Green Building: It’s Good for the Earth. It’s Good for Business.

Cover: Developed in partnership by Allied and Westbank, KING Toronto incorporates sustainable design elements to conserve water, reduce energy use, and manage stormwater. The project targets LEED Gold standards and has achieved Toronto Green Standard Tier 1. Rendering by Hayes Davidson, courtesy of Westbank.

Green Building: It’s Good for the Earth. It’s Good for Business.

Introduction

Green building is undoubtedly urgent for the environment, but data shows that it’s also good for business. If executed correctly, a green building doesn’t cost money; it makes money. According to a 2021 Dodge Data & Analytics report, green buildings typically have lower operating costs and provide more value to their owners. The average operating-cost savings of a new green building within its first year exceed 10%, and the five-year cost savings exceed 16%. Green renovations and retrofits of existing buildings perform even better, at 11.5% and 17%, respectively.

It’s no surprise, then, that 70% of building owners around the world surveyed by Dodge said that lower operating costs are the top business benefit of green building. It’s also the top reason owners increase their green building efforts, followed by “it’s the right thing to do.” This mix of financial and moral drivers bodes well for the future as the role of building owners in green building becomes critical. That’s because buildings are the largest source of the world’s carbon emissions, generating nearly 40% of annual global carbon dioxide emissions, according to Architecture 2030, a nonprofit dedicated to altering the course of climate change. What’s more, approximately 66% of today’s global building stock will still exist in 2040, underscoring the need for sustainable retrofits.

At CannonDesign, a global architecture, engineering and design firm, I use my long experience in architecture to help our clients identify challenges and opportunities within sustainability. I’m passionate about creating pathways to a regenerative, restorative, and equitable future, for all. The designers and their projects showcased in this e-book exhibit a passion for a sustainable future, as well, whether they’re extending the life and value of building materials beyond their initial use, aiming to become the largest certified Passive House office building in the world, or collaborating with an automaker to create a prototype green home of the future.

In 2006, Architecture 2030 issued the 2030 Challenge, which called for all new buildings and major renovations to be carbon neutral by 2030—a deadline that’s fast approaching. At CannonDesign, we’re committed to achieving this goal in our own operations, as well as in the operational and embodied carbon of our projects. My hope is that the stories in this e-book will show building owners and architects how much of an impact they, too, can have—and how quickly they can have it. We have everything we need to make this goal a reality.

ERIC COREY FREED
Director of Sustainability, CannonDesign

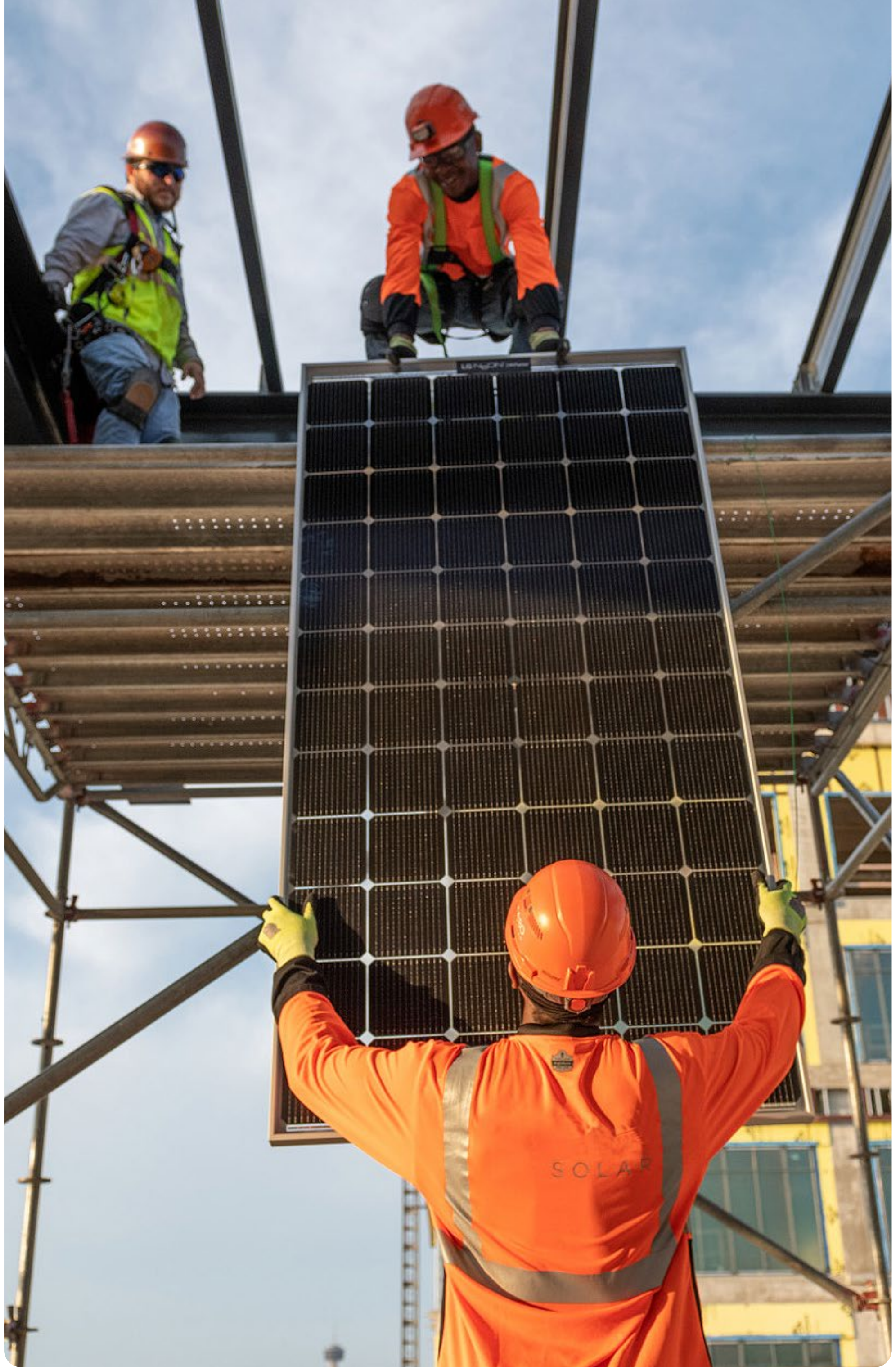
Rendering by Hayes Davidson, courtesy of Westbank.

Meeting midcentury net-zero carbon goals means aggressively reducing emissions right now; actions in the next decade will be critical to mitigating climate change for the future.

The Path to Net-Zero Carbon: Stabilizing Climate Change Takes a (Global) Village

With megafires and catastrophic floods happening at an alarming pace, learn how the design and build industry is working to achieve net-zero carbon.

BY SARAH JONES



Firefighters battle infernos from Lake Tahoe ski lifts. A hurricane reverses the flow of the Mississippi River. Thermometers read 121 degrees Fahrenheit—in Canada. A dip in gravity is detected in the Antarctic ice sheet. Sound like some kind of futuristic dystopian disaster movie? Not quite: These scenes are real; they're happening right now; and they're fueled by climate change.

Since the Industrial Revolution, humans have sent more than 2,000 gigatons of carbon dioxide into the atmosphere. This thickening blanket of heat-trapping pollutants is the cause of global warming. The impact of fossil fuel use is staggering: Pollution kills 8 million people annually. In the United States alone, fossil fuel use causes more than 50,000 deaths and $445 billion in economic damage each year.

The degree of global warming is directly proportional to the amount of carbon dioxide that human activities add to the atmosphere. It's a brutally simple equation: To stabilize climate change, global carbon emissions must fall to zero. The longer it takes to do that, the more the climate will change.

Construction workers install solar panels at a San Antonio construction site for a building that will include a geothermal energy system, solar, and a large-scale rainwater and condensation collection system.

What Is Net-Zero Carbon, and Why Is It Important?
Simply put, net zero is a state in which the amount of greenhouse gas released into the atmosphere is equal to the amount removed from the atmosphere. Net zero is achieved through carbon reduction, offsetting, and removal.

