Sustainable Management of Dams with Greener Concrete

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Presented By: Joshua D. Gilman, P.E., Portland Cement Association

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Presenter

Joshua D. Gilman, P.E.
Manager, Water Resources & Geotechnical Support

PCA Since 1916
America's Cement Manufacturers™

jgilman@cement.org

Background

PCA Since 1916

America's Cement Manufacturers™

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.

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shaped BY CONCRETE

History of Concrete Dams in the U.S.

History of Concrete Dams in the U.S. (2)

1872 – 1st Cement Plant Built

1910 – Buffalo Bill Dam

1935 – Hoover Dam

1982 – Willow Creek Dam

2012 – San Vicente Dam

1904 – ACI Founded

1916 – PCA Founded

1941 – Grand Coulee Dam

2010 – Taum Sauk Reservoir

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History of CVC Dams in the U.S.

Dam Name	Year Completed	Dam Type	Height (feet)	Achievement
Buffalo Bill (formerly Shoshone)	1910	Arch	325	1st mass concrete dam in U.S.
Keokuk	1913	Buttress	53	When completed, was longest monolithic concrete dam in the world (7/8 miles long)
Arrowrock	1915	Gravity-arch	350	Tallest dam in the world until 1932
Elephant Butte	1916	Gravity	300	When completed, impounded largest reservoir in the world
Hoover	1935	Gravity-arch	726	Tallest concrete dam in U.S., 2nd tallest dam in U.S.
Grand Coulee	1941	Gravity	550	Largest concrete structure in U.S. (12 million cubic yards) and largest hydropower producer in U.S.

History of RCC Dams in the U.S.

Dam Name	Year Completed	Dam Type	Height (feet)	Achievement
Willow Creek	1982	Gravity	170	1st RCC dam built in U.S.
Olivenhain	2001	Gravity	306	2nd tallest RCC dam in U.S., fastest RCC placement rates achieved in U.S. (avg. 159,433 CY/month)
Taum Sauk Reservoir (replacement)	2010	Gravity	125	Largest RCC dam in U.S. (by volume of RCC)
San Vicente Raise	2012	Gravity	337	Raised existing dam 177 feet, tallest RCC dam in U.S.
Portugués	2013	Arch	220	1st RCC arch dam built in U.S. and U.S. territories
Gibson Pond	2021	Gravity	6	1st use of IVRCC in North America

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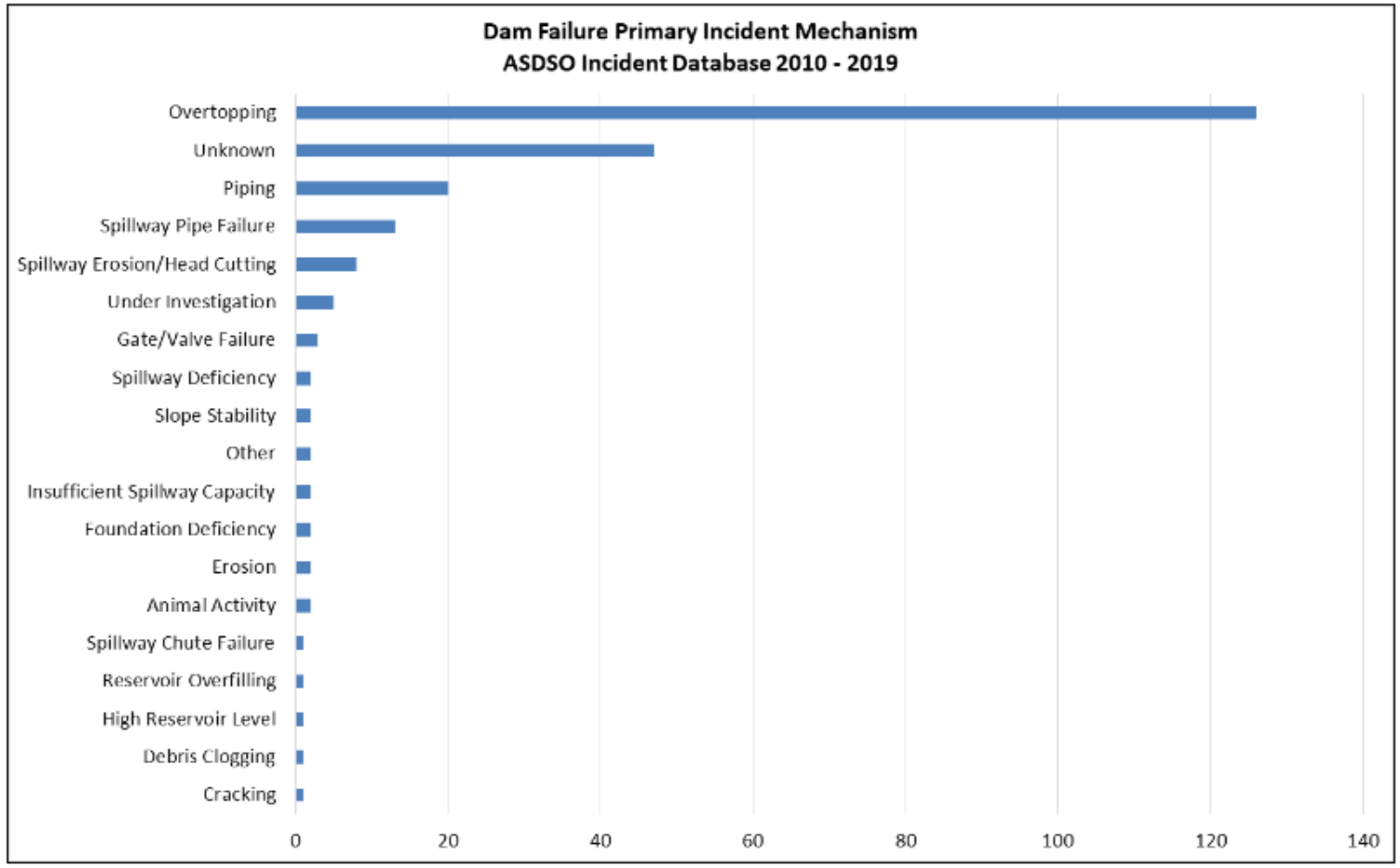
More Uses of Concrete for Dams

