Embodied Carbon in the Built Environment

A Technical Builder's Perspective

DPR CONSTRUCTION

Agenda

- Intro – myself & DPR
- Operating vs embodied carbon
- Key embodied carbon policies and regulations in the US
- Embodied carbon reduction tools and rating systems
- Measurement approaches: material-based procurement (ex. EPD’s) and whole-building life-cycle assessment

PLANET: SUSTAINABILITY VISION

We are committed to creating a more sustainable work and built environment. We are revolutionizing how we:

Operate
Build
Travel
Influence

BY THE NUMBERS

"0" Waste Culture

DPR hit 89% waste diversion from landfill for the top 33% of green projects by revenue.

ENR #4

DPR climbed from #18 to #8 in just 2 years.

550+ Projects

DPR has completed over five hundred and fifty certified projects within green rating systems

500+ APs

DPR has over five hundred green accredited building professionals.

8 Living Labs

Seven of DPR's own offices are designed to NZE, with many others achieving high standards in both LEED, WELL, Fitwell, and LBC Pedal Certification.

$4.8 B in 2022

DPR has completed $4.8 billion of green certified buildings in the last year. This does not include the many projects with sustainable features that don't pursue a green certification.

THE PATHWAY

Best Practices

Detailed Guide – What our people can do to help

Overview of the framework

The guidelines will be updated periodically and cover five categories:

- Carbon Reduction
- Jobsite Wellness
- Waste Management
- Water Management
- Materials

A guideline may have up to three tiers:

- Good
- Better
- Best

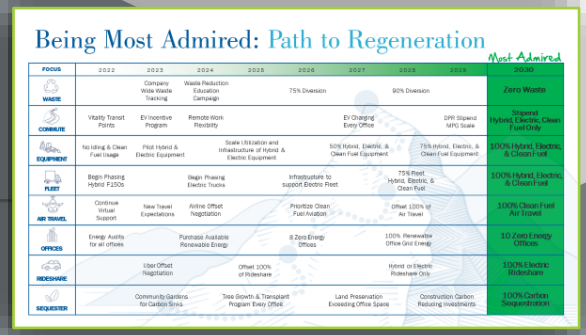
Guidelines must be applied to 30% of the company projects by dollar volume.

Contractor's Commitment

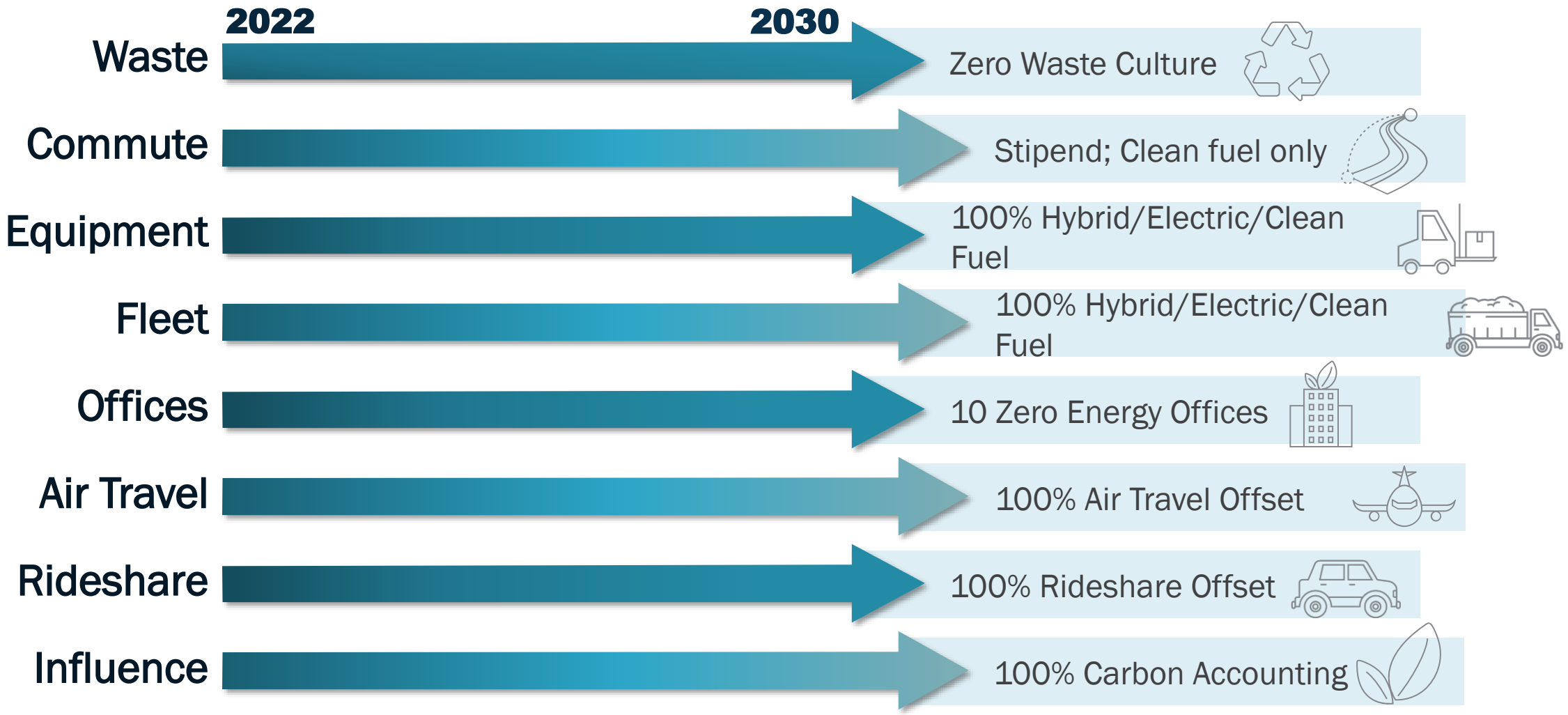
Industry Aligned Framework – What our Best Practices are trying to achieve

Path to Regeneration

Mission 2030 Alignment – Overarching goals necessary to be most admired



Path to Regeneration



Embodied Carbon

Embodied carbon refers to the greenhouse gas emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of building materials.

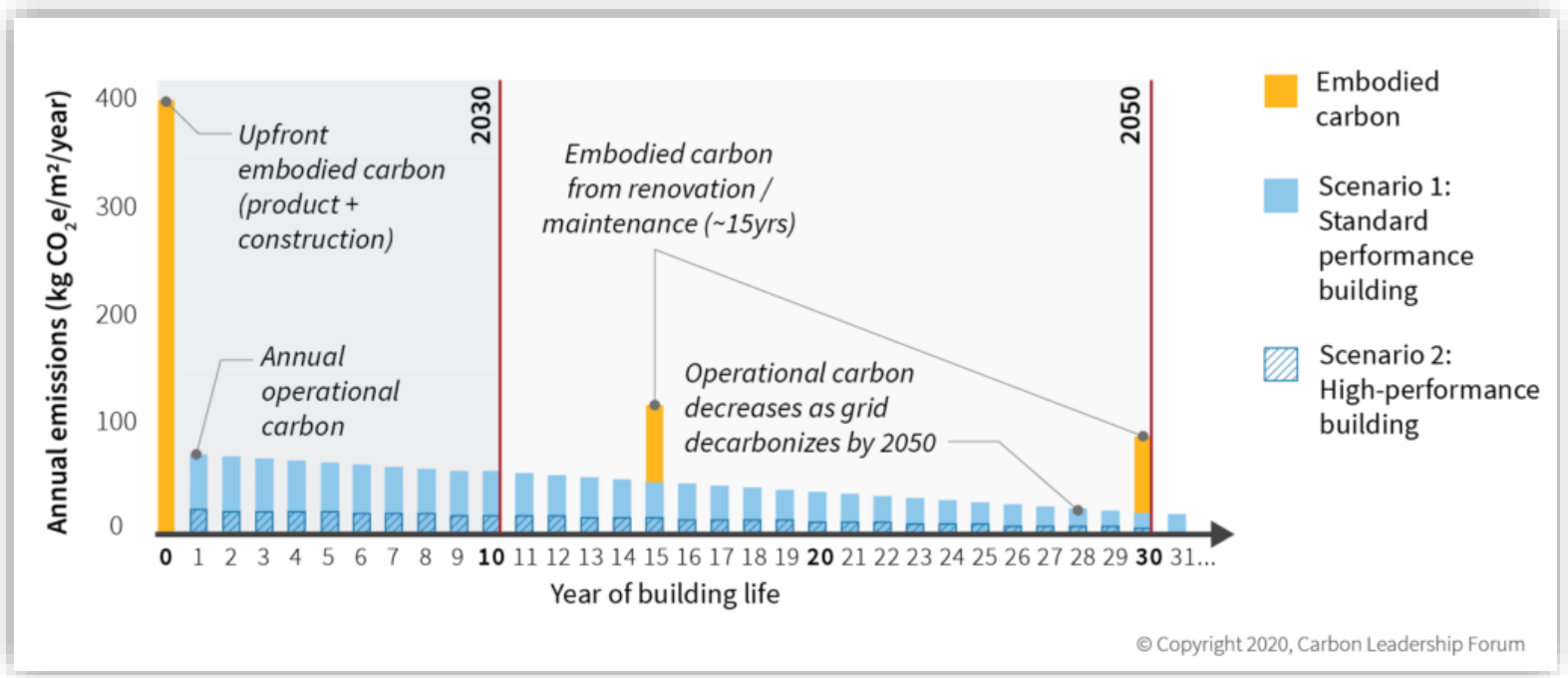
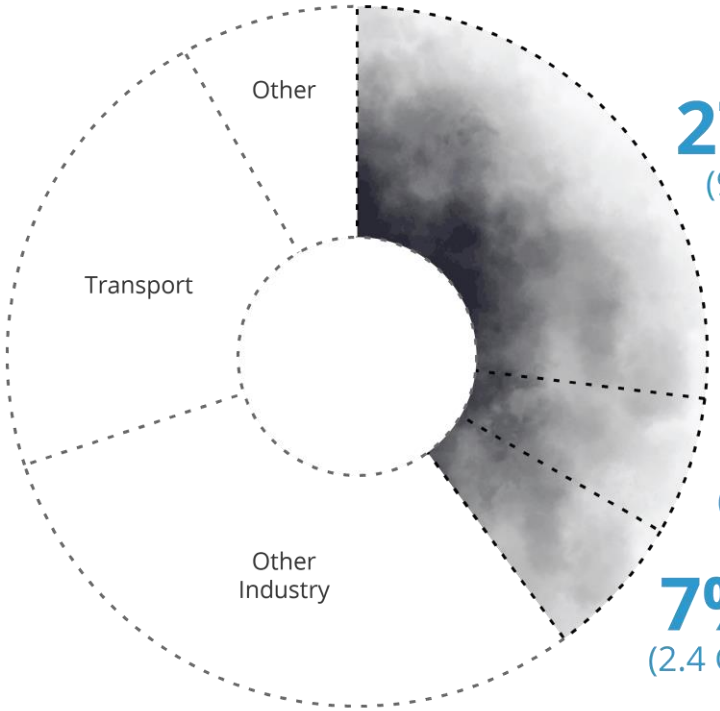


Figure 1. Embodied carbon (yellow) and operational carbon (blue) across the key life cycle stages of a building.

