

Sustainable Design & Embodied Carbon: What Structural Engineers Need to Know

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1



NCSEA Sustainable Design Committee

Mission: Promote sustainable design practices within
the profession of structural engineering through
leadership, advocacy, outreach and education



2

Objectives

- **Advocate** for the inclusion of sustainable design within the practice of structural engineering
- **Advocate** for the role of the structural engineer in sustainable design
- Support the formation of sustainable design committees on the **local SEA** level and regularly correspond with local SEA committees
- Share/disseminate **educational** material, white papers, presentations, etc. created at the local level to all SEA Member Organizations, as well as materials produced by complementary organizations
- **Partner** with complementary organizations such as the SEI Sustainability Committee to share information, develop best practices, and coordinate activities
- **Advocate** for the structural engineering community with respect to policy



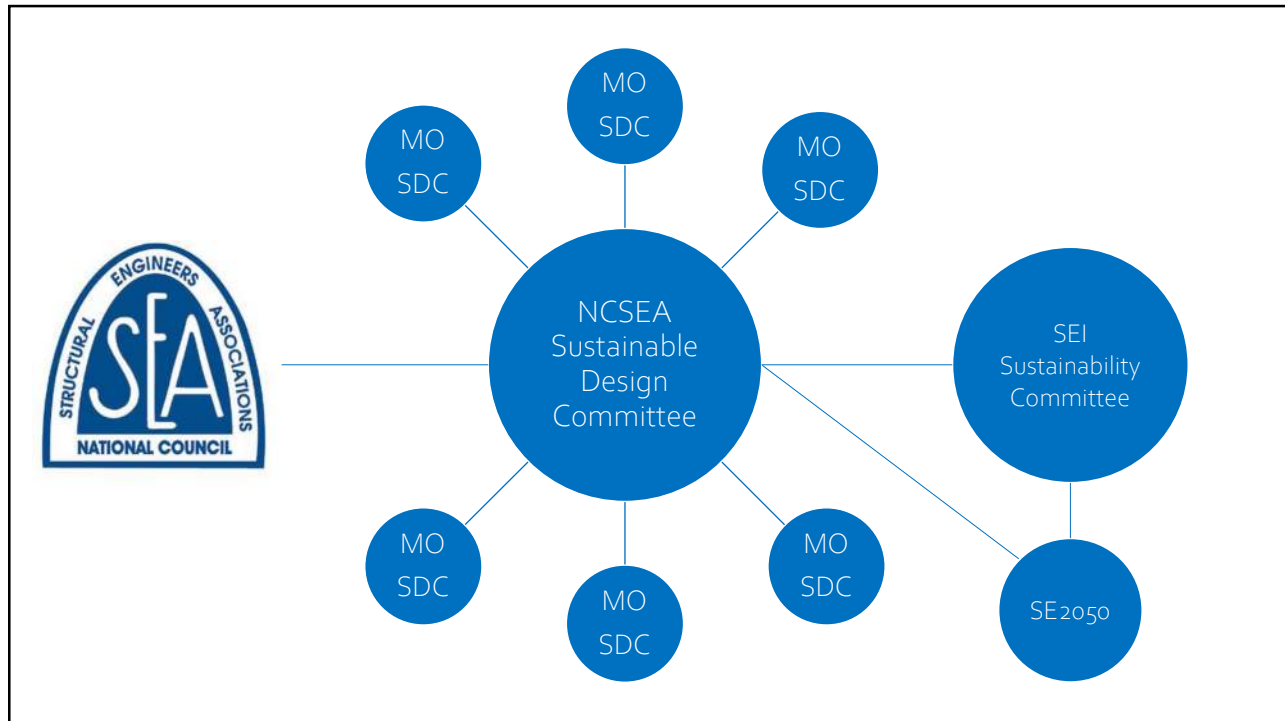
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Goals for Member Organizations

- Find one person in every NCSEA Member Organization (MO) ie SEAoG to serve as a liaison between the national SDC and the local MO
- Eventually establish an SDC within each MO
- Share information at meetings between national SDC and Local MOs



