Reducing Embodied Carbon in Construction

An inside look into how Microsoft is reducing emissions during the construction of new buildings and datacenters

Contents

Foreword

Energy efficiency in buildings has been increasing since the oil crisis of the 1970s, and combined with the rise of renewable energy, operational carbon emissions have been steadily decreasing. That places focus on a key source of greenhouse gas emissions associated with buildings—embodied carbon.

At Microsoft, we have a longstanding commitment to sustainability and reduction of carbon emissions. Recently, we have begun to test new carbon reduction strategies on new projects—our Puget Sound campus modernization project and datacenter builds.

The Puget Sound campus modernization project, located at our headquarters in Redmond, Washington, includes the construction of 17 new buildings totaling 2.5 million square feet of workspace. We have committed to removing fossil fuels from these new buildings for daily operations, and we operate our campus on 100 percent carbon-free electricity. We are also reducing the amount of carbon associated with the construction materials of our new buildings by at least 30 percent enabled by a new online tool called the Embodied Carbon in Construction Calculator (EC3). Combined with our smart building technology, Microsoft will be among the first large corporate campuses to achieve zero-carbon and zero-waste milestones.

In our datacenters we continue to focus on sustainable design and operations, and we are using EC3 in our datacenter projects to reduce the embodied carbon of our construction materials.

From our work so far, we have gathered a wealth of information about how to reduce embodied carbon through the selection and procurement of low-carbon products and the tracking and reduction of carbon emissions during construction. We have learned a lot along the way, but know we still have a long way to go.

At Microsoft we believe in changing the world through data science and transparency. Our hope is that by sharing our insights with this white paper, we will help sustainability consultants, owners, engineers, architects, general contractors, suppliers, and manufacturers learn more about how to reduce embodied carbon.

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Executive summary

At Microsoft, carbon is one of our four environmental priorities (alongside water, waste, and ecosystems). We have committed to being carbon negative by 2030. While carbon emissions occur in all aspects of operations here at Microsoft, from operating our buildings and datacenters to employee transportation, this white paper places a focus on what we are doing to reduce embodied carbon in the design and construction of our buildings and datacenters.

We know that, to combat climate change, big steps must be made in embodied carbon emissions reductions. But where do we start? The first step is to understand the true carbon emissions impact of our buildings by procuring materials with third-party verified Environmental Product Declarations (EPDs). The carbon footprint of a product, such as insulation, varies based on where it was manufactured, how it was manufactured, transportation methods and distances to the plant, and material efficiency. The informed selection of a product requires knowing this information ahead of time, and we have piloted a new tool to help us unlock this data.

The second major step in understanding the embodied carbon of a building is the construction phase. Tracking of carbon emissions during construction has not been done at this level before, and Microsoft has done it for our entire 17-building campus in Redmond, Washington. Through this endeavor we have learned new processes and created new methods to make the data collection process smoother.

Construction best practices at Microsoft
Use EC3 from design through construction to select and compare materials
Request EPDs from manufacturers and suppliers
Write performance-based specifications
Identify recycling and reuse opportunities
Create a Construction Activity Carbon Reduction Plan (CACRP)
Identify water reclamation opportunities during construction

Using this carbon emissions from construction data, we can set our own baselines. This data can then be used to set benchmarks for carbon emissions related to future construction, and will enable us to understand what level of reduction is possible. Beyond carbon emissions, Microsoft has also committed to being water positive and zero waste by 2030, and has worked to benchmark and reduce potable water consumption and deconstruction waste in the building process.

Our goal is to share the data coming out of our pilot projects, as well as our lessons learned, with the hopes that other organizations adopt deep carbon reduction commitments and share their experiences in return. Together we can tackle climate change.

Introduction

Microsoft's ambition is to become a carbon negative company in less than a decade. Our focus on carbon emissions started in 2009 when we made a series of commitments to reduce the company's carbon footprint. We have been carbon neutral across our Scope 1 and 2 emissions and employee travel since 2012. Like most carbon-neutral companies, Microsoft achieved carbon neutrality primarily by investing in offsets.

However, in 2020 we concluded that "neutral" is not enough and pledged to be carbon negative by 2030. Our commitment focuses on three main components. First, we will drive down our Scope 1 and 2 emissions to near zero by the middle of this decade. Second, we will reduce our Scope 3 emissions by more than half by 2030. Lastly, we will remove more carbon than we emit, setting us on a path to remove by 2050 all the carbon the company has emitted either directly or by electrical consumption since it was founded in 1975. One year in, we have reduced Microsoft's carbon emissions by 6 percent and removed 1.3 million metric tons of carbon from the atmosphere.

The biggest challenge of this moonshot is Scope 3. At Microsoft, we were responsible for almost 16 million metric tons of carbon emissions in 2020. Of this total, about 100,000 were Scope 1 emissions and about 4 million were Scope 2 emissions. The remaining 12 million tons—three quarters of our responsibility—all fell into Scope 3. Scope 3 emissions covers a wide variety of sources grouped into 15 categories, including purchased goods and services, waste generated in operations, and investments.

Purchased goods and services includes the design and construction of buildings. According to the latest data from the Global Alliance for Buildings and Construction, manufacturing of building materials and construction of buildings makes up 10 percent of total global energy-related carbon emissions and 26 percent of global building sector emissions. To address this, the architecture, engineering, and construction (AEC) industry must drastically reduce carbon emissions. The industry has recognized this and has taken steps to establish reduction targets. For example, Architecture 2030, an organization focused on responding to the ongoing climate emergency, issued the 2030 Challenge for Embodied Carbon asking the global architecture and building community to reduce embodied carbon emissions from all new buildings, infrastructure, and associated materials by 40 percent now, 65 percent by 2030, and 100 percent by 2040. The focus of this white paper will be on the steps Microsoft is taking to reduce our Scope 3 carbon emissions through the building of sustainable campuses and datacenters.

The big picture: why are carbon emissions important?

Climate change is here. With it comes a host of long-term effects, including rising global temperatures, more droughts, floods, and heat waves, more intense hurricanes, and rising sea levels. To drastically reduce these effects, the Intergovernmental Panel on Climate Change (IPCC) and the Paris Agreement have set a limit on global warming to "well below" 2°C with efforts to limit to 1.5°C. If we do not focus on reducing total global carbon emissions now, we will have lost the opportunity to meet the 1.5–2°C warming threshold, and climate change will continue at an alarming rate.