Annual Global CO_2 Emissions



27% (9.9 GT) BUILDING OPERATIONS

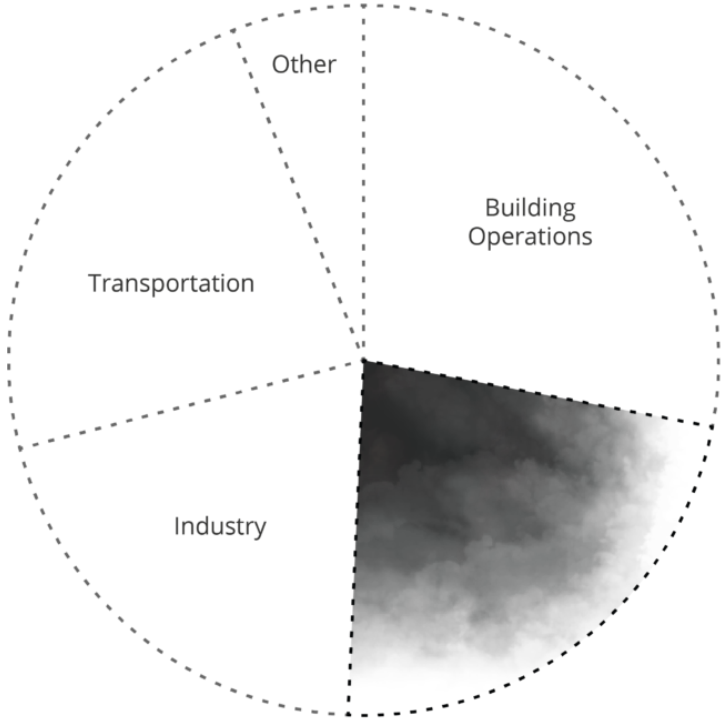
6% (2.3 GT) BUILDING CONSTRUCTION INDUSTRY

7% (2.4 GT) OTHER CONSTRUCTION INDUSTRY

 Data Source: IEA (2022), Buildings, IEA, Paris

Building Construction Industry and Other Construction Industry represent emissions from concrete, steel, and aluminum for buildings and infrastructure respectively.

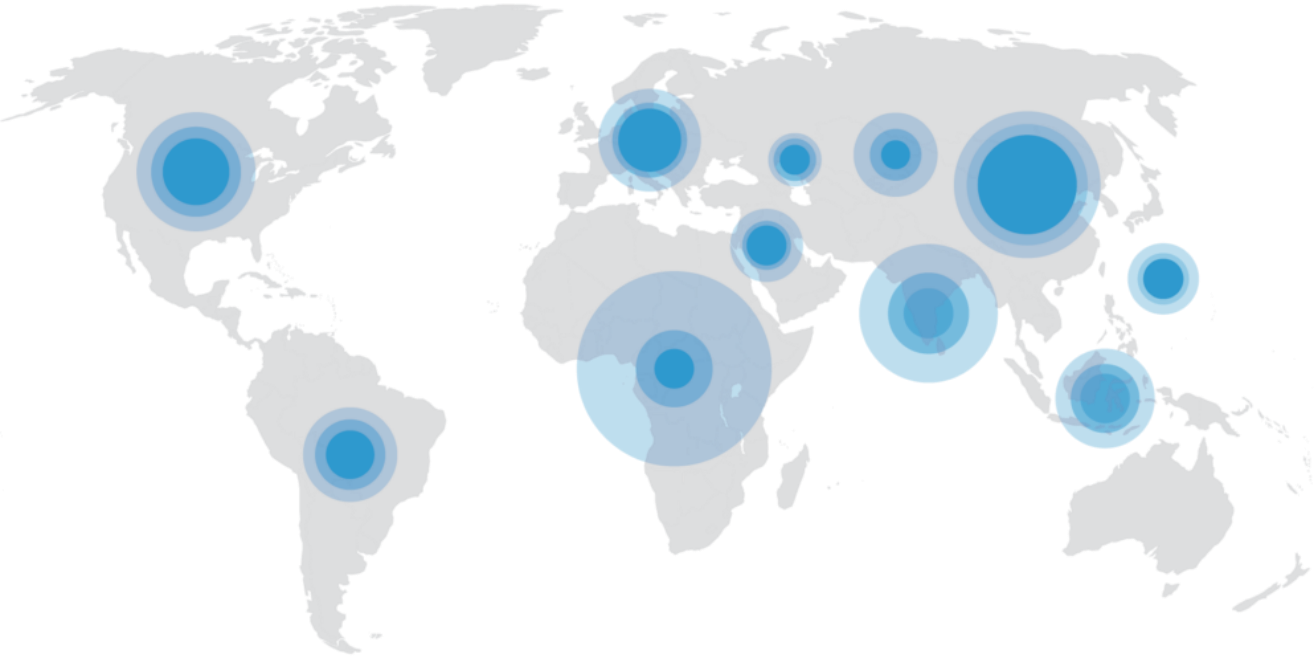
Annual Global CO_2 Emissions



23%
Concrete (11%)
Steel (10%)
Aluminum (2%)

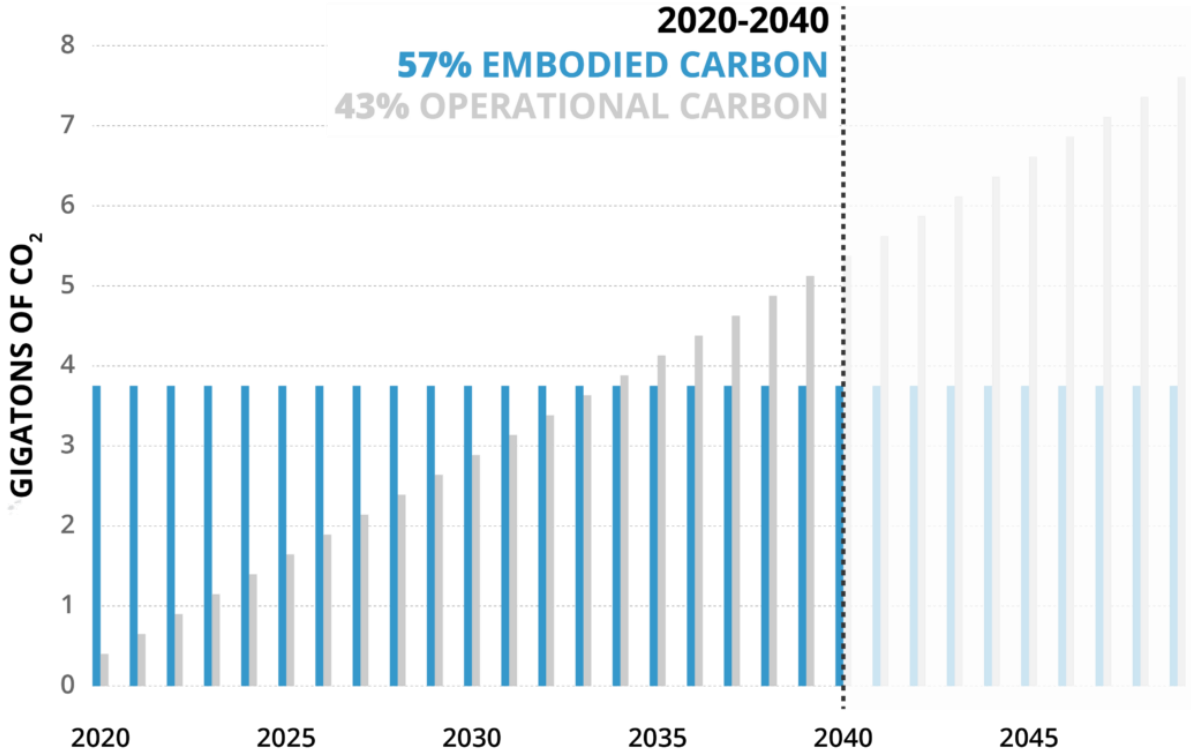
Data Sources: Global ABC Global Status Report 2018, EIA

Global building floor area
is expected to **double** by 2060.