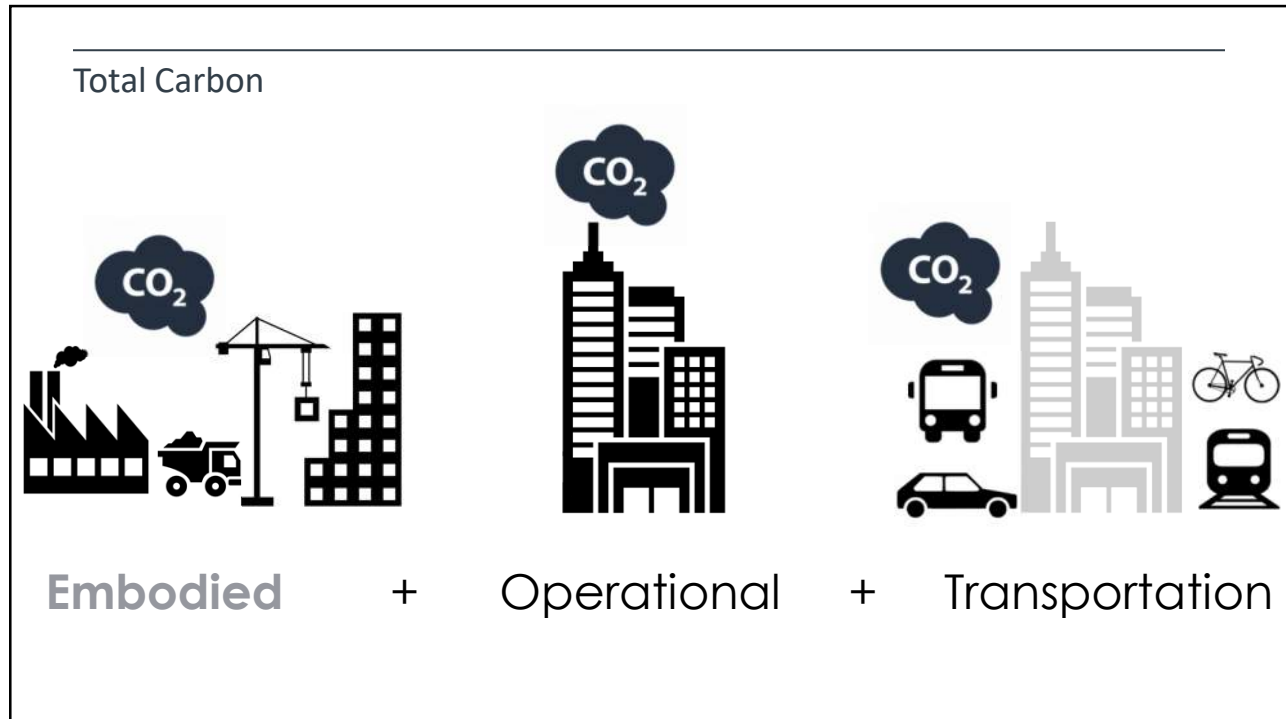
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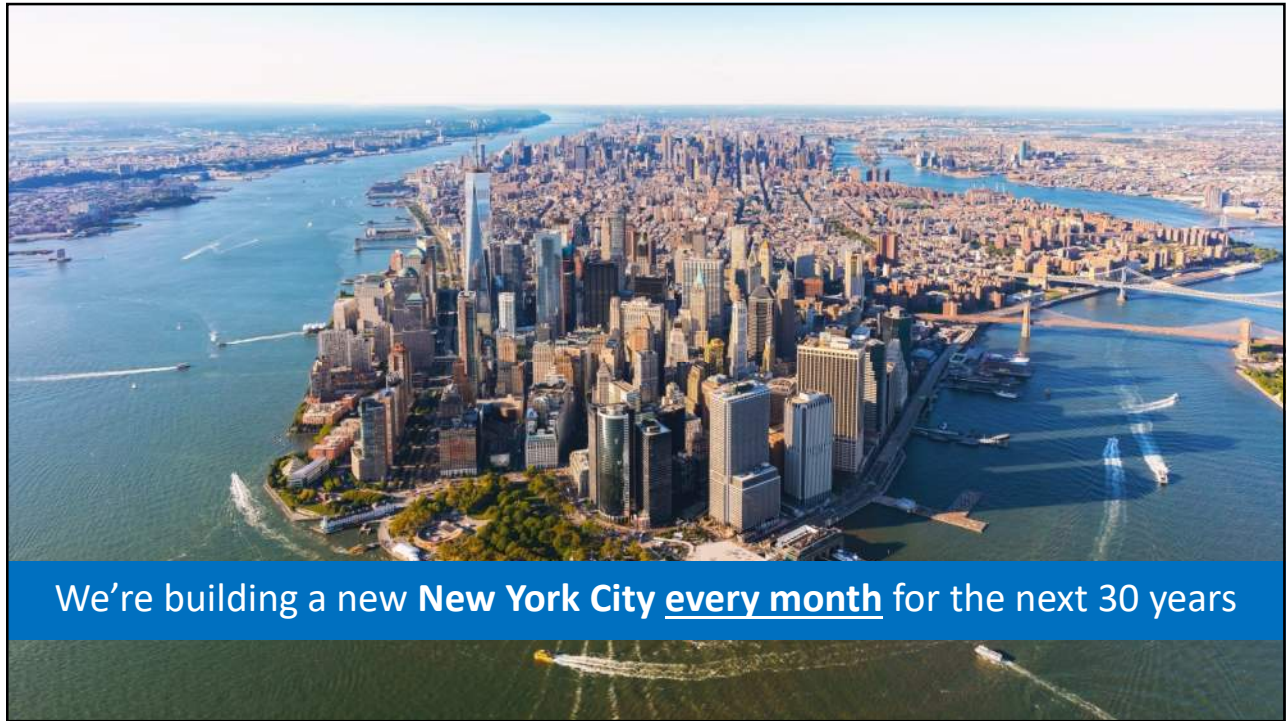
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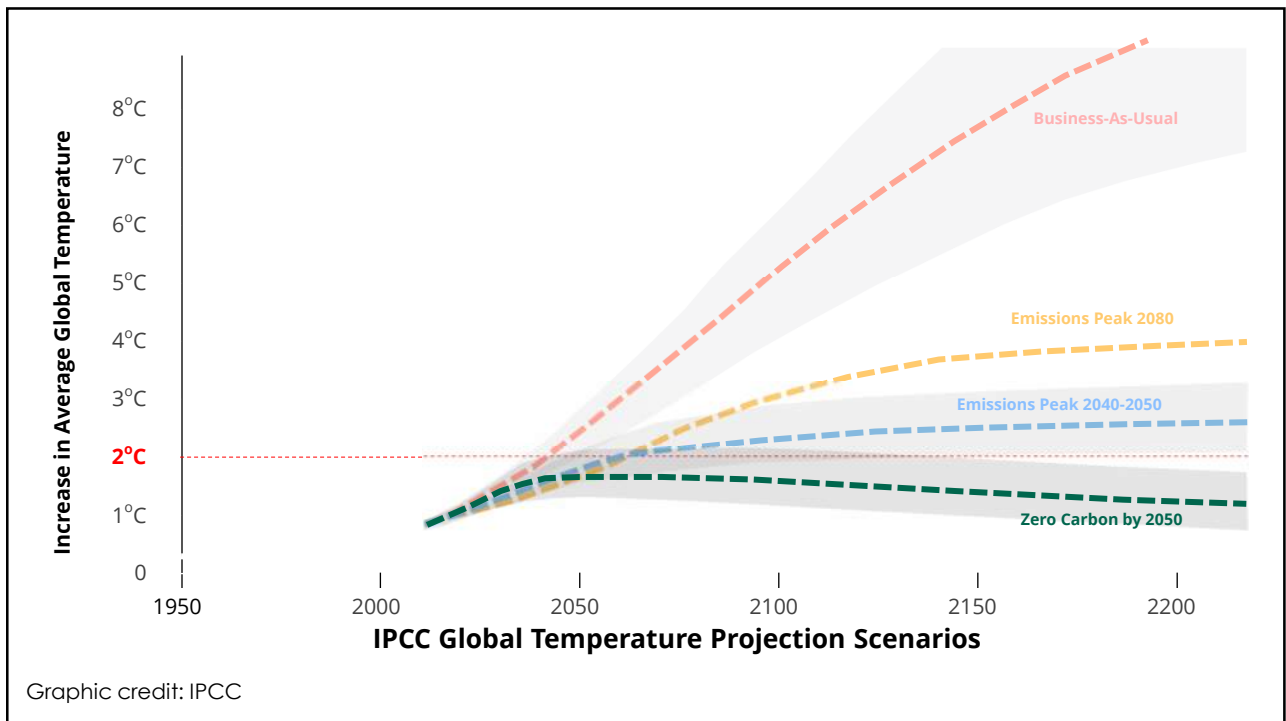
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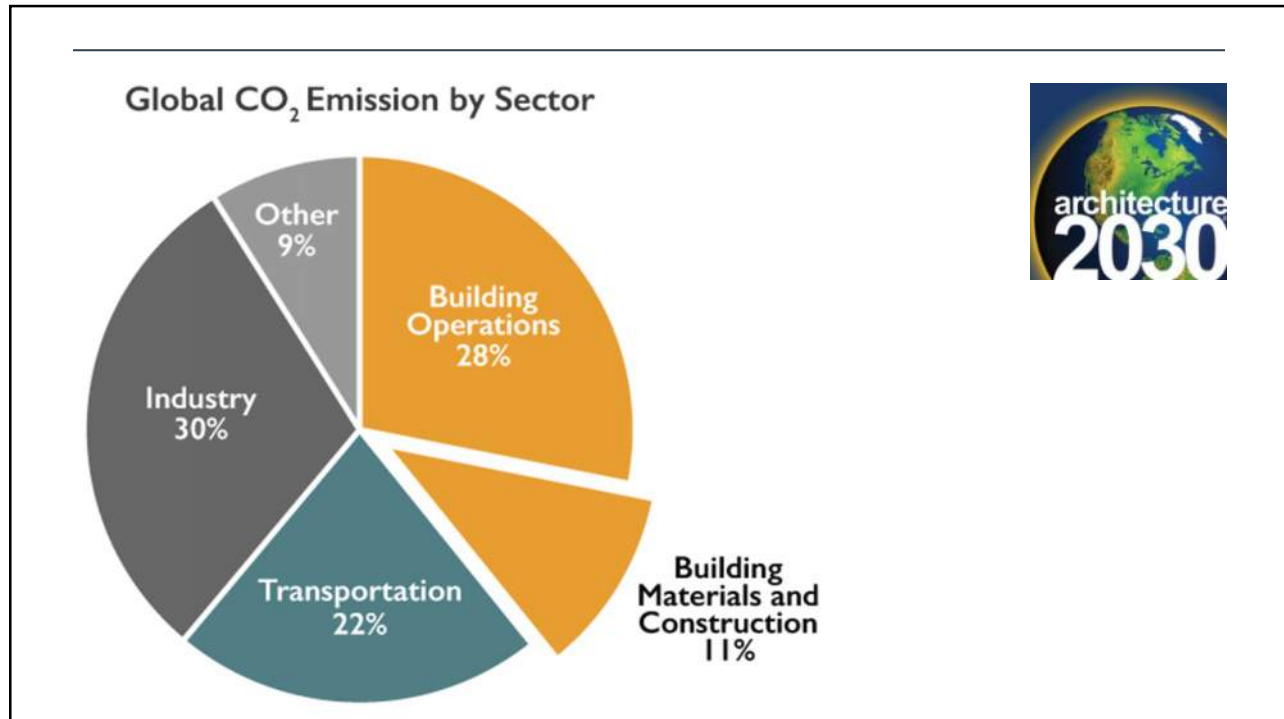
