U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Cement

Concrete

Research, Development, and Pilot Demonstrations for Industrial Decarbonization of the Cement & Concrete Sectors

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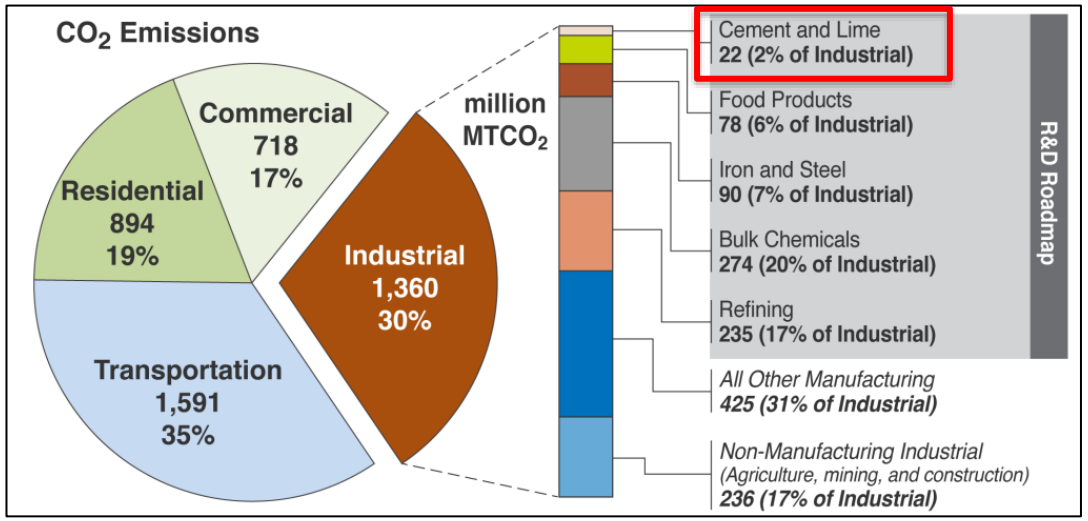
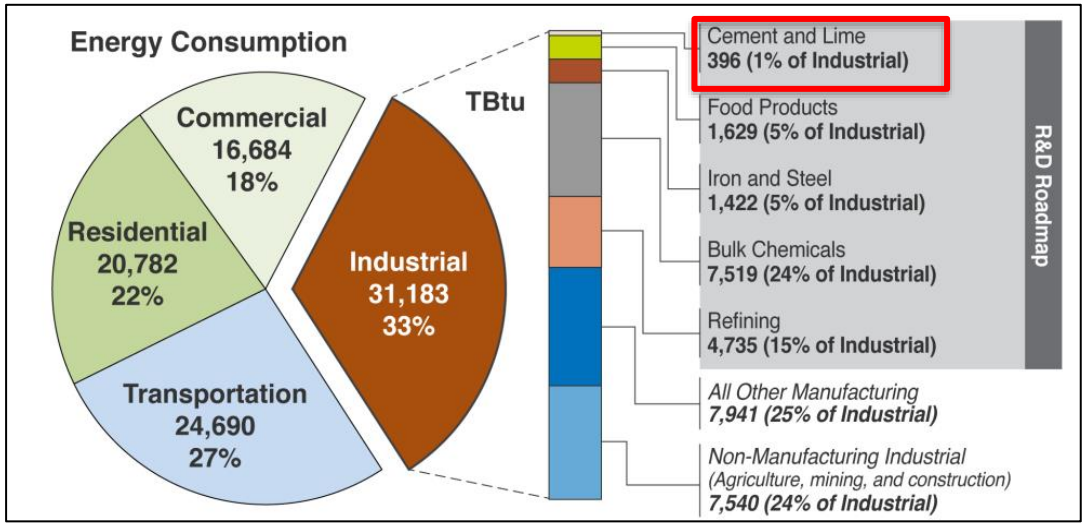
manufacturing.energy.gov

Cement and concrete subsector within EEII

- EEII focuses on **industry- specific RD&D** especially the **"hard-to-decarbonize"** ones. They are described as industries with the highest concentration of energy use and carbon emissions.

- The cement industry account for 2% of GHG emissions (process related), 1% of energy consumption and is part of a **complex value chain**