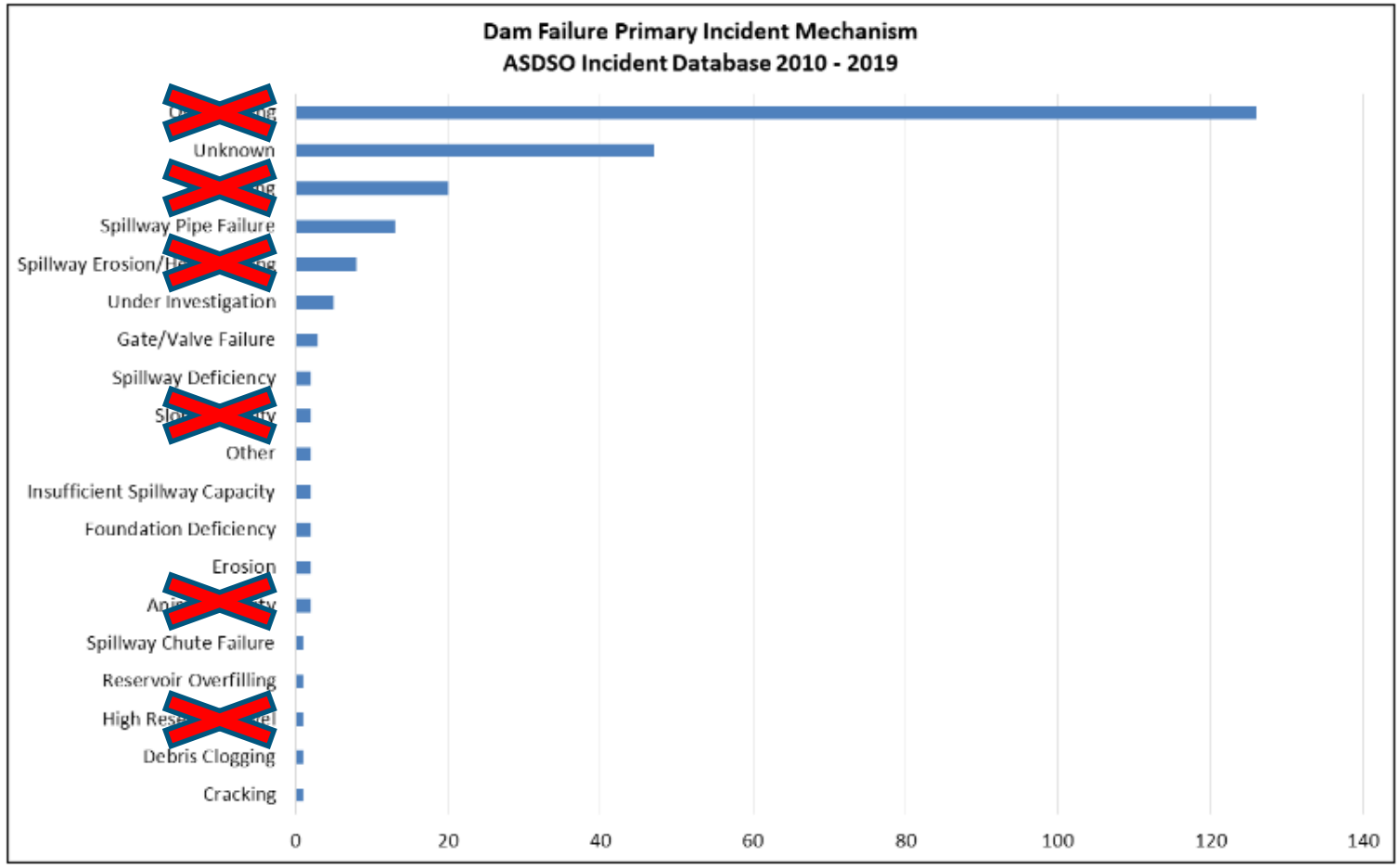
- New Construction
  - Gravity Dams (small to very large)
  - Arch and Buttress Dams
  - Spillway & Appurtenant Structures
  - Embankment Slope Protection
- Rehabilitation
  - Overtopping Protection
  - Raising Concrete Dams
  - Erosion Protection
  - Stability Improvement

Dam Failures



Source: ASDSO

Dam Failures (2)

