
BUILD WITH STRENGTH
LOW-CARBON CONCRETE
ROUNDTABLE: WASHINGTON, DC
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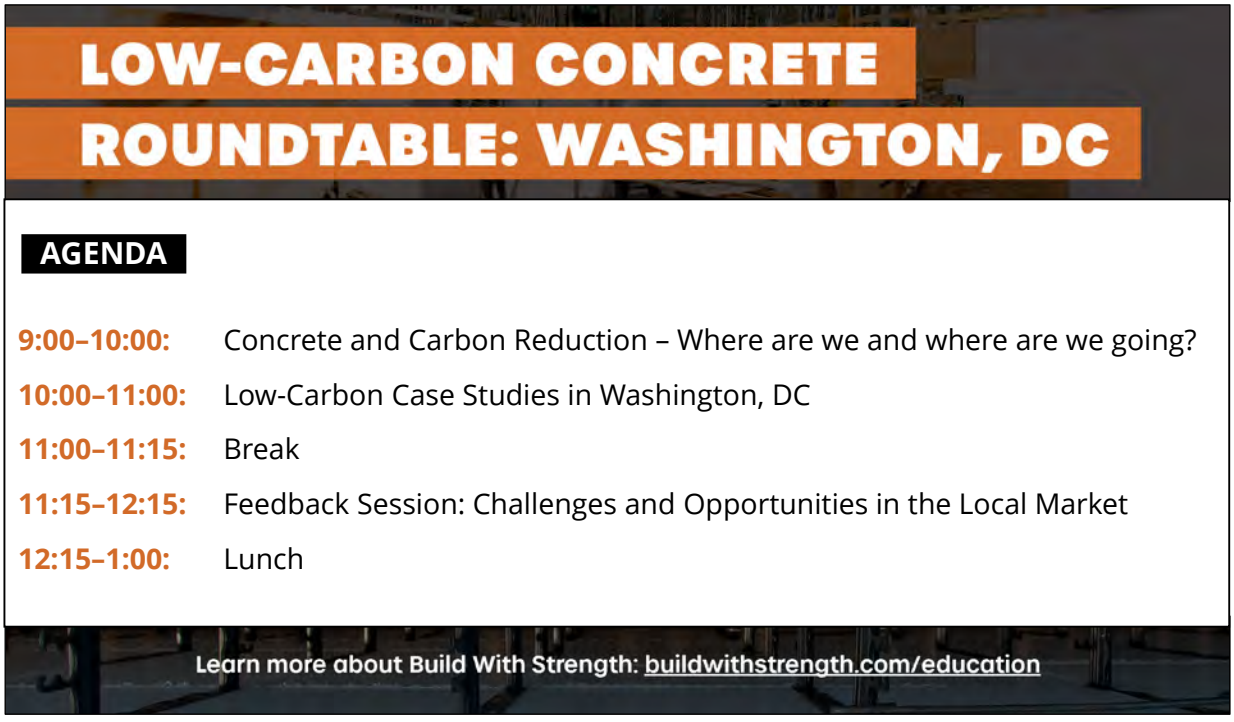
LOW-CARBON CONCRETE
ROUNDTABLE: WASHINGTON, DC
AGENDA
9:00–10:00: Concrete and Carbon Reduction – Where are we and where are we going?
10:00–11:00: Low-Carbon Case Studies in Washington, DC
11:00–11:15: Break
11:15–12:15: Feedback Session: Challenges and Opportunities in the Local Market
12:15–1:00: Lunch
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Concrete and Carbon Reduction
Where are we and where are we going?

Lionel Lemay, EVP, Structures and Sustainability, National Ready Mixed Concrete Association

Walter Tersch, LEED AP, Sustainability Program Manager, Office of Architecture and Engineering, GSA Public Buildings Service

Connor Rattey, Green Building Program Analyst, Department of Energy & Environment, Washington, DC

Lauren Wingo, Senior Structural Engineer, ARUP

NRMCA

BUILD WITH STRENGTH

NRMCA's Commitment to Carbon Neutrality

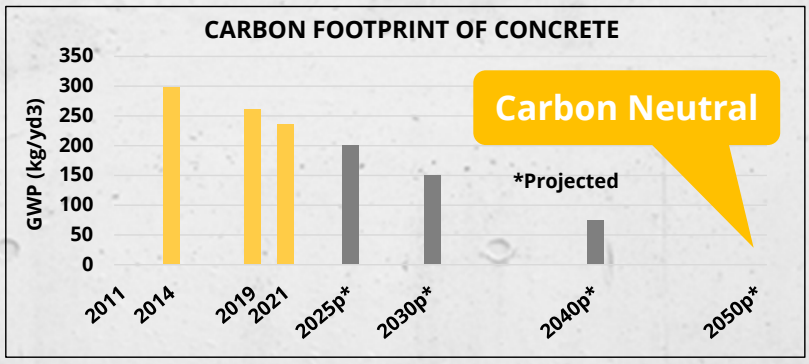
2009 | 2012 | 2014 | 2016 | 2021

ADOPTER architecture 2030 CHALLENGE

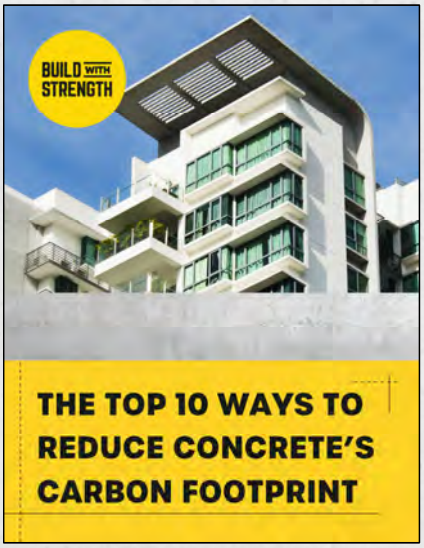
NRMCA CERTIFIED EPD

BUILD WITH STRENGTH

Roadmap to Carbon Neutrality
A more sustainable world is Shaped by Concrete



Key Strategies to Lower Carbon Footprint

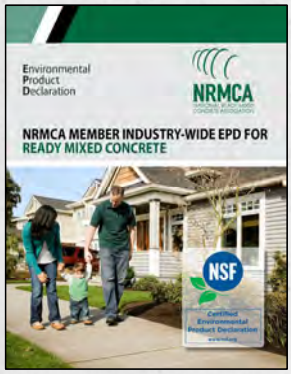


The Top 10 Ways to Reduce Concrete's Carbon Footprint

1. Communicate carbon reduction goals
2. Ensure good quality control and assurance
3. Optimize concrete design
4. Specify innovative cements
5. Specify supplementary cementitious materials
6. Specify admixtures
7. Set targets for carbon footprint
8. Don't limit ingredients
9. Sequester carbon dioxide in concrete
10. Encourage innovation

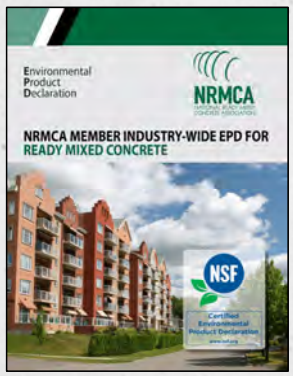
www.nrmca.org/sustainability

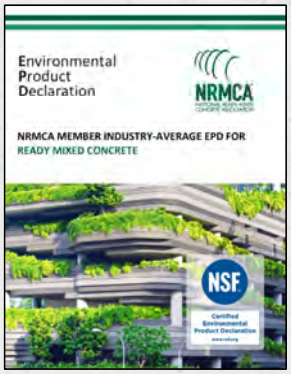
Measurement: NRMCA IW EPD and Benchmarks



Version 1 (2014)

Version 2 (2016)





Version 3 (2019)
- v3.1 (2021)
- v3.2 (2022)

Version 4 (2024)

Coming Soon

Product Specific EPDs

ENVIRONMENTAL IMPACTS

Declared Product:
Mix S62C450011 • Irvine Plant
1 3500PSI PU PL SHR
Compressive strength: 3500 PSI at 28 days

Declared Unit: 1 m^3 of concrete

Global Warming Potential (kg CO_2-eq)	427
Acidification Potential (kg SO_2-eq)	1.38
Eutrophication Potential (kg N-eq)	0.51
Photochemical Ozone Creation Potential (kg O_3-eq)	28.7
Abiotic Depletion, non-fossil (kg Sb-eq)	7.5E-5
Abiotic Depletion, fossil (MJ)	681
Total Waste Disposed (kg)	3.66
Consumption of Freshwater (m^3)	3.16

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

NRMCA CERTIFIED EPD

Concrete EPDs

77,506

Source: EC3

Performance Specifications

Shear Walls:
Strength, stiffness

Columns:
Strength

Floors 2-18:
Strength

Floors B2-1:
Strength

Basement Walls:
Strength, exposure class

Foundation:
Strength, exposure class

Performance vs Prescriptive Criteria

Performance Criteria

- Strength
- Exposure class
- Hydraulic cement: ASTM C150, 595 or 1157
- SCM: ASTM C618, C989, C1240, C1866
- Admixtures: ASTM C260, C494, C1582
- Permit recycled concrete and water

Likely meet all performance criteria

Prescriptive Criteria

- Max. or min cement content
- Max. or min. SCM content
- Hydraulic cement: ASTM C150
- Max. w/cm (water to cementitious materials ratio)
- Max. or min. SCM content
- Aggregate gradation
- Slump

May not meet all performance criteria

Specifications for Low-Carbon

- Avoid GWP limits for each mixture

Member	Mix ID	Durability Exposure				Specified Strength, f'_c, psi	Max w/cm or Performance Alternative	Nom. max Aggregate, in.	Air Content	Slump/ Slump Flow	Chloride Limit	Temp. Limits	Max. GWP (kg/yd3 CO_2e)
		F	S	W	C								
Footings													250
Foundation Walls													250
Slabs-on-grade													25
Exterior slabs													0
Suspended slabs (interior)													3 0
Suspended slabs (exterior)													
Frame members													30
Columns (interior)													300
Columns (exterior)													300
Walls (interior)													250
Concrete toppings													250