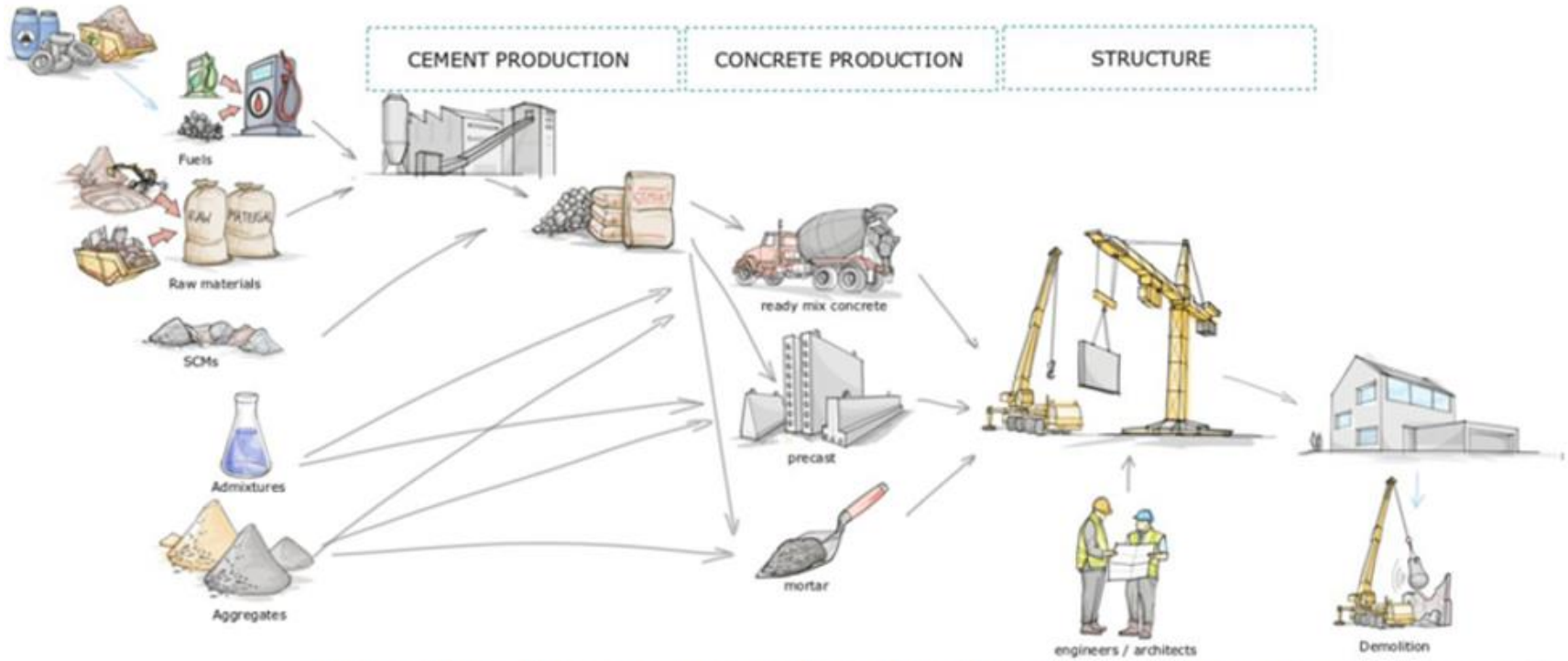




DOE Industrial Decarbonization Roadmap: https://www.energy.gov/eere/doe-industrial-decarbonization-roadmap

The building industry value chain

Concrete is the second-most used substance in the world after water!
The U.S. produces ~ 95 MMT of cement and ~394 million cubic yards (725 MMT) of ready-mixed concrete
Concrete is the final product, not the cement

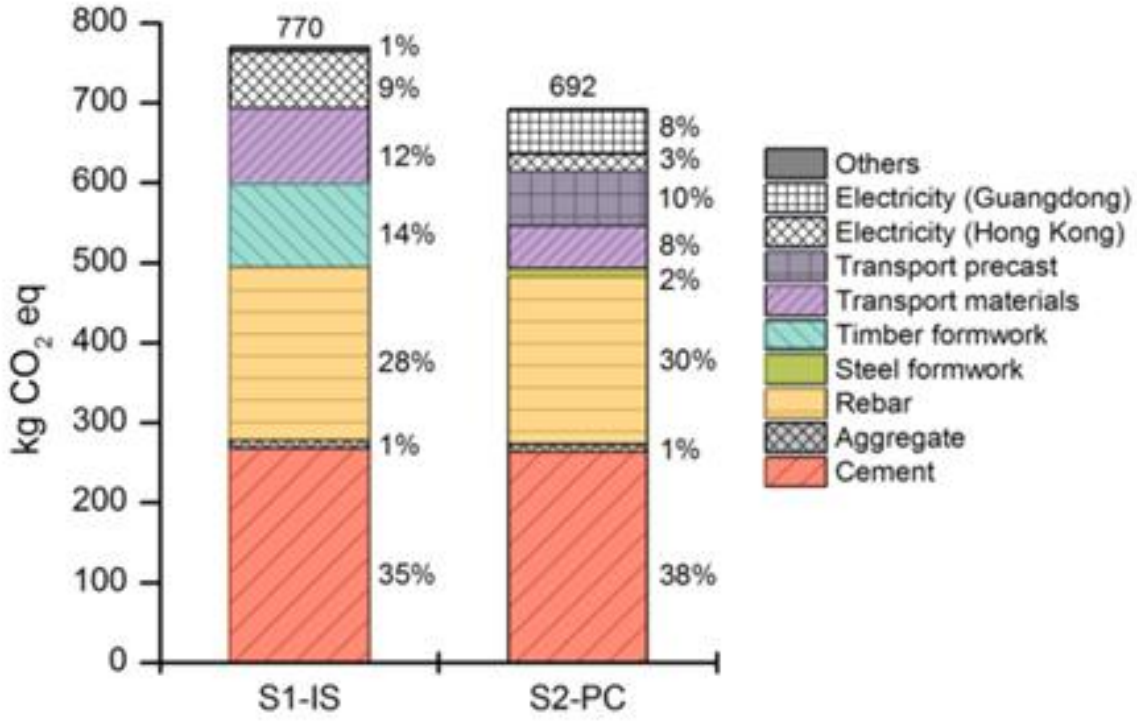


Value chain from raw materials to demolition in cement and concrete sector

- Complex concrete value chain **complex**
- Impact of downstream applications on cement use
  - Design, codes/standards, application type, use environment
- **Opportunities** for CO_2 savings along the value chain
  - Clinker substitutions, cement content, design, CO_2 use
- Opportunities for **end-of-life**
  - Recycling & CO_2 storage (mineralization)

