# A Sustainable Concrete Journey

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Heidelberg Materials

# Why this Sustainability Journey

Climate Change

The right thing to do

Gov. Policies (carbon taxing)

Sustainability Targets and Commitments

Change takes a long time

Cement impacts are ~85% of Concrete's

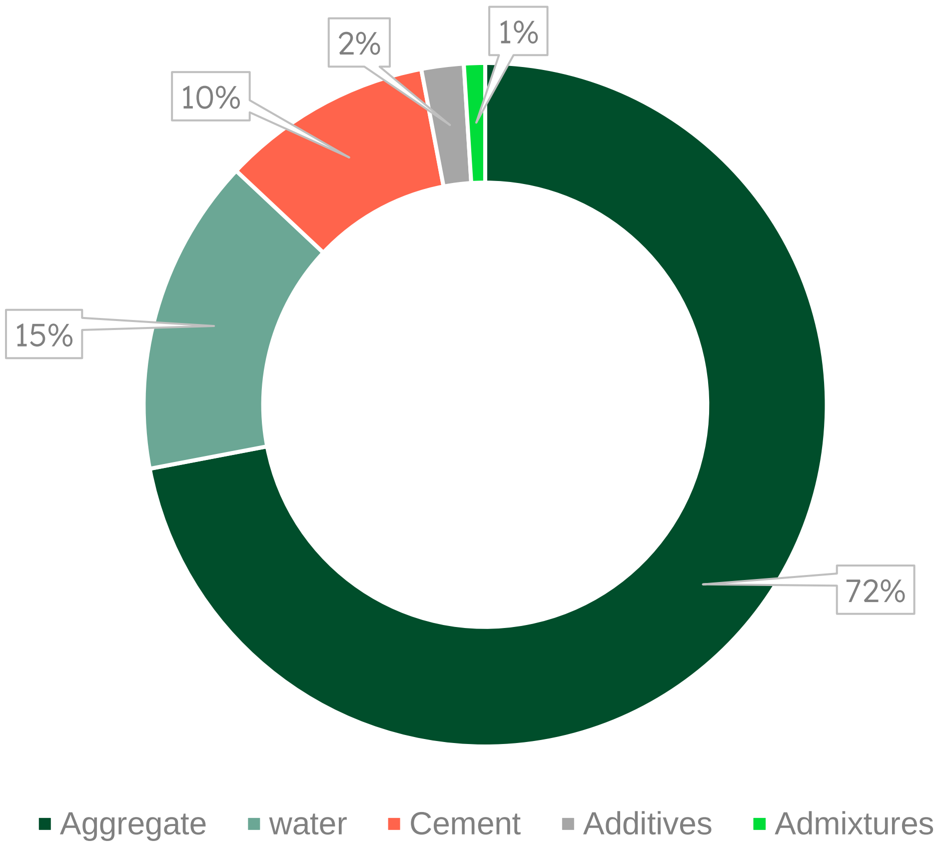
Concrete is just about synonymous with construction

