CLIMATE ACTION WEBINARS
Z N C D

Wednesday, March 13
12:00P | 1 LU | 1hr of ZNCD MCE

CALGREEN EMBODIED CARBON SERIES

Whole Building Life Cycle Assessment for Code Compliance

AIA California

SEAOC
STRUCTURAL ENGINEERS ASSOCIATION OF CALIFORNIA

Learning Objectives

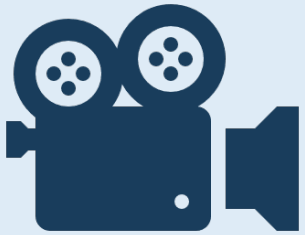
Review the fundamental principles and processes involved in WBLCA to enhance sustainable design practices.

Gain proficiency in conducting material quantity takeoffs to accurately measure building components for environmental impact assessments.

Interpret and utilize EPDs for informed decision-making on material selection based on their environmental footprint.

Explore tools that are compliant for completing the CALGreen WBLCA performance pathway.

Housekeeping Reminders



Access to today's recording will be made available on our website

Today's session qualifies for 1 AIA HSW/LU & 1hr of ZNCD

Please use the Q&A function to ask questions for today's presenters

Cultivate a positive learning environment

Luke Lombardi, PE
Sr. Sustainability
Consultant, Buro Happold

Avideh Haghighi, AIA, LFA
Associate Principal
Sustainable Design Lead, ZGF

Laura Karnath, AIA, NCARB, LEED AP BD+C
Senior Enclosure Consultant, Walter P Moore

Isabelle Hens, LEED AP BD+C, WELL AP, EIT
Environmental Designer, Atelier Ten

Q&A Help!

John O’Hagan
SEAONC SDC
Forell Elsesser

Rachelle Habchi
SEAOSC SDC
Glotman Simpson

Anish Tilak
RMI

Amie Lewis
New Buildings Institute

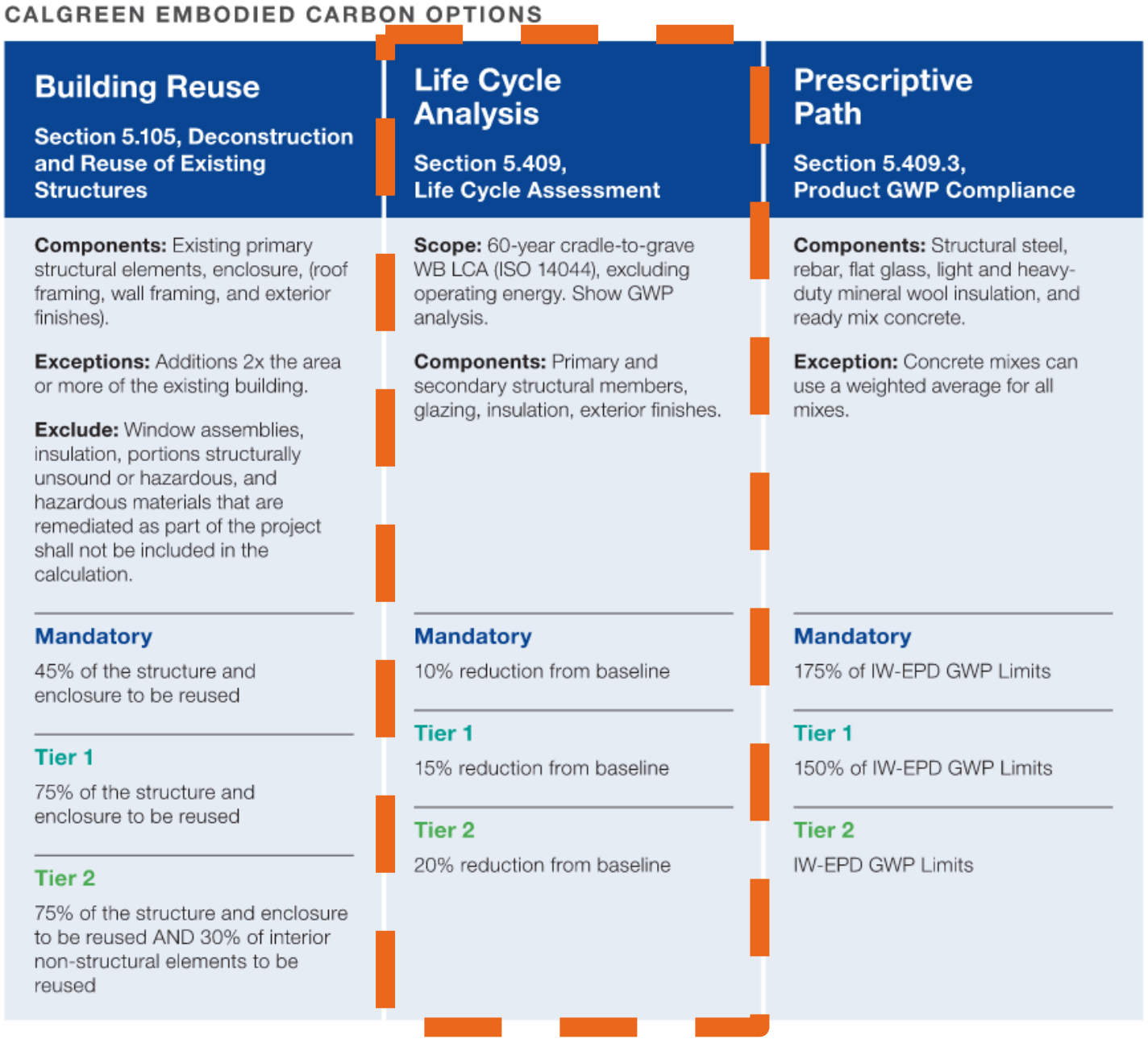
CALGreen Embodied Carbon Series

4-part series made in partnership with SEAOC's Sustainable Design Committee

Feb. 21, 2024	Understanding the 2023 Embodied Carbon Amendments
Mar. 13, 2024	**WBLCA for Code Compliance**
Apr. 10, 2024	Implications of Material Procurement for Design Professionals *(registration open!)*
June 2024 [TBD!]	Building Reuse for Decarbonization and Compliance

Refresher from last webinar

- Starting July 2024
- Non-residential buildings over 100,000 sf
- Schools over 50,000 sf
- **Three compliance pathways**



California Energy Codes and Standards: CALGreen Embodied Carbon Requirements Fact Sheet

Is my project covered by the measure?

Covered

Public Schools (K-12), Community College >50,000 sf

Building types covered by *CALGreen Non-residential Provisions* and >100,000 sf

- Industrial
- Commercial Office
- Retail
- Lab
- Private School (K-12)
- University Academic (Public & Private)
- Institutional / Civic

Not Covered

Public Schools (K-12), Community College <50,000 sf

Hospitals - *pending OSHPD approval*

Building types covered by *CALGreen Non-residential Provisions* and <100,000 sf

Building types covered by *CALGreen Residential Provisions*

- Single Family Residential
- Multifamily Residential
- Hotel / Motel / Lodging
- University Housing (***Note that Public University Housing IS covered by Buy Clean CA)***

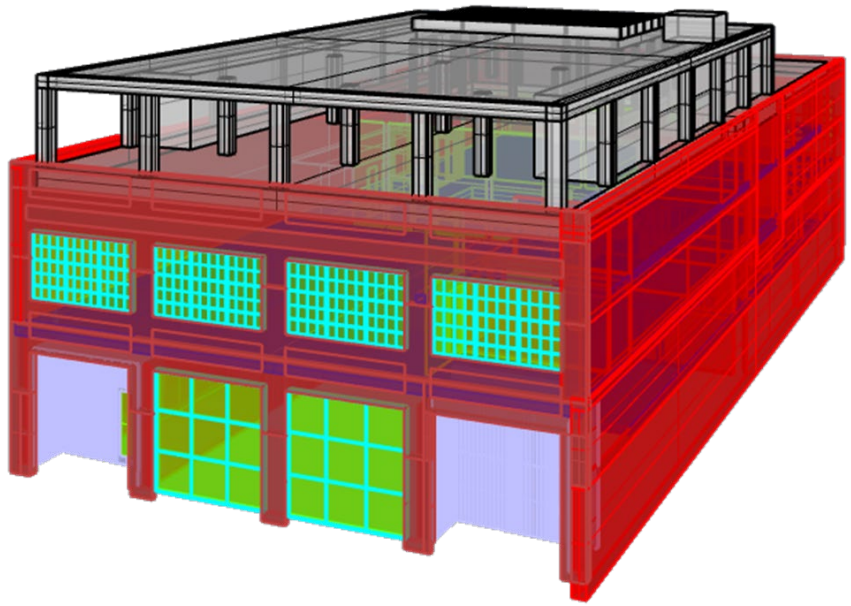
Today's Outline

1. Introduction
2. How to Conduct a Life Cycle Assessment
3. How to Achieve a 10% Reduction
4. How to Demonstrate Compliance
5. Resources and Working Groups

Goal: Build confidence and learn LCA fundamentals to comply with CALGreen regulations.

Example Template

Sample Building



CALGreen Whole Building LCA Reporting Template

LCA model run	User input	Units	Overall scope included (select all that apply)
LCA Modeler (company) *[private]*			Structure (required) ☐
Date of Model Run (mm/yyyy)			Envelope (required) ☐
Project Phase at Model Run			Interiors (optional) ☐
Reference Study Period (years)			MEP (optional) ☐
Software and Version Used*			Site/Landscaping (optional) ☐
Biogenic Carbon Reduction (kg)			FF&E (optional) ☐
Model Floor Area		m2	

Mandatory Scope Items

Please break out the following in per element emissions by life cycle in kgCO2e. Leave blank any sections that were not calculated separately from Whole Building GWP

	Upfront Carbon			Use Phase	End of Life	Total
	A1-3	A4	A5	B1-5	C1-4	
Baseline Structure GWP (kgCO2e):						
Baseline Enclosure GWP (kgCO2e):						
Baseline Whole Building GWP (kgCO2e):						
Proposed Structure GWP (kgCO2e):						
Proposed Enclosure GWP (kgCO2e):						
Proposed Whole Building GWP (kgCO2e):						

A1-A3*
(A1) Raw Material Supply, (A2) Transport to Factory, and (A3) Manufacturing

A4*
(A4) Transportation to site

A5*
(A5) Construction Installation or "on-site energy use". Leave blank if unkown

B1-B5*
(B1) Use, (B2) Maintenance, (B3) Repair, (B4) Replacement, (B5) Refurbishment

Percent Reduction	
Mandatory	
Tier 1	
Tier 2	

C1-C4*
(C1) Deconstruction/Demolition, (C2) Transport to Waste Processing/Disposal, (C3) Waste Processing, (C4) Disposal of Waste

D*
(D) Reuse-Recovery & Recycling Potential

Optional Items - Proposed Design ONLY

Please break out the following in per element emissions by life cycle in kgCO2e. Leave blank any sections that were not calculated separately from Whole Building GWP

	Upfront Carbon			Use Phase	End of Life	Total
	A1-3	A4	A5	B1-5	C1-4	
Interiors GWP (kgCO2e):						
MEP GWP (kgCO2e):						
Site/Landscaping GWP (kgCO2e):						
FF&E GWP (kgCO2e):						

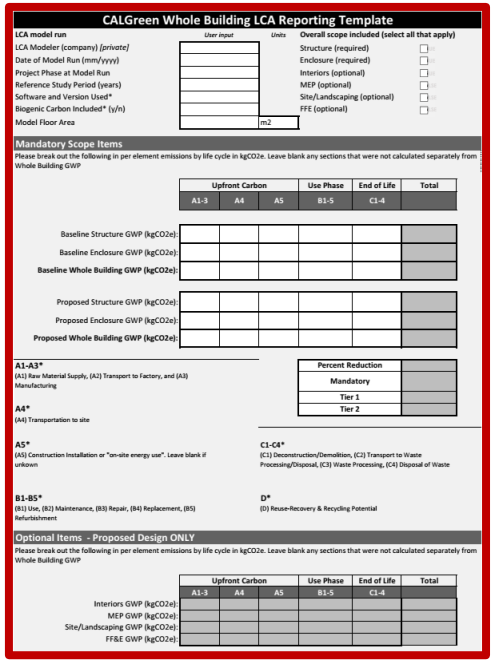
Reporting Template Submitted at Permitting

Understand overall impact to inform system selection

Estimate and document reduction measures

*CALGreen

In Drawing or Specs:



CALGreen Whole Building LCA Reporting Template

LCA model run

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Date of Model Run (mm/yyyy)		
Project Phase at Model Run		
Reference Study Period (years)		
Software and Version Used*		
Biogenic Carbon Included* (y/n)		
Model Floor Area		m2

Overall scope included (select all that apply)

- Structure (required)
- Enclosure (required)
- Interiors (optional)
- MEP (optional)
- Site/Landscaping (optional)
- FFE (optional)

Mandatory Scope Items

Please break out the following in per element emissions by life cycle in kgCO2e. Leave blank any sections that were not calculated separately from Whole Building GWP

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Proposed Structure GWP (kgCO2e):						
Proposed Enclosure GWP (kgCO2e):						
Proposed Whole Building GWP (kgCO2e):						

Percent Reduction	
Mandatory	
Tier 1	
Tier 2	

A1-A3* (A1) Raw Material Supply, (A2) Transport to Factory, and (A3) Manufacturing

A4* (A4) Transportation to site

A5* (A5) Construction Installation or "on-site energy use". Leave blank if unkown

B1-B5* (B1) Use, (B2) Maintenance, (B3) Repair, (B4) Replacement, (B5) Refurbishment

C1-C4* (C1) Deconstruction/Demolition, (C2) Transport to Waste Processing/Disposal, (C3) Waste Processing, (C4) Disposal of Waste

D* (D) Reuse-Recovery & Recycling Potential

Optional Items - Proposed Design ONLY

Please break out the following in per element emissions by life cycle in kgCO2e. Leave blank any sections that were not calculated separately from Whole Building GWP

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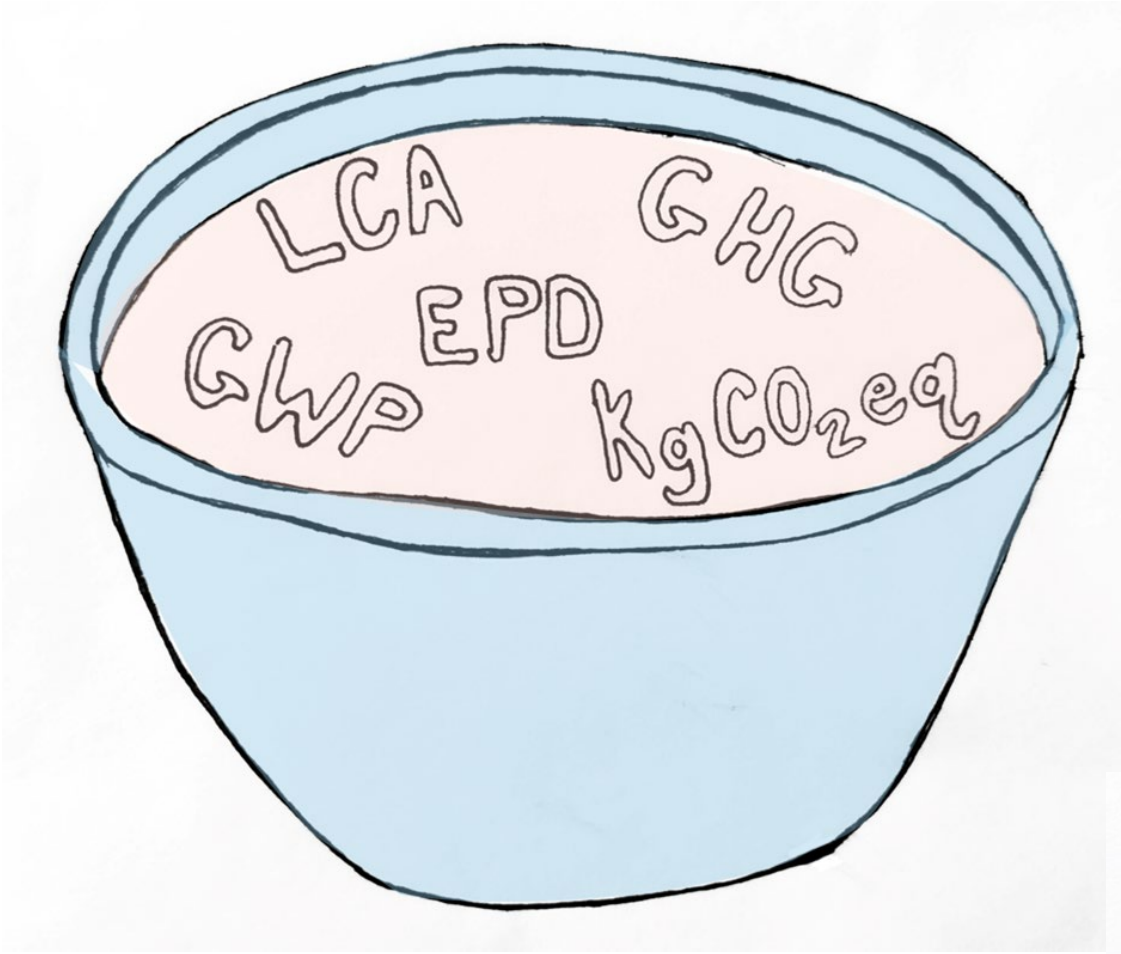
Interiors GWP (kgCO2e):						
MEP GWP (kgCO2e):						
Site/Landscaping GWP (kgCO2e):						
FF&E GWP (kgCO2e):						

Concept → SD → DD → CD → Permitting → CA

Many Contributors!