Carbon emissions: cement contributions in concrete applications

- The most energy-intensive phase of the cement-concrete-end user value chain is at the **cement plant**!
- For reinforced concrete, manufactured **steel rebar is the second largest contributor**
- **Precast concrete can be greener by 10-25% than cast-in-situ concrete.**

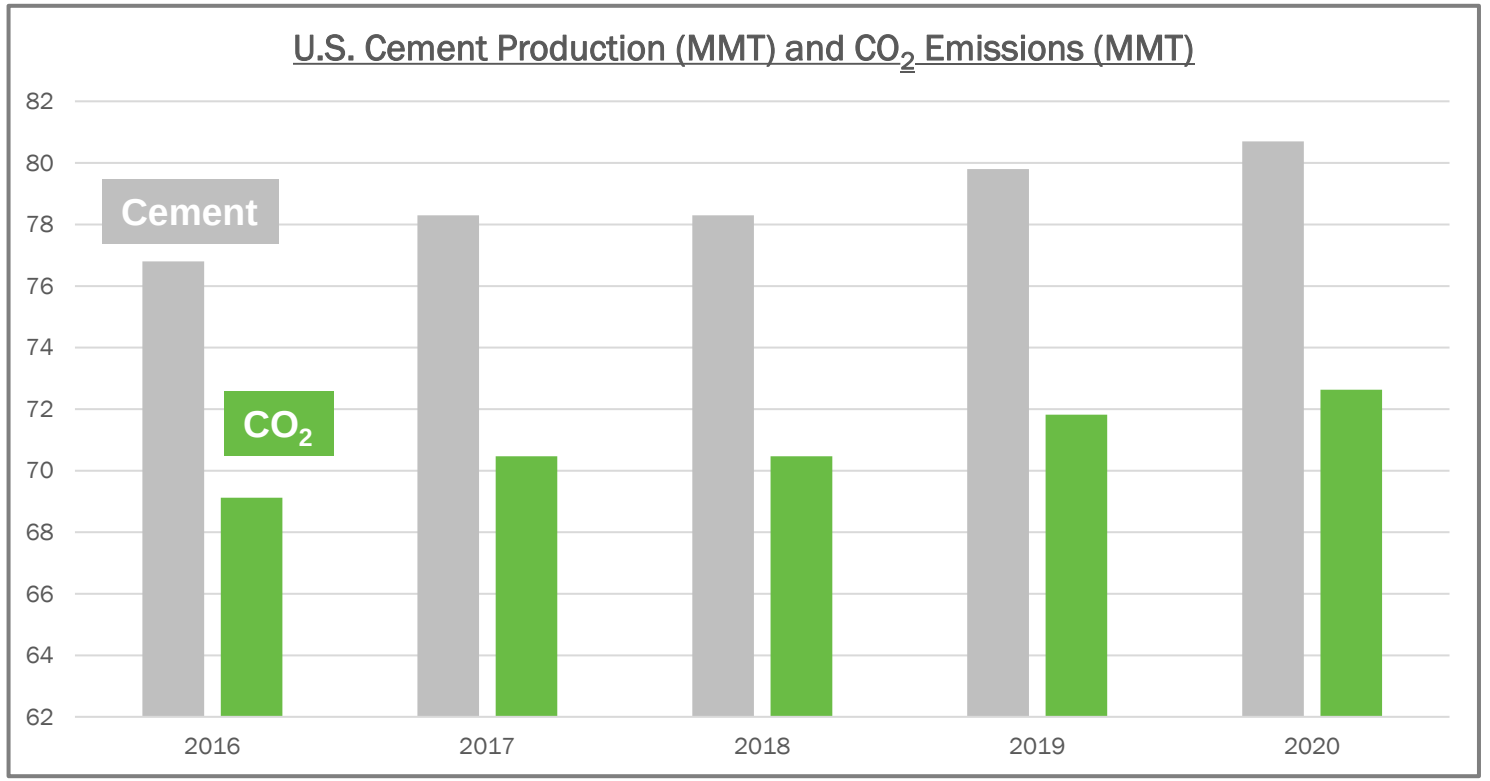


Carbon emissions of 1 m3 concrete
(IS: cast-in-situ concrete; PC: precast concrete).

10.1016/j.conbuildmat.2015.08.145
City University of Hong-Kong

U.S. Cement Industry CO_2 Emissions

In 2019:
~88 MMT cement produced[1]
~71 MMT of CO_2 emissions[2]



Production volume of Portland and masonry cement and associated CO_2 emissions in the United States from 2016 to 2020