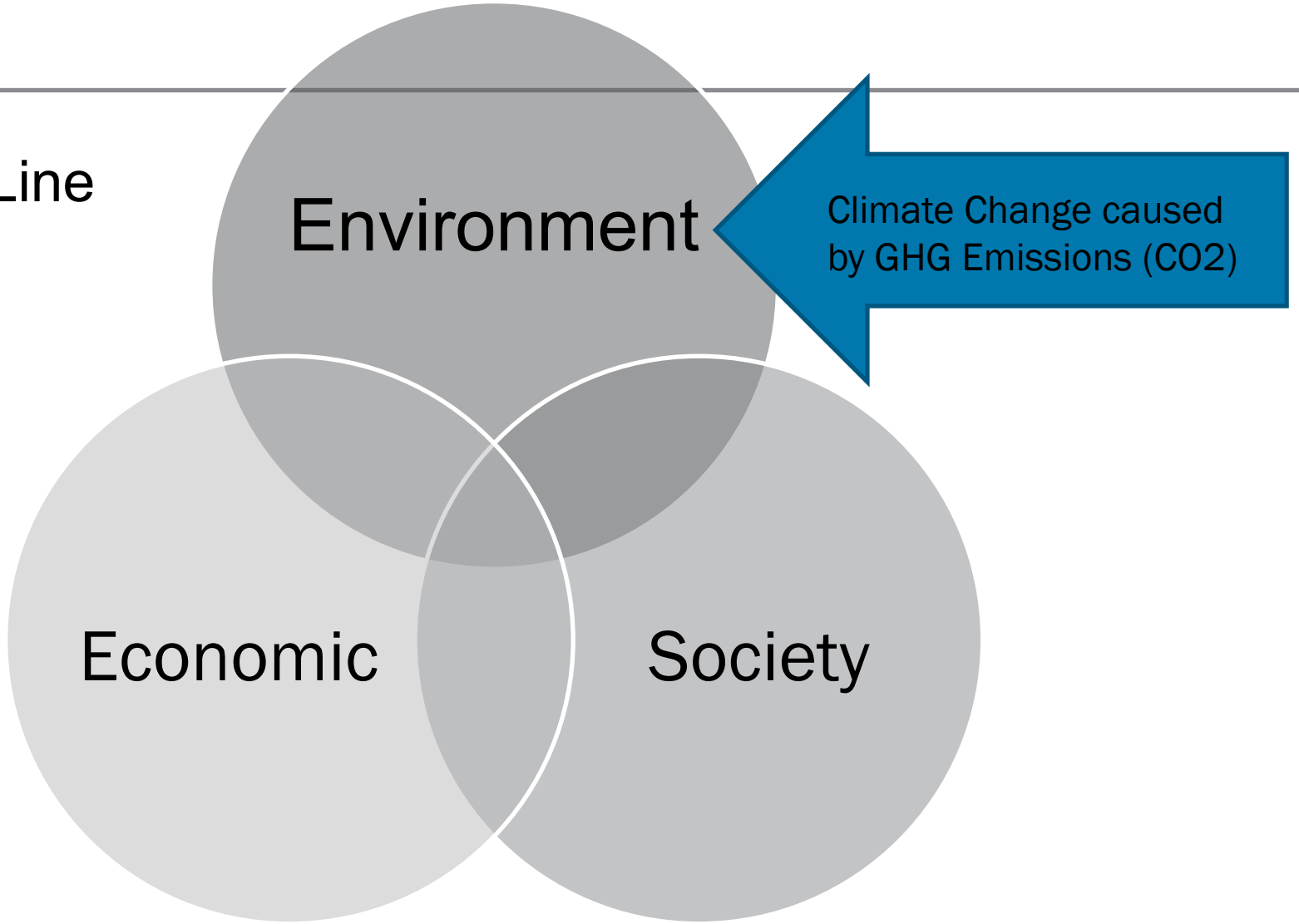


Source: ASDSO

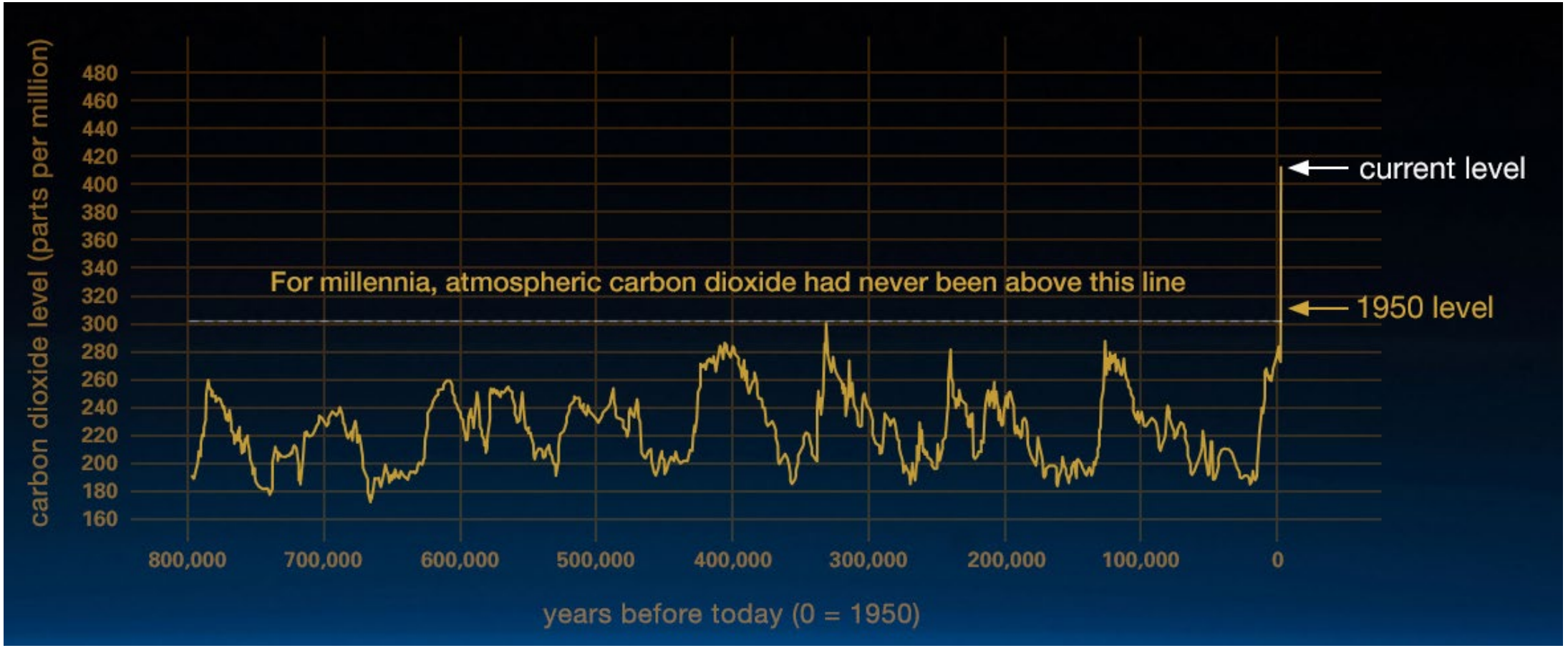
What Makes Concrete Sustainable?

