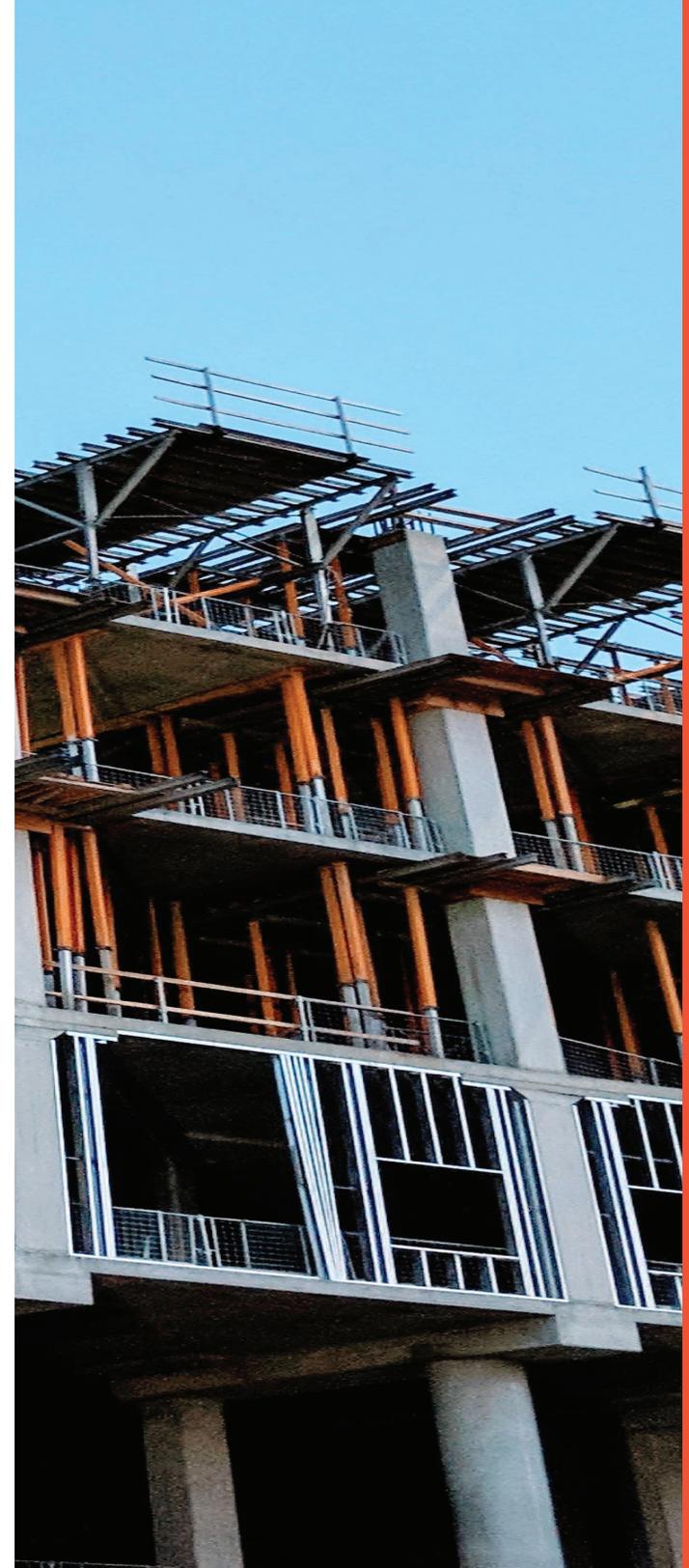
Perhaps the most compelling feature of embodied carbon reductions in real estate is the potential for significant progress without any upfront “green premium.” With the use of LCA tools, EPDs, careful selection of materials, as well as conscientious design, embodied carbon can be reduced with no incremental cost.

This outcome requires a focus on embodied carbon in a project from the very early stages and a willingness from the developer to ask the right questions of contractors. The most important piece is to have the right data. By looking at an initial building design and identifying hotspots, the team likely will find an opportunity to reduce embodied carbon through smarter design and concrete or steel specifications, all without a cost premium.

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So far, low-carbon options are price-competitive compared to higher embodied carbon options.”

—STACY SMEDLEY
Director of Sustainability, Skanska



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Microsoft is currently redeveloping part of its Redmond [Washington] headquarters to deliver 17 new buildings for our employees. We thought about our carbon footprint for the project and wanted to address both sides of the equation—the embodied and the operational. For embodied carbon, we set a target of a 15 to 30 percent reduction in embodied carbon and partnered with Skanska and the University of Washington’s Carbon Leadership Forum to be the first corporate pilot of the EC3 [Embodied Carbon in Construction Calculator] tool.

