TRI-COUNTY
REGIONAL ENERGY NETWORK
SAN LUIS OBISPO • SANTA BARBARA • VENTURA

Practical Ways to Address Embodied Carbon

Michelle Zimney & Tatiana Soglin | In Balance Green Consulting

May 1, 2025

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  Be sure **full name** is displayed.
- Did you call in? Please **share** first and last name with us.
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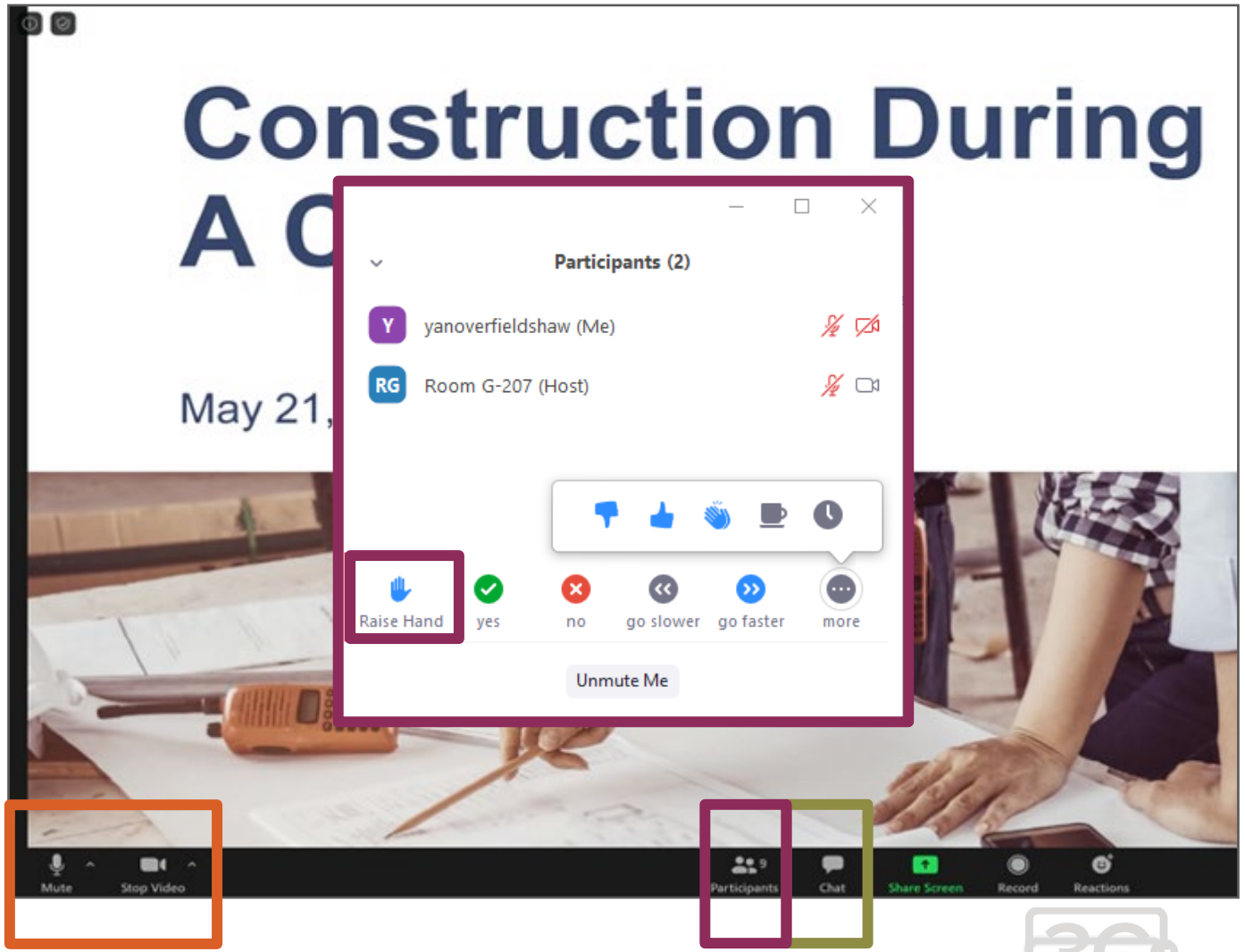

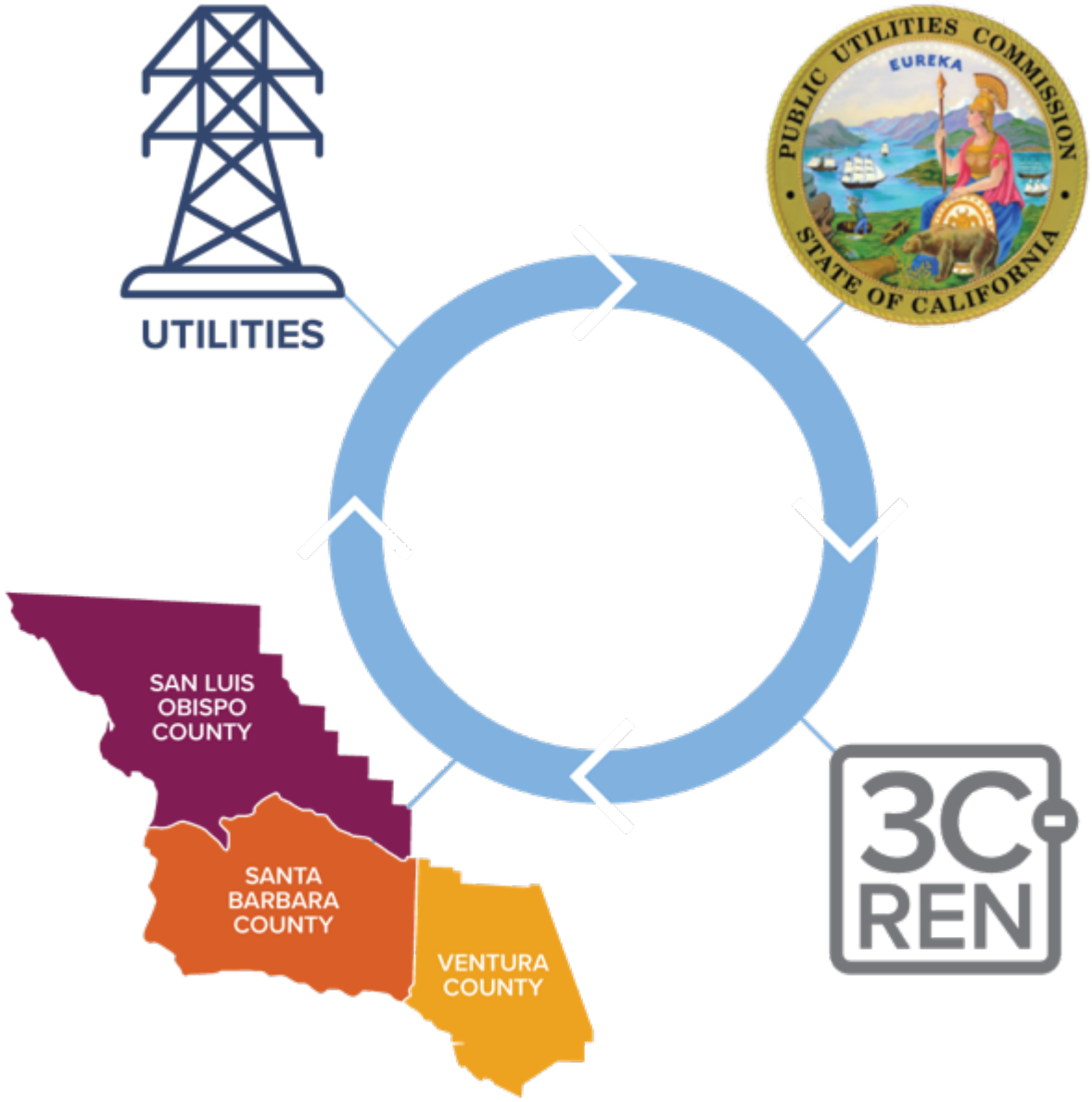

Tri-County Regional Energy Network

3C-REN is a collaboration between the tri-counties

Our programs reduce energy use for a more sustainable, equitable and economically vibrant Central Coast

Our free services are funded via the CPUC, bringing ratepayer dollars back to the region

Our Services

Incentives

HOME ENERGY SAVINGS

3c-ren.org/for-residents
3c-ren.org/multifamily

COMMERCIAL ENERGY SAVINGS

3c-ren.org/commercial

Contractors can enroll at
3c-ren.org/contractors

Training

BUILDING PERFORMANCE TRAINING

3c-ren.org/events
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ENERGY CODE CONNECT

3c-ren.org/code

View past trainings at
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Technical Assistance

AGRICULTURE ENERGY SOLUTIONS

3c-ren.org/agriculture

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3c-ren.org/assurance

Practical Ways to Address Embodied Carbon

May 1, 2025

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In This Presentation

- Operating vs Embodied Carbon – and other terms
- Why Care about Embodied Carbon?
- Embodied Carbon in the Construction Process – Understanding Relative Impacts
- Practical steps (and shortcuts) for Reducing EC
- 3 Methods for CALGreen Compliance
- Innovations: Materials and Landscapes

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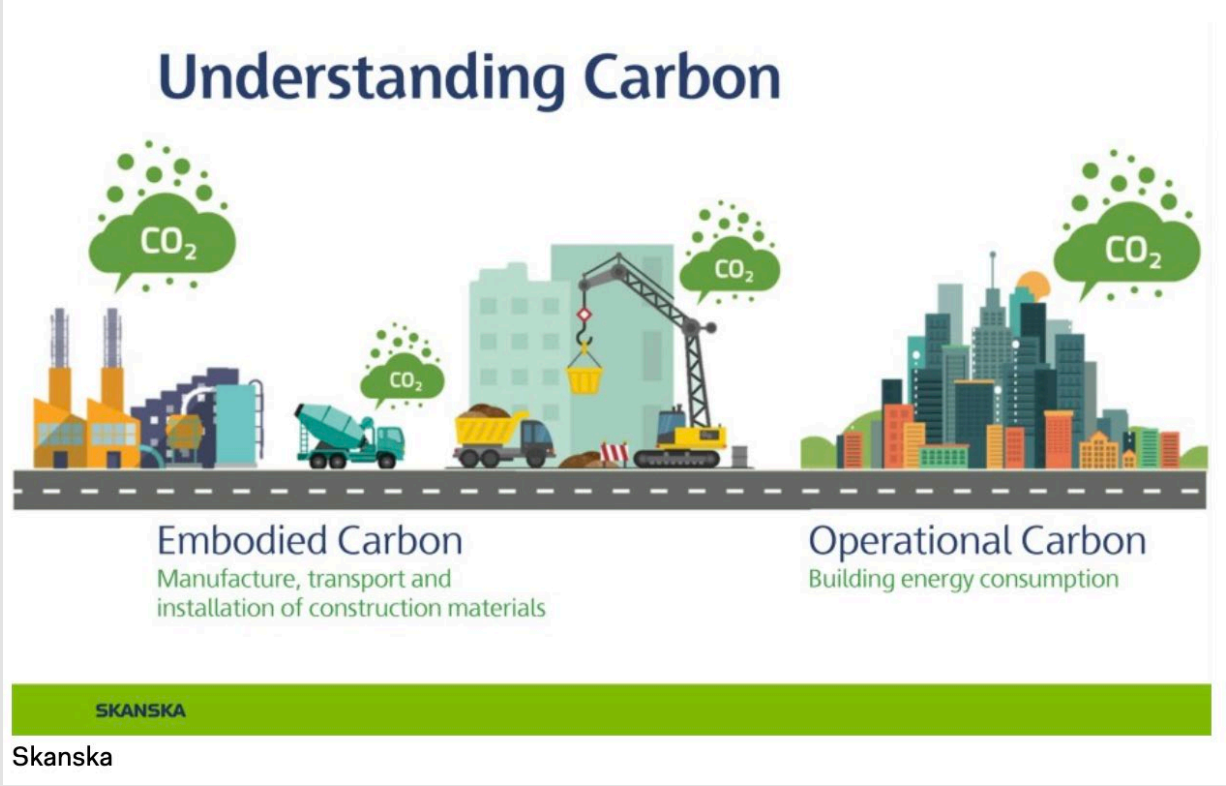
Differentiating Types of Carbon



Skanska

- **Embodied carbon (EC)** refers to the greenhouse gas emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of building materials.
- **Kg CO2e** is often used as proxy measure for embodied carbon (valid across CO2, methane, etc.)

- **Operational carbon** refers to the greenhouse gas emissions due to building energy consumption.

Source: https://carbonleadershipforum.org/embodied-carbon-101/

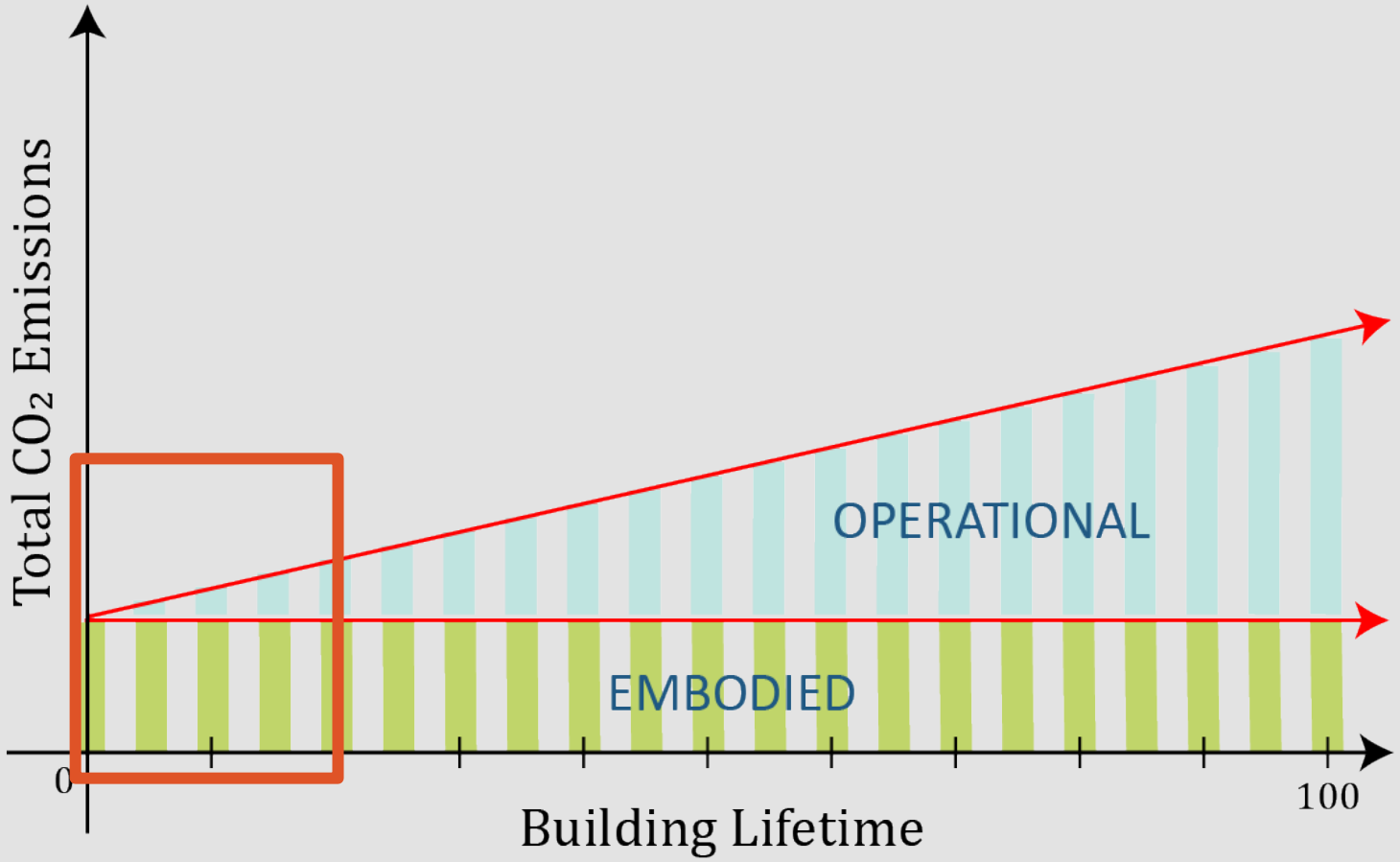
Other Terms

- **GWP – Global Warming Potential (in kg CO2e)** - A proxy for Embodied Carbon
- **ECI – Embodied Carbon Intensity (in kg CO2e/m²) –** A metric used to describe GWP associated with embodied emissions of a building
- **EPD – Environmental Product Declarations** *(env. Impacts including GWP)*
- **HPDs – Health Product Declaration** *(health impacts such as pollutants/toxins)*
- **LCA – Life Cycle Analysis –** A systematic analysis of environmental impact of a product, material, process, etc.
- **WBLCA – Whole Building Life Cycle Assessment –** An evaluation of the environmental impact of a building's systems and materials
- **For reference:**
  - **MT/t (metric tonne)** = 1000kg or 2204.62lbs
  - **Ton** – 2000 lbs

Why Care about EC?

Time value of carbon – Project level

Embodied carbon makes up the majority of carbon associated with a building in the first 20 years.