Data Sources: Global ABC, Global Status Report 2017

Total Carbon Emissions of **Global New Construction**
with no building sector interventions



Data Sources: UN Environment Global Status Report 2017; EIA International Energy Outlook 2017

50%

Embodied carbon will be responsible for

almost half

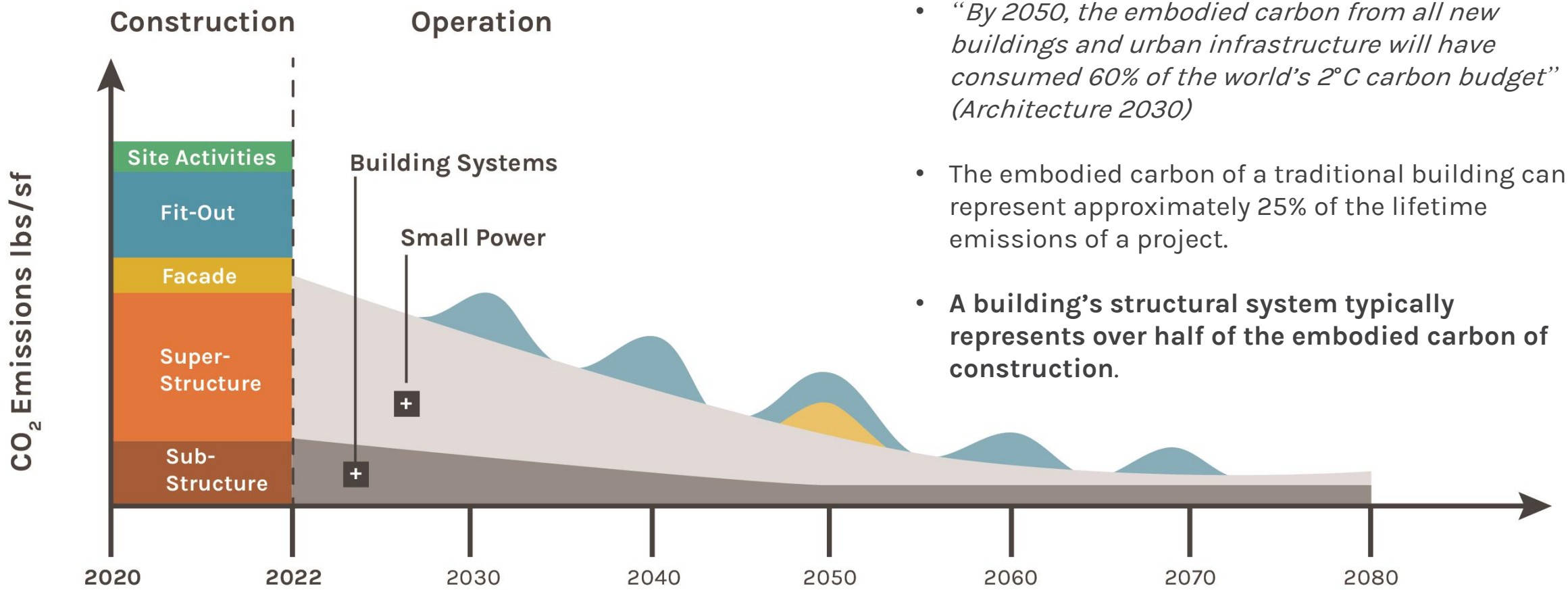
of total new construction emissions between now and 2050.[2]

Unlike operational carbon emissions, which can be reduced over time with building energy efficiency renovations and the use of renewable energy, embodied carbon emissions have irreversibly entered the atmosphere as soon as a building is built.

SOURCE: Carbon Leadership Forum & Architecture 2030 Commitment

TOTAL CARBON IMPACTS

***Minimize embodied energy** and low-carbon, robust and maintainable materials*



- *"By 2050, the embodied carbon from all new buildings and urban infrastructure will have consumed 60% of the world's 2°C carbon budget" (Architecture 2030)*
- The embodied carbon of a traditional building can represent approximately 25% of the lifetime emissions of a project.
- **A building's structural system typically represents over half of the embodied carbon of construction.**

DPR CONSTRUCTION SMITHGROUP

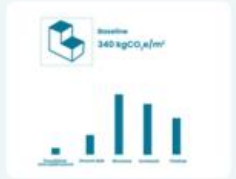
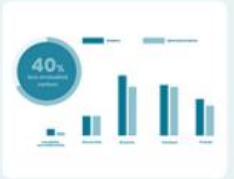
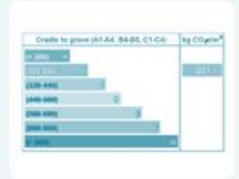
Whole Building LCA (WBLCA)

Environmental Factor –
EPDs (Environmental Product Declaration)

€ (Quantity of material
x Environmental factor)

= Embodied environmental impact of a building

Stages of LCA

	CONCEPT DESIGN	DETAILED DESIGN	PROCUREMENT	USE STAGE
Construction stages	Sketch or concept 	BIM model 	Building in construction 	Building in use and adaptation 
Material quantities	Data can be obtained from cost estimation tools or early design tools like Rhinoceros 3D, Tekla Structural Designer. Alternatively, model can be generated with Carbon Designer.	Detailed design drawings or BIM models.	Construction drawings, BIM models and cost plans of final materials.	Actual quantities.
One Click LCA workflow	Carbon Designer baseline 	Compare designs 	Benchmarking Select best products from manufacturers EPDs 	Interior fit outs and refurbishments 

Whole Building LCA (WBLCA)

