

Embodied Carbon and CALGreen Embodied Carbon Requirements

When it comes to building decarbonization, many professionals are familiar with operational carbon, which refers to the greenhouse gases (GHG) emitted from energy use (electricity and fossil fuels) for building operations. As California State building codes (Title 24) increase building energy efficiency, the relative proportion of a building's embodied carbon will increase compared to operational carbon.

Professionals are quickly becoming familiar with embodied carbon as the state legislature has passed bills like Buy Clean California that require limited embodied carbon in building products on statefunded projects.¹ As of July 1, 2024, CALGreen, the state green building code, requires commercial projects 100,000 sf and larger, and schools 50,000 sf and larger to comply with one of three paths for embodied carbon.²

What is Embodied Carbon?

Embodied carbon refers to the GHG emissions from the non-renewable energy use associated with raw material extraction, manufacturing, transportation, installation, maintenance, and disposal of building materials and products. Upfront embodied carbon relates to stages A1-A3 in a product's life cycle, also called cradle-to-gate. Cradle-to-grave refers to stages A1-C4, called life cycle emissions (see Figure 1).

¹ California Department of General Services (DGS), Buy Clean California Act, GWP Limits, January 2022. <u>https://www.dgs.ca.gov/PD/Resources/Page-Content/Procurement-Division-Resources-List-Folder/Buy-Clean-California-Act</u>

² California Building and Standards Commission, Final Express Terms for Proposed Building Standards of the California Building Standards Commissiong Regarding the 2022 California, Green Building Standards Code, California Code of Regulations, Title 24, Part 11, 2022. <u>drive.google.com/file/d/15FqnAJ7bnKH-LxCMpj-u5oPvjshJn0uQz/view</u>

FIGURE 1. LIFE CYCLE STAGES

Data source: BS EN 15978:2011

Most product or building life cycle analyses (LCA) and environmental product declarations (EPDs) focus on stages A1-A3: the extraction of raw materials, transport to the factory, and manufacturing of the products. Stage A has the biggest potential for embodied carbon reduction.



Why does Embodied Carbon Matter?

Worldwide, 28% of emissions come from building operations and another 11% come from embodied carbon.³ Embodied carbon emissions are expected to increase due to a growing global demand for construction to accommodate population growth and the need to replace aging infrastructure.⁴ Globally, we must reduce emissions by 45% by 2030 to have a chance of limiting warming to under 1.5°C. In addition, California's goal is to reduce economywide emissions by 40% by 2030 from 1990 levels, and 80% by 2050. With these strict timelines to mitigate the impacts of climate change, it becomes imperative to address embodied carbon.

While a building's operational carbon can be reduced throughout its lifetime via energy efficiency improvements and retrofits, most of the embodied carbon of a building is already emitted once it has been constructed. Not much can be done to reduce its embodied carbon after construction. For highly efficient buildings, embodied carbon accounts for over 50% of a building's total lifetime emissions, further strengthening the case for mitigating embodied carbon.

How is Embodied Carbon Measured and Represented?

Each building product has a specific amount of embodied carbon, which is measured by the product's **global warming potential (GWP).** The GWP is represented by kg of CO2-equivalent (kg-CO2e) per weight or area of the product and per embodied carbon module (See Figure 1). A product-level **life cycle assessment (LCA)** is a study that uses a preapproved analysis (as detailed by International Organization for Standardization (ISO) 14040) to determine the environmental impacts. Similarly, measuring the impact of an entire building is referred to as a **whole building life cycle assessment (WB LCA)**. A **product category rule** (**PCR**) defines (ISO 14025) how a product's LCA data will be communicated in the easier-to-read format known as an **environmental product declaration** (**EPD**), developed by a third-party professional.

EPDs quantify the environmental impact of a product, including GHG emissions. There are several types of EPDs. An EPD from one company's product is called product-specific EPDs, while EPDs from a product from a single factory is a factory-specific EPDs. Industry-wide EPDs (IW-EPD) capture an average of environmental attributes from several manufacturers representing the industry. EPDs are growing in number as third-party rating systems, policies, and one of the CALGreen embodied carbon provisions require Type III EPDs. See definitions on page 11 for more detail.

