Concrete & Sustainability

Embodied Carbon Issues and Opportunities

WACA Winter Workshop
January 30, 2025

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Carbon and Concrete
Key Terms and Issues

Carbon & Concrete
Key Terms

What's Carbon:

"Carbon" = Greenhouse Gases

- **Carbon Dioxide (CO_2)** 1 x CO2
  Fossil Fuel Combustion
  (Coal, Natural Gas, Gasoline, Diesel…)
  Natural Sources

- **Other Greenhouse Gases:**
  - **Methane (CH_4)** 25 x CO2
    Landfills
    Agriculture
    Natural Gas Systems
  - **Nitrous Oxides (N_2O)** 300 x CO2
    Car Emissions, Manufacturing
    Soils Management
  - **Hydrofluorocarbons (HFCs** 1,000+ x CO2
    Refrigerants, Manufacturing
  - **Perfluorocarbons (PFCs)** 10,000+ x CO2
    Aluminum Production

Two Categories of Carbon:

Operational Carbon

Emissions from:

- **Energy Use from building operations**
- **Water Use from building operations**

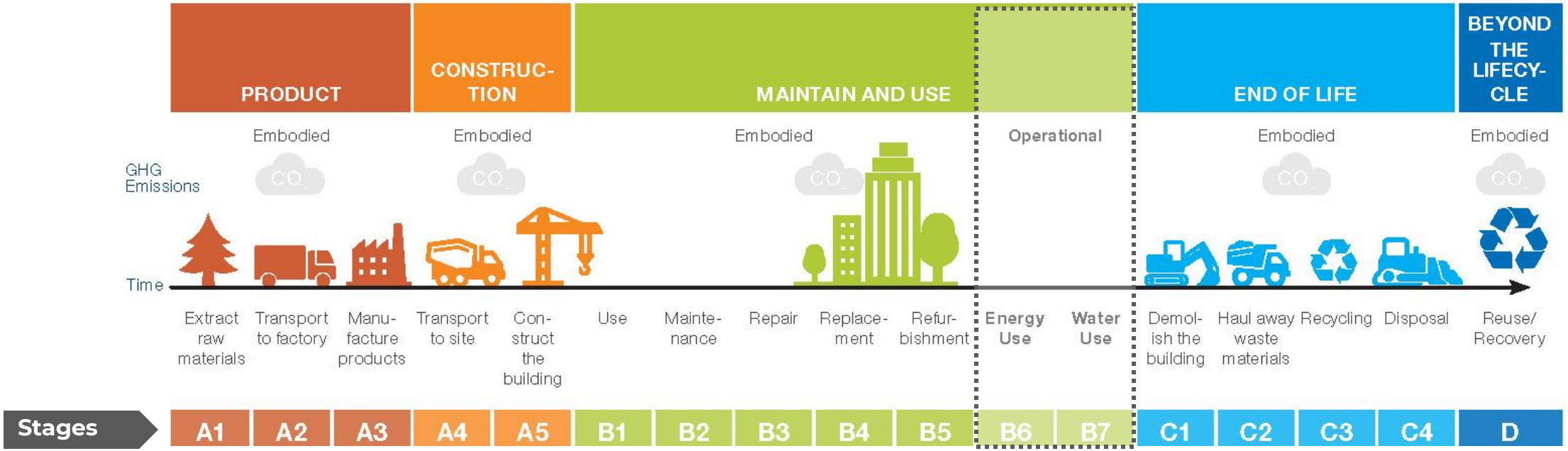
Embodied Carbon

Emissions from:

- **Material Extraction**
- **Manufacturing**
- **Transport to Job Site**
- **Construction Activity**
- **Renovation Activity**
- **Demolition**
- **Disposal**

Carbon & Concrete
Key Terms

When Emitted – The Life Cycle Stages A through D



Graphic: New Building Institute

Carbon & Concrete
Key Terms

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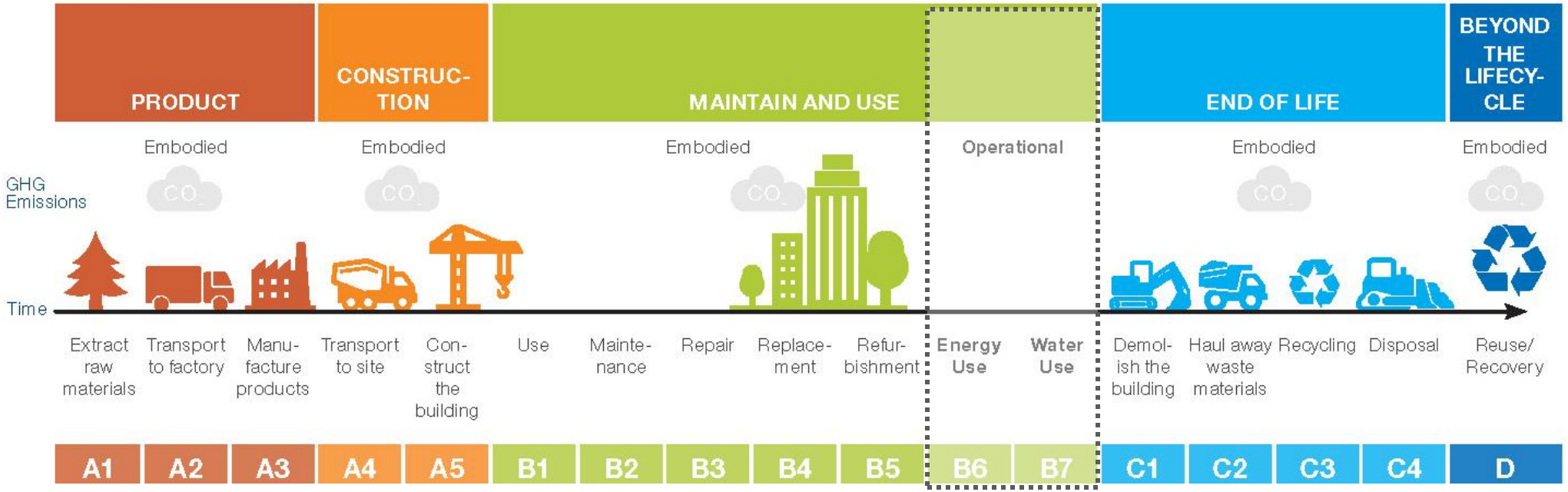