“The tool enables us to measure and manage the amount of embodied carbon associated with our building materials and choose lower-carbon material options. What we have found so far is that by simply asking our suppliers for their lower-carbon options, **we have been able to procure materials that meet our reduction targets and performance specifications with zero cost premium.**”

—KATIE ROSS
Real Estate and Facilities Global
Sustainability Lead, Microsoft

Action Gains Community Goodwill

Being a leader in embodied carbon reductions helps demonstrate to local governments and community organizations that a developer is aligned with the values of the community, thus building a stronger, more collaborative relationship.

In addition to adopting green building regulations, many cities today incorporate sustainable ideals into planning and development decisions. The

community engagement process is also of critical importance in real estate development, and developers can gain community goodwill more easily when planning a highly sustainable project that benefits the surrounding neighborhood, whether that is by reducing emissions or purchasing local materials. Thus, developers who show municipalities and community-based organizations that they are driving advancements in deep carbon reductions can expect a smoother approval process.



Morgan Creek Ventures

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At Morgan Creek Ventures, our goals are to get ahead of trends and be a leader, because people who lead on this now will be able to do low carbon much more cost-effectively down the line. And for new projects in cities like San Francisco and Washington, D.C., it's easier to get approval for projects that represent the city's values.”

—ANDY BUSH
Principal and Founder,
Morgan Creek Ventures



Getting Started on Reducing Embodied Carbon

For the real estate industry, the question remains how to achieve embodied carbon reductions in a cost-effective manner. Challenges exist to reducing embodied carbon:

- The low-embodied-carbon materials market is underdeveloped, and the related market for materials with EPDs also is young.
- LCAs are still developing as a market, and accuracy is dependent on the still-incomplete data and difficult-to-compare set of EPDs.
- Legislation is limited and no price has been placed on carbon, measures which if taken would spur faster action among developers.

All the same, the market is sophisticated enough that real estate has opportunities to achieve some early wins on embodied carbon. Key strategies for reducing embodied carbon are illustrated in the following sections.

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As a real estate developer and owner, Kilroy Realty is committed to doing its part in battling climate change. Having already committed to carbon neutral operations by the end of 2020, we are now looking at the role of upfront and embodied carbon in new developments. Our projects are already on track to achieve our current goal of at least 20 percent recycled content and 20 percent regional sourcing across all materials, and we will set formal upfront carbon reduction targets in 2020.”

—SARA NEFF
Senior Vice President, Sustainability,
Kilroy Realty Corporation



New versus Used: Reuse Buildings with Redevelopment

Structural systems can comprise up to 80 percent of a building's embodied carbon, depending on building type, so the most significant factor in a building's embodied carbon is whether the development uses an existing building or constructs a new one. Large quantities of steel and concrete are most frequently used in the structure of new buildings, so by taking advantage of existing infrastructure via redevelopment of existing assets, projects can avoid spending on raw materials and significantly decrease embodied carbon.

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Use existing buildings.
That's the most important
early step to take.”

—ANDREW LEE
Director of the Zero Carbon Program,
International Living Future Institute

Less Is More: Design for Material Efficiency

The U.S. Environmental Protection Agency estimates that in 2015, 584 million tons of waste was generated during building construction and demolition, more than twice the amount of generated municipal solid waste. To reduce those numbers, projects can be planned with the goal of simplicity and materials efficiency, thus focusing on eliminating nonessential elements of building design. In practice, streamlining design means abandoning certain finishing details, by leaving wall, floor, and ceiling elements exposed. Although this practice requires rethinking aesthetic goals, it also capitalizes on the raw beauty of construction materials and the biophilic appeal of timber elements. Using fewer building materials can also improve the health of a space by improving indoor air quality through reduced off-gassing from volatile organic compounds or other chemicals used in common building materials. In addition, reducing the amount of materials used saves on project costs, limiting the spending on overall materials procurement.

The Circular Economy: Gain New Use from Used Materials

Oftentimes, material waste from demolished buildings or retrofitted office spaces is disposed of directly. In a circular economy, waste of new materials is minimized and resources are continually reused. As materials for buildings become scarcer and more expensive, reusing those materials opens up a new value stream for buildings during deconstruction and creates a steady stream of low-carbon materials for new buildings.

One way to ensure that materials can be easily reused is to request that the architect select solutions and materials that generate the least amount of waste and then draw up a plan for how the materials are to be reused later during reconstruction or demolition work.

Reusing materials also ties a building to the local environment, creating an authentic experience for tenants and providing substantial marketing value.