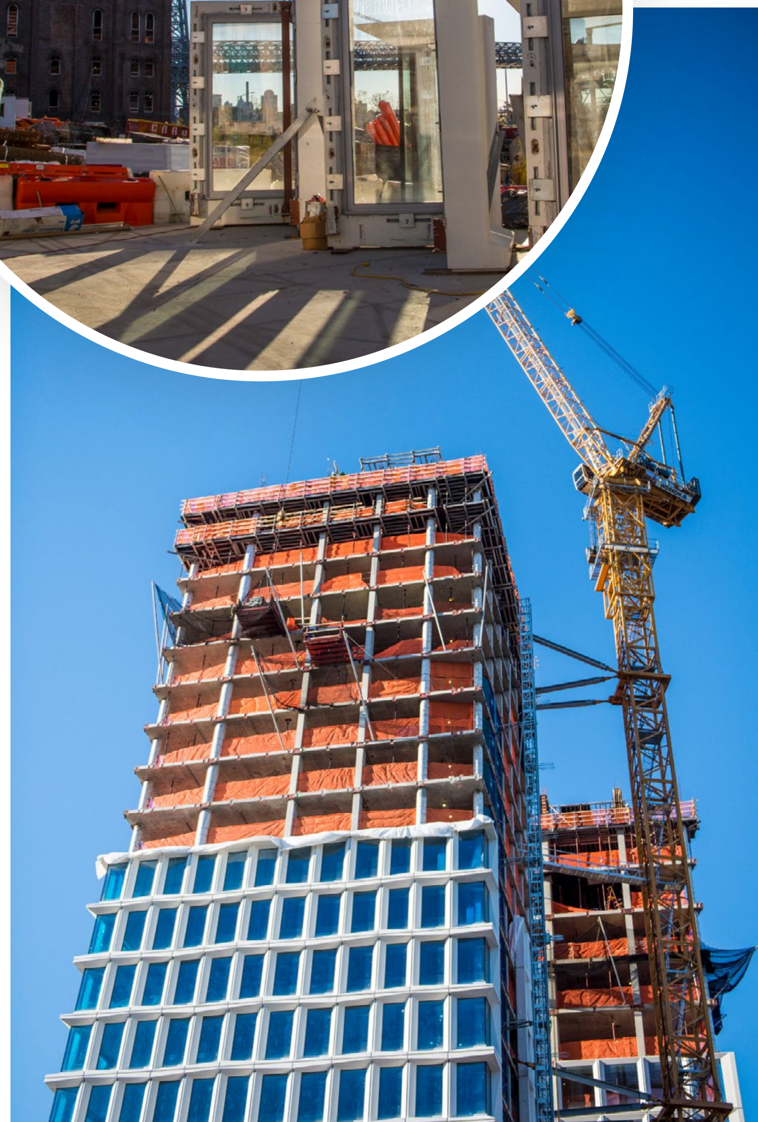
Net-zero carbon is important because climate change is widespread and intensifying, and experts agree that the best way to tackle it is by reducing global warming.

In 2015, the Paris Agreement outlined an international framework to limit the rise in global temperatures to less than 1.5 degrees Celsius (2.7 degrees Fahrenheit) above preindustrial levels, which would significantly limit the impacts of climate change. To meet this target, most experts agree, global carbon emissions must reach net zero by 2050. Nearly 200 countries agreed to take action, and some—including France, New Zealand, and Sweden—have ratified net zero into legislation

Meeting midcentury net-zero goals means aggressively reducing emissions right now; actions in the next decade will be critical. “We’re going to be in trouble because we’re now at a 1-degree Celsius rise over preindustrial temperatures,” says architect and educator Ed Mazria, founder of Architecture 2030, which aims to transform the built environment from being the major emitter of greenhouse gases to a central solution to the climate emergency. Mazria, like many leading the progressive side of the movement, says 2050 is too late: “In order to keep under 1.5 degrees, we have to have a steep decline in emissions between now and 2030 and then phase them out by 2040.” To have a good (67%) probability of meeting that 2040 target, Mazria says, global carbon emissions must reach a 50% reduction by 2030 and zero by 2040.

How Does Net Zero Apply to the Design and Build Industry?
Any built structure has carbon emissions associated with it, in both the building process and the operation phase. A net-zero building balances its greenhouse gas emissions from traditional energy by reducing energy use to minimize carbon emissions, using renewable energies such as wind and solar, or purchasing carbon offsets to reach a break-even point.

Net-zero building goals are ambitious, to say the least. “By 2030, the built environment should halve its emissions, whereby 100% of new buildings must be net-zero carbon in operation, with widespread energy-efficiency retrofit of existing assets well underway,” says Victoria Burrows, director of Advancing Net Zero at the World Green Building Council. “Embodied carbon must be reduced by at least 40%, with leading projects achieving at least 50% reductions in embodied carbon. By 2050 at the latest, all new and existing assets must be net zero across the whole life cycle, including operational and embodied emissions.”



Top: Gate Precast Company used 3D-printed concrete molds to create panels for the One South Tower mixed-use complex, built in a former Domino Sugar factory in Brooklyn, NY. Bottom: The molds are 20 times more reusable than wood-and-fiberglass molds.

A rendering of the Grange Insurance Audubon Center in Columbus, OH, highlights sustainable design features such as solar panels and a roof garden.

> ***"Underserved communities have the most to lose with climate change but the most to gain from more efficient, sustainable buildings."***
>
> —CLAY NESLER
>
> GLOBAL LEAD, BUILDINGS AND ENERGY,
> WRI ROSS CENTER FOR SUSTAINABLE CITIES
> AT THE WORLD RESOURCES INSTITUTE

It's difficult to overstate the built world's impact on global emissions. "We're on a path to double the amount of building floor space by 2060," says Clay Nesler, global lead, Buildings and Energy, WRI Ross Center for Sustainable Cities at the World Resources Institute. "If you do the math, that's equivalent to building another New York City every month. Those buildings will have to be heated, cooled, and lighted; provide a comfortable, healthy environment; and be resilient to the impacts of climate change.

"If cities and countries are to achieve net zero, there's no way to do it without focusing on their buildings because buildings represent 39% of global carbon emissions and even higher percentage of carbon emissions in cities," Nesler continues. "But [buildings] also represent the greatest opportunity for immediate reductions, using available technology, that are cost-effective over their life cycle."

Total Carbon Management: What Does It Mean?
In the context of the architecture, engineering, and construction (AEC) industry, total carbon management is the process of measuring and managing the sum of a building's embodied and operational carbon. "What's tricky is that the term *net zero* is often only used to describe addressing operational energy,'" says Tony Saracino, Autodesk senior manager, Sustainability Success. "*Net zero* in its true sense should be used to describe buildings that measure, manage, and reduce total carbon emissions—the sum of embodied carbon and operational carbon to zero or beyond."

Embodied Carbon. Everything that is built has a hidden climate impact due to embodied carbon—the carbon emissions generated by extracting resources, refining, manufacturing, and logistics. The embodied carbon of all the materials going into buildings and infrastructure is hard to trace but accounts for

11% of global greenhouse gas emissions. Unlike a building's operational carbon emissions, which can be reduced over time with energy-efficiency renovations and the use of renewable energies, embodied carbon emissions are locked in place as soon as a building is built.

Construction is the No. 1 consumer of raw materials in the world. According to Architecture 2030, embodied carbon will be responsible for more than half of total new construction emissions by 2030. With a projected 2.5 trillion square feet of new buildings being constructed by 2060, it's critical to get embodied carbon under control now and achieve net-zero carbon in construction. Tools like the open-source Embodied Carbon in Construction Calculator (EC3) help stakeholders make informed choices about choosing materials with the least carbon impact.

Operational Carbon. Operational carbon is the amount of carbon a structure emits during its use, including management and maintenance. Operational carbon makes up 28% of global emissions; that number will rise as the built world expands during the next three decades.

High-performance building design delivers buildings that are efficient, safe, and comfortable—and that exceed performance and greenhouse-gas reduction regulations. This is accomplished by combining techniques and tools to optimize energy consumption, materials usage, and occupant safety and comfort, taking advantage of renewable energy sources wherever possible.