Concrete is second only to water in consumption

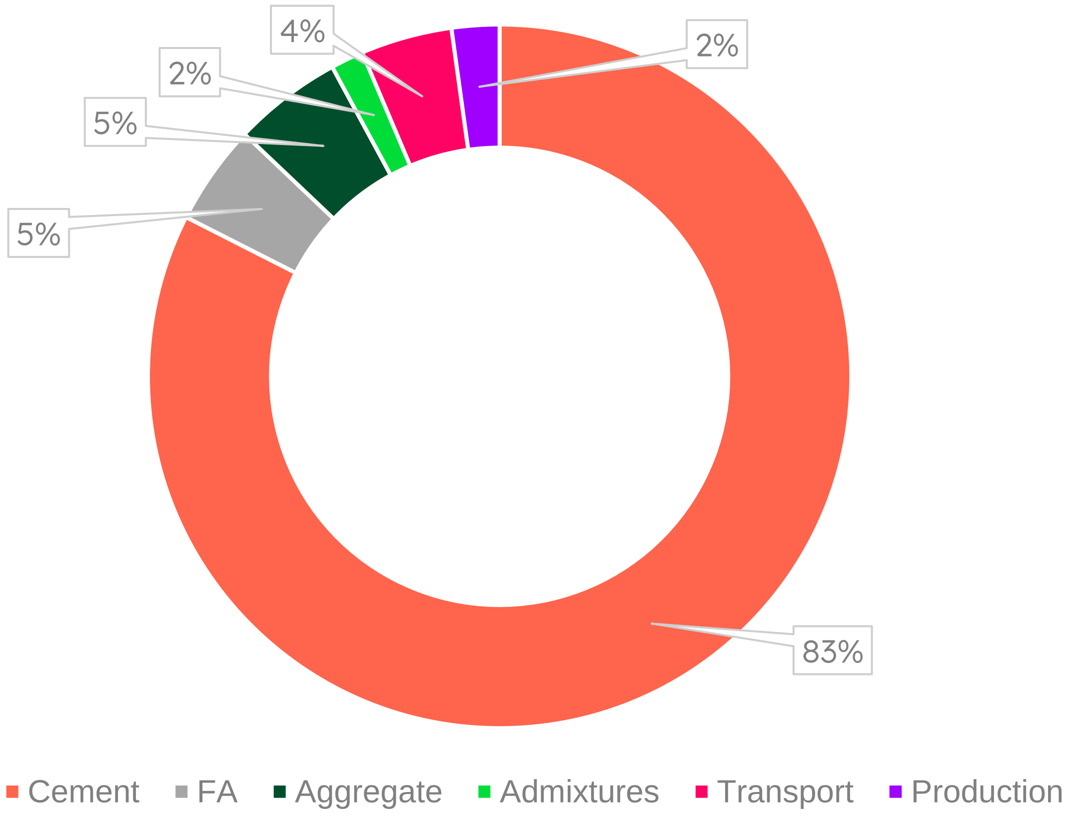
**Together we can make a significant impact on emissions**

# $CO_2$ emissions from concrete

Concrete composition [Vol.-%]




GWP = 219 kg GWP/m³: Example for 4,350 – 5,400 psi conc.



# Another concrete mix - $CO_2$ during concrete production


- Process technology in cement
- Alternative binding agents
- Implementation in concrete by utilising flexible concrete

Local, low energy and low GWP building materials are a central. An uncounted $CO_2$ success factor

- Efficient logistics
- Utilising state-of-the-art drive units
- Openness for new technologies