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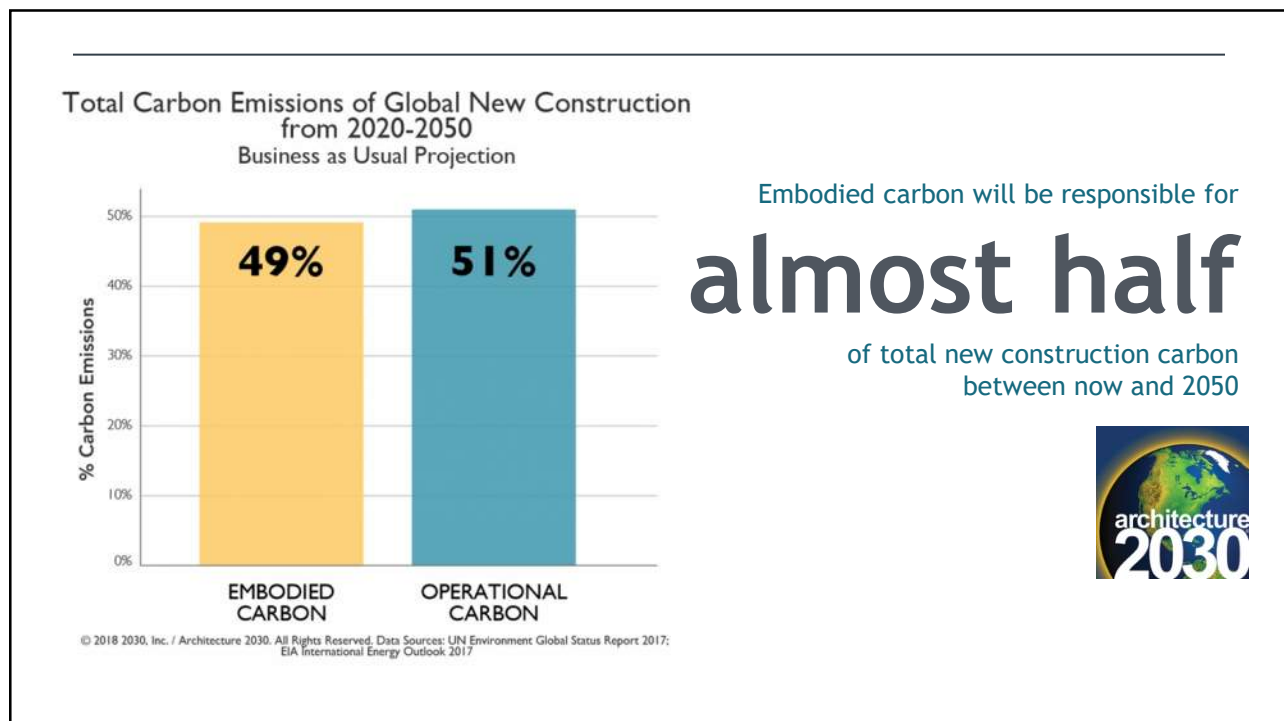
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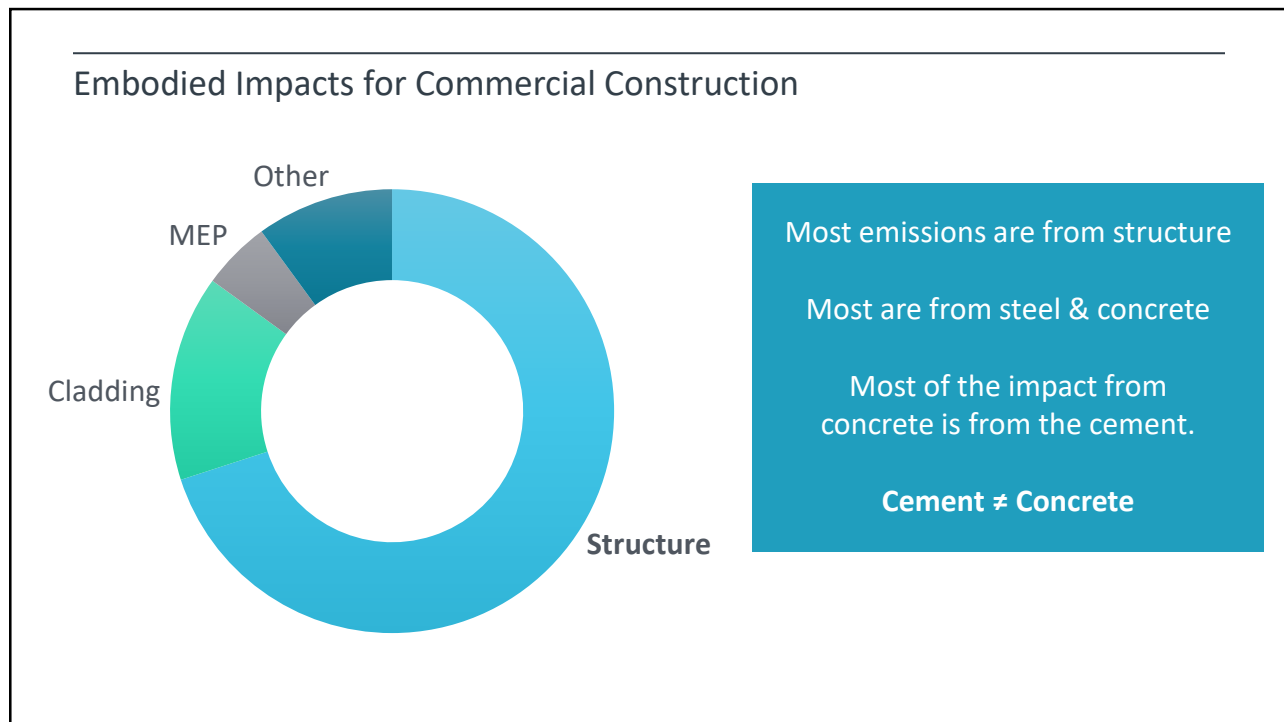
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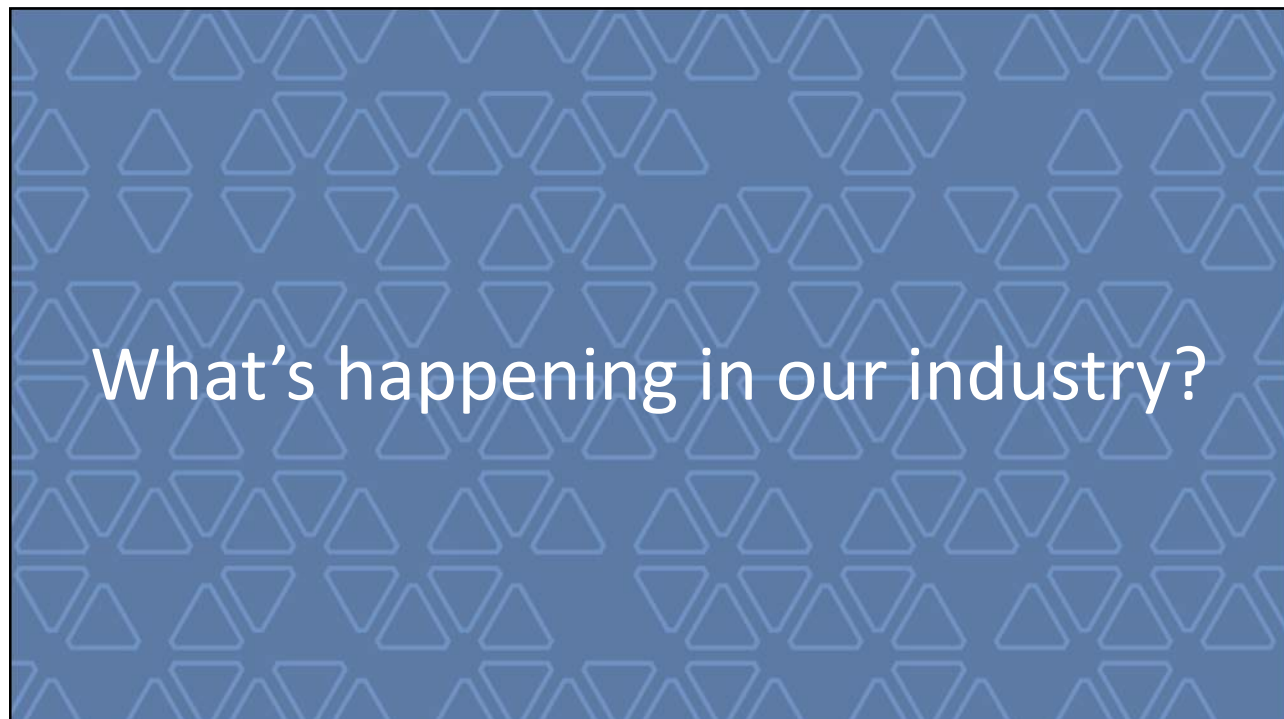
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13