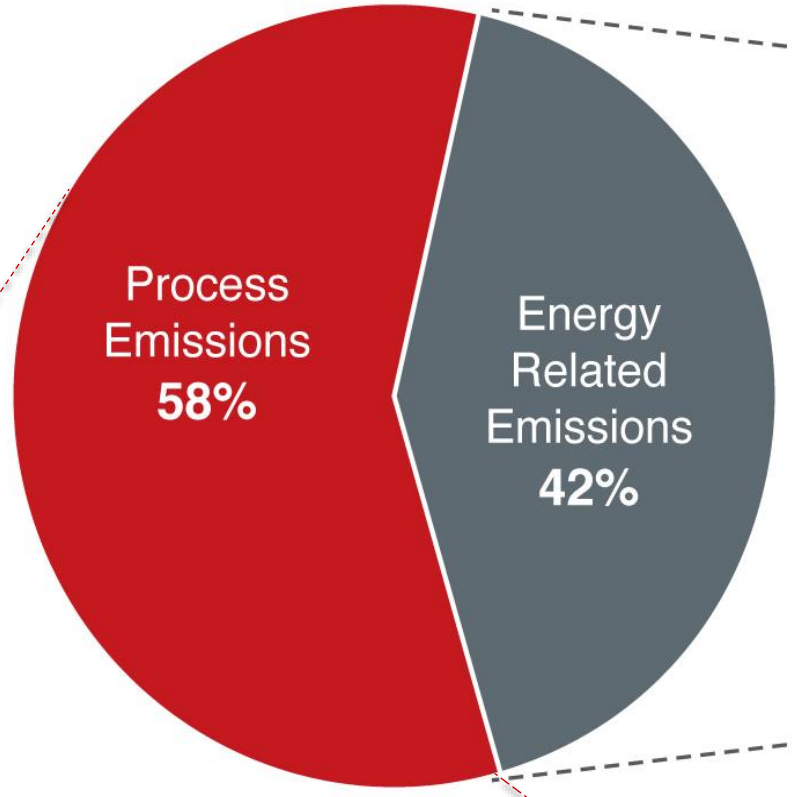
2019 Direct Carbon Intensities

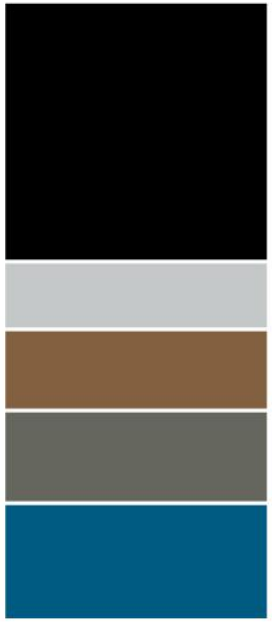
Quartile	Metric Ton CO_2 / Metric Ton of Clinker	Metric Ton CO_2 / Metric Ton of Cement	Carbon Intensity
75th percentile	0.787	0.722	Low
50th percentile (median)	0.838	0.776	Midpoint
25th percentile	0.934	0.886	High

For every 1 MT of cement, 0.8 - 0.9 MT of CO_2 is emitted.

[1]*Production volume source: https://pubs.usgs.gov/periodicals/mcs2023/mcs2023.pdf*
[2]*Carbon intensities derived from: https://www.epa.gov/system/files/documents/2021-10/cement-carbon-intensities-fact-sheet.pdf*

Sources of CO_2 Emissions in the U.S. cement industry





Coal, **12, 18%**

Natural Gas, **3, 4%**

Petroleum Coke, **4, 6%**

Tires/Waste, **4, 6%**

Electricity, **6, 8%**

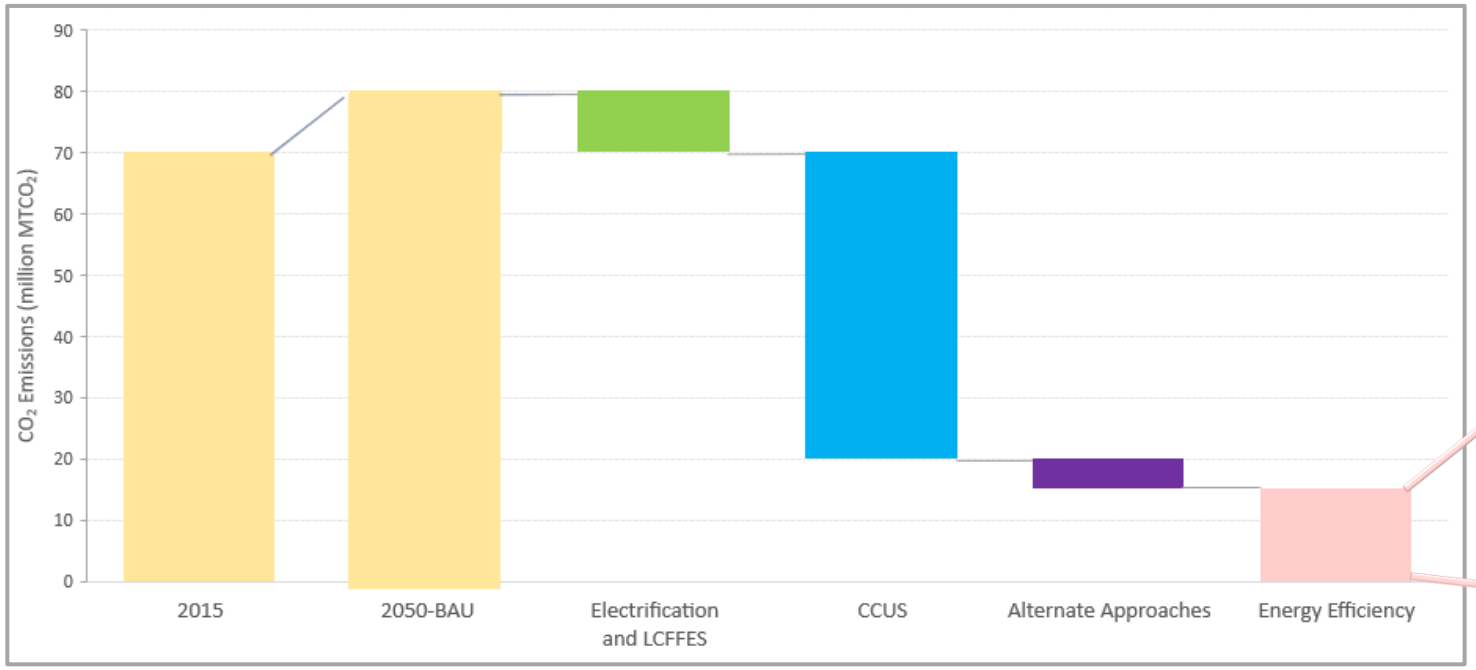
$$3\ CaCO_3 + SiO_2 \xrightarrow{\text{Heat}} Ca_3SiO_5 + 3\ CO_2$$