Renewable energy is a usable benefit today

**$CO_2$ in concrete is more than just cement**

# Cement's carbon footprint – where does in come from?

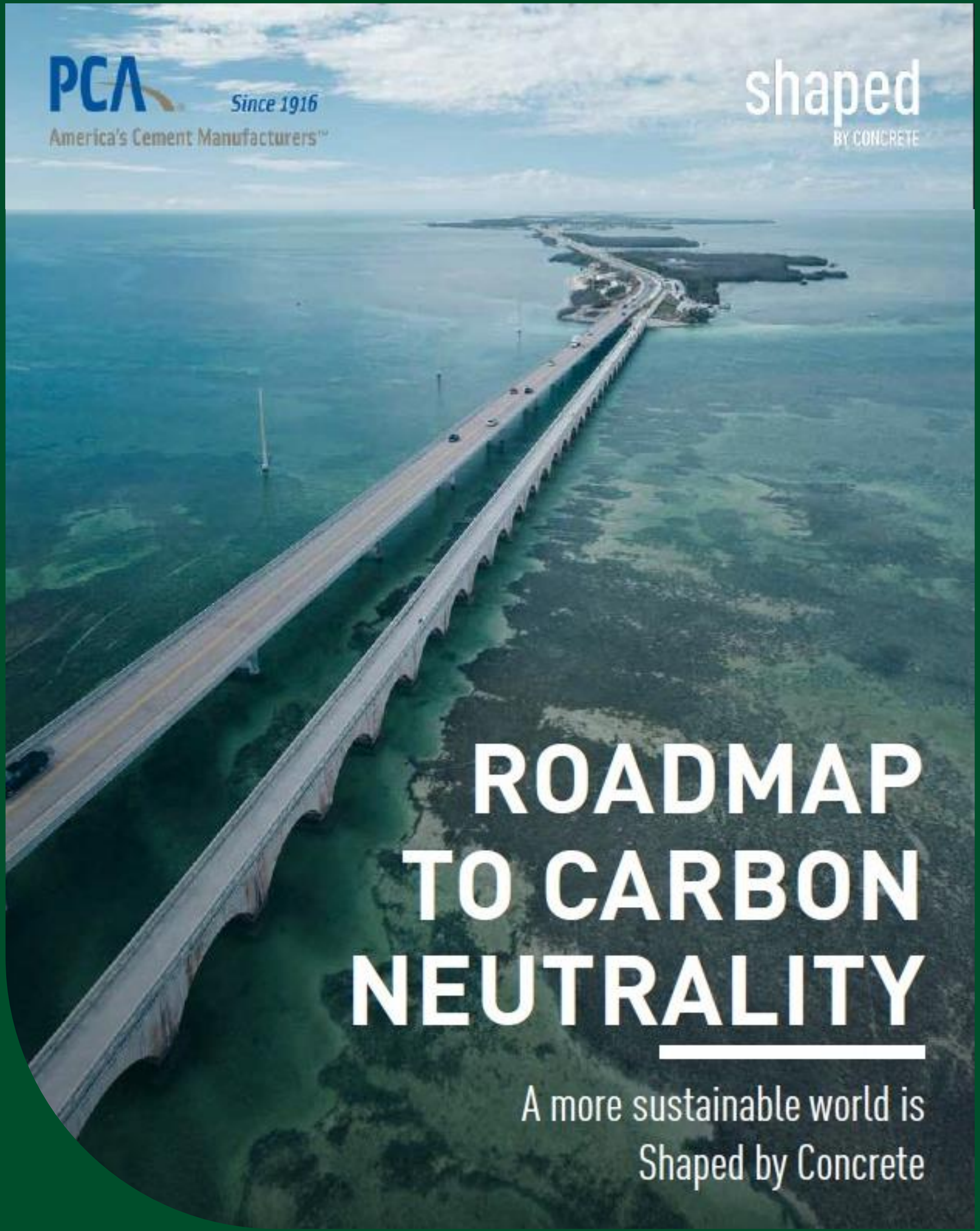
## CO2 Emissions

- Energy emissions ~1/3 (working toward Alt. fuels)
  - Coal --- Natural Gas --- Alternatives/Electric
- Clinker process emissions ~ 2/3 (calcination)
  - Less clinker = less GHG emissions

# PCA’s Road Map to Carbon Neutrality

## Ambitious comprehensive plan by the Cement Industry

- Five key links in concrete value chain
    - Clinker production
    - Cement production
    - Concrete - the primary end product
    - Construction and service life of concrete structures
    - Natural carbonation process

# PCA’s Road Map to Carbon Neutrality

## The Roadmap

- Requires investment and innovative technologies
- Developing eco-friendly practices
- Calls for action in all LCA stages
    - Production: At The Cement Plant
    - Construction: Designing And Building
    - Everyday: Concrete Infrastructure In Use…
        - Use stage
        - End of life stage

