THE PRECAST PODCAST

PCA® Since 1916

America's Cement Manufacturers™

Roadmap to Carbon Neutrality

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PCA Since 1916
America's Cement Manufacturers™

shaped BY CONCRETE

ABOUT THE PORTLAND CEMENT ASSOCIATION

PCA, founded in 1916, is the premier policy, research, education, and market intelligence organization serving America's cement manufacturers. PCA member companies represent the majority of U.S. cement production capacity, having facilities across the country. PCA promotes safety, sustainability, and innovation in all aspects of construction; fosters continuous improvement in cement manufacturing and distribution; and promotes economic growth and sound infrastructure investment.

For more information, visit www.cement.org and shapedbyconcrete.com.

PCA® Since 1916
America's Cement Manufacturers™

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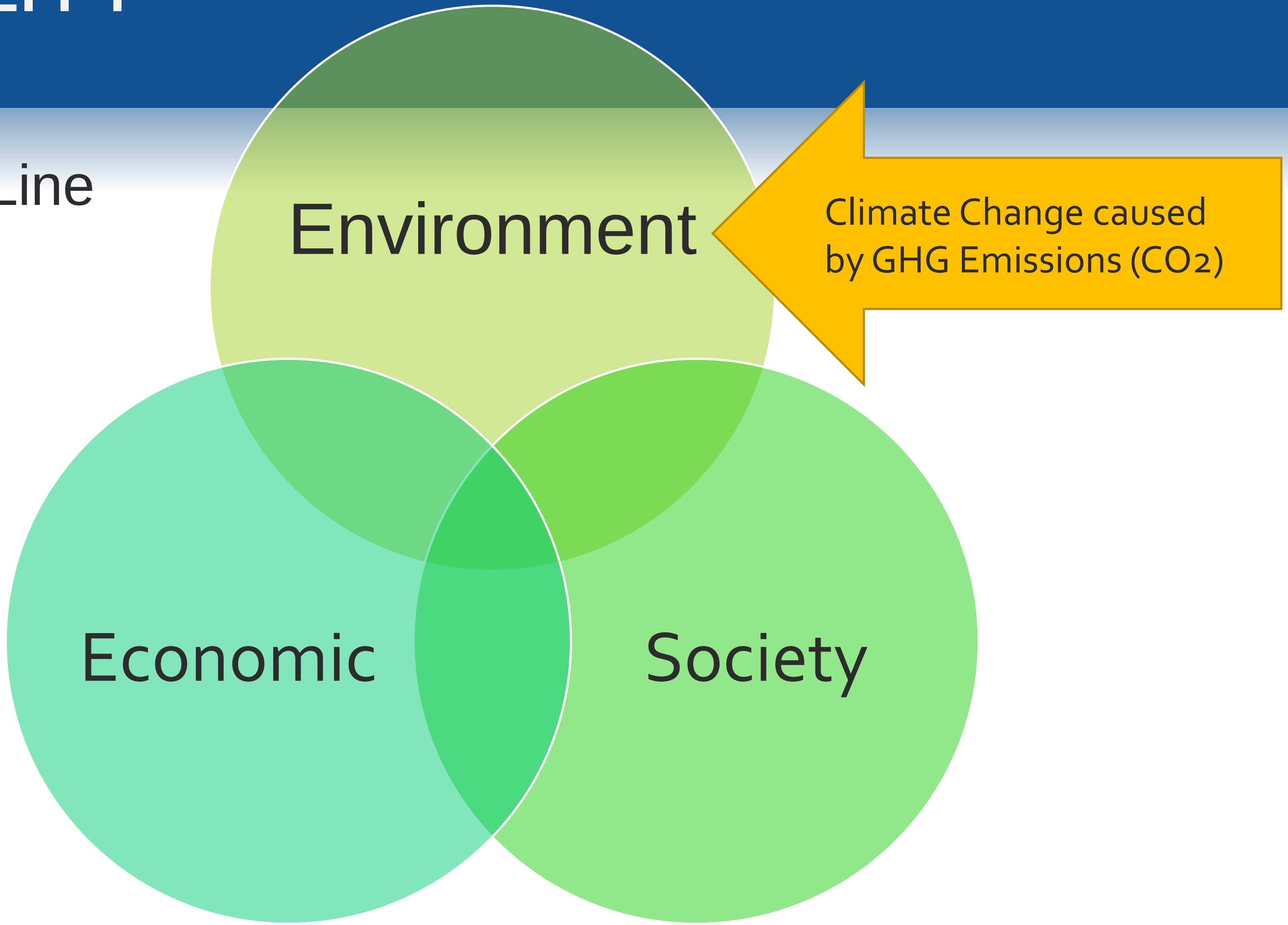
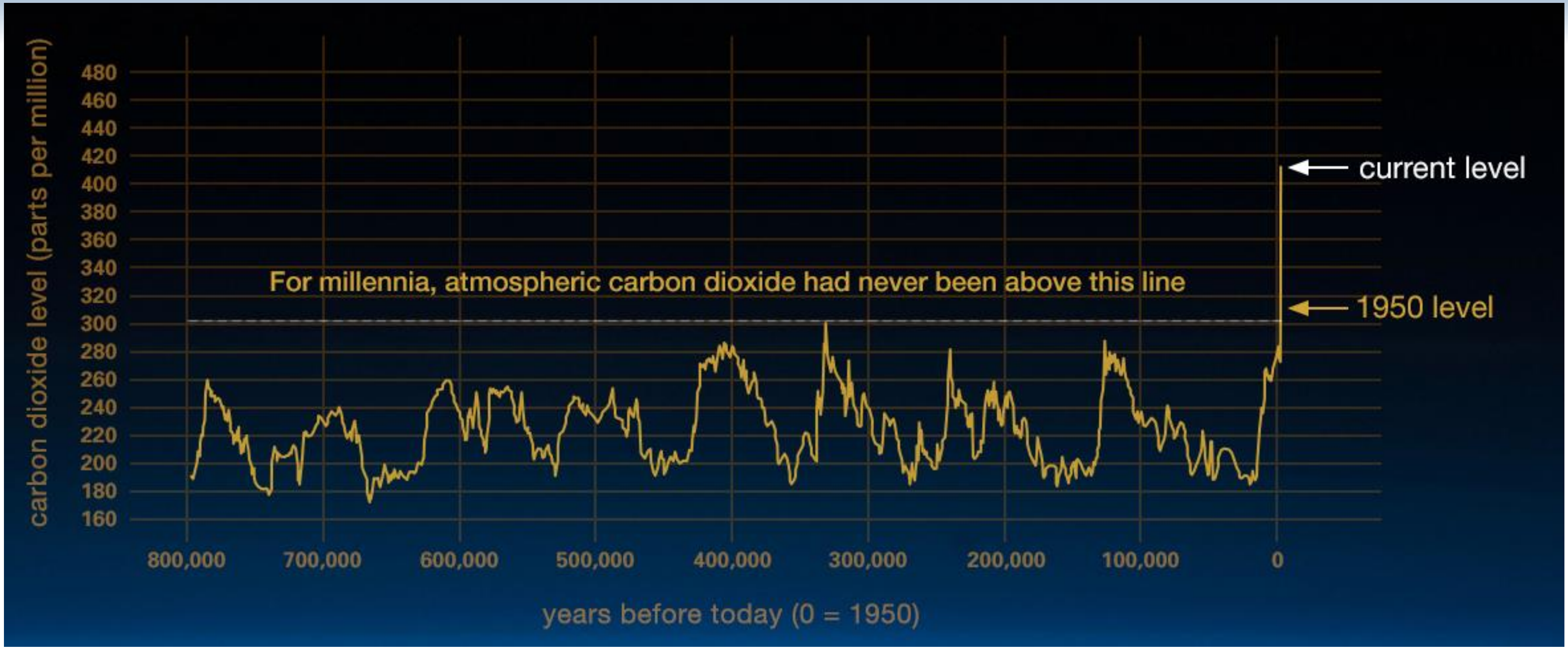
SUSTAINABILITY