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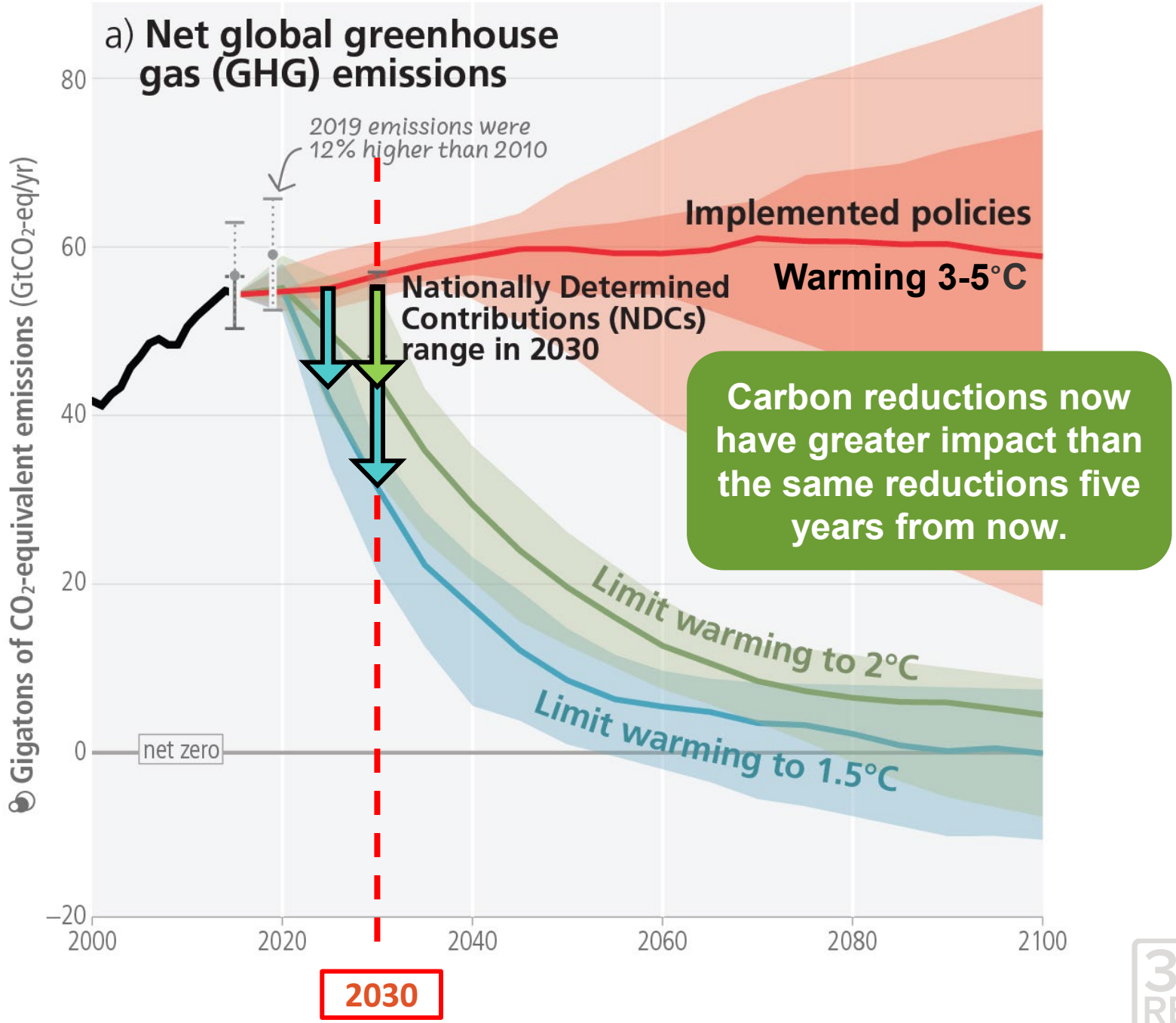
Why Care about EC?

Time value of carbon – Global level



Carbon reductions now have greater impact than the same reductions five years from now.

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Another Curve

- "To approach zero emissions by 2050, however, we must immediately **pick the low-hanging fruit everywhere** possible and simultaneously accelerate the embodied carbon learning curve to advance our knowledge beyond the easy reductions, uncover further decarbonization strategies, and **turn buildings into climate solutions with carbon-storing materials."**

  - RMI, "Driving Action on Embodied Carbon in Buildings"

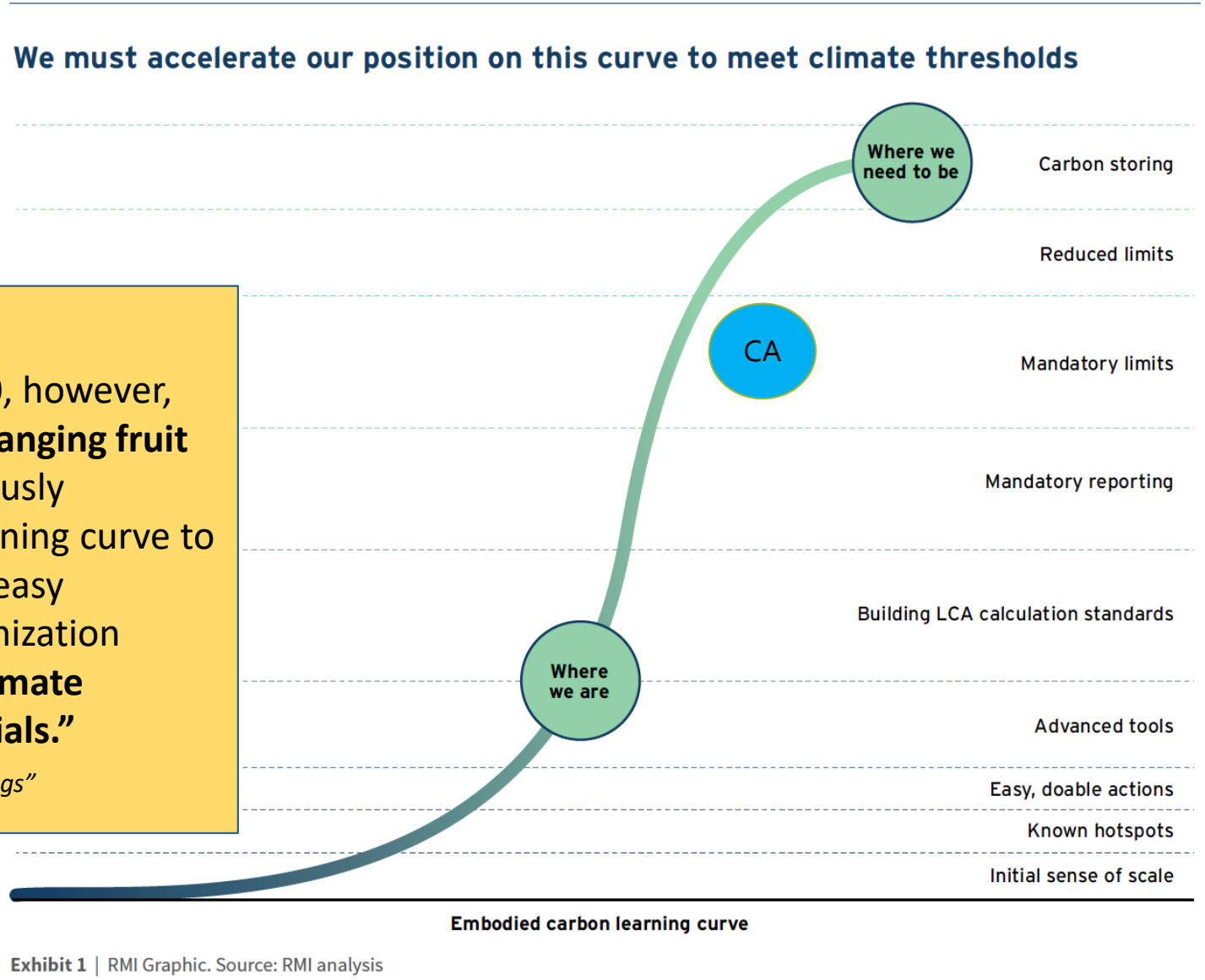

Exhibit 1 | RMI Graphic. Source: RMI analysis

Will decrease to 50,000 SF Jan. 1, 2026!

Why Care about EC?

You now have to….

CALGreen Intervening Code Cycle Update – Effective as of July 1, 2024

Threshold: 100,000 square foot aggregate project size. Schools under jurisdiction of DSA have a 50,000 SF threshold.

Building Reuse **Section 5.105, Deconstruction and Reuse of Existing Structures**	Life Cycle Analysis **Section 5.409, Life Cycle Assessment**	Prescriptive Path **Section 5.409.3, Product GWP Compliance**
Components: Existing primary structural elements, enclosure, (roof framing, wall framing, and exterior finishes). **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.	**Scope:** 60-year cradle-to-grave WB LCA (ISO 14044), excluding operating energy. Show GWP analysis. **Components:** Primary and secondary structural members, glazing, insulation, exterior finishes.	**Components:** Structural steel, rebar, flat glass, light and heavy-duty mineral wool insulation, and ready mix concrete. **Exception:** Concrete mixes can use a weighted average for all mixes.
Mandatory 45% of the structure and enclosure to be reused	**Mandatory** 10% reduction from baseline	**Mandatory** 175% of IW-EPD GWP Limits
Tier 1 75% of the structure and enclosure to be reused	**Tier 1** 15% reduction from baseline	**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	**Tier 2** 20% reduction from baseline	**Tier 2** IW-EPD GWP Limits

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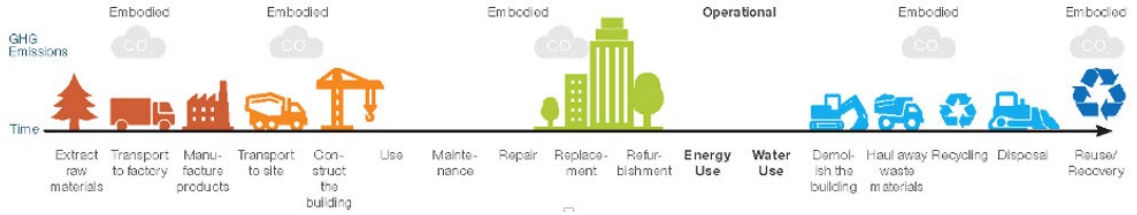
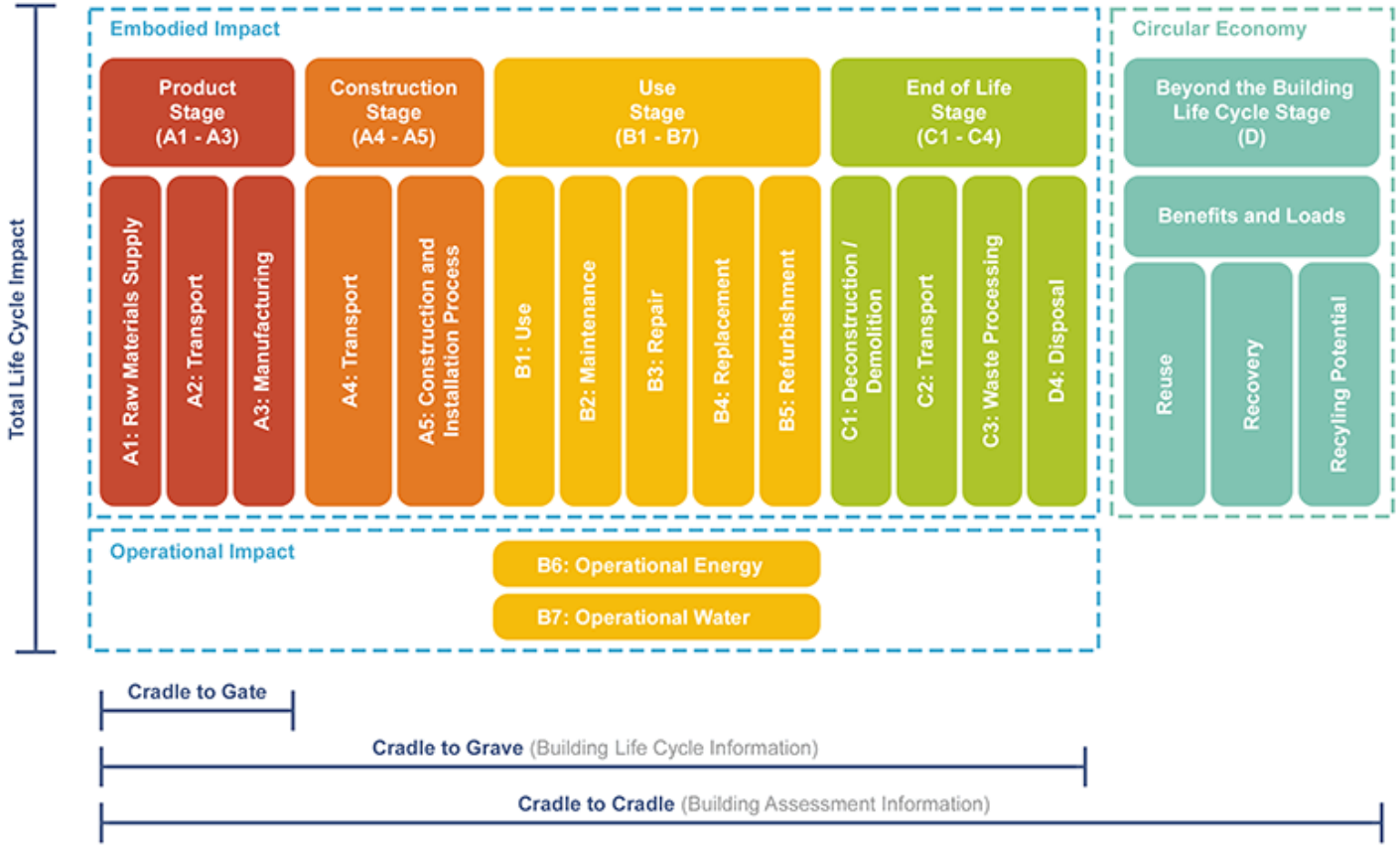
Embodied Carbon in the Construction Process

Credit: Skanska

Life-Cycle Analysis: Stages and Scopes





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Embodied Carbon Emissions by life cycle stage