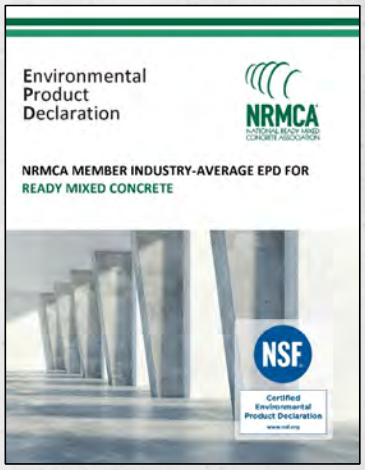
10

Establishing a Carbon Budget

Benchmark Project

VS

Proposed Project



Establishing a Carbon Budget

Project Budget

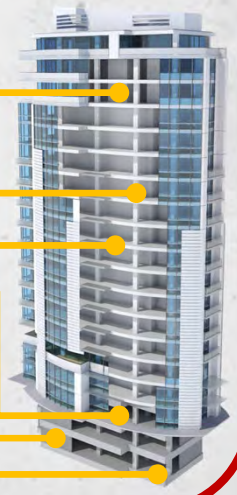
TOTAL GWP < 4.30 x 10^6

VS

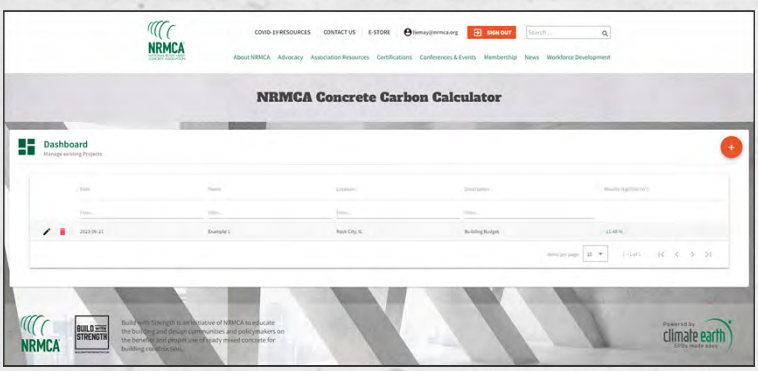
Individual Mix Limits

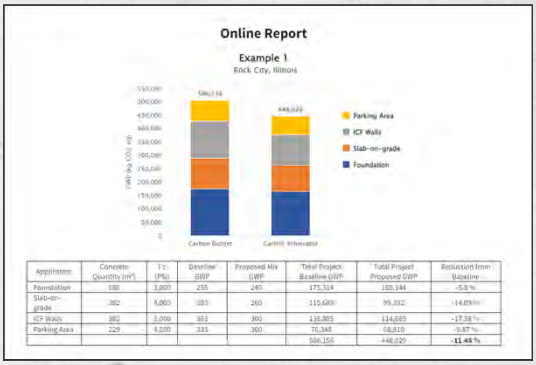
May not achieve all performance criteria

- **Shear Walls:** 180 kg CO_2 eq/m^3
- **Columns:** 190 kg CO_2 eq/m^3
- **Floors 2-18:** 240 kg CO_2 eq/m^3
- **Floors B2-1:** 225 kg CO_2 eq/m^3
- **Basement Walls:** 190 kg CO_2 eq/m^3
- **Foundation:** 175 kg CO_2 eq/m^3



NMRCA Concrete Carbon Calculator





Other considerations to lower carbon footprint

Extend test age

- **Consider 56 or 90 days**
- Foundations
- Shear walls?

- **3,500 psi at 3 days instead of 2 days**
- Post-tensioned slabs

Use appropriate strength in design

- Exposure: 5,000 psi
- Structural: 4,000 psi
- **Use 5,000 psi in design**

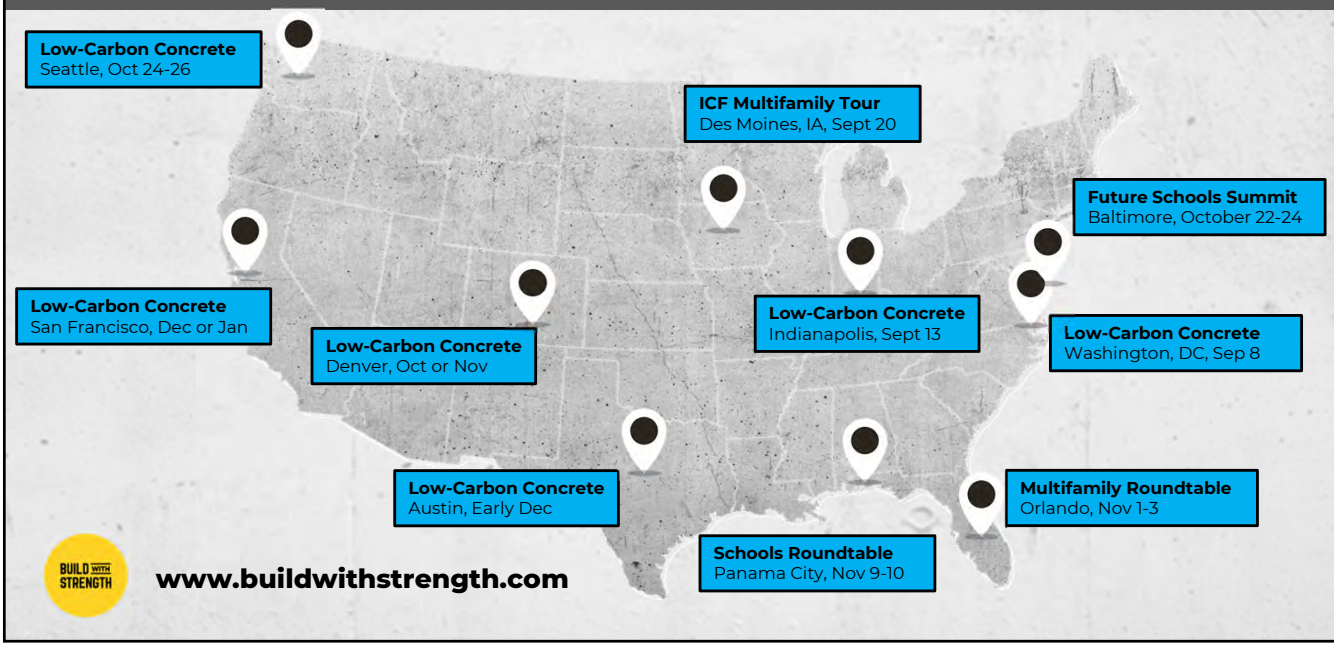
- Contractor: 3,500 psi at 2 days
- Result is 8,000 psi at 28 days
- **Use 8,000 psi in design**

Encourage innovative products

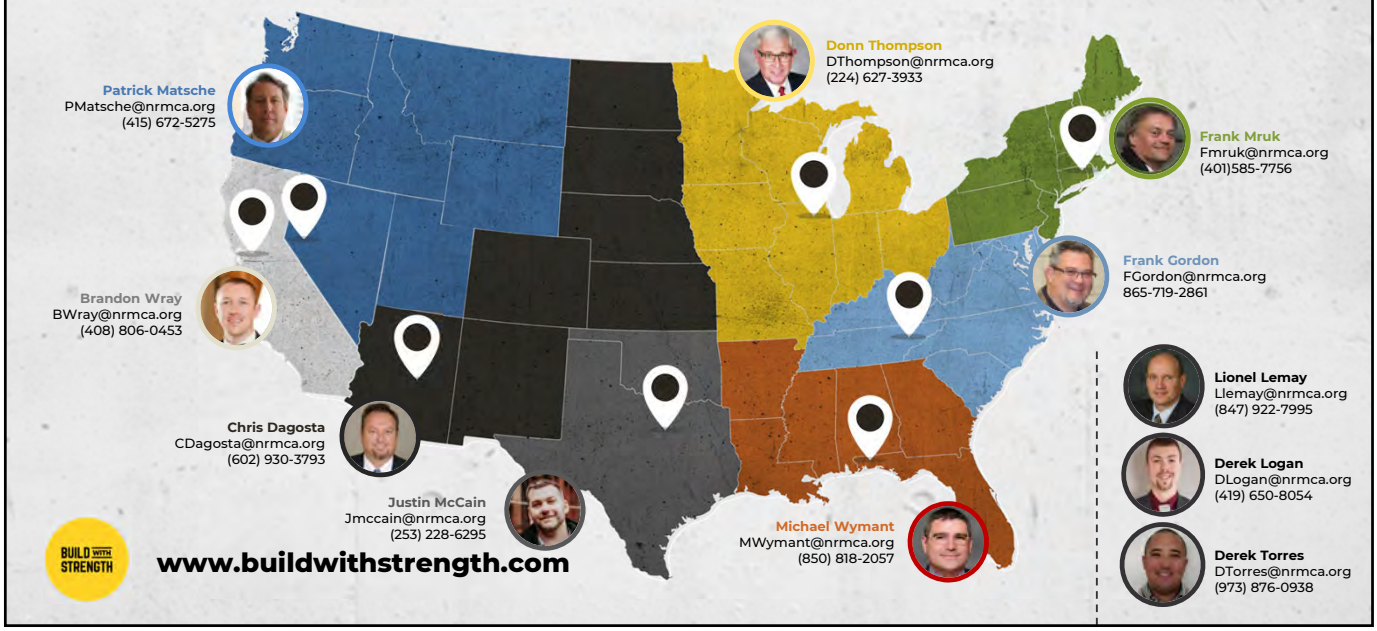
- Innovative cements, SCMs, admixtures
- **Engage contractors and producers early**

