

# Decarbonizing construction

Guidance for investors  
and developers to reduce  
embodied carbon



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# Foreword

**To meet the Paris Agreement objectives, it is essential to decarbonize economies by 2050. For the built environment, this means reaching net-zero emissions across all activities in the building and construction system, meaning emissions from energy use during building use as well as emissions from materials production and construction processes – so-called embodied carbon.**

Alignment and collaboration between all companies in the building and construction system is crucial to reaching this goal, as no stakeholder can do it alone. To achieve full system decarbonization, it is necessary to ensure each company focuses not only on its own emissions reductions, but also on how it can actively support an overall net-zero transition of built assets. Central to these efforts is achieving net zero across the entire life cycle, rather than a silo approach that detaches products in the system from one another.

Financial institutions mobilize capital for buildings and infrastructure and influence their construction. Their investment and financing decisions provide powerful incentives to shape the activities in the building system and the behavior of all market participants.

Many companies have recognized this potential and are raising their climate action ambitions. Under the Glasgow Financial Alliance for Net Zero, over 160 firms, responsible for more than USD \$70 trillion assets across the financial system, have made public commitments to accelerate the transition to net-zero emissions by 2050 at the latest. The alliance is translating these commitments into measurable targets.

Investors, lenders and developers are deeply involved in the development process for real estate assets and efforts are underway to help them account for their “financed” emissions across different asset classes, such as through the Partnership for Carbon Accounting Financials. These firms are therefore increasingly looking to set requirements for low-carbon solutions across the full life cycle of built environment projects, including reductions in emissions from building materials and the construction process. There are many concrete actions that financial actors can take to reduce the carbon impact of their investments. Investors can adopt decarbonization policies and set requirements for the real estate part of their investment portfolios. Asset managers can support investors in setting and executing their strategies.

Lenders can link carbon performance to their loans and provide incentives. Property developers can set carbon performance requirements as part of the procurement process for their projects. And lastly, all these firms occupy and manage real estate themselves and can develop policies for low-carbon performance in their role as tenants, thereby driving the change from the end-user side.

This report provides a resource to companies who want to set requirements for embodied carbon reductions in projects they finance and develop in a performance-based way. It also references a selection of emerging national regulations focusing on embodied carbon. And it provides examples of how to include circular solutions in the design phase of projects, which is an important economic, environmental and social opportunity to catalyze innovation and new business models to reduce embodied carbon. We encourage investors, developers, asset managers, lenders and tenants to use this resource to set requirements for carbon performance and pursue sustainability strategies in the earliest phases of project planning and development.

**Roland Hunziker**  
Director, Sustainable  
Buildings & Cities, WBCSD



# Executive summary

**Buildings and construction are responsible for 38% of global energy and process-related carbon dioxide emissions. Approximately a third of this, equivalent to 11% of the total, comes from building products and materials and is known as embodied carbon.<sup>1</sup> As building operation becomes more efficient and energy grid efficiency improves, estimates suggest embodied carbon will become the construction sector's dominant climate impact driver. This has made it the focus of regulators and market actors.**

The increased level of scrutiny given to carbon emissions also means that carbon is becoming a risk factor that companies need to price into construction projects. Therefore, reducing embodied carbon contributes to climate change mitigation and is also good for a company's and a country's long-term economic vision.

Project originators, investors and developers have both the power and the responsibility to set the course of a project aligned with the Paris Agreement.

This report provides embodied carbon reduction guidance and tools for project owners and project teams, such as investors, developers, owner-operators and large tenants, as well as the design teams and contractors working with them.

It condenses over 50 leading embodied carbon reduction practices (requirements) across all project life-cycle phases into a single report. We have grouped each measure into one of the following five categories.

1. Create a carbon policy that sets out consistent requirements for all projects to follow.
2. Set targets and transparency requirements for projects to meet across all their phases.

3. Prioritize circularity – that is, less new building and more reuse and refurbishment.
4. Design optimization to use less material and to choose materials with a low carbon footprint.
5. Low-carbon procurement to ensure acquisition of materials with a low carbon footprint.

We have developed these to target specific embodied carbon reduction opportunities. We have evaluated each measure for embodied carbon savings and cost impacts, and provide detailed implementation guidance.

We have shortlisted the following core requirements (next page) due to their high impact and applicability in most contexts for every investor and developer to implement. The full list of recommendations is available in the report.



Companies can use the requirements as they stand or adapt them to specific needs. The requirements are flexible and easily combinable with different green building certification or sustainability reporting systems, such as GRESB (Global ESG Benchmark for Real Assets), LEED (Leadership in Energy and

Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method) or the Greenhouse Gas (GHG) Protocol.

This report focuses on new buildings, but organizations can adapt much of the content and use it for infrastructure and renovations as well.

This report is not a guide to developing new low-carbon cities or districts; the focus here is on a project level. It promotes low-carbon construction on a material- and technology-neutral basis and supports a level playing field for solutions.

<b>Core requirements</b>	
<b>A. Project owner’s internal policies and processes</b>	
<b>A01</b>	Create embodied carbon related requirements for all projects
<b>A08</b>	Report embodied carbon alongside other carbon emissions annually
<b>A10</b>	Evaluate the possibility of refurbishing existing buildings
<b>B. Concept design requirements</b>	
<b>B01</b>	Propose a life-cycle carbon or embodied carbon target for the project
<b>B07</b>	Investigate suitability of low carbon structural material options
<b>B08</b>	Develop alternative designs and carbon and cost evaluations
<b>C. Detailed design requirements</b>	
<b>C04</b>	Materials efficiency optimization
<b>C05</b>	Embodied carbon and cost factored detailed design options
<b>C08</b>	Evaluate alternatives for the top ten highest carbon products
<b>D. Construction and procurement requirements</b>	
<b>D01</b>	Demonstrate meeting embodied carbon targets with final quantities
<b>D06</b>	Minimizing and recycling construction and demolition waste
<b>D09</b>	Contractor to buy and install materials meeting set carbon limits

# Glossary

This report uses the definitions for carbon as indicated in the World Green Building Council's (WorldGBC) *Bringing Embodied carbon upfront*<sup>2</sup> report and the terms of the European Committee for Standardization Sustainability of construction works.

- Assessment of environmental performance of buildings.
- Calculation method standard EN 15978 and International Organization for Standardization (ISO) Sustainability in buildings and civil engineering works.

- Core rules for environmental product declarations of construction products and services ISO 21930 standards for life-cycle assessment.

We illustrate the terms below. We do not use all terms shown in the visualization in the report but provide them for completeness and clarity.

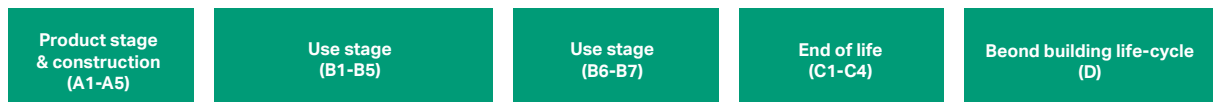
**Figure 1:** Overview of the terminology used in this report

## WHOLE LIFE CARBON



*As additional information*

## BUILDING LIFE-CYCLE MODEL ACCORDING TO EN 15804/ISO 21930



**Building system:** This report uses the WBCSD Building System Carbon Framework definition to describe the interdependencies of all actors throughout the entire building and construction value chain. A building and construction system is a value chain consisting of the different segments involved in delivering buildings.

**Carbon footprint or carbon emissions:** The sum of all GHG emissions of a given product, asset or activity. Experts quantify its global warming potential (GWP) into carbon dioxide equivalents (CO<sub>2</sub>e).

**Embodied carbon:** Carbon emissions associated with materials throughout their whole life cycle. Embodied carbon includes the emissions arising from each stage of the building life-cycle model, as defined by

EN 15978 and ISO 21930: raw material extraction (A1), transport to manufacturing facilities (A2), manufacturing (A3), transport to a construction site (A4), construction (A5), use phase (B1), maintenance (B2), repair (B3), replacement (B4), refurbishment (B5), deconstruction (C1), transport to waste processing (C2), waste processing (C3) and final disposal (C4).

**Environmental product declaration (EPD):** Third-party verified declaration providing quantified environmental data using predetermined parameters in conformity with ISO 21930 or EN 15804.

**Life-cycle assessment (LCA):** Inventory and evaluation of the inputs, outputs and potential environmental impacts of a product system throughout its life cycle.

**Operational carbon:** The emissions associated with energy usage in heating, powering or cooling a building during its use phase (B6), as well as operational water usage (B7).

**Upfront carbon:** Carbon emissions caused during the materials production phase (A1-A3) and construction phase (A4-A5) of the life cycle, meaning all carbon emissions released before the building starts its use phase.

**Whole-life carbon:** Carbon emissions from the entire life cycle of the building, including both embodied and operational carbon. This includes the following life cycle stages: A1-A5, B1-B7, C1-C4 and module D.



# ① Why embodied carbon matters for construction clients





# ① Why embodied carbon matters for construction clients

## 1.1 The critical role of embodied carbon in construction

The building and construction sector is responsible for 38%<sup>3</sup> of global energy and process-related carbon dioxide emissions. Awareness is growing across the industry of the need to take urgent action to decarbonize projects and portfolios to reduce impact and remain relevant for the market.

Sectoral emissions consist of:

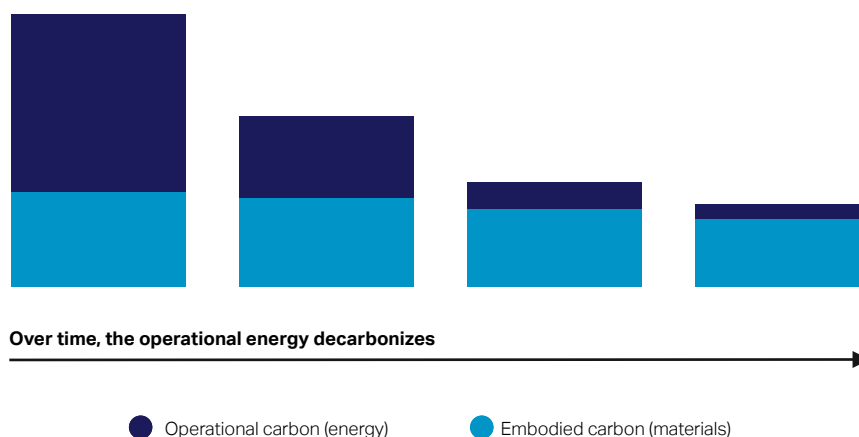
- **Embodied carbon:** resulting from the extraction, manufacturing, transportation, installation, maintenance, repair and end of life of construction materials.
- **Operational carbon:** resulting from the use of energy to heat, power and cool buildings and infrastructure.

Efforts in the sector have long focused on reducing operational carbon. Regulations are driving buildings to be more energy-efficient and trends indicate that energy policies will lead to the rapid decarbonization of the electricity sector. These changes mean that embodied carbon will become the dominant source of carbon emissions for new buildings. In low-carbon energy regions, embodied carbon may already represent the main share of carbon emissions. Indeed, in locations with a high proportion of renewable energy, such as Norway, embodied carbon already exceeds operating carbon for most buildings over their lifetime, even without considering expected grid decarbonization.

Consequently, the World Green Building Council set a target for the sector to reduce embodied carbon by at least 40% by 2030, while at the same time aiming for all new buildings to reach net-zero carbon in operations by 2030 and requiring all buildings to be net-zero along the full life cycle by 2050.

Many construction products, such as cement, steel and aluminum, emit chemical carbon during the manufacturing process – so called process emissions. Additionally, many of these manufacturing processes require high temperatures and therefore usually use fuels instead of electricity, making the GHG emissions from these industries much harder to abate. While reductions in electricity-based carbon emissions could reduce embodied carbon for future manufacturing, it would only apply to the materials replaced in the more distant future (so not upfront carbon) and only to the extent to which electricity can cover manufacturing energy demand. Section 10 provides more information on embodied carbon.

**Figure 2:** Importance of embodied carbon grows proportionally as the energy demand is reduced and energy sources are decarbonized



## 1.2 National and local embodied carbon regulations

Below is a snapshot of some national jurisdictions that have enacted, or are preparing to enact, embodied carbon regulations. The list is not exhaustive and some of the regulations are still under development. In addition, several other European jurisdictions and ambitious city councils are preparing regulations to reduce the carbon footprint of construction.

Global and regional roadmaps (such as the GlobalABC roadmaps), national roadmaps (such as the #BuildingLife initiative of the WorldGBC for European States) and city commitments (such as the C40 clean construction declaration) show the growing attention to policies that drive whole-life carbon and embodied carbon reductions.

## 1.3 Financial regulation drivers

### The European Union (EU) Sustainable Finance

**Taxonomy** is one of the most important upcoming carbon regulations.<sup>4</sup> It will require financial market participants in defined sectors in Europe to provide disclosures aligned with the taxonomy by 2025.

Legislation incorporates the disclosures through several separate elements, some of them not yet enacted.

Such disclosures include, for example, requiring that a financial market participant state how and to what extent they have used the taxonomy in evaluating the sustainability of their investments, to what environmental objective their investments contribute and what proportion of their investments they have aligned with the taxonomy.

Financial market participants with activities that substantially contribute to climate change mitigation or adaptation in a phased introduction must provide these disclosures starting from the end of 2021 (the Sustainable Finance Disclosure Regulation, or SFDR)<sup>5</sup>. This affects companies offering financial products, including pension funds, non-financial companies with over 500 employees (covered by the EU Non-Financial Reporting Directive) and EU member states setting public measures, standards or labels for green financial products or green corporate bonds.

According to the EU Sustainable Finance Taxonomy, all building trade activities have a high potential to contribute to climate change mitigation. The activities listed in the taxonomy include new building construction, building renovation, individual renovation measures, and building acquisition and ownership. Among construction material manufacturers, the regulation similarly affects cement, aluminum, iron, steel and plastics.

For non-financial companies, the disclosure must include: the proportion of turnover, capital expenditure and, if relevant, operating expenditure aligned with the taxonomy. The taxonomy requires new buildings of over 5,000 m<sup>2</sup> to account for whole-life carbon emissions to qualify but there are currently no threshold values for whole-life carbon or embodied carbon. The implementation advisory body – the Sustainable Finance Platform – will set and introduce embodied carbon thresholds by 2025.

The **Task Force on Climate-Related Financial Disclosures** (TCFD) recommends that firms disclose relevant, specific and complete information and report their GHG emissions and relevant risks.<sup>6</sup> It further recommends that disclosures be comparable among companies within a sector, industry or portfolio. At the TCFD preparer forum,<sup>7</sup> WBCSD shared the experience of construction and building materials companies in implementing the TCFD recommendations. Companies whose corporate disclosures exclude embodied carbon – referred to as Scope 3 emissions in corporate GHG accounting – should include it. Many governments worldwide are implementing the TCFD recommendations into law. The United Kingdom (UK), for example, phases mandatory requirements, which will affect commercial organizations listed on the UK stock exchange in 2021 and affecting additional organizations in 2023 and 2025.

**Table 1:** Jurisdictions with embodied carbon regulations

<b>Jurisdiction</b>	<b>Program summary</b>	<b>Status</b>	<b>Introduction</b>
<b>Vancouver, Canada</b>	Life-cycle emission reporting requirement, limits by 2030	Mandatory	In force
<b>Minnesota, U.S.</b>	State-funded projects must reduce impacts by 10%	Mandatory	In force
<b>California, U.S.</b>	Placing limit values on certain materials for state agencies	Mandatory	In force
<b>Netherlands</b>	National life-cycle impact limits on new buildings	Mandatory	In force
<b>London, UK</b>	Greater London Authority requirement for new projects	Mandatory	In force
<b>Belgium</b>	National LCA requirement for state government buildings	Mandatory	In force
<b>Germany</b>	National LCA requirement for federal government buildings	Voluntary	In force
<b>European Union</b>	Sustainable finance taxonomy criteria for large buildings	Voluntary	In force
<b>Canada</b>	National LCA requirement for federal buildings, limit by 2025	Mandatory	2022
<b>France</b>	National life-cycle carbon limits on new buildings	Mandatory	2022
<b>Sweden</b>	National carbon reporting for new buildings, limits by 2027	Mandatory	2022
<b>Denmark</b>	National life-cycle carbon limits on new buildings	Mandatory	2023
<b>Finland</b>	National life-cycle carbon limits on new buildings	Mandatory	2025
<b>New Zealand</b>	National life-cycle carbon limits on new buildings	Mandatory	Open
<b>United States</b>	National materials LCA requirement for federal buildings	Mandatory	Open



## 1.4 Market requirements

The construction and real estate markets focus on decarbonizing projects and portfolios to ensure their liquidity and attractiveness to tenants. Different green building standards, certifications or disclosure programs typically incorporate embodied carbon as one component.

### [The Embodied Carbon Review](#)<sup>8</sup>

found in 2018 that 105 of the 156 green building standards, certifications, policies and regulations analyzed globally address embodied carbon. However, most systems include only voluntary or disclosure-only requirements, as opposed to embodied carbon performance requirements.

GRESB or the Global ESG Benchmark for Real Assets, one of the most widely adopted real estate environmental

benchmarks, introduced several embodied carbon disclosures to its 2020 [Real Estate Reference Guide](#).<sup>9</sup> To comply, developers need to ensure designers and builders translate them into practice in their projects. GRESB asks developers to implement a policy covering the environmental and health attributes of building materials, consider project life-cycle emissions and disclose the embodied carbon emissions of development projects. Section 8.3 provides a practical example of setting these requirements.

We have introduced the [Building System Carbon Framework](#),<sup>10</sup> which enables each user to identify the best emissions-reduction strategies for their part of the value chain and allows stakeholders to make informed decisions based on clear and transparent information.

Several influential real estate industry organizations have either set their own targets and commitments or joined industry-wide initiatives, such as the World Green Building Council's [Net Zero Carbon Buildings Commitment](#)<sup>11</sup> which is now expanding this commitment to consider whole-life carbon.

Organizations implementing this type of commitment will expect their business partners to align accordingly with an appropriate level of carbon reductions. Organizations such as the Carbon Disclosure Project (CDP) collect whole-organization carbon performance reports, listing over 10,000 organizations disclosing their environmental risks and impacts and their work to reduce them.

## **CASE STUDY: Landsec** – Timber Square, Lavington Street, London

Landsec is one of the largest commercial property developers and investors in the UK. In 2016, Landsec became the first property company in the world to achieve approved science-based targets; it is now one of the few real estate companies in the UK with science-based targets in line with a 1.5°C target, including all three reporting scopes.

Scope 3 indirect emissions, including energy procurement for customers and supply chain emissions, make up close to 90% of the company's carbon footprint and are an area of focus of the sustainability strategy. To address supply chain emissions (29% of Scope 3 emissions in 2020-21), Landsec gives all projects typology-specific embodied carbon intensity targets from project inception. This serves to drive the early design phase towards low-carbon structural and architectural design options. It then complements each intensity target by an additional target that aims to reduce at least 15% of emissions against a project-specific Royal Institute of British Architects (RIBA) Stage 3 baseline. This is to drive the procurement of low-carbon materials, for example, by using environmental product declarations (EPDs) to inform decision-making. It uses embodied carbon questionnaires during the tender stage for the procurement of key packages so that supply chain carbon information can inform decision-making.