- The Triple Bottom Line



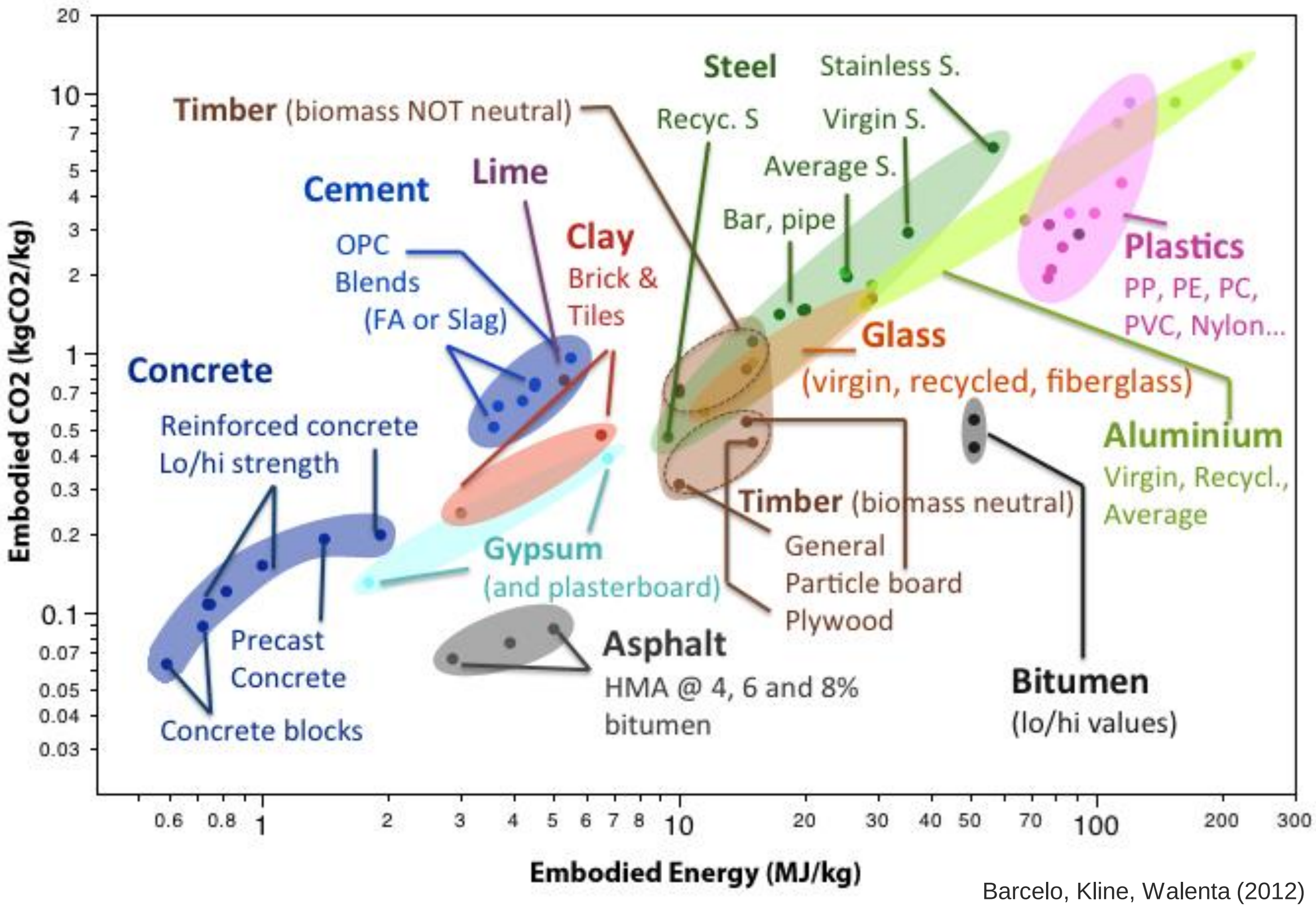
SUSTAINABILITY



Source: climate.nasa.gov

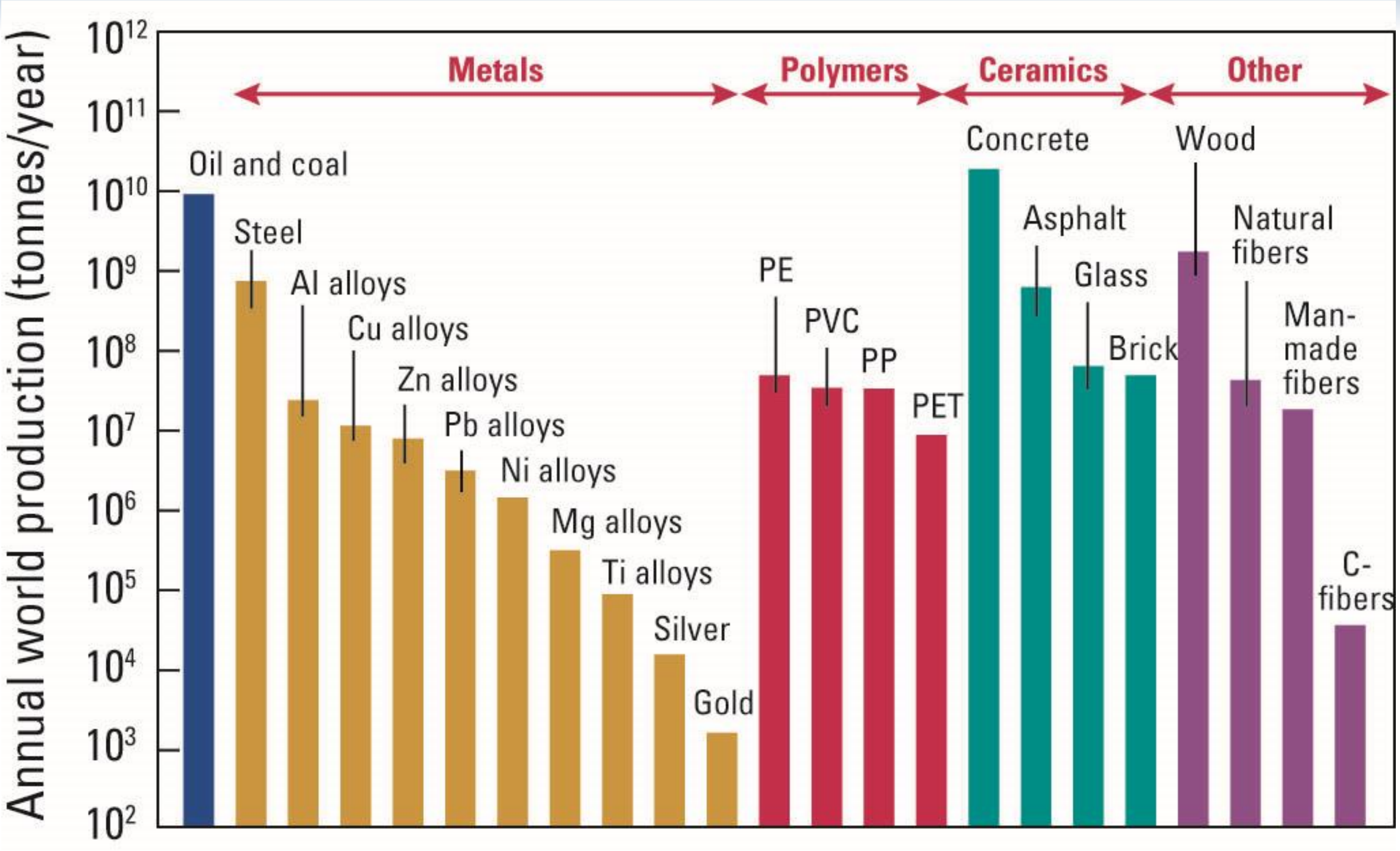
CONCRETE IS SUSTAINABLE

- Misperceptions about cement and concrete
- Relatively low embodied energy and CO_2 by mass compared to other materials



Barcelo, Kline, Walenta (2012)

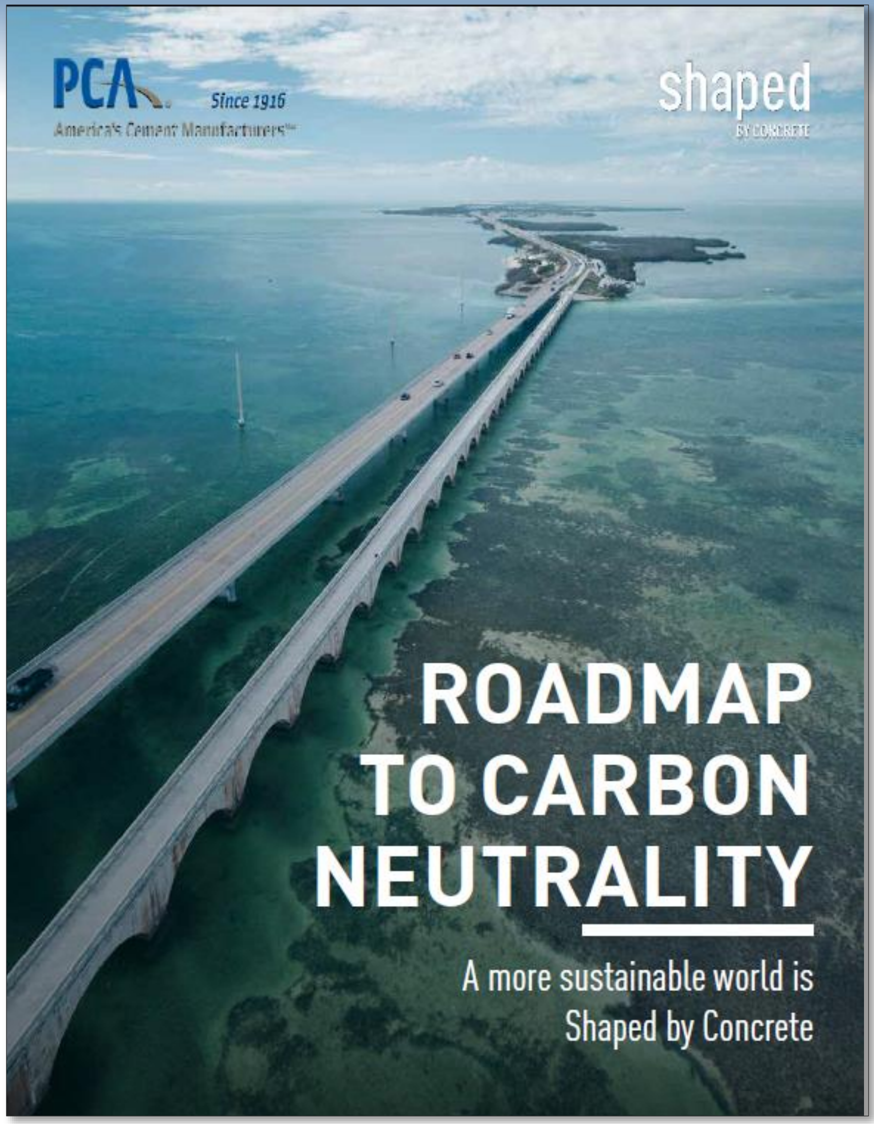
SOCIETY USES A LOT OF CONCRETE



(after Ashby 2009)

- Concrete is the most widely used construction material, by more than a factor of ten.
- The United States consumes about 340 million cubic yards of ready mixed concrete each year.

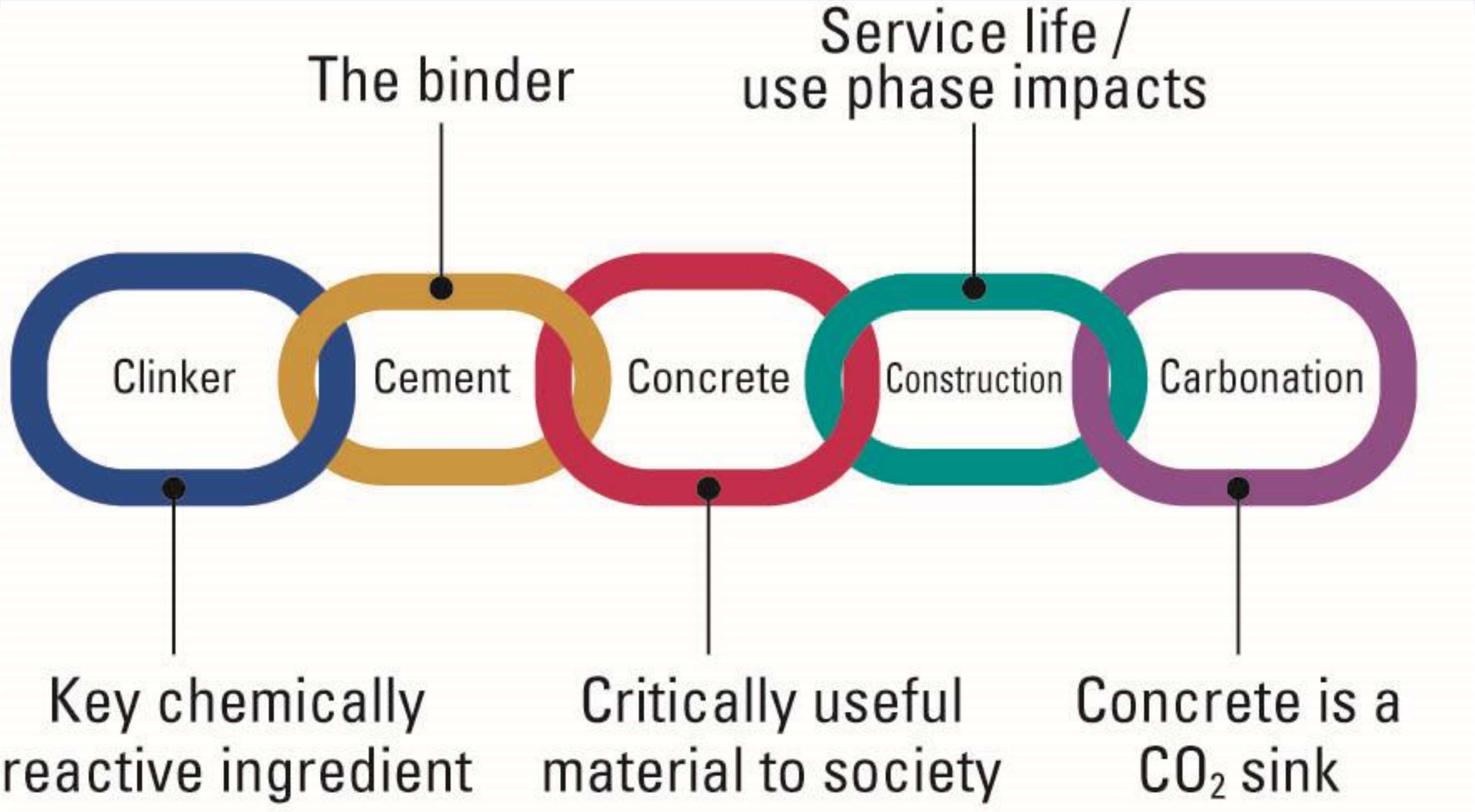
THE PCA ROADMAP TO CARBON NEUTRALITY



PCA Since 1916 America's Cement Manufacturers™

shaped BY CONCRETE

THE VALUE CHAIN



CLINKER
Key chemically reactive ingredient

CEMENT
The binder

CONCRETE
Critically useful material to society

CONSTRUCTION
Service life / use phase impacts

CARBONATION
Concrete is a CO_2 sink

AT THE CEMENT PLANT

- Increase the use of decarbonated raw materials
- Decrease the use of traditional fossil fuels by 5X
- Increase the use of alternative fuels
- Push efficiency and decrease energy intensity for one metric ton of clinker
- Utilize carbon capture to avoid the release of CO_2 emissions
- Reduce clinker production emissions

