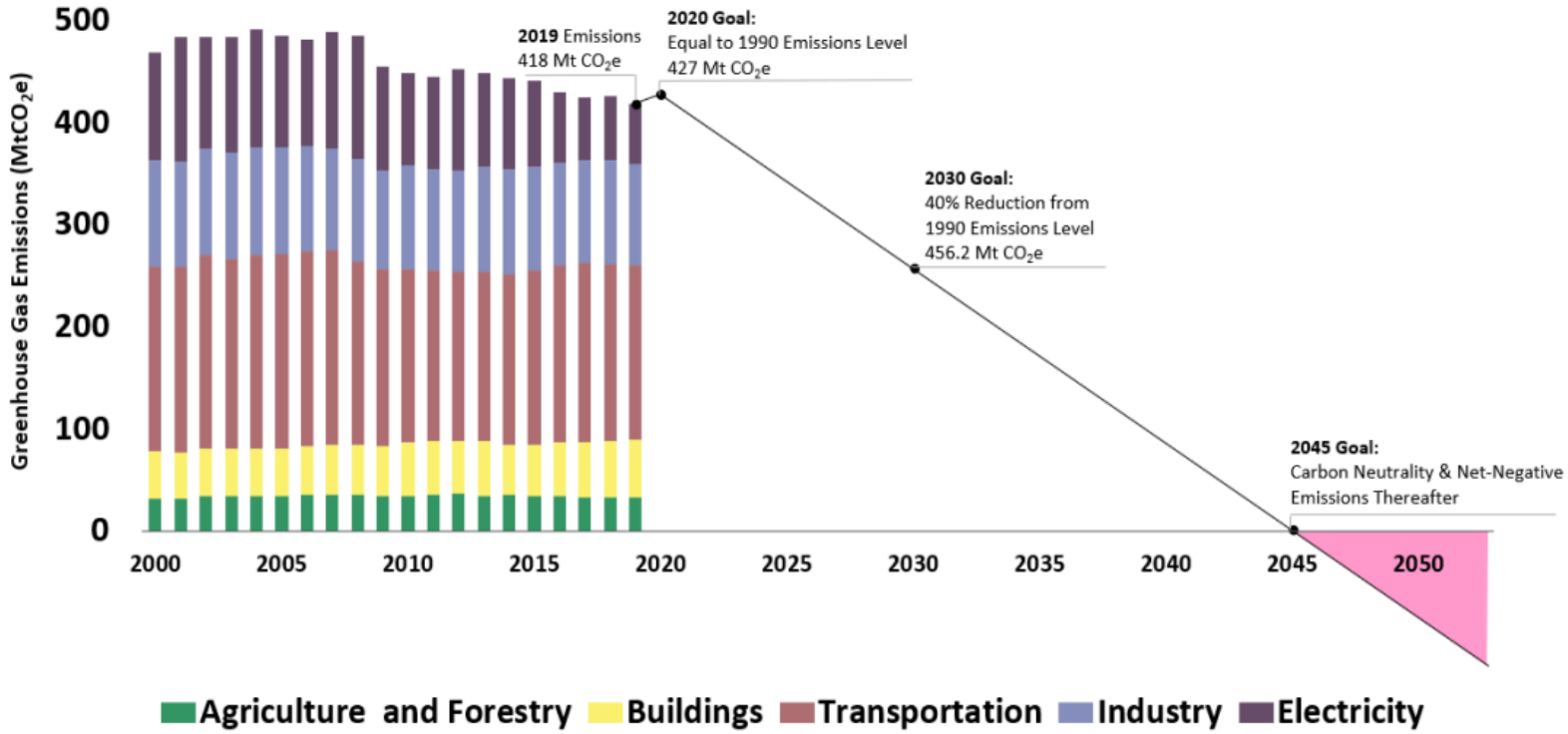
Impacts of Senate Bill 596 and other Low Carbon Policy Initiatives in California