Sustainability

- The Triple Bottom Line



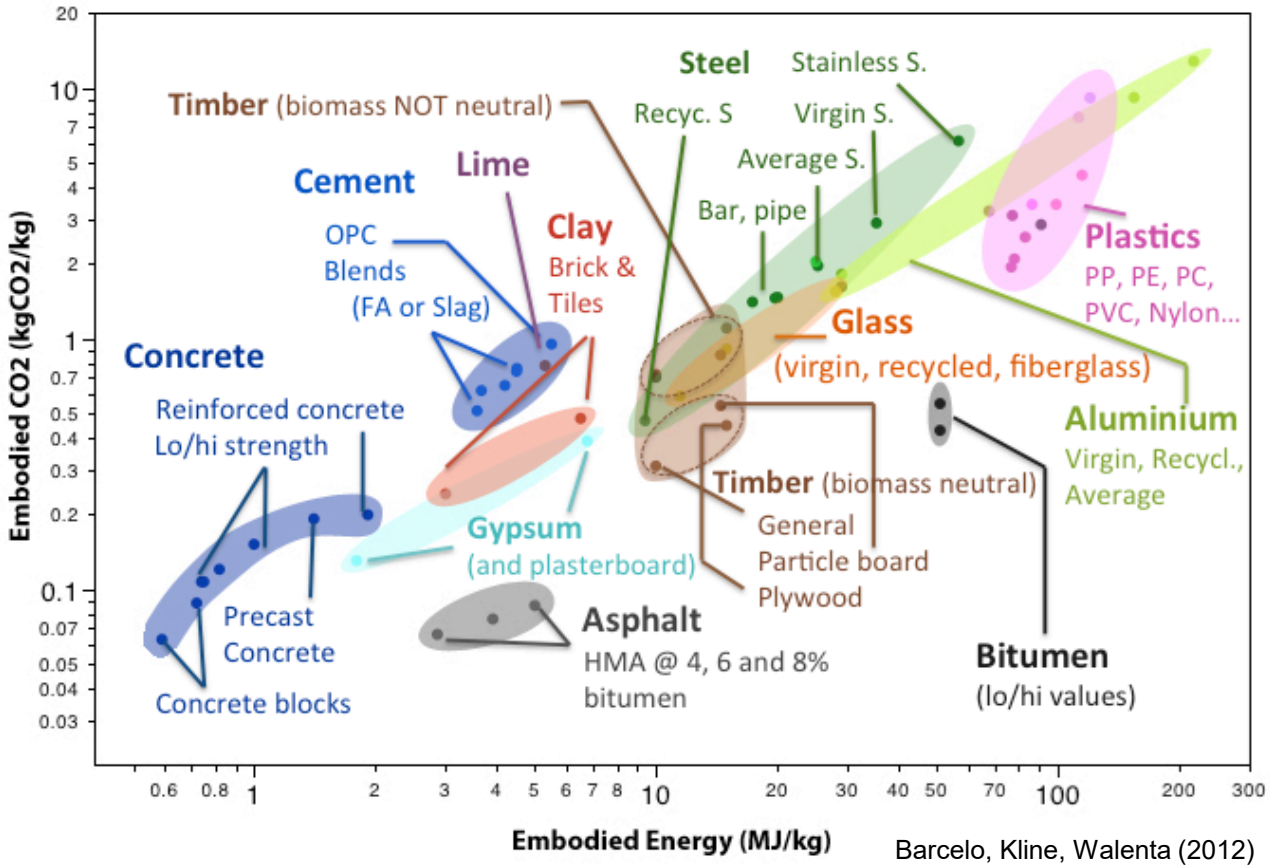
Sustainability (2)



Source: climate.nasa.gov

Concrete is Sustainable

- Misperceptions about cement and concrete
- CO2 footprint of cement production in US – 1.25% (U.S. EPA)
- Relatively low embodied energy and CO_2 by mass compared to other materials



Barcelo, Kline, Walenta (2012)

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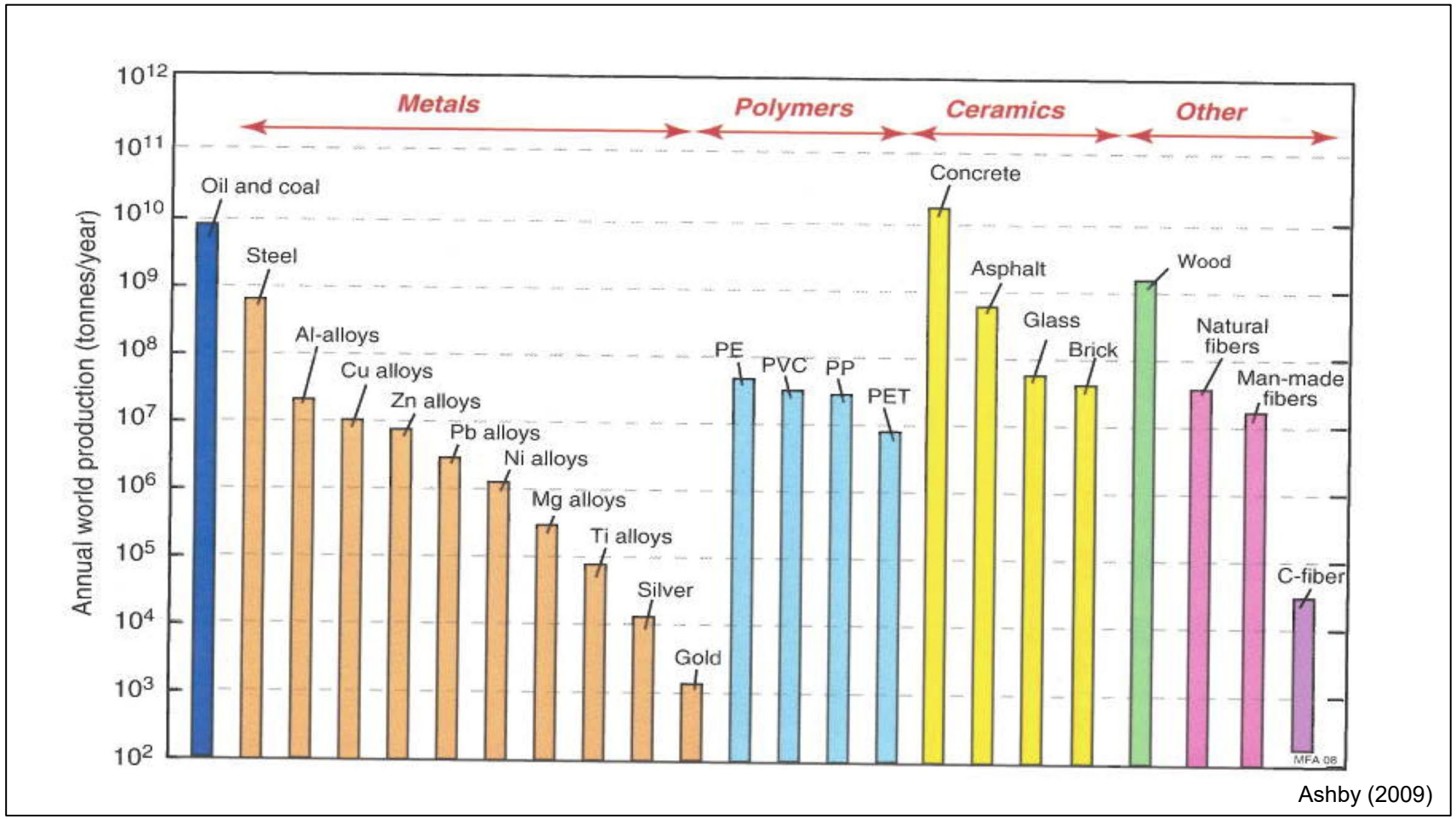
Society Uses a Lot of Concrete