SCOPE

ILFI Zero Carbon

LEED

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

WORKFLOW

BIM
Extracted Quantities

R
RVT

LifeCycle Analysis

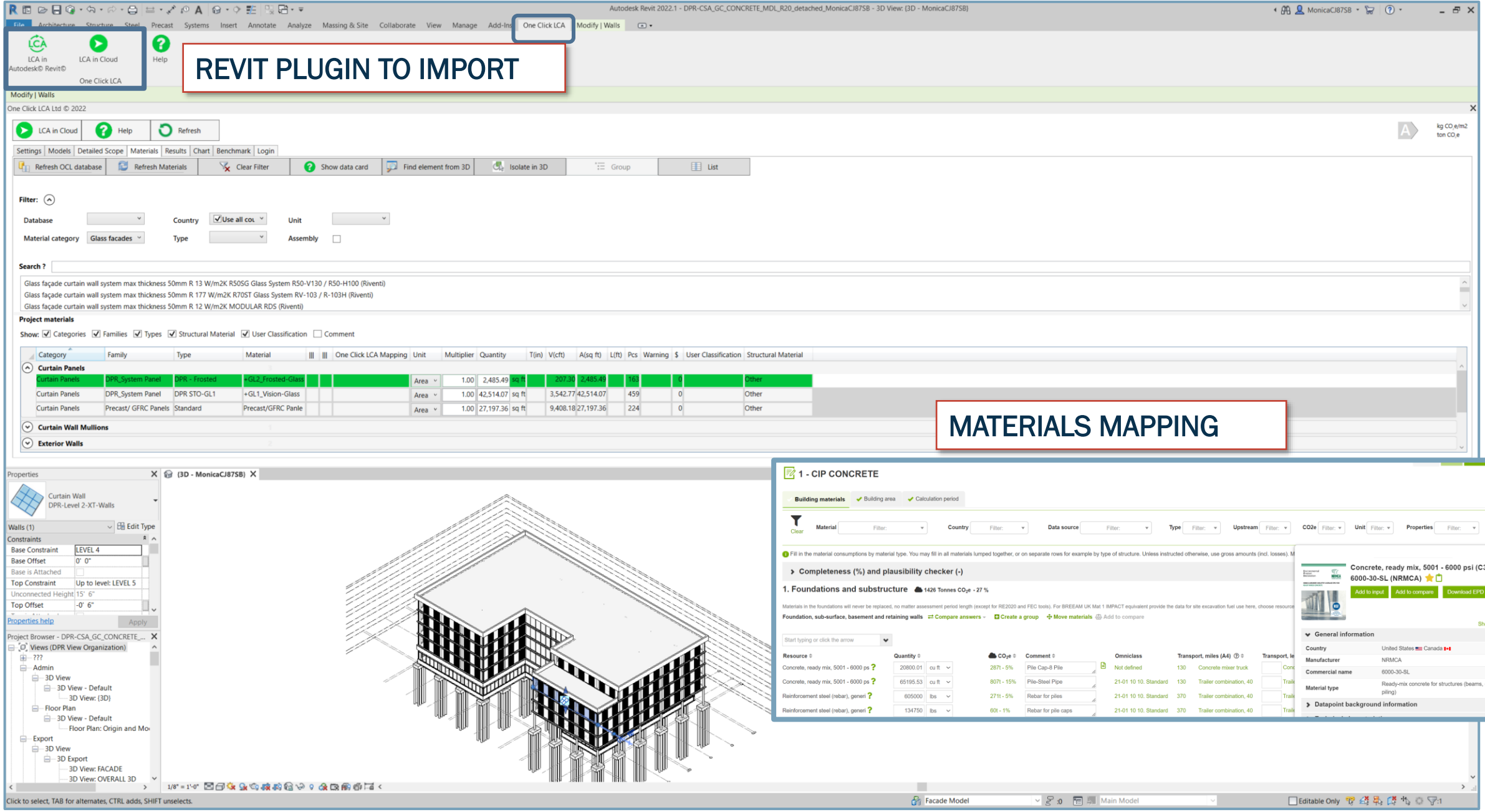
One Click LCA

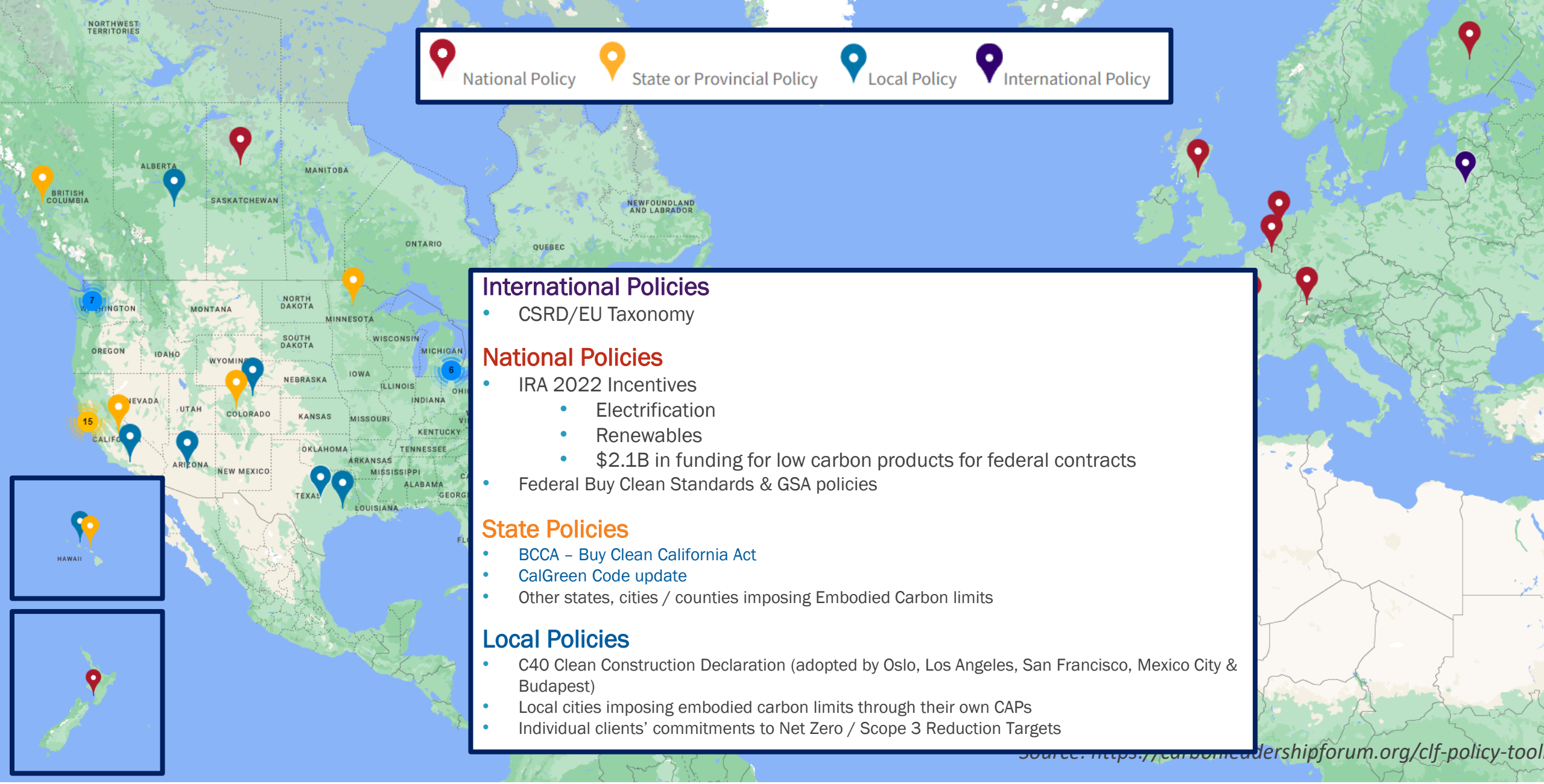
Other Tools:

tally EC3

Teams Required

- Preconstruction
- Virtual Design & Construction
- Sustainability


REVIT PLUGIN TO IMPORT
LCA in Autodesk© Revit©
LCA in Cloud
One Click LCA
Help
Modify | Walls
One Click LCA Ltd © 2022
LCA in Cloud
Help
Refresh
Settings
Models
Detailed Scope
Materials
Results
Chart
Benchmark
Login
Refresh OCL database
Refresh Materials
Clear Filter
Show data card
Find element from 3D
Isolate in 3D
Group
List
Filter:
Database
Country
Unit
Material category
Glass facades
Type
Assembly
Search ?
Glass façade curtain wall system max thickness 50mm R 13 W/m2K R50SG Glass System R50-V130 / R50-H100 (Riventi)
Glass façade curtain wall system max thickness 50mm R 177 W/m2K R70ST Glass System RV-103 / R-103H (Riventi)
Glass façade curtain wall system max thickness 50mm R 12 W/m2K MODULAR RDS (Riventi)
Project materials
Show: Categories Families Types Structural Material User Classification Comment
Category
Family
Type
Material
One Click LCA Mapping
Unit
Multiplier
Quantity
T(in)
V(cft)
A(sq ft)
L(ft)
Pcs
Warning
$
User Classification
Structural Material
Curtain Panels
Curtain Panels DPR_System Panel DPR - Frosted +GL2_Frosted-Glass Area 1.00 2,485.49 sq ft 207.30 2,485.49 163 0 Other
Curtain Panels DPR_System Panel DPR STO-GL1 +GL1_Vision-Glass Area 1.00 42,514.07 sq ft 3,542.77 42,514.07 459 0 Other
Curtain Panels Precast/ GFRC Panels Standard Precast/GFRC Panle Area 1.00 27,197.36 sq ft 9,408.18 27,197.36 224 0 Other
Curtain Wall Mullions
Exterior Walls
MATERIALS MAPPING
Properties
Curtain Wall
DPR-Level 2-XT-Walls
Walls (1)
Edit Type
Constraints
Base Constraint LEVEL 4
Base Offset 0' 0"
Base is Attached
Top Constraint Up to level: LEVEL 5
Unconnected Height 15' 6"
Top Offset -0' 6"
Properties help
Apply
Project Browser - DPR-CSA_GC_CONCRETE_...
Views (DPR View Organization)
Admin
3D View
3D View - Default
3D View: {3D}
Floor Plan
3D View - Default
Export
3D View
3D Export
3D View: FACADE
3D View: OVERALL 3D
{3D - MonicaCJ87SB}
1 - CIP CONCRETE
Building materials
Building area
Calculation period
Completeness (%) and plausibility checker (-)
1. Foundations and substructure
Concrete, ready mix, 5001 - 6000 psi (C35/40), 6000-30-SL (NRMCA)
Add to input
Add to compare
Download EPD
General information
Country
Manufacturer
Commercial name
Material type
Datapoint background information
Facade Model
Main Model
Editable Only
Click to select, TAB for alternates, CTRL adds, SHIFT unselects.



International Policies

- CSRD/EU Taxonomy

National Policies

- IRA 2022 Incentives
  - Electrification
  - Renewables
  - $2.1B in funding for low carbon products for federal contracts
- Federal Buy Clean Standards & GSA policies

State Policies

- BCCA – Buy Clean California Act
- CalGreen Code update
- Other states, cities / counties imposing Embodied Carbon limits

Local Policies

- C40 Clean Construction Declaration (adopted by Oslo, Los Angeles, San Francisco, Mexico City & Budapest)
- Local cities imposing embodied carbon limits through their own CAPs
- Individual clients' commitments to Net Zero / Scope 3 Reduction Targets

Source: https://carbonleadershipforum.org/clf-policy-tool

Name of policy/program	Country	State/Province	City/County	Scale	Jurisdictional level	Type of program	Eligible Projects	Current status
California AB2446: Embodied carbon emissions: construction materials	USA	California		All	State/Province	Regulatory	Public & Private	Passed/Active
Lexington Integrated Building Design and Construction Policy	USA	Kentucky	Lexington	Building	City/County	Regulatory	Public	Passed/Active
California Public Resources Code 42703	USA	California		Material	State/Province	Regulatory	Public	Passed/Active
Brookline Resolution	USA	Massachusetts	Brookline	Material	City/County	Regulatory		Passed/Active
California SB 261	USA	California		All	State/Province	Regulatory	Private	Passed/Active
Buy Clean Buy Fair Minnesota (HF 2310)	USA	Minnesota		All	State/Province	Regulatory	Public	Passed/Active
California SB 253	USA	California		All	State/Province	Regulatory	Public & Private	Passed/Active
Kirkland High Performance Green Buildings Embodied Carbon Criteria	USA	Washington	Kirkland	All	City/County	Regulatory		Passed/Active
NY Executive Order 22	USA	New York	New York City	All	State/Province	Regulatory		Passed/Active
Procurement of Construction Materials (Buy Clean Maryland Act)	USA	Maryland		Material	State/Province	Regulatory		Passed/Active
Zoning Ordinance of the City of Cambridge	USA	Massachusetts	Cambridge	Building	City/County	Regulatory		Passed/Active
2023 Vermont Residential Building Energy Standard AMENDMENTS	USA		Vermont	Material	City/County	Regulatory		Passed/Active
Seattle Department of Construction & Inspections: Residential Deconstruction Permitting	USA	Washington	Seattle	Deconstruction	City/County	Regulatory		Passed/Active
Austin's Construction and Demolition Recycling Ordinance	USA	Texas	Austin	Building	City/County	Regulatory		Passed/Active
Federal Buy Clean	USA		Washington D.C.	Material	National	Regulatory		Passed/Active
Boulder Sustainable Deconstruction Requirements	USA	Colorado	Boulder	Deconstruction	City/County	Regulatory		Passed/Active
Preferential purchasing for Oregon-made and recycled content goods	USA	Oregon	Portland	Material	City/County	Regulatory		Passed/Active
California AB 43 GHG Emissions Trading	USA	California		All	State/Province	Regulatory	Private	Passed/Active
Executive Order 594: Decarbonizing and Minimizing Environmental Impacts of State Government	USA	Massachusetts		Building	State/Province	Regulatory		Passed/Active
2021 Washington State Residential Code: Construction, Demolition & Deconstruction	USA	Washington		Deconstruction	State/Province	Regulatory		Passed/Active
Lake Oswego Municipal Code Update: Demolition Tax	USA	Oregon	Lake Oswego	Deconstruction	City/County	Regulatory		Passed/Active
New York City Executive Order 23	USA	New York	New York City	Material	City/County	Regulatory	Public	Passed/Active
GreenNY Specification: Lower Carbon Concrete	USA	New York		Material	State/Province	Regulatory		Passed/Active
GSA Concrete/Asphalt Standards	USA							
San Francisco Construction and Demolition Debris Recovery Law	USA	California						
Portland Low-Carbon Concrete Purchasing	USA	Oregon						

List of Embodied Carbon Policies is growing constantly, at all levels - City / State / National

Buy Clean California Act (BCCA)

Sets limits for GWP of four major construction materials: Structural steel, concrete reinforcing steel (NOT concrete), flat glass and mineral wool board insulation