Timber Square is a proposed redevelopment scheme that will deliver a mix of workspace and retail spaces. Embodied carbon reductions have been a critical consideration driving design from project inception. The project aims to keep the carbon intensity of supply chain emissions, including timber carbon sequestration, under 550 kgCO<sub>2</sub>e/m<sup>2</sup> gross internal area (GIA). Compared to a typical office, this target represents a 50% reduction in construction emissions. The company will achieve it by retaining part of the existing structure; using engineered timber in the structural design; incorporating offsite construction methods; and specifying low-carbon materials.



## 1.5 Transition risk and carbon pricing

Companies recognize that the climate crisis poses a financial risk in terms of both physical and transition risks. Transition risks will arise as the economy shifts to become low-carbon and more climate-resilient. According to The Economist Intelligence Unit,<sup>12</sup> the total value at risk for assets managed by non-bank financial institutions ranges from USD \$4.2 to USD \$43 trillion from now to the end of the century. Various organizations have developed carbon risk quantification tools to address this challenge, including the [Carbon Risk Real Estate Monitor \(CRREM\)](#) widely used in the built environment, which covers both direct and indirect operational GHG emissions.

The [European Commission's guidelines on reporting climate-related information](#) identify the following types of transition risks for businesses with a negative impact on climate:

- Policy risks from exposure to various types of future regulations
- Legal risks, for example, from litigation or failing to adapt to climate change

- Technology risks, for example, if the technologies the company uses become obsolete in favor of less damaging solutions
- Market risks from a shift in customer behavior towards alternative suppliers offering low-carbon solutions
- Reputational risks, such as difficulty in attracting and retaining customers, staff and investors.

One overall policy mechanism adopted by leading businesses is carbon pricing. Setting a carbon price mechanism for investment decisions involves converting the life-cycle carbon emissions of investment options into a component in the profitability equation. On the one hand, this ensures the full inclusion of carbon in the price and, on the other, the implementation of all cost-effective yet not directly profitable carbon reduction investments to reduce exposure to transition risks. Setting an appropriate carbon price can lead to net-zero projects while minimizing future business risks.

The EU's Emissions Trading System (ETS) uses regulatory carbon pricing, which also covers some essential construction materials manufacturing sectors. The EU ETS price mechanism limits the total available emissions rights to all players within the EU; manufacturers receive a portion of their emissions rights at no cost. Organizations can also purchase emissions rights and can sell leftover ones to other organizations. As of mid-April 2021, the carbon price in the EU ETS was around EUR €45 per metric ton of carbon emissions. Twelve states in the United States use a similar carbon pricing system, the [Regional Greenhouse Gas Initiative](#).

Some organizations, including British Land (UK), use the internal carbon price proceeds to fund energy retrofitting for their existing properties. Some manufacturers, such as Saint-Gobain (France) apply internal carbon pricing to their manufacturing and research and development investments. CDP's 2021 [Global Carbon Price](#) report reveals that 853 companies are using internal carbon pricing and 1159 anticipate introducing it in the next two years.

## ② Future-proofing new construction projects



## ② Future-proofing new construction projects

### 2.1 Understanding the Building System

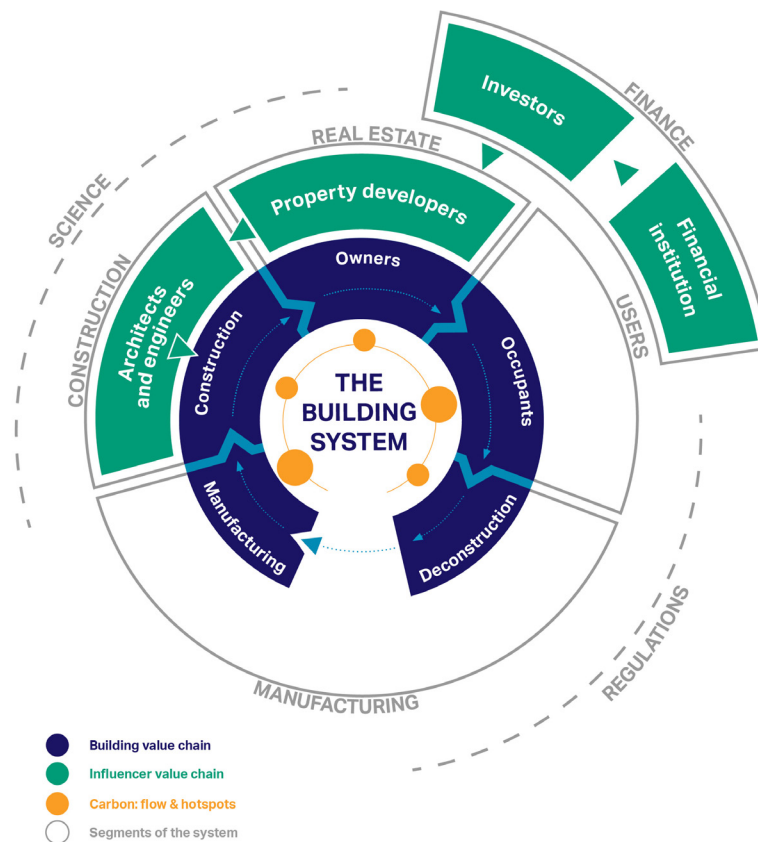
The building and construction system is a diverse value chain consisting of various segments, from manufacturing to financing, where each segment contributes to the common goal of delivering buildings. Our [Building System Carbon Framework shows these relations in detail](#). Understanding the links and interactions between the segments of the building system can also support the creation and achievement of sustainability targets.

All components of the building system tie closely together; thus, no single way to represent it in its entirety exists. Figure 3 represents WBCSD's view on how to model building systems.

The Building System Carbon Framework is a conceptual assessment tool representing the carbon emissions in the building and construction system.

It provides a clear overview of embodied and operational carbon emissions according to the different life-cycle stages of buildings and their layers or components. We developed the framework to make it clear where and when buildings generate carbon emissions, allowing stakeholders to make informed decisions and accelerate the transition to net zero. It is based on EN 15978:2011 building life-cycle standards.

Figure 3: The buildings system



Source: The Building System Carbon Framework, WBCSD (2020).



**Figure 4:** The Building System Carbon Framework (BSCF)

		BUILDING STAGES						
		PRODUCT	CONSTRUCTION	USE		END OF LIFE	EMISSIONS	BEYOND LIFE
		A1-A3	A4-A5	B1-B5	B6-B7	C	CO <sub>2</sub> e/m <sup>2</sup>	D
BUILDING LAYERS	<b>Structure</b> Foundation, load-bearing							
	<b>Skin</b> Windows, roof, insulations							
	<b>Space Plan</b> Interior finishes							
	<b>Services</b> Mechanical, electrical, plumbing							
	<b>Stuff (optional)</b> Furniture & appliances							
	<b>Building carbon emissions</b>							
	<b>Carbon compensation</b> Removals and offset							

● Embodied carbon    ● Operational carbon    ● Partial and total sums

**Source:** The Building System Carbon Framework, WBCSD (2020).

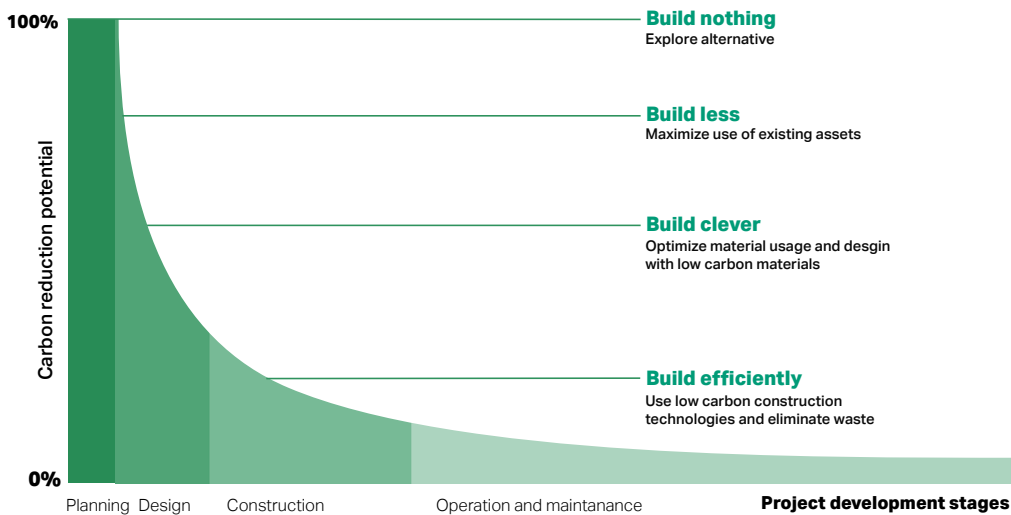
**2.2 Investor and developer requirements are the key to low-carbon projects**

As investors and developers originate most projects, their requirements are essential for effective decarbonization as they can set carbon requirements early on, which is necessary for high impact. It is not possible to add low-carbon requirements as a feature later in a project; it is necessary to design them into the project from the start. Carbon reduction opportunities irrevocably disappear as projects progress, as shown in Figure 5.

An investor or developer can reduce embodied carbon using the following types of strategies:

1. Creating a carbon policy that sets out consistent requirements for all projects to follow
2. Setting targets and transparency requirements for projects to meet across all their phases
3. Prioritizing circular design – less new building and more reuse and refurbishment
4. Requiring design optimization to use less material and choose lower carbon materials
5. Requiring low-carbon procurement to ensure the materials used are lower impact than average.

**Figure 5:** Opportunities to reduce embodied carbon across all project phases





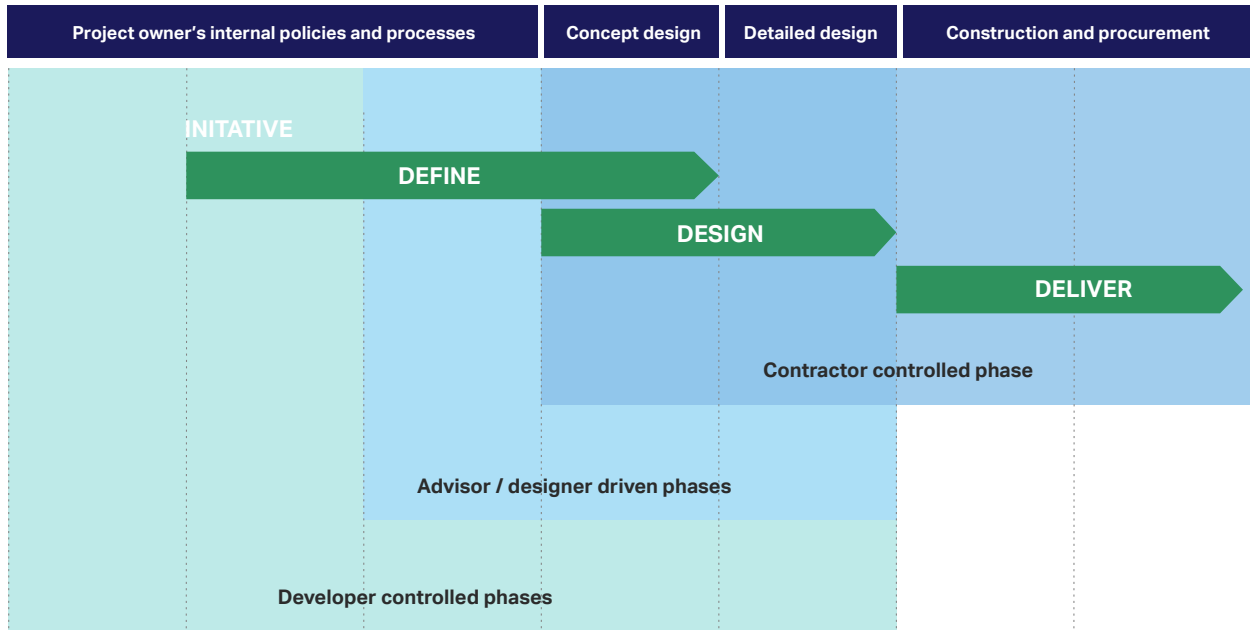
### 2.3 Control of the project in different project phases

Investors and developers initiate and shape the exploratory project phases. Upon project formation, the developer or construction client often

controls it, briefing designers and advisors in the design of the project until handing it over to the contractor for construction. Even if others shape a project on a day-to-day basis, the original requirements continue to guide it.

The degree of control exercised over the different parties depends on the client and the project delivery model applied. Section 9 discusses the impact of project delivery models for the requirements in detail.

Figure 6: Project phases and the activities across all project phases



#### CASE STUDY: Bouygues Bâtiment International

Bouygues Bâtiment International (BBI), a subsidiary of Bouygues Construction, has specialized in complex construction projects on the international stage for 50 years. Operating on all five continents and in nearly 30 countries, the firm relies on deep local knowledge based on its office network. The expertise of the central engineering department guarantees the provision of state-of-the-art solutions to BBI subsidiaries around the world. It enables them to offer global, innovative, sustainable solutions tailored to client needs.

The ambitious climate strategy that Bouygues Construction is introducing will reduce Bouygues Bâtiment International's carbon footprint by 30% by 2030, in line with the ambition of the Paris Climate Agreement. Beyond reducing its own direct and indirect emissions, BBI also supports the responsible use of the buildings and structures it constructs. To achieve this, it offers a wide range of solutions promoting the energy performance of built assets. The firm takes action across the entire value chain: design, purchase of materials, project execution, and building operation and structures.

The One Click LCA platform helps the group evaluate different low-carbon design options with a full life-cycle assessment for any project anywhere in the world. It provides a large training program to get operational teams involved and supports them in successfully assessing their projects.

# ③ How to use this report



# ③ How to use this report

## 3.1 Who should use this report?

This report provides over 50 embodied carbon-reduction policies and best practices that investors and developers can adopt for their projects and guidance on how to use them. The project owner is invited to freely modify all policies and best practices to suit their preferences and local context.

This guidance is useful for any demand-side organizations interested in mitigating the negative climate impacts of their construction projects. It helps public and private sector investors, developers, and tenants, as well as parties acting on their behalf and those seeking to work directly with them. Designers and contractors can also use this report to decarbonize their projects' indirect carbon emissions (Scope 3 emissions) or embodied carbon.

More specifically, different stakeholders can use these requirements in the following ways:

- Investors can require that the projects they fund apply the stated requirements as best practices to ensure portfolio sustainability without detailing them for each investment case separately.
- Tenants can use them to require that the development of any projects for which they are an anchor tenant, specifically any build-to-suit

or refurbishment projects for their use, meet their requirements.

- Developers can apply these requirements to ensure excellent sustainability credentials and thus high marketability and enforceability for their developing projects.
- Consultants and designers helping clients develop and implement their sustainability requirements can use them as the basis for embodied carbon-related aspects. Embodied carbon is particularly relevant for mechanical and structural engineers and architects.
- Design-build contractors can apply these requirements to make their operations more efficient in terms of materials used and embodied carbon.

City-scale developments typically require broader system considerations than those made at a single project level, which is the scale of focus of this report. We suggest that municipalities looking for guidance for broader policies read Carbon Neutral Cities Alliance's [City Policy Framework for Dramatically Reducing Embodied Carbon](#)<sup>13</sup> or C40's [Why cities need to address the construction sector's hidden emissions policy](#)<sup>14</sup> brief.









## 3.2 The structure of these requirements

The report contains requirements for the four major project phases, assigning the requirements to different parties in each phase:

- A. Project owner's internal policies and processes (before forming a project) – internal policies
- B. Concept design phase (also called schematic design) – requirements for the design team
- C. Detailed design phase (also called construction drawings) – requirements for the design team
- D. Construction and procurement phase – requirements for the general contractor.

We have listed the different requirements for each phase in chapters 4 and detailed them in Annexes A-D. Annexes E and F give general requirements applicable to all project phases. Similar requirements carry across the different project phases to continue or complement their implementation. From each phase, we chose three core requirements due to their feasibility and adaptability to all types of projects. Table 2 illustrates the logical sequencing of different project phases and requirements.

**Table 2:** Connection of the requirements for the embodied carbon objectives

	PROJECT OWNER'S POLICIES AND PROCESSES	CONCEPT DESIGN	DETAILED DESIGN	CONSTRUCTION AND PROCUREMENT
 Embodied carbon targets	<b>A10</b> Set a mandatory embodied carbon target for all projects	<b>B01</b> Propose a life-cycle carbon or embodied carbon target for the project  <b>B03</b> Benchmark building design options for embodied carbon	<b>C01</b> Demonstrate meeting embodied carbon targets with updated quantities	<b>D01</b> Demonstrate meeting embodied carbon targets with final quantities
 Embodied carbon disclosure	<b>A09</b> Report embodied carbon alongside other carbon emissions annually	<b>B02</b> Use a screening-level embodied carbon assessment to identify hotspots	-	<b>D02</b> Require independent third-party verification of carbon performance
 Embodied carbon optimization	-	<b>B08</b> Develop alternative designs and carbon and cost evaluations	<b>C05</b> Factor embodied carbon and cost in detailed design options	<b>D07</b> Ensure contractor proposes embodied carbon-related improvements
 Reuse of existing buildings	<b>A11</b> Evaluate the possibility of refurbishing existing buildings  <b>A12</b> Commission a pre-demolition audit for any asset requiring deconstruction	<b>B04</b> Optimize the reuse of existing facilities (onsite and offsite)	-	<b>D04</b> Require deconstruction to remove unwanted existing elements
 Design for adaptability & disassembly	-	<b>B06</b> Require design for deconstruction for structural and key elements  <b>B05</b> Optimize building adaptability during its lifetime  <b>B13</b> Incorporate climate resilience measures into the building design	<b>C03</b> Design materials installation practices to allow for their future reuse	<b>D05</b> Follow design for disassembly specifications  <b>D10</b> Require project to implement a materials takeback program
 Consider major options	<b>A13</b> Evaluate buildability and accessibility prior to securing land	<b>B07</b> Investigate suitability of low-carbon structural material options  <b>B14</b> Require landscaping to consider carbon removal opportunities	<b>C07</b> Require mechanical design optimization for life-cycle carbon reductions  <b>C08</b> Plan, design and specify low-carbon concrete solutions	<b>D11</b> Require contractor to use near zero-emissions construction machinery
 Materials efficiency	<b>A15</b> Evaluate zoning carbon impacts and consider rezoning if necessary  <b>A14</b> Commission a detailed geotechnical survey for the site prior to design	<b>B12</b> Investigate ways to reduce unnecessary systems or materials  <b>B11</b> Ensure space efficiency and right sizing  <b>B10</b> Design adaptable/reversible parking with optimized capacity  <b>B09</b> Optimize building form for site topography and properties	<b>C04</b> Require materials efficiency optimization  <b>C02</b> Require materials efficiency report  <b>C06</b> Appoint a reviewer for the building's structural material efficiency	<b>D06</b> Minimize and recycle construction and demotion waste (CDW)
 Low Carbon Products	-	<b>B15</b> Investigate the availability of carbon-negative, -absorbing or -storing materials  <b>B16</b> Investigate the applicability of circular procurement models	<b>C08</b> Evaluate alternatives for the top ten products highest in carbon  <b>C10</b> Ensure communication between structural engineers and material suppliers  <b>C11</b> Deliver an embodied carbon optimizing specification for the project	<b>D08</b> Ensure contractor uses products that comply with restrictions set  <b>D09</b> Ensure contractor buys and installs materials meeting set carbon limits  <b>D03</b> Require environmental product declarations (EDPs) for key products



The visualization does not cover the project owner's internal policies and processes for requirements A01-A08, which are not directly linked to any of the individual group of measures but rather provide an overall framework.