U.S. Department of Energy Industrial Decarbonization Roadmap, DOE/EE-2635, September 2022.

2050 Net Zero Pathway

- The Cement and concrete sector identified several **high-level decarbonization levers**

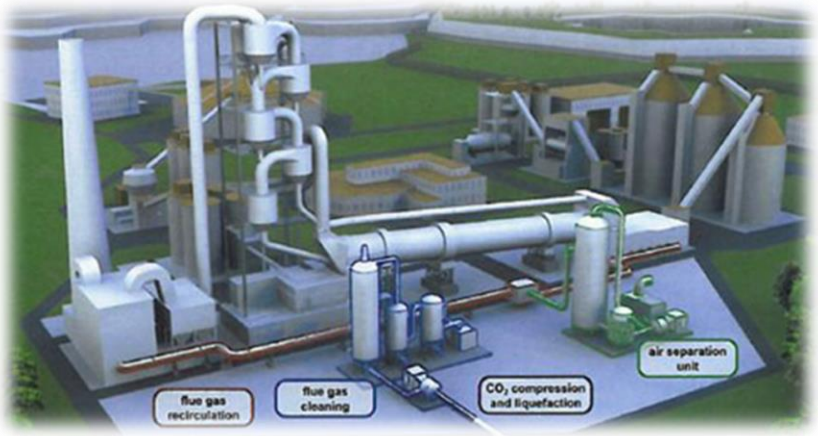
- Despite the lower benefits identified for alternative approaches in general, the **disaggregation** of that lever helped identifying additional **promising pathways**



Including:
- Clinker Substitutes
- Alternative Binder
- Alternative SCMs

DOE Industrial Decarbonization Roadmap: https://www.energy.gov/eere/doe-industrial-decarbonization-roadmap

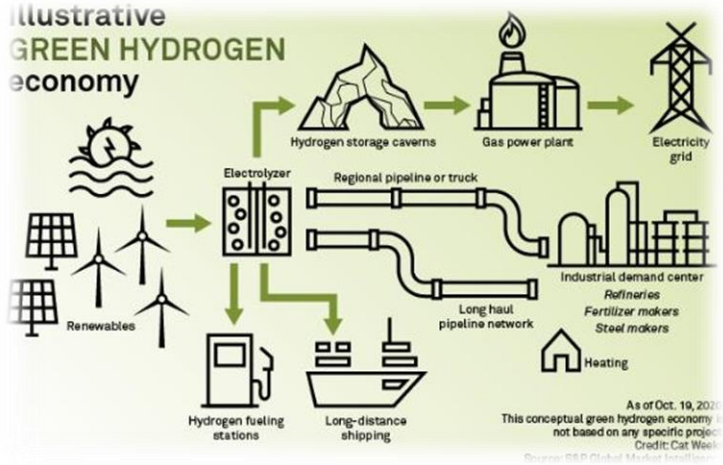
Cement Industry Decarbonization Barriers