Ashby (2009)

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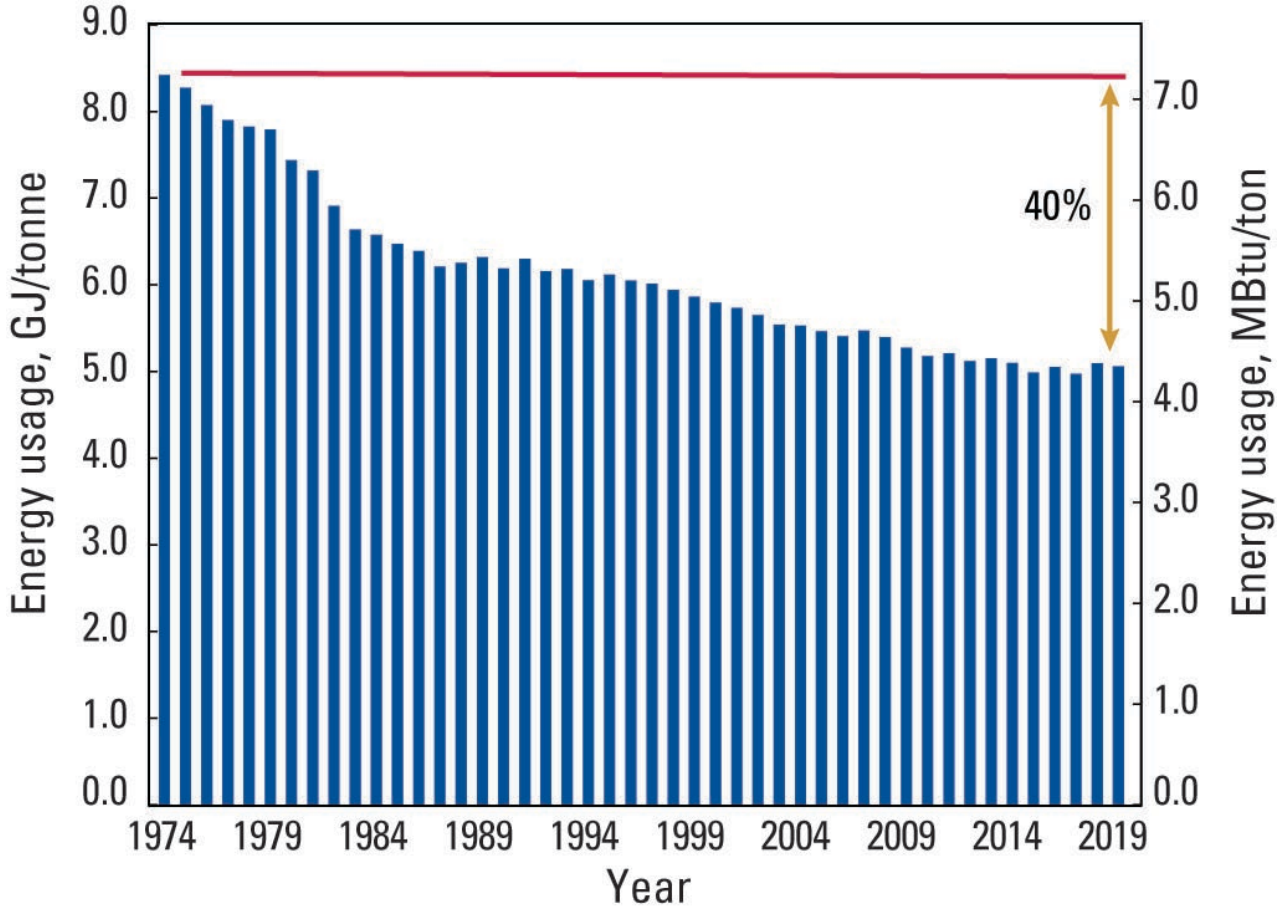
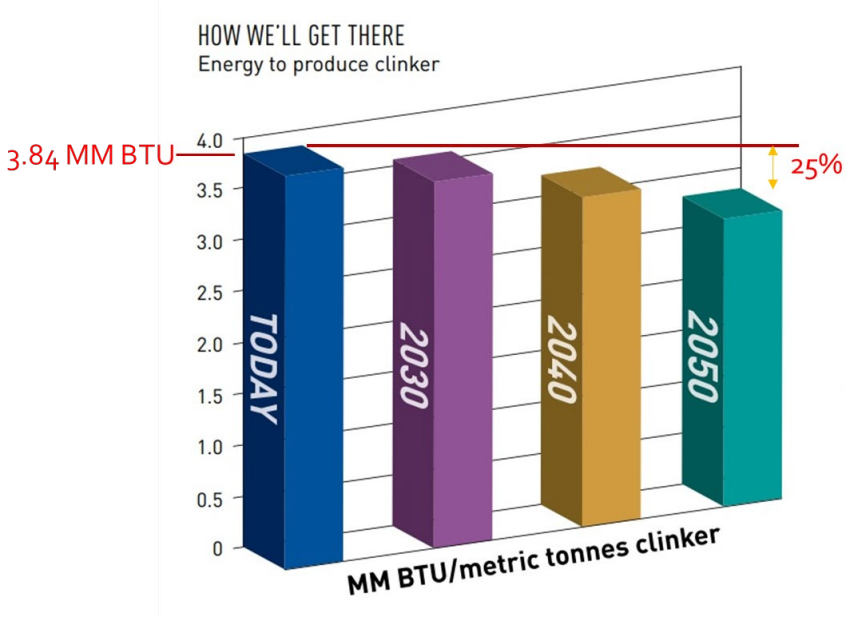
At the Cement Plant: Increasing Combustion Efficiency