Education: Concrete Innovations

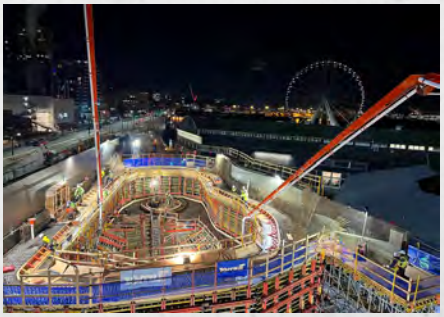
Low-Carbon Concrete Roundtables

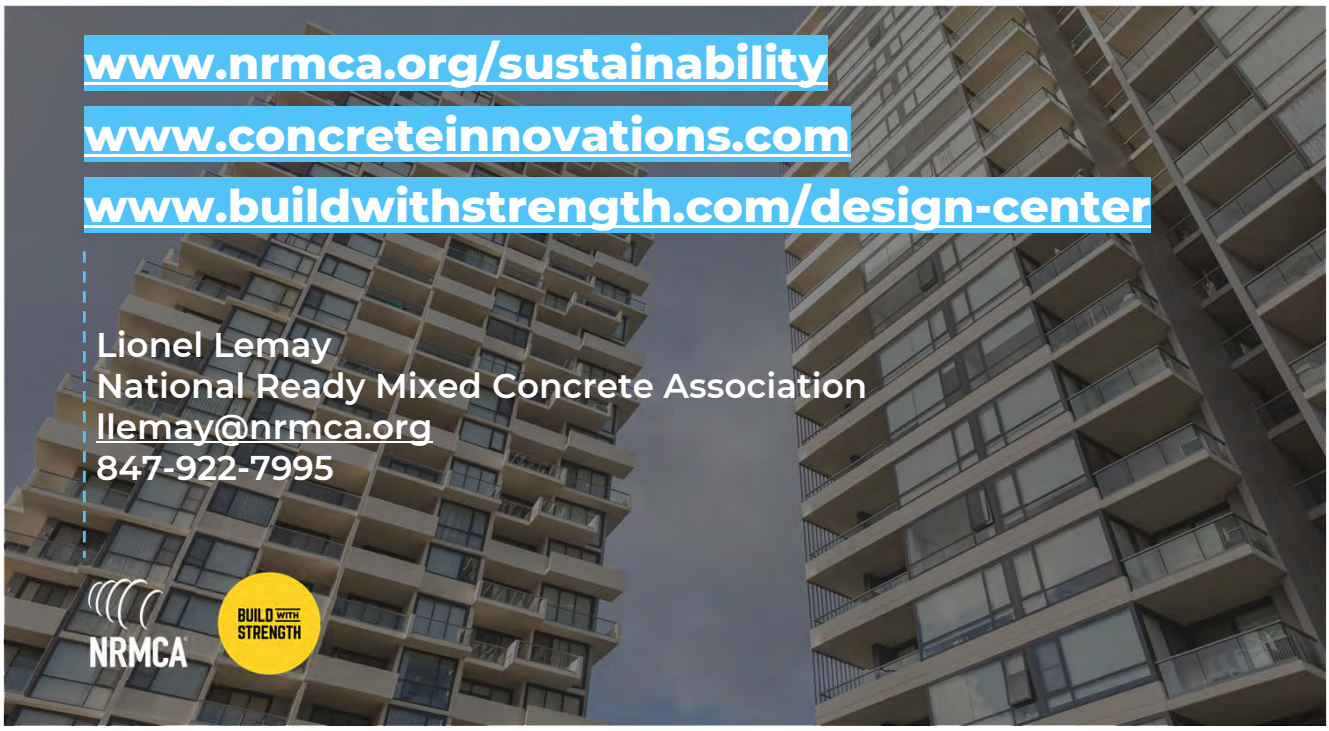


Design Assistance / Spec Reviews / WBLCA



Celebrate Innovation




www.nrmca.org/sustainability
www.concreteinnovations.com
www.buildwithstrength.com/design-center
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GSA
U.S. General Services Administration
GSA Low-Carbon Concrete Update
NRMCA
NATIONAL READY MIXED CONCRETE ASSOCIATION
Low-Carbon Concrete Roundtable
September 8, 2023
Walter Tersch, LEED AP
Sustainability Program Manager
Office of Architecture and Engineering
GSA Public Buildings Service

Roadmap

1. GSA's 2022 **concrete and asphalt standards**
2. **Federal Buy Clean** initiative
3. **Inflation Reduction Act**
4. **Business Case for EPDs**

1. Implementation Update: GSA's 2022 Low Embodied Carbon Concrete Standards

- Issued 3/17/2022, and incorporated into PBS P100 Facilities Standards section 4.8.5
- GSA requires EPDs for all concrete (and asphalt) mixes where at least 10 cubic yards of material are used. Waiver process available -- requires GWP estimate
- Established middle-of-the road GWP limits for concrete. Also issued asphalt standards.

Concrete Outcomes So Far

- So far our projects to implement these standards had little to no extra cost
- Concrete
  - Two projects have met our standard so far: a land port of entry near San Diego, and a U.S. Courthouse in Tucson
  - Three projects got P100 waivers approved.
    - Two were in a remote part of SE Arizona where no concrete EPDs are available.
    - One, in Washington state, had an EPD, but is 3.6% off GSA's GWP limit until the plant has completed changes and documentation updates.
  - **2,300 kg of CO2 equivalent avoided by the two compliant concrete projects**
    - That jumps to 18,000 if we include an unverified GWP estimates provided by the projects that were issued waivers based on lack of available EPDs
- One of our asphalt suppliers **developed its first-ever environmental product declaration (EPD) in just five weeks**. This showed that a paving project in the Denver area saved almost 2,500 kg of CO2 equivalent

2. Federal Buy Clean Initiative

Leverages Federal procurement and funding to catalyze markets for low-carbon construction materials and upgrade our transportation, buildings and energy infrastructure

- As the **world's largest buyer of goods and services**, the Federal government's supply chain emissions are twice as large as emissions from Federal buildings and vehicles.
- The **U.S. manufacturing sector** produces the materials that are critical to rebuilding and strengthening the nation's infrastructure.
- U.S. manufacturing sector is linked to nearly **a third of U.S. greenhouse emissions** from industrial processes.
- Buy Clean Federal efforts aim to build upon and accelerate **existing Buy Clean efforts** led by cities and states with critical support from industry, labor and environmental groups.
- A White House-led **Buy Clean Task Force** is coordinating interagency efforts to send the **first Federal demand signal** for lower embodied-carbon construction materials – **steel, concrete (and cement), asphalt and glass** – that are made in America with union jobs.
- Announced in September 2022.

www.sustainability.gov/buyclean

24

3. GSA Inflation Reduction Act (IRA) - $3.375B

$2.15 billion

for ***substantially lower* embodied carbon (LEC)** construction materials. *Funding available through 9/30/26*

$975 million

for **emerging and sustainable technologies**. *Funding available through 9/30/26*

$250 million

for measures to convert GSA facilities into **High-Performance Green Buildings** *Funding available through 9/30/31*

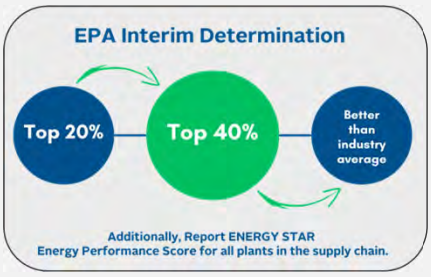
GSA's appropriations are in IRA sections 60503, 60504, and 60502
FHWA also received $2B for LEC materials
EPA received $200M for a labeling program and EPD assistance

2023 IRA Pilot LEC Requirements

The U.S. Environmental Protection Agency (EPA) issued an Interim Determination in December 2022 to guide GSA and DOT's Federal Highway Administration on selecting IRA-qualifying materials and products.

For each material, GSA established GWP limits and announced them in May for:

- the best-performing 20% of materials in terms of embodied carbon,
- the best performing 40% of materials in terms of embodied carbon, and
- better than industry average.



Currently-Approved LEC Materials

Concrete | Asphalt | Glass | Steel

How we got here

- Per EPA's Interim Determination, GSA set global warming potential (GWP) limits "using **data from a verified source** (e.g., an open source EPD database, industry-wide EPDs or a 3rd party-verified LCA developed using the relevant PCR)."
- GSA's limits are based on **publicly-available industry average and product-specific EPDs**, filtered by material type, PCR(s) specified in GSA's Requirements, North American geographical scope, and validity dates of 1/1/2022 or later.
- GSA's IRA requirements leveraged **industry feedback** and our experience with 2022 concrete and asphalt standards.

Comparison of GSA's 2022 concrete standards for all projects vs. 2023 Interim IRA Low-Carbon Concrete Limits

Specified compressive strength (f'c in PSI)	Maximum Global Warming Potential Limits for GSA Low Embodied Carbon Concrete (kilograms of carbon dioxide equivalent per cubic meter - CO_2e kg/m³) Standard Mix
up to 2499	242
2500-3499	306
3500-4499	346
4500-5499	385
5500-6499	404
6500 and up	414

These numbers reflect a 20% reduction from GWP (CO_2e) limits in proposed code language: "Lifecycle GHG Impacts in Building Codes" by the New Buildings Institute, January 2022.

	GSA IRA Limits for Low Embodied Carbon Concrete - May 16, 2023 (EPD-Reported GWPs, in kilograms of carbon dioxide equivalent per cubic meter - $kgCO_2e/m^3$)		
Specified concrete strength class (compressive strength [f'c] in pounds per square inch [PSI])	Top 20% Limit	Top 40% Limit	Better Than Average Limit
~~≤2499~~	~~228~~	~~261~~	277
~~3000~~	~~257~~	~~291~~	318
~~4000~~	~~284~~	~~326~~	352
~~5000~~	~~305~~	~~357~~	382
~~6000~~	~~319~~	~~374~~	407
~~≥7200~~	~~321~~	~~362~~	402

Add 30% to these numbers for GWP limits where high early strength[1] concrete mixes are required for technical reasons.

Strengthened from middle-of-the road to "substantially lower" levels of embodied GHG emissions. Leveraged a broader, updated data set. "Waterfall" approach seeks Best 20% where available.