Introduction

Terms and Definitions



LCA	Life Cycle Assessment
WBLCA	Whole Building Life Cycle Assessment
EPD	Environmental Product Declaration
GHG	Greenhouse Gas
GWP	Global Warming Potential
kgCO2eq	unit of measure for GWP, i.e. “carbon”

Illustration: Laura Karnath

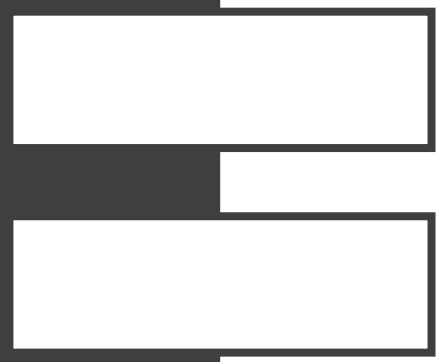
LCCA

LIFE CYCLE COST ASSESSMENT

LCA

LIFE CYCLE ASSESSMENT

EMBODIED CARBON



‘GWP’

GLOBAL WARMING POTENTIAL

Myths

An LCA costs too much (ie: eats into budget)

Specialized Expertise is needed to run an LCA

I have to pay a certified consultant

An LCA takes too long to run (ie: eats into schedule)

Structural Engineers are not impacted by this code change

Truths

LCA typically cost a small fraction of project fees (< 1%)

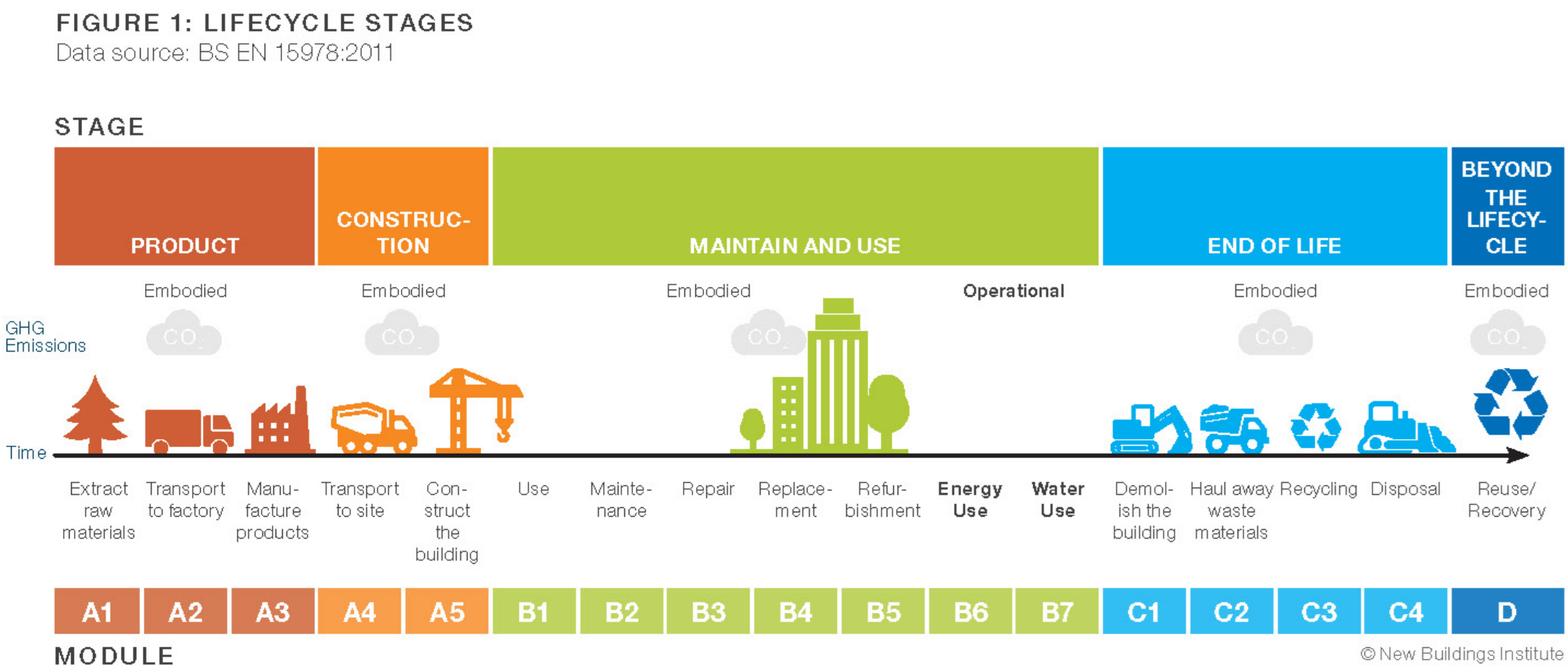
Anyone can learn to do an LCA with a basic understanding

LCA does not require professional accreditation

A typical LCA takes on the order of 40-80 hrs... not months

Structural engineering is an integral part of project compliance

Whole Building Life Cycle Assessment



New Buildings Institute

Embodied Carbon Calculation

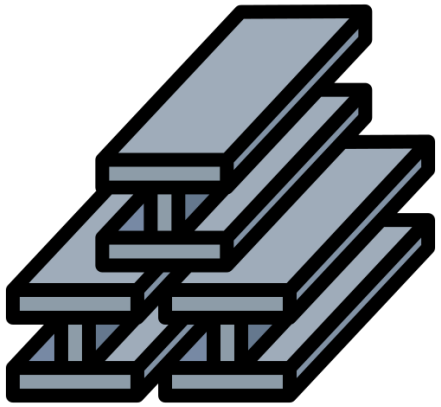
Quantity
(functional unit)

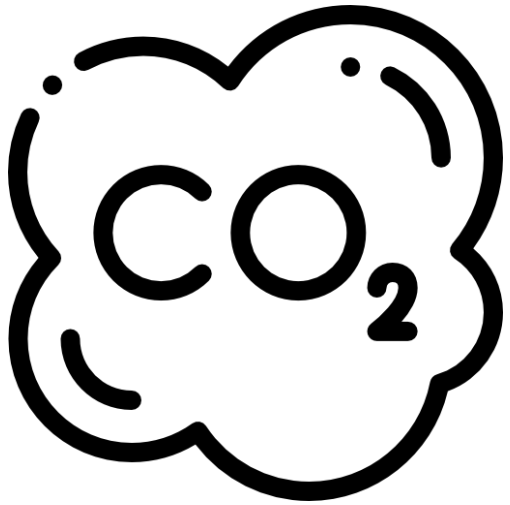
X

GWP Intensity
(kgCO2e / functional unit)

=

GWP
(kgCO2e)





100 tons of steel

X

1,000 kgCO2e per ton of steel

=

100,000 kgCO2e

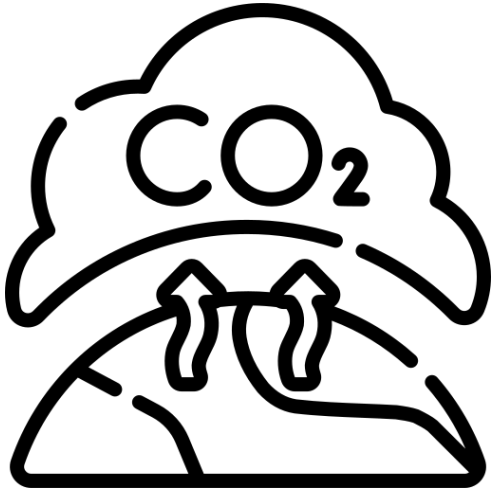
Equivalent to driving the circumference of the world ~10 times

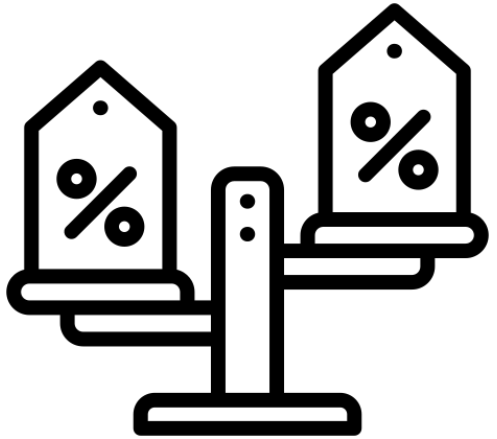
How to do an LCA

Steps of a Whole Building LCA

Step 1 | *Step 2* | *Step 3* | *Step 4*

Goal and Scope | Inventory | Impacts | Results



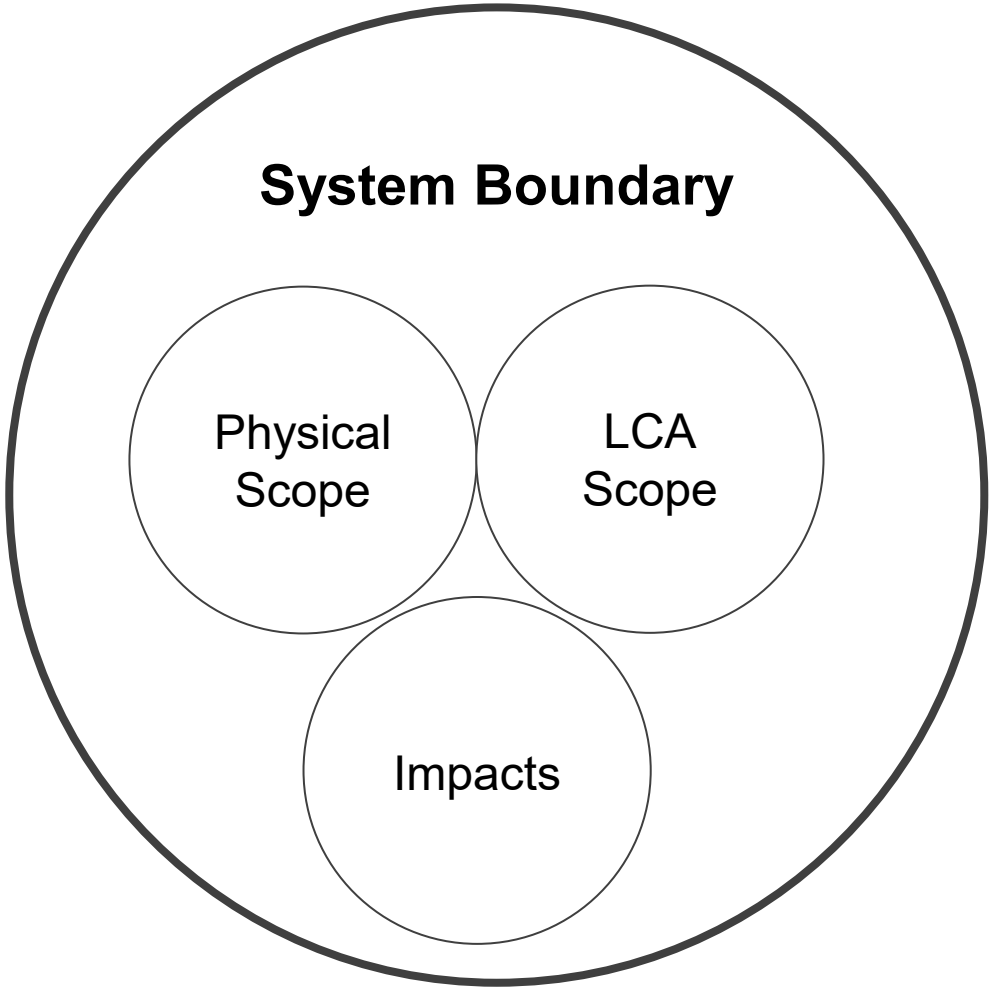


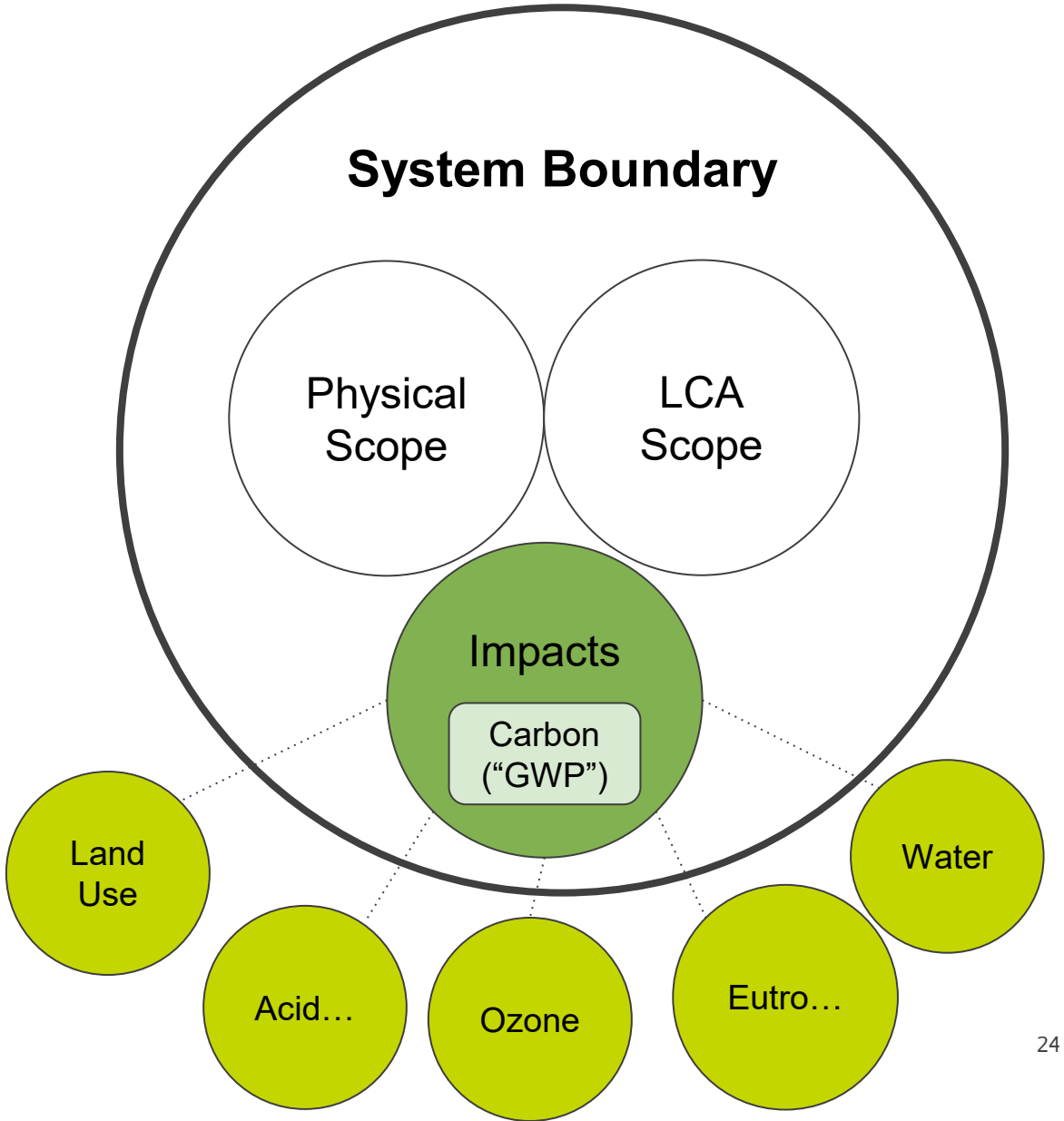
Goal: Compliance with CALGreen

- Mandatory = 10% reduction

Study Period: typically 60-years

This will be the same for every CALGreen project.




System Boundary
Physical Scope
LCA Scope
Impacts
Carbon ("GWP")
Land Use
Acid…
Ozone
Eutro…
Water

Life Cycle Assessment Scope

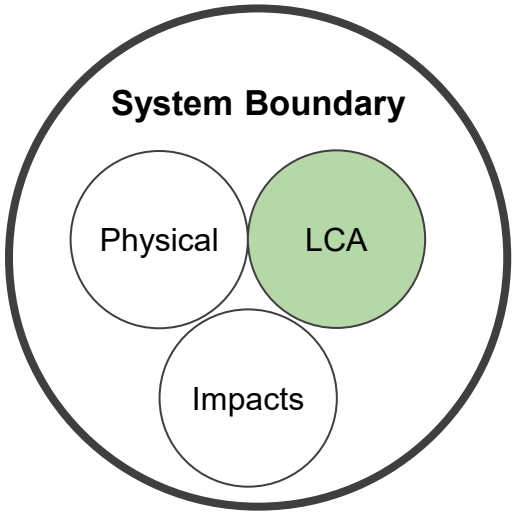
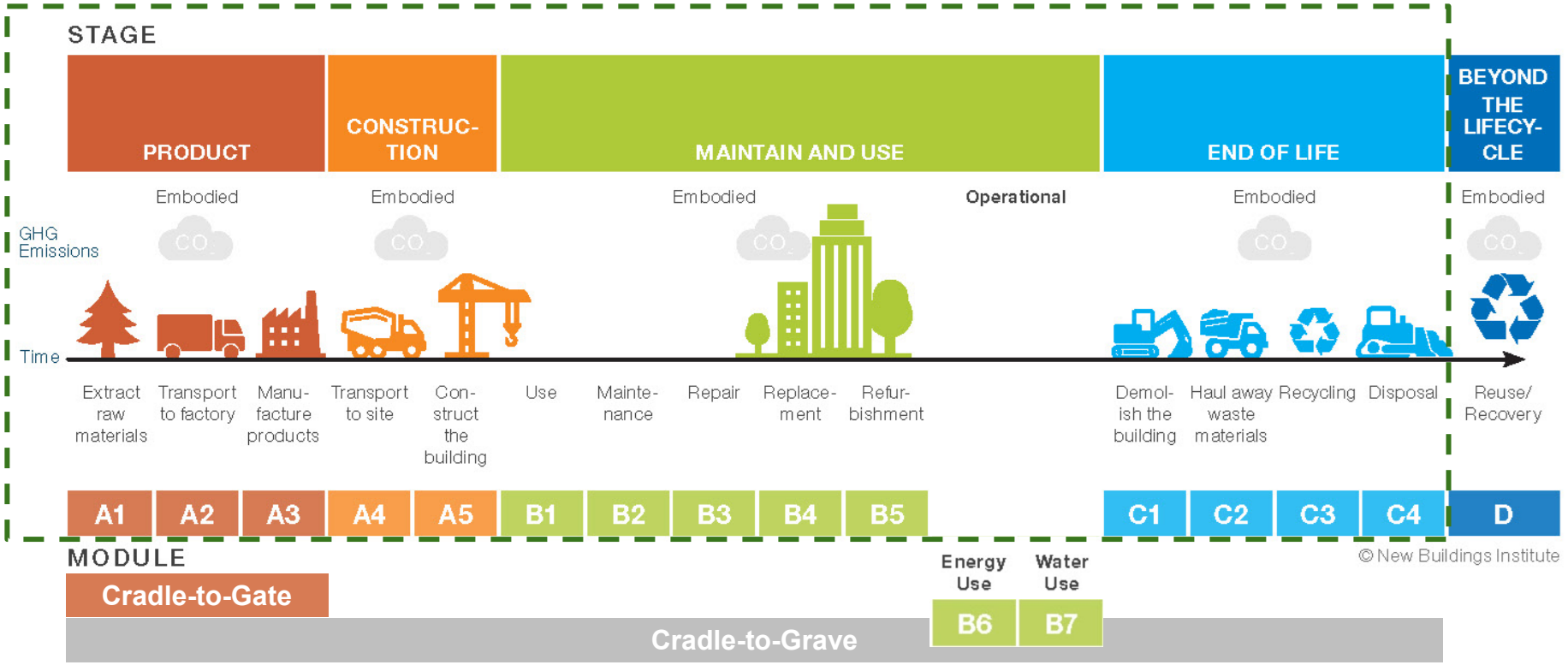


