



Embodied Carbon Guidance

**A Resource for Calculating and
Reducing Embodied Carbon**

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INTERNATIONAL
LIVING FUTURE
INSTITUTESM

living-future.org/zero-carbon-certification
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EMBODIED CARBON GUIDANCE

INTRODUCTION

The International Living Future Institute (ILFI) has prepared the following guidance on embodied carbon that is intended to support projects that are pursuing either the Living Building Challenge (LBC 4.0) Energy Petal or Zero Carbon (ZC) certification programs. The guidance provided in this document is focused specifically on meeting the embodied carbon performance targets, and does not address energy efficiency or renewable energy requirements.

If a requirement or guidance has a Living Building Challenge logo next to it, said section only applies to a project pursuing either the Living Building Challenge or the Energy Petal through Petal Certification.



If a requirement or guidance has a Zero Carbon logo next to it, said section only applies to a project pursuing Zero Carbon certification.



Otherwise, all requirements and guidance apply to both the Living Building Challenge and Zero Carbon Certification.

INTENT

Promote the design of high performance, climate-positive buildings that account for their total carbon impacts by reducing and offsetting both operational and embodied carbon.

REQUIREMENTS

EMBODIED CARBON REDUCTIONS

All projects must demonstrate a reduction of the embodied carbon of the primary materials (foundation, structure, enclosure) within the project scope, compared to a project-specific baseline scenario with equivalent building size, function and energy performance. Teams should identify and quantify reductions from intentional actions that were taken during design and construction to lower the project's total embodied carbon.

LBC/ENERGY PETAL LIVING BUILDING CHALLENGE™

New and Existing buildings must demonstrate a **twenty percent** reduction in the embodied carbon of primary materials compared to an equivalent baseline. Existing buildings may count in-situ materials against the required twenty percent.

All projects must select interior materials with lower than industry baseline embodied carbon emissions for product categories for which data is readily available.



New and Existing buildings must demonstrate a **ten percent** reduction in the embodied carbon of primary materials compared to an equivalent baseline. Existing buildings may count in-situ materials against the required ten percent.

The embodied carbon associated with the construction and materials installed in the project must not exceed 500kg CO₂e/m².

CARBON OFFSETS

For all projects, approved carbon offsets must be procured to cover the embodied carbon emissions related to any new materials utilized in the project. Projects that are calculated to have a net carbon-neutral or carbon-sequestering value from their materials are not required to procure additional carbon offsets.

GENERAL CLARIFICATIONS

EMBODIED CARBON

Applicable Building Materials

For the purposes of assessing embodied carbon, project teams should include all permanently installed materials that represent the majority of material quantities and costs associated with the project. All temporary materials, building systems, interior furnishings, equipment, site work and small or miscellaneous products are optional to include in the assessment. An example scope of material list is shown in Table 1; project teams should identify an equivalent list of materials that is applicable to their project.

Baselines and Reductions - Buildings

Embodied carbon baselines should include the carbon emissions associated with the impacts of raw material extraction, manufacturing, transportation, and installation (life cycle stages A1-A5) for materials used in the project. This baseline is used to show individual reduction strategies implemented as compared to the initial design.

Material quantity reduction baselines must reflect:

- A building design that is identical to the initial design except for the claimed reduction measures
- The same project scope and function; a building of equivalent area, use type(s) and energy performance
- Materials and design parameters based on common industry practice for the building scale and region, and comply with all of the same applicable land use and building codes as the initial design

Project teams may utilize material type and quantity assumptions from either recently built project examples or a modeled baseline building with comparable properties to support these assumptions.