OPTIMIZING THE DESIGN AND CONSTRUCTION OF THE BUILT ENVIRONMENT

- Lower concrete manufacturing emissions to zero at the plant
- Transition to zero emission fleets
- Optimize concrete mixes
- Reduce overdesign
- Construct concrete structures for durability, resiliency, stiffness, and thermal mass benefits

CONCRETE IN USE

- 10% — The amount of CO_2 that concrete buildings, structures, and pavements can permanently absorb from the air is 10%
- A reduction of 46.5 million metric tons of GHG emissions per year could be realized if the entire U.S. road system used concrete pavement according to the MIT Concrete Sustainability Hub (MIT CSHUB)

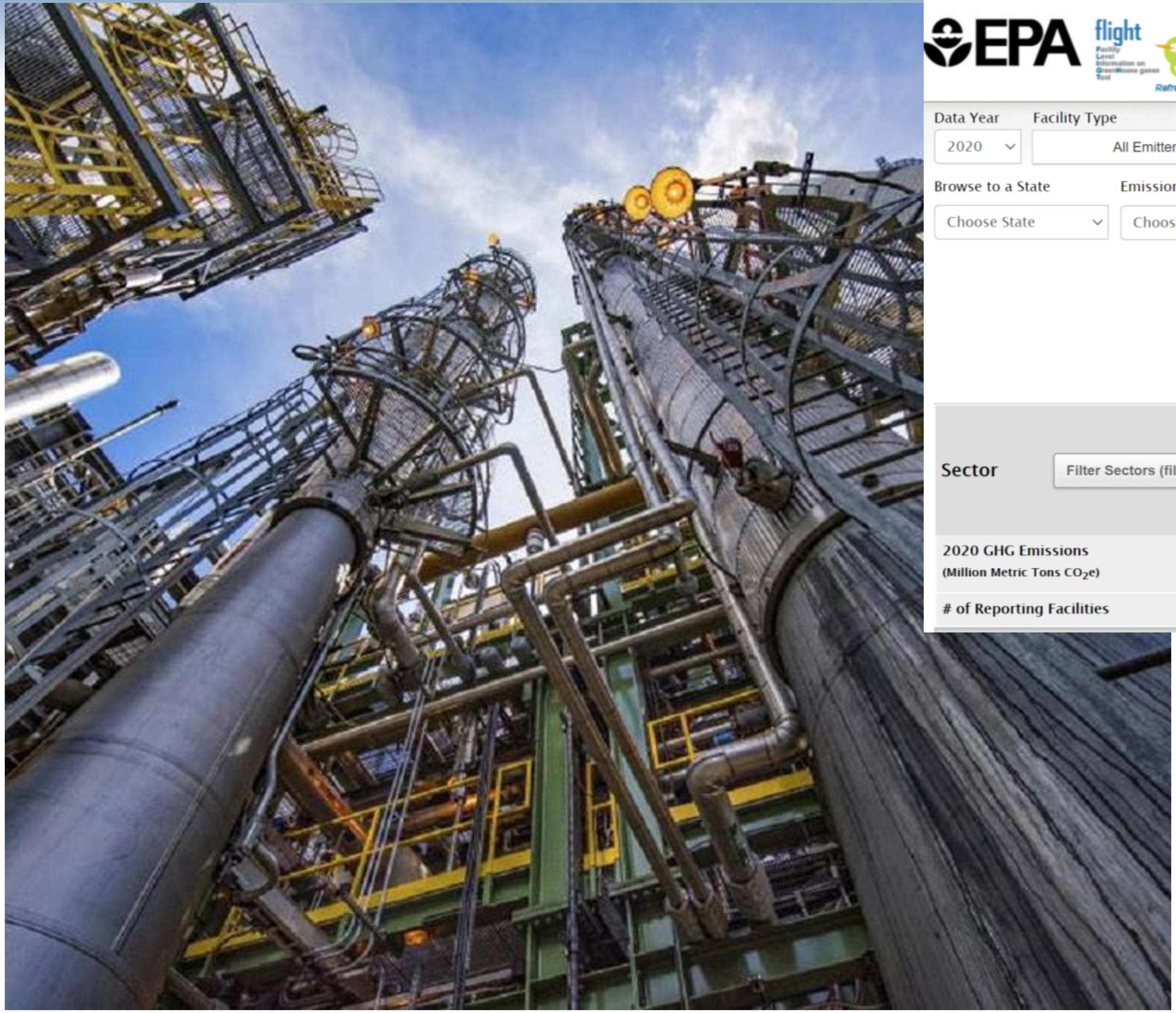
CLINKER

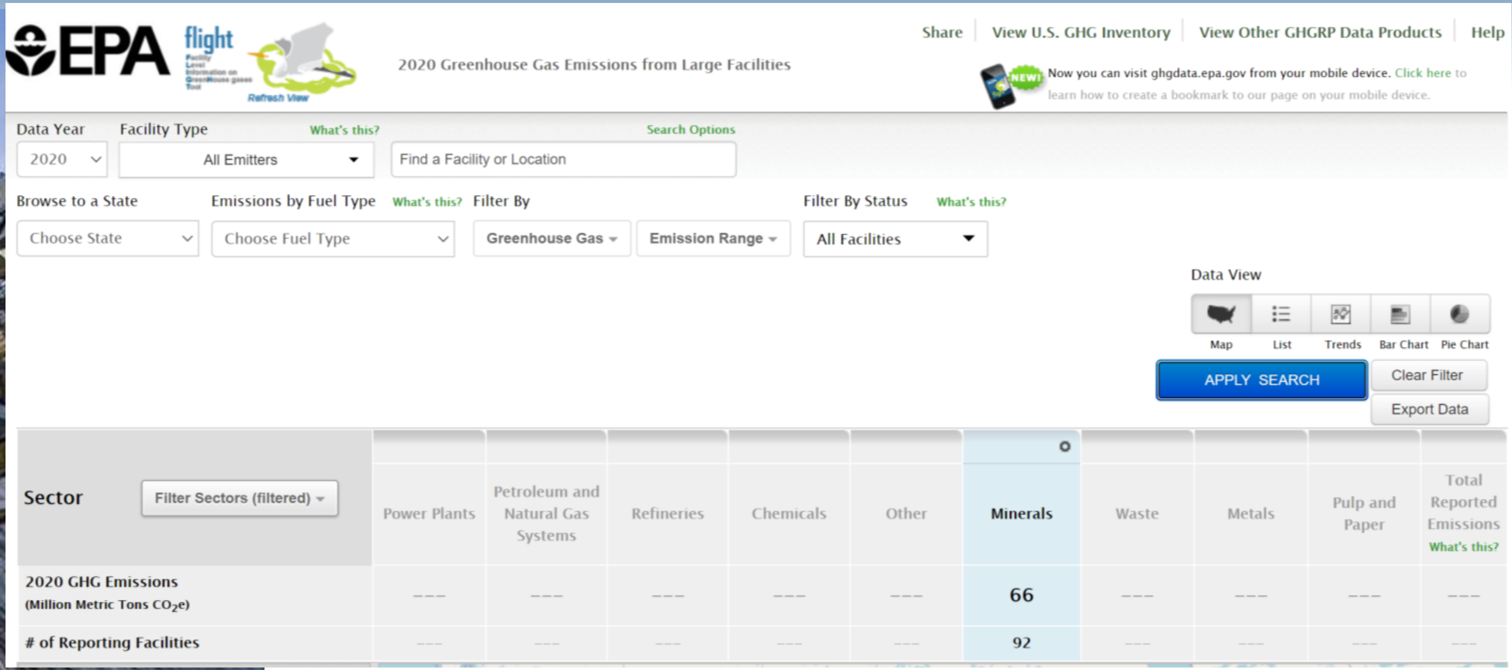
Key chemically reactive ingredient

$$CaCO_3 \longrightarrow CaO + CO_2$$

$$C + O_2 \longrightarrow CO_2$$

REPORTING EMISSIONS





Sector (Filter Sectors (filtered))	Power Plants	Petroleum and Natural Gas Systems	Refineries	Chemicals	Other	Minerals	Waste	Metals	Pulp and Paper	Total Reported Emissions What's this?
2020 GHG Emissions (Million Metric Tons CO_2e)	---	---	---	---	---	66	---	---	---	---
# of Reporting Facilities	---	---	---	---	---	92	---	---	---	---

<u>U.S. Cement Industry contribution</u>:

- Global GHG = 0.17% CO_{2eq}
- U.S. GHG = 1.25% CO_{2eq}

OPTIMIZING CLINKER

AT THE CEMENT PLANT

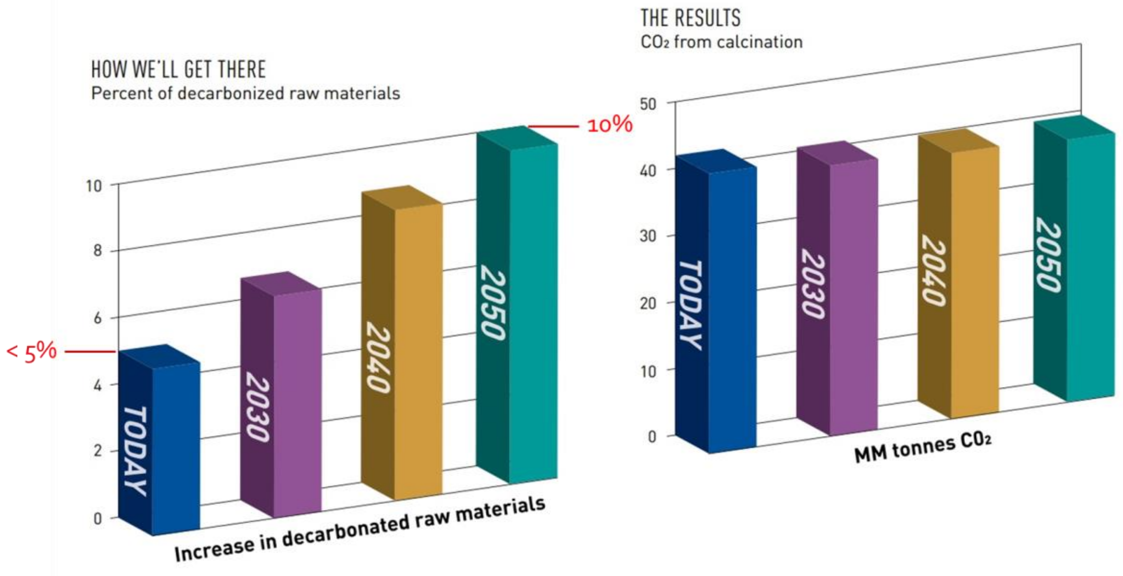
- Increase the use of decarbonated raw materials
- Decrease the use of traditional fossil fuels by 5X
- Increase the use of alternative fuels
- Push efficiency and decrease energy intensity for one metric ton of clinker
- Utilize carbon capture to avoid the release of CO_2 emissions
- Reduce clinker production emissions