Manufacturing

"Cradle to Gate" (i.e., most EPDs)

Graphic: New Building Institute

Carbon & Concrete
Key Terms

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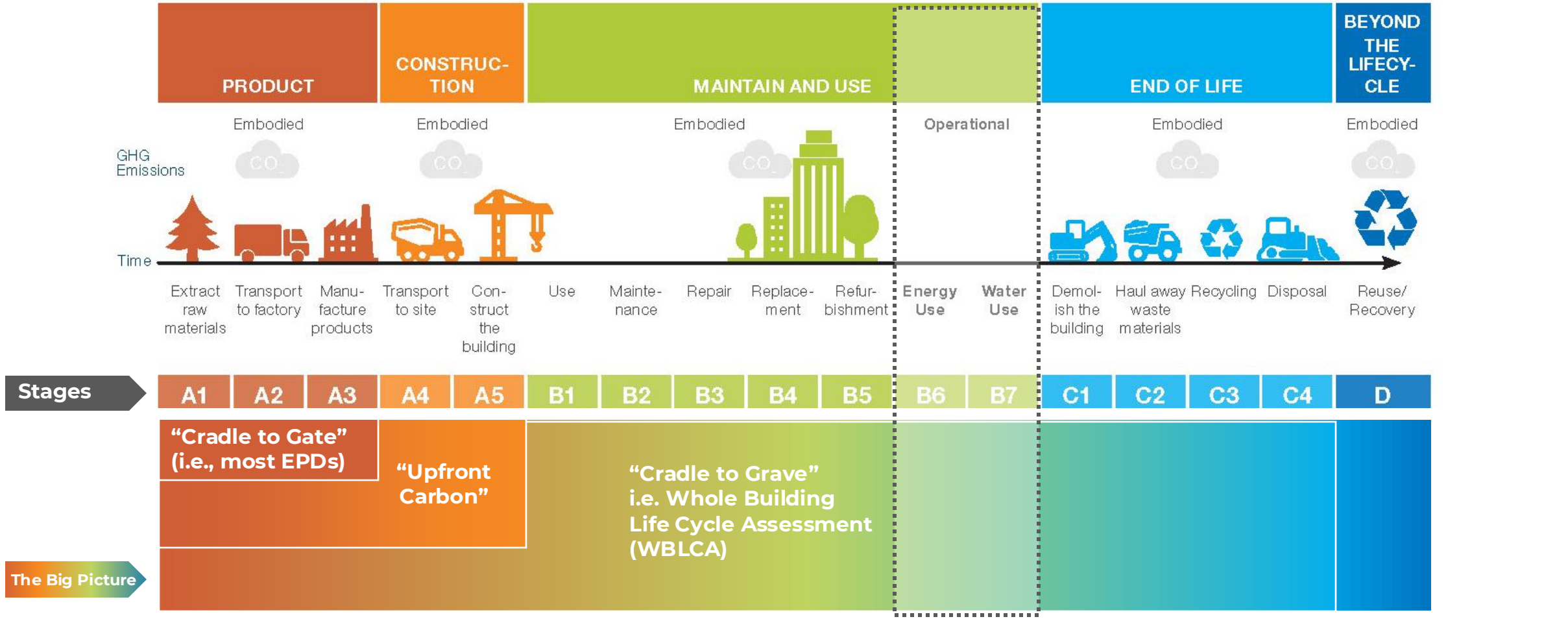
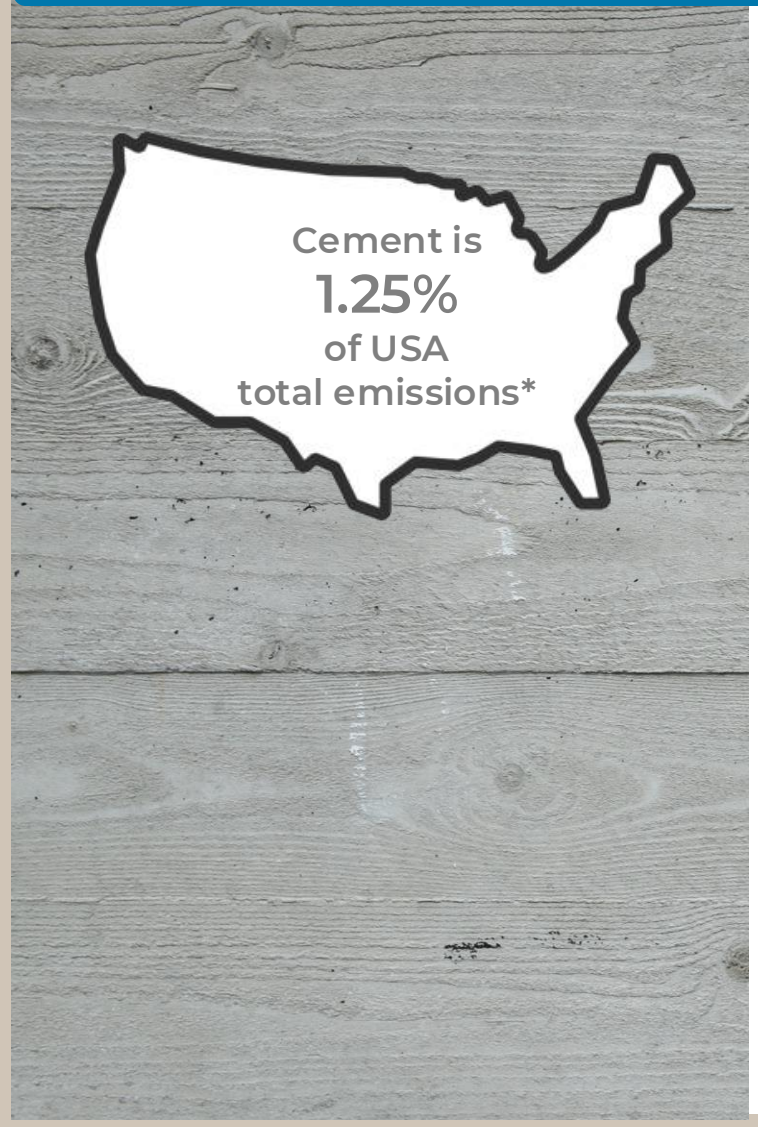
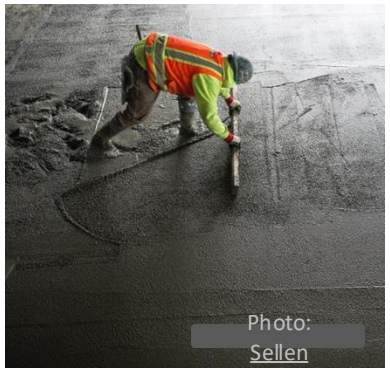