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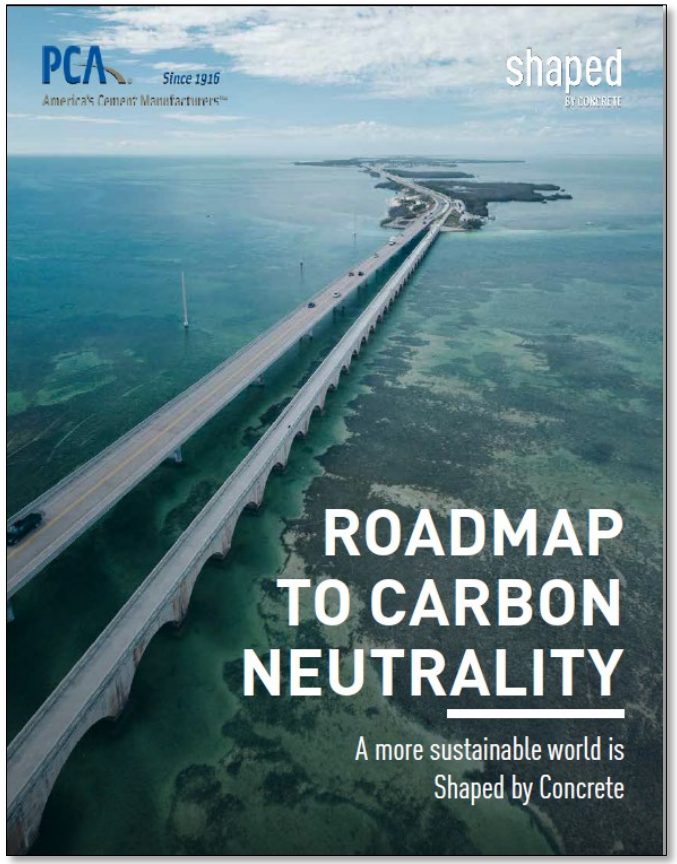
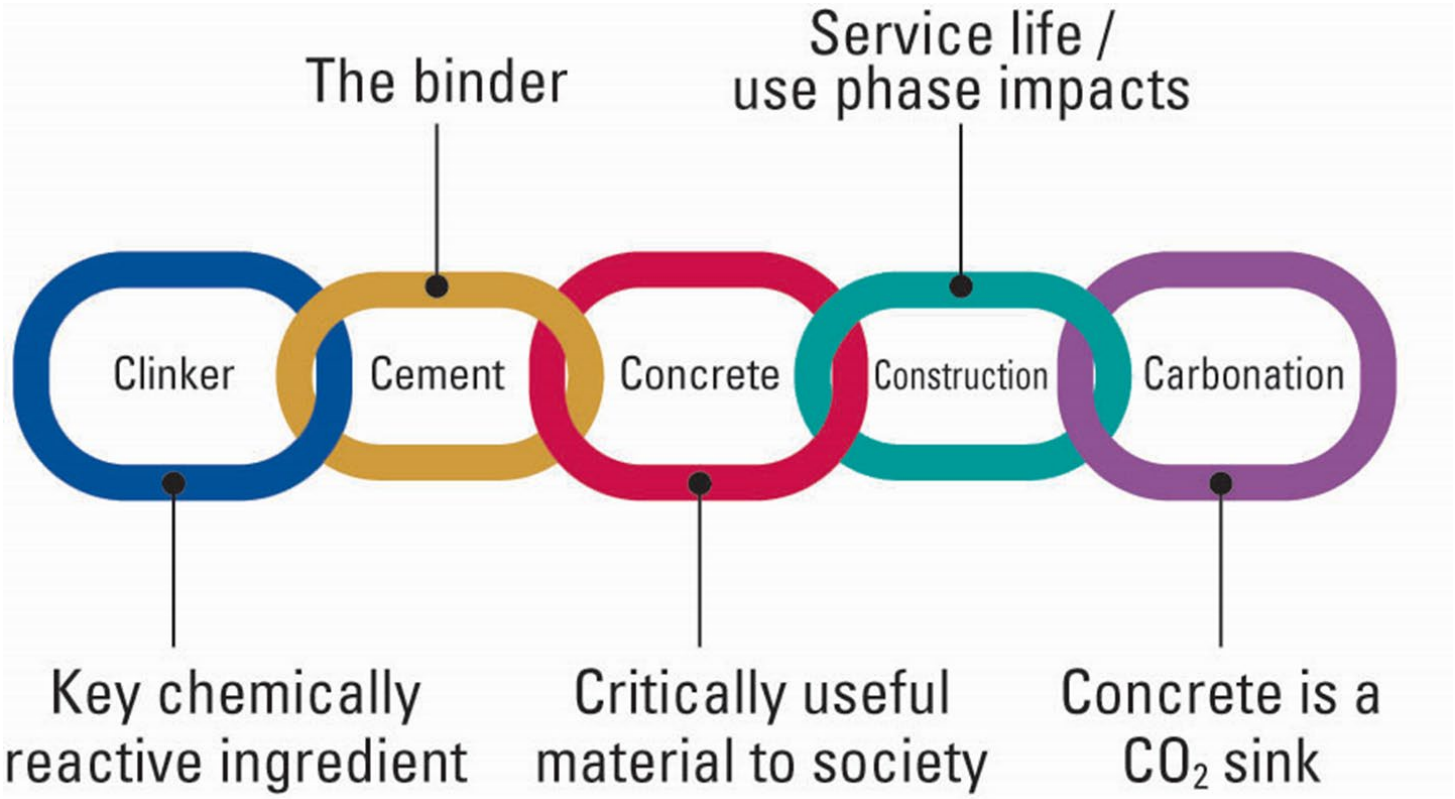
PCA Roadmap to Carbon Neutrality