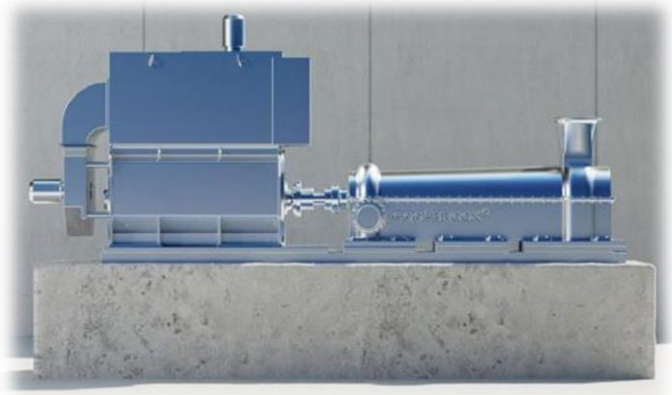
Economic

Scalability

Perceived Non-OPC cement risks



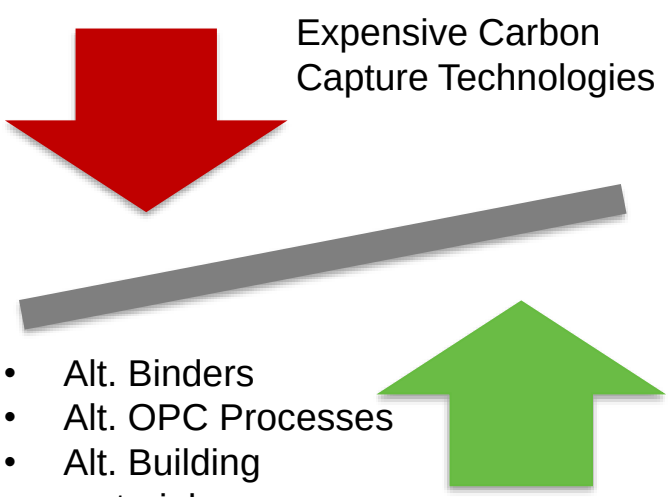
Infrastructure/Supply chains

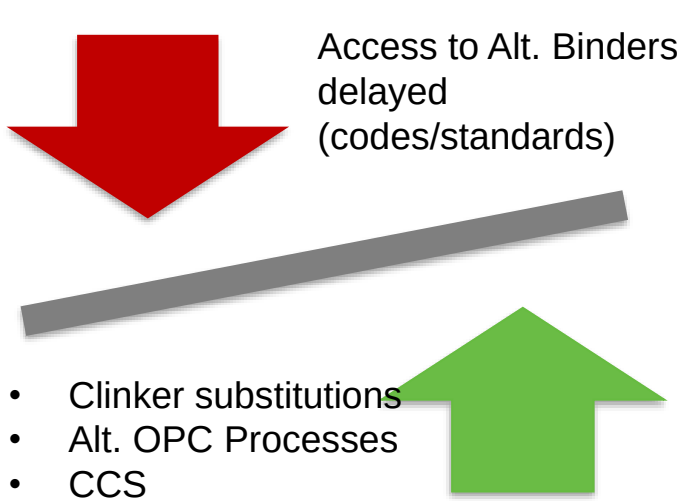


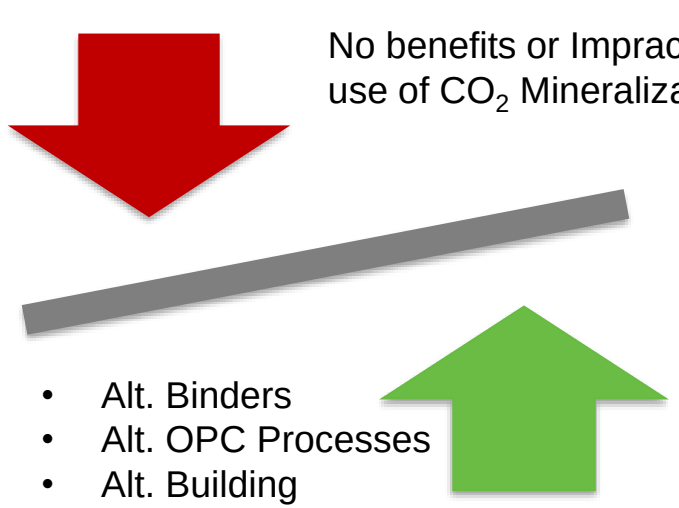
Technical

A multi approach strategy

- There is **no single decarbonization lever** that will eliminate all emissions.
- Because of the multi-option approach, **pivots will be relatively easy**