AT THE PLANT: ALTERNATIVE RAW MATERIALS

TABLE 12-2. Waste Materials and By-Products Used in Cement Manufacture

LIME RICH	SILICA RICH	SILICA/ALUMINA RICH	IRON RICH	GYPSUM RICH
• Marginal limestone • Waste carbonate • Paper sludge • Wastewater lime • Sugar sludge • Fertilizer sludge • Metal slag	• Foundry sand • Sand washings • Catalytic fines • Rice husk ash	• Fly ash • Ponded ash • Bottom ash • Ore tailings • Basalt rocks • Bauxite waste	• Red mud • Mill scale • Laterite waste	• Desulfurization sludge

Wilson and Tennis, 2021



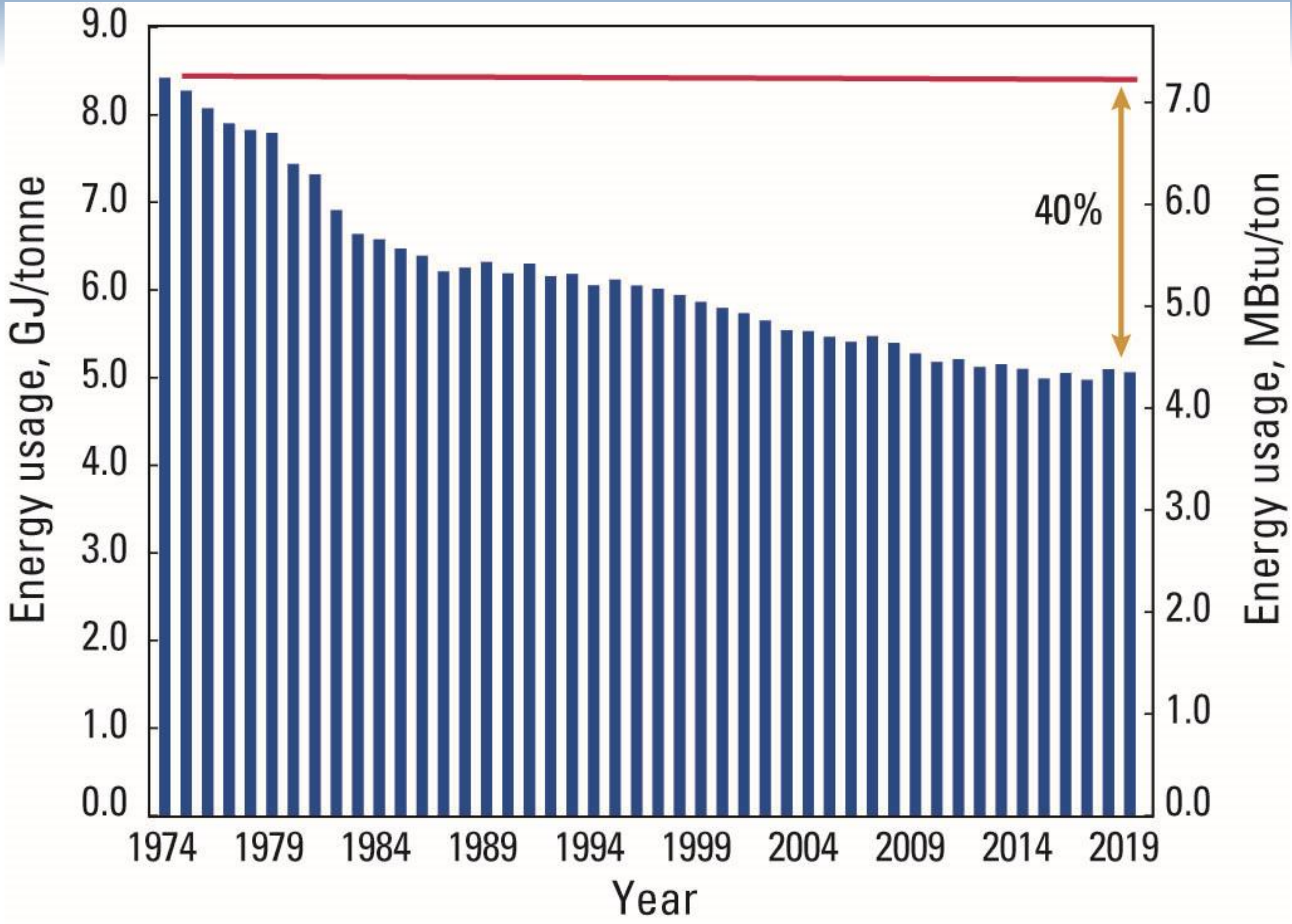
AT THE PLANT: FUEL SWITCHING/FUEL SUBSTITUTION

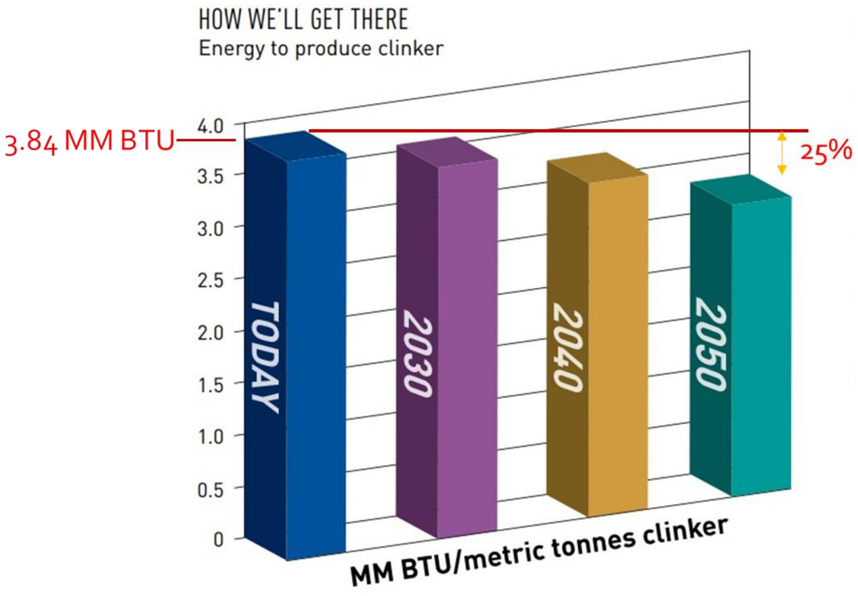
TABLE 12-3. Waste Materials Used as Alternative Fuels in Cement Kilns

Gaseous waste	Landfill gas
Liquid waste	Cleansing solvents
	Paint sludges
	Solvent contaminated waters
	"Slope" – residual washing liquid from oil and oil products storage tanks
	Used cutting and machining oils
	Waste solvents from chemical industry
Solid or pasty waste	Farming residues (rice husk, peanut husk, etc.)
	Municipal waste
	Plastic shavings
	Residual sludge from pulp and paper production
	Rubber shavings
	Sawdust and wood chips
	Sewage treatment plant sludge
	Tannery waste
	Tars and bitumens
	Used catalyst
	Used tires

Wilson and Tennis, 2021

AT THE PLANT: INCREASING COMBUSTION EFFICIENCY

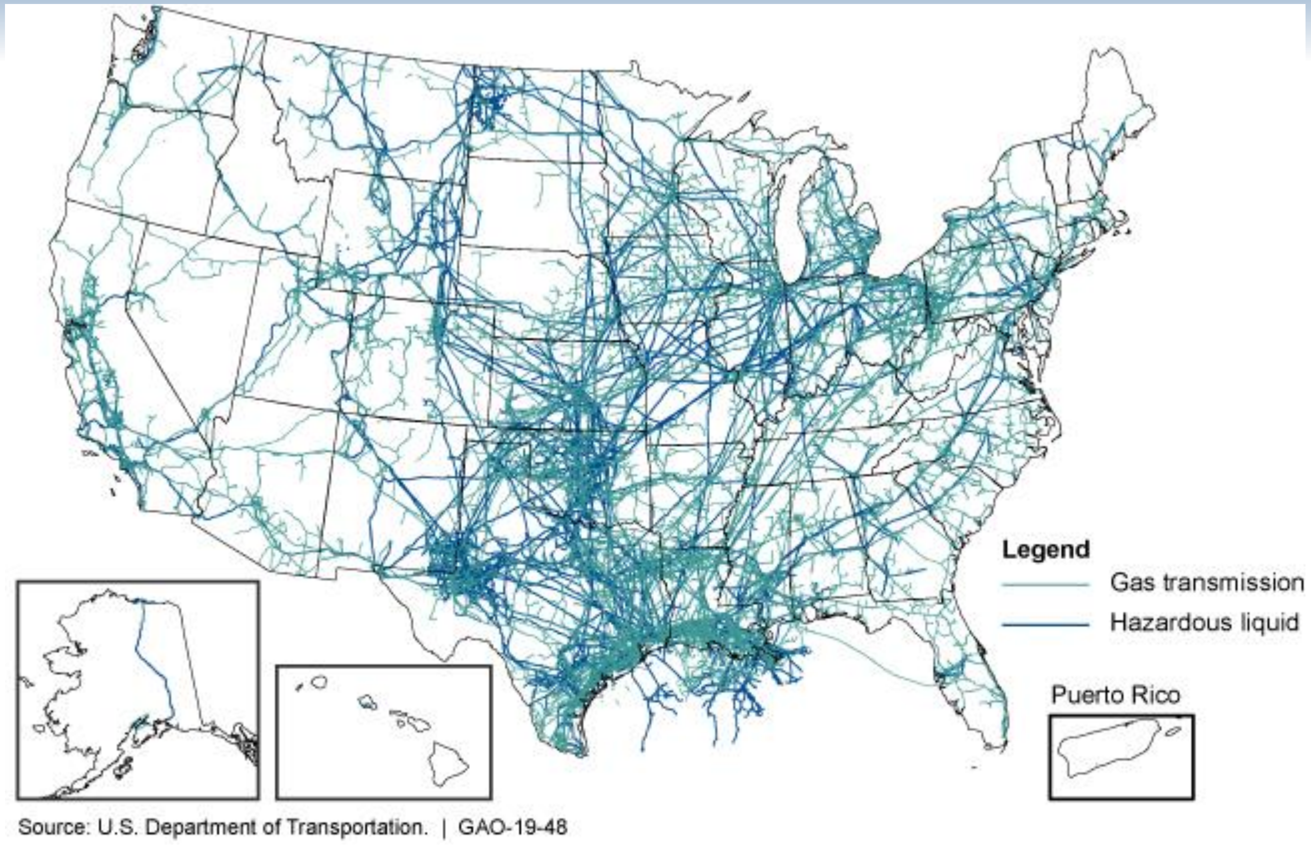




AT THE PLANT: CARBON CAPTURE (CCUS)