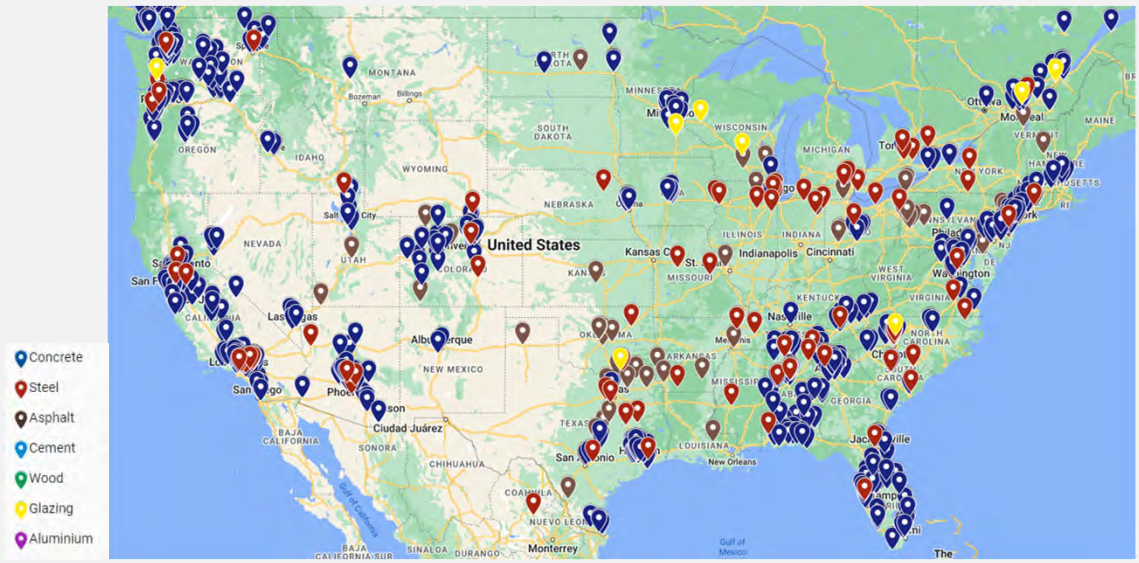
Implementation Update on GSA's Inflation Reduction Act Low Embodied Carbon Appropriations (IRA Section 60503)

- We are piloting our interim IRA-specific requirements over a six-month pilot period.
  - Projects were selected based on their ability to immediately integrate, and benefit from, substantial amounts of the initially-IRA-eligible material types.
  - 11 projects with $1.1 billion estimated total project cost.
    i. Of that, over $400 million is estimated for IRA LEC materials.
  - We will **learn from the pilots, gather data, and continue to coordinate with industry** and other agencies on GSA's post-IRA approach.

- These material-specific standards complement our **whole-building life cycle assessment (WBLCA) performance measure**.
  - It is designed to ensure that we are not only choosing better "like for like" material selections, but also taking a **holistic approach** at design decisions that can use less material, or different types of materials, to achieve the best result on a whole-building life cycle basis.

EPD availability varies by region

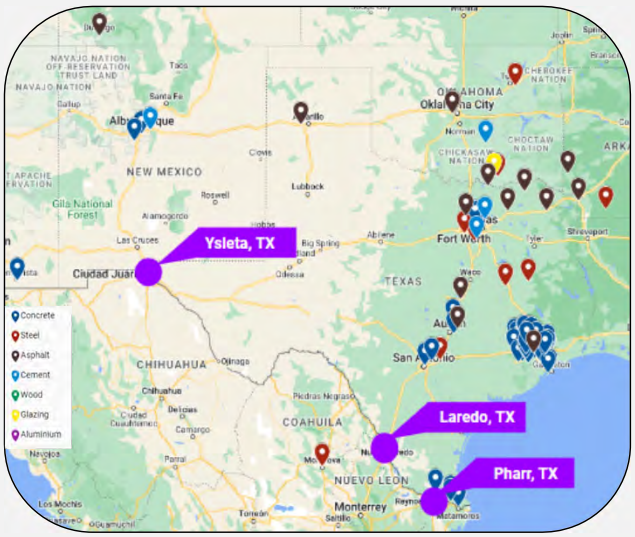
Useful publicly-accessible EPD map -- filtered to show only concrete, asphalt, steel, and glass.



Building Transparency manages the EC3 database of published EPDs, which it uses to power this map.

Challenges in certain regions

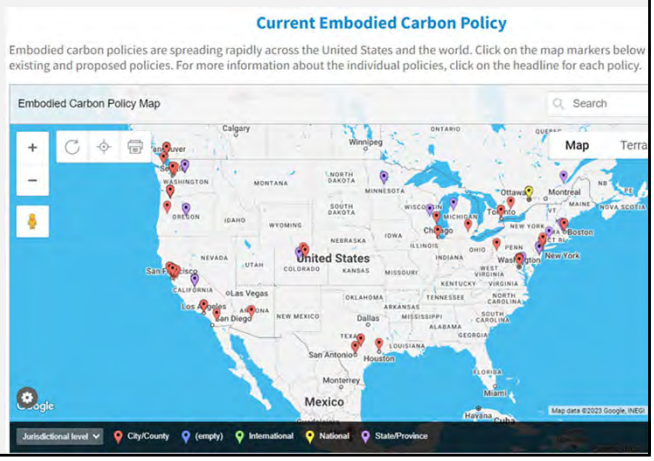
- Limited interest in/availability of LEC materials
- June 23, 2023 Sources Sought
- August 2, 2023 Industry Day
  - Attendees included construction firms, manufacturers/materials suppliers, trade associations, and a consultant
- Strengthening our market research strategy for availability of LEC materials and EPDs.



31

4. The Business Case for EPDs

- **EPDs are at the heart of all state and Federal Buy Clean Initiatives**, and are the key to receiving any low-carbon material appropriations.
  - For example, the Inflation Reduction Act of 2022 (IRA) allocates $2.15 billion to GSA and $2 billion to the U.S. DOT's Federal Highway Administration (FHWA) alone, exclusively for low-carbon concrete, steel, glass, and asphalt with EPDs.
- GSA considers offerors' low-carbon offerings during its **source selection** process to choose a winning bidder.
- **Other public agencies** also consider whether materials have EPDs and low carbon. For example:
  - TxDOT participates in FHWA's Climate Challenge
  - The New York Low Embodied Carbon Concrete Act and New Jersey's low embodied carbon concrete requirements offer bid discounts and tax credits to compliant offerors.



The Business Case for EPDs

- **Market demand for EPDs continues to increase.** For example, projects pursuing **LEED** certification often target "Environmental Product Declarations" points.
  - EPDs are also key for calculating a building's whole-building "embodied carbon" footprint associated with material selections
  - GSA's new construction and major modernizations target a 20% whole-building embodied carbon reduction. (P100 section 1.9.2.9 "Decarbonization")

- The business decision to develop an EPD may yield a competitive advantage.
  - It distinguishes your company's offerings, shows market leadership, can get your products listed in popular EPD databases, and can help increase efficiency.

- **All IRA low-carbon funding received by GSA and FHWA requires an EPD.**
  - There is no waiver process for IRA-funded materials.

How to get an Environmental Product Declaration*

- Climate Earth is one popular tool for generating concrete EPDs. With Climate Earth, it costs about $7,000 and takes about four months to generate initial EPDs.
  - Theta EPD for Concrete and Cement is another new platform for efficiently construction material EPDs.

- Asphalt: Emerald Eco-Label EPD Tool

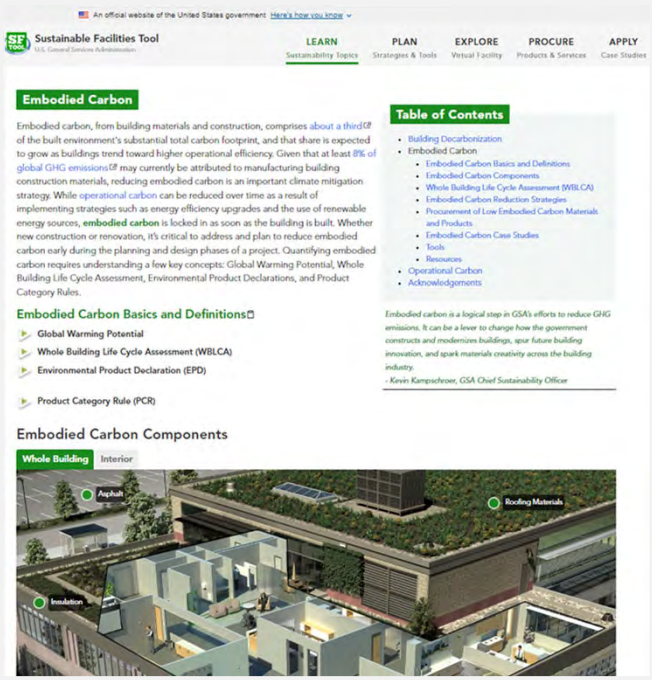
- EPDs get easier, quicker, and cheaper after the first one.
  - Automated links to your existing data help.

- This general "How to get an EPD" overview gives more detail, including on EPD Program Operators.

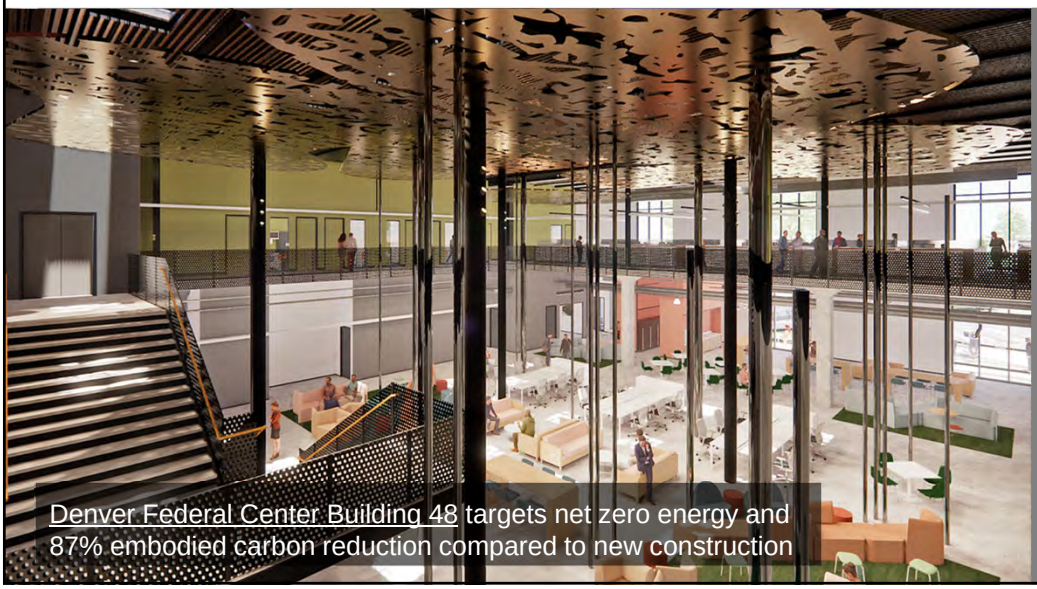
***GSA does *not* endorse these or any other third-party resources.**

Resources & Next Steps

- GSA Sustainable Facilities Tool's decarbonization module and embodied carbon page
- General IRA information: gsa.gov/ira and fhwa.dot.gov/inflation-reduction-act/
- Do market outreach, raise awareness, and learn from GSA's IRA pilot program
- Partner with EPA and CEQ on IRA-covered materials
- Collaborate w/ industry and government partners (e.g. interagency Buy Clean Technical Advisory Group, FHWA, EPA, DOE, FEMA)
- Embodied carbon policy questions? embodiedcarbon@gsa.gov
- GSA IRA Program/ Project Questions? IRAexternalinquiries@gsa.gov



U.S. General Services Administration



Denver Federal Center Building 48 targets net zero energy and 87% embodied carbon reduction compared to new construction

walter.tersch@gsa.gov

Backup: Whole Building Life Cycle Assessment Approach for Large Projects
P100 § 1.9.2.9

GSA's Whole-Building Embodied Carbon Reduction measure requires our new construction and major modernization projects to look at the big picture.

