Urban Land Institute

THE MATERIALS MOVEMENT

Creating Value with Better Building Materials

About

Urban Land Institute

Urban Land Institute is a global, member-driven organization comprising more than 48,000 real estate and urban development professionals dedicated to advancing the Institute's mission of shaping the future of the built environment for transformative impact in communities worldwide. ULI's interdisciplinary membership represents all aspects of the industry, including developers, property owners, investors, architects, urban planners, public officials, real estate brokers, appraisers, attorneys, engineers, financiers, and academics. Established in 1936, the Institute has a presence in the Americas, Europe, and Asia Pacific regions, with members in 84 countries.

Randall Lewis Center for Sustainability in Real Estate

The ULI Randall Lewis Center for Sustainability in Real Estate leads the real estate industry in creating places and buildings where people and the environment thrive.

In collaboration with ULI members and partners, the Lewis Center drives industry transformation, cultivates leaders and champions, and helps foster solutions for sustainable, resilient, healthy, and equitable cities and communities. The center pursues these goals via cutting-edge research, global convenings, community technical assistance, and other strategies. The center's main programs are Decarbonization, Urban Resilience, and Healthy Places.

Discover transformative practices for real estate and land use at uli.org/sustainability.

Connect with the Lewis Center at sustainability@uli.org.

This Report

The Materials Movement: Creating Value with Better Building Materials provides an introduction for real estate owners, developers, and investors to understand why and how to integrate healthy, sustainable building materials in new and existing development projects. The report highlights best practices for cost-effectively integrating nontoxic, low-carbon materials that help real estate meet sustainability, health, and financial goals. Specifically, this report

- Articulates the drivers of the movement toward healthy and sustainable building materials in the real estate industry;
- Outlines the science behind the life cycle impacts of building materials on human health and the environment;
- Highlights high-level strategies and best practices for incorporating better building materials; and
- Shares innovative projects that successfully integrate healthy and sustainable materials to achieve positive outcomes.

Cover photo: Created using Midjourney.

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Executive Summary

In the realm of construction, every component matters—from the concrete foundations to the final brush of paint. It is not just about structural integrity, but also about the profound influence these materials have on human well-being, the climate, and global ecosystems.

Nearly 11 percent of global carbon emissions can be directly attributed to the production of construction materials. Typically less visible, but no less important, are the impacts that construction materials and products have on human health and ecosystems during their extraction, production, transportation, installation, and disposal.

Incorporating better materials in real estate can help maximize financial returns while delivering social and environmental benefits to tenants, communities, and real estate itself. Market drivers that are encouraging the industry's shift include the following:

BENJAMIN BENSCHNEIDER

As a Living Building Challenge–certified project, the PAE Living Building in Portland, Oregon, had to meet stringent requirements for sustainability, health, and equity, including the complete avoidance of "red list" chemicals, which are known to cause harm to people and the environment. Read more about the PAE Living Building on page 63.

- **Regulations.** New policies and financial reporting requirements for embodied carbon and certain chemicals are pushing the industry to integrate low-carbon and nontoxic materials in buildings.
- **Green building certifications.** Nearly every prominent sustainable building certification program includes requirements for embodied-carbon reporting, chemical avoidance, or ethical material sourcing.
- **Occupier demand.** Integrating healthy, low-carbon materials in buildings can make assets more attractive to sustainability-minded tenants, who increasingly desire spaces that promote wellness, productivity, and cognitive performance.
- **Enhanced building value.** Incorporating better building materials into a project can increase a development's value, especially if the project achieves a healthy or green building certification.
- **Environmental, social, and governance (ESG) investing requirements.** As investor interest in ESG intensifies, real estate owners and developers are increasingly including building materials as part of their sustainability targets.

Understanding Material Impacts

Building materials have significant, far-reaching effects on the climate, human health, and global ecosystems. These impacts are often categorized into the five areas noted below.

Climate Health

How a material contributes to (or mitigates) global warming through greenhouse gas emissions that are released or minimized at each stage of its life cycle. Embodied carbon, or the emissions from the extraction, production, and disposal of materials, can account for up to half a building's total carbon footprint over its lifetime.

Ecosystem Health

How natural ecosystems, including soil, waterways, and habitats, are affected by the extraction, production, and eventual disposal of a material. Insufficient regulation and challenging economic conditions can allow invasive and unethical extraction practices that deplete natural resource stocks before they can regenerate.

Human Health

How exposure to a material or a material's ingredients can affect human health during different phases of the life cycle, from workers involved in extraction, manufacturing, installation, or disposal, to people who occupy a building, to surrounding communities. Insufficient chemical regulation in the United States and other countries has allowed harmful substances to be used in building products.

Circularity

How well a material supports a circular economy, in which there is little waste, and materials can be recycled or reused many times before they are disposed of. The built environment is one of the largest producers of solid waste, and only a small fraction of construction and demolition material is reused in other buildings.

Social Health and Equity

How certain people and communities may experience more significant health or socioeconomic impacts from activities during a material's life cycle. This category also applies to ethical working conditions for people involved in production or disposal processes. People of color and those with low incomes are disproportionately affected by toxic chemicals, air pollution from material manufacturing facilities, and climate change.

Note: Categories adapted from Architecture & Design Materials Pledge created by the American Institute of Architects.

Action Steps for Integrating Healthy, Sustainable Building Materials

Making the transition to healthy and sustainable materials does not have to be complicated. Changes throughout the development process can significantly affect the overall health and sustainability of the final project. The timeline provides an overview of key action steps real estate owners, developers, and their project teams can take to integrate better materials.

Integrating Healthy and Sustainable Building Materials throughout the Project Life Cycle

Project kick-off and visioning	Pre-design	Schematic design	Design development	Construction documents	Bidding/pricing	Construction administration	Operations and maintenance	End-of-life
Articulate big-picture ESG goals. Start early. Reuse and repurpose existing buildings instead of building new.	Define a materials strategy. Identify and engage knowledgeable partners and champions. Pursue green building certifications with a focus on materials.	Consider the structural system. Do not overlook mechanical, electrical, and plumbing (MEP) systems. Design for adaptability, reuse, and disassembly. Use whole-building modeling tools (such as whole- building life cycle assessment) to inform design. Engage with manufacturers and suppliers. Choose performance-based specifications for concrete mixes.	Design for efficiency and use fewer materials. Limit or “optimize” high-impact materials. Select reclaimed, salvaged, or recycled materials. Specify bio-based or low-carbon/nontoxic materials. Request product certifications (such as EPDs and HPDs) and transparency labels.	Streamline material evaluation and reporting with material libraries and project management software.	Incorporate embodied carbon and health requirements into the competitive bidding process.	Watch for substitutions. Minimize construction waste. Reduce construction site emissions. Work with local partners to funnel construction and demolition waste out of landfills. Document the as-built embodied carbon and health of the building.	Establish health and sustainability targets for tenant fit-outs and MEP equipment replacements.	Opt for deconstruction, rather than demolition, to preserve materials for reuse.

Summary of Featured Projects

Name	Location	Product type	Project type	Developer	Status	Sustainability certifications	Material attributes
Climate Health							
1550 on the Green	Houston, Texas	Office	New construction	Skanska USA Commercial Development	Under construction; early 2024 expected delivery	Pursuing LEED Platinum and WELL	Low embodied carbon materials, material efficiency
Westlake 66	Hangzhou, China	Mixed use	New construction	Hang Lung Properties	Under construction; opening in phases starting in 2024	LEED Platinum and LEED Gold precertification for core and shell	Low-carbon materials: recycled concrete aggregate; carbon-storage concrete bricks
Human Health							
PAE Living Building	Portland, Oregon	Office	New construction	Edlen & Co	Completed 2021	Living Building Challenge certified	Sustainable mass timber, salvaged materials, healthy materials
Sven	Long Island City, New York	Multifamily	New construction	The Durst Organization	Completed 2022	LEED v4 BD+C: New Construction Multifamily Platinum certification	Low-carbon and healthy materials
Social Health and Equity							
U-lex @ Othello Square (Othello Square Affordable Homeownership Building)	Seattle, Washington	Affordable housing	New construction	HomeSight	Planned, finalizing financing	Pursuing Living Building Challenge (Affordable Housing Pilot Program)	Healthy materials; social justice
Ecosystem Health							
Prologis Evergreen	Brampton, Ontario, Canada	Industrial — warehouse	New construction	Prologis	Under construction; expected completion December 2024	Pursuing LEED Silver	Sustainable mass timber, prefab concrete
505 First	Seattle, Washington	Office	Major renovation	Hudson Pacific Properties	Completed 2023	Pursuing ILFI Core Certification	Salvaged timber, healthy materials, building reuse/ retrofit
Circularity							
Holbein Gardens	London, U.K.	Office	Major renovation	Grosvenor	Completed 2023	BREEAM Outstanding, WELL Gold, Wired Score Gold	Building reuse/retrofit, salvaged materials, low embodied carbon
Watershed Row and Wood River Mercantile	Klamath Falls and Fort Klamath, Oregon	Mixed use	Major renovation	Watershed Row LLC	Under construction; opening in 2024 and 2025, respectively	Pursuing Living Building Challenge	Building reuse/retrofit, deconstruction, salvaged materials, healthy materials

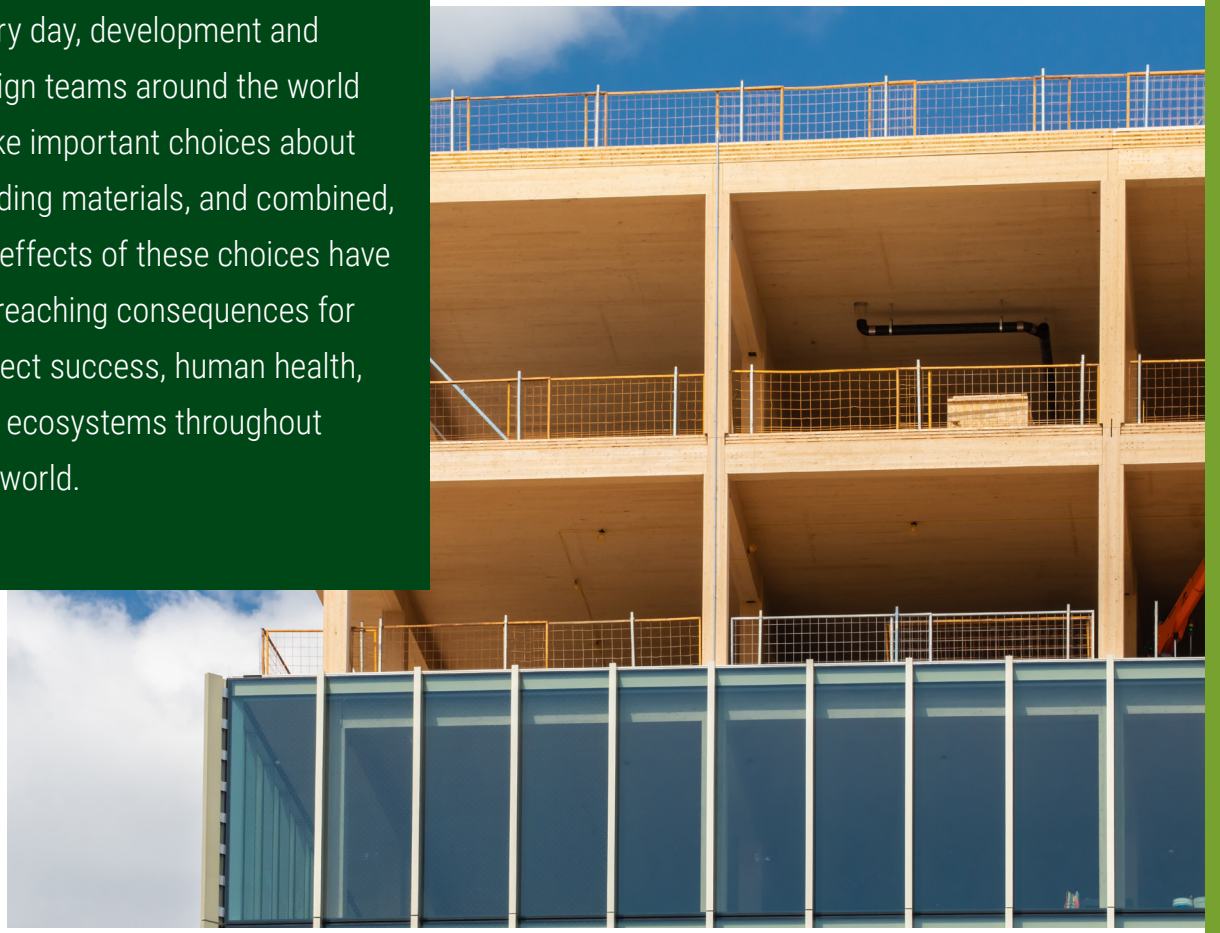
Introduction

Nearly 11 percent of global carbon emissions can be directly attributed to the production of construction materials. Typically less visible, but no less important, are the impacts that building materials have on human health and ecosystems during their extraction, production, transportation, installation, and disposal. Mitigating the most harmful consequences of building materials is necessary to realize both business and government sustainability targets and support healthy, resilient cities throughout the world.

The movement to prioritize better materials in real estate has accelerated significantly over the past several decades. Architects and designers, who are traditionally on the front lines of material selection, have mainly championed these efforts. Today, stakeholders across the industry are recognizing that failure to address building material impacts could hinder project success, financial performance, and the attainment of health and sustainability goals.

Until recently, sustainability efforts in the industry have focused primarily on energy efficiency and reducing operational carbon—the energy required to keep buildings at an ideal temperature, lighted, ventilated, and powered. Today, the urgency to decarbonize, spurred by investor trends, regulatory requirements, and community pressures, is driving industry stakeholders to also consider embodied carbon, or the footprint of the materials in their buildings.

Every day, development and design teams around the world make important choices about building materials, and combined, the effects of these choices have far-reaching consequences for project success, human health, and ecosystems throughout the world.



Traditionally, building products are formulated in distant factories and travel thousands of miles before reaching their final destinations. An enormous amount of energy is required to extract, produce, and transport these materials, resulting in significant greenhouse gases emitted into the environment during each stage. According to the United Nations' *2022 Global Status Report for Buildings and Construction*, the real estate industry is not currently on track to achieve net zero carbon by 2050. If global carbon emissions do not achieve net zero by 2050, the world's average temperatures are at risk of surpassing the 1.5-degree Celsius threshold set by the Paris

Agreement. Addressing the carbon emissions from materials will be essential to meeting industry goals and avoiding the worst effects of climate change.

At the same time, awareness has grown about the impact of construction materials on indoor air quality and human health. While the evidence base continues to evolve, the effects of certain compounds, such as lead, mercury, formaldehyde, asbestos, and other toxins commonly found in building products are relatively well studied. Over the past few decades, these substances have been phased out of many products because of enhanced regulatory action, consumer demand, and changes in manufacturing processes.

Yet thousands of potentially harmful chemicals are still present in commonly used building products. These chemicals can negatively affect the health of future tenants as well as those who may never step foot into the building. Toxins released during manufacturing and disposal processes harm workers, communities, and ecosystems. Since people of color and those with low incomes are more likely to live in industrial areas or work in construction and related trades, the disparities often fall along racial and socioeconomic lines.

However, thanks to the dedicated efforts of leading real estate companies, advocacy organizations, and product manufactures, it is easier than ever to make smart choices about materials.

The manufacturing of just one material—concrete—is responsible for approximately 8 percent of global carbon emissions.

Often, the most sustainable choice is to simply reuse a building that already exists. Since most of the predicted building stock for 2050 exists today, building retrofits will become increasingly common—and necessary—as owners adapt to energy efficiency regulations while avoiding embodied carbon. Similarly, embracing a circular economy by specifying reclaimed, salvaged, and recycled materials minimizes strain on natural resource stocks and avoids carbon emissions and pollution associated with material manufacturing.

Real estate leaders have a wealth of tools at their disposal to make informed decisions about materials. Product disclosure and transparency in the form of Environmental Product Declarations (EPDs) and Health Product Declarations (HPDs) are required for many green building certification programs, and developers and owners are recognizing the value of healthy and green features in their buildings. Combined, these efforts are supporting the movement toward materials that are better for people and the planet.

Although progress has been substantial, more robust changes in the building materials landscape will be necessary to meet global emission targets and ensure healthy and equitable communities. Fortunately, perfection is not necessary, and incremental changes made toward one goal, like reducing embodied carbon, are likely to support other desirable outcomes for tenants, workers, communities, and real estate itself.

Quick Definitions

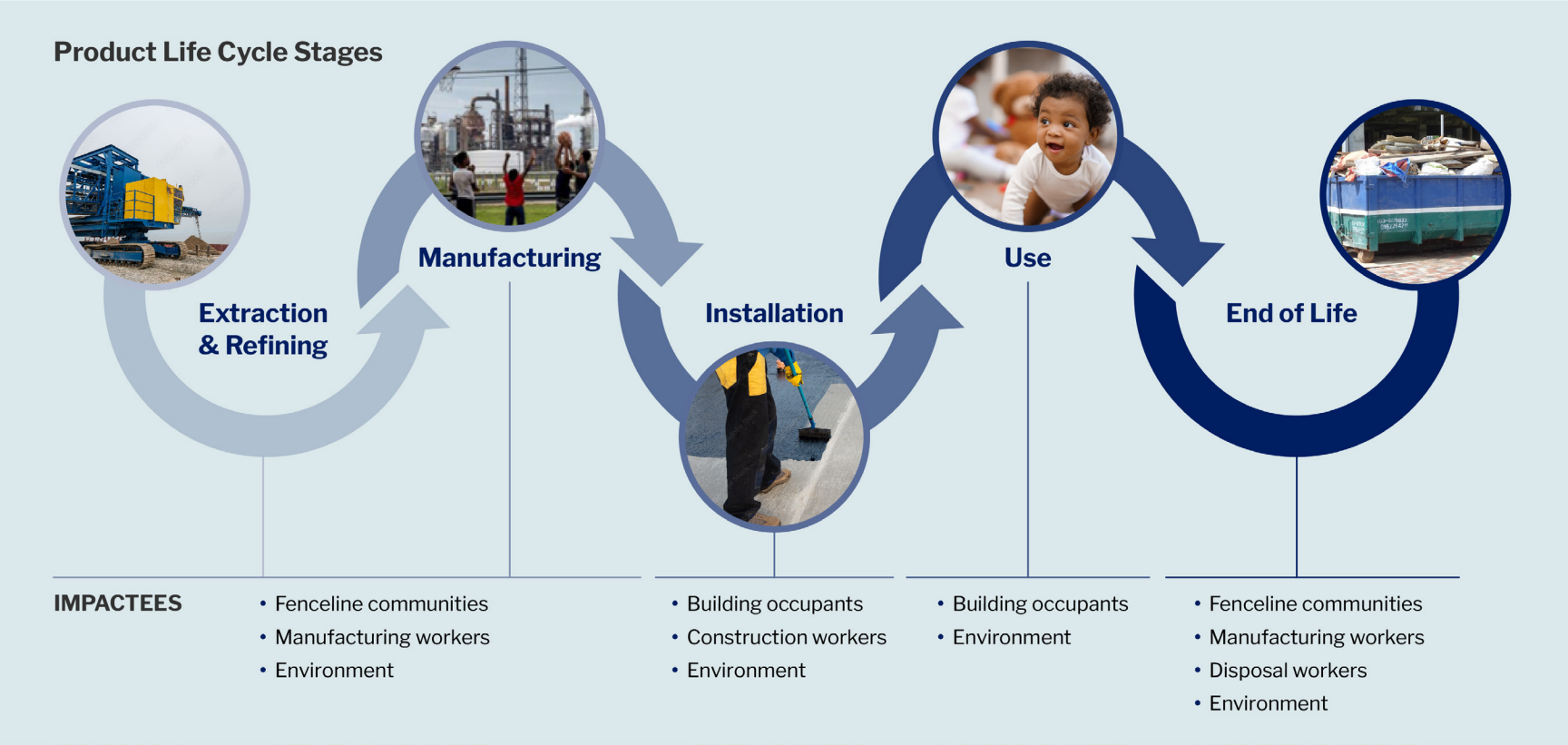
- **Embodied carbon:** The greenhouse gas (GHG) emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of building materials.
- **Life cycle assessment (LCA):** A detailed analysis of the potential environmental impacts of products during their entire life cycle.
- **Environmental Product Declaration (EPD):** A document that communicates the environmental performance or impact of any product or material over its lifetime. It is usually based on the results of a life cycle assessment.
- **Health Product Declaration (HPD):** An assessment of a building product's contents and associated health information.

Incremental changes made toward one goal, like reducing embodied carbon, are likely to support other desirable outcomes for tenants, workers, communities, and real estate itself.

Impacts across the Life Cycle

A material's journey from extraction to disposal is known as its life cycle. Each stage of the life cycle presents new opportunities to reduce environmental and human health impacts, conserve resources, and reduce costs. While life cycles vary significantly between products, most include the following key phases: extraction or raw material supply, manufacturing, transportation, construction and/or installation, use and maintenance, and end-of-life.

By using a life cycle approach to understand the effects of material choices, project teams can analyze cumulative impacts from all phases and make decisions accordingly. Life cycle analysis is most frequently used to quantify carbon emissions and environmental impacts for both individual materials as well as for entire buildings. Life cycle thinking can also be valuable for understanding how material production and disposal processes affect the health of workers, communities, and ecosystems beyond the material's use phase.



Each stage of the life cycle presents new opportunities to reduce environmental and human health impacts, conserve resources, and reduce costs. *(Healthy Building Network)*

Drivers of the Movement toward Healthy and Sustainable Building Materials

Drivers of the Movement toward

Healthy and Sustainable Building Materials

Incorporating healthy and sustainable building materials into development projects can help maximize financial returns while delivering social and environmental benefits to tenants, communities, and real estate itself.

The following section outlines five key drivers that are spurring the industry's shift toward healthy and sustainable building materials.

Regulations

Developing with healthy and sustainable materials can ensure projects are compliant with policies restricting carbon and chemicals now and into the future. As cities and regions ramp up efforts to decarbonize as well as to regulate harmful chemicals, policies and initiatives encouraging healthy and low-embodied-carbon construction will soon become more common. Adopting these design and construction practices now minimizes challenges and costs of transitions in the future.