Digital technologies such as BIM (Building Information Modeling) empower designers to simulate energy use. But while technology enhances the design process, that design process is getting more complex.

Builders can invest in third-party offset projects or start their own programs, such as tree plantings, wind farms, geothermal power plants, and solar projects.

"If we're going to design these zero-carbon buildings, we not only have to make them structurally sound; we've got to analyze the lighting levels because we're using more natural lighting," Nesler says. "We have to estimate the impact of things like green roofs, white roofs. We have to figure out the best building orientation. We're going to have to do very detailed energy simulation because we're going to have to match renewable energy to the actual heating, cooling, and lighting loads of the building. And we're also going to have to control the buildings in different ways."

Carbon Offsets. Carbon offsets help businesses meet sustainability goals by counteracting their carbon emissions through investments in projects that avoid or reduce carbon consumption. They sometimes take the form of carbon credits, with one credit equaling the removal of 1 metric ton of carbon dioxide from the atmosphere or the avoidance of producing that carbon dioxide. Builders can invest in third-party offset projects or start their own programs, such as tree plantings, wind farms, geothermal power plants, and solar projects.

Carbon Removal. While emissions-reduction strategies are a critical step in the path to net zero, they are not enough; getting there requires strategies that actively remove carbon from the atmosphere.

Carbon-removal methods include natural strategies such as forest restoration and soil management; high-tech strategies such as direct air capture and enhanced mineralization; and hybrid strategies such as ocean-based carbon removal.

In the built world, carbon removals can include capturing carbon coming out of a chimney stack, turning industrial emissions into building materials, and storing carbon in materials like concrete.

"The most exciting developments are those that have the potential to drastically reduce the carbon footprint of concrete or even produce concrete that has net-negative carbon footprint and is therefore a carbon sink," says Dr. Claire White, associate professor of civil and environmental engineering at Princeton University. "There are alternative cements that have at least 70% lower CO2 emissions than portland cement. We need these materials if we are to drastically cut the carbon footprint of concrete and transition to a net-zero carbon industry."

Building Design for a Circular Economy

The circular economy, a zero-waste mindset that focuses on the continual use and reuse of resources, is gaining ground in architecture. It's more than recycling; it's embracing the idea of upcycling in the context of design and build. Implementing this closed-loop cycle means taking a top-down approach that encompasses everything from the performance of individual materials to the purpose of the building itself.

Designing for circularity means accounting for a building's entire lifecycle and beyond—a "cradle-to-cradle" approach.

"Consider a simple bookcase," Saracino says. "Maybe it's in too bad a shape to repair, but the boards that made up the shelves can be used in another thing that uses that same-width and same-length wood, rather than just tearing it down. That's where smart design can lead toward circularity."

The same concept can be applied at a building scale. "Think about if you've ever gone to a loft where people have turned an old factory into housing," Saracino says. "That's a great example of circularity in a building. They've taken a building that once was a manufacturing site, and now people are living in it and sometimes with very minimal intervention—the same big redwood beams are floating through the ceilings and the columns, and the floors are still there."

Converting an old warehouse into condos or lofts is an example of circularity in the design and build industry.

To reap the most benefits of circularity in building design, end-to-end digitalization is critical, Nesler says: "You go from a crayon sketch on an iPad to a BIM model. You simulate everything; you optimize the design [for optimal energy use]; you figure out how much carbon is embodied in the materials.

"And then you download that into a system that associates data with all the sensors and the devices in the building so that we can not only optimally control the building, but we can also make the building a *producer* instead of a *consumer* of energy," he continues. "It stores it; manages it; and, yes, it uses a little bit of hopefully clean energy. And oh, by the way, there's going to be a little tag on the concrete walls and on the steel beams so when we're tearing down that building 50 years from now, it's going to tell us what's exactly in there."

A new model for city living: Multiuse urban development KING Toronto is designed to foster community well-being.

READ MORE

Rendering by Hayes Davidson, courtesy of Westbank.

Designing Buildings as Materials Banks

Today's building processes treat materials in inefficient ways; structures are designed for finite applications. What if, instead, buildings were treated as temporary storage for valuable materials and components? That's the idea behind buildings as materials banks.

"A building is made up of all of this 'stuff,'" Saracino says. "There's wood on the floors; there are some concrete slabs, some copper piping. Those are all materials that are deposited in that bank of the building. Now, we can put a building together so that when it's reached its end of life, we know what's in that bank. And it's easy to take apart. You're not just hitting it with a wrecking ball."

Digitalization is an increasingly important step in designing buildings as materials banks. "Right now, we tear down a wall, we've no idea what's in it," Nesler says. "A BIM model is going to have to include everything about the materials in there and facilitate the reuse, the remanufacture, things such as that."

The Future of Net-Zero Carbon

Net zero is achievable, but meeting midcentury goals will take a collaborative effort among all stakeholders and must be driven by policy. But according to Nesler, the private sector also needs to be proactive. "Not all policy makers have the background of really building buildings and saving energy," he says. "The private sector can bring credibility and practicality to discussions."

As countries move toward net zero, it's critical to build resilience in the world's vulnerable communities that contribute the least to carbon emissions yet bear some of the greatest health and economic impacts. "Underserved communities have the most to lose with climate change but the most to gain from more efficient, sustainable buildings because the interventions that we make to buildings to drive their carbon emissions to zero also makes them more comfortable, makes them healthier," Nesler says.

"The trick is to find ways of being able to pay that upfront cost of higher-performance buildings or the cost of doing a major renovation and paying for it over time," he continues. "There are a number of creative business models that are private-sector oriented that can allow those communities to address that."

And that's where the AEC industry, more than any other sector, can be the biggest agent of change. "When the architecture community came to terms with the fact that they played a role in climate change, they jumped on board because, as designers, they are taught to make the world a better place," Mazria says. "That's the calling of the profession."

The Construction Solution Has Been Here All Along: Renewable Materials

Conventional construction depends on finite resources and emits high levels of carbon. Fortunately, alternative renewable materials are on the rise.

BY CAROLIN WERTHMANN

Werner Sobek AG developed the energy concept for a clinic in Eisenberg in eastern Germany. Courtesy of HG Esch, Hennef.

“Let’s focus on gray energy,” says architect and sustainability expert Werner Sobek. *Gray energy* is the term used to describe the primary energy required to construct a building. And when it comes to saving energy, it’s much more effective to use recyclable building materials during construction than to save energy downstream when managing the building later.

That’s why an increasing number of architects rely on renewable materials, including Sobek for a clinic in Eisenberg and Kaden+Lager architects for Skaio, Germany’s tallest wooden skyscraper.

Skaio is just 34 meters (111 feet) high. Floor-to-ceiling windows break through the light-gray cladding like honeycombs in a beehive. It won’t be long before a taller German wooden building is constructed.

But it’s not Skaio’s height that earned the building and Kaden+Lager, a Berlin–based architecture firm, the German Sustainability Award for Architecture in 2021. The building is a pioneering statement for greater sustainability in the construction sector. Not only has it been made mostly of wood—a renewable raw material increasingly described by the media as a solution for climate-positive construction—no glue was used to build it. According to Kaden+Lager, all components can be disassembled and used again. It’s a model of what can happen when combining needs-based planning, urban densification, and climate-friendly construction.

Top: Skaio, a wooden high-rise in Heilbronn, southwestern Germany, received the German Sustainability Award for Architecture in 2021. Courtesy of Hofele.

Bottom: A year earlier, the award went to the Alnatura headquarters in Darmstadt, southwestern Germany. Designed by haascoozemmrich Studio2050, the building has a facade made from rammed earth, an ecological building material. Courtesy of Roland Halbe.

Challenging the Demolition Culture
Awarding a project like Skaio signifies the German Sustainable Building Council's (DGNB) commitment to combat throwaway culture. The 2021 Pritzker Prize, the world's most prestigious award for architects, also reflects the trend to recognize architectural firms that prioritize resource conservation. The 2021 Pritzker Laureates, French architects Lacaton & Vassal, prefer to add to buildings rather than demolish them.

