

Hines

Embodied Carbon Reduction Guide

September 2025



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About Hines

Our founder, Gerald D. Hines, believed in creating long-term value for the people and communities we touch, and that ethos and commitment have driven us to become one of the largest and most respected real estate organizations in the world.

Hines believes that providing a healthy, productive environment that supports businesses, employees, and residents makes buildings successful and sustainable in the long term. Now more than ever, creating value means providing safe, healthy places for people to live, work, and play.

Carrying on our founder's legacy, we continue to explore innovative ways of advancing new technologies to reduce our carbon footprint, including embracing the use of new materials to reduce the environmental impact. From construction to the operations and management of the building, our focus is to harness the latest technologies to work with our partners toward net zero carbon.

Our focus on sustainability drives innovation at Hines, provides a platform for us to engage and collaborate with like-minded partners, and challenges us to stay on the leading edge of our industry. To create this latest version of the Embodied Carbon Reduction Guide, we partnered with Davies-Crooks Associates with contributions from LMN Architects. This builds on the previous version created in partnership with Magnusson Klemencic Associates (MKA).

Acknowledgements

About Davies-Crooks Associates

Davies-Crooks Associates is a mission-driven consulting and adaptive reuse development practice focusing on lowering the built environment's climate impact on the planet. It supports AEC industry leaders, government, and non-profits in creating impact at scale.

Don Davies, SE, has been a key collaborator for this Guide. Don is an industry champion for promoting urban density and lower-carbon construction, a 2024 US Special Presidential Envoy on Climate, and a 2023 ENR Top 25 Newsmaker. Don helped found the Carbon Leadership Forum, Building Transparency, the Lower-Carbon Concrete Task Force, and the MKA Foundation. He has been inducted into the UC Berkeley Academy of Distinguished Alumni. He is part of the American Concrete Institute (ACI) 323 – Lower Carbon Concrete Committee, the American Institute of Steel Construction (AISC) Sustainability Committee, and the Climate Smart Wood Group Executive Committee.

The past President of Magnusson Klemencic Associates (MKA), Don has driven diverse teams in the design of high-rise and mixed-use projects in more than 50 major metropolitan centers and 18 countries, including over 47 performance-based seismic design projects in areas of high seismicity. This included guiding the practice's focus on lowering construction's carbon footprint through optimization, life cycle analysis, and industry education and advocacy.

About LMN

Recognized with the prestigious 2016 National AIA Architecture Firm Award, LMN is a distinguished multidisciplinary team of architects, interior designers, and urban planners based in Seattle. Renowned for its commitment to enhancing the health and vitality of communities through innovative design and sustainability, LMN's work spans a diverse array of project typologies, including urban mixed-use developments, civic and cultural projects, higher education facilities, conference and convention centers, and transportation infrastructure.

The firm's design philosophy is rooted in creating environments that elevate the social experience, enriching civic life, strengthening cultural identity, and innovating advanced sustainability solutions. Through its dedication to research, innovation, decarbonization, and community engagement, LMN continues to push the boundaries of design, creating spaces that are not only functional and aesthetically pleasing but also responsive to the evolving needs of our clients and the communities they serve. LMN is a recognized national leader in embodied and operational carbon.

About Magnusson Klemencic Associates

For more than 100 years, Magnusson Klemencic Associates (MKA) has provided enduring, creative, and innovative structural and civil engineering solutions worldwide. MKA's portfolio spans \$100 billion in design across 49 states and 61 countries, establishing the firm as an industry leader in technical expertise and client service.

MKA champions carbon-conscious engineering as a powerful tool in combating climate change, guiding projects from early design through construction. Their engineers pioneer new technologies to advance understanding, ensure reliable outcomes, and improve the built environment for a healthier planet.

The pillars of MKA's work are reliability, resource stewardship, and collaboration—creating materially efficient structures that push the industry forward. True innovation requires moving beyond the status quo. Building a lower-carbon future demands collective effort, and MKA is committed to leading that charge.



INTRODUCTION

The Built Environment's Carbon Impact

Hines is committed to improving the built environment for people and the planet. Through the years, our firm has endeavored to bring responsible, sustainable practices to our developments, and we will continue to lead our industry by creating guides that raise the bar as we build for the future.

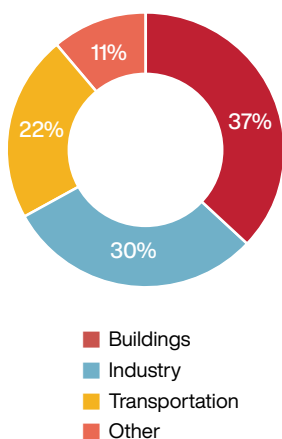
With this mindset to better our firm and industry, we are advancing sustainable design and construction practices through our Hines Embodied Carbon Reduction Guide. The primary goal of this Guide is to reduce the embodied carbon of new developments as they are added to our vast and diverse portfolio. We also recognize the unique opportunity Hines has as a leader in our industry. We are committed to collaboration with and education of our investment partners, clients, employees, and consultants. This Guide is intended to provide a foundation for understanding embodied carbon and the strategies needed to achieve reduction.

The impact of climate change is visible today. Global communities are consistently experiencing extreme weather events and sea-level rise, with the [United Nations reporting](#) over two million deaths and over \$4 trillion in economic losses in the last 50 years.

Worldwide, researchers agree that if global temperatures rise more than 2°C above preindustrial levels, irreparable global damage to ecosystems is likely. Furthermore, the [Intergovernmental Panel on Climate Change \(IPCC\)](#) has endorsed targeting 1.5°C as the maximum rise to limit the lasting effects on ecosystems.

The built environment plays a significant role within this global climate context, with buildings alone responsible for [37% of global energy- and process-related emissions](#). Reducing these has become the goal of many worldwide organizations, and this Guide intends to depict how Hines can contribute to this shared mission.

GLOBAL ENERGY AND PROCESS-RELATED EMISSIONS



Source: United Nations Environment Programme 2022
Global Status Report for Buildings and Construction



Using this Guide

Embodied carbon can be a daunting topic. Through education, though, any stakeholder in the building industry can understand how they might contribute to embodied carbon reductions. To this end, the first three chapters of this Guide focus on providing foundational knowledge of embodied carbon: Chapter 1 introduces carbon, how buildings and their components generate emissions, and what data is used to quantify them; Chapter 2 covers the categorization of carbon over a building's lifespan and how it is quantified throughout; and Chapter 3 dives deeper into this quantification by introducing whole-building life cycle assessment (WBLCA).

Following this educational foundation, Chapter 4 focuses on how embodied carbon may be reduced throughout the various phases of a building project, providing material-, product-, and construction-specific reduction strategies. Finally, Chapter 5 outlines the ask of Hines' various consultants and partners throughout project delivery, including key deliverables and milestones.

Questions addressed by each chapter include:

Chapter 1

- What does the term “carbon” mean?
- How does a building and its components emit carbon?
- What kind of data is used to quantify carbon?

Chapter 2

- How is carbon categorized over a building's lifespan?
- What is the basic equation for calculating carbon?
- How is carbon calculated at each stage of a building's lifespan?

Chapter 3

- What is whole-building life cycle assessment (WBLCA)?
- What are the key components of performing a WBLCA?
- What should be done with WBLCA results?

Chapter 4

- How can embodied carbon be addressed throughout a building's design and construction?
- Who are the key stakeholders in reducing embodied carbon?
- What reduction strategies should be considered?

Chapter 5

- What embodied carbon deliverables does Hines expect of their project team?
- What project team member is responsible for what deliverable?
- What is the interplay between deliverables?

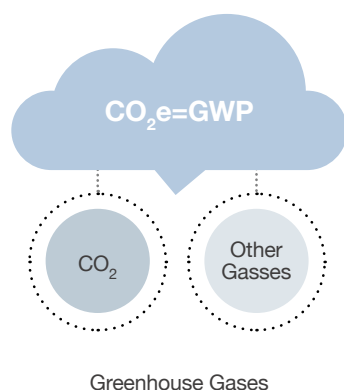
Through these chapters, we hope that the topic of embodied carbon is demystified and building-industry professionals feel empowered to take action to reduce it.



CHAPTER 1

Understanding Carbon

CARBON



The term “carbon” is commonly associated with climate change. Greenhouse gases include a variety of substances, such as carbon dioxide, nitrous oxide, and methane; however, carbon dioxide is the most commonly referenced among them, and therefore, “carbon” has become the shorthand term used worldwide. The metric used to measure these gases and their effect on climate change is Global Warming Potential (GWP), reported in kilograms of carbon dioxide equivalent, or “kgCO₂e.”

Buildings and their construction have a significant impact on global carbon emissions. To reduce this impact, we must understand the various processes and components that go into constructing and operating a building and how they result in carbon emissions.

Building Emissions

The life of a building includes upstream manufacturing, construction, renovations, and eventual decommissioning. All of these use energy and produce carbon emissions.

Embodied Carbon vs. Operational Carbon

Building carbon emissions are classified into two categories—**embodied carbon** and **operational carbon**. Embodied carbon includes the emissions from all aspects of the building’s life cycle (material production, transportation, etc.) unrelated to its energy and water consumption while in use. Operational carbon is the emissions resulting from the regular operation of the building (lights, air conditioning, water distribution, etc.).

The ability to track operational carbon is relatively sophisticated. Consider, for example, a public utility meter on a building measuring and tracking energy use. This information allows a building’s operational impact to be understood and managed. By comparison, no meter tracks embodied carbon, and it is more difficult to measure.

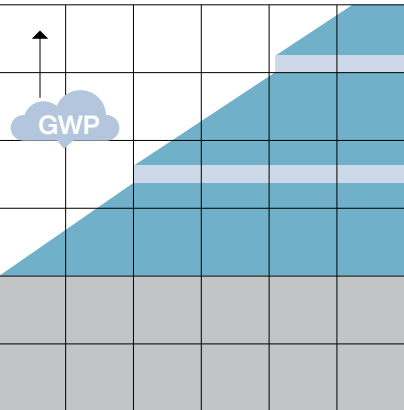
While operational carbon accrues over the life of a building, its impact varies and is influenced by the local energy supply. As buildings and energy grids become less fossil-fuel dependent, the impact of operational carbon will lower over time. Therefore, in locations where the local grid efficiency leads to lower operational emissions, the embodied carbon impact is significant by comparison. Because of this, the industry is turning its attention to the quantification and reduction of embodied carbon.

Although its study is an evolving topic, estimating and reducing embodied carbon is an important next step to lowering the overall carbon impact of our built environment.

TOTAL CARBON EMISSIONS OVER TIME

Scenario A

- Upfront embodied carbon remains as-is
- Energy grid remains as-is

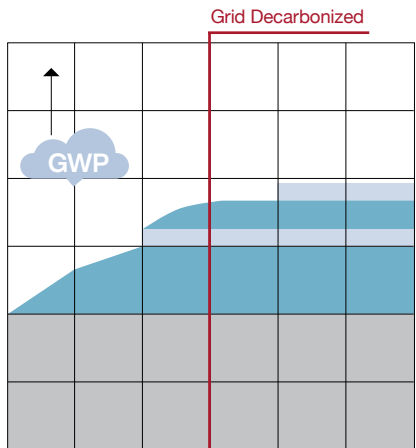


BUILDING LIFE SPAN →

- Upfront Embodied Carbon
- Operational Carbon
- Embodied Carbon Due to a Renovation

Scenario B

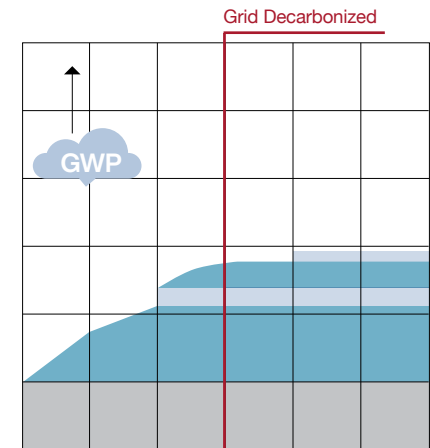
- Upfront embodied carbon remains as-is
- Energy grid increases in efficiency until it switches to renewable energy (is “decarbonized”)



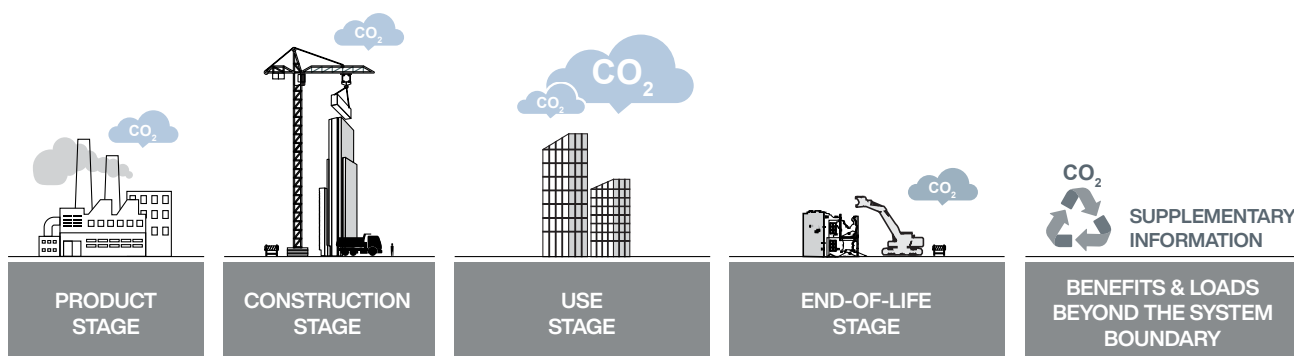
BUILDING LIFE SPAN →

Scenario C

- Upfront embodied carbon is reduced
- Energy grid increases in efficiency until it is decarbonized



BUILDING LIFE SPAN →



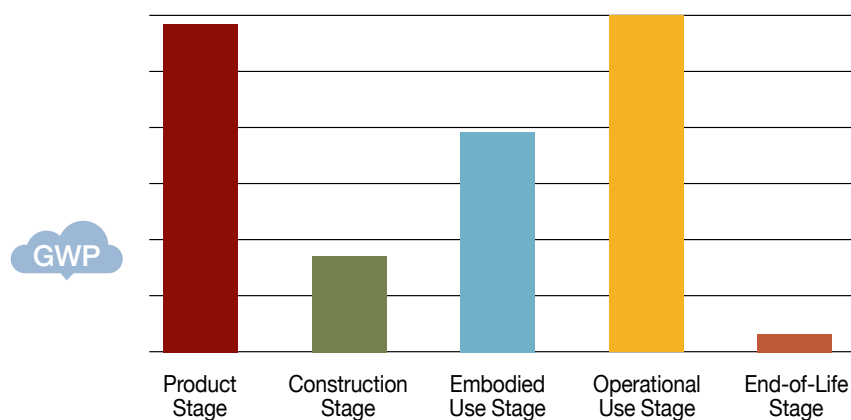
Building Lifespan

To organize and track a building's carbon impact, its lifespan can be broken into different stages. Each stage represents a different timeframe in a building's life cycle, from beginning to end, and is associated with varying sources of carbon emissions. These stages are identified below and described in detail in [Chapter 2](#):

- Product Stage: raw material supply, transport, and manufacturing
- Construction Stage: transport and construction
- Use Stage:
 - Embodied Use Stage: use, maintenance, repair, replacement, and refurbishment
 - Operational Use Stage: energy and water usage
- End-of-Life Stage: deconstruction, transport, waste processing, and disposal

All of these stages, except the Operational Use Stage, contribute to the total embodied carbon impact of a building. For many buildings, the initial Product Stage is the most significant contributor to embodied carbon emissions, often making it a focus for reductions.

EXAMPLE CONTRIBUTION BY LIFE CYCLE STAGE (OFFICE)



Building Components

Each building **material** and **product** has its own characteristics and life cycle and, therefore, its own unique considerations that inform its carbon emissions. Explored in more detail below, these materials and products can be broken into the categories of Structure, Enclosure, Interiors, and Services.

Structure

A building's structure – including its foundations, substructure, and superstructure – is often the largest contributor to its embodied carbon impact. Typically, the primary carbon components of the structure include concrete, steel, and timber.

CONCRETE

Concrete is the world's most widely used building material. It also has a relatively large **carbon intensity**. These two factors result in this single material alone making up about [8% of global carbon emissions](#). Concrete is a mixture of various materials—aggregate, water, sand, etc.—but it is its cement, which makes up a small portion of the volume, that leads to its high carbon intensity. This is because cement production is an energy-intensive process through which carbon dioxide is released as a by-product.

STEEL

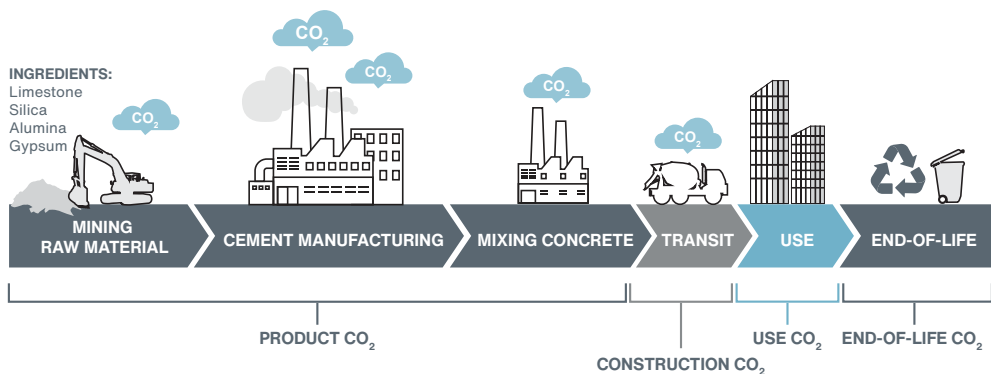
Another widely used construction material is steel. Combined, structural steel and rebar alone account for [over 7% of global emissions](#). The steel manufacturing process is the largest determinant of its carbon impact—mainly the difference between a mill using a basic oxygen furnace (BOF) or an electric arc furnace (EAF). BOFs generally consume raw materials and burn coal or natural gas to melt these materials to create first-generation steel. This means the recycled content for BOFs is relatively low, about 25%. In comparison, EAFs use scrap material to produce steel, making their recycled content often greater than 90%. While many steel mills in the U.S. and Europe use an EAF, other large-volume production regions use both processes.

TIMBER

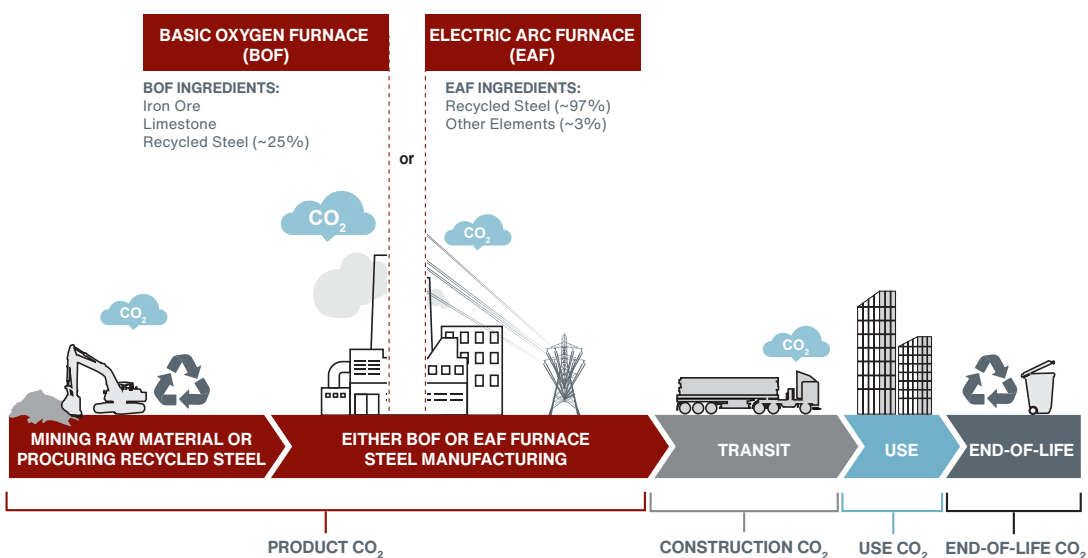
Unlike concrete and steel, wood is obviously grown. While a tree grows, it sequesters (or pulls out) carbon from the atmosphere, resulting in a negative carbon emission. However, if a timber product is burned or left to decompose at the end of its life, the sequestered carbon is released back into the atmosphere.

How to account for the carbon **sequestration** of timber is a debated topic, made more complicated by supply chains that often lack sourcing transparency and variations in forest management practices. Generally, including the sequestration of timber products in carbon calculations should only be done if the timber is sourced from a sustainably managed forest. In these, the net tree stock of the forest is either maintained or increased over time rather than decreased due to harvesting. When a forest experiences neutral or positive growth, it is assumed that harvested trees are replaced and the average tree stand size is maintained; therefore, the carbon contained within the forest is not diminished. Since forests are a critical carbon sink globally, it is imperative that their stock does not dwindle over time and that deforestation is prevented.

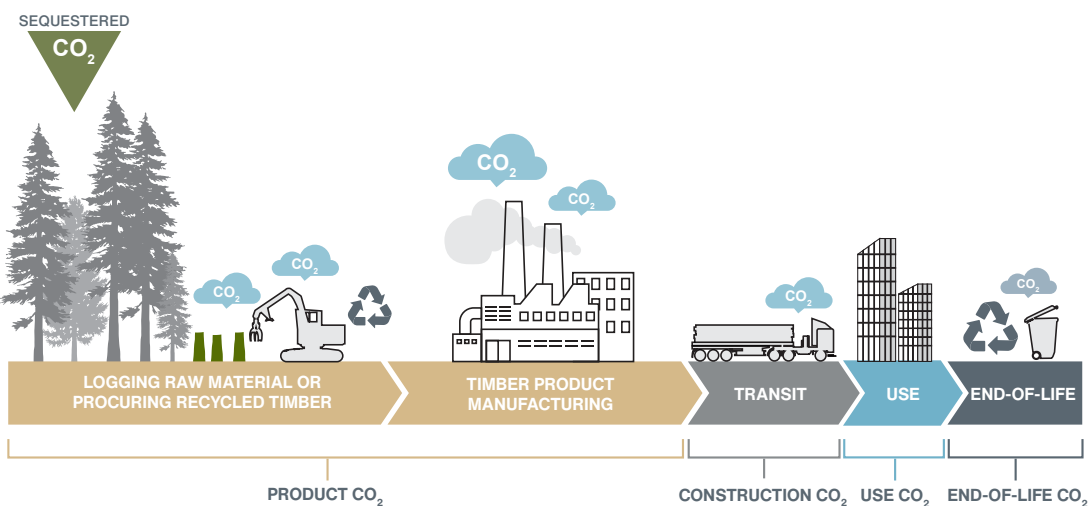
CONCRETE



STEEL



TIMBER



Enclosure

Elements that make up the building enclosure showcase the relationship between embodied carbon and operational carbon. Since the envelope directly affects a building's energy performance, a poorly insulated envelope will cause greater operational emissions over the building's life span.