FIGURE 1: LIFECYCLE STAGES
Data source: BS EN 15978:2011

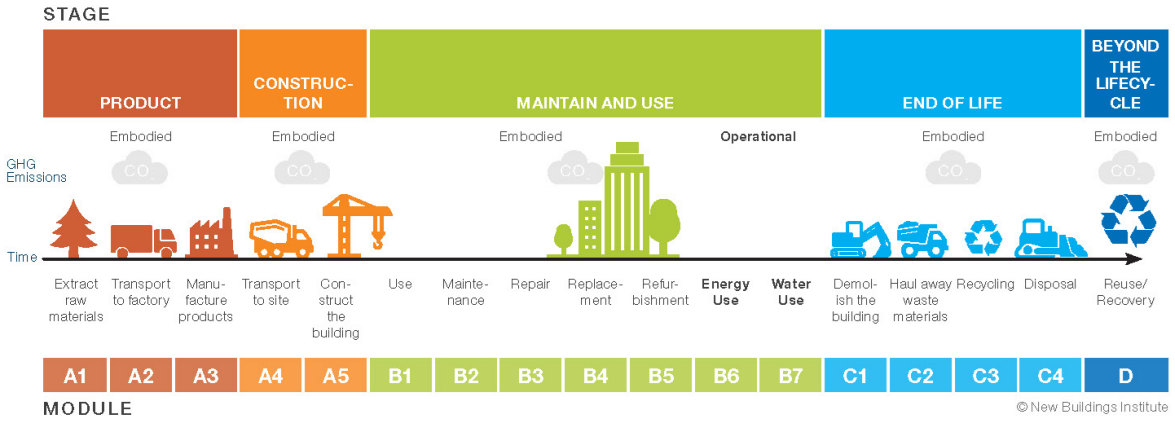
CALGreen Required Scope

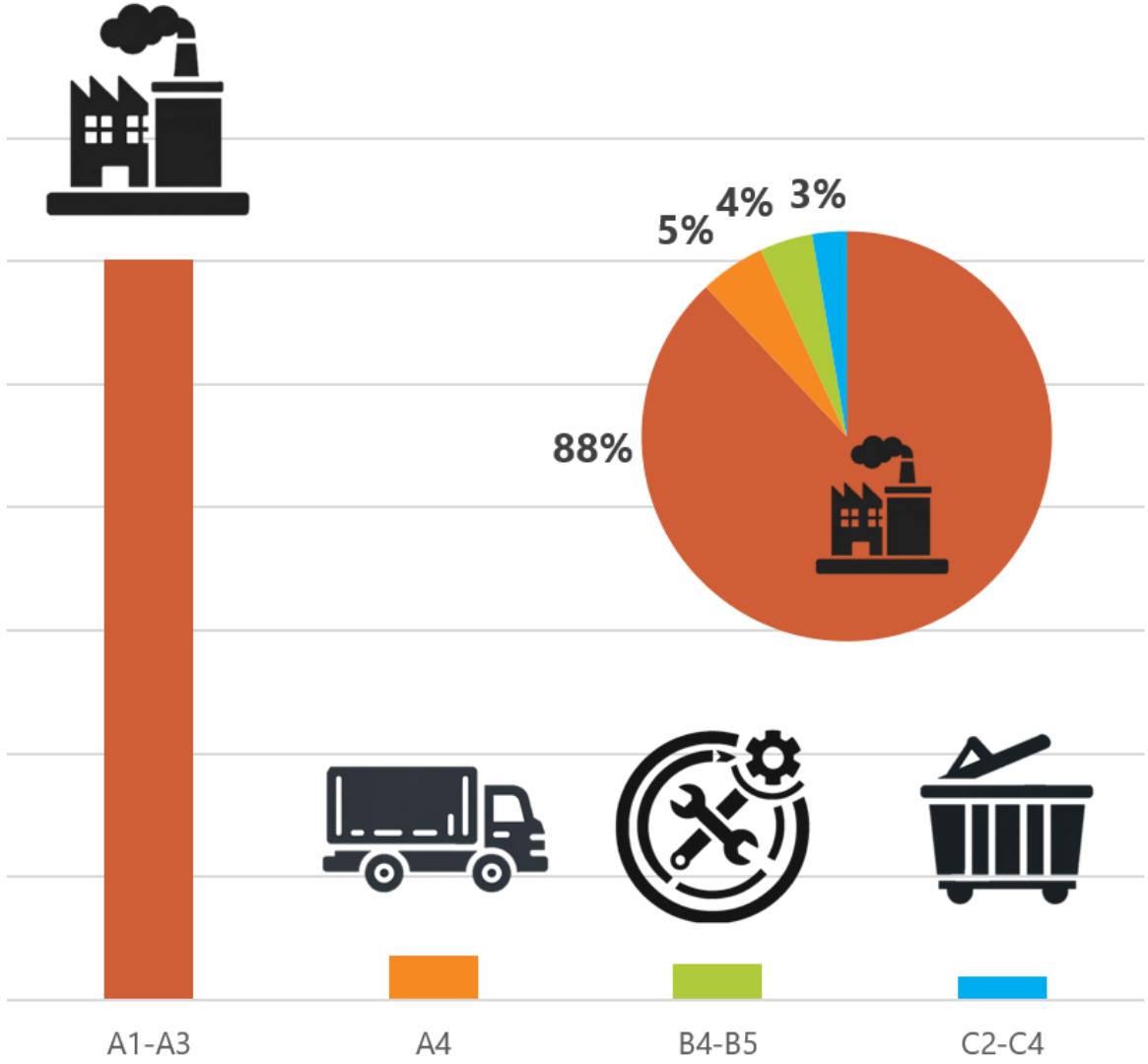


New Buildings Institute

Life Cycle Assessment Scope

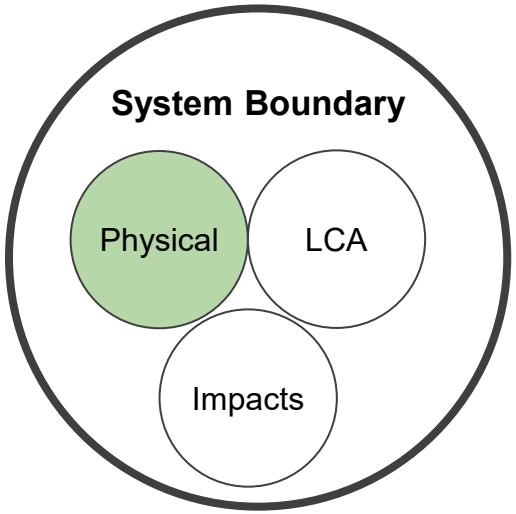
FIGURE 1: LIFECYCLE STAGES
Data source: BS EN 15978:2011





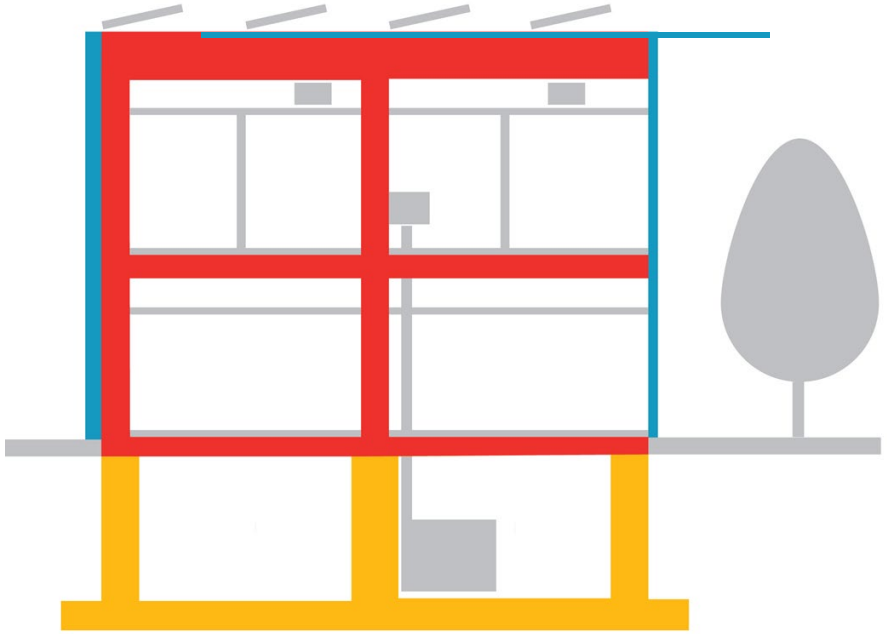
Graphic by Buro Happold

Physical Scope



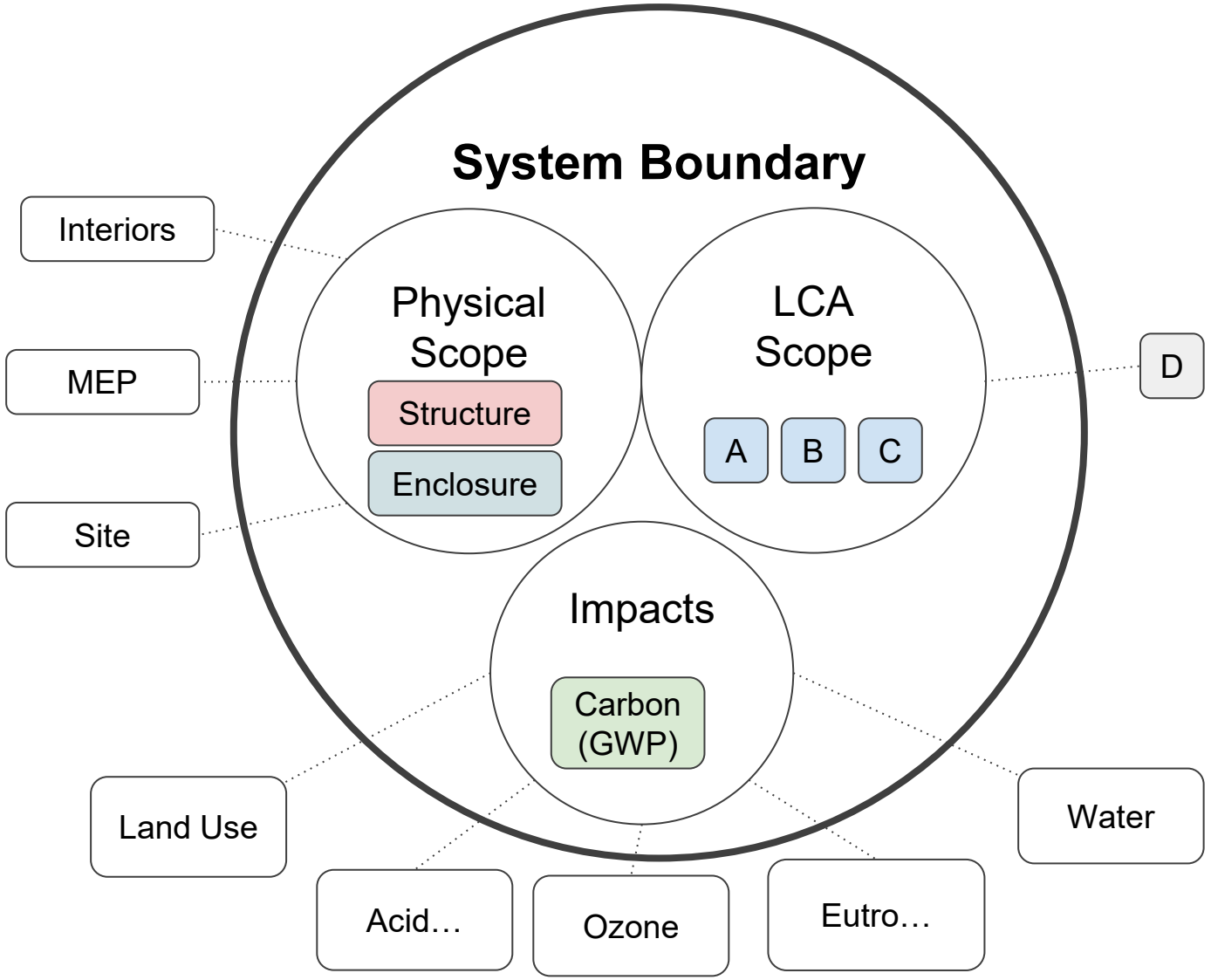
CALGreen Required Scope

Substructure
Superstructure
Enclosure

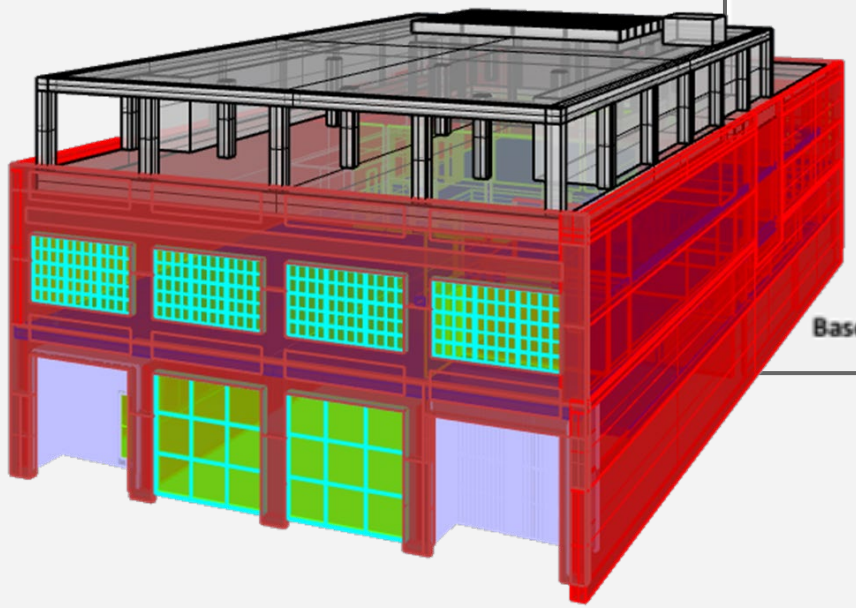


Optional:
Interiors
MEP
Site/Landscaping

Image from Atelier Ten (2024)


System Boundary
Interiors
MEP
Site
Physical Scope
Structure
Enclosure
LCA Scope
A
B
C
D
Impacts
Carbon (GWP)
Land Use
Acid…
Ozone
Eutro…
Water

Example



CALGreen Whole Building LCA Reporting Template

LCA model run	User input	Units
LCA Modeler (company) *[private]*		
Date of Model Run (mm/yyyy)		
Project Phase at Model Run		
Reference Study Period (years)		
Software and Version Used*		
Biogenic Carbon Included* (y/n)		
Model Floor Area		m2

Overall scope included (select all that apply)

- ☐ Structure (required)
- ☐ Enclosure (required)
- ☐ Interiors (optional)
- ☐ MEP (optional)
- ☐ Site/Landscaping (optional)
- ☐ FFE (optional)

Mandatory Scope Items

Please break out the following in per element emissions by life cycle in kgCO2e. Leave blank any sections that were not calculated separately from Whole Building GWP

	Upfront Carbon			Use Phase	End of Life	Total
	A1-3	A4	A5	B1-5	C1-4	
Baseline Structure GWP (kgCO2e):						
Baseline Enclosure GWP (kgCO2e):						
Baseline Whole Building GWP (kgCO2e):						

Example

CALGreen Whole Building LCA Reporting Template

LCA model run	User input	Units
LCA Modeler (company) *[private]*		
Date of Model Run (mm/yyyy)		
Project Phase at Model Run		
Reference Study Period (years)	60	
Software and Version Used*		
Biogenic Carbon Included* (y/n)		
Model Floor Area		m2

Overall scope included (select all that apply)

Structure (required)	x
Enclosure (required)	x
Interiors (optional)	
MEP (optional)	
Site/Landscaping (optional)	
FFE (optional)	

Mandatory Scope Items

Please break out the following in per element emissions by life cycle in kgCO2e. Leave blank any sections that were not calculated separately from Whole Building GWP

	Upfront Carbon			Use Phase	End of Life	Total
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Baseline Enclosure GWP (kgCO2e):						
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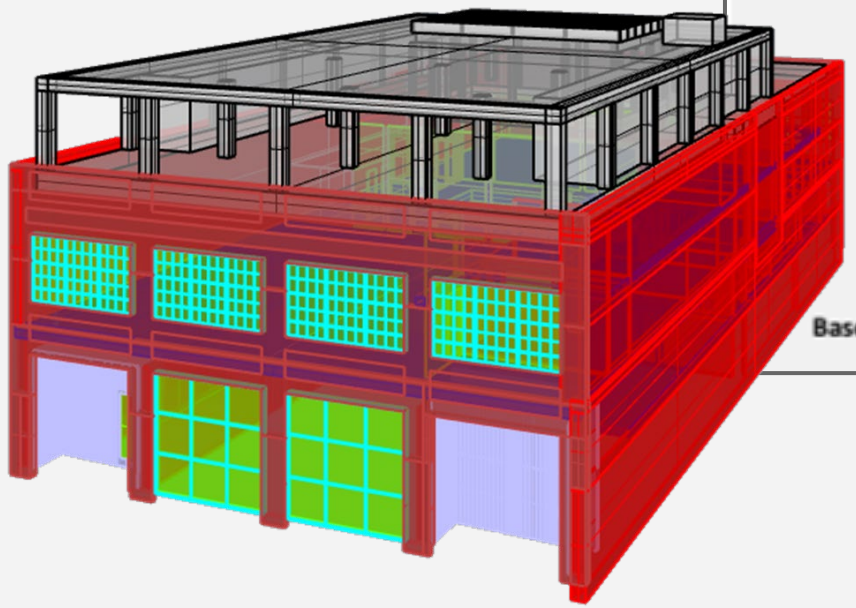


Study Period

Physical Scope

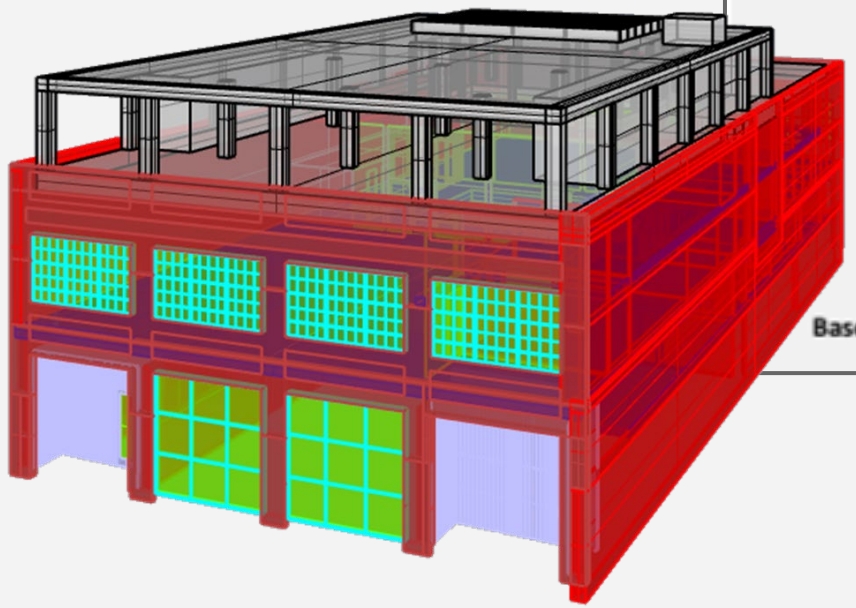
LCA Scope

Impacts

Example

Biogenic carbon storage associated with wood products shall be excluded or reported separately from embodied carbon reductions.

Model floor area is the gross floor area consistent with the architectural drawings.



CALGreen Whole Building LCA Reporting Template

LCA model run	User input	Units	Overall scope included (select all that apply)	
LCA Modeler (company) *[private]*	Atelier Ten		Structure (required)	x
Date of Model Run (mm/yyyy)	03/2024		Enclosure (required)	x
Project Phase at Model Run	DD		Interiors (optional)	
Reference Study Period (years)	60		MEP (optional)	
Software and Version Used*	One Click LCA. 0.24.1		Site/Landscaping (optional)	
Biogenic Carbon Included* (y/n)	n		FFE (optional)	
Model Floor Area	25,000	m2		

Mandatory Scope Items

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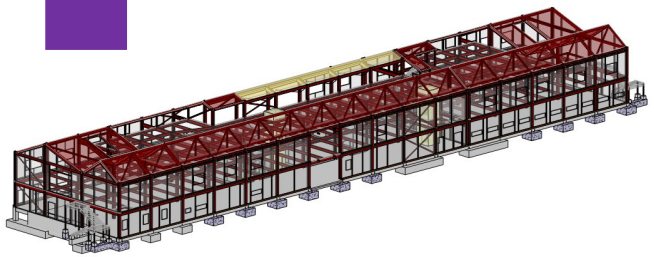
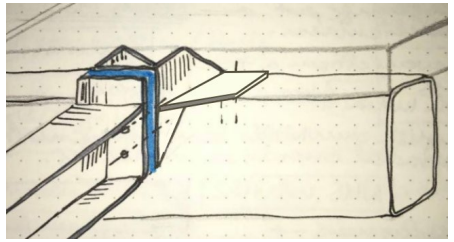
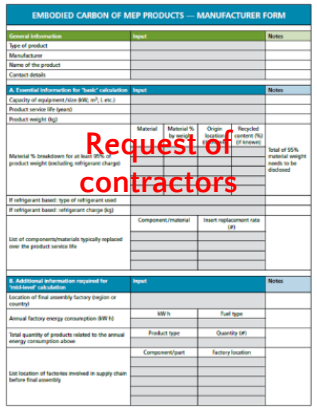
	Upfront Carbon			Use Phase	End of Life	Total
	A1-3	A4	A5	B1-5	C1-4	
Baseline Structure GWP (kgCO2e):						
Baseline Enclosure GWP (kgCO2e):						
Baseline Whole Building GWP (kgCO2e):						

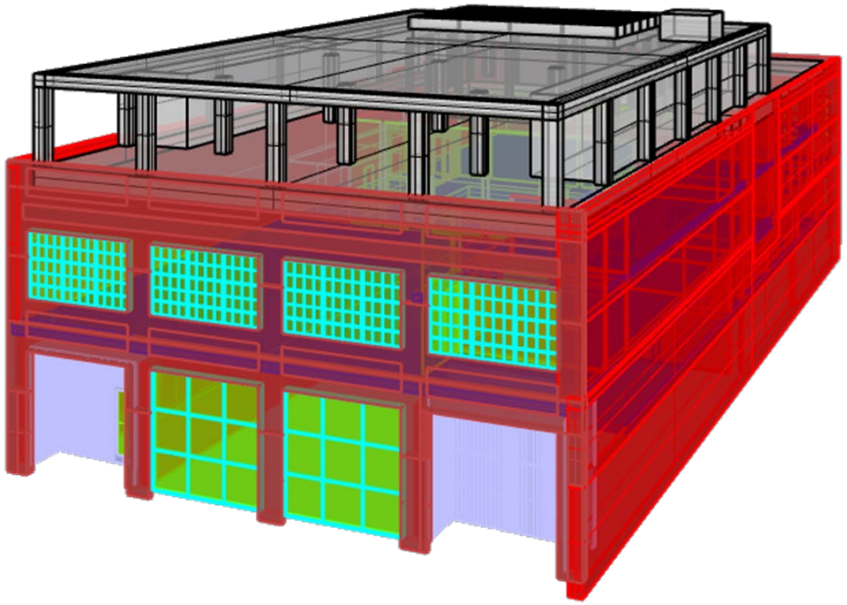
Quantity (functional unit) **x** **GWP Intensity** (kgCO2e / functional unit) **=** **GWP** (kgCO2e)