Table 1: GWP limits for eligible materials

Eligible Material	Maximum Acceptable GWP Limit[1] For Unfabricated Product (Cradle-To-Gate)[2]	Maximum Acceptable GWP Limit[1] For Fabricated Product (A1 Module Only)[3]
Hot-rolled structural steel sections	1,010 kg CO_2eq.[4] or 1.01E+03 kg CO_2eq. for one metric ton of structural steel.	1,080 kg CO_2eq. or 1.08E+03 kg CO_2eq. for one metric ton of structural steel.
Hollow structural sections	1,710 kg CO_2eq. or 1.71E+03 kg CO_2eq. for one metric ton of structural steel.	1,830 kg CO_2eq or 1.83E+03 kg CO_2eq for one metric ton of structural steel.
Steel plate	1,490 kg CO_2eq. or 1.49E+03 kg CO_2eq. for one metric ton of structural steel.	1,590 kg CO_2eq. or 1.59E+03 kg CO_2eq. for one metric ton of structural steel.
Concrete reinforcing steel	890 kg CO_2eq. or 8.90E+02 kg CO_2eq. for one metric ton of bar.	920 kg CO_2eq. or 9.20E+02 kg CO_2eq. for one metric ton of bar.
Flat glass	1,430 kg CO_2eq. or 1.43E+03 kg CO_2eq. for one metric ton of glass.	N/A
Light-density mineral wool board insulation	3.33 kg CO_2eq. for 1 m^2 of insulation at R_{SI}=1.[5]	N/A
Heavy-density mineral wool board insulation	8.16 kg CO_2eq. for 1 m^2 of insulation at R_{SI}=1	N/A

Table 2: Description of eligible materials

Eligible Material	Description
Structural steel	**Hot-rolled sections** consisting of wide flange beams (W-shape and HP-shape used in structural applications), standard beams (S-shape), misc. beams (M-shape), channels, angles, and tees. **Hollow structural sections** with round, square, or rectangular cross-section. **Plate material.**
Concrete reinforcing steel	ASTM A615/A615M ASTM A706/A706M ASTM A767/A767M ASTM A775/A775M
Flat glass	**Float or rolled glass** that is clear or tinted either installed by itself or as a part of a window assembly. **Processed glass** (e.g., tempered, coated, or laminated) is out of scope of the BCCA.
Mineral wool board insulation	Board insulation made of **rock or slag** in **light-** and **heavy-density** types. **Light-density:** 2.5 lbs/ft^3 – 4.3 lbs/ft^3 **Heavy-density:** 4.4 lbs/ft^3 – 8 lbs/ft^3 lbs/ft^3 is pounds per cubic foot.

Applies to:

- Department of Transportation
- **Department of Water Resources**
- Department of Parks & Recreation
- Department of Corrections & Rehabilitation
- Military Department
- **Department of General Services**
- High-Speed Rail Authority
- **Regents of the University of California**
- **Trustees of the California State University**
- State Agencies on Public Works Under Management Memo 18-01

GWP Material Limits

BCCA

Table 1: GWP limits for eligible materials

Eligible Material	Maximum Acceptable GWP Limit[1] For Unfabricated Product (Cradle-To-Gate)[2]	Maximum Acceptable GWP Limit[1] For Fabricated Product (A1 Module Only)[3]
Hot-rolled structural steel sections	1,010 kg CO_2eq.[4] or 1.01E+03 kg CO_2eq. for one metric ton of structural steel.	1,080 kg CO_2eq. or 1.08E+03 kg CO_2eq. for one metric ton of structural steel.
Hollow structural sections	1,710 kg CO_2eq. or 1.71E+03 kg CO_2eq. for one metric ton of structural steel.	1,830 kg CO_2eq or 1.83E+03 kg CO_2eq for one metric ton of structural steel.
Steel plate	1,490 kg CO_2eq. or 1.49E+03 kg CO_2eq. for one metric ton of structural steel.	1,590 kg CO_2eq. or 1.59E+03 kg CO_2eq. for one metric ton of structural steel.
Concrete reinforcing steel	890 kg CO_2eq. or 8.90E+02 kg CO_2eq. for one metric ton of bar.	920 kg CO_2eq. or 9.20E+02 kg CO_2eq. for one metric ton of bar.
Flat glass	1,430 kg CO_2eq. or 1.43E+03 kg CO_2eq. for one metric ton of glass.	N/A
Light-density mineral wool board insulation	3.33 kg CO_2eq. for 1 m^2 of insulation at R_{SI}=1.[5]	N/A
Heavy-density mineral wool board insulation	8.16 kg CO_2eq. for 1 m^2 of insulation at R_{SI}=1	N/A

Marin County

Table 19.07.050 Cement and Embodied Carbon Limit Pathways

	Cement limits for use with any compliance method 19.07.050.2 through 19.07.050.5	**Embodied Carbon limits** for use with any compliance method 19.07.050.2 through 19.07.050.5
Minimum specified compressive strength f'_c, psi (1)	Maximum ordinary Portland cement content, lbs/yd^3 (2)	Maximum embodied carbon kg CO_2e/m^3, per EPD
up to 2500	362	260
3000	410	289
4000	456	313
5000	503	338
6000	531	356
7000	594	394
7001 and higher	657	433
up to 3000 light weight	512	578
4000 light weight	571	626
5000 light weight	629	675

Notes
(1) For concrete strengths between the stated values, use linear interpolation to determine cement and/or embodied carbon limits.
(2) Portland cement of any type per ASTM C150.

CalGreen Embodied Carbon Requirements

IN EFFECT AS OF JULY 1, 2024

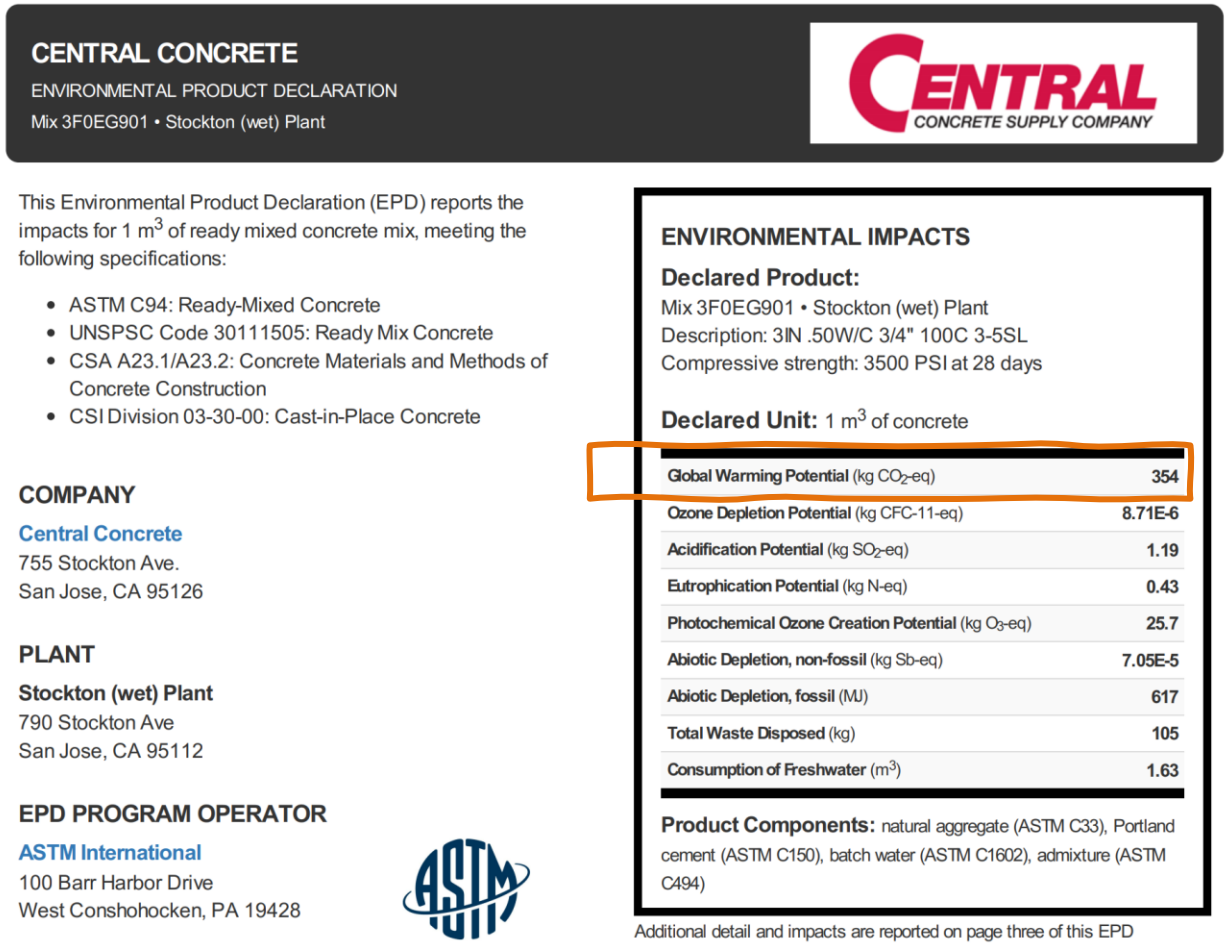
These embodied carbon requirements will apply to K–12 schools 50,000 ft² or larger and to other non-residential buildings 100,000 ft² or larger. The threshold goes down to 50,000 ft² for all non-residential projects in 2026.