Narrowing the focus: construction and materials emissions

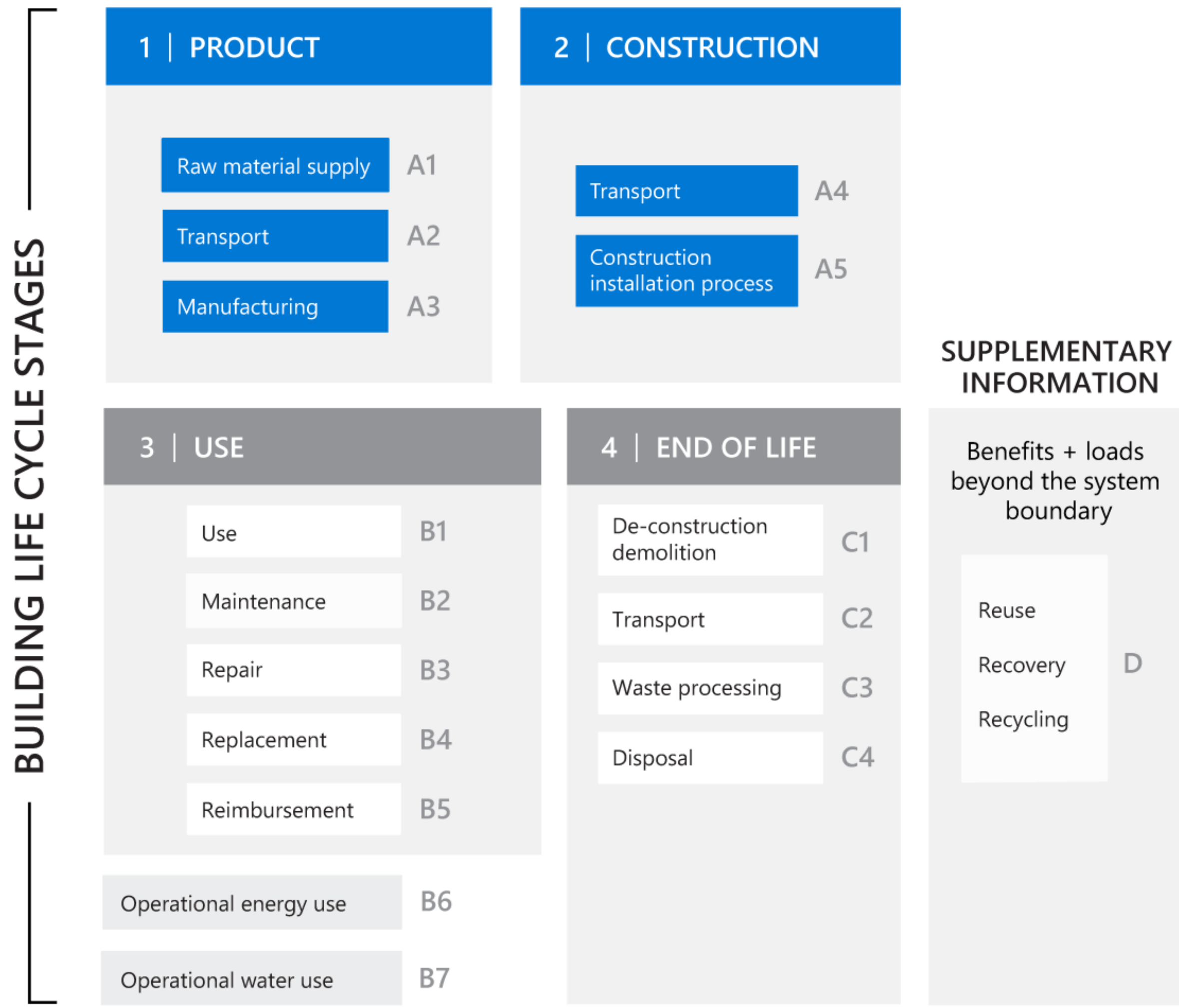
The carbon emissions associated with a building can be grouped into two major categories—operational carbon and embodied carbon. Operational carbon, which includes carbon emitted while heating, cooling, and providing power to a building, falls under Scope 1 and 2 emissions. Microsoft has historically focused on reducing operational carbon through energy efficiency projects, eliminating use of fossil fuels, generating renewable energy onsite, and procuring offsite renewable energy. Microsoft is committed to sourcing 100 percent renewable energy by 2025 for operational needs, and is increasingly electrifying our infrastructure such as our all-electric Puget Sound campus modernization project.

Embodied carbon, which is the carbon released during the material extraction, manufacturing, production, and transportation of building materials, and during the construction of a building, falls under Scope 3 emissions. Unlike operational carbon emissions which can be reduced over time through energy efficient renovations and renewable energy, embodied carbon emissions are locked in place as soon as a building is built. For that reason, it is critical to understand and reduce embodied carbon before construction begins. Tracking embodied carbon begins in early design, through a life cycle assessment (LCA).

Life cycle assessments: opportunities by stage

An LCA captures the environmental impacts of a building (or product) from all phases of its life, including material selection and procurement, construction, operations, and decommissioning.

The following graphic outlines the stages of a building LCA. The system boundary of a whole-building LCA accounts for cradle-to-grave scope, which includes upfront emissions during design and construction (A1-A5), product replacement and refurbishment (B1-B5), and end of life (C1-C4). Each of these stages includes opportunities to reduce carbon emissions.



In the product stage (A1-A3), emissions reductions are achieved by the design and construction team through careful selection of products that have more sustainable material extraction and manufacturing processes, and fewer transportation emissions. One example of this is selecting manufacturers who use and document less carbon-intensive manufacturing processes.

In the construction process stage (A4-A5), emissions reduction opportunities include focusing on efficient transportation of materials to the site, selecting energy-efficient equipment for installation, and using biofuel blends for equipment.

In the use stage (B1-B5), carbon can be reduced by selecting durable materials that require less maintenance and less frequent replacement. In the end-of-life stage (C1-C4), deconstruction of buildings rather than demolishing can reduce emissions by diverting waste from waste processing (C3) and disposal (C4), and also reduces transportation emissions (C2). In addition, deconstruction can ensure more opportunity for reuse and recycling which reduces the need for raw materials. Such circular practices are beyond the system boundary for one LCA, but they can reduce the embodied carbon of a future building.

As outlined previously, the focus of this white paper is on the first two stages (A1-A5), including material selection and procurement, and construction phases. We have placed special focus on these areas to highlight recent developments and to share the lessons Microsoft has learned along our journey of tracking and reducing carbon emissions.

You can learn more about LCAs through the Carbon Leadership Forums LCA Practice Guide or through ISO Standard 14040 Environmental Management – Life Cycle Assessment – Principles and Framework.

The business case for reducing embodied carbon

At Microsoft, our motivations for reducing embodied carbon first stem from the desire to be good stewards of our environment and prevent the worst impacts of climate change. However, increasingly there are many reasons beyond environmental impacts and climate change that can motivate organizations to measure and reduce embodied carbon. Several of these are outlined in the UK Green Building Council's document Embodied Carbon: Developing a Client Brief, including:

- **Reputational**—Customers and investors are increasingly prioritizing the environment in their purchasing and investment decisions. ESG investing is a form of sustainable investing which evaluates companies on three categories: environment, social, and corporate governance. Environmental factors including embodied carbon and greenhouse gas emissions mitigation, use of natural resources, and sustainable products are considered.
- **Commercial and operational**—Considering embodied carbon in design encourages resource efficiency and unlocks innovations. It can also assist in achieving credits in building rating schemes such as U.S. Green Building Council's (USBGC) LEED and International Living Futures Institute (ILFI).

Product stage: making smarter design decisions

Architects, engineers, sustainability consultants, and contractors have long been exploring how to reduce embodied carbon in buildings. One option is to find ways to make better use of what's already built or optimize designs to build less. For example, in our datacenter projects we have updated our design to accommodate more capacity within the same footprint, and on our new Silicon Valley campus we elected to keep two of the original structures to keep existing buildings in use.

Outside of identifying ways to optimize building footprint, there are opportunities to reduce embodied carbon based on the materials selected. As outlined previously, the first step in an LCA is the product stage, which accounts for the carbon emissions from raw materials extraction, transportation of materials to a plant, and manufacturing of a final product. However, there are still gaps in this process, and the focus of this section is on new tools and processes that Microsoft teams have discovered and developed which can be used in the procurement of low-embodied carbon materials.

Early on, many decisions are made about the building form, structure, and enclosure, which will ultimately set the direction of the building's A1-A3 emissions. To help guide this process, design teams use whole-building LCA (WBLCA) software tools. The focus of early phase whole-building LCAs is often to compare different structural systems (such as steel versus concrete) or architectural massing options across a variety of impact categories, including greenhouse gas emissions, ozone depletion, acidification of soil and water, and air pollution. Based on this information, changes can be made to the building systems, such as the type of structure or flooring, or to the architecture of the building to reduce the building's environmental impact through its end of life.