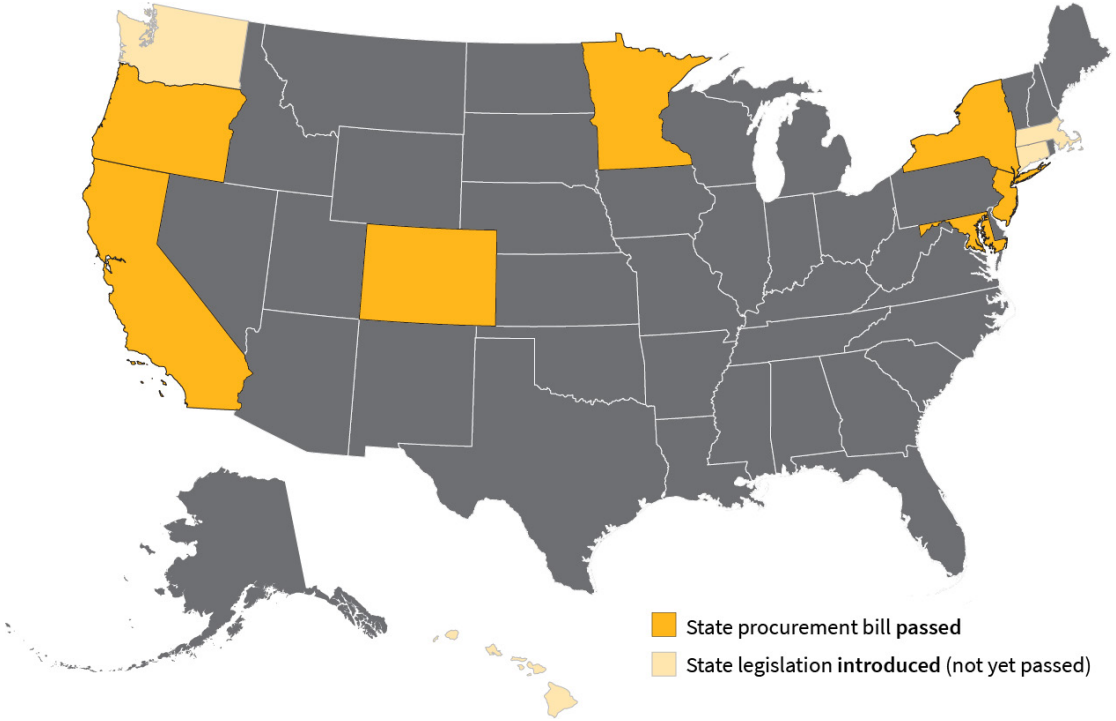
Embodied-Carbon Policies

The past few years have seen a dramatic increase in the number and scale of carbon policies, incentive programs, and disclosure requirements, driving the real estate industry to invest resources and time into understanding how their business operations and activities impact climate. Policies targeting embodied carbon come in many different forms, including procurement policies (also called "buy clean"), climate action plans, building codes, zoning and incentive programs, and policies that address industrial sector emissions.

Many of these policies are being enacted in Europe and Canada, and some will likely make their way to the United States soon. For example:

- **Denmark**. Project teams must complete an assessment of the building's life cycle climate impact when applying for a building permit and when completing construction.
- **Finland**. Finland recently established a set of green public procurement requirements that include (1) calculating the greenhouse gas emissions of materials, (2) selecting options that are both low cost and carbon optimal, (3) requiring at least 10 percent of materials to be renewable or recycled, and (4) performing an audit of reusable components before demolition.
- **Oslo, Norway**. Seven municipalities in Norway, including the country's capital, Oslo, have agreed to a policy that requires all construction sites to achieve net zero emissions by 2030. Construction machinery must be fully electric, significantly reducing air and noise pollution.
- **Vancouver, British Columbia**. The city of Vancouver announced updates to the Vancouver Building By-Law that require embodied-carbon calculation and reporting as part of the building permit submission process, which went into effect in fall 2023.

The U.S. federal government is one of the largest users of many traditionally high-carbon products, such as steel, concrete, flat glass, and asphalt.



A growing number of states are passing clean procurement policies to support low-embodied-carbon material supply chains. Map current as of 2023. *(Carbon Leadership Forum)*

While embodied-carbon policies are relatively new in the United States, they are spreading quickly across the local, regional, state, and federal levels. At the federal level, two key initiatives will dramatically affect the real estate industry: the proposed climate disclosure protocol from the U.S. Securities and Exchange Commission (SEC), and the Federal Buy Clean Initiative implemented by the Biden-Harris administration.

SEC Proposed Climate Disclosure Rules. In March 2022, the SEC proposed a new rule that would require publicly traded companies to provide more comprehensive reporting of their climate-related risks, emissions, and net zero transition plans. Although the rule has not yet been finalized, it has already motivated real estate leaders to understand how their firms will comply with the new requirements.

If approved, the rule will eventually require firms to assemble and report data on Scope 1 and Scope 2 greenhouse gas emissions (described in more detail in box on next page). Companies would also have to report Scope 3 emissions if material,* or if the company has set an emissions target.

The SEC's proposal for climate reporting has generated pushback in several areas, including the materiality threshold and the Scope 3 reporting requirement. If implemented, these regulations will likely prompt some private companies to follow suit in disclosing matters relating to climate risk.

The SEC rule closely aligns to the disclosure requirements set forth by the Task Force on Climate-related Financial Disclosures (TCFD). The TCFD has created a framework for companies to voluntarily report on their exposure to climate-related risks by providing information on governance, strategy, risk management, and metrics and targets.

By disclosing climate-related financial information through the TCFD or other frameworks, companies can better assess their risks and exposures, and investors can make more informed decisions about where to allocate their capital. Climate change poses an unquestionable risk to the health of global markets, and these disclosures aim to mitigate potential financial losses through the transparent sharing of climate-related risks and opportunities.

*Information is considered material if there is a reasonable likelihood that an investor would consider it important in making investment and voting decisions.

LAURA SWIMMER PHOTOGRAPHY

PAE Living Building in Portland, featured in detail on page 63.

Scope 1, 2, and 3 Emissions for Real Estate

Greenhouse gas emissions are classified into three scopes:

Scope 1 emissions, also known as direct emissions, are emissions from sources owned or controlled by the organization. This might include, for example, natural gas combusted in a boiler at a company's head office to heat or cool the property.

Scope 2 emissions, also known as indirect emissions, result from electricity, heat, steam, or cooling consumed by the company, but generated elsewhere. Scope 2 emissions are released at the facility where the electricity is generated (i.e., the power plant). The power plant would report these emissions as Scope 1, but the organization purchasing and consuming the electricity would report these as Scope 2.

Scope 3 emissions, also known as other indirect emissions, occur as a consequence of the operations of the organization, but are not directly owned or controlled by that organization. For example, emissions from waste generated by a company's operations are defined as Scope 3 emissions. In real estate, the most material Scope 3 emissions are usually tenant-controlled greenhouse gas emissions and the emissions associated with development, such as the production of building materials or emissions released during the construction process.

Adapted from GRESB.

> "While the SEC's landmark climate-related disclosure proposal would require public companies to disclose what a growing number of companies already share voluntarily in annual sustainability and ESG transparency reports, it could truly move the needle since it directly impacts real estate."
>
> —DIANE HOSKINS, Co-CEO, Gensler

For a global review of existing and anticipated climate-risk disclosures, see the ULI report *Change Is Coming: Climate-Risk Disclosures and the Future of Real Estate Investment Decision-Making*

California Embodied-Carbon Requirements (CALGreen)

Effective July 1, 2024, California will have mandatory embodied-carbon requirements through the state's Green Building Standards Code—known as CALGreen. The measures apply to public and private nonresidential buildings larger than 100,000 square feet and schools larger than 50,000 square feet. Eligible projects must follow one of three discrete compliance pathways:

- Demonstrate a 10 percent reduction in global warming potential (GWP) using a cradle-to-grave whole-building life cycle assessment (WBLCA);
- Reuse at least 45 percent of an existing building's structure and envelope; or
- Leverage EPDs to comply with product GWP limits, similar to Buy Clean California.

California's requirements set an important precedent for embodied-carbon requirements in other states and even national building codes. To learn more, see AIA California's Frequently Asked Questions page about the requirements.

Federal Buy Clean Initiative. The Biden-Harris administration launched the Federal Buy Clean Initiative in September 2022 to boost the development of low-carbon construction materials that are manufactured in the United States. This initiative prioritizes the purchase of low-embodied-carbon materials for all publicly funded infrastructure projects.

Since the federal government is a significant user of many traditionally high-carbon products, like steel, concrete, asphalt, and flat glass, this initiative could cause a major shift in how building materials are manufactured in the United States. For example, 32 percent of the embodied carbon of construction in the United States from 2008 to 2018 was attributed to public projects, resulting in about 153 million metric tons of carbon dioxide per year in emissions.

The goal is to change manufacturing processes and technologies to minimize carbon at the beginning of the supply chain, in the hopes that once manufacturers prioritize low-carbon production for federal customers, shifts will occur in the private sector as well. In addition to prioritizing the federal government's purchase of low-embodied-carbon materials, the Buy Clean Initiative will expand lower-carbon construction materials used in federally funded projects, convene states to partner on Buy Clean, and provide funding to manufacturing companies wishing to secure EPDs for their products. The Federal Buy Clean Initiative follows on the heels of other city- and state-level clean procurement legislation in Colorado, Connecticut, Minnesota, New Jersey, New York, Oregon, and Washington.

Carbon Leadership Forum Policy Toolkit

The Carbon Leadership Forum, a nonprofit research group affiliated with the University of Washington, offers resources and educational information to advance government and corporate policy involving embodied carbon in the built environment. The Policy Toolkit includes a series of videos and fact sheets about embodied carbon, buy-clean policies, embodied-carbon disclosure, and other topics. To learn more, visit https://carbonleadershipforum.org/clf-policy-toolkit/.

Chemical Regulations

Growing awareness of the negative health effects associated with certain chemicals is prompting public agencies to hold polluters accountable and ban non-essential uses of known toxic substances. For example, per- and polyfluoroalkyl substances (PFAS) are synthetic chemicals that are commonly used throughout the building industry in a variety of applications. However, as a class they do not degrade in the environment and have been shown to cause cancer and other negative health outcomes in people and wildlife (see box on next page).

As a result, regulatory scrutiny of PFAS in consumer products, drinking water, and the environment is increasing across the globe. PFAS have been regulated in the European Union for more than 10 years, and U.S.-based regulations are becoming more common. Since 2021, the U.S. Environmental Protection Agency (EPA) has been ramping up efforts to combat PFAS contamination, especially in water sources. These initiatives include proposing a national drinking water standard for six PFAS chemicals and designating two of the most common PFAS as hazardous substances.

By seeking out PFAS-free products and materials, real estate can avoid potential liabilities and costly transitions, especially as litigation and calls for chemical transparency in building products become more widespread.

If finalized, these rules would trigger increased evaluation and remediation on contaminated sites, which may introduce future liabilities and costs for the real estate industry. Specifically, property owners could be held liable for PFAS contamination regardless of if they were responsible for the pollution. In addition, nearly two dozen U.S. states have adopted legislation to monitor and eliminate PFAS in drinking water, food packaging, textiles, cosmetics and other consumer products.

PFAS in a *New York Times Magazine* online article published August 16, 2023.

PFAS in Building Products

Per- and polyfluoroalkyl substances are a class of more than 9,000 synthetic chemicals that have many useful applications in building products as well as in clothing, cosmetics, and other consumer goods. Known colloquially as "forever chemicals," PFAS compounds do not break down in the environment and can build up (bioaccumulate) in humans and wildlife. Research estimates that 98 percent of people in the United States, including newborn babies, have PFAS in their bodies.

PFAS chemicals have unique properties that resist heat, oil, stains, grease, and water, making them useful in a wide range of contexts. The most famous application of PFAS is Teflon, the coating added to cookware to make it nonstick. In the building industry, PFAS is commonly found in paints and coatings, caulks, adhesives, fabrics, roofing materials, and more.

The properties that make PFAS desirable for industrial uses also make them harmful to humans and the environment. High exposure to PFAS has shown adverse health effects, including various cancers, elevated cholesterol, liver disease, decreased fertility, thyroid problems, changes in hormone functioning, and developmental effects.

Green Building Certifications

A growing number of building certifications and reporting standards include embodied carbon and material health requirements. Recognizing the importance of green certifications for investment potential, more than 100 voluntary sustainability certifications now address embodied carbon with many others focused on indoor air quality and nontoxic materials.

RESET compared some of the most common building standards to understand their similarities and differences. Each emphasizes a different area, and not all address embodied carbon and material health.[†] A summary of the results that pertain to materials (with minor amendments[‡]) is presented in the accompanying table.

[†]For the purpose of this analysis, RESET used the following definitions for embodied carbon and embodied health: **Embodied Carbon**: embodied carbon consists of the GHG emissions associated with building construction, including those that arise from extracting, transporting, manufacturing, and installing building materials on site, as well as the operational and end-of-life emissions associated with those materials; **Embodied Health**: embodied health refers to the impact of the material components on human health, including volatile organic compound emissions and material ingredients.

[‡]In the original RESET analysis, Fitwel was listed as addressing material health. In ULI's re-creation of this graphic, Fitwel is listed as partially addressing material health.

Comparison of Green Building Certifications

Name	Description	Country of origin	Countries covered	Addresses embodied carbon?	Addresses material health?
BOMA Best	Green building standard administered by BOMA Canada	Canada	Global	No	Yes
BREEAM	Green building standard administered by the BRE Group	U.K.	Global	Yes	Yes
CASBEE	Japanese green building standard administered by the Japan Sustainable Building Consortium	Japan	Japan (mainly)	Yes	Yes
China Green Building Standard	Chinese green building standard administered by the China Academy of Building Research (CABR)	China	China	Yes	Yes
DGNB	Green building standard administered by the German Sustainable Building Council	Germany	Global	No	No
EDGE	Green building standard administered by Green Business Certification Inc.	Switzerland	Global	Yes	No
EnergyStar	Energy standard administered by the U.S. EPA and Department of Energy	United States	Global	No	No
Fitwel	Healthy building standard administered by the Centers for Disease Control and Prevention (CDC) and U.S. General Services Administration	United States	Global	No	Partially addressed
Green Globes	Green building standard administered by the Green Building Initiative	Canada	North America	Yes	No
LEED	Green building standard administered by the U.S. Green Building Council	United States	Global	Yes	Yes
Living Building Challenge (LBC)	Green building standard administered by the International Living Future Institute	United States	Global	Yes	Yes
NABERS (AU)	Australian green building standard administered by the New South Wales government	Australia	Australia, New Zealand, U.K.	No	No
Passive House Standard	Standard for Passive House design administered by Passive House Institute	Germany	Global	No	No
RESET	Performance-driven building standard administered by GIGA	Canada	Global	Yes	Yes
SG Green Mark	Green building standard administered by the Singapore Building and Construction Authority	Singapore	APAC	Yes	Yes
WELL	Healthy building standard administered by the International WELL Building Institute	United States	Global	Yes	Yes

Chart adapted from RESET analysis conducted in June 2023.

Occupier Demand

Better materials can boost marketability by directly supporting a project's or firm's commitment to health and sustainability. Occupiers are increasingly demanding workplaces that are environmentally friendly and promote productivity. Combined, these unique attributes attract users and differentiate healthy and sustainable projects from the crowd.

In office spaces, building materials can be a powerful expression of a tenant's brand. By addressing carbon and health in materials, companies can highlight their commitment through a visible part of their space and operations. This helps tenants tell their brand story as well as recruit top talent, who increasingly expect their workplaces to have positive effects on the environment and on society. In addition, nontoxic building materials contribute to healthier air quality, which is important for worker productivity and cognitive performance as well as mental and physical health (see box).

As a result of this change in tenant perspectives, demand for healthy buildings has grown sharply and is expected to continue; according to a study by the Center for Active Design, 92 percent of survey respondents expected demand for healthy buildings to grow over the next three years. By incorporating healthy and sustainable building materials, developers can help ensure a project's ongoing relevance and usability as market demand continues to evolve.

Some of this demand has been created by a renewed focus on health and well-being after the COVID-19 pandemic. For example, 42 percent of respondents to the 2022 JLL Future of Work Survey plan to accelerate investment in health and wellbeing amenities and improving indoor air quality. In addition,

> "People are going to demand low-embodied-carbon materials, and the people who can supply these products will own that market."
>
> —VICTOR OLGYAY,
> Principal in RMI's Carbon-Free Buildings Program
> and co-author of RMI and Skanska's
> Reducing Embodied Carbon in Buildings report

Indoor Air Quality

Following the COVID-19 pandemic, healthy indoor air quality (IAQ) has become a top priority for building developers, owners, and managers. Beyond the risk of disease transmission, poor IAQ in offices can have significant, negative effects on employees' cognitive function, including response times, ability to focus, and productivity.

While IAQ is affected by a range of factors, the products and materials within a building are an important contributor to air quality. Therefore, one of the easiest ways to improve indoor air is to source low-emission and nontoxic interior products, with a focus on paints, finishes, textiles, flooring, furniture, and other product categories that may release potentially harmful substances into the air.

Poor ventilation is still a key issue across many buildings and is a contributor to sick building syndrome. Improving filtration and HVAC systems is important for improving air quality but should not be relied upon as the only line of defense against airborne chemicals or other particulates. The best approach is to minimize or avoid products that will negatively affect air quality.

Improving IAQ can result in a host of benefits for tenants, including reduced absenteeism and work hours affected by asthma, respiratory allergies, depression, and stress, and leads to self-reported improvements in productivity. The important role of IAQ in health is one of the reasons why numerous building certifications, including LEED, WELL, RESET, Living Building Challenge, and others, are prioritizing low-emitting materials (in addition to high-quality air filters) in real estate developments.

millennials and gen Z, who will soon become the largest workforce cohort, overwhelmingly desire high-quality workplaces with employers that care about their well-being and support climate action.

More and more, companies no longer view human health and sustainability as separate priorities, but rather as two closely connected concerns. Large end-users, including Google, Salesforce, Meta, Microsoft, Kaiser Permanente and others, have incorporated healthy and sustainable building material programs into their company-wide sustainability and social impact commitments.

These firms are interested in creating spaces that not only promote wellness for their workforce, but that also have positive benefits on stakeholders, communities, and the environment. In many ways, green buildings are now considered an essential part of a company's risk mitigation and sustainability strategies, rather than just "nice-to-have" additions.

JOSH PARTEE PHOTOGRAPHY

Peavy Hall at Oregon State University in Eugene is built with mass timber primarily grown and harvested in the Pacific Northwest, demonstrating the value of local material sourcing.

“

We want to play our part in ensuring that occupants in our buildings, workers in our supply chain, and communities and ecosystems impacted throughout the life cycle stages of material production are kept healthy. Sustainability is one of our core values, and that includes sustaining human and environmental health to the best of our ability.”

—AMANDA VON ALMEN,
Director, Emissions Reduction, Salesforce

Salesforce’s Journey to Healthier Materials

The technology company Salesforce began its healthy materials journey in 2016 as it was preparing to build out its headquarters at Salesforce Tower in San Francisco, California. Since then, the company has released two guides (*Healthy Materials in the Workplace: An Introductory Guide* and *Healthy and Sustainable Materials in the Workspace, Volume II*) describing its rationale and approach for incorporating healthy and sustainable building materials into Salesforce workplaces.

SALESFORCE

Salesforce shares these guides and their criteria for materials selection to facilitate industry dialogue and inspire change. The company values transparency—both in the way it openly communicates its path to better materials, and in the way it prioritizes products with publicly disclosed and transparent information about environmental and human health impacts. This transparency sets the stage for collaboration with product manufacturers to shift the industry toward better products. “We want to play our part in ensuring that occupants in our buildings, workers in our supply chain, and communities and ecosystems impacted throughout the life-cycle stages of material production are kept healthy. Sustainability is one of our core values, and that includes sustaining human and environmental health to the best of our ability,” says Amanda von Almen, the company’s director of emissions reductions.

Salesforce gives each product a score out of 100 based on five main criteria: health, carbon, circularity, resource efficiency, and social and governance. This scoring tool has provided the company with a consistent method for evaluating products and providing scores that are easily interpreted by its real estate, design, and procurement teams. While this holistic approach to health and sustainability adds complexity to the company’s decision-making, Salesforce believes that it is necessary for pushing the market toward truly sustainable materials.

To learn more, visit www.salesforce.com/sustainability.

Enhanced Building Value

Incorporating better building materials into a project can increase a development's value, especially if the project achieves a healthy or green building certification. Certified healthy and sustainable buildings have been shown to command higher rents and tend to have faster lease-ups compared to noncertified peer buildings.