However, better-insulated envelopes may require more material, increasing the embodied carbon impact. This embodied cost may be recovered within a relatively short payback period, though, when compared to the operational savings over time. Because of the interplay between these two types of carbon, it is important to weigh both impacts simultaneously on a case-by-case basis to make informed decisions.

GLASS

Glass production involves melting raw materials at high heat, resulting in a chemical reaction that restructures their composition. The high-energy and chemical by-products make glass production a carbon-intensive process. Heating recycled glass, however, requires less energy than creating glass from virgin materials and avoids the by-products.

ALUMINUM

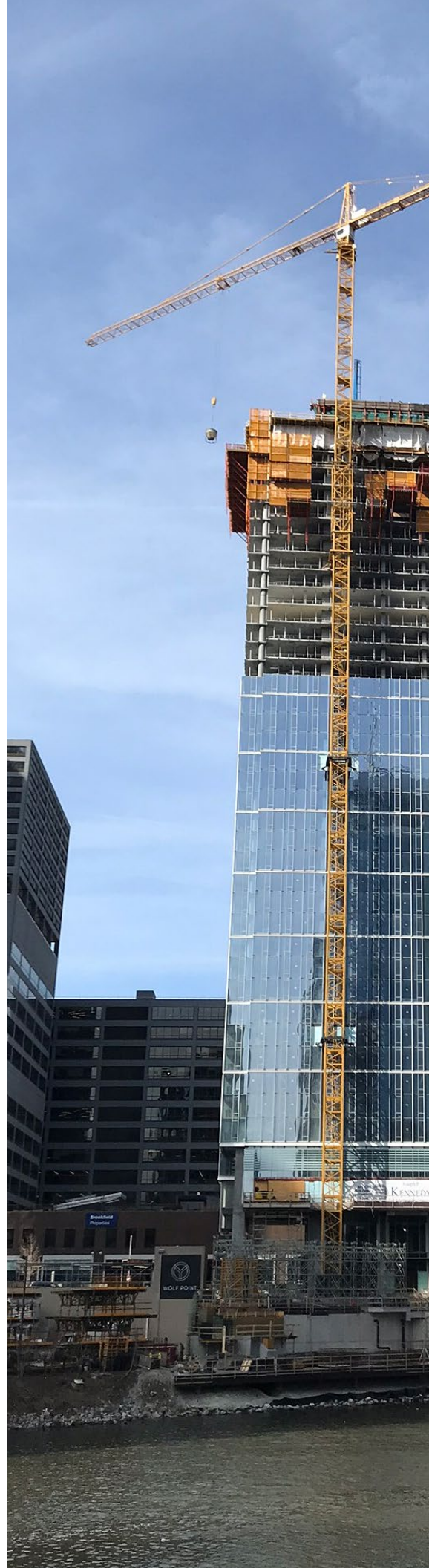
Aluminum is the second-most used metal in the world. With a carbon intensity much larger than steel, aluminum is responsible for about [2% of global carbon emissions](#). This is mainly due to the smelting process, an energy-intensive process reliant on the carbon intensity of the local electricity supply.

CLADDING

Cladding is an assembly made up of many materials—glass, aluminum, concrete, etc.—and the carbon emissions of each contribute to its overall impact. Adding to the complexity, cladding is often a custom design to achieve a specific architectural vision and energy performance. These aspects make it difficult to quantify the whole carbon impact of cladding, which should consider impacts on both embodied and operational carbon.

INSULATION

Insulation, used in enclosure and interior assemblies, is a broad category encompassing a range of products manufactured from various materials. A significant variance in GWP can be realized depending on the selected material. In general, the most carbon-intensive options are spray foam or extruded polystyrene (XPS). Less intensive options include expanded polystyrene (EPS) or those created from natural materials, such as mineral wool batting.





Interiors

Architectural interiors encompass a wide array of products with a wide selection of materials for various purposes. In general, the carbon impact of a product correlates to its material makeup (natural versus synthetic), the processes used to create them (synthetic materials require more manufacturing than natural alternatives), and their durability and resulting lifespan.

CMU

Concrete masonry unit (CMU) block, also used in structural applications, is a form of precast concrete and, therefore, has similar considerations to concrete. Because blocks are manufactured in a controlled environment rather than on-site like ready-mixed concrete, it is easier to test their structural performance before placing them, allowing them to be at the forefront of low-carbon concrete technology deployment.

DRYWALL

Drywall, or gypsum board, can be made from natural or recycled materials; both are energy-intensive to manufacture. Its use also results in a large amount of waste from over-ordering, damage, and off-cuts during construction. And while drywall is easy to recycle, finding recycling facilities can be difficult.

METAL STUDS

Metal stud framing typically consists of sheet metal. Due to stringent dimensional tolerances, sheet metal often requires high use of virgin material and less recycled content, resulting in a higher carbon impact than other steel products.

FLOORING

Similar to insulation, flooring is a broad category consisting of a variety of materials, resulting in a wide variability in GWP. This ranges from synthetic materials (e.g., nylon carpet) to those made of natural (e.g., wood) or recycled (e.g., second-life carpet) materials.

CEILING FINISHES

Similar to flooring, ceiling finishes encompass a wide variety of materials, some of which are highly processed and some of which are recycled. Like others, these materials present a large range in GWP data.

Services

Building service components such as mechanical/electrical/plumbing (MEP) equipment, elevators, and building maintenance units (BMUs) play a large role in embodied and operational carbon impacts. Research indicates that the embodied carbon impact from building systems is significant, often due to its heavy use of metals. However, the data to quantify this has lagged other components, resulting in building services often being excluded from embodied carbon calculations. Thankfully, due to efforts such as the development of [TM65](#) by the Chartered Institution of Building Service Engineers (CIBSE), this is changing.

EQUIPMENT

Various building service equipment, such as boilers, water pumps, cooling towers, etc., is needed to support a building. This equipment is built from electronic and mechanical parts and is often encased in metal. Because of the complexity of each of these pieces, the variety of ways in which they may be assembled, and their range in physical size, it is difficult to quantify their carbon impact. Typically, though, a large contributor to their overall impact is the quantity of metal they utilize and the strict tolerance it must be manufactured to, which determines the level of recycled metal that can be used.

REFRIGERANTS

Refrigerants are chemicals found in electric mechanical equipment used for heating and cooling. Common refrigerants used today, especially in markets such as the U.S., have very high carbon intensities. When these refrigerants leak throughout a building's operations or are not fully recovered at the end of a piece of equipment's life, they become powerful emitters of greenhouse gases. This makes refrigerants one of the building industry's [most significant contributors](#) to climate change today. Efforts to shift from high-carbon refrigerants to low-carbon alternatives are currently underway and gaining momentum globally but are complicated due to refrigerants' additional attributes, such as PFAS chemicals (known as "forever chemicals"), toxicity, and flammability.

DUCTWORK

A key component of any HVAC (heating, ventilation, and air conditioning) system is the ductwork that distributes air throughout the building. These ducts are typically formed out of high-impact metals like steel and aluminum.

PLUMBING

Like ductwork, pipes are a major portion of a plumbing system's impact. This piping can be made from a variety of materials, including copper, cast iron, and plastics such as ABS, PVC, and PEX. These materials carry a carbon intensity, while some, like PVC, are also red-list items due to their risk to human health.

The previous sections illustrate the variety of emission sources that may be found within a building, with many more that are not covered here. Although many of these materials are embodied carbon-intensive, mitigation strategies have emerged and are continuously expanding. See [page 76](#) for a list of embodied carbon reduction strategies.

Embodied Carbon Data

Associated with each building component is a different embodied carbon impact based on the constituent materials and processes used in their manufacture. Different embodied carbon data sources are available to quantify these impacts.

Generic Data

Generic data is a term used for data that describes the carbon impact of a typical—or generic—product. It is not associated with a specific manufacturer or production facility and is often representative of manufacturing processes used in broad geographies (e.g., North America).

Databases containing generic data are built from one or more **life cycle inventories (LCIs)**, a collection of environmental assessments conducted for products or upstream processes contributing to a product's impact. When these LCIs are performed by the same experts or intentionally aligned, a comparison between their GWP results is possible—for example, comparing a wood-based flooring to carpet.



Environmental Product Declarations

In addition to generic data, **Environmental Product Declarations (EPDs)** are a standard reporting mechanism for environmental data that describes a material or product's environmental impact. An EPD is analogous to a nutrition label, reporting a variety of health information. In this case, one of the important tracked "nutrients" is the product's GWP.

EPDs may be commissioned by trade organizations or manufacturers to report their environmental impacts. When performed by a trade, the results are representative of a variety of manufacturers, resulting in what is referred to as an **industry-average EPD**. In some cases, this data may be used as the generic data for that product. When performed by an individual manufacturer, the results are supplier-specific and referred to as **product-specific EPDs**. In this case, the impact data is no longer generic and instead representative of a product from a single manufacturer. When this product-specific data is third-party verified, it is the most sought-after type of data due to its high specificity to the product under assessment.

Nutrition Facts	
Serving Size	1/2 cup (130 g)
Amount Per Serving	
Calories	120
	%Daily Value*
Total Fat 2g	3%
Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 130mg	6%
Total Carbohydrate 20g	7%
Dietary Fiber 4g	14%
Sugars 3g	
Protein 7g	
Vitamin A	2%
Vitamin B	0%
Vitamin C	0%
Vitamin D	0%

* Percent Daily Values are based on a 2,000-calorie diet. Your daily values may be higher or lower depending on your calorie needs.

An EPD is analogous to a nutrition label.

TYPES OF EPDs

	PCR IS THIRD-PARTY REVIEWED?	EPD IS THIRD-PARTY REVIEWED?	SPECIFIC TO A SINGLE PRODUCT FROM A SINGLE SUPPLIER	STANDARD FOLLOWED
Product-Specific Declaration (Self-Declared)	—	—	✓	ISO 14044
Product-Specific Type III PREFERRED	✓	✓	✓	ISO 14025 ISO 14040 ISO 14044 ISO 21930 / EN 15804
Industry-Wide	✓	✓	—	ISO 14025 ISO 14040 ISO 14044 ISO 21930 / EN 15804

EPDs often include a large breadth of environmental data for the product they represent. For this Guide, the most important piece of information provided in an EPD is the product's GWP, reported in kgCO₂e, which measures the product's effect on carbon emissions.

CONCRETE COMPANY
ENVIRONMENTAL PRODUCT DECLARATION
Mix 1234567X • Seattle Plant

1. WHO

This Environmental Product Declaration (EPD) reports the impacts for 1 m³ of ready mixed concrete mix, meeting the following specifications:

- ASTM C94: Ready-Mixed Concrete
- UNSPSC Code 30111505: Ready Mix Concrete
- CSI Section 03 30 00: Cast-in-Place Concrete

COMPANY
Concrete Company
4321 16th Ave
City, ST 12345

PLANT
Seattle Plant
4231 E. Aggregate St.
Seattle, WA 98123

EPD PROGRAM OPERATOR
ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19380

DATE OF ISSUE
02/11/2019 (valid for 5 years until 02/11/2024)

2. WHAT

Declared Product:
Mix 1234567458374X • Seattle Plant
F0, #8 CA, ADVA, 8" Slump Compressive strength: 5000 PSI at 28 days

Declared Unit: 1 m³ of concrete

Global Warming Potential (kg CO₂-eq) 354

Environmental Impact Category	Value
Ozone Depletion Potential (kg CFC-11-eq)	0.0E+00
Acidification Potential (kg SO ₂ -eq)	2.0E+00
Eutrophication Potential (kg N-eq)	3.0E-01
Photochemical Smog Creation Potential (kg O ₃ -eq)	19.2
Total Primary Energy Consumption (MJ)	2,321
Nonrenewable (MJ)	2,206
Renewable (MJ)	115
Total Concrete Water Consumption (m³)	2.86
Batching Water (m³)	1.6E-3
Washing Water (m³)	0.01
Nonrenewable Material Resource Consumption (kg)	2,413
Renewable Material Resource Consumption (kg)	2.54
Hazardous Waste Production (kg)	0.02
Nonhazardous Waste Production (kg)	3.42

3. GWP

Product Components: crushed aggregate (ASTM C33), natural sand (ASTM C33), Portland cement (ASTM C150), slag cement (ASTM C955), admixture (ASTM C494), batch water (ASTM C1602)

4. IS IT VALID?

The Carbon Leadership Forum PCR: Product Category Rules (PCR) for ISO 14025 Type III Environmental Product Declarations (EPDs) for Concrete, Version 1.1 dated 12/4/2013, serves as the PCR for this EPD. <http://www.carbonleadershipforum.org>

5. PCR FOLLOWED

PCR review was conducted by: Nicholas Santero • thinkstep (formerly PE International).

Independent verification of the declaration, according to ISO 14025:2006: ☐ internal ☒ external

Third party verifier: Thomas P. Gloria (T.gloria@industrial-ecology.com) • Industrial Ecology Consultants

LCA and EPD developer: Laurel McEwen (laurel.mcewen@concretecompany.com)

6. IS IT VERIFIED?

Since embodied carbon is a growing topic, many vendors or manufacturers are now commissioning EPDs for their products. The more the AEC industry and building owners request and require EPDs, the greater the availability and accuracy of the data will become. This will drive the market in a positive direction toward increased transparency, allowing stakeholders the opportunity for more informed decision-making.

Manufacturers looking to commission an EPD for their product can refer to [Appendix A](#) for additional information.

Currently, EPD comparisons are not straightforward between different materials and products (e.g., concrete to steel to timber) because different EPDs are governed by different **Product Category Rules (PCRs)**, the rules governing their creation. Each material's governing PCR may allow different assumptions, which makes it difficult to compare the resulting data. It is like comparing “apples to oranges to bananas” when comparing the GWP of different materials reported by EPDs directly.

Overall, while inconsistency and uncertainty exist with EPD data, it is the best information at our disposal for measuring the carbon emissions of building components. This data will be refined and improved over time as industry adoption grows.

EPDs Count





CHAPTER 1

Summary

- A building's carbon emissions are categorized into **embodied and operational** and reported in terms of **global warming potential (GWP)** in units of **kgCO₂e**
- Embodied carbon includes emissions from **product creation, construction, remodeling, and deconstruction**
- Operational carbon includes emissions from **regular energy and water usage**
- The **Product Stage** is typically the largest contributor to embodied carbon over a building's lifespan
- **Structural materials** are often the largest contributor to embodied carbon
- **Environmental Product Declarations (EPDs)** report environmental impacts of materials or products, including GWP
- Today, the availability of EPDs varies widely across regions and products, but this is **expanding due to industry efforts**
- Dissimilar materials **cannot** be easily compared

LIFE CYCLE STAGES & MODULES

A0 PRE- CONSTRUCTION	A1-A3 PRODUCT STAGE	A4-A5 CONSTRUCTION STAGE	B1-B7 USE STAGE	C1-C4 END-OF-LIFE STAGE	MODULE D BENEFITS & LOADS BEYOND THE SYSTEM BOUNDARY
Study/Design	A1 Raw Material Supply	A4 Transport	EMBODIED USE STAGE B1 Use B2 Maintenance B3 Repair B4 Replacement B5 Refurbishment	C1 Deconstruction	Reuse / Recovery / Recycle
	A2 Transport		B6 Energy B7 Water	C2 Transport	
	A3 Manufacturing	A5 Construction		C3 Waste Processing	
				C4 Disposal	

CHAPTER 2

Categorizing Carbon

Quantifying the embodied carbon of a building involves the detailed accounting of its components and their respective carbon intensities. To organize this, carbon assessments break a building's lifespan into distinct periods called life cycle stages.

These life cycle stages are defined by **European Standard EN 15978** and can be broken down further into modules. They start before development and end after demolition, aiming to account for all emissions related to a building's construction, use, and end-of-life.

Any embodied carbon assessment must have a clearly defined scope, a key aspect of which is identifying which life cycle stages are included and excluded. This defines the type of evaluation, ranging from small-scope assessments targeting key stages of a building's lifespan to **whole-building life cycle assessments (WBLCAs)** that capture its entirety.

CARBON ASSESSMENTS & SCOPES

	A0 PRE- CONSTRUCTION	A1-A3 PRODUCT STAGE	A4-A5 CONSTRUCTION STAGE	B1-B5 EMBODIED USE STAGE	B6-B7 OPERATIONAL USE STAGE	C1-C4 END-OF-LIFE STAGE	MODULE D BENEFITS & LOADS BEYOND THE SYSTEM BOUNDARY
CRADLE-TO-GATE	✓	✓					
UPFRONT CARBON	✓	✓	✓				
WHOLE-LIFE EMBODIED CARBON	✓	✓	✓	✓		✓	
CRADLE-TO-GRAVE / WHOLE-LIFE CARBON	✓	✓	✓	✓	✓	✓	
CRADLE-TO-CRADLE	✓	✓	✓	✓	✓	✓	✓

Quantification Fundamentals

Carbon calculation for all life cycle stages can be distilled down to a fundamental equation: the amount of an emitter multiplied by the **global warming potential (GWP)** intensity of that emitter.

QUANTIFYING CARBON

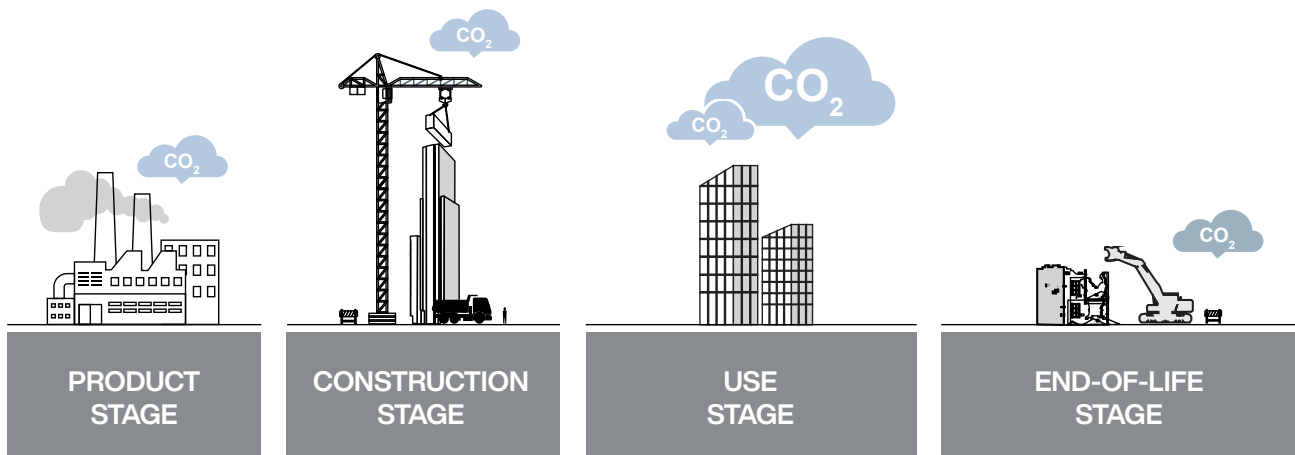
$$\text{Quantity} \times \text{Carbon Intensity} = \text{Carbon Impact}$$

This first variable asks the question, “How much of this emitter is there?” An emitter is anything that results in carbon emissions throughout a building’s life cycle, such as construction materials.

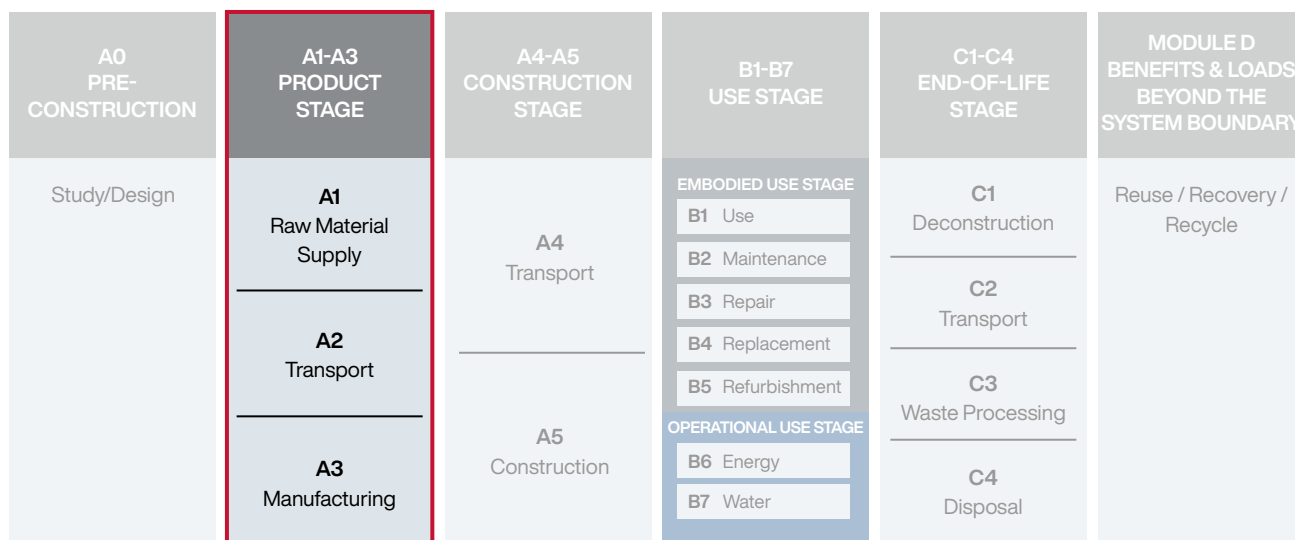
The second variable asks the question, “How much carbon does this emitter produce?” **GWP intensity** is the amount of GWP that can be attributed to each emitter per unit of emitter. Each source of building emissions will have a distinct GWP intensity.

Combined, these two variables provide the total carbon produced by any emission source. When this simple equation is performed for all building emitters of all categories and stages within scope, the individual results can be summed to determine a total carbon footprint.