While WBLCA tools serve a targeted purpose in the design of a low-carbon building, Microsoft has recently been focusing on how we can reduce emissions from the product stage (A1-A3) by concentrating on procurement of materials in our buildings during construction. When selecting a low-carbon product, the first thing we look for is an Environmental Product Declaration (EPD).

EPDs are "a standardized way of communicating the environmental effects associated with a product or system's raw material extraction, energy use, chemical makeup, waste generation, and emissions to air, soil and water" (USGBC LEED v4 Building Design and Construction Reference Guide). WBLCA tools typically use average material LCAs or industry-wide EPDs which are purposely generic to a product, such as concrete, and not specific to any one manufacturer. These EPDs, or generic assessments, can be used to help guide a designer to select materials that, on average, have lower embodied carbon, but they cannot be used to inform selection of specific products or manufacturers. These industry wide EPDs are especially helpful to guide the design of a building before material quantities are known.

In contrast, product-specific type III EPDs have third-party certification, and the declaration is specific to a particular manufacturer and does not necessarily reflect the practices of the rest of the industry. Therefore, transitioning from the industry-wide EPD data used in early design to type III EPD data when materials being used are known creates an opportunity to further reduce embodied carbon by enabling teams to verify the carbon impact of a product purchased from a single manufacturer.

Introducing the Embodied Carbon in Construction Calculator (EC3)

Until recently, there has been little standardization for this process of moving from the industry-wide EPD datasets used during the design phase to product-specific EPD data when the construction phase begins. This is where EC3, the Embodied Carbon in Construction Calculator, steps in. This free, open-access tool was co-conceived by Skanska and C-Change labs, and was incubated by the Carbon Leadership Forum with over 50 industry partners, including Microsoft. Once launched, EC3 was transferred to Building Transparency, a non-profit organization whose mission is to provide open-access data and tools to address embodied carbon's role in climate change.

Historically, material suppliers have found it challenging and expensive to publish EPDs. The EPDs that were published could be found in a variety of different EPD databases, some of them proprietary and competitive with each other. Virtually all EPDs were in a format that could not be easily evaluated or compared digitally.

With the launch of the EC3 tool, for the first time, thousands of digital product-specific type III EPDs are now available in a free, open-access database. This allows building design and construction teams to directly compare EPDs against each other and select products based on their emissions performance criteria.

> *"The thing we like most about EC3 is the commitment to be free and open access—the data is democratized making it easier for companies and organizations to use it to inform decisions."*
>
> *—Katie Ross, Microsoft Real Estate & Facilities*

Besides being a database of product-specific EPDs, EC3 takes in material quantities (such as concrete, steel, aluminum, carpet), and, using conservative reference material estimates, as well as baselines set by the Carbon Leadership Forum (CLF), shows the potential range of carbon emissions for a specific material based on that EPD database. The tool creates a Sankey diagram that allows teams to see what the CLF baseline emissions are for each material category, along with the potential carbon reduction based on the EPDs available in EC3, and finally the actual carbon reduction "realized" based on the product selected for the project. To find out more about EC3, visit Building Transparency's website, which outlines key features and user benefits, and includes a product brief.

Microsoft is a lead sponsor of EC3 and its first large corporate user. Using EC3 has enabled our campus modernization project team to be on track to reach our commitment to reducing A1-A3 embodied carbon by at least 30 percent compared to the 2019 CLF baselines, as well as supported our pursuit of ILFI's Zero Carbon Certification.

Manufacturer EPDs

While EC3 has opened the floodgates to make the process of collecting and comparing product-specific EPDs easier, there is still a constant need for EPDs to be created for both new products and existing products already on the market. The more EPDs that are available, the more informed product decisions can be made.

So how do you ensure the products you want to use have EPDs? In our experience, it has been helpful to engage the supply chain by reaching out to manufacturers and suppliers well before construction starts. EPDs that aren't already available can take anywhere from four months to a year to produce. When engaging with the supply chain, we recommend discussing the project and owner's embodied carbon reduction goals and requesting that the manufacturer produce product-specific type III (third-party verified) EPDs so that when the project comes to bid, they can be prepared.

To assist in requesting EPDs, it is helpful to send an official letter to suppliers and manufacturers. To have maximum impact, this letter can be signed not only by design and construction teams, but also by the owner. This ensures suppliers understand that these EPDs are needed not only for this project, but for all future projects from a particular owner. The Puget Sound campus modernization project sent out a letter to suppliers to request EPDs, resulting in new EPDs being created for a variety of products and manufacturers, including the first precast concrete EPD in the United States. Building Transparency includes sample EPD request letters on their website.

Once EPDs are requested from suppliers, the suppliers still need to go through the process of collecting the data points required for an EPD, getting it third-party verified, and publishing it. This process must be repeated for each unique product, and since typical EPDs can take a minimum of four months to produce, this can create a bottleneck, especially for highly customized products such as concrete mixes. To help remedy this for concrete mixes, suppliers can utilize Climate Earth to create on-demand EPDs. Climate Earth offers a Ready Mix EPD Generator which enables concrete producers to created unlimited, instant, and verified (type III) EPDs for any concrete mix.

More information for manufacturers and suppliers on obtaining an EPD is available from Building Transparency.

Writing specifications

As an added level of insurance that EPDs are provided, we have required EPDs in specifications. We found that it is best to require product-specific type III EPDs for at least the major material categories: concrete, structural steel, insulation, ceiling tile, carpet, aluminum, and glass. We have also found that writing performance-based specifications for materials like ready-mix concrete, rather than specifying a particular product by name, allows EC3 to guide the team to the best product. This also allows teams the flexibility to find the best solutions.

For example, in our datacenter projects, for cast-in-place concrete, instead of specifying a percentage of supplementary cementitious material in a concrete mix, the following specifications are used:

- **Benchmarks for carbon emissions.** For example, the Carbon Leadership Forum's (CLF's) current High—National Embodied Carbon Baselines for Ready Mixed Concrete, or the current National Ready Mixed Concrete Association (NRMCA) regional benchmarks where available for the specific region that the project will be located.
- **A requirement that the contractor must supply an EPD.** The specification required that the contractor supply a product-specific type III EPD targeting a Global Warming Potential (GWP) that is at a specified percentage better than the baseline.
- **A list of best practices to optimize embodied carbon.** Guidance was provided for the contractor on methods to reduce embodied carbon, such as higher levels of fly ash or slag; Type 1L cement as an alternative to Portland cement; and longer curing time, among other options. The NRMCA has a Specification in Practice series which outlines important considerations for concrete specifications.