Project Profile: Circl, Amsterdam

ABN AMRO Bank's approximately 30,000-square-foot Circl Pavilion in heart of the Zuidas business district of Amsterdam shows the potential for deep carbon reductions and the power of planning for a building's entire life cycle. With the Dutch government announcing a national goal to transition to a 50 percent circular economy by 2030 and fully circular economy by 2050, ABN AMRO seized the opportunity to be an early adopter and action leader in the switch to circularity. Circl incorporated energy reduction and circularity into every aspect of its construction and operation; even the on-site restaurant and landscaping are circular. Because the circular economy is focused on reducing the need for new primary resources, reducing waste, and continually reusing resources, this development, inherently reduces embodied carbon by maximizing the reduction and reuse of its building materials.



The Circl team designed out materials deemed unhealthy or unnecessary, abandoning some design components typical of similar bank developments. This option meant losing marble flooring and elaborate glass and steel elements that ABN AMRO employees were used to in the bank's typical buildings. By reducing the total amount of materials by a third (nearly 2,425 tons, or 2.200 kilotonnes) of the original plan, however, Circl avoided a considerable fraction of embodied carbon emissions typically produced by similar projects. By harvesting materials from other structures, Circl prioritized reuse over aesthetics, gave new life in the form of upcycled facades and flooring, reused cable ducts, and reused pavement slabs as ballasts for solar panels.

Low-Carbon Materials

- Large local Dutch larch beams were used to replace the traditional concrete structure.
- Long-lasting solar panels developed and created in the Netherlands were used on the building's roof and facade, reducing materials, shipping, and the need for early replacement.
- The ventilation ducts have been finished with sustainable textiles.

Reused Materials

- On the ground floor, a collection of hardwood taken from a former monastery and the bar of Dutch football club Top Oss was used to make the floor.
- The partition walls for the basement conference rooms came from the facade of another building.
- The insulating material in the ceilings is made from 16,000 old pairs of jeans (collected from ABN AMRO employees).
- The plastered walls and the felt on the stands contain old work clothing of ABN AMRO's retail employees.

Most important, Circl was designed so that when the building is eventually taken down, the high-quality materials can be reused. Although an exercise in creativity, this approach creates additional value because buildings can also be considered a raw materials bank. The strategy can also add value by increasing preparedness for materials shortages and by lowering transportation costs and emissions. ABN AMRO Bank is also partnering in various initiatives and upscaling new opportunities in circular business models and is ready to invest in circular ventures and urban mining concepts.

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As the construction and real estate sector is a heavy user of raw materials, we are standing on top of an enormous raw materials bank. Often, the value of the raw materials in the building is of secondary importance to rental income or operating costs, but this view will change fundamentally in the transition from a linear to a circular economy. At Circl, ABN AMRO brought this idea into practice by opting for circular material inputs and design ready for disassembly. The first steps into serious urban mining projects!”

—PETRAN VAN HEEL

Sector Banker, Construction and Real Estate, ABN AMRO

Ask for It: Specify Low-Embodied-Carbon Products in RFPs

Materials selection during design is one of the most significant determining factors of a project's embodied carbon. Requesting EPDs from manufacturers can help determine the best materials option for both monetary and carbon budgets, and including requirements for EPDs and embodied carbon performance in a request for proposals (RFP) sends a strong message to contractors at the outset of a project and ensures accountability.

When one is looking for low-embodied-carbon materials, it is important to keep in mind the “worst offender” materials. These are materials that tend to have high levels of embodied carbon, such as concrete, steel, and insulation. Concrete alone accounts for 6 percent of global GHG emissions, but avoiding traditional, dirty concrete is becoming increasingly easy. Concrete made with high levels of recycled materials helps reduce total embodied carbon in a project, and options for steel and insulation with high shares of recycled material are also already on the market.

Natural materials are another good low-carbon alternative to traditionally manufactured materials. Timber and natural fiber insulation are considered to be carbon-sequestering because their growth pulls carbon out of the atmosphere. Those materials are also renewable, making them more dependable and sustainable than high-embodied-carbon materials that no longer fit within the parameters of green building certifications and embodied-carbon regulations.

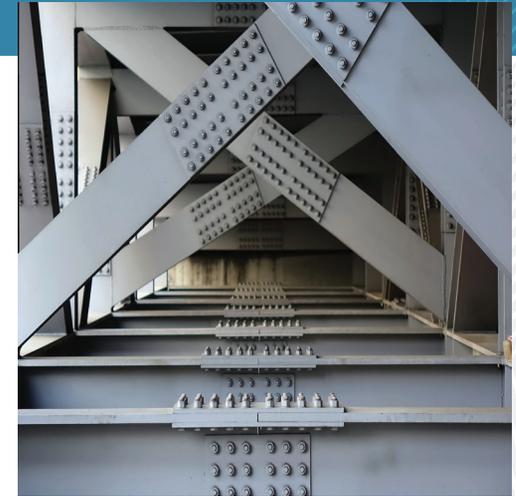
For guidance in materials choices, the Carbon Smart Materials Palette from Architecture 2030 can help explore lower-carbon options to traditional high-impact materials, as well as carbon-sequestering nontraditional material options. The palette also serves as a useful tool to educate others on the carbon impacts of traditionally manufactured building materials and on how to inform low-carbon design decisions.