- Chemical absorption
- Physical adsorption
- Membrane technologies and mineralization
- Studies in U.S. underway at 5 plants in Texas, Missouri, and Colorado

INFRASTRUCTURE NEEDS – PIPELINE CAPACITY



INFRASTRUCTURE NEEDS - ENERGY

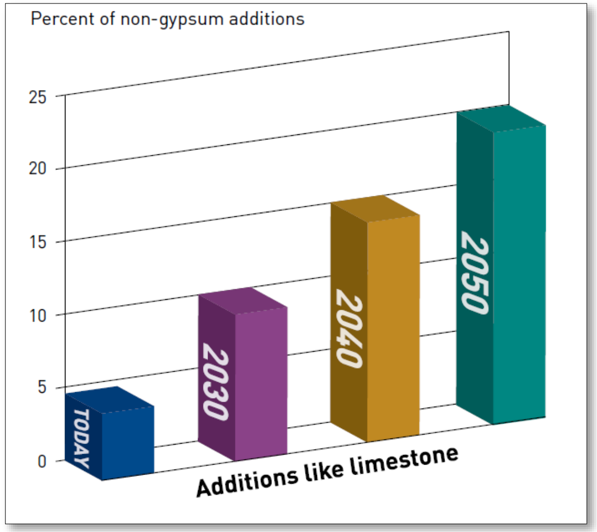
- Energy Consumed by CCUS
- Energy Delivered by On-site Power Generation
- Energy from Renewable Sources

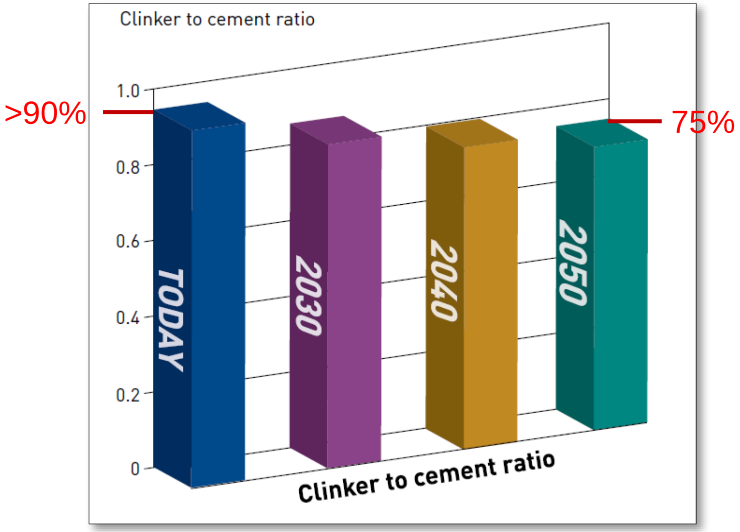
CEMENT

The binder

OPTIMIZING CEMENT

- Right sizing the amount of clinker in cement
- Using more non-gypsum additions
- Choosing the right cement specification for specific application





CEMENT STANDARDS

- **ASTM C150** / AASHTO M 85
  - Types I, II, I/II, III, V
- **ASTM C1157**
  - "Performance" specification
  - Types GU, HE, MS, HS, MH, LH
- **ASTM C595** / AASHTO M 240
  - Types IP, IS, IL, IT

portland-limestone cement

- 1:1 replacement
- Same performance and workability
- Same dosages of SCMs
- Up to 10% carbon footprint reduction
- www.greenercement.com

EVOLVING CEMENT SPECIFICATIONS

Performance cements ASTM C1157 (1992)

Portland cements ASTM C150

Limestone (2004, 2007)

Inorganic processing additions (2009)

Blended cements ASTM C595

- Nomenclature (2006)
- Type IT (2009)
- **Type IL (2012)**

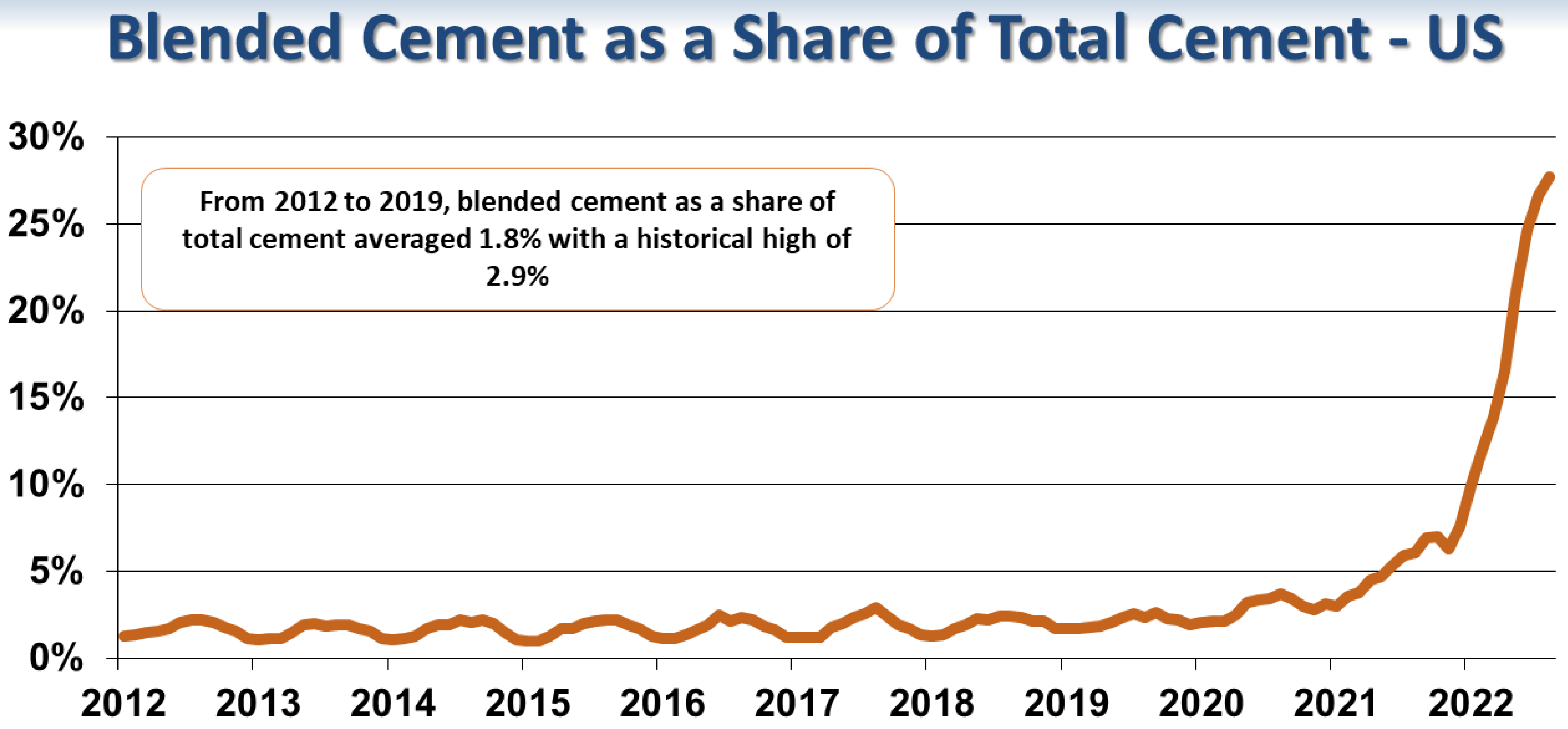
Industry-Wide EPDs for Cement

2016 and 2021 GWP results – cement footprints are getting smaller

11.3% reduction from 2016 to 2021

PLC is 8.3% lower than OPC in 2021

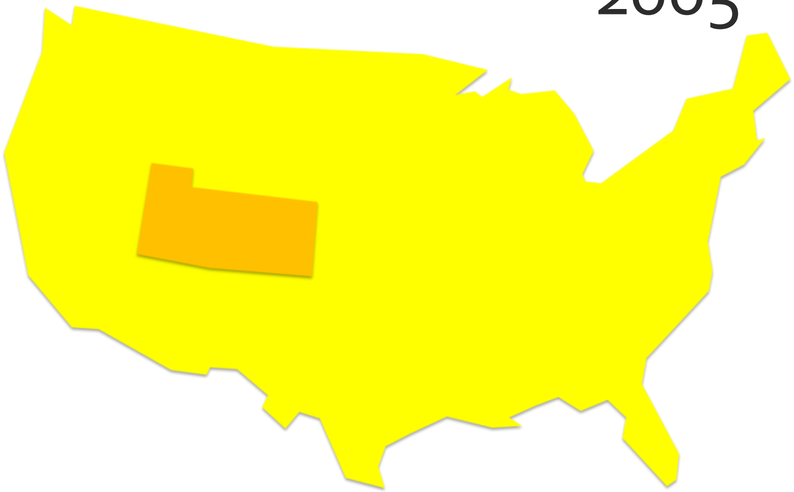
USE OF BLENDED CEMENTS IN U.S.



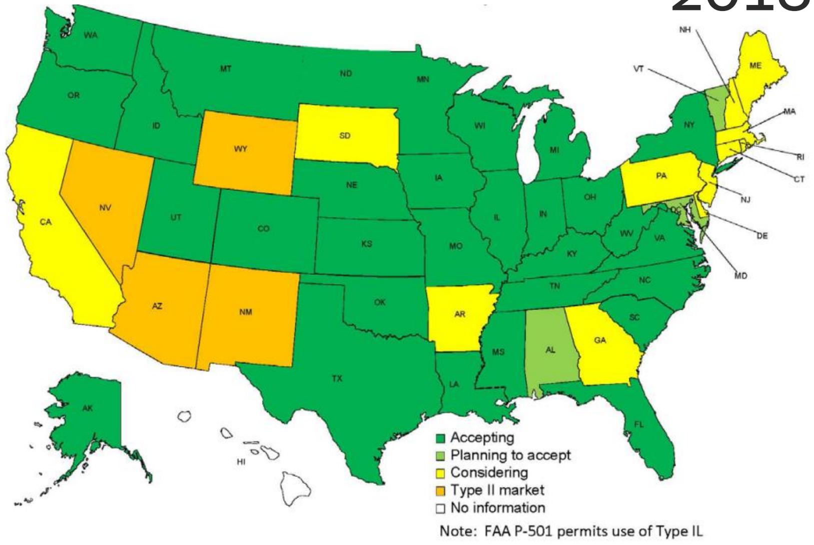
ACCEPTANCE OF PORTLAND LIMESTONE CEMENT (Type IL)