We have categorized the requirements in this report into the following groups:

1. Carbon policy, which sets out consistent requirements for all projects to follow. Policies are generally set for the entire organization and, as such, predate specific projects.

2. Targets and transparency requirements covering all project phases.
3. Circularity, which is about building new less often and reusing and refurbishing more often in all phases.
4. Design optimization to use less material and to choose lower-carbon materials. This applies to most phases.
5. Low-carbon procurement, which organizations specify and execute in the later phases of a project.

Different groups of measures support embodied carbon reductions in projects at different points in time. Table 3 elaborates on this. Circularity measures also reduce embodied carbon at a building system level beyond an individual project by providing other projects with reusable building products.

**Table 3:** Contribution to embodied carbon reduction in projects for the different groups of measures at different points in time

<b>Measure</b>	<b>Upfront carbon (A1-A5)</b>	<b>Whole-life carbon (A-C)</b>	<b>Beyond the life cycle (D)</b>
<b>Carbon policy</b>	Some reduction	Main reduction	Some reduction
<b>Targets and transparency</b>	Some reduction	Main reduction	-
<b>Circularity</b>	Some reduction	Some reduction	Main reduction
<b>Design optimization</b>	Main reduction	Some reduction	Some reduction
<b>Low-carbon procurement</b>	Main reduction	Some reduction	-

## CASE STUDY: Skidmore, Owings & Merrill

Skidmore, Owings & Merrill (SOM) is a collective of architects, designers, engineers and planners responsible for some of the world's most technically and environmentally advanced buildings and significant public spaces. SOM's designs anticipate change in the way people live, work and communicate, and have brought lasting value to communities around the world. The firm's approach is highly collaborative and its interdisciplinary team is engaged on a wide range of international projects, with creative studios based worldwide.

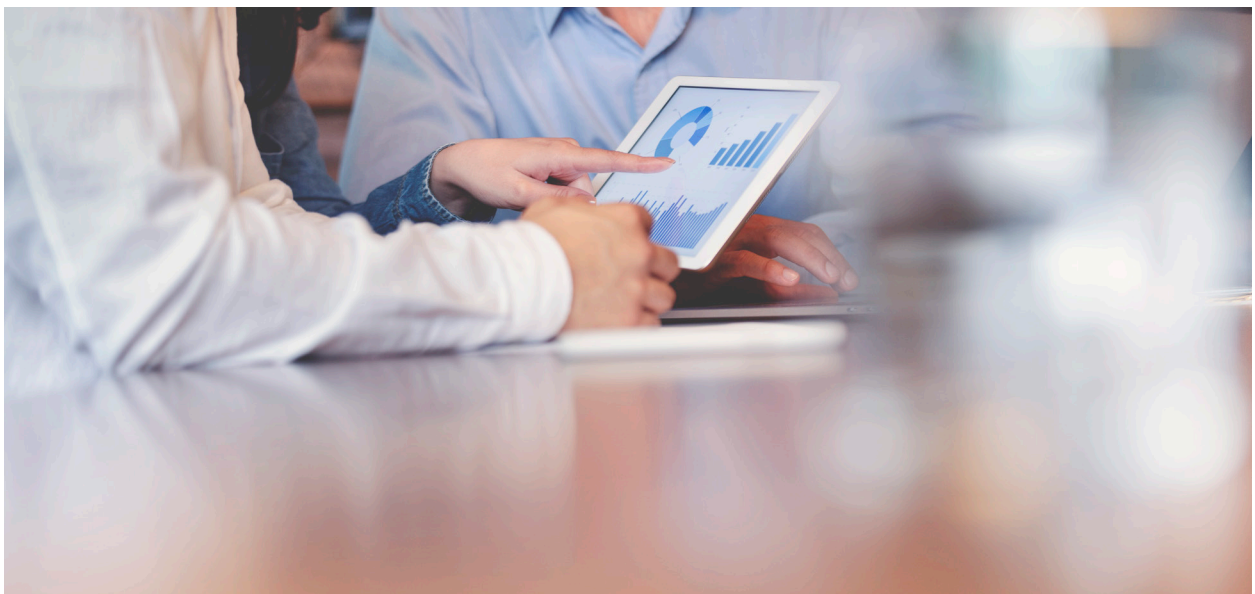
SOM answers the most urgent challenge of the times: protecting the Earth's resources and supporting the transition to a zero-carbon economy. Its architects, engineers and planners lead the charge by shaping buildings and cities to advance sustainable development.

### 63 Madison Avenue, New York

SOM's competition proposal to reimagine 63 Madison Avenue, a typical 1960s office building in Manhattan, serves as a prototype for the decarbonization and transformation of New York City's aging commercial properties. SOM's design approach balances embodied, operational and end-of-life carbon emissions throughout the building's lifespan. Collaborating with engineering firm Werner Sobek and sustainability consultant Atelier Ten, SOM proposed a design that prioritizes reuse and significantly reduces the renovation's embodied carbon.

Based on whole life-cycle carbon analysis, the design retains as much of the existing façade and structure as possible and avoids the extra embodied carbon impact of recladding. Instead, SOM proposed overcladding the building with a lightweight "veil" façade system – taking advantage of technological advances in glass to create a light, high-performance, double-skin façade that reduces heat loss and produces significant energy savings.

This approach, derived from whole-life-cycle carbon analysis, reduces embodied carbon emissions by 40% and operational carbon emissions by 75%. At the same time, it prioritizes end-users' well-being by enhancing air quality and maximizing natural ventilation, daylight and views.



### 3.3 Decide your level of ambition for embodied carbon reduction

The WorldGBC has called for an embodied carbon reduction of at least 40% by 2030. While every organization needs to work toward achieving at least this level of reductions, businesses may choose to start with a more limited level of ambition to build competence and gather experience.

After gaining experience, they can progress and increase their level of ambition to and beyond a 40% reduction to keep pace with market expectations and climate commitments.

Starting today is more important than starting with perfect requirements; we encourage continuous improvement. Each company can choose the requirements they wish to adopt and incorporate them to fit their own business context best

(see Table 4). Each organization should review and, where possible, tighten requirements every few years, as their and their suppliers' experience and capability in this field grow. Annex F: Recommended project carbon accounting standards provides the carbon accounting standards and parameters for use in projects.

**Table 4:** Level of ambition for embodied carbon reduction

Level	Description of the level	Suggested requirements to achieve results	Suggested initial level for
<b>Reporting</b>	For starting the journey only and for up to two years.	Select the three most applicable core requirements, and apply them, initially without limits or targets.	Inexperienced organizations without strong local expertise.
<b>Light green</b>	For achieving meaningful embodied carbon reductions.	Select the six most applicable core requirements and apply them consistently across projects. Require either concept phase target-setting (B01), screening (B02) or benchmarking (B03).	North America, Eastern Europe, Asia-Pacific and inexperienced organizations who can use external experts.
<b>Green</b>	WGBC target: at least 40% less embodied carbon.	Select the nine most applicable requirements, including a 40% reduction and apply them consistently. Require verification of results (D02).	Northern and Western Europe and organizations with previous experience.
<b>Deep green</b>	At least 50% less embodied carbon and a continued reduction trajectory.	Use all requirements set out above, with a 50% reduction target, and develop new requirements to go beyond examples given here as needed.	Organizations with significant previous experience.





### 3.4 The estimated carbon and cost impact of adopting the requirements

Many of the requirements provide opportunities to save on the costs of materials through design optimization. Others grow commercial potential by strengthening projects with stronger carbon credentials.

For cost assessment, we only consider direct cost savings. We do not include potential savings or benefits accruing to other parties in the value chain, except for cases marked “on life cycle”. Requirements do not consider potential commercial gains or government incentives as these vary locally.

While the actual cost and carbon performance of the different requirements will depend on the project context, we provide overall indicative estimates to highlight typical impact. These are based on the assumption that the skills needed to perform the required services are locally available.

**Table 5:** Carbon saving estimate symbols

Carbon saving symbol	Description of the indicative estimated carbon saving
	An enabling or transparency requirement that supports reductions but does not deliver them directly.
	Moderate carbon reduction potential, or higher potential but only in circumstances where applicable.
	High carbon reduction potential, or very high potential but only in certain circumstances.
	Very high carbon reduction potential, or high potential but with near ubiquitous applicability.
<b>Varies by level</b>	The carbon reduction potential varies by the level of requirements.

**Table 6:** Cost impact estimate symbols

Carbon saving symbol	Description of the indicative estimated cost impact
<b>++\$</b>	This requirement is likely to increase costs noticeably in the category of purchasing concerned.
<b>+\$</b>	Requirements may incur a generally minor extra cost. Reporting measures are usually in this case. While they may only require only limited additional work from designers, it would not come free.
<b>Neutral</b>	The requirement is generally cost neutral – it requires delivering a comparable outcome, but differently. This does not preclude that the new approach may be more costly for the first iterations until it is mastered.
<b>Varies by level</b>	The cost impact of the requirement depends on the level of requirement applied.
<b>-\$</b>	The requirement either saves costs or is a similar cost and reduces risks.
<b>-\$-\$</b>	Saves costs noticeably in the category concerned or is a similar cost and reduces risks.
<b>On CAPEX</b>	Qualifier for cost-saving requirements: this qualifier means it saves in investment costs.
<b>On lifecycle</b>	Qualifier for cost-saving requirements: this qualifier means it saves in life-cycle costs of the asset.



### 3.5 The project phasing model used in this report

The project phasing model used in this report is a synthetic one created by using the UK, US, French and Finnish project phasing models as the basis. Table 7 displays their differences. Most project phasing models have similarities and contain similar milestones, even if the details vary.

**Table 7:** Project phasing model differences

Phase		RIBA stages (UK)	AIA phases (US)	French decree 22.3.2019	Finland RT 10-11224
A	<b>Project owner's internal policies and processes</b>	0 Strategic definition 1 Preparation and brief	1 Programming	1 Preliminary studies	Needs analysis Project plan
B	<b>Concept design</b>	2 Concept design	2 Schematic design	2 Pre-project design	Schematic design
C	<b>Detailed design</b>	3 Developed design 4 Technical design	3 Design development 4 Construction docs	3 Project design 4 Construction docs	Construction drawings
D	<b>Construction and procurement</b>	5 Construction 6 Handover and close out	6 Construction admin. 7 Project close out	5 Construction admin. 6 Construction supervision	Construction
E	<b>Use phase</b>	7 In use	-	-	Warranty period



## ④ List of requirements



## A. Project owner's internal policies and processes summary









The requirements outlined here form part of the project owner's internal policy and processes and, as such, it cannot purchase them from marketplace actors. Also, many of these requirements occur before the forming of a specific project and are portfolio-level decisions.

**Annex A:** further details of these project owner's internal policies and processes requirements.

Core requirements for this phase, which we recommend every project owner implement, are:

- **A01** Create embodied carbon-related requirements for all projects
- **A09** Report embodied carbon alongside other carbon emissions annually
- **A11** Evaluate the possibility of refurbishing existing buildings.

**Table 8:** Summary of project owner's internal policies and processes

#	Measure	Requirement	Carbon	Cost
A01	Carbon policy	Create embodied carbon-related requirements for all projects. Include embodied carbon aspects in overall sustainability/ project briefs.	 - Varies	\$
A02	Carbon policy	Provide a financial incentive for improving final embodied carbon. Create a financial incentive for improving results above the minimum required.	 - Varies	+\$ - \$\$ Varies
A03	Carbon policy	Apply carbon pricing to optimize a project's overall carbon and cost. Set an internal price for carbon to ensure impacts are priced into projects.	 - Varies	+\$ - \$\$ Varies
A04	Carbon policy	Make embodied and life-cycle carbon part of project funding reviews. Include carbon information in project funding reviews alongside costs.		Neutral
A05	Carbon policy	Estimate cost difference for delivering each project at net-zero carbon. Require cost evaluation of additional measures to achieve net-zero carbon.		+\$
A06	Carbon policy	Prioritize design teams with materials efficiency and carbon experience. Require a team with experience in materials efficiency, circularity and carbon.		Neutral
A07	Carbon policy	Appoint a project sustainability advisor with a focus on carbon. Appoint a specialized sustainability advisor for the project.		+\$
A08	Carbon policy	Use a green building rating system for embodied carbon reductions. Choose a system prioritizing embodied carbon and require relevant credits.		+\$
A09	Targets and transparency	Report embodied carbon alongside other carbon emissions annually. Public disclosure of embodied carbon as part of total emissions reporting.		+\$



<b>A10</b>	Targets and transparency	Set a mandatory embodied carbon target for all projects. Set mandatory, effective carbon targets (by type) for all projects to meet.	○ - ●● Varies	+\$ - \$\$ Varies
<b>A11</b>	Circularity	Evaluate the possibility of refurbishing existing buildings. Consider brownfield sites with existing buildings that could be refurbished.	● - ●●	+\$
<b>A12</b>	Circularity	Commission a pre-demolition audit for any asset to be deconstructed. Ensure that materials reuse potential is analyzed well ahead of project start.	○	+\$
<b>A13</b>	Design optimization	Evaluate buildability and accessibility prior to securing land. Consider a site's geotechnical condition and mass transit access prior to buying.	○	Neutral
<b>A14</b>	Design optimization	Commission a detailed geotechnical survey for the site prior to design. Increase resolution of test drilling to reduce uncertainty and cost of building.	●●	-\$ on CAPEX
<b>A15</b>	Design optimization	Evaluate zoning carbon impacts and consider rezoning if necessary. Review parking, massing and others and apply for rezoning if high carbon.	○ - ●●	-\$ on CAPEX





## B. Concept design phase requirements summary

Companies can apply these requirements in contracts to shape the project in the most optimal manner from a cost and carbon perspective for a single project or for several contracts.

**Annex B:** further details of these concept design phase requirements.

Core requirements for this phase, which we recommend every project owner implement, are:

- **B01** Propose a life-cycle carbon or embodied carbon target for the project
- **B07** Investigate suitability of low-carbon structural material options
- **B08** Develop alternative designs and carbon and cost evaluations.

**Table 9:** Summary of concept design phase requirements

#	Measure	Requirement	Carbon	Cost
<b>B01</b>	Targets and transparency	Propose a life-cycle carbon or embodied carbon target for the project. Create an embodied carbon baseline value and use it to set a carbon target.	●● - ○ Varies	+\$ - \$\$ Varies
<b>B02</b>	Targets and transparency	Screening-level embodied carbon assessment to identify hotspots. Require an early phase carbon estimation to focus carbon reduction efforts.	○	+\$
<b>B03</b>	Targets and transparency	Benchmark building design options for embodied carbon. Benchmark retained design and alternatives to average market carbon data.	○	+\$
<b>B04</b>	Circularity	Optimize the reuse of existing facilities (on-site and off-site). Optimize the reuse of what is already on-site and what is available nearby.	●	Varies
<b>B05</b>	Circularity	Optimize building adaptability during its lifetime. Require the design to consider changing building use or users over time.	●	-\$ on lifecycle
<b>B06</b>	Circularity	Require design for deconstruction for structural and key elements. Require that designers design the building for deconstruction, where possible.	●	Neutral (but novel)
<b>B07</b>	Design optimization	Investigate the suitability of low-carbon structural material options. Require evaluation of structural materials with a significant carbon reduction.	●●	+\$
<b>B08</b>	Design optimization	Develop alternative designs and carbon and cost evaluations. Require that the design team present quantified alternative designs.	○	+\$
<b>B09</b>	Design optimization	Optimize building form for site topography and properties. Use a building form matching the site properties and constraints (as applicable).	●●	-\$ on CAPEX

<b>B10</b>	Design optimization	Design adaptable/reversible parking with optimized capacity. Optimize parking to the extent permitted and ensure reversible/adaptable design.	●	-\$ on CAPEX
<b>B11</b>	Design optimization	Space efficiency and right sizing. Design for high space use efficiency and right size building program.	●●	-\$ on CAPEX
<b>B12</b>	Design optimization	Investigate ways to reduce unnecessary systems or materials. E.g., use shading or exposed thermal mass to reduce cooling load and finishes.	●	-\$ on CAPEX
<b>B13</b>	Design optimization	Incorporate climate resilience measures into the building design. Design building to resist and perform during severe climate events.	●	+\$
<b>B14</b>	Design optimization	Require landscaping to consider carbon removal opportunities. Use trees and other plants that bind carbon to the soil in landscaping.	○	+\$
<b>B15</b>	Design optimization	Investigate the use of carbon negative, absorbing or storing materials. Require evaluation of the applicability of carbon-negative or storing materials.	●	++\$
<b>B16</b>	Low-carbon procurement	Investigate the applicability of circular procurement models. Evaluate the applicability of leased or otherwise circular systems.	●	Varies



## C. Detailed design phase requirements summary

Companies can apply the following requirements in design phase contracts or in all design-build contracts. These requirements concern several separate fields of design.

**Annex C:** further details of these detailed design phase requirements.

Core requirements for this phase, which we recommend every project owner implement, are:

- **C04** Require materials efficiency optimization
- **C05** Factor embodied carbon and cost in detailed design options
- **C08** Evaluate alternatives for the top ten products highest in carbon.

**Table 10:** Summary of detailed design phase requirements

#	Measure	Requirement	Carbon	Cost
<b>C01</b>	Targets and transparency	Demonstrate meeting embodied carbon targets with updated quantities. Use updated quantities and specifications to update the carbon target.	○	Varies by level
<b>C02</b>	Targets and transparency	Materials efficiency report. Collect detailed quantities data from all relevant fields of design and report.	○	Neutral
<b>C03</b>	Circularity	Design materials installation practices to allow for their future reuse. Design structures and materials connections for disassemble and reuse.	●	-\$ on lifecycle
<b>C04</b>	Design optimization	Materials efficiency optimization. Systematic evaluation of materials efficiency opportunities in the project.	●●	-\$ on CAPEX
<b>C05</b>	Design optimization	Embodied carbon and cost factored detailed design options. Use updated quantities and data to create new optimization options.	●	+\$
<b>C06</b>	Design optimization	Appoint a reviewer for the building's structural material efficiency. Appoint a specialist reviewer to review and optimize material efficiency.	●	-\$ on CAPEX
<b>C07</b>	Design optimization	Require mechanical design optimization for life-cycle carbon reduction. Require optimization to consider energy efficiency, refrigerants and materials.	○ - ●●	Neutral
<b>C08</b>	Low-carbon procurement	Evaluate alternatives for the top ten highest carbon products. Evaluate alternatives and propose product specific carbon limits.	● - ●●	Neutral to +\$
<b>C09</b>	Low-carbon procurement	Plan, design and specify low-carbon concrete solutions. Ensure that design, scheduling and specification supports low-carbon concrete.	●●	on CAPEX
<b>C10</b>	Low-carbon procurement	Communication between structural engineers and material suppliers. Require coordination between designers specifying products & key suppliers.	○	Neutral
<b>C11</b>	Low-carbon procurement	Deliver an embodied carbon optimizing specification for the project. Create a specification that optimizes products using embodied carbon.	●	Neutral to +\$

## D. Construction and procurement phase requirements summary

Companies can apply the following requirements in all main works contracts and applicable side contracts and subcontracts. Depending on the project model, they are likely to be the responsibility of the main contractor.