1. **Target a 20% reduction in the project's whole-building embodied carbon from materials,** compared to an equivalent conventional building project, using a GSA-approved estimation tool; and
2. Earn at least one **Building Life-Cycle Impact Reduction** **LEED BD+C: New Construction point**, using *whole-building life-cycle assessment* to conduct cradle-to-grave life-cycle assessment of structure and enclosure.

LEED · tally · One Click LCA · Athena Impact Estimator for Buildings · CARBON SMART MATERIALS PALETTE

Green Building and Climate Policy in the District

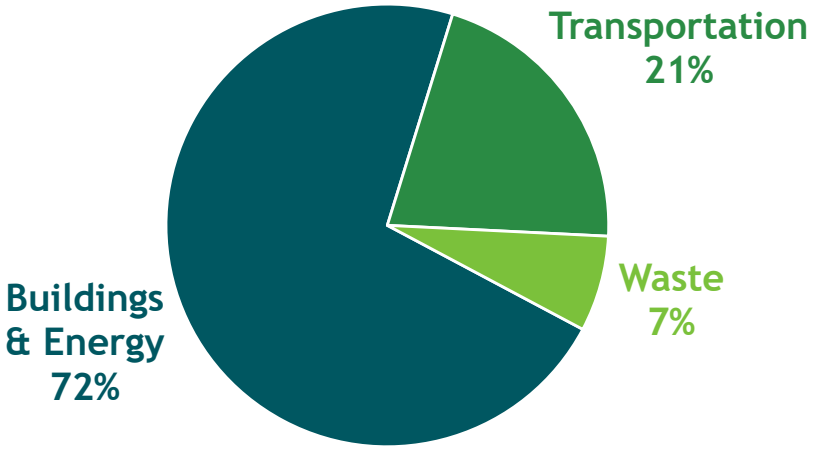
Connor Rattey
Program Analyst, Green Building and Climate Branch
Urban Sustainability Administration
Department of Energy & Environment

Lauren Wingo
Senior Engineer
Arup

DEPARTMENT OF ENERGY & ENVIRONMENT · ARUP

Current Emissions

6.3M tons (2020)



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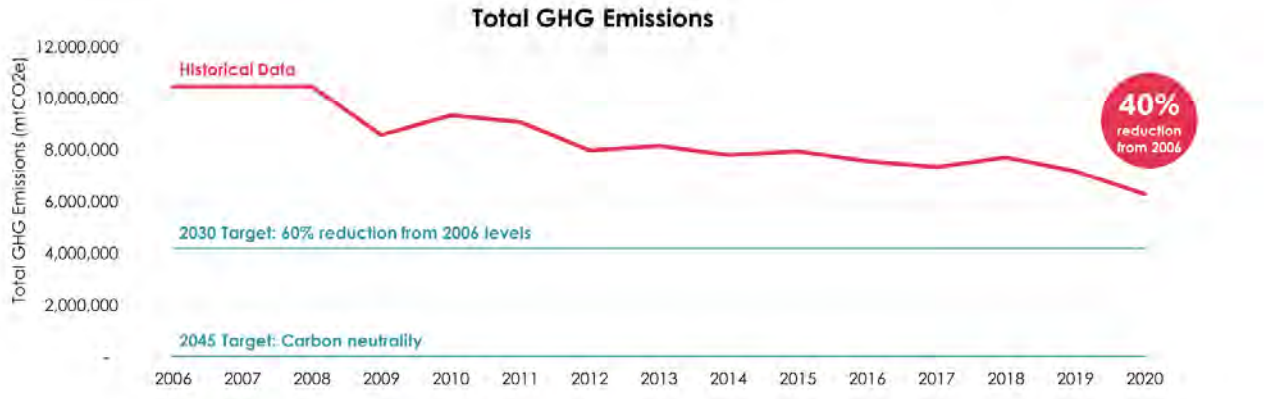
39

Our Progress
Greenhouse Gas (GHG) Emissions

60% reduction in GHG emission **by 2030**
from 2006 levels

Carbon neutrality by 2045



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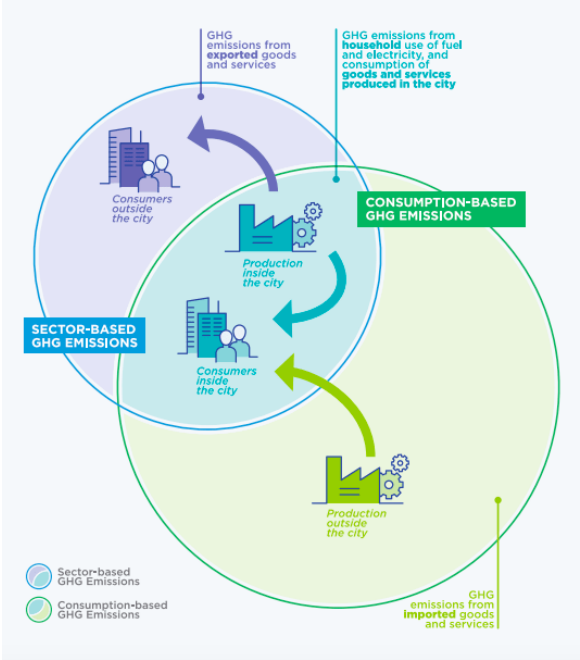
Consumption-Based Emissions



Source: C40 Knowledge Hub

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41

Embodied Carbon – What's next?

- **Consumption-based GHG inventory** – Accounting for scope 3 emissions
- **Clean Energy DC 2.0** – DC's climate and energy action plan
- **Carbon Free DC** – DC's roadmap to carbon neutrality by 2045
- **Green Food Purchasing Act** – DC's first consumption-based GHG reduction targets (25% by 2030 for food purchased by District government)
- **Environmentally Preferrable Products & Services** – DC's program for sustainable government procurement
- **DCPS Embodied Carbon Pilot** – Disclosure requirement incorporated into RFPs
- **Green Building Innovation Grants** – Incentives to support research, implementation, education, and engagement
- **Green Building Advisory Council** – Collaboration with private-sector peers

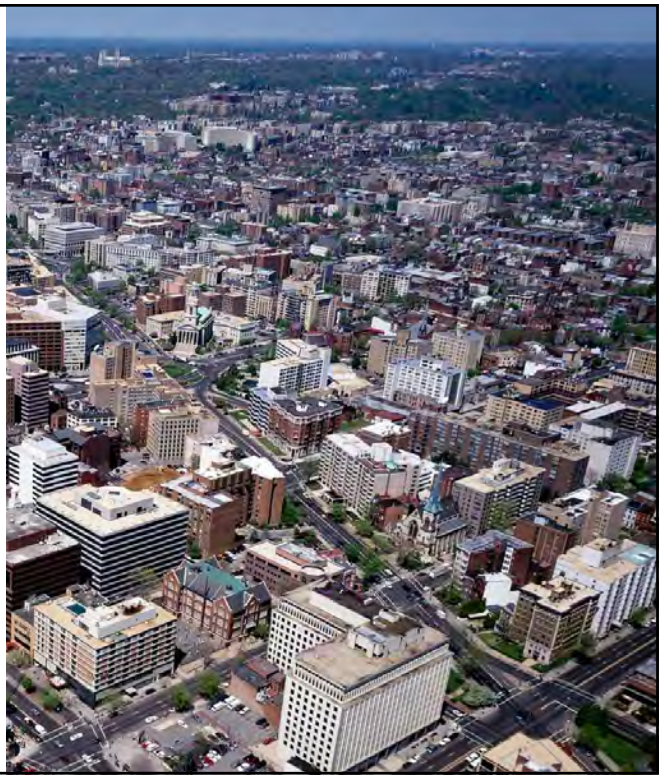
DEPARTMENT OF ENERGY & ENVIRONMENT | GOVERNMENT OF THE DISTRICT OF COLUMBIA MURIEL BOWSER, MAYOR

42

DC Green Building Advisory Council
Embodied Carbon Policy Recommendation

September 8, 2023

The Green Building Advisory Council (GBAC) monitors the District's compliance with relevant green building requirements and makes recommendations on green building policies. The GBAC is comprised of representatives from District government agencies and volunteer (unpaid) representatives from the private and non-profit sectors who live or work in the District.