A building’s life cycle consists of four embodied carbon stages: Product Stage, Construction Stage, Embodied Use Stage, and End-of-Life Stage. Although the carbon accounting for all is based on the fundamental equation, each stage has its unique approach and special considerations.



WHOLE-BUILDING LIFE CYCLE



EXAMPLE EMBODIED CARBON
CONTRIBUTION BY LIFE CYCLE
STAGE (OFFICE)



- Product Stage
- Construction Stage
- Embodied Use Stage
- End-of-Life Stage

Product Stage (A1-A3)

The first of the four life cycle stages, the Product Stage consists of life cycle Modules A1, A2, and A3. These correspond to raw material extraction (A1), transportation of these materials to a manufacturing facility (A2), and production of final **materials or products** (A3). Together, these cover the whole process of producing a building component.

Special attention is often given to the Product Stage as it typically has the highest embodied carbon emissions. It also requires the least complicated accounting and the least amount of speculation because all activities occur prior to construction completion. This makes it a meaningful way to focus on the biggest impacts over which project teams have the most control.

Quantification

Quantification of the Product Stage uses the fundamental equation directly: the amount of a building component multiplied by that component's GWP intensity.

QUANTIFYING PRODUCT STAGE CARBON

$$\text{Quantity} \times \text{Carbon Intensity} = \text{Embodied Carbon Impact}$$

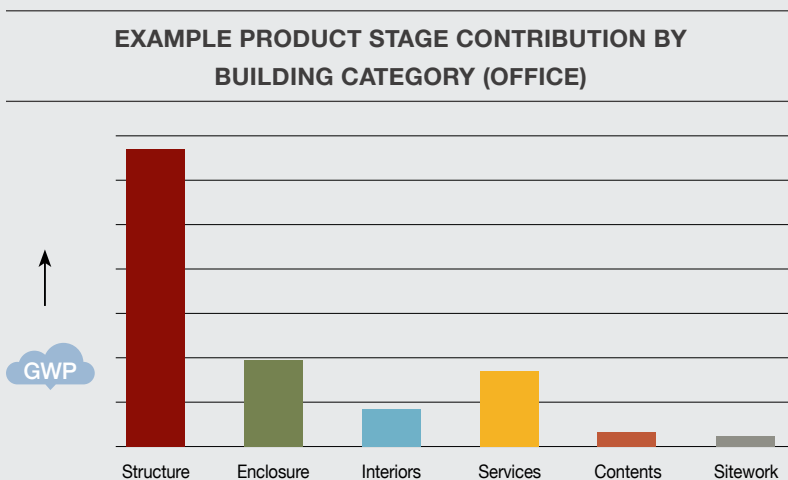
QUANTITIES

Product Stage calculation starts with gathering the quantities of all building components included within the scope of the assessment.

Components To Include

Buildings are complex and comprise many components that contribute to their carbon footprint. Before starting an assessment, project teams should consider which building categories are most relevant to their project and may result in the highest emissions. The assessment scope should then ensure the components within these categories are tallied.

Although the most accurate assessments include all building components, this may be overwhelming in practice. At minimum, efforts should prioritize high-impact components as opposed to miscellaneous ones with a relatively small contribution. For these minor contributing elements, estimation methods may be used in lieu of project-specific tallies. This way, accounting effort is spent where the impact is greatest, and estimation is used for the remainder.



At a minimum, Hines projects should include the following building categories in the assessment scope:

- Structure
- Enclosure
- Interiors
- Services

However, for best results, all building categories should be considered.

CONSULTANT SCOPE OF WORK

To ensure participation in the quantity determination process, confirm appropriate language has been added to the respective Scope of Work or Request for Proposal documents for the design team and General Contractor.

Refer to Hines Conceptual Construction Group for assistance.

Quantity Sources

Accurate material quantities are critical to embodied carbon accounting. The best source of quantities is a **Bill of Materials** from the General Contractor, a tally of all materials procured and delivered to the construction site.

Quantity tracking should start in early design, however, well before a Contractor can provide a Bill of Materials. Hence, another good source is the design team, such as the Architect and Structural Engineer, who may leverage digital Building Information Models (BIM) or hand calculations when it is too early for BIM or for items not modeled. Although powerful, great thought should be given to and caution should be taken when utilizing BIM. Models must be explicitly created with quantity extraction in mind to ensure accurate quantities, requiring strict modeling standards.

GWP INTENSITY

With component quantities in hand, the component's GWP intensity is the remaining variable. Depending on when the assessment is performed and what information is known at that time, different sources of GWP data will be appropriate.

GWP DATA SOURCE HIERARCHY



"You can't manage what you don't measure."

Risk Management

When quantities are measured and reconciled consistently throughout design and construction, the effort can serve as both a quantity and cost control method - providing the benefit of budgetary risk management.

In early design or when little information is known about the specification of a component, assessors will likely rely on generic GWP data. As the design progresses, assessors can ideally shift to using **Environmental Product Declarations (EPDs)**. Prior to procurement, **industry-average EPDs** are likely best because the exact products and suppliers are unknown. Once the Contractor is on board and procurement has begun, however, assessors will have more information about the final products and suppliers selected. At this point, **product-specific EPD** data should be used. This type of EPD results in the most accurate Product Stage accounting. Note that product-specific EPDs, or even industry-average EPDs, do not always exist. In this case, assessors will still need to rely on generic data to fill gaps in EPD availability.

Special Considerations

In addition to often constituting the highest embodied emissions over a building's lifespan, the Product Stage creates the foundation for carbon accounting of the subsequent stages; component quantities collected here are again used in all future stages, as well as their carbon intensity in the Embodied Use Stage. The Product Stage is also the stage over which project teams have the most direct influence, both in design and procurement, resulting in the greatest opportunity to achieve embodied carbon reduction over the building's lifespan.

For these reasons, the Product Stage should garner special attention from project teams. Take care and time to set the foundation for later stages and thoroughly review results to ensure reduction opportunities are recognized.

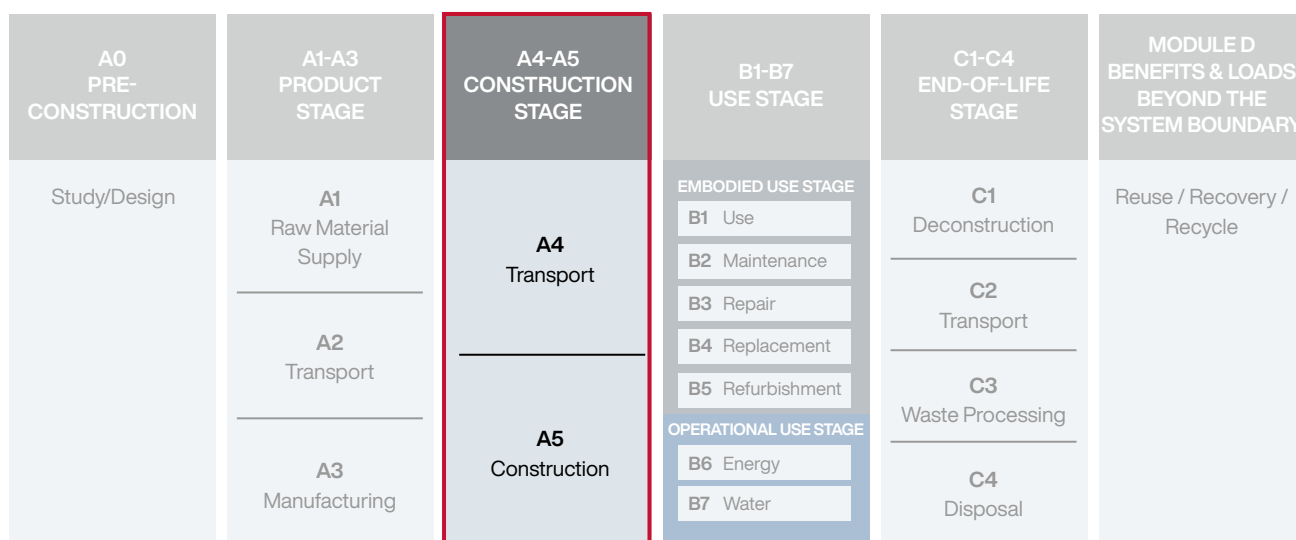
THE PRODUCT STAGE

represents the greatest opportunity to achieve embodied carbon reduction.



Salesforce Tower | Chicago

WHOLE-BUILDING LIFE CYCLE



Construction Stage (A4-A5)

Following the Product Stage, the Construction Stage includes life cycle Modules A4 and A5. These refer to transporting materials or products to the construction site (A4) and their installation and other construction-related processes (A5). Combined, these cover all that's needed to construct an operational building.

Similar to the Product Stage, the Construction Stage does not require future speculation as it is the last stage before construction is complete. Although the carbon impact of this stage may be lower by comparison, it represents the last opportunity to implement reduction strategies before building operations.

Transport (A4)

The Construction Stage’s A4 transport module is analogous to the Product Stage’s A2 transport module: in A2, the component is transported from the raw material extraction location to the manufacturing facility; in A4, the component is transported from the manufacturing facility to the construction site. While A2 carbon data is sourced from a generic database or EPD, A4 impacts reflect project-specific conditions.

QUANTIFICATION

Module A4 is quantified by understanding the amount of and distance that a component is transported along with the GWP intensity of the transportation type used to cover that distance.

QUANTIFYING MODULE A4 CARBON

Mass

X

Transportation Distance

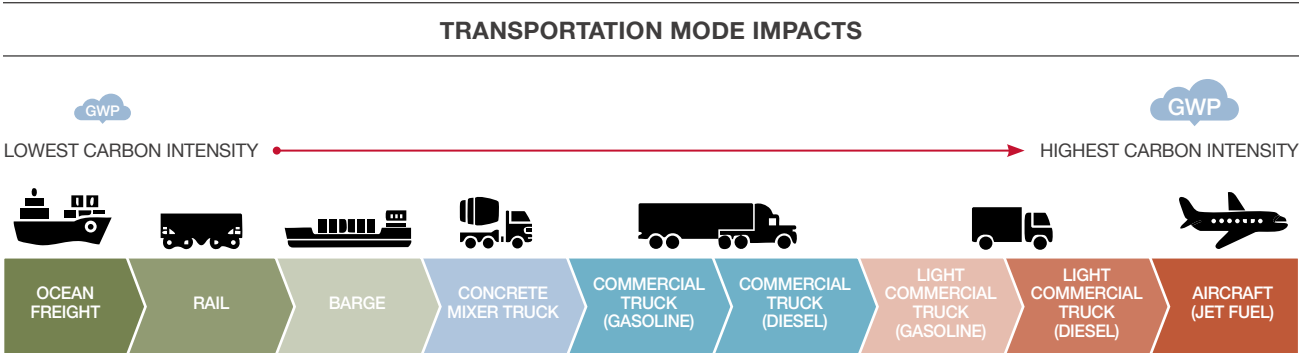
X

Carbon Intensity

=

Embodied Carbon Impact

Different transportation modes correspond to different carbon intensities, determined by the efficiency of the transportation vehicle and the fuel it consumes. For example, shipping a component by barge is much less carbon-intensive than by air. Often, a component may travel via multiple modes before arriving at the site. Each of these and their corresponding distances should be tracked and summed for accurate accounting.



SPECIAL CONSIDERATIONS

Distance traveled and transportation type used are the key determinants of Module A4’s impact, making General Contractor participation critical for A4 accounting. Often, project teams will focus efforts on sourcing locally. Although this can be a great way to cut A4 emissions, local sourcing initiatives should not neglect Product Stage emissions. If the Product Stage impacts of a local supplier are much higher than that of a distant one, this may negate any benefits to Module A4. Transportation mode also plays an important role. Suppose a local supplier relies on commercial truck delivery while a distant supplier has access to rail shipping. In that case, the distant supplier may again be the smarter carbon choice since rail is less carbon-intensive than trucking.

These considerations highlight the nuance involved with embodied carbon tracking and the holistic approach necessary to achieve reductions.

EXAMPLE LOCAL VS. DISTANT SOURCING COMPARISONS FOR MASS TIMBER, ASSUMING ALL PRODUCT STAGE IMPACTS EQUAL

SOURCING OPTION	SCENARIO 1		SCENARIO 2	
	LOCAL	DISTANT	LOCAL	DISTANT
TRANSPORTATION MODE & DISTANCE	Light Commercial Truck  100 mi	Ocean Freight  5000 mi Rail  200 mi Light Commercial Truck  10 mi	Light Commercial Truck  100 mi	Rail  2500 mi Light Commerical Truck  10 mi
	Total Distance 100 mi	Total Distance 5210 mi	Total Distance 100 mi	Total Distance 2510 mi
A4 GWP TOTAL	49 MT CO2e	64 MT CO2e	49 MT CO2e	39 MT CO2e

✓ LOCAL SOURCING IS BEST OPTION

✓ DISTANT SOURCING IS BEST OPTION

Results calculated with EC3 Tool (buildingtransparency.org)

Construction (A5)

The Construction Stage's A5 module is meant to capture all building construction and installation emissions. Constructing a building is a complex process involving many activities with distinct carbon impacts. These activities can be broadly organized into four categories:

- 1) Site preparation, including the demolition of existing structures and excavation
- 2) Temporary works, including temporary shoring, temporary vertical transportation (e.g., tower crane), and means and methods materials (e.g., formwork)
- 3) Fuel consumption, including for on-site generators, job site trailers, and construction equipment
- 4) Waste, including from job site activities and on-site sizing (e.g., cutting drywall to size)

QUANTIFICATION

Due to its breadth and complexity, Module A5 is particularly challenging to quantify because each category has its own approach. Typically, assessors will need to use estimation values for site preparation emissions. Temporary works, fuel consumption, and waste can all be quantified through careful accounting throughout construction. For this, tracking of materials used, including fuel, is key.

QUANTIFYING MODULE A5 CARBON



SPECIAL CONSIDERATIONS

Module A5 aims to quantify a wide range of processes, each with its own considerations. To capture this complexity, a deep knowledge of what activities are happening on-site is necessary. The General Contractor has the best vantage for this, making them a key partner in A5 accounting. Engagement with the Contractor early on, even before construction starts, will assist project teams in establishing processes to track carbon-relevant metrics and identify A5 reduction strategies.

GENERAL CONTRACTOR RFP

To ensure participation in Module A5 tracking, confirm appropriate language has been added to the General Contractor Request for Proposal.

Refer to Hines Conceptual Construction Group for assistance.

WHOLE-BUILDING LIFE CYCLE

A0 PRE- CONSTRUCTION	A1-A3 PRODUCT STAGE	A4-A5 CONSTRUCTION STAGE	B1-B7 USE STAGE	C1-C4 END-OF-LIFE STAGE	MODULE D BENEFITS & LOADS BEYOND THE SYSTEM BOUNDARY
Study/Design	A1 Raw Material Supply A2 Transport A3 Manufacturing	A4 Transport A5 Construction	EMBODIED USE STAGE B1 Use B2 Maintenance B3 Repair B4 Replacement B5 Refurbishment OPERATIONAL USE STAGE B6 Energy B7 Water	C1 Deconstruction C2 Transport C3 Waste Processing C4 Disposal	Reuse / Recovery / Recycle

Embodied Use Stage (B1-B5)

The third life cycle stage is the Embodied Use Stage, consisting of Modules B1 through B5. These modules represent emissions from the use (B1), maintenance (B2), repair (B3), replacement (B4), and refurbishment (B5) of building components. This stage aims to capture all emissions unrelated to energy or water use that occur during a building's operational life. Note that energy- and water-related emissions are captured in the Operational Use Stage but are not considered embodied carbon emissions (more on this toward the chapter's end).

Unlike the previous stages, the Embodied Use Stage requires speculation as its activities will not occur for some time. This future prediction leads to higher uncertainty in the results of this stage.

Use (B1)

Module B1 covers emissions from building components that don't sit inert while in use. This may be due to off-gassing, fugitive emissions, carbonation, or **sequestration**. An off-gassing material example is insulation that uses blowing agents. Fugitive emissions result from refrigerant leakage over time, refrigerants found in mechanical systems. Concrete that remains exposed to air can carbonate over time. Live vegetation will sequester carbon as it grows. Off-gassing and fugitive emissions result in carbon, while carbonation and sequestration pull carbon out of the atmosphere.

QUANTIFICATION

The quantification of Module B1 often relies on manufacturer-supplied data found in EPDs or placeholder values. Quantifying fugitive emissions requires knowing the amount of a refrigerant, its **carbon intensity**, and an estimated leakage rate over its service life (for further information, refer to [CIBSE TM65](#)).

QUANTIFYING MODULE B1 CARBON

$$\left(\text{Quantity} \times \text{In-Use Carbon Intensity} \right) + \left(\text{Quantity} \times \text{Refridgerant Carbon Intensity} \times \text{Leakage Rate} \right) = \text{Embodied Carbon Impact}$$

SPECIAL CONSIDERATIONS

Not all building components lead to Module B1 emissions (for example, steel is inert). During design and procurement, project teams should identify which materials or products will lead to in-use emissions and consider alternate options if possible.

Recent studies have highlighted the importance of refrigerants due to their relatively high impact (for example, one kilogram of R-410A refrigerant is equal to 2,088 kgCO₂e, while one kilogram of cement is roughly equal to 0.922 kgCO₂e). Refrigerant leakage emissions should be included in the assessment, and preference should be given to low-GWP refrigerants, if available.

Maintenance, Repair, & Refurbishment (B2, B3, & B5)

The second, third, and fifth modules of the Embodied Use Stage cover activities like cleaning (B2), unanticipated repair (B3), and planned upgrades (B5). Module B5 includes small- or large-scale improvements, ranging from replacing a piece of MEP equipment with a higher efficiency model to expanding the MEP room to accommodate newly added building area.

QUANTIFICATION

As with the other modules, the carbon impact of Modules B2, B3, and B5 will depend on how many building components are impacted by these activities and the carbon intensity of the activities. These modules are grouped here because their quantification is complex and highly speculative, making estimation the primary quantification approach. In some cases, manufacturer-specific information may be available.

QUANTIFYING MODULE B4 CARBON

$$\text{Maintenance Impact} + \text{Repair Impact} + \text{Retrofit / Refurbishment Impact} = \text{Embodied Carbon Impact}$$

SPECIAL CONSIDERATIONS

Selecting durable materials and equipment may reduce the impact of these modules. Also, maintaining regular upkeep of components should lengthen their service life and reduce the need for replacement.



Replacement (B4)

Module B4 covers the replacement of a building component, specifically like-for-like replacement. It is distinct from Module B5, which instead refers to replacement with a different – often improved – component. B4 replacement happens when a component has reached the end of its useful life, which depends on its material and function. For example, less durable or high-trafficked items, such as carpet, will require more replacement than more durable or out-of-reach items, such as ceiling tiles.

QUANTIFICATION

Module B4 quantification includes the end-of-life impact of the old, replaced item and the upfront impact of the new item. Key to quantification is the anticipated service life of a component.

QUANTIFYING MODULE B4 CARBON

(

End-of-Life Impact

+

Upfront Impact

)

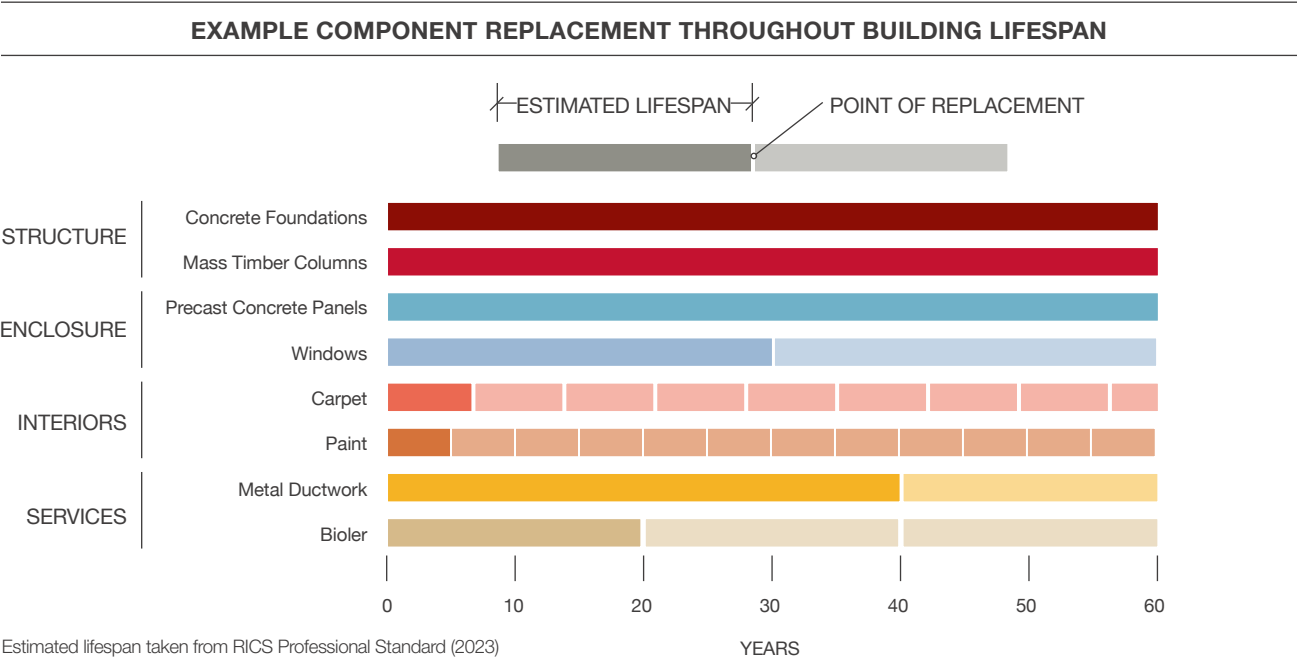
X

Replacement Rate

=

Embodied Carbon Impact

Depending on an item’s lifespan, a component may need to be replaced multiple times over a building’s operations, meaning these emissions will repeat at distinct periods. No replacement is anticipated for some building components (e.g., the structural system). The Module B4 impact of these components, then, is zero.



SPECIAL CONSIDERATIONS

Within the Embodied Use Stage, the relative impact of Module B4 is typically high. This is because it is essentially multiple repetitions of upfront and end-of-life emissions. Opting for low-carbon and durable materials is key to mitigating these impacts.

Although service life can be estimated, less predictable is the swapping of components due to trends. For example, a carpeted area may still be functional (i.e., not worn out), but the tenants no longer like its aesthetics. Here, the component is replaced before it reaches the end of its useful life. Mitigating this requires forecasting trends and aspiration toward timeless design, which is understandably difficult to achieve. Another good approach is selecting materials that can be removed from the building and reused elsewhere with minimal reprocessing.