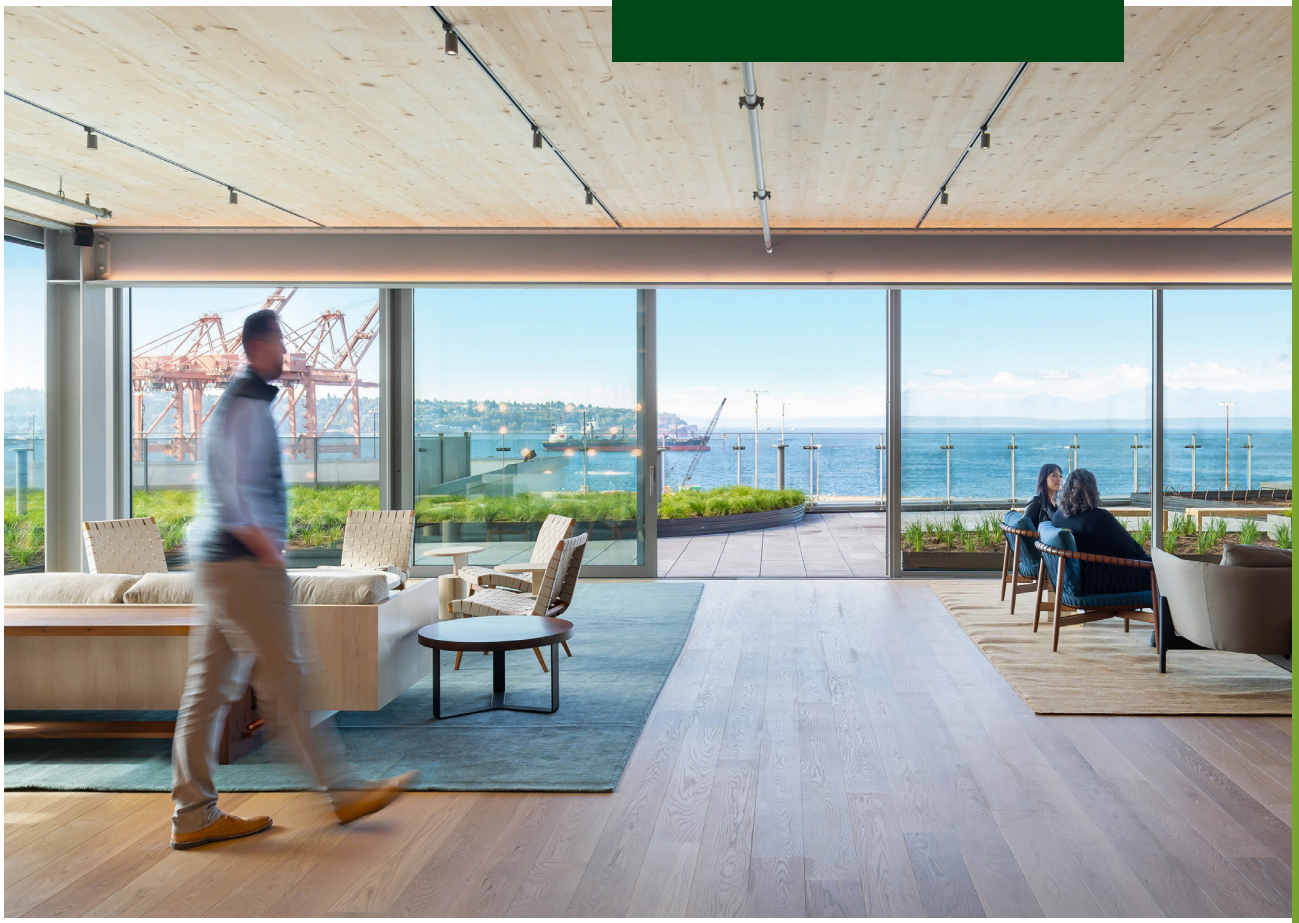
In a growing number of markets, buildings that are ahead of the sustainability curve command a green premium, just as those not on track to meet emission reduction targets in line with the Paris Agreement can earn a brown discount. Buildings that are not built or retrofitted to reduce operational and embodied carbon will become increasingly difficult to lease or sell. A 2021 analysis by Fidelity International suggests that brown discounts will quickly become large enough to make upgrading buildings worth the upfront investment.

Owners and tenants recognize the value of healthy and environmentally-friendly buildings and are willing to pay more for a space that has green and healthy credentials. For example, studies have shown the following:

- For office properties, the estimated green premium on rent ranges from just over 2 percent to over 15 percent.
- Certified healthy buildings transact 4.4 to 7.7 percent higher rent per square foot than noncertified and nonregistered peers.
- LEED-certified buildings have been shown to command up to a 21.4 percent higher price per square foot than comparable noncertified properties.

Even without a certification, real estate owners and developers reap the financial benefits of better materials as demand for healthy and sustainable spaces is expected to increase over the short and long terms.

For office properties, the estimated green premium on rent ranges from just over 2 percent to over 15 percent.



HUDSON PACIFIC PROPERTIES

505 First in Seattle, featured in detail on page 67.

ESG Investing Requirements

Building materials can play a key role in environmental, social, and governance (ESG) strategies for companies throughout the real estate value chain. As investor interest in ESG intensifies, real estate owners and developers are setting aggressive targets that consider impacts beyond the operations of their assets.

Within the "E" category, many leading real estate companies are including embodied-carbon targets as part of their net zero strategies. For example, Lendlease announced science-based targets to achieve net zero carbon by 2025 (Scope 1 and Scope 2 GHG emissions), and absolute zero carbon by 2040 (Scopes 1, 2, and 3 emissions) with no offsets. These targets have been validated by the Science Based Target initiative as being in line with a 1.5-degree Celsius trajectory. As embodied-carbon data for materials becomes more readily available, real estate companies will be able to track and report on these measures more easily as part of their overall carbon reduction strategy.

These changes are also affecting vendors and suppliers whose main activities occur upstream or downstream of building construction. In some cases, leading corporations like Salesforce and Microsoft are now requiring that vendors and suppliers attempt to meet their own carbon targets.

For the "S" category, real estate firms are reporting on a variety of activities, including their material procurement practices and how well their buildings support the health, well-being, and productivity of users. For procurement, firms are establishing objectives for their global supply chains that include efforts to eliminate unethical treatment of workers and communities involved in material extraction, manufacturing, or disposal. In addition, the inclusion of healthy and nontoxic materials in buildings illustrates a company's commitment to the health and safety of employees, tenants, and communities—an important component of the "S" in ESG.

HUDSON PACIFIC PROPERTIES

505 First in Seattle, featured in detail on page 67.

Understanding Material Impacts

When development and design teams evaluate and select building materials, they typically consider product attributes like aesthetics, durability, functionality, and cost. Indeed, these characteristics are important for meeting project expectations and understanding how a product or material will perform once installed in a building. Less frequently, material evaluation processes incorporate the many ways that products may have negative consequences for humans and the environment before and after they are installed. Often invisible to development teams and tenants, these impacts may occur at the local, regional, or global scales.

The American Institute of Architects created the *Architecture and Design Materials Pledge* to provide a framework for understanding and categorizing the life cycle effects of materials and inspire a shift in how teams evaluate the materials and products in their buildings.

The A&D Materials Pledge outlines five key considerations that generally align with how building materials and products impact humans and the environment:

Climate Health

How a material contributes to (or mitigates) global warming through GHG emissions that are released or minimized at each stage of its life cycle.

Human Health

How exposure to a material or a material's ingredients can affect human health during different phases of the life cycle, from workers involved in extraction, manufacturing, installation, or disposal, to people who occupy a building, to surrounding communities.

Social Health and Equity

How certain people and communities may experience more significant health or socioeconomic impacts from activities during a material's life cycle. This category also applies to ethical working conditions for people involved in production or disposal processes.

Ecosystem Health

How natural ecosystems, including soil, waterways, and habitats, are affected by the extraction, production, and eventual disposal of a material.

Circularity

How well a material supports a circular economy, in which there is little waste, and materials can be recycled or reused many times before they are disposed of.

The A&D Materials Pledge offers a helpful structure to all real estate professionals looking to understand the basics of building material impacts to make more informed choices. The following sections of this report discuss the five focus areas in more detail.

The Common Materials Framework and Measuring the Five "Buckets" of Sustainability

The Common Materials Framework (CMF) is an initiative that aims to establish a common language for material evaluation based on consistent data points within the five "buckets" of sustainability and outlined by the AIA A&D Materials Pledge: human health, climate health, ecosystem health, social health and equity, within a circular economy. Within each of the five main categories are sub-categories that provide measurable criteria for evaluating products.

The CMF was created by industry stakeholders and led by mindful MATERIALS, a nonprofit organization founded in 2014 as an initiative to make information about materials more transparent and accessible to project teams. The CMF is now integrated into *mindful MATERIALS' portal,* which allows users to identify and evaluate products based on the sustainability "bucket" that is most meaningful for their developments. Learn more at https://www.mindfulmaterials.com/the-common-framework.

Material Impacts and Real Estate Actions

	Climate health	Human health	Social health and equity	Ecosystem health	Circularity
					
Why is it important?	11% of global carbon emissions are from the manufacture, transportation, and disposal of building materials. Embodied carbon can account for up to half a building's total carbon footprint over its lifetime.	Humans spend about 90 percent of their lives inside buildings. Insufficient chemical regulation in the United States and other countries has allowed harmful substances to be used in building products.	People of color and those with low incomes are disproportionately impacted by toxic chemicals, air pollution from material manufacturing facilities, and climate change. Complex global supply chains can hide unethical working conditions and even modern slavery.	Ecosystems around the world are impacted by the extraction, manufacture, and disposal of materials. Insufficient regulation in certain areas can allow invasive and unethical extraction practices that deplete natural resource stocks before they can regenerate.	The built environment is one of the largest producers of solid waste, and only a small fraction of construction and demolition material is reused in other buildings. Many recycling processes require energy and release carbon to grind up, burn, or convert material into different products.
What can real estate do?	Reuse and repurpose existing buildings. Select reclaimed, salvaged, or recycled materials when possible. Commit to an embodied-carbon target or "budget" for new projects. Integrate low-carbon materials for the structure and its mechanical, engineering, and plumbing (MEP) systems. Measure it: request Environmental Product Declarations (EPDs) when specifying products, conduct whole-building life cycle assessments.	Follow a chemical avoidance list to minimize and avoid the worst offenders. Prioritize high-impact areas (i.e., interiors), and choose nontoxic or low-emitting paints, finishes, and coatings. Select products and manufacturers that transparently disclose ingredients and production practices. Measure it: request Health Product Declarations (HPDs) when specifying products.	Choose nontoxic and/or bio-based materials with fewer life cycle impacts on communities and workers. Implement an ethical procurement policy and set supply chain requirements for suppliers. Select products and manufacturers with third-party verified certifications for fair labor practices. Measure it: request HPDs or other multi-attribute product certifications when specifying products.	Choose nontoxic and/or bio-based materials with fewer life cycle impacts on ecosystems, communities, and workers. Incorporate reclaimed, salvaged, or recycled materials to reduce strain on natural resource stocks. Choose bio-based materials that are sustainably harvested (i.e., Forest Service Council for timber). Measure it: request EPDs when specifying products.	Reuse and repurpose existing buildings. Prioritize reclaimed and salvaged materials when possible. Design for adaptability, reuse, and disassembly. Work with local partners to funnel construction and demolition waste out of landfills.

Note: Categories adapted from the *AIA Materials Pledge* and *mindful MATERIALS Common Materials Framework* (CMF).

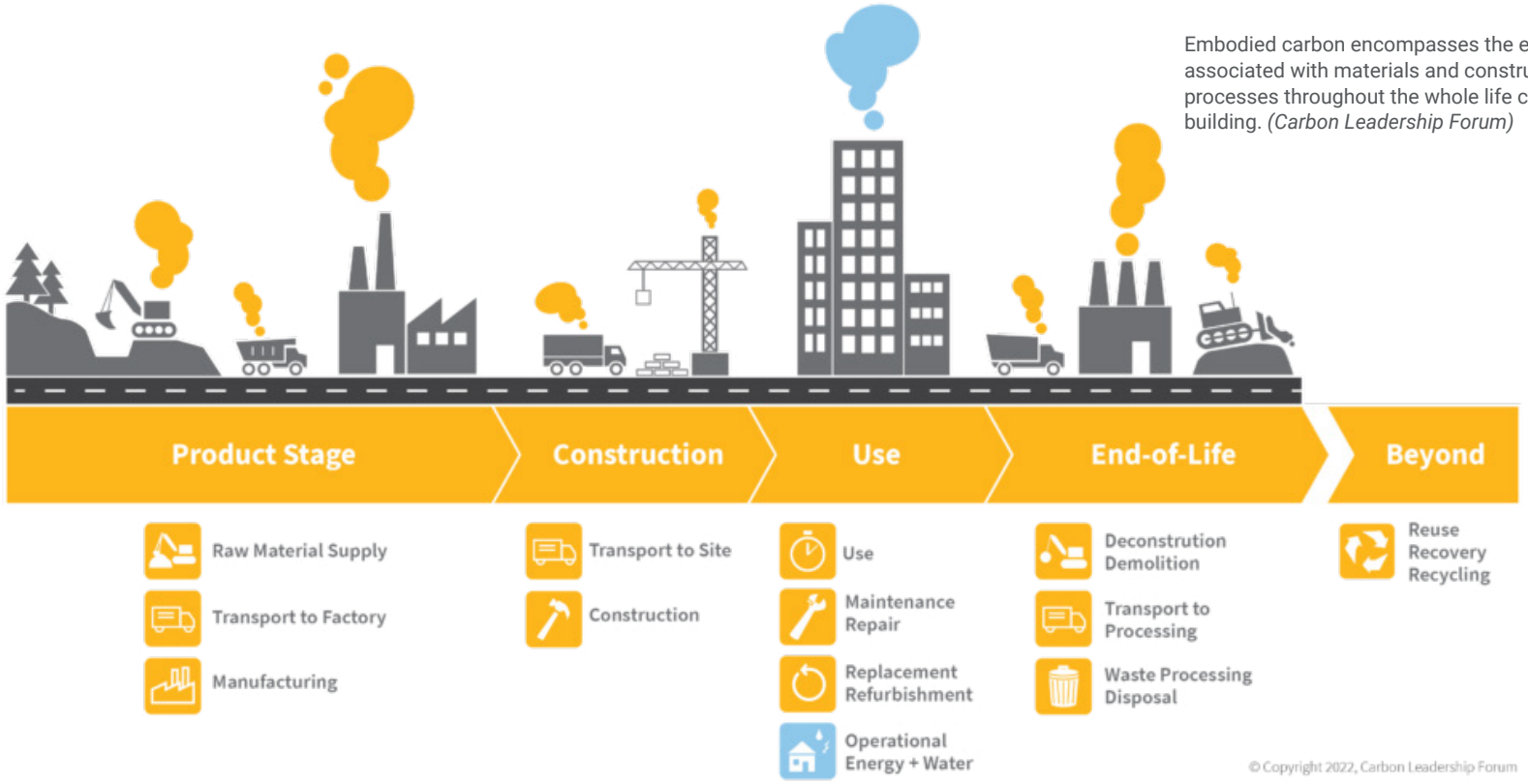
Climate Health

The extraction, manufacturing, transportation, and disposal of building materials contribute nearly 11 percent of global carbon emissions. Collectively, these emissions are known as embodied carbon. For example, producing one ton of cement requires 4.7 million BTU of energy, equivalent to about 400 pounds of coal, and the process generates nearly a ton of carbon dioxide. In comparison, an average 22 mile-per-gallon car must drive 2,500 miles to emit the same amount of carbon dioxide.

Increasingly, real estate leaders are improving energy efficiency and seeking renewable energy for their buildings in pursuit of reaching net zero operational carbon across their portfolios. While these changes are key to driving down emissions, they are not enough to keep global warming below the 1.5-degree Celsius threshold set out in the Paris Climate Agreement. To prevent global temperatures from exceeding 1.5-degree Celsius, global net emissions must decline by about 45 percent from 2010 levels by 2030 and reach net zero by 2050. This means that the building sector, specifically the production of construction materials, must radically decarbonize in the next decade.

Materials that make up structural systems, like concrete and steel, are by far the largest sources of carbon emissions in the industry. The manufacturing of both materials requires significant combustion, and the power typically comes from fossil fuels and other "dirty" grids.

For example, it is estimated that 61 percent of electricity in the United States and nearly 80 percent of electricity globally comes from fossil fuels, including coal, oil, and natural gas. Yet even if only renewable electricity were used to produce these materials, significant carbon would still be emitted during their production, transportation, and eventual disposal.



Embodied carbon encompasses the emissions associated with materials and construction processes throughout the whole life cycle of a building. *(Carbon Leadership Forum)*

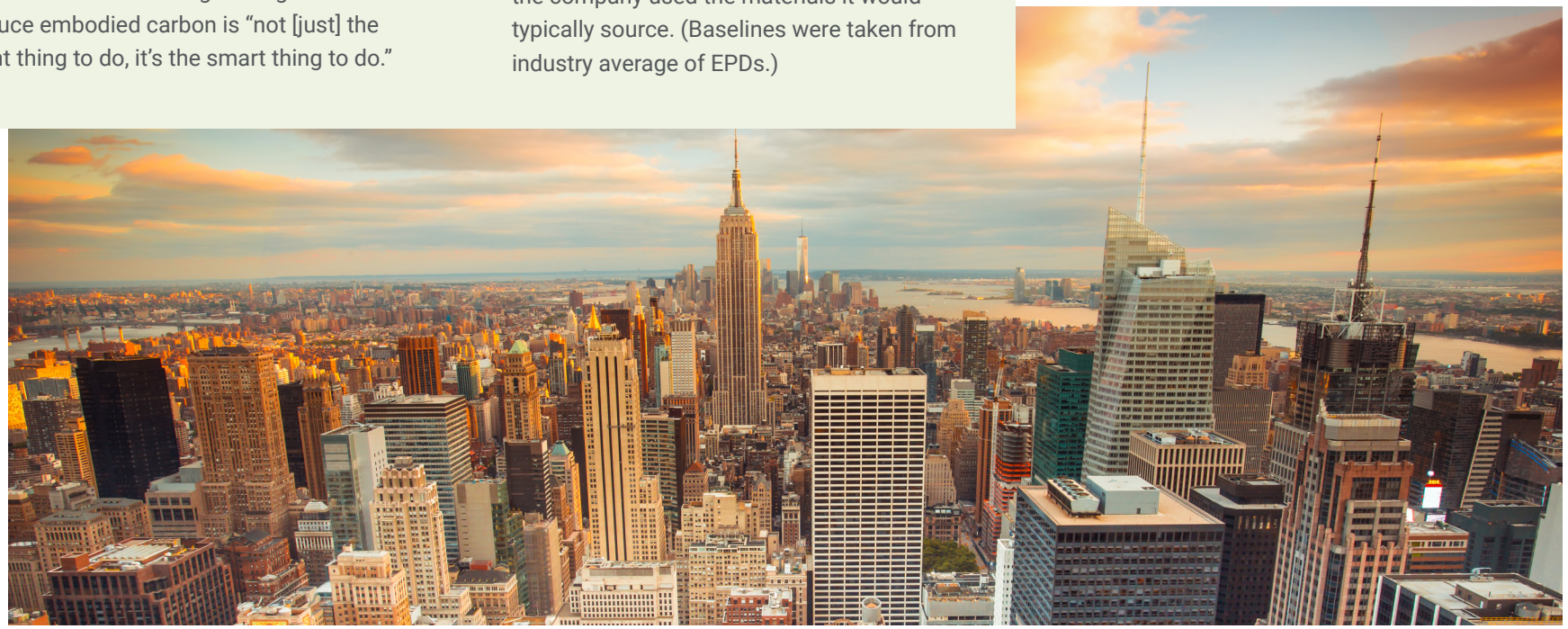
BXP Shares Insights at ULI Embodied-Carbon Convening

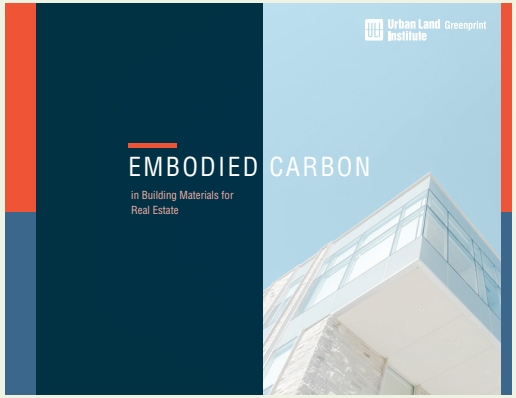
Recognizing the need for real estate to move fast on embodied carbon, ULI launched a series of convenings that bring real estate executives together to understand and remove barriers to reducing carbon emissions in development.

At the first convening in January 2023, ULI hosted real estate leaders, including Owen Thomas, chairman and chief executive officer (CEO) of BXP; Kim Roy, CEO of HITT Contracting; and Diane Hoskins, co-CEO of Gensler. While participants varied in their progress on embodied-carbon reduction policies and experience, all agreed with Owen Thomas that addressing the urgent need to reduce embodied carbon is "not [just] the right thing to do, it's the smart thing to do."

During the convening, BXP presented about its future development, 343 Madison, in New York City. As part of the LEED Design and Construction pre-certification for this asset, BXP conducted a life cycle assessment. Structural concrete (38 percent) and structural steel (34 percent) were the highest contributors to embodied carbon for the project, contributing over 12,000 metric tons of carbon dioxide each. Rebar was the next highest contributor after concrete and steel, adding about 3,000 metric tons. For these three materials—concrete, steel, and rebar—BXP targeted low-carbon procurement, thereby allowing a 16 percent reduction from the established baseline had the company used the materials it would typically source. (Baselines were taken from industry average of EPDs.)

> "The industry needs to urgently address embodied carbon reduction at all stages of the development process. It's not just the right thing to do, it's the smart thing to do."
>
> —OWEN THOMAS, BXP





For an in-depth look at how real estate leaders are cost-effectively reducing embodied carbon in their developments, see ULI's report *Embodied Carbon in Building Materials for Real Estate*.

Key strategies from the report include the following:

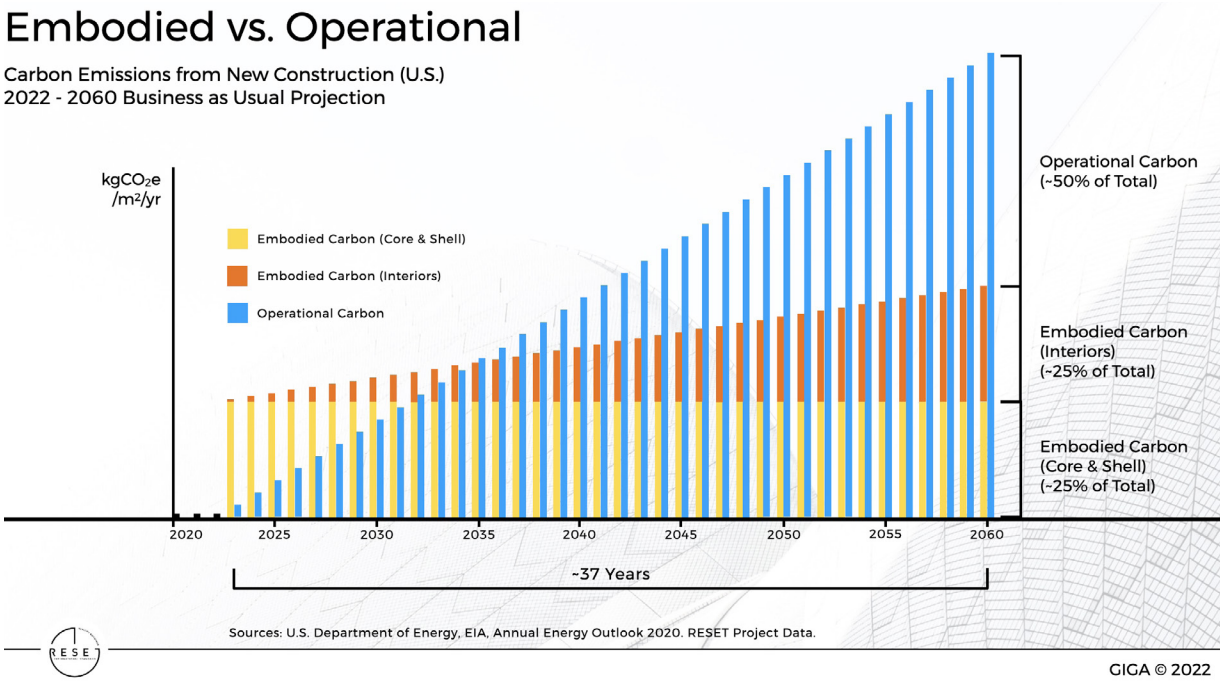
- Reuse buildings (as opposed to building new) to save carbon as well as cost.
- Use fewer materials by streamlining design, avoiding finishes, and leaving walls, ceilings, and other areas exposed.
- Reuse materials and divert waste from landfills.
- Specify low-embodied-carbon products like low-carbon concrete and bio-based materials.
- Leverage embodied carbon calculators like the Embodied Carbon Calculator in Construction (EC3), One Click LCA, Tally, and others.