14



Bringing Embodied Carbon Upfront



Embodied carbon call to action report

The World Green Building Council's pioneering report demands radical cross-sector coordination to revolutionise the buildings and construction sector towards a net zero future, and tackle embodied carbon emissions.



WORLD GREEN BUILDING COUNCIL

15


NEWS ANALYSIS

AIA Ethics Code Now Covers Sustainability in Depth

The AIA Code of Ethics now addresses specific environmental priorities like water, energy, and climate change.

by [Paula Medton](#)
September 24, 2018

Sustainability-Related Updates to the AIA Code of Ethics




AIA COTE Top Ten Toolkit:

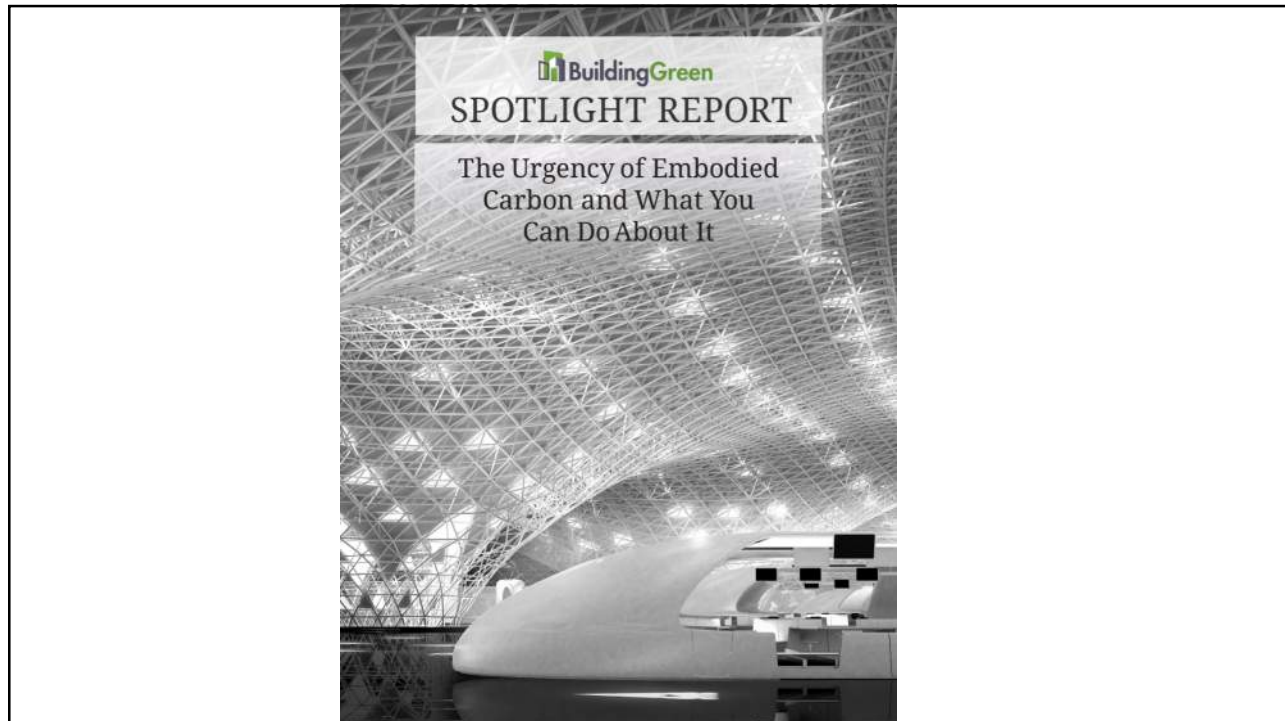
8. Materials

Suggested Best Practices


1. Whole Building Life Cycle Analysis
2. Tracking Building Product Environmental Impacts



16




17



- [Home](#)
- [About](#)
- [Empowering the Building Sector](#)
- [Actions](#)
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- [🐦](#)
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2030 CHALLENGE FOR EMBODIED CARBON

The embodied carbon emissions from all new buildings, infrastructure, and associated materials must be reduced by **50% by 2030**, and zero by 2050.

THE 2030 CHALLENGE FOR EMBODIED CARBON:

In order to limit the rise in global average temperature to well below the 2 degree Celsius threshold set by the scientific community, we must phase out fossil fuel CO₂ emissions by 2050. This requires that all new construction be designed to high energy efficiency standards, use no CO₂-emitting fossil fuel energy to operate, and be constructed with less embodied carbon emissions by 2020, and the entire built environment be **carbon neutral by 2050**.

18

CARBON SMART MATERIALS PALETTE™

HOME CARBON SMART MATERIALS PALETTE ABOUT 2030 PALETTE Q

AN IMMEDIATELY APPLICABLE, HIGH-IMPACT PATHWAY TO EMBODIED CARBON REDUCTIONS IN THE BUILT ENVIRONMENT

The image shows the top section of a website. It features a green navigation bar with the 'CARBON SMART MATERIALS PALETTE' logo on the left and menu items 'HOME', 'CARBON SMART MATERIALS PALETTE', 'ABOUT', '2030 PALETTE', and a search icon on the right. Below the navigation bar is a large hero image of a construction crane against a blue sky with clouds. A semi-transparent grey box is overlaid on the left side of the crane image, containing the text: 'AN IMMEDIATELY APPLICABLE, HIGH-IMPACT PATHWAY TO EMBODIED CARBON REDUCTIONS IN THE BUILT ENVIRONMENT'.

19

CLF Carbon Leadership Forum

Join us in decarbonizing the built environment - better buildings for a better planet.

The building and construction sector have a vital role to play in eliminating carbon, as it is responsible for nearly 40% of greenhouse gas emissions. [Learn More](#) | [Watch Video](#)

View Video + Materials Matter

Read + Decarbonizing Strategies for Buildings

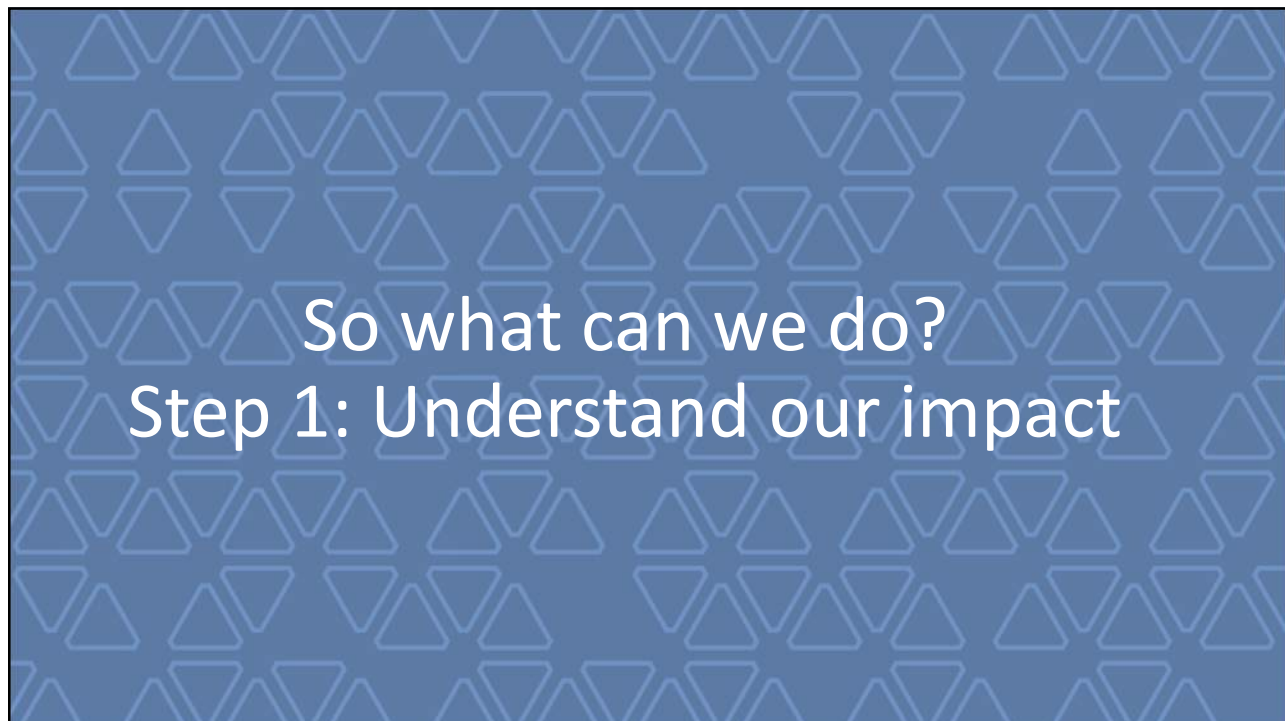
Read + 6th Graders Build a Carbon Smart City

The image shows the top section of the Carbon Leadership Forum website. It features the 'CLF Carbon Leadership Forum' logo in the top left. Below the logo is a large hero image of a construction site with a crane and scaffolding. A semi-transparent dark box is overlaid on the bottom left of the hero image, containing the text: 'Join us in decarbonizing the built environment - better buildings for a better planet.' and 'The building and construction sector have a vital role to play in eliminating carbon, as it is responsible for nearly 40% of greenhouse gas emissions. Learn More | Watch Video'. Below the hero image are three smaller images with captions: 'View Video + Materials Matter', 'Read + Decarbonizing Strategies for Buildings', and 'Read + 6th Graders Build a Carbon Smart City'.