BoQ.xlsx









Toolbox
Revit plug-ins for LCA
Revit material takeoffs
Material takeoffs from Contractor
Spreadsheet calculations (supplemental)

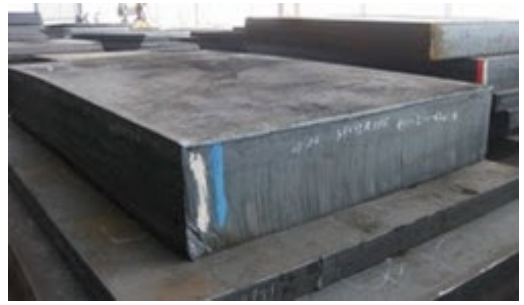
Advanced Considerations

Perform QA/QC to confirm:

- Quantities make sense (e.g. curtain wall mullions, steel deck)
- Everything is modeled (e.g. rebar, vapor barrier)

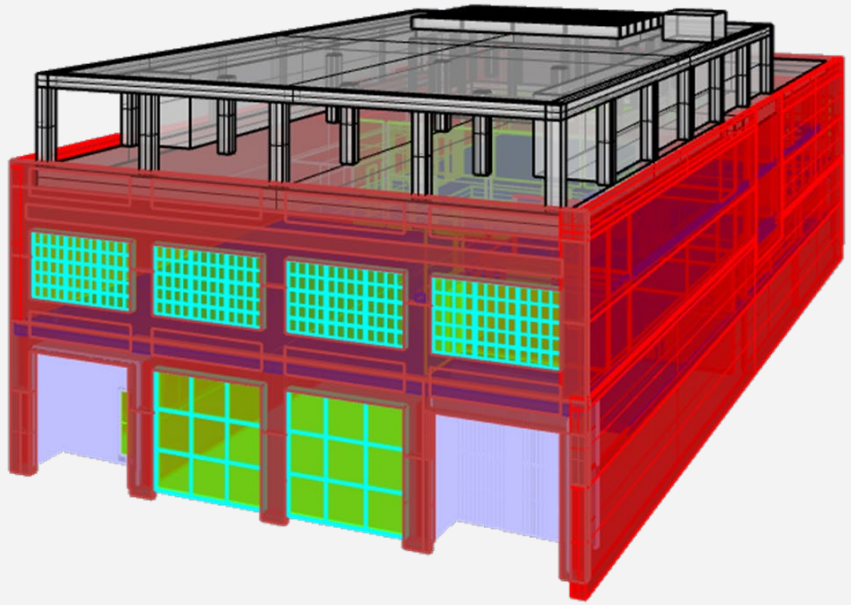
Elements contributing less than 1% need not be considered in the analysis.

3” metal deck or…



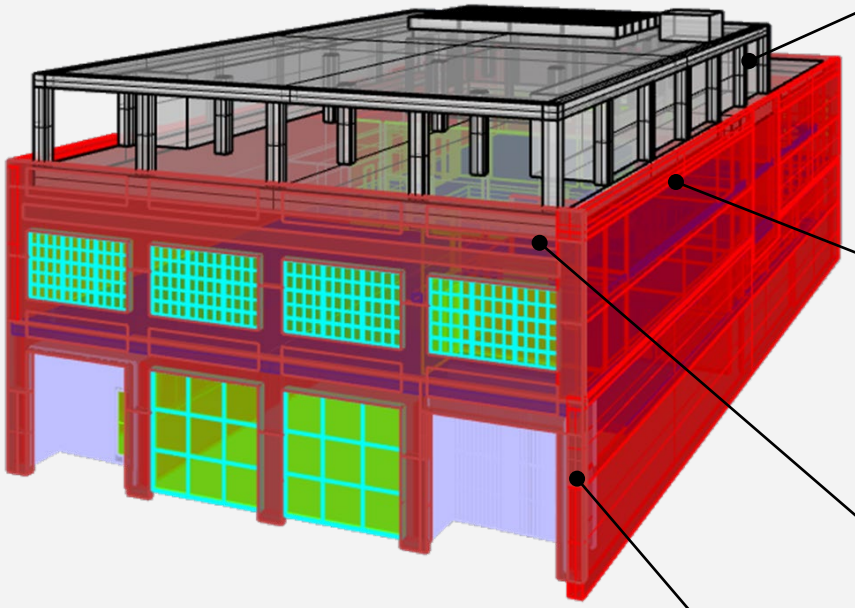
…3” metal deck?

Example



Scope	Material	Item Description	Quantity	Unit
Foundation	Concrete	Elevator pits, pile caps, piles, grade beams (Mix #1 - 5000 PSI 70% SCM)	3,800	CU YD
Foundation	Concrete	Slab on Grade (Mix #2 - 5000 PSI 40% SCM)	37,800	CU FT
Foundation	Steel and Metals	Reinforcing - Level 1, Pile caps, grade beams	1,524,854	LBS
Foundation	Steel and Metals	Reinforcing - Misc	1,628	LBS
Structure	Steel and Metals	Reinforcing - Slab on metal deck	104,265	LBS
Structure	Steel and Metals	Metal deck (18 Ga)	72,460	LBS
Structure	Steel and Metals	Misc metal deck steel support	7,000	LBS
Structure	Steel and Metals	Misc metal steel framing	606,306	LBS
Structure	Concrete	Slab on Deck (Mix #3 - 4000 PSI 25% SCM)	167	CU YD
Enclosure	Steel and Metals	Aluminum Extrusions / Curtain Wall Framing (Hydro)	585,111	LBS
Enclosure	Steel and Metals	Aluminum Plate /Weather & Shadow Box Panels (Pohl)	30,941	SQ FT
Enclosure	Steel and Metals	Aluminum Plate / Copper Anodized Finish Panels (Pohl)	74,601	SQ FT
Enclosure	Glass	Curtain Panels - Glass IGU	92,462	SQ FT
Enclosure	Concrete	Curtain Panels - Precast Concrete	9,586	CU FT
Enclosure	Insulation	Curtain panels - semi rigid insulation	9,764	CU FT
Enclosure	Gypsum, Plaster, and Cement	Roof - gypsum board	36,255	LBS
Enclosure	Insulation	Roof - rigid insulation	43,000	SQ FT
Enclosure	Steel and Metals	Roof - metal stud layer	1,533	LBS
Enclosure	Plastics, Membranes, and Roofing	Roof - TPO roof	43,000	SQ FT
Enclosure	Steel and Metals	Exterior doors - anodized aluminum	750	LBS
Enclosure	Glass	Exterior doors - glass	2,040	SQ FT
Structure	Concrete	Concrete Columns (6000 PSI)	511	CU YD
Structure	Concrete	PT Slab (6000 PSI)	4,600	CU YD
Structure	Concrete	Shear walls (6000 PSI)	1,778	CU YD
Structure	Concrete	Slab on Metal Deck (4000 PSI)	133	CU YD
Structure	Steel and Metals	PT Slab Reinf.	2,210,760	LBS
Structure	Steel and Metals	Shear Wall Reinf.	2,373,630	LBS
Structure	Steel and Metals	Slab on Metal Deck Reinforcing	7,200	LBS
Structure	Steel and Metals	Misc Reinforcing	773,766	LBS

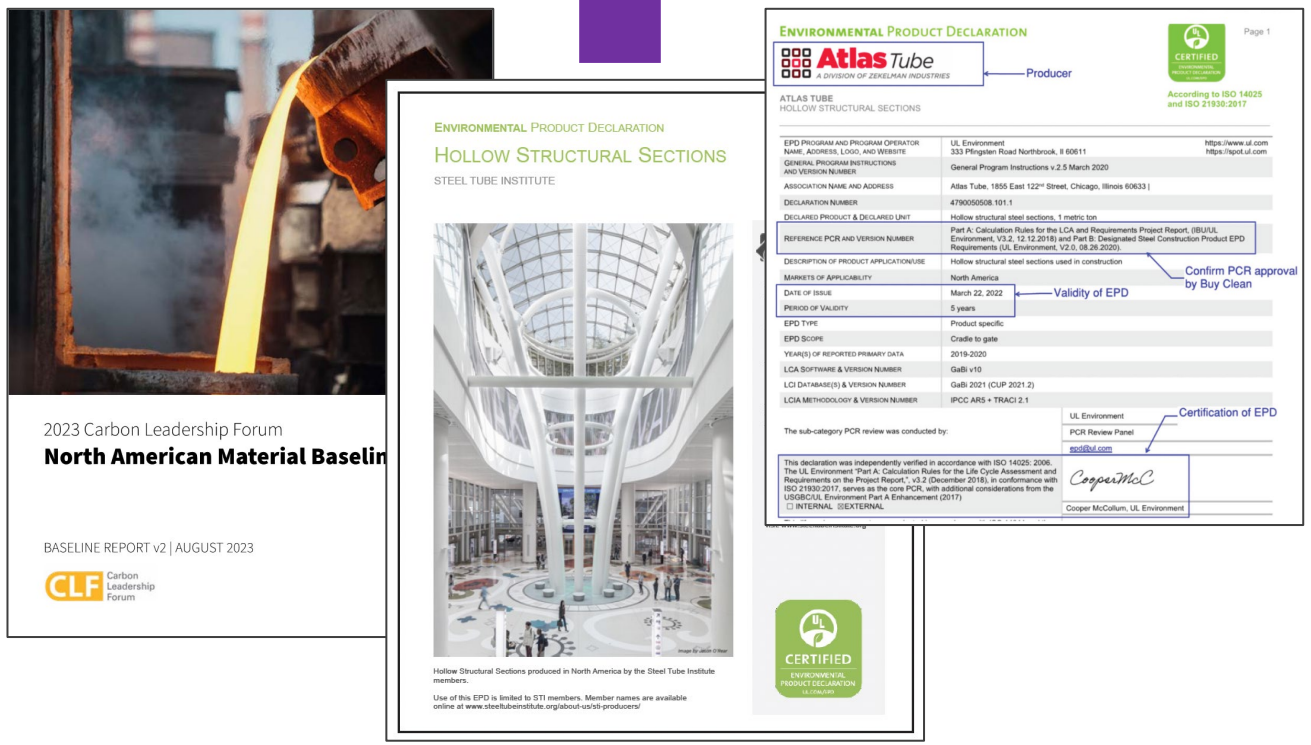
Example



Quantity	
1,000 CY	Concrete 5000 psi
1,000 CY	Concrete 6000 psi
100 tons	Fabricated hot-rolled steel sections
100,000 ft²	Mineral wool insulation

**generic numbers for representation only*

Quantity (functional unit) **x** **GWP Intensity** (kgCO2e / functional unit) **=** **GWP** (kgCO2e)



Environmental Product Declarations

Food Nutritional Labels

Health Impacts

Nutrition Facts

Serving Size 2/3 cup (55g)
Servings Per Container About 8

Amount Per Serving

Calories 230 Calories from Fat 40

	% Daily Value*
Total Fat 8g	**12%**
Saturated Fat 1g	**5%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 160mg	**7%**
Total Carbohydrate 37g	**12%**
Dietary Fiber 4g	**16%**
Sugars 1g	
Protein 3g	
Vitamin A	10%
Vitamin C	8%
Calcium	20%
Iron	45%

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

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Product EPDs

Environmental Impacts

Environmental Impacts

Declared Product:
Mix 4F05C5Q1 • Bode Plant
EF50 Gen Use 4" line w/c .50
Compressive strength: 4000 psi at 28 days

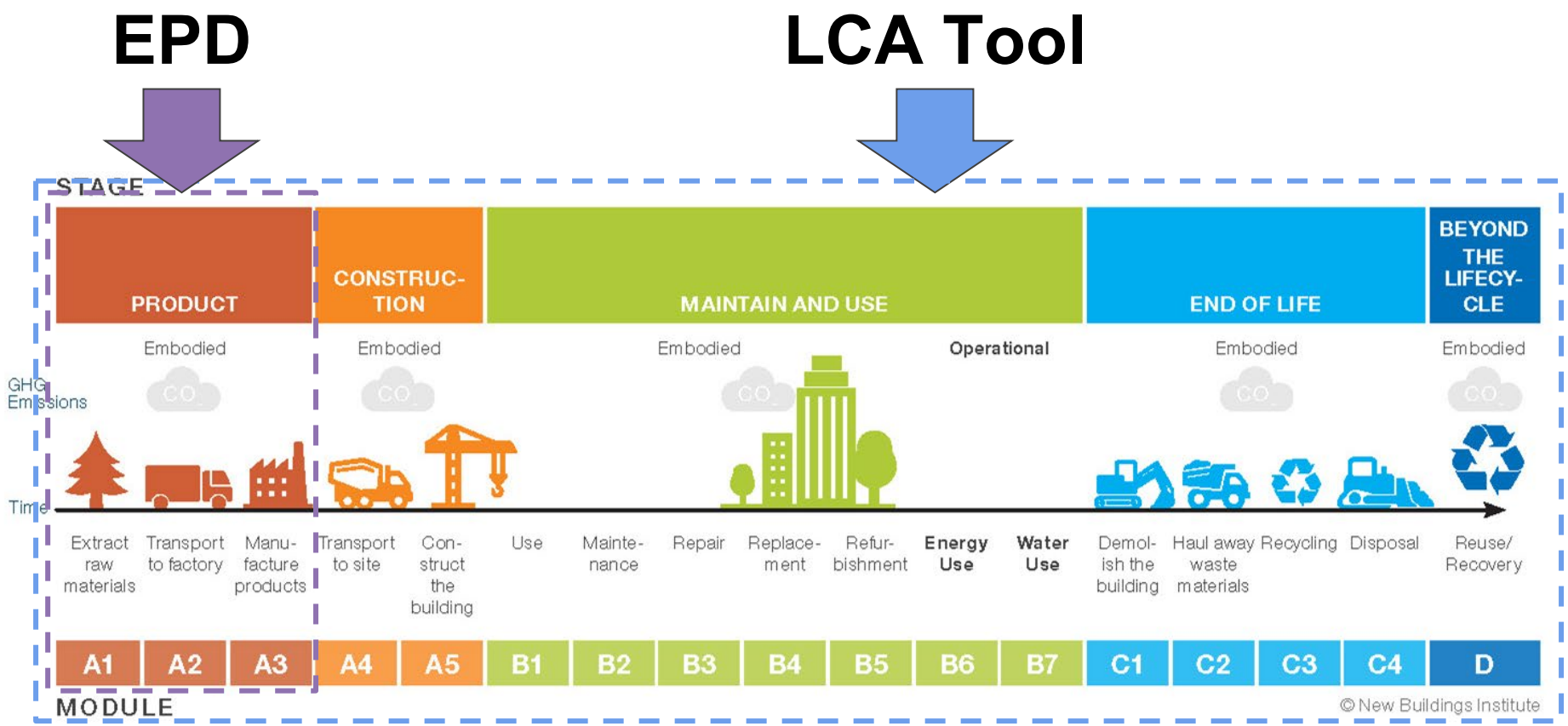
Declared Unit: 1 m^3 of concrete

Global Warming Potential (kg CO_2-eq)	272
Ozone Depletion Potential (kg CFC-11-eq)	7.4E-6
Acidification Potential (kg SO_2-eq)	2.06
Eutrophication Potential (kg N-eq)	0.37
Photochemical Smog Creation Potential (kg O_3-eq)	53.8
Total Primary Energy Consumption (MJ)	2,577
Nonrenewable (MJ)	2,504
Renewable (MJ)	70.7
Total Concrete Water Consumption (m_3)	3.65
Batching Water (m_3)	0.09
Washing Water (m_3)	8.8E-3
Nonrenewable Material Resource Consumption (kg)	2,494
Renewable Material Resource Consumption (kg)	1.57
Hazardous Waste Production (kg)	0.01
Nonhazardous Waste Production (kg)	2.76

Product Components: crushed aggregate (ASTM C33), Portland cement (ASTM C150), slag cement (ASTM C989), fly ash (ASTM C618), admixture (ASTM C494), batch water (ASTM C1602)

- EPDs are LCAs of Products
- Third Party Verified
- ISO 14044 & EN 15804
- Avoids Greenwashing
- EPDs can be Industry Average or Manufacturer / Plant / Product Specific

Life Cycle Scope



New Buildings Institute

Environmental Product Declarations (EPDs)

Industry Average

ENVIRONMENTAL PRODUCT DECLARATION

HOLLOW STRUCTURAL SECTIONS

STEEL TUBE INSTITUTE

Hollow Structural Sections produced in North America by the Steel Tube Institute members.

Use of this EPD is limited to STI members. Member names are available online at www.steeltubeinstitute.org/about-us/sti-producers/

STEEL TUBE INSTITUTE

The Steel Tube Institute was formed in 1930 when a group of manufacturers joined forces to promote and market steel tubing. Their goal was to mount a cooperative effort that would improve manufacturing techniques and inform customers about their products' utility and versatility. This remains the basic motivation for the Institute's efforts today. Using that strong history as a foundation, STI is constantly evolving to best meet the needs of a sophisticated and competitive marketplace. The organization is dedicated to the betterment of the steel industry and to the advancement of its member companies.