Embodied Carbon of Tenant Fit-Out and Equipment Replacement Materials Equal to Upfront Core and Shell

While concrete, steel, flat glass, and asphalt have high embodied carbon and therefore receive most of the attention, interior products and finishes should not be overlooked. A study by GIGA found that over the lifetime of an asset, carbon emissions from tenant fit-outs and equipment replacements are about equivalent to those of the entire core and shell's upfront emissions, because tenant interiors change every two to eight years as leases expire and equipment is replaced throughout a building's life cycle. An average office interior may see up to 20 interior fit-outs over its life span, generating thousands of tons of carbon and waste.

Finding the embodied-carbon "hot spots" for fit-outs and interiors is important for knowing where to prioritize reduction efforts. The Carbon Leadership Forum's Lifecycle Assessment of MEP and TI in Buildings project identifies five product categories that tend to have the highest embodied carbon:

- Cubicles;
- Furniture;
- Flooring;
- Ceiling panel suspension systems; and
- Walls.



An analysis by GIGA, the company known for the RESET certification program, found that over the lifetime of an asset, carbon emissions from interiors are about equivalent to upfront emissions from core and shell.

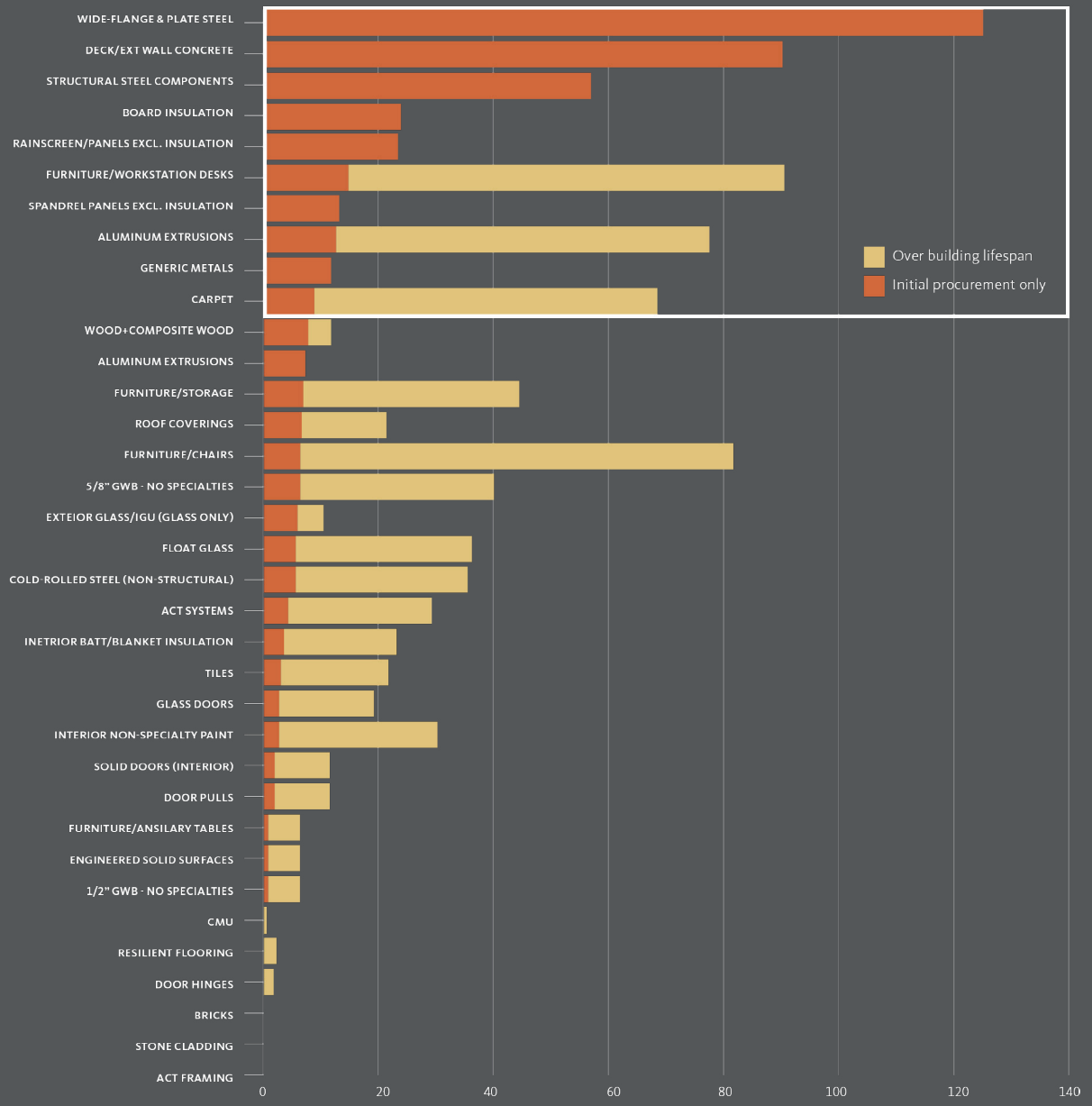
Commercial office landlords and owners are offering guidance to help tenants decarbonize their fit-outs. For example, Hudson Pacific Properties published a *Low Embodied Carbon Tenant Fit-Out Guide* to share insights learned from the company's efforts to reduce carbon in its Vancouver, British Columbia, office. Strategies include using less material and reusing when possible, selecting natural materials, increasing recycled content, and choosing local materials. Many of these strategies can be implemented with minimal impact to schedule and budget.

MEP Systems: A Hidden Carbon Contributor

Mechanical, electrical, and plumbing systems are largely made with materials that are high in embodied carbon like galvanized steel and aluminum (for ductwork), insulation, copper (for wiring and piping), and plastic (for piping and wire sheathing). This is mainly because of their energy-intensive production and manufacturing processes. In addition, most MEP equipment cannot be recycled, leading to continued increase of mining, processing, and transportation of virgin materials, mostly metals. Since MEP systems, especially heating, air conditioning, and ventilation (HVAC), are commonly replaced multiple times over the life a building, material demand compounds these negative environmental impacts.

High-Embodied-Carbon Materials

Nearly all materials contain some level of embodied carbon. Structural materials, like steel and concrete, are high in embodied carbon during initial procurement. Interior materials and products, like furniture and carpets, are high in embodied carbon because they are replaced many times over the building's life span (which is estimated at 60 years in this graphic). *(Gensler)*



MEP systems are made with high-embodied-carbon materials such as aluminum, insulation, copper, and plastic.

To reduce the embodied carbon of MEP systems, particularly HVAC, teams can use Passive House design strategies to improve the overall thermal performance and efficiency of the building. Passive House is a building design standard that promotes ultra-airtight building envelopes to maintain interior temperatures and save energy. These strategies include changing the building orientation and strategically placing windows and overhangs to avoid excessive solar heat gain. Smart design that helps the building maintain interior temperature without robust HVAC systems results in less equipment needed to meet heating and cooling demands.

When Passive House strategies are not feasible, teams should aim to design MEP systems for long-term operation and flexibility so the systems can adapt to new uses over time. This helps minimize the need for disposal and replacement over the life of the building. Teams can also seek out recycled or refurbished materials to help lessen impact.

In addition, reducing the global warming potential of refrigerants has been identified as one of the most important actions the building industry can take to mitigate climate change. One report estimates that if the building industry were to reduce refrigerant leakage to 0.4 percent of refrigerant used over the next 30 years, it would save 89.7 gigatons of carbon from the atmosphere. Strategies to manage the negative impacts of refrigerants include reducing refrigerant needed by using Passive House design, using low-embodied-carbon refrigerants, and encouraging building management practices that limit refrigerant leakage and ensure 100 percent refrigerant recovery.

Many MEP engineering and design teams have committed to the MEP 2040 Challenge, an initiative led by the Carbon Leadership Forum to dramatically reduce embodied carbon in MEP systems throughout the industry. To learn more, visit mep2040.org.

How Is Climate Health and Embodied Carbon Measured and Reported?

Embodied carbon is measured by tallying up the carbon emissions and environmental impacts from each stage of a product's life cycle from extraction through disposal. The following table provides more detail about using EPDs and life cycle assessments.

Environmental Product Declarations and Life Cycle Assessments

Name	Description
Environmental Product Declarations	EPDs are the most common method for reporting environmental impact information for products and are based on calculations produced in a life cycle assessment (LCA) report (see below). EPDs are sometimes product-specific whereas others are created to represent an entire product line, making them difficult to compare. However, 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.
Life cycle assessments	LCAs are in-depth analyses of the environmental impact of a product and often form the basis of EPDs. LCAs quantify the impacts of carbon emissions, energy use, water consumption, acidification, and ozone layer depletion at all stages of a product's life cycle.

Human Health

On average, people spend about 90 percent of their lives inside buildings. This extended time indoors means that nearly everyone faces some level of exposure to chemical toxins from building materials.

As building materials degrade, change temperature, encounter moisture, or transition from a solid to a gas (also known as off-gassing), they release chemicals into the environment. These chemicals attach to air molecules, to dust particles, or onto surfaces where people and animals come into contact with them.

In some cases, building occupants can experience acute health and comfort effects that appear to be linked to time spent in a building. These effects, known as sick building syndrome, can include symptoms ranging from respiratory issues to trouble concentrating. While the number of people reporting sick building symptoms has decreased substantially over the past decade due to improved HVAC technologies and the emergence of healthier building materials, chemical exposure and poor indoor air quality remain a concern for building owners, managers, and tenants.

Chemical Exposure and Health Impacts

The chemicals commonly found in building materials can lead to a wide variety of negative health outcomes, which include the following:

Volatile Organic Compounds

Volatile organic compounds (VOCs) are chemical substances that evaporate into the air under normal indoor conditions of temperature and pressure. Once evaporated, they can spread rapidly in the air and be inhaled by people and animals. VOCs are classified by their boiling point; a lower boiling point indicates a higher volatility and higher likelihood the compound will be emitted into the air.

In building materials, VOCs and SVOCs (*semi* volatile organic compounds) are of main concern. VOCs evaporate into the air quickly and dissipate, while SVOCs evaporate more slowly, releasing chemicals over a longer period. SVOCs are more likely to be present in the air long after a building has been constructed. Common sources of VOCs include paints, solvents, cleansers,

and furnishings. Common sources of SVOCs include coatings and additives to flooring, furniture, and other finishes.

Although there are some state and federal regulations limiting VOC content and emissions in products, indoor air pollution from VOCs can still be an issue in older buildings or those with weak HVAC systems.

- **Asthma.** Research has found connections between chemicals used in building products and asthma, especially in children. Asthma rates have been growing steadily since 1980, and today about 25 million people in the United States, or about one in 13, suffer from the illness. The burden of asthma falls disproportionately on people of color, with Black children nearly three times as likely to have asthma compared to white children. Studies have shown that systemic racism and social determinants of health, like socioeconomic status, housing, education level, and zip code, are partially to blame for the disparity. Examples of asthmagens in building products include paints with epoxy resins and polyurethane in thermal insulation, flooring, fillings, binders, sealants, and varnishes.

- **Cancer.** Most cancer-causing chemicals are found in applied surface treatments, not the core materials themselves. PFAS (as discussed on pages 15–16) and other related compounds have been shown to cause cancer in humans

and wildlife. Other carcinogens include asbestos and crystalline silica, which can lead to illness when they are inhaled. Construction workers, painters, and demolition workers tend to be highly exposed to asbestos and silica, although workplace safety practices have been successful in reducing allowable exposure thresholds.

- **Cognitive issues.** Research by Harvard's Chan School of Public Health found that cognitive performance scores were significantly lower in workplaces with low ventilation and high concentrations of VOCs. Lowering VOC concentrations alone by 90 percent (from a typical building concentration) resulted in a 61 percent average increase in cognitive function scores. Lead is a prime example of a substance that can cause both short-term and permanent neurological and behavioral changes, especially in children.

- **Endocrine disruption.** Numerous chemicals used in building materials disrupt the endocrine system, which can lead to a variety of diseases and disorders, including fertility issues, adverse pregnancy outcomes, neurobehavioral disorders, and other health concerns that are connected to hormone regulation. Well-known endocrine disruptors include paints and coatings made from bisphenol A (BPA) and plasticizers that are added to polyvinyl chloride (PVC) to make it soft and malleable.

Chemical Regulation in the United States and Europe

The EPA maintains an inventory of more than 86,000 unique chemical substances under the Toxic Substances Control Act. However, very few of these chemicals have been evaluated for their potential to cause harm to human health and the environment, and only a handful have been banned from use. While regulatory scrutiny of chemicals has grown in the United States since 2016, the system still requires a high level of evidence that a substance causes harm before restrictions can be implemented.

In comparison, the European Union has REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals) laws that require manufacturers to prove that a product is safe before it can be manufactured and installed at scale. Since the burden to prove safety is placed on the manufacturer, significantly fewer potentially toxic chemicals are used in everyday products, including building materials.

"Regrettable Substitutions" and the Precautionary Principle

In the world of chemicals, "regrettable substitutions" occur when a known hazardous chemical is replaced by other substances that lack safety information and may be just as (or more) harmful than the original. This is one of the challenges with chemical regulation, especially in the United States; new chemical formulations are created frequently without sufficient evidence proving they are safe for consumers.

To avoid regrettable substitutions, some industry leaders, especially architects, are applying the precautionary principle, which assumes no new substance is safe until research is made available to ensure it is.

In practice, this means minimizing materials made with new, untested chemicals. Polystyrene insulation is an example of a material that is commonly found in buildings and often incorporates flame-retardant chemicals that are not well studied. Existing research about certain types of flame retardants indicates that they are persistent in the environment and human bodies and are linked to health and cognitive issues.

Becoming familiar with chemicals of concern and where they are likely to show up in building products is another way to make more informed choices.

Chemicals of Concern

Certain classes of chemicals, including plastics, heavy metals, and additives, are particularly harmful to human health and the environment. The identification of these compounds has been helpful for manufacturers, building owners, developers, and architects who wish to understand which ingredients should be minimized or avoided.

Chemical avoidance lists, also known as precautionary lists or red lists, have emerged as a valuable tool for teams looking to reduce the worst-in-class substances known to cause harm to humans, wildlife, and the environment. Common chemical avoidance lists include the following:

> “Innocent until proven guilty may be the right starting point for criminal justice, but it is disastrous chemical policy. We need to recognize regrettable substitution for what it is: repeated substitution of toxic chemicals with equally toxic chemicals in a dangerous experiment to which none of us knowingly signed on.”
>
> —JOSEPH ALLEN, Associate Professor and Director of Harvard Healthy Buildings Program, from this article

- Living Building Challenge Red List. First created in 2006 by the International Living Future Institute (ILFI), the LBC Red List is one of the most well-known avoidance lists in the building industry. It contains thousands of chemicals across 19 categories. The list is reviewed and updated every year to reflect changes in manufacturing processes and chemical regulations. ILFI also updates a Watch List, which includes chemicals that have the potential to cause harm and might be included on the Red List in the future.

- Perkins&Will Precautionary List. Compiled by architecture and planning firm Perkins&Will as a resource for industry professionals to analyze the negative impacts of substances found in building products and seek safer alternatives. The online tool is free and allows users to search and filter substances by project area, products, health hazards, and more.

- Cradle to Cradle Restricted Substances List. Contains a core list of banned substances for all materials and products, plus additional substances for specific product categories. The list defines a maximum allowable concentration of each restricted substance in order for products to qualify for Cradle to Cradle certification. The list is updated periodically to match international chemical regulations, particularly European standards like REACH.

Completely avoiding all harmful substances is extremely challenging and may not be feasible for most developments. In some product categories, manufacturers have not yet produced healthier alternatives, so it can be difficult for teams to comply without incorporating substitutions. Fortunately, the market has come a long way in the last decade and suppliers continue to evolve their products away from harmful substances.

While there is variation between red lists managed by different entities, many include known toxic compounds like those listed in the table on the next page.

Harmful Chemicals Commonly Found in Building Materials

Category	Chemical name or group	Health effects	Where is it found?
Plastics	PVC—polyvinyl chloride	Cancer, endocrine disruption, and damage to liver, central nervous, respiratory, and reproductive systems.	Numerous products including pipes, roofing, electrical cables, window frames and sills, siding, fascia, flooring (hard and resilient), ceiling tiles, interior wall and window coverings, wallpaper, and upholstery.
	BPA—bisphenoids and phthalates (SVOCs)	Cancer and hormone disruption. They have been found to negatively affect children's development and reproductive health; exposure is related to asthma, allergies, cognitive problems, obesity, type 2 diabetes, heart disease, decreased fertility, and prostate cancer.	Commonly added to plastics to make them stronger, more flexible, and last longer. Vinyl flooring, flexible PVC piping, shower curtains, glues, caulks, and epoxy adhesives, some paints and coatings.
	PFAS—per- and polyfluoroalkyl substances (SVOCs)	Cancer, elevated cholesterol and diabetes, decreased fertility, and thyroid problems. See callout box.	Commonly added to other products as a stain or water repellant, including roofing, glass, paint, caulks and adhesives, carpet, fabric coatings, plumbing fixtures, thread seal tape, electrical wiring, and composite wood panels.
Heavy metals	Lead	Cancer, damage to brain and nervous systems that causes behavior problems, delayed puberty, decreases in cognitive performance, and cardiovascular effects, fertility problems, and more. It is especially dangerous in the womb and early childhood.	Although banned in many products, it is still found in piping, roofing, and contaminated dust.
	Mercury	Cancer, disruption to cognitive development in children, and damage to nervous, cardiovascular, digestive and immune systems, kidneys, and eyes.	Concrete and fly ash, gypsum board, acoustic ceiling tiles, adhesives, fluorescent lamps, and carpet backing.
	Hexavalent chromium	Cancer, skin irritation, and damage to kidneys and intestine when inhaled.	Added to products to create a chrome-like metal finish, including stainless steel, ductwork, and plumbing fixtures.
Additives	Halogen flame retardants (SVOCs)	Cancer, lower IQ, hormone disruption, decreased fertility, and cancer.	Building insulation, furniture, textiles, rebounded carpet padding, fabric blinds, paints, wire and cable sheathing, and contaminated dust.
	Antimicrobials	Developmental, hormonal, nervous, immunological, respiratory, and reproductive problems. Linked to allergen sensitivity, asthma, and skin irritation.	Wall finishes, paints and coatings, countertops, flooring tiles, wood flooring, vinyl carpet backing, textiles, toilet seats, and roof membranes.
	Formaldehyde (VOC)	At low levels, formaldehyde exposure can cause adverse respiratory issues and skin irritation. At high levels, formaldehyde is linked with cancer.	Resins and binding agents in composite wood and paper-based products. It is also found in resins used to make laminate countertops, glues, and fabrics.

Note: Information in chart provided by SERA Architects.

Health-Focused Product Labels and Certifications

Name	Description
Health Product Declaration	An HPD reports on a product's contents and its potential to cause harm to human health. Product ingredients are compared against scientific, toxicological, and epidemiological research to demonstrate potential adverse health effects. HPDs are considered complementary to EPDs and LCAs and are required for some building-level sustainability certifications. HPDs are a disclosure tool and do not label products as healthy or unhealthy.
Declare	A Declare label provides ingredient transparency in alignment with ILFI's Living Building Challenge (LBC). With a Declare label, a product's ingredients are screened against the LBC Red List and the LBC Watch List and then the product is given one of three statuses based on its composition.
Living Product Challenge Certification	The Living Product Challenge is a product certification program created by ILFI and structured on seven petals: Place, Water, Energy, Health and Happiness, Materials, Equity, and Beauty. Like the Living Building Challenge, the Living Product Challenge aims to create a regenerative, circular materials economy without the use of harmful chemicals. Products can receive full certification, petal certification, or a lower-level "imperative" certification, which companies can build on to achieve higher levels of certification.
GREENGUARD	GREENGUARD and GREENGUARD Gold certifications are third-party indoor air quality certifications that set limits on total VOCs, particulates, and other harmful emissions. GREENGUARD Gold is considered one of the most robust IAQ standards.
Cradle to Cradle Certification	Cradle to Cradle (C2C) is a rigorous certification program that measures a product's environmental and social sustainability across five categories: material health, material reutilization, renewable energy and carbon management, water stewardship, and social fairness. C2C also has a separate Material Health Certification to recognize performance of a product in the material health category only. While the certification process can be time-consuming, real estate leaders recognize the value of a C2C label and are often willing to pay more for certified products.

How Is Material Health Measured and Reported?

As research demonstrates the link between harmful chemicals and negative health outcomes, real estate stakeholders are increasingly calling manufacturers and suppliers to report on ingredients in building products. The focus on transparency and disclosure has led to a rise in labels that list a product's chemical makeup and potential to cause harm to human health. Several of the most popular health-oriented and multi-attribute product labels are outlined in the table.