20



21



22

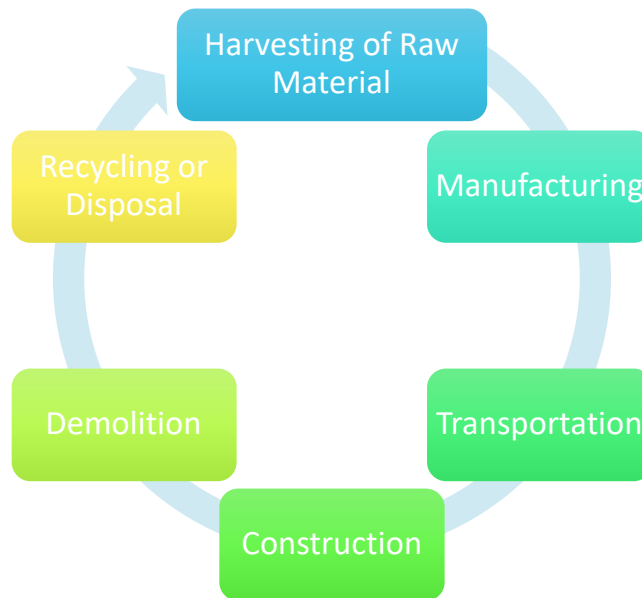
Life Cycle Assessment (LCA):

The evaluation of the **environmental effects** associated with any given activity from the initial gathering of raw material from the earth until the point at which all residuals are returned to the earth.

Source: US EPA

23

Life Cycle Assessment



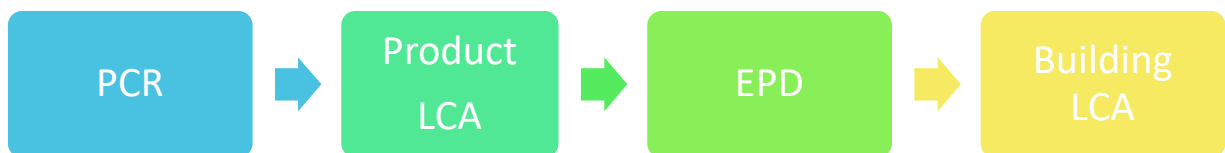
24

Environmental Impact Categories



25

PCRs, EPDs and LCAs



LCA is a **METHOD**

EPD is a **REPORT**

26

LCA & EPDs



Life Cycle Impact Results (per m³)
Declared Unit: 1 m³ of 3,000 psi concrete

OPERATIONAL IMPACTS		CAGB5R30
Plant Operating Energy (MJ)		14.7
On-Site Plant Fuel Consumption (MJ)		165.5
Concrete Batch Water (m ³)		1.63E-01
Vehicle and Equipment Wash Water (m ³)		5.59E-01
On-Site Waste Disposal (kg)		0.19
ENVIRONMENTAL IMPACTS		
Total Primary Energy (MJ)		2,903
Climate Change (kg CO ₂ eq)		332
Ozone Depletion (kg CFC 11 eq)		1.20E-08
Acidification Air (kg SO ₂ eq)		2.14
Eutrophication (kg N eq)		0.07
Photochemical Ozone Creation (kg O ₃ eq)		1.070



Life Cycle Impact Results (per m³)
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About Titan Concrete

Our products protect human life and natural property, improve the quality of life, generate economic prosperity and cement society. Our values guide how we conduct ourselves and our business affairs, particularly with regard to our customers, our employees, our communities and the environment.

We, at Titan Concrete, know that customer satisfaction begins with strict adherence to quality control and that quality-minded people create quality products. Our ready-mixed concrete is manufactured with the most technically advanced equipment available, ensuring that our facilities are among the most efficient and environmentally friendly in the world.

Titan Concrete
455 Farmway Drive
Dunfield Beach, FLA 33441
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www.titanconcrete.com



27

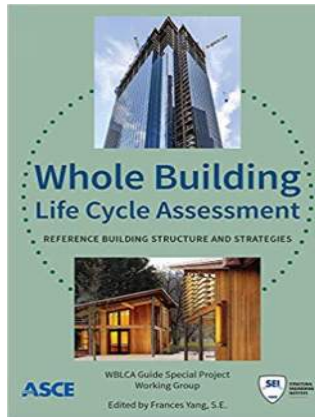


28

So what do we start from? What's the baseline?



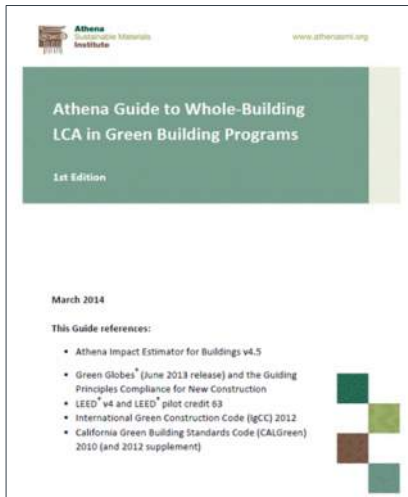
Defines the baseline building for operational energy modeling



Defines the baseline building for embodied energy modeling

29

Builds from existing materials



30

Environmental Product Declaration

NRMCA MEMBER INDUSTRY-AVERAGE EPD FOR READY MIXED CONCRETE

NSF Certified Environmental Product Declaration

Figure D1-NRMCA Regions

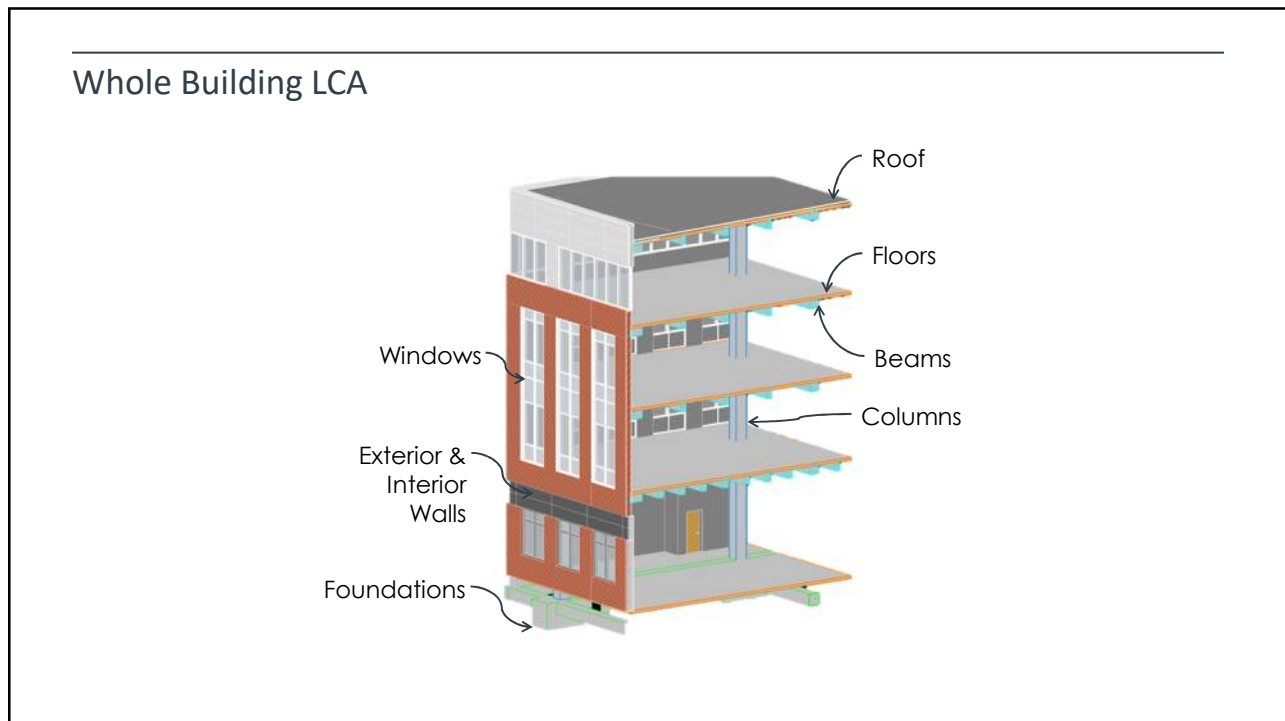
Other Sustainable Materials Include

D-9: South Eastern Region

Category	Value	Unit
Number of Plants	131	
% Transit Mix Plants	82%	
% Central Mix Plants	18%	
% Batch Waste	0.40%	
Average Production	48,023	yd ³
Total Production	6,409,141	yd ³
Minimum Production	1,394	yd ³
Maximum Production	253,110	yd ³