WHOLE-BUILDING LIFE CYCLE

A0 PRE- CONSTRUCTION	A1-A3 PRODUCT STAGE	A4-A5 CONSTRUCTION STAGE	B1-B7 USE STAGE	C1-C4 END-OF-LIFE STAGE	MODULE D BENEFITS & LOADS BEYOND THE SYSTEM BOUNDARY
Study/Design	A1 Raw Material Supply	A4 Transport	EMBODIED USE STAGE B1 Use B2 Maintenance B3 Repair B4 Replacement B5 Refurbishment OPERATIONAL USE STAGE B6 Energy B7 Water	C1 Deconstruction C2 Transport C3 Waste Processing C4 Disposal	Reuse / Recovery / Recycle
	A2 Transport				
	A3 Manufacturing	A5 Construction			

End-of-Life Stage (C1-C4)

The final life cycle stage is aptly named the End-of-Life Stage, consisting of Modules C1 through C4. These refer to the deconstruction of building components (C1), their transportation away from the site (C2), and their waste processing (C3) and/or final disposal (C4). This stage aims to capture all building-related emissions that occur after its operations.

Like the Embodied Use Stage, the End-of-Life Stage requires speculation. In carbon accounting, the service life of a building is often taken as 60 years, meaning this stage attempts to predict activities that won't happen for over half a century. This leads to high uncertainty associated with its results.

Deconstruction & Transport (C1 & C2)

End-of-Life Stage Module C1 includes deconstruction, demolition, or decommissioning activities that occur on- or off-site. Module C2 covers transportation from the project site of any materials resulting from C1. These Modules parallel those in the Construction Stage. Instead of transporting materials to the site (A4) for construction (A5), material is deconstructed (C1) and transported away from the site (C2).

QUANTIFICATION

Because of their similarities, it is useful to refer back to the Construction Stage when quantifying Modules C1 and C2.

Like Module A5, Module C1 can consist of various construction-related emissions, such as temporary works and fuel consumption. Unlike A5, however, quantifying C1 requires estimation rather than precise accounting. One approach is to take C1 results as a percentage of A5 results.

The same quantification approach for Module A4 can be used for Module C2. Again, assessors will rely on assumptions, potentially estimating distances based on locations of nearby waste facilities.

QUANTIFYING MODULE C1, C2 CARBON

Deconstruction / Demolition Impact	+	Transport Impact	=	Embodied Carbon Impact
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SPECIAL CONSIDERATIONS

Although far in the future, Module C1 emissions can be mitigated through thoughtful design at the outset. For example, designing a system for disassembly allows it to be deconstructed with less effort and with the intent of reuse. Connection design and the type of fasteners used are critical to this reduction strategy.

Waste Processing & Disposal (C3 & C4)

End-of-Life Stage Modules C3 and C4 cover emissions related to component preparation for future use (C3) and final disposal (C4). Ideally, building components are salvaged to some level through direct reuse with minimal processing or reprocessing and recycling into a secondary product. Reuse, recovery, and recycling are all activities associated with C3. When this is not possible, final disposal through incineration or landfill is required and covered by C4.

MODULE C3	VS	MODULE C4
REUSE RECOVER RECYCLE		LANDFILL INCINERATE

EXAMPLE RELEVANT WASTE MODULES FOR BUILDING MATERIALS

	C3	C4
CONCRETE	✓	✓
METALS	✓	
TIMBER	✓	✓
GLAZING		✓
DRYWALL		✓
INSULATION		✓

C3 may be relevant for some building components, while C4 is relevant for others. Both modules might be applicable for some components that consist of multiple materials.

QUANTIFICATION

Quantification of Modules C3 and C4 will depend on the anticipated end-of-life scenario, which involves different processes and therefore equates to different emissions.

For C3, assessors need to know the amount of material for a given recovery process, how much that process can recover, and the GWP intensity of the recovery process. For example, cutting a steel beam to a new length to be reused elsewhere is less carbon intensive than recycling a steel beam through melting.

Similarly, C4 is also based on the amount of material for a given disposal process and the GWP intensity of that process. These emissions may occur over a short time period, such as incineration, or over a long time period, such as landfill decomposition.

QUANTIFYING MODULE C3, C4 CARBON

Mass

X

Waste
Proportion

X

Carbon
Intensity

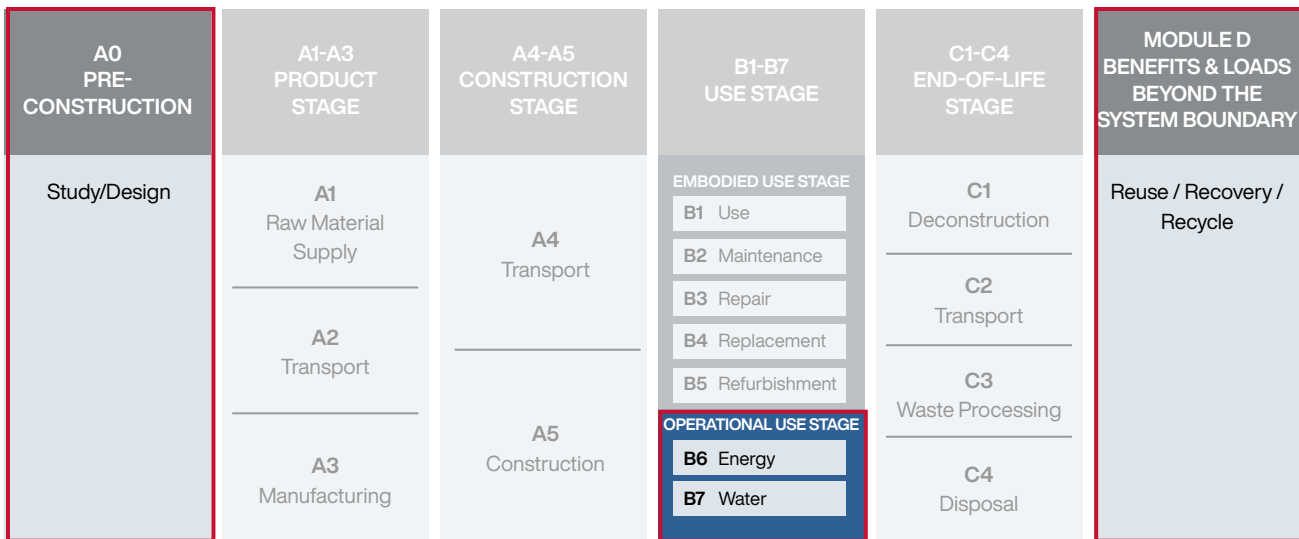
=

Embodied Carbon
Impact

SPECIAL CONSIDERATIONS

A building component's end-of-life circumstance represents an opportunity for carbon recovery and the potential for high carbon emissions. Materials recovered and reused elsewhere relieve the carbon burden of future projects and contribute to a circular economy. Conversely, materials incinerated or left to decompose are converted into direct emissions to the atmosphere. Here again, the importance of material selection and thoughtful design is highlighted to enable low-carbon end-of-life scenarios in the future.

WHOLE-BUILDING LIFE CYCLE



Additional Stages

The four life cycle stages covered—Product Stage, Construction Stage, Embodied Use Stage, and End-of-Life Stage—represent the stages where embodied carbon emissions occur throughout a building’s lifespan. For some assessments, additional stages may be considered by the assessor depending on the defined scope and goal of the assessment.

Pre-Construction (A0)

Pre-Construction Module A0 covers activities that occur prior to construction as a result of the project design. This may include project-related travel and site investigation, such as surveys and testing. Because the impact of this stage is relatively low compared to the following stages, it is not typically included in assessments.

Operational Use Stage (B6-B7)

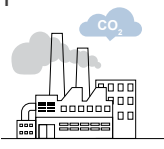
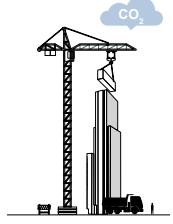
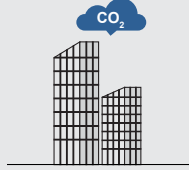
The Operational Use Stage, referred to simply as “**Operational Carbon**,” captures operational carbon emissions related to a building’s use, including from energy and water consumption. Because this Guide focuses on embodied carbon, this stage is not covered here. However, energy and water usage are ongoing throughout a building’s operations, which translates to high carbon emissions in this stage. Over a building’s lifespan, these emissions often rival or overcome the emissions from embodied carbon sources alone. For this reason, complete accounting of a project’s carbon emissions should include the Operational Use Stage.

WHAT ABOUT OPERATIONAL CARBON?

Although the focus of this Guide is embodied carbon, Hines recognizes the critical importance of addressing operational carbon. See our net zero commitment for more information.

Hines employees should refer to our Operational Carbon Guide. Reach out to Hines Energy & Decarbonization for assistance.

Building Life Cycle Stages Summary

STAGE (MODULE)	DESCRIPTION	QUANTIFICATION	EXAMPLE
PRE-CONSTRUCTION (A0)	Emissions resulting from building design; occurs prior to start of construction	A0: Varies based on activities	Surveying the existing structures on the future building site
PRODUCT (A1-A3) 	Emissions resulting from raw material extraction, transportation and manufacture into building components; occurs prior to start of construction	A1-A3: Environmental Product Declarations (EPDs)	Mining of stone from quarry, crushing stone into aggregate, transporting aggregate to ready-mixed plant, combining aggregate with other components to create concrete
CONSTRUCTION (A4-A5) 	Emissions resulting from transportation from manufacturing facility to construction site and construction-related activities; occurs during construction and prior to start of building operations	A4: Travel distance, transportation mode and associated fuel source A5: Complex to quantify; construction site fuel and waste consumption	Transportation elevator unit from assembly facility to construction site and its installation Excavating soil for basement construction
EMBODIED USE (B1-B5) 	Emissions resulting from building processes unrelated to energy and water consumption; occurs periodically throughout building operations	B1: EPDs or manufacturer data B2, B3, B5: Complex to quantify B4: Similar to Product Stage, considering replacement rate	Leaking refrigerants from a heat pump Replacing a curtainwall panel after a severe weather event
OPERATIONAL USE (B6-B7) 	Emissions resulting from building energy and water consumption; occurs consistently throughout building operations	B6: Energy model B7: Water use model	Consuming energy to heat a building Consuming water to flush a toilet
END-OF-LIFE (C1-C4) 	Emissions resulting from building demolition, transportation of waste, and waste processing activities; occurs after building operations have ceased	C1: Similar to A5 C2: Similar to A4 C3-C4: Waste stream and associated processes	Demolishing a parking structure, transporting the resulting concrete waste to processing facility, crushing the concrete into recycled aggregate
MODULE D 	Emissions resulting from processes beyond the building system boundary	D: Complex to quantify, with active industry debate	Considering biogenic carbon from bio-based materials or products



Module D

Module D covers impacts relevant to the project under assessment but are considered outside the boundary of the project system. This typically refers to a carbon benefit resulting from the project but not credited to the project (from recycling, for example). Although not beneficial to the project under study, noting benefits can assist design teams in understanding their contribution to circular design practices. Any reporting of Module D should be done separately from those of the other life cycle stages.

Biogenic Carbon

Construction materials made from vegetation, such as trees and grass, are unique. As plants grow, they pull carbon out of the air through a process called photosynthesis. This carbon is captured and then stored within the plant's or soil's organic material. This carbon storage is known as sequestration. Carbon captured through sequestration is referred to as **biogenic carbon**.

Bio-based materials, then, have the unique opportunity to remove and store carbon naturally. This can sometimes lead to net negative emissions attributed to a construction product after considering any emissions related to their manufacture.

Similar to Module D, if biogenic carbon is included in an assessment, the assumptions used to quantify it should be considered carefully, and its reporting should be done separately. The conservative approach is to underestimate the benefits of biogenic carbon given land use change impacts are generally not well quantified or reported today.

The choice of building materials should always consider the probable end-of-life scenario of that material. In the case of bio-based materials, if they are destined for the landfill, they may release much of the stored carbon as emissions through decomposition. This highlights why it is important to consider all life cycle stages of a product to truly understand its carbon impact.



CHAPTER 2

Summary

- For carbon accounting, a building's lifespan is broken into distinct periods called **life cycle stages**, which are broken further into **modules**
- The fundamental equation for quantifying carbon is the **amount of an emitter multiplied by the GWP intensity of that emitter**
- The **Product Stage** is typically the stage with the highest embodied carbon impact
- The Product Stage and Construction Stage offer project teams the **most direct influence on embodied carbon results**
- The Embodied Use Stage and End-of-Life Stage involve **speculation of future activities**
- Module D and biogenic carbon results should be **reported separately, with their assumptions clearly defined**
- The most complete carbon accounting **includes all life cycle stages**



CHAPTER 3

Quantifying Carbon

To quantify a building's emissions over its entire lifespan, a whole-building life cycle assessment (WBLCA) may be performed. WBLCAs combine the results from all life cycle stages to provide a holistic understanding of when carbon is emitted and how it might be addressed.

WBLCAs first originated in Europe and are governed by the **International Organization for Standardization (ISO) standards** 14040 and 14044, with the assessments of buildings covered by **European Standard (EN)** 15978. Although carbon is the focus of this Guide, complete WBLCAs provide results for all environmental impact categories, such as ozone depletion and eutrophication.

WHOLE-BUILDING LIFE CYCLE ASSESEMENT

A1-A3 PRODUCT STAGE	A4-A5 CONSTRUCTION STAGE	B1-B7 USE STAGE	C1-C4 END-OF-LIFE STAGE	MODULE D BENEFITS & LOADS BEYOND THE SYSTEM BOUNDARY
A1 Raw Material Supply	A4 Transport	EMBODIED USE STAGE B1 Use B2 Maintenance B3 Repair B4 Replacement B5 Refurbishment	C1 Deconstruction	Reuse / Recovery / Recycle
A2 Transport		OPERATIONAL USE STAGE B6 Energy B7 Water	C2 Transport	
A3 Manufacturing	A5 Construction		C3 Waste Processing	
			C4 Disposal	

Because a WBLCA includes both the Embodied Use Stage and the Operational Use Stage, it can illuminate the trade-offs between **embodied** and **operational carbon**. It is also useful when assessing the carbon implications of a renovation versus new construction, comparing the carbon impact of dissimilar materials (when comparable data is used), or accounting for the long-term consequences of durability and resiliency choices.

A project team may choose to perform a WBLCA for various reasons, including for green building certification. The most valuable reason, however, is to take advantage of the holistic view of carbon emissions that a WBLCA offers. Leveraging this perspective, project teams can ultimately achieve best-value carbon reductions powered by informed decision-making.

WBLCA OR WLCA?

Whole-Building Life Cycle Assessment vs. Whole-Life Carbon Assessment

The primary difference between a whole-building life cycle assessment (WBLCA) and a whole-life carbon assessment (WLCA) is the output:

WBLCA results will address all environmental impact categories, including those beyond carbon such as eutrophication and smog formation. WLCA results will only address carbon.

Although both are important tools for assessing environmental performance, a WBLCA is arguably more comprehensive.

Conducting a WBLCA

WBLCA CONSULTANTS

For assistance with WBLCA consultant scoping and selection, refer to Hines Conceptual Construction Group or Hines Energy & Decarbonization.

A WBLCA can be described as the combination of results from each life cycle stage discussed in [Chapter 2](#) for every building component included in the assessment's scope. This means a WBLCA can be broken down into the equations provided for each stage in Chapter 2, which stem from the fundamental equation that consists of two principal variables – a component's quantity and **GWP intensity**.

To best perform a WBLCA, experience with and knowledge of building construction is key. Typically, a WBLCA is conducted by a Sustainability Consultant whose scope includes WBLCA services. Sometimes, though, this work may be executed by the Architect or other design consultant. When performed by the Sustainability Consultant, they must rely upon and collect information from the design team to ensure their understanding of the building and, therefore, the accuracy of the assessment. In this way, a well-crafted WBLCA requires collaboration from all stakeholders, including the Owner, design team, Sustainability Consultant, and Contractor.

Goal Setting

Before beginning a WBLCA, the project team should set clear goals. Examples include:

- Understanding the embodied carbon impact of the building
- Proving compliance with a governing regulation
- Achieving a % reduction from a baseline scenario
- Achieving green building certification points or requirements
- Identifying early-stage carbon 'hot-spots'
- Weighing the trade-off between systems that impact both embodied and operational carbon
- Identifying which building systems should be the focus of material optimization
- Identifying which building **products** should be the focus of carbon-smart procurement

The selected goal or goals will inform the following items.

Scope Selection

A detailed outline of what is included and excluded in the WBLCA's scope should be created based on the selected goal or goals. This includes building categories (e.g., structure, services, etc.) and life cycle stages (e.g., Module D inclusion or exclusion). Questions to ask when crafting the scope include:

- What scope is required to achieve the stated goals?
- What scope is required by the governing policy or pursued certifications?
- What scope will capture the most impactful components of the building?

HINES MINIMUM WBLCA SCOPE

LIFE CYCLE STAGES (MODULES)

- ☐ Product Stage (A1-A3)
- ☐ Construction Stage (A4-A5)
- ☐ Use Stage (B1, B4, B6)
- ☐ End-of-Life Stage (C1-C4)

BUILDING CATEGORIES

- ☐ Structure
 - ☐ Substructure
 - ☐ Superstructure
- ☐ Enclosure
 - ☐ Envelope
- ☐ Interiors
 - ☐ Interior walls/ partitions
 - ☐ Finishes
- ☐ Services
 - ☐ MEP



When to Perform

As a project moves through design, the ability to use the information provided by a WBLCA diminishes. Decisions begin to lock in, and the ability to leverage insights from the WBLCA is reduced. Proper budgeting at the outset of a project is also critical to ensuring that stated goals can be met financially. For these reasons, WBLCA should be performed as early as possible and updated at key milestones, including:

- Schematic Design – may be used as the **Baseline** scenario for comparison purposes
- Design Development
- Construction Documents – referred to as the **As-Designed** scenario
- Construction Close-Out – referred to as the **As-Built** scenario

Early-stage WBLCA should focus on hot-spot analysis and design-related reduction opportunities, such as assembly and material swaps. Late-stage WBLCA will shift focus to procurement-related reduction opportunities, such as lower-carbon manufacturing and sourcing recycled materials, and track progress toward declared goals.

Tool Selection

Various tools are available to assist designers in performing WBLCAs. These range from concept-level tools (e.g., [c.scale](#) and [CARE Tool](#)) to full-scale WBLCA tools (e.g., [One Click LCA](#)). Questions to answer include:

- Is the tool accepted by the governing policy or pursued certifications?
- Does the tool address the building categories and life cycle stages outlined in the scope?
- Does the tool contain regionally appropriate data?
- Does the tool leverage BIM software?

Documentation

Just like the buildings they assess, WBLCAs are informed by many factors. This includes their declared goal(s), scope, methodology, and any assumptions used to fill gaps in data. Examples include assumed quantities when as-built **Bill of Materials** are unavailable and assumed GWP intensities when **product-specific EPDs** are unavailable.

To keep track, assessors need to document these key items clearly. This creates consistency in WBLCAs throughout the project phases and enables quality assessment review and project-to-project comparisons. If, for example, two WBLCAs do not clearly state which life cycle stages were included, a comparison between the two becomes problematic.

BASIS OF ANALYSIS

This important documentation can be through a Basis of Analysis (BOA). By clearly outlining items such as scope and assumptions, the BOA becomes a means of communication between the assessor, Owner, design team, and Contractor that ensures all stakeholders are aware of key WBLCA inputs.

A mistake seen in WBLCA is when the consultant performing the study makes assumptions based on defaults provided by the WBLCA tool or based upon their limited understanding of the project if only interacting with BIM information. It is essential that all project stakeholders be engaged when determining assumptions. The BOA creates an opportunity to discuss assumptions and their implications before conducting the WBLCA.



Basis of Analysis Checklist

PROJECT INFORMATION

- ☐ Name
- ☐ Location
- ☐ Typology
- ☐ Description
- ☐ Certification
- ☐ Construction Date (Start, Completion)
- ☐ Gross Internal Area
- ☐ Height
- ☐ Floors (Above Ground, Below Ground)
- ☐ Structural Description
- ☐ Envelope Description
- ☐ Services Description

ASSESSMENT INFORMATION

- ☐ Assessor
- ☐ Date
- ☐ Phase
- ☐ Goal
- ☐ Methodology
- ☐ Reference Standard
- ☐ Units
- ☐ Software
- ☐ Reference Study Period
- ☐ Scope (Life Cycle Stages, Building Categories / Components)
- ☐ Data Sources (Material Quantities, GWP Intensities)
- ☐ Assumptions
- ☐ Uncertainty & Variability

WBLCA Results

The process of performing a WBLCA can be helpful in and of itself. As project teams collect the data necessary to conduct a WBLCA, it is natural to scrutinize it and perhaps challenge business-as-usual approaches or assumptions. This alone can lead teams toward cost and carbon reductions.

Once WBLCA results are available, it is important that project teams thoughtfully review them to make informed design or procurement decisions. Results may be reported in a variety of ways. Still, they should always use units of kgCO₂e or MTCO₂e (kilograms or metric tons of carbon dioxide equivalent) for **GWP** results and kgCO₂e/m² for GWP intensity results, regardless of the unit system local to the project. Beyond decision-making, WBLCA results are also critical for carbon reporting.

UNITS FOR ALL CARBON REPORTING

Carbon: kgCO₂e

Carbon Intensity: kgCO₂e/m²

EXAMPLE WBLCA RESULTS



SETTING A BASELINE

For assistance with setting an appropriate WBLCA baseline, refer to Hines Energy & Decarbonization.

Baseline Comparison

A carbon baseline is needed to assist project teams in interpreting WBLCA results and tracking against reduction targets. This baseline will serve as the point of reference to which the project results will be compared.