**Annex D:** further details of these construction and procurement phase requirements.

Core requirements for this phase, which we recommend every project implement, are:

- **D01** Demonstrate meeting embodied carbon targets with final quantities
- **D06** Minimize and recycle construction and demolition waste (CDW)
- **D09** Ensure contractor buys and installs materials meeting set carbon limits

**Table 11:** Summary of construction and procurement phase requirements

#	Measure	Requirement	Carbon	Cost
<b>D01</b>	Targets and transparency	Demonstrate meeting embodied carbon targets with updated quantities. Use updated quantities and specifications to update the carbon target.	○	Varies by level
<b>D02</b>	Targets and transparency	Require independent third-party verification of carbon performance. Carry out a third-party audit of actual carbon performance.	○	Neutral
<b>D03</b>	Circularity	Require Environmental Product Declarations (EPDs) for key products. Require EPDs for the top ten carbon materials and ten additional ones.	○	-\$ on lifecycle
<b>D04</b>	Design optimization	Deconstruction to remove unwanted existing elements. Require deconstruction and use or sale of the recovered materials.	●	-\$ on CAPEX
<b>D05</b>	Design optimization	Design for disassembly specifications shall be followed. Require that connections and systems are built for disassembly, where possible.	●	+\$
<b>D06</b>	Design optimization	Minimize and recycle construction and demolition waste (CDW). Minimize waste and require that at least 90% of the CDW is not landfilled.	●	-\$ on CAPEX
<b>D07</b>	Design optimization	Minimize waste and require that at least 90% of the CDW is not landfilled.	○	Neutral
<b>D08</b>	Low-carbon procurement	Evaluate alternatives for the top ten highest carbon products. Evaluate alternatives and propose product specific carbon limits.	●	Neutral to +\$



<b>D09</b>	Low-carbon procurement	Contractor to buy and install materials meeting set carbon limits. Require procurement of use of materials that meet set carbon limits.	○	on CAPEX
<b>D10</b>	Low-carbon procurement	Project to implement a materials takeback program. Require that suppliers/partners agree to take back unused, unspoiled goods.	●	Neutral
<b>D11</b>	Low-carbon procurement	Contractor to use near zero zero-emission construction machinery. Require that 90% of all site construction machinery uses green electricity.	●	Neutral to +\$





## ⑤ Using the guidance with green building standards



# ⑤ Using the guidance with green building standards

## 5.1 Embodied carbon in connection with corporate GHG reporting

Corporate GHG reporting, including in GRI (Global Reporting Initiative) reporting, is mainly based on the GHG Protocol. The GHG Protocol separates companies' emissions into direct emissions (Scope 1), indirect emissions from electricity consumption (Scope 2) and value chain emissions upstream and downstream (Scope 3). Scope 3 reporting accounts for indirect GHG emissions that occur outside the organization, either upstream or downstream of its operations, and encourages companies to work with suppliers and customers to address climate impacts throughout the value chain.

Embodied carbon emissions are the Scope 1 emissions of manufacturers and represent, in general, the Scope 3 emissions of the other value chain players. The WBCSD Building System Carbon Framework supports this visualization of the roles and responsibilities of carbon emissions across the built environment.

[The Corporate Value Chain \(Scope 3\) Accounting and Reporting Standard](#)<sup>15</sup> provides guidance on Scope 3 emissions. Further sectoral guidance is available in the [UKGBC Guide to Scope 3 Reporting in Commercial Real Estate](#).<sup>16</sup>

Of the 15 Scope 3 categories in the GHG Protocol, emissions related to embodied carbon connect mainly with the following categories, as they refer to the flow of materials:

- **Category 1: Purchased goods and services**  
For a building developer, this will relate to the supply chain emissions from the design and delivery of a new building.
- **Category 2: Capital goods**  
For a new building owner purchasing an asset, this will relate to the upstream emissions of the new building (A1 to A5 modules).
- **Category 8: Upstream leased assets**  
For a building tenant (lessee) this relates to any emissions associated with the operation of an asset not included in Scope 1 and Scope 2. This may also include the embodied carbon associated with manufacturing or constructing leased assets.
- **Category 12: End-of-life treatment of sold products**  
For a building developer, who will treat the building as a "product" and include the end-of-life treatment of the building (module C) in its Scope 3 reporting for the year in which the building is sold.

To cover these transparency requirements, project owners should implement the following requirements:

- The detailed design stage should deliver and comply with the C01 Demonstrate meeting embodied carbon targets with updated quantities requirement.
- The construction phase should deliver and comply with the D01 Demonstrate meeting embodied carbon targets with final quantities requirement.

## 5.2 Embodied carbon in connection with LEED and BREEAM certifications

Using green building rating systems can motivate and support developers in analyzing and disclosing their project's emissions. The requirements in this report can help to achieve the targeted certifications.

The new construction certification systems by LEED and BREEAM have several credits that recognize work done to reduce embodied carbon. Of these systems, LEED v4.1 applies the same standard globally, whereas BREEAM has a range of national versions. The versions of BREEAM we consider here are BREEAM UK New Construction 2018 and BREEAM International New Construction 2016; use the latter when no national version is applicable. Other certification standards, such as Australian Green Star v1.2 (Credit 19A, Life cycle assessment), can use these requirements, similarly, as shown below.

Table 11 summarizes the interactions between the requirements outlined in this report and the matching credits (where applicable) in these green building rating systems for new constructions.

**Table 12:** Summary of interactions between requirements and matching credits

<b>Requirement(s)</b>	<b>LEED v4.1</b>	<b>REEAM UK 2018</b>	<b>BREEAM Int 2016</b>
<b>B01 Propose a life-cycle carbon or embodied carbon target for the project AND D01 Demonstrate meeting embodied carbon targets with final quantities</b>	MR Credit: Building Life-Cycle Impact Reduction – Option 2: Whole Building LCA, 4 points	Mat 01 Life Cycle Impacts – up to 10 points	Mat 01 Life Cycle Impacts, up to five points + points below
<b>B07 Investigate suitability for low carbon structural material options</b>	Part of above: 40% embodied carbon reduction, 1 point	Part of above: superstructure option appraisal	-
<b>B08 Develop alternative designs and carbon and cost evaluations, AND C05 Embodied carbon and cost factored detailed design options</b>	-	Mat 01 Life Cycle Impacts – up to 10 points AND Man 02 Life cycle cost and service life planning, 4 points	Man 02 Life cycle cost and service life planning, 4 points
<b>D03 Require Environmental Product Declarations for key products</b>	MR Credit: Environmental Product Declarations, 1 point	Mat 02 Environmental impacts from construction products – EPDs – 1 point	Mat 01 Life Cycle Impacts, 1-2 points: EPDs
<b>C11 Deliver an embodied carbon optimizing specification for the project AND D09 Contractor to buy and install materials meeting set carbon limits</b>	Pilot credit: Procurement of Low-carbon Construction Materials, 1-2 points	-	-
<b>B05 Optimize building adaptability during its lifetime</b>		Mat 05 Designing for durability and resilience – 1 point	
<b>Mat 05 Designing for durability and resilience – 1 point</b>	C04 Materials efficiency optimization	Mat 06 Material efficiency – 1 point	Mat 06 Material efficiency – 1 point



### 5.3 Embodied carbon in connection with GRESB disclosures

The GRESB Real Estate Public Disclosure Reference Guide includes several requirements for embodied carbon. The last reference guide to date has the following disclosures:

- **DMA1 Materials selection requirements**  
Does the entity have a policy requiring the consideration of building materials' environmental and health attributes for development projects?
- **DMA2.1 Life cycle assessments**  
Does the entity assess the life-cycle emissions of its development projects?

- **DMA2.2 Embodied carbon disclosure**  
Has the entity disclosed the embodied carbon emissions of its development projects completed within the last three years?

Projects should implement the following requirements:

- The concept design stage should deliver and comply with the following Annex B: Brief and conceptual design phase requirements – B01 Propose a life-cycle carbon or embodied carbon target for the project and B08 Develop alternative designs and carbon and cost evaluations.

- The detailed design stage should deliver and comply with the following Annex C: Detailed design phase requirements – C11 Deliver an embodied carbon optimizing specification for the project.

- The construction phase should deliver and comply with the following Annex D: Construction and procurement phase requirements – D01 Demonstrate meeting embodied carbon targets with final quantities.

The GRESB disclosures and the requirements below are not a comprehensive list of all requirements compatible with the GRESB but provide an example of how companies can use the requirements for GRESB.

**Table 13:** Measures linked with GRESB requirements

<b>GRESB requirement</b>	<b>Concept design</b>	<b>Detailed design</b>	<b>Construction and procurement</b>
<b>DMA1 Material selection requirement</b>	B01 Propose a life-cycle carbon or embodied carbon target for the project	-	-
<b>DMA2.1 Life cycle assessment</b>	B08 Develop alternative designs and carbon and cost evaluations	-	-
<b>DMA2.2 Embodied carbon disclosure</b>	-	C11 Deliver an embodied carbon optimizing specification for the project	D01 Demonstrate meeting embodied carbon targets with final quantities

## CASE STUDY: YIT

YIT is the largest Finnish urban development and construction company and a significant player in Northern Europe. The company's goal is to create more sustainable, functional and attractive cities and living environments. YIT develops and builds apartments, business premises and entire areas, and specializes in demanding infrastructure construction. It also jointly owns properties to support the implementation of major development projects and provides services that increase the value of properties.

Tampereen Tohtori is a housing project in Tampere, Finland. YIT built it for the OP-Vuokratuotto investment fund. It consists of 64 apartments on five floors. The construction of Tohtori uses wooden modules, which lowered its embodied carbon footprint and shortened the construction phase. According to the LCA calculations performed by YIT, the embodied carbon footprint was 15-20% lower compared to reference buildings with a concrete frame.

## CASE STUDY: Statsbygg's new construction carbon reduction targets

Statsbygg is the Norwegian government's building commissioner, property manager and developer, advising the government in construction and property affairs. Its work includes commissioning building projects serving public and government needs. Embodied carbon is an important part of the climate footprint of its value chain. As new building construction is central to the organization's activities, Statsbygg is committed to addressing the whole climate footprint of commissioning new buildings. This means starting from design phase decisions and continuing to the embodied carbon of construction materials and emissions from the machinery at the building site, to emissions from energy use in the building's use phase.

Statsbygg has the strategic goal to reduce the public civil sector's climate footprint, including by increasing the use of existing spaces. Its portfolio of construction projects reduces GHG emissions from energy, materials and the construction process by a minimum of 40% compared to standard practices and the regulatory levels in Norway. It achieves this through expert advice and assessment related to changing spatial demands, design selection and site choices.

### Statsbygg key performance indicators (KPIs) include:

- GHG reductions per project and for the portfolio [%]
- Climate footprint per project and per built area [kg CO<sub>2</sub>e/m<sup>2</sup>/year].

Its environmental management system includes procedures and templates explaining how to include targets addressing the climate footprint and embodied carbon of its construction projects. Statsbygg's environmental advisors use One Click LCA and Carbon Designer to analyze the potential mitigation measures in every construction project as a basis for setting a target for the project. Once established, the target will become a mandatory part of the contract with planners and developers. Statsbygg also ensures that developers report on the achievement of the carbon target.

## ⑥ Using the guidance with different contract and delivery models



# ⑥ Using the guidance with different contract and delivery models

## 6.1 Impact of project delivery model on issuing requirements

Project delivery models affect when and to whom companies issue project owner requirements, as shown in Figure 7. Express a project's carbon requirements in a form appropriate for the delivery model: for example, for integrated project delivery models, targets are generally high level.

## 6.2 Summary of different project contract and delivery models

Different project contract and delivery models have a fundamental impact on the following key parameters,

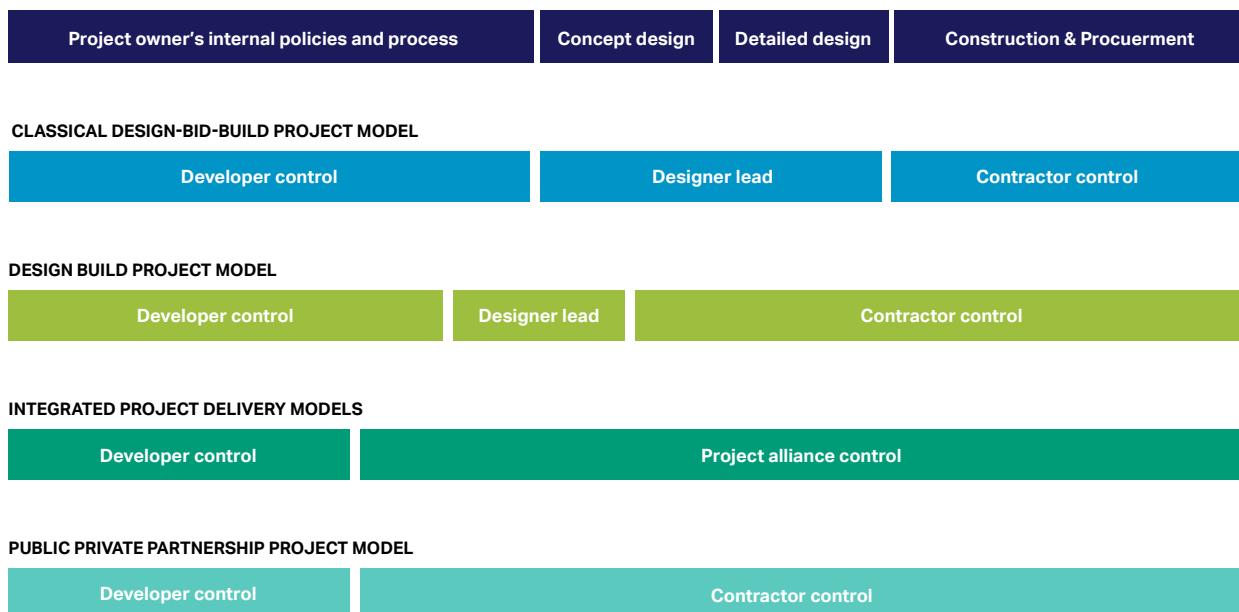
which in turn affect how companies make decisions impacting the project's carbon emissions. These are:

- Level of design prior to contract (level of design which is the basis of the contract)
- Responsibility for the design (liability for design accuracy and compliance)
- Subcontracting decisions (the right to make sourcing and subcontracting decisions).

To set and effectively implement decarbonization requirements, it is necessary to integrate and express them in a manner matching the applied project delivery model. Table 12 summarizes how different project contract and delivery models differ on these parameters.

We explain the most common contract and delivery models and their practical differences in the following section. Other contracting models exist; however, they are typically less prevalent.

Figure 7: Project model and control exercised across project phases

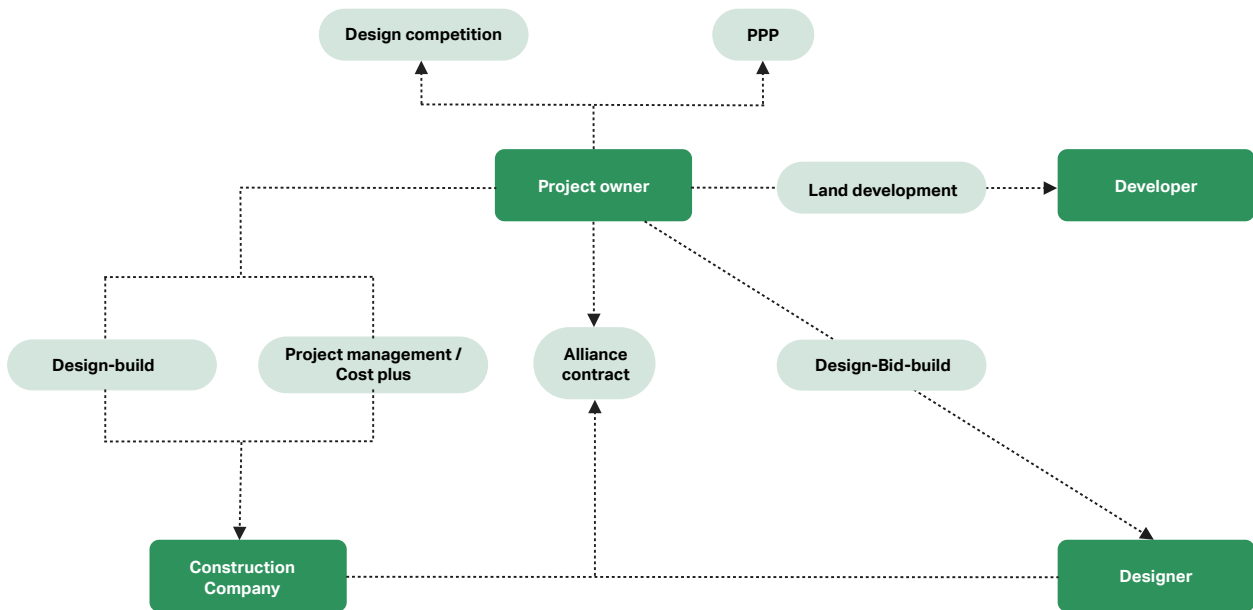




**Table 14:** How project contract and delivery models differ

<b>Contract and delivery model</b>	<b>Level of design prior contract</b>	<b>Responsibility for the design</b>	<b>Subcontracting decisions</b>
<b>Design-bid-build</b>	Typically, detailed design	Project owner	Contractor
<b>Project management contracts</b>	From conceptual to detailed	Project owner, in general	Project owner
<b>Design-build</b>	Conceptual design	Contractor	Contractor
<b>Public-private partnership</b>	Conceptual design; or less	Contractor	Contractor
<b>Alliance contract</b>	Depending on the project	Joint responsibility	Joint responsibility

**Figure 8:** Visualization of typical project contract and delivery models



### 6.3 Traditional contract and delivery models

In traditional models, the project owner exercises a highly detailed level of control. At the same time, the traditional models fail to make use of the expertise of the construction company, which could otherwise help improve the constructability or maintainability of the asset, for example:

#### Design-bid-build (traditional project delivery model)

In a design-bid-build project, the project owner contracts the design work directly from designers, usually as separate contracts including building and landscape architecture and structural, mechanical and electrical engineering, and asks for tenders from construction companies with finished drawings. In this model, the contractor has no influence on the design. Typically, the project owner awards the schematic design contract before the final design and construction drawings as a separate contract. The schematic design contract, and requirements associated with it, have the most influence on the project's sustainability.

#### Project management/cost plus contract and delivery model

This contract model makes it possible to initiate a project without knowing all the project parameters.

The company can draft it as a maximum price contract, cost plus contract or project management contract, whereby the project owner pays sub-contracts separately. The project owner hires a contractor to drive the project forward according to the mutually agreed direction and constraints. Contractors are typically bound to seek project owner acceptance for major decisions. The project owner can apply this contractual model when uncertainty regarding a project is high. Decision-making power stays with the project owner from start to finish and the owner can influence the project throughout its duration.

### 6.4 Integrated contract and delivery models

In integrated project delivery models, the responsibilities are either more shared or provide the contractor with more freedom to make decisions.

#### Design-build (integrated design and build delivery model)

In a design-build project, the project owner contracts a single entity to deliver the design and construction. The integration allows the company to use the contractor's knowledge of constructability and costs as part of the design and thus influence it in the early phase of the project. While the contractor in this model optimizes the design for constructability, there is no inherent incentive to deliver life-cycle performance.