| PRODUCTION: AT THE CEMENT PLANT | |
|---|---|
| **Replace raw materials with decarbonated materials** | Using decarbonated materials eliminates $CO_2$ emissions from processing traditional raw materials, like limestone. |
| **Use alternative fuels** | Replacing traditional fossil fuels with biomass and waste-derived fuels lowers greenhouse gas (GHG) emissions and keeps materials out of landfills. |
| **Continue efficiency improvements** | Increasing energy efficiency reduces the amount of $CO_2$ emitted for each ton of product. |
| **Implement carbon capture, utilization, and storage (CCUS) technology** | CCUS directly avoids a significant portion of cement manufacturing emissions. |
| **Promote new cement mixes** | Creating new cements using existing and even alternative materials reduces emissions from mining for new materials, while optimizing the amount of clinker used ensures emissions correspond to necessary production. |
| **Increase use of portland-limestone cement (PLC)** | As an existing lower-carbon blend, universal acceptance of PLC will reduce clinker consumption and decrease emissions. |
| **CONSTRUCTION: DESIGNING AND BUILDING** | |
| **Optimize concrete mixes** | Considering the specific needs of the construction project and using only the materials necessary, avoiding excess emissions. |
| **Use renewable fuels** | Switching to solar, wind and other renewable sources of energy directly reduces emissions from other energy sources. |
| **Increase the use of recycled materials** | Diverting these materials from landfills. |
| **Avoid overdesign and leverage construction technologies** | Designing for the specific needs of the construction project reduces unnecessary overproduction and emissions; incorporating just-in-time deliveries. |
| **Educate design and construction community** | Improve design and specifications to be more performance oriented which will permit innovation in cement and concrete manufacturing. Encourage the use of advanced technologies to improve structural performance, energy efficiency, resiliency, and carbon sequestration. |
| **EVERYDAY: CONCRETE INFRASTRUCTURE IN USE** | |
| **Incentivize energy efficient buildings** | Increasing buildings’ energy efficiency can cut energy use and resulting emissions from heating and cooling. |
| **Reduce vehicle emissions by improving fuel efficiency** | Because of its rigidity, concrete pavements enhance the fuel efficiency of vehicles driving over them, reducing vehicle emissions. |
| **Decreased maintenance** | Due to their durability, concrete structures (buildings, pavements, bridges, dams, etc.) last longer and require less frequent maintenance. |
| **Recycling** | Concrete in place can be 100% recycled, limiting the use of raw materials and production emissions. |
| **Carbonation** | Every exposed concrete surface absorbs $CO_2$ and over the course of its service life, a building can reabsorb 10% of cement and concrete production emissions. |

# The Industry is Responding

## Companies are responding

- At the Cement Plant
    - Efficiency improvements, drives fuel/energy emission savings
    - Burn alternative fuels such as biomass and waste-derived fuels
    - Increase use of portland limestone cement (PLC)
    - New blended cements with lower clinker to lower carbon intensity
    - Use Carbon Capture, Utilization, and Storage (CCUS) technology


# Mitchell K4 - One of the most technologically and sustainable cement plants ever built

$CO_2$

**2.4 MMT**

Second Largest Plant in North America

**Systems:** The new plant capacity is 3 times larger, adding many efficiencies with new equipment and latest technologies and using Natural Gas with options for alternative fuels when permitted

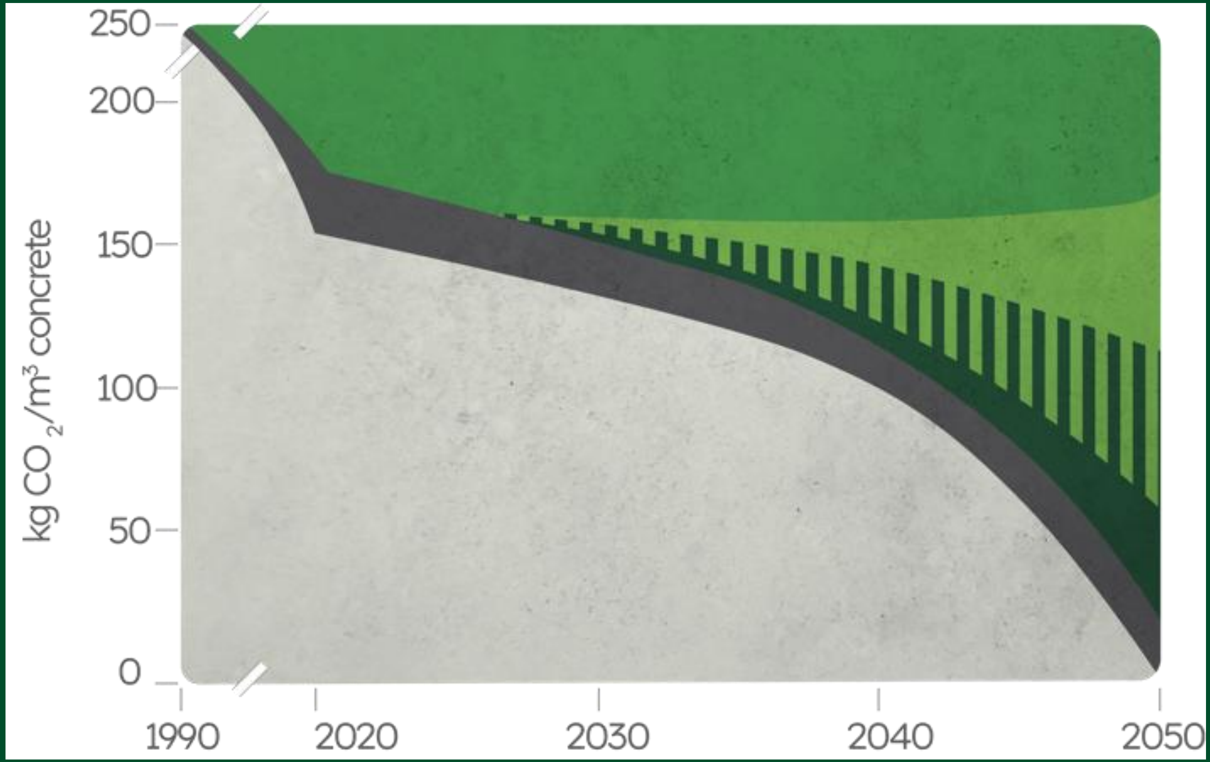
**Products:** The Kiln 4 project came online in mid 2023 to produce primarily EcoCemPLC and Masonry Cement (both lower carbon products).