Graphic: New Building Institute

Cement's Impact on Concrete Emissions



Concrete



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Cement

+

Gravel, Sand, Water, SCMs like Fly Ash or Slag and Chemical Admixtures

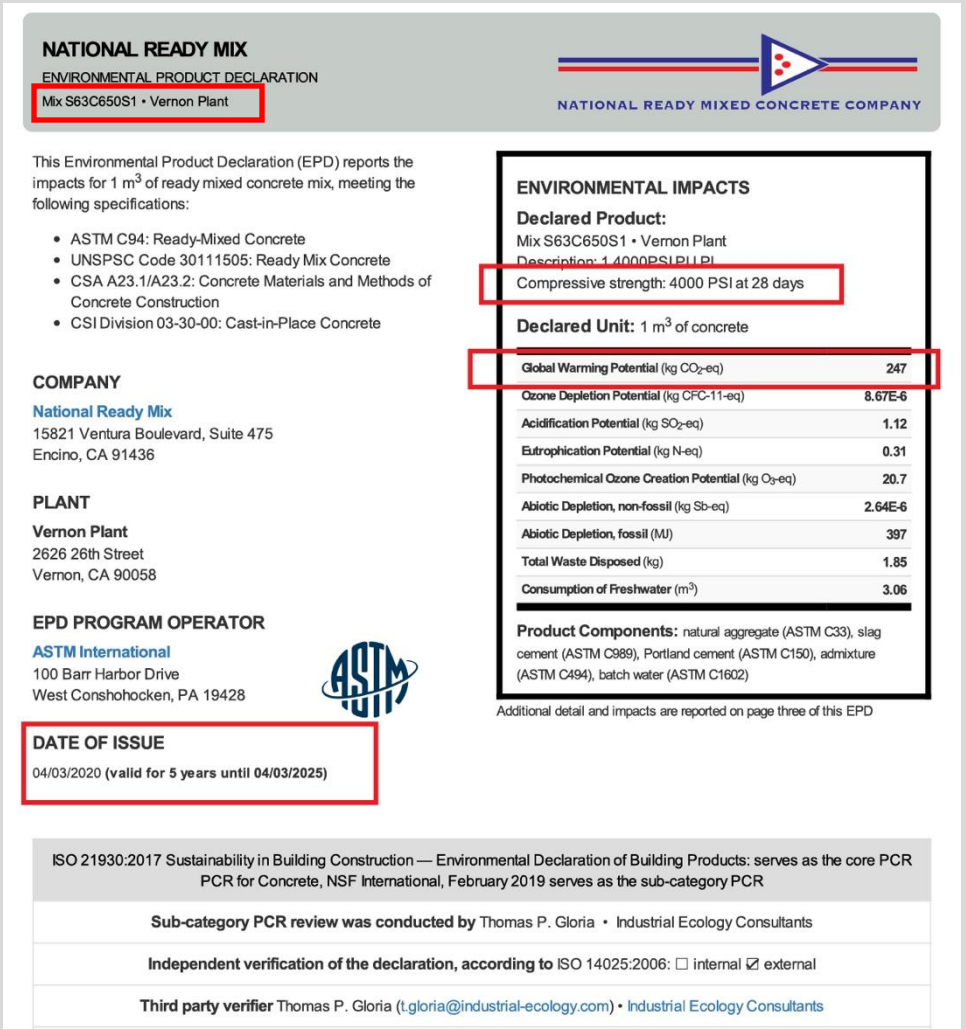
Cement is up to
90%
of all GHG emissions
in a conventional concrete mix

Disclosing Emissions: EPDs

Environmental Product Declarations (EPDs):
a "food label" for building materials

Terms:

- **EPD: Environmental Product Declaration**
- **Product and Plant Specific EPD:** Specific to a Mix and the batch plant
- **Type III EPD:** Verified through Life Cycle Analysis and by a Third Party
- **GWP :** Global Warming Potential -- the emissions in kg in CO2 equivalents