Compliance Path	Mandatory	Optional Stretch Code Tier 1	Optional Stretch Code Tier 2
Building reuse	45% of structure and enclosure	75% of structure and enclosure	75% of structure and enclosure 30% of interior non-structural elements
Prescriptive: steel, flat glass, and mineral wool (expressed as a percentage of the industry-wide global warming potential limit set by the 2022 version of the Buy Clean California Act)	175%	150%	100%
Prescriptive: ready-mixed concrete	Option 1: individual prescriptive requirements by product category Option 2: weighted average meeting 130% of allowed limits by product category		
Performance (determined through whole-building life-cycle assessment)	10% reduction from baseline	15% reduction from baseline	20% reduction from baseline

Compliance: EPDs

Environmental Product Declarations

- An EPD is an independently verified and registered document that reports a product's environmental impact over its life cycle.
- Need to request them during buy-out
- Sources to look up products with EPDs:
  - EC3 Database: https://buildingtransparency.org/ec3
  - Transparency Catalog: https://transparencycatalog.com/



CENTRAL CONCRETE
ENVIRONMENTAL PRODUCT DECLARATION
Mix 3F0EG901 • Stockton (wet) Plant

CENTRAL CONCRETE SUPPLY COMPANY

This Environmental Product Declaration (EPD) reports the impacts for 1 m^3 of ready mixed concrete mix, meeting the following specifications:

- ASTM C94: Ready-Mixed Concrete
- UNSPSC Code 30111505: Ready Mix Concrete
- CSA A23.1/A23.2: Concrete Materials and Methods of Concrete Construction
- CSI Division 03-30-00: Cast-in-Place Concrete

COMPANY
Central Concrete
755 Stockton Ave.
San Jose, CA 95126

PLANT
Stockton (wet) Plant
790 Stockton Ave
San Jose, CA 95112

EPD PROGRAM OPERATOR
ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428

DATE OF ISSUE
10/04/2021 **(valid for 5 years until 10/04/2026)**

ENVIRONMENTAL IMPACTS

Declared Product:
Mix 3F0EG901 • Stockton (wet) Plant
Description: 3IN .50W/C 3/4" 100C 3-5SL
Compressive strength: 3500 PSI at 28 days

Declared Unit: 1 m^3 of concrete

Global Warming Potential (kg CO_2-eq)	**354**
Ozone Depletion Potential (kg CFC-11-eq)	**8.71E-6**
Acidification Potential (kg SO_2-eq)	**1.19**
Eutrophication Potential (kg N-eq)	**0.43**
Photochemical Ozone Creation Potential (kg O_3-eq)	**25.7**
Abiotic Depletion, non-fossil (kg Sb-eq)	**7.05E-5**
Abiotic Depletion, fossil (MJ)	**617**
Total Waste Disposed (kg)	**105**
Consumption of Freshwater (m^3)	**1.63**

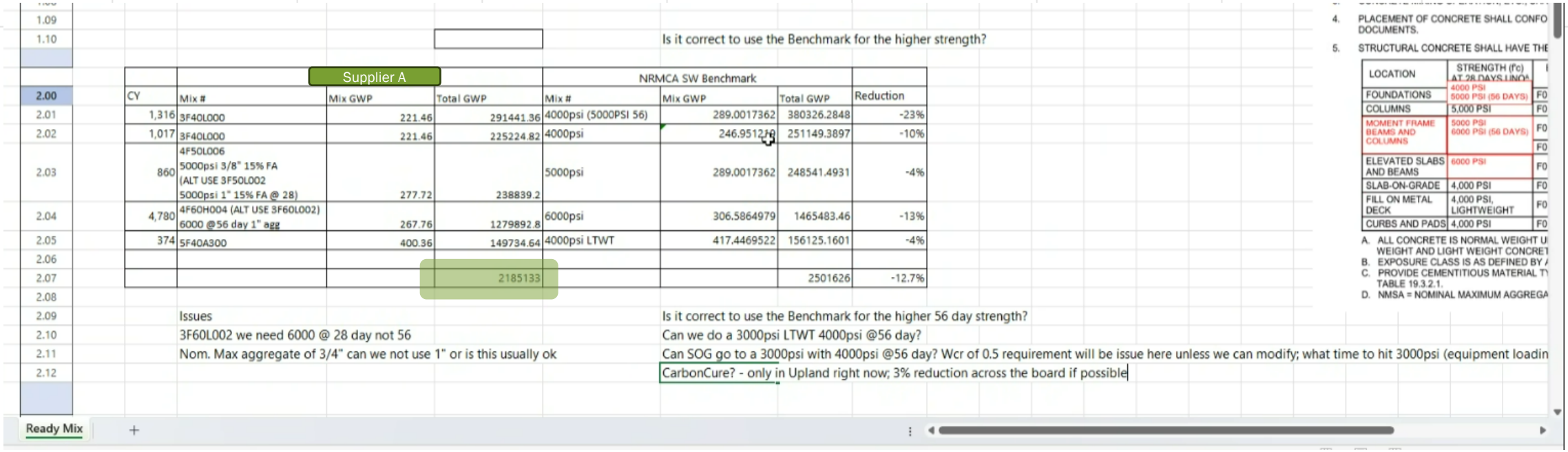
Product Components: natural aggregate (ASTM C33), Portland cement (ASTM C150), batch water (ASTM C1602), admixture (ASTM C494)

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

Concrete Bid Tally Example

Including GWP limits based on BCCA during buy-out

Supplier A			Supplier B			Supplier C		
Mix #	Mix GWP	Total GWP	Mix #	Mix GWP	Total GWP	Mix #	Mix GWP	Total GWP
3F40L000	221.46	291441.36	62131A	263	346108	1628570-S	223.2501242	293797.1635
3F40L000	221.46	225224.82	54001A	295	300015	1629770-OS	233.9538973	237931.1136
4F50L006	297.18	255574.8	16381A	327	281220	1629767-S	269.8879927	232103.6737
4F60H004	299.06	1429506.8	60934Y	348	1663440	1629769-S	301.2347567	1439902.137
5F40A300	400.36	149734.64	42710A	460	172040	1621236-AS	405.9788218	151836.0794
		2351482			2762823			2355570



Is it correct to use the Benchmark for the higher strength?

		Supplier A			NRMCA SW Benchmark			
CY	Mix #	Mix GWP	Total GWP	Mix #	Mix GWP	Total GWP	Reduction
1,316	3F40L000	221.46	291441.36	4000psi (5000PSI 56)	289.0017362	380326.2848	-23%
1,017	3F40L000	221.46	225224.82	4000psi	246.9512[illegible]	251149.3897	-10%
860	4F50L006 5000psi 3/8" 15% FA (ALT USE 3F50L002 5000psi 1" 15% FA @ 28)	277.72	238839.2	5000psi	289.0017362	248541.4931	-4%
4,780	4F60H004 (ALT USE 3F60L002) 6000 @56 day 1" agg	267.76	1279892.8	6000psi	306.5864979	1465483.46	-13%
374	5F40A300	400.36	149734.64	4000psi LTWT	417.4469522	156125.1601	-4%
			2185133			2501626	-12.7%

Issues

3F60L002 we need 6000 @ 28 day not 56

Nom. Max aggregate of 3/4" can we not use 1" or is this usually ok

Is it correct to use the Benchmark for the higher 56 day strength?

Can we do a 3000psi LTWT 4000psi @56 day?

Can SOG go to a 3000psi with 4000psi @56 day? Wcr of 0.5 requirement will be issue here unless we can modify; what time to hit 3000psi (equipment loadin

CarbonCure? - only in Upland right now; 3% reduction across the board if possible

4. PLACEMENT OF CONCRETE SHALL CONFO DOCUMENTS.

5. STRUCTURAL CONCRETE SHALL HAVE THE

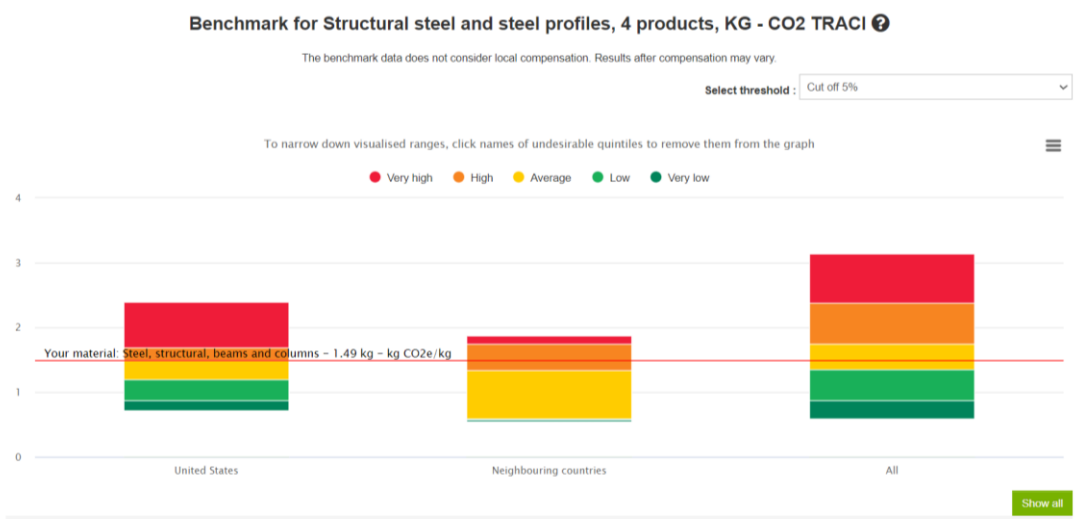
LOCATION	STRENGTH (f'c) AT 28 DAYS UNO
FOUNDATIONS	4000 PSI 5000 PSI (56 DAYS)
COLUMNS	5,000 PSI
MOMENT FRAME BEAMS AND COLUMNS	5000 PSI 6000 PSI (56 DAYS)
ELEVATED SLABS AND BEAMS	6000 PSI
SLAB-ON-GRADE	4,000 PSI
FILL ON METAL DECK	4,000 PSI, LIGHTWEIGHT
CURBS AND PADS	4,000 PSI

A. ALL CONCRETE IS NORMAL WEIGHT U WEIGHT AND LIGHT WEIGHT CONCRET
B. EXPOSURE CLASS IS AS DEFINED BY A
C. PROVIDE CEMENTITIOUS MATERIAL TY TABLE 19.3.2.1.
D. NMSA = NOMINAL MAXIMUM AGGREGA