How Do Designers Select Low Carbon Materials?

A recent report showed a potential 46% whole building embodied carbon reduction with less than a 1% total cost premium, illustrating that cost-effective, lowcarbon solutions exist today to reduce construction emissions.⁵ The table on <u>page 4</u> summarizes the emissions reduction potential per product and the totalproject cost premium of using low-carbon versions of various building materials.

3 International Energy Agency for the Global Alliance for Buildings and Construction, 2018 Global Status Report, Towards a Zero Emission, Efficient, and Resilient Buildings and Construction Sector, United Nations Environment Programme, 2018. https://www.unep.org/resources/report/global-status-report-2018

- 4 United Nations Intergovernmental Panel of Climate Change, Summary for Policymakers, 2018. www.ipcc.ch/sr15/chapter/spm/
- 5 Jungclaus, M., et al., Low-Cost, High-Value Opportunities to Reduce Embodied Carbon in Buildings, RMI, 2021. <u>rmi.org/insight/reducing-embodied-car-bon-in-buildings</u>



What Can Building Professionals Do?

Building professionals informed about the updated codes, strategies, and resources available to track and reduce embodied carbon will be better prepared to meet the changing market trends and policies while helping us collectively achieve our climate and environmental goals.

Everyone on the building design and construction team has an opportunity to reduce the total embodied carbon footprint. Low-carbon decisions are best made early in the design process with an integrated design approach. See <u>page 9</u> for ideas on how to incorporate CALGreen embodied carbon requirements into the design and construction process.

Owners

Ask about embodied carbon, how to reduce it, and set total GWP per square foot goals. Require building and material reuse.

Architects

Minimize materials and specify recycled and low-carbon materials. Set an embodied carbon budget based on WB LCAs of similar types of buildings. Design buildings for resiliency, longevity, and reuse. Request EPDs from manufacturers and set GWP limits for materials used in high quantities. If meeting CALGreen requirements, work with the contractor to ensure that the specified lowcarbon products are installed.

Structural engineers

Efficiently design structural systems for material efficiency, longevity, and flexibility for future reuse.

Contractors

Procure lower-carbon products, reuse materials from previous projects, and minimize fossil fuels on-site. If meeting CALGreen requirements, collect and provide EPDs to the architect during the submittal review process.

Mechanical engineers

Select heat pump systems that use low-GWP refrigerants, and design systems to minimize duct and pipe runs.

Studies show that cost-effective, low-carbon solutions exist today to reduce construction emissions. Using less product, recycled content, and selecting low-carbon alternatives are some of the easiest and most effective ways to reduce building embodied carbon emissions.

Cost-effective, Low-Carbon Product Selection

Concrete

Actions to Reduce Carbon

Substitute cement with alternative cementitious materials (ACMs). Choose recycled aggregate. Select structural shapes and sizes that use less material while keeping the same structural integrity.

Emissions Reduction Potential 14-33%

Cost Premium No to low

Insulation

Actions to Reduce Carbon

Replace foam (especially XPS) with lower-carbon materials, like cellulose and mineral wool batt.

Emissions Reduction Potential 16%

Cost Premium No

Structural Steel

Actions to Reduce Carbon Specify CA or U.S.-made steel and steel with high recycled content. Prioritize electric arc furnace (EAF) production over basic oxygen

furnace (BOF) production.

Emissions Reduction Potential 1-10%

Cost Premium 1%

Glazing

Actions to Reduce Carbon

Select low-carbon window frame materials. Specify no more than two panes of glazing.

Emissions Reduction Potential 3%

Cost Premium 10%

Rebar

Actions to Reduce Carbon

Use 97% or higher recycled content rebar. Select a structural concrete design that uses less material while keeping the same structural integrity.

Emissions Reduction Potential 4-10%

Cost Premium

Finish Materials

Actions to Reduce Carbon

Select low-carbon and durable finish materials. Reuse materials and design for deconstruction and reuse for future tenant improvements.

Emissions Reduction Potential 5%

Cost Premium No to low



California Embodied Carbon Policies

Policies to address embodied carbon are underway in climate action plans, buy clean procurement policies, CALGreen, and local codes.