**Objective:** Improve the carbon footprint of concrete; we are repurposing the old Speed, IN plant to a slag grinding facility in mid - 2024

Awaiting 12 months of data to produce an EPD

Mitchell, Indiana

# Our Road Map to Net Zero Concrete – A Multidimensional Approach

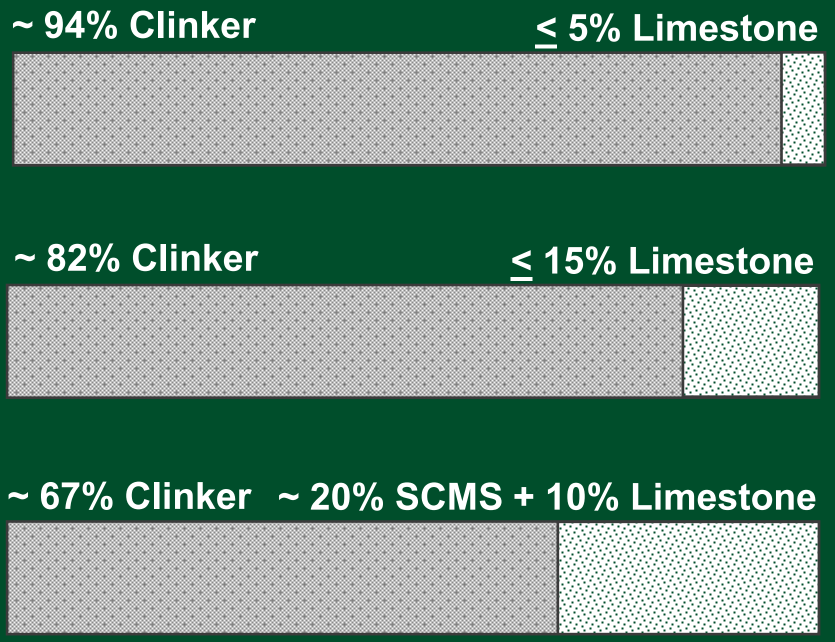




**OPC / Portland**

**PLC Type IL / GUL**

**Blended Cements Type IT (P20)(L10)**





## Innovative Products

### Low Carbon Cements for Concrete Mixes

Clinker reduction

- Key strategy for reducing embodied $CO_2$ aka GWP
- Performance Specifications enable their use
- Significant reduction potential depending on available materials and type of application

### ASTM C595 / AASHTO M 240

- Portland Limestone Cement allows up to 15% limestone
- Binary and Ternary Blended Cements…
- IT(P20)(L10) is ternary blend, 20% pozz. 10% limestone

# Important Part of Today's Mixes - Supplementary Cementitious Materials (SCMs)

- Defined by ACI Concrete Terminology ACI CT-23

  "Supplementary cementitious material - inorganic material such as fly ash, silica fume, metakaolin, or slag cement that reacts pozzolanically or hydraulically"