WOOD



SHEEP'S WOOL



STEEL



STRAW-BALE

Materials Choices to Reduce Embodied Carbon

Traditional Material

Concrete For each ton of concrete produced, 0.5 tons of carbon are emitted, and concrete accounts for around 7% of global GHG emissions. Concrete is highly polluting due to the dirty process of creating cement, which uses large amounts of fossil fuels to heat kilns that release chemical pollution during firing.

Steel For each ton of steel produced, 1.83 tons of carbon are emitted, and steel accounts for around 7% to 9% of global GHG emissions. Mining and processing of steel is an energy-intensive enterprise that degrades the environment and relies on fossil fuels for heating furnaces.

Synthetic insulation Petroleum-based synthetic insulation requires high levels of energy to manufacture

Good Replacement

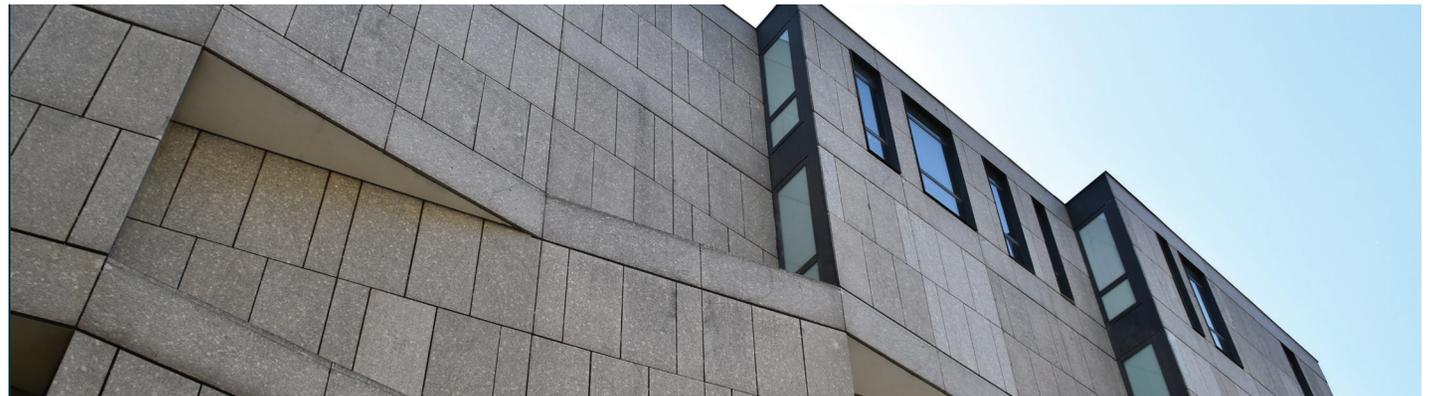
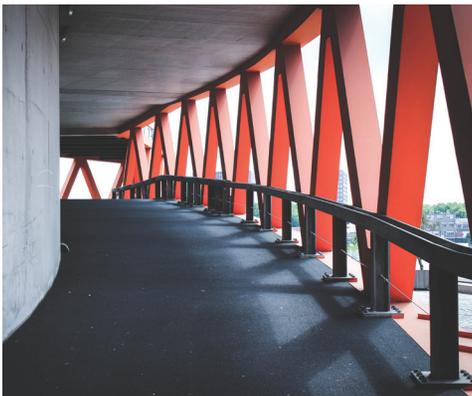
Green concrete Green concrete can greatly reduce the embodied carbon of a project just by slightly increasing the recycled content of concrete mix.

Recycled steel Readily available in the U.S. market, recycled steel avoids the raw materials extraction component of traditional steel.

Cross-laminated timber (CLT) CLT is an innovative mass timber material that makes construction with wood a safe, low-carbon alternative to traditional structural materials. It uses forest waste to make lightweight, strong, and seismically safe modular wooden pillars and sheets that require less labor to piece together on a shorter timeline. Construction also produces less on-site waste by designing out the need for excess materials.

Low-carbon insulation Mineral wool batt and fiberglass batt have a significantly lower embodied-carbon impact than rigid insulation and spray foams do. Mineral wool batt, in particular, is a lower-carbon alternative to extruded polystyrene, expanded polystyrene, and polyisocyanurate (polyiso) insulation for wall assembly.