Acronyms: CCS: Carbon Capture and Storage

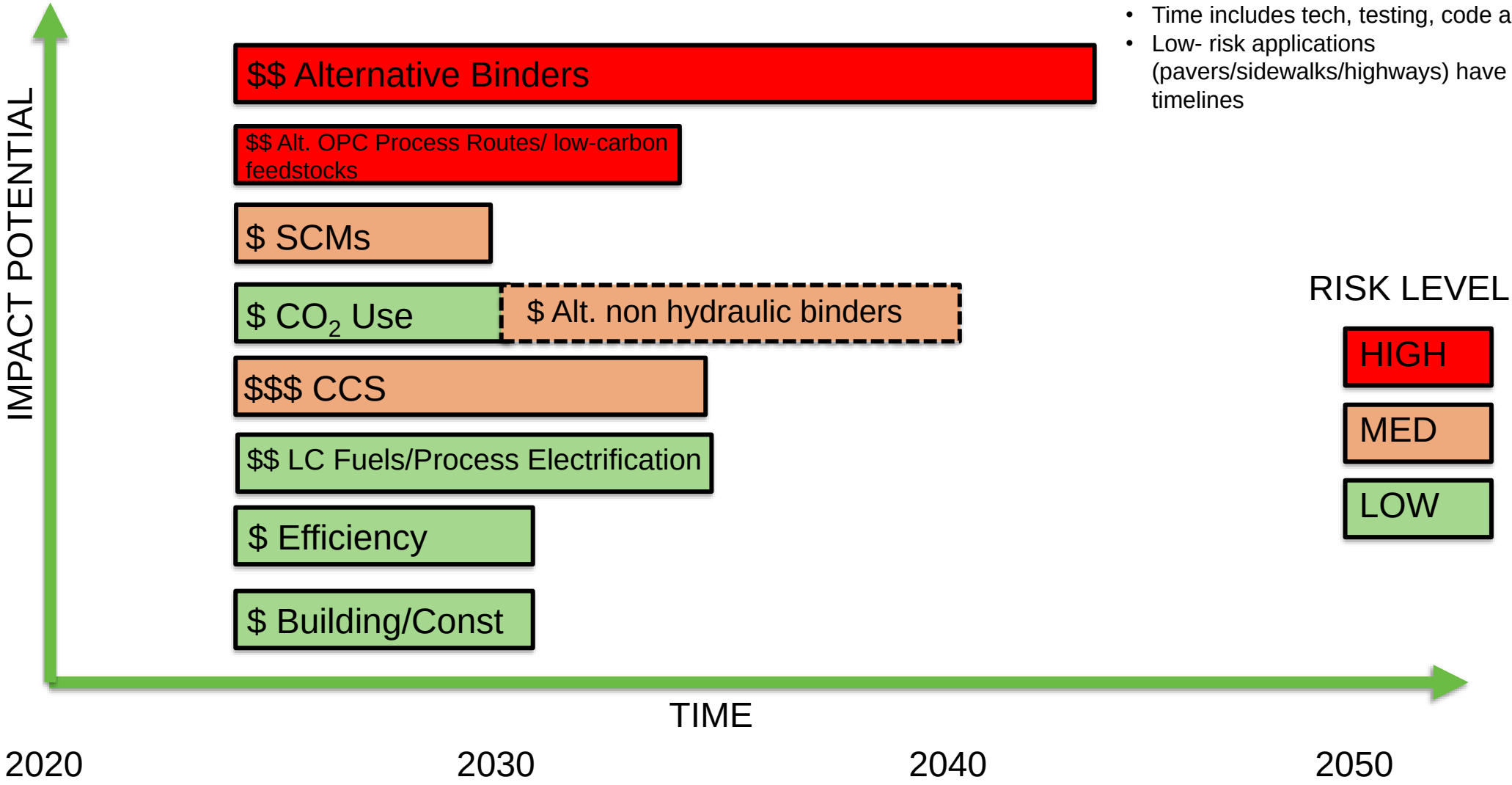
Goal and Targets

Goals:

- Advances to **accelerate** the commercial readiness of low-carbon or net-zero-carbon technologies to provide energy savings, carbon emissions reduction, and other benefits in the cement/concrete production sector.
- Strategic position and advantage as a global leader in innovation

Goal	Metric	Target	Baseline Performance
Reduction of carbon intensity	% carbon intensity change as measured by ton CO_2e/kg product	50 – 80%	Applicant defined
Scalable production of **durable concrete** with **reduced embodied carbon**	Clinker-to-cement ratio	< 0.75 by 2050 (current national avg. = 0.92)	ASTM C595 performance
Minimal economic impacts of decarbonized raw materials, products, or processes	Cost	Cost competitive – Cost parity	OPC-centric baseline