- Combined in concrete mixes in conjunction with and to replace some of the Portland Limestone or Portland Cement binder
- SCMs have lower Global Warming Potentials (GWP)
- SCMs can improve concrete durability:
  - Stronger, less permeable, less susceptible to chemical attack and ASR

# Coal Ash aka Fly Ash in Concrete Mixes

## Waste Product from Coal Combustion, Typically by Electrical Power Plants

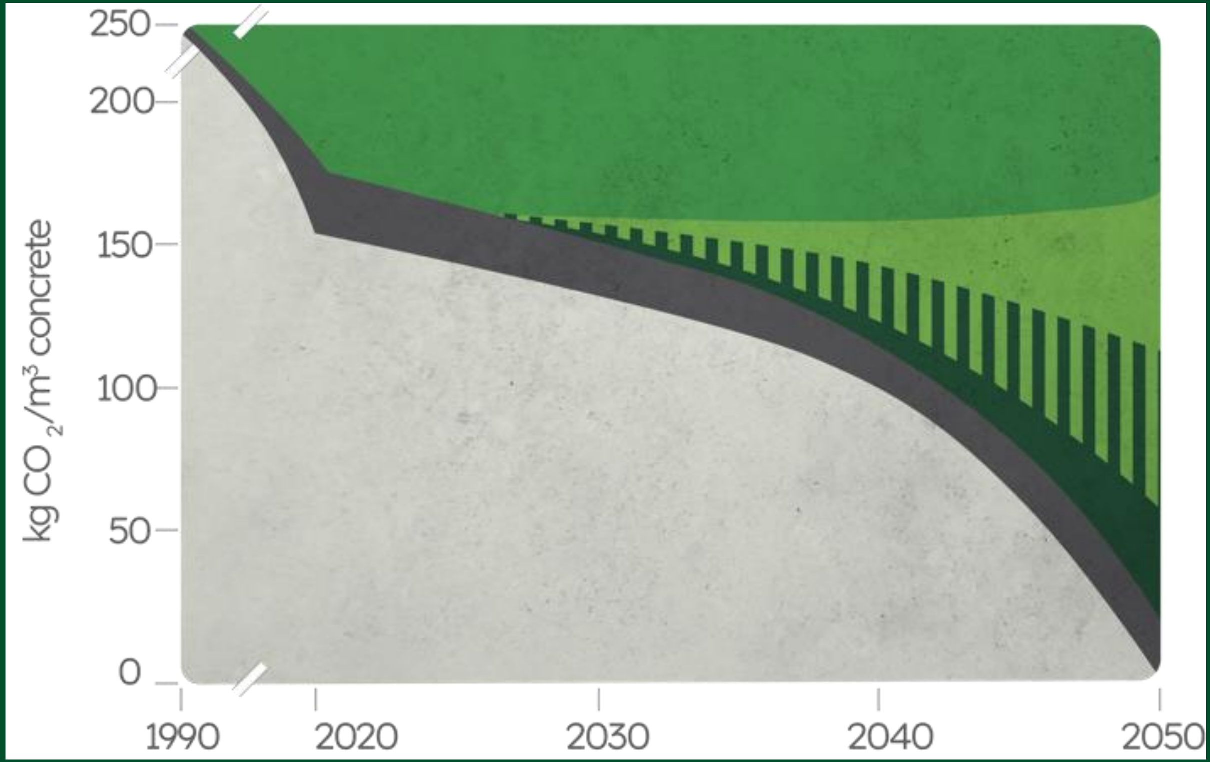
- Fly Ash often used to replace 15% - 25% of PLC or OPC, $\geq$ 50% for special applications
- Two primary source conditions
  - Fresh aka production "Fly Ash"
  - Ash harvested from ponds or landfills
- Fresh Fly Ash, is a siliceous flue gas residue
  - Has very low moisture contents used "as is"
- Harvested aka "reclaimed" fly ash must be…
  - Dewatered and thermally treated for use
  - This "beneficiation" process increases GWP ($CO_2$ eq.)