DOT Acceptance

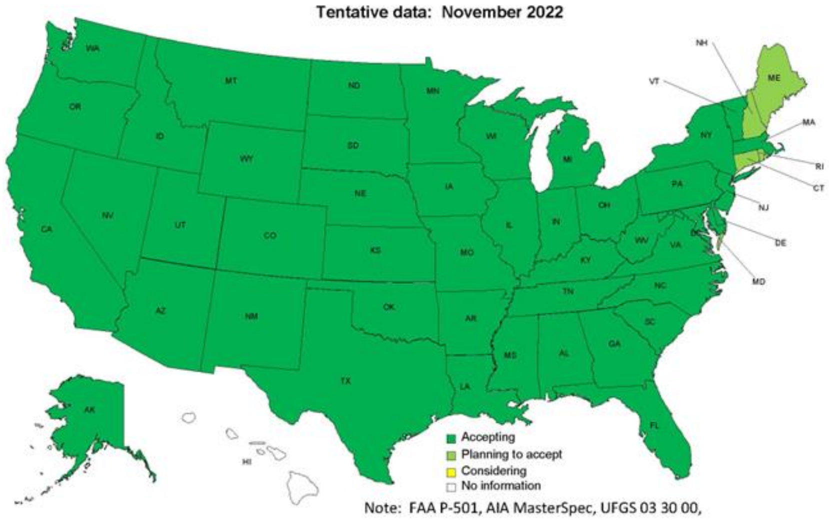
2005



2018



2022



PLC FOR SPECIAL PROPERTIES

CEMENT MODIFIERS

Sulfate resistance – MS, HS

- Sulfate-containing soils
- Sulfate-containing groundwaters

Heat of hydration – LH, MH

- For mass concrete placements

High-early strength – HE

- For precast concrete

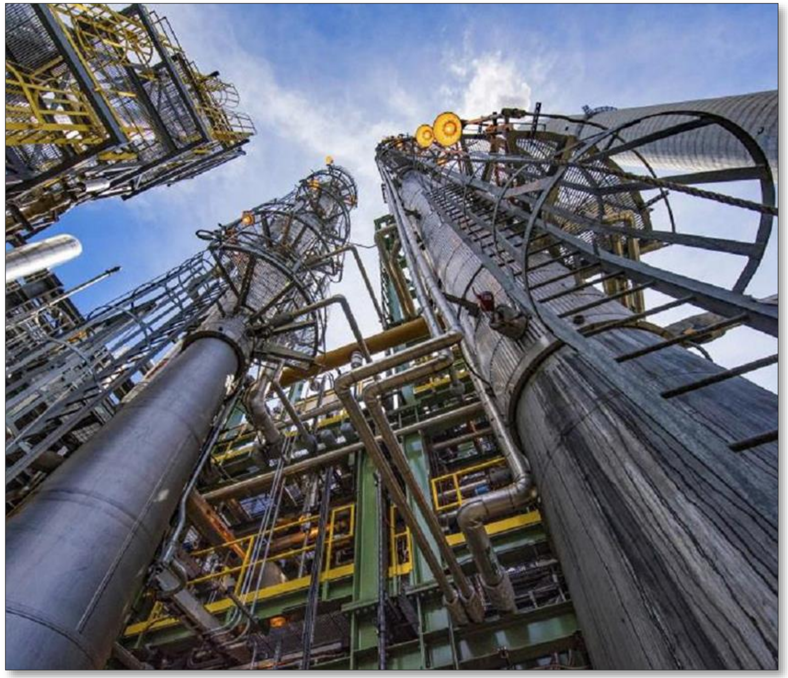
Cement type	OPC ASTMC150 (AASHTO M85)	PLC ASTMC595 (AASHTO M240)
General use	I	IL
Moderate sulfate resistance	II, II(MS)	IL(MS)
Moderate heat of hydration	II(MH)	IL(MH)
High sulfate resistance	V	IL(HS)
Low heat of hydration	IV	IL(LH)
High-early strength	III	IL(HE)

CONCRETE

Critically useful material to society

OPTIMIZING CONCRETE

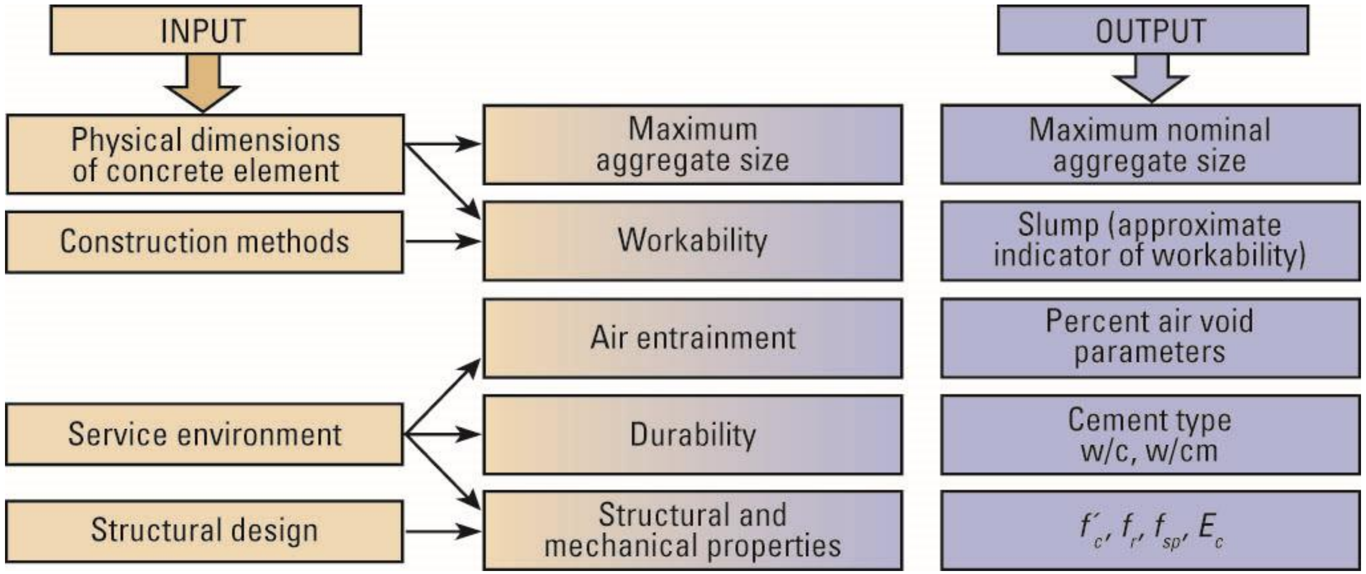
- Improvements in mix designs
- Increasing supplementary cementitious materials like slag, fly ash, silica fume, and other additives
- Reduced concrete plant energy consumption/reduced concrete delivery energy consumption
- Performance-engineered mixtures (PEM)
- Utilize Carbon Capture, Utilization, and Storage (CCUS) to avoid the release of CO_2 emissions



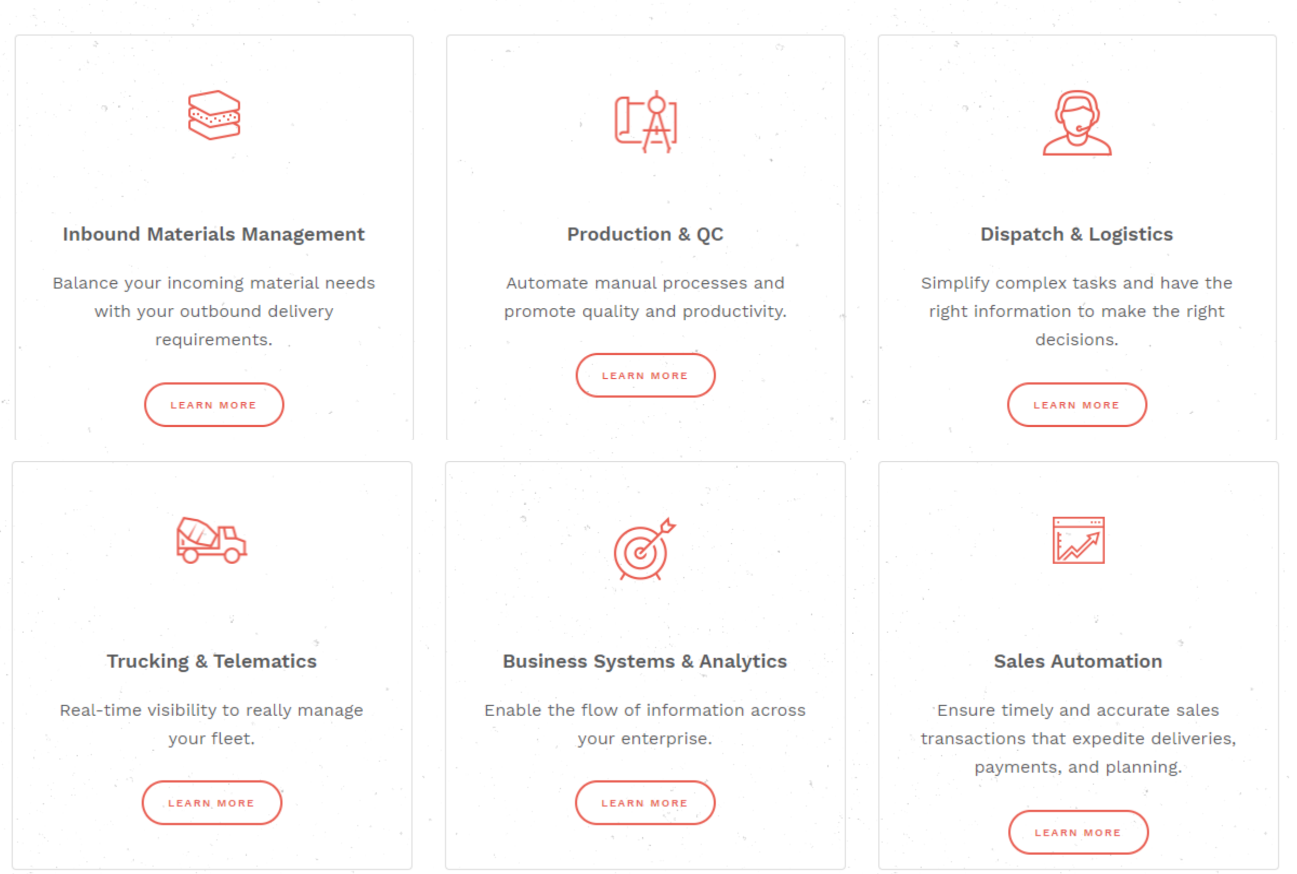
OPTIMIZING CONCRETE MIXTURES

- Shift from Prescriptive to Performance
- Incentivize Innovation
- Design Concrete Mixtures Intentionally for Each Application to Achieve Performance without Inherent Overdesign