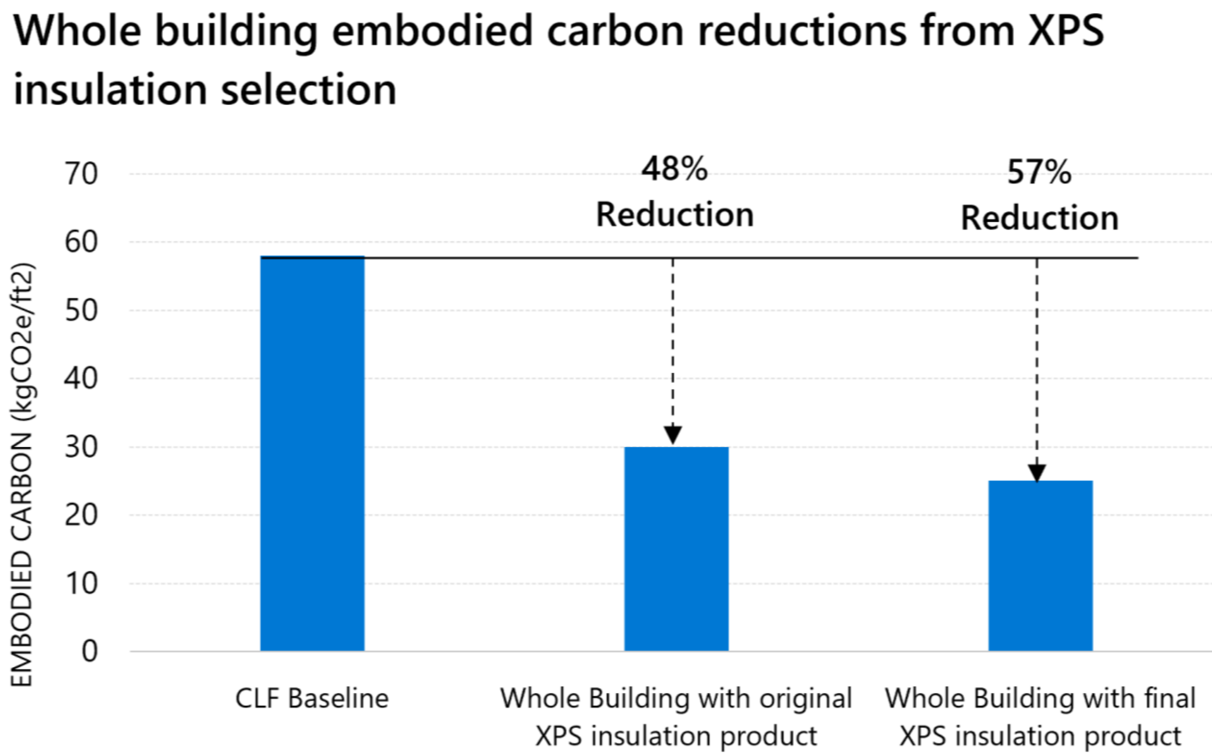
For specifications for a variety of materials including concrete mixes, Building Transparency includes example specifications, as does the Carbon Leadership Forum, and the Carbon Smart Materials Palette provides guidelines for low/no-carbon material selections and specifications.

Material alternatives

While obtaining EPDs for products or manufacturers specific to your project is critical, there are already thousands of EPDs available on EC3 that enable design and construction teams to compare products and identify performance targets for specifications. It is not necessary to wait for new materials to come onto the market to reduce carbon as there are ample opportunities right now. There are many products which have comparable cost and performance but have very different embodied carbon. Often making a simple switch from one manufacturer to another for a particular product can result in a carbon emissions reduction.

For example, one could switch to products with high recycled content, or source steel that comes from electric arc furnaces which use less than half the CO_2 as basic oxygen furnaces. Another example might be to swap carpet tile for broadloom carpet, which results in 10–20 percent less installation waste.

On our campus modernization project, we found that simply changing our XPS insulation manufacturer reduced our embodied carbon by about 5–8 percent overall per building. More information about material alternatives can be found from the Carbon Smart Materials Palette.



Another resource for the potential of using low-carbon and carbon-storing materials in new construction is the Carbon Leadership Forum's recent study Carbon Storing Materials. The study found that a sizable reduction (around 60 percent) in embodied carbon is possible in two to three years by bringing readily available low-carbon materials into wider use. Furthermore, this work predicts that fostering a carbon-storing material supply system by investing in the development and manufacturing of nascent carbon-storing materials industries will make a carbon-positive future for individual projects possible in three to five years.

Procuring low embodied carbon materials

The last step in the product stage is the final procurement of materials by the contractor. There are several areas to consider, one of which is embodied carbon. On our campus modernization project, Skanska Balfour Beatty (SBB) started by asking bidders for specific product information at time of bid and throughout the procurement process to confirm that product's EPD availability in EC3. Once that information was obtained, SBB utilized EC3 to present the embodied carbon impacts alongside cost, schedule, and responsiveness during the bid process, among other factors. The criteria will look different for each product.

For example, for the concrete bids, the categories considered were price, quality of product, team, schedule, plant capacity, proposal responsiveness, carbon reductions, and innovations. Next, EPDs were required for project mixes, and the general contractor compared these EPDs to NRMCA regional industry average emissions (EC3 was not yet an available resource). In the end, SBB presented the emissions data between the two concrete bidders and was able to recommend the supplier with the lowest cost, largest plant capacity, and highest carbon reductions.

For carpet manufacturer specification and selection, cost and carbon emissions were compared for each manufacturer, along with PVC content of the carpet, type of adhesive used, and moisture mitigation. All manufacturers had PVC-free carpet with high moisture mitigation, so the decision came down to cost and carbon emissions. For most of the carpet chosen to date, the selected manufacturer had both the lowest overall cost and the highest carbon reduction.

Applying EC3 in pilot projects

Now that we have outlined how to make smarter product selection decisions, we will shift focus to how to capitalize on the use of EC3 throughout the design and construction process. Microsoft has used EC3 on our Puget Sound campus modernization project, which includes 17 new construction buildings, and on datacenter projects. The campus modernization project alone includes three general contractors and six architects, all working closely together to ensure our 30 percent embodied carbon reduction goal is met, which means we have had a lot of practice with understanding how to work together as a team.

Microsoft teams have learned that while it is important to use EC3 in the construction phase to drive product selection, using it from the schematic design phase enables the greatest impact and provides a more seamless implementation. Datacenter projects often have a global model that is replicated to maintain standardization and to control costs. However, for embodied carbon, the opportunities are different for each project based on what materials are available locally. Requiring the use of the EC3 tool in our construction contracts was very important for the team because it helped to manage our global portfolio.

"We see EC3 as an opportunity to not only reduce the embodied carbon of our own builds, but to drive data transparency and sustainable construction materials on a global scale."

—Jim Ellis, Microsoft Cloud Operations + Innovation

The following outline was created to help guide the process of using EC3. More on this process, including how to use EC3 alongside a WBLCA tool, can be found in Building Transparency's resource EC3 Primer for AEC Professionals.

1. Architecture/Engineering (AE) firm:

a. Create the initial EC3 model to review materials and identify potential carbon hot spots in the building design. Use EC3 projections to define an achievable carbon reduction target.
b. Before construction starts, do outreach to suppliers and manufacturers to notify them that this project will be collecting data on embodied carbon through EPDs, and ask if they can provide this information.
c. At the end of the construction documents phase, update specifications to optimize embodied carbon reductions.

2. Sustainability Consultant or Quality Controller:

a. Identify overlap with LEED credit opportunities and provide options to align the embodied carbon and LEED frameworks.

b. Review EPDs and embodied carbon submittals to ensure they are in line with the project requirements and ensure that EPDs submitted by suppliers meet industry best practices.