Healthy Building Network (HBN)

While not a product label, another resource for understanding material health data is the Healthy Building Network, a nonprofit that conducts scientific research and provides education and solutions that increase transparency in the building products industry, reduce human exposure to hazardous chemicals, and create market incentives for healthier innovations in manufacturing.

HBN's Product Guidance and Informed use a red-to-green ranking system to compare different types of products based on their hazardous content. Both are informed by HBN's comprehensive research into the hazards associated with building products that may impact building occupants as well as fenceline communities and workers throughout a product's life cycle.

Social Health and Equity

From manufacturing to disposal, each stage of a building material's life cycle affects people and communities. While some impacts are positive, like providing jobs and financial security, many impacts are negative, especially for people of color and low-income communities. In general, low-income individuals are more likely to live in subpar housing near manufacturing or disposal facilities or to work in construction and other trades that expose them to potentially harmful substances. Others are at risk because of forced labor or unethical working conditions. The burden of these outcomes is not evenly distributed and often perpetuates and exacerbates existing socioeconomic and racial inequities.

In the United States, decades of structural racism and discriminatory land use practices have created racial disparities in housing. Black people are twice as likely to live in substandard housing compared to white people, which can expose Black communities to an array of physical and health hazards, including contamination from lead or other toxins, gas leaks, and crumbling structures. Smaller multifamily units concentrate airborne toxins in small, confined spaces, thereby increasing exposure risk.

Many studies have shown the connection between poor housing quality and negative health outcomes, especially for Black and Hispanic families. Regardless of socioeconomic status or race, people with preexisting health conditions and those with weak immune systems, or immune systems that are still developing—like children—are at the highest risk of experiencing health issues related to indoor chemical exposure.

Historically disadvantaged communities are also disproportionately affected by outdoor air pollution. Decades of discriminatory zoning policies allowed industrial development in communities with people of color and those with low incomes. For example, St. Louis adopted a policy that—although it did not explicitly mention race—designated zones for future industrial development that were in or nearby neighborhoods with significant populations of Black residents. Even today, U.S. neighborhoods with higher populations of people of color or with lower incomes and homeownership rates are more likely to be rezoned for industrial uses.

The densest concentration of petrochemical plants in the United States is in an area known as "Cancer Alley," Louisiana, where the predominantly Black residents face a significantly elevated cancer risk. A number of these facilities produce various chemicals

> "Material selection is a social justice issue. People of color and those with low incomes are burdened with toxic material manufacturing and disposal sites in their neighborhoods. Opting for nontoxic products not only creates healthy buildings, but it results in positive ripple effects for communities around the world."
>
> GINA CIGANIK,
> Chief Executive Officer,
> Healthy Building Network

In the United States, people of color are 75 percent more likely to live near facilities that produce hazardous waste, and they are exposed to 38 percent more polluted air than their white counterparts.

that are later incorporated into common building materials, like polyvinyl chloride, adhesives, resins, and interior finishes.

Most material production processes include a complex web of supply chains and manufacturers, most of which are located thousands of miles from where a material will eventually be installed in a building. The offshoring of some material manufacturing processes means that many negative health and environmental impacts occur in developing nations, where labor and materials are less expensive than in the United States.

Complicated and often opaque supply chains also hide nefarious activities, including forced labor and modern slavery. The U.S. Department of Homeland Security defines forced labor as any situation where people are compelled to work involuntarily through the use of force, fraud, or coercion. It is estimated that nearly 28 million people around the globe suffer these circumstances.

How Is Social Health and Equity in Material Selection Identified?

Stakeholders in the built environment have started recognizing real estate's role in this issue and are implementing transparency tools that allow project teams to identify and avoid potentially harmful supply chains. For example:

- **Health Product Declarations**, product labels that report on ingredients and associated health information, are now incorporating information about manufacturers' social equity practices.
- The **International Future Institute Living Building Challenge** encourages projects to prefer locally sourced products and those with third-party verified certifications for fair labor practices.
- **Leadership in Energy and Environmental Design (LEED)** version 4.1 contains pilot credits for "Social Equity within the Supply Chain," which aim to create "more equitable, healthier environments for those affected by and involved in the production of materials in products used in a project."
- **Healthy Building Network's Informed** product guidance helps teams select products that mitigate environmental injustices by color-ranking preferred products green and yellow, and products to be avoided red and orange.

Other efforts include Grace Farms Foundation's Design for Freedom movement, which has convened industry leaders to address the issue of forced labor in the real estate industry.

Ecosystem Health

While analyzing the embodied carbon of a building material is an important way to understand its impact on the environment, carbon emissions alone do not tell a complete story. The extraction, manufacturing, and disposal of building materials also play a role in the depletion of natural resource stocks and the pollution of air, water, and soil. These processes can cause irreparable damage to plants and animals throughout the world. Since humans rely on healthy, functioning ecosystems for clean water, air, and soil, damage to habitats and biodiversity directly affects the health of people and communities.

Even natural resources that are considered renewable are sometimes depleted unsustainably to meet demand. A range of factors can contribute to invasive resource extraction, including insufficient regulatory oversight and economic situations in which workers have few options for earning income other than to engage in unethical practices. For example, about half of all tropical deforestation is illegal, due to growing demand for the timber itself as well as the land, which is often converted to agricultural uses after the timber is harvested.

Habitat and biodiversity loss occur when resources are extracted faster than ecosystems can regenerate. The rise of global industrialization has negatively affected biodiversity, with global wildlife populations 69 percent lower than they were in 1970. With the construction sector accounting for around 40 percent of global resource demand every year, the industry is well positioned to reduce negative impacts at a large scale.

After materials are extracted from natural sources, they are assembled, refined, or manufactured in facilities. Most of the time, these processes result in substances being released into the air, nearby waterways, or the soil. Some of the most detrimental impacts occur because pollutants are released into waterways, harming aquatic species and human and animal habitats downstream.

Among rivers and streams in the United States that have been assessed for their health, roughly half are too polluted to support fishing, swimming, heathy aquatic habitats, or use as drinking water. The pollution mainly comes from the chemical and mining industries, which produce materials and feedstocks that later become common building materials.

Climate Change and Materials

In general, building materials are not designed to withstand extreme conditions, including extended exposure to water, heat, or fire. Yet, as climate change results in more frequent and severe weather events, materials will increasingly be affected by these and other stressors. Research has shown that chemical reactions catalyzed by elevated ambient temperatures can cause materials that are inert under normal circumstances, such as vinyl flooring, to off-gas more quickly and release new, potentially harmful compounds. Choosing bio-based over synthetic materials, especially for interior spaces, helps to avoid the possibility of increased toxicity when flooding, extreme heat, or fire occurs.

Mass Timber

Mass timber is gaining popularity as an alternative to traditional concrete and steel construction. According to WoodWorks, a nonprofit organization that supports the mass timber industry, nearly 2,000 multifamily, commercial, or institutional mass timber projects were in progress or built in the United States as of June 2023.

Mass timber products are manufactured by bonding lumber pieces together with glue, dowels, nails, or other materials to create extremely strong and fire-resistant panels. The most well-known mass timber product is cross-laminated timber, or CLT.

Building with mass timber provides a host of benefits to stakeholders across the real estate value chain. When exposed in interior spaces, timber provides significant aesthetic and health value through biophilia, or the human tendency to seek connections with nature. In addition, mass timber can shorten construction timelines and reduce labor costs because the panels are lightweight and prefabricated before they reach the job site.

Mass timber can also be an environmentally-friendly choice when compared to traditional construction materials. Trees sequester carbon while they are growing and will continue to store carbon after they are harvested and turned into mass timber. The manufacturing process is also significantly less energy- and water-intensive compared to concrete and steel production. For these reasons, many in the industry believe that scaling up mass timber construction will be integral to real estate's efforts to decarbonize.

When opting for mass timber, development teams should prefer lumber sourced from sustainably managed forests, ideally those with third-party certifications from entities such as the Forest Stewardship Council (FSC), the Sustainable Forestry Initiative (SFI), and the American Tree Farm System (ATFS). While each certification program differs in its requirements, they all support sustainable harvesting practices and the long-term health of forest ecosystems.

BENJAMIN BENSCHNEIDER

Exposed mass timber adds warmth to a space.

Circularity

In the last 50 years, global material consumption has quadrupled, outpacing population growth. If current trends continue, global consumption will double by 2060. Intentional materials management will be necessary to ensure the sustainability of future natural resource stocks and the economy.

In contrast to a linear economy that extracts natural resources and then throws them away as waste, a circular economy keeps products and materials in circulation indefinitely. The concept of circularity proposes that economic activity should not rely on the consumption of finite resources and that eliminating waste and pollution will be beneficial for business, people, and the environment.

According to the U.S. Environmental Protection Agency, construction and demolition is one of the largest sources of waste in the United States, generating more than twice the amount of municipal solid waste every year. While sometimes overlooked, tenant renovations and fit-outs are a key contributor to construction and demolition waste. On average, office interiors are renovated every 10 years, with retail and hospitality projects updated even more frequently. Over the life of a building, interior renovations might occur anywhere from five to 20 times, producing a high volume of waste and new material demand.

In the construction industry, circularity is motivating a shift toward the thoughtful reuse of building materials and products to save costs and reduce negative environmental impacts.

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The development of Holbein Gardens followed circular economy principles by preserving the original structure, reusing materials, and diverting 99 percent of site waste from the landfill.

Although advances have been made to increase the amount of recycled content in building products, waste creation outpaces recycling efforts. In addition, recycled content can bring toxic substances from the original product into a new material. For example, research by the Healthy Building Network found that a range of vinyl floors had high levels of toxic lead and cadmium from recycled content.

After demolition, most materials are "downcycled," meaning they are ground up, melted, burned, or otherwise transformed into another material or product. Although downcycling is an important method for

Deconstruction and material reuse is one of the best ways to achieve embodied-carbon reductions and avoid potentially harmful chemicals, since the process conserves natural resources and avoids emissions from new material production, transportation, and installation.

JOSH ROMBERG/LOVETT DECONSTRUCTION

Portland was the first city in the nation to pass a deconstruction ordinance, which requires homes built before 1941 to be deconstructed to salvage materials for reuse.

extending a material's useful life, many in the industry believe that the focus should be on reusing, rather than recycling materials.

Finding ways to salvage and reuse materials that would normally go to the landfill is a growing trend in the industry, with many leaders building material reuse into the design of a building—a concept known as designing for disassembly. These methods can help support a circular economy, drive down carbon emissions, and avoid chemicals from new material production, transportation, and installation.

Deconstruction and Designing for Disassembly

Instead of demolishing structures on a given site—which creates significant waste—teams can opt to deconstruct buildings and salvage materials that may be reused. Capturing and repurposing materials that would otherwise be downcycled or go to the landfill saves carbon and supports a circular economy.

The U.S. EPA, the AIA, and other organizations are promoting a concept called "designing for deconstruction," which encourages project teams to consider how a project's materials will be reused after the building has reached the end of its useful life. Instead of traditional demolition, where materials may be destroyed and contaminated, deconstruction (also known as disassembly) allows the careful extraction of materials that can be reused for other purposes.

Since deconstruction requires manual labor to extract materials, it can take longer and result in higher upfront costs compared to traditional demolition. These costs can often be recouped by reusing or reselling the salvaged materials. Tax breaks may also be available to owners if reclaimed materials are donated to charitable organizations.

Several cities and states are enacting policies to incentivize or mandate deconstruction. For example, the city of Seattle, Washington, offers expedited permits for residential deconstruction, allowing owners to begin deconstruction before receiving a new building permit for the site. In Portland, Oregon, the city requires full deconstruction, versus mechanical demolition, for houses and duplexes that were built in 1940 or earlier or designated historic regardless of age. This policy applies to about 33 percent of single-family demolitions and is estimated to divert 8 million pounds (4,000 tons) of materials for reuse annually.

> "Circular economy principles are about preserving the value of assets by embedding zero-waste thinking early in the life cycle and designing with reuse or repurposing in mind. They redefine the concept of waste, recognizing the value in the materials. Reducing the carbon emissions of planned new buildings can significantly help the transition to net zero."
>
> CYNTHIA CURTIS,
> SVP and Corporate Sustainability Officer—Americas, JLL, quoted in this article

Action Steps for Integrating Better Building Materials

Action Steps for Integrating Better Building Materials

Making the transition to healthy and sustainable materials does not have to be complicated. Incremental changes throughout the development process can have a significant impact on the overall health and sustainability of the final project.

Integrating Healthy and Sustainable Building Materials throughout the Project Life Cycle

Project kick-off and visioning	Pre-design	Schematic design	Design development	Construction documents	Bidding/pricing	Construction administration	Operations and maintenance	End-of-life
Articulate big-picture ESG goals. Start early. Reuse and repurpose existing buildings instead of building new.	Define a materials strategy. Identify and engage knowledgeable partners and champions. Pursue green building certifications with a focus on materials.	Consider the structural system. Do not overlook mechanical, electrical, and plumbing (MEP) systems. Design for adaptability, reuse, and disassembly. Use whole-building modeling tools (such as whole-building life cycle assessment) to inform design. Engage with manufacturers and suppliers. Choose performance-based specifications for concrete mixes.	Design for efficiency and use fewer materials. Limit or “optimize” high-impact materials. Select reclaimed, salvaged, or recycled materials. Specify bio-based or low-carbon/nontoxic materials. Request product certifications (such as EPDs and HPDs) and transparency labels.	Streamline material evaluation and reporting with material libraries and project management software.	Incorporate embodied carbon and health requirements into the competitive bidding process.	Watch for substitutions. Minimize construction waste. Reduce construction site emissions. Work with local partners to funnel construction and demolition waste out of landfills. Document the as-built embodied carbon and health of the building.	Establish health and sustainability targets for tenant fit-outs and MEP equipment replacements.	Opt for deconstruction, rather than demolition, to preserve materials for reuse.

The following section offers strategies and resources for project teams wishing to make more informed material choices. These approaches are applicable to new construction projects as well as building upgrades, retrofits, and refurbishments. In nearly all cases, renovating an existing building is preferred to building new, as it avoids the upfront carbon and chemicals that would be released for new construction.

Architecture, engineering, and construction (AEC) teams are essential partners in executing a sustainable materials strategy, and many are experts in material health and embodied carbon. Developers should leverage the expertise of these professionals to implement the strategies described in this section. AEC teams also can use these methods to educate clients around best practices in material evaluation, selection, installation, and operations.

Equipped with a basic knowledge of material health and a commitment to reducing carbon and chemicals of concern across their buildings, project teams can make substantive change within their developments and the industry at large.

Before a Project

The corporate policies of investors and developers are essential to reducing embodied carbon and advancing material health. Company-wide sustainability commitments, green building policies and initiatives, and sustainable procurement policies send positive market signals that incentivize suppliers, manufacturers, and contractors to optimize their products and services.

Opportunities to reduce embodied carbon and integrate healthy materials become more expensive and more challenging as projects progress. Prioritizing carbon early on (by leveraging the firm's sustainability commitments) can reduce cost and increase the range of strategies available.

Building the foundation of a sustainability program or expanding an existing one to incorporate materials should begin with understanding baseline data and then setting goals to motivate action across the company. For detail on creating a firmwide sustainability program, see ULI's *Blueprint for Green Real Estate* report.

Project Kickoff and Visioning

Early phases represent the greatest opportunity for reducing embodied carbon and incorporating healthy materials. At the visioning stage, the project team should ensure all stakeholders have a shared understanding of the project goals, which will guide decision-making throughout design and construction. This phase typically involves defining the project scope, identifying requirements, and establishing the overall budget and timeline.

Key actions in this phase include the following:

- **Articulate big-picture ESG goals.** Define how material selection and embodied-carbon contribute to your company's ESG strategy. Consider how the project will align with stated ESG goals and reporting commitments.
- **Start early.** Prioritize materials at the outset, giving the project team more time to identify, evaluate, and source better products—saving time and money in the long run.
- **Prioritize adaptive use and retrofits of existing buildings, instead of building new**. Look for ways to reuse existing buildings to avoid the embodied carbon and chemical production related to new construction.

Pre-design

During pre-design, the team assesses project requirements and feasibility to determine whether to proceed with the project. This phase includes setting the project requirements, analyzing the site's characteristics, and conducting a financial feasibility study. The team will also work to develop a project schedule and timeline.

Key action items in this phase follow:

- **Define a materials strategy.** Determine the team's approach to material evaluation and be explicit about priorities and benchmarks, like embodied-carbon reduction goals or chemicals to avoid.
- **Identify and engage knowledgeable partners and champions.** Include requirements for reducing embodied carbon and improving material health in contract language to demonstrate project priorities and attract the right partners and champions. Depending on the project, it may be beneficial to bring the contractor and/or engineering team on early to streamline design and construction.
  - See Basis of Design/Contract Language (created by Building Transparency).
- **Pursue green building certifications with a focus on materials.** Consider green building certifications such as WELL, Living Building Challenge, RESET, and LEED that incorporate requirements for embodied carbon and material health.

Schematic Design

The SD phase is characterized by the creation of the project's overall design concept and may include exploration of a range of ideas to determine the most appropriate solution. This phase is important for reducing embodied carbon and integrating healthy materials because this is when design teams will begin to identify structural components as well as HVAC and MEP systems. Because this phase sets the foundation for the remainder of the design process, it can be valuable to revisit the materials strategy established in earlier phases.

Key action items in this phase include the following:

- **Consider the structural system.** The structural system typically represents the largest share of a building's embodied carbon footprint. Consider alternative structural systems that reduce carbon intensity or pursue low-carbon materials (like mass timber and/or recycled materials). Modular construction can also help reduce waste and material use.
  - See WoodWorks for mass timber resources, case studies, and support.

- **Do not overlook MEP systems.** MEP systems are a growing area of concern for owners wishing to reduce embodied-carbon emissions. Selecting durable materials to avoid frequent equipment replacements, designing the building with Passive House strategies, and minimizing refrigerant leakage can reduce embodied carbon in MEP systems.

- **Design for adaptability, reuse, and disassembly.** Embrace flexibility in the design so the development can adapt to future uses as needs evolve. Designing for disassembly encourages project teams to consider how a building's materials will be salvaged and repurposed after the building has reached the end of its useful life, promoting a circular economy.

- **Use whole-building modeling tools to inform design.** Leverage tools like the Carbon Avoided Retrofit Estimator (CARE) Tool (for retrofits), Embodied Carbon in Construction Calculator (EC3), whole-building life cycle assessments (WBLCA), and the Healthy Building Network's Informed to model embodied carbon and chemical content in the final project. See "Tools and Resources" on page 75 for more information.

- **Engage with manufacturers and suppliers.** Build relationships with product manufacturers outside procurement to establish trust, ask questions, and request product transparency documentation. Alert suppliers that product declarations like EPDs and HPDs may be required for the bidding process. See resources from Building Transparency:
  - Example Specification Language
  - EPD Request Letter for Individual Company and for Project Team

- **Choose performance-based specifications for concrete mixes.** Performance-based specifications outline the preferred characteristics of a concrete mix for a specific application. In contrast to prescriptive-based specifications, which set requirements for components or proportions of the mixture, performance specifications give ready-mix suppliers the flexibility to create mixes that are tailored for specific uses. Prescriptive-based specifications are often overly conservative and can result in concrete mixes that have more cement than is necessary for the application. Developers should work with their architect and structural engineer to establish performance-based targets, as opposed to relying on prescriptive specifications for their concrete mixes. Even well-intended prescriptive specifications that require low-carbon concrete or new technologies can have unexpected effects that impede sustainability efforts. For example, low-carbon concrete may not be suitable for every application, and the supplier may end up compensating in other ways, like adding more cement.
  - See NRMCA Guide to Improving Specifications for Ready Mixed Concrete.

Embodied Carbon and Material Health: You Can Do Both!

Project teams—as well as tenants—want buildings that are both environmentally sustainable and healthy for people. However, sustainability and health can sometimes appear to be in conflict, and teams must choose between either reducing embodied carbon or minimizing chemicals of concern. While this may be the case for certain product types, new research has shown that selecting low-embodied-carbon products may also result in improvements to material health, and vice versa. This is in part because many synthetic materials with energy-intensive manufacturing or disposal processes also contain chemicals of concern.

A recent study by HBN and Perkins&Will indicated alignment between efforts to reduce embodied carbon and avoid chemicals of concern in two product categories that are ubiquitous across the industry: gypsum wallboard and flooring. For gypsum wallboard, teams can select natural gypsum and thinner, lighter boards that require less energy to produce and have fewer additives. For flooring, bio-based products are preferred because of their lower embodied carbon and fewer chemicals compared to traditional flooring. Bio-based products, as discussed earlier in this section, are also easier to reuse and recycle, minimizing end-of-life impacts.

As another example, the table below highlights how, among insulation products, high chemical content is associated with high embodied-carbon emissions.

Embodied Carbon and Health of Insulation Products

Insulation product type	Carbon emissions	Health ranking (according to Healthy Building Network)
Extruded polystyrene (XPS)	High	Red
Closed cell sprayfoam (HFC)	High	Red
Closed cell sprayfoam (HFO)	High	Red
Expanded polystyrene (EPS)	High	Red
Cork	Low	Green
Hempcrete	Low	Green
Strawbale	Low	Green

Design Development

In the design development phase, the architect will add more detailed information to the schematic design to create a more comprehensive concept. The design team will further refine floor plans, elevations, sections, and other design elements. This phase also includes continued conversations with structural and mechanical engineers, consultants, contractors, and other stakeholders to ensure the design meets the project requirements and budget.

As the architect begins to develop a more detailed specification for materials, systems, and equipment for the construction documents, the development team should ensure that selections meet established criteria for embodied carbon and material health. Outreach and engagement with product manufacturers and suppliers should continue in this phase.

Key action items in this phase follow:

- **Design for efficiency and use fewer materials.** Simplify the materials palette to reduce chemicals and save carbon and cost. In short, less is more.
- **Limit or "optimize" high-impact materials.** Understand which product categories are likely to be high in embodied carbon (concrete, steel, insulation) and chemical content (vinyl flooring, paints, and roofing) and select products and design strategies that avoid the worst impacts.
- **Specify reclaimed, salvaged, or recycled materials.** Procure salvaged materials to avoid carbon emissions from manufacturing and divert waste from landfills.
- **Specify bio-based materials and those with lower embodied carbon and chemical content.** Seek out bio-based or low-carbon/low-chemical traditional products (i.e., low-carbon concrete) to drive down emissions and potentially toxic chemicals.
  - See Architecture 2030 Materials Palette.
- **Request product certifications and transparency labels.** Request EPDs, HPDs, or other disclosure labels to understand product content and impacts on human health and the environment.