A separate schematic design contract, awarded prior to the design-build contract to prepare its parameters, could typically also precede this project model. Both the design-build contract and schematic design contract have a significant impact on the project's carbon footprint.

#### Public-private partnership (PPP, integrated design, construction and maintenance)

The public-private partnership or PPP model is a single contractual arrangement to procure the constructed asset's design, construction and maintenance. As the name suggests, public sector clients often use it. In a PPP model, a single set of contracts also governs the lifetime maintenance – and sometimes also operations – relating to an asset. Setting contract parameters can be demanding, as the project owner fixes the parameters contractually for the entire maintenance period of the asset. On the other hand, this is likely to lead to better life-cycle performance. A separate strategy definition contract, which defines the parameters and performance required from the PPP delivery in a manner suitable for a long-term agreement, can precede this project. Organizations in the UK refer to PPP agreements as private finance initiatives (PFI).

## Alliance contracting and delivery model

In alliance contracting, the project parties work as part of the same organization, where all parties share risks and benefits. The alliance contract is a single contractual arrangement for the entire project. The project owner sets the targets and defines sanctions (positive and negative) that direct the successful completion of the project. A design competition is typical for entry into the alliance contract. The project owner sets objectives and targets, which direct design competition participants. These also have the most impact on the project. An alliance project typically has two parts, with a preliminary project development phase that reduces associated uncertainty. Project owners mostly use alliance projects for large infrastructure or other complex projects.

## 6.5 Other early phase contracting mechanisms of relevance

The following contracting mechanisms are relevant tools for embodied carbon reductions and are for use when developing land or awarding contracts.

### Design competition

The project owner arranges a design competition to obtain competitive proposals to develop either a piece of land or property. Design competitions may or may not lead to the appointment of the design team for an actual construction design project. Such competitions can take numerous shapes and various forms of implementation, including a full design team competition or a competition involving a contractor as part of the team. The award criteria set by the project owner drives design competitions. The competitions can be either an open or invitation-based competitive approach to contracting the preliminary design for a project. They can include carbon-based weighing criteria.

## Land development agreements

A land development agreement is a contractual model where the project owner contracts a developer to undertake the development of land with the view of selling or leasing the resulting property. The land development agreement may involve rezoning the area to build a type of property that current zoning does not allow for. The developer often receives a portion of their fee in the form of a success incentive from a commercial outcome. The success criteria defined by the developer drives this type of contract. It can also include carbon-based targets for land development.





# ⑦ Embodied carbon emissions and how to reduce them





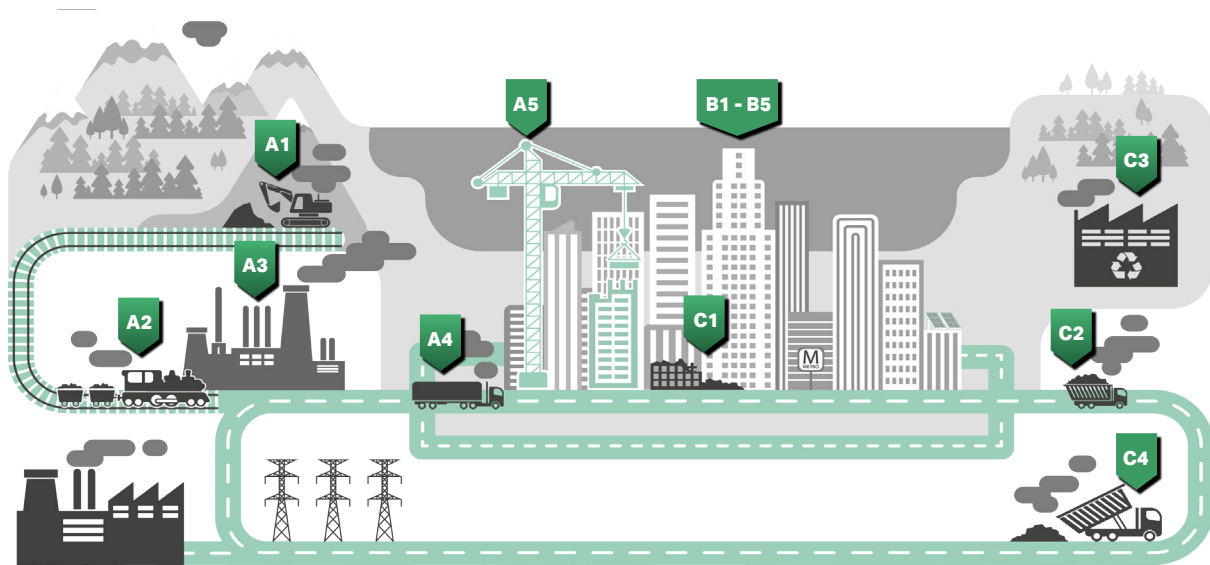
# 7 Embodied carbon emissions and how to reduce them

## 7.1 What are embodied carbon emissions?

Embodied carbon comes from the emissions from product, construction, use and end-of-life stage, as displayed in figure 9. The main sources of embodied carbon emissions are:

- Fossil fuels used for the manufacturing of building materials and process emissions in some of the manufacturing of certain materials (such as cement)
- GHG emissions from chemical reactions (process emissions) in the manufacturing process, for example in cement, aluminum and iron manufacturing
- Carbon emissions from the transport of and machinery required for the installation of materials
- Carbon emissions released during end-of-life handling of materials, including the incineration of plastic-based products or methane emissions from landfilling wood-based products
- Carbon emissions released from the degradation of forestry and release of soil carbon, at times reported separately as land-use and land-use change emissions
- Direct GHG emissions from leakages of refrigerants.

**Figure 9:** Embodied carbon arises from flows of materials to and from buildings over their lifetime



### A1 - A3 Product stage

- A1 Raw material extraction
- A2 Transport to manufacturing site
- A3 Manufacturing

### A4 - A5 Construction stage

- A4 Transport to construction site
- A5 Installation / Assembly

### B1 - B5 Use stage

- B1 Use
- B2 Maintenance
- B3 Repair
- B4 Replacement
- B5 Refurbishment

### C1 - C4 End of life stage

- C1 Deconstruction & demolition
- C2 Transport
- C3 Waste processing
- C4 Disposal

## 7.2 Material-efficient design and construction

Material efficiency is all about minimizing the use of materials and the effective management and usage of side-streams, waste and recycled materials. The goal is to design alternatives that can minimize the quantities of materials altogether over the lifetime of a building. Materials efficiency is the starting point for decarbonization.

Structural materials are often the most significant sources of embodied carbon emissions due to the large quantities and masses of materials used. Materials efficiency and waste reduction effectively minimize embodied carbon emissions and reduce the strain on raw materials. In addition, they hold no drawbacks even when looked at across the whole life cycle, as long as the durability and adaptability of different materials and structures is not compromised.

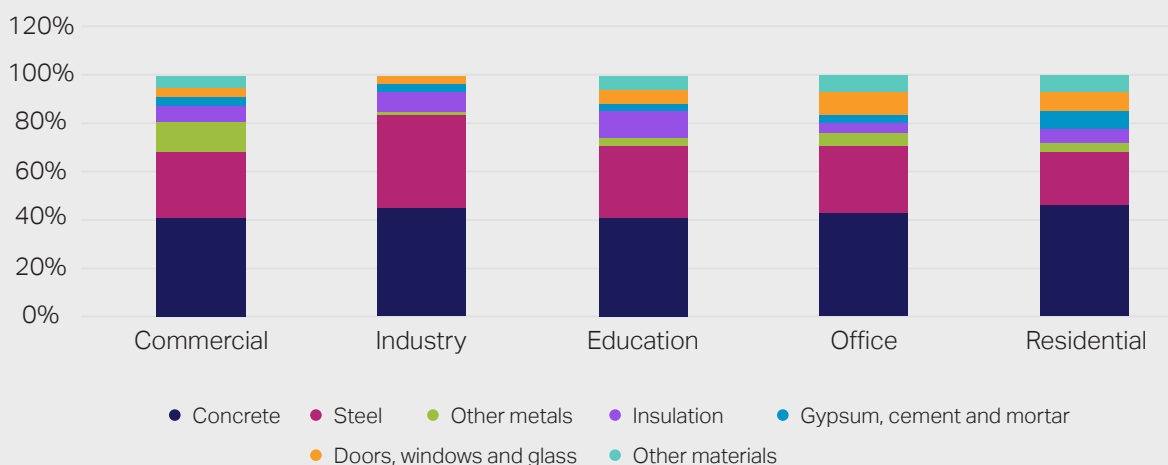
Materials efficiency can include using lightweight structures or secondary raw materials and products, minimizing material loss on the building site and improving the service life and thus durability of products used in buildings. Methodologies and tools, such as design option comparisons, can help identify where to improve materials efficiency. For example, structural designs are often over-engineered and dimensioned above the required level of performance. A focus on materials efficiency can help unlock significant embodied carbon and cost savings.

### DATA BOX 1: Embodied carbon emissions in European buildings

The four most important construction material categories for embodied carbon are cement, steel, aluminum and plastics. Fuels used in earth-moving and other construction equipment, transporting materials and building services also have significant impacts. To analyze the typical embodied carbon at a building level across different building types, we extracted a sample of approximately 1,000 European buildings from the Carbon Heroes Benchmark Program, cleaning this dataset to remove outliers and extreme values and reviewing it to increase the quality of the results.

The following figures show the embodied carbon results by building type. Steel and concrete were the only two material categories to always feature as the most important contributors for all building types. Among the remaining material categories, insulation, other metals (including aluminum), doors, windows and glass products, and gypsum, cement and mortar also stood out in importance.

Figure 10: Embodied carbon breakdown by material for key building types<sup>17</sup>



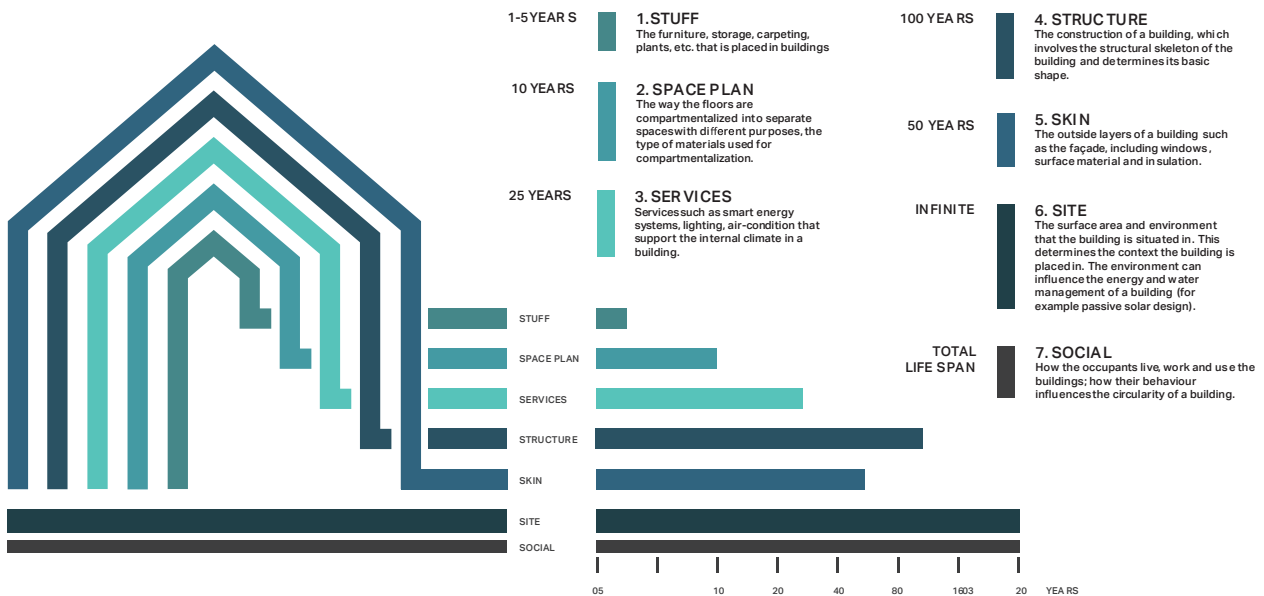
### 7.3 Short-and long-lived materials

The shorter a material's lifespan, the more often it is necessary to replace it during a building's lifetime. Using materials with a longer service life reduces the embodied carbon emissions in the building's use phase. Durable materials may also be more desirable to reuse at the end of the building's life. The assessment of durability always takes place in the context of the building's specific requirements, for example, the weather conditions, footfall, and other parameters. In life-cycle assessments, national guidance documents such as the [Royal Institute of Chartered Surveyors \(RICS\) professional standards and guidance](#)<sup>18</sup> in the UK often give the building product service life.

When it is necessary to replace a product, there is potential impact far beyond the new product's manufacturing, transportation, and construction emissions. If a building's design does not include disassembly and maintenance, the replacement of one part can lead to the need to unnecessarily rip out other components and replace them. For example, pipes cast in concrete will require the replacing of the concrete layer when replacing the pipes. And if such repairs are more extensive, they could prevent continued occupancy during the renovation, thus requiring users to lease a temporary building.

Architects Frank Duffy and Stewart Brand have introduced a way of conceptualizing the different service lives of building components. They describe buildings as being composed of several layers, as shown in Figure 11. Each layer in the picture represents a different part of the building and has a different lifetime. Some layers will contribute to emissions over the whole life cycle of the building, others mostly upfront. For example, the structure layer mainly contributes to upfront carbon. In contrast, the services layer contributes to the operating embodied carbon and influences operational carbon from the energy use of systems.

Figure 11: Building model consisting of the building related layers based on the sharing layers



Source: Scaling the Circular Built Environment: pathways for business and government, WBCSD (2018).

The contribution of the stuff and space plan layers to upfront carbon is relatively low. Still, it increases with refurbishments often needed when a new tenant starts occupancy, which usually requires redesigning the space plan. Refurbishment emissions are particularly high in commercial buildings where the renovation cycle closely follows the leasehold cycle. When companies use longer-lasting materials and adaptable design practices (such as to allow moving the internal walls), it is possible to reduce these emissions.

#### **7.4 Embodied carbon from transport, site, refrigerants and end of life**

It is also possible to reduce embodied carbon by prioritizing the use of local products, where possible, and managing transportation via low emission alternatives (such as transport by barge as opposed to truck). This matters the most for products used in large quantities.

The construction phase matters as well, both from energy use and materials efficiency points of view. Construction site machinery uses energy and companies can lease some machines with electrical engines. Construction process management has a significant impact on the amount of construction product waste. The more materials become waste, the higher the overall use of materials and the embodied carbon. Using prefabrication is one way to reduce both waste and energy use in assembly.

Heat pumps, chillers and some other mechanical systems require refrigerant fluids for their operation. Many refrigerants have an extremely high global warming potential and some inevitably leak into the atmosphere. Estimates suggest typical leakage rates at around 5% of the installed refrigerant volume, which varies by equipment and maintenance quality.

The European Union and other jurisdictions have banned some of the most harmful refrigerants. At a global scale, however, all types of refrigerants remain in use. Ensuring the use of low-impact refrigerants in projects should be a priority for all projects using refrigerant-based systems.

The end of life of a project also impacts embodied carbon. Products that are easy to disassemble and reuse have a lower carbon footprint at the end of life. Materials that are directly reusable without further processes have the lowest impact on end-of-life emissions, followed by materials recycled or used for energy recovery.



# Annexes



# Annex A: Project owner's internal policies and processes

## A01: Create embodied carbon-related requirements for all projects

The project owner should develop embodied carbon requirements for all projects. The recommended minimum scope of the requirements would cover at least the following aspects, with requirements referring to locally applicable standards:

- Explanation of how the project owner will embed the requirements into contracts awarded.
- Guidance for prioritizing refurbishments that preserve and reuse existing structures and materials from buildings.
- Embodied carbon targets for different types of buildings the project owner is commissioning for building.
- Use of embodied carbon information to direct design to prioritize design options and ensure that it is possible to choose the design with the lowest embodied carbon.
- Guidance for prioritizing construction materials choices and environmental impact limits for them (if applicable).
- Any mandatory requirements that have a direct linkage to embodied carbon, such as material bans for projects.
- Any project size or investment size minimums that would avoid applying requirements for projects e.g., below EUR €1 million.
- Embodied carbon reporting requirement for all projects.

**Example:** Selected examples of comprehensive embodied carbon policies in the public domain and in English language include those from [British Land's sustainability brief for developments](#) and the [Landsec sustainability brief](#).

## A02: Provide a financial incentive for improving final embodied carbon

The project's carbon footprint is final (barring rework within the warranty period and unplanned events in the life cycle of an asset) when the contractor has finished the project. Therefore, the project owner should set this requirement for the general contractor. There are two prerequisites for using this mechanism. 1. The project owner sets a project-specific target in the design phase based on the final design, which it uses to request contract bids and to consider the materials specifications that the project imposes (if any). 2. A third party must calculate or verify the final project carbon footprint. It may also be advisable to have the same third party calculate the design phase carbon target, although it is not necessary. The project owner should decide if the target is based on life-cycle carbon (also comprising operational carbon) or only embodied carbon. The mechanism remains the same in both cases. In this context, the project owner should also set the range of acceptable variation from the performance for the incentive.

**Example:** The mechanism could work as follows (the City of Helsinki, Finland has used this specific mechanism on construction works tenders). The project owner determines the lump sum value of the incentive, which could be, for instance, up to 0.5% of the value of the project for smaller projects, or less for larger projects, while remaining big enough to drive changes. The project owner sets the design phase carbon target to which it compares the final third-party verified carbon results. If the results are within +/-10% of the target, nothing happens. If the results are more than 10% below the target, the project owner pays out the incentive to the contractor. If the results are over 10% above the target, the project owner withholds the payment of the incentive to the contractor.

### **A03: Apply carbon pricing to optimize a project's overall carbon and cost**

Carbon pricing is an effective mechanism to steer design and specification decisions for the project. This requires the project owner to set the price that it is prepared to pay to avoid one metric ton of carbon-equivalent emissions. It does not change the optimal decisions when the lowest carbon option is also the one with the lowest cost (as often is the case) but supports achieving carbon reductions also when this is not the case. The project owner then instructs designers to compare the costs of options so that it can add the carbon costs to the direct financial costs of each option. One tested implementation would be to use internal carbon pricing, so the company's internal carbon fund receives the carbon cost of every project for use to finance energy retrofits or to fund related costs. In the absence of internal pricing, the project owner must be ready to choose options that cost more in financial terms.

**Example:** A design or specification improvement would cost an additional EUR € 45,000. The change would reduce project embodied carbon by 900 metric tons. This is economically advantageous for a carbon price of EUR € 50 per metric ton.

### **A04: Make embodied and life-cycle carbon part of project funding reviews**

Most project owner organizations have periodic funding reviews for their project portfolios. Funding reviews can happen in specific stages or with a specific frequency. Including the embodied and life-cycle carbon of a project in the funding review alongside performance measured against internal or external benchmarks helps to improve senior management awareness of project impacts. It can also be critical to winning support for additional funding requests for projects to improve carbon performance, as projects' carbon literacy and benchmark performance gain better understanding.