These winners represent an important paradigm shift in thinking for the industry. According to a 2020 United Nations report (PDF, p. 10), the buildings and construction sector is responsible for 38% of global carbon emissions and is not moving quickly enough toward the Paris Agreement's goal of keeping average global warming below 2 degrees Celsius. As the global population continues to grow, raw materials such as sand and gravel—which are essential for the production of concrete—are becoming scarce and expensive. There is increasing political, economic, and ecological pressure for alternative building materials in the construction industry.

For architect Sobek, who is also a civil engineer and co-initiator of the DGNB, this industry shift is a welcome change. He was aware of the scarcity of resources back in the 1990s. Today, he has an empire of offices that spans from New York to Dubai to Buenos Aires. His portfolio ranges from facade planning and sustainability consulting for the ADNOC Tower in Abu Dhabi, United Arab Emirates, to the development of an energy concept for a clinic in Eisenberg in eastern Germany.

"We use a variety of different building materials, all of which are fully recyclable," he told DEKRA Solutions. "The question of how to connect all these different materials is a very important one. It's a matter of whether it can be ensured that all joins are also reversible or whether composite materials are created that can no longer be recycled by type."

Sobek's private home in Stuttgart, Germany, explains this best. Sobek calls his home R128, which sounds a bit like a Star Wars droid and evokes images of an amazing smart home with all kinds of intelligently networked gadgets.

R128, the private house of civil engineer and architect Werner Sobek in Stuttgart, Germany. Courtesy of Zooey Brown.

> ***“From now on, we have to design and build so that rather than putting materials in landfills or throwing them away after the building is demolished, we can generate added value from them.”***
>
> —DIRK. E. HEBEL
>
> PROFESSOR OF SUSTAINABLE BUILDING, KARLSRUHE INSTITUTE OF TECHNOLOGY

The Mehr.WERT.Pavillon at the German Federal Garden Show in Heilbronn, southwestern Germany, 2019. It uses recycled glass, steel from a dismantled coal-fired power plant, broken concrete, and porcelain. Courtesy of Felix Heisel.

In fact, the name is just a slightly hipper abbreviation for his address, Römerstraße 128. This modestly sized house is entirely glazed and is situated on a slope, surrounded by nature. The interior is so minimalist you would assume it’s uninhabited. Sobek’s home is a manifesto for his thoughts: It uses as little energy as possible and consists of recyclable and reusable materials, including copper plates, glass, and steel frameworks that were previously part of other buildings. “My childhood dream was to live in a soap bubble on a green field,” Sobek adds. “Today, it’s a cubic soap bubble.”

Giulia Peretti, team manager of building physics and sustainability at Werner Sobek Green Technologies, emphasizes the importance of measures that compensate for damage caused in the past—approaches such as reusing and recycling materials that have already been installed. The principle behind the concept is to regard the built environment as a space in which building materials are stored before being reused and recycled as part of the circular economy.

A Paradigm Shift in Construction

One example of this ideal is NEST, a modular research building on the campus of the Swiss Federal Laboratories for Materials Science and Technology (EMPA) near Zurich. Sobek is responsible for NEST’s Urban Mining and Recycling Module (UMAR), together with Dirk. E. Hebel, professor of sustainable building at the Karlsruhe Institute of Technology (KIT), and Felix Heisel. The copper sheeting around the glazing was once a church steeple roof, and the cladding was repurposed from a local savings bank.

Like Sobek, Hebel is one of the architects advancing this paradigm shift. For years, he has conducted research into alternative solutions with his students at the KIT Department of Architecture in southwestern Germany. He designed the Mehr.WERT. Pavillon for the German Federal Garden Show in 2019. Like NEST in Switzerland, this construction features recycled materials. The treelike structure's steel comes largely from a coal-fired power plant that was dismantled further north.

Hebel explains that the structure uses no adhesives, foams, or paints, as it would otherwise not be possible to sort and recycle even supposedly ecological building materials. "From now on, we have to design and build so that rather than putting materials in landfills or throwing them away after the building is demolished, we can generate added value from them," he says.

Although Hebel admits that the demand for buildings is still higher than the number of materials that could flow back into the materials cycle, the use of regenerative organic materials that are produced, grown, and cultivated using sunlight could close this resource gap. In recent years, the construction industry has experimented with alternative building materials such as hemp, bamboo, and fungi. Such experimental projects include Hebel's MycoTree, which was created for the Seoul Biennale of Architecture and Urbanism 2017, and the compostable Hy-Fi tower, which uses mycelia-based bricks and was designed by the American architect David Benjamin for the Museum of Modern Art in New York.

However, a building does not automatically become sustainable through prudent choice of materials alone. Hebel explains that architects have to ask how the materials will be connected, how repair-friendly and durable the building will be, and how to supply it with electricity and heating. The option of deconstructing a building to continue on its journey through the circular economy must also be taken into account from the very start of the planning process.

An Ecological Building Materials Passport

Hebel sees much potential in digitalization for managing materials information. "We need a cadastre for materials and a passport for every material," he says, suggesting that such a register should provide a record of the composition, production, and

The steel frame of the pavilion looks like a tree. Courtesy of Zooey Brown.

mechanical properties of each material, as well as how much of the material is used in each building and how it has been incorporated. "We would then know where our valuable materials are and how to put them back into circulation."

Current digitalization tools such as Autodesk Insight building-efficiency analysis software help builders on the path toward more sustainable construction. And the new circular-economy service ReCapture by Swedish architecture firm White Arkitekter scans existing buildings to identify recyclable materials for conversion.

Sobek once warned against sacrificing style in the name of saving resources: Doing so would not make people excited and inspired by sustainable design, which wouldn't be of service to the circular economy. "Architecture must be beautiful," he says. "Because we can only love and care for beautiful things."

Downtown Boston's Winthrop Center links carbon-emission performance with human health. Courtesy of Steelblue | Millennium Partners Boston.

Boston's New Winthrop Center Takes Passive House Design to New Heights

With its focus on sustainable practices and better wellness for future occupants, a new skyscraper is on track to be the largest certified Passive House design office building in the world.

BY ZACH MORTICE

Winthrop Center, the 691-foot, $1.3 billion skyscraper under construction in downtown Boston, began with an ambitious goal: to integrate WELL Building Standard certification, which focuses on occupant health, with stringent Passive House energy-performance criteria. This would make it the largest Passive House–certified office building in the world.

“Passive House at this scale has never been done before in the United States,” says John Fernandez, director of MIT’s Environmental Solutions Initiative and a key consultant on the design and development team. “This building is an experiment in some ways.”

Handel Architects, renowned for socially transformative and environmentally conscious design, advocated in the early stages of design for integrating Passive House into the Winthrop Center project. Having previously designed and achieved certification for the largest Passive House residential building in the world at Cornell Tech in New York City, Handel brought its expertise on the benefits of Passive House design and how to apply it to Winthrop Center.

When complete, Winthrop Center will feature 800,000 square feet of office space and 317 luxury residences. Courtesy of Millennium Partners Boston.

Passive House Design Features

The project team faced setbacks along the way—including the developer's refinancing of the project, brought on by the COVID-19 pandemic. The team also had to closely monitor how much energy the building would consume to maintain Passive House status, aided by the serendipitous overlap of the building rating systems (including LEED) that define its performance. "Almost everything that one does for wellness is complementary to sustainability," Fernandez says.

As examples, access to daylight, gained through glass facades and outdoor terraces, offers biophilic wellness benefits and lowers lighting loads. The triple-glazing and tight connections of the glass facades create a snug thermal envelope, further reducing heating and cooling costs. Winthrop Center's faceted, mirrored glass and T-shape floor plan allow natural light to penetrate into each floor plate so that 95% of working space is within 35 feet of a window. And the building's isolated acoustic environment edits out street noise.

By piggybacking gains from one set of criteria onto another, Fernandez and the project developers at Millennium Partners Boston are testing the potential of rigorous, performance-based sustainability. When it's completed in 2023, Winthrop Center's office space is projected to use 65% less energy than a standard building of its type.