Unfortunately, no standard approach governs the calculation of an embodied carbon baseline. Some options for consideration include the following:

- **Regulatory or Certification** | When a local jurisdiction (e.g., London's GLA) dictates embodied carbon requirements, the project team must use these as the minimum baseline. Similarly, pursued green building certifications may include an embodied carbon requirement (e.g., ILFI's Zero Carbon Certification). Care should be taken to investigate which targets govern the project.
 - *Example claim: The project achieved an embodied carbon intensity of 900 kgCO₂e/m², a 5% reduction from the GLA requirement.*
- **Business-as-Usual Design** | The baseline is created by taking a business-as-usual design and applying regional generic or industry-average GWP intensities. The building components and their quantities should reflect business-as-usual building typology and regional conditions. Later phases are then compared to this baseline scenario.
 - *Example claim: The project achieved a 15% reduction in embodied carbon compared to a business-as-usual scenario.*
- **Regional or Voluntary** | When local benchmarks (e.g., **Carbon Leadership Forum's** North American Benchmarks) are available, they can serve as a baseline. Also available is a global pathway set by the Science Based Target Initiative (SBTi). Although both examples are voluntary, they are valuable references when other requirements do not exist.
 - *Example claim: The project achieved alignment with SBTi's embodied carbon target for 2030.*

In all cases, the selected baseline should be appropriate for its intended purpose, aligned in scope to the results being compared, and cautious of accidental greenwashing.



Uncertainty & Variability

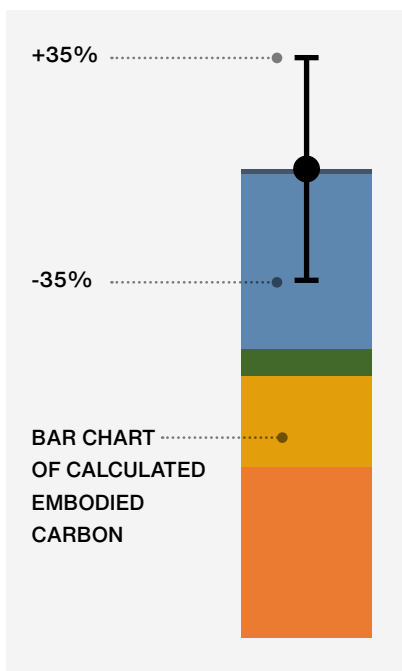
Understanding and assessing the range of potential outcomes within the data presented in a WBLCA is important to making reliable project decisions. Sources of imprecision come from the uncertainty, or “unknowns,” in the underlying data (e.g., actual emissions from a manufacturing process or using quantity estimates before a design is complete) as well as the variability (e.g., use of average data that represents a range of possible manufacturing processes).

Typically, a range of potential outcomes is not included in WBLCA results. This is mainly due to the lack of standards and complexity in confidently assessing data quality. However, by expressing results as a range rather than a single value, results become more directionally accurate and provide more information when comparing options, enabling best-informed decisions.

Reducing uncertainty is best done by aligning and improving LCI datasets behind WBLCA calculations, using the same LCI dataset for a given study, and refining the material quantity estimates throughout the design. Reducing variability is achieved by utilizing as much project- and product-specific data as available. Naturally, uncertainty and variability will reduce over the course of a project as material quantities are finalized, vendors are selected, and the material supply chain becomes known.

ISO 21930:2017: provides some guidance on how the range of potential outcomes should be addressed within WBLCA and EPD data reporting, including a requirement stating that “the information provided for any comparison shall be transparent to allow a clear understanding of the limitations of comparability.”

REPORTING DATA RANGES



ESTIMATING THE RANGE OF POTENTIAL OUTCOMES

Calculating a range of results for data is complex. Where possible, consultant WBLCA results should estimate and disclose uncertainty and variability due to the two primary sources: building component quantities and their **carbon intensity**. Note that these correspond to the variables in the fundamental equation discussed on [page 26](#). The range attributed to each source for each emitter included in the WBLCA should be combined utilizing the square root sum of squares (SRSS) method, producing an overall $\pm$ range for that emitter.

$$\text{Data Range} = \pm \sqrt{(\text{quantity range})^2 + (\text{kgCO}_2\text{e range})^2}$$

Once a component's range of potential outcomes is assessed, the bounds of reasonable confidence for a data point can be shown. One way to communicate this visually is by adding whisker bars to data points, representing a given result's high and low values.

EXAMPLE DATA RANGE CALCULATION:

Embodied Carbon Result = 100 kgCO₂e

Quantity Range Estimate = $\pm 10\%$

Carbon Range Estimate = $\pm 33\%$

Combined Range = $\pm 35\%$

Top of Whisker Bar =
(1-0.35)*100 = 65 kgCO₂e

Bottom of Whisker Bar = (1+0.35)*100 = 135 kgCO₂e

Documentation

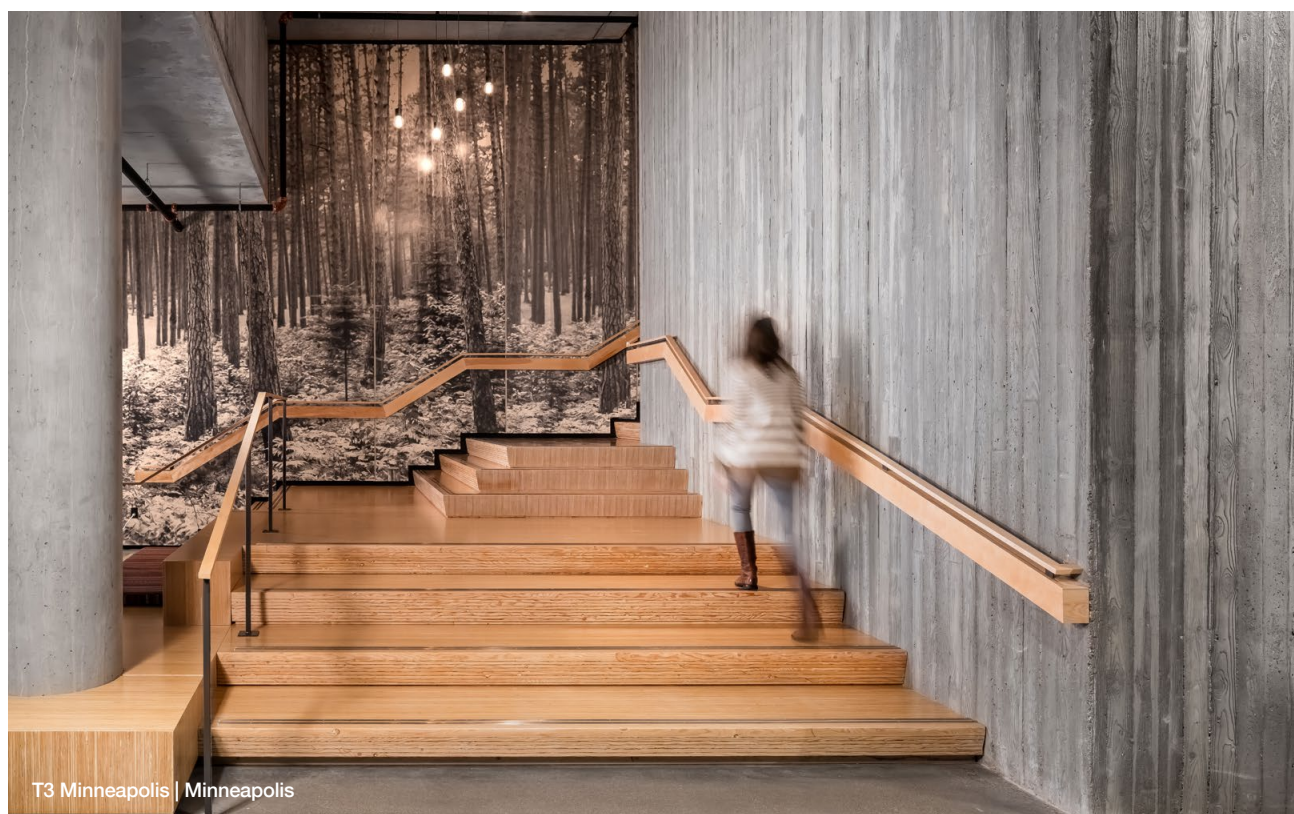
As with the items documented by the BOA, documentation and presentation of WBLCA results warrant careful consideration. Results should be communicated clearly and leverage concise visuals.

An example visual is the color-coded WBLCA table on the next page that displays not only the numeric results but also the quality of the data. Here, color density is used to visually communicate what is being measured, estimated, or excluded from the analysis. Most WBLCA today do not directly measure or even include all building categories or life cycle stages, which should be clear when viewing the results. Directly measured information will have the least uncertainty over project-specific assumptions or industry placeholders. Typically, the highest quality information is available for the Product Stage.

Also included in this example is a bar chart highlighting the relative impacts of the different WBLCA stages. Here, whisker bars are included for each project stage to indicate the range of possible outcomes.

Although data uncertainty and variability are not typically reported, when an estimated range of GWP values is provided, the overlap between comparative choices indicates that the WBLCA results alone may not be adequate to inform a decision. However, it can help identify probable outcomes, pinpoint where better data is needed, and if it is worth investigating further. As a project progresses through design and construction, the quantity and carbon intensity data quality naturally improves. Documenting data quality along the way improves a team's confidence in the results.

Conducting a comprehensive WBLCA continues to be an evolving process. Even when comprehensive information is limited, WBLCA still provide directional information that is helpful for evaluating reduction opportunities. However, understanding a WBLCA's limitations and critically evaluating its findings are important for project teams before making decisions.



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WHOLE-BUILDING LIFE CYCLE ASSESSMENT REPORTING TEMPLATE

					STAGE & MODULE																
					PRODUCT		CONSTRUCTION			USE										END-OF-LIFE	
CATEGORY	MATERIAL	QUANTITY	UNIT	SERVICE LIFE	A1-A3		A4	A5	B1	B2	B3	B4	B5	B6	B7	C1-C4	TOTAL by MATERIAL				
				MT CO2e	MT CO2e	MT CO2e	MT CO2e	MT CO2e	MT CO2e	MT CO2e	MT CO2e	MT CO2e	MT CO2e	MT CO2e	MT CO2e	MT CO2e	MT CO2e				
Structure	Concrete	500	m3	60	250,000	10,000	15,000									12,500	287,500				
	Rebar	30	tons	60	24,000	960	1,440									1,200	27,600				
	Steel	80	tons	60	100,000	4,000	6,000									5,000	115,000				
	Steel Deck	15	tons	60	29,000	1,160	1,740									1,450	33,350				
Enclosure	Curtainwall	500	m2	30	120,000	4,800	7,200				120,000					6,000	258,000				
	Glazing	50	m2	30	700	28	42				700					35	1,505				
Interiors	Drywall	60000	m2	30	2,000	80	120				2,000					100	4,300				
	Studs	60	tons	60	1,000	40	60									50	1,150				
	Flooring	3000	m2	10	300	12	18				1,500					15	1,845				
Services	HVAC	300	tons	40	25,000	1,000	1,500	10,000			25,000		920,000			1,250	983,750				
	Electrical	30	tons	30	700	28	42				700					35	1,505				
	Plumbing	500	tons	25	11,000	440	660				22,000					550	34,650				
TOTAL by STAGE					563,700	+33% -31%	22,548	+25% -25%	33,822	+30% -30%	10,000	+20% -5%		171,900	+10% -10%	920,000	+10% -10%	28,185	+100% -50%	1,750,155	+19% -19%

LEGEND (TYPICAL ALL COLORS):

MEASURED

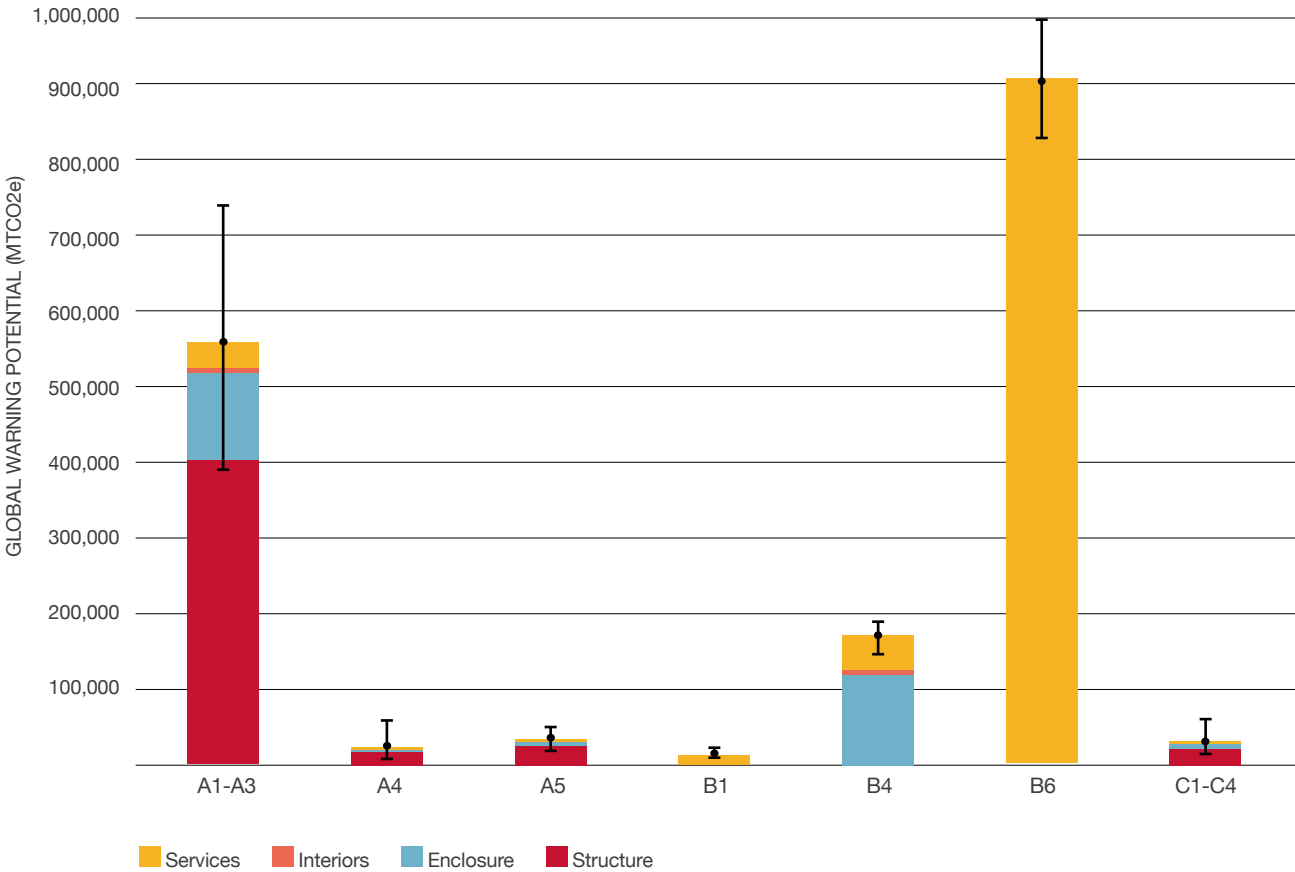
PROJECT-SPECIFIC ESTIMATE

INDUSTRY DEFAULT

EXCLUDED

NOT APPLICABLE

WBLCA RESULTS BY MODULE



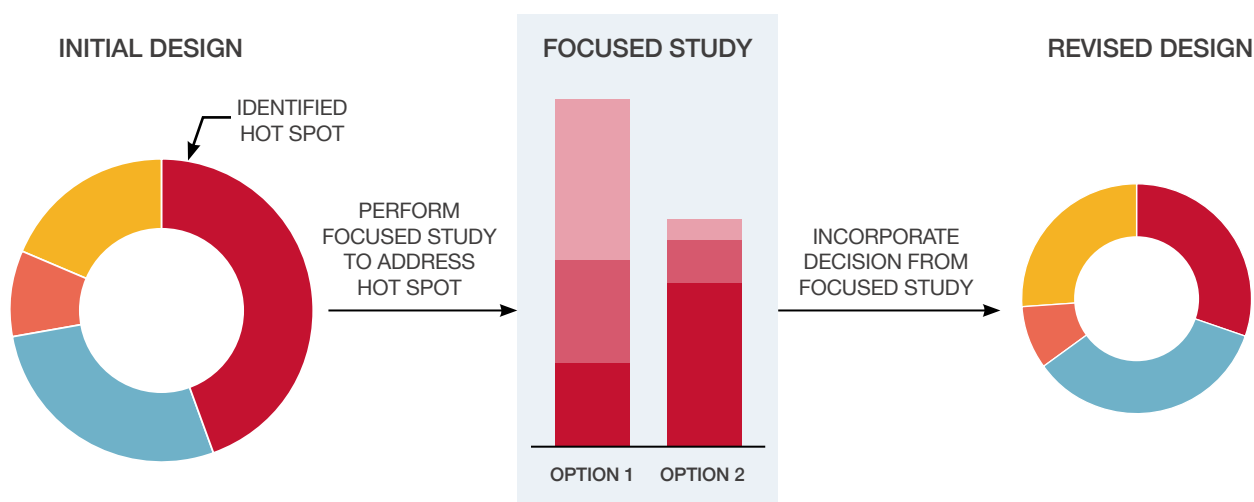
Focused Studies

Although the power of a WBLCA comes from its ability to combine results from any desired building component across all life cycle stages, there are scenarios in which this comprehensive assessment is unnecessary or overly arduous. In these cases, it may be appropriate to conduct a reduced study. These include studies that are focused in their scope of building categories and/or life cycle stages.

For example, suppose a project team is trying to assess which exterior façade system is the carbon-smart option. In that case, they may create a focused study with a scope reduced to the façade system, any relevant structural support, and the HVAC system. In this case, all life cycle stages should still be included to weigh the trade-offs between embodied and operational carbon appropriately. Another example might be for the selection of the structural system. In this case, the scope would include the structure only and could exclude the Use Stage, given it is typically null for structural elements.

The purpose of these focused studies is to provide quick assessments of project options. One approach is to perform an early-phase WBLCA for the full intended scope, use this to determine project ‘hot-spots,’ and then use studies to assess potential options for addressing these hot-spots. Once decisions are made, the selected design is incorporated into the next iteration of the WBLCA.

USING FOCUSED STUDIES TO ACHIEVE REDUCTIONS



Estimating Future Carbon Emissions in WBLCA

DECISION-MAKING

While options exist to account for future carbon emissions, project teams should always make decisions based on best available science and reasonable approximations.

Carbon emissions that make up a building's footprint are influenced by external factors, including upstream supply chain and electrical grid emissions. How these will change over time is unknown, but reasonable assumptions can be made through industry guidance available today. Considering its uncertainty, this guidance is another tool that project teams may leverage to inform today's decisions.

Although not the focus of this Guide, operational carbon emissions are impacted by this effect due to their correlation to grid emissions. In the U.S., for example, the GWP intensity of electricity generation is declining and is expected to continue to drop over the coming decades due to increased renewables. To project these reductions, the National Renewable Energy Laboratory (NREL) has created the Cambium tool that estimates future electricity emissions considering policy, costs, and practices. Incorporating the data from tools such as this into Operational Use Stage calculations can give teams an idea of future-state conditions.

A primary influence on embodied carbon is the decarbonization of material manufacturing. Industry associations for key **materials** such as steel and concrete, along with many individual manufacturers, have recently placed importance on the increased carbon performance of their products. Many have created decarbonization roadmaps or set carbon neutrality goals for the coming decades.

One method to capture decarbonization plans such as these was created by the Royal Institution of Chartered Surveyors (RICS) and published in its professional standard, [Whole Life Carbon Assessment for the Built Environment](#). By incorporating these assumptions, project teams can see the importance of avoiding the use of new materials today as new materials in the future are expected to be less carbon-intensive or carbon-smart materials will be more commonplace. This accentuates strategies such as building or material reuse and using high-recycled content products.

Residual Value

Using the RICS projections for embodied carbon provides a **residual value** estimate for materials that can be reused today as they delay the purchase of new material. Since future replacement materials are projected to be lower carbon, delaying replacement creates a carbon value.

For existing buildings, comparing a demolished and build-new scenario versus the reuse of an existing one can also be guided by this approach. Here, the future savings accrued by retaining the existing materials are quantified at the building level.

Including these carbon projections adds a realistic perspective to WBLCA results. It also adds another factor when comparing scenarios, including across time. Although future-forward, project teams should utilize future scenarios carefully and conservatively. If a WBLCA includes decarbonization scenarios, it should be clearly and separately documented.



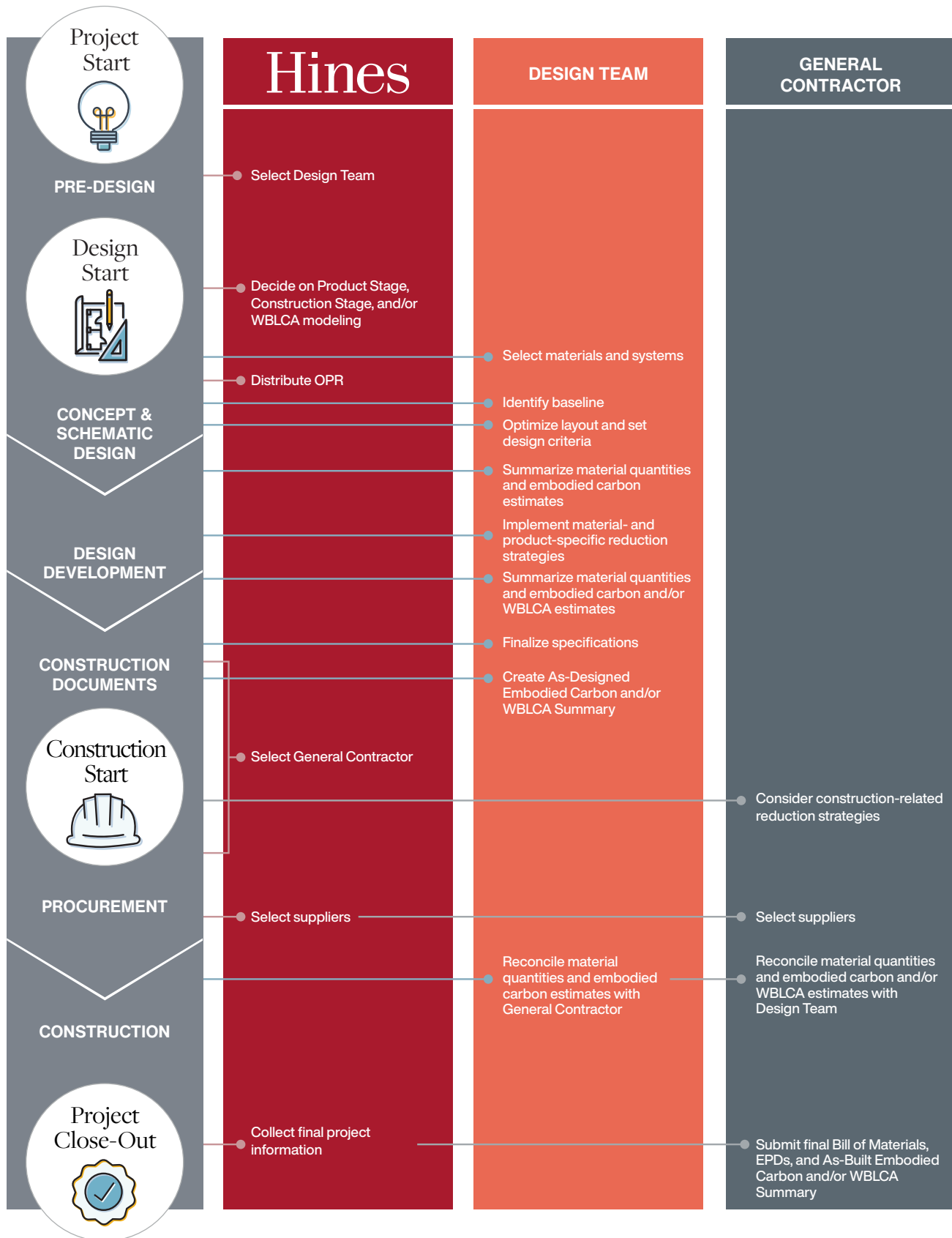


CHAPTER 3

Summary

- **Whole-Building Life Cycle Assessment (WBLCA)** quantifies the impact of a building across all life cycle stages and environmental impact categories, including GWP
- WBLCA can be used to **weigh the trade-off** between embodied and operational carbon emissions
- Key components of a WBLCA are its goal, scope, and assumptions, which can be documented in a **Basis of Analysis**
- WBLCA results should be **critically reviewed** before any decisions or claims of achievement are made
- When possible, create a range of WBLCA results by **estimating uncertainty and variability**
- **Focused studies** can be used for quick and focused assessments for comparison purposes
- Although **future conditions** are unknown, resources are available today to project future carbon emissions

Embodied Carbon Reduction Responsibilities



CHAPTER 4

Reducing Carbon

CARBON'S COST

The best way to reduce embodied carbon is by building with less materials, creating a win-win scenario between carbon reduction and cost savings.