### **A05: Estimate cost difference for delivering each project at net zero carbon**

Eventually, all projects need to be net zero carbon, excluding carbon offsetting. At the current time, most projects as implemented do not meet this definition. However, many projects would have the potential for implementation at a net zero carbon performance level. Estimating the cost difference and delivering a project at net zero carbon involves identifying projects where net zero carbon is commercially achievable. This helps to raise the bar for all projects as even going part of the way towards net zero helps projects reduce their carbon footprint and increase their green credentials. Similarly, systematic cost benchmarking for projects creates an understanding of how to optimize the cost of carbon reductions in projects.

### **A06: Prioritize design teams with materials efficiency and carbon experience**

Most project owners have specific requirements for design teams, often based on experience. Achieving materials efficiency and carbon savings on a project is far more likely to happen if project owners state in their briefs that they seek such experience and consider this factor in their design project award decisions. Skills to seek in structural engineering should include materials usage and choice optimization for projects of similar complexity. For architects, it should include materials choice and specification optimization from a life-cycle carbon reduction perspective. Requiring each designer to outline the projects where they achieved significant materials and carbon savings makes choosing the right partner easier.

**Guidance:** Retaining designers with experience in materials efficiency can create significant project capital expenditure savings.



### **A07: Appoint a project sustainability advisor with a focus on carbon**

For consistency in project carbon assessment across all life-cycle stages and all disciplines, project owners may choose to appoint a specialized sustainability advisor focusing on carbon. The sustainability advisor's role would be to ensure all carbon assessments across all project phases and options are comparable and consistent and fit for their purpose (e.g., to make decisions between several design options or to provide the final project carbon results). The sustainability advisor is also impartial in terms of the designers and the contractor and could help to challenge some decisions. If combining this responsibility with one of the existing disciplines working on the project, appoint a designer who continues with the project until completion.

### **A08: Use a green building rating system for embodied carbon reductions**

External third-party evaluation, in the form of a certification scheme, is mainstream practice for commercial buildings. Most green building rating systems do not require specific embodied carbon reductions, with the exception of Sweden Green Building Council's [NollCO<sub>2</sub>](#) and [Norway's FutureBuilt ZERO](#). Some rating systems incorporate embodied carbon transparency and offsetting requirements, such as the International Living Future Institute's (ILFI) [Zero Carbon Certification](#) and Canada Green Building Council's [Zero Carbon Building Standard](#), or credits for embodied carbon or life-cycle assessment analyses or reductions, including LEED, BREEAM, Green Star, DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen, the German Sustainable Building Council's rating system) and HQE (Haute Qualité Environnementale, a French green building certification) to name a few.

Project owners should choose the specific credits or objectives that their chosen green building rating systems support. If such credits are available, project owners should require achieving the said credits to their maximum embodied carbon potential for all projects. Incorporating embodied carbon credits in a green building rating system can support initial steps in embodied carbon reduction.

**Guidance:** Section 8.2 of this report explains embodied carbon-related credits in LEED and BREEAM certifications.

### **A09: Report embodied carbon alongside other carbon emissions annually**

Most project owners already report their direct carbon emissions (so-called Scope 1 and 2 emissions) annually or quarterly. However, for reporting relevance, embodied carbon for any real estate organization that also constructs new buildings is a significant part of the total emissions (so-called Scope 3 emissions). Companies should calculate and report embodied carbon emissions from all projects that complete during the period either as Capital goods (category 2) or Investments (category 15); and for companies that construct or purchase construction materials themselves as Purchased goods and services (category 1).

**Guidance:** Section 8 of this report provides examples of how to integrate embodied carbon in GHG Protocol, GRI and GRESB reporting.



## A10: Set a mandatory embodied carbon target for all projects

Project owners whose projects are mainly in locations with public carbon benchmark values generally use these to set their project targets. If the local carbon benchmarks are tiered, we recommend choosing a requirement tier aligning with investor ambition. Otherwise, for single-tier benchmarks, project owners can set their reduction requirements as a percentage reduction from the benchmark value (e.g., 20% below the national benchmark). Since conditions and requirements between different sites can vary strongly, project owners can recalibrate the carbon benchmark in the concept design phase to a project-specific carbon target. The project-specific carbon target can be either stricter or more lenient depending on factors such as site foundation conditions.

**Guidance:** See B03 for references to published benchmark values.

**Example:** Unibail-Rodamco-Westfield (URW), a developer operating in Europe and the United States, systematized life-cycle assessment from 2017 using its own methodology and guidelines and has trained its development teams to apply them. The company first introduced the methodology to its US operations in 2019. By the end of that year, 53% of development projects had conducted a life-cycle assessment in the concept design or the feasibility phase. This comprehensive approach to assessing projects throughout their entire life cycle (construction and operation) supports URW's policy of reducing the carbon footprint of the group's projects. It helps make the best construction, technical and energy choices through a multi-criteria approach (capital expenditures, costs, carbon emissions in construction and operation, aesthetics and sustainability).

## A11: Evaluate the possibility of refurbishing existing buildings

The project owner should always include relevant brownfield sites when surveying land lease or purchase options.

For each shortlisted brownfield site, the project owner should report on the following to be able to consider a site's suitability for adoption:

- If the project owner has not cleared the site, is there a building to demolish or to refurbish?
- Existing building condition, structural materials, energy performance and applied design standards for the building.
- Level of information available on potentially hazardous substances present in the building.
- Initial estimation of the potential to refurbish the building to the needs and purposes of the project owner.
- Identified zoning restrictions that could limit refurbishment potential.
- List of identified potential issues that could hinder or prevent a refurbishment project for the building.

However, deconstructing an existing building can be the most carbon-efficient solution if it can increase urban density. To inform such decisions, we encourage the project owner to use a whole-life carbon assessment to consider the options and include the impacts of transport and site choices in the scope of the study.

## A12: Commission a pre-demolition audit for any asset requiring deconstruction

If the site to develop has an existing building that requires part or full deconstruction, the project owner should commission a pre-demolition audit to survey the extent of possible materials reuse or to repurpose materials in future projects. The pre-demolition audit should identify salvageable products, their quantities and key properties. For example, a pre-demolition audit might identify a range of products for reuse in the new project, in addition to being able to reuse existing ground floor slab, as well as being able to salvage some materials for other projects. The audit helps recover the deconstructed materials as separate material streams, which will reduce waste handling costs in jurisdictions with landfill taxes.

**Guidance:** We recommend using pre-defined pre-demolition audit guidelines to ensure the value of the results. The EU's [Waste Audit Guidelines](#) align with EU regulations; and Nordic countries also have their own national guidelines. Products recovered within the European Union/European Economic Area (EEA) may need to comply with CE (European compliance) marking requirements, which could incur additional costs and delays. If recovering the materials from the same site as the new project, it is unlikely that the CE requirements will be necessary.

## A13: Evaluate buildability and accessibility prior to securing land

The project owner should consider buildability and accessibility when surveying land lease or purchase options. We recommend reporting the following items for each shortlisted site option:

- The site's geotechnical condition and its associated uncertainty. The report shall state the geotechnical condition of the general area, the site-specific geotechnical condition to the extent that it is known, and if the site is on offer in a pre-constructed condition. Attach analyses, if any.
- Mass transit access to the site and associated options. The report shall identify the nearest practically accessible mass transit access points (of all locally available forms), with their actual walking distances on a map and in table form.
- List the number of options that the building users on the site would likely use on a recurring basis.
- If it is possible to improve the access conditions by modifications to access roads or footpaths, identify these.
- In addition, for locations that have a bike road or bike lane network, highlight access to them.

**Guidance:** These emissions are often not typically in the scope of the building's carbon footprint. However, for most building types, the transport impacts of end-users over the asset's lifetime tend to dominate the total climate impact of a site choice. Furthermore, choosing a construction site with unstable soil requiring heavy stabilization, which companies typically do using carbon-intensive cement and slaked lime, can double the embodied carbon of a building.

#### **A14: Commission a detailed geotechnical survey for the site prior to design**

Geotechnical surveys leave uncertainty. The higher the uncertainty, the higher the likelihood the structural designer will over-dimension the materials. To avoid using materials wastefully and causing avoidable extra costs, the project owner should increase the resolution of the geotechnical surveys commissioned, including requiring drilling more test holes than normal. In addition to reducing materials use in piling and foundations, this can support placing the building mass in the most optimal way on the site. This policy has a solid return on investment and cost savings, especially for sites where the bedrock is under a deeper layer of soil.

#### **A15: Evaluate zoning carbon impacts and consider rezoning if necessary**

The project owner should identify the carbon-impacting zoning requirements for shortlisted options. Here, we understand zoning as any legally binding instrument, irrespective of whether it is determined by zoning, city regulation or other levels of regulation. Identify any ongoing zoning revision processes. If the applicable requirements for a potential future revision are available, a survey should detail both current and potential scenario results.

- Report on the parking requirements imposed by zoning and parking density waivers available, if any.
- Report on building massing, shape and placement restrictions applicable, and possibilities for changes, if any.
- Report on any structural and façade materials choices imposed by the zoning.
- Report on any additional construction requirements (storage areas, balconies, common areas, air raid shelters, etc.)

**Example:** Some cities, including Vancouver, Canada, and Stockholm, Sweden, require rezoning applications to demonstrate carbon footprint reductions. While such policies may not be present in other cities, it can support making a case for rezoning.

# Annex B: Brief and conceptual design phase requirements

When a project owner has not provided otherwise, use the carbon accounting standards and scopes in **Annex F**: Recommended project carbon accounting standards for all requirements in this section.

## **B01: Propose a life-cycle carbon or embodied carbon target for the project**

The design team shall seek the project owner's decision on which carbon reduction options to use in the project and refine the retained design further to create a proposal for the project's life cycle or embodied carbon target, as chosen by the project owner. The team shall document the scope and method of carbon assessment used to set the target and any key assumptions and associated uncertainties, for example, concerning materials demand or suppliers.

- Report on the parking requirements imposed by zoning and parking density waivers available, if any.
- Report on building massing, shape and placement restrictions applicable, and possibilities for changes, if any.
- Report on any structural and façade materials choices imposed by the zoning.
- Report on any additional construction requirements (storage areas, balconies, common areas, air raid shelters, etc.).

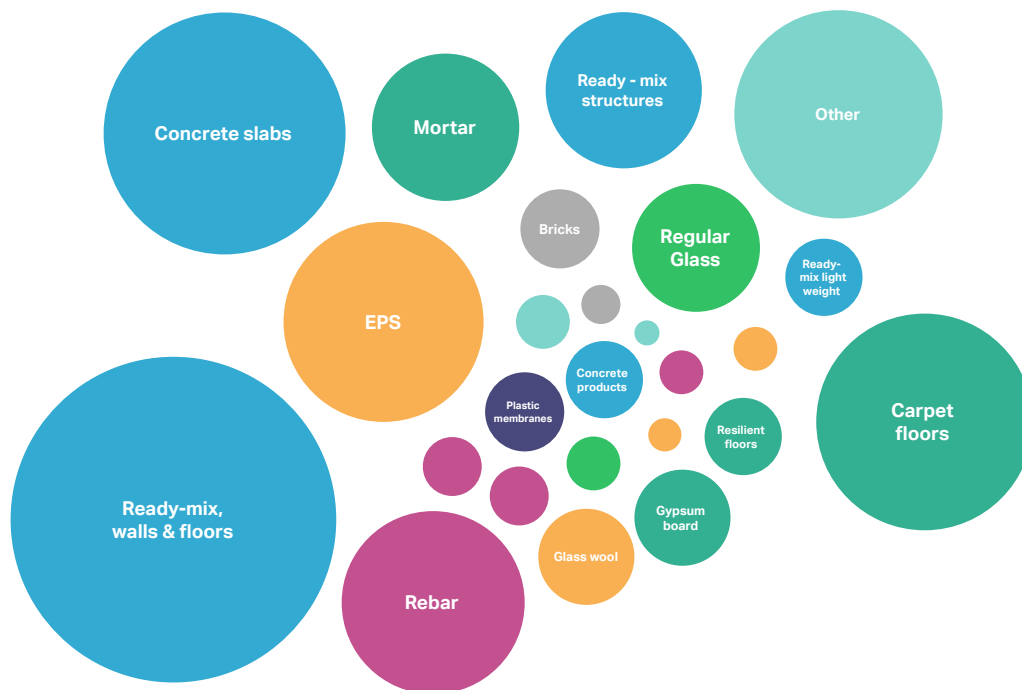
**Deliverable:** Proposal for a carbon target for the project, including a definition of scope, method and associated uncertainties. Use the Buildings System Carbon Framework to perform this assessment.

**Example 1:** Statsbygg, the Norwegian government's real estate organization, is setting a project carbon target for all projects in the concept design phase. Statsbygg evaluates the impacts based on the specific site and building parameters using an early phase carbon design tool that encompasses embodied carbon, operational carbon and carbon from end user transport. The portfolio-level reduction must be 40% but individual projects may retain higher or lower reduction targets.

**Example 2:** Landsec, a UK real estate investor, has set embodied carbon targets as part of its Science-Based Targets initiative's (SBTi) approved targets. Landsec has both absolute and relative embodied carbon targets. It measures embodied carbon using the RICS Whole Life Carbon guidance. The absolute caps are 900 kg CO<sub>2</sub>e/m<sup>2</sup> of gross internal area (GIA) for commercial buildings and 500 kg CO<sub>2</sub>e/m<sup>2</sup> for retail for the scopes A1-A5. Landsec requires a further 15% reduction from the embodied carbon baseline design quantified in RIBA stage three; the contractor is to beat this target.



**Figure 12:** Embodied carbon hotspots of a project shown as bubble chart (diameter = life-cycle impact)  
 Source: One Click LCA



### B03: Benchmark building design options for embodied carbon

The design team should identify a relevant embodied carbon benchmark for the project, measure building design option(s) against it and provide the comparison to the project owner. In the absence of a local benchmark, the design team should preferably use data from their past projects or the most relevant national or international benchmark instead.

**Annex E:** Project embodied carbon limit values references various embodied carbon benchmarks and limit values. If the project owner has not set requirements to the contrary, use the benchmarking parameters in **Annex F:** Recommended project carbon accounting standards.

**Example:** British Land, a UK real estate developer, requires the performing of whole-life carbon assessments in RIBA Stage 3, creating a table of design options quantified for carbon footprint, including details of technical solutions. It decides on targets and specifications for the project based on the analyzed options. These targets and specifications are binding for contractors.

#### **B04: Optimize the reuse of existing facilities (onsite and offsite)**

The project team should survey existing facilities on the site and consider the cost and carbon footprint of refurbishment compared to reconstruction, if previous findings support this option. The project team should make a reuse and refurbishment proposal showing where it is possible to preserve parts of existing facilities and integrate them into the overall project, and how they would achieve this. The project team should also investigate the feasibility of using relevant, nearby offsite facilities, such as gyms, restaurants and other services, instead of replicating these functions onsite.

**Deliverable:** Reuse survey and reuse plan for existing and nearby services.

#### **B05: Optimize building adaptability during its lifetime**

The project team should survey existing facilities on the site and consider the cost and carbon footprint of refurbishment compared to reconstruction, if previous findings support this option. The project team should make a reuse and refurbishment proposal showing where it is possible to preserve parts of existing facilities and integrate them into the overall project, and how they would achieve this. The project team should also investigate the feasibility of using relevant, nearby offsite facilities, such as gyms, restaurants and other services, instead of replicating these functions onsite.

- Potential to replace major building systems without affecting other systems, including replacing façades, floors, etc.
- Potential to redistribute the internal areas within the building without affecting load-bearing structures.
- Accessibility and maintainability of building services and systems.
- Current and demographic-based future need for this building type and potential other types in the area.
- Potential to convert the building to another building type, including technical and functional requirements, including acoustics, fire safety, load bearing, seismic safety, ventilation, daylighting and other requirements.
- Modifications and constraints to enable future conversion of the, considering cost and material use impacts of enabling the conversion.

**Deliverable:** Proposed optimized building adaptability plan, including its implementation in the design to the extent approved.

#### **B06: Require design for deconstruction for structural and key elements**

Where possible, the design team and structural designer should design the building's structure and structural connections such that it is possible to deconstruct it using the least destructive commercially available means suitable for the structural material used. It should be possible to disassemble and deconstruct the building structure without destroying the used structural elements. It must be possible to deconstruct the materials for potential reuse or as clean recycling. The team should define connection types to fit the needs of the project.

**Deliverable:** Plan for structural connections design and disassembly, identifying mandated design connection types.

## **B07: Require design for deconstruction for structural and key elements**

The design team should investigate the availability and applicability of structural material options with a low carbon footprint for the project and identify applicable options that have the potential to significantly reduce the structure's embodied carbon. If the project owner targets do not set a different level of ambition, the embodied carbon reduction objective should be 40%. The evaluation should cover only options that meet relevant building regulations and may cover wood- or bamboo-based structures, low-carbon concrete, and low-carbon steel structures, as well as hybrids and other structural alternatives. Where the marketplace cannot deliver the targeted level of reduction, the design team should identify the best available reduction options. The design team should make a recommendation on which material to use.

**Deliverable:** Recommendation on which low-carbon structural material to use with a summary of suitable material options.

## **B08: Develop alternative designs and carbon and cost evaluations**

The design team should jointly develop alternative designs seeking to optimize the whole building. It should evaluate retained alternative designs for carbon footprint and capital costs and, where operating costs differ, for operating costs as well. The purpose of the evaluations is to provide directionally accurate feedback to support decisions about which design option to pursue.

**Deliverable:** Summary of design alternatives with the recommended option, including a carbon and cost impact evaluation for each.

## **B09: Optimize building form for site topography and properties**

The design team should optimize the building form for the site properties, within any zoning constraints, considering:

### **Input from all design disciplines involved in the project, optimizing the elements below:**

- Potential to place the building masses above the parts of the site with best constructability, using geotechnical data
- Potential to place the building masses aligned with the site's natural topography, considering slopes and dips, excavation, rock blasting and removal, avoiding stabilization and preserving existing trees (where applicable)
- Avoid low-quality excavations; avoid or, if not possible, minimize construction below the water table level
- Potential to adapt the building form to site-specific daylight, wind, snow and rainfall patterns
- Potential to adapt the number of openings in the façade to optimize daylight and energy performance

### **Optimizing the building shape and ensuring a form factor that avoids unnecessary elements.**

**Deliverable:** Proposed optimized building form and summary explaining how it has optimized the building form for the parameters above.

## **B10: Design adaptable/reversible parking with optimized capacity**

The design team shall optimize parking capacity and solutions within zoning constraints, considering the following:

- Current and estimated future need for property-specific parking capacity, considering the development of mass transit options and trends in private car usage in the project location, and availability of nearby and street parking
- Where zoning imposes a minimum parking capacity higher than the required capacity, potential for exemptions
- Possibility to build and later convert/reverse stranded parking capacity to other uses when some of it becomes obsolete
- Most cost- and carbon-efficient ways to deliver the required parking capacity

**Deliverable:** Optimized parking capacity and solution plan including exemptions sought and their basis and reconversion plans.

**Guidance:** The ability to reconvert parking spaces or, even better, to build fewer spaces would save needless and significant capital outlay both for the project owner and the eventual users of the building.