Table 1. Applicable Building Materials

PRIMARY MATERIAL ASSEMBLIES	Foundation	Footings Retaining Walls
	Structure	Framing Reinforcement Slabs + Decking
	Enclosure	Cladding Fenestration Insulation Roofing
INTERIOR MATERIAL ASSEMBLIES	Finishes	Ceilings Floors Walls + Partitions
	Partitions	Fenestration Framing Insulation
ADDITIONAL ASSEMBLIES (OPTIONAL TO INCLUDE)	Interior Furnishings	Equipment Fixtures Furniture
	Building Systems	Electrical Mechanical Plumbing + Fire Protection
	Site Work	Excavation Exterior Paving Shoring + Formwork

Baselines and Reductions - Products

When project teams claim an embodied carbon reduction via a product alternative or selection of interior materials with a lesser impact, teams must establish a product baseline. Product baselines may be determined by one of the following:

- ILFI-approved tools that establish product category baselines

- A review of comparable products in the same material category that reflect common industry practice for the building type and region. Team is to submit a proposal to the Dialogue for approval including methodology, data sources and assumptions

Building or Material Reuse

The reuse of buildings is the most effective means to reduce the overall embodied carbon of a project. Therefore, project teams that reuse an existing building may count any in-situ primary materials against the required reduction percentage. Similarly, the use of salvaged or reused materials may contribute to meeting the reduction requirement for primary materials; this reduction can be quantified by removing the embodied carbon impacts of the materials that would have otherwise been sourced, while adding additional impacts associated with any refurbishment or processing required for reclaimed materials.

Carbon Sequestering Products

Projects may claim a benefit from substituting a carbon sequestering product for one that is carbon producing (e.g. wood vs. steel). Also, the specification of approved third-party certified sustainable harvesting strategies may be claimed as an additional product-specific embodied carbon reduction. The carbon sequestering benefits of a qualified product must be described and calculated separately from the embodied carbon of the material itself, even if it is not clearly distinguished in the Environmental Product Declaration (EPD).

At this time, the Institute recognizes Forest Stewardship Council (FSC) certification as an approved sustainable harvesting standard with scientifically verified carbon-sequestering benefits for wood products beyond the sequestration of standard harvesting practices. Alternative certification programs or verification standards for carbon-sequestering materials must be submitted to the Dialogue for review and approval prior to use.

Embodied Carbon Data

Product-specific embodied carbon data should be sourced from Environmental Product Declarations (EPDs) provided by qualified program operators on behalf of product manufacturers or industry organizations. All EPDs referenced in calculations should meet the protocols for scope, preparation and verification as outlined in ISO Standard 14025. All EPDs referenced should be as current as possible, and at a minimum must not be expired. EPD databases that ILFI has identified are as follows:

- mindful MATERIALS
- International EPD System
- Sustainable Minds
- UL SPOT

Project teams should strive to utilize EPDs that are product-specific whenever possible. When only industry average EPDs are available, teams should request or advocate for product-specific data directly from manufacturers.

Industry Averages

Project teams may either select products with embodied carbon values that individually fall below the industry average baseline for the product category, or select products that fall below that product category baseline through a weighted average. Weighted average calculations may only include products of the same category.

Intentional Action

All claimed embodied carbon reductions must be associated with intentional actions taken by the project team during the design and construction phases of the project. Project teams should provide evidence of preparing comparative embodied carbon evaluations or carbon-based specifications for material or product alternatives to document this intention.

Interior Product Categories LIVING BUILDING CHALLENGE

Project teams must demonstrate the use of interior materials that have lower embodied carbon emissions than the industry baseline, where sufficient embodied carbon data is available for the product category to establish a baseline. Product baselines are currently specified in the ILFI-approved baseline tools for the following categories:

- Carpet
- Ceiling tile
- Gypsum wallboard

Reduction Types

Eligible embodied carbon reduction strategies are classified into one of three categories: a material quantity reduction, a material alternative, or a product alternative. Example strategies to reduce embodied carbon within these categories may include, but are not limited to those listed in Table 2.

Table 2. Embodied Carbon Reduction Categories and Example Strategies

REDUCTION TYPE	EXAMPLE STRATEGIES
MATERIAL QUANTITY REDUCTION	Building or material reuse Prefabrication for material reduction Structural design for material efficiency
MATERIAL ALTERNATIVE	Structural assembly alternative Wall assembly alternative Natural or carbon-sequestering alternative
PRODUCT ALTERNATIVE	Salvaged product alternative Locally sourced product alternative Sustainably harvested product alternative Product manufactured from renewable energy

The beneficial impact of each claimed embodied carbon reduction should be described and calculated separately, even if a material or assembly represents multiple reduction strategies.