Reducing embodied carbon requires input and effort from various project team members throughout all design and construction phases. There is no universal method for reduction, but rather a combination of potential options unique to each project.

Embodied carbon reduction is not a single event that happens at a single point in time. For new construction, it is instead a mindset that should be integrated throughout the entire project delivery, from pre-design to project close-out. By keeping reduction top of mind, project teams have the best opportunity to identify reduction opportunities early on so that resulting strategies can be implemented throughout design and construction.



T3 | Minneapolis

Pre-Design

Before design even begins, factors that will influence a project team's ability to achieve reductions are already at play. During this pre-design phase, some key actions to consider include:

Select Project

An obvious first step for any project is the decision to move forward with it, selecting its location, function, and size. These factors play a significant role in the eventual embodied carbon emissions: the location sets the site conditions (e.g., existing structures), reuse opportunity, whether carbon regulations are applicable, and the availability of **products** and technologies; the function and size set the design criteria. Given how influential these factors are, and how they may “lock-in” choices, it is valuable to keep carbon in mind even at the outset.

Conduct Market Research

Investigating current and projected local market conditions is necessary when first deciding to move forward with a project and is beneficial to other actions in the pre-design phase as well. This includes researching applicable regulations, regional practices, knowledgeable consultants, and available suppliers. It should also include local market enablers, such as tenant attraction to ‘green’ assets and available cost incentives. These will set the team's understanding of business-as-usual and assist in defining market-leading goals.

Set Goals

Owner and deal teams should set embodied carbon goals at the investment or project outset to act as a north star for the project. These may be voluntary (e.g., green building certification) or mandatory (e.g., local regulation) and should be clearly defined with the ability to verify at the project's end. Goals should reflect team ambitions and consider the findings of the market research.

Select Project Team

Project consultants are critical to a project's ability to achieve its goals. At a minimum, selected professionals should be willing to participate in carbon reduction strategies. Ideally, consultants show enthusiasm and leadership for the topic and have experience in its execution. The more carbon champions a project has, the more likely innovative ideas will be presented.

DESIGN TEAM SCOPE OF SERVICES

Design team members key to embodied carbon reduction include the Architect, Structural Engineer, and MEP Engineer(s). For this reason, their respective scope of work documents should include consistently summarizing quantities, participating in reduction workshops, and investigating reduction strategies.

Refer to Hines Conceptual Construction Group or Hines Energy & Decarbonization for assistance.

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Design

The design phase is a prime opportunity to set up the project for success before construction begins. The following sections describe actions at each design phase. Note that the general progression of a design will vary from project to project, as will the timing for when to take these actions.

	PRE-DESIGN		DESIGN			CONSTRUCTION	HANDOVER	IN-USE
AIA (USA)			SCHEMATIC DESIGN	DESIGN DEVELOPMENT	CONSTRUCTION DOCUMENTS	CONSTRUCTION		
RIBA (UK)	0 STRATEGIC DEFINITION	1 PREPARATION & BRIEF	2 CONCEPT DESIGN	3 DEVELOPED DESIGN	4 TECHNICAL DESIGN	5 CONSTRUCTION	6 HANDOVER & CLOSE-OUT	7 IN-USE

Adapted from: RIBA Plan of Work

Concept & Schematic Design

These early stages are foundational for the design phase and include actions such as:

FINALIZE GOALS

Once the project team has been onboarded, the project's ambitions should be revisited. Consultants may provide further input from experience, capabilities, and market knowledge that should be considered. This additional expertise may unlock more ambitious carbon goals.

As teams set goals, it is important to define their reference points or what they will be compared against, known as the **baseline** scenario (see [page 55](#)). This will remain constant as the design progresses unless significant changes occur, with comparisons against it carried out at key milestones.

SET DESIGN CRITERIA

The project design criteria are essential to communicate performance requirements, including those that impact carbon. As it is established by the Owner and design team, the criteria should be reviewed against the project's goals to ensure it is creating a roadmap toward achieving them. Design criteria examples that can impact carbon performance include:

- Programming criteria, including design loads
- Finish criteria, including secondary coverings and exposed structure
- Energy efficiency and daylighting criteria, including envelope assembly and geometry
- Serviceability criteria, including deflections and vibrations
- Site-specific lateral criteria, including resiliency

Owner Project Requirements

The Hines Owner Project Requirements (OPR) is a powerful tool to ensure the design team has critically reviewed the design criteria for embodied carbon reduction opportunities. Embodied carbon items have been added under each trade to prompt discussion.

Refer to Hines Conceptual Construction Group for assistance.



SELECT MATERIALS & SYSTEMS

What components a building is made of is the biggest driver of its embodied carbon emissions. Therefore, **material** and system selection—such as concrete versus steel and curtain wall versus precast panels—is critical. Cost, schedule, and labor conditions typically drive these decisions, but embodied carbon should also be included as a key metric.

A primary design-related reduction strategy is the selection of low-carbon materials or products. Teams should explore alternatives beyond the business-as-usual and encourage consultants to offer out-of-the-box suggestions. Before making decisions, these should be investigated to determine their viability, considering all the market factors above.

IDENTIFY FOCUSED STUDIES

As project teams encounter decision points, focused carbon studies may be useful in assessing their options. It's here in early design that studies most relevant to the project should be identified, and a plan to execute them made.

CONDUCT SD WBLCA

At the end of Schematic Design (SD), a **whole-building life cycle assessment (WBLCA)** should be performed. This serves as the initial understanding of the project's carbon, including a hot-spot analysis that illuminates what building categories or components are most carbon intensive. This will facilitate the selection of the focused studies to be performed and allow project teams to identify where reduction efforts will be most impactful.

SD ASSUMPTIONS

Quantities: design team estimates

GWP: generic / industry-average data

All carbon assessments should utilize the best information available. At this early stage, a heavy reliance on estimates may be required. For some building component quantities, design team estimates may be all that's available. For applied **GWP** values, unless more specific information is known, assessments should utilize generic or industry-average values applicable to the region.

It is important that GWP assumptions are accurately cataloged throughout all stages of design in the form of a Basis of Analysis (see [Page 52](#)). This will allow informed comparisons to be made between stages and to other projects.

Design Development

With the design underway but not finalized, Design Development (DD) is a midpoint where enough decisions have been made to provide direction, but enough flexibility remains to generate opportunity. Key actions include:

CONDUCT FOCUSED STUDIES

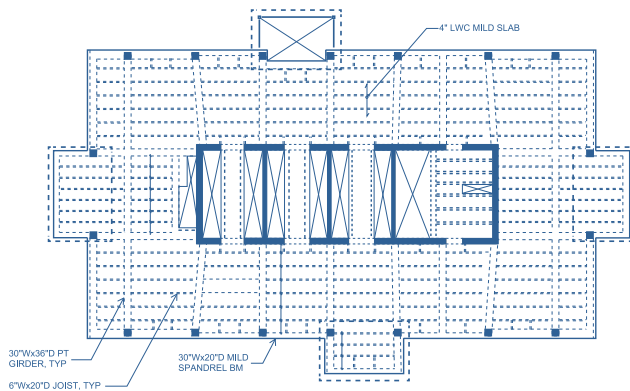
At the start of DD, enough information should be available to conduct the focused studies identified in SD. The most knowledgeable consultant(s) should create a material quantity estimate for each option considered. Industry-average GWP values can then be applied to generate preliminary results unless more specific information is available. These results, ideally combined with initial cost estimates, should be reviewed by the broader team to make carbon-informed decisions.

This is an opportunity for teams to focus on high-impact areas and make targeted decisions based on key metrics, such as cost, schedule, and carbon. Once a decision has been made, the appropriate consultant should integrate it into the broader building design, updating documentation as needed.

COMPARISON OF ALTERNATE STRUCTURAL SYSTEMS EXAMPLE

Concrete Option 1

Pan Joist System

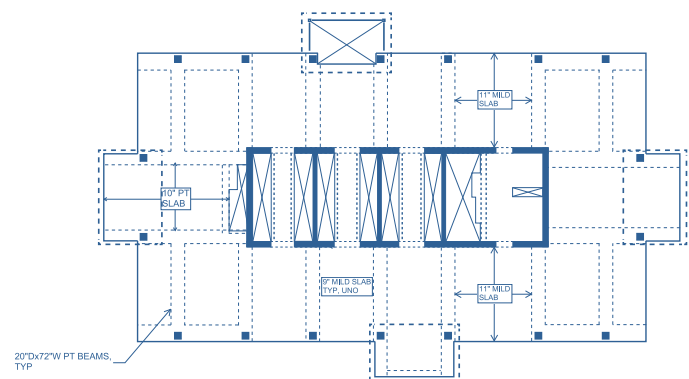


OPTION 1 MATERIAL QUANTITY SUMMARY

POST-TENSIONING	0.5 PSF
MILD REINFORCING	5.5 PSF
CONCRETE VOLUME RATIO	0.73 ft ³ /ft ²
INDUSTRY-AVERAGE GLOBAL WARMING POTENTIAL	15 kg CO ₂ eq/ft ²

Concrete Option 2

Post-tensioned Wide-shallow Beam System



OPTION 2 MATERIAL QUANTITY SUMMARY

POST-TENSIONING	0.75 PSF
MILD REINFORCING	5.0 PSF
CONCRETE VOLUME RATIO	0.93 ft ³ /ft ²
INDUSTRY-AVERAGE GLOBAL WARMING POTENTIAL	19 kg CO ₂ eq/ft ²

REDUCTION STRATEGIES

See tear-out sheets starting on [Page 76](#) for design-related reduction strategies to consider.

IMPLEMENT DESIGN-RELATED REDUCTION STRATEGIES

As the design advances, project teams should be on the lookout for and compile potential embodied carbon reduction strategies. It may be necessary to investigate these strategies as part of the focused studies to evaluate their effectiveness and feasibility, considering project-specific conditions. Like decisions resulting from the focused studies, once a strategy has been vetted and confirmed, it should be implemented into the project design.

Exploring design-based strategies in the design phase is important before considering procurement-based options. Reductions achieved through design are innovative, less susceptible to future conditions such as supply chain availability, and can even equate to cost savings if they stem from quantity reduction.

OPTIMIZE DESIGN & DETAILING

Once the materials and systems have been selected, design optimization is key—taking materials out of the building is the most direct way to reduce embodied carbon. This entails reviewing spatial requirements and assessing them for inefficiencies. For example, consider relocating columns to reduce large spans and transfers, reshaping façade geometry to minimize surface area, and revisiting landscape assemblies to reduce materials and loading. Along with optimization, thoughtful detailing is also important. Examples include simplifying assembly connections, curtailing concrete reinforcement, and designing for disassembly.

CONDUCT DD WBLCA

An updated WBLCA should be conducted at the end of DD for continued monitoring as the design develops. Teams may observe shifts in relative impacts between building categories. Still, ideally, the overall impact of the building is trending lower than the initial values from SD as a culmination of this stage's efforts.

Although some estimation may still be required for component quantities, much less should be needed. Designers may be able to leverage BIM software take-off capabilities at this stage to reduce manual efforts and increasingly reflect project-specific geometry. Since it is still early in the design, and project specifications are yet to be finalized, GWP values should still come from generic or industry-average sources. If the General Contractor is already engaged at this stage, their take-offs may be available for the assessment. Any discrepancies between the design team and Contractor values should be reconciled.

DD ASSUMPTIONS

Quantities: design team take-offs

GWP: generic / industry-average data

Construction Documents

The last design stage, Construction Documents (CD), acts as a bridge between design and construction and includes the following key actions:

FINALIZE SPECIFICATIONS

Finalized specifications should reflect the reduction strategies chosen as appropriate. This may include design-related strategies, such as relaxed day-of-strength requirements for concrete, and procurement-related strategies, such as recycled content. Care should be taken when crafting the specifications to identify unintended consequences, such as limiting supplier choice and setting GWP thresholds that are too easily achieved.

Specifications should also include language requiring the General Contractor to submit **Environmental Product Declarations (EPDs)** for all components considered and tracked for embodied carbon reduction. These should be **product-specific Type III EPDs** conforming to **ISO** standards. GWP data provided by the EPDs should cover, at a minimum, impacts from the Product Stage (Modules A1-A3). Specifications should also call for the Contractor to submit a **Bill of Materials** that itemizes building quantities by application and type, with the GWP for each item—based on EPDs—also included.

SPECIFICATION LANGUAGE

For assistance with adding specification language for EPD collection and other embodied carbon-related items, contact Hines Conceptual Construction Group or Hines Energy & Decarbonization.

PROJECT MASTER SPEC AND EXAMPLE BILL OF MATERIALS

The following language can be added to any material specification where EPDs and total GWP are to be considered. Include the following in the Submittals section of specification.

ENVIRONMENTAL PRODUCT DECLARATION (EPD):

Submit product-specific Type III EPDs conforming to ISO 14025 and ISO 21930 including Life-Cycle Assessment Modules A1-A3 which at a minimum must include Global Warming Potential (GWP).

BILL OF MATERIALS:

Submit amount of each product type and specification, prior to start of construction and at completion of construction. Report any assumptions and allowances included in amounts.

Concrete Bill of Materials:				
ELEMENT	QTY (CY)	STRENGTH (PSI)	GWP #/SQ CY	GWP #/SQ YD
MAF FOUNDATIONS	250	8,000	373.75	45.445
GRADE BEAMS	350	8,000	343.45	85.208
SLAB ON GROUND	625	4,000	275.98	172.468
SUPPORTED SLABS	13,550	6,000	352.52	4,488.895
CEILING AND FILL SLABS	150	4,000	275.98	45.397
WALLS	50	12,000	275.98	137.995
COLUMNS	500	8,000	270.28	135.140
CONCRETE SHEAR WALLS	750	12,000	275.98	206.993
CONCRETE SHEAR WALLS	1,100	8,000	270.28	297.308

ELEMENT	GRADE NO.	REINFORCING TONS	REINFORCING METRIC TONS	GRIP- TON CO2 / METRIC TON	GRIP- METRIC TONS	GRIP- CO2 / TON
RAIL FOUNDATIONS	200	35	35	0.728	25.48	45.02
GRADING	200	1	1	0.728	0.73	23.18
GRADING & CAPS	200	43	43	0.728	31.21	53.66
SLAB ON GRADE	200	5	5	0.728	3.64	9.36
REINFORCING SLAB & BEAMS	200	628	628	0.728	457.26	767.26
GROUP PADS AND TIE SLAB	200	23	23	0.728	16.74	40.33
COLUMNS	200	280	280	0.728	203.76	335.24
CONCRETE BEAM HEADS	200	13	13	0.728	9.46	23.18
TOTAL	115	1,961	1,961		1,427.07	

	GWP - KG CO ₂ / TON
SPECIFICATION SECTION NAME SECTION XX XX XX	
263 TBD	

PROJECT - MASTER SPEC
LOCATION

SPECIFICATION SECTION NAME
SECTION XX XX XX

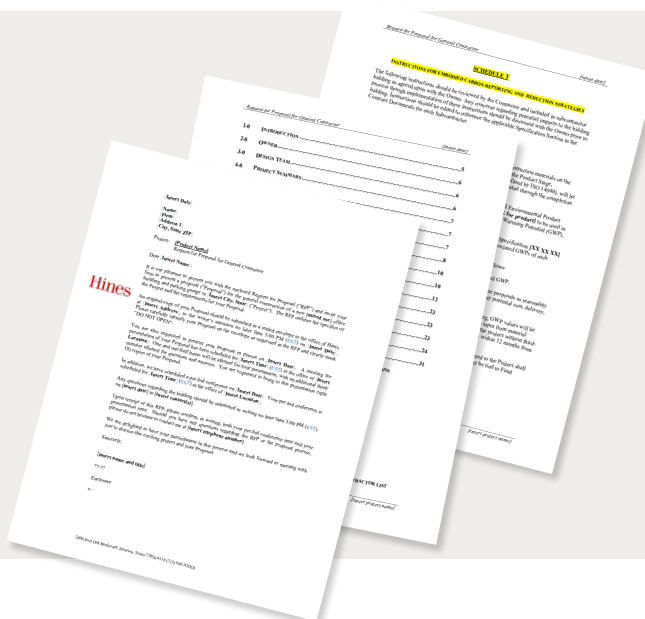
[NOTES: The following language can be added to any material specification where EPDs and total GWP are to be considered. Include the following in the Submittals section of specification.]

Environmental Product Declaration (EPD): Submit product-specific Type III EPDs conforming to ISO 14025 and ISO 21930 including Life-Cycle Assessment Modules A1-A3 which at a minimum must include Global Warming Potential (GWP).

Bill of Materials: Submit amount of each product type and specification, prior to start of construction and at completion of construction. Report any assumptions and allowances included in amounts.

GENERAL CONTRACTOR REQUEST FOR PROPOSAL

The RFP document for the General Contractor by Hines Conceptual Construction Group has been updated to request voluntary alternates from the Contractor that address transportation to the site and installation processes. This language has specifically been added to address the Construction Stage.



SELECT GENERAL CONTRACTOR

The Request for Proposal (RFP) for the General Contractor should include language indicating the Contractor's embodied carbon responsibilities. The Contractor's proposal should identify capabilities, experience, and strategies related to embodied carbon reporting and reduction. It should also include considerations for mitigating emissions throughout construction, including transportation-related ones. The Contractor's bid should disclose the cost of embodied carbon reporting and any carbon reduction strategies. If these strategies require additional cost beyond business-as-usual, they should be broken out as alternates for consideration.

CONDUCT CD WBLCA

A WBLCA, known as the **As-Designed WBLCA**, should be conducted when the project design is complete. This will serve as the final milestone for the design phase.

At this stage, design team estimates should be replaced with detailed take-offs, either by the design team or the Contractor. With the specifications finalized, generic or industry-average GWP data should be selected to reflect the final design. In some cases, if procurement has already begun or market research has been conducted, it may be possible to begin utilizing product-specific EPD data. Care should be taken, however, to ensure this is only done when the procurement of a particular material or product is assured to guarantee the assessment accurately captures project-specific conditions.

CD / AS-DESIGNED ASSUMPTIONS

- Quantities:** design team take-offs or CG Bill of Materials
- GWP:** generic / industry-average data or EPDs

Procurement & Construction

The procurement and construction phase is where design turns into reality. As building components are procured, their Product Stage impact becomes known and locked in. As they are installed or constructed, the impact of the Construction Stage occurs. Combined, procurement and construction are when the **upfront embodied carbon** impact (Modules A1-A5) of the project is finalized.

This phase is the project team's last significant chance to positively reduce emissions before building handover. Key actions include:

Implement Procurement-Related Reduction Strategies

As the project team completes the design and with the General Contractor onboard, project teams should compile reduction strategies targeting procurement. Distinguished from design-related strategies, these will likely focus on low-carbon alternates available in the market. Any alternate should be vetted by both the Contractor and design team to ensure it still meets performance and specification requirements. As strategies are vetted, confirmed, and implemented, they and their achieved reductions should be tracked for final carbon accounting purposes.

Select Subcontractors

Similar to the Contractor RFP, Subcontractor bid documents should also include language regarding embodied carbon and, most importantly, the requirements to provide product-specific Type III EPDs and a table of quantities for each product with its associated GWP.

During selection, the Subcontractor or bid RFP should include instructions for submitting a **Base Bid** and **Alternate Voluntary Bids**. The Base Bid should reflect the lowest-cost or business-as-usual bid and its GWP. Alternate Voluntary Bids should reflect an alternate option with a reduced embodied carbon from the Base Bid while identifying potential cost and schedule impacts. By collecting both sets of information from suppliers, informed decisions can be made by balancing carbon, cost, and schedule.

REDUCTION STRATEGIES

See tear-out sheets starting on [Page 76](#) for procurement-related reduction strategies to consider.

BIDDER SELECTION

For assistance with considering embodied carbon during bidder selection, contact Hines Conceptual Construction Group or Hines Energy & Decarbonization.

CONCRETE BASE BID VS. ALTERNATE BID EXAMPLE

USEAGE	SPECIFIED PSI	VOLUME cy	Design Team Estimate		Supplier BASE Bid		Supplier ALTERNATE Bid	
			kgCO ₂ eq/cy	kgCO ₂	kgCO ₂ eq/cy	kgCO ₂	kgCO ₂ eq/cy	kgCO ₂
			INDUSTRY-AVERAGE EPD		PRODUCT-SPECIFIC EPD		PRODUCT-SPECIFIC EPD	
Slab on Steel Deck	4,000 NWC	5,000	253	1,265,000	251	1,255,000	251	1,255,000
	4,000 LWC	20,000	446	8,920,000	385	7,700,000	385	7,700,000
Shear Walls	10,000 NWC	10,000	450	4,500,000	276	2,760,000	229	2,290,000
	12,000 NWC	15,000	540	8,100,000	327	4,905,000	242	3,630,000
Other Concrete (7 Other Mixes)		7,200		2,306,200		1,997,563		788,613
TOTAL		57,200		25,091,200		18,617,563		15,478,860
GWP REDUCTION				—		-26%		-38%

Collect Base Bids and Alternate Bids to weigh options for embodied carbon reduction. Alternate Bids may boast larger reductions, but this needs to be considered alongside any cost premium.