Bio-Based Materials

Low-carbon/carbon-sequestering materials

BAMBOO

HEMPCRETE

SHEEP'S WOOL

STRAW-BALE

Bio-based materials such as bamboo, hempcrete, sheep's wool, and straw-bale are low in embodied carbon and chemicals, making them a better choice for buildings, tenants, workers, and communities. *(Adapted from the Architecture 2030 Carbon-Smart Materials Palette.)*

Bidding/Pricing

During the bidding and pricing phase, the architect and project team work to finalize the project budget based on the design and specifications developed in previous phases. This often involves obtaining quotes or bids from contractors and suppliers to determine the project's actual cost. The architect, developer, and sometimes the owner work together to review the proposals and adjust the specifications as necessary to meet the budget. The architect may also work with the contractor to find ways to reduce costs while maintaining the project's integrity.

At the end of this phase, the project team will have a final budget and a clear understanding of the scope of work. The project can then move forward into the construction documents phase, where the final construction plans and specifications will be developed based on the approved design and budget.

- **Streamline material evaluation and reporting with material libraries and management software.** Take advantage of programs that allow comparisons between products based on established criteria. Material libraries include EC3 (embodied carbon), Origin, mindful MATERIALS, and Madaster.

The table on the following page provides more information about these and other programs.

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Material Libraries, Project Management Tools, and Material Evaluation Platforms

Name	Cost	Geography	Description
Embodied Carbon in Construction Calculator (EC3)	Free	Global	EC3 is an online tool and one of the most well-known carbon calculators in the industry. While it does not address material health, it is a trusted resource for carbon data and can be used at all stages of design, procurement, and reporting. The tool is powered by an extensive database of digital, third-party-verified EPDs, helping teams compare embodied-carbon levels across products. EC3 is intended to complement whole-building LCAs and visualize a project's potential and realized embodied emissions to set achievable reduction targets.
Healthy Building Network Informed	Free	Global	Informed is a free online tool that helps teams select healthier building products. It uses a color-based system to rank product types based on their chemical impacts over their life cycle. This approach gives project teams visual cues that make it easier to avoid the most hazardous products (red and orange) and select safer options (yellow and green). The system was created by the Healthy Building Network (HBN), a nonprofit that conducts scientific research and provides education and solutions that increase transparency in the building products industry, reduce human exposure to hazardous chemicals, and create market incentives for healthier innovations in manufacturing. Informed features a materials modeling tool that guides healthier product selection at all stages of design.
Madaster	Subscription fee	Select European countries	Madaster is an online registry for building materials that documents and reports on sustainability and circularity impacts within completed projects. For registered buildings, the platform shows where the materials are located within the structure, their environmental impacts, and any residual value they represent. This information creates a "material passport" for every product in the building to understand their embodied carbon and reuse potential.
mindful MATERIALS and the Common Materials Framework	Free	Global	mindful MATERIALS (mM) was founded in 2014 by architecture group HKS as an initiative to make information about materials more transparent and accessible to project teams. As the effort gained traction with leaders from across the industry, mM developed a digitized materials library based on the Common Materials Framework (CMF). The CMF aims to establish a common language for the industry based on consistent data points within the five "buckets" of sustainability, which are outlined by the AIA Materials Pledge: human health, climate health, ecosystem health, social health and equity, and circular economy. Within each of the five main categories are sub-buckets that provide measurable criteria for evaluating products. The mindful MATERIALS portal can be accessed for free online.
ORIGIN	Subscription fee	Global	This cloud-based materials data hub was established in 2008 by GIGA. GIGA is an international organization that combines the development of building standards with cloud technology. It is most well known for creating the RESET Standard. ORIGIN acts as centralized hub for verified product performance data and contains over 170,000 products from nearly 5,000 manufacturer brands. ORIGIN is connected to other GIGA-managed products including MATTER, a materials management software, and the RESET Standard, which now includes RESET Embodied, a method for accounting and visualizing of embodied carbon, circularity, and health of the materials in buildings. The RESET Embodied Standard is an advanced pilot stage.
Tangible	Subscription fee	Global	Tangible is a software solution that enables real estate professionals to identify, manage, and report on products that meet their carbon, environmental, and social goals. Tangible is built with developers and owners in mind, making the process of sourcing and reporting on products easier and more streamlined. The Tangible library features products that have already been vetted for sustainability to help teams save time when evaluating and selecting products. Although currently focused on carbon reduction, Tangible plans to expand into material health, including VOC and chemical content.

Making Concrete Green

Concrete has four main components: cement, aggregate, water, and air. Of these four components, cement, and its precursor material clinker, are associated with high embodied-carbon emissions. According to research by the Rocky Mountain Institute, the production of clinker alone is responsible for around 90 percent of emissions in the concrete manufacturing process.

One of the most straightforward ways to reduce the environmental impact of concrete is to use less cement. Researchers and cement manufacturers are discovering ways to reduce the amount of cement required for concrete while retaining the material's strength and integrity. The two most common ways of reducing cement include

- **Incorporating supplementary cementitious materials** (SCMs). SCMs, including fly ash, slag, silica fume, and others, are waste materials from various industrial and agricultural processes that are repurposed for concrete mixes. The use of these materials in concrete can partially decrease the amount of Portland cement needed for a mix, which, in turn, can reduce construction costs and carbon emissions. When SCMs come from non–fossil fuel–based sources, further reductions in carbon can be achieved. Some SCMs, especially fly ash, are pollutants and have come under scrutiny over the past few years because of their potential to cause harm to humans and the environment.

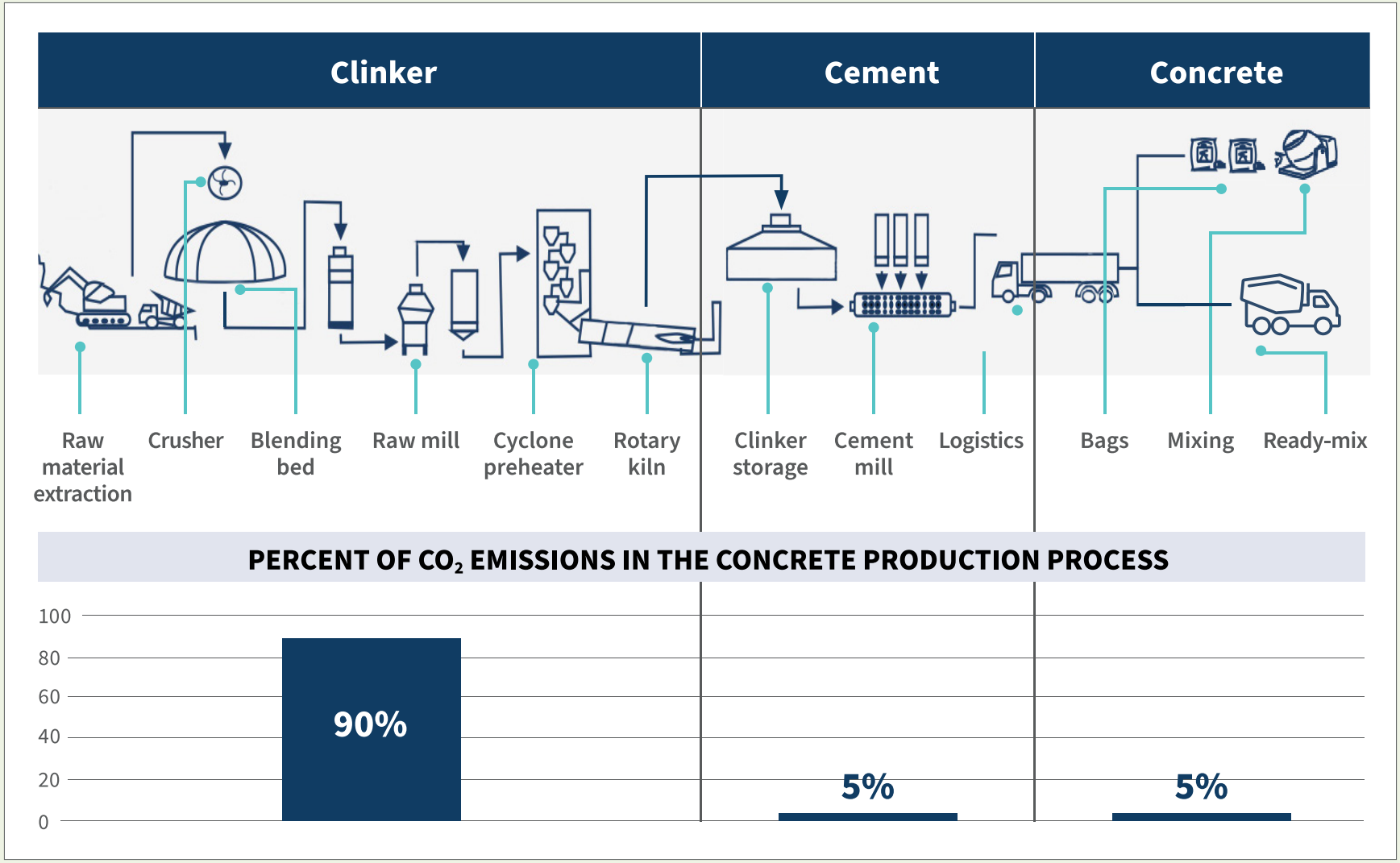
- **Incorporating admixtures.** Admixtures, including superplasticizers (water reducers) and hardening accelerators are substances that can be added to the concrete mix to modify its properties, such as workability, strength, and durability. The use of certain admixtures permits the greater use of SCMs, thereby reducing the amount of cement needed for the mix.

In addition, technological advances have led to the development of new products and manufacturing methods that minimize embodied-carbon emissions. Some of these alternative approaches and products include:

- **Carbon capture, utilization, and storage (CCUS) technologies.** These technologies remove carbon from the atmosphere or from a manufacturing process and store it underground, inject it into concrete, or use it to make new products. There are carbon capture technologies at the clinker production stage as well as later in the concrete production process. For example, CarbonCure takes recycled carbon dioxide from industrial processes and injects it into a concrete ready mix where it mineralizes and strengthens the mix.

- **Low-carbon clinker production.** These strategies modify the cement manufacturing process to minimize carbon emissions. For example, Sublime Systems is developing technology that leverages an electrochemical process to avoid the cement kiln, which is the most energy and fossil fuel–intensive part of the cement manufacturing process.

The future is promising for carbon reductions in concrete. Recently, the Global Cement and Concrete Association announced plans to fully decarbonize the concrete and cement industry by 2050.



Research suggests that the production of clinker (the precursor material to cement) is responsible for around 90 percent of emissions in the concrete manufacturing process. This graphic is published with permission from the Rocky Mountain Institute based on source information from McKinsey and Material Economics. To learn more about innovations in low-carbon concrete, see RMI's insight brief: *The 3Cs of Innovation in Low-Carbon Concrete: Clinker, Cement, and Concrete.*

Construction Documents

During CD, the design team creates the final set of plans, elevations, sections, and details of the project that will be used for construction. These plans will include information on the building's structural, mechanical, and electrical systems, as well as interior finishes, exterior cladding, and other important design elements. The specifications will outline the materials, products, and equipment required for the build.

The construction documents will be used to obtain bids from contractors and to establish the final construction cost of the project. It is crucial that the final plans are complete and accurate, as any errors or omissions can lead to delays and extra expenses during construction. Many of the action items from the previous stage should be continued in this phase.

Key action items in this phase include the following:

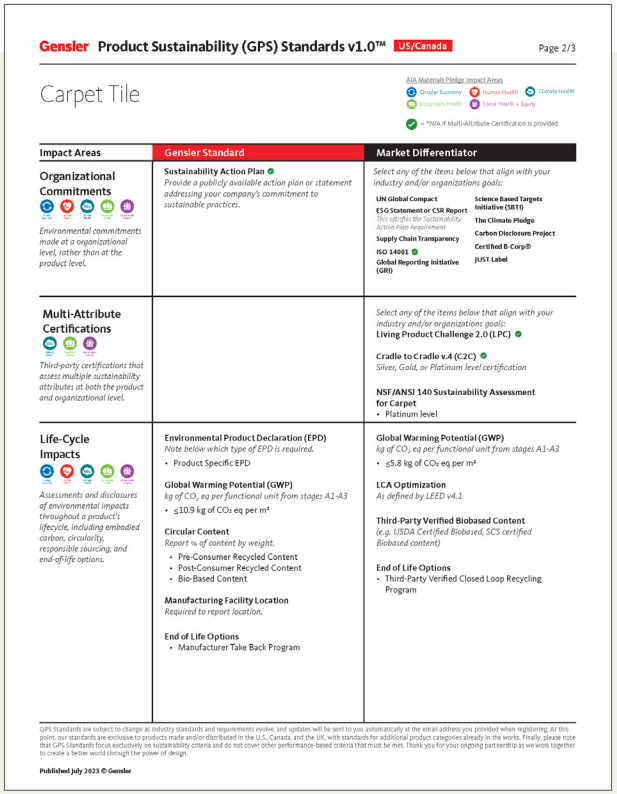
- **Incorporate embodied carbon and health requirements into the competitive bidding process.** Require that contractors share embodied carbon and/or material health data in their bids so the project team can evaluate material data alongside cost and other criteria.
- **Watch for substitutions.** Establish a policy for substitutions so that any new materials procured align with the project's sustainability and health goals.

Gensler Product Sustainability Standards

In August 2023, global architecture and design company Gensler released the Gensler Product Sustainability (GPS) Standards, which define minimum sustainability criteria for 12 of the most commonly used, high-impact product categories in its architecture and design projects. Gensler's goal is to provide clear and concise standards that can be easily communicated to clients and product manufacturers, ultimately accelerating the industry's progress toward better materials.

In the first version of the standards, Gensler selected 12 product categories that have a substantial sustainability impact and already have sustainability disclosures from manufacturers available in today's market. The 12 product categories include acoustic ceiling panels, tiles, and suspension grids; batt insulation; board insulation; carpet tile; decorative glass; glass demountable partitions; gypsum board; interior latex paint; nonstructural metal framing; resilient flooring and base; systems furniture workstations; and task chairs.

For Gensler to specify a product in one of the 12 categories, the product must meet all of the requirements within five impact areas: organizational commitments, multi-attribute certifications, life cycle impacts, indoor air impacts, and material health and transparency.



Gensler Product Sustainability (GPS) Standards v1.0™ US/Canada Page 2/3

Carpet Tile

AIA Materials Pledge Impact Areas: Circular Economy, Human Health, Climate Health, Ecosystem Health, Social Health + Equity

– *N/A if Multi-Attribute Certification is provided

Impact Areas	Gensler Standard	Market Differentiator
Organizational Commitments *Environmental commitments made at a organizational level, rather than at the product level.*	**Sustainability Action Plan** *Provide a publicly available action plan or statement addressing your company's commitment to sustainable practices.*	*Select any of the items below that align with your industry and/or organizations goals:* **UN Global Compact** **ESG Statement or CSR Report** *This satisfies the Sustainability Action Plan Requirement* **Supply Chain Transparency** **ISO 14001** **Global Reporting Initiative (GRI)** **Science Based Targets Initiative (SBTi)** **The Climate Pledge** **Carbon Disclosure Project** **Certified B-Corp®** **JUST Label**
Multi-Attribute Certifications *Third-party certifications that assess multiple sustainability attributes at both the product and organizational level.*		*Select any of the items below that align with your industry and/or organizations goals:* **Living Product Challenge 2.0 (LPC)** **Cradle to Cradle v.4 (C2C)** *Silver, Gold, or Platinum level certification* **NSF/ANSI 140 Sustainability Assessment for Carpet** • Platinum level
Life-Cycle Impacts *Assessments and disclosures of environmental impacts throughout a product's lifecycle, including embodied carbon, circularity, responsible sourcing, and end-of-life options.*	**Environmental Product Declaration (EPD)** *Note below which type of EPD is required.* • Product Specific EPD **Global Warming Potential (GWP)** *kg of CO_2 eq per functional unit from stages A1-A3* • ≤10.9 kg of CO_2 eq per m² **Circular Content** *Report % of content by weight.* • Pre-Consumer Recycled Content • Post-Consumer Recycled Content • Bio-Based Content **Manufacturing Facility Location** *Required to report location.* **End of Life Options** • Manufacturer Take Back Program	**Global Warming Potential (GWP)** *kg of CO_2 eq per functional unit from stages A1-A3* • ≤5.8 kg of CO_2 eq per m² **LCA Optimization** *As defined by LEED v4.1* **Third-Party Verified Biobased Content** *(e.g. USDA Certified Biobased, SCS certified Biobased content)* **End of Life Options** • Third-Party Verified Closed Loop Recycling Program

GPS Standards are subject to change as industry standards and requirements evolve, and updates will be sent to you automatically at the email address you provided when registering. At this point, our standards are exclusive to products made and/or distributed in the U.S., Canada, and the UK, with standards for additional product categories already in the works. Finally, please note that GPS Standards focus exclusively on sustainability criteria and do not cover other performance-based criteria that must be met. Thank you for your ongoing partnership as we work together to create a better world through the power of design.

Published July 2023 © Gensler

Example of Gensler's Product Standards for Carpet Tile. *(Gensler)*

The GPS Standards are structured around two levels of performance: Gensler Standard and Market Differentiator. Gensler Standard criteria define their baseline requirements, while Market Differentiator criteria represent current best-in-class sustainability attributes and reflect Gensler's aspirational goals.

For example, the chart (above) outlines the GPS Standards for carpet tile in the first three impact areas: organizational commitments, multi-attribute certifications, and life cycle impacts.

Construction Administration

As construction gets underway, the architect and developer will visit the construction site on a regular basis to ensure that the work is being completed in accordance with the construction documents. The architect will review submittals from the contractor, which are documents that demonstrate how the contractor plans to execute certain aspects of the construction, such as materials and methods of installation. Product substitutions can also occur in this stage, so sticking with the policy developed in the previous section will be essential in this phase.

Key action items in this phase include the following:

- **Reduce construction waste.** Control for construction mistakes, order the right amount of material, store materials properly, and reuse products when possible to minimize waste produced during the construction phase.
- **Reduce construction site emissions.** Add specification requirements for electric construction equipment, electric trailer equipment, and reduced idling times to drive down carbon emissions at the job site.
- **Work with partners to funnel construction and demolition waste out of landfills.** Seek out material salvage, reuse, and recycling organizations to minimize the amount of waste going to going to landfills and save embodied carbon.

Building a Circular Economy with Shingles and Mushrooms

In 2022, Lendlease accomplished a unique feat for the real estate industry: using mushrooms to divert thousands of asphalt roofing shingles from landfills. Mycoremediation, a method that uses the enzymes in mushrooms to break down pollutants, shows growing promise as a nature-based solution to the construction industry's massive waste problem.

The shingles were from a re-roofing project of 214 homes at Campbell Crossing, the residential community of the Fort Campbell Army base that serves soldiers and their families. Lendlease partnered with Rubicon Technologies, Mycocycle, and Rockwood Sustainable Solutions to combine the shingles with different types of fungi and natural material to remove toxins and create a recyclable product.

Asphalt shingles are a significant contributor to construction and demolition waste and can take upward of 300 years to fully break down. In addition, shingles are frequently coated with various toxic chemicals that make them difficult to recycle. It is estimated that less than 10 percent of shingles are recycled every year.

As a net zero–oriented company, Lendlease was motivated to explore mycoremediation and nontraditional recycling methods to decarbonize their waste stream. The process creates a new product that can be reused on site for landscaping as clean fill or recycled, contributing to a circular economy. Lendlease and its partners believe this pilot project has the potential to be a template for the future to reduce waste and carbon emissions, and ultimately make building material supply chains more sustainable.

Move-in and Occupancy

As construction is completed, the project team should track and report final embodied carbon and material health data for the project. Embodied carbon can be reported through a whole-building life cycle assessment, and health data can be confirmed through product certifications such as HPDs.

During tenant improvement (TI), the developer should encourage tenants to select healthy, low-embodied-carbon materials for all fit-outs. This may involve educating tenants on the importance of healthy and sustainable building materials and how the integration of better products will help achieve ESG goals across the value chain. Hudson Pacific Properties' Low Embodied Carbon Tenant Fit-Out Guide provides recommendations for reducing embodied carbon in typical fit-out materials.

Key action items in this phase include the following:

- **Document the as-built embodied carbon and health of the building.** Track and document realized carbon and health data as the project is built to understand how well the finished development achieves its goals for materials.
- **Ensure healthy and sustainable tenant fit-outs.** Encourage the selection of healthy, low-embodied-carbon materials for tenant fit-outs and equipment replacements to limit embodied carbon and chemicals as occupants move in and update their space.
- **Perform regular maintenance to MEP systems.** Regular maintenance to MEP systems is important for reducing frequent equipment replacements and avoiding refrigerant leaks. Conduct leak checks at regular intervals and keep refrigerant racks and the mechanical room clean to make it easier to spot leaks when they do occur.

End of Life

When a building has reached the end of its useful life, efforts should be made to preserve the building before resorting to demolition. If the building needs to be taken down, opting for deconstruction, rather than demolition, allows valuable materials to be salvaged and repurposed, as opposed to going to a landfill.

Key action items in this phase include the following:

- **Opt for deconstruction.** Deconstruction involves carefully taking a part a building piece-by-piece, with a goal of salvaging materials that can be reused again in another building.

> "We build and operate homes for our residents—places they live and work. This means the composition of materials we select influences not only the look of a home but also air quality, health, and our carbon footprint. We want to look at material health comprehensively, meaning not just chemical toxicity, but also climate health, ecosystem health, circularity, and social justice and equity."
>
> —KATIE ROTHENBERG,
> Vice President, ESG, AvalonBay

Project Examples

Westlake 66

Hangzhou, China

Developer: Hang Lung Properties

Designer: Kohn Pedersen Fox (KPF) Associates

Size: 2.1 million sq ft (194,100 sq m)

Project type: New construction

Status: Under construction; opening in phases starting in 2024

As the first commercial development to use low-carbon concrete bricks in Hong Kong and mainland China, Westlake 66 is taking an important step forward for sustainability. The 2.1 million-square-foot (194,100 sq m) mixed-use development—including five office towers, a hotel, and a retail podium—is located in Hangzhou, China, a rapidly growing tech hub, home to online commerce company Alibaba and other tech players.