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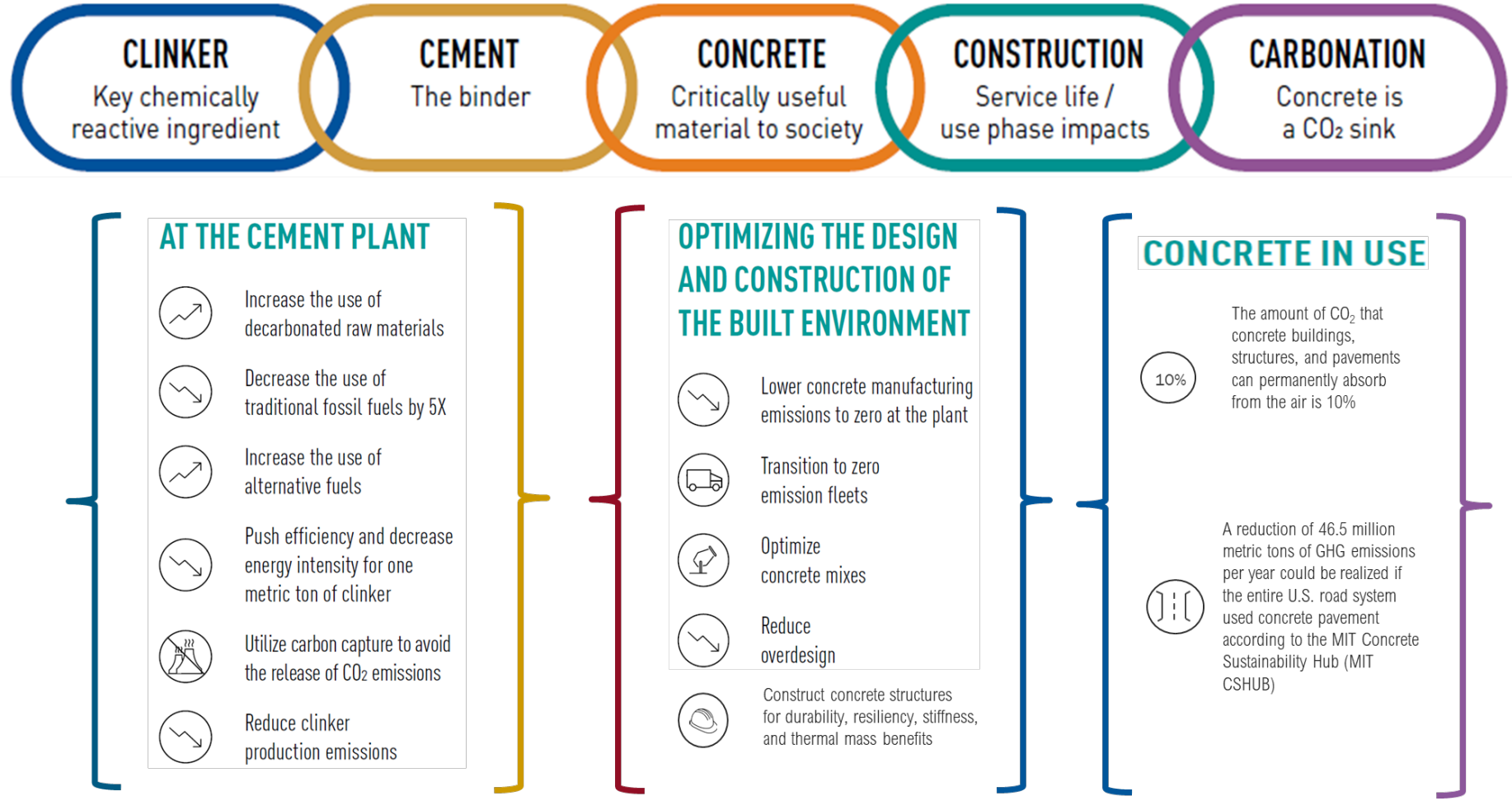
2050: Cement/Concrete Industry Achieves Carbon Neutrality



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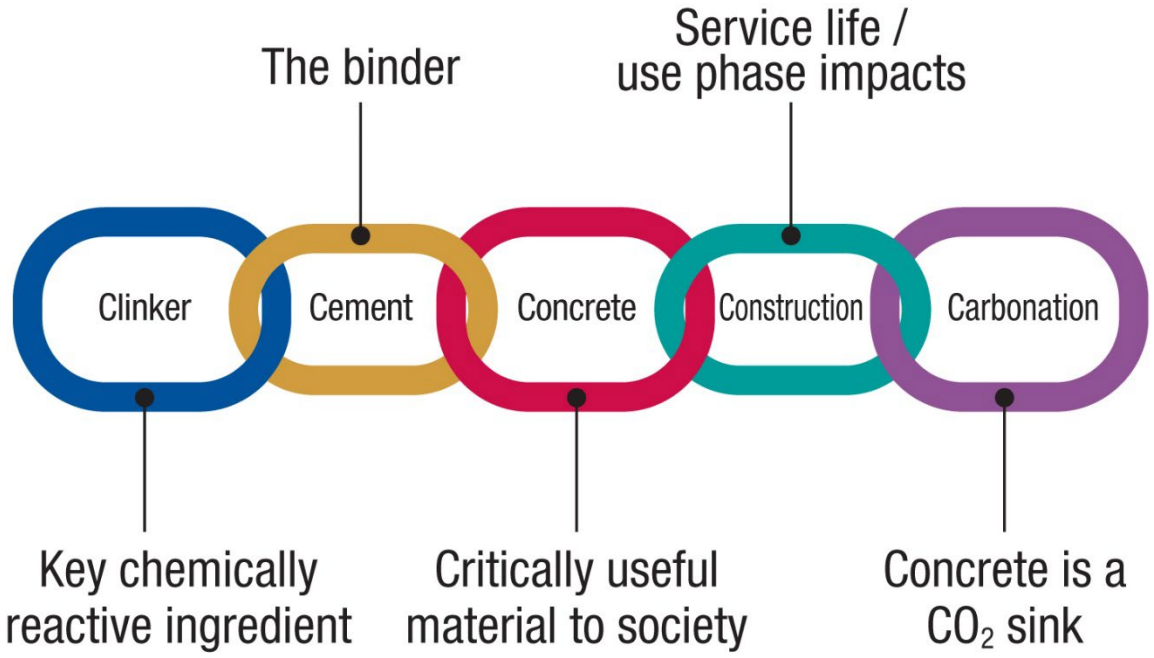
2050: Cement/Concrete Industry Achieves Carbon Neutrality (2)