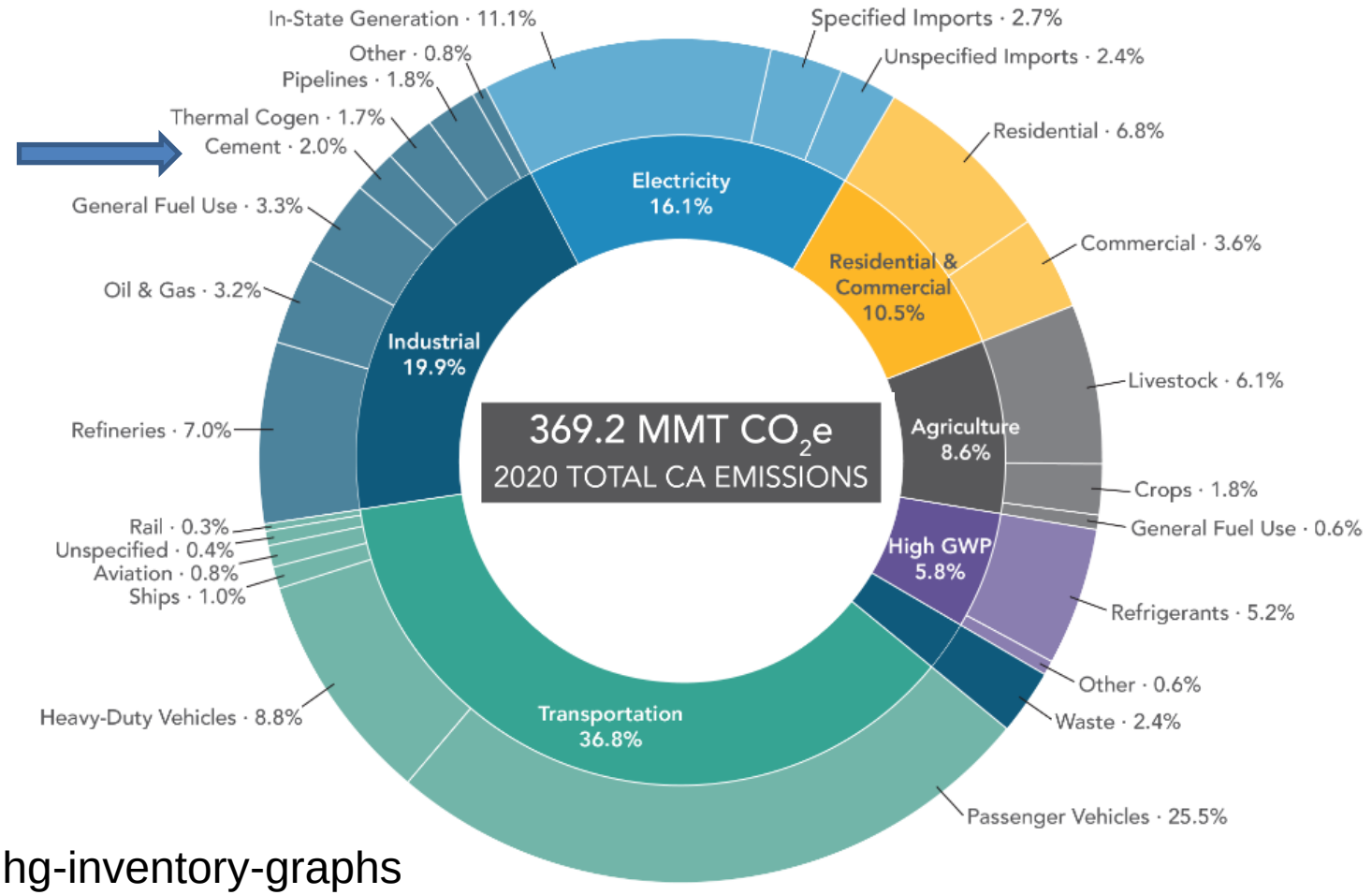
California Historic Emissions and Future Targets



Source: Adapted from CARB (2021)