"Getting to zero energy goes through Passive House," says Brad Mahoney, director of sustainable development for Millennium Partners Boston. "We saw Passive House as a key market differentiator."

A rendering of The Connector.
Courtesy of Steelblue | Millennium Partners Boston.

Passive House + the WELL Building Standard

Administered by the International WELL Building Institute (IWBI) and released in 2014, the WELL Building Standard uses performance-based and prescriptive criteria to rate buildings on how they improve human physical health, mental health, and well-being. Its criteria cover air and water quality, light, thermal comfort, materials, sound, and more.

Conversely, the Passive House standard uses just a handful of energy-performance criteria to rate buildings. Established in 1996 by the Passive House Institute, the standard limits heating, cooling, and plug-load use per square foot. It also specifies envelope air-change limits, which decrease the amount of fresh air that needs to be conditioned to maintain thermal integrity and comfort. Instead of complicated active energy-generation systems, Passive House focuses on building envelopes and insulation so that structures can be temperature-controlled with the fresh air brought in to meet air-quality requirements.

Per its name, Passive House was originally developed for single-family homes, where its application can reduce energy usage by 90% in cold climates. But the standard is now applied to a wide range of buildings in a variety of climates. In single-family homes, achieving extreme energy efficiency is partly related to material composition: Houses often use wood structural systems; because wood has strong insulation properties, heat transfers slowly from the inside or the outside.

Winthrop Center's faceted, mirrored glass and T-shape floor plan allow natural light to penetrate into each floor plate so that 95% of working space is within 35 feet of a window. And the building's isolated acoustic environment edits out street noise.

Winthrop Center will work differently. Designed by Handel, with IA Interior advising the development team, it will be a T-shape, 62-story high-rise, with 800,000 square feet of office space and 317 luxury residences. In the podium of the high-rise, a vast, triple-height atrium called The Connector will offer meeting and event spaces that are available to the general public, all fronted by a 50-foot-tall, monumental structural glass wall.

Between the residential floors and the lower office levels, a set of amenities for residents and office tenants, called The Collective, will host a fitness center, a bar, a café, and an electromagnetic-free "earth room"—a place to relax and recharge where electromagnetic signals from smartphones and laptops are blocked. The office tower section is projected to attain Passive House certification, WELL Building Standard Gold, and LEED Platinum; the residential section will be LEED Gold only.

How to Make a High-Rise a Passive House

Adapting the Passive House standard to a high-rise is an integrative design challenge that requires solving multiple variables simultaneously, from the thermal isolation and efficient HVAC systems to exterior-wall performance. All variables must work in tandem to achieve optimal energy balance.

The project started with a high-performance building envelope that's well insulated and largely transparent. Of several competing difficulties that the team addressed, Blake Middleton of Handel Architects says that "isolating all those connections between the tower structure and the exterior in a way that maintains the thermal separation is much more difficult in high-rises because there are so many more connections." Solving these kinds of problems in an affordable way meant "creating a high-performance building with off-the-shelf technology," he says.

As such, Handel chose a triple-glazed, modular curtain-wall system with thermal breaks between exterior walls and an internal structure that stops the transfer of heat energy where the panel joints are gasketed and sealed.

Winthrop Center's ventilation and heating systems focus on efficiently moving air through spaces and across floors and selecting mechanical systems that can condition vast volumes with minimum energy. To meet the Passive House design guidelines, designers "always keep tabs on your energy budget," Mahoney says.

Winthrop Center's Heat Recovery and Exchange

"Heat recovery and exchange are absolutely essential in a Passive House," Fernandez says. One way

The Connector begins to take shape. Courtesy of Millennium Partners Boston.

Winthrop Center recycles heat energy is through a recovery system located on a mechanical floor between the office and residential sections of the building. In winter, warm air inside the building is evacuated, charging a heat-exchange wheel, which comes into contact with cold air from outside. The exchange wheel transfers some of this heat energy to the cooler, fresh outdoor air, thereby significantly reducing the direct conditioning energy needs.

This process can also be reversed, with cooler air inside moderating hot air outside during summer months. As encouraged by the WELL Building Standard, Winthrop Center will bring in 30%–50% more fresh air than a standard building of this type. "Though increased fresh air can be more energy intensive," Mahoney says, "by ensuring high-efficiency energy recovery systems at Winthrop Center and carefully planning for the increased ventilation from the project's beginning stages, the benefit outweighs the cost."

This interior-to-exterior heat-exchange dynamic explains why Passive House buildings are best suited for colder climates. Because the human body generates heat at a steady 98.6-degree clip, in an occupied structure, there's always a supply of warmer air to moderate cold air coming in from outside, especially in densely populated office buildings. In warm months, air-conditioning systems are already fighting against this biological heating and have to expend more energy to remove heat energy from the transfer wheel.

"There's always going to be some demand for cooling that may not exist on the residential side," Mahoney says.

Channeling fresh air for human health purposes while using as little energy as possible to condition it for thermal comfort is perhaps the most critical synthesis between the WELL Building Standard and Passive House. Since the onset of COVID-19, air quality and ventilation are areas of concern that require attention from designers and engineers. By starting with WELL, the design and development team were in a good position to incorporate more stringent air-quality and surface-microbial measures, Mahoney says.

Optimizing Human and Climate Health for the Future

From the outset, Millennium Partners Boston and Handel planned on using medical-grade MERV air filters and no-touch surfaces and devices, as well as mobile log-in and access systems. The pandemic refocused everyone's attention on optimizing the built envelopment to prevent the spread of contagions. Winthrop Center is equipped to integrate thermal wellness-check cameras, no-touch doors, and custom tenant fan coil units where microbe-killing ultraviolet lights can be installed to cleanse the air.

By combining Passive House and WELL standards, Winthrop Center links carbon-emission performance with human health, which are already connected in terms of managing particulate matter in the air and climate change's disruptions of ecosystems. This commercial project shows that rethinking the approach to design and engineering improves wellness and sustainability.

"I think this has pushed us forward in ways that I couldn't have imagined," Mahoney says. "It's creating a new paradigm for how people look at buildings, how office users want to interact with a building. It's looking to the future."

When completed in 2023, Winthrop Center's office space is projected to use 65% less energy than a standard building of its type. Courtesy of Steelblue | Millennium Partners Boston.

The interior of the EQ House. Courtesy of Noboru Inoue.

Japan’s Futuristic EQ House Uses AI and BIM to Bring the Outside World In

In Tokyo, the Takenaka Corporation and Mercedes-Benz have collaborated on a project that brings technology, mobility, and human-centered design together.

BY YASUO MATSUNAKA

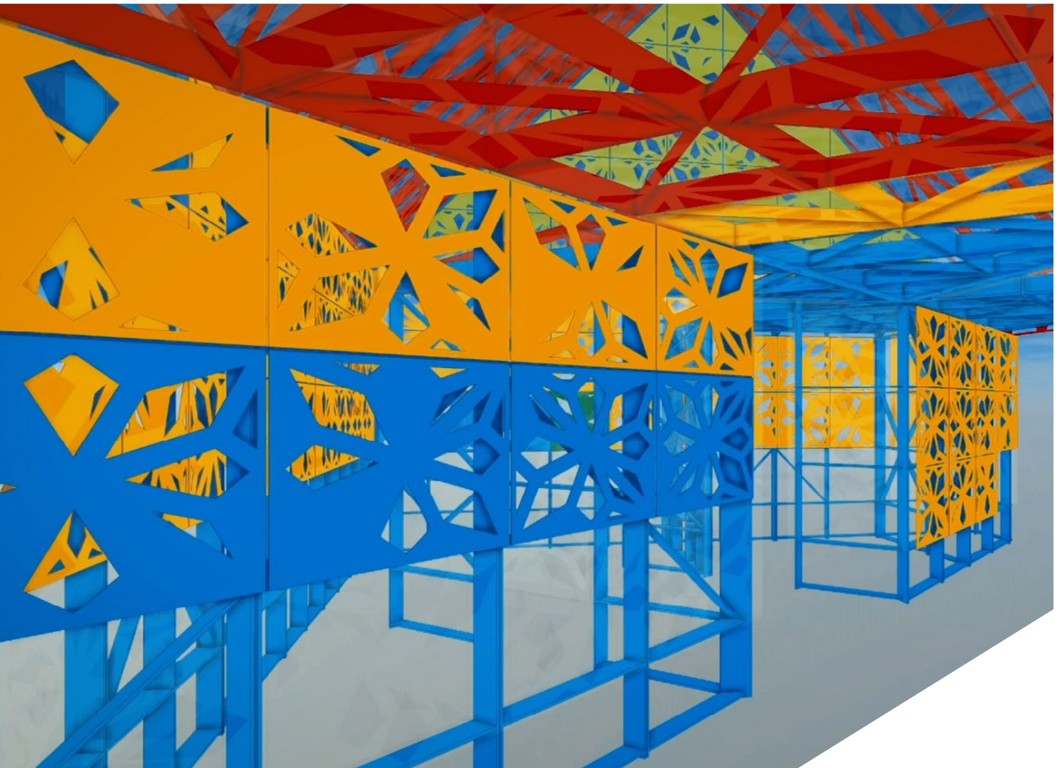
The EQ House will be open to the public for two years. Courtesy of Noboru Inoue.