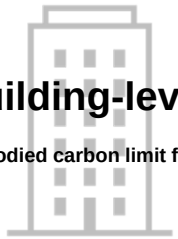
Embodied Carbon Policies

Global context

Local and national embodied carbon policies are rapidly emerging

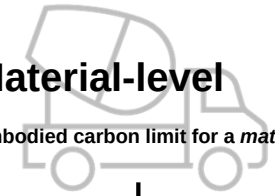
Embodied Carbon Policies

Policy approaches



Building-level

Embodied carbon limit for a *building*



Material-level

Embodied carbon limit for a *material*

- Building code policies
- “Buy Clean” policies

Embodied Carbon Policies

Material-level approach

Building Code

Applies to **new construction** buildings over a certain size

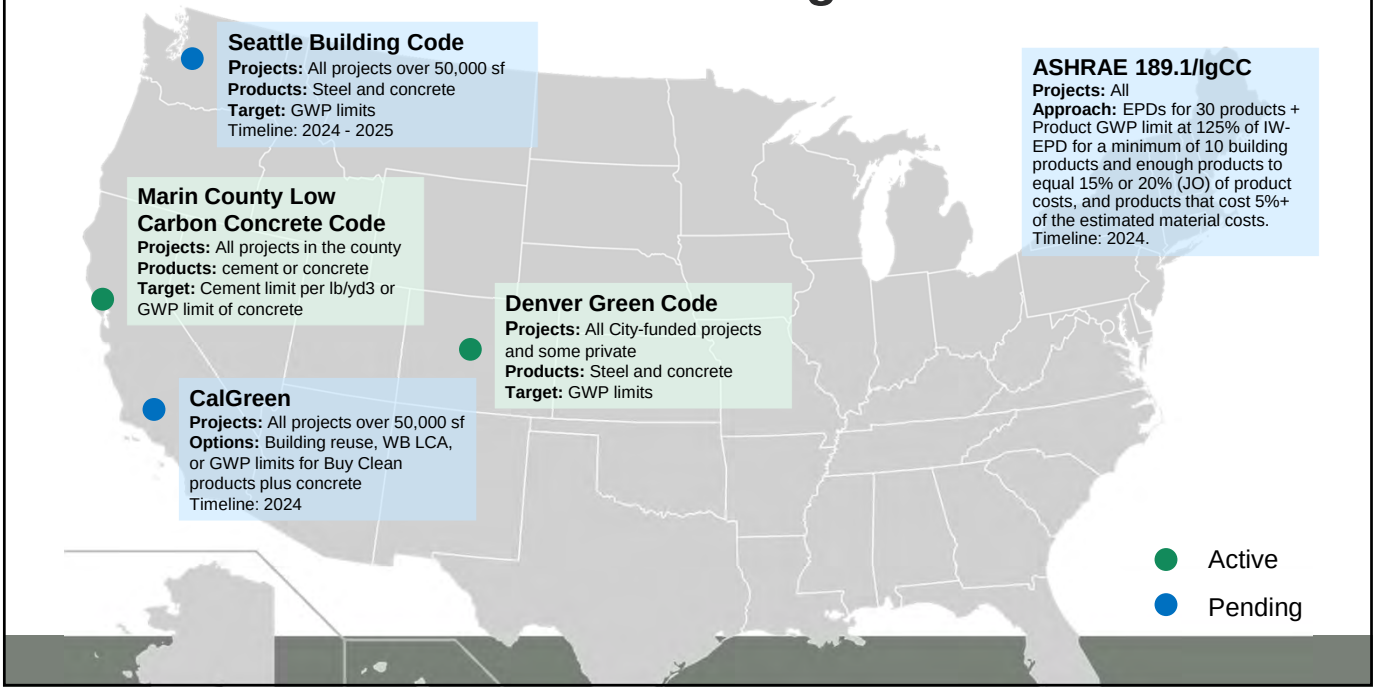
Incorporates **global warming potential limits** for construction materials into the building code

"Buy Clean"

Applies to **public procurement** of construction materials

Directs an agency to establish **global warming potential limits** for construction materials

Embodied Carbon in US **Building Codes**



Embodied Carbon in US **Buy Clean Policies**

Embodied Carbon Policies

DC context

DC green building requirements include voluntary clauses for environmental product declaration (EPD) collection, which many projects already pursue.

These clauses are for transparent reporting using EPDs but do not include any global warming potential limits.

GBAC Policy Recommendations

Priority 1: Building Code

Amend the DC Building Code to include global warming potential limits for high impact materials

Goal: To reduce the upfront carbon emissions associated with building construction in support of DC's climate goals.

Priority 2: Buy Clean

Establish an interim standard for DC-funded capital projects to procure low carbon materials

Goal: For DC government to demonstrate market leadership in procuring low carbon materials

Proposed Phase I covered materials: concrete, structural steel
Proposed Phase II covered materials: asphalt, glass, insulation, aluminum

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Low-Carbon Concrete Case Study
Metropolitan Park
17xM
Photo by Lucas Photography
Photo courtesy Skanska

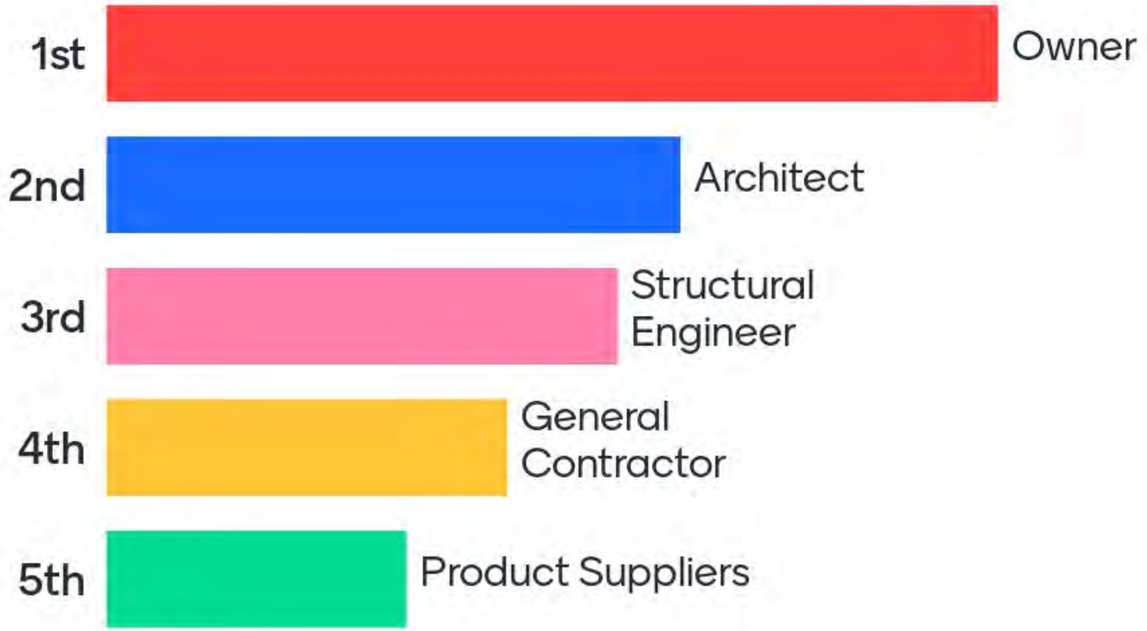
Feedback Session

Challenges and Opportunities in the Washington, DC Market

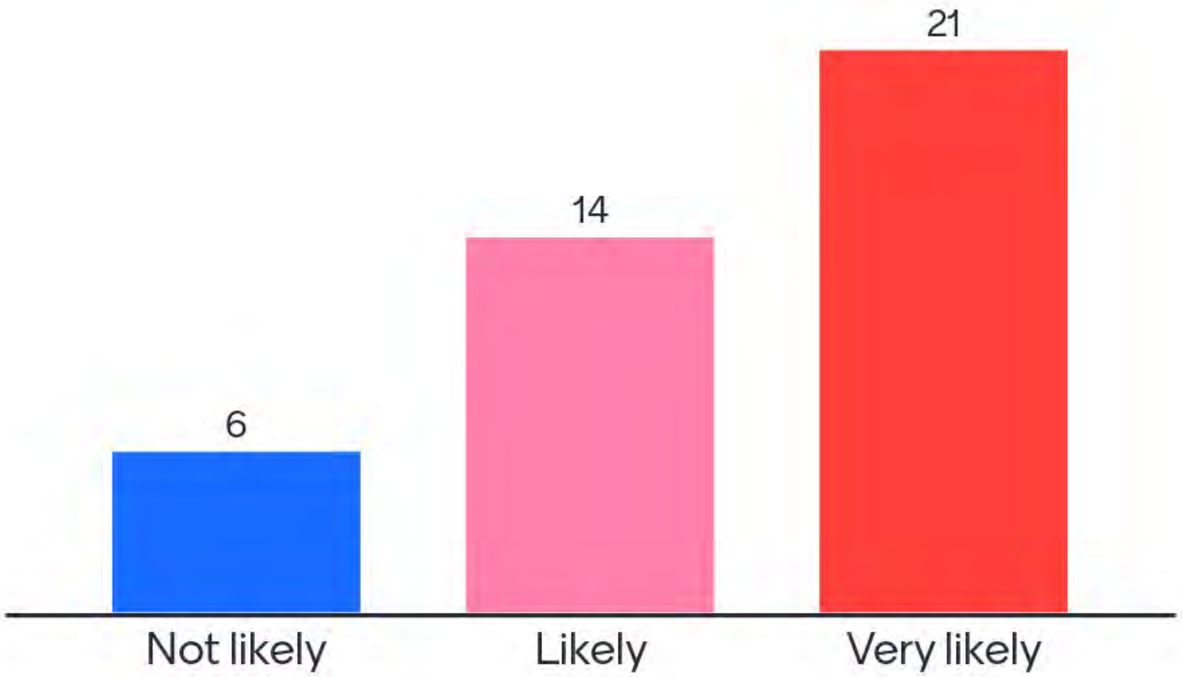
Instructions

General

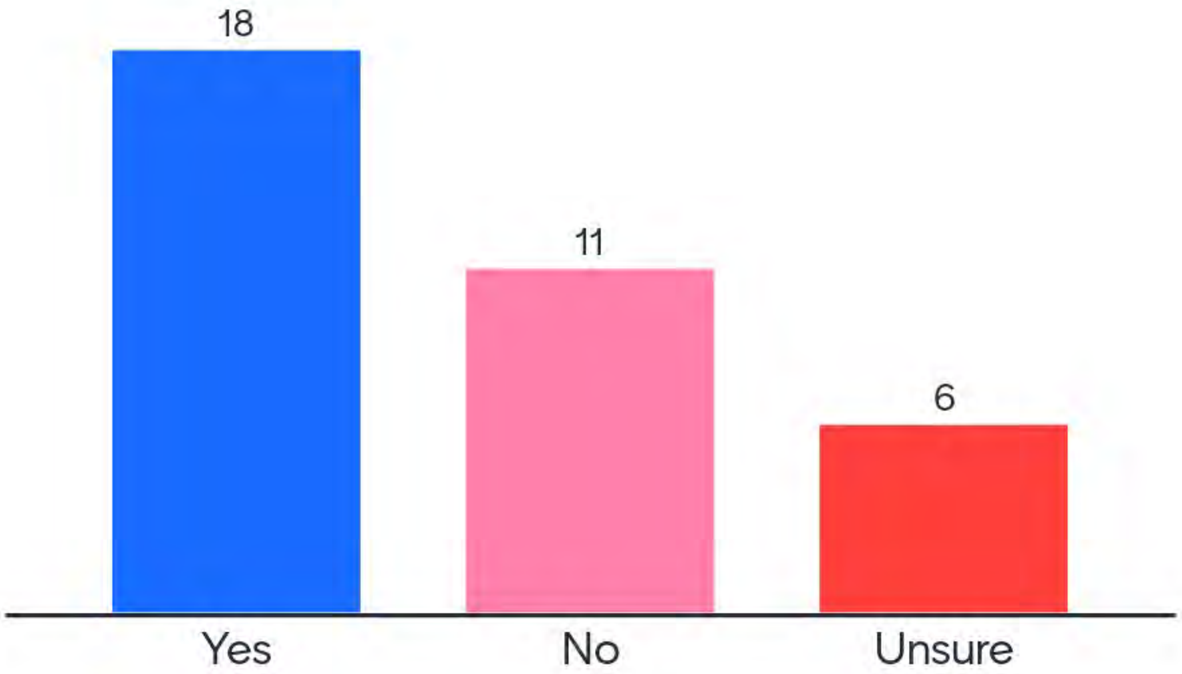
Who has the most responsibility to ensure a project meets its embodied carbon goals?