HANG LUNG PROPERTIES

Westlake 66 incorporates recycled concrete aggregate and carbon-storage concrete bricks, which help reduce the development's embodied-carbon emissions.

Hong Kong–based developer Hang Lung Properties teamed up with CLEANCO2, a carbon capture, use, and storage company, to integrate low-carbon recycled concrete aggregate and carbon-storage concrete bricks throughout the project. Reducing embodied carbon is one of Hang Lung's 25 sustainability targets to accomplish before the end of 2025, a concept the company has named "25 × 25." Hang Lung also has a 2030 target to reduce Scope 3 emissions (including embodied carbon).

In 2022, Hang Lung's Scope 3 emissions were about 72 percent of its overall emissions, with embodied-carbon emissions from building materials its largest source of emissions. Incorporating low-carbon concrete bricks in Westlake 66 advances progress toward Hang Lung's 25 × 25 goals while inspiring change and innovation in the industry.

The low-carbon concrete bricks will be used on the secondary partition walls of Westlake 66's basement, with the total number of bricks covering a wall area of around 183,000 square feet (17,000 sq m). The bricks will use cement, fly ash, and other solid waste together with CLEANCO2's carbon dioxide mineralization process. The embodied-carbon emissions of the low-carbon concrete bricks are expected to be 87.5 percent lower than those of conventional shale bricks.

Although the project's overall embodied-carbon emissions will not be dramatically reduced by the CLEANCO2 bricks, the

HANG LUNG PROPERTIES

Hang Lung Properties is working with its tenants, including LVMH Group, to reduce the embodied carbon of fit-outs, which can be a significant source of embodied carbon over a development's lifetime.

decision to incorporate technology is important, says John Haffner, deputy director–sustainability, and Viki Du, senior manager–sustainability, for Hang Lung Properties. "The significance of this effort is not so much in the volume of carbon reduced, but in its message to the industry for much-needed innovation in this space." The hope is that the success of Westlake 66 will motivate other projects to incorporate low-carbon bricks and support the widespread use of the technology.

This is a meaningful goal in China, which is the world's largest producer and consumer of concrete, according to a 2022 report by the Rocky Mountain Institute. "Decarbonizing real estate, particularly from embodied carbon, is a marathon, not a sprint," says Adriel Chan, Hung Lung Properties vice chair, and chair of its Sustainability Steering Committee. The CLEANCO2 bricks are slightly more expensive than regular concrete bricks, but the upfront cost is worth it, explain Haffner and Du. "We see the investment as supporting innovation and our carbon reduction targets."

In addition to reducing embodied carbon in structural materials, Hang Lung is starting to address the embodied carbon in tenant fit-outs, which can contribute a significant portion of a building's overall emissions during its lifetime. Hang Lung is working with GIGA, the organization that manages the RESET Standard, and tenant LVMH Group (parent company of Louis Vuitton and other leading luxury brands), to conduct a carbon footprint assessment for LVMH's new store fit-outs in Hang Lung's properties. Hang Lung plans to leverage the analysis to identify and communicate opportunities for carbon reduction in tenant spaces.

Westlake 66 represents an exciting step for Hang Lung Properties, CLEANCO2, and Hangzhou real estate. The announcement of the partnership between Hang Lung Properties and CLEANCO2 has resulted in positive press and attention from the public, tenants, and stakeholders. "Sustainability progress is intrinsically tied to the continuity of our core business, as our tenants, especially our luxury tenants, attach more importance to it," say Haffner and Du.

1550 on the Green

Houston, Texas

Developer: Skanska USA Commercial Development

Designer: Bjarke Ingels Group (BIG)

Size: 387,000 sq ft (35,953 sq m)

Project type: New construction

Status: Under construction; early 2024 expected delivery

SKANSKA USA COMMERCIAL DEVELOPMENT

Skanska leveraged the EC3 tool to select products and materials that were low in embodied carbon.

1550 on the Green, a 28-story, 387,000-square-foot office tower developed by Skanska USA Commercial Development, is on track to become one of the most sustainable buildings in Houston. In addition to targeting WELL and LEED Platinum certifications, the development aims to reduce embodied carbon by 60 percent compared to baseline.

Located adjacent to Discovery Green, a 12-acre park in Houston's central business district, 1550 on the Green represents the first phase of a three-block, mixed-use development owned by Skanska. 1550 on the Green features more than 7,000 square feet of ground-floor retail; three outdoor roof terraces on levels 12, 20, and 28; and panoramic views of Discovery Green on every floor.

To accomplish the project's lofty embodied-carbon goal, 1550 on the Green is leveraging the Embodied Carbon in Construction Calculator (EC3) to evaluate and reduce embodied carbon in the materials selected for the project. EC3 is a free, online tool and database of EPDs, which document the environmental impact and global warming potential of building materials.

Skanska and other industry partners co-created EC3 in 2019. Since then, the database has grown exponentially and as of 2023 included more than 100,000 building material EPDs. Addressing embodied carbon has become a key priority across Skanska's portfolio, and its U.S. commercial development team has been using the EC3 tool on all its projects in design and construction since 2020. These efforts align with the company's science-based target to achieve net zero carbon emissions across Scopes 1, 2, and 3 by 2045.

The scope of materials includes the foundations, basement construction, superstructure, exterior enclosure, roofing, and the core and shell interior construction. For 1550 on the Green, the project team used EC3 to track carbon-intensive materials like concrete, rebar, and aluminum to understand where reductions might be possible in the structure. They quickly discovered that local suppliers, especially concrete suppliers, did not have EPDs in place for their products

SKANSKA USA COMMERCIAL DEVELOPMENT

Before Skanska began requesting EPDs for 1550 on the Green, very few suppliers in Houston were estimating the embodied carbon of their products.

and were just starting to become more transparent about embodied carbon. For manufacturers, the process to get an EPD can be lengthy, so Skanska's demand was important for prompting the market to move toward transparency.

Now, those EPDs are providing important information for other Houston projects that want to cut embodied carbon. "With projects like 1550 on the Green, and other Skanska-led projects in Texas, we are really beginning to move the needle by growing supplier interest in [embodied carbon] and looking at how the carbon footprint of their product might size up against that of their competitors," said Matt Damborsky, executive vice president at Skanska USA Commercial Development's Houston market. "We are excited . . . to bring more transparency."

Partnerships with other team members were essential to the project's success. For example, an early relationship with the contractor, Skanska USA Building, and engineer, Walter P Moore, presented opportunities to enhance structural efficiency and reduce the amount of material that was necessary for different components. Notably, the project saved 700 cubic yards of concrete, or 70 truckloads, by reducing the slab thickness of the pan-formed floor system by three-eighths of an inch. This limited the amount of time trucks servicing the project were on the road and in turn contributed to improved air quality.

The team's relationships with local concrete ready-mix suppliers also proved to be valuable. Since cement is the most carbon-intensive component of concrete, the team created concrete mixes that reduced the cement ratio while delivering the same performance. Working closely with the concrete contractor and ready-mix supplier, the team created a new mix that replaced 55 percent of the cement with other, low-carbon materials while meeting performance specifications.

The team also used EC3 to evaluate the impact of roofing material, carpeting, ceiling tiles, and MEP systems, which are sometimes overlooked but can be significant contributors of embodied carbon over a building's life cycle.

For Skanska, the urgency to decarbonize building materials was in part motivated by the discovery that Scope 3 emissions—or the indirect emissions resulting from operations or activities—make up a significant portion of the company's overall carbon footprint. According to Heidi Creighton, Skanska USA Commercial Development's vice president–sustainability, Scope 3 emissions are responsible for 90 percent of the company's overall emissions. As a result, Skanska's U.S. Commercial Development team is laser-focused on creative solutions to reduce embodied carbon in every project.

For 1550 on the Green, these investments are already paying off. The project's embodied-carbon reductions and other sustainability and health features, including a rainwater collection system, energy-efficient glass, and enhanced air filtration, have attracted tenants despite a tough office market nationally. International law firm Norton Rose Fulbright signed a 15-year lease for seven floors, and the project has received overwhelmingly positive feedback from prospective office tenants and retail operators.

When complete, 1550 on the Green will set a new standard for sustainable, low-embodied-carbon development in Texas and across the country.

Sven

Long Island City, New York

Developer: The Durst Organization

Designer: Handel Architects (design); Selldorf Architects (interior and amenity)

Size: 978,000 sq ft (90,859 sq m)

Project type: New construction

Status: Opened in 2022

Sven is a 71-story residential tower developed by the Durst Organization and located in Long Island City, New York. Embodying Durst's commitments to sustainability and environmental stewardship, Sven incorporates low-impact materials and is the first building in the world to achieve LEED v4 BD+C: New Construction Multifamily Platinum certification.

The building is the second tallest in Queens and features 958 residences ranging from studios to three bedrooms, 288 of which are income restricted. Amenities include a landscaped terrace with outdoor swimming pool, resident lounges, library, game rooms, tot spot, and large fitness center. The development plan also includes a public half-acre park and the adaptive use of the historic Long Island City Clock Tower, both at the base of the residential tower.

For over 100 years, the Durst ethos has been driven by a desire to "leave each place better than you found it." This philosophy is carried through the company's approach to materials, with a focus not only on the immediate effects of material choices on carbon emissions and resident health, but also on the life cycle impacts that materials have on natural resources, communities, and ecosystems.

While traditionally developers have relied on their design teams to manage material evaluation and selection processes, Durst has created its own criteria for vetting and procuring products. Over the years, Durst has refined this process, creating bespoke requirements within each product category, like carpet tile, concrete, and insulation. The team analyzes each category to understand the unique environmental and human health impacts associated with each product type. "We look at everything," said Sydney Mainster, vice president of sustainability and design management for the company.

Durst increased its healthy materials focus while designing VIA 57 West, another multifamily development, at a time when very few manufacturers were reporting product ingredients and impacts with Environmental Product Declarations and Health Product Declarations. Since then, the number of

THE DURST ORGANIZATION

Sven is the first multifamily residential building in the world to achieve LEED v4 New Construction (BD+C) Platinum certification.

THE DURST ORGANIZATION

Interiors feature wood and other natural materials, creating an inviting atmosphere with healthy indoor air quality.

manufacturers disclosing product information and working toward optimization has increased dramatically, in part thanks to developers like Durst and their partners who shift the industry by requesting transparency.

Durst also works with nonprofit research organizations such as the Healthy Building Network and the Green Science Policy Institute, and private partners like Socotec, to ensure they are asking the right questions when it comes to material health. For example, Durst asks manufacturers to disclose the presence of formaldehyde, antimicrobials, bisphenols, halogenated flame retardants, heavy metals, isocyanates, PFAS, phthalates, and PVC based on research linking these chemicals with a range of health concerns. Durst asks manufacturers for material ingredient disclosure at 100 parts per million to understand what chemicals are in the products being assessed and to seek and specify alternatives as needed.

Applying its rigorous material vetting process to the development of Sven, Durst assessed health and sustainability factors alongside more traditional product selection criteria such as performance, durability, and cost. This allowed the team to consider product attributes that might normally be overlooked in a conventional evaluation process.

With concrete, for example, Durst avoids fly ash, a common supplementary cementitious material (SCM) that is frequently added to concrete ready mixes to reduce the amount of cement in the mix. While increasing SCMs is helpful for reducing cost and embodied carbon associated with cement, fly ash has come under scrutiny because it is a byproduct of coal-fired power plants and often contains heavy metals and toxins. Durst is now piloting Ground Glass Pozzolan (GGP) made from recycled glass bottles as an alternative SCM, helping reduce the cement content while keeping material out of landfills.

During the development of Sven, the Durst team felt that their materials strategy hit its stride. “This project epitomized effective use of our process and approach. We had buy-in from our general contractor and subcontractors, and everyone understood the vision and knew what we needed to get there,” said Mainster.

To build alignment, Durst spent a lot of time educating the project team about materials and Durst’s criteria. Durst also developed a workflow tool and product database that allowed anyone to quickly see how products stacked up against the established criteria. This eventually led to the team creating a “best in class” product list, which can be leveraged for future projects to save time.

While Durst admits that its requirements are ambitious, the benefits of incorporating better materials outweigh the effort. One such benefit is improved indoor air quality. The team conducted air-quality testing immediately following construction and could demonstrate that Sven’s interior spaces, especially residential units, easily met the requirements for the LEED Indoor Air Quality Assessment credit.

In addition to healthy materials, the building features on-site water treatment and a combined heat and power system for efficient energy use. Combined, these elements embody Durst’s commitment to environmental stewardship and resident well-being.

PAE Living Building

Portland, Oregon

Developer: partnership between Edlen & Co., Downtown Development Group, PAE, ZGF Architects, Walsh Construction Co., and Apex Real Estate Partners

Designer: ZGF Architects

Size: 58,000 sq ft (5,388 sq m)

Project type: New construction

Status: Complete; opened in October 2021

Designed in accordance with the world's most rigorous sustainability standards, the PAE Living Building in Portland, Oregon, is the first developer-driven and largest commercial urban Living Building in the world. Constructed with mass timber and nontoxic, bio-based materials, the building sequesters carbon while delivering health and economic benefits to its occupants and owners.

The five-story, 58,000-square-foot mass timber building is located in Portland's Skidmore/Old Town Historic District and comprises four floors of office space above ground-floor retail and tenant amenities. Designed and engineered to last more than 500 years, the development surpasses code requirements for energy efficiency and carbon reduction as well as for seismic, achieving the same structural standards as hospitals and fire stations.

Key project partners and investors include Downtown Development Group, Edlen & Co., Apex Real Estate Partners, ZGF Architects, Walsh Construction, and PAE engineers, who serve as the building's anchor tenant. To gain the Living Building Challenge title, the development had to meet stringent sustainability, health, and equity requirements set by ILFI. The LBC is a green building certification program that promotes environmental stewardship and regenerative design through seven key focus areas, called petals: Place, Water, Energy, Health and Happiness, Materials, Equity, and Beauty.

Whereas most all other LBC projects have been developed and funded by public institutions or nonprofits, the PAE Living Building demonstrates that hyper-green buildings are possible under a traditional real estate development model. "One of the things that make this project so unique for a Living Building is that we used a more conventional investor-driven financing model. The project is primarily funded with equity and debt, and there's a very small amount, less than 2 percent of the overall project cost, from nontypical sources, like grants," said Jill Sherman, co-founder of Edlen & Co.

BENJAMIN BENSCHNEIDER

Mass timber structural elements cut down the building's embodied carbon emissions while creating a welcoming, biophilic environment for tenants.

To achieve the Materials petal, the project team had to avoid substances noted on the LBC Red List, a collection of chemicals known to cause harm to people and the environment. This meant limiting the materials palette and sticking with bio-based products like mass timber for structural elements and wool textiles for the interiors. ZGF also stayed away from finishing materials and plastic laminates that off-gas and affect indoor air quality. However, meeting the Red List–free requirement was not easy. "This is primarily due to the fact that the industry is still not at the point where enough manufacturers are offering Red List–free material solutions," says Michael O'Mara, principal for ZGF and project architect for the building. "As more projects demand and advocate for Red List–free solutions, this will start to change, and it will become easier to find materials as the selection range increases."

Interior components celebrate the aesthetic and structural value of mass timber. Exposed cross-laminated timber ceilings, glulam columns and beams, and salvaged wood throughout the project offer a nod to Oregon's timber industry. The PAE reception desk located on the third floor is made from wood repurposed from maple trees that were felled on site. Combined, the project team estimates that the use of mass timber reduced embodied carbon by 30 percent compared to traditional concrete and steel construction. Fortunately, the use of healthy and sustainable building materials did not require any sacrifices in terms of building performance. A tight building envelope allows the development to use significantly less energy for heating and cooling, facilitating a 53 percent energy savings over code.

> "To address the climate crisis, we must make the use of cutting-edge technology and innovative design routine, not an exception to the rule. PAE's Living Building work puts these principles into action and is a model for others to follow."
>
> U.S. REPRESENTATIVE EARL BLUMENAUER, quoted on the PAE Living Building website

In addition to the development's thoughtful approach to materials, the building generates its own electricity and captures and recycles water on site. A combination of on- and off-site solar panels provides 110 percent of the energy needed to power the building. Surplus power is donated to the affordable housing project that hosts the off-site solar array and to the city's grid via a two-way power connection. Rainwater is stored in a 71,000-gallon cistern before it is treated and repurposed as the building's potable water. Recovered gray water rinses toilets and irrigates exterior landscaping, while blackwater is treated with the help of composting toilets.

BENJAMIN BENSCHNEIDER

The project team selected natural and bio-based products to avoid potentially harmful chemicals and comply with the LBC Red List.

Despite cooling demand for office space nationwide, PAE Living Building's unique mission, commitment to sustainability, and healthy indoor environment have been a draw for tenants since the building opened in October 2021. Project stakeholders see a bright future for the development, which is making waves in Portland and beyond. "The world needs real stories that show us the path to a healthy, thriving, and equitable future . . . I look forward to witnessing the incredible impact that this work has on the next generation of Living Buildings around the world," says Lindsay Baker, the CEO of the International Living Future Institute.

U-lex @ Othello Square (Othello Square Affordable Homeownership Building)

Seattle, Washington

Developer: HomeSight

Designer: Sundberg Kennedy Ly-Au Young Architects

Size: 71,000 sq ft (6,600 sq m)

Project type: New construction

Status: Planned; finalizing financing

The Othello Square Affordable Homeownership Building demonstrates that equitable affordable homeownership can be good for both the well-being of people and the planet. Developed by Seattle-based nonprofit housing developer HomeSight, the project aims to improve the health of communities affected by generational barriers to holistic wellness and economic stability. The project will include 68 permanently affordable homeownership units constructed with nontoxic, sustainable building materials.

The project demonstrates the importance of delivering high-quality affordable housing for low-income communities who are more likely to experience unsafe living conditions. The development was selected as a pilot project in the ILFI Living Building Challenge for Affordable Housing and seeks to earn Petal certifications for community placemaking, social equity, and healthy materials. To achieve the certifications, the development must follow stringent requirements for health and sustainability, including the complete avoidance of substances on ILFI's Red List, which are known to cause harm to people and ecosystems.

The Affordable Homeownership Building is part of a larger, four-building development known as Othello Square, which includes affordable and market-rate residential, a community health care clinic, day care, a multicultural center, and job-training facilities. Rooted in the traditional territories of Coast Salish Tribal communities, the Affordable Homeownership Building is called "ʔúləx (U-lex) @ Othello Square. ʔúləx (pronounced OH-lew), means "gather" in Lushootseed, a Coast Salish language.

U-lex will serve the racially diverse Othello community, which has faced increasing development pressures and gentrification over the past few decades. The building is a limited equity co-op, a homeownership model in which residents purchase a share in a development and commit to reselling their share at a rate that keeps it forever affordable. All 68 units will be affordable to families earning 80 percent of area median income or less at the time of purchase, with a variety of unit sizes, including one-, two-, and three-bedroom homes, to accommodate intergenerational families.

"This development is community-led and driven, and the goal is to prevent residential,

SKL ARCHITECTS

When complete, U-lex @ Othello Square will provide 68 permanently affordable homeownership units constructed with nontoxic, sustainable building materials.

SKL ARCHITECTS

As a pilot project in the ILFI Living Building Challenge for Affordable Housing, U-lex @ Othello Square incorporates a range of sustainable elements, including healthy materials.

commercial, and cultural displacement and to increase access to opportunity for multicultural communities in Southeast Seattle," shares Gladys Ly-Au Young, lead project architect.

The choice to pursue the Living Building Challenge and the Materials Petal in particular was driven by the project team's dedication to providing safe, nontoxic housing for the Othello community. To begin, the project team streamlined the materials palette to cut costs and reduced the number of materials that needed to be evaluated. SKL Architects also looked at ways to reduce the project's scope in certain areas to compensate for higher costs in others. These changes included reducing the underground parking scope 20 percent from what was originally planned, using communal rather than individual balconies, condensing to one elevator and adding central stairs, leveraging meaningful adjacencies to maximize spaces, reducing the size of the ground-floor storefront windows, and standardizing the size of the windows in each unit.

Although some Red List–free products proved to be more expensive, the team found several categories where healthier alternatives were the same cost or even less than traditional materials. For example, in the flooring category, Forbo Marmoleum (linoleum) priced out less than the cost of luxury vinyl tile. Since linoleum is primarily made from bio-based and low-hazard ingredients, it is considered one of the best flooring options for avoiding toxic substances.

Inspired by the project's pursuit of the LBC Materials Petal, some product manufacturers offered discounted pricing to help the development achieve its social and environmental goals without exceeding the budget. These partnerships have facilitated the integration of healthy and sustainable materials that may have otherwise been cost prohibitive.

"There have been more and more manufacturers and suppliers that are producing healthier materials. We think that everyone should have access to those things. Everyone should have a right to live in a healthy environment, and our goal at HomeSight is to have that included in all of our projects," said Uche Okezie, HomeSight's director of development.

One key barrier for the project has been the lack of policies and programs that incentivize the use of healthy building materials in affordable housing developments. The project team found readily available financial incentives and grants for energy efficiency and renewable energy, with virtually no resources for healthy materials. This clear gap illustrates that more is needed, especially with policies and funding, to ensure sustainability and health are infused through the entire ecosystem of businesses that make affordable housing possible.

Despite the challenges, HomeSight and SKL have continued to champion Red List–free materials and reinforce the vision of the Materials Petal throughout the planning process. Gladys Ly-Au Young of SKL Architects has been a leading force, alongside the Housing Development Consortium and Toxic Free Futures, to develop the Healthy Materials Matrix, a publicly accessible guide for healthy materials.

HomeSight and SKL architects believe that bringing this project to completion will inform and lead structural changes to expand the pathway for affordable homeownership that is also sustainable for people and the environment. As of 2023, the development is finalizing financing and seeking partners to realize the project's vision and ultimately set a new standard for healthy, sustainable, and equitable affordable homeownership in Seattle and across the United States.