The majority of building product embodied emissions occur up front

Breakdown of product life-cycle, not including building operational emissions

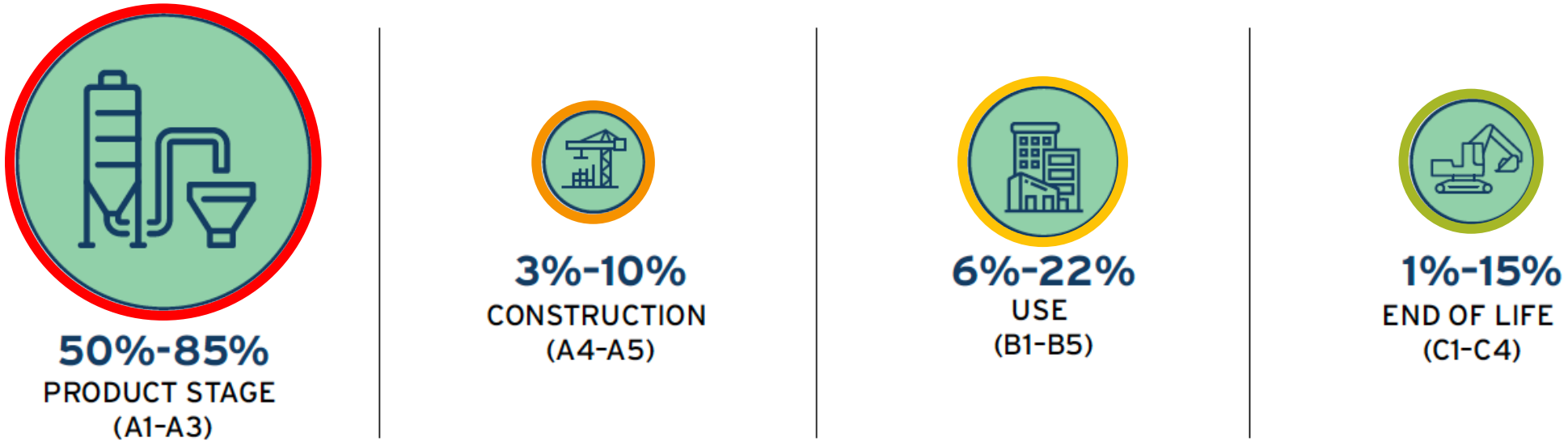

Exhibit 2 | RMI Graphic. Source: See endnote 7

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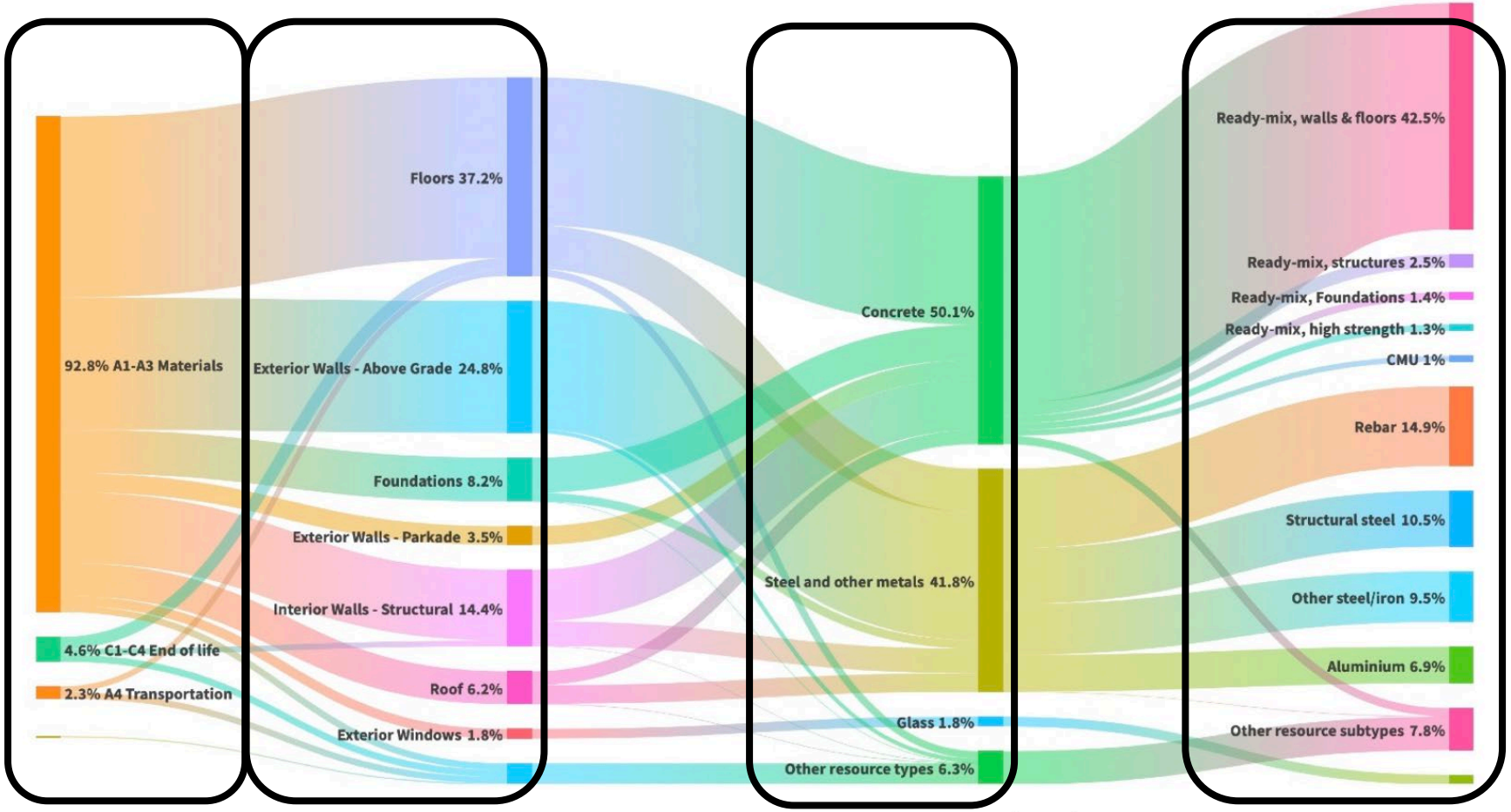
Embodied Carbon emissions by materials



An LCA evaluation by Priopta looks at the embodied carbon, or Global Warming Potential (GWP), of the materials used in a building.

Source: https://www.canadianarchitect.com/embodied-carbon-key-considerations-for-key-materials/

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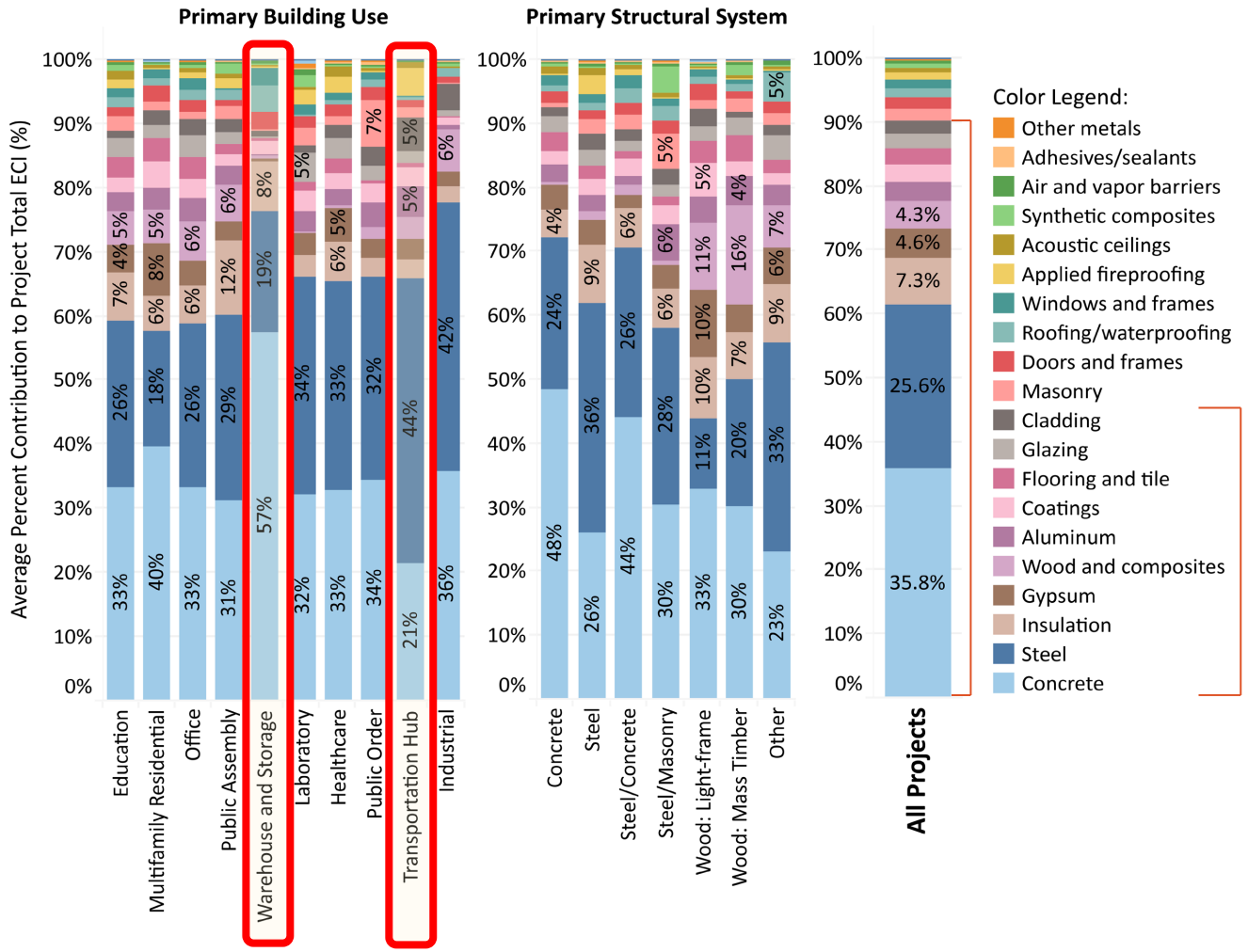
Embodied Carbon by Building Type



Source: The Embodied Carbon Benchmark Report: Embodied Carbon Budgets and Analysis of 292 Buildings in the US and Canada, Carbon Leadership Forum, 2025

Embodied carbon intensity (ECI) - metric used to describe GWP associated with embodied emissions of a building expressed in kilograms of carbon dioxide equivalents per square meter

10 material groups make up **90%** or more of project EC: **Concrete, Steel, Insulation, Gypsum, Wood and composites, Aluminum, Coatings, Flooring and Tile, Glazing, and Cladding**

Cost-effective, Low-Carbon Product Specification

Source: https://rmi.org/embodied-carbon-101/

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.

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.

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.

Insulation

Actions to Reduce Carbon

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

Glazing

Actions to Reduce Carbon

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

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.

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Source: Embodied Carbon and CALGreen Embodied Carbon Requirements, California Energy Codes & Standards, 2024

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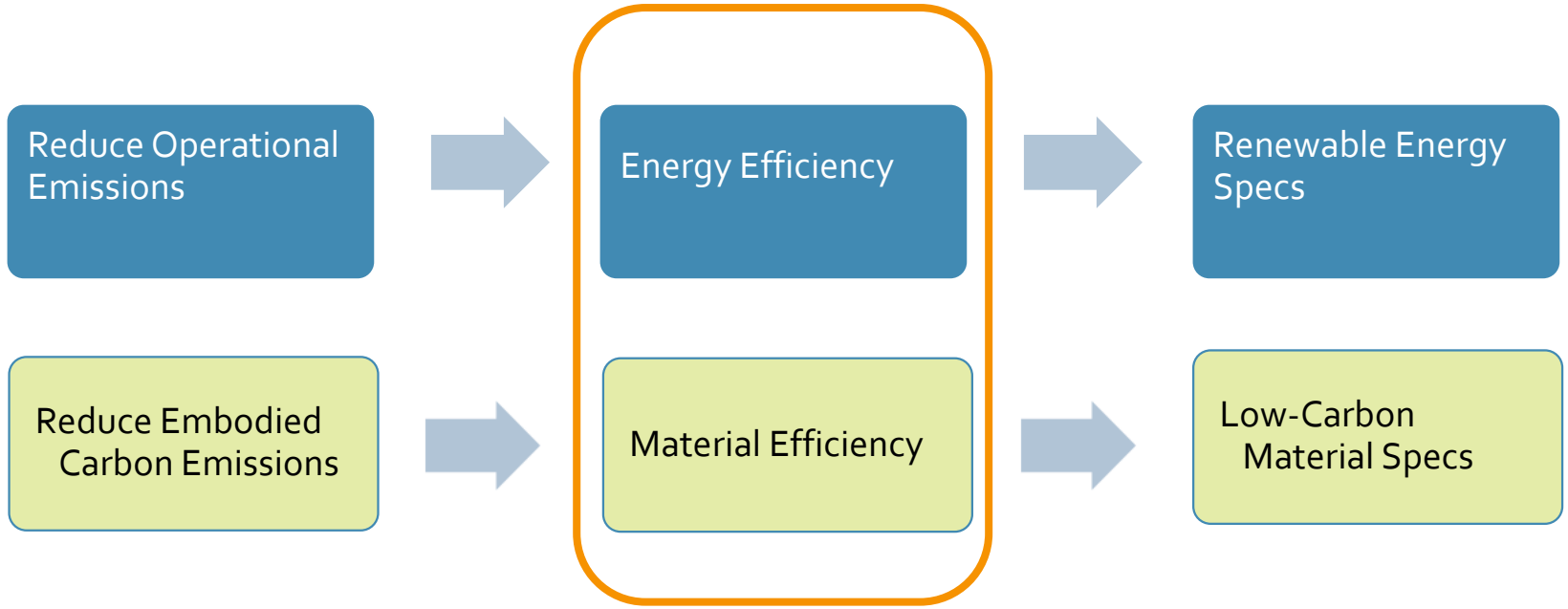
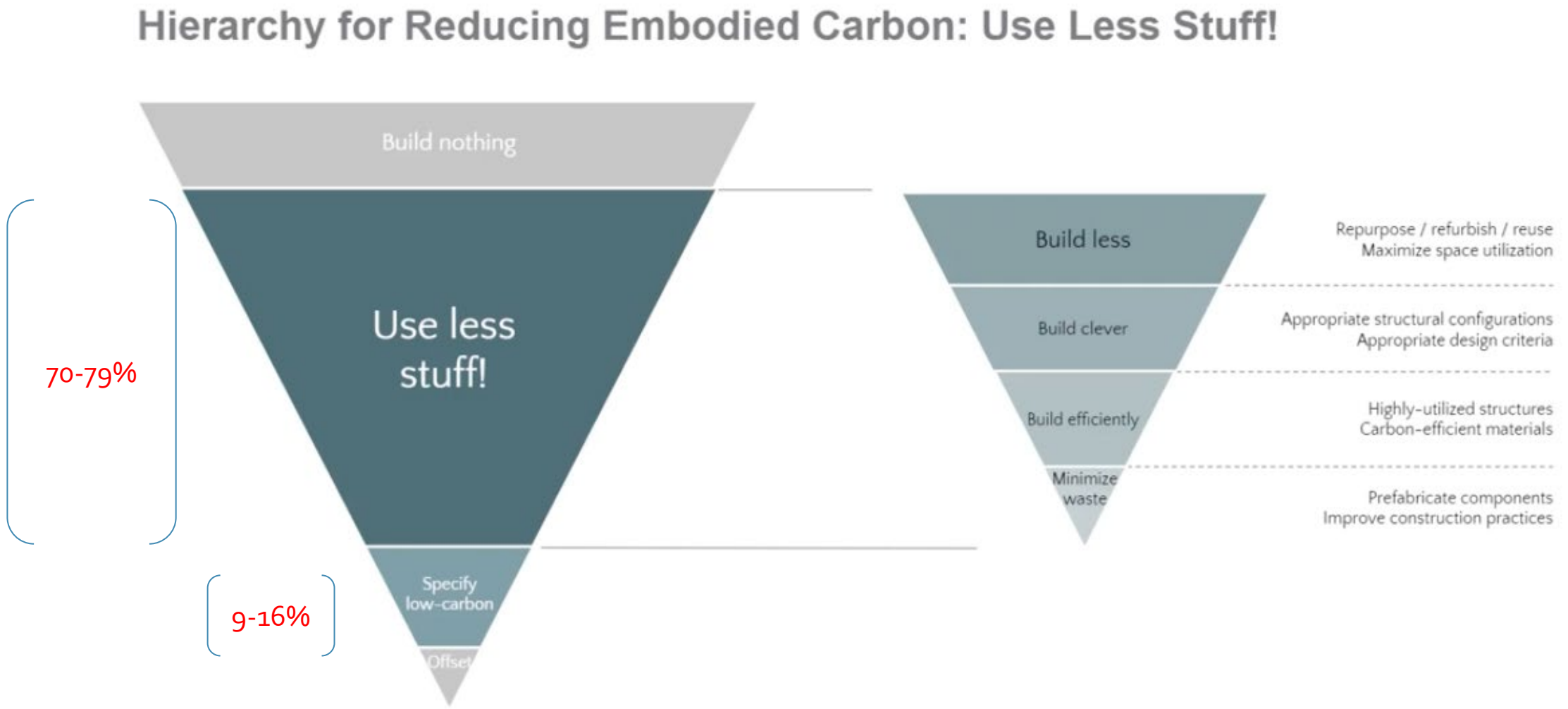
Parallel Strategy: SE2050 Material Efficiency

"If we equate the strategies of reducing embodied carbon to those we've successfully applied in reducing operating emissions, it would seem that material efficiency is the equivalent of energy efficiency and specifying low-carbon materials is like renewable energy -- lowering the emissions of the supply."