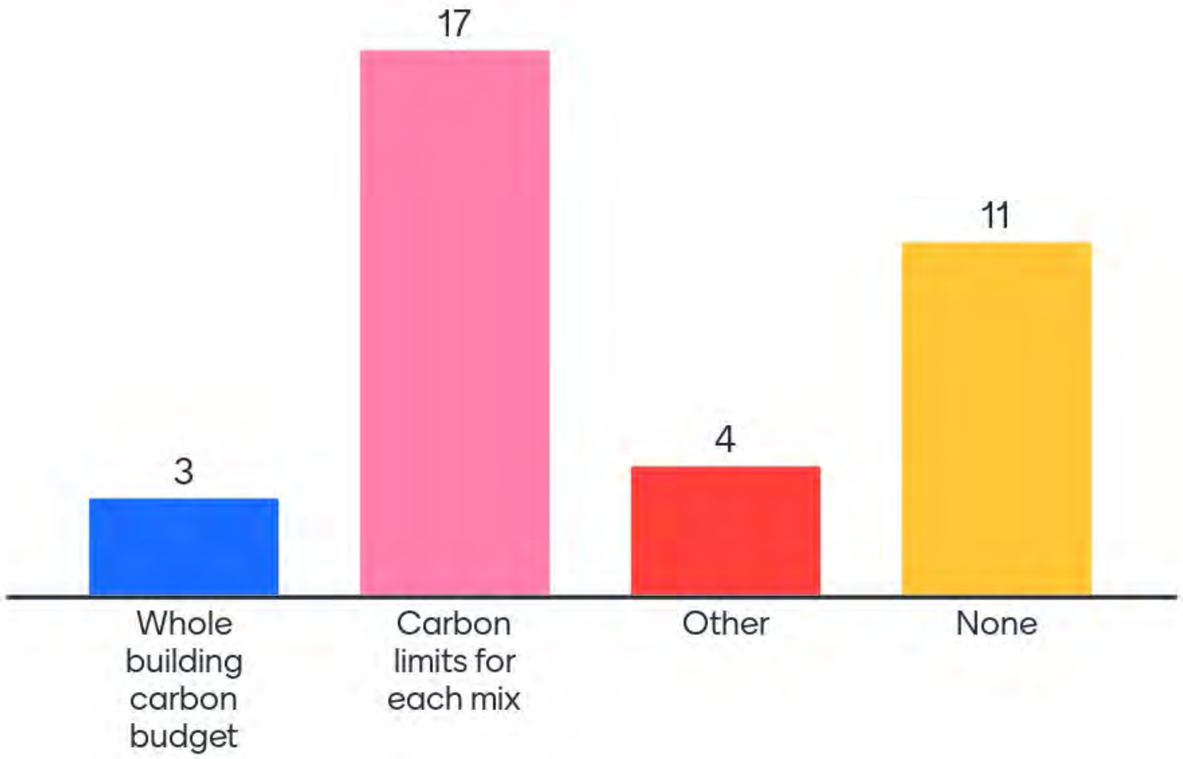
How likely are you to ask for or be asked for low-carbon concrete on your next project?



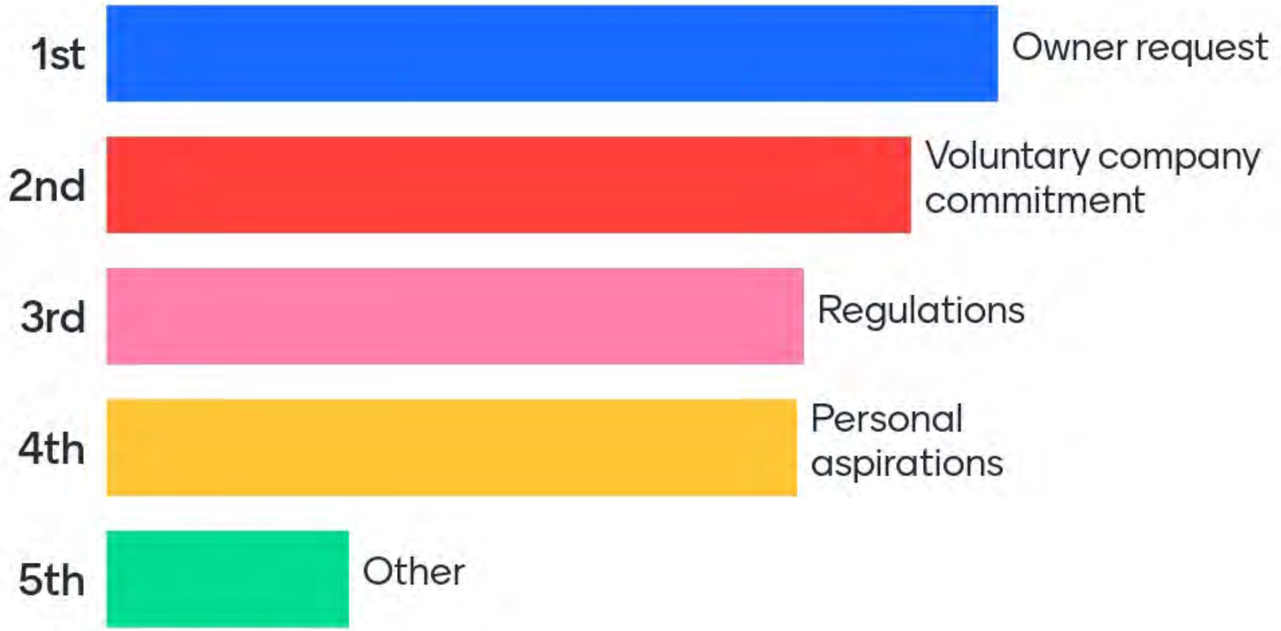
On your most recent project, were prescriptive specifications used?



On your most recent project, what method did you use to reduce carbon footprint of concrete?



What is your primary motivation for using low-carbon concrete on your next project?



What is the biggest/most frequent constraint preventing you from reducing embodied carbon on your projects?

29 Responses

Cost	Workability requirements	Prescriptive specs
Low breaks in concrete, schedule	Material availability	Project Budget
Resistance to change(by everyone)	Lack of knowledge of design community	Project team buy in

What is the biggest/most frequent constraint preventing you from reducing embodied carbon on your projects?

29 Responses

Minimizing cost

Lack of knowledge

CostCan only go so low

The idea that reducing embodied carbon is voluntary, it's a "nice to have" if we have time

Cost

Culture

Cost

Prescriptive specs (min cement, SCM, too high air.....)bad testing

Cost

What is the biggest/most frequent constraint preventing you from reducing embodied carbon on your projects?

29 Responses

Cost

Perceived cost / risk

Project team

SCM product availability

Prescriptive specifications

Lack of knowledge on the design / owner level

Cost

Don't annoy the client.

Ambivalence

What is the biggest/most frequent constraint preventing you from reducing embodied carbon on your projects?