Compressive Strength (psi)	2500	3000	4000	5000	6000	8000	3000 LW	4000 LW	5000 LW
Portland Cement (lb)	354	393	465	555	591	664	390	462	532
Silica Ash (lb)	0	0	111	133	141	163	0	111	138
Slag Cement (lb)	22	24	29	34	36	42	24	29	33
Mineral Water (lb)	347	347	347	359	390	390	351	351	351
Crushed Coarse Aggregate (lb)	1,700	1,558	1,266	1,000	840	680	0	0	0
Natural Coarse Aggregate (lb)	290	284	276	262	270	259	0	0	0
Crushed Fine Aggregate (lb)	413	413	399	378	390	374	395	364	339
Natural Fine Aggregate (lb)	1,046	1,036	996	946	876	806	960	911	868
Max Lightweight Aggregate (lb)	0	0	0	0	0	0	930	930	930
Air (%)	6%	6%	6%	6%	6%	6%	6%	6%	2%
Air Entraining Admixture (oz)	3	3	3	3	3	3	3	3	0
Hardener & Superplasticizer (oz)	3	3	3	3	3	3	3	3	7
Set Accelerator (oz)	25	20	15	10	25	20	15	10	10
Total Weight (lb)	3,892	3,841	3,688	3,648	4,055	4,037	3,241	3,227	3,231

31



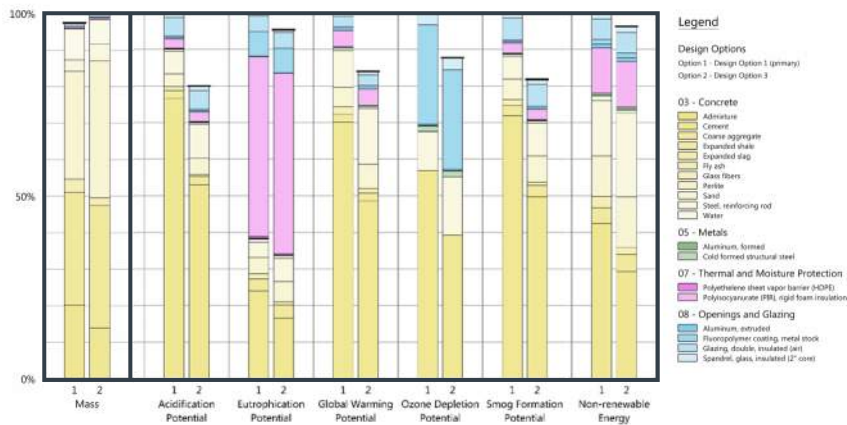
32

How do we do this?



33

WBLCA



34

LEED v4.1: Life Cycle Impact Reduction

Option 1: Historic Building Reuse (5 Points)

Option 2: Renovation of abandoned or blighted building (5 pts)

Option 3: Building and material reuse(1-4 points)

Option 4: Whole-Building Life Cycle Assessment (1-4 points)

- Path 1: Conduct a life cycle assessment of the project's structure and enclosure (1 point).
- Path 2: Conduct a LCA, show **5% reduction (2 points)**.
- Path 3: Conduct a LCA, show **10% reduction (3 points)**.
- Path 4: Conduct a LCA, show **20% reduction GWP + salvage (4 points)**.



35

Life Cycle Impact Results (per m³)
Default Unit: 1 m³ of 10,000 psi concrete at 28 days

OPERATIONAL IMPACTS		Performa™ RECC 100K
Plant Operating Energy (MJ)		28.6
On-Site Plant Fuel Consumption (MJ)		11.1
Concrete Batch Water (m ³)		1.68E-01
Concrete Wash Water (m ³)		1.91E-02
On-Site Waste Disposal (kg)		0.0
ENVIRONMENTAL IMPACTS		
Total Primary Energy (MJ)		3,017
Climate Change (kg CO ₂ eq)		445
Ozone Depletion (kg CFC 11 eq)		1.31E-08
Acidification (kg SO ₂ eq)		2.96
Eutrophication (kg N eq)		0.04
Photochemical Ozone Creation (kg O ₃ eq)		0.61

MATERIAL QUANTITY ESTIMATE

×

EMBODIED CARBON PER MATERIAL EPDs

=

BUILDING EMBODIED CARBON (EC) ESTIMATE

36

Low Carbon Material Strategies

- Specify less cement
- Specify mixes appropriate for usage
- Consider longer cure times
- Consider bay size
- Efficiency, efficiency
- Use structure as finish
- Repurpose existing buildings
- Design for deconstruction
- Specify products with EPDs
- Design for lifespan
- Use carbon-sequestering materials
- Use salvaged materials
- Use recycled materials
- Understand your region
- Source locally
- Know the supply chain
- Optimize for material efficiency
- Renewables for manufacturing
- Establish a carbon budget!

37

Material Strategies

Concrete

- Specify less cement
- Performance and element-based specification
- Longer cure times
- Maximize SCMs
- Specify max GWP
- Request EPDs

Steel

- Efficiency
- Buy American
- Specify EAF
- Consider steel shape
- Use salvaged steel
- Design for deconstruction
- Thermal bridging
- Don't forget about the concrete

Wood

- Use structure as finish
- Consider bay size
- Supply chain, specify FSC
- Compare different wood products
- Don't forget about the concrete

38



39

SE 2050 Overview

40

Summer 2019



SE 2050 Challenge

“All structural engineers shall understand, reduce and ultimately eliminate embodied carbon in their projects by 2050”

December 2019



41

November 2019 - Program Launch



**STRUCTURAL
ENGINEERING
INSTITUTE**



www.SE2050.org

42

Program Stats

580 Email Subscribers

40 Committed Firms | Goal: 50 by 2022

Armstrong-Douglass Partners	Grimm & Chen Structural Engineering, Inc.	Meyer Borgman Johnson
Arup (North America)	HGA	NORR
Aspect Structural Engineers	HOK	O'Donnel & Naccarato, Inc.
Bush, Bohlman & Partners	Holmes	PCS Structural Solutions
Clark Nexsen	IMEG Corp.	Silman
Conn Shaffer Consulting Engineers	Keast & Hood	Simpson Gumpertz & Heger Inc.
Coughlin Porter Lundeen	KPFF Consulting Engineers	Skidmore, Owings & Merrill
Degenkolb Engineers	KICSEC Ltd.	Studio NYL Structural Engineers and Facade Designers
DCI Engineers	KL&A Engineers and Builders	Thornton Tomasetti
Engineering Ventures	LeMessurier	Verdant Structural Engineers
EQUILIBRIUM Consulting	LERA Consulting Structural Engineers	Walter P Moore
Flad Structural Engineers	McMullan & Associates, Inc.	Wight & Company
Forell Elsesser Structural Engineers	McNamara Salvia Structural Engineers	
Glotman Simpson Consulting Engineers	Magnusson Klemencic Associates	