Tech Development Pathway: Cost, Impact, Risk, Time-to-Launch

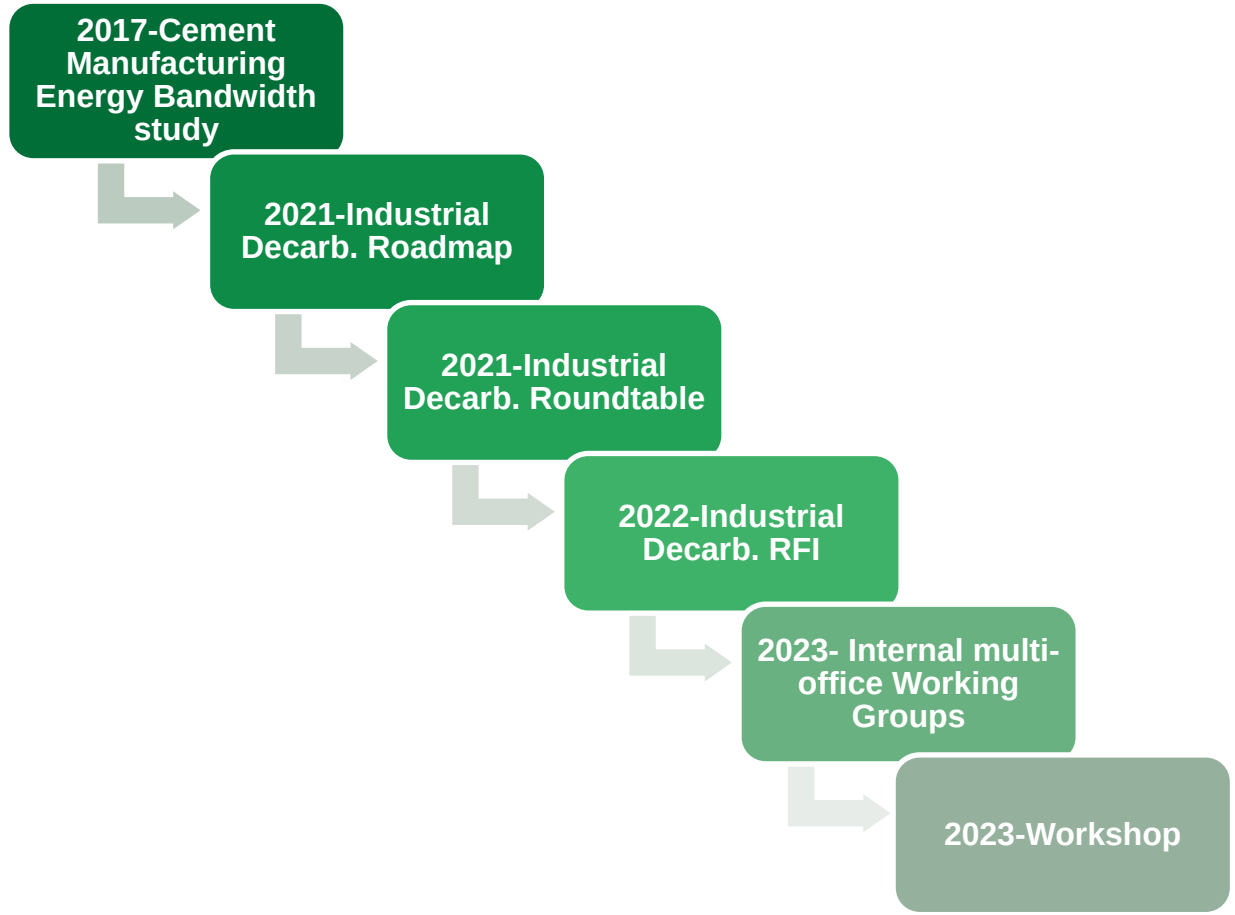


- Time includes tech, testing, code acceptance
- Low- risk applications (pavers/sidewalks/highways) have shorter timelines

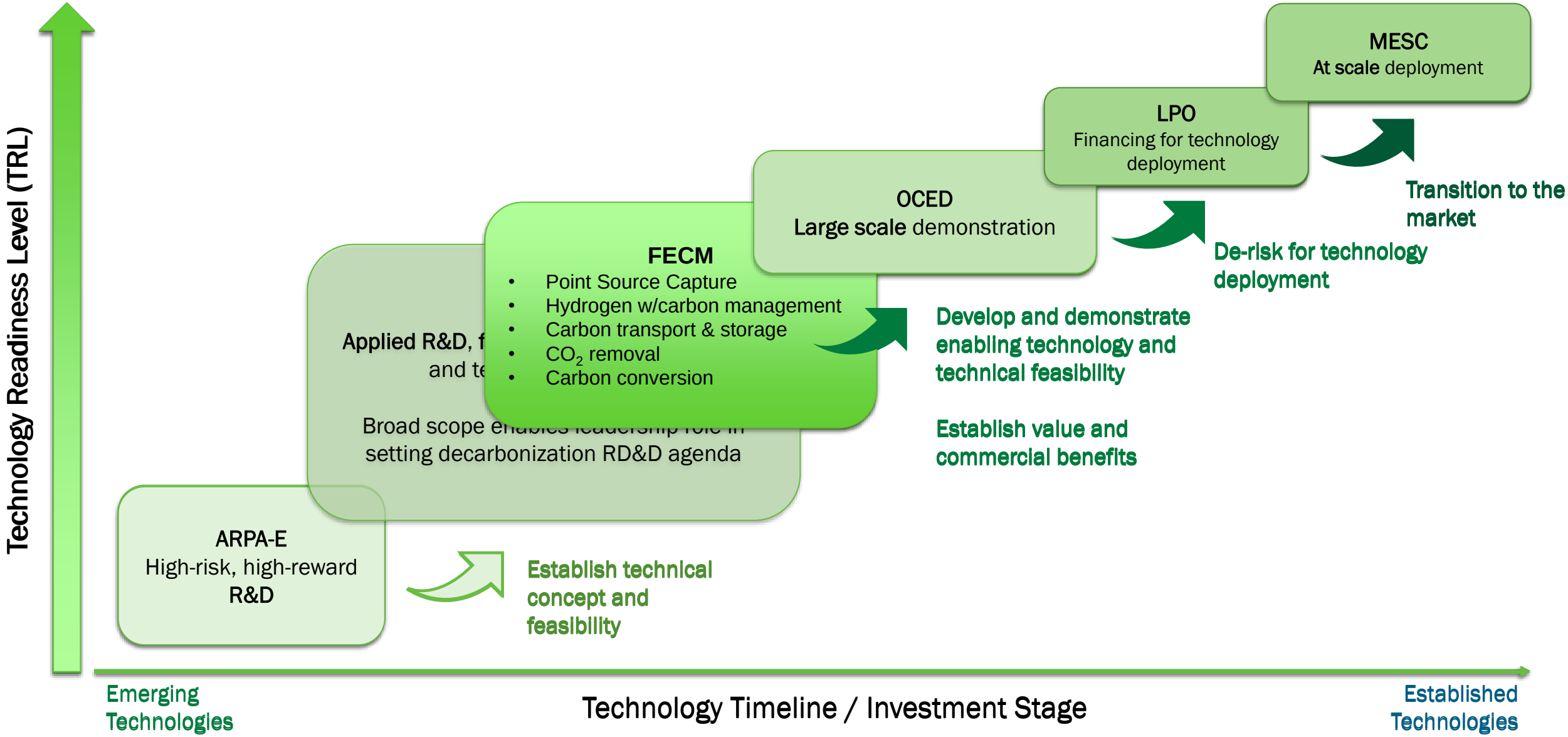
Stakeholder Engagement

- Stakeholders
  - Cement industry (Associations, producers, equipment manufacturers)
  - Concrete industry (associations, producers, equipment manufacturers)
  - Startups (Binders, SCMs, carbonated concrete, alt OPC process/feedstocks, aggregate, etc)
  - End users (Architects, design engineer)
  - Codes and standard (ASTM, NBI, States & cities setting buy clean standards)
  - Environmental actors (LCA, EPD developers
  - Administrations (FHWA, GSA)
  - Non-profits (GPI, WRI, GCCSI, etc)
  - Carbon Capture : emitters, hubs, infrastructure

- Key Stakeholder Activities



IEDO Fit within DOE Landscape



Questions?

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Thank you