3. General Contractor:

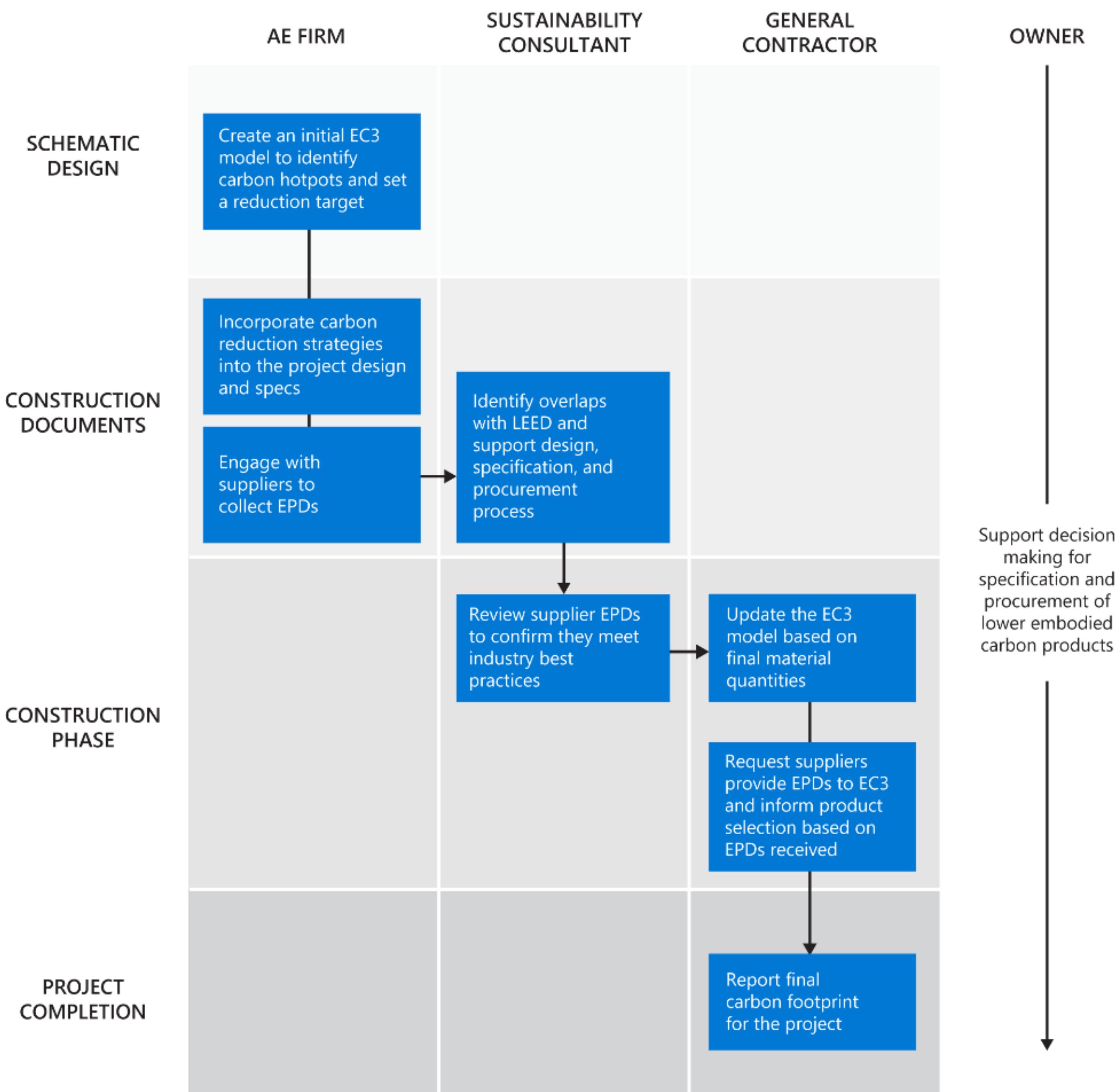
a. Update and refine the EC3 model with actual project materials and quantities.
b. Use direct connections with subcontractors and suppliers to reiterate the need for embodied carbon documentation through EPDs, and ensure the owner has all the information needed up front to compare products and make choices across multiple data points, including carbon.
c. Update the EC3 model through construction completion by verifying material quantities and selecting product-specific EPDs used on projects, and track progress against embodied reduction targets. At the end of construction, provide final numbers to owner for greenhouse gas inventory reporting.

4. Owner:

a. Throughout all phases, support decision making for purchase of lower-embodied carbon products.

Refer to Building Transparency's Owners Carbon Action Network (OwnersCAN) Embodied Carbon Action Plan. OwnersCAN is a group of owners convening to align on embodied carbon accounting methodology and reductions, and Microsoft is a founding member. The Embodied Carbon Action Plan will be released in summer of 2021 as an open, interactive resource on Building Transparency's website.

Use of the Embodied Carbon in Construction Calculator (EC3)



Lessons learned

By using EC3 throughout the design and construction process, we have learned a few lessons that general contractors, architects, and engineers may benefit from:

1. **Set an embodied carbon reduction target.** At the beginning of the project, set an achievable reduction target to focus the team on identifying materials and reuse opportunities that will contribute to the overall project goals.
2. **Get buy-in from all team members.** Make sure the entire team is onboard early on, including the owner, architects, engineers, and general contractors. Ensure everyone has working knowledge about embodied carbon and what the project is trying to achieve. Many decisions will be made that can affect carbon and everyone in the design and construction teams needs to work together.
3. **Start early.** Start using EC3 in the design phase. Once the model is built, review the detailed output reports to identify carbon intensive hot spots in the design. Are there certain materials beyond the typical (concrete, steel, glass, aluminum) that have a high carbon intensity?
4. **Require general contractors to use EC3 and include embodied carbon as an award criteria with subcontractors.** Ensure general contractors are required to use EC3, and subcontractors are required to include embodied carbon reporting in their bids by providing language in RFPs. For example, for concrete subcontractor bids, the campus modernization project required EPDs for all concrete mixes utilized on the project, actual reductions of carbon emissions in concrete mixes utilized on the project, and an embodied carbon reporting form.
5. **Update the model constantly with information from subcontractors.** In the construction phase, use EC3 more iteratively. Constantly update it with new material selections, and make sure you have someone on the construction team who knows how to use EC3. This allows the construction team to stay on top of the influx of information from suppliers and bids. For the campus modernization project, all bid/procurement-level information from subcontractors was input into EC3. For many materials (such as steel and glazing), suppliers are not secured until after subcontractors have been awarded the project. A lot can change from the time a scope of work is awarded to a subcontractor to when an actual purchase order is made for a material, so following through during the entire process—from procurement of a subcontractor through actual installation of the material—is crucial to realizing embodied carbon reductions.
6. **Ensure the design team has visibility to any potential changes to the supply chain during the procurement process**. The architect/engineer should be aligned with any potential material change as it relates to their design and specifications. For example, the contractor may identify a lower-carbon glass manufacturer but it is essential to make sure that manufacturer can meet the architect's specifications and design intent.

Construction process stage: creating a baseline

For construction process (A4-A5) emissions, which include transportation of materials to the construction site and construction installation, there is little data or established methodology for creating a baseline, making it difficult for design teams to know if their emissions are better or worse than a typical construction project. Almost no projects have tracked construction activity emissions to a high level of detail on a typical construction project.

Microsoft, along with our general contractors, decided to focus on this challenge and piloted the tracking of construction activity emissions on our Puget Sound campus modernization project. Through this endeavor, we've learned a lot about what works and what doesn't and have distilled out some best practices to share. We can't say it will be easy, and we can't say that we've figured it all out, but the more teams that decide to tackle this challenge, the easier it will become for those who follow.

We tracked carbon emissions starting with the demolition phase (including site excavation) and even tracked how much water we used. When construction is complete, we will translate this data into normalized metrics so they can easily be used on future projects. For example, we will measure by $kgCO_2e$/cubic yard for excavated soil and $kgCO_2e$/square meter for demolished buildings. Armed with the right data, we can weigh decisions about carbon reductions in a way virtually nobody in the construction industry ever could before.