CARBON OFFSETS

Approved Carbon Offsets

Carbon offsets must be certified by Green-e Climate (www.green-e.org), or an equivalent program that ensures additionality, leakage prevention, permanence and audited verification. Only Certified Emission Reduction (CER) and Verified Emission Reduction (VER) carbon credits are suitable for purchase; Renewable Energy Certificates (RECs) are not acceptable alternatives to carbon offsets.

Certified carbon offsets must meet the Gold Standard, Voluntary Carbon Standard, or the Climate Action Reserve requirements for third-party verification. Other certification programs or verification standards must be submitted to the Dialogue for review/approval prior to use.

The types of carbon offsets must be VERs or CERs sourced as:

- Renewable energy projects,
- Landfill gas-to-energy projects where the methane would otherwise be released to the atmosphere, or
- Reforestation projects

Carbon offsets may be sourced from any location in the world; consideration of local or community-based solutions is encouraged but not required. Consideration of carbon offsets with additional ecological, cultural, human health or equity benefits is also encouraged, but not required.

Prohibited Carbon Offsets

The carbon reducing function of on-site elements, such as native landscape, may not be applied to the project as a carbon offset or otherwise accounted for in calculating the embodied carbon footprint of the project.

Large-scale carbon sequestration assets or activities associated with the project owner must be audited through an approved third-party certifier in order to be claimed as a qualifying carbon offset. Such requests should be submitted to the Dialogue for review and approval prior to use.

CALCULATIONS

EMBODIED CARBON

Calculation Scope

Calculations for the embodied carbon of buildings, materials, or products, should be completed using an approved LCA tool [See [Approved Tools](#)].

Calculation scopes reference the life cycle stages as defined by standard EN 15978¹, shown in Figure 1. Project teams should utilize an approved LCA tool to calculate the aggregated carbon emissions impacts of the project materials for stages A1-A5.

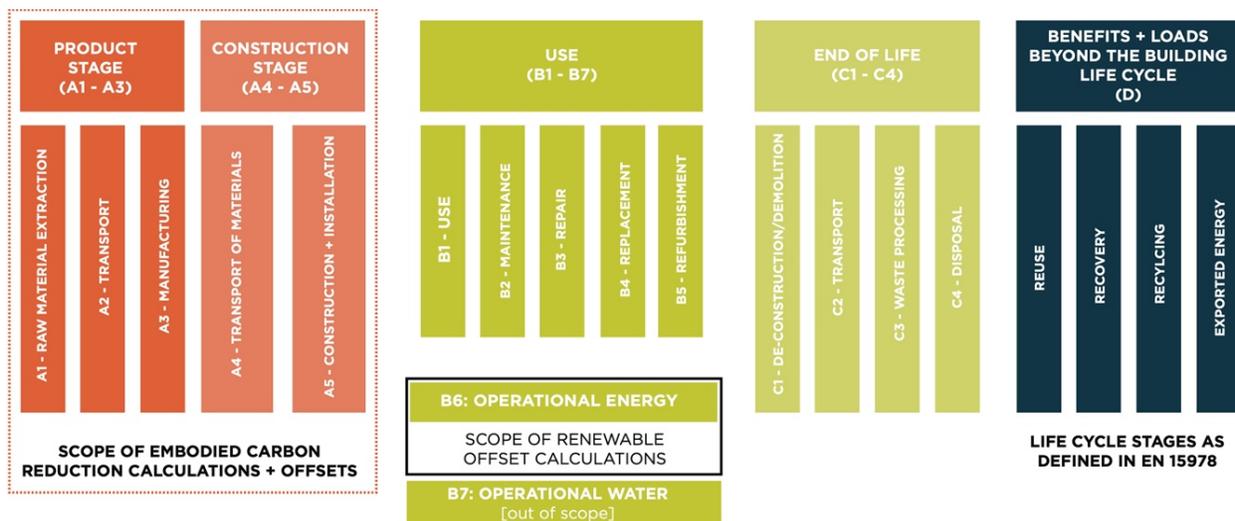


Figure 1. Life Cycle Assessment Scope Diagram

Carbon Offsets

Carbon offsets must be purchased to account for impacts of the materials and construction of the project; this includes the Product (A1-A3) and Construction Stages (A4-A5).