Bio-insulation Natural alternatives to synthetic insulation include sheep's wool, dense-pack cellulose, cork, and straw bale, all of which are also considered to be carbon-sequestering.



Project Profile: Carbon12, Portland, Oregon

Carbon12, from Kaiser Group and Path Architecture, was, at the time of its completion in 2018, the tallest cross-laminated timber (CLT) building in the United States. At 85 feet tall, the development in Portland, Oregon, is an eight-story multifamily residential building and pioneering CLT project. CLT is a very strong and lightweight timber structural material, a composite containing layers of smaller, compressed planks. CLT can make use of natural forest waste, such as beetle-killed trees and small trees cleared for fire management, making it highly sustainable and resource-efficient.

In total, building Carbon12 with CLT avoided 223 metric tons of CO₂e and returned financial benefits in addition to embodied carbon reductions. Before construction, the building's concrete subcontractor estimated that the entire building in concrete would cost \$39 per square foot, while the selected hybrid system of steel core, glulam beams and columns, and CLT floors would cost \$41.50 per square foot, or \$2.50 more per square foot. However, CLT was so efficient during construction that the building construction timeline was cut from 19 weeks to eight weeks. With CLT, the developer built quickly, during any weather, with fewer workers on site, and saved on construction costs. CLT is also becoming more common, making the material less expensive.

In addition to its financial feasibility and embodied carbon reductions, CLT also offers biophilic design benefits and performs better seismically than traditional building materials.

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We wanted to be inspiring, but also replicable. Today we could build a second Carbon12 right next door for 20 to 25 percent less.”

—BEN KAISER
Principal and Owner,
Kaiser Group and Path Architecture



Kaiser Group and Path Architecture



Kaiser Group and Path Architecture

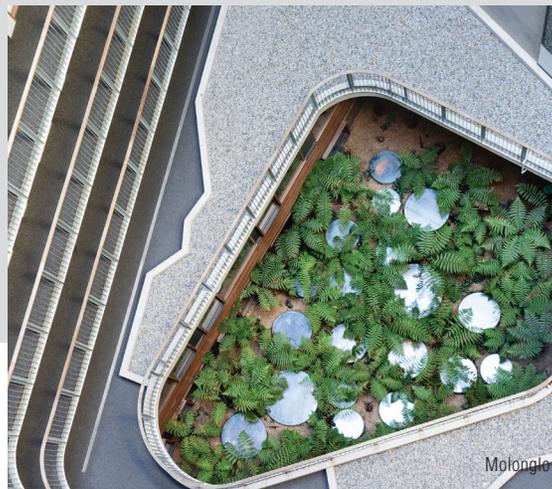
Project Profile: Nishi Building, Canberra, Australia

The Nishi Building in Canberra, Australia, balances sustainability with human-focused design and provides another notable example of using low-carbon materials in real estate development. A mixed-use development that includes 233,653 square feet of multifamily residential space and 524,442 square feet of commercial space, including office space, a hotel, retail, and a movie theater, the Tetris-like Nishi Building complex is the brainchild of Molonglo.

The sustainable materials were nonnegotiable to Molonglo and were mandated early during work with its suppliers and contractors. Examples of these materials included:

- 100 percent Green Star concrete
- 25 miles (40 km) of sustainably harvested timber from regional blackbutt gum trees
- Reclaimed timber—the entryway alone used more than 2,000 pieces of reclaimed timber
- Art installations made from repurposed waste—85 percent of construction waste was recycled and diverted from landfills

By outlining sustainability principles from the outset of a project, Molonglo saw deep carbon reductions without drastic financial sacrifice. Investment in low-carbon materials and design communicates higher value to the tenant, and happy tenants are more valuable to a building owner, either through faster lease-up, lower turnover, or a higher willingness to pay.



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Often, buildings are too focused on design and forget the human element. People want to live and work in buildings that are sustainable, promote social cohesion and well-being, and provide access to amenities and value when extra time and care has been taken. If you plan for it, the economics works out.”

—NIKOS KALOGEROPOULOS
Director, Molonglo

Calculate Embodied Carbon Emissions

Developers can make use of the embodied carbon calculator tools already on the market to understand the impact of building materials. The sustainable buildings team of EllisDon, a construction services company based in Canada, has partnered with education institutions and industry experts to conduct research into embodied carbon and to identify opportunities for reduction. For projects

undergoing LEED v4 certification, EllisDon uses a tool to conduct whole-building LCAs and to source materials with EPDs. EllisDon also is working with several key subtrades and suppliers to assess their readiness for reporting embodied carbon and help clients who are looking to conduct comprehensive carbon accounting get a more complete dataset and ultimately make informed decisions.