For more information, please visit: www.steeltubeinstitute.org

CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION

Baseline Model

Product-Specific

ENVIRONMENTAL PRODUCT DECLARATION

Page 1

Atlas Tube — A DIVISION OF ZEKELMAN INDUSTRIES ← Producer

CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION

ATLAS TUBE
HOLLOW STRUCTURAL SECTIONS

According to ISO 14025 and ISO 21930:2017

EPD PROGRAM AND PROGRAM OPERATOR NAME, ADDRESS, LOGO, AND WEBSITE	UL Environment 333 Pfingsten Road Northbrook, Il 60611	https://www.ul.com https://spot.ul.com
GENERAL PROGRAM INSTRUCTIONS AND VERSION NUMBER	General Program Instructions v.2.5 March 2020	
ASSOCIATION NAME AND ADDRESS	Atlas Tube, 1855 East 122nd Street, Chicago, Illinois 60633 |	
DECLARATION NUMBER	4790050508.101.1	
DECLARED PRODUCT & DECLARED UNIT	Hollow structural steel sections, 1 metric ton	
REFERENCE PCR AND VERSION NUMBER	Part A: Calculation Rules for the LCA and Requirements Project Report, (IBU/UL Environment, V3.2, 12.12.2018) and Part B: Designated Steel Construction Product EPD Requirements (UL Environment, V2.0, 08.26.2020).	
DESCRIPTION OF PRODUCT APPLICATION/USE	Hollow structural steel sections used in construction	
MARKETS OF APPLICABILITY	North America	
DATE OF ISSUE	March 22, 2022	
PERIOD OF VALIDITY	5 years	
EPD TYPE	Product specific	
EPD SCOPE	Cradle to gate	
YEAR(S) OF REPORTED PRIMARY DATA	2019-2020	
LCA SOFTWARE & VERSION NUMBER	GaBi v10	
LCI DATABASE(S) & VERSION NUMBER	GaBi 2021 (CUP 2021.2)	
LCIA METHODOLOGY & VERSION NUMBER	IPCC AR5 + TRACI 2.1	

Confirm PCR approval by Buy Clean

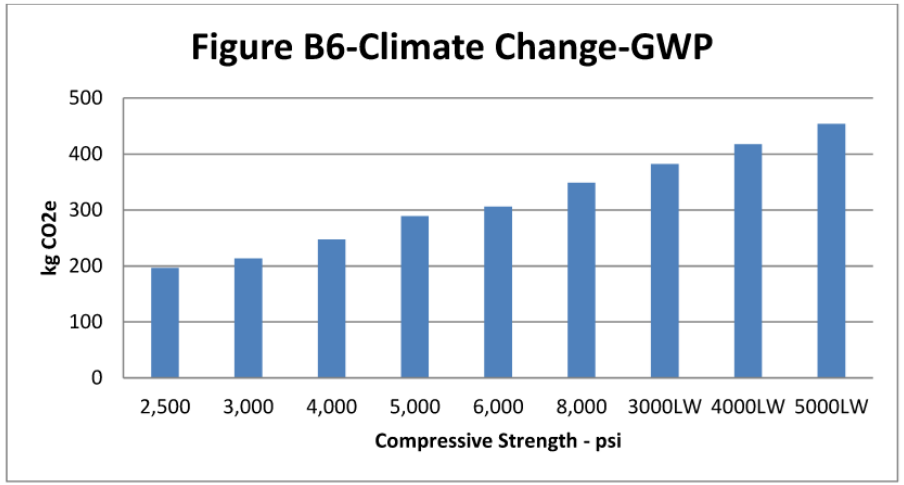
Validity of EPD

The sub-category PCR review was conducted by:	UL Environment PCR Review Panel epd@ul.com	Certification of EPD
This declaration was independently verified in accordance with ISO 14025: 2006. The UL Environment "Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Project Report,", v3.2 (December 2018), in conformance with ISO 21930:2017, serves as the core PCR, with additional considerations from the USGBC/UL Environment Part A Enhancement (2017) ☐ INTERNAL ☒EXTERNAL	CooperMcC Cooper McCollum, UL Environment	

Steel Tube Institute

NRMCA LCA Report 2022

51 Plants



D-6: Pacific Southwest Region

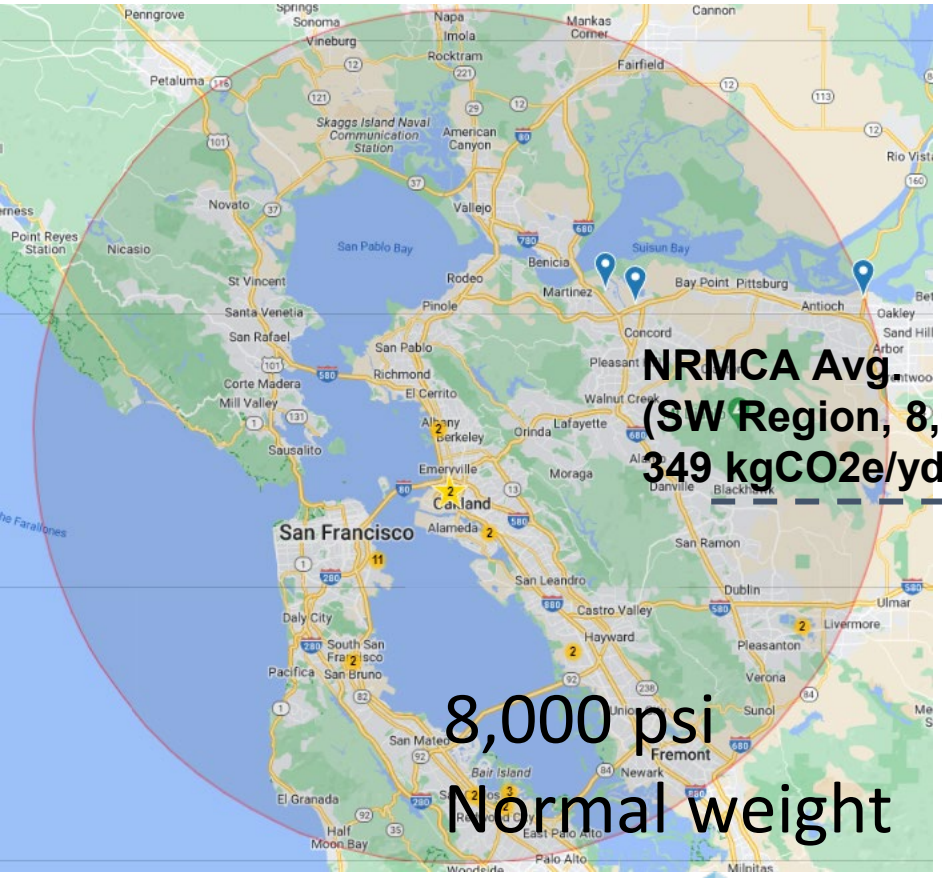
Table A6-Pacific Southwest Production Data Summary		
Number of Plants	51	
% Transit Mix Plants	66%	
% Central Mix Plants	34%	
% Batch Waste	1.03%	
	yd3	m3
Average Production	97,308	74,397
Total Production	4,962,694	3,794,251
Minimum Production	7,561	5,781
Maximum Production	403,143	308,225

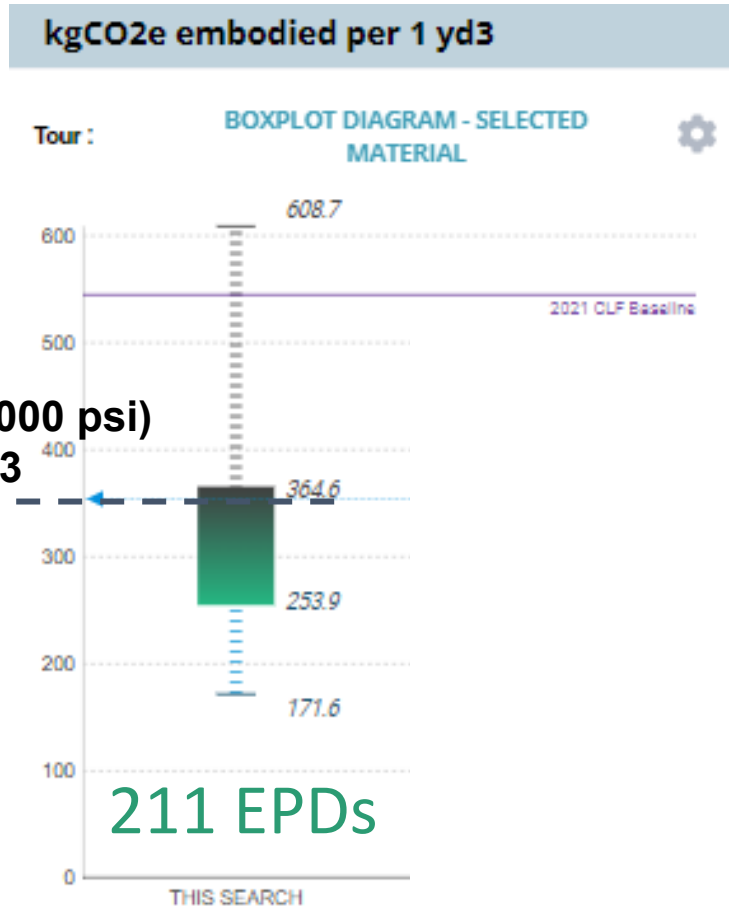
Table E6-Pacific Southwest LCA Results (per cubic yard)										
Strength	psi @28 days	2,500	3,000	4,000	5,000	6,000	8,000	3000LW	4000LW	5000LW
Core Mandatory Impact Indicator										
GWP	kg CO2e	196.51	213.46	247.32	288.90	306.44	348.96	382.19	417.50	453.93

8,000psi Average: 349 kgCO2/CY

NRMCA (2022)

Product Specific Example





CENTRAL CONCRETE SUPPLY COMPANY

ENVIRONMENTAL IMPACTS

Declared Product:
Mix 99A112P3 • Oakland Plant
Description: HS 900 LB 1/2" 30SLAG 7-9"
Compressive strength: 8000 PSI at 28 days

Declared Unit: 1 m^3 of concrete (1 cyd)

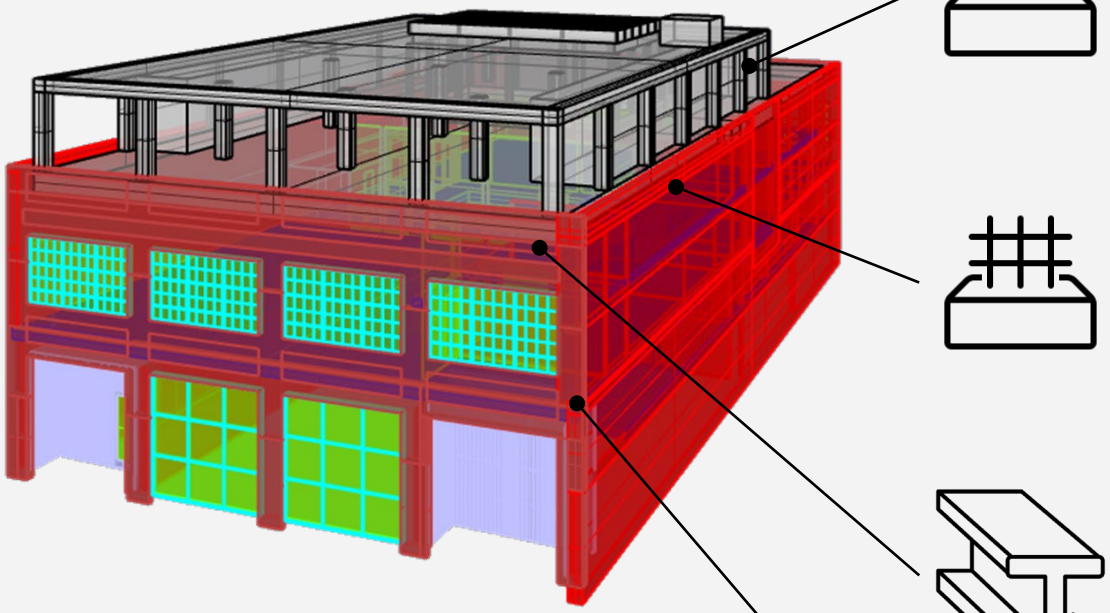
Global Warming Potential (kg CO_2-eq)	**422 (322)**
Ozone Depletion Potential (kg CFC-11-eq)	**9.46E-6 (7.23E-6)**
Acidification Potential (kg SO_2-eq)	**2.44 (1.87)**
Eutrophication Potential (kg N-eq)	**0.20 (0.15)**
Photochemical Ozone Creation Potential (kg O_3-eq)	**54.1 (41.4)**
Abiotic Depletion, non-fossil (kg Sb-eq)	**1.29E-4 (9.83E-5)**
Abiotic Depletion, fossil (MJ)	**2,778 (2,124)**
Total Waste Disposed (kg)	**0.82 (0.63)**
Consumption of Freshwater (m^3)	**0.81 (0.62)**

Product Components: natural aggregate (ASTM C33), Portland cement (ASTM C150), slag cement (ASTM C989), admixture (ASTM C494), batch water (ASTM C1602)

Additional detail and impacts are reported on page three of this EPD

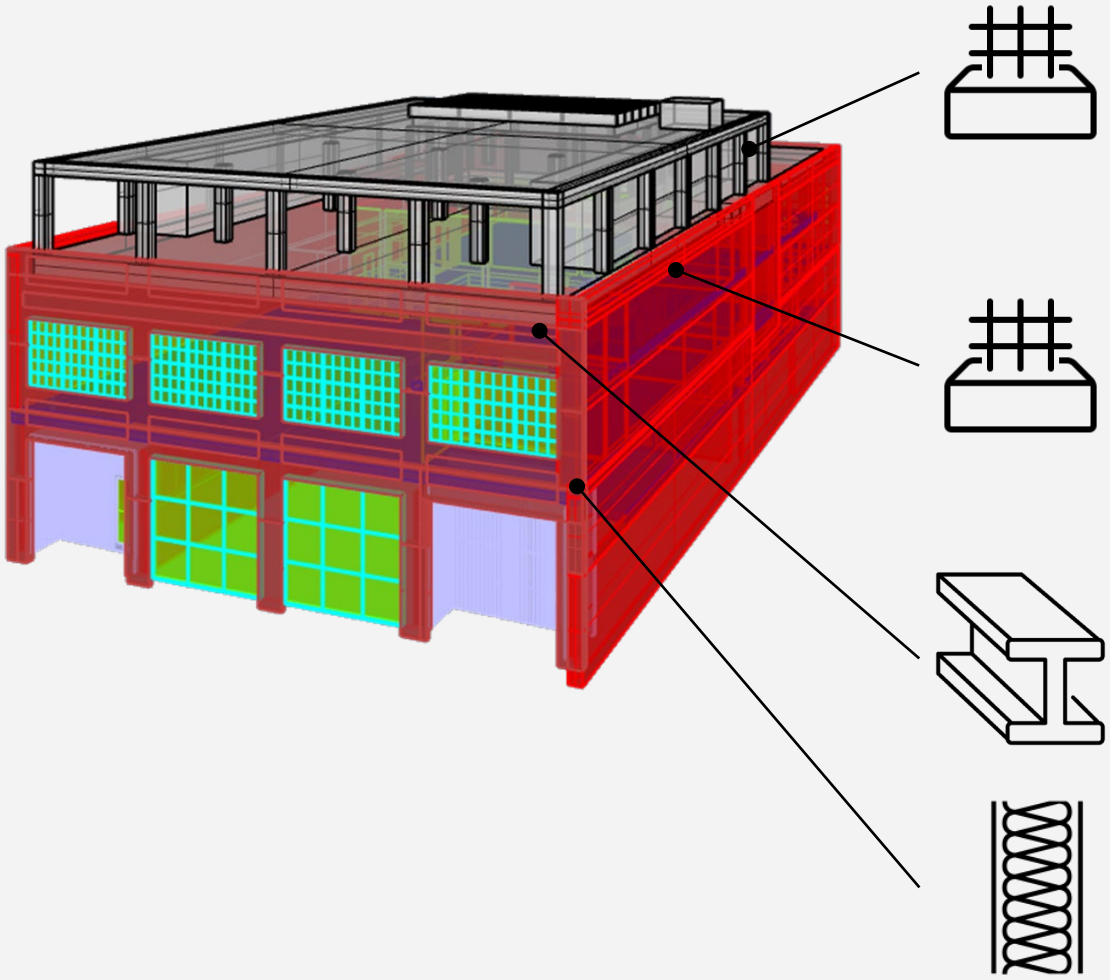
EC3

Example



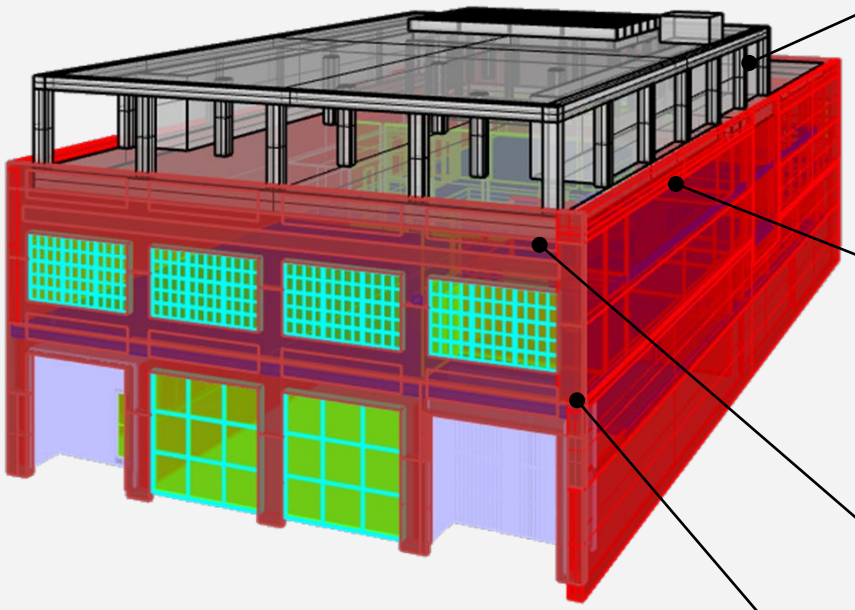
Quantity	GWP Intensity
1,000 CY Concrete 5000 psi	**401 $kgCO_2e/m^3$** NRMCA Pacific Southwest Regional Baseline
1,000 CY Concrete 6000 psi	**378 $kgCO_2e/m^3$** NRMCA Pacific Southwest Regional Baseline
100 tons Fabricated hot-rolled steel sections	**1,220 $kgCO_2e$/ton** AISC (2021) Fabricated hot-rolled sections
100,000 ft^2 Mineral wool insulation	**3.33 $kgCO_2e/m^2$ at RSI-1** NAIMA (2018) Mineral wool board

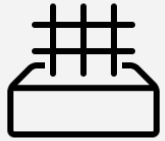
Example



Quantity		GWP Intensity		GWP
1,000 CY Concrete 5000 psi	x	**401 $kgCO_2e/m^3$**	→ **Unit conversion**	**306,586 $kgCO_2e$**
1,000 CY Concrete 6000 psi	x	**378 $kgCO_2e/m^3$**	→ **Unit conversion**	**289,002 $kgCO_2e$**
100 tons Fabricated hot-rolled steel sections	x	**1,220 $kgCO_2e$/ton**	→	**122,000 $kgCO_2e$**
100,000 ft^2 Mineral wool insulation	x	**3.33 $kgCO_2e/m^2$ at RSI-1**	→ **Unit conversion**	**41,435 $kgCO_2e$** Assuming R-7.6 (RSI-1.34)

Example



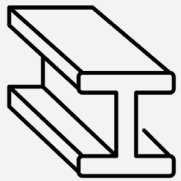


1,000 CY
Concrete 5000 psi

401 kgCO_2e/m^3

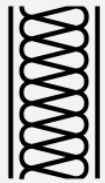
1,000 CY
Concrete 6000 psi

378 kgCO_2e/m^3



100 tons
Fabricated hot-rolled steel sections

1,220 kgCO_2e/ton



100,000 ft^2
Mineral wool insulation

3.33 kgCO_2e/m^2 at RSI-1

Sum
717,588 kgCO_2e

Baseline Structure GWP

Sum
41,435 kgCO_2e

Baseline Enclosure GWP

Example

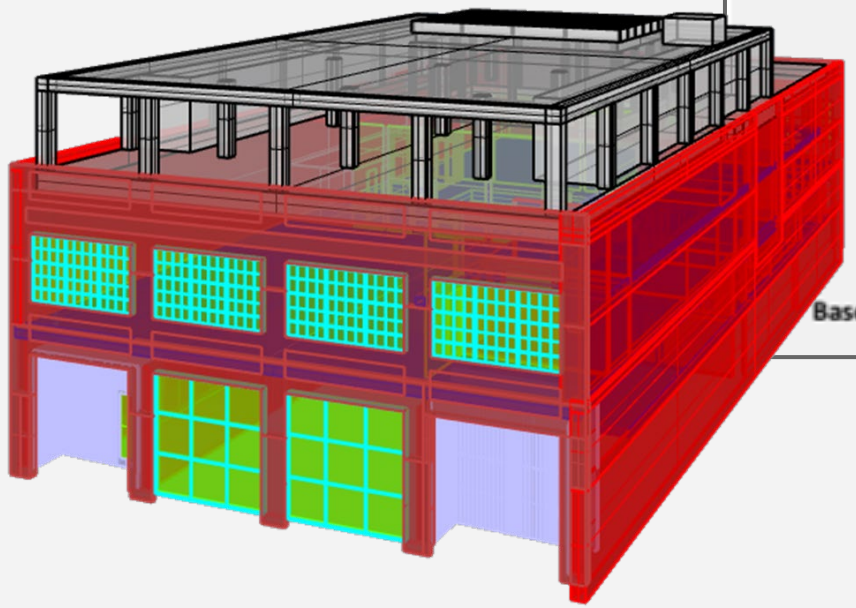
CALGreen Whole Building LCA Reporting Template

LCA model run	User input	Units	Overall scope included (select all that apply)	
LCA Modeler (company) *[private]*	Atelier Ten		Structure (required)	x
Date of Model Run (mm/yyyy)	03/2024		Enclosure (required)	x
Project Phase at Model Run	DD		Interiors (optional)	
Reference Study Period (years)	60		MEP (optional)	
Software and Version Used*	One Click LCA. 0.24.1		Site/Landscaping (optional)	
Biogenic Carbon Included* (y/n)	n		FFE (optional)	
Model Floor Area	25,000	m2		

Mandatory Scope Items

Please break out the following in per element emissions by life cycle in kgCO2e. Leave blank any sections that were not calculated separately from Whole Building GWP