> *"We have to realize that just tracking this is a big win. It's like that zero-waste quote we all love, 'We don't need a few people doing zero waste perfectly. We need millions of people doing it imperfectly.' Having each of the partners on the team step up to do this in the first place and track this data on the project level is that critical first step. Every bit counts when dealing with carbon emissions reduction."*
>
> *—Stacy Smedley, Skanska Balfour Beatty*

Deconstruction: recycling and reuse

In 2016, Microsoft became the first technology company in the United States to be certified Zero Waste for diverting at least 90 percent of its waste from the landfill. The company's goal with the Puget Sound campus modernization project is to remain in line with this certification for construction materials and divert a majority of building materials from the landfill. This means focusing on reusing, donating, and recycling.

As a part of the campus modernization project, 12 existing buildings were deconstructed. This created ample opportunities for our construction teams to get creative and work with suppliers and manufacturers to identify ways to achieve 90 percent diversion of waste from landfill. We started with asking ourselves and our suppliers: What can we do with deconstruction waste? Can we work with suppliers to take back materials and recycle them into new materials, perhaps reusing them in the new construction project? How can we reduce the emissions associated with transporting this waste offsite?

Asking these questions led to several reuse opportunities. The concrete waste from the existing reinforced concrete buildings was crushed on site and used as rock for temporary roads and for fill for the new campus. This not only eliminated the use of a new material, but eliminated the emissions associated with hauling out the demolition waste and hauling in new fill.

We worked with one of our acoustical ceiling tile manufacturers and one of our carpet manufacturers to salvage the ceiling and carpet tiles from the existing buildings and move it into the production of new products. We've even taken it a step further to discuss with our ceiling tile manufacturer if the salvaged ceiling tile can be recycled into new ceiling tile which is then installed on the new campus. While the procurement process is still in progress, we are excited to support a circular economy and showcase what can be done.

Beyond salvaging and recycling materials onsite, hauling of salvaged material offsite can also be optimized. Instead of trucking the salvaged ceiling tile to the manufacturer's plant to be recycled, the construction teams used rail cars, reducing the transportation emissions.

> *"The key to making Zero Waste work is a close relationship with suppliers. We had an existing relationship with our carpet and ceiling tile suppliers through the Materials Carbon Action Network (materialsCAN), which enabled our team to ask openly about material reuse opportunities and work together to come up with a plan of action."*
>
> *— Stacy Smedley, Skanska Balfour Beatty*

Construction Activity Carbon Reduction Plan

After considering recycling and reuse opportunities in the deconstruction of our existing buildings, we shifted our focus to construction of the new campus. Because tracking of construction carbon emissions is an emerging area, most of our construction team had not done it before, at least not at this scale. To help guide the process, the general contractors on Microsoft's Puget Sound campus modernization project, including Skanska Balfour Beatty, Sellen Construction, and GLY Construction, collaborated to write a Construction Activity Carbon Reduction Plan (CACRP). This plan applies to all subcontractors, suppliers, and general contractors, and outlines the requirements to track fossil fuel use of all A4 and A5 emissions, covering the construction installation process as well as monthly reporting requirements:

- Off-road vehicles, equipment, and tools used within the jobsite—
    - Report number of vehicles, fuel type, engine tier of equipment, and either the total amount of fuel used or total number of hours for each type of equipment.
- Delivery vehicles for building materials—
    - Report total round-trip miles per each type of vehicle and the type of vehicle (such as light or heavy duty) used for the delivery, as well as miles per gallon, if known.
- Crew transport provided by the general contractor—
    - Report fuel use of shuttle busses from parking lots to the jobsite.

This plan also sets an anti-idling requirement to reduce non-productive idling, and outlines recommended best practices which include:

- Equipment electrification.
- Prioritizing Tier 4 final equipment, which includes large equipment used for earthwork or paving.
- Retrofitting older large equipment with best available technology. For Tier 3 or lower, investigate retrofits, such as diesel oxidation catalysts or diesel particulate filters.
- Using biofuel blends. Where permitted by rental agreements and equipment warranties, use a B20 biofuel blend (20 percent biofuel and 80 percent diesel or renewable diesel fuel).
- Delivery optimization. Review the on-jobsite wait times for concrete truck deliveries. Identify patterns of excessive wait time and discuss with field team how to optimize ordering and placement. For other deliveries, group items into as few delivery trips as possible.
- Temporary power. Connect to temporary electric power instead of generators where possible. If generators are needed, select generators with a Tier 4 engine. Use temporary power units that have timed shut-off with manual override.
- Solar charging. Consider a photovoltaic charger station for charging small tool batteries, and a photovoltaic array for powering construction site trailer.

From implementing this plan on our Puget Sound campus modernization project, we have learned a lot. Since all of our general contractors and subcontractors are working together to collect this data for the first time, everyone is constantly learning, collaborating, and adapting.

Following are a few of our top learnings for implementing a CACRP. No matter what requirements you set forth in the beginning, one of our biggest tips is to allow room for flexibility and change—this is a rapidly changing process in the construction industry, and we all need room to grow and learn.

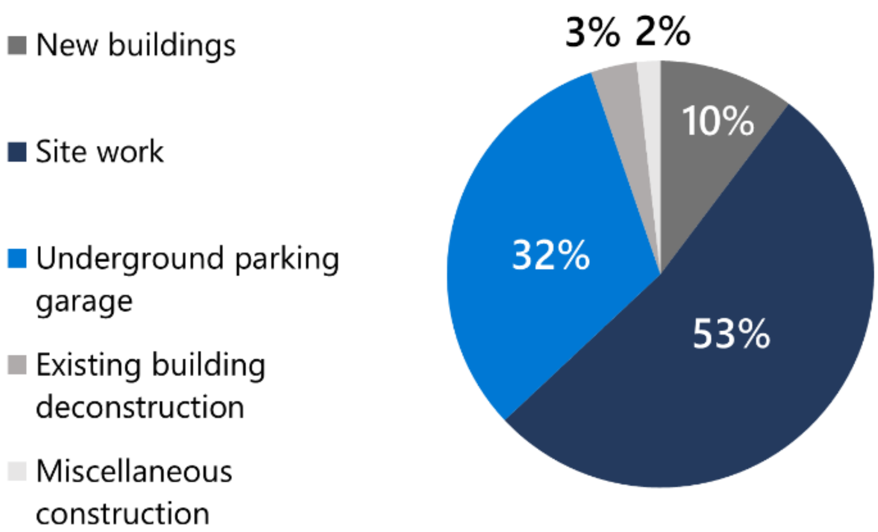
1. **Create a Construction Activity Carbon Reduction Plan (CACRP).** This plan should outline the requirements for tracking A4, A5, and other construction activity related emissions.
2. **Reflect CACRP requirements in contracts.** Place this language in RFPs and subcontractor exhibits. Setting expectations early on will help subcontractors prepare for tracking and documentation.

3. **Educate everyone involved in the construction process.** Discuss requirements at preconstruction meetings with subcontractors and suppliers. Train field laborers, flaggers, and people who check in the trucks as they approach the jobsite. Everyone involved has to understand the goal and what is included in the CACRP.
4. **Use technology to catch as much data as possible.** While the CACRP looks simple on paper, it takes a lot of work to obtain all of the required information consistently. Use technology to help capture data where possible. On the Puget Sound campus modernization project, each general contractor used a different approach to capture the necessary data for construction activity carbon reporting. GLY Construction is using a QR code at their jobsite entrance that links to a form every driver is required to fill out. Sellen Construction is using a Smartsheets webform tied to their pay app for when suppliers report out.
5. **Allow flexibility in data collection.** Some suppliers track mileage on their vehicles while others track fuel purchases. No matter what the format is, keep it simple by allowing suppliers to maintain their existing tracking systems, which will also keep any added costs down.
6. **Articulate what reporting needs to look like and build this into the project schedule.** With so many possible ways to report for a CACRP, standardizing the process and setting clear expectations is helpful. Communicate when reporting is due in the project schedule so everyone understands what is required.
7. **Budget for planning and coordination.** The subcontractors and general contractors on Microsoft's projects have found, so far, that tracking of construction activity carbon doesn't increase costs. The data is already there, it just needs to be compiled. However, soft costs, like brainstorming sessions, meetings, and coordination needed among our teams to create and implement a game plan can result in added costs.