A variety of calculator tools on the market offer slightly different services, each with its own methodology for calculating embodied carbon. The table provides a sample of the tools available.

Embodied Carbon Calculators and LCA Tools		
	Athena EcoCalculator	Structured Excel spreadsheet workbook in which to input total square footage of specific structural materials in a project; results are displayed instantly for both residential and commercial projects.
	Embodied Carbon Calculator for Construction (EC3)	Free web-based tool created by Skanska that analyzes high-level design information using a large database of product-specific environmental product declarations (EPDs). Makes it easier to compare the carbon impact of specific materials choices.
	eToolLCD	A web-based life cycle assessment (LCA) tool developed by engineers and best suited for international rating schemes, including BREEAM and Green Star.
	One Click LCA	Subscription LCA service with options for multiple design stages, including broader design guidance and more specific EPD-based calculations of the final building design.
	Tally	For architects and engineers working in the Revit building design platform, Tally integrates whole-building design and materials information to perform a highly detailed LCA.
	United Kingdom's Environment Agency Carbon Calculator	A freely downloadable Excel-spreadsheet carbon calculator for construction activities to help highlight areas of potential carbon savings and help make construction decisions.
	WoodWorks Carbon Calculator	Subscription LCA service with options for multiple design stages, including broader design guidance and more specific EPD-based calculations of the final building design.

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Just like in energy modeling, it is beneficial to get in early to see where the embodied carbon hotspots are and find opportunities for improvements. And after calculating out the options, many low-carbon materials are found to be cost-neutral or at least cost-competitive to carbon offsets.”

—FRANCES YANG
Americas Region Leader,
Sustainable Materials, Arup

Embodied Carbon Calculator for Construction

The newly introduced Embodied Carbon Calculator for Construction (EC3) tool developed by Skanska and C Change Labs, in partnership with the University of Washington's Carbon Leadership Forum, is a free, open source tool that helps measure embodied carbon and track the impact of individual materials. The results make it easier to perform comparisons between specific materials and see potential reductions based just on which cement, or steel, or insulation choice is made.

In 2018, owner/occupier Microsoft began piloting EC3 with the redevelopment of part of its headquarters in Redmond, Washington. Today, EC3 is helping Microsoft track to its goal of a 15 to 30 percent reduction in embodied carbon for its 17 new buildings. Skanska, Microsoft, and the Carbon Leadership Forum hope to see an uptake in embodied carbon reduction from cities, institutions, and developers thanks to this new simple tool. The aim of the tool is to make embodied carbon reductions achievable and accessible, quickly. Microsoft's successful pilot sends the message that embodied carbon can be accounted for and reduced in real estate projects.

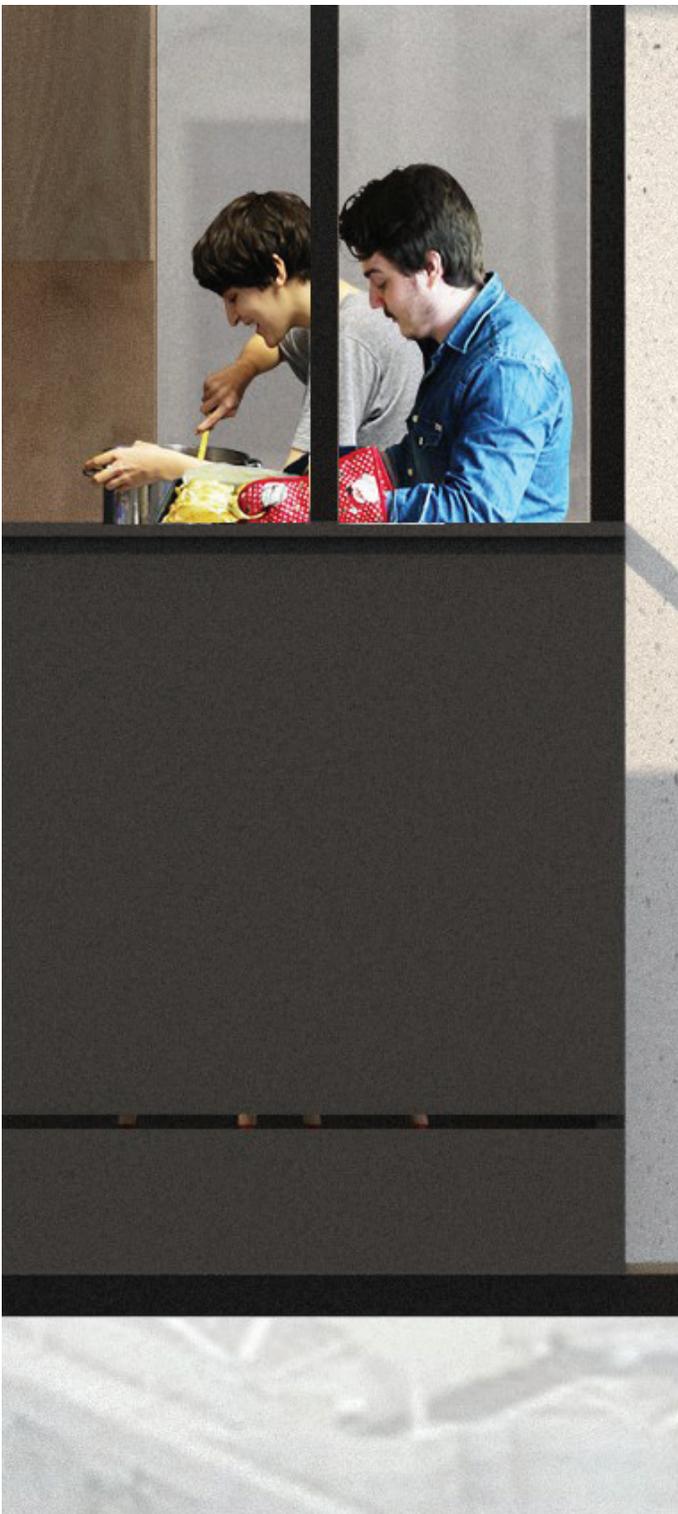
Another notable supporter of the Carbon Leadership Forum's EC3 tool is Alexandria Real Estate Equities, which joined Skanska's efforts and is the only commercial real estate company involved in the tool's pilot program. Although Alexandria has already set a 30 percent operational-carbon-pollution reduction goal from 2015 to 2025, the company also recognizes that buildings under construction represent a significant opportunity for additional carbon pollution reduction. Alexandria aims to raise awareness of the issue by demonstrating an early commitment to reducing embodied carbon. Alexandria will use EC3 on development and redevelopment projects going forward, establishing quantitative metrics and measuring carbon reductions using the latest research.