“Modern architecture is being highly influenced by the automotive industry,” says Ikuya Hanaoka, a head of the advanced design group at the Takenaka Corporation, a global architecture and design firm based in Osaka, Japan. “Ever since the assembly line emerged in the early 20th century, design as a whole has undergone a revolution, with far-reaching results.”

So it’s no surprise that Takenaka has designed and built a prototype dwelling called EQ House in collaboration with Mercedes-Benz Japan. The structure, located in Tokyo’s Roppongi district, aims to connect people, architecture, mobility, and living space. It’s customizable and connected, and it fully integrates sensor technology.

The proof-of-concept, forward-looking architecture project incorporates aspects of Mercedes-Benz’s EQ electric-car line and Daimler’s CASE Intuitive Mobility platform. Though its methodology might have begun on an assembly line more than a century ago, the EQ House is possible now due to dramatic developments in the Internet of Things (IoT) and artificial intelligence (AI) technologies that are redefining the relationships between mobility and housing. An electric car can be a part of bigger ecosystem—along with inhabitants’ smart devices—by sharing information.

“When mobility enters living spaces, the relationship between the outdoors and indoors changes,” Hanaoka says. “The outside world enters the indoor space, creating complex living environments that transcend conventional architectural frameworks.” This new architecture requires advanced IT-based environmental controls and interfaces that can learn personal habits to optimize the living environment. “As people begin to demand environments that meet their needs, architecture will become more and more personalized,” he says.



A Showroom That Feels Like Home

Although its current form is a showroom, the EQ House is also a perfectly habitable—and aesthetically pleasing—space. Paneling envelops the structure; individual panels are laser cut with construction efficiency in mind. Cutouts in each panel are designed to let in the optimal amount of sunlight while dispersing artificial lighting. Among the roughly 1,200 cutouts are more than 1,000 unique patterns, creating a lighting effect like that of sunlight filtering through trees in a forest.

Inside the EQ House, mobility and living spaces intersect in a tunnel of sorts. A glass-panel interface located in the center of the building displays information about the status of the building and the vehicle. The information is drawn from sensors that detect people in rooms, monitor ambient temperature, and handle other information. Data is also collected from smart devices in the home, such as the owner's smartwatch. The sensor data is aggregated by the Building Communication System developed by Takenaka and stored on the cloud.

In the EQ House kitchen, panels are designed with a genetic algorithm that selects optimal values for brightness, light exposure, and manufacturing cost. Computational design was used for many facets of planning and construction. In the design phase, multivariable optimization (in which several variables—such as comfort, eco-friendliness, and cost—are all considered) was used to balance light capture, heat dispersion, and efficiency. Variations were then generated from the best proposed designs using a genetic algorithm.

For the structure itself, the aluminum panels sandwiched supportive flat steel bars and concealed them from view. This was achieved by calculating an ideal arrangement that reduced the number of braces and avoided placing them in difficult-to-install locations.

"A Living, Breathing Building"

Sensors throughout the house meld the information infrastructure with the building space while providing an enormous amount of information: A weather station measures wind direction and speed, rainfall, atmospheric pressure, and sunlight.

Top: Wall-panel cutouts in the kitchen let in the optimal amount of sunlight while dispersing artificial lighting. Courtesy of Noboru Inoue.

Bottom: Panels and other components are color-coded to indicate the order of construction. Courtesy of Takenaka Corporation.

Data is gathered from multifunction sensors detecting surface temperatures, carbon-dioxide levels, and the presence of humans; smartwatches and smartphones; electricity meters; magnetic door sensors; cameras that measure brightness and analyze images; microphones for voice recognition; battery and solar-power charging and discharging measurements; and climate-control facilities.

The collected data is studied using AI, which then sends information through the Building Communication System to control the house, repeating the process in a continuous feedback loop. Glass walls can be electronically controlled to change transparency levels; on a bright, sunny day, they can be made opaque, or they can be set to turn transparent only when a person is nearby. Bedroom walls feature dimming films that can adjust the room's brightness depending on needs or time of day.

"The building communicates with its inhabitants and learns their likes and dislikes," Hanaoka says. "This is a living, breathing building that coexists with the people in it. We have come to call this new type of building style 'archiphilia,' where an inanimate building feels like it has come to life. The home reacts to the voices and movements of people; watches over their vehicle, their comfort, and energy usage; and shares information with other devices."

BIM Data Plays Vital Role

BIM was used throughout the design and construction process of the EQ House. BIM data created in Autodesk Revit appends project-management information such as time, labor, and material cost requirements to 3D models, displaying panels and other house components in different colors that indicate the order of construction. The design-phase data was also put to use to laser-cut the aluminum panels. Each panel had a unique QR code identifier, which could be managed using a smartphone. The process of attaching the panels to the building frame was assisted by using mixed reality (MR): By scanning the QR code on each panel, a worker wearing a Microsoft HoloLens device could view its installation location and a work guide. When each QR code was scanned, the part was logged and time-stamped to manage work progress.

BIM data also played a vital role in building application and inspection work. By using Autodesk BIM 360 Docs, drawings, documents, and models could be effectively distributed, managed, reviewed, and approved. Takenaka Corporation has been sharing BIM data for preliminary checks; when building the EQ House, it was also used for midconstruction and final inspections. Data created in Revit was loaded into an MR system that combines a HoloLens display with a tablet device for displaying 3D models. Workers could view design data overlaid onto the actual work site for inspections.

In the final inspection, legally required fixtures (such as smoke detectors) and underfloor equipment were displayed as an MR overlay for viewing on-site. "It was really helpful because we could display guidelines indicating each detector's effective range within the space," Hanaoka says. "By being able to visualize areas that are normally inaccessible, such as underfloor vents, our work could proceed smoothly." Results were shared with the Building Centre of Japan (BCJ), a designated inspection-validation institution.