## **B11: Ensure space efficiency and right sizing**

The design team shall develop and optimize the building program for the owner's needs, designing enough but not more, considering:

- Current and potential future needs and changes in considered parameters
- Number of users by user group, their occupancy patterns and any telecommuting scenarios (where applicable)
- Space-use efficiency using the relevant best in class benchmarking metric (for building types where relevant)
- Potential additional useful functions for delivery with the asset

**Deliverable:** Building program separated by functions, with key space-use patterns and space-use efficiency metrics.

## **B12: Investigate ways to reduce non-essential systems or materials**

The design team shall investigate opportunities to reduce the need for additional systems that do not perform a necessary function. Examples include using shading, building orientation or thermal mass to reduce cooling system sizing or avoiding installing acoustic tiles in areas that do not require them, using untreated surfaces where possible, or purely aesthetic materials.

**Deliverable:** Proposal to reduce non-essential systems and materials.



### **B13: Incorporate climate resilience measures into the building design**

The project team shall identify the climate risks that could lead to building parts being damaged or the building failing to perform according to its requirements due to changing and extreme climate conditions. The risks to consider shall include the relevant ones among the following: flooding, landslides, hurricanes or tsunamis, tornadoes, drought and wildfires, sea-level rise and storm surges, winter storms, and extreme temperature, rainfall and storm intensity changes. The project team shall list the identified risk factors and associated forecasts, where available.

The design team shall investigate opportunities to reduce the need for additional systems that do not perform a necessary function. Examples include using shading, building orientation or thermal mass to reduce cooling system sizing or avoiding installing acoustic tiles in areas that do not require them, using untreated surfaces where possible, or purely aesthetic materials.

**Risk data sources:** Several governments publish risk scenarios. For the United States, these include the Federal Emergency Management Agency ([FEMA](#)), Pacific Northwest Seismic Network ([PNSN](#)), National Oceanic and Atmospheric Administration ([NOAA](#)) and U.S. Geological Survey ([USGS](#)). For Europe, scenarios are available from the [European Commission](#) and [PreventionWeb](#), and national governments.

### **B14: Require landscaping to consider carbon removal opportunities**

The design team shall avoid unnecessary construction on the site to allow for green areas to remain and shall use the trees and other vegetation in the unbuilt areas of the site to remove carbon from the atmosphere. Project owners should only take this measure as a separate carbon targeting measure when the site has a more substantial plot to design. We do not recommend it for dense city center developments.

The design team shall investigate opportunities to reduce the need for additional systems that do not perform a necessary function. Examples include using shading, building orientation or thermal mass to reduce cooling system sizing or avoiding installing acoustic tiles in areas that do not require them, using untreated surfaces where possible, or purely aesthetic materials.

**Deliverables:** Optimized landscaping design.

### **B15: Investigate the use of carbon-negative, -absorbing or -storing materials**

Identify any carbon negative, carbon-absorbing or biogenic carbon-storing materials or materials manufactured using carbon that other processes would otherwise release into the atmosphere. Timber and other plant-based materials store biogenic carbon whether recycled, reclaimed or virgin. Their carbon storage potential is highest where they have end-of-life uses beyond incineration. The designer shall review them for suitability, cost and feasibility and make recommendations for their use.

**Deliverable:** Recommendation on carbon-negative, -absorbing or -storing materials.

**Note:** In EN 15804 and ISO 21930 standards, products storing biogenic carbon can account for biogenic carbon storage (from the biosphere) as a removal in the raw materials phase but generally tend to release the stored biogenic carbon in the end-of-life phase, which in most contexts is incineration. Therefore, prioritize reusing and repurposing products where possible.

### **B16: Investigate the applicability of circular procurement models**

For locations where they are available, investigate and identify relevant systems that project owners could procure using a lease or other circular procurement model that enables either direct reuse or assigning a commercial value to materials when replacing them in the building. Such systems could include, for example, carpets, building services, lighting systems and others, as well as directly movable partition wall systems and other adaptable elements or other easy-to-disassemble systems.

**Deliverable:** Recommendation on systems and materials for which the project owner should use a circular procurement model

# Annex C: Detailed design-phase requirements

Unless the project owner has provided otherwise, use the carbon accounting standards and scopes in **Annex F: Recommended project carbon accounting standards for all requirements in this section.**

## **C01: Demonstrate meeting embodied carbon targets with updated quantities**

Applying the final retained design and final quantities of materials, the project team shall calculate the embodied carbon for the project and compare the result to the conceptual design phase embodied carbon target that was set (if one was set). The project team can use supplier-specific material profiles only for materials for which it has explicitly selected the supplier or otherwise contracted through a framework agreement or similar undertaking. For other materials, they shall use generic values. The project team shall compare actual performance with the screening-level carbon assessment and carbon target and explain deviations. If the carbon target remains unmet, the project team must provide an explanation.

**Deliverable:** Detailed design phase embodied carbon assessment report.

## **C02: Require materials efficiency report**

The design team shall collect materials efficiency figures from all relevant design fields and deliver a detailed quantity report for the following materials categories (in metric tons or in thousands of pounds):

<b>Ready-mix concrete</b>	Bricks	Reinforcement steel, excluding
<b>Precast concrete elements</b>	Glass	amounts used in precast elements
<b>Cement</b>	Insulation materials (all types)	Structural and other steel
<b>Mortars, plasters and screeds (all types)</b>	Gypsum and plasterboards	Wood-based structural materials
<b>Quicklime (used in soil stabilization)</b>	Aluminum	Asphalt

**Deliverable:** Materials efficiency report.

### **C03: Design materials installation practices to allow for their future reuse**

The project team shall design structural and non-structural materials installation practices to allow for their future reuse and disassembly. Where possible, they shall avoid non-reversible connections, nails and irrevocable chemical bonds between products and materials. Where possible, they shall not embed products in other materials. This does not prevent the use of prefabricated products or systems comprising multiple materials using such connections, as long as it is possible to disassemble those products or systems from the building in a non-destructive manner. These practices do not apply to any water- or vapor-proofing solutions, surface treatment materials, fixtures and fittings, or any building services. The project team shall incorporate these practices into design documents. This does not apply to elements within the substructure and foundations.

**Deliverable:** Installation and design for disassembly guidance incorporated into design documents.

### **C04: Require materials efficiency optimization**

The design team shall use materials efficiency data and designs from all relevant design fields and seek materials efficiency improvements in the overall project. This can take into account structural design optimization, architectural solutions and materials replacements, as well as increasing the level of prefabrication, reducing the number of elements used, and materials-optimized structures.

**Deliverable:** Report on materials efficiency optimization recommendations.

### **C05: Factor embodied carbon and cost in detailed design options**

The design team shall evaluate detailed design options and propose options that would support embodied carbon reductions in the overall project. It shall evaluate each option based on embodied carbon and cost, and any other advantages or disadvantages. The design team shall make a recommendation on the final design option to retain for the project.

**Deliverable:** Detailed report on design options for embodied carbon and cost.

### **C06: Appoint a reviewer for the building's structural material efficiency**

Structural material efficiency can save significantly in material costs; the most effective way to reduce embodied carbon is to use fewer materials. To ensure the design is not over-engineered, where beneficial, the owner shall commission a peer review by a structural engineer with at least the same level of qualifications as the most experienced structural engineer in the design team. The reviewing structural engineer shall give recommendations on design optimization and a statement on the materials efficiency of the design. Subject to the approval of the project owner, the design team shall implement the recommendations on the design.

**Examples:** On the West Coast of the United States organizations adopt mandated structural peer review processes in highly seismic zones with performance-based seismic regulations. The cities of San Francisco, Los Angeles and Seattle, for example, have adopted these types of policies. Examples of using more than one half more structural material than required are common; the [City Policy Framework for Dramatically Reducing Embodied Carbon](#) (p.65) catalogues such examples.

### **C07: Require mechanical design optimization for life-cycle carbon reductions**

The design team shall review and optimize the overall mechanical design-influenced whole-life carbon of the building. We recommend applying this requirement to buildings with cooling systems. This shall encompass refrigerant leakages (during installation, lifetime and end of life of the equipment), operational energy use and embodied carbon of major mechanical systems. The design team shall carefully optimize the specification of systems and refrigerants to avoid refrigerants with very high global warming potential (GWP).

**Deliverable:** Mechanical, electrical and plumbing (MEP) design with recommended and non-recommended refrigerants.

**Guidance:** A detailed explanation of the impact of optimizing mechanical systems from a carbon point of view is available in the following standard: [Chartered Institution of Building Services Engineers \(CIBSE\) TM65: Embodied carbon in building services](#). Recommendations about refrigerants, as well as EU-level prohibited refrigerants, are available in the [EU fluorinated greenhouse gases regulation](#).

### **C08: Evaluate alternatives for the top ten products highest in carbon**

The design team shall review the commercially available and appropriately located suppliers for the ten products or product groups causing the highest total embodied carbon at the project level. Procurement planning shall identify commercially achievable low-carbon product carbon intensities for the relevant product groups. Where possible, the design team shall recommend carbon performance levels to use in sourcing that are feasible for several relevant suppliers for each material and preferably documented by ISO 14025, EN 15804 or ISO 21930-compliant third-party verified EPDs, which are within their period of validity. For material groups that lack such options, we do not have any recommended limits.

**Deliverable:** Recommended carbon performance levels for product categories to use in sourcing.

### **C09: Plan, design and specify low-carbon concrete solutions**

For most projects, concrete is the single biggest source of upfront carbon. Ensuring that the concrete used has a low-carbon footprint requires consideration and planning in the design phase. The structural designer shall make a plan for the overall use of concrete, the required performance and use for each group of elements and, where using cast-in-place concrete, also consider project scheduling and a critical path for loading elements to allow for the optimization of the concrete strength evaluation time to for different applications. The designer shall draft a performance-based concrete specification that sets a requirement for the upfront carbon level required (comprising cradle-to-gate impacts as well as transport, installation, and wastage on the construction site) considering the local market supply of the purchased concrete for the different applications.

**Deliverable:** Specification and plan that sets out optimized concrete specification and requirements for this project.

**Guidance:** Examples of national low-carbon concrete standards are available in Norway and at a local level in Marin County in the US. In the absence of a local standard, reviewing local supplier capabilities to deliver low-carbon concrete can help set the appropriate level of carbon performance. If local suppliers do not have EPDs, we recommend focusing on the clinker substitution rate. Do this by mandating the use of alternative binders and optimizing strength evaluation time to allow the alternative binders to develop to their full strength.



## C10: Ensure communication between structural engineers and material suppliers

The structural engineers shall ensure sufficient communication between them and either the appointed structural material suppliers or leading suppliers for the material type to ensure the designs and plans regarding materials efficiency opportunities, design for disassembly solutions, and availability and applicability of low-carbon solutions for the project.

**Deliverable:** Report validating the commercial availability of the proposed design for disassembly and low-carbon solutions.

## C11: Deliver an embodied carbon optimizing specification for the project

The design team shall incorporate embodied carbon-driven requirements in the project specifications by specifying low-carbon alternatives to replace carbon-intensive materials and setting carbon limits and EPD requirements. The design team shall incorporate into the specification either the requirements or the characteristics that correspond to the low-carbon product supply on the market.

For markets that do not have EPDs, it is also possible to apply requirements for the recycled content share and manufacturing energy mix, particularly for product categories where the recycled feedstock and final manufacturing energy matter for total product impacts. Specifiers should not include requirements that would limit the use of local products for any product category where transport carbon impacts have a significant role. Specifiers shall also incorporate the relevant elements from the Annex E: High global warming potential (GWP) products and materials to avoid or reduce into their specification.

**Deliverable:** Specification that considers and advances low-carbon product and material choices for the project.

### Limitations on products with high global warming potential (GWP).

Some materials have very high embodied carbon and notably sometimes limited or no disclosure of their environmental impact via environmental product declarations (EPD), making accounting for their impact in projects can be difficult. In fact, some materials are already limited or even banned in some jurisdictions.

We encourage project owners to set and review the limited materials list and apply restrictions to prevent the use of environmentally harmful materials in their projects. For project owners working across jurisdictions, a consistent approach to limiting their use is essential to effectively reduce embodied carbon.

Some examples (non-exhaustive list) of critical materials that should be reduced and possibly avoid include:

- Avoid wood from unsustainable forest. Ensure use of certified wood" (source EU [https://ec.europa.eu/environment/forests/timber\\_regulation.htm](https://ec.europa.eu/environment/forests/timber_regulation.htm)).
- To avoid the use and emissions of hydrofluorocarbons (HFCs), a variety of climate-friendly, energy-efficient, safe and proven alternatives are available. The alternatives include Natural refrigerants, HFCs with lower GWP, such as R32, Hydrofluoroolefins (HFOs), HFC-HFO blends. (source EU [https://ec.europa.eu/clima/policies/f-gas/alternatives\\_en](https://ec.europa.eu/clima/policies/f-gas/alternatives_en))

- Reduce use of heavy/dense materials (such as natural stone) transported over long distances (for example >3000km). Use preferably material sourced in the proximity and use low carbon transport".

Examples of material lists from companies:

[Landsec Prohibited Materials List](#) cover all of the limited materials mentioned above and many more.

[The CIBSE TM65: Embodied carbon in building services](#) standard provides a detailed explanation of the impact of refrigerants and their optimization.

# Annex D: Construction and procurement phase requirements

When the project owner has not provided otherwise, use the carbon accounting standards and scopes in **Annex F**: Recommended project carbon accounting standards for all requirements in this section.

## **D01: Demonstrate meeting embodied carbon targets with final quantities**

Using the final materials quantities and materials procurement choices, the contractor shall calculate the embodied carbon for the project and compare the result to the detailed design phase embodied carbon calculation and target (if one was set). The contractor shall prioritize suppliers with environmental product declarations (EPDs) for their materials and always use supplier-specific EPDs when calculating the embodied carbon when available. Otherwise, the contractor shall use generic values. The contractor must justify any deviations from the embodied carbon target.

**Deliverable:** As-built embodied carbon assessment report.

## **D02: Require independent third-party verification of carbon performance**

The contractor shall commission an independent and qualified third party to verify the as-built carbon performance of the project. They shall do the third-party verification when the contractor has completed all procurement is and knows the final quantities and suppliers. The verifier cannot have a conflict of interest with the third-party verification coming from either their position or their relationship with the contractor.

The verifier must have, at minimum, experience performing at least five comparable embodied carbon, life-cycle carbon or life-cycle assessments for projects of comparable or a higher degree of complexity. Additionally, the verifier must be familiar with the typical construction practices, materials and products for the project's location. The verifier must ensure that the assessment results are plausible, accurate, complete, and meet the assessment requirements.

The verifier must require the contractor to correct material deficiencies, omissions and errors. The verifier must present a verification statement that also shows the verification dialogue that highlights performed verifications and requested corrections and their status.

**Deliverable:** Third-party verification report.

**Guidance:** If the project location has an existing practice for comparable third-party verification, the contractor can use that practice instead. This includes a critical review of results, such as the one used for the Australian Green Star certification system LCA, or third-party verification of results, such as the one used for the BREEAM UK NC 2018.

### **D03: Require environmental product declarations (EPDs) for key products**

The contractor shall demonstrate the installation in the building of at least 20 products with EPDs: 10 from among the 15 highest embodied carbon products for the project and at least 10 others. The EPDs must conform to ISO 14025 and EN 15804 or ISO 21930. An ISO 14025 compliant EPD program operator must register or issue them and an independent third party must verify them. The EPD must be specific to a manufacturer and be valid at the time of specification for the material in question. Multi-manufacturer and internally verified EPDs are not acceptable.

**Deliverable:** List of EPDs for products installed in the project.

**Guidance:** This requirement aligns with several commercial rating systems, including LEED v4 Building product disclosure and optimization credit – environmental product declarations, BREEAM UK New Construction 2018 Mat 02 Environmental impacts from construction products – EPDs, and BREEAM International New Construction Mat 01 credits, among others.

### **D04: Require deconstruction to remove unwanted existing elements**

For sites with existing assets to remove, once the assets are free from hazardous materials, it is necessary to dismantle them as far as possible and to channel the deconstructed materials to an organization trading in such materials if found within the region of the construction project.

**Deliverable:** Deconstruction and secondary materials recovery report issued by the party trading in the materials.

### **D05: Follow design for disassembly specifications**

The contractor shall follow the design for disassembly specifications for both structural and non-structural materials in the project's construction, where possible. The contractor shall use specified installation methods, allow the project owner to verify their use by inviting the project manager to review their use, and document used methods.

**Deliverable:** Design for disassembly documentation and guideline for the project, supported by photographic evidence.

### **D06: Minimize and recycle construction and demolition waste (CDW)**

The contractor shall ensure the reuse, recycling or incineration energy recovery of at least 90% of the construction and demolition waste, by mass, including downcycling (e.g., using crushed concrete as backfill).

**Deliverable:** Construction and demolition waste report for the site issued by the party managing waste handling for the site.

### **D07: Ensure contractor proposes embodied carbon-related improvements**

The contractor shall analyze the project and propose embodied carbon-related improvements that are possible to achieve for the project, either without adapting specifications or design or with possible adaptations to the specifications and design. The contractor shall further outline the estimated embodied carbon and cost savings (or incurred additional cost, as the case may be) of such changes to the project owner. The contractor may implement embodied carbon savings aligned with specifications and design and that do not increase costs without separate approval. Other changes require project owner approval. The changes may include a change of supply, specification, installation method, design features and other parameters.

**Deliverable:** List of embodied carbon savings identified by the contractor.

### **D08: Ensure contractor uses products that comply with restrictions set**

The contractor shall not buy, use or install any products, or let any of their subcontractors use or install any products, that are on the list of prohibited or limited products as set either for the project or by the project owner. For every product category having prohibited or limited products, the contractor must either declare that they did not use products of that type or that the products meet the requirements set and provide evidence to show this to be true. If the project owner has not set their own list of materials with such limitations, apply the list from Annex E: High global warming potential (GWP) products and materials to avoid or reduce.

**Deliverable:** List products with prohibitions or limits and the products used in each category with proof of their compliance.

### **D09: Ensure contractor buys and installs materials meeting set carbon limits**

The contractor shall buy and install, and document having bought and installed, materials and products meeting any carbon performance levels, whether set for the specific project or by the project owner in general. The contractor shall use valid EPDs from the materials supplier to document that the limits have been set.

**Deliverable:** Materials takeback operator's report(s) listing the goods received.

### **D10: Require project to implement a materials takeback program**

The contractor shall implement a materials takeback program covering at least 90% (by mass) of unused and unspoiled construction materials. The contractor shall ensure the channeling of at least 90% (by mass) of all unused and unspoiled construction materials to the takeback program or programs the contractor has arranged to commercialize the unused materials. The takeback program operator must commercialize at least 90% of the materials received, as measured by mass.

**Deliverable:** List of products with carbon limits, suppliers and products used and their relevant EPDs.

### **D11: Require contractor to use near zero-emissions construction machinery**

The contractor shall use near zero-emissions construction machinery for at least 90% of the fixed (elevators, heaters) and mobile machines used for site operations. The eligible types include machinery running on biofuels – excluding first-generation biodiesel and bioethanol – or hydrogen and electrically powered machinery. The proportion of the machinery is based on their estimated fuel consumption. This does not apply to trucks delivering goods to and from the site. The contractor must use a certified renewable electricity supply for the project for all locations where the location-specific grid electricity carbon intensity is over 300 g CO<sub>2</sub>e/kWh for electricity.

**Deliverable:** List of construction machinery used on the site, with the specific power train and fuel used for each type.