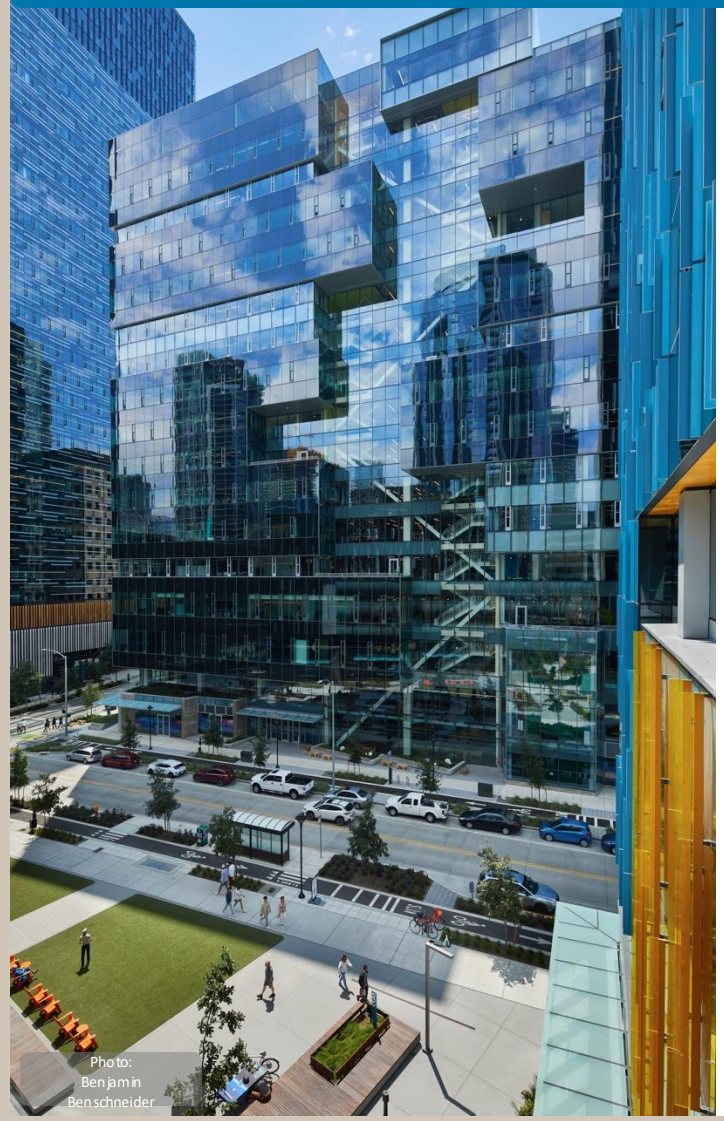


Owners & Designers

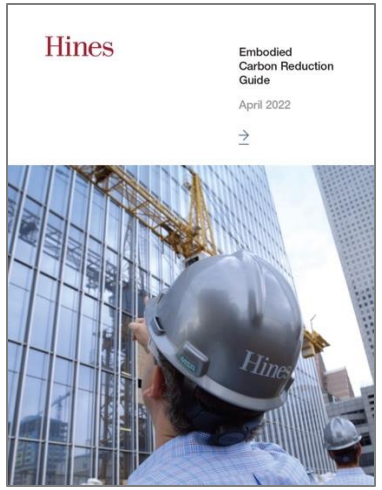
Moving from Pledges to Required Reductions

Owners
Private Projects, Public Commitments

Companies Investing in Carbon Reductions



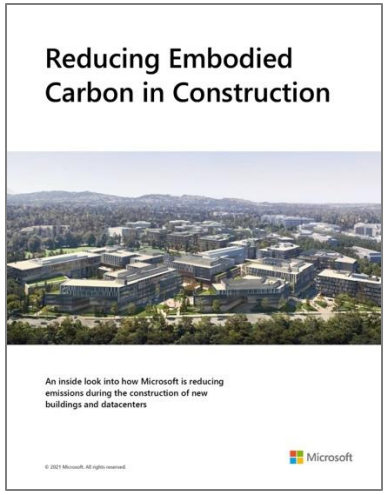
- **Corporate Pledges** for Net Zero Carbon and Total Offsetting of historical emissions
- **Responding to Investors'** Demands
- **Authoring Guidance** on Carbon Reductions
- **Responding to Employee Demands** and Customer Values
- **Reduction Required in some:**
  - Data Centers
  - Corporate Office
  - Higher Education
  - Healthcare
  - Sports Training Facilities



THE CLIMATE PLEDGE

First Movers Coalition

materialsCAN
Carbon Action Network



Owners
Public Sector Projects

Required Carbon Tracking and Required Reductions

Photo: Flickr, Atomic Taco, CC BY-SA 2.0


Photo: Benjamin Benschneider

- **Transit Agencies**
  - Emissions Tracking for Mixes
  - Performance Specifications
  - Lower Carbon Mixes
- **Ports:**
  - Port of Seattle Century Agenda
  - Concourse C Expansion at SeaTac
- **State of Washington Projects**
  - Helen Sommers Building
  - Newhouse Building Renovation
- **In-progress Federal Projects funded by the Inflation Reduction Act (IRA)**

Locations of Federal Projects requiring Lower Carbon Materials


Image: Port of Seattle

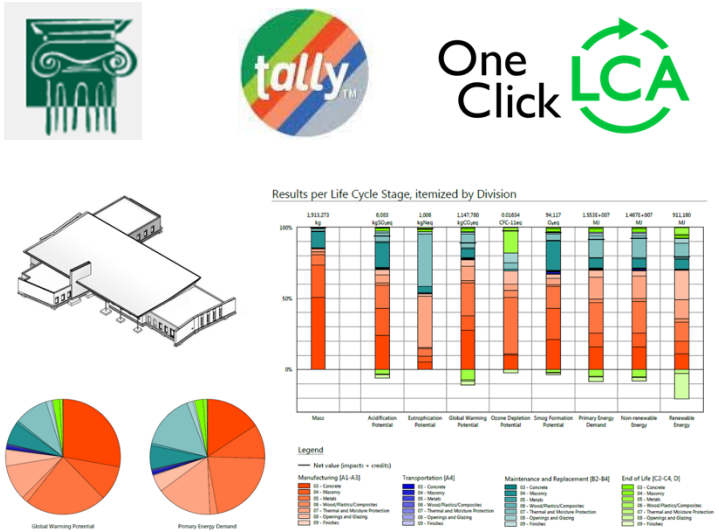
Designers
Design Strategies to Reduce Carbon

Selection of Material-Efficient Design / Efficient Load Paths

- **Reducing Concrete Volumes** saves money and carbon
- **The lightest structure possible** that meets the project needs
- **Reducing spans** where possible
- **Efficiency core design,** stacking columns

Model Carbon Emissions over Building's Lifetime

- **Test the carbon impact** of early massing alternatives and different structural options
- **Model the Lifetime Carbon Emissions and Carbon Update** with Life Cycle Assessment (LCA) Software



Allow in the Specs: Blended Cements Extended Maturity Dates, SCMs

- **Performance Specifications** instead of prescriptive cement and SCM amounts
- **Allow Multiple Types of Blended Cements**
  - **1L (PLC)**
  - **1S, 1P, or 1T**
- **Allow Multiple Types of SCMs**
- **Consider Allowing Recycled Aggregate (RCA)**
- **Don't Specify a fixed w/cm Value** – let ACI 318 govern
- **Maturity Dates:** Let the construction team determine what applications can have 56 day or longer maturity dates

Designers
How are Carbon Reductions being Specified?