– Vincent Martinez Architecture 2030



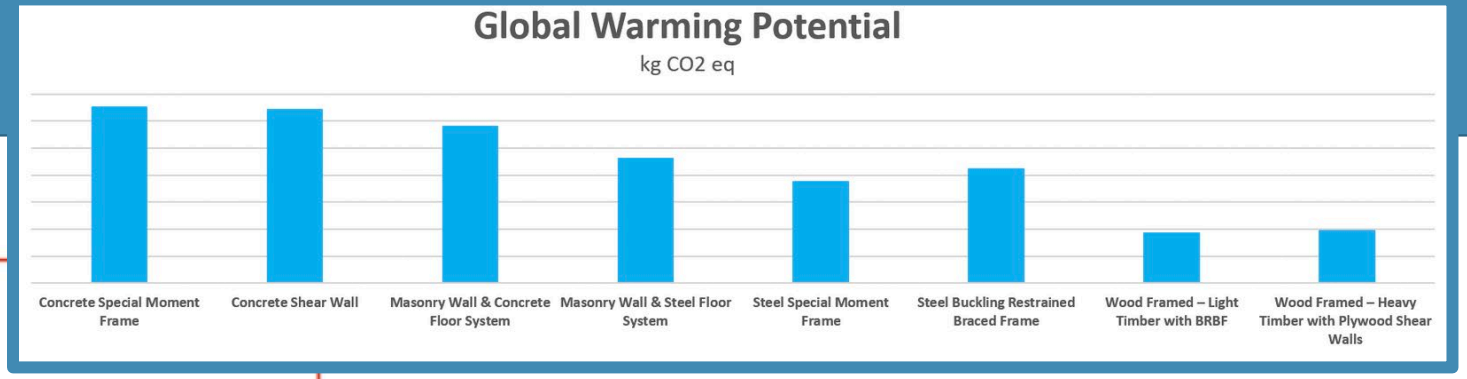
Material Efficiency First

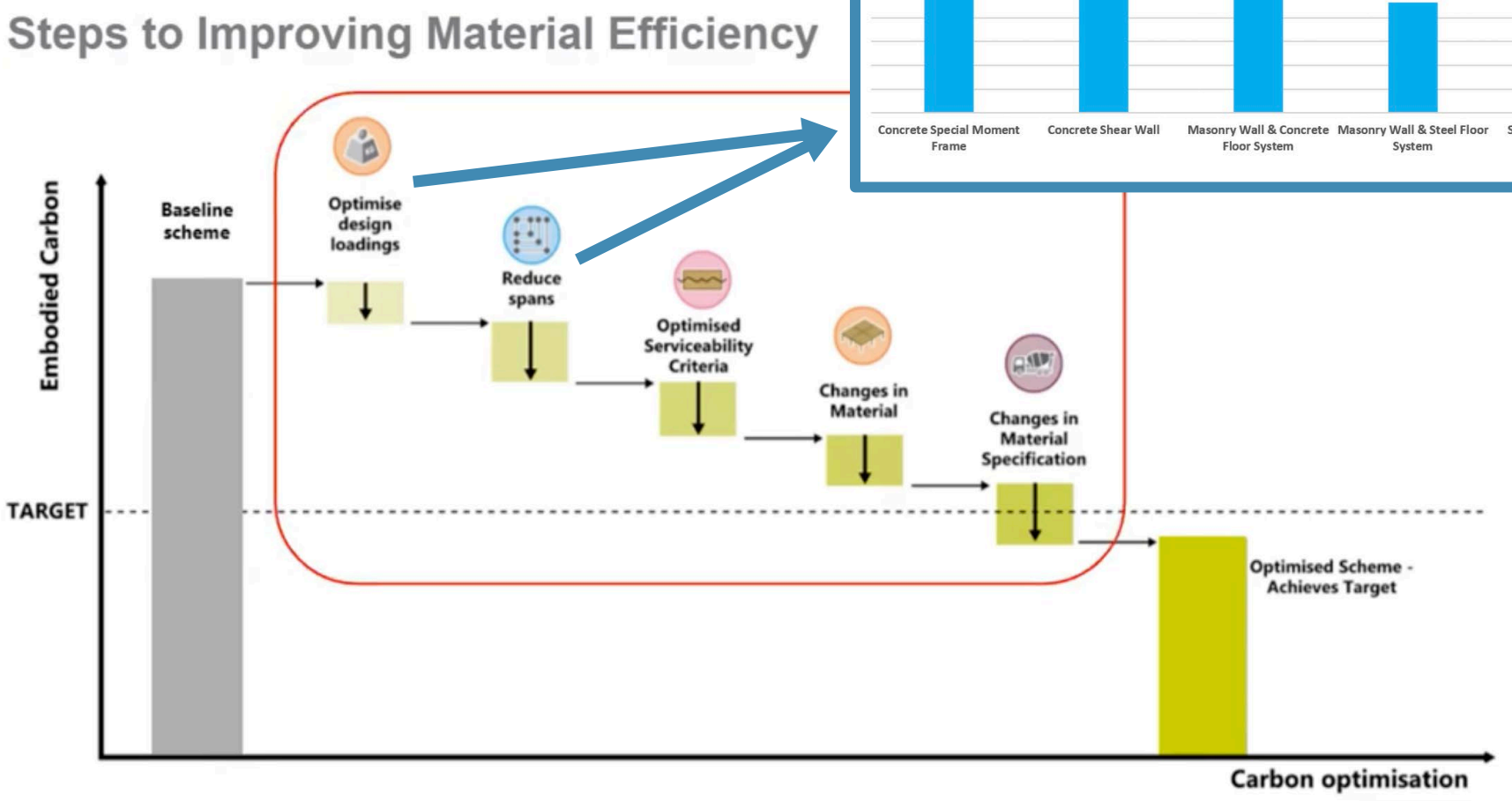


Snapshot from Material Efficiency Webinar | CLF and SE2050

Statistics source: Kiley Feickert and Caitlin T. Mueller, "Policy and design levers for minimizing embodied carbon in United States buildings: A quantitative comparison of current and proposed strategies", *Building and Environment*, vol. 270, 15 February 2025.

Build Clever





CLF Carbon Leadership Forum

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Practical Steps for Reducing EC

Top design interventions for embodied carbon reduction

1 Reuse

Reuse an entire building and/or components of a deconstructed building. Limit the scope of renovations to what is needed. Prioritize salvaged materials over new production.

2 Right-size

Optimize building size by using space more intensively and minimizing excess space. Design with better scheduling or dual-use spaces to decrease the building size.

3 Dematerialize

Expose structure instead of applying finishes. Optimize structural system to minimize excess material. Consider reducing overdesign by evaluating conservative load assumptions.

4 Carbon storing materials

Carbon storing materials can speed transition to zero embodied emissions. Building projects can ask for responsibly produced biobased and concrete materials that can store carbon durably.

5 Product substitutions

Make substitutions for the highest impact materials informed by a whole-building integrated approach or by low-material GWP limits when you cannot do an LCA.

6 Sourcing

Ensure products are coming from legal and sustainable or regenerative sources. Prioritize local materials when data reveals they have reduced impacts associated with transport.

7 Circular design

Reduce the impact over the building's life cycle and enable low-embodied-carbon future construction by prioritizing reusability, recyclability, design for disassembly, and durability.

Source: RMI, Driving Action on Embodied Carbon Reduction, pg 20.

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Three Methods for CALGreen Compliance

	Building Reuse	Whole Building LCA	Prescriptive Approach
Mandatory*	**45% REUSE** of structure and enclosure	**10% REDUCTION** from baseline building	Limit Materials to **175%** of GWP limits
Tier 1	**75% REUSE** of structure and enclosure	**15% REDUCTION** from baseline building	Limit Materials to **150%** of GWP limits
Tier 2	**75% REUSE** of structure and enclosure **AND** **30% REUSE** of interior non-structural	**20% REDUCTION** from baseline building	Limit Materials to **100%** of GWP limits

2022 Code Threshold: 100,000 square foot aggregate project size. Schools under jurisdiction of DSA have a 50,000 SF threshold.
2025 Code Threshold: 50,000 square foot aggregate project size.

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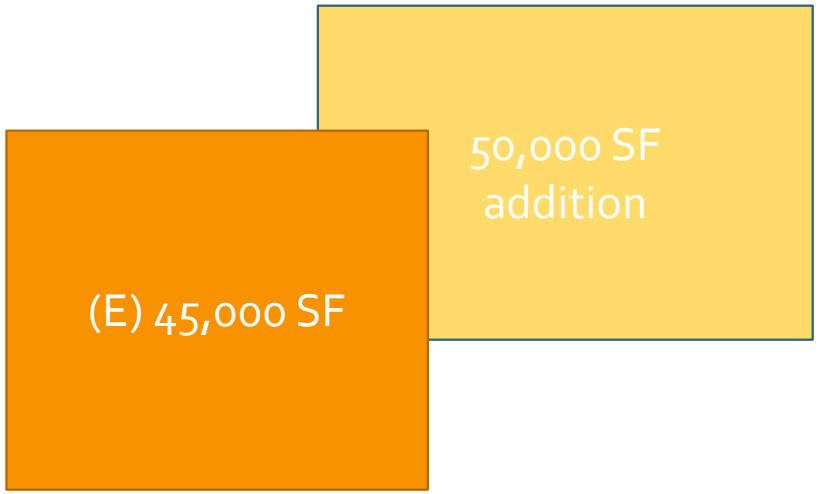
CALGreen: Building Reuse

- 5.105.2 Reuse of existing building. An alteration or addition to an existing building shall maintain at a minimum 45 percent combined of the existing building's primary structural elements (foundations; columns, beams, walls, and floors; and lateral elements) and existing building enclosure (roof framing, wall framing and exterior finishes). Window assemblies, insulation, portions of buildings deemed structurally unsound or hazardous, and hazardous materials that are remediated as part of the project shall not be included in the calculation.

- Exception [BSC-CG, DSA-SS]: Combined addition(s) to existing building(s) of two times the area or more of the existing building(s) is not eligible to meet compliance with Section 5.105.2.

Case Study: Reuse



Total SF > 100,000 SF?

No

	Existing Building SF	Addition SF	Total SF	Total > 100k SF?	Addition is 2x or more of Existing?	CALGreen Documentation Method
Building A	45,000 SF	50,000 SF	90,000 SF	No		Does not trigger EC compliance req.
Building B	45,000 SF	80,000 SF	105,000 SF	Yes	No	Reuse documentation
Building C	45,000 SF	100,000 SF	145,000 SF	Yes	Yes	WBLCA or Prescriptive

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Case Study: Reuse

Total SF > 100,000 SF?

Yes

Addition > 2x Existing SF?

No

	Existing Building SF	Addition SF	Total SF	Total > 100k SF?	Addition is 2x or more of Existing?	CALGreen Documentation Method
Building A	45,000 SF	50,000 SF	90,000 SF	No		Does not trigger EC compliance req.
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Case Study: Reuse

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Yes

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Building B	45,000 SF	80,000 SF	105,000 SF	Yes	No	Reuse documentation
Building C	45,000 SF	100,000 SF	145,000 SF	Yes	Yes	WBLCA or Prescriptive

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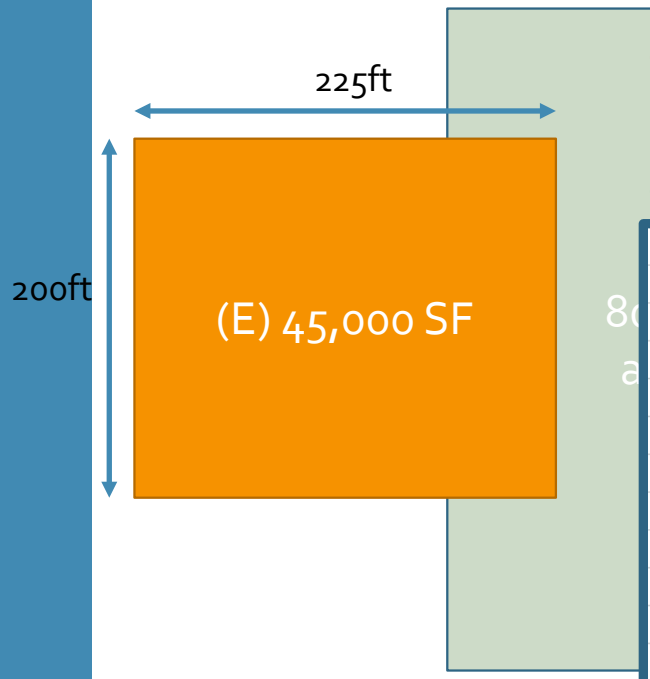
Documenting Reuse

- Primary structural elements (foundations; columns, beams, walls, and floors; and lateral elements)
- Existing building enclosure (roof framing, wall framing and exterior finishes)
- Exclude windows, insulation, hazardous



Primary Structure					
			Existing SF	Retained SF	
	perimeter foundation		2550	2550	
	concrete floor		45,000	45,000	
	CMU walls		8500	4250	
	lateral beams		900	0	
	excl windows		50	0	
		subtotal	*57000*	*51800*	*90.88 %*
Existing enclosure					
	roof framing		45000	0	
	wall framing		n/a	n/a	
	exterior finishes		8450	8450	
		subtotal	*53450*	*8450*	*15.81 %*
Total			**110,350**	**60,250**	**54.60 %**

WORKSHEET (WS-3)
5.105.2 BUILDING REUSE

DOCUMENTATION OF COMPLIANCE OF EXISTING BUILDING REUSE

Area of Existing Building(s) 45,000 **SF**

Area of Aggregate Addition(s) (if applicable) 80,000 **SF**

	EXISTING TOTAL AREA (A)	RETAINED TOTAL AREA (B)	% OF RETAINED STRUCTURE (B)/(A)
Primary Structural Elements of Existing Building(s) (foundations; columns, beams, walls, and floors; and lateral elements)	57,000 SF	51,800 SF	90.88 % SF
Building Enclosure of Existing Building(s) (roof framing, wall framing and exterior finishes only)	53,450 SF	8450 SF	15.81 % SF

Total % Reuse of Required Elements ≥ 45% 54.60 %

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CALGreen: WBLCA

5.409.2 Whole building life cycle assessment. Projects shall conduct a cradle-to-grave whole building life cycle assessment performed in accordance with ISO 14040 and ISO14044, excluding operating energy, and demonstrating a minimum 10-percent reduction in global warming potential (GWP) as compared to a reference baseline building of similar size, function, complexity, type of construction, material specification, and location that meets the requirements of the California Energy Code currently in effect.

5.409.2.1 Building components. Building enclosure components included in the assessment shall be limited to glazing assemblies, insulation, and exterior finishes. Primary and secondary structural members included in the assessment shall be limited to footings and foundations, and structural columns, beams, walls, roofs, and floors.

ASTM E2921-22 **Reference building** shall have the same location, orientation, size, function and space conditioning as the proposed building. Materials shall be based on typical design or construction practices for the area in which the site is located.

CALGreen WBLCA Scope

Exhibit 2 Typical high-embodied-carbon structural elements, building envelope materials, and finish materials

Source: Mithun

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Documenting WBLCA

- A summary of the GWP analysis produced by the software and Worksheet WS-4 signed by the design professional of record shall be provided in the construction documents as documentation of compliance.

WORKSHEET (WS-4)
Section 5.409.2 WHOLE BUILDING LIFE CYCLE ASSESSMENT

Responsible Designer's Declaration Statement:
I attest that the Whole Building Life Cycle Analysis has been performed according to the requirements of Section 5.409.2 and has met the minimum 10 percent reduction in global warming potential as compared to a reference baseline building of similar size, function, complexity, type of construction, material specification, and location that meets the requirements of the *California Energy Code* currently in effect. Furthermore, I will ensure during construction that the material specifications will be reviewed for substantial conformance with the life cycle assessment indicated on the approved plans so at the close of construction the minimum 10 percent reduction in global warming potential is thereby secured.

Signature:	.
Company:	Date:
Address:	License:
City/State/Zip:	Phone:

- A copy of the whole building life cycle assessment which includes the GWP analysis produced by the software, in addition to the maintenance and training information, shall be included in the O&M manual.

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Tools for modeling WBLCA

Free software:

Athena Sustainable Materials Institute

One Click LCA

Planetary

Paid software:

sphera®

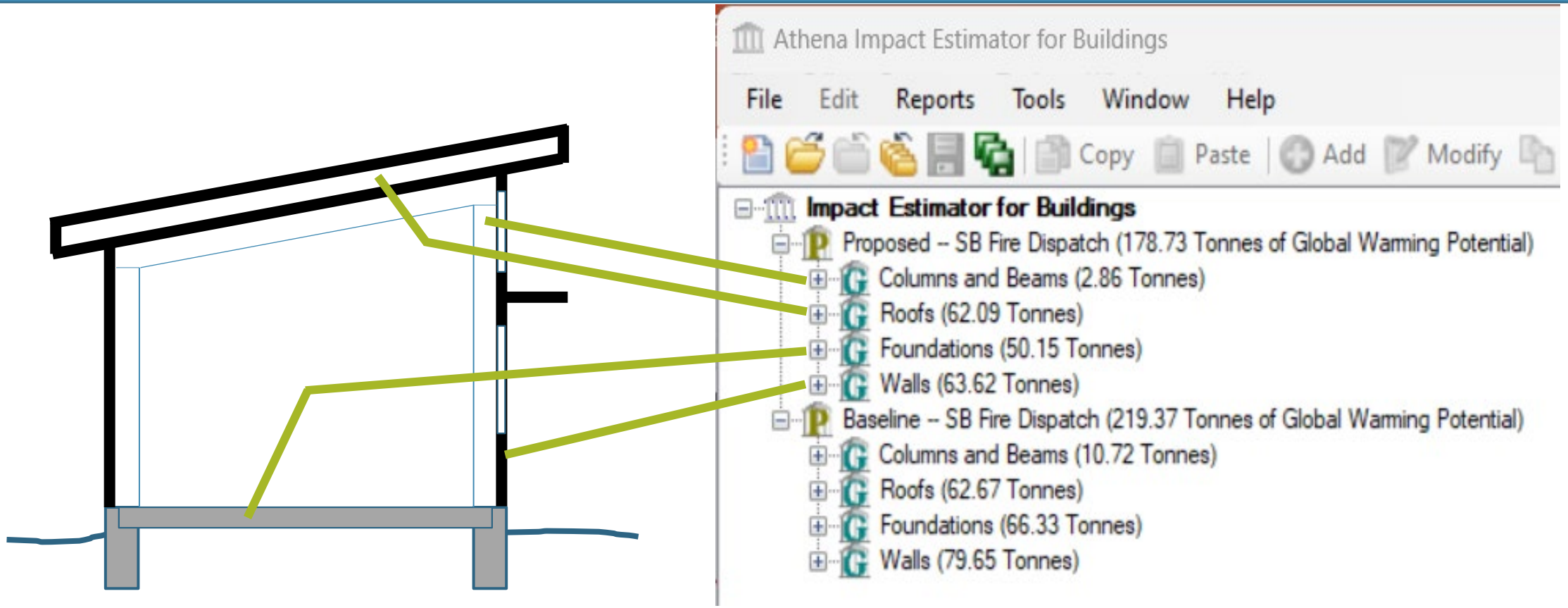
(fka GaBi)

SimaPro

tally®

(Revit plug-in)

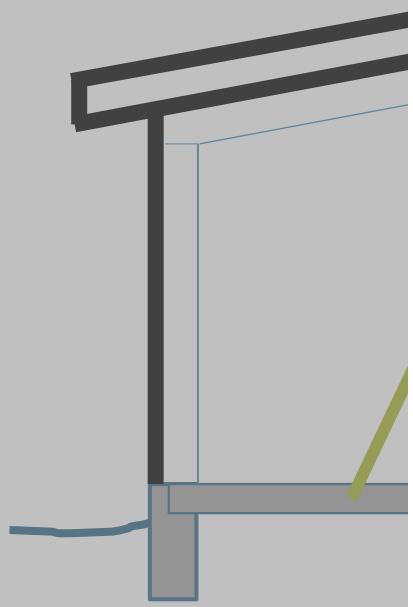
Athena – Building Tree Organization



The user can build a **Baseline** model and a **Proposed** model for comparison.
The user can define the wall and roof assemblies.
The wall assemblies include "openings" for basic window inputs.
The foundation can include slab, footings, grade beams, pad footings and rebar.