	Upfront Carbon			Use Phase	End of Life	Total
	A1-3	A4	A5	B1-5	C1-4	
Baseline Structure GWP (kgCO2e):	717,588					
Baseline Enclosure GWP (kgCO2e):	41,435					
Baseline Whole Building GWP (kgCO2e):	759,023					



* based on simplified and limited example calculation

LCA tool will output values for all stages

Quantity
(functional unit)

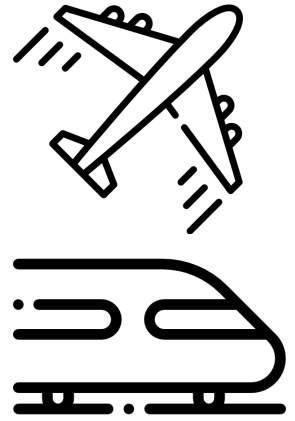
x

GWP Intensity
(kgCO2e / functional unit)

=

GWP
(kgCO2e)

- Transportation
- Waste
- End of Life

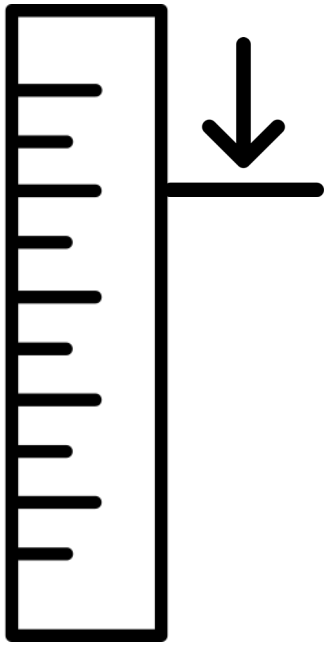


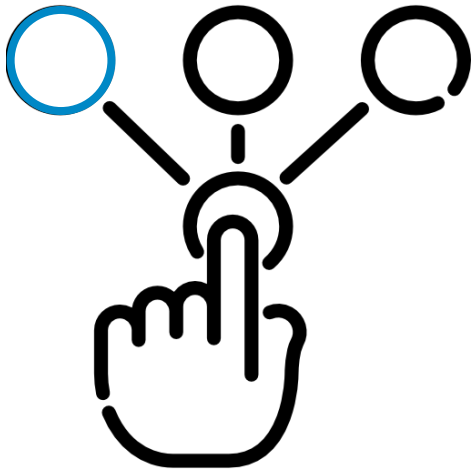
How to Achieve a 10% Reduction

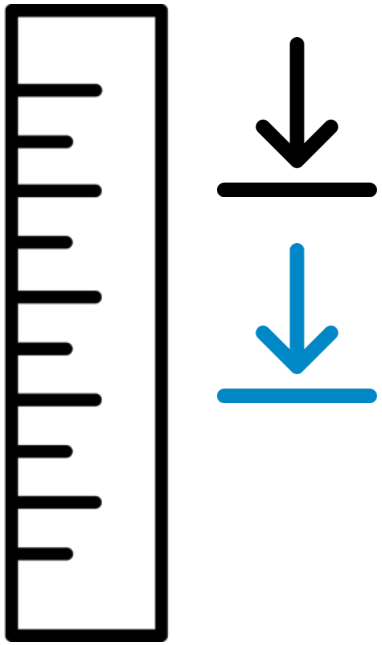
How to Get 10% Reduction

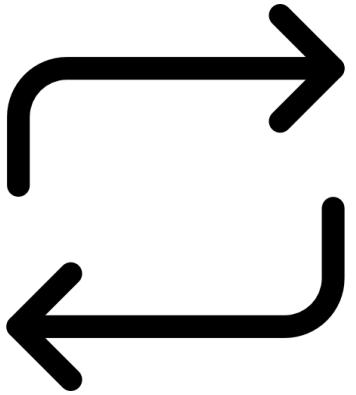
Step 1 | *Step 2* | *Step 3* | *Step 4*

Set a Baseline → Evaluate Reduction Measures → Run Proposed LCA → Repeat







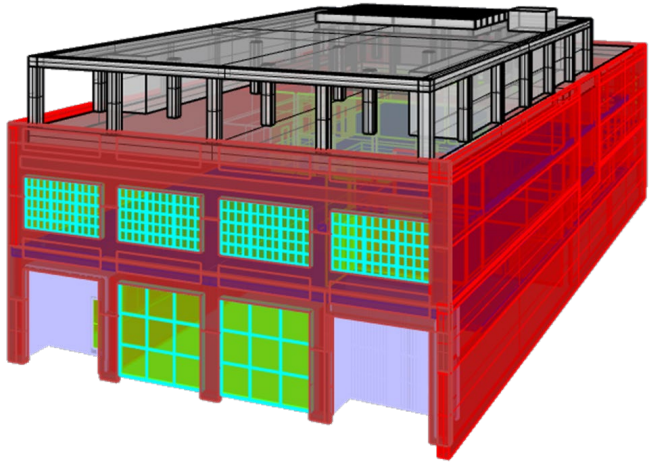


CALGreen

Project of comparable:

- Size (Gross floor area)
- Function (e.g. office)
- Complexity
- Type of Construction
- Material Specification
- Location

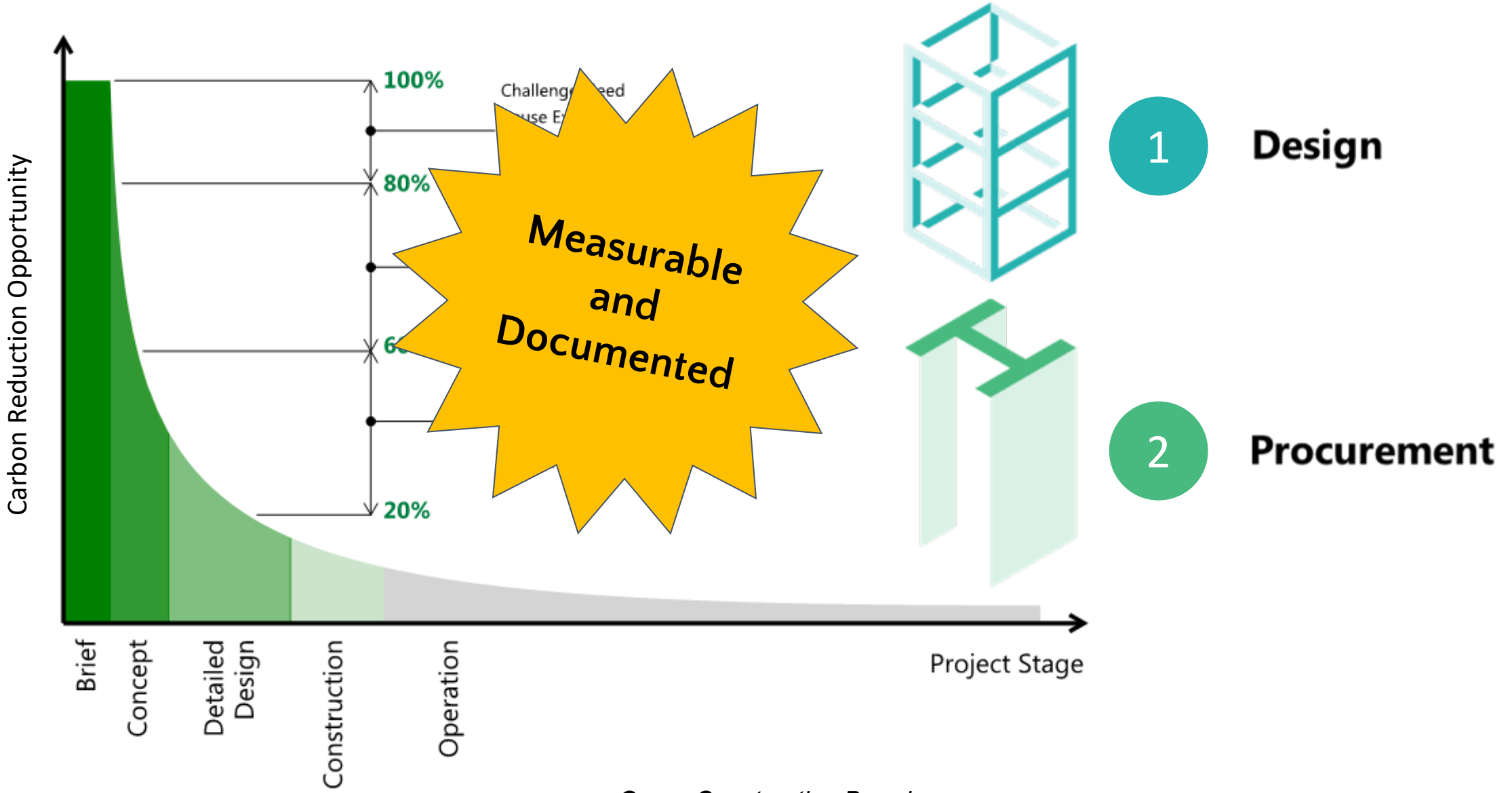
Baseline "Conventional"



Material Quantity ➢ Conventional design (Business as usual)

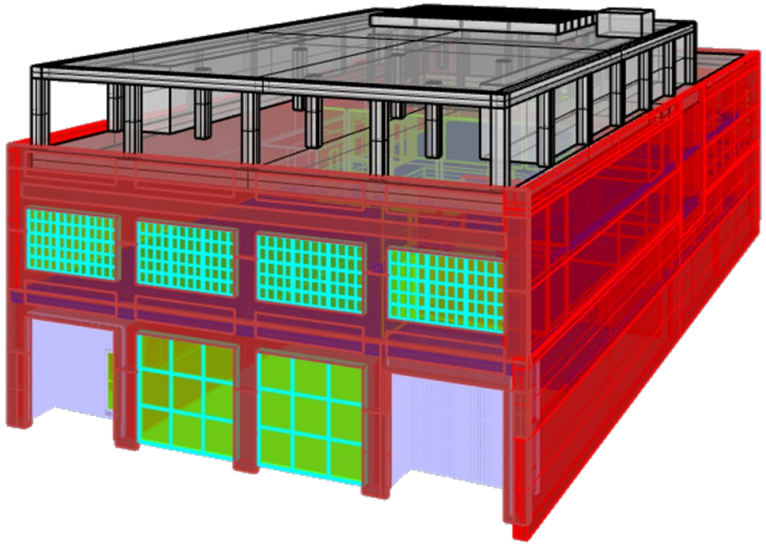
GWP Factors ➢ Industry Average EPDs

Set a Baseline | Evaluate Reduction Measures | Run Proposed LCA | Repeat



Green Construction Board

Baseline Model – Hot Spot Analysis



What are the biggest contributors to my emissions?

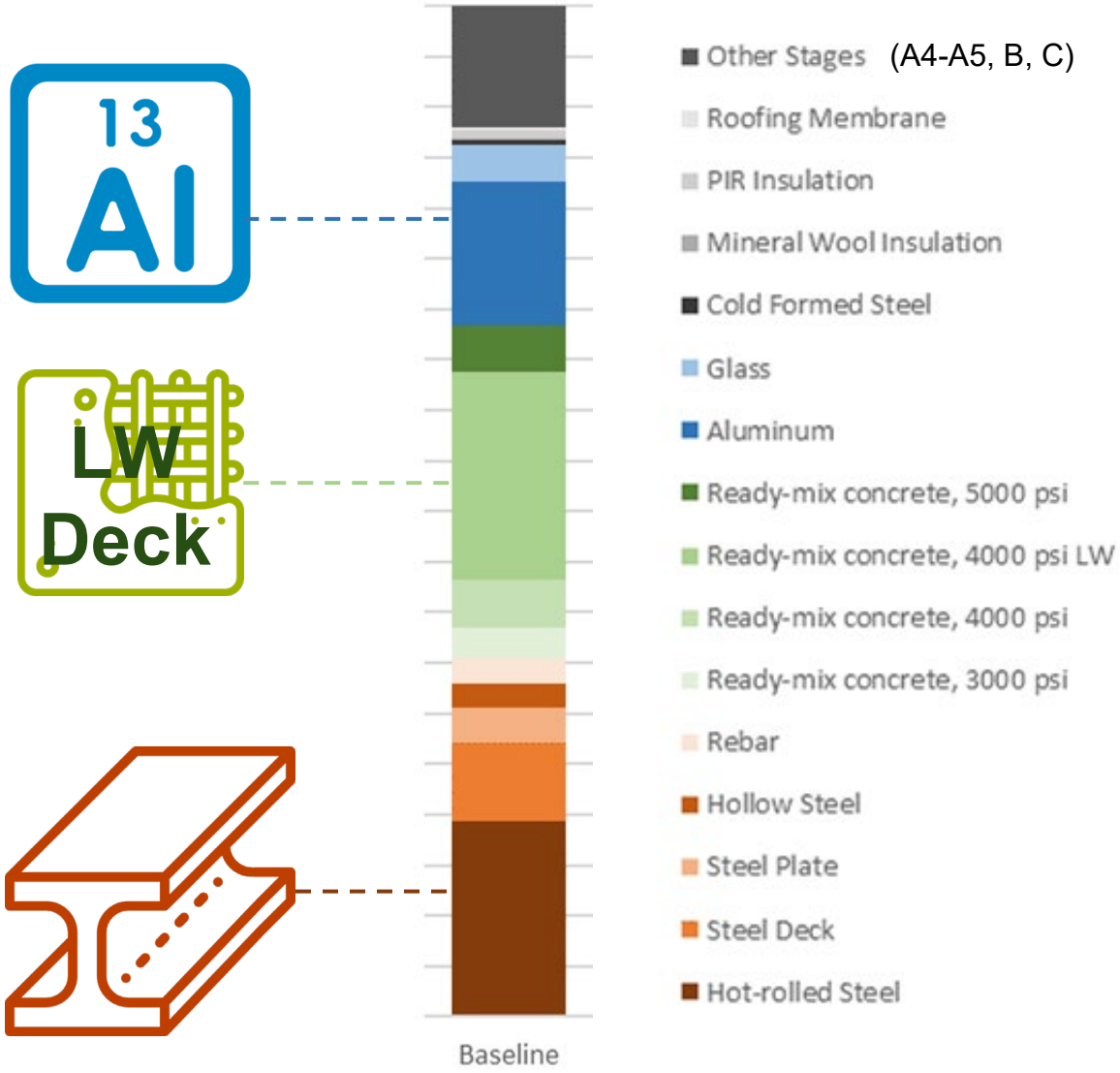
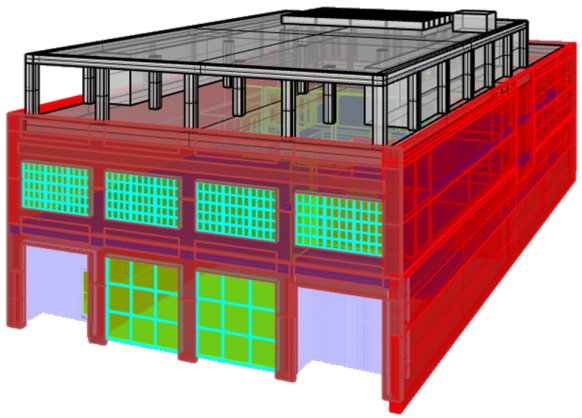
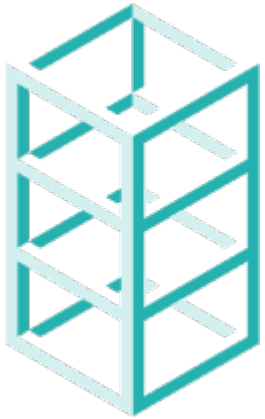