Material-level Reductions -- focused on one material:

Compare a Weighted Average Emissions of all Mixes to an Industry Baseline –
Requires a Percent Reduction of Emissions

- Requirement is expressed a percent reduction **compared to baseline emissions**

  Example: Concrete required to be 30% below the weighted average NRMCA regional baseline

- **Considers just concrete:** a proportionally weighted average is used
- **Measures only "Cradle to Gate" Carbon (Manufacturing)**

  A1 A2 A3

- **Straightforward to specify**
- **Allows procurement flexibility** for contractor, but needs tracking throughout construction

Building Level Reductions – considers multiple materials:

Compares the Emissions of a "Whole Building" Design to a Reference Building –
Requires a Percent Reduction of Emissions

- Requirement is expressed a percent reduction **compared to reference building**

  Example: Building Design requires a 10% emissions reduction from to a Reference Building

- **Considers materials in multiple assemblies** in a building (structure, enclosure etc.)
- **Measures "Cradle to Grave" carbon (Entire Project Life)**

  A1 A2 A3 A4 A5 B1 B2 B3 B4 B5 C1 C2 C3 C4

- **Requires Life Cycle Analysis & Software**
- **Allows multiple materials to contribute** in the project's carbon savings strategy.

Turning Down the Heat

Supplier Strategies to Reduce Emissions

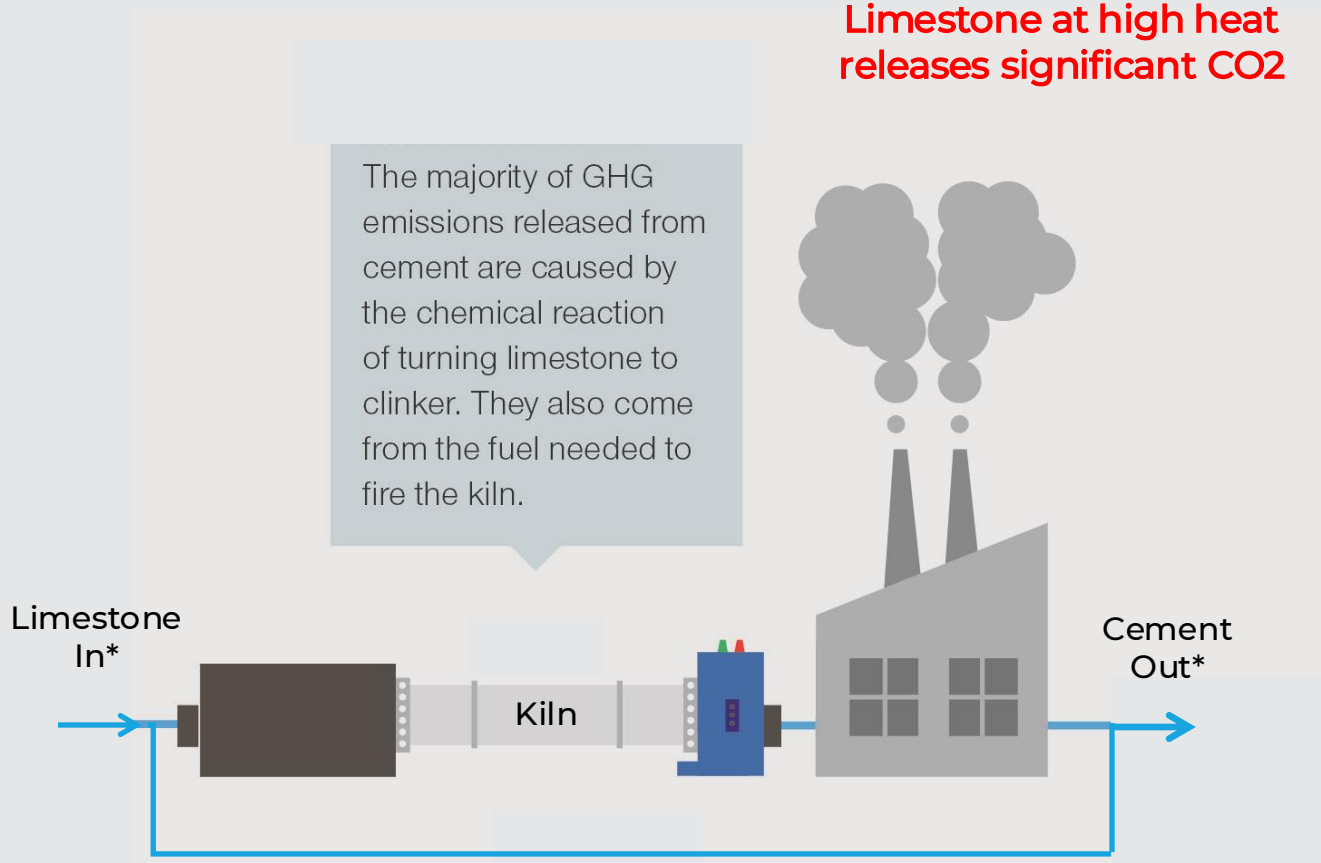
Turning Down the Heat
Solutions Available Today

Blended Cements

- **60% of Ordinary Portland Cement (OPC) Emissions** are from the Calcination Process
- **Calcination is a chemical reaction** when limestone is heated to high temperatures
- **Bypassing the Kiln** avoids emissions from Calcination
- **Portland Limestone Cement (PLC or Type 1L)** reduces emissions by 10% to 15%
- **Other Blended Cements also reduces impacts** compared to OPC

Reducing Process Emissions

Calcination Process: Limestone at high heat releases significant CO2



With Blended Cements about 10% - 15% does not go through kiln and does not have calcination emissions

Image Credit: Sellen

Turning Down the Heat
Solutions Available Today

Replacing OPC with Supplementary Cementitious Materials

- **Replacing Cement** with Supplementary Materials reduces emissions
- **Some SCMs may have co-benefits:**
  - Slag: lighter appearance
  - Fly Ash: workability
- **Special Use/Emerging SCMs:**
  - Natural Pozzolans
  - Silica Fume
  - Ground Glass

Working with Team to have Extended Maturity Dates

- **Less Schedules-sensitive Applications** reaching design strength in 56 days or longer:
  - Foundations
  - Slab on grade / mat slabs
  - Topping slabs on metal decks
  - Site Flatwork such as sidewalks
- **Mass Concrete / Controlling Heat of Hydration**

Using Recycled Aggregate

- **Avoiding Emissions from Quarrying**
- **Co-benefit of Avoiding Landfilling Demolished Concrete**
- **Consider Recycled Aggregate for Lower Risk Applications**
  - Flatwork
  - Sidewalks

Turning Down the Heat
Future Solutions

Carbon Capture and Sequestration of Kiln Emissions

- **CCUS = Carbon Capture and Storage** is needed to Reach Net Zero
- **CCUS is the strategy** with the largest potential savings