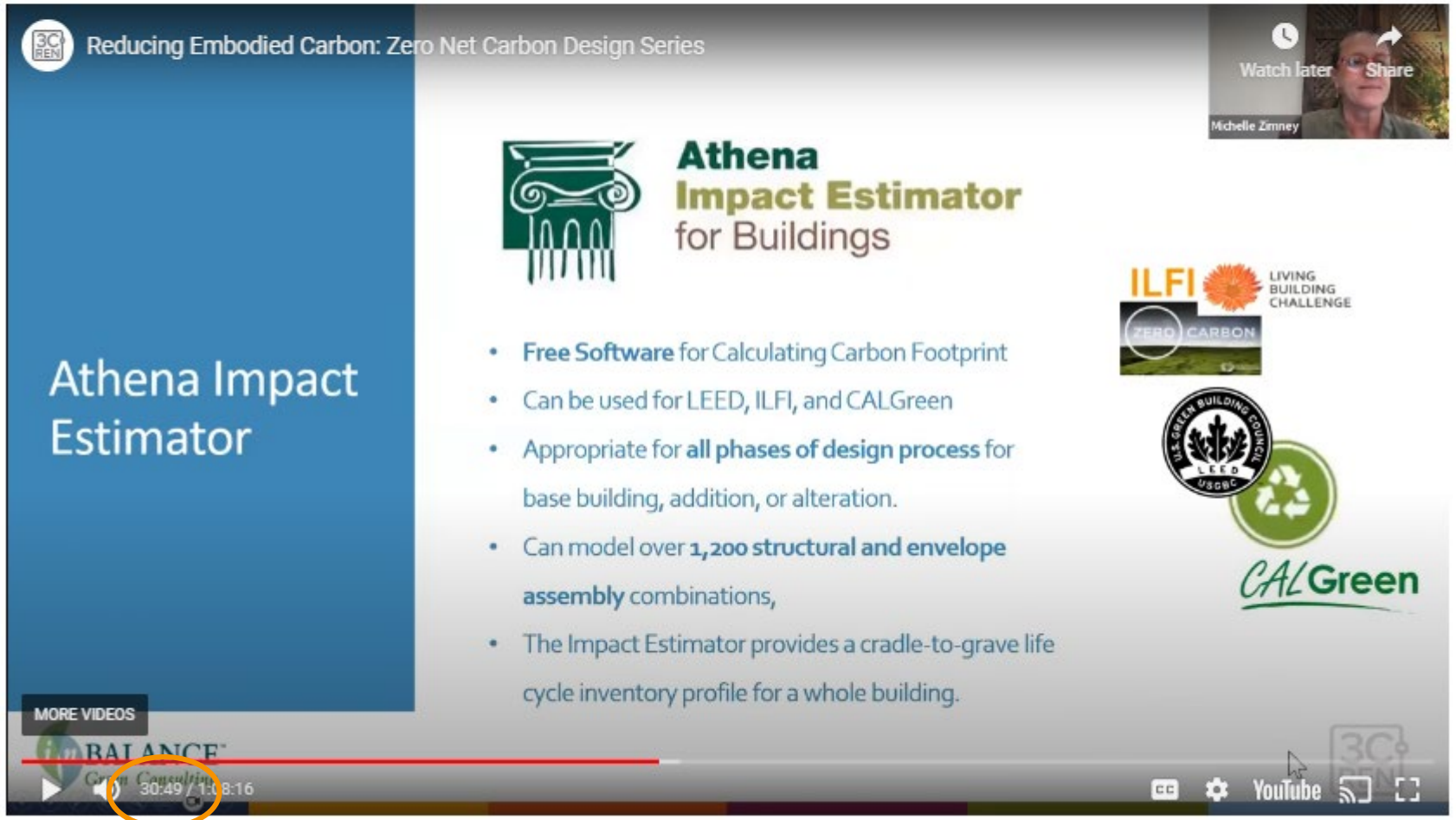
Ather

Athena Impact Estimator for Buildings



CONTRACTORS & INDUSTRY | MULTIFAMILY PROPERTIES | FOR RESIDENTS

ON DEMAND TRAININGS



Date: August 31, 2023

Reducing Embodied Carbon: Zero Net Carbon Design Series

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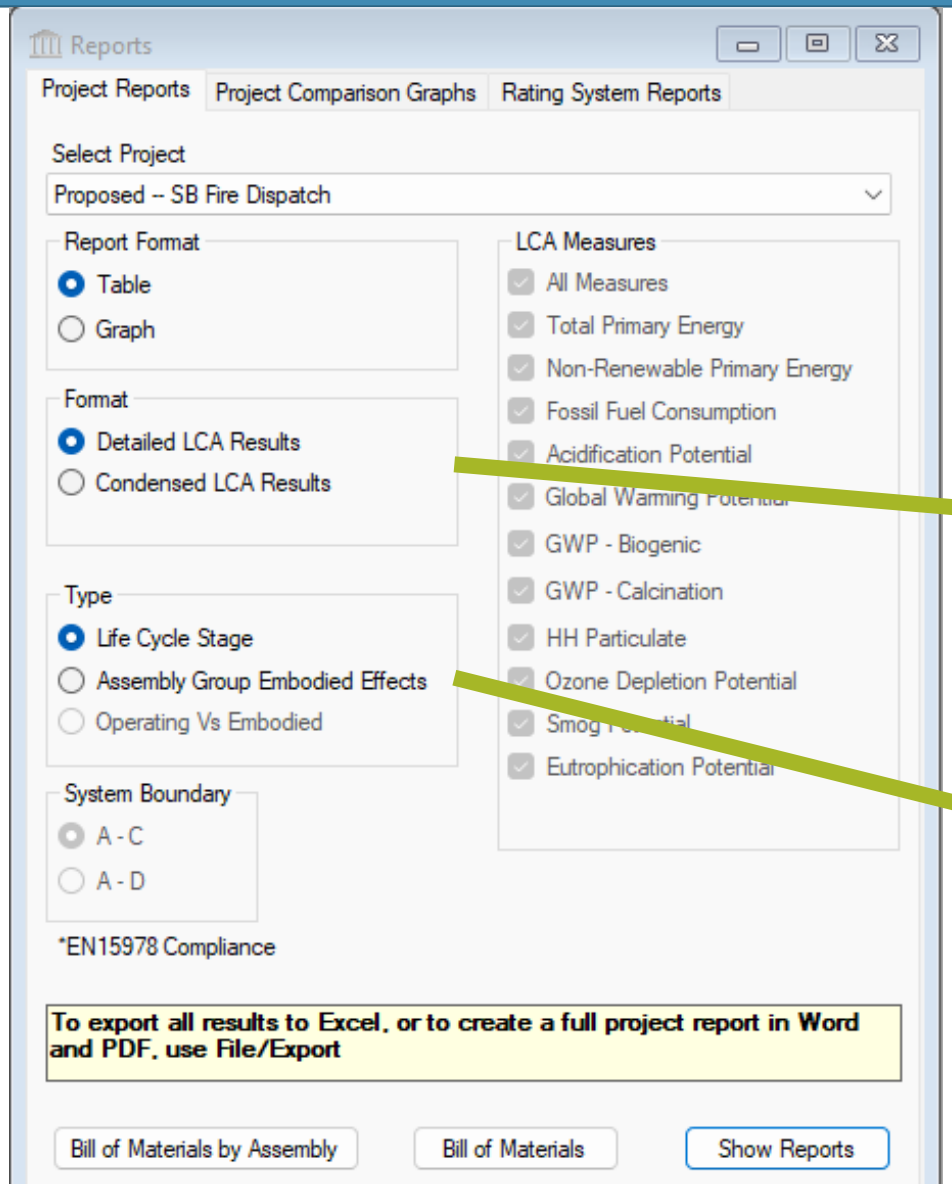
Athena – Excerpt from Project Reports: Data for CALGreen Reporting



Note:
Reports to be run for Proposed and Baseline projects for comparison

Detailed LCA Results

Life Cycle Stage

Athena: Summary Comparison Report (Data for CALGreen Reporting)

		PRODUCT (A1 to A3)			CONSTRUCTION PROCESS (A4 & A5)			USE (B2, B4 & B6)				END OF LIFE (C1 to C4)			TOTAL EFFECTS	
LCA Measures	Unit	Manufacturing	Transport	Total	Construction-Installation Process	Transport	Total	Replacement Manufacturing	Replacement Transport	Operational Energy Use Total	Total	De-construction, Demolition, Disposal & Waste Processing	Transport	Total	A to C	A to D
Global Warming Potential	kg CO2 eq	7.24E+04	5.06E+02	**7.29E+04**	1.05E+04	4.36E+04	**5.41E+04**	1.58E+04	1.77E+03	0.00E+00	**1.76E+04**	3.90E+04	2.13E+03	**4.12E+04**	**1.86E+05**	**1.85E+05**
GWP - Biogenic	kg CO2 eq	-8.42E+04	0.00E+00	**-8.42E+04**	-2.54E+03	0.00E+00	**-2.54E+03**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	3.27E+04	0.00E+00	**3.27E+04**	**-5.40E+04**	**-5.40E+04**
GWP - Calcination	kg CO2 eq	1.45E+04	0.00E+00	**1.45E+04**	7.26E+02	0.00E+00	**7.26E+02**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	**0.00E+00**	**1.52E+04**	**1.52E+04**
Acidification Potential	kg SO2 eq	5.80E+02	5.07E+00	**5.85E+02**	8.42E+01	4.93E+02	**5.77E+02**	1.03E+02	1.95E+01	0.00E+00	**1.22E+02**	7.66E+01	2.05E+01	**9.71E+01**	**1.38E+03**	**1.33E+03**
HH Particulate	kg PM2.5 eq	9.71E+01	2.70E-01	**9.74E+01**	9.51E+00	2.40E+01	**3.35E+01**	3.81E+01	9.86E-01	0.00E+00	**3.91E+01**	3.20E+01	1.14E+00	**3.31E+01**	**2.03E+02**	**1.97E+02**
Eutrophication Potential	kg N eq	1.89E+02	3.15E-01	**1.89E+02**	1.67E+01	3.05E+01	**4.72E+01**	1.73E+01	1.21E+00	0.00E+00	**1.85E+01**	6.16E+00	1.27E+00	**7.44E+00**	**2.62E+02**	**2.62E+02**
Ozone Depletion Potential	kg CFC-11 eq	4.04E-02	1.81E-08	**4.04E-02**	2.13E-03	1.71E-06	**2.13E-03**	4.42E-04	6.96E-08	0.00E+00	**4.42E-04**	2.43E-04	7.44E-08	**2.43E-04**	**4.32E-02**	**4.32E-02**
Smog Potential	kg O3 eq	1.14E+04	1.61E+02	**1.15E+04**	2.30E+03	1.57E+04	**1.80E+04**	9.00E+02	6.21E+02	0.00E+00	**1.52E+03**	2.39E+03	6.47E+02	**3.04E+03**	**3.41E+04**	**3.38E+04**
Total Primary Energy	MJ	1.67E+06	7.37E+03	**1.68E+06**	1.29E+05	6.29E+05	**7.58E+05**	3.03E+05	2.56E+04	0.00E+00	**3.28E+05**	9.33E+04	3.11E+04	**1.24E+05**	**2.89E+06**	**2.89E+06**
Non-Renewable Energy	MJ	1.28E+06	7.37E+03	**1.29E+06**	1.07E+05	6.28E+05	**7.36E+05**	2.92E+05	2.56E+04	0.00E+00	**3.18E+05**	9.28E+04	3.11E+04	**1.24E+05**	**2.47E+06**	**2.47E+06**
Fossil Fuel Consumption	MJ	1.21E+06	7.35E+03	**1.22E+06**	1.03E+05	6.27E+05	**7.30E+05**	2.65E+05	2.55E+04	0.00E+00	**2.91E+05**	9.06E+04	3.10E+04	**1.22E+05**	**2.36E+06**	**2.38E+06**

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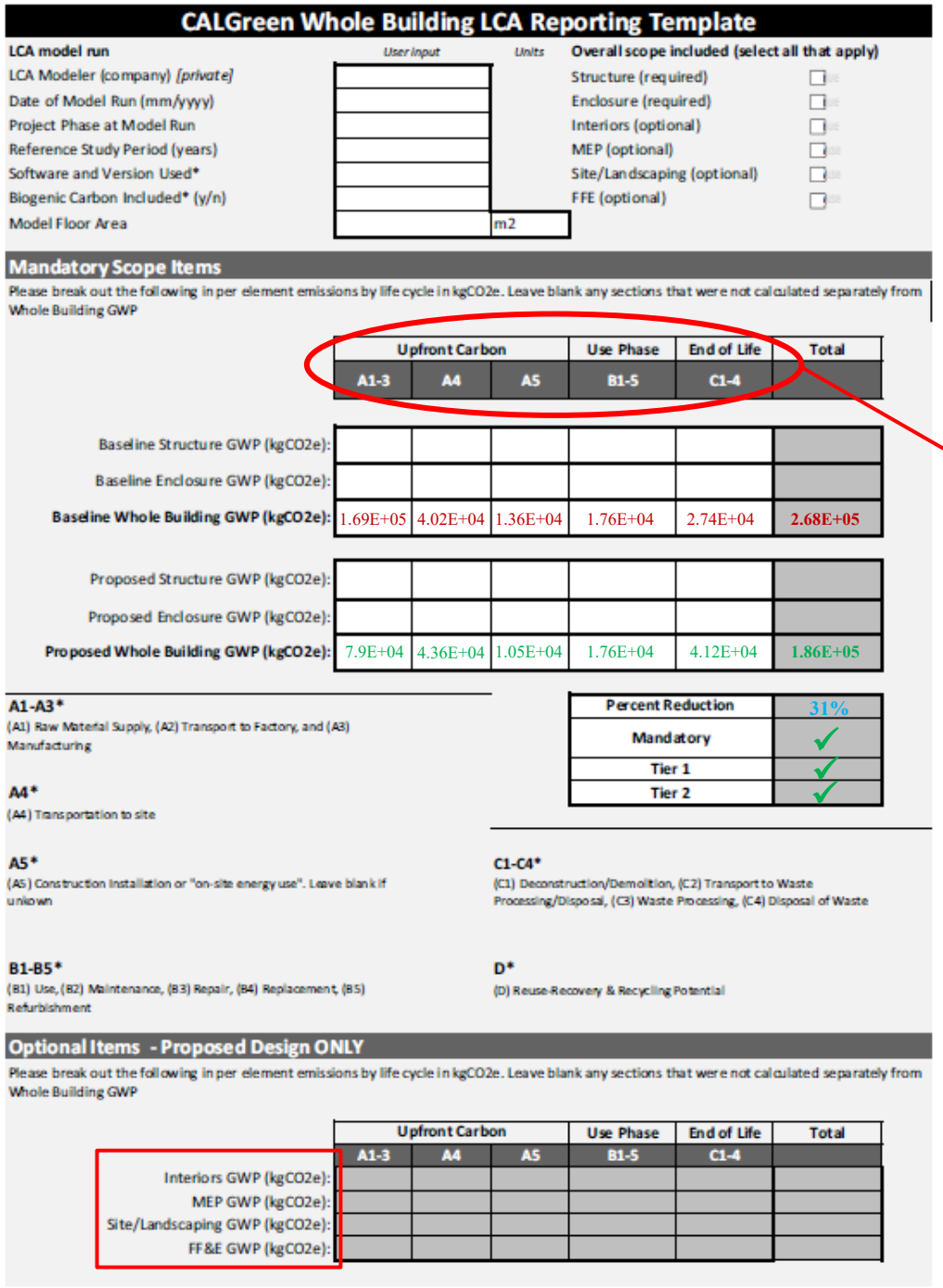
Documenting WBLCA



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):	1.69E+05	4.02E+04	1.36E+04	1.76E+04	2.74E+04	**2.68E+05**
Proposed Structure GWP (kgCO2e):						
Proposed Enclosure GWP (kgCO2e):						
Proposed Whole Building GWP (kgCO2e):	7.9E+04	4.36E+04	1.05E+04	1.76E+04	4.12E+04	**1.86E+05**

Percent Reduction	31%
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

	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):						

- In addition, the enforcing entity may require Worksheet WS-9 to demonstrate compliance with the requirements.
- Cradle-to-Grave
- Consult ASTM E2921-22 for standard practice guidelines for baseline
- Mandatory measure targets a 10% reduction from baseline; 15% for Tier 1; 20% for Tier 2

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CALGreen: Prescriptive Path

- 5.409.3 Product GWP compliance—prescriptive path. Each product that is permanently installed and listed in Table 5.409.3 shall have a Type III environmental product declaration (EPD), either product-specific or factory-specific.
  - 5.409.3.1 Products shall not exceed the maximum GWP value specified in Table 5.409.3.

- Exception: Concrete may be considered one product category to meet compliance with this section. A weighted average of the maximum GWP for all concrete mixes installed in the project shall be less than the weighted average maximum GWP allowed per Table 5.409.3. For the purposes of this exception, industry-wide EPDs are acceptable.