In 2017, the <u>Buy Clean California Act</u> (BCCA) was enacted to require the Department of General Services (DGS) to create GWP limits for four materials used in public works projects: structural steel (hot-rolled sections, hollow structural sections, and plate), concrete reinforcing steel, flat glass, and mineral wool board insulation.

Climate action plans from San Diego, San Francisco, and Oakland mention efforts to curb embodied carbon. **San Francisco** and **Los Angeles** signed <u>C40's Clean Construction Declaration</u>, which aims to reduce embodied emissions by at least 50% for all new buildings, major retrofits, and all infrastructure projects by 2030.⁶ **Marin County's** low-carbon concrete code was the first in the nation.⁷ Starting July 1, 2024, <u>CALGreen</u> requires schools over 50,000 square feet, and commercial projects over 100,000 square feet to meet one of three embodied carbon options: reuse 45% of a building's existing structure, conduct a whole building life cycle assessment, or meet a prescriptive path which is similar to Buy Clean California.

Federal Embodied Carbon Policies

On a national scale, in December 2021, President Biden signed <u>Executive Order 14057</u> that includes a net zero emissions requirement for federal procurement no later than 2050, including a buy clean procurement policy to promote the use of construction materials with lower embodied emissions.⁸ The Federal Government will prioritize purchasing American-made, lower-carbon construction materials in federal procurement and federally funded projects, which will also advance the industrial capacity for supplying low-carbon building products to the private sector.

⁶ C40, Clean Construction Declaration, 2020. www.c40.org/news/clean-construction-declaration-launch/

⁷ Marin County, Title 19 Marin County Building Code, Chapter 19.07 - Carbon Concrete Requirements, 2019. <u>www.marincounty.org/depts/cd/divisions/sus-tainability/low-carbon-concrete-2022</u>

⁸ White House, Executive Order on Catalyzing Clean Energy Industries and Jobs through Federal Sustainability, 2021. <u>www.whitehouse.gov/briefing-room/</u> presidential-actions/2021/12/08/executive-order-on-catalyzing-clean-energy-industries-and-jobs-through-federal-sustainability/



The Inflation Reduction Act (IRA), signed in August 2022, includes millions of dollars for embodied carbon programs that will drive additional decarbonization through federal purchasing while setting standards that can be utilized by state, local, and private partners, and providing grants to support the building product industries to comply.⁹

\$250 million is allocated to develop and standardize EPDs for construction materials, with grants and technical assistance for manufacturers. \$100 million is allocated to developing a low-carbon construction product labeling program and millions more to support the General Services Administration, the Federal Highway Administration, and other government agencies in procuring low-carbon construction products for their buildings.

9 House of Representatives, Congress. H.R. 812 (IH) - Inflation Reduction Act of, 2022.

CALGreen Embodied Carbon Options

The CALGreen 2022 Intervening Code Adoption Cycle (effective July 1, 2024) includes new embodied carbon provisions. The code offers three paths of compliance: building reuse, WB LCA, or a prescriptive approach similar to Buy Clean California but with concrete. The code applies to nonresidential buildings greater than 100,000 sf and school projects over 50,000 sf in both adaptive reuse and new construction projects.

For the new embodied carbon measures, the enforcing agency may require inspection and inspection reports during and at the completion of construction to demonstrate substantial conformance. Inspection is to be performed by the design professional of record or a third party acceptable to the enforcing agency.

CALGREEN EMBODIED CARBON OPTIONS

Building Reuse Section 5.105, Deconstruction and Reuse of Existing	Life Cycle Analysis Section 5.409,	Prescriptive Path Section 5.409.3,		
Structures	Life Cycle Assessment	Product GWP Compliance		
Components: Existing primary structural elements, enclosure, (roof framing, wall framing, and exterior finishes).	Scope: 60-year cradle-to-grave WB LCA (ISO 14044), excluding operating energy. Show GWP analysis.	Components: Structural steel, rebar, flat glass, light and heavy- duty mineral wool insulation, and ready mix concrete.		
 Exceptions: Additions 2x the area or more of the existing building. Exclude: Window assemblies, insulation, portions structurally unsound or hazardous, and hazardous materials that are remediated as part of the project shall not be included in the calculation. Mandatory A5% of the structure and enclosure to be reused Tier 1 T5% of the structure and enclosure to be reused 	Analysis. Components: Primary and secondary structural members, glazing, insulation, exterior finishes. Mandatory 10% reduction from baseline Tier 1 15% reduction from baseline	Exception: Concrete mixes can use a weighted average for all mixes. Mandatory 175% of IW-EPD GWP Limits Tier 1 150% of IW-EPD GWP Limits		
Tier 2 75% of the structure and enclosure to be reused AND 30% of interior non-structural elements to be reused	20% reduction from baseline	IW-EPD GWP Limits		