Including Sustainability in Design Input

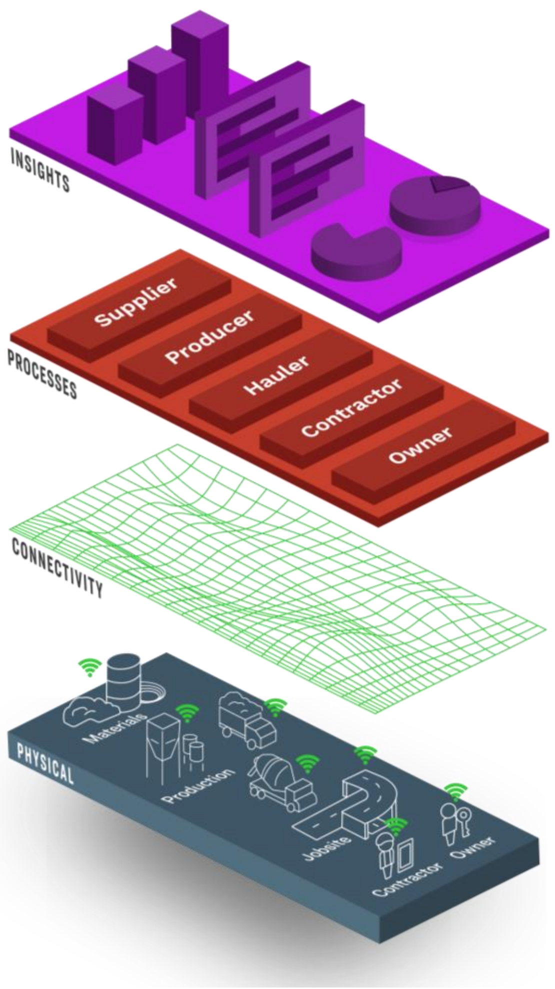


AUTOMATED SUPPLY CHAIN SYSTEMS



Command Alkon

connex

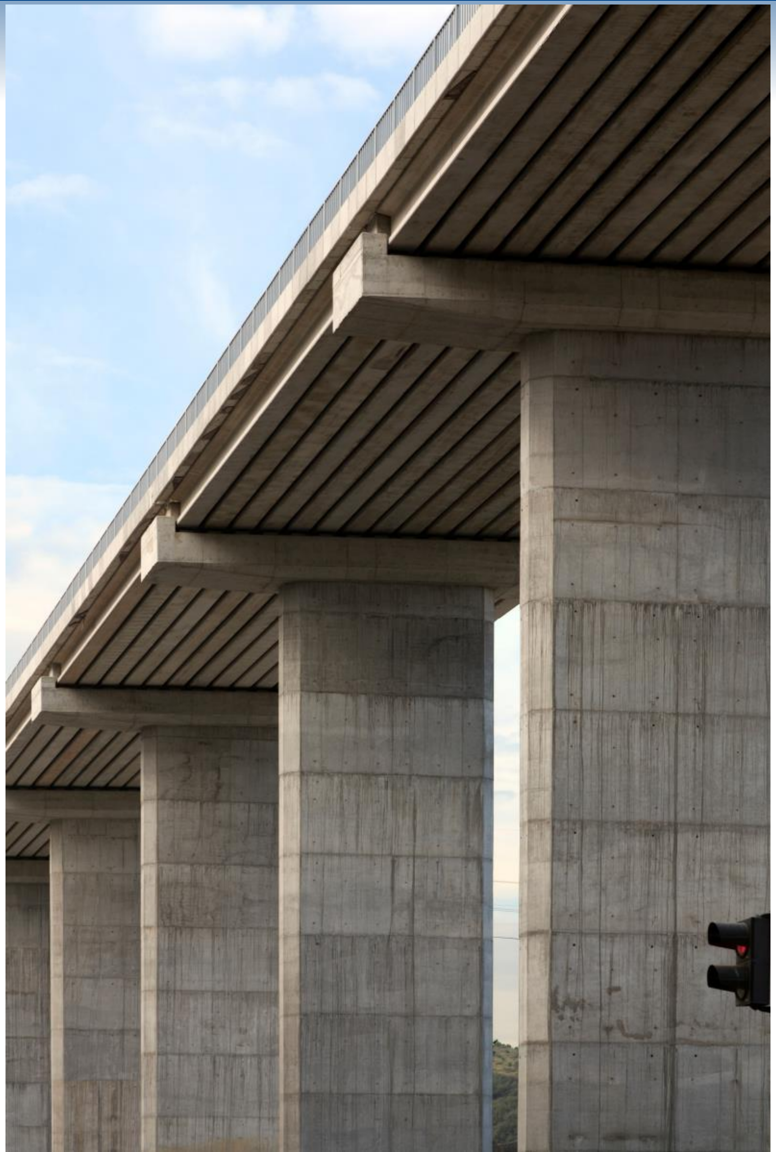


- Digitizes the supply chain and promotes collaboration with all partners.
- Systems help to achieve carbon neutrality goals by:
  - optimizing materials management and delivery and
  - providing real-time feedback on quality and productivity.
- Result is reduced waste and improved environmental performance.

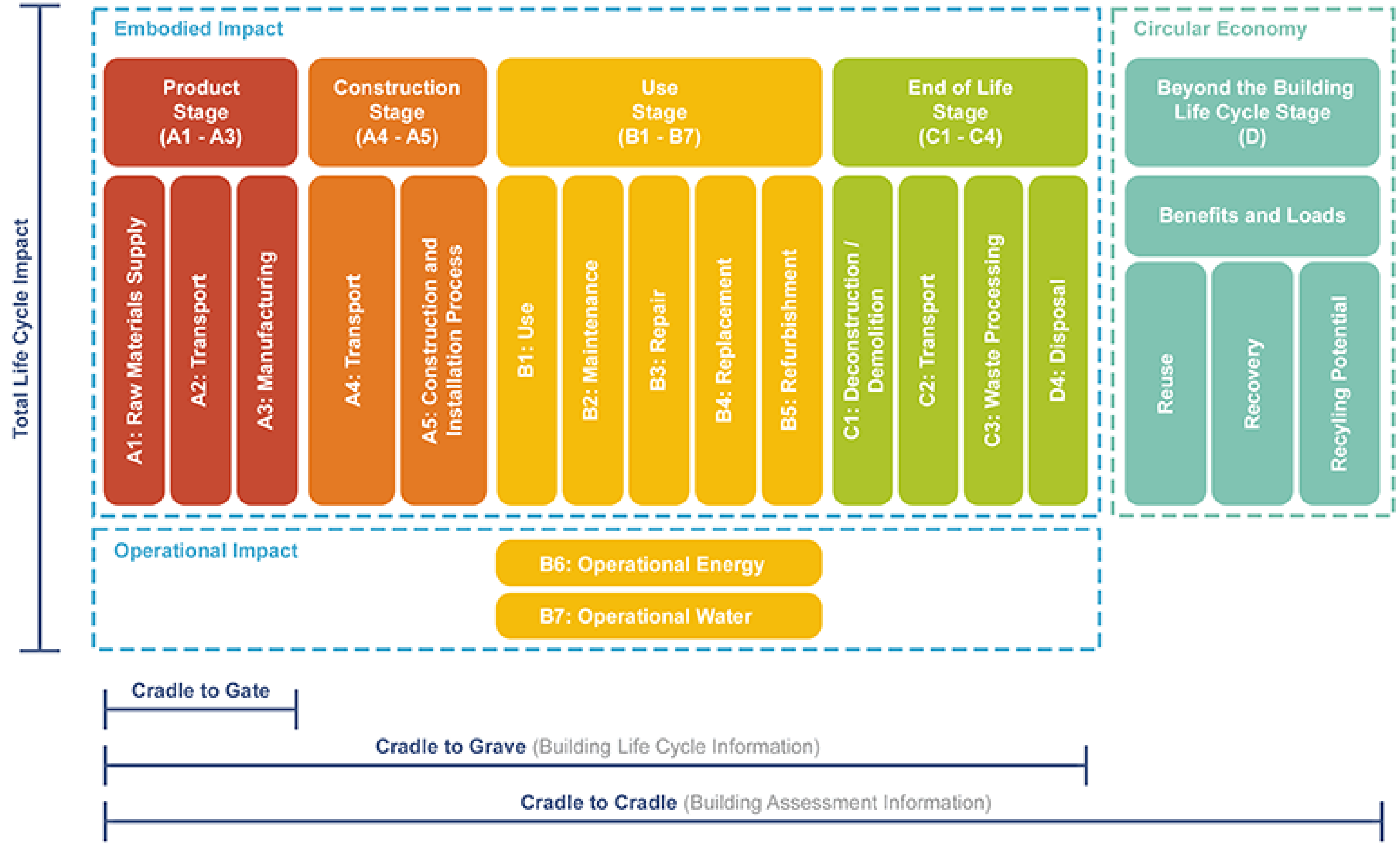
CONSTRUCTION

Service life / use phase impacts

START WITH THE END IN MIND

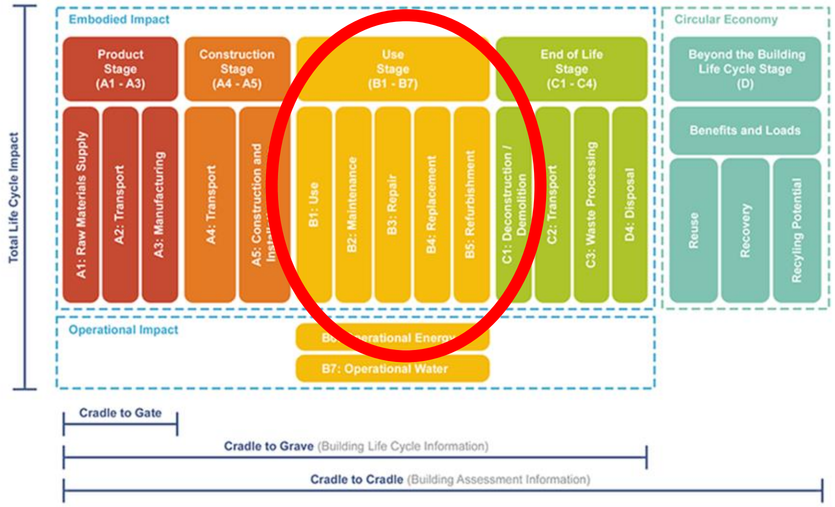


THE IMPORTANCE OF LIFE CYCLE



OPTIMIZING CONSTRUCTION

- Optimize and Avoid Overdesign
- Leverage Construction Technologies
- Incentivize Energy Efficient Buildings
- Design for Entire Service Life
- Decrease Repair, Maintenance