Table 5.409.3 GWP Limits

TABLE 5.409.3
PRODUCT GWP LIMITS

BUY CLEAN CALIFORNIA MATERIALS PRODUCT CATEGORY[1]	MAXIMUM ACCEPTABLE GWP VALUE (unfabricated) ($GWP_{allowed}$)	UNIT OF MEASUREMENT
Hot-rolled structural steel sections	1.77	MT CO_2e/MT
Hollow structural sections	3.00	MT CO_2e/MT
Steel plate	2.61	MT CO_2e/MT
Concrete reinforcing steel	1.56	MT CO_2e/MT
Flat glass	2.50	kg CO_2e/MT *
Light-density mineral wool board insulation	5.83	kg CO_2e/1 m^2
Heavy-density mineral wool board insulation	14.28	kg CO_2e/1 m^2
Concrete, Ready-Mixed[2, 3]		
CONCRETE PRODUCT CATEGORY	**MAXIMUM GWP ALLOWED VALUE ($GWP_{allowed}$)**	**UNIT OF MEASUREMENT**
up to 2499 psi	450	kg CO_2e/m^3
2500–3499 psi	489	kg CO_2e/m^3
3500–4499 psi	566	kg CO_2e/m^3
4500–5499 psi	661	kg CO_2e/m^3
5500–6499 psi	701	kg CO_2e/m^3
6500 psi and greater	799	kg CO_2e/m^3
Concrete, Lightweight Ready-Mixed[2]		
CONCRETE PRODUCT CATEGORY	**MAXIMUM GWP ALLOWED VALUE ($GWP_{allowed}$)**	**UNIT OF MEASUREMENT**
up to 2499 psi	875	kg CO_2e/m^3
2500–3499 psi	956	kg CO_2e/m^3
3500–4499 psi	1039	kg CO_2e/m^3

Only certain steel, glass and insulation…

…. and concrete. Allowed GWP keyed to strength and type of ready-mix

Note: Units for steel are MT or metric tonne. Often noted in EPDs as t.

GWP data will be found on EPDs

* Metric will change to MT CO2e/MT on Jan. 1, 2026

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Environmental Product Declarations (EPDs)

- Standardized document with information about environmental impact of products – including GWP
- Type III EPDs are third-party verified
- May represent:
  - Product-specific data
  - Factory-specific data
  - Industry average – one product across several manufacturers

ENVIRONMENTAL PRODUCT DECLARATION

FABRICATED HOT-ROLLED STRUCTURAL STEEL SECTIONS

NUCOR CORPORATION

COVER PAGE

NUCOR®

Nucor Corporation operates two ISO 14001-certified structural steel mills, Nucor-Yamato Steel and Nucor Steel Berkeley, that have the capacity to annually produce up to 3,250,000 tons of wide-flange steel beams, pilings and heavy structural steel products for fabricators, construction companies, manufacturers and steel service centers.

Nucor Corporation is North America's largest recycler, turning approximately 20 million net tons of scrap steel in 2019 into new steel. Nucor uses Electric Arc Furnace (EAF) technology at each of its 25 steel recycling facilities. EAFs use post-consumer scrap as its major feedstock, unlike traditional blast furnace steelmaking, which produces more than 70% of the world's steel using mined iron ore and metallurgical coal as feedstock.

Through its use of EAFs, Nucor's steelmaking CO_2 emissions are one-half of the global average on a per ton basis, and Nucor's energy intensity is approximately one-quarter the global average.

UL CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION UL.COM/EPD

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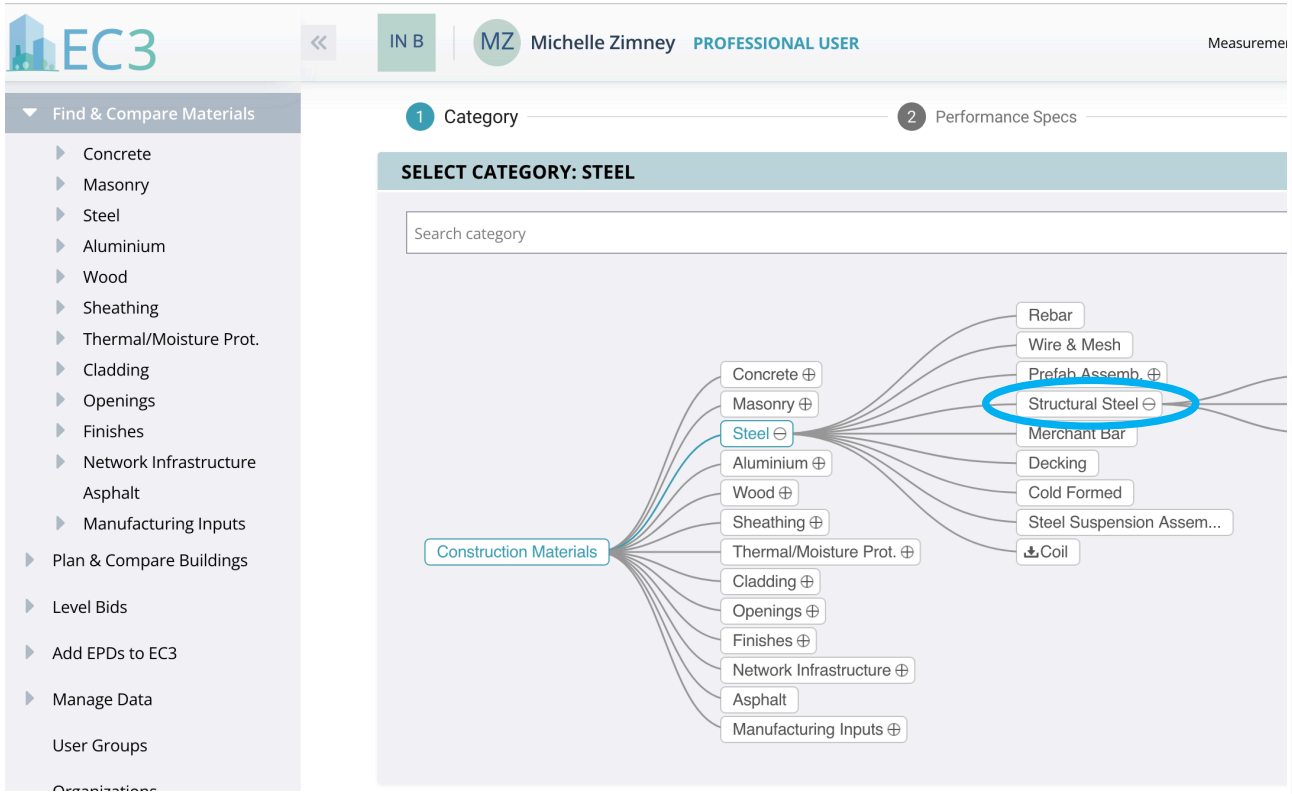
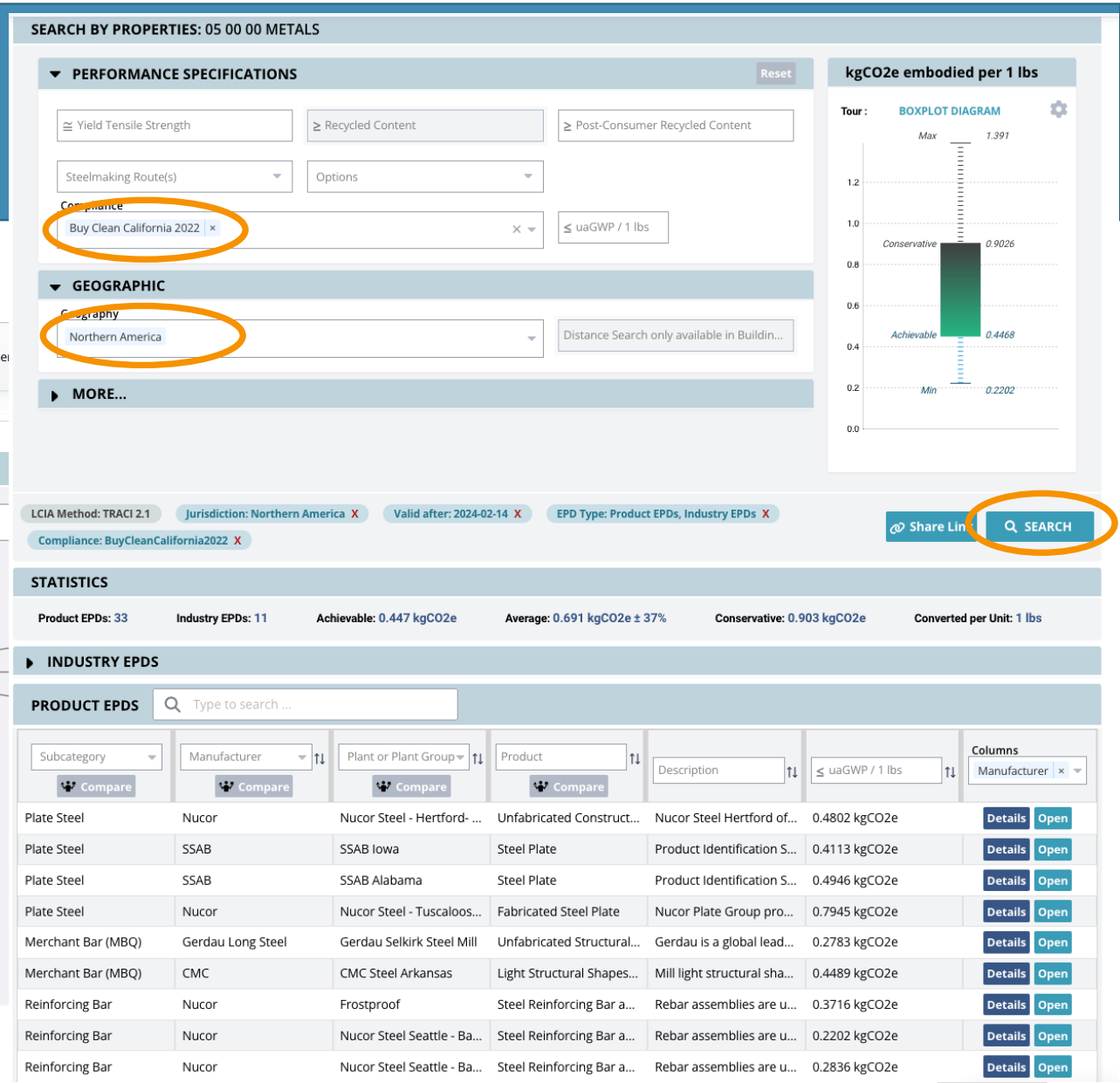
EC3 Tool: Searchable EPD database





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Sample EPD: Declared Unit, Validity and Scope

INFO PAGE

MENTAL PRODUCT DECLARATION

NUCOR®

Fabricated Hot-Rolled Structural Steel Sections
Designated Steel Construction Product

According to ISO 14025, EN 15804 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	
MANUFACTURER NAME AND ADDRESS	Nucor Corporation, 1915 Rexford Road, Charlotte, North Carolina 28211	
DECLARATION NUMBER	4789793365.102.1	
DECLARED PRODUCT & FUNCTIONAL UNIT OR DECLARED UNIT	Fabricated Hot-Rolled 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	Hot rolled structural steel sections used in construction	
PRODUCT RSL DESCRIPTION (IF APPL.)	N/A	
MARKETS OF APPLICABILITY	North America	
DATE OF ISSUE	January 1, 2021	
PERIOD OF VALIDITY	5 Year	
EPD TYPE	Product-Specific	
EPD SCOPE	Cradle to gate	
YEAR(S) OF REPORTED PRIMARY DATA	2019	
LCA SOFTWARE & VERSION NUMBER	GaBi v10	
LCI DATABASE(S) & VERSION NUMBER	GaBi 2020.2	
LCIA METHODOLOGY & VERSION NUMBER	IPCC AR5 + TRACI 2.1	

This PCR review was conducted by:	UL Environment PCR Review Panel epd@ulenvironment.com
This declaration was independently verified in accordance with ISO 14025: 2006. ☐ INTERNAL ☒ EXTERNAL	Grant R. Martin, UL Environment
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	James Mellentine, Thrive ESG

This PCR Review was conducted by:

This declaration was independently verified in accordance with ISO 14025: 2006.
☐ INTERNAL ☒ EXTERNAL

This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:

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Sample EPD: Where to find kg CO2 eq (aka GWP)

ENVIRONMENTAL PRODUCT DECLARATION

NUCOR®

Fabricated Hot-Rolled Structural Steel Sections
Designated Steel Construction Product

CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION

According to ISO 14025, EN 15804 and ISO 21930:2017

Table 2. LCIA results, per 1 metric ton

PARAMETER	UNIT	A1	A2	A3	TOTAL
GWP 100	kg CO_2 eq.	1.10E+03	1.07E+01	1.10E+02	**1.22E+03**
ODP	kg CFC 11 eq.	4.67E-10	1.00E-09	3.38E-08	**3.53E-08**
AP	kg SO_2 eq.	2.80E+00	4.96E-02	2.98E-01	**3.15E+00**
EP	kg N eq.	1.32E-01	4.20E-03	1.51E-02	**1.51E-01**
SFP	kg O_3 eq.	4.49E+01	1.43E+00	2.92E+00	**4.92E+01**
ADP_{fossil}	MJ surplus	1.27E+03	1.72E+01	8.52E+01	**1.37E+03**

Table 3. LCIA results, per 1 short ton

PARAMETER	UNIT	A1	A2	A3	TOTAL
GWP 100	kg CO_2 eq.	9.96E+02	9.70E+00	9.97E+01	**1.10E+03**
ODP	kg CFC 11 eq.	4.24E-10	9.08E-10	3.07E-08	**3.20E-08**
AP	kg SO_2 eq.	2.54E+00	4.50E-02	2.70E-01	**2.86E+00**

TABLE 5.409.3
PRODUCT GWP LIMITS

BUY CLEAN CALIFORNIA MATERIALS PRODUCT CATEGORY[1]	MAXIMUM ACCEPTABLE GWP VALUE (unfabricated) ($GWP_{allowed}$)	UNIT OF MEASUREMENT
Hot-rolled structural steel sections	1.77	MT CO_2e/MT
Hollow structural sections	3.00	MT CO_2e/MT
Steel plate	2.61	MT CO_2e/MT
Concrete reinforcing steel	1.56	MT CO_2e/MT
Flat glass	2.50	kg CO_2e/MT
Light-density mineral wool board insulation	5.83	kg CO_2e/1 m^2
Heavy-density mineral wool board insulation	14.28	kg CO_2e/1 m^2

1.22E+03 kg CO2e per MT

= 1.22*1000 kg CO2e

(Remember from definitions:
MT/t (metric tonne) = 1000kg)

SO
= 1.22MT CO2e per MT

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TABLE 5.409.3
PRODUCT GWP LIMITS

BUY CLEAN CALIFORNIA MATERIALS PRODUCT CATEGORY[1]	MAXIMUM ACCEPTABLE GWP VALUE (unfabricated) ($GWP_{allowed}$)	UNIT OF MEASUREMENT
Hot-rolled structural steel sections	1.77	MT CO_2e/MT
Hollow structural sections	3.00	MT CO_2e/MT
Steel plate	2.61	MT CO_2e/MT
Concrete reinforcing steel	1.56	MT CO_2e/MT
Flat glass	2.50	kg CO_2e/MT
Light-density mineral wool board insulation	5.83	kg CO_2e/1 m^2
Heavy-density mineral wool board insulation	14.28	kg CO_2e/1 m^2

Documenting Prescriptive Path (non-concrete)

There is no form, but documentation to demonstrate compliance might include a table similar to below with each required material listed and accompanied by EPD-sourced EC numbers. Also submit EPDs and signed WS-5 declaration statement.