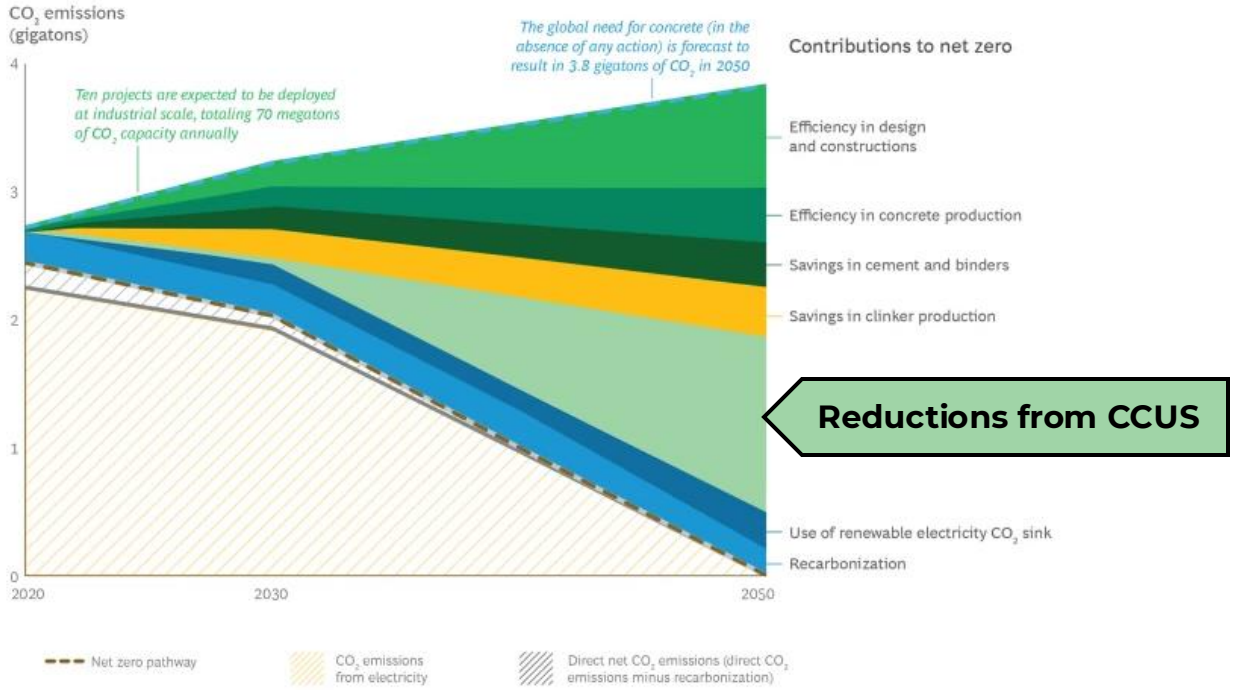
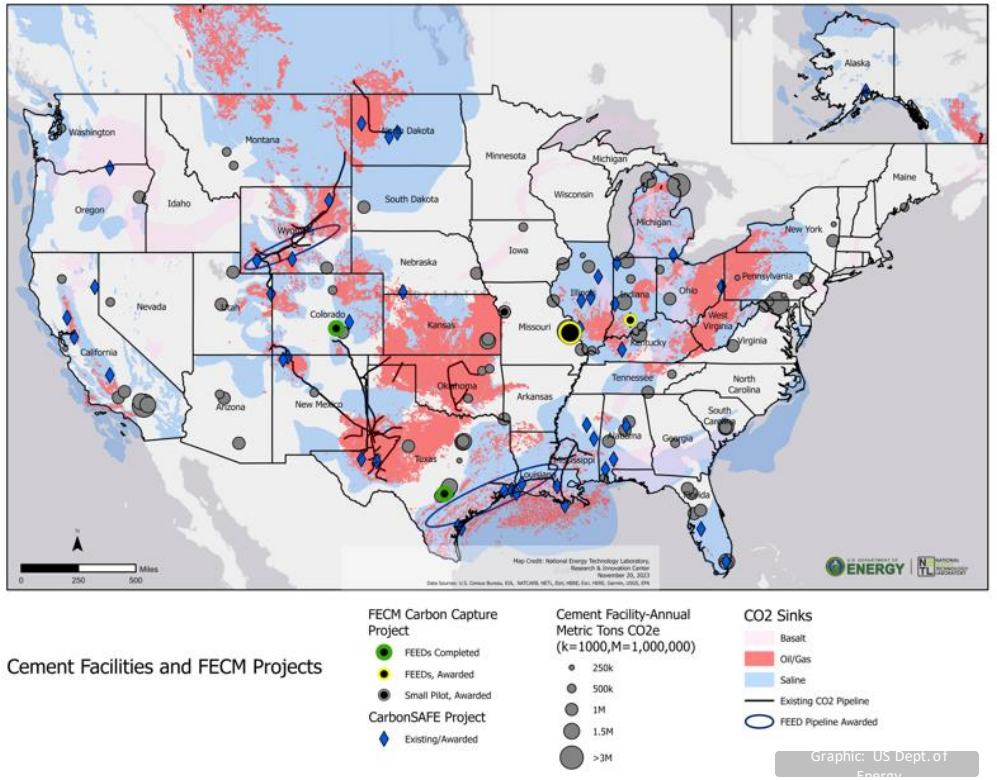


Image: Boston Consulting Group

- **Pilot Projects in Progress** Heidelberg, Holcim, CEMEX
- **Locations of Cement Plants are Fixed; The Availability of CO2 Sinks are Limited by Geology**



Graphic: US Dept. of Energy

Lower Carbon Mixes as a Competitive Advantage for Suppliers

Low Carbon Mixes as a Competitive Advantage
Comparing Impacts

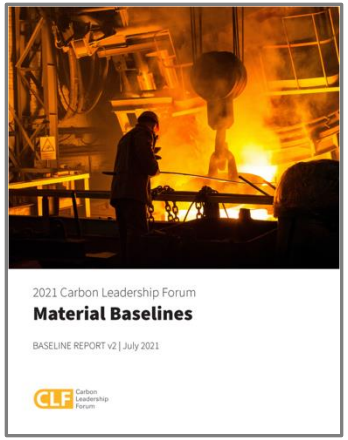
What's meant by "Low" Carbon?