- Clinker – better manufacturing, optimization, transformative tech
- Cement – improved formulations
- Concrete – better ingredients, more SCMs, more efficient design
- Construction – optimization in design, delivery, handling, zero waste
- Carbonation – quantify natural process



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Keys to Sustainable Dam Management with Greener Concrete

Roadmap Opportunities

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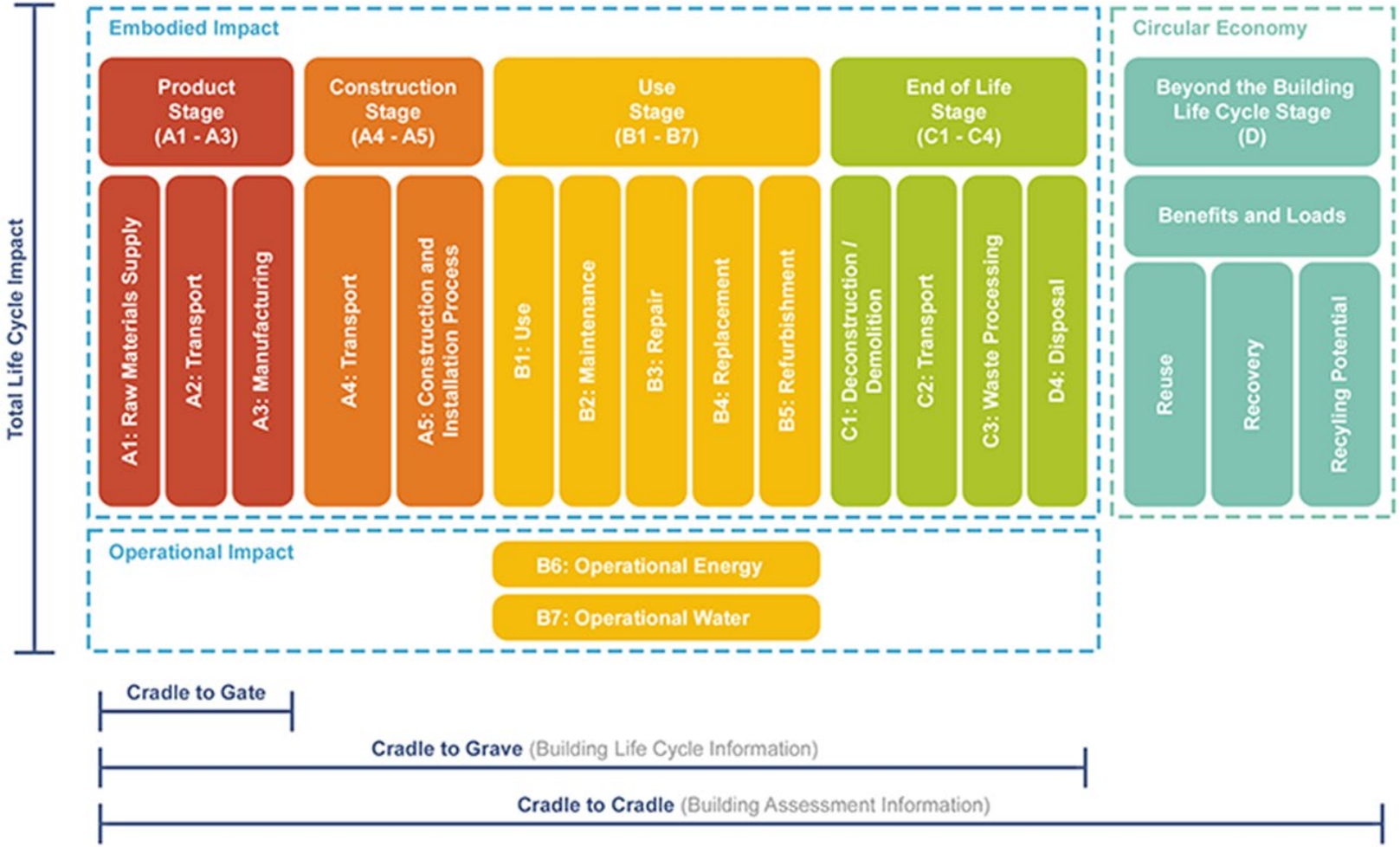
Start with the End in Mind

The Importance of Life Cycle Analysis



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U.S. Cement Standards

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

plc
portland-limestone cement

- 1:1 replacement
- Similar performance and workability
- Up to 10% carbon footprint reduction
- www.greenercement.com

What Makes Concrete Sustainable? (2)

- Durability
- Longevity
- Resilience
- Low Maintenance
- Carbonation
- Reuse, Recycle

Keys to Sustainable Dam Management with Greener Concrete

- "Start With the End In Mind"
  - Life Cycle Analysis
- Incentivize Innovation
  - Shift from Prescriptive to Performance Specs
  - Leverage Construction Technology (new RCC techniques)
- Design Optimization
  - Avoid Overdesign
  - Reduce/Reuse/Recycle
  - Long Service Life/Decrease Maintenance
- Choose Lower Carbon Materials
  - PLC and Other Blended Cements

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Questions?

Joshua D. Gilman, P.E.
Manager, Water Resources & Geotechnical Support
Portland Cement Association
jgilman@cement.org

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