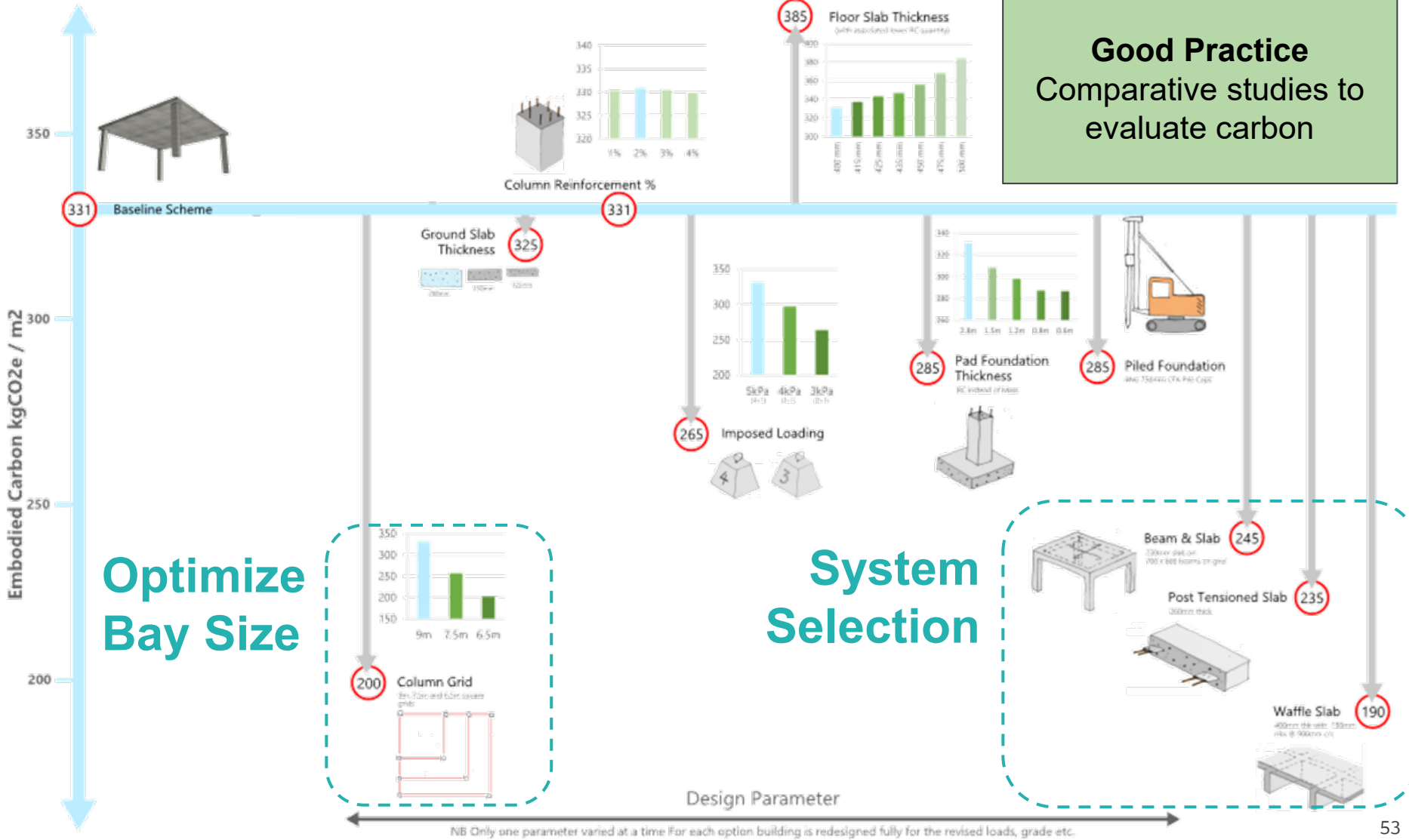
Image by Buro Happold

Set a Baseline | Evaluate Reduction Measures | Run Proposed LCA | Repeat



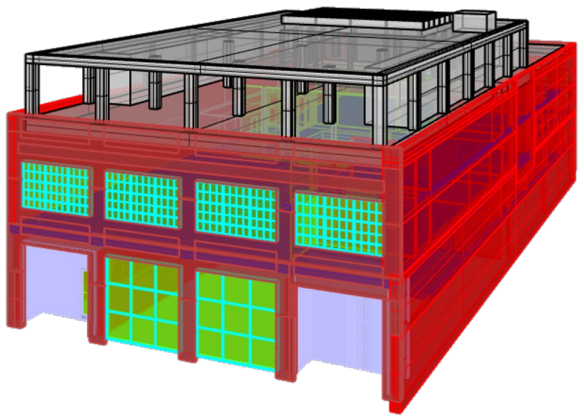


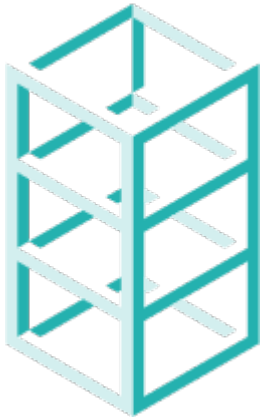
Design Optimization



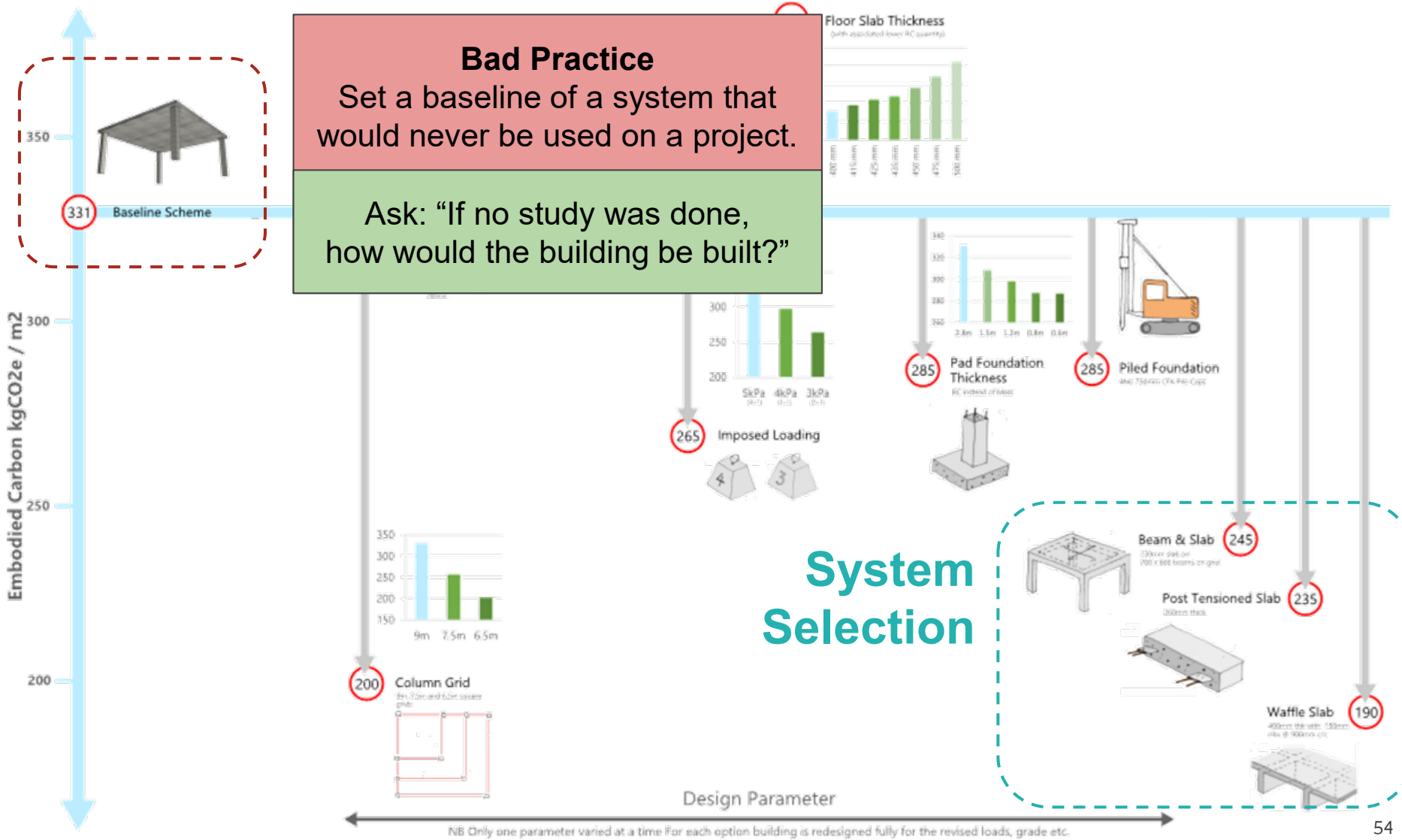
Good Practice
Comparative studies to evaluate carbon

Buro Happold, Embodied Carbon Sensitivity Study





Design



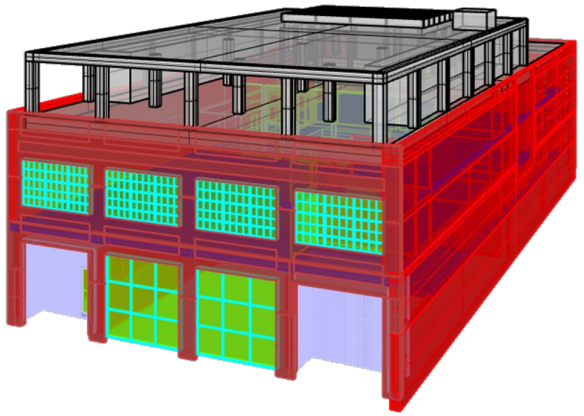
Bad Practice
Set a baseline of a system that would never be used on a project.

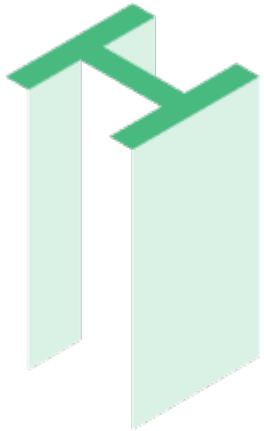
Ask: "If no study was done, how would the building be built?"

System Selection

Buro Happold, Embodied Carbon Sensitivity Study

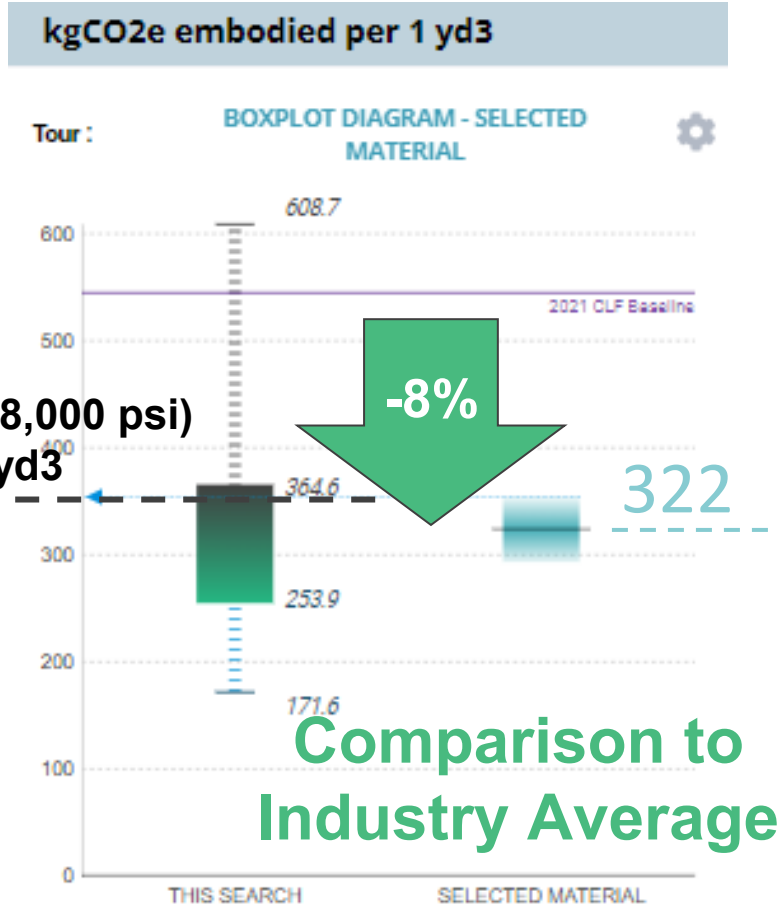
Concrete Foundation Mix





Procurement

NRMCA Avg.
(SW Region, 8,000 psi)
349 kgCO2e/yd3



Comparison to Industry Average

Good Practice
Engage your GC and ready-mix supplier. Document requirement in a performance specification.

ENVIRONMENTAL IMPACTS

Declared Product:
Mix 99A112P3 • Oakland Plant
Description: HS 900 LB 1/2" 30SLAG 7-9"
Compressive strength: 8000 PSI at 28 days

Declared Unit: 1 m^3 of concrete (1 cyd)

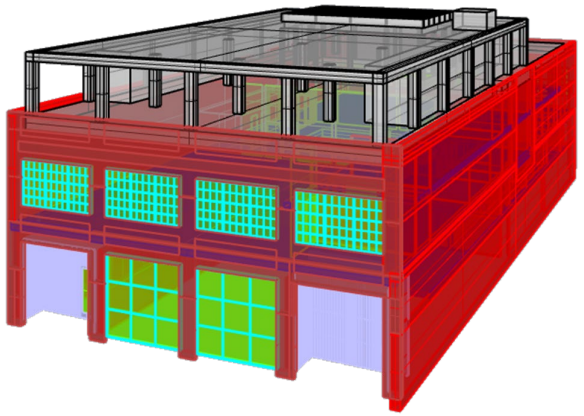
Global Warming Potential (kg CO_2-eq)	**422 (322)**
Ozone Depletion Potential (kg CFC-11-eq)	**9.46E-6 (7.23E-6)**
Acidification Potential (kg SO_2-eq)	**2.44 (1.87)**
Eutrophication Potential (kg N-eq)	**0.20 (0.15)**
Photochemical Ozone Creation Potential (kg O_3-eq)	**54.1 (41.4)**
Abiotic Depletion, non-fossil (kg Sb-eq)	**1.29E-4 (9.83E-5)**
Abiotic Depletion, fossil (MJ)	**2,778 (2,124)**
Total Waste Disposed (kg)	**0.82 (0.63)**
Consumption of Freshwater (m^3)	**0.81 (0.62)**

Product Components: natural aggregate (ASTM C33), Portland cement (ASTM C150), slag cement (ASTM C989), admixture (ASTM C494), batch water (ASTM C1602)

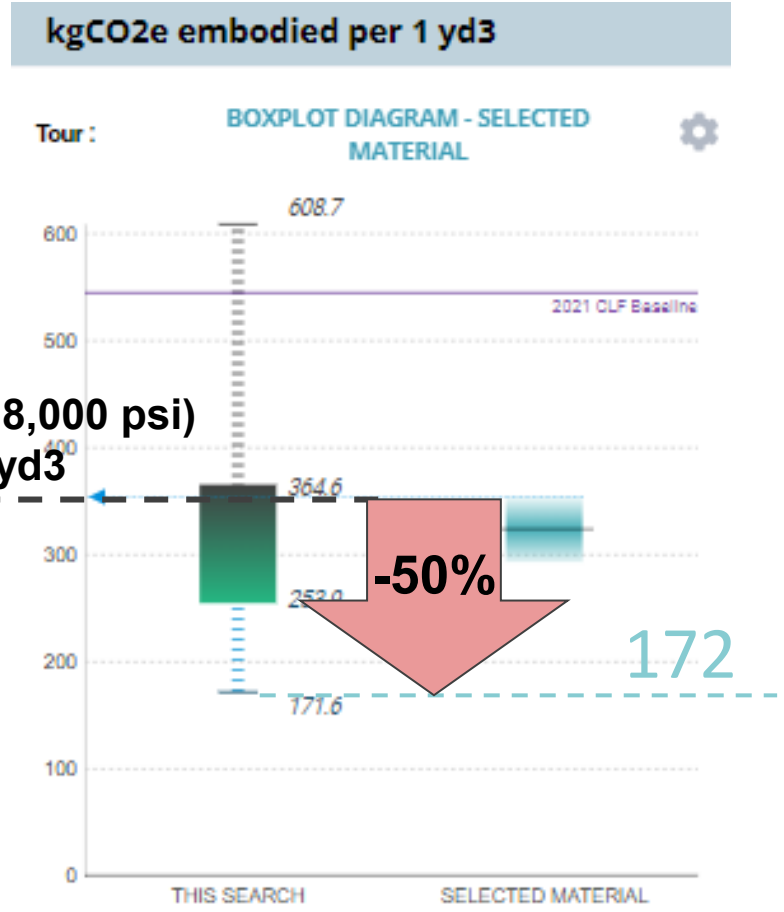
Additional detail and impacts are reported on page three of this EPD

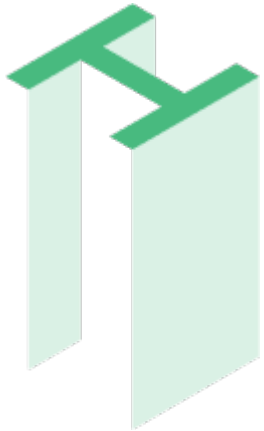
EC3

Concrete Foundation Mix



NRMCA Avg.
(SW Region, 8,000 psi)
349 kgCO2e/yd3



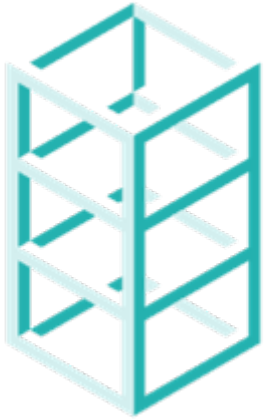


Procurement

Bad Practice
Arbitrarily select the lowest available product without coordination or documentation

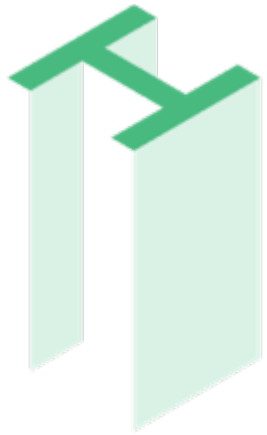
Potential Reduction Measures

Non-exhaustive list! Be creative!



1 **Design**

- Optimize structural bay size
- Limit long cantilevers and column transfers
- Scrutinize heavy loading requirements
- Optimize concrete mix strength
- Select lower embodied carbon insulation materials
- Reduce skin to floor area ratio
- Optimize facade support structure



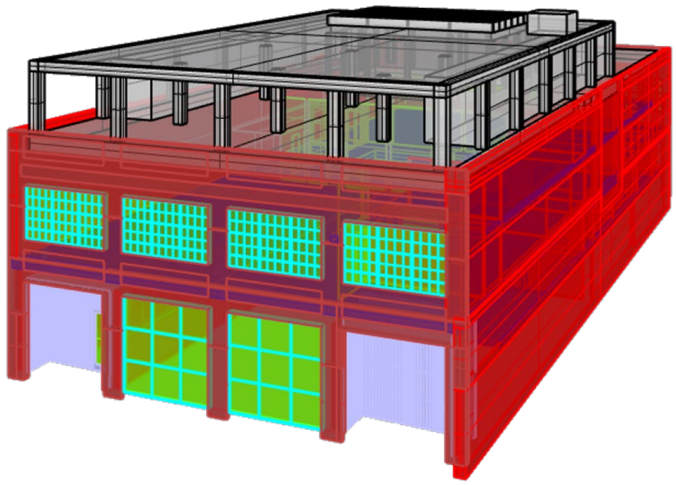
2 **Procurement**

- Specify GWP limits and require EPDs (Type III) demonstrating compliance
- Engage ready mix concrete supplier

Concrete Example:

50%	x	-20%	=	-10%
Concrete Contribution		Reduction Potential		Overall

Set a Baseline | Evaluate Reduction Measures | Run Proposed LCA | Repeat



Reduction Measures:

1. Structural Optimization
2. Steel Procurement

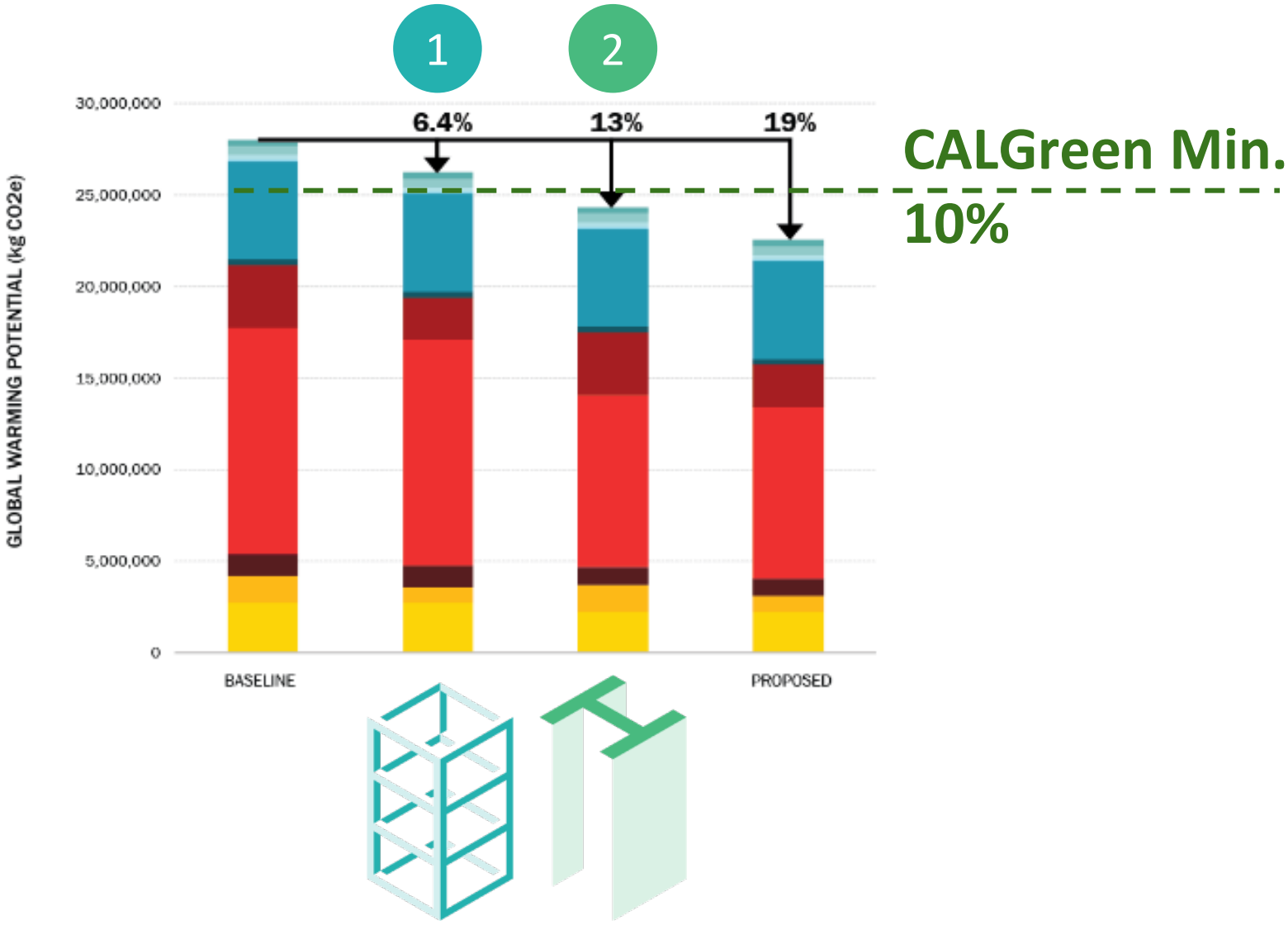


Image by Atelier Ten

WHOLE BUILDING LCA

Emery Yards B2

Project Info

Location	Emeryville, CA
Building area	270,681 ft^2
Program	Lab and office
Project type	New construction
Status	Construction in progress

Team

Client	BioMed Realty
Architect	Flad Architects
LCA	Atelier Ten
Structural	Forell | Elsesser Engineers

WBLCA Parameters

Scope	A1-A4, B1-B5, C1-C4
Boundary	Substructure, superstructure, enclosure
Service life	60 years
Phase	CA

Embodied Carbon Reduction Strategies

- Concrete embodied carbon reduction
- Insulation procurement
- Steel and rebar procurement