Aggregated totals for these stages must be data extracted from an approved LCA tool.

Embodied Carbon Accounting

The embodied carbon of the project should include the emissions associated with the materials and construction of the project scope and must not exceed the threshold of 500kg CO₂e/m²; this includes the Product (A1-A3) and Construction Stages (A4-A5).

Aggregated totals for these stages must be data extracted from an approved LCA tool.

¹ Note LCA Stage B6 (operational energy) falls outside the scope of these embodied carbon calculations; also, B7 (operational water use) is accounted for outside of the embodied carbon offset.

Reductions - Interior Materials LIVING BUILDING CHALLENGESM

Interior materials that have lower than industry baseline must be selected where embodied carbon data is readily available for a product category. There are two pathways in which a product category can meet this requirement:

1. All products used in the project fall below the industry baseline.
For example, all carpet tile types have an embodied carbon value of 15kg CO₂e/m² where the industry baseline is 20kg CO₂e/m².
2. All products within the same category have a weighted average that falls below the industry baseline.
For example, one type of carpet tile has a value of 25kg CO₂e/m² that accounts for 10% of the project carpeted area. The other carpet type, representing 90% of the area, has an embodied carbon value of 18kg CO₂e/m². This results in a weighted average of 18.7kg CO₂e/m² and thus meets the requirement of falling below the example industry baseline of 20kg CO₂e/m².

Reductions - Primary Materials

Embodied carbon reductions made in primary materials must be documented compared to a baseline that is identical to the final design except for the changes made to achieve the reduction.

Each reduction must highlight a change in the total value of embodied carbon in the project, measured in carbon dioxide equivalent (CO₂e) and exported from the approved tool the team elects to use.

For example, the baseline building design may include:

- Structural steel: 340 metric tons CO₂e,
- Concrete foundation: 270 metric tons CO₂e, and
- Enclosure materials: 150 metric tons CO₂e

This would result in a total embodied carbon value of 760 metric tons CO₂e.

After implementing low carbon strategies, the new design includes:

- Structural steel manufactured using renewable energy: 310 metric tons CO₂e,
- Concrete mix that uses less cement per unit volume: 230 metric tons CO₂e, and
- Enclosure materials with portions sourced locally: 120 metric tons CO₂e

This would result in a total embodied carbon value of 660 metric tons CO₂e and a subsequent reduction of 13% from the baseline building design.

The total embodied carbon value out of this assessment (660 metric tons CO₂e) is then the amount that needs to be offset by purchasing carbon offsets.

APPROVED TOOLS

Tools utilized for LCA calculations must have the capability to complete a full cradle-to-grave analysis as defined by ISO 14044. In order to increase industry understanding of the LCA process and facilitate more accurate evaluations, tools that reveal their methodology and encourage data transparency are preferred.

The Institute has approved the following tools for use by project teams to conduct LCA calculations for buildings, materials, and products:

- **Athena Impact Estimator**
A tool that is a more sophisticated version of the Athena EcoCalculator wherein users create their own assemblies and envelope configurations, allowing flexibility for complex designs and existing buildings
- **Environment Agency's Carbon Calculator**
Free downloadable spreadsheet tool that requires detailed material information such as weight of material, distance traveled and type of transportation
- **eTool**
Free web-based calculator with a user-friendly interface that can either use predefined assemblies or allow the user to create their own; based upon Australian product data
- **One Click LCA**
A web-based LCA software that calculates a variety of design data in one platform
- **Tally**
An LCA application for Autodesk® Revit® that calculates the environmental impacts of building materials and compares options directly within a Revit® model

The Institute has identified the following tools for use by project teams to establish product baselines:

- **Embodied Carbon in Construction Calculator (EC3)**
An open-source EPD database and building planner tool that enables a performance-based approach to evaluating embodied carbon reductions in design, procurement, and construction

Project teams may use a tool that is not listed if it approved through the Dialogue and is comparable to at least one of the listed calculators.