Through the process of tracking A4 and A5 emissions, we have discovered how big of an impact they have on the embodied carbon of an overall project. Contractors play an essential role in gathering and reporting this data as it won't be done by suppliers or manufacturers. On the Puget Sound campus modernization project, we found that A4 and A5 emissions contributed to about 10–20 percent of total embodied carbon emissions, double than our initial expectations, with site work and excavation of the underground parking structure far exceeding the emissions from individual building construction sites. Armed with this information, we can make more informed decisions in the future on ways to reduce these emissions.

The following chart shows the projected breakdown of construction carbon emissions from our Puget Sound campus modernization project. Site work currently accounts for 53 percent of the A4 and A5 emissions, while excavation of the underground parking garage accounts for 32 percent. The deconstruction of the existing campus and construction of the new campus buildings accounts for the final 15 percent. We have not yet completed construction on this project, so these emissions are constantly being tracked and updated.

Projected carbon emissions



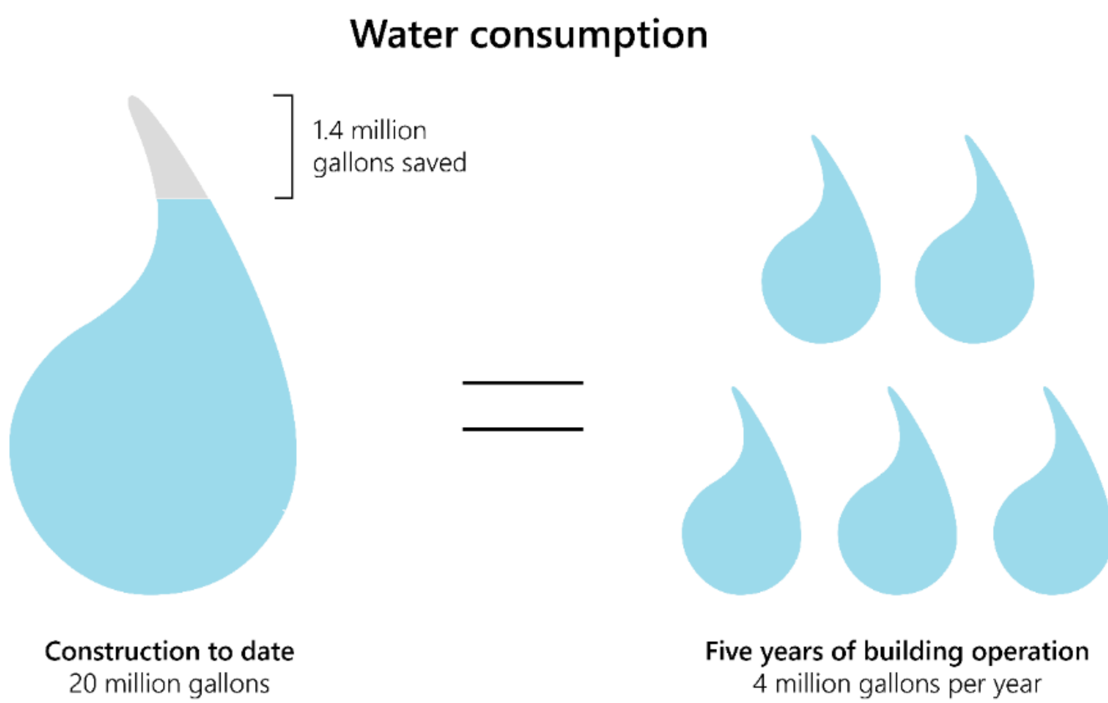
ILFI Zero Carbon reporting

In addition to our 30 percent carbon reduction target, the campus modernization project is also pursuing International Living Futures Institute (ILFI) Zero Carbon Certification. This certification requires that 100 percent of the embodied carbon emissions impacts associated with construction and materials of the project be disclosed and offset. Through the process of gathering and reporting the A4 and A5 emissions, our construction teams and general contractors collaborated with ILFI to update the Zero Carbon certification documentation requirements.

Beyond embodied carbon: water use

Given the connection between carbon emissions and water consumption, we decided to track water use as well to understand and establish a benchmark for water consumption. The Puget Sound campus modernization project has used over 20 million gallons of water for construction activity to date. Each of the new buildings will use an estimated average of 4 million gallons of water a year in operation, meaning the construction activity alone uses five years' worth of one building's water just for construction.

Because Microsoft tracked the water use and understood the vast amount of water being consumed, Skanska Balfour Beatty and our team of general contractors were able to come up with water reuse opportunities. For example, instead of sending stormwater in the sediment pond into the drain, we pumped it into a storage tank and used it for dust control and construction haul road cleaning. This saved close to 1.4 million gallons of water and will continue to save more water throughout construction.



Looking ahead

At Microsoft, we have used our Puget Sound campus modernization and datacenter projects to pilot the strategies outlined in this paper. These strategies are critical to achieve our commitment to being carbon negative by 2030. So far, we've learned how much of an impact a single material alternative can make, how much carbon is emitted during the demolition and construction of a new campus, and how much water is needed for that construction. Beyond collecting this data, we have piloted a new tool, EC3, to specify and procure low-carbon materials, outlined and implemented best practices for reducing carbon emissions in construction, and reduced potable water use during construction.

We feel we are just at the beginning of identifying processes, tools, and guidelines for tracking and reducing embodied carbon. Addressing the climate crisis requires that we all do our part to keep the momentum going. Contractors, specifically, have a huge opportunity to contribute. While the embodied carbon reduction process starts in the design phase, it is implemented and realized in the construction phase. Microsoft found that construction activity carbon emissions, often not tracked, can make up 10–20 percent of a project's total embodied carbon. Only contractors have the power to track and reduce those emissions.

While contractors play an important role, everyone in the design and construction process can help propel the industry forward. Owners can set ambitious goals for projects. Engineers can find creative ways to reduce material volume and specify low-embodied carbon products. Suppliers and manufacturers can create EPDs for their products and create more low-carbon emissions products. Everyone can pitch in to create more demand and more data.

We know we don't have it all figured out and we are continuing to learn more every day. Our hope is that by sharing our journey, you can learn from us and in turn share your journey so we can learn from you. Together we can tackle climate change by benchmarking and reducing embodied carbon emissions in the construction industry.

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Appendix

Sample contract language requiring EPDs and use of EC3

The following language can be included in legal contracts to ensure that general contractors are required to use EC3, and subcontractors are required to include embodied carbon reporting in their bids.

The Microsoft Campus Modernization Project is committed to tracking and reducing the embodied carbon footprint of the materials used in construction by 50 percent compared with project baseline. Due to this mandate from Microsoft of actionable carbon reduction of materials, the following items are required as a part of the Interior scope of work:

1. Environmental Product Declarations (EPDs) for All Concrete Mixes Utilized on the Project:
    a. Subcontractor/Supplier shall provide on-demand EPDs for Project ready-mix concrete mixes, at milestones as the design progresses, to support Project emissions reductions tracking.
    b. EPDs of concrete mixes generated will be required with construction submittals to confirm carbon emissions, aka Global Warming Potentials (GWPs) of mixes installed.
2. Actual Reductions of Carbon Emissions in Concrete Mixes Utilized on the Project:
    a. MSCM is piloting the use of the Embodied Carbon in Construction Calculator (EC3) which includes a database of available EPDs from national materials associations (such as the NRMCA) as well as local suppliers and manufacturers of certain materials, including ready mix concrete.
    b. The Project will utilize these available EPDs in the EC3 database to enable assessment of Project-specific EPD GWP numbers in order to understand reductions from the project baseline.