Building Reuse

(Section 5.105.2) When a renovation includes an existing building, the project team can meet the requirement by maintaining 45% of the existing structure and enclosure. This consists of the foundations, columns, beams, walls, floors, and lateral elements; existing building enclosure, which includes roof framing, wall framing, and exterior finishes. The list of excluded components includes window assemblies, insulation, portions of buildings deemed structurally unsound or hazardous, and hazardous materials that are remediated.

A CALGreen worksheet is provided to calculate the retained structure and enclosure by square feet.

Voluntary options include:

Tier 1

When reusing a building, maintain 75% of the existing structure and enclosure.

Tier 2

Tier 1 + 30% of the interior non-structural elements.

Life Cycle Analysis

(Section 5.409.2) For new buildings, conduct a cradle-to-grave whole building life cycle assessment demonstrating a 10% reduction in global warming potential (GWP). The WB LCA must include the building enclosure components, including the glazing assemblies, insulation, and exterior finishes; and primary and secondary structural members, including footing foundations, structural columns, beams, walls, roofs, and floors.

The WB LCA must be conducted in accordance with ISO 14040 and ISO 14044 and exclude operating energy. The reference baseline and design LCAs must be of similar size, function, complexity, type of construction, material specification, and location, and use the same LCA data set compliant with ISO-14044, and ISO 21930 or EN 15804. The code also requires the LCA software to conform to ISO 21931 and/or EN 15978. The reference study period must be 60 years.

Documentation of compliance includes a report from the software and a signed CALGreen worksheet.

Voluntary options include:

Tier 1

Conduct a cradle-to-grave WB LCA demonstrating a 15% reduction in GWP.

Tier 2

Conduct a cradle-to-grave WB LCA demonstrating a 20% reduction in GWP.

Prescriptive Path

(Section 5.409.3) For new buildings, procure Type III product-specific or factory-specific EPDs for structural steel shapes, ready mix concrete, rebar, flat glass, and mineral wool insulation that illustrate the GWP is at or below the values listed in the tables. These values are based on 175% of the industry wide EPD's GWP value. Concrete mixes can use a weighted average calculation, as laid out in the code, which treats all concrete as one product.

Documentation of compliance includes Type III EPDs for structural steel, concrete, rebar, flat glass, and mineral wool insulation permanently installed in the building and a worksheet signed by a licensed design professional on the project.

Voluntary options include:

Tier 1

Listed products must comply with lower GWP values set at 150% of IW-EDP GWP.

Tier 2

Listed products must comply with lower GWP values set at the IW-EDP GWP.



How Can Designers Ensure Compliance with CALGreen Embodied Carbon Requirements?

Designers and contractors can incorporate the CALGreen embodied carbon requirements into the existing process to comply. Code compliance should be a reoccurring meeting topic for the owner, architect, and contractor (OAC).

Specifications: Architects can incorporate the requirements into the Division 1 specifications for reuse and carbon requirements. For specific low-carbon products, either for the performance or prescriptive paths, include EPD reporting and product GWP limits in each production section within the specifications.

Drawings: With the construction documents, include the completed and signed CALGreen worksheets on the drawings.

Bid documents: Within the bid documents, ensure the contractors are aware of the reporting requirements. Indicate the intent for reuse or lower carbon products, specifically identifying products or structural components of high importance.

Submittal review: During the construction submittal review process, contractors should submit the EPDs to the architect to confirm the product's GWP meets the WB LCA design or prescriptive approach.

Project closeout: Consider providing EPDs for the procured products or the updated WB LCA to the owner. While this is not required for code, the owner should have the documentation.