Image by Flad

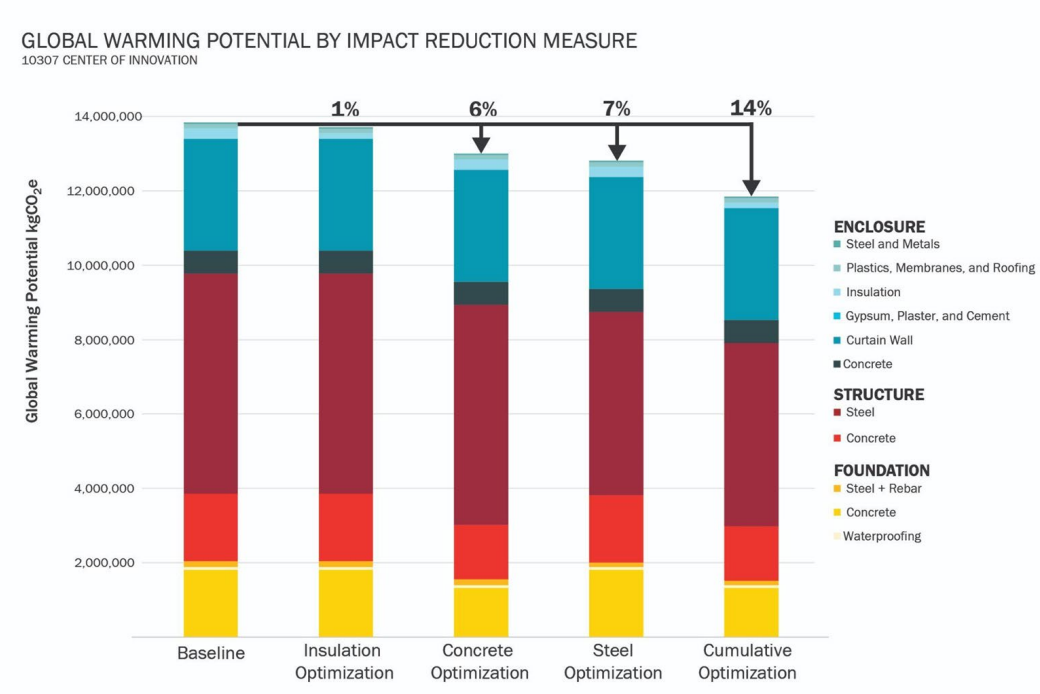
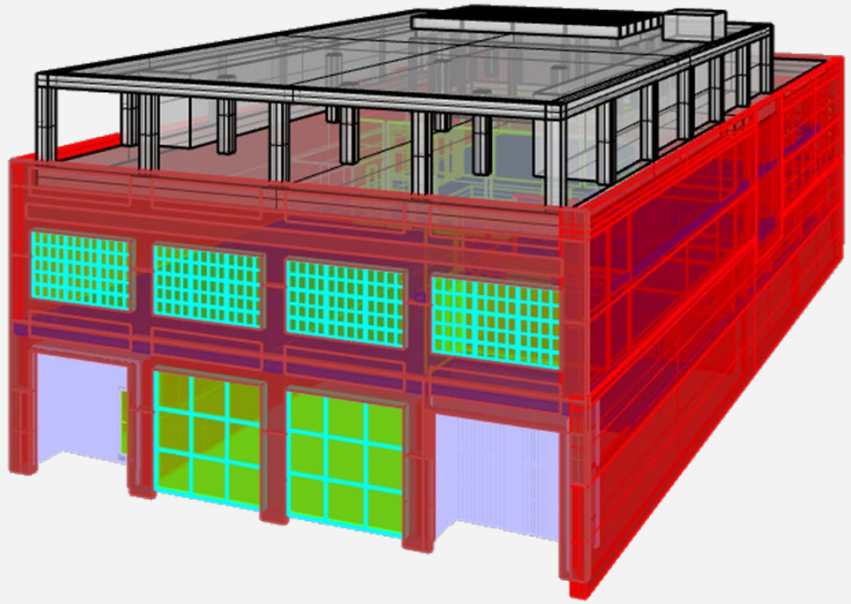


Image by Atelier Ten

Example



Mandatory Scope Items

Please break out the following in per element emissions by life cycle in kgCO2e. Leave blank any sections that were not calculated separately from Whole Building GWP

	Upfront Carbon			Use Phase	End of Life	Total
	A1-3	A4	A5	B1-5	C1-4	
Baseline Structure GWP (kgCO2e):	9,000,000	500,000	700,000	50,000	200,000	9,700,000
Baseline Enclosure GWP (kgCO2e):	2,400,000	20,000	300,000	1,600,000	70,000	4,100,000
Baseline Whole Building GWP (kgCO2e):	11,300,000	500,000	1,000,000	1,700,000	300,000	13,800,000
Proposed Structure GWP (kgCO2e):	7,100,000	500,000	700,000	50,000	200,000	7,900,000
Proposed Enclosure GWP (kgCO2e):	2,300,000	20,000	300,000	1,600,000	60,000	3,900,000
Proposed Whole Building GWP (kgCO2e):	9,400,000	500,000	1,000,000	1,600,000	300,000	11,800,000

Percent Reduction	14%
Mandatory	10%
Tier 1	
Tier 2	

A1-A3*
(A1) Raw Material Supply, (A2) Transport to Factory, and (A3) Manufacturing

A4*
(A4) Transportation to site

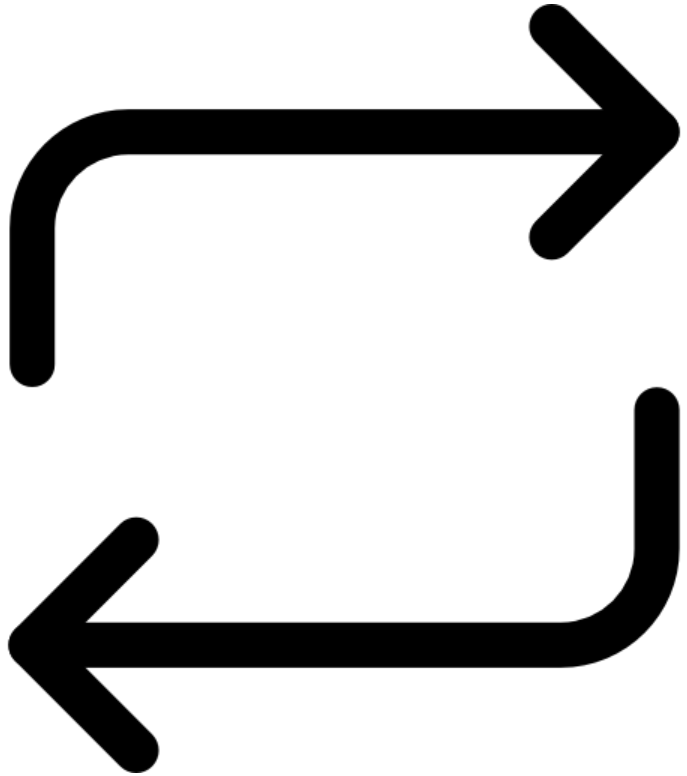
A5*
(A5) Construction Installation or "on-site energy use". Leave blank if unkown

B1-B5*
(B1) Use, (B2) Maintenance, (B3) Repair, (B4) Replacement, (B5) Refurbishment

C1-C4*
(C1) Deconstruction/Demolition, (C2) Transport to Waste Processing/Disposal, (C3) Waste Processing, (C4) Disposal of Waste

D*
(D) Reuse-Recovery & Recycling Potential

Set a Baseline | Evaluate Reduction Measures | Run Proposed LCA | Repeat



Myths

Getting locally sourced materials is sufficient to get 10% reduction.

LCA only has to be done at the end of the project.

We can artificially choose a worst case scenario baseline.

Truths

Transportation typically is the least impactful category in an EPD, and therefore will have minimal impact in a WBLCA.

To ensure 10% reduction, LCA needs to be done during design process.

The baseline is set by what is considered conventional for the building type.

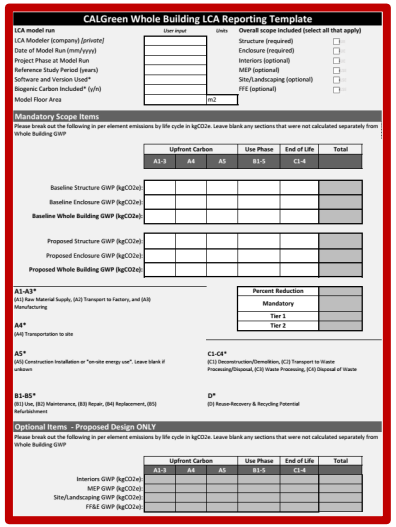
How to Demonstrate Compliance

Example Timeline for Embodied Carbon Tools

Understand overall impact to inform system selection

Estimate and document reduction measures

*CALGreen



Concept → SD → DD → CD → Permitting → CA

Inform goal setting with targeted LCA studies

epic.

Kaleidoscope

Refine material selections and run Whole Building LCA

One Click LCA

tally

Athena Sustainable Materials Institute

Track material procurement

EC3

Tools

Tool	CALGreen Compliant	Cost	Scope	Excel Import	Revit Integration
OneClick LCA	Yes	$	A1 A2 A3 A4 A5 B C	X	R RVT
Tally	Yes	$	A1 A2 A3 A4 A5 B C	No	R RVT Only
Athena	Yes	FREE	A1 A2 A3 A4 A5 B C	X	No
GaBi (uncommon for buildings)	Yes	$	A1 A2 A3 A4 A5 B C	X	No
SimaPro (uncommon for buildings)	Yes	$	A1 A2 A3 A4 A5 B C	X	No
OneClick LCA – Planetary	Yes	FREE	A1 A2 A3 A4 A5 B C	X	R RVT
EC3	No	FREE	A1 A2 A3 A4 A5	No	tallyCAT
EPIC	No	FREE	A1 A2 A3 A4 A5 B6 (estimated)	No	Not Applicable

Compliance Form

Needs to be included in drawings or specs

CALGreen Whole Building LCA Reporting Template

LCA model run	User input	Units	Overall scope included (select all that apply)	
LCA Modeler (company) *[private]*	Atelier Ten		Structure (required)	x
Date of Model Run (mm/yyyy)	03/2024		Enclosure (required)	x
Project Phase at Model Run	DD		Interiors (optional)	
Reference Study Period (years)	60		MEP (optional)	
Software and Version Used*	One Click LCA. 0.24.1		Site/Landscaping (optional)	
Biogenic Carbon Included* (y/n)	n		FFE (optional)	
Model Floor Area	25,000	m2		

Mandatory Scope Items

Please break out the following in per element emissions by life cycle in kgCO2e. Leave blank any sections that were not calculated separately from Whole Building GWP

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A4*
(A4) Transportation to site

A5*
(A5) Construction Installation or "on-site energy use". Leave blank if unkown

B1-B5*
(B1) Use, (B2) Maintenance, (B3) Repair, (B4) Replacement, (B5) Refurbishment

C1-C4*
(C1) Deconstruction/Demolition, (C2) Transport to Waste Processing/Disposal, (C3) Waste Processing, (C4) Disposal of Waste

D*
(D) Reuse-Recovery & Recycling Potential

Optional Items - Proposed Design ONLY

Please break out the following in per element emissions by life cycle in kgCO2e. Leave blank any sections that were not calculated separately from Whole Building GWP

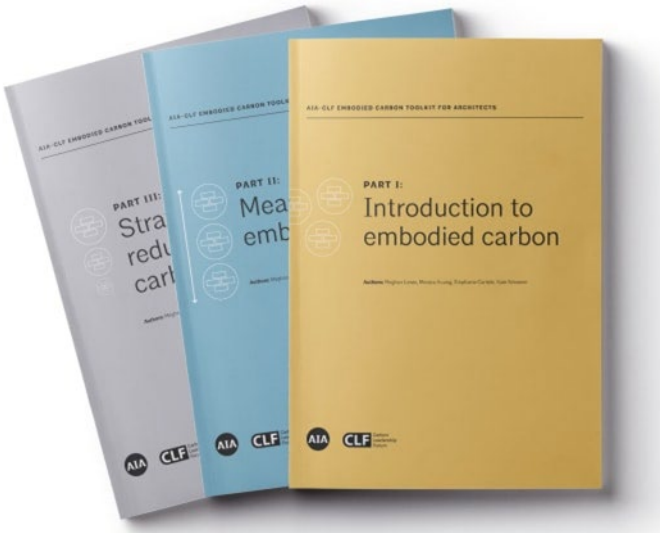
	Upfront Carbon			Use Phase	End of Life	Total
	A1-3	A4	A5	B1-5	C1-4	
Interiors GWP (kgCO2e):						
MEP GWP (kgCO2e):						
Site/Landscaping GWP (kgCO2e):						
FF&E GWP (kgCO2e):						

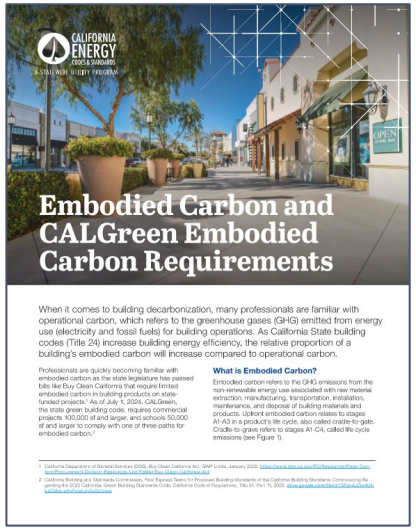
Resources and Working Groups

Resources

Where to start:

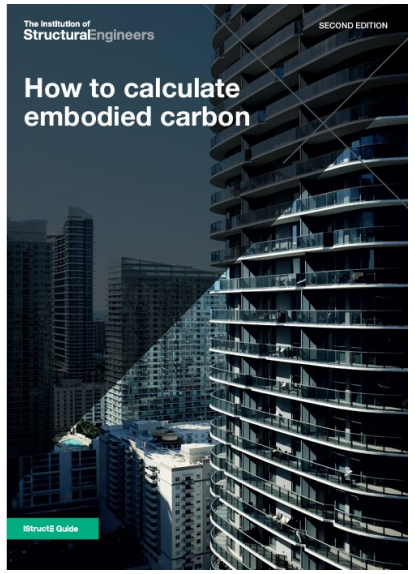
- FREE Calgreen code access
- Local Energy Codes – CALGreen Fact Sheet
- AIA + CLF Toolkit for Architects





Where to learn more:

- CLF LCA Practice Guide (2019)
- CLF Material Baselines (2023)
- SE 2050 Resources and Design Guidance
- IStructE How to Calculate Embodied Carbon
- IStructE, Buro Happold, Sensitivity Study
- Arup, Carbon Footprint of Facades
- Priopta, 2023, Embodied Carbon 101
- Building Transparency Resources
- CLF Wood Carbon Seminars

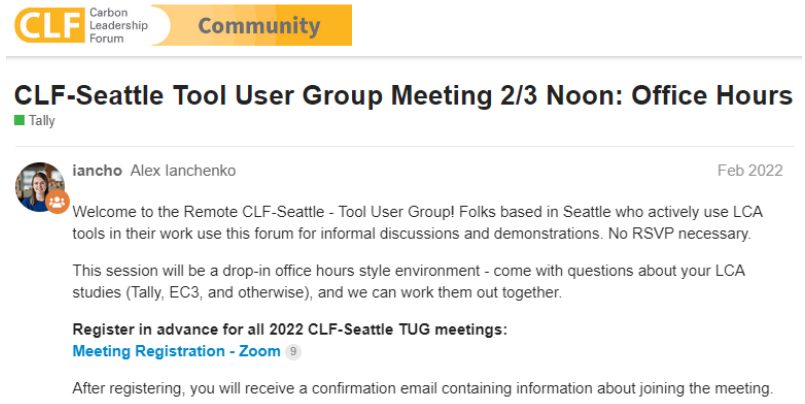


Coming Soon:

- CALGreen State Supplementary Guidance (pending)
- ASHRAE 240P (*public review*)
- SEI Pre-Standard for Assessing the Embodied Carbon of Structural Systems for Buildings (*pending*)

LCA User Groups

Seattle



Boston

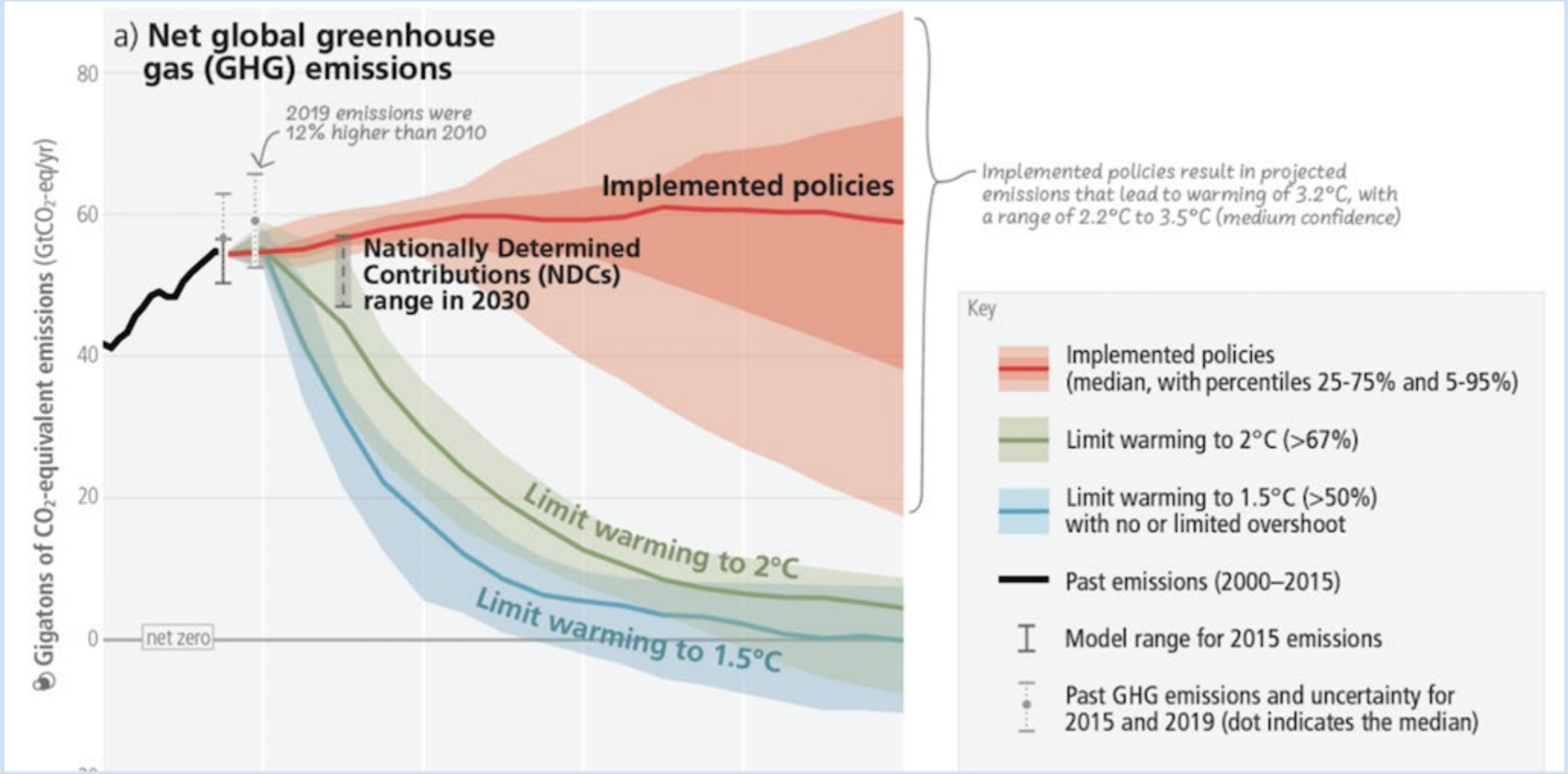
LIFE CYCLE ASSESSMENT USER GROUP

EMBODIED CARBON REDUCTION CHALLENGE

Carbon Leadership Forum
Los Angeles

Los Angeles LCA User Group - Coming soon!

Closing Remarks



CarbonBrief

Time for Q&A