Sample Construction Activity Carbon Reduction Plan (CACRP)

In partnership with our general contractors, we developed the following CACRP to outline the requirements for subcontractors, suppliers, and general contractors to track fossil fuel use of all A4 and A5 emissions.

1. APPLICABILITY AND INTENT
    a. This Plan applies to all subcontractors, suppliers, and General Contractors working anywhere on the Microsoft East Campus Modernization construction site or delivering materials or products to the construction site.
    b. The intent is to support the Owner's goal in reducing all sources of greenhouse gas (carbon) emissions associated with this project, including from construction activity.
    c. The Plan has mandatory requirements and suggested best management practices (strategies) to minimize greenhouse gas (carbon) emissions.
    d. While the emissions from construction activity is one component of the project's total lifecycle greenhouse gas emissions, it is distinct from the emissions related to the sourcing and manufacturing of building materials and products (embodied carbon emissions) and is distinct from the emissions from operating building systems (operational carbon emissions). Embodied and operational carbon requirements are addressed in the design documents and in the Sustainability Exhibit.

2. REQUIREMENT: TRACK FOSSIL FUEL USE
    a. As applicable to the scope, track fossil fuel use of:
        i. Off-road vehicles, equipment and tools used within the jobsite.
            1. Use the specific spreadsheet provided by the General Contractor.
            2. Information required each month:
                a. List and number of each fossil fuel off-road vehicles/equipment/tools used during the month. Include both owned and rented equipment.
                b. The fuel type (diesel, gasoline, propane, etc.) used by each type of equipment.
                c. The engine tier level of the equipment, if applicable.
                d. Provide either:
                    i. the total amount of fuel used by type (diesel, gasoline, etc.) for all the subcontractor's equipment used on this project during the month, OR
                    ii. the total amount of hours for each type of equipment used on this project during the month
        ii. Delivery vehicles for building materials.

1. Scope includes all on-road delivery vehicles (tractor-trailer trucks, flatbed trucks, side-loader trucks, dump trucks, walk-in delivery trucks, delivery trucks/service vans, pickup trucks, or company fleet cars used for deliveries) but only the mileage from the last supply house to the job site.
2. This scope does not include crew transport or commuting miles using personal vehicles.
3. Use the specific spreadsheet provided by the General Contractor.
4. Information required each month:
    a. Total round trip miles per each type of vehicle driving in a month.
    b. The type of vehicle (light duty truck, medium/heavy duty truck, car, etc.) used for the delivery.
        i. Optional: provide the MPG for each vehicle, if known.

iii. Crew transport provided by the General Contractor.
1. If provided by the General Contractor, the General Contractor will report each month's fuel use of shuttle buses from parking lots to the jobsite.

b. Subcontractors shall submit to the General Contractor all documentation by the 15th of the month for the previous month reports. Completion of these reports shall be a condition precedent for monthly payment.

3. REQUIREMENT: ANTI-IDLING

The purpose of this requirement is to reduce non-productive, unnecessary idling, save maintenance hours and engine life, and reduce fuel costs and emissions.

a. Idling of a vehicle owned by a rental company is the responsibility of the renter or lessee.
b. Requirements:
    i. Idling is not permitted during periods of non-active use.
    ii. Idling is not permitted more than 5 consecutive minutes in a 60 minute period when the equipment is not in use, occupied by operator, or otherwise in motion with these EXCEPTIONS:
        1. When traffic conditions or mechanical difficulties force equipment to remain motionless and idling.
        2. When equipment or vehicle is briefly started to verify it is in safe operating condition.
        3. When it is necessary to operate an auxiliary system that is necessary to accomplish tasks, such as a concrete tumbler.
        4. To bring equipment to operating temperature as required by the manufacturer.
        5. A diesel-fueled engine operating in an ambient air temperature below 25°F for more than 2 hours.
        6. When equipment is being actively tested, serviced, repaired, or run for diagnostic purposes.

7. When the outside temperature is below 40°F or above 80°F and the operator is required to stay in the vehicle.
8. When involved in an emergency.

c. Automated electronic anti-idling devices to shut down and restart combustion engines are not required, but are encouraged where they do not impede the safe operations of the equipment or vehicle.

4. RECOMMENDED BEST MANAGEMENT PRACTICES

If applicable to scope and feasible, the General Contractor and the subcontractor shall consider and provide alternate pricing for the following recommended best management practices. Alternates with cost impacts must be approved by Microsoft CM Project Development Manager.

a. Equipment Electrification:
    i. Wherever possible, use electrified equipment, such as electric tower cranes instead of mobile cranes.
b. Prioritize Tier 4 Final Equipment (i.e. for large equipment used for earthwork or paving):
    i. If renting equipment, at the time of bidding, work with rental companies to reserve and maximize the use of Tier 4 on this project.
    ii. If Tier 4 equipment is owned, prioritize its use in this project.
c. Retrofitting Older Large Equipment with Best Available Technology:
    i. Tier III or lower: investigate retrofits with Best Available Technology (BAT) such as diesel oxidation catalysts (DOCs) or diesel particulate filters (DPFs).
d. Use of Biofuel Blends:
    i. Where permitted by rental agreements and when in accordance with the equipment warrantee, use a B20 biofuel blend (20% biofuel and 80% diesel). Track use of biofuel and diesel amount separately. Investigate if higher blends of biofuel are permitted.
e. Delivery Optimization:
    i. Concrete deliveries: Using the app from the concrete supplier, review on a weekly basis the on-jobsite wait times for concrete truck deliveries. Identify patterns of excessive wait time (i.e. unproductive idling time) and discuss with field team how to optimize the ordering and placement process.
    ii. Other deliveries: Group items into as few delivery trips as possible while meeting needs of the project schedule.
f. Temporary Power:
    i. Where temporary power is available, connect to temporary power instead of connecting to generator-supplied power.
    ii. If temporary generators are needed, use generators with a Tier 4 final engine.
    iii. Use temporary power units (TPU) that have a timed shut-off with manual override. Where safety is not compromised, set schedule to automatically shutoff site lighting 30 minutes after typical working hours.

g. Solar Charging:
    i. Consider a photovoltaic charger station for charging small tool batteries.
    ii. Consider a photovoltaic array for powering construction site conference trailer.
h. Subcontractor-specific Carbon Reduction Plan—optional.
    i. List of equipment to be used to complete the work.
    ii. Indicate whether owned or rented.
    iii. Indicate Type of fuel.
    iv. Indicate Motor Horsepower and Engine Tier (if applicable).
    v. Indicate if major repair or replacement of the equipment is anticipated during the course of the work.
    vi. Estimated fuel burn for all engines.
    vii. Describe how equipment idling or excessive use will be reduced:
        1. Training, posters, incentives
        2. Idling interlock on on-road vehicle
    viii. Describe how generator power impacts use will be reduced:
        1. Identify which area(s) can be on temp power from utility and which area(s) will require generator power.
        2. Identify the Engine Tier of generator; use Tier 4.
    ix. Describe efforts to minimize impacts of temp heating:
        1. Will temporary heat be used?
        2. Can temp heat be avoided through re-phasing the project without delaying overall completion date?
        3. Use electric temporary heat if feasible.
    x. Describe how carpooling or commuting via transit to jobsite will be encouraged for subcontractor employees.

[End of Plan]