DOCUMENTATION REQUIREMENTS



CARBON OFFSETS

Documentation of project's embodied carbon offset, including either:

- Calculations showing how carbon-sequestering materials sufficiently account for the project's embodied carbon along with third-party verified sustainable harvesting, or
- Receipt from an approved carbon offset program as proof of purchase

EMBODIED CARBON CALCULATIONS

The input assumptions and results from the selected life cycle assessment tool, showing:

- Primary materials project embodied carbon baseline,
- Primary materials project embodied carbon after reductions, and
- Embodied carbon of materials + construction (A1-A5) of primary and interior materials

Material documentation supporting reductions in primary + interior materials claimed in narrative, including:

- Basis of Design statements
- LCA hot spot analyses
- Material specifications

EMBODIED CARBON REDUCTIONS

A two- to three-page narrative describing actions taken to reduce project embodied carbon by 20%, including:

- Primary material reduction strategies and the phase(s) in which they occur,
- List of interior materials selected, comparing their embodied carbon value to the industry baseline, and
- Procurement requests or letters



CARBON OFFSETS

Documentation of project's embodied carbon offset, including either:

- Calculations showing how carbon-sequestering materials sufficiently account for the project's embodied carbon along with third-party verified sustainable harvesting, or
- Receipt from an approved carbon offset program as proof of purchase

EMBODIED CARBON CALCULATIONS

The input assumptions and results from the selected life cycle assessment tool, showing:

- Primary materials project embodied carbon baseline,
- Primary materials project embodied carbon after reductions, and
- Embodied carbon of materials + construction (A1-A5) of primary and interior materials showing it does not exceed 500kg CO₂e/m²

Material documentation supporting reductions in primary materials claimed in narrative, including:

- Basis of Design statements
- LCA hot spot analyses
- Material specifications
- Procurement requests or letters

EMBODIED CARBON REDUCTIONS

A two- to three-page narrative describing actions taken to reduce project embodied carbon by 10%, including:

- Primary material reduction strategies and the phase(s) in which they occur

DEFINITIONS

Embodied Carbon

The greenhouse gas emissions associated with the raw material extraction, manufacturing and processing, transportation, and installation of a building material.

Interior Materials

Permanently installed materials included in the finishes (wall, ceiling, floor) and partitions within the envelope of a building. This does not include miscellaneous items or moveable components such as furnishings, fixtures or equipment.

Life Cycle Assessment

A method to assess the environmental impacts associated with all stages of a product's life cycle (i.e., from raw material extraction through materials processing, manufacture, distribution, use, repair, maintenance, and end of life disposal or recycling), determined in compliance with the ISO 14044 standard.

Operational Carbon

The greenhouse gas emissions associated with the energy uses of a building, or life cycle stage B6, as defined by EN 15798.

Primary Materials

The permanently installed building components that comprise the foundation, structure, and enclosure of a building.

Product

An item that arrives on the project site either as a finished element ready for installation or as an individually specified component of another item assembled on-site. Items that are mixed or assembled on-site, but specified and sold as a unit are considered components of a product, not individual products.

Renewable Energy

Passive solar, photovoltaics, solar thermal, wind turbines, water-powered micro-turbines, direct geothermal or fuel cells powered by hydrogen generated from renewably powered electrolysis. Nuclear energy is not considered renewable, nor are combustion-based sources.

RESOURCES

Carbon Benchmarking Study, Carbon Leadership Forum

- This technical report has summarized results of a study wherein data from over 1,000 building life cycle assessments were collected and analyzed.

Carbon Smart Materials Palette, Architecture 2030

- This online toolkit provides material options with lower embodied carbon to replace traditional building materials.

LCA Practice Guide, Carbon Leadership Forum

- This technical report provides guidance to building professionals regarding how to incorporate life cycle assessment into their typical projects.

Methodology to Calculate Embodied Carbon of Materials, RICS

- This informational paper provides guidance about how to calculate cradle-to-gate embodied carbon impacts associated with a project.

Whole Building LCA: Reference Building Structure & Strategies, ASCE

- This book provides guidance regarding the role structural engineers can play in reducing the life cycle impacts of a building.

Zero Code: Offsite Procurement of Renewable Energy, Architecture 2030

- This technical report provides an analysis of the various options for off-site renewable energy procurement.