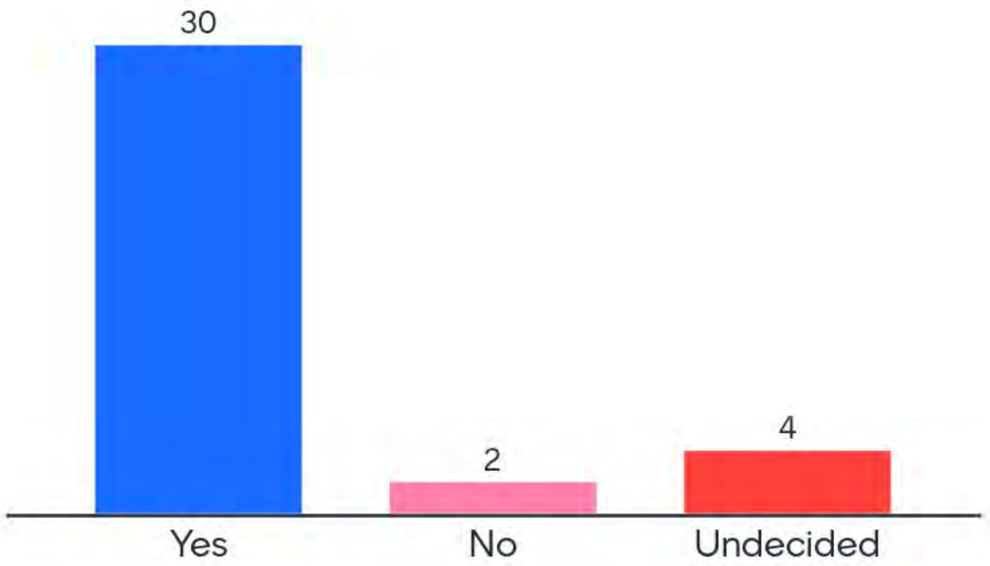
29 Responses

The idea that reducing embodied carbon is voluntary

CLT/Heavy Timber

Policy

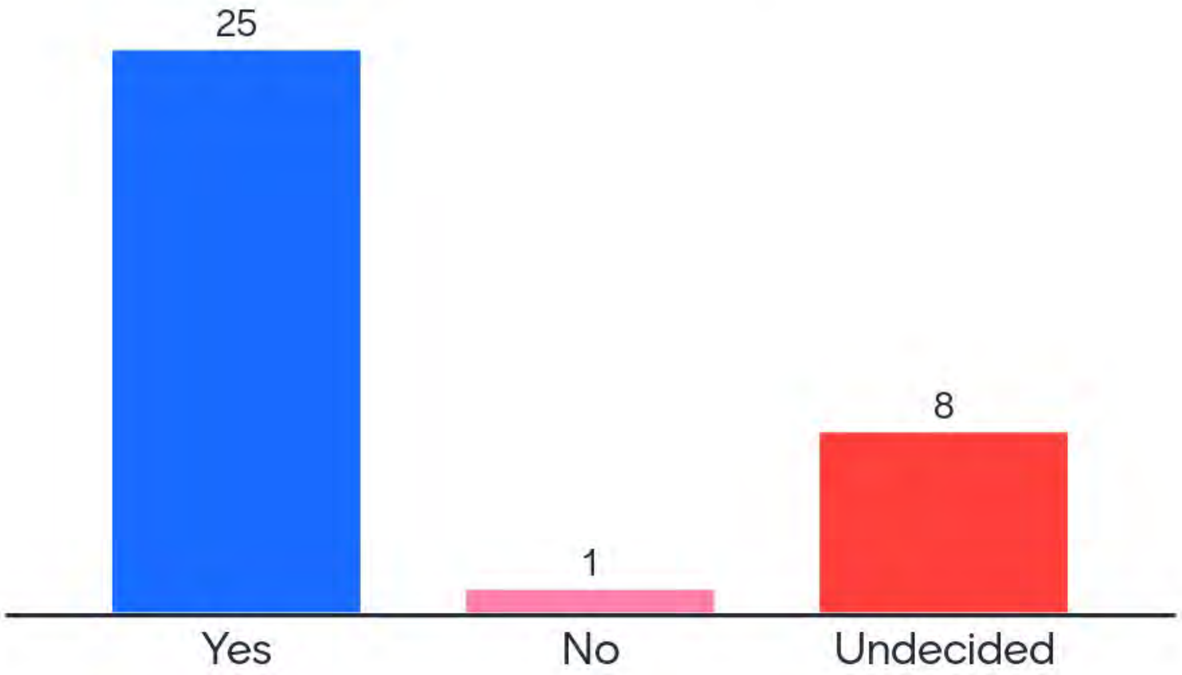
Are government regulation and/or building codes an effective way of ensuring low carbon projects?



Which products/materials should be included in low-carbon building codes or regulations?

57 Responses

Should building codes, rating systems and regulations include cradle-to-grave impacts?



Resource Needs

What resources would help you with setting or pursuing embodied carbon targets?

21 Responses

Example spec language

Model specs

Cost knowledge/ transparency

The new NRMCA carbon budget calculator!

Further education

Program it into the structural analysis software

Guidance specs

Reliable data

sample specs

What resources would help you with setting or pursuing embodied carbon targets?

21 Responses

Targets

More data

Clear, consistent guidelines and uniform regulations.

Sample specifications

Updated material GWP benchmarks

Further education

Facilitayed communication between local producers, designers, and regulators

Flexibility from owner/engineer

Info to persuade owners to consider it

What resources would help you with setting or pursuing embodied carbon targets?

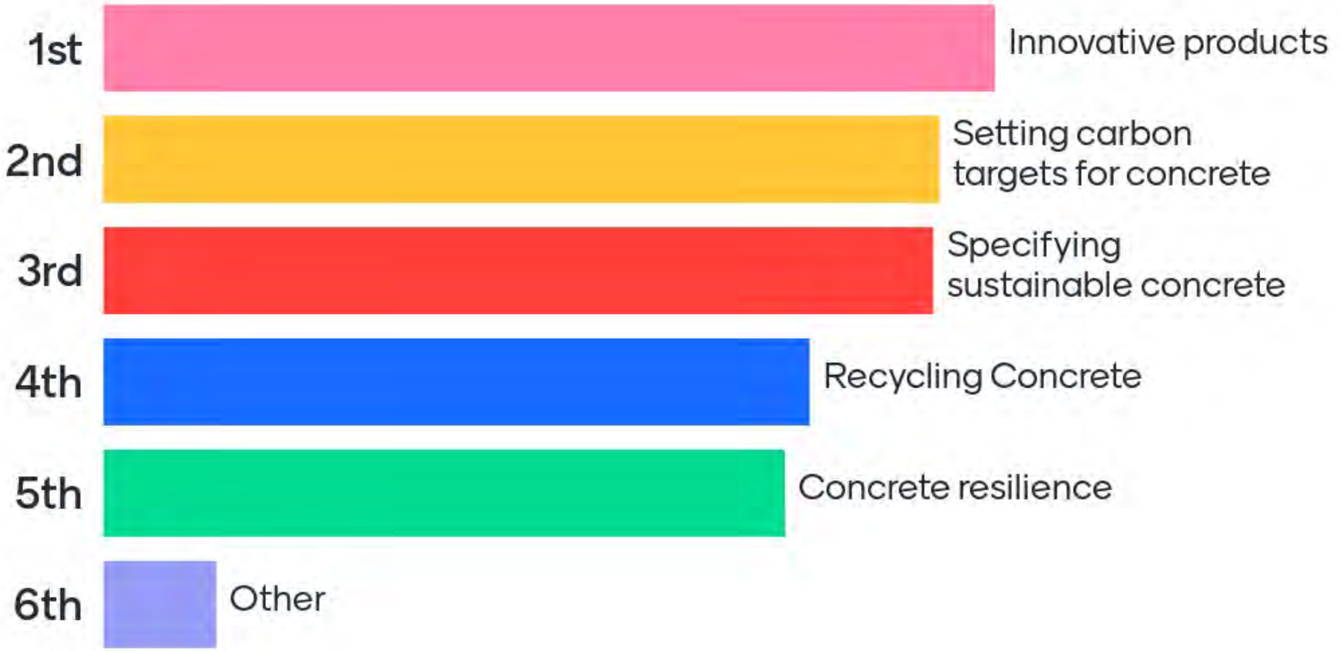
21 Responses

Addtl carbon budget calculators

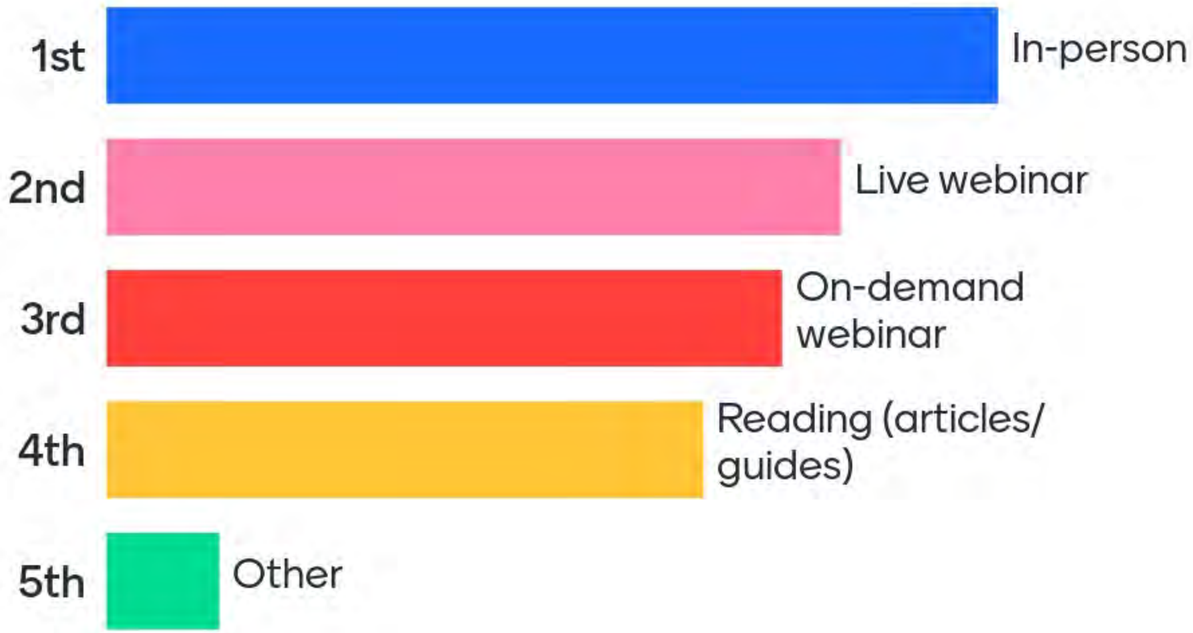
Clear standards for setting targets

ASTM of new productsEducation for GC & SubsClear specifications

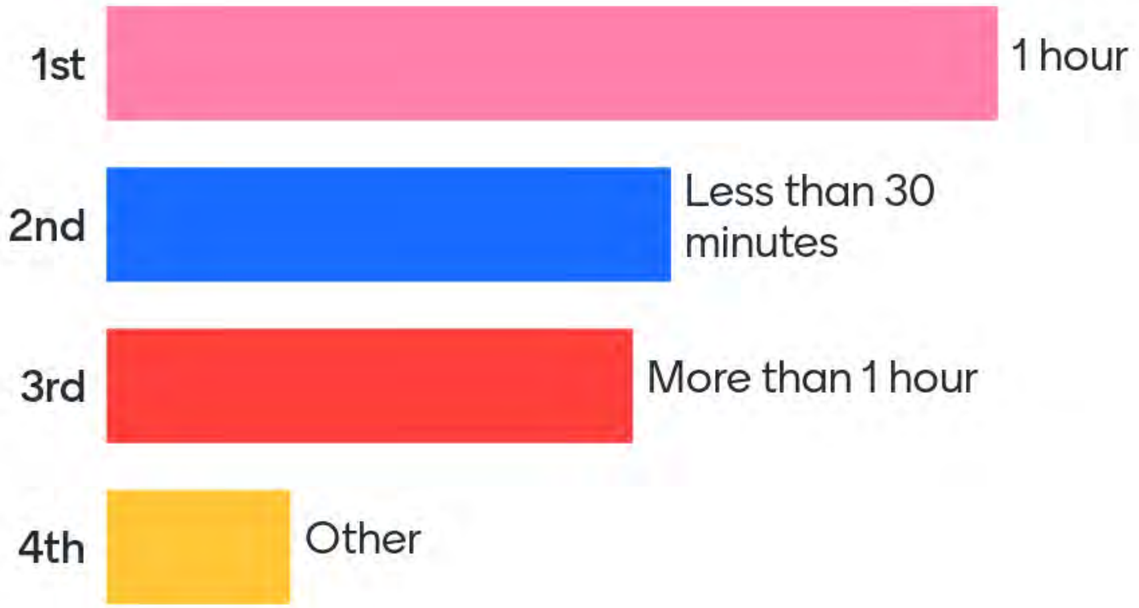
What topics would you like to learn about in the future?



Rank your preferred delivery method for education:



What is your preferred length for education programs?



Thank you!

- Next Steps
- www.nrmca.org/sustainability
- www.cement.org/sustainability
- Certificate of Completion