Material	Manufacturer	Max GWP Allowed	Product Actual GWP (per EPD)
Hot-rolled structural steel	Nucor	1.77 MT CO2e/MT	1.22MT CO2e/MT
Hollow structural steel	N/A	3.00 MT CO2e/MT	
Steel plate	N/A	2.61 MT CO2e/MT	
Concrete reinforcing steel		1.56 MT CO2e/MT	
Flat glass		2.5 kg CO2e/MT *	
Light-density mineral wool board insulation		5.83 kg CO2e/1 m2	
Heavy-density mineral wool board insulation	N/A	14.28 kg CO2e/1 m2	

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Documenting Prescriptive Path (concrete)

(E) 45,000 SF

100,000 SF addition

For Concrete, a weighted calculation must be performed per exception equation 5.409.3.1

GWPn < GWPallowed

Where GWPn = Σ (GWPn)(vn) and GWPallowed = Σ (GWPallowed)(vn)

- n = each concrete mix installed in the project
- GWPn = the GWP for concrete mix n (from concrete mix EPD)
- GWPallowed = the GWP potential allowed for concrete mix n per Table 5.409.3
- vn = the volume of concrete mix n installed in the project, in m3

GWP data will be found on EPDs

- GWPn = the GWP for concrete mix n per concrete mix EPD

Concrete, Ready-Mixed[2,3]		
CONCRETE PRODUCT CATEGORY	MAXIMUM GWP ALLOWED VALUE ($GWP_{allowed}$)	UNIT OF MEASUREMENT
up to 2499 psi	450	kg CO_2e/m^3
2500–3499 psi	489	kg CO_2e/m^3
3500–4499 psi	566	kg CO_2e/m^3
4500–5499 psi	661	kg CO_2e/m^3
5500–6499 psi	701	kg CO_2e/m^3
6500 psi and greater	799	kg CO_2e/m^3
Concrete, Lightweight Ready-Mixed[2]		
CONCRETE PRODUCT CATEGORY	MAXIMUM GWP ALLOWED VALUE ($GWP_{allowed}$)	UNIT OF MEASUREMENT
up to 2499 psi	875	kg CO_2e/m^3
2500–3499 psi	956	kg CO_2e/m^3
3500–4499 psi	1039	kg CO_2e/m^3

GWPallowed = the GWP potential allowed for concrete mix n per Table 5.409.3

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Concrete, Ready-Mixed[2,3]		
CONCRETE PRODUCT CATEGORY	MAXIMUM GWP ALLOWED VALUE ($GWP_{allowed}$)	UNIT OF MEASUREMENT
up to 2499 psi	450	kg CO_2e/m^3
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up to 2499 psi	875	kg CO_2e/m^3
2500–3499 psi	956	kg CO_2e/m^3
3500–4499 psi	1039	kg CO_2e/m^3

100,000 SF addition

GWPn < GWPallowed

Where GWPn = Σ (GWPn)(vn) and GWPallowed = Σ (GWPallowed)(vn)

- n = each concrete mix installed in the project
- GWPn = the GWP for concrete mix n per concrete mix EPD
- GWPallowed = the GWP potential allowed for concrete mix n per Table 5.409.3
- vn = the volume of concrete mix n installed in the project, in m3

Documenting Prescriptive Path (concrete)

GWP data will be found on EPDs

From Table 5.409.3

Concrete Calculation

n (mix)	volume (vn)	psi	GWPn	GWPn * vn		GWPallowed	GWPallowed * vn
	m3		*kgCO2e*			*kgCO2e*	
foundation	108	4000	320.1	34570.8		566	61128
slab	1080	3000	225.9	243972		489	528120
columns	12	4500	291.5	3498		661	7932
			Σ GWPn*vn	282040.8	<	Σ GWPallowed*vn	597180

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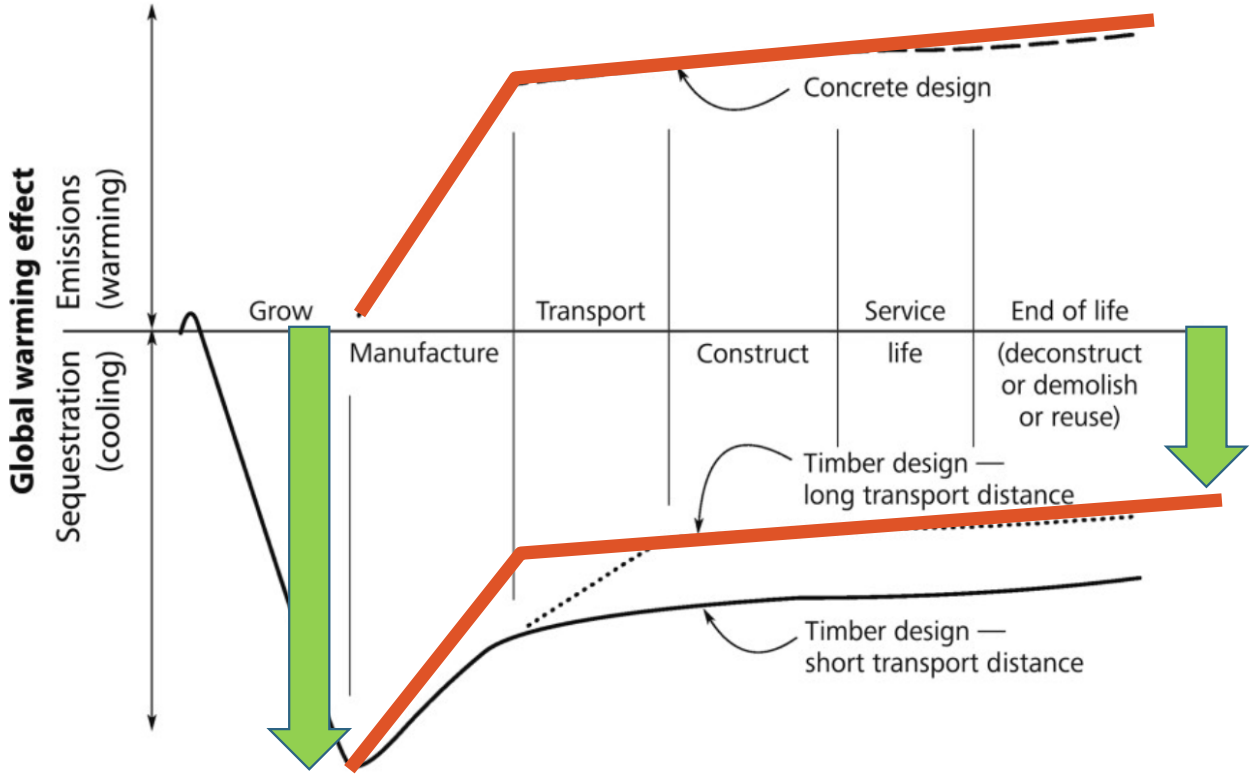
Innovations: Carbon Sequestering Materials

Trees but also….

- Hemp
- Straw
- Ag residues
- Seaweed
- Cork
- Bamboo
- Mushrooms
- Even Algae



Courtesy New Society Publishers

More Carbon Sequestering Materials

Categories of carbon-storing materials

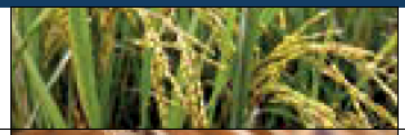
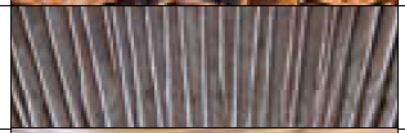
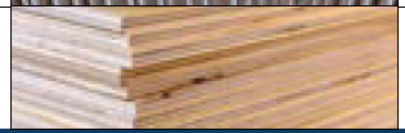
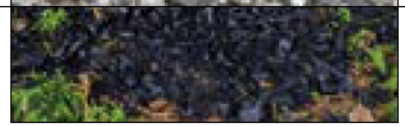
SOURCES			PRODUCTS
Biogenic Carbon Storage			
Agricultural and forestry residues and by-products	Straw (rice, wheat), hulls (rice), shells (nuts), stalks		Board products, insulation, cladding, aggregate
Waste stream fibers	Paper, cardboard, textiles		Board products, insulation
Purpose-grown crops	Cork, bamboo, hemp		Boards, flooring, insulation, structure, cladding
Lab-grown materials	Mycelium composites		Insulation, structure
Timber	Lumber, mass timber, sheet goods		Structure, board products, flooring, cladding
Mineralized Carbon Storage			
Biomineralization	Algae and microbe-grown cement		Concrete, concrete masonry unit (CMU), brick
Captured carbon	Synthetic limestone aggregate and accelerated carbonation		Concrete, CMU, brick
Biochar	Biogenic carbon transformed into stable, pyrogenic carbon through combustion in the absence of oxygen		Aggregate, tiles, bricks

Exhibit 2 | RMI Graphic. Source: RMI Analysis.

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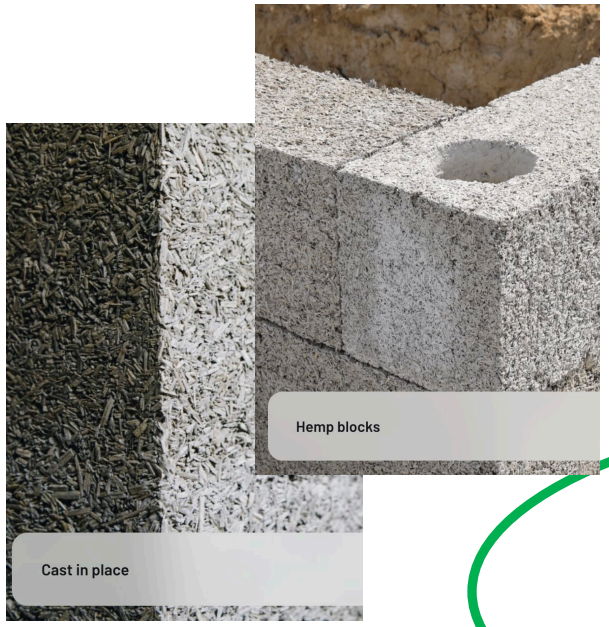
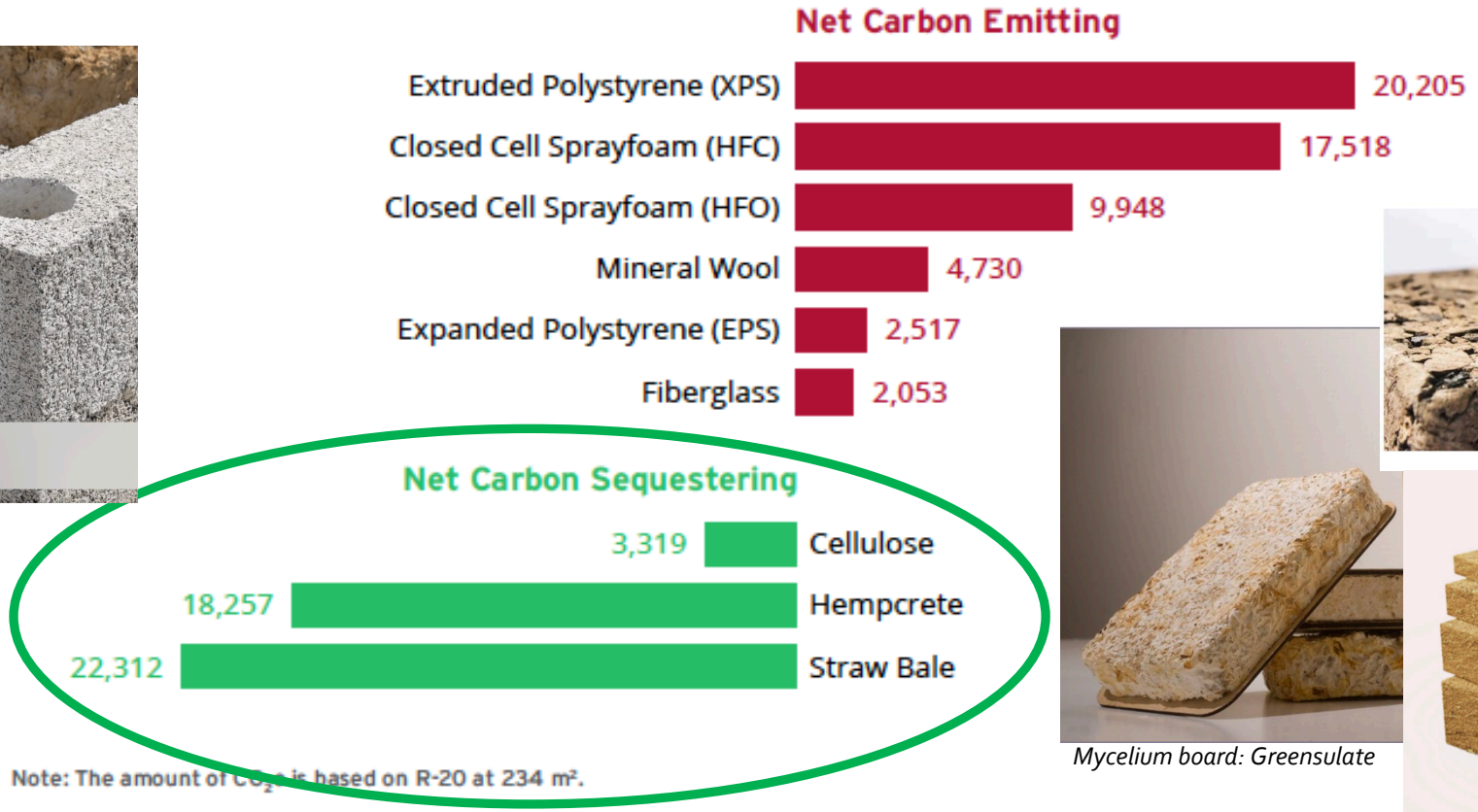
Carbon Sequestration Opportunities: Insulation

Exhibit 3 **Embodied carbon of insulation materials (kg CO_2e)**



Hempitecture.com



Note: The amount of CO_2 is based on R-20 at 234 m².

Source: Chris Magwood, *Opportunities for CO_2 Capture and Storage in Building Materials*, 10.13140/RG.2.2.32171.39208, 2019.

Expanded Cork: Corklink

Image courtesy of CorkLink.

Mycelium board: Greensulate

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Carbon Sequestration Opportunities: Structural Materials

Structural panels/OSB replacement
Grown from perennial grasses

Source: Plantd

CMUs can use industrial waste (slag) and CO_2 injection at curing.

Source: CarbiCrete

Source: Kenoteq

Low-carbon bricks made from construction waste, mixed with resin and formed under pressure. Cured, not fired.

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Innovations: Storing Carbon into the Future – Landscape Materials

Materials selection

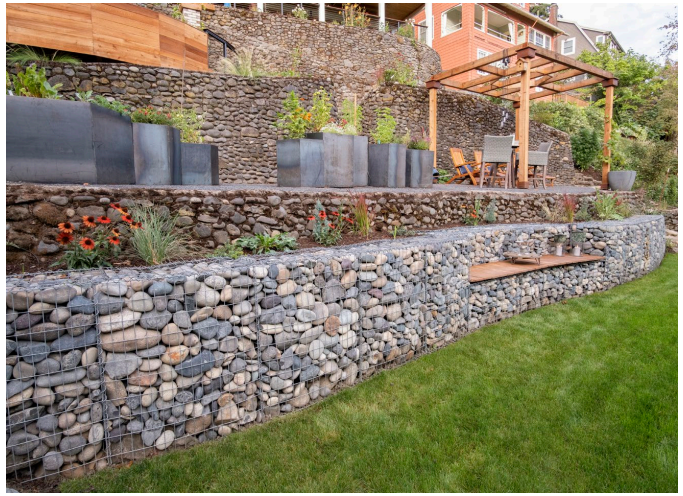
Low-Carbon Pavers

Source: Bradstone, Ashbourne ECO Concrete Paving

Charred Wood

Source: Ross NW Watergardens, Shoi Sugi Ban: Setting Fire to Portland's Fences

Gabion Walls



Source: Premier Backyard Living Landscaping & Exterior Design, Gabion Walls

Rammed Earth

Source: Rammed Earth Enterprises, Landscaping

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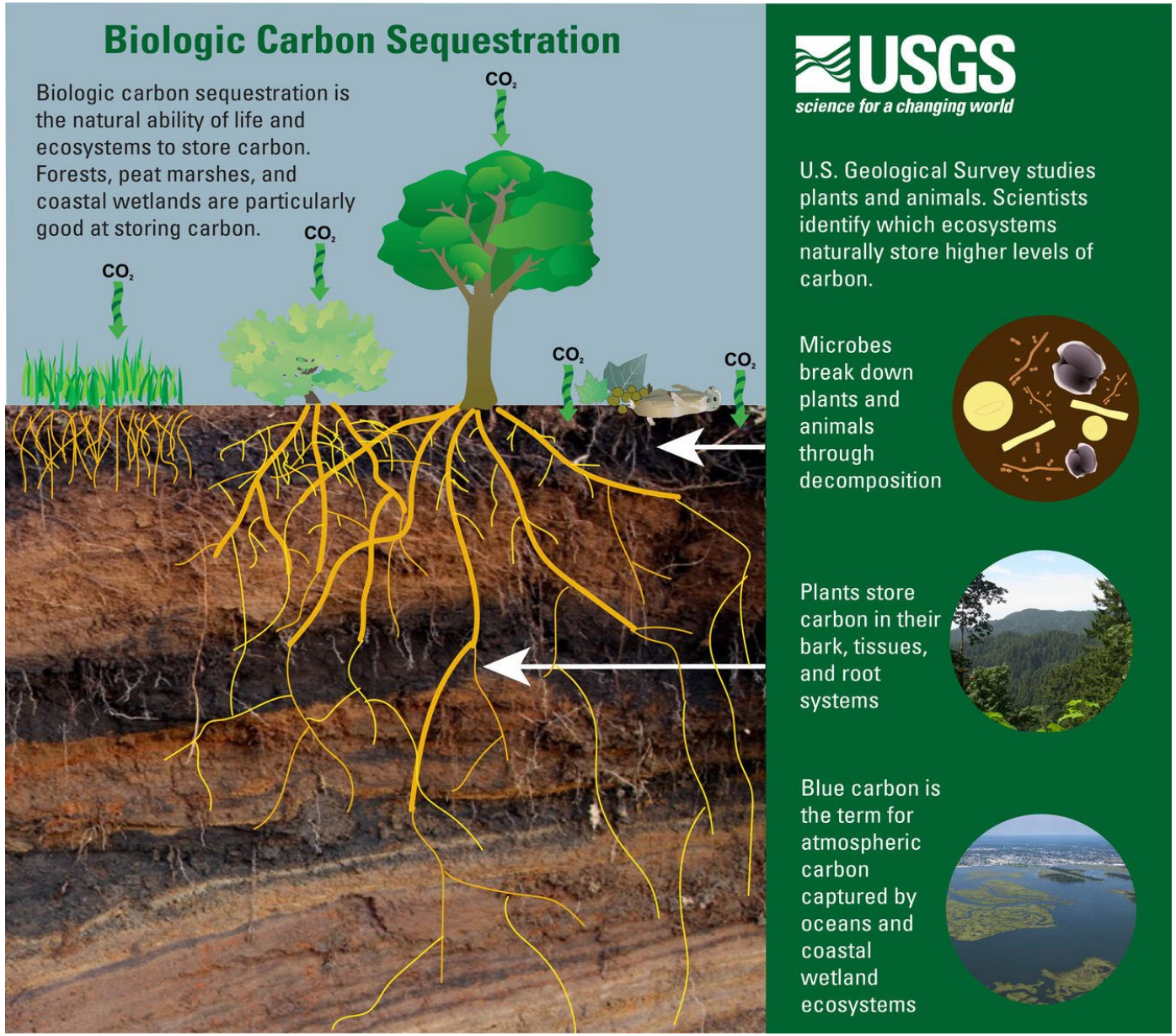
Storing Carbon into the Future – Soil Sequestration



Source: https://www.usgs.gov/media/images/biological-carbon-sequestration/

Earth's soils contain

~2,500 gigatons

of carbon – more than 3x the amount of carbon in the atmosphere and 4x the amount stored in all living plants and animals.