Our tenants, cities, and investors look to Alexandria for our thought leadership and as a trusted source for innovative, practical solutions to reducing the carbon pollution attributed to buildings. By contributing to the establishment of industry standards for measuring and reducing the global warming impact of construction materials, and by already using EC3 on live projects, we are meeting and exceeding expectations.

“We look forward to collaborating with the Carbon Leadership Forum, its partners, and architects, engineers, and contractors to raise awareness about this new tool that can help the real estate and construction industries reduce embodied carbon emissions, while making a positive impact on our communities and playing an active role in drawing down global warming pollution.”

—ARI M. FRANKEL
Assistant Vice President, Sustainability and High
Performance Buildings, Alexandria Real Estate Equities



Project Profile: Civic Grove Redevelopment Proposal, San Francisco

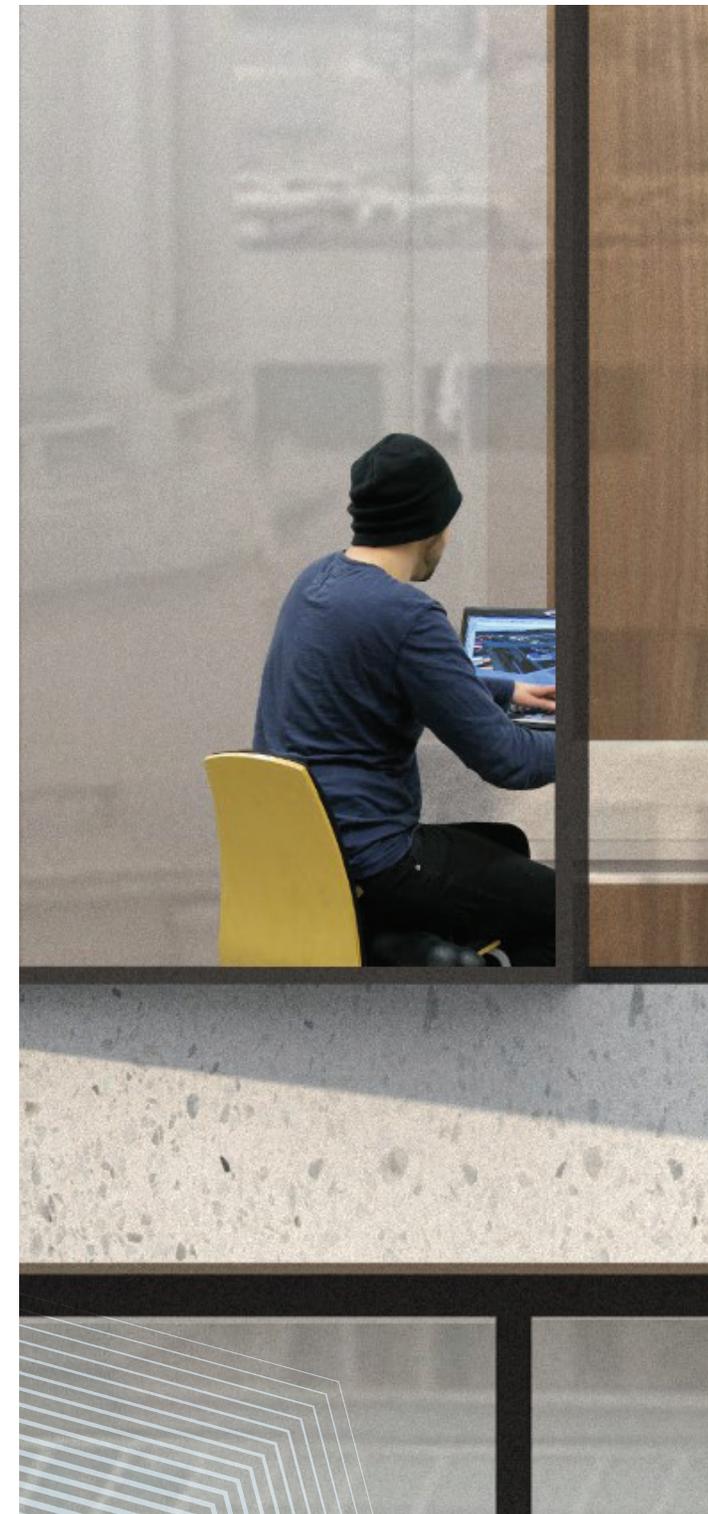
Real estate developer Morgan Creek Ventures focuses on net-zero-energy design and other high-level sustainability advancements in real estate development. To show how embodied carbon can be reduced for a potential project, Morgan Creek Ventures determined an over 40 percent reduction in embodied carbon by calculating the differences between a baseline building and a building with a 38 percent reduction in concrete and 45 percent reduction in structural steel.

Strategy 1: Cross-Laminated Timber

- Using wood mass timber construction, specifically cross-laminated timber (CLT) panels—for floor-ceiling assemblies and columns for as many floors as is permissible by code officials—saves 2,488 tons of concrete or 800 tons of CO₂.
- Wood also sequesters roughly 200 tons of CO₂.
- A side-by-side cost comparison showed a baseline concrete building to be cost neutral to a mass timber structure

Strategy 2: Concrete

- Pouring concrete with a low cement content, using fly ash, slag, or other substitutes.
- Conventional concrete has an emissions factor of 0.32 tons of CO₂ per ton of concrete, and this project targeted a combined concrete emissions factor of 0.20 tons of CO₂ per ton of concrete. That would yield a savings of 483 tons of CO₂ compared with standard concrete.



Engage with Others on the Topic