Stanford University

2020 GHG Emission by Scoping Plan Sub-Category



https://ww2.arb.ca.gov/ghg-inventory-graphs

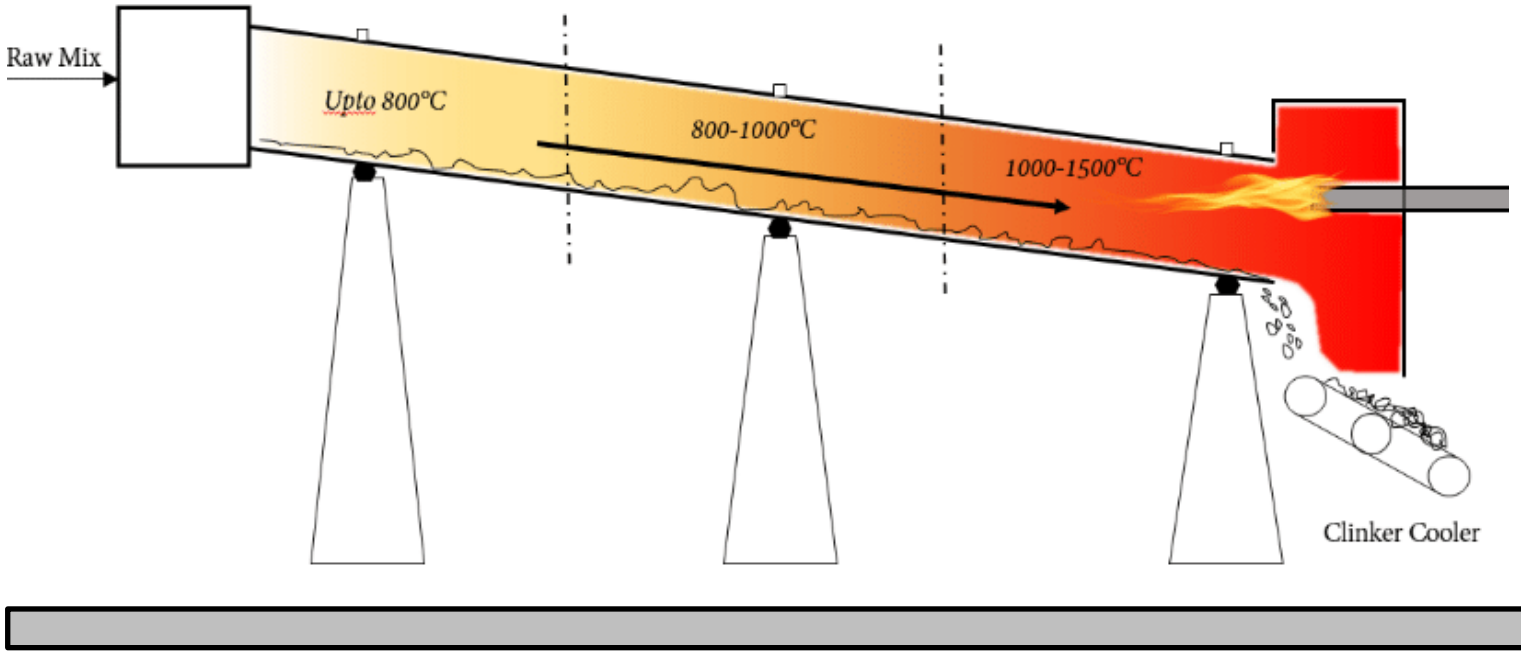
The California Cement Industry is committed to carbon neutrality by 2045

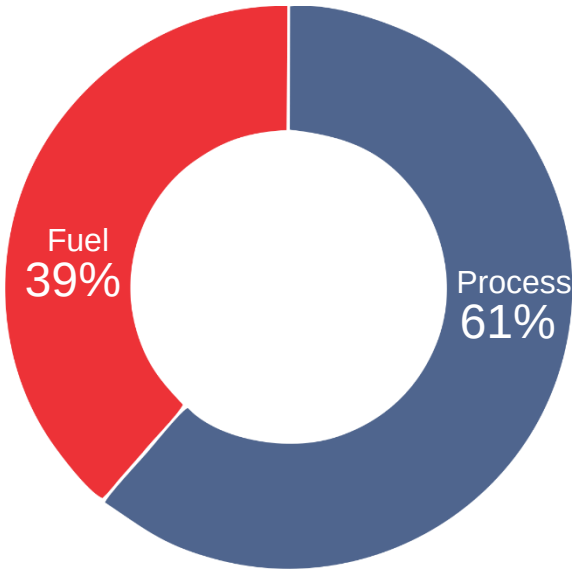
1 Bold Goal.

Achieving this goal will require:

- A commitment to pursuing **an "all-of-the-above" approach** that unlocks a flexible portfolio of pathways such that each plant can chart a course that aligns with its unique needs and circumstances.
- **Close coordination among stakeholders throughout the cement-concrete-construction value chain**, including cement manufacturers, concrete plants, project owners, developers, engineers, and architects.
- **Constructive engagement among stakeholders throughout the public policy ecosystem,** including legislators, regulators, and other interested parties.