# Annex E: Project embodied carbon limit values

## Sources of embodied carbon limit values

We encourage project owners to use their locally available limit values, where present:

- [Embodied Carbon Benchmarks for European Buildings](#) (Europe) is a compilation of approximately 4,000 real building life-cycle assessments in Europe grouped into three regions.
- [RIBA](#) (UK) provides an embodied carbon target for all building types using the RICS Whole Life Carbon methodology for the entire life cycle (A-C). The 2020 target is < 800 kg CO<sub>2</sub>e/m<sup>2</sup>, the 2025 target is <650 kg CO<sub>2</sub>e/m<sup>2</sup>, and the 2030 target is <500 kg CO<sub>2</sub>e/m<sup>2</sup>.
- [Carbon Leadership Embodied Carbon Benchmark Study](#) (US and international) provides a statistical analysis for five main building-use types. It may not align all underlying data.
- [Carbon Heroes Benchmark Program](#) (Europe and global) provides a statistical analysis of buildings screened for plausibility and derived using a consistent method. Country and building-type specific benchmarks are available for selected countries; broader regional benchmarks cover the whole world.
- Upcoming regulatory limits for [Finland](#), with preliminary values at 10-14 kg CO<sub>2</sub>e/ m<sup>2</sup> per year from 2025 depending on the building type (whole life-cycle scope, including energy, over 50 years).

- Upcoming proposed regulatory limits for [Denmark](#), initially 12 kg CO<sub>2</sub>e/m<sup>2</sup> per year from 2023 and decreasing every two years (whole life-cycle scope, including energy, over 50 years).
- Upcoming regulatory limits for [France](#), drafted at between 12.8 and 14.8 kg CO<sub>2</sub>e/m<sup>2</sup> per year and decreasing every three years (whole life-cycle scope, including energy, over 50 years).
- Other limit values including those in the Netherlands (MPG), Austria (OI3) and Switzerland (SIA).

The carbon limit values above are set for different criteria and scopes and use different assessment methods, which may diverge from the figures provided in this section.

When no national or otherwise relevant limit values are available, we encourage project owners to set their own requirements; or they can use the embodied carbon limit values provided in this annex as the basis for their projects.

We intend for these embodied carbon limits to provide a continuous improvement path for businesses that can start with self-set targets and progress as they develop their expertise in embodied carbon management. We explain the methodology used to create the benchmarks below.

### Suggested embodied carbon base limits for use in the absence of national benchmarks

The suggested application method for the limit values provided in this report is the following:

1. Choose the embodied carbon base limit for the building type and targeted level.
2. Apply the relevant top-up factors as applicable for the actual scope and local conditions.

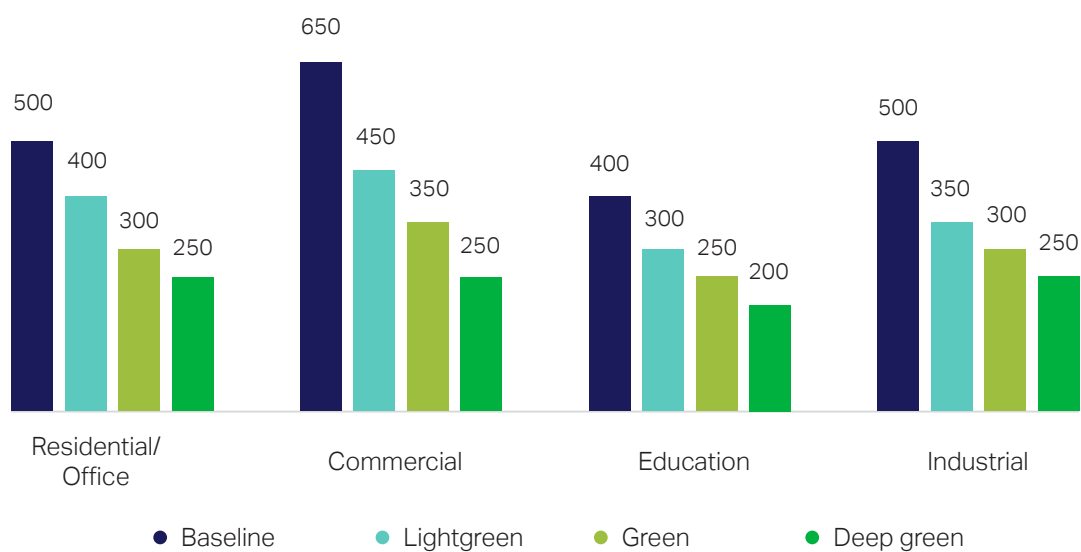
These embodied carbon base limit values represent the building structure and enclosure for A1-A3 life-cycle phases in normal conditions. Obtain a project-specific limit by adding relevant top-up factors, adjusting for disadvantageous conditions or an extended assessment scope or system boundary to the base limit. We only provide the limit values below for the A1-A3 scope to avoid inconsistency arising from different assessment period, service life or life-cycle scenario assumptions in different contexts (see the top-up factors for these later).

Table 15 below provides the embodied carbon base limits for building structures and enclosures, and space-dividing elements, including internal walls and foundations and A1-A3 phases only, kg CO<sub>2</sub>e/ m<sup>2</sup> (gross internal floor area, as defined by International Property Measurement Standards (IPMS/RICS)). The assessment excludes finishes, external areas and external parking structures (see top-up factors later). The assessment does not consider additional uncertainty factors in data, meaning statistical or arbitrary top-up values incorporated into LCA data, which are prevalent in government-issued generic data values in many jurisdictions.

**Table 15:** Embodied carbon base limit values for A1-A3

Embodied carbon base limit	Residential	Office	Commercial	Education	Industrial
Baseline (not suggested limit value)	500	500	650	400	500
Light green	400	400	450	300	350
Green	300	300	350	250	300
Deep green	250	250	250	200	250

**Figure 13:** Embodied carbon base limit values for A1-A3

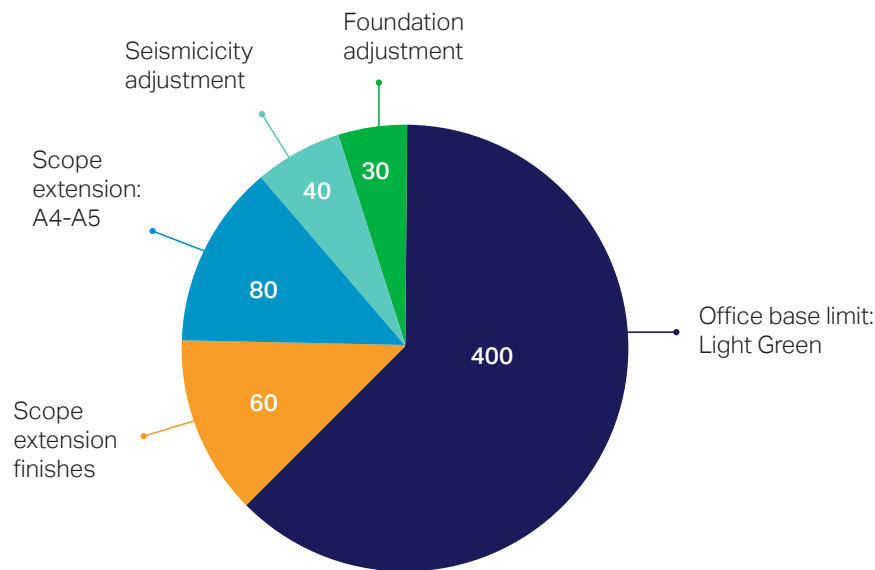


**Table 16:** Embodied carbon base limit top-up factors for specific scopes and local conditions

Embodied carbon top-up factors	Metric	Factor(s)
Scope of assessment extended to cover finishes	-	Industrial: +5% Residential: +10% Other types +15%
Scope of assessment extended to cover transport and construction site activities (full A4-A5 phases)	-	Residential, education and industrial: +50 kg CO <sub>2</sub> e/m <sup>2</sup> Other types: +80 kg CO <sub>2</sub> e/m <sup>2</sup>
Building located in a somewhat seismic location with prescriptive seismic regulations	Peak ground acceleration <= 0,15 (engineering metric for seismicity)	Industrial and residential: +10% Other building types: +15%
Building located in a highly seismic location with prescriptive seismic regulations	Peak ground acceleration > 0,15 (engineering metric for seismicity)	Industrial and residential: +20% Other building types: +30%
Building located on a site requiring piling foundation	Depth of piling <= 10 meters	+30 kg CO <sub>2</sub> e/m <sup>2</sup>
Building located on a site requiring piling foundation	Depth of piling >10 meters	+70 kg CO <sub>2</sub> e/m <sup>2</sup>

Figure 14 visualizes how to build a specific limit value from the base limit and the top-up factors by applying the specific top-up factors to adjust the limit value. The example office building would end up having a target limit value of 610 kg CO<sub>2</sub>e/m<sup>2</sup> if adjusting the original base limit of 400 kg CO<sub>2</sub>e/m<sup>2</sup> to include finishes and life-cycle stages A4-A5 and if its location is a somewhat seismic area requiring piling foundations.

**Figure 14:** Example of embodied carbon base limit top-up factors for specific scopes and local conditions



## The creation of these embodied carbon limit values and top-up factors

We created these embodied carbon limit values based on a sample of 1,000 reviewed assessments from the Carbon Heroes Benchmark Program. The dataset used to create the benchmark consists of European buildings and we weighted it against the countries working to achieve sustainable construction, including the UK, Nordic countries and Western Europe. These limits may not be appropriate in significantly different contexts and users should consider this when using these limit values outside of the regions mentioned.

We screened the sample for any outliers. We further analyzed the sample mechanically for plausibility and completeness using materials category-specific data to review whether a project contained all types of construction material found on every project in plausible quantities.

We calculated the dataset in two different ways:

- Baseline results, which include only impacts of A1-A3 phases without finishes and flooring
- Extended results, including impacts of finishes and flooring, which provide the first top-up factor.

We ran a full set of descriptive statistics to determine each typology's average, median, terciles and quintiles. The dataset, as expected, shows that the sample is not normally distributed. We set the values at increments of 50 kg CO<sub>2</sub>e/m<sup>2</sup> to reflect their inherent imprecision using the following method:

- Baseline values set based on the 80th percentile of all buildings in the sample. This reflects a relatively typical embodied carbon performance level, just under the top fifth highest embodied carbon emissions for each building type.
- Light green limits set based on the mean value of all the buildings in the sample. This reflects a good embodied carbon performance level, as the sample includes predominantly sustainability-oriented buildings, including numerous wood buildings.
- Green limits set as the average of light green and deep green values to provide a consistent progression. The values themselves are relatively close to a statistical median of the sample.
- Deep green limits set based on the first tercile of all the buildings in the sample. This reflects the lowest third of buildings in each type from an overall sample of sustainability-oriented buildings.

We estimated the top-up factors associated with seismicity using One Click LCA's Carbon Designer tool, which produces a typical bill of materials based on various criteria, one of which is the ability to choose between peak ground acceleration scenarios. To ensure the applicability of peak ground acceleration values for European projects, we used the European Commission Joint Research Centre's [Review of the Seismic Hazard Zonation in National Building Codes in the Context of Eurocode 8](#) (Solomos G, Pinto Vieira A, Dimova S., 2008). In this report, the authors present peak ground acceleration values for multiple European countries, which they then transferred and averaged to obtain a scale, yielding a distribution for peak ground acceleration in Europe between 0.1 and 0.29.

We created the top-up factors associated with piling foundations using One Click LCA's Carbon Designer, which evaluates options for different foundation types. We selected steel piling (without soil stabilization) as a typical, non-extreme piling scenario. In reality, both seismic and foundation conditions vary significantly between different sites and a continuum of different embodied carbon targets would reflect the appropriate performance levels more precisely. However, we have chosen the scenarios above for clarity.

# Annex F: Recommended project carbon accounting standards

We encourage project owners to use national standards for project carbon accounting when available and when aligned with EN 15804/ISO 21930.

## Recommended carbon accounting standards

We recommend that projects in any location without local standards use EN 15978:2011 Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method. This standard aligns with ISO 21930 and is the most widely accepted life-cycle assessment standard globally.

## Building System Carbon Framework

We encourage projects to use the WBCSD [Building System Carbon Framework](#) to understand and assess their carbon emissions across the life cycle and structure of buildings. This enables the identification of embodied carbon and whole-life carbon emissions hotspots.

## Recommended compatible national standards

- UK: Whole-life carbon assessment for the built environment, RICS (November 2017).
- Norway: NS 3720:2018 Metode for klimagassberegninger for bygninger.

- Finland: Ministry of Environment, Finland (latest).
- Sweden: Boverket's Klimatdeklaration (latest).
- France: Méthode pour la Réglementation environnementale 2020 (RE2020).
- Netherlands: Bepalingsmethode (NMD3.0, latest).
- Or any other national ISO 21930/EN 15804-aligned standardized methodologies.

## Recommended carbon accounting standard parameters

If the applicable national standard, green building rating system or project owner has not set requirements to the contrary, use the following parameters:

- Assessment scope shall cover the building structure, enclosure and finishes, including foundations and parking structures, excluding building services. Exclude only materials whose mass is below 1% of the total mass, up to a maximum of 5% of the total mass.
- The minimum required life-cycle modules are A1-A3 construction materials, B4-B5 replacement of materials and C1-C4 end of life. The calculation shall not include impacts beyond the life cycle (D).

- For assessments that also cover operational energy differences, include module B6 energy use in the scope. However, do not use this for embodied carbon limits.
- The assessment period shall be set to 60 years.
- Report the calculation per building area, using the nationally applicable standard usable area definition, on the same basis for all options. In the absence of a national standard, use the gross internal floor area, as defined by International Property Measurement Standards (IPMS/RICS).
- Further details of the assessment shall follow the applicable national standard(s), where present, requirements of applicable green building rating systems (if used), and otherwise the ISO 21930 and EN 15978 standards.



# Endnotes

- <sup>1</sup> Global Alliance for Buildings and Construction, International Energy Agency and the United Nations Environment Programme (2019). 2019 Global Status Report for Buildings and Construction. Available online at: <https://www.worldgbc.org/sites/default/files/2019%20Global%20Status%20Report%20for%20Buildings%20and%20Construction.pdf> (accessed on 14 May 2021).
- <sup>2</sup> World Green Building Council (2019). Bringing Embodied Carbon Upfront. Available online at: <https://www.worldgbc.org/news-media/bringing-embodied-carbon-upfront> (accessed on 14 May 2021).
- <sup>3</sup> Global Alliance for Buildings and Construction, International Energy Agency and the United Nations Environment Programme (2020). 2020 Global Status Report for Buildings and Construction. Available online at: [Buildings-GSR-2020\\_ES\\_ENGLISH.pdf](https://www.worldgbc.org/sites/default/files/2020%20Global%20Status%20Report%20for%20Buildings%20and%20Construction.pdf) ([globalabc.org](https://www.globalabc.org))
- <sup>4</sup> EU Technical Expert Group on Sustainable Finance (2020). Taxonomy: Final report of the Technical Expert Group on Sustainable Finance. Available online at: [https://ec.europa.eu/info/sites/default/files/business\\_economy\\_euro/banking\\_and\\_finance/documents/200309-sustainable-finance-teg-final-report-taxonomy\\_en.pdf](https://ec.europa.eu/info/sites/default/files/business_economy_euro/banking_and_finance/documents/200309-sustainable-finance-teg-final-report-taxonomy_en.pdf) (accessed on 14 May 2021).
- <sup>5</sup> Regulation (EU) 2019/2088 of the European Parliament and of the Council of 27 November 2019 on sustainability-related disclosures in the financial services sector (Text with EEA relevance). EU Sustainable Finance Disclosure Regulation. Original document available online at: <https://eur-lex.europa.eu/eli/reg/2019/2088/oj>. GRESB article available online at: <https://gresb.com/eu-regulatory-environment-changes-sfdr-eu-taxonomy/>
- <sup>6</sup> Task Force on Climate-Related Financial Disclosures (2017). Recommendations of the Task Force on Climate-related Financial Disclosures. Available online at: <https://assets.bbhub.io/company/sites/60/2020/10/FINAL-2017-TCFD-Report-11052018.pdf> (accessed on 14 May 2021).
- <sup>7</sup> World Business Council for Sustainable Development (2020). Construction and Building Materials share TCFD implementation experience. Available online at: <https://www.wbcsd.org/Programs/Redefining-Value/External-Disclosure/TCFD/Resources/Construction-and-Building-Materials-share-TCFD-implementation-experience>
- <sup>8</sup> One Click LCA Ltd (2018). The Embodied Carbon Review. Available online at [www.embodiedcarbonreview.com](http://www.embodiedcarbonreview.com)
- <sup>9</sup> Global Real Estate Sustainability Benchmark (2020). 2020 Real Estate Reference Guide. Available online at [https://documents.gresb.com/generated\\_files/real\\_estate/2020/real\\_estate/reference\\_guide/complete.html](https://documents.gresb.com/generated_files/real_estate/2020/real_estate/reference_guide/complete.html)
- <sup>10</sup> World Building Council for Sustainable Development (2020). The Building System Carbon Framework: A common language for the building and construction value chain. Available online at: <https://www.wbcsd.org/building-system-carbon-framework> (accessed on 14 May 2021).
- <sup>11</sup> World Green Building Council (2018). The Net Zero Carbon Buildings Commitment. Available online at <https://www.worldgbc.org/thecommitment>
- <sup>12</sup> The Economist Intelligence Unit (2015). The cost of inaction: Recognising the Value at Risk from Climate Change. Available online at: <https://www.eldis.org/document/A73317> (accessed on 14 May 2021).
- <sup>13</sup> Carbon Neutral Cities Alliance, One Click LCA Ltd, Architecture 2030. City policy framework for dramatically reducing Embodied Carbon. Available online at: <https://www.embodiedcarbonpolicies.com/>
- <sup>14</sup> C40 Cities Climate Leadership Group, C40 Knowledge Hub (2020). Why cities need to address the construction sector's hidden emissions. Available online at: [https://www.c40knowledgehub.org/s/article/Why-cities-need-to-address-the-construction-sectors-hidden-emissions?language=en\\_US](https://www.c40knowledgehub.org/s/article/Why-cities-need-to-address-the-construction-sectors-hidden-emissions?language=en_US)
- <sup>15</sup> Greenhouse Gas Protocol, World Resource Institute, World Business Council for Sustainable Development (2011). Corporate Value Chain (Scope 3) Accounting and Reporting Standard. Available online at: [https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporting-Standard\\_041613\\_2.pdf](https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporting-Standard_041613_2.pdf)
- <sup>16</sup> UK Green Buildings Council, Advancing Net Zero (2019). Guide to Scope 3 Reporting in Commercial Real Estate. Available online at: <https://www.ukgbc.org/wp-content/uploads/2019/07/Scope-3-guide-for-commercial-real-estate.pdf>
- <sup>17</sup> One Click LCA Ltd. Carbon Heroes Benchmark. Available online at: <https://www.oneclicklca.com/construction/carbonheroes/>
- <sup>18</sup> RICS professional standards and guidance, (2017). UK Whole life carbon assessment for the built environment. Available online at: <https://www.rics.org/globalassets/rics-website/media/news/whole-life-carbon-assessment-for-the-built-environment-november-2017.pdf>

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Together, we are the leading voice of business for sustainability: united by our vision of a world where more than 9 billion people are all living well and within planetary boundaries, by 2050.

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