43

Program Stats – Signatory Firms

Table 1: Distribution of Committed Firms Number of Employees

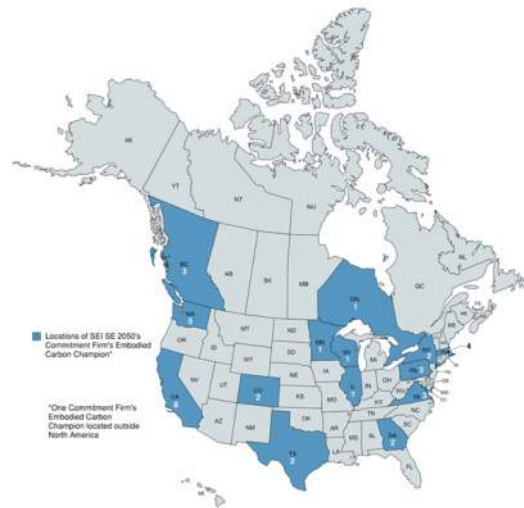
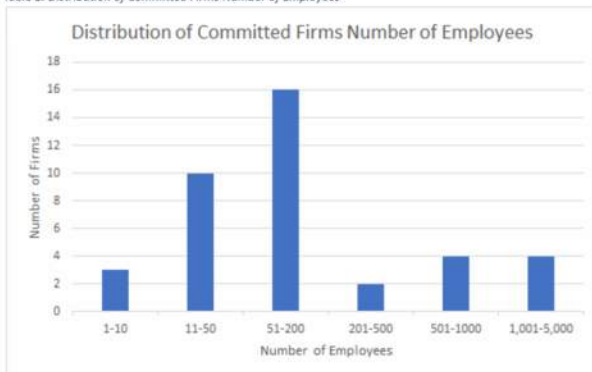
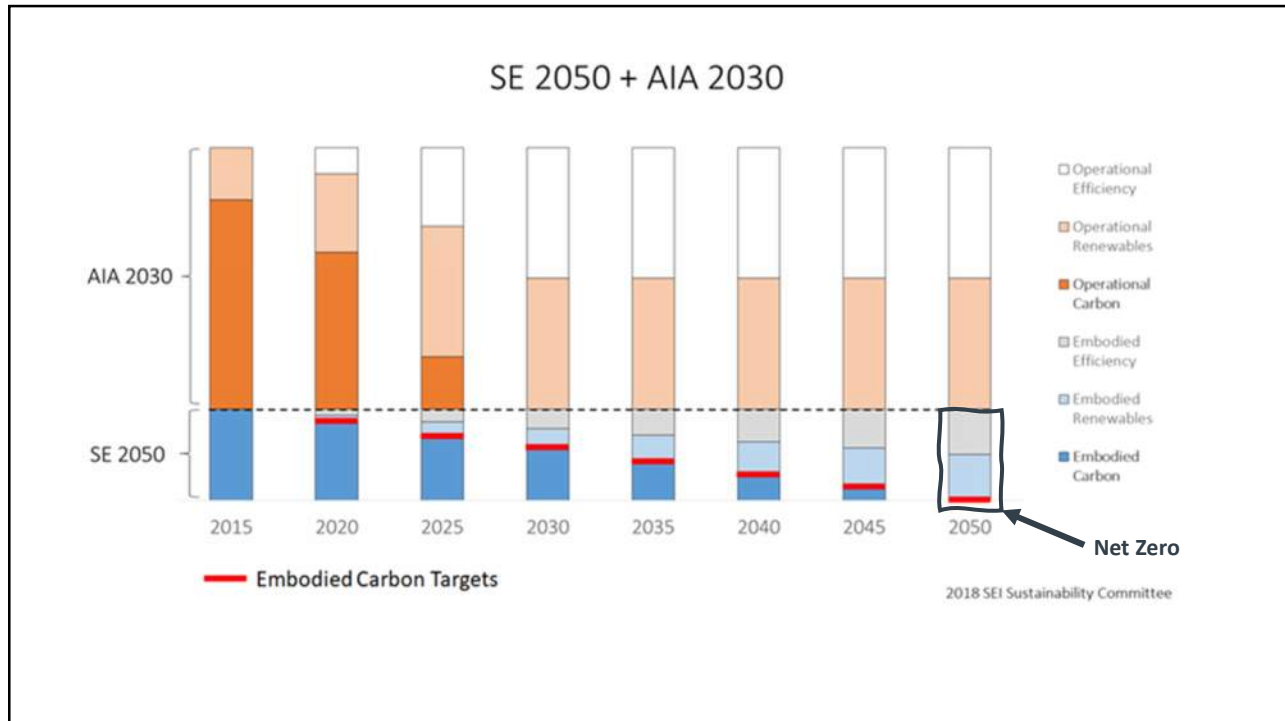


Figure 1: Distribution of SEI SE 2050 Commitment Firm's Embodied Carbon Champion in North America

44



45

Achieving Net Zero Embodied Carbon

- White Paper published in March 2020
- This paper addresses the first question many engineers ask about eliminating embodied carbon in construction:

– How is that even possible??

Achieving Net Zero Embodied Carbon in Structural Materials by 2050

A White Paper by the Structural Engineering Institute's Sustainability Committee Carbon Working Group
Mark D. Waldor, Editor
March 2020
Updated May 2020

Image inspired by Figure 2.16 from IPCC Report Global Warming of 1.5°C (2018)
<https://www.ipcc.ch/report/sr15/>

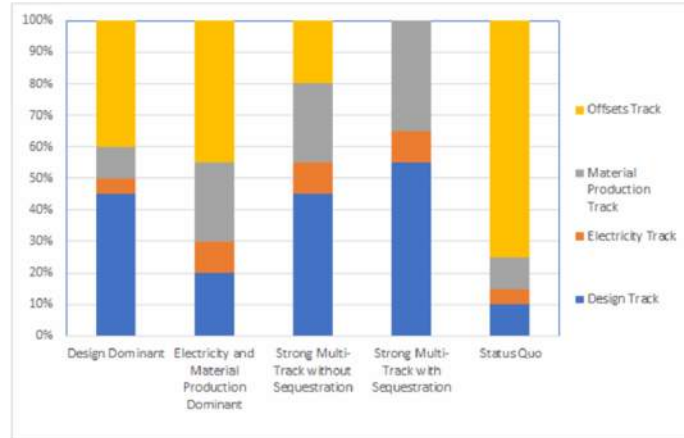
<https://seisustainability.files.wordpress.com/2020/05/how-to-get-to-zero-200525.pdf>

46

Achieving Net Zero Embodied Carbon

Four Tracks:

1. Design improvements implemented by engineers and architects.
2. Greening the electrical grid.
3. Improving material production.
4. Carbon offsets.



May be combined in different proportions.

47



Education, advocacy, accountability, firm culture

48

Program Requirements

49

SE 2050 Commitment Program

SE 2050 Program Requirements

The SE 2050 Commitment entails three primary requirements:

- 1. *Upon joining:* Commitment Letter from Firm Leadership**
- 2. *Within six months and annually:* Embodied Carbon Action Plan (ECAP)**
- 3. *Within one year and annually:* Submit data to SE 2050 project database**

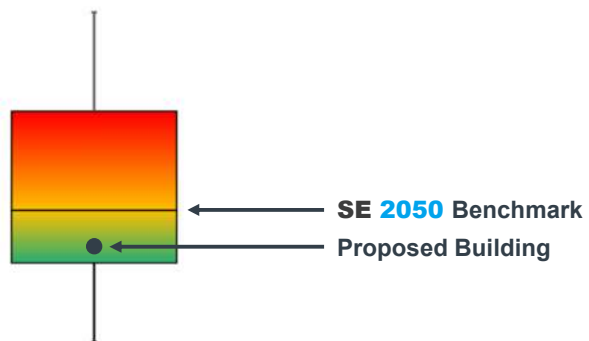
Each of the above requirements are further detailed in the [SE 2050 Program Guidance document](#). Below is a summary of the second requirement, which warrants more attention because it sets forth the first set of actions that a firm must take in the Commitment Program.

50

SE 2050 Database

51

Embodied Carbon Benchmarks



52

SE 2050 Beta Database

Priorities:

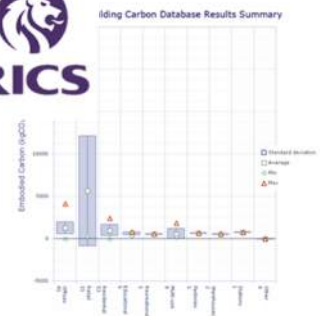
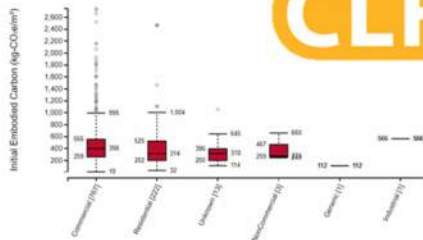
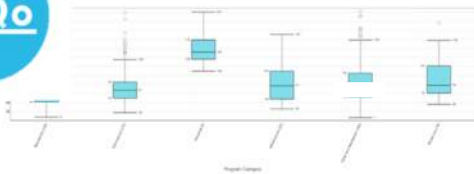
Familiarize structural firms with embodied carbon reporting