Thermal Process: Two CO_2 Sources





3 Pathways. 8 Levers.

✓ = Action is necessary to remove barriers and fully unlock pathway.

Measure	Legislative Assistance	Regulatory Assistance	Public Acceptance	Public Funding	RD&D	Supply Limitations
PATHWAY 1: PROCESS EMISSIONS						
Portland Limestone Cement / Blended Cements	-	✓	✓	-	-	-
Carbon Capture Use & Storage (CCUS)	✓	✓	✓	✓	✓	-
Alternative Raw Materials (ARM)	-	✓	✓	-	✓	✓
Alternative Cements & Clinkers	-	-	-	-	✓	✓
PATHWAY 2: COMBUSTION EMISSIONS & FUEL SWITCHING						
Natural Gases	✓	✓	✓	-	-	✓
Alternative Fuels	✓	✓	✓	-	-	✓
PATHWAY 3: ELECTRICITY GENERATION						
Waste Heat Recovery	✓	- ✓	-	✓	-	-
On-Site Renewables	✓	✓				
	5	7	5	2	3	4

Pathway 1: Reducing Process Emissions

The most significant constraint on the industry's ability to reach net neutrality is the presence of "**process emissions**" – CO_2 released as a byproduct of clinker production

Source: California Air Resources Board (2020). Greenhouse Gas Emission Inventory - Query Tool for years 2000 to 2018 (13th Edition). Link

Sample Short Term Lever: Portland Limestone Cement

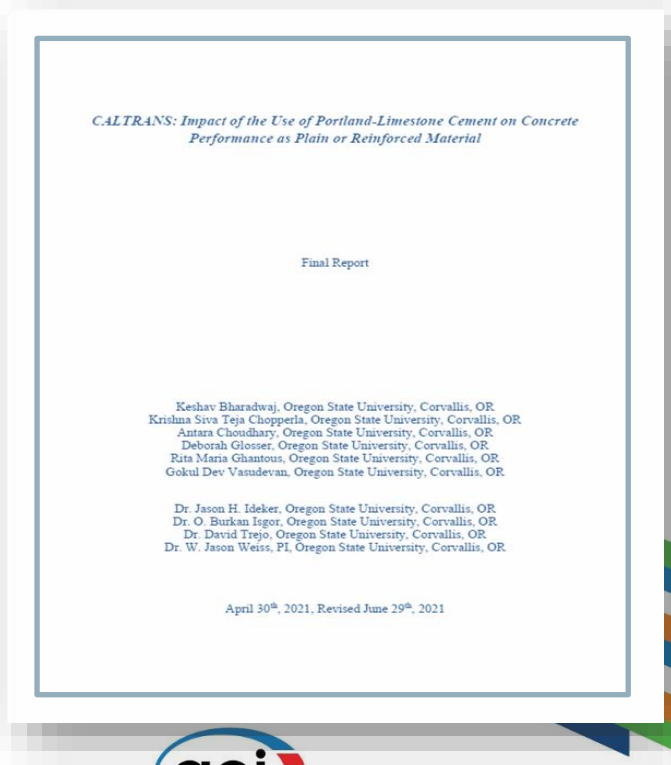
Key Barriers

Regulatory Barriers Removed

- **Federal:** FAA P-501; AIA Masterspec; Unified Facilities Guide Specifications UFGS 03 30 00; ACI and ICC building codes
- **State and Local**: Caltrans approval; Greenbook for public works

Supply. Cement and ready-mix concrete coordination – many with just one silo.

Caltrans Research Report


CALTRANS: Impact of the Use of Portland-Limestone Cement on Concrete Performance as Plain or Reinforced Material

Final Report

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April 30th, 2021, Revised June 29th, 2021