505 First

Seattle, Washington

Developer: Hudson Pacific Properties

Designer: Olson Kundig

Size: 288,000 sq ft (26,756 sq m)

Project type: Major renovation

Status: Completed 2023

HUDSON PACIFIC PROPERTIES

HPP incorporated salvaged wood elements throughout 505 First, including in the building's lobby, shown here.

505 First is a 288,000-square-foot class A office building that is on track to become the first existing building to obtain Core Green Building certification (Core) from the International Living Future Institute. In a world where most green building certification schemes are usually only attainable for new developments, 505 First demonstrates the power of existing buildings and salvaged materials to meet sustainability and health targets.

The major renovation, completed by real estate investment trust Hudson Pacific Properties (HPP) and architecture firm Olson Kundig, incorporates reclaimed and sustainably harvested timber alongside a host of other sustainable design elements in alignment with the requirements of the Core certification.

Sharing similarities with ILFI's more commonly recognized Living Building Challenge certification, Core is a simplified framework organized around 10 imperatives: place, transit, water, energy, health, materials, equity, inclusion, biophilia, and inspiration. Any type of development project can achieve Core certification, including new construction, existing buildings, and interior projects.

The 505 First renovation project included major changes to the building's structure and systems, a lobby repositioning, and the addition of an approximately 3,500-square-foot rooftop amenity space. Other updates included a complete overhaul of the building's west-facing facade glass openings and the inclusion of a new bike lobby to serve tenants taking advantage of commuter bike trails on Seattle's waterfront.

When the opportunity to pursue Core presented itself, the decision was a "no brainer," said Cherie Lecours, HPP's director of construction management. HPP has a longstanding focus on ESG practices and values, with science-based targets for reducing carbon emissions

and creating healthy spaces for tenants and communities, among other goals. The value created by prioritizing sustainability made navigating the Core requirements for an existing building—an uncharted path—worth the extra time and effort.

505 First sought Core certification as part of its compliance with Seattle's Green Building Standard. Local zoning codes under the Green Building Standard provide real estate developments with additional height and floor/area ratio in exchange for meeting the difficult certification requirements. This added height and floor area allowed 505 First to expand its usable program area to the new rooftop pavilions and terraces.

To meet the materials imperative of the Core certification, 20 percent of the materials budget had to be sourced within 500 kilometers of the construction site and 50 percent of the wood products had to be salvaged, harvested on site, or certified by the Forest Stewardship Council.

Project contractor Gateway Construction called around to dozens of local timber suppliers before finally finding Pacific Northwest Timbers, a wood reclamation yard in Seattle that could provide salvaged timber for the project. HPP used the reclaimed timber in the lobby and created a feature wall that welcomes guests into the biophilic setting. In addition, the rooftop amenity space features an exposed cross-laminated timber roof structure that uses local renewable resources and eliminates typical secondary ceiling systems.

HUDSON PACIFIC PROPERTIES

HPP has a longstanding focus on ESG practices and values, with science-based targets for reducing carbon emissions and creating healthy spaces for tenants and communities, among other goals.

HPP created a healthy interior environment by ensuring that key materials and systems specified for the retrofit were low emitting per requirements set by ILFI. To prevent the spread of indoor pollutants during construction, the project team had to carefully close off parts of the existing building's HVAC systems while the new areas were being built. The Core certification also required the installation of MERV 13 filters throughout the building.

As more stakeholders recognize the environmental and economic value associated with reusing buildings, the number of existing assets being updated for energy efficiency and human health is expected to increase. HPP's 505 First building serves as a meaningful case study on how to sustainably renovate a building with better building materials.

Prologis Evergreen

Brampton, Ontario, Canada

Developer: Prologis

Designer: Ware Malcomb Architects

Size: 250,000 sq ft (23,200 sq m)

Project type: New construction

Status: Under construction; expected completion December 2024

Prologis Evergreen, located near Toronto, Canada, is pioneering a new kind of industrial development—one that successfully integrates healthy and sustainable building materials. Built with mass timber certified by FSC, the 250,000-square-foot (23,200 sq m) warehouse demonstrates that industrial buildings can lead the industry in decarbonization.

For Prologis, the building's developer, the choice to build with alternative materials was driven by its focus on innovation and strong market forces: the company's customers are increasingly interested in lower-carbon buildings to assist in meeting their sustainability initiatives. The building will also help Prologis meet its science-based target to achieve net zero carbon across all three emissions scopes by 2040. Embodied carbon represents 20 to 25 percent of the company's total GHG emissions, with a high percentage coming from concrete and steel.

PROLOGIS

Prologis Evergreen combines mass timber and prefabricated concrete panels to reduce the embodied carbon of the structure.

Traditionally, concrete and steel are the go-to materials for industrial warehouses, chosen for their durability and strength. However, the emissions from these materials can be difficult to reduce, so Prologis is seeking alternatives. Prologis Evergreen is part of a company-wide effort to test innovative building materials and set the stage for widespread industrial implementation. According to Prologis, the use of mass timber instead of steel will reduce embodied-carbon emissions by 1,163 metric tons compared to baseline (or 62 percent less than generated by its steel counterpart), equivalent to the annual emissions of 147 homes' energy use for one year, according to the EPA greenhouse gas equivalencies calculator.

The development incorporates mass timber in place of structural steel framing and roof decking to avoid the high emissions associated with steel components. Prologis further

PROLOGIS

Prologis selected mass timber elements that were certified by the Forest Stewardship Council, meaning the lumber was harvested sustainably.

prioritized sustainability by selecting mass timber products that were FSC certified. FSC requires forests to be grown and harvested in ways that protect ecosystems, biodiversity, and the rights of Indigenous peoples and workers. In addition, in an FSC-certified forest, every tree that is removed will be replanted and replaced. Prologis expects that the wood components of the structure will last about 100 years and can be repurposed when they no longer serve the building, allowing less waste and more efficient use of materials.

In addition to the mass timber structure, Prologis incorporated prefabricated concrete panels into the building design. One key advantage of using prefab concrete panels is increased speed of construction. Like other modular construction materials, prefab concrete panels (which can become walls or roofs) are manufactured at a factory and then rapidly assembled into a building at the construction site. The panels use low-carbon cement and filler mixtures to reduce the panel fabricating emissions below industry baseline. Buildings made with prefab concrete are significantly more airtight and insulated compared to buildings constructed with traditional materials, helping reduce operational carbon emissions as well as heating and cooling costs.

Prologis views this project as an important investment toward its net zero goal. The company shared that while some of the lower-carbon materials come at a cost premium, an increasing number of clients are interested in sustainable buildings with features and materials that go beyond operational efficiency. In a competitive marketplace, the use of alternative materials helps Prologis differentiate itself while reducing emissions and driving innovative changes in the industry. Over time, Prologis expects that prices for low-carbon materials could fall as they are implemented more widely and brought to commercial scale.

In addition to sustainable materials, the development will follow Prologis's design standards that require all new builds to be ready for electric vehicle charging and solar, achieve sustainable certifications, and complete third-party life cycle assessments to understand embodied emissions. The development is targeting LEED Silver certification, and the facility will be equipped with electric heat pump air-conditioning (in lieu of natural gas).

"This project shows that it is possible to use lower-carbon construction materials without compromising building performance or quality—or customer satisfaction," says Suzanne Fallender, vice president of global ESG for Prologis. "In fact, in some cases, our customers are requesting these sorts of building features and more sustainable construction materials to help achieve their own sustainability goals."

Watershed Row and Wood River Mercantile

Klamath Falls (Watershed Row) and Fort Klamath (Wood River Mercantile), Oregon

Developer: Watershed Row LLC

Designer: Place Collaborative

Size: 19,000 sq ft (1,765 sq m) (Watershed Row); 4,000 sq ft (370 sq m) (Wood River Mercantile)

Project type: Major renovation

Status: Under construction; opening in fall 2024 (Watershed Row) and fall 2025 (Wood River Mercantile)

With their focus on material reuse and regenerative design, Watershed Row and Wood River Mercantile demonstrate the value of circularity principles as a core tenet of sustainable construction. Developed by Watershed Row LLC with the support of design firm Place Collaborative, these adaptive use projects are leveraging thoughtful material sourcing and reclamation principles to deliver regenerative, community-focused spaces in the heart of southern Oregon.

When complete, Watershed Row will transform an underused constellation/conglomerate of one-story buildings into a mixed-use commercial center and food hub celebrating farm-to-table vendors and local agriculture. The project is located in downtown Klamath Falls, Oregon, a town of 22,000 people about 20 minutes north of the California border.

Watershed Row's sister project, Wood River Mercantile (known locally as the Merc), is a general store and farm-to-fork restaurant located at the foot of Crater Lake National Park, just 45 minutes north of Watershed Row. Watershed is pursuing full Living Building Challenge certification from the International Living Future Institute and incorporating a host of sustainable features including on-site power generation, rainwater collection, wastewater treatment, native landscaping, and healthy materials.

Once operating, the two projects will work together, with Watershed Row creating the goods (both fresh and country-style preserves) that will be sold at the Merc. The projects are also working together during their renovation: materials salvaged from the Merc's deconstruction will be used to renovate Watershed Row and vice versa. The entire ethos of the two projects is to leave no usable material behind. Material that still has life left to give will be prioritized over building with a new resource.

The projects have undergone careful deconstruction, instead of demolition, to salvage materials from the existing buildings, minimize waste, and promote a circular economy. For Watershed Row, Place Collaborative chose to break up the deconstruction process into two phases. The first phase focused on the removal of intermediate partitions while leaving the exterior envelope intact. The second phase included exterior upgrades and renovation of the interior. In total, the deconstruction stripped roughly 11,000 square feet of the building's interior and salvaged lumber that will be used to reconstruct various aspects of the new building. A local Klamath Falls contractor provided the deconstruction work, which took about 10 weeks to complete.

In Fort Klamath, the same local contractor stripped the Merc's interiors and broke down another structure that was on the property in about 12 weeks. The general contractor

PLACE COLLABORATIVE

Watershed Row is an adaptive use of a constellation of buildings in downtown Klamath Falls, Oregon. The commercial mixed-use project will consist of a food hub with a variety of vendors.

PLACE COLLABORATIVE

Watershed Row and its sister project, Wood River Mercantile, have undergone careful deconstruction, instead of demolition, to salvage materials. These images depict Watershed Row before and after deconstruction.

PLACE COLLABORATIVE

Watershed Row is also pursuing Living Building Challenge certification by the International Living Building Institute.

that was awarded this job did not previously specialize in deconstruction and this effort was the first it had completed at scale. Although traditional demolition of the two properties would have likely taken less time, deconstruction has provided key benefits, like producing a ready-to-go bank of salvaged lumber, saving cost and material sourcing challenges, and creating a project site that is ready for the construction of the Merc.

Celeste Clayton, manager at Place Collaborative, shared that the most challenging element to the project has been integrating existing elements into the design of the new Watershed Row building. While building with reclaimed lumber is relatively straightforward because it can be swapped on a one-for-one basis with purchased materials, using other recovered materials in unique ways has been more difficult. In addition, the project required a unique staging approach; instead of stopping design at the culmination of the design development phase, design continued through later stages to allow more salvaged products to be incorporated. For example, the team had an idea to reuse the existing exterior paneled windows as frames for an acoustic panel system only two months before the bidding phase. Although the addition had to be justified—it required reinforcing each flimsy window frame—the team decided that the reuse story was more impactful than simply recycling the frames.

To achieve the LBC certification, Watershed Row must comply with the requirements of the Materials Petal, including the avoidance of substances on the LBC Red List, which are known to cause harm to people and the environment. This can pose a challenge for projects using materials salvaged from older structures. Yet, so far, this has not been a difficulty for the project, and the team reported finding only a small amount of asbestos and noncompliant adhesives in the floor tiles, which is not uncommon for a building this old.

Another early challenge was securing permits for Watershed Row because of its heavy use of reclaimed materials. Place Collaborative addressed this by hosting a walk-through of the existing building with city staff to share the project's vision and build local support. "After the walk-through, the city was excited about the impact Watershed Row would have on the local community, and was extremely supportive," said Megan Recher, principal at Place Collaborative. Inspired by the project's future, the city relaxed parking requirements and other hurdles to help Watershed Row move forward.

Holbein Gardens

Belgravia, London, United Kingdom

Developer: Grosvenor

Designer: Barr Gazetas

Size: 26,500 sq ft (2,462 sq m)

Project type: Major renovation

Status: Completed 2023

With Holbein Gardens, Grosvenor transformed an outdated and inefficient office building into a modern, net zero workplace. By retaining structural elements from the original building, this project saved 59 tons of embodied carbon, equivalent to the emissions of 557 return flights from London to Amsterdam.

When Grosvenor began exploring redevelopment options for the site in 2019, the 1980s office building was in need of an update. Located adjacent to a tube station in Sloane Square, one of London's most coveted neighborhoods, the five-story building was characterized by a red-brick facade, mansard roof, and ribbon windows. Grosvenor recognized that, despite the building's older appearance, the structure and materials were worth saving. The development team considered a range of options for the site, including new-build and residential conversion, but in the end opted to preserve the building with a net zero retrofit.

Today, Holbein Gardens stands as a leading example of how to refurbish existing office stock while meeting net zero goals. Structural changes to the building involved removing the old mansard roof, extending the building up a floor, and adding an outside terrace on the sixth level. The building is now fully electric, with heat pumps providing heating and cooling for the building. Solar energy generated from rooftop photovoltaic panels covers about 17 percent of the building's energy demand, and remaining energy comes from green power sources. Extensive landscaping with native plants on the rooftop, ground floor, and one of the exterior walls improves air quality and increases biodiversity.

Grosvenor's ambitious net zero targets and culture of sustainability informed decision-making at Holbein Gardens. The company aims to be carbon neutral across its whole value chain by 2025 and to reduce its absolute carbon emissions 52 percent by 2030. In addition, Grosvenor's sustainable development brief offered a framework for Holbein Gardens' materials strategy and net zero design. Organized around nine key themes, the document details the company's sustainability requirements, performance metrics, and design approaches for all development projects. The "Resource Use" and "Wellbeing" themes, which require developments to incorporate low-embodied-carbon and healthy and ethically

BUILDINGTON

PHILIP VILE

Before redevelopment, Holbein Gardens was characterized by its outdated red brick, ribbon windows, and mansard roof. Its dramatic transformation demonstrates the value of adaptive use for meeting net zero targets.

PHILIP VILE

sourced building materials, provided essential guidance for the Holbein Gardens project team.

Recognizing that the most effective way to avoid embodied-carbon emissions is to reuse existing buildings, Grosvenor took a host of measures to preserve as much of the assembly as possible. Most critically, Grosvenor retained the building's recognizable brick facade as well as its concrete structure, leading to significant embodied-carbon savings compared to new construction. While the development sourced new brickwork for the exterior of the sixth-floor extension (instead of reused bricks), the project team opted for a special lime mortar that will facilitate future disassembly and reuse.

Another unique aspect of Holbein Gardens is its use of reclaimed steel. The development is one of the first projects in the U.K. to reuse structural steelwork salvaged directly from a demolition site. In early phases, the project team identified the steelwork frame of the rooftop extension as one of the largest contributors to embodied carbon and began looking for opportunities to reduce impact. Through research and structural investigations, nine tons of existing steel were identified and reclaimed from a warehouse in Grosvenor's portfolio that was scheduled for demolition. This steel was combined with an additional 15 tons of reused steelwork sourced by Cleveland Steel and refabricated to form the building's rooftop extension. In total, Grosvenor integrated 24 tons of salvaged steelwork in the building's structure, avoiding about 60 tons of carbon emissions from new steel production.

"By ensuring environmental performance was central to the Holbein Gardens brief from day one, the team have been able to trial an array of new construction methods and materials," said Tom White, senior project manager at Grosvenor. "The reuse of salvaged steel is just one example of how we have sought to drive a reduction in embodied carbon. By continuing to work closely with our suppliers, the lessons learnt will be invaluable to our future pipeline and journey to achieving net zero carbon by 2030."

When reclaimed materials were not available, the project team prioritized new materials that were healthy and low in embodied carbon. This included integrating Cemfree concrete, a concrete alternative with 85 percent lower embodied carbon compared to traditional Portland cement. In addition, the team chose to use cross-laminated timber for the new slabs between the fifth and sixth floors and the roof slab over the new extension to further reduce upfront embodied carbon. Following requirements of the WELL building standard, interior materials and products have low VOC content and emissions, supporting a healthy indoor environment.

As one of the first projects of its kind in London, Holbein Gardens has achieved a long list of certifications. Grosvenor and the project architect followed the U.K. Green Building Council's net zero carbon framework, and the building is certified BREEAM Outstanding, WELL Platinum, and has received a five-star rating from the National Australian Built Environment Rating System (NABERS). As part of the NABERS requirements, the building diverted 99.95 percent of its waste from the landfill, equating to 184.8 tons.

Among its many achievements, Holbein Gardens leaves an important legacy in London. Through the development process, Grosvenor helped several contractor partners set their own science-based targets as part of a wider supplier mentoring program that has increased the number of U.K. small and medium-sized enterprises with science-based targets by 20 percent. The new sustainability commitments of these organizations will have ripple effects on development projects throughout the U.K. and the world.

Tools and Resources

ULI Resources

- Embodied Carbon in Building Materials for Real Estate
- Blueprint for Green Real Estate
- Building Healthy Places Toolkit

External Resources

Embodied Carbon

TOOLS

- **Architecture 2030 Carbon Avoided Retrofit Estimator (CARE) Tool:** A calculator tool allowing users to compare the total carbon impacts of renovating an existing building vs. replacing it with a new one.
- **Building Transparency Embodied Carbon in Construction Calculator (EC3):** A database of more than 100,000 Environmental Product Declarations (EPDs) to help building professionals understand and mitigate embodied carbon in their projects. Described in more detail on page 50.

GUIDES AND RESEARCH

- **Architecture 2030 Carbon Smart Materials Palette:** An interactive online tool providing detailed embodied carbon data for common building materials and "carbon smart" alternatives.
- **Building Transparency Embodied Carbon Action Plan:** Outlines key steps and actions necessary to reduce embodied carbon throughout the design, construction, and operations phases. Other resources include:
  - Basis of Design Contract Language
  - Specification Instructions
  - EPD Request Letter Template
  - Bid Document Example Language
- **Carbon Leadership Forum:** A nonprofit research entity of the University of Washington, CLF advances best practices and knowledge sharing about embodied carbon reduction in the built environment. Its website contains many valuable resources, including:
  - **Policy Toolkit:** Resources to support the creation of policies that reduce embodied carbon.
  - **Building Owners Toolkit:** Resources to support the creation of corporate policies that reduce embodied carbon.
  - **Architects Toolkit:** Created in partnership with AIA, a series of guides to help architects and designers reduce embodied and operational carbon in development projects.
- **Hines Embodied Carbon Reduction Guide:** A tactical guide created by Hines and Magnusson Klemencic Associates (MKA) describing specific techniques for reducing embodied carbon at each stage of development.
- **Hudson Pacific Properties Low Embodied Carbon Tenant Fit-Out Guide:** An introductory guide to reducing embodied carbon, especially for tenants.

- **Rocky Mountain Institute *Reducing Embodied Carbon in Buildings*:** A research report detailing high-impact materials and methods for reducing embodied carbon throughout a building's life cycle.

Human Health and Equity

TOOLS

- **Healthy Building Network Product Guidance and Informed tool:** A red-to-green ranking system that compares different types of products based on their hazardous content. It is informed by HBN's comprehensive research into the hazards associated with building products that may affect building occupants as well as fenceline communities and workers throughout a product's life cycle.

- **mindful Materials Portal:** A free materials library providing holistic sustainability data for products based on the Common Materials Framework. Described in more detail on page 50.

- **Chemical Avoidance Lists:**
  - **Living Building Challenge Red List.** One of the most well-known chemical avoidance lists in the building industry, containing thousands of chemicals across 19 categories.
  - **Perkins&Will Precautionary List.** A chemical avoidance list and free online tool allowing users to search and filter substances by project area, products, health hazards, and more.
  - **Cradle to Cradle Restricted Substances List.** A chemical avoidance list created and managed by the Cradle to Cradle Innovation Institute. It defines a maximum allowable concentration of each restricted substance in order for products to qualify for Cradle to Cradle certification.

GUIDES AND RESEARCH

- **American Institute of Architects (AIA) *Prescription for Healthier Building Materials: A Design and Implementation Protocol*:** A detailed research report outlining methods for improving material selection written for an architecture/design audience.

- **Grace Farms Design for Freedom Toolkit:** Resources for real estate professionals wishing to avoid modern slavery and unethical treatment for workers in material supply chains.

- **Green Science Policy Institute *Eliminating Unnecessary PFAS in Building Materials*:** Research report outlining the problem of PFAS in building materials and solutions for avoiding unnecessary PFAS in the industry.

- **Health Product Declaration Collaborative:** Resource for learning more about Health Product Declarations (HPDs).

- **Salesforce *Healthy Materials in the Workplace: An Introductory Guide* and *Healthy and Sustainable Materials in the Workspace, Volume II*:** Guides outlining Salesforce's evaluation process for materials with detailed background information about material impacts, certification schemes, and sustainable procurement approaches.

Circularity

- **AIA Buildings that Last: Design for Adaptability, Deconstruction, and Reuse:** Design guidance for buildings that are adaptable, flexible, and can be deconstructed or disassembled for future use.

- **All for Reuse Initiative:** A coalition of built environment professionals committed to the reuse of commercial building materials. The website provides a comprehensive list of salvaged material suppliers, deconstruction experts, manufacturer take-back programs, material databases, and other resources.

- **Arup and Ellen MacArthur Foundation Circular Building Toolkit:** An interactive online resource outlining strategies and actions that promote circularity in the built environment.

- **Circle Economy *Circularity Gap Report 2023*:** Research report with suggested solutions for improving circularity in the built environment.

- **EPA Fact Sheets on Designing for Disassembly and Deconstruction of Buildings:** A series of fact sheets that highlight innovative approaches, results, and environmental and economic benefits from deconstruction pilot projects.

- **Gensler *Designing for Disassembly* Report:** A research report analyzing strategies for and benefits of disassembly based on interviews with developers, manufacturers, city officials, and product development teams.

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