Collect GWP results at minimum

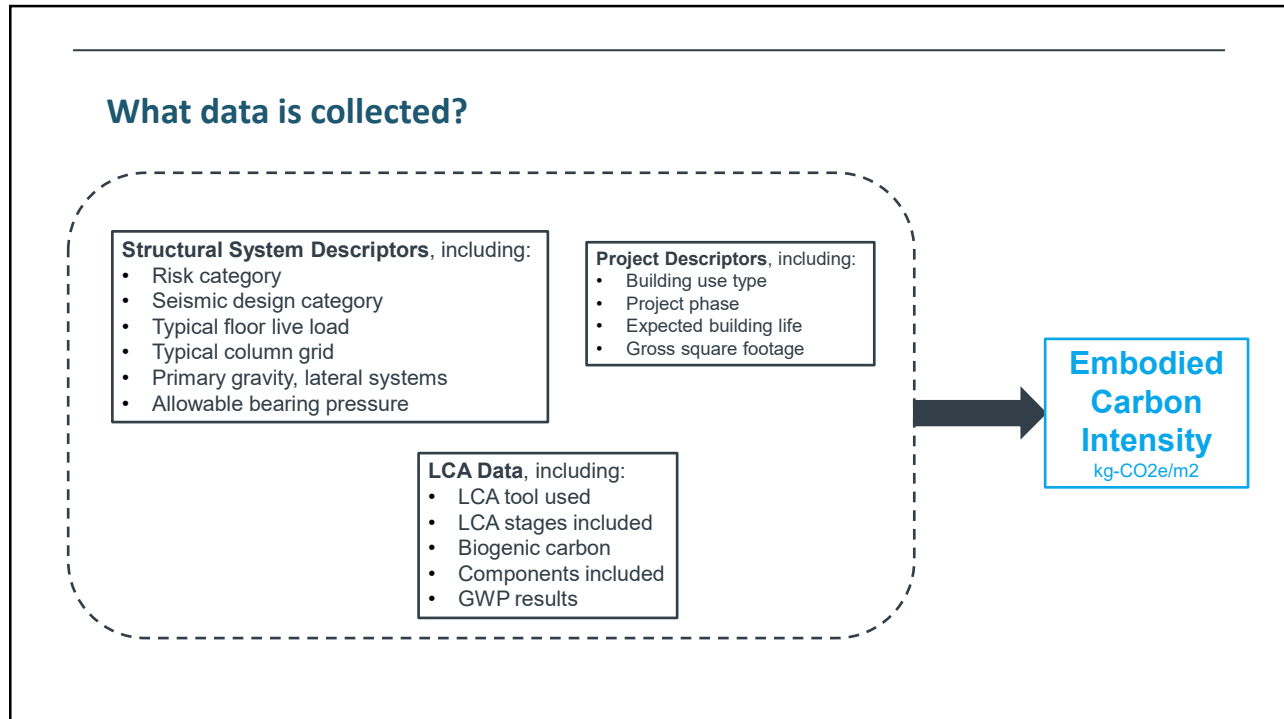
Increase visibility of need for embodied carbon benchmarks

53

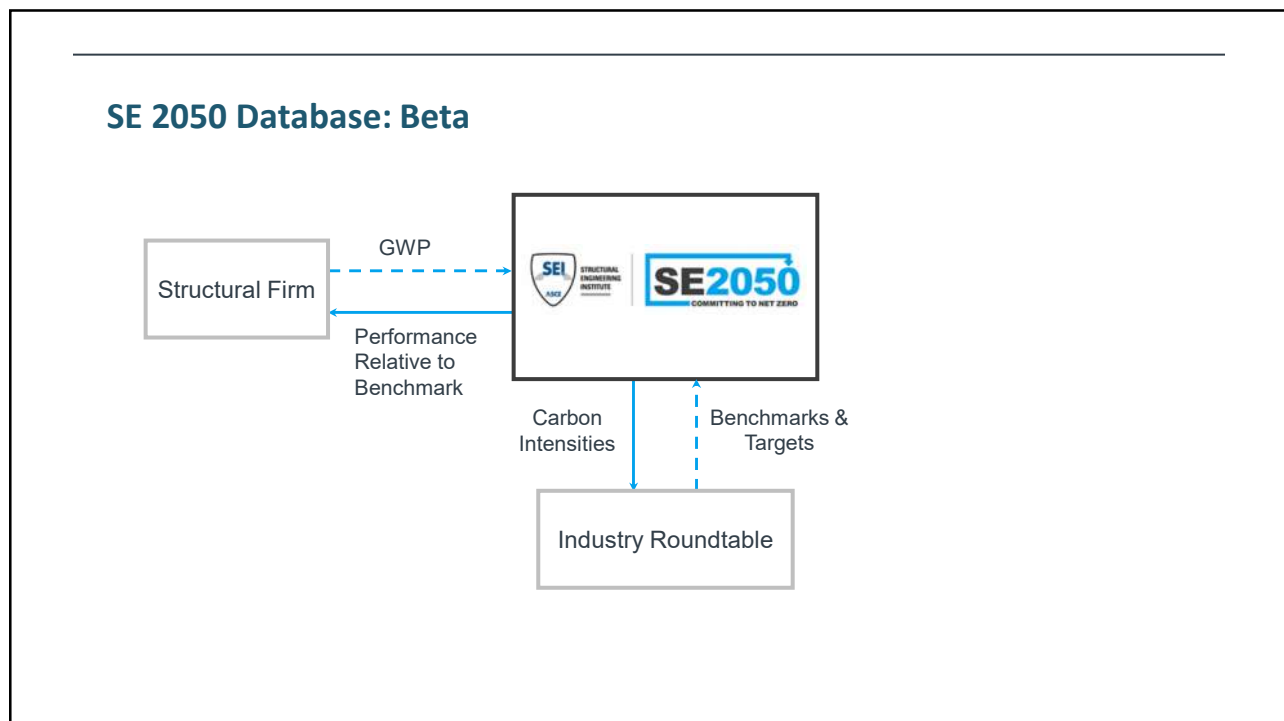
Beta Database Precedents



54



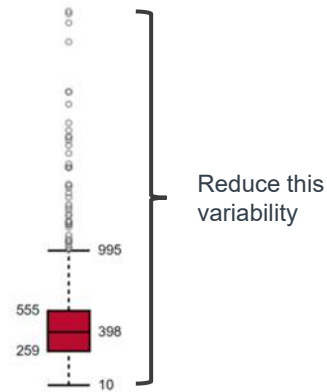
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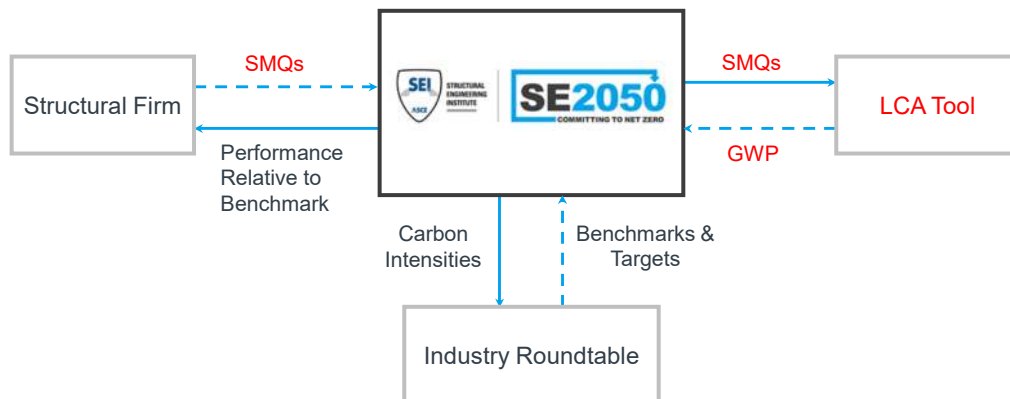
SE 2050 Database: Future

- Collect structural material quantities (“SMQs”)
- Focus on reducing data variability
- Establish industry benchmarks and targets using aggregated data



57

SE 2050 Database: Future?



58

SE 2050



59

**This is All New!
Where Do We Start?**

60

Resources

61

2-Way Street Commitment

- Our ask *of* the Profession
- We Commit to Providing Resources and Support *to* the Profession



62

WAYS TO ENGAGE
Helpful Resources

Whole Building Life Cycle Assessment

Structural Materials and Global Climate

Sustainability Guidelines FOR THE STRUCTURAL ENGINEER

63

SE 2050 Resources

Embodied Carbon

Structural Materials

Strategies

EMBODIED CARBON INTENSITY DIAGRAMS

Check out diagrams of structural material quantities and embodied carbon intensities for typical structural framing schemes to assess where you are against a baseline.

[View Diagrams](#)

Tools and Data

Case Studies

ECOM

ECOM

ECOM is a simple embodied carbon estimator to calculate the approximate embodied carbon (order of magnitude) based on your structural material quantities.

[Calculate Now](#)

64

What Can I Do?

65

What Can I Do?

- Have your firm join the SE 2050 Commitment Program
- Educate yourself on embodied carbon reduction strategies
- Share your project data to the SE 2050 Database
- Create an Embodied Carbon Action Plan (ECAP)
- Employee embodied carbon reduction strategies on project
- Advocate within industry and to your clients!
- Donate - <https://se2050.org/donate/>

66

Are you ready to join the movement?

<https://se2050.org/sign-up/>

67

Join Us!

- Interested in getting involved either by just liaising with the NCSEA SDC or starting an SDC in your local MO?
 - Contact: kroberts@walterpmoore.com
 - <http://www.ncsea.com/committees/sustainabledesign/>
- Want to learn more about SE2050?
 - Contact: Megan.Stringer@holmes.us
- Reference materials re: sustainable design in structural engineering:
 - Sustainability Guidelines for the Structural Engineer
 - Whole Building Life Cycle Assessment – Reference Building Structure and Strategies
 - Structural Materials and Global Climate
- Web Resources:
 - www.SE2050.org
 - www.seisustainability.org
 - <https://carbonleadershipforum.org/>



68