The focus on embodied carbon provides a real opportunity for stakeholders across the real estate value chain to collaborate and share success stories. From architects to general contractors, all must understand their role in reducing embodied carbon and be empowered to act. Real estate developers

must work together to achieve scale and create demand for low-carbon materials and processes.

The real estate community can engage with leading organizations across the market to learn more about embodied carbon and about how the real estate industry can make changes to reduce it. A number of such organizations are described in the table.

Join ULI Greenprint to connect with peers on the topic of embodied carbon and other sustainable building topics.

Learn more at uli.org/greenprint.

Resources

Organization	Related Activities
Carbon Leadership Forum	Works to inspire cross-sector collaboration and spur collective action toward net zero embodied carbon in buildings and infrastructure.
Embodied Carbon Network	A collective group of individuals within focus groups committed to designing embodied and operational carbon out of new and renovated buildings to achieve a carbon-neutral built environment by 2050. The group is free to join.
Architecture 2030	Architecture 2030's mission is to rapidly transform the global built environment from the major contributor of greenhouse gas (GHG) emissions to a central part of the solution to the climate crisis.
WoodWorks	WoodWorks provides free technical support as well as education and resources related to the code-compliant design of nonresidential and multifamily wood buildings.
World Green Building Council	Collectively, with Green Building Councils in about 70 countries, the World Green Building Council accelerates action to deliver on the ambition of the Paris Agreement by eliminating the building and construction sector's emissions by 2050.
International Living Future Institute (ILFI)	ILFI works to build an ecologically minded, restorative world for all people. ILFI is the certifying body for the Living Building Challenge as well as several other programs: the Living Product Challenge, the Living Community Challenge, and the Reveal, Declare, and Just labels.
materialsCAN	MaterialsCAN includes members of the global building industry that are ready to act on the smart prioritization of embodied carbon in building materials.

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