Ready Mix

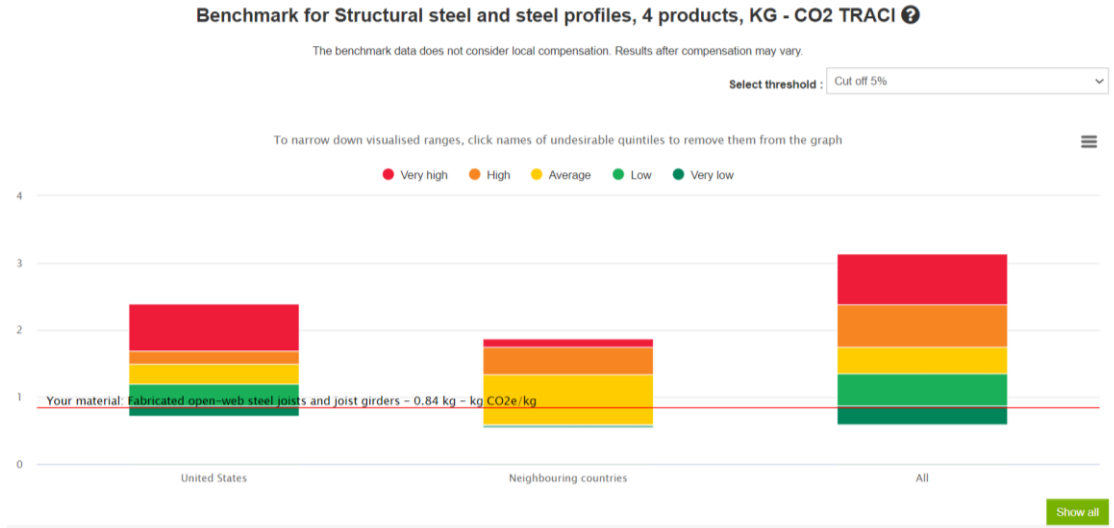
Steel Comparison

Baseline



Factor	Unit	California	United States	Neighbouring countries	All
Products in area	product	2	79	20	178
80th percentile	kg CO2e/kg	1.92	1.72 - Use as benchmark	1.77 - Use as benchmark	2.39 - Use as benchmark
Average	kg CO2e/kg	1.327	1.361 - Use as benchmark	1.106 - Use as benchmark	1.644 - Use as benchmark
Median	kg CO2e/kg	1.327	1.315 - Use as benchmark	0.73 - Use as benchmark	1.486 - Use as benchmark

Optimized

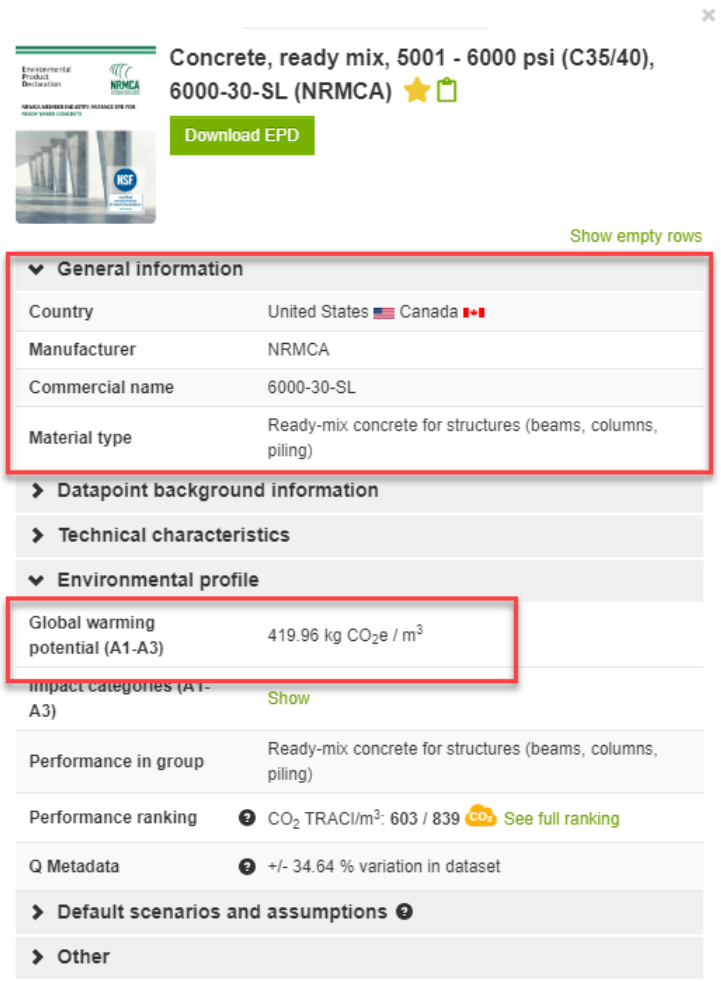


Factor	Unit	California	United States	Neighbouring countries	All
Products in area	product	2	79	20	178
80th percentile	kg CO2e/kg	1.92	1.72 - Use as benchmark	1.77 - Use as benchmark	2.39 - Use as benchmark
Average	kg CO2e/kg	1.327	1.361 - Use as benchmark	1.106 - Use as benchmark	1.644 - Use as benchmark
Median	kg CO2e/kg	1.327	1.315 - Use as benchmark	0.73 - Use as benchmark	1.486 - Use as benchmark

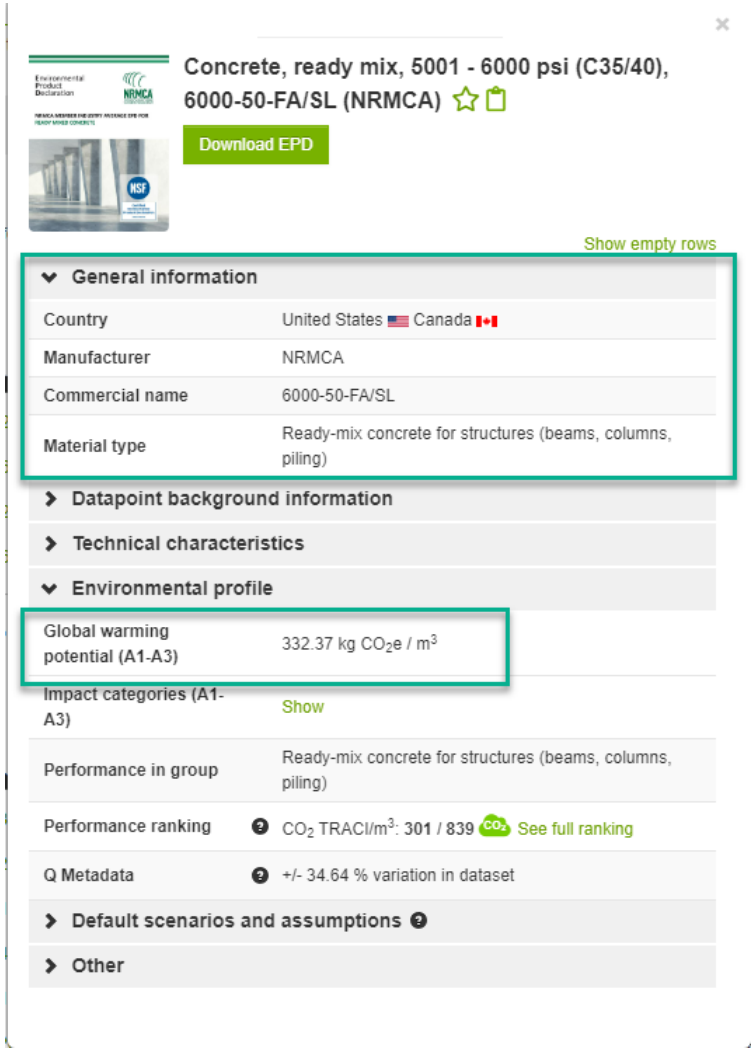
BCCA Limits are not as stringent for steel – much higher than the selected product. We chose a better product that falls in the “Low” quintile.