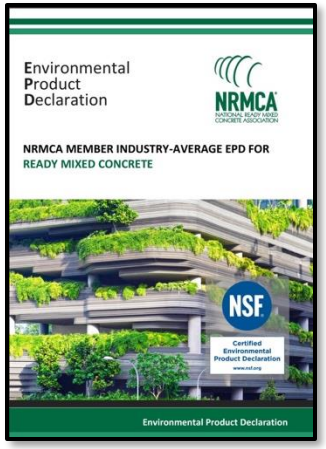
Compares Mix Emissions to:

- **Published Baseline Averages**
  - Carbon Leadership Forum's Publications
- **Regional Averages**
  - NRMCA's Pacific Northwest Data
  - Future Metro-specific data
- **EC3 Database**
  - Allows comparison with "peer" products

Compares the emissions found the mix's EPD, with…

…the emissions of similar products with similar functions found in:



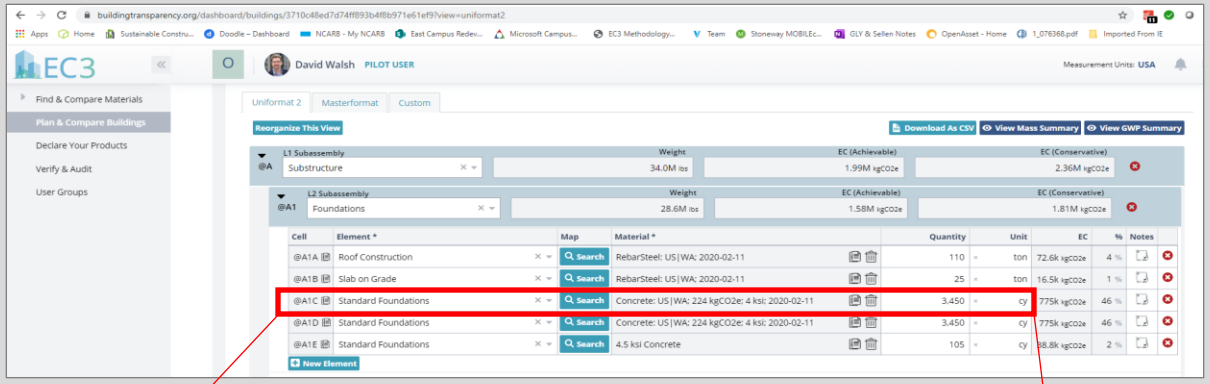


Low Carbon Mixes as a Competitive Advantage
Comparing Impacts

How Designers are Using EC3

- **Often their first stop** in understanding local mixes
- **If your mix is not in EC3,** it may not be visible to designers
- **Compares Mix's Carbon Performance** of to the competition
- **Able to filter** by strength class and by distance radius from project
- **Limitations:** Filtering by strength class doesn't mean all mixes work for all applications

EC3
(Embodied Carbon Calculator in Construction)
Free **Online** Tool



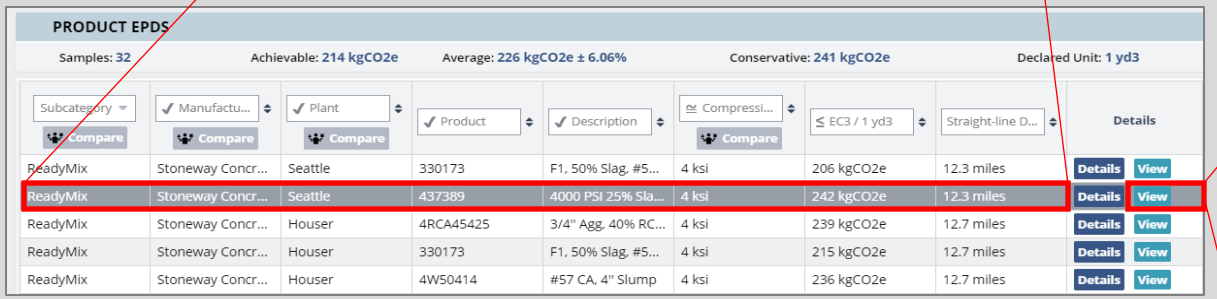
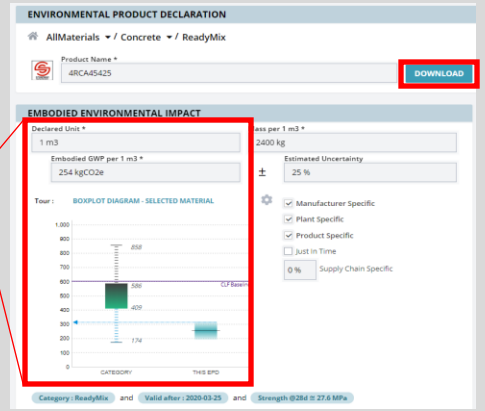


Image: Building Transparency

EC3

https://buildingtransparency.org/



Low Carbon Mixes as a Competitive Advantage
Outreach to Designers

Informing Reduction Targets During Design

Hold an Embodied Carbon Concrete Workshop
- During Preconstruction
- In Design Development before Specs are finalized

Agenda:

- **4-way Conversation:**
  Concrete Supplier, Contractor, Architect & Structural Engineer
- **Criteria Review:**
  the structural design criteria for each application
- **Where's the Opportunity:**
  Discuss relative quantities of each application
- **What's Schedule or Weather Sensitive:**
  Get GC's input on early strength needs for pour cycles and weather/temperature concerns
- **What's Business as Usual:**
  Discuss the business-as-usual emissions for similar strengths and applications
- **Get a Game Plan:**
  Identify applications for priorities for reductions and establish reduction targets

Low Carbon Mixes as a Competitive Advantage

Ability to Participate in Major Projects and/or Leading Edge Projects

Projects with Low Carbon Concrete Specifications & Bid Requirements

- **Model Specification Language** for Lower Carbon Concrete from Carbon Leadership Forum
- **Bid Packages Require EPDs** at time of bidding
- **Selection of Successful Bids** considering Lower Carbon Mixes
- **Tech Firms Researching** low carbon protypes & GWP targets

Microsoft Campus Expansion Project

Projects with Funding Requirements tied to Lower Carbon Materials

- **GSA Funding Requirements** of Lower Carbon Concrete in Inflation Reduction Act Projects