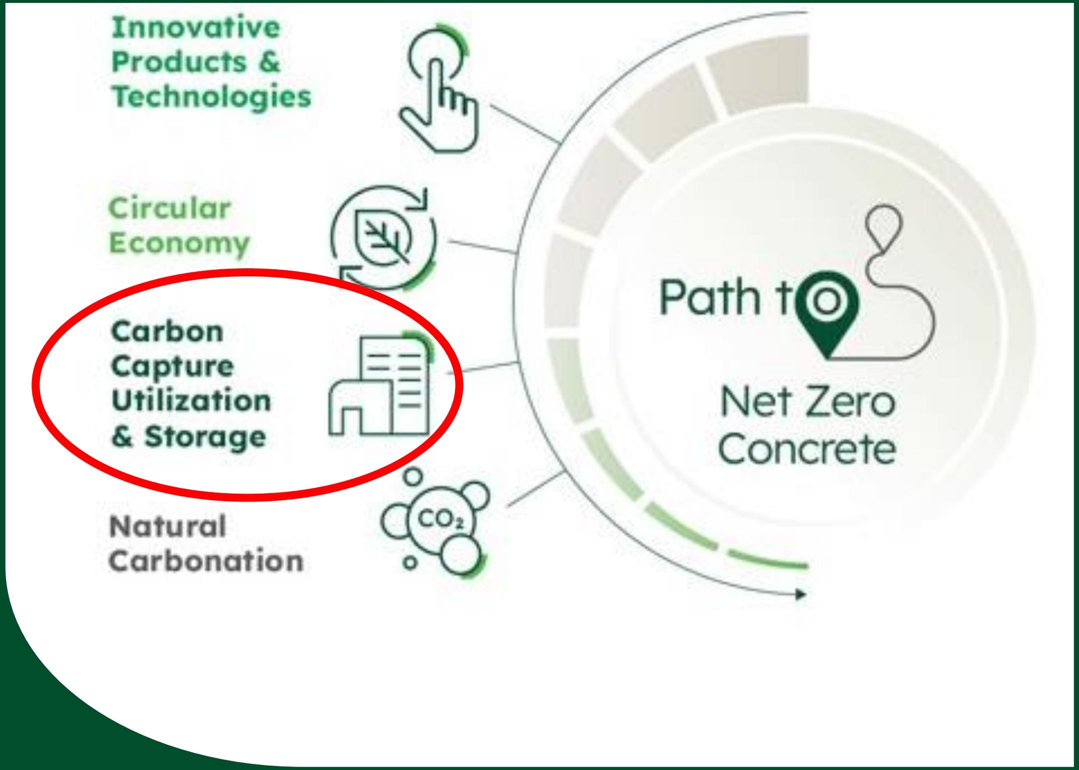
## Slag Cement Use in Concrete Mixes

### Byproduct of primary iron manufacturing in blast furnaces

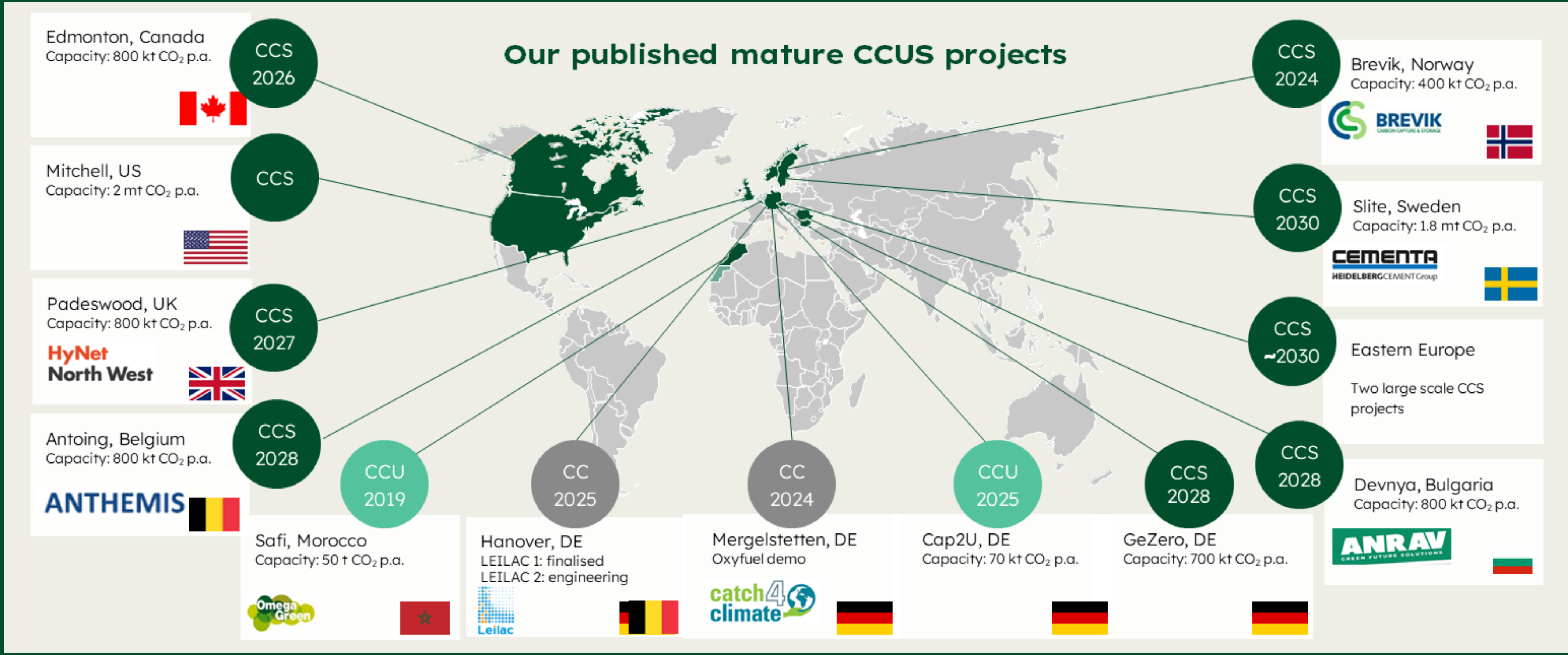
- Must go through “granulation” by rapid quenching
- Slag granules have similar chemistry, Portland cement clinker
- Can be interground to make Portland slag cement ie IS40
- Once ground does have hydraulic attributes on its own
- In practice, coupled with PLC or Portland cement in mixes
- Slag cement often used to replace 30% - 50% of PLC or OPC
- Some applications very high replacement rates of $\geq$ 80%
- Can provide excellent resilience benefits
- Good synergies with PLCs

# Our Road Map to Net Zero Concrete – A Multidimensional Approach




# Carbon Capture, Utilization and Storage



# Edmonton’s Net Zero Future

**1 million**

mt $CO_2$ p.a.

**Scope:** Amine-based $CO_2$ removal system & combined heat & Power plant

**Status:** Feasibility study complete and project preparation well on track (Commissioning: 2026)

**Objective:** The world’s first full-scale carbon neutral cement plant

Rendering Edmonton, Alberta


# Mitchell, IN – Carbon Capture Utilization and Storage (CCUS) - by 2030

**2 million**

mt $CO_2$ p.a.

**Scope:** Amine-based CO2 removal system, targeting 2mt $CO_2$ annually at 95% rate

**Status:** Feasibility study for capture and onsite storage onsite; three (3) DOE grant awards

**Objective:** The first full-scale carbon neutral cement plant in the United States

Mitchell, Indiana

# Edmonton Carbon Capture and Storage Overview

## Storage

- $CO_2$ to be stored in deep saline reservoirs
  - Permanent storage 1,500-3,000 meters below ground in porous rock filled with brine with multiple overlying layers of impermeable cap-rock
  - Far below potable water and oil and gas reservoirs
  - Current global storage capacity 40 million tons/yr.
- Examples of $CO_2$ Storage
  - Alberta – Shell's Quest project has permanently stored over 6 million tons of CO2 since 2015
  - Saskatchewan – Aquistore project permanently stored 500,000+ tons of $CO_2$ annually since 2015
  - Illinois – Decatur project permanently stored over 1 million tons from 2011 to 2014