Addressing building whole life carbon emissions is becoming an important area of focus for policymakers nationwide, and California is leading the charge. The embodied carbon provisions in the 2022 CALGreen code offer a viable pathway for local governments to evaluate this area of emissions for climate action plan inclusion or reach code development.

The <u>Local Energy Codes</u> website continues to update its embodied carbon resources webpage and include this topic as the statewide reach codes team pursues activities in support of local government reach codes development efforts.

MANDATORY AND VOLUNTARY GWP VALUES FOR THE PRODUCT GWP COMPLIANCE PATH

Maximum acceptable GWP value

	(unfabricated)				
Products to Comply with Product GWP Compliance (Prescriptive Path)	Mandatory	Tier 1	Tier 2	Unit of Measurement	
Hot-rolled structural steel sections	1.77	1.52	1.01	MT CO ₂ e/MT	
Hollow structural sections	3.0	2.57	1.71		
Steel plate	2.61	2.24	1.49		
Concrete reinforcing steel	1.56	1.34	0.89		
Flat glass	2.5	2.15	1.43	kg CO ₂ e/MT	
Light-density mineral wool board insulation	5.83	5.0	3.33	kg CO ₂ e/m ²	
Heavy-density mineral wool board insulation	14.28	12.24	8.16		

Ready Mix Concrete Product Category	Maximum acceptable GWP value (unfabricated) (GWP allowed)			
up to 2499 psi	450	386	257	
2500-3499 psi	489	419	279	
3500-4499 psi	566	485	323	
4500-5499 psi	661	567	378	
5500-6499 psi	701	601	401	kg CO ₂ e/m ³
6500 psi and greater	799	685	456	
up to 2499 psi, Lightweight Ready Mix	875	750	500	
2500-3499 psi, Lightweight Ready Mix	956	819	546	
3500-4499 psi, Lightweight Ready Mix	1,039	891	594	



New CALGreen Definitions

BUY CLEAN CALIFORNIA ACT. The Buy Clean California Act (BCCA) (Public Contract Code Sections 3500-3505), targets carbon emissions associated with the production of structural steel (hot-rolled sections, hollow structural sections, and plate), concrete reinforcing steel, flat glass, and mineral wool board insulation. The maximum acceptable global warming potential (GWP) limits are established by the Department of General Services (DGS), in consultation with the California Air Resources Board (CARB).

CRADLE-TO-GATE. Activities associated with a product or building's life cycle from the extraction stage through production stage and covering modules A1 through A3 in accordance with ISO Standards 14025 and 21930.

CRADLE-TO-GRAVE. Activities associated with a product or building's life cycle from the extraction stage through disposal stage and covering modules A1 through C4 in accordance with ISO Standards 14025 and 21930.

TYPE III ENVIRONMENTAL PRODUCT

DECLARATION (EPD). A third-party verified report that summarizes how a product impacts the environment. Type III EPDs can be either product-specific, factory-specific, or industry-wide EPDs. See CRADLE-TO-GATE.

PRODUCT-SPECIFIC EPD. A Type III EPD in which the environmental impacts can be attributed to a product design and manufacturer across multiple facilities.

FACTORY-SPECIFIC EPD. A product-specific Type III EPD in which the environmental impacts can be attributed to a single manufacturer and manufacturing facility.

INDUSTRY-WIDE EPD (IW-EPD). A Type III EPD in which the environmental impacts are an average of the typical manufacturing impacts for a range of products within the same product category for a group of manufacturers.

REFERENCE STUDY PERIOD. The period of use for the building, in years, that will be assumed for life cycle assessment.



Architect's Embodied Carbon Toolkit Life Cycle Assessment Case Studies Where Do We Stand? Case Studies Life Cycle GHG Impacts in Building Codes CALGreen Embodied Carbon Provision Local Energy Codes



The Codes & Standards program is designed to improve compliance with the state's building and appliance energy codes and standards. The program aims to advance the adoption and effective implementation of energy efficiency measures and building practices to lock in long-term energy and GHG savings to meet California's ZNE, decarbonization and climate goals. The program recognizes that codes and standards are one of the most effective pathways to ensuring sustained market transformation—and that key to making them work well are well-informed industry professionals and consumers.







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