An alternate bid approach helps the team target best-value alternatives. Asking questions about embodied carbon and reviewing various bids can lead to significant carbon reduction at little to no additional cost simply by researching and presenting substitute options.

REDUCTION STRATEGIES

See tear-out sheets starting on [Page 79](#) for construction-related reduction strategies to consider.

Implement Construction-Related Reduction Strategies

Design- and procurement-related strategies focus on the building itself, mainly targeting the Product Stage, Use Stage, and End-of-Life Stage emissions. During construction, however, the Contractor should implement strategies to reduce the Construction Stage impact as well. Rather than the upstream events like manufacturing or maintenance and demolition that occur later in a building's life, these focus on the events happening during the limited years of construction.

Material-Specific Embodied Carbon Reduction Strategies STRUCTURE

CONCRETE



- D** » Use performance-based / performance-oriented concrete specifications to allow for supplier flexibility in mix designs to reduce GWP intensity
- D** » Use columns with high-strength concrete at lower levels to reduce concrete volume
- D** » Use lowest reasonable concrete strength per application to lower necessary mix design cement content to reduce GWP intensity
- D** » Relax concrete day-of-strength requirements where loading schedule allows to lower necessary mix design cement content to reduce GWP intensity
- D** » Use round columns where architecturally acceptable to reduce column volume and reinforcement density
- D** » Consider construction schedule when evaluating early strength gain requirements for post-tensioning to avoid overdesign
- P** » Consider alternatives to traditional Ordinary Portland Cement (e.g., Portland Limestone Cement, Limestone Calcinated Clay Cement) to reduce GWP intensity
- P** » Use supplementary cementitious materials (e.g., fly ash, slag) to offset cement content requirements to reduce GWP intensity
- P** » Consider emerging technologies (e.g., low-carbon cement, carbonized aggregate) to reduce GWP intensity
- P** » Compare EPDs across ready mix suppliers to inform supplier selection

STEEL



- D** » Use high-grade steel where most effective (e.g., columns, transfers, trusses) to reduce steel tonnage
- D** » Optimize member shapes (e.g., asymmetrical built-up shapes, castellated beams) where economically feasible to reduce steel tonnage
- D** » Optimize steel detailing (e.g., camber, right-sizing, column splicing) to reduce steel tonnage
- P** » Procure steel from EAF manufacturing mills to reduce GWP intensity
- P** » Compare EPDs across steel suppliers to inform supplier selection

TIMBER



- D** » Use sawn lumber for elements up to 2x10 (50mm x 250mm) and mass timber (i.e., glulam) for larger members to reduce timber volume
- D** » Increase spacing of wood stud framing (e.g., 24" OC over 18" OC) to reduce timber volume
- D** » Design mass timber slabs as composite systems for spans greater than 25 feet (8 m) to reduce timber volume
- D** » Compare available mass timber products (e.g., CLT, DLT, NLT) to select optimized solution
- D** » Consider hybrid options (e.g., mass timber combined with structural steel) to select optimized solution
- D** » Optimize connection detailing to reduce member sizing and steel connection requirements
- P** » Procure timber from responsibly and sustainably managed forests to ensure net carbon sequestration
- P** » Use a Forest Sourcing Questionnaire to provide traceability and validate sustainable forestry practice
- P** » Compare EPDs across timber and mass timber suppliers to inform supplier selection

REINFORCEMENT



- D** » Use high-grade reinforcement where most effective (e.g., thick foundations, columns, shear walls) to reduce steel tonnage
- D** » Optimize steel detailing (e.g., lap splices, development lengths, curtailment) to reduce steel tonnage
- P** » Procure reinforcement from EAF manufacturing mills to reduce GWP intensity
- P** » Compare EPDs across reinforcement suppliers to inform supplier selection

- D** » design-related strategies
- P** » procurement-related strategies

Material- & Product-Specific Embodied Carbon Reduction Strategies

ENCLOSURE

GLASS



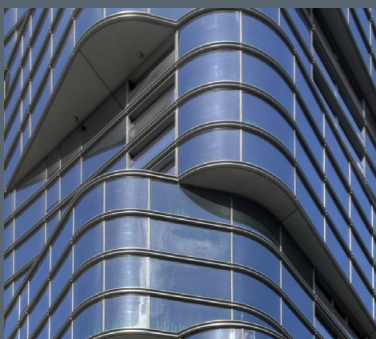
- D** » Weigh the energy or operational carbon performance, determined by thickness, treatments, and coatings, against the embodied carbon impact over the building lifespan to optimize for lowest overall carbon
- P** » Procure high-recycle (i.e., cullet) content glass where available to reduce GWP intensity
- P** » Compare EPDs across glass suppliers to inform supplier selection

ALUMINUM



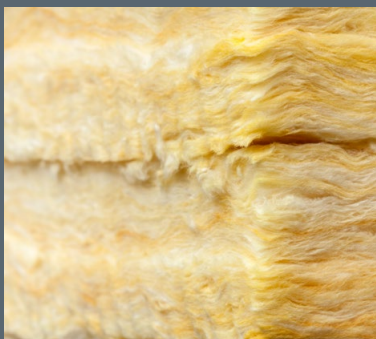
- D** » Use powder coated over anodized finishing to reduce GWP intensity
- P** » Procure high-recycle content aluminum to reduce GWP intensity
- P** » Procure aluminum from renewable-powered smelting facilities to reduce GWP intensity
- P** » Compare EPDs across aluminum suppliers to inform supplier selection

CLADDING



- D** » Use lower-carbon materials in the cladding assembly to reduce GWP intensity
- D** » Use wind tunnel testing to determine project-specific wind pressures to avoid overdesign
- D** » Weigh the energy or operational carbon performance against the embodied carbon impact over the building lifespan to optimize for lowest overall carbon
- D** » Weigh the energy performance, daylighting, and embodied carbon impact associated with the window-to-wall ratio to optimize design
- P** » Procure high-recycle content assembly materials (e.g., glass, aluminum) to reduce GWP intensity
- P** » Compare EPDs across cladding suppliers to inform supplier selection

INSULATION



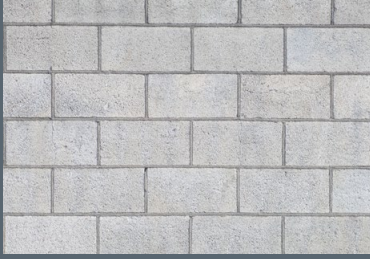
- D** » Avoid petroleum-based products (e.g., XPS, EPS, foam) to reduce GWP intensity
- D** » Avoid insulation that utilizes high-GWP blowing agents to reduce GWP intensity
- D** » Use natural materials (e.g., wool, straw, wood) to reduce GWP intensity
- D** » Weigh the energy or operational carbon performance against the embodied carbon impact over the building lifespan to optimize for lowest overall carbon
- P** » Compare EPDs across insulation suppliers to inform supplier selection

- D** » design-related strategies
- P** » procurement-related strategies

Product-Specific Embodied Carbon Reduction Strategies

INTERIORS

CMU



- D** » Avoid fully grouting walls where not required to reduce material volume
- D** » Use ASTM C476 strength method for grout proportioning to reduce grout volume
- D** » Weigh compressive strength impact against member sizing and reinforcement requirements to reduce overall material volume
- D** » Avoid coating CMU walls to encourage carbonation
- P** » Consider emerging technologies (e.g., algae-grown cement, carbonation curing) to reduce GWP intensity
- P** » Compare EPDs across CMU suppliers to inform supplier selection

DRYWALL



- D** » Use lightweight drywall over standard weight where possible to reduce GWP intensity
- D** » Use minimum thickness possible for application to reduce GWP intensity
- D** » Consider lower-carbon alternatives (e.g., CAF) where allowed to reduce GWP intensity
- D** » Design connections for deconstruction to reduce end-of-life carbon
- P** » Compare EPDs across drywall suppliers to inform supplier selection

METAL STUDS



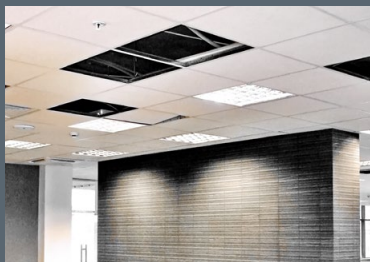
- D** » Consider wood framing in lieu of metal where allowed to reduce GWP intensity
- D** » Increase stud spacing to reduce metal tonnage
- D** » Use minimum thickness possible for application to reduce metal tonnage
- D** » Consider HSS or rolled shapes at high-load applications to reduce stud-pack tonnage
- P** » Compare EPDs across cold-formed stud suppliers to inform supplier selection

FLOORING



- D** » Use exposed structure as the floor finish where possible to reduce material area
- D** » Use natural materials (e.g., wood, stone) to reduce GWP intensity
- D** » Use carpets with solution-dyed yarn to reduce GWP intensity
- P** » Procure high-recycle content products to reduce GWP intensity
- P** » Procure carpet from manufacturers with established take-back programs to increase circularity
- P** » Compare EPDs across flooring suppliers to inform supplier selection

CEILING FINISHES



- D** » Use exposed structure as the ceiling where possible to reduce material area
- D** » Use natural materials (e.g., wood) to reduce GWP intensity
- P** » Procure high-recycle content products to reduce GWP intensity
- P** » Procure ceiling tiles from manufacturers with established take-back programs to increase circularity
- P** » Compare EPDs across ceiling finish suppliers to inform supplier selection

- D** » design-related strategies
- P** » procurement-related strategies

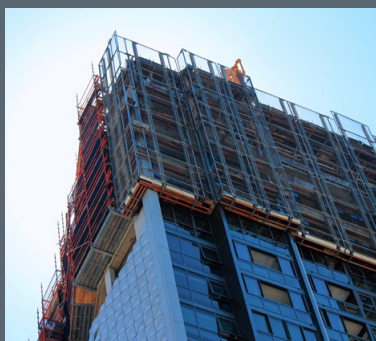
Construction-Specific Embodied Carbon Reduction Strategies

TRANSPORTATION



- » Procure from suppliers with close proximity to long-haul shipping options (e.g., rail) to reduce GWP intensity
- » Weigh local sourcing and Product Stage (A1-A3) impacts to achieve lowest overall carbon
- » Use long-haul shipping options (e.g., rail, barge) over last-mile (e.g., commercial trucking) when available to reduce GWP intensity
- » Use lightweight product options to reduce material shipping weight
- » Use full-load transportation options to reduce trips to site
- » Use electric vehicles where available to reduce GWP intensity

CONSTRUCTION



- » Use deconstruction over demolition of existing structures to avoid construction waste and increase circularity
- » Use electric vehicles and equipment on-site where available to reduce GWP intensity
- » Avoid use of on-site generators to reduce GWP intensity
- » Avoid nighttime lighting when not a safety concern to reduce energy consumption
- » Avoid vehicle idling to reduce fuel consumption
- » Use material waste recycling programs when available to increase circularity
- » Consider standard CMU block dimensions to avoid construction waste
- » Consider standard drywall sizing to avoid construction waste
- » Consider carpet tiles over broadloom or sheet carpet to avoid construction waste
- » Use prefabrication (e.g., partition walls) when available to reduce GWP intensity



Construction Close-Out

With design and construction complete, the last phase is no longer about achieving reductions but rather collecting final data and reflection. By taking stock of project challenges and solutions, this intentional reflection becomes a resource for future projects. Although all projects face unique complexities, lessons learned from the recently completed project can flatten the learning curve for ones to come. Key actions in this phase include:

AS-BUILT ASSUMPTIONS

Quantities: CG Bill of Materials

GWP: EPDs

Conduct Final WBLCA

A final WBLCA should be performed when the project is complete. Known as the **As-Built WBLCA**, this version should incorporate information gathered by the Contractor throughout construction.

Design team quantity estimates should no longer be used; instead, they are replaced by Contractor Bills of Materials that reflect amounts purchased and delivered, including waste. As much as possible, generic or industry-average GWP data should be replaced by product-specific EPDs. With both quantity and **GWP intensity** values swapped for values that reflect actual project conditions, this assessment will most accurately reflect the final embodied carbon impact of the project.

Before the As-Built WBLCA is finalized, assessors should compare its values to those from the As-Designed WBLCA. Some variation is expected, as quantities are refined by purchase data and placeholder GWP values are swapped for supplier-specific data. Still, large discrepancies should be scrutinized to confirm aligned methodologies and assumptions.

Review Achievements

Now that final embodied carbon results are available, project teams can evaluate them against the declared goal. With busy schedules and juggling multiple projects, it's tempting to close out one project and move directly to another. Pausing for reflection, however, gives time to digest and learn from the likely years-long embodied carbon effort that just ended. Questions the team might reflect upon include:

- Was the goal achieved? At what cost premium, if any?
- What were the primary barriers to achieving the goal, and how were they overcome?
- Was the goal surpassed? Could a more ambitious goal have been set?
- If the goal was not achieved, why not? What are the consequences?
- What factors impacting the ability to meet the goal were unique to this project? Which might translate to similar projects?

When embodied carbon goals are met, they should be celebrated. Achievement might lead to green building certification, internal and external presentations, and public announcements. Teams should ensure

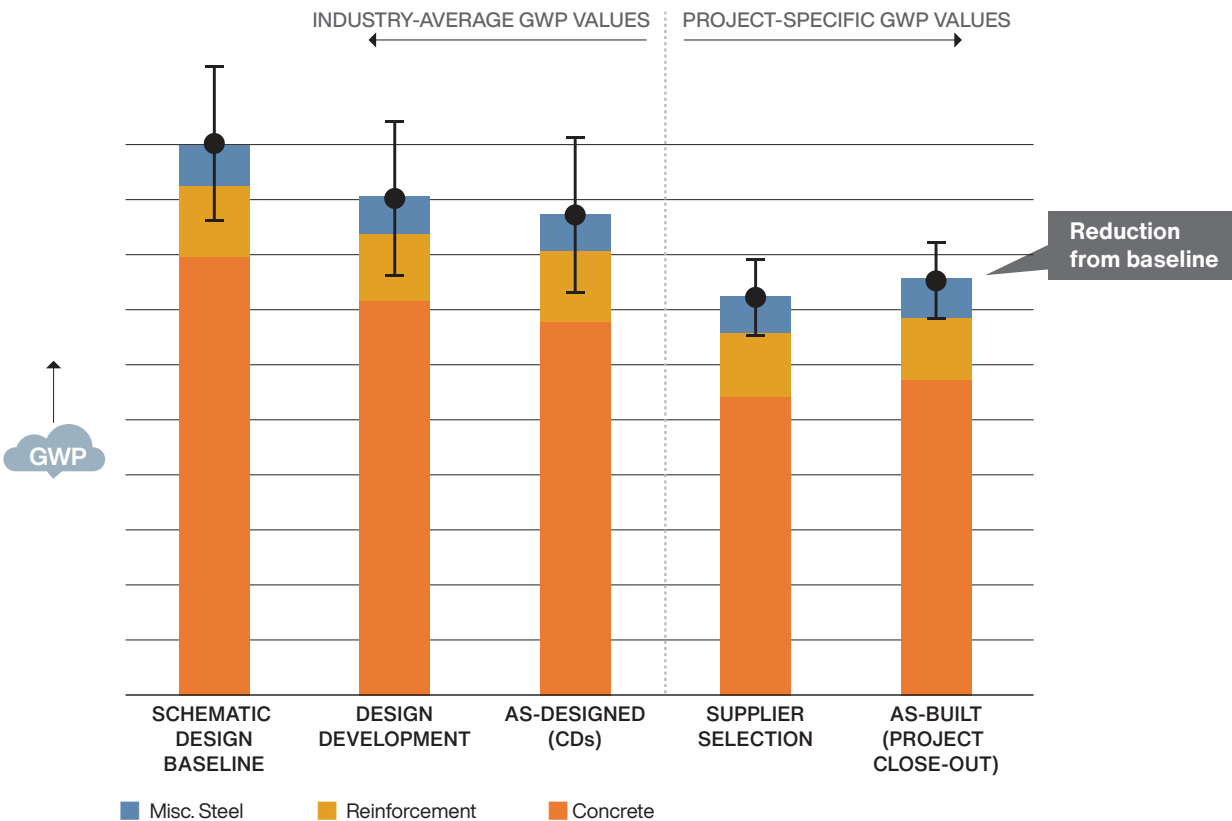
that any claims made are rooted in the data contained within the final assessment. Rigorous interpretation of the results should be combined with careful language to ensure claims are accurate and to avoid accidental greenwashing.

Compile Lessons Learned

After the project has been completed, teams will have multiple data points describing the project’s embodied carbon throughout design and construction. This can be charted to observe the general trend of carbon over time.

Embodied carbon may increase or decrease throughout the project, depending on many factors. For example, a decrease may be observed when an alternate bid is selected to reduce carbon. Inversely, an increase may be observed during construction if a higher-strength concrete mix is utilized due to availability. Through monitoring of these impacts, informed decisions are made throughout design and construction—allowing the opportunity for a general downward trend in embodied carbon. By reviewing these impacts at project close-out, project teams can catalog successes and setbacks to create a summary of lessons learned. These then inform the approach toward reduction on future projects.

MONITORING STRUCTURAL EMBODIED CARBON THROUGHOUT DESIGN & CONSTRUCTION EXAMPLE





CHAPTER 4

Summary

- Achieving embodied carbon reduction requires effort from **all project team members**, from design to construction
- All project phases present opportunities for reduction with **key actions** relevant to each
- Reduction strategies can be categorized into **design-, procurement-, and construction-related** with each being appropriate focal points at different phases
- Whole-building life cycle assessments should be performed at **project milestones**, including **As-Designed** and **As-Built**
- At the project's end, **review achievements** and **compile lessons learned**



CHAPTER 5

Reporting Carbon

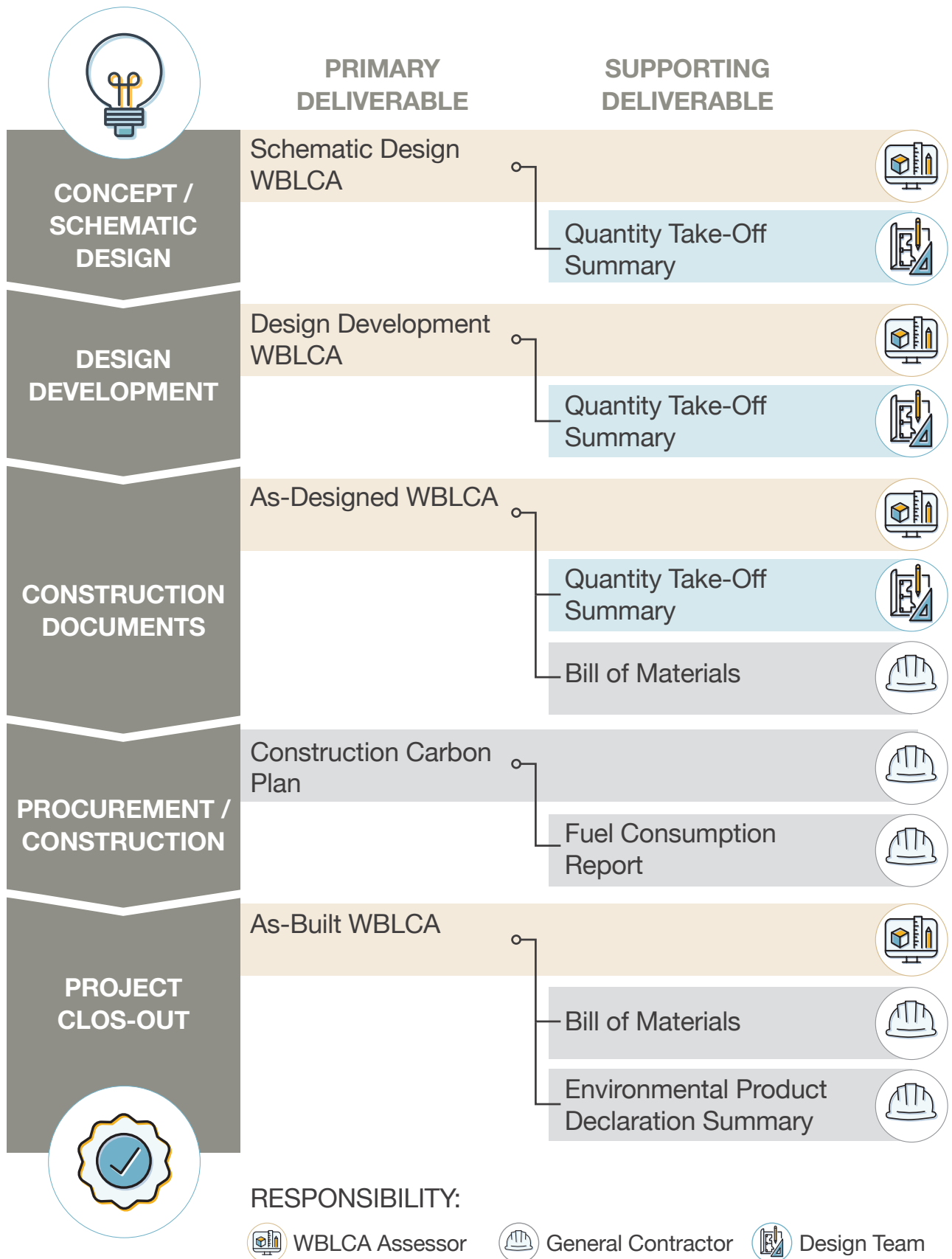
To support embodied carbon reduction efforts, Hines looks to the project team to provide key deliverables throughout design and construction.

These deliverables can be categorized as **primary deliverables** and **supporting deliverables**. Primary deliverables are collected at the end of each design milestone and in construction. Also collected throughout delivery are supporting deliverables, which provide the data necessary to generate the primary deliverables. Primary deliverables directly enable embodied carbon reduction, action, and tracking over time; supporting deliverables provide the complementary data required to do so.