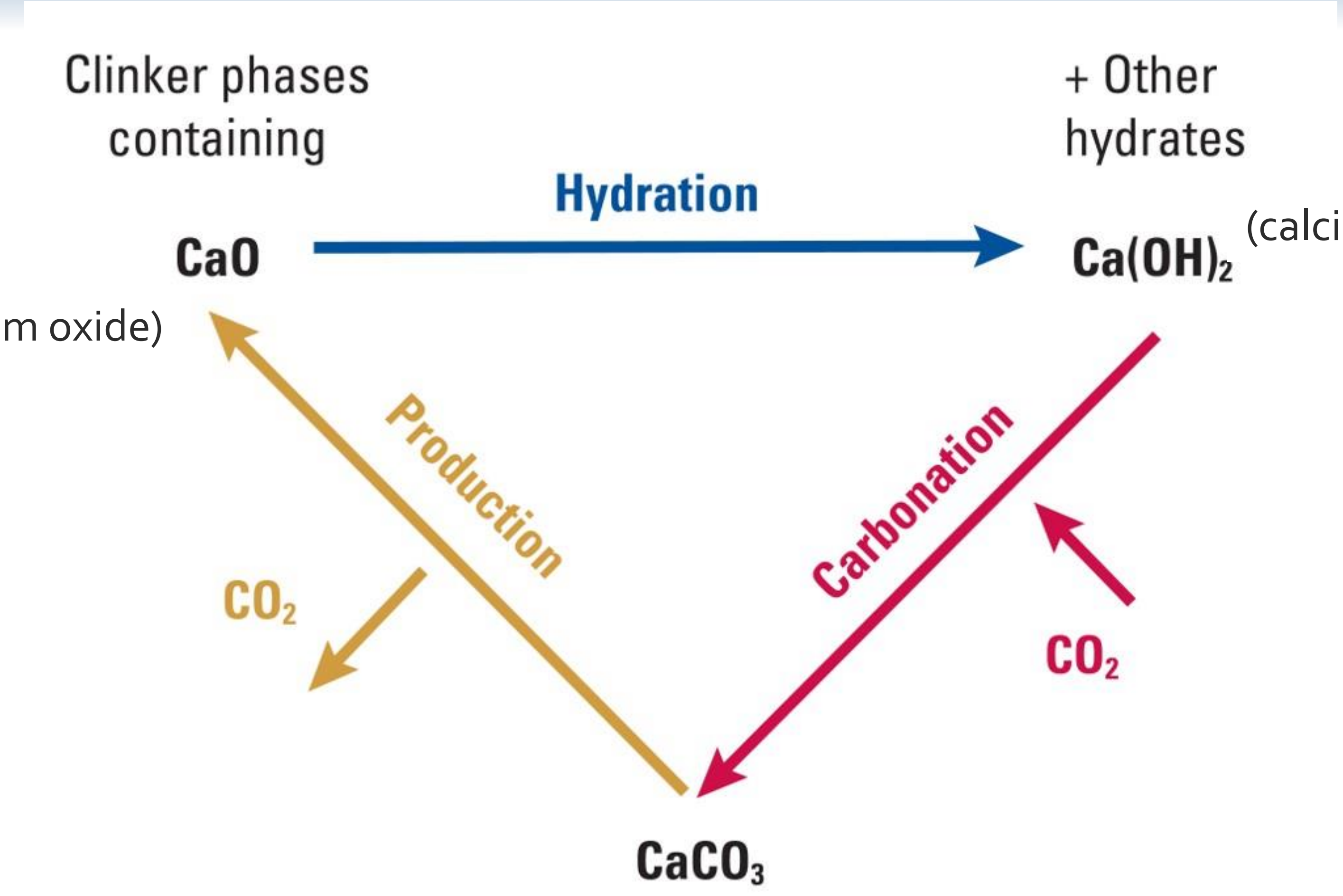
WAYS TO MINIMIZE CO_2 DURING CONSTRUCTION

- Source local materials to reduce transportation emissions
- Maximize the efficient planning of machinery
- Source carbon-neutral biofuels or renewable energy
- Install renewable energy on-site both during construction phase and operational stage
- Recycle and reuse materials

CARBONATION

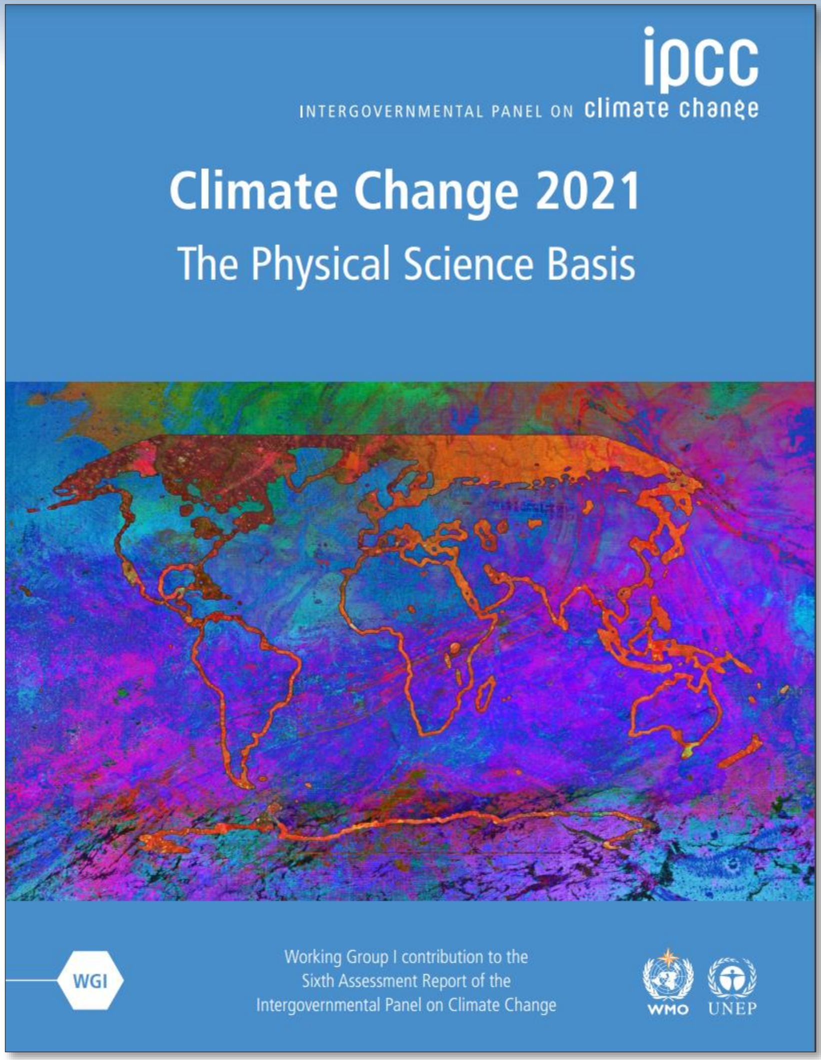
Concrete is a CO_2 sink

CONCRETE CARBONATES



Approximately 10% of cement and concrete production emissions can be reabsorbed and permanently sequestered

RECOGNITION OF CARBONATION



- Intergovernmental Panel on Climate Change (IPCC)
- The United Nations body for assessing the science related to climate change
- Research into carbonation now accepted as a Tier 1 measurement

TEN MAJOR POLICY NECESSITIES

- Research, Development & Innovation
- Regulations, Permitting & Guidance
- Financial Incentives & Support
- Performance-Based Material Standards
- Market-Based Carbon Pricing
- Market Acceptance
- Community Acceptance
- Cradle to Cradle Life Cycle-Based Procurement
- Low-Carbon Infrastructure
- Level Playing Field

NEAR AND LONG-TERM SOLUTIONS

NEAR-TERM

Replace raw materials with recycled materials

Produce low-carbon cement blends

Optimize designs for the lowest life cycle emissions

MID-TERM

Increase the use of alternative fuels

Use renewable energy

LONG-TERM

Carbon capture

Introduce new cement blends

OUR PROGRESS

CLINKER
Key chemically reactive ingredient

- CCUS Studies and Pilot Projects
- Input/Review of DoE Decarbonization Roadmap and Carbon Capture Cost Analysis
- PCA and PCA Member company Energy Star Awards
- Continuing energy efficiency improvements

CEMENT
The binder

- More than 35% of all cements consumed in the U.S. are now lower carbon cements including portland limestone cements and blended cements, up from less than 5% just two years ago

CONCRETE
Critically useful material to society

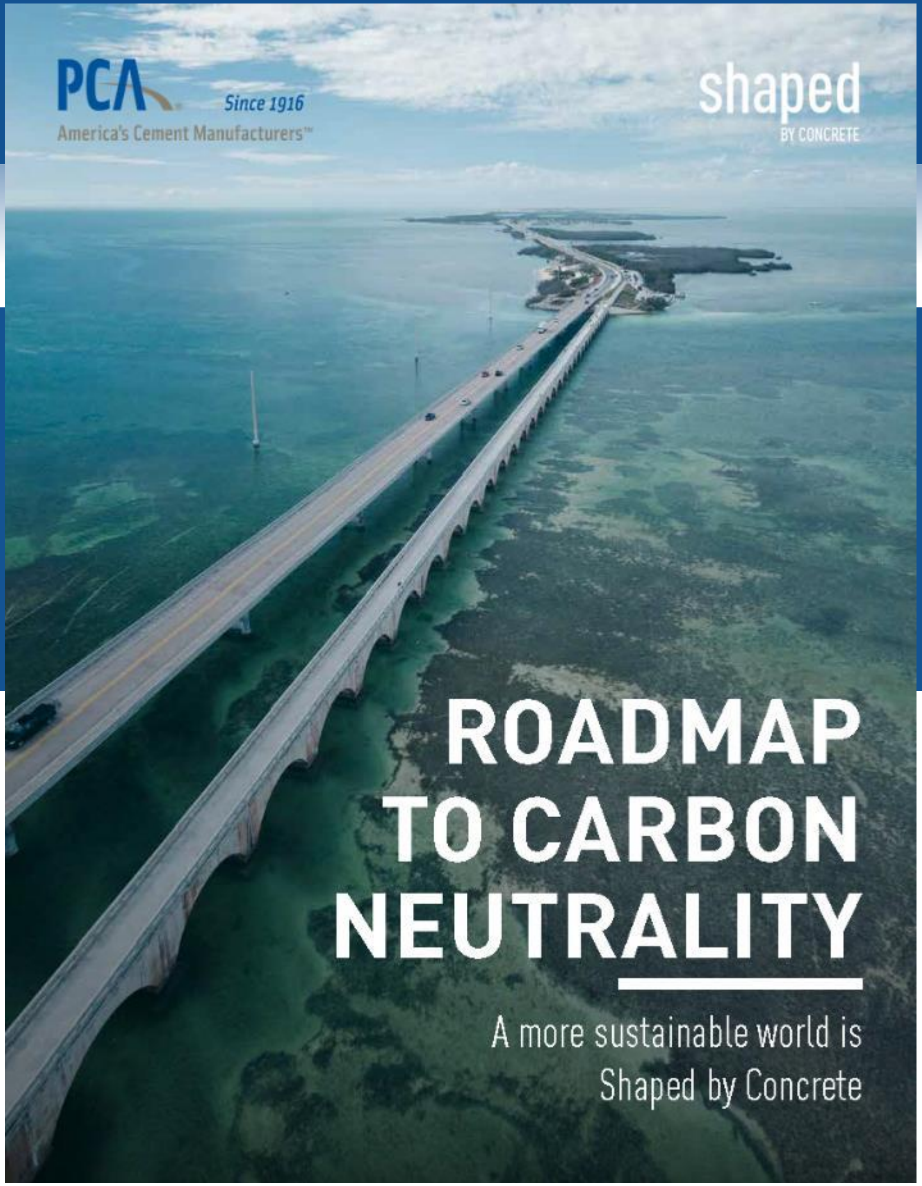
- More than 80,000 EPDs in US for Ready Mixed Concrete available with the vast majority produced in the last two years alone
- GSA Low-Embodied Carbon Concrete specification
- Ad-hoc group developing voluntary guidance for low-carbon cement and concrete
- NRMCA Green-Star Plant Certification

CONSTRUCTION
Service life / use phase impacts

- BuildingGreen.com "The Contractor's Commitment"
- Completed research into overdesign by Pankow Foundation to drive proposed building code change

CARBONATION
Concrete is a CO_2 sink

- IPCC recognition that concrete permanently sequesters CO_2
- PCA and NRMCA participating in NIST Low Carbon Cements and Concretes Consortium
- MIT preliminary results indicate up to 4 Mton per year of CO_2 sequestration in buildings alone.



Available At:

cement.org/sustainability/roadmap-to-carbon-neutrality

THANK YOU!

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Portland Cement Association

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