Sample Long Term Lever: Carbon Capture

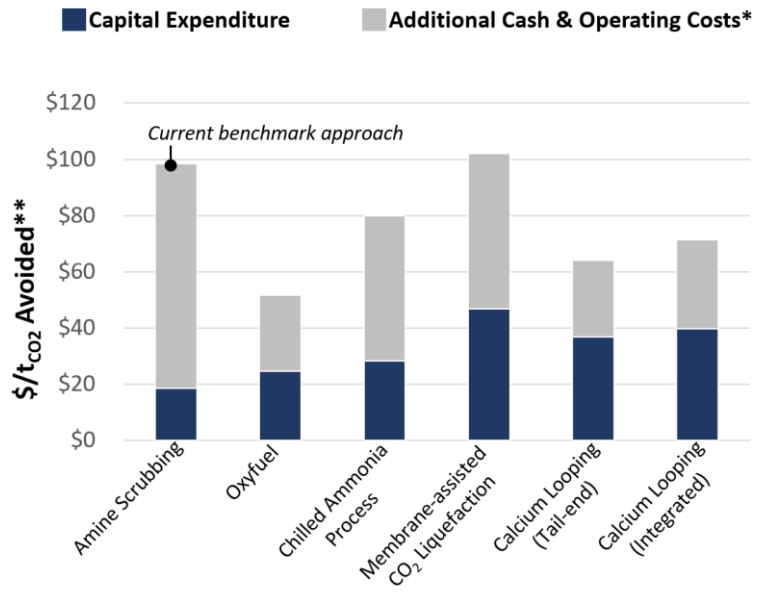
State of Play. Globally, industry deployment of CCUS technology is still in the early stages with only a handful of projects in the pipeline.

Opportunity. With carbon capture rates upwards of 90% of process and combustion emissions, CCUS yields industry GHG abatement on a scale otherwise not achievable by other measures.

Key Barriers

- **Cost.** CCUS projects are extremely capital-intensive and are not economically feasible without significant public sector financial support.
- **Regulatory.** Current state and federal policies leave significant gaps. For example, the California cap-and-trade scheme does not currently reward carbon capture.

Est. Cost per Ton of CO_2 Emissions Avoided, by Cement Industry Capture Tech



** Includes fixed operating costs, raw materials, energy consumption/generation, and other variable costs; assumes an economic life of 25 years and retrofitting of existing cement plant.*

*** Converted from EUR to USD using spot exchange rate.*

Source: Gardarsdottir, S. O., De Lena, E., Romano, M., Roussanaly, S., Voldsund, M., Perez-Calvo, J. F., ... & Cinti, G. (2019). Comparison of Technologies for CO_2 Capture from Cement Production-Part 2: Cost Analysis. Energies, 12(13), 11 Link

Pathway 2: Reducing Emissions through Fuel Switching

While the industry has made significant improvements in the thermal energy intensity of cement production, the **emissions intensity** of its fuel mix has dropped much less rapidly.

Independent Statistics and Analysis
U.S. Energy Information Administration

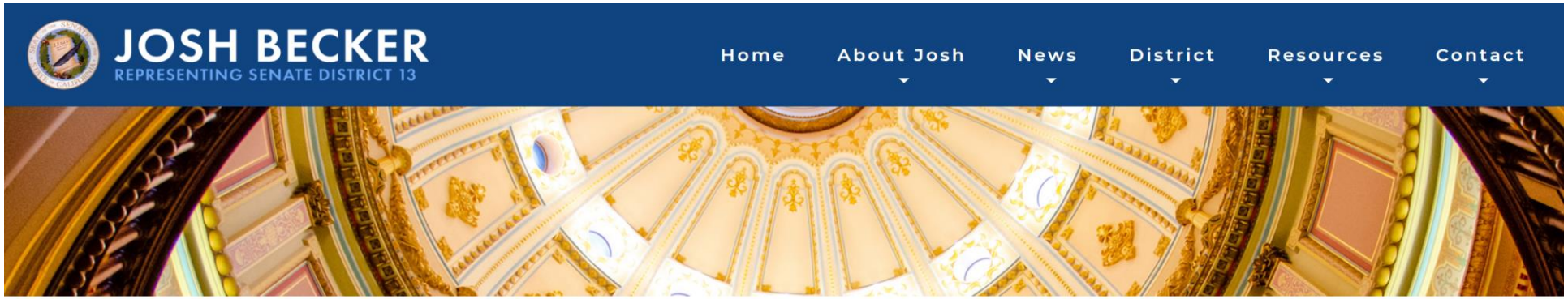
Fuel Type	kg CO_2 per million BTU
Coal	96.1
Natural Gas	52.9
Municipal Solid Waste	49.9
Tire-Derived Fuel	86.0

https://www.eia.gov/environment/emissions/co2_vol_mass.php

Pathway 3: Reducing Emissions through Distributed Generation

Waste Heat Recovery and On-Site Renewables represent an opportunity to shift toward more **distributed generation capacity** and effectively generate zero-carbon electricity as a result.