Concrete Comparison

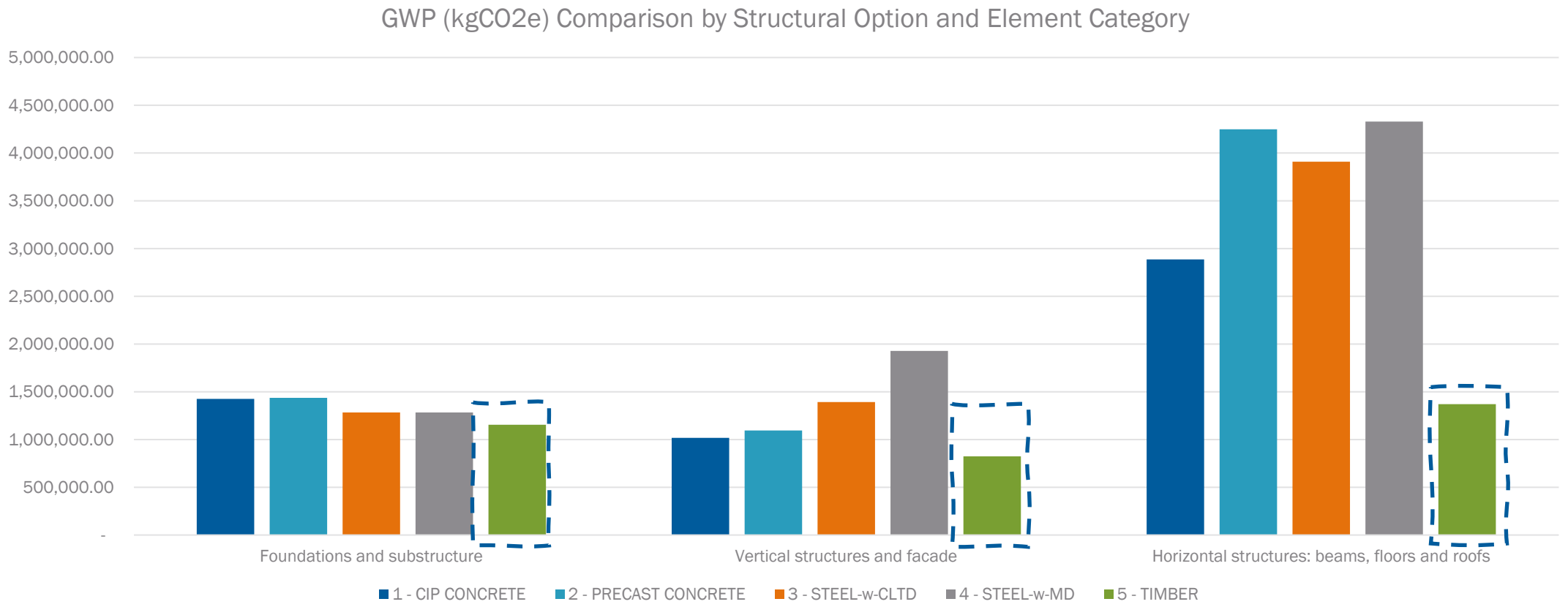
Baseline



Optimized



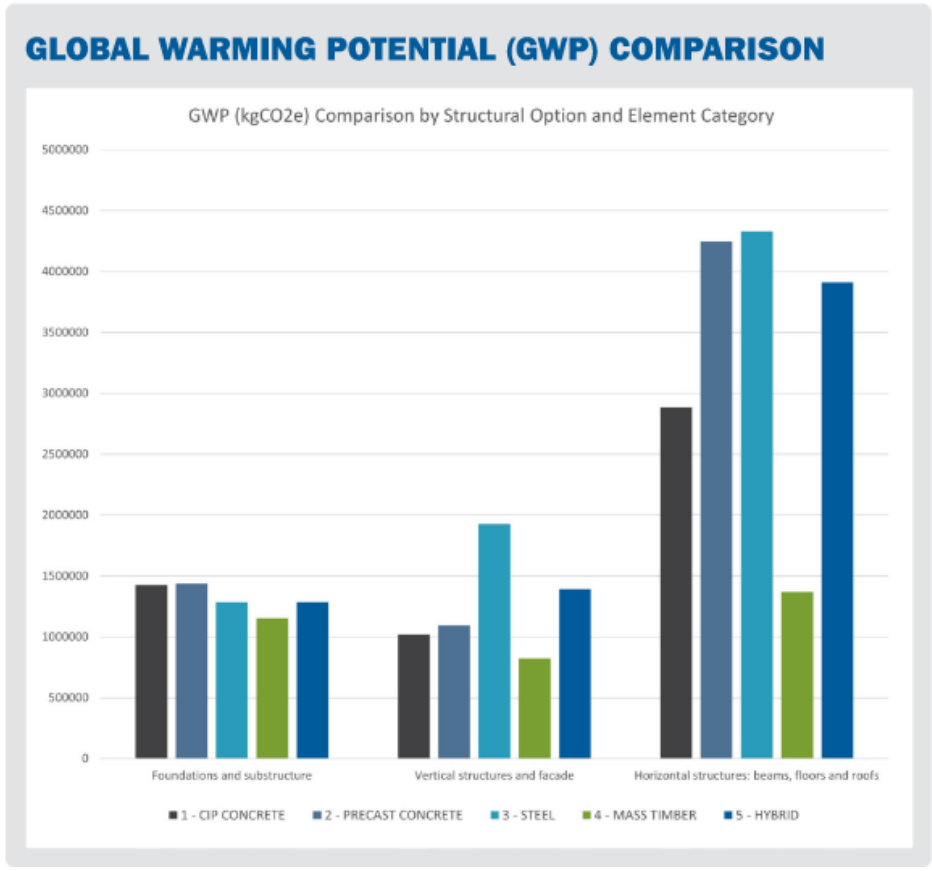
Compliance: WBLCA Examples



Mass timber had the lowest GWP of all options studied

Structural Systems Comparison

Case Study with Prefab



MASS TIMBER

Sustainability studies show that this system has the lowest GWP. Timber structures have high biogenic carbon storage, however, we have little data on the end-of-life carbon impact of such systems. There are intrinsic uncertainties and challenges in the carbon footprint assessment of CLT buildings: treatment of biogenic carbon, service life predictions, maintenance and repair assumptions, end-of-life treatment of wooden materials (reuse/recycle/incineration methods are not fully studied or explored yet). Scientific review of 27 standalone LCA studies concluded on an average 40% carbon savings a CLT building offers from a traditional build (consistent with our study).

CIP + PRECAST CONCRETE

The GWP of concrete systems can be improved through the use of alternate, eco-friendly admixtures, recycled aggregate materials, or geopolymers.

STEEL

Steel structures have the highest GWP but they also have a high recycle material content and high recyclability potential at end of life.

Performed a case study using a hypothetical Commercial project in CA to compare 5 different structural systems. Sustainability was one of the Criteria in the CBA Methodology to help guide selection of the best system for a given client.

Mass timber and Precast concrete provide high Prefab Opportunity as well.

Buy Clean Language in Contracts

Benefits and Challenges

- Existing regulation gives the GC's leverage to include this in sub-contracts
- EPDs – pushes more manufacturers to provide EPDs beyond the ones voluntarily going about it
- Understanding & familiarity EPDs, Global Warming Potential Limit requirements varies a lot regionally and between CSA / MEP
- MEP – not enough data available – MEP 2040 is trying to work on this
- In some current regulation, the GWP limits are not stringent enough – it's a good starting point but improvement can only be made if we actually encourage/incentivize low carbon materials
- Construction Stage Carbon is not addressed by most policies – A4 & A5 emissions

Path to Carbon Reduction

LEADING CHANGE

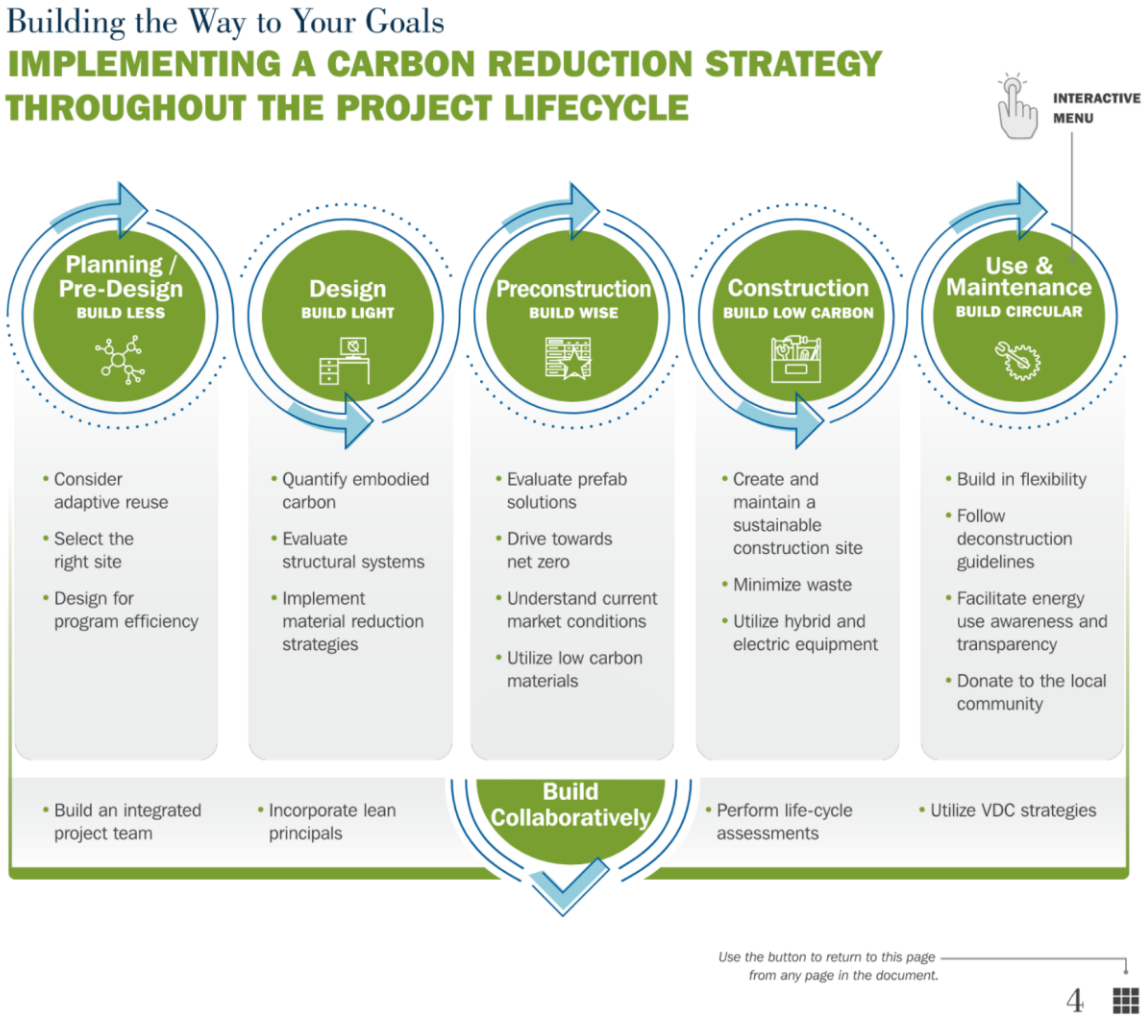
42% of companies in the Fortune Global 500 have now delivered a significant climate milestone or are publicly committed to do so by 2030, up 11% from last year.

This is no longer just a part of corporate social responsibility plans because it is the right thing to do, but a tangible goal tied to financial incentives and disincentives with some companies. There is also a potential for market share loss by doing nothing, making Environmental, Social, and Governance (ESG) a growing factor in decision making at the highest levels.

And this is happening across markets with advanced technology/mission critical, life sciences, higher education, healthcare, and commercial customers alike requiring their physical infrastructure to be more sustainable. Not planning for this early can lead to missed opportunities.

42%
Percentage of companies in the Fortune Global 500 with significant climate goals.

47%
Percentage of organizations with ≥$1B in revenue which rank environmental topics as a higher priority than all other ESG goals.



Download QR Code

Rating Systems/ Certification Impacts

Driver for clients

Embodied Carbon / LCA is required for achieving the required credits for certifications such as:

- LEED v4.1 BD+C: MR Credit - Building Life-cycle Impact reduction
  - LEED Zero Carbon future versions (for operational carbon currently)
- Living Building Challenge – Materials Petal
- ILFI Zero Carbon: demonstrate sufficient carbon reduction compared to baseline building

Resources

Learning

1. CLF – Carbon Leadership Forum (Series on EC Policy)
2. ILFI Embodied Carbon Guidance
3. NREL – Embodied Carbon Resource Navigator
4. Stanford Building Decarbonization Learning Accelerator
5. DPR Toolbox Sustainability Page
6. DPR Carbon Reduction White Paper

Tools

1. EC3 – Free, opensource database
2. EPIC – high level analysis
3. ZeroTool - high level analysis
4. OneClick LCA – detailed analysis