Pacific Hwy US-Canada Border Crossing

Projects Pursuing "Deep Green" Building Certifications

- **Embodied Carbon Reduction Requirements in:**
  - New version of LEED
  - Net Zero Carbon Certification
  - Living Building Challenge Certification

Port of Seattle Maritime Innovation Center

Thinking Bigger:
Moving towards Whole Building Life Cycle Assessment

Thinking Bigger:
An Evolution in Policy and Code Focus

Moving from General Intentions … to Caps … to a Whole Building Focus

Climate Action Plans currently without implementing Codes or Legislation

Whatcom Co.
Thurston Co.
Spokane
Vancouver WA
Tacoma
King Co
Bellevue
Seattle
and others

Report-only Requirements for Materials

Washington

Passed

Buy Clean / Buy Fair Law

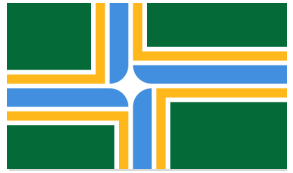
Report-now; Material Caps set Later

Oregon

Passed

Affecting Specific Public Projects: Mandatory Emissions for Materials Caps

Portland



Passed

Affecting Public and Private Projects: Mandatory Emissions Caps for Materials

Washington

In Discussion

State Bldg. Code Proposal

Mandatory Emissions Reduction for Project using Life Cycle Assessment

California

Passed

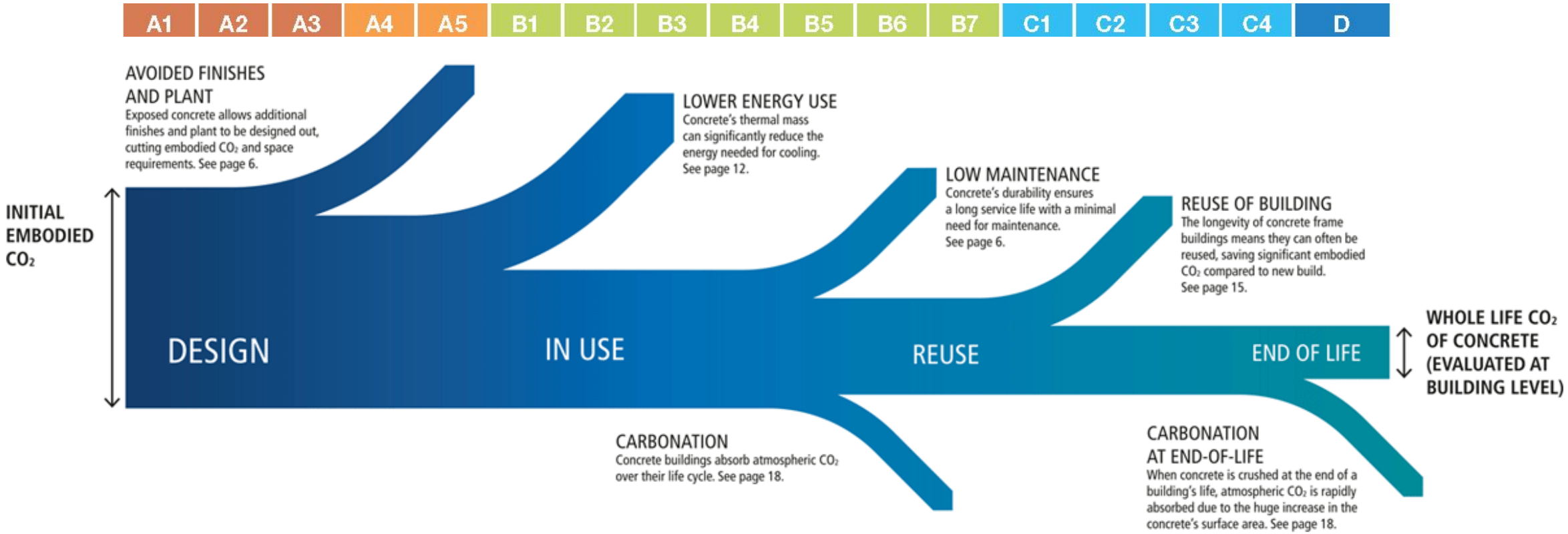
CalGreen Bldg. Code

Policies — **Report Only** — **Material-level Focus** — **Building-level Focus**

Thinking Bigger:
Opportunities of Thinking at the Building Scale

Thinking at Building Scale Considers Emissions at all Life Cycles Stages

Potential Avoided Emissions
over the Project's Life Cycles



Source: Roadmap to Beyond Net Zero
Mineral Products Association

Thinking Bigger:
Opportunities of Thinking at the Building Scale

WBLCA Modeling informing Design Decisions

WBLCA =
Whole Building
Life Cycle Assessment

Uses software to model emissions (and other impacts) of multiple materials in multiple building elements over the project's lifetime.

Examples of LCA Software:

tally™

c.scale™

One Click LCA

Some Design Questions that WBLCA may help Answer:

- **Structural Material Choice and Type of Structure**
  - Can I reach reduction goals through mix optimization alone?
  - Which type of concrete structural system has the lowest embodied carbon?
  - What's the carbon impact of a Hybrid Structure (mix of structural materials)?
- **Durability**
  - Which materials have the longest service life?
  - What's the carbon impact of frequent replacement cycles?
- **Energy Co-benefits**
  - What are the energy co-benefits associated with thermal mass?
- **Carbon Uptake**
  - Which materials and building element can sequester carbon?
  - What's the amount of carbon uptake from concrete (Carbonation)
- **New Build vs. Renovation**
  - What's the carbon impact of a major renovation vs. a new build?

Key Takeaways:

1. **Owners are interested** in embodied carbon reductions in concrete – some projects are requiring reductions.

2. **There is a business opportunity** for suppliers who offer lower carbon mixes, have EPDs and reach out to designers.

3. **Significant reductions are possible today** using blended cements, replacing OPC with SCMs and relaxing maturity dates.

4. **Larger reductions in the future** will likely use Carbon Capture and Storage (CCUS).

5. **Legislation is not going away** and may move from material emissions caps to considering emissions on the building scale

6. **Whole Building Life Cycle Analysis is an opportunity** to focus not only on just structural materials and emissions from manufacturing but considers carbon over the lifetime of the project

Thanks

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