Hines teams should ensure the contract language for the Sustainability Consultant or other consultant performing the **whole-building life cycle assessment (WBLCA)**, including the design team, General Contractor, and Subcontractors, clearly reflects the expectations for these deliverables. For assistance with this, Hines teams should contact the Conceptual Construction Group.



Embodied Carbon Deliverables



Primary Deliverables

Throughout design and construction, the project team's primary deliverables consist of:

Schematic Design WBLCA

Conducted by:  WBLCA Assessor

Supported by: Quantity Take-Off Summary



The Schematic Design (SD) WBLCA is the project's first formal assessment prepared by the Sustainability Consultant. Although limited studies may have been conducted beforehand, the SD WBLCA should cover the entirety of the outlined scope under business-as-usual conditions (see [page 69](#)). Project information (e.g., area, height, etc.) and assessment information (e.g., goal, scope, etc.) should be documented in a Basis of Analysis (BOA) and included with the assessment results (see [page 52](#)).

Submitted to Hines at the end of SD, the SD WBLCA results serve as the first embodied carbon snapshot of the project. It should identify carbon hot-spots per component and/or category and across **life cycle stages**.

The submitted report should include recommended design-related reduction strategies based on the findings. These should be discussed with Hines and the project team to determine which should be vetted further, perhaps through limited studies. Approved strategies should be incorporated in the next design phase.

Design Development WBLCA

Conducted by:  WBLCA Assessor

Supported by: Quantity Take-Off Summary



The next iteration of the embodied carbon assessment is the Design Development (DD) WBLCA. Collected at the end of DD, this assessment should reflect the evolution of the design (see [page 71](#)), including any implemented reduction strategies. A comparison to the SD WBLCA results should be made to track progress. New strategy recommendations may emerge and should again be weighed with Hines and the project team.

As-Designed WBLCA

Conducted by:  WBLCA Assessor

Supported by: Quantity Take-Off Summary



Bill of Materials



The **As-Designed WBLCA** is the final set of design-phase results submitted to Hines at the end of Construction Documents (CD). It should reflect the final design documents and as much project-specific information as available (see [page 73](#)), including **product-specific Environmental Product Declarations (EPDs)**. Comparison to previous milestones should be made, and ideally, design-related reduction strategies and general design optimization have led to a reduction in total embodied carbon. In some cases, the results from the As-Designed assessment may be submitted for green building certification or policy compliance purposes.

In addition to the final design-phase results, the As-Designed WBLCA should provide guidance for the project during construction. This includes procurement-related reduction strategy recommendations aligned to the final project specifications.

Construction Carbon Plan

The Construction Carbon Plan (CCP) is a project-specific plan for tracking embodied and **operational carbon** emissions during construction, specifically Module A4 and A5 emissions. It should identify sources of construction-related carbon emissions and outline a plan for tracking and reducing them, including documentation of the roles and responsibilities of those involved. While the CCP is the responsibility of the General Contractor, its execution is impossible without the Subcontractor's input and support.

Conducted by:  General Contractor

Supported by:  Fuel Consumption Report

The Contractor should create the CCP before construction begins and continue its activities and reporting through close-out. During this time, reports summarizing the tracked emissions should be submitted to Hines at regular intervals (e.g., monthly). Key sources of construction-related emissions that should be considered in the CCP include:

MEANS & METHODS MATERIALS

Many **materials** are consumed or utilized throughout the process of construction. Referred to as 'means and methods,' this category of materials is typically forgotten once the building is occupied. Despite this and the current lack of data quantifying their impact, consideration of this emission source and ways to reduce it is warranted.

Emissions related to temporary works means and methods are not captured in the Product Stage (Modules A1-A3) but in Module A5 of the Construction Stage (see [page 34](#)). Often, default or placeholder assumptions are used to quantify A5's impact. To support more detailed accounting, however, means and methods materials tracking should be included in the CCP. These include temporary works materials and equipment such as:

- Earthwork and non-structural site preparation elements (e.g., excavation, rat slabs, etc.)
- Temporary foundation support systems (e.g., temporary shoring walls, internal bracing, dewatering systems)
- Man-lift, tower crane, job site trailer, or other large equipment foundations and support structures
- Formwork (reused or single-use)
- Other construction waste

ANTI-IDLING RECOMMENDATION

The CCP should include language that reduces unnecessary engine idling on-site.

FOSSIL FUEL USE

Generally, fossil fuels are used throughout construction for transportation as well as on-site. Transportation includes delivery of earthwork, materials, or **products** to and from the site. On-site usage may include job site trailers, generators, and equipment.

With support from the subs, the General Contractor should regularly track the consumption of these fossil fuels. Reporting should itemize the fuel type (natural gas, diesel, gasoline, propane, etc.) per activity, as well as the amount consumed.

For transportation-related fuel use relevant to Module A4, tracking should include:

- Number of trips
- Distance traveled per trip
- Type of transport (e.g., concrete truck, rail, barge, etc.) used per trip
- Fuel type per transport (e.g., gasoline, diesel, etc.)
- Emissions intensity per fuel type, when known

For on-site usage relevant to Module A5, tracking should include:

- Quantity of fuel consumed per use
- Type of fuel consumed per use
- Emissions intensity per fuel type, when known



ELECTRICAL USE

In addition to fossil fuels, electricity is consumed to power on-site construction activities. This may include jobsite trailers or on-site electric vehicles or equipment. Like fossil fuel usage, electric consumption should be tracked by the General Contractor and included in the CCP.

Electricity consumption tracking may be easier than means and methods or fossil fuels because it can likely leverage site utility bills. Where possible, reported electrical usage should also include its associated emissions intensity. This will be based off the type of production used for the local energy grid, such as solar, coal, or natural gas.

Power Reduction Recommendation

Where temporary power is available, contractors should connect to that power source instead of generator-supplied power. Temporary Power Units (TPUs) should also have a timed shut-off with manual overrides. Where safety is not compromised, crews should establish shut-off schedules to automatically turn off the lighting 30 minutes after typical working hours end.





Means and methods, fossil fuel, and electrical tracking support a project's ability to perform detailed Module A4 and A5 accounting and, most importantly, identify construction-related carbon reduction opportunities. For example, monthly tracking of electrical usage will allow the Contractor to quickly flag months of high usage, providing the opportunity to investigate whether interventions are appropriate.

A final summary document outlining observed trends, realized reduction opportunities, and lessons learned should be submitted to Hines at close-out.

As-Built WBLCA

The final primary deliverable is the **As-Built WBLCA** prepared by the Sustainability Consultant. To be submitted to Hines at project close-out, this final embodied carbon assessment should reflect project-specific information collected throughout construction (see [page 81](#)). This includes the **Bill of Materials** and product-specific EPDs provided by the Contractor.

Documentation for the As-Built WBLCA should include a final version of the BOA, updated per any construction-related changes, and provide a catalog of the ultimate data sources used. It should also leverage charts and graphics to communicate the results clearly. These should illustrate the results in various ways to reflect the key scopes (e.g., by building category and life cycle stage), indicate the quality of the data sources used and the resulting uncertainty and variability, and demonstrate changes throughout the various milestones (see [page 59](#)).

If a certification or goal was set for the project, the As-Built WBLCA should document the project's compliance. To assist on future projects, it should compile any pursued design-, procurement-, or construction-related strategies and summarize best practices, lessons learned, and future opportunities.

Conducted by:  WBLCA Assessor

Supported by: Bill of Materials



Environmental Product Declaration Summary



Supporting Deliverables

Project team members often need supporting information to generate the primary deliverables. These supporting deliverables consist of:

Quantity Take-Off Summary

Key to any embodied carbon assessment is a summary of the project's quantities (see [page 28](#)). **GWP intensities** are applied to these, creating individual material or product **GWP** results, which are then compiled at the building level as overall embodied carbon results. As needed, project quantities are to be summarized by the design team and submitted to the WBLCA assessor. Quantities should be itemized appropriately to capture any variance in the specification (for example, concrete quantities should be broken out by compressive strength and degree of cement replacement).

Quantities may be extracted from a BIM environment, such as Revit, or calculated by hand. Quantities should reflect the current milestone's design documents and include allowances for elements that are hard to quantify, such as concrete reinforcement or assembly connections. Any assumptions should be clearly stated.

Conducted by:  Design Team

Supporting:

Schematic Design WBLCA



Design Development WBLCA



As-Designed WBLCA



Conducted by:  General Contractor

Supporting:

As-Designed WBLCA



As-Built WBLCA



Bill of Materials

A Bill of Materials serves the same function as a design team's quantity take-off summary—it provides the WBLCA assessor with the necessary quantity data to carry out an assessment. Compiled by the General Contractor or Quantity Surveyor, a Bill of Materials should be more accurate than the design team's quantities because it reflects materials and products procured and delivered to the site.

A Bill of Materials may be used for the As-Designed WBLCA. In this case, it likely won't reflect purchased quantities but rather estimations from the Contractor. However, the Bill of Materials used for the As-Built WBLCA should reflect the procured, as-built quantities. This provides the highest accuracy of quantity data for the final assessment.

Fuel Consumption Report

To execute the CCP, the General Contractor will need to collect fuel consumption data from the various Subcontractors active on-site. The CCP should outline roles and responsibilities between the Contractor and subs, along with expectations regarding the cadence of report submissions.

Environmental Product Declaration Summary

Project-specific environmental performance is cataloged by EPDs collected throughout construction, reflecting procured materials or products. The most desirable type of EPDs for this purpose are product-specific Type III EPDs, which aim to provide a specific GWP intensity for the product they cover (see [page 20](#)). The General Contractor should compile a summary of these EPDs and submit them to the WBLCA assessor for incorporation into the final As-Built WBLCA. This will allow for the most accurate embodied carbon accounting of the as-built conditions of the project.

Conducted by:  General Contractor

Supporting:

Construction Carbon Plan



Conducted by:  General Contractor

Supporting:

As-Built WBLCA





Central Collection

All deliverables above play an important role in executing embodied carbon reduction at the project level. For example, the SD WBLCA should inform design decisions made in DD, and the CD WBLCA should inform carbon-smart procurement during construction.

Once the project is complete, the primary deliverables should be submitted to Hines Energy & Decarbonization team to support firmwide embodied carbon accounting, benchmarking, and intelligence. This centralized knowledge will support future developments and ultimately allow Hines to continue to make progress in its goal of achieving embodied carbon reductions at scale.



CHAPTER 5

Summary

- Hines teams will collect **primary deliverables** from the project team at design and construction milestones
- Primary deliverables rely on information supplied by **supporting deliverables**
- The **Sustainability Consultant, design team, General Contractor, and Subcontractors all play a role** in generating the primary and/or supporting deliverables
- At project completion, the **primary deliverables should be submitted to the Hines Energy & Decarbonization team**

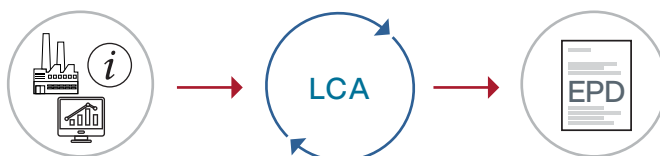


Appendices

Appendix A: How to Create an EPD

What Is an EPD?

An EPD is an Environmental Product Declaration. Through performing a life cycle assessment, an EPD quantifies and reports a material or product's environmental impact. The most frequently tracked of these impacts is greenhouse gas emissions, known as Global Warming Potential (GWP), reported in kilograms of CO₂ equivalent (kgCO₂e).



What Does Type III Mean?

Type III EPDs are third-party, independently verified according to ISO standards 14025 and 21930. Because they are audited, they are the preferred type of EPD.

PREFERRED

Who Writes the Rules for an EPD?

Product Category Rules (PCRs) are a set of specific guidelines for developing EPDs, defined by ISO standards 14025 and 21930. PCRs are written by a Program Operator, typically in association with the national trade organization for that material.

Who Do I Contact to Get an EPD?

There are multiple EPD providers, with a variety of offerings to create an EPD. When selecting an EPD provider, consider the following:

- » What is their understanding and experience with the issues associated with the material or product?
- » Do they have associations with third-party verifiers who can provide the verification as a single, joint service, or does that verification need to be contracted separately?

Where Can I Get More Information?

These online resources are additional trusted sources of information regarding EPDs and embodied carbon:

- » **Carbon Leadership Forum (CLF)** an independent and non-profit organization that is the leading entity in North America on embodied carbon and life cycle assessment
<https://carbonleadershipforum.org/>
- » **Embodied Carbon in Construction Calculator (EC3) Tool**, a free and open-access database of North American EPDs
<https://www.buildingtransparency.org/>

Appendix B: Certifications & Regulations

Last Updated: April 2025

Certifications

Green building certifications address operational carbon, often through an emphasis on increased energy efficiency. In recent years, these certifications have added embodied carbon requirements as well. This may be in the form of total embodied carbon or carbon intensity restrictions, WBLCA / WLCA requirements, or Environmental Product Declaration requirements.

The following table lists a selection of green building certifications around the globe. Please note the list is not exhaustive.

NAME	REGION	EMBODIED CARBON HIGHLIGHTS
LEED	Global	Points for WBLCA, project-level reduction, and EPD collection
BREEAM	Global	Combines embodied and operational carbon considerations under net zero carbon
ILFI	Global	Considerations under the Energy and Materials Petals and Zero Carbon certification
Green Globes	Global	Points for WBLCA among other reduction activities
Zero Carbon Building	CAN	Considers WBLCA in design with potential reduction strategies
DGNB	Europe	Points for WBLCA and project-level reduction
NoIICO2	SWE	Imposes whole-life carbon limits by life cycle stage
Miljöbyggnad	SWE	Requires upfront carbon calculation with optional additional criteria
Green Star	AUS	Requires upfront carbon calculation with optional additional criteria
NABERS Embodied Carbon	AUS	Calculates embodied carbon performance
CASBEE	JPN	Awards per level of embodied carbon reduction
Green Mark	SGP	Points awarded for WLCA reductions achieved for key construction materials

Regulations

Similar to certifications, many regulations or building codes address energy efficiency (and therefore operational carbon performance). Recently, some jurisdictions have also proposed or adopted regulations related to embodied carbon. Many of these take the form of reporting embodied carbon results, perhaps through WBLCA / WLCA, addressing high-impact construction materials in procurement, or even restricting the embodied carbon of new projects.

The following table lists a selection of passed embodied carbon regulations applicable to private construction around the globe. Please note this list is not exhaustive.

NAME	REGION	EMBODIED CARBON HIGHLIGHTS
CALGreen	California, USA	Requirements to conduct a WBLCA or collect EPDs for designated materials and achieve reductions
Marin County Building Code	Marin County, USA	Requirements to adhere to concrete GWP limits
Denver Green Code	Denver, USA	Requirements to adhere to concrete and steel GWP limits
Net Zero Carbon Zoning	Boston, USA	Requirements to report
Vancouver Building By-Law	Vancouver, CAN	Requirements to report and reduce
Toronto Green Standard	Toronto, CAN	Requirements to conduct an upfront carbon assessment and meet limits
London Plan Policy SI 2	London, UK	Requirements to conduct a WLCA, with reductions encouraged
RE2020	FRA	Requirements to conduct an LCA and meet limits

Appendix C: Additional Resources

Last Updated: April 2025

The following table lists a selection of global embodied carbon resources. Please note the list is not exhaustive.

NAME	DESCRIPTION	RESOURCE HIGHLIGHTS
Carbon Leadership Forum (CLF)	North American-based non-profit dedicated to reducing embodied carbon through research and resources	· Embodied Carbon Policy Tracking Map · WBLCA Benchmark Study · North American Material Baselines · Regional Hubs
Royal Institute of Chartered Surveyors (RICS)	UK professional body creating industry standards	· Whole life carbon assessment (WLCA) for the built environment
Building Transparency	North American-based non-profit dedicated to reducing embodied carbon through software tools and resources	· Embodied Carbon in Construction Calculator (EC3) Tool + EPD database · tallyLCA · Guides and videos
One Click LCA	Global sustainability platform aimed at construction and manufacturing decarbonization	· LCA tools · EPD tools · Guides and research
Chartered Institution of Building Services Engineers (CIBSE)	UK professional body creating industry standards	· TM65 Embodied carbon in building services: A calculation methodology
Embodied Carbon Harmonization and Optimization (ECHO)	North American coalition aimed at aligning the collection and reporting of data	· ECHO Reporting Schema · ECHO Recommendations for Alignment
Rocky Mountain Institute (RMI)	North American-based non-profit aimed at a zero-carbon future	· Embodied Carbon Initiative · White papers
International EPD System	Global EPD program	· EPD Library
Structural Engineers 2050 Commitment Program (SE 2050)	North American program housed by the Structural Engineering Institute (SEI) aimed at providing tools and resources for structural engineers	· SE 2050 Database · ECOM Tool · Specification and design guidance
MEP 2040 Commitment (MEP 2040)	North American initiative aimed at reducing the embodied carbon of MEP systems	· Refrigerants resources · Specification templates





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Glossary of Terms

A

Alternate Voluntary Bids

Alternate, voluntary bids submitted by the Subcontractor or Supplier that reflect embodied carbon reduction compared to the Base Bid and identify potential cost and schedule impacts.

As-Built WBLCA

A final WBLCA performed during or after construction and calculated using actual material quantities and GWP factors as determined from project-specific EPDs, to be submitted to Hines at project close-out.

As-Designed WBLCA

A final WBLCA performed at the end of design and calculated using estimated material quantities and generic or industry-average GWP factors, to be submitted to Hines at design completion.

B

Base Bid

The lowest-cost bid submitted by the Subcontractor or Supplier that reflects “business-as-usual” costing.

Baseline

A starting point identified at the beginning of a project to be used as a point of reference for embodied carbon comparison throughout design and construction. If embodied carbon reduction targets are set for a project, this baseline becomes the comparison point from which to evaluate achieved reductions.

Bill of Materials

A tally of materials and products procured and delivered to the construction site to be installed in a building produced by the General Contractor.

Biogenic Carbon

The carbon captured by bio-based sequestration.

C

Carbon

Term often used to refer to greenhouse gas emissions or climate change impact.

Carbon Intensity

A metric used to describe the carbon impact of a component or building. For components, it is GWP per functional unit (also referred to as “GWP intensity”); for buildings, it is determined by dividing the GWP over the building area (GIA) and expressed in units of kgCO₂e/m².

Carbon Leadership Forum (CLF)

A leading independent non-profit organization that produces embodied carbon and WBLCA resources.
www.carbonleadershipforum.org

Cradle-to-Cradle

The Product Stage through Module D (Modules A1-D), which includes a system that begins with raw material extraction and ends with recycling or reuse for future purposes.

Cradle-to-Gate

The Product Stage (Modules A1-A3), which begins with raw material extraction and ends at the factory “gate” ready for transportation to a construction site.

Cradle-to-Grave

The Product Stage through End-of-Life Stage (Modules A1-C4), which begins with raw material extraction and ends with building demolition. Also referred to as “whole-life carbon.”

E

Embodied Carbon

The greenhouse gas emissions that result from construction, renovation, and demolition of a building.

Environmental Product Declaration (EPD)

A report that describes a component's environmental impact, including GWP; analogous of a nutrition label for food. It is determined by performing a life cycle assessment of the component under consideration following ISO standards. Varying types of EPDs exist but Type III product-specific EPDs are most desirable.

European Standards (EN)

Document standards that have been ratified by one of the three European Standardization Organizations.

G

Global Warming Potential (GWP)

The metric used to measure greenhouse gases and their effect on climate change, expressed in kilograms of carbon dioxide equivalent (kgCO₂e). "Carbon" is the generic, easy to understand term commonly used to refer to GWP.

Greenhouse Gas (GHG)

Gas that absorbs and emits radiant energy into the atmosphere, causing the greenhouse effect or warming of the Earth. The primary GHGs in Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone.

GWP Intensity

Term for the carbon intensity of a material or product, expressed in units of GWP per applicable functional unit (e.g., kgCO₂e/m³).

I

Industry-Average EPD

EPDs whose results represent a range of manufacturers, often commissioned by a trade organization. Although

more readily available, because they are not specific to a single manufacturer, they are less accurate to a product's actual emissions compared to a product-specific EPD. They are often used as the basis for generic GWP data.

International Organization of Standardization (ISO)

The international, non-government organization that develops and publishes standards.

L

Life Cycle Inventory (LCI)

The accounting behind a life cycle assessment, considering all emissions flowing in and out of the system boundary.

Life Cycle Stage

Distinct periods of time before, throughout, and after a building's lifespan used to categorize carbon impacts in carbon accounting and WBLCA.

M

Materials

Building components made up of unprocessed or processed substances, such as concrete and timber.

Modules

A term used to describe different points in time throughout a building's lifespan for the purpose of conducting a WBLCA.

O

Operational Carbon

The greenhouse gas emissions that result from a building's energy and water use operations.

P

Primary Deliverable

Major deliverables due to Hines throughout a project including SD, DD, As-Designed, and As-Built WBLCAs and the Construction Carbon Plan.

Product Category Rules (PCRs)

Industry-established standards determined by trade associations that document the environmental reporting requirements and guidelines for a specific building component's EPD.

Products

Building components that are processed, finished items that are offered for sale, typically created with manufactured combinations of a variety of materials.

Product-Specific EPD

EPDs whose results represent a single product from a single manufacturer. Although less readily available, they are the most accurate representation of a product's actual emissions.

R

Residual Value

The estimated value of a building at the end of its life, defined by the amount of value that the owner will obtain when the asset is dispositioned.

S

Sequestration

Pulling carbon dioxide out of the atmosphere by way of natural processes such as tree growth, considered a "negative" emission.

Supporting Deliverable

Minor deliverables used to generate primary deliverables including quantity take-off summaries, Bill of Materials, Fuel Consumption Reports, and Environmental Product Declaration Summaries.

U

Upfront Carbon

The embodied carbon emitted before building operations, including the Product Stage (Modules A1-A3) and Construction Stage (A4-A5).

W

Whole-Building Life Cycle Assessment (WBLCA)

The process used to account for all carbon emissions from all emitters throughout a building's lifespan.

Whole-Life Carbon

All embodied and operational carbon emitted due to a building, including the Product Stage (Modules A1-A3), Construction Stage (A4-A5), Use Stage (B1-B7), and End-of-Life Stage (C1-C4). Also referred to as "cradle-to-grave" emissions.

Whole-Life Embodied Carbon

All embodied carbon emitted due to a building, including the Product Stage (Modules A1-A3), Construction Stage (A4-A5), Embodied Use Stage (B1-B5), and End-of-Life Stage (C1-C4).

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