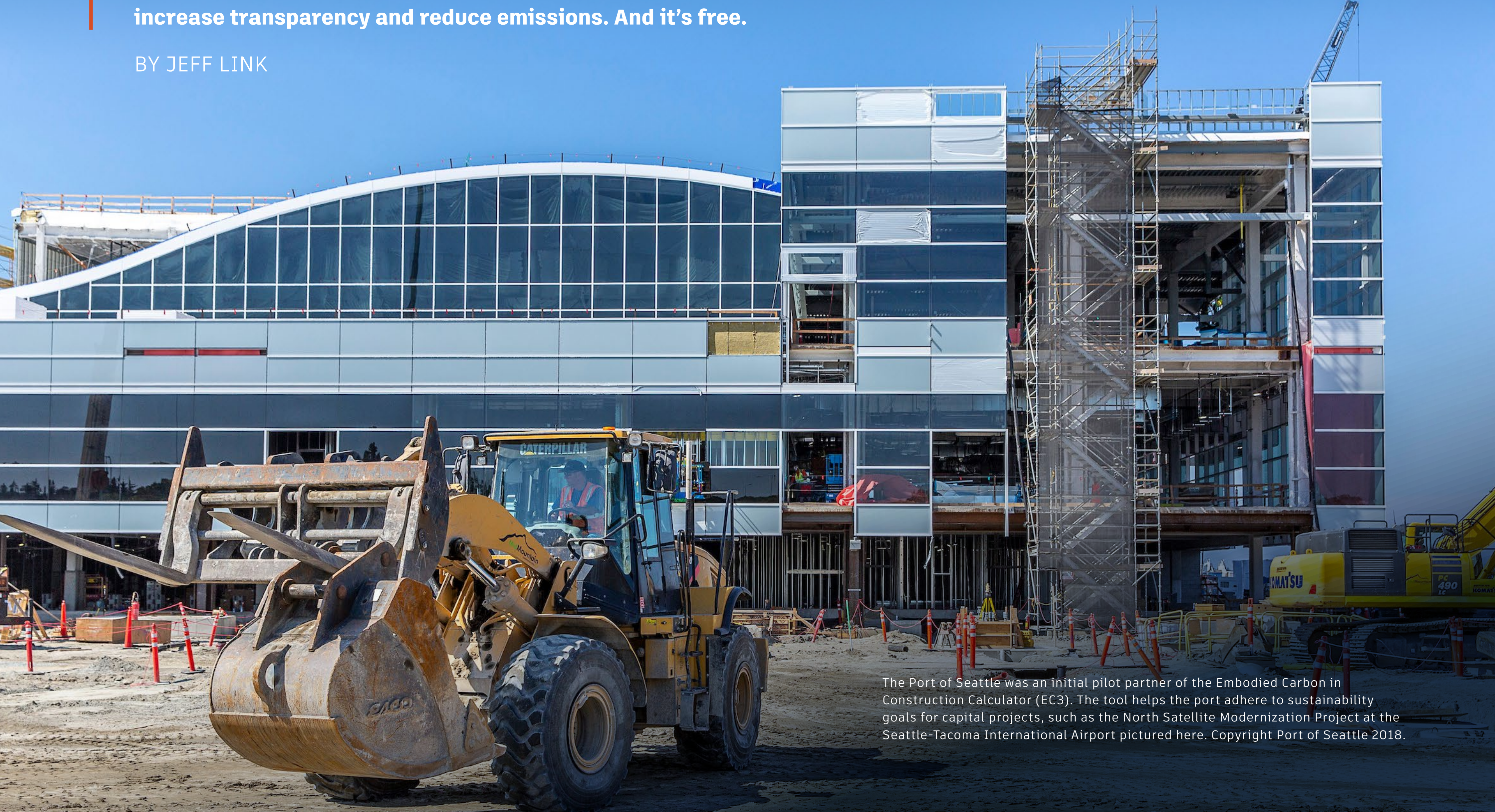
"With each visitor, the EQ House continues to learn and grow," Hanaoka says. "As this happens, the relationship between mobility and housing will continue to evolve at the EQ House. I think that soon, mobility and living will be seamlessly integrated, making the outside world an extension of your home, creating the potential for new experiences and a new way of life."

The EQ House is installed at Mercedes-Benz's retail store in the Roppongi district of Tokyo. Courtesy of Noboru Inoue.

Ready to Reduce Your Construction Emissions? Use the Embodied Carbon Calculator

Developed collaboratively, the EC3 is a tool that can help the construction industry increase transparency and reduce emissions. And it's free.

BY JEFF LINK



The Port of Seattle was an initial pilot partner of the Embodied Carbon in Construction Calculator (EC3). The tool helps the port adhere to sustainability goals for capital projects, such as the North Satellite Modernization Project at the Seattle-Tacoma International Airport pictured here. Copyright Port of Seattle 2018.

It’s no secret that the construction industry is one of the biggest contributors to greenhouse-gas emissions. The numbers are staggering: Embodied carbon currently makes up 11% or more of global emissions; by comparison, that’s more than five times higher than the 2% of global emissions produced by the entire aviation industry.

With a projected 2.5 trillion square feet of new buildings being constructed around the world by 2060, emissions associated with embodied carbon will skyrocket if left unchecked.

“Construction is the number one consumer of raw materials in the world, and much of that material is wasted,” says Autodesk Director of Sustainable Business Ben Thompson. “The building sector accounts for almost 40% of waste in the developed West. In the US, that’s twice the amount that’s generated from municipal sources.”

Given such grim statistics, it’s fortunate that many in the construction sector are beginning to make sustainability commitments—not only because reducing waste is good for the bottom line but also because companies and consumers are increasingly choosing to spend money with firms doing right by the planet. “To win business, these suppliers are ensuring that they’re delivering sustainable products and services and also managing their own companies responsibly,” Thompson says. “In a recent study on consumers, 61% said that they would switch and purchase from a more sustainable company. They also said they would pay more for it, too.”

It’s a critical time to address one of the most significant (and often hidden) contributors to carbon emissions: building materials. Fortunately, the construction industry now has a way to quickly and accurately measure the impact of those products, thanks to the collaborative efforts of forward-thinking technology providers and industry organizations.

The free, cloud-based EC3 tool reveals the embodied carbon of materials so architects, engineers, and contractors can select materials with the lowest carbon emissions.

WATCH THE VIDEO


A rendering of Microsoft's redeveloped headquarters in Redmond, WA. Courtesy of Microsoft.

Measuring Embodied Carbon With the EC3 Tool
When Microsoft announced plans for a high-profile redevelopment of its 500-acre headquarters in Redmond, WA, the company set its sights on going beyond the traditional approach of addressing emissions with energy efficiency and renewables and began exploring opportunities to reduce the carbon footprint of each building material used.

"Everything we build has a hidden climate impact, due to embodied carbon, the carbon emissions generated from extracting resources, refining, manufacturing, and logistics," says Katie Ross, Microsoft's senior sustainability program manager of real estate and facilities. "Not all building materials are created equally; depending on how they were manufactured, one building component could have much lower embodied carbon than another component that looks and performs the same."

With 17 new buildings and 2.5 million square feet of new workspace, Microsoft understood its project's potential climate impact and knew how important reducing embodied carbon would be in meeting its sustainability goals. By partnering with industry leaders, the company was able to uncover significant opportunities to reduce embodied carbon—by as much as 30% and without major cost increases—using the Embodied Carbon in Construction Calculator (EC3) tool.

What Is the EC3 Tool?
Launched as a public beta in November 2019, this free, open-access platform reveals the embodied carbon in materials going into buildings so architects, engineers, and contractors can make informed choices, selecting materials with the lowest climate impact. Pulling embodied carbon data from third party–verified Environmental Product Declarations (EPDs), the EC3 tool compares the carbon intensity of available materials that meet required specifications, enabling fast, climate-smart substitutions.

Conceived by global construction company Skanska and Canadian software developer C-Change Labs and initially piloted by Microsoft, the EC3 tool was incubated by the Carbon Leadership Forum (CLF), which brought together a network of nearly 50 private companies and nongovernmental organizations cooperating to fund the technology and scale it across the building sector. (The CLF aims to propel knowledge, collaboration, and action to radically reduce the embodied carbon in building materials and construction.)

“The idea for the EC3 tool came out of Skanska’s work around carbon accounting for commercial developers and contractors,” says Skanska USA Building Director of Sustainability Stacy Smedley, who leads the company’s EC3 implementation and sits on CLF’s advisory board. “For five years, we’ve mandated carbon accounting in the US on our own commercial-development projects. That led us to the understanding that lifecycle assessments and building codes are often based on average factors and quantities that don’t inform design choices. We wanted to drive reductions not just through carbon-directional choices on the systems level, but in the later specification and procurement phases of a project so we could actually realize carbon-emissions savings.”

Using the EC3 tool, Microsoft reduced the embodied carbon of its campus-redevelopment project by nearly 30%. Courtesy of Microsoft.