Senate Bill 596 (Becker): First law in any California sector to focus on achieving net-zero emissions



LATEST NEWS

California Enacts Legislation To Slash Cement Emissions

September 24, 2021

CA GOVERNOR SIGNS STATE SENATOR JOSH BECKER'S LANDMARK BILL TO DECARBONIZE CEMENT

Timeline: CARB to develop strategy by July 2023; Targets 40% below 2019 levels by 2035; net-zero GHG cement by end of 2045

SB 596 excerpts…

A wide range of commercially available technologies and practices exist to reduce and remove emissions of GHG throughout the life cycle of cement and concrete production and use, but these technologies and practices face a series of market and regulatory barriers hindering their deployment.

How SB 596 can accelerate levers

The state board shall document the feasibility constraints… and recommend measures and actions, including proposed statutory changes, necessary to overcome those constraints to enable the cement sector to achieve net-zero emissions of greenhouse gases as soon as possible, but no later than December 31, 2045.

How SB 596 can accelerate levers

Include provisions to minimize and mitigate potential leakage and account for embedded emissions of GHG in imported cement… such as through a border carbon adjustment mechanism.

Additional State and Local Actions

Source: carbonleadershipforum.org/clf-policy-toolkit/

Carbon Leadership Forum Embodied Carbon Policy Toolkit

aci CONCRETE CONVENTION

Additional Statewide Actions

Passed in 2017 and enacted in 2022, Buy Clean California sets the maximum Global Warming Potential for the following products when purchased by the State:

Structural Steel

Reinforcing Steel

Flat Glass

Mineral Wool Board Insulation

Additional Statewide Actions

Assembly Bill 2446: passed 9/2022

Requires the California Air Resources Board to include a comprehensive strategy to achieve a 20% net reduction in the GHG emissions of building materials by December 31, 2030, and a 40% net reduction no later than December 31, 2035.

Additional Statewide Actions

Assembly Bill 43: current

Requires the California Air Resources Board to establish an embodied carbon trading system made applicable to building material providers, developers, architectural and engineering firms, and construction companies.

Aims to enforce reductions in average carbon intensity of materials in construction of new buildings

Additional Statewide Actions

Senate Bill 682: current

Requires state agencies to enter into advanced procurement agreements for the purchase or specification of low carbon concrete up to 10 years in advance per benchmarks of First Movers Coalition.

Additional Statewide Actions

NRMCA Regional Average

Strength psi @28 days	GWP kg CO_2e/m^3
2500	285
3000	310
4000	360
5000	421
6000	446
8000	509

Specified compressive strength (f'c in psi)	Embodied carbon (kg CO_2e/m^3)
0 - 2500 psi	70
2501 - 3000 psi	78
3001 - 4000 psi	96
4001 - 5000 psi	117
5001 - 6000 psi	124
6001 - 8000 psi	144

Additional Statewide Actions

New codes proposal has:

Mandatory carbon reduction regulations require maximum global warming potential (GWP) levels in concrete mixes as disclosed in product-specific EPD's

Voluntary provisions for Whole Building Life Cycle Assessment to reach targeted code requirements

Additional Statewide Actions

Caltrans Activities Summary for LCCA, eLCAP and EPD: MARCH 2023

	Tentative Steps and Schedule for EPD and LCA Implementation							
	EPD and LCA likely steps	2023	2024	2025	2026	2027	2028	2029
1	EPD collections for concrete and asphalt							
2	GWP limits establishment for concrete and asphalt							
3	eLCAP with non-proprietary data may become available							
4	LCA with EPD data for shadow projects							
5	Guidance for interactive use of LCA and pavement design programs (CalME, concrete design programs) that consider materials/mix selection (developed through PMPC and research)							
6	LCA using EPDs to provide better average materials impacts for design may become available that quantify full impact of sustainability strategies to be used for shadow projects							
7	Likely ready for implementation of LCA with corresponding guidance for durability considerations for new materials							

Caltrans

Low-Carbon Concrete Specifications: They're Already Here!

Private Buildings
Public Infrastructure
State Procurements
Federal GSA….

Low-Carbon Concrete Specifications: They're Already Here!