Soils remove about

25%

of the world's fossil fuel emissions each year.

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Storing Carbon into the Future – Landscape Design Strategies

DESIGN TOOLKIT

	Strategies		Description	Actions
1	Increase biomass		Increasing the size and longevity of plants will increase the potential carbon sequestration in biomass. Layering plants increases potential biomass of the whole system.	• Include larger trees and plants, if given appropriate space • Include species that are longer-lived and low-maintenance • Include both fast and slow-growing trees and plants • Include deep-rooted trees and plants • Increase the amount of woody plants • Include deciduous trees in the plant palette • Increase vertical layering of plant types
2	Increase biodiversity		Maximizing biodiversity provides another avenue to achieve functional diversity of plants and has important co-benefits to provide habitat	• Include a diversity of plant species • Increase phylogenetic diversity of the plant community • Choose native plants • Choose genetically local plant sources
3	Increase plant functional diversity		Combining plants with a diversity of functional traits creates a system where more spatial and functional niches are filled, leading to increased productivity and carbon sequestration.	• Include a range of plant sizes: height and spread • Include a range of plant forms and habits • Include a diversity of root depths and architectural type • Include both warm and cool season grasses • Include nitrogen-fixing plants, especially with warm season grasses
4	Design with plant life history strategies		Planting the right type or plant or combining the right type of plants for the site will increase efficiency and resilience of the landscape.	• Match plant life history strategies to the site. • Mix plant life history strategies when appropriate • Include both annual and perennial plants, but a larger proportion of perennial plants • Avoid including plants that will be too competitive or aggressive
5	Layer and cluster plants		Layering and grouping plants can pack in more biomass create nested ecosystems that form rich interconnections and self-organize.	• Grouping small plant communities • Clustering or massing similar types of plants • Vertical layering • Layering through time

Source: American Society of Landscape Architects, Landscape Design for Carbon Sequestration

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Storing Carbon into the Future – Landscape Impact Tools

Tools:

i-Tree

Athena Pavement LCA

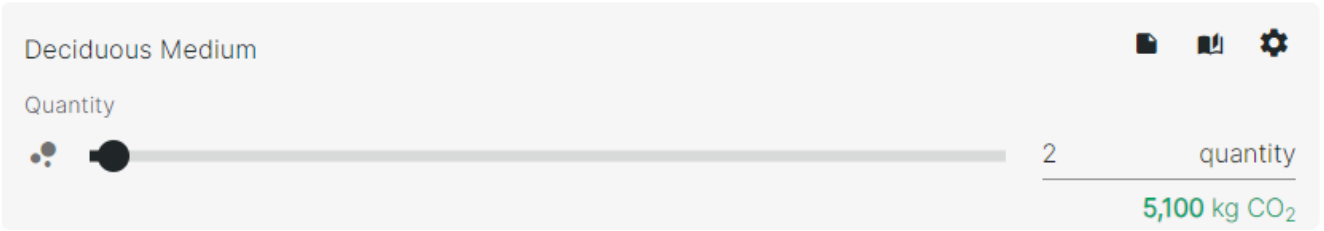
climatepositive design Pathfinder

Materials

Fences, Gates & Rails

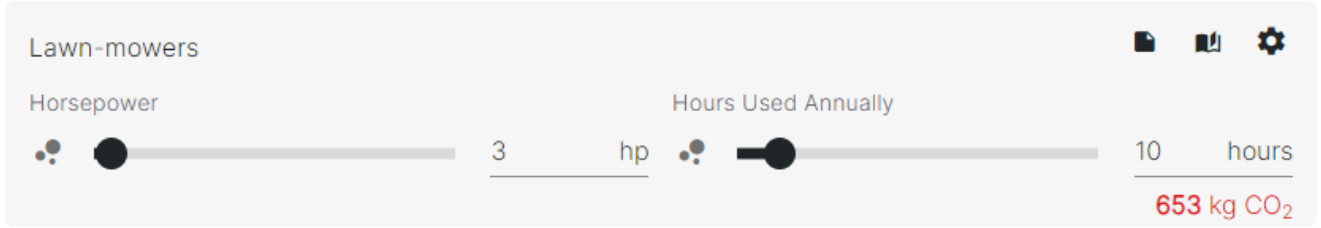
Plants

Trees



Operations

Gas-Powered Equipment



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Storing Carbon into the Future – Landscape Impact Tools

Tools:

i-Tree

climatepositive design Pathfinder

Athena Pavement LCA

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Climate Positive Design **Scorecard**

Materials

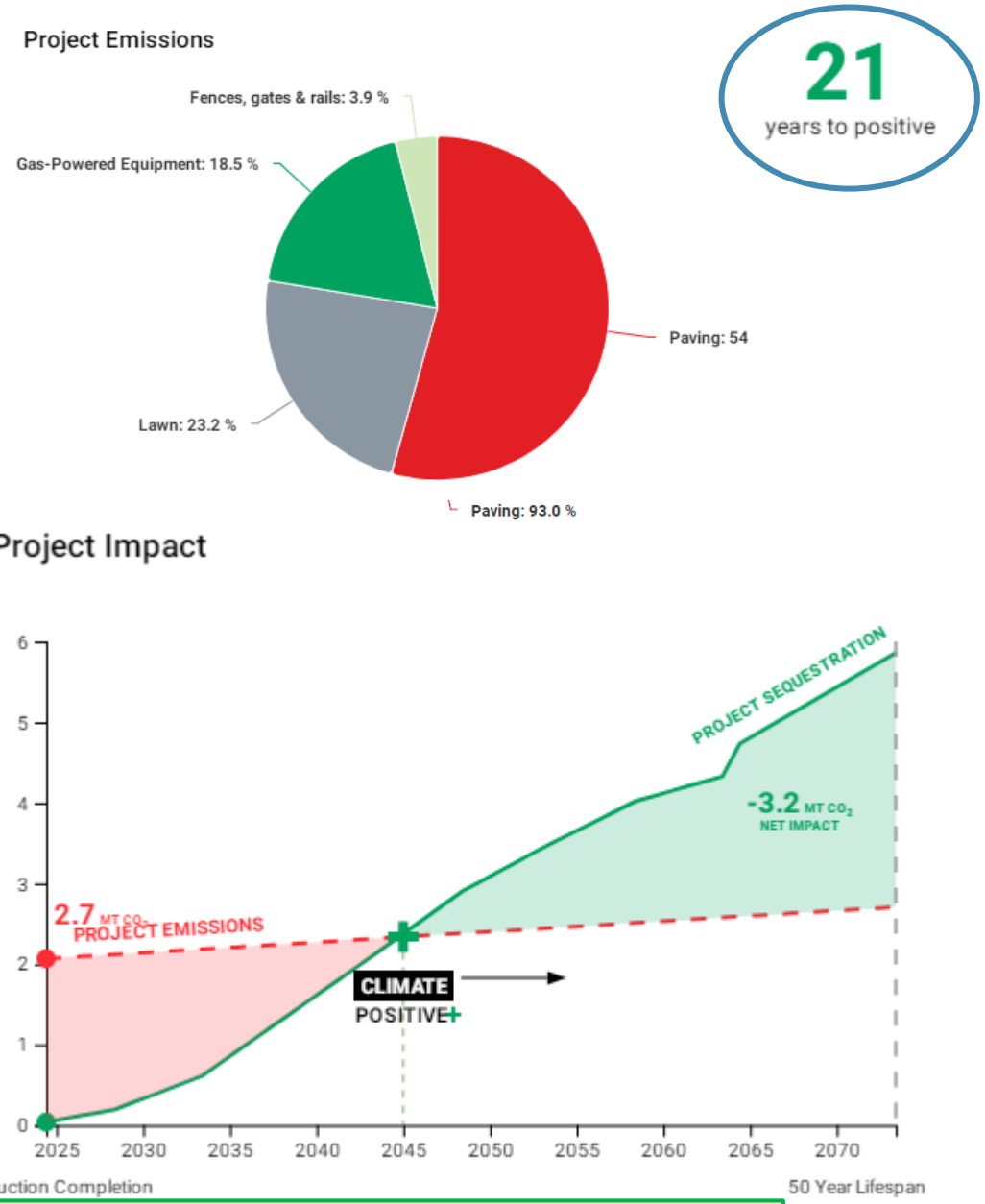
Element	Total impact
Wood	138.5 kg
Organic Mulch	0 kg
Concrete - Pervious	1,150.7 kg
Concrete - Pedestrian	230.1 kg
Natural Stone Pavers	534.7 kg
Subtotal	**2,054 kg**

Plants

Element	Total impact
Intensive management lawn	819.5 kg
Perennial Grasses perennials	553.2 kg
Deciduous Small shrubs	507 kg
Deciduous Medium shrubs	507 kg
Evergreen Small shrubs	31 kg
Deciduous Medium trees	5,100 kg
Subtotal	**5,879 kg**

Operations

Element	Total impact
Lawn-mowers	653.1 kg
Subtotal	**653 kg**
Net Impact over 50 Years	3,172 kg CO2-eq



Design suggestions: Remove lawn, add more trees or shrubs

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Storing Carbon into the Future – Landscape Impact Tools

Tools:

i-Tree

climatepositive design Pathfinder

Athena Pavement LCA

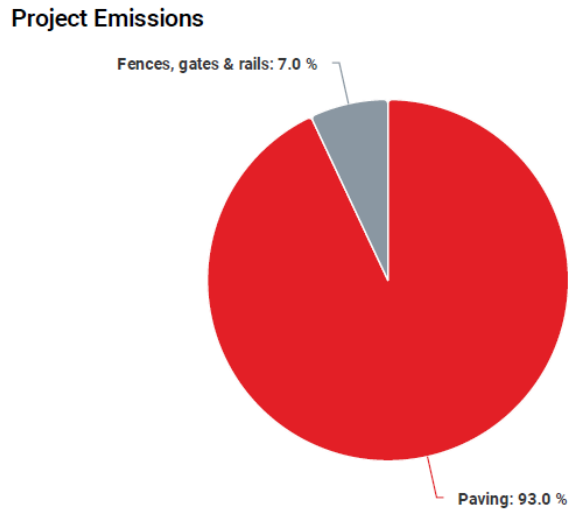
Climate Positive Design **Scorecard**

Materials

Element	Total impact
Wood	138.5 kg
Organic Mulch	0 kg
Local Natural Stone Pavers	460.7 kg
Concrete - Pervious	1,150.7 kg
Concrete - Pedestrian	230.1 kg
Subtotal	**1,980 kg**

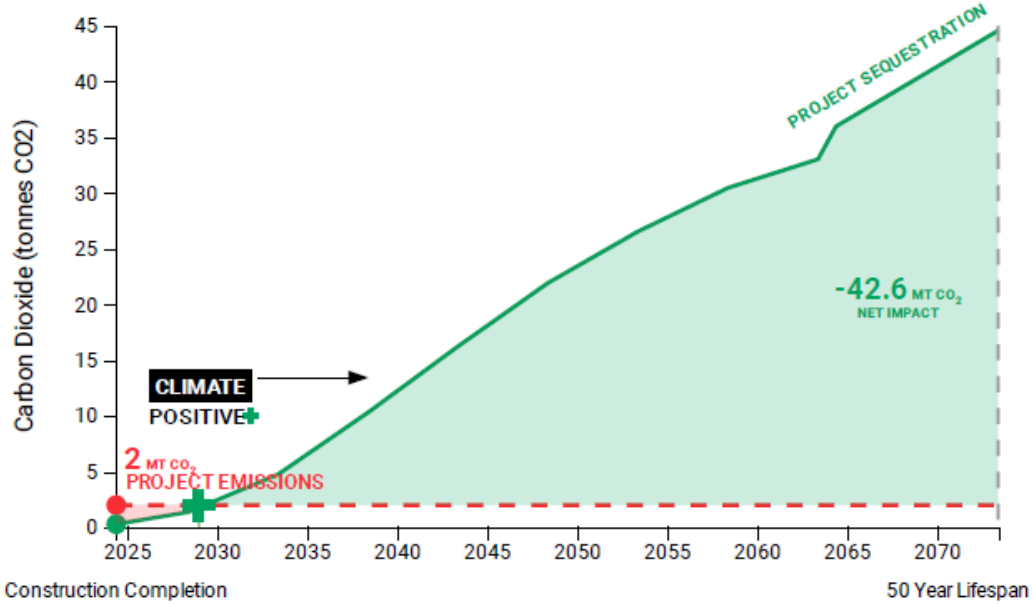
Plants

Element	Total impact
Perennial Grasses perennials	2,950.6 kg
Deciduous Small shrubs	1,522 kg
Deciduous Medium shrubs	1,751 kg
Evergreen Small shrubs	85 kg
Deciduous Medium trees	38,237 kg
Subtotal	**44,546 kg**
Net Impact over 50 Years	42,566 kg CO2-eq



5 years to positive

Net Project Impact



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Resources

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CALGreen Resources

- https://calgreeninfo.com/

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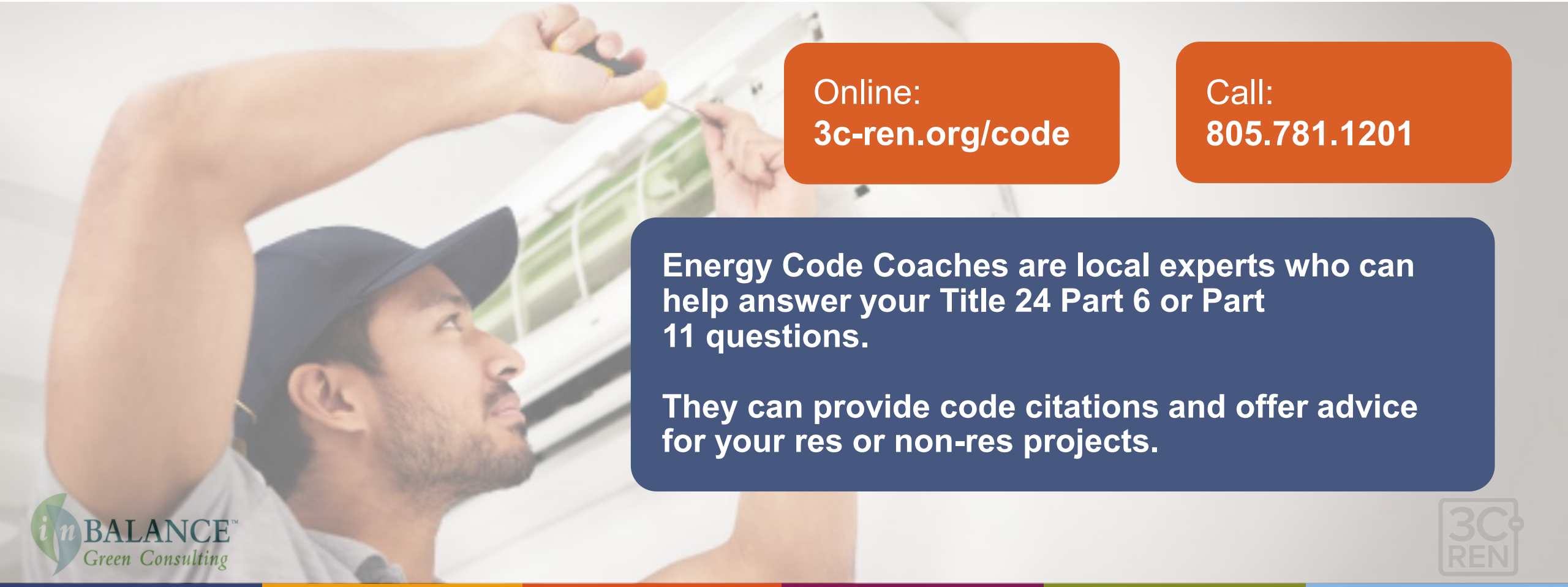
Embodied Carbon Resources

- **Carbon Leadership Forum**
  - https://carbonleadershipforum.org/
- **SE2050**
  - https://se2050.org/resources-overview/embodied-carbon/
- **Carbon Smart Palette**
  - https://www.materialspalette.org/palette/
- **Building Transparency (EC3 Tool)**
  - https://buildingtransparency.org/ec3

Questions about Title 24?

3C-REN offers a *free* Code Coach Service



Online:
3c-ren.org/code

Call:
805.781.1201

Energy Code Coaches are local experts who can help answer your Title 24 Part 6 or Part 11 questions.

They can provide code citations and offer advice for your res or non-res projects.

Closing

Continuing Education Units Available

- Contact chloe.swick@ventura.org for AIA LUs

Coming to Your Inbox Soon!

- Slides, Recording, & Survey – Please Take It and Help Us Out!

Upcoming Courses:

- Electrification Products for the Central Coast Climate (5/6)
- Everything You Always Wanted to Know About EVs (But Were Afraid to Ask) (5/8)
- All Electric ADUs *In-Person in Santa Barbara* (5/16)
- A Builder's Perspective on Zero Net Energy (5/20)
- Certified Passive House Designer/Consultant (CPHD) Pacific Summer Hybrid Cohort (Free!) (7/1)

Any phone numbers who joined? Please share your name!

Thank you!

More info: **3c-ren.org**

Questions: **info@3c-ren.org**

Email updates: **3c-ren.org/newsletter**

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TRI-COUNTY REGIONAL ENERGY NETWORK

SAN LUIS OBISPO • SANTA BARBARA • VENTURA

Questions & Discussion

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