The nonprofit organization Building Transparency was established in early 2020 to manage and continue development of the EC3 tool. Building Transparency also provides education and resources to help ensure EC3’s adoption across the industry.

Although renewable energy and efficient building systems will likely bring down the operational carbon emissions of these structures over time, the sunk impact of embodied carbon cannot be erased after construction.

“To meet the science-based targets for decarbonization between now and 2050, the construction industry will have to make a huge contribution,” says Kate Simonen, director of the CLF and a professor at the University of Washington. “Technically, we know how to make zero-carbon buildings, but we have to act together to give the industry time to respond. We have to act now and make choices based on better available data.”

For the industry, the real impact could be increased demand for products with a lower embodied carbon—which could lead to manufacturers competing to develop affordable, high-performing options. “There is a lot of interest coming from manufacturers,” Simonen says. “They’re seeing the EC3 tool as a scorecard and want to know how they’re stacking up.”

“The EC3 tool helps you understand where to focus efforts,” Ross says. “Glazing, in the grand scheme of carbon emissions, is a fairly small portion of total emissions compared to the structural foundation. Using the tool allowed us to prioritize reductions in those target areas that have the most emissions.”

"We started with a list of what the tool must do to be successful," Smedley says. "It must be open to everyone—and free—to remove the access barrier. It must be easy to use so architects, engineers, and contractors can all use it. And the data must be transparent, with a wide-open methodology."

A Tool With the Potential to Change Construction

The EC3 tool is free with registration and will continually improve as more EPDs are manually transferred to a searchable database that now includes more than 17,000 individual products; eventually, AI will ideally handle this task. "There's a lack of digital optimization of EPDs," Smedley says. "[AEC] practitioners have had to go through 28 pages of a PDF to find one emissions factor and other relevant data. It's the same thing for the EC3 tool; there isn't widespread use of APIs [application programming interfaces] for transferring this information digitally, so we're doing a good portion of it manually, which is not efficient. Eventually, we'd like to have a digital EPD framework that is used by all." Since the EC3 launched in 2019, the materials data available through the app has more than doubled (PDF, p. 15).

Ross is already envisioning the tool's potential in Microsoft's broader commitment to become carbon negative by 2030—and what that could mean for companies of all sizes. "Our sustainability commitments are twofold: keeping our own house in order but also thinking about how we can enable others to scale this," she says. "Climate change is at a scale that everyone has to participate."

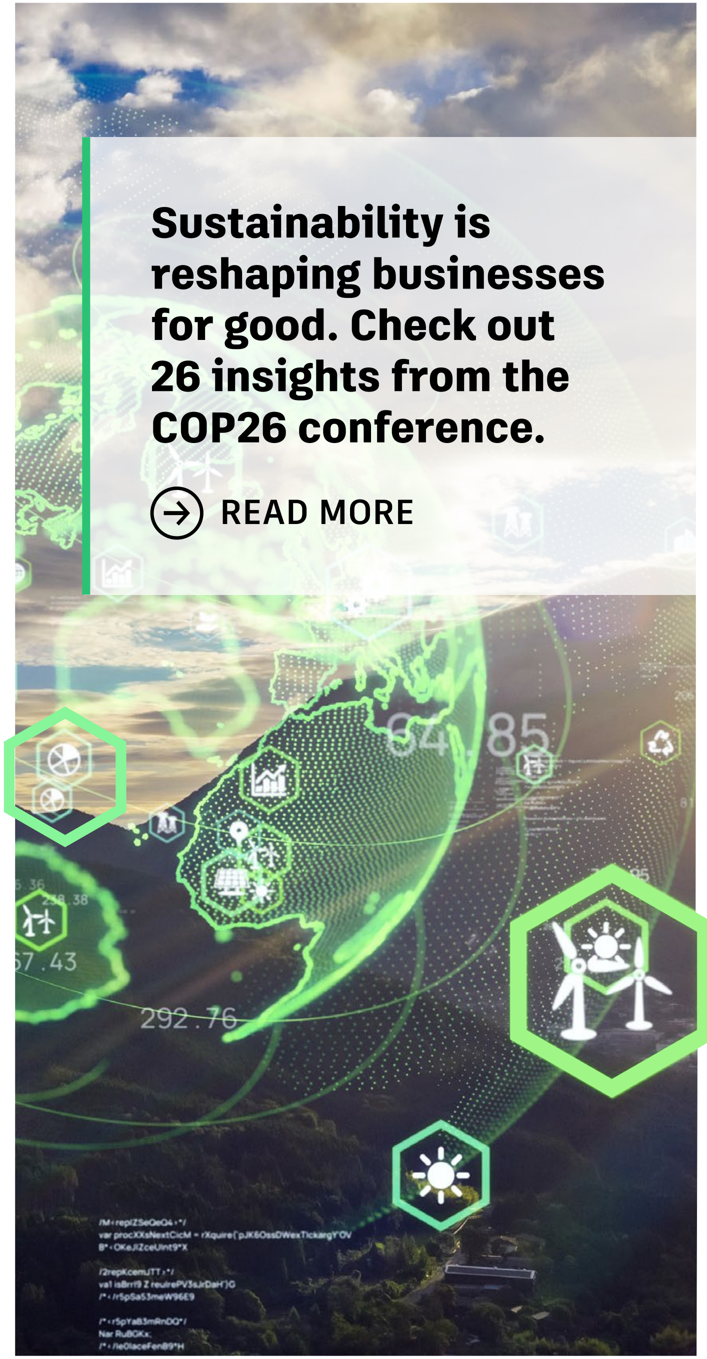
Historically, a lack of transparency in carbon-accounting practices has plagued the construction industry, which made the need to act—and to diverge from business as usual—urgent. "We need to understand as an industry that we can't wait for perfection," Smedley says. "We wanted to put something out there so folks can start doing something now."

If the industry's reaction to the launch of the EC3 tool—with more than 14,000 registered users and companies such as Webcor committing to use the calculator on all new construction projects—is any indicator, this was definitely the right move.

Lifecycle Assessment App Tally Joins EC3, With tallyCAT on the Horizon

In May 2021, KieranTimberlake architecture firm gifted its lifecycle assessment (LCA) app, called Tally, to Building Transparency, making the EC3 tool more powerful and efficient. With Tally, users can include detailed information about the products and materials their buildings will contain and conduct whole-building LCAs during the design phase. According to Smedley, "The list of materials and quantities generated in Tally imports directly to the Embodied Carbon in Construction Calculator tool, so bringing these assets under one roof fosters a more efficient process workflow to optimize both tools' capabilities."

The CleanBC Building Innovation Fund awarded a grant of $460,000 to architecture firm Perkins&Will to create the next-generation Tally Climate Action Tool (tallyCAT), which will be able to leverage Tally and EC3 directly within BIM programs. Developed in collaboration with C Change Labs and Building Transparency Canada, tallyCAT will build on existing technologies to provide open, real-time access to material and product information. The tool is slated for release in March 2023.



Takeaways

Green building is good for the environment and good for business. Whether their goal is to create net-zero buildings, control embodied carbon, or meet Passive House and other building design standards, building owners who engage in green building efforts can achieve both environmental and financial benefits.

WILD, courtesy of Katrina Urbanik AS.

Building owners play a critical role in green building.

Buildings are the largest source of the world's carbon emissions, generating nearly 40% of annual global CO2 emissions. Approximately 66% of today's global building stock will still exist in 2040.

If done right, green buildings don't cost money; they make money.

The average operating-cost savings of a new green building within its first year exceed 10%, and the five-year cost savings exceed 16%. Green renovations and retrofits of existing buildings perform even better, at 11.5% and 17%, respectively.

The need for new green buildings and green retrofit projects has never been greater.

And the methods for going green have never been wider, from a tool that measures embodied carbon to sensor technology that makes buildings more energy efficient.

Learn more about the drivers behind green building, what industry peers are planning, and how to stand out from the competition in the World Green Building Trends *2021 report.*

DOWNLOAD THE REPORT

The Sustainable Innovation Forum at COP26 featured thought-provoking discussions on how technology can help create greener and more resilient buildings and infrastructure.

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