Private Office Building & Parking Garage in San Diego

B. Prepare Environmental Product Declaration (EPD) Sustainable Design Submittals:

1. For a minimum of 90% by volume of the cast-in-place concrete, submit Environmental Product Declarations in accordance with the Product Category Rules (PCR) for ISO 14025 Type III Environmental Product Declarations (EPDs) for Concrete.
2. Calculate the weighted average Benchmark Global Warming Potential (GWP) for the volume of concrete with EPDs. The calculation shall include:

   a. A list of all classes of concrete used in the project. A class of concrete is determined by the 28-day specified design compressive strength (i.e. 3000 psi concrete, 4000 psi concrete). CDF mixes need not be included in the calculation of the total volume of cast-in-place concrete for this requirement.
   b. A list of the projected volume of each class of concrete to be used in the project. The total volume reported per class shall match the total volume of concrete listed in the weighted average Proposed Mix GWP calculations.
   c. A list of the GWP for each class of concrete for the Pacific Southwest Region as reported in the NRMCA Member National and Regional Life Cycle Assessment Benchmark (Industry Average) Report, dated October 2016. These regional benchmarks are as follows:

Concrete Class Required f'c at 28 days	Benchmark Global Warming Potential (GWP) kg CO^2	
2500 psi Concrete	210.24	per yd^3
3000 psi Concrete	229.14	per yd^3
4000 psi Concrete	267.24	per yd^3
5000 psi Concrete	314.08	per yd^3
6000 psi Concrete	333.54	per yd^3
8000 psi Concrete	381.72	per yd^3
3000 psi Light Weight Concrete	394.02	per yd^3

Low-Carbon Concrete Specifications: They're Already Here!

City of San Jose ADA Ramps:

90-1.02 SUBMITTALS

The mix design(s) shall show the proposed concrete mixture proportions including all material weights, volumes, density (unit weight), water-cement ratio, and void content. The mix design(s) shall specify an average compressive or flexural strength that meets or exceeds the acceptance criteria for the specified strength.

Mix designs shall:

- Be designed to reduce the carbon footprint of concrete production
- Not exceed a Global Warming Potential (GWP) of 250 kg CO_{2e}/m^3.

Provide the following information:

1. Environmental Product Declaration (EPD) showing the GWP associated with the mix design.
2. If using recycled CO_2, concrete producer's certificate verifying mineralization of carbon dioxide. Include quantity, location, and supplier of carbon dioxide.

Low-Carbon Concrete Specifications: They're Already Here!

Marin County Low-Carbon Concrete Code

	Cement limits for use with any compliance method 19.07.050.2 through 19.07.050.5	**Embodied Carbon limits** for use with any compliance method 19.07.050.2 through 19.07.050.5
Minimum specified compressive strength f'_c, psi (1)	Maximum ordinary Portland cement content, lbs/yd^3 (2)	Maximum embodied carbon, kg CO_2e/m^3, per EPD
up to 2,500	362	260
3,000	410	289
4,000	456	313
5,000	503	338
6,000	531	356
7,000	594	394
7,001 and higher	657	433
up to 3,000 light weight	512	578
4,000 light weight	571	626
5,000 light weight	629	675
Notes (1) For concrete strengths between the stated values, use linear interpolation to determine cement and/or embodied carbon limits. (2) Portland cement of any type per ASTM C150 or ASTM C595.		

Low-Carbon Concrete Specifications: They're Already Here!

Capital Annex: Sacramento

1) Individual concrete classes/mixes shall have a GWP less than or equal to that shown in the table below.

2) Applications with an age for cylinder testing of 56 days may be extended to 90 days with approval from the Architect.

Typical Application of Concrete Class/Mix Design	Strength (psi)	Age for Cylinder Testing (days)	Maximum GWP per EPD (kg/m3)
Typical (unless noted otherwise)	4,000	28	290
Mat Foundations and Footings	6,000	28	340
Slab-on-Grade	4,000	28	290
Columns and Pilasters	5,000	28	320
Walls	5,000	28	320
Suspended Slabs	6,000	28	340
Beams	5,000	28	320
Lightweight Concrete Fill on Metal Deck	4,000	28	440
Curbs, Pads and Miscellaneous	4,000	28	290
Site Walls, Slabs and Footings	4,000	28	290
Shotcrete Basement Walls	Refer to Section 03 37 13 - Shotcrete		

Summary

Decarbonizing cement production is essential in meeting aggressive GWP reduction goals.

The California cement industry is committed to working with policymakers, regulators, developers, engineers, architects, advocates, and others to advance solutions to barriers to achieve the provisions of Senate Bill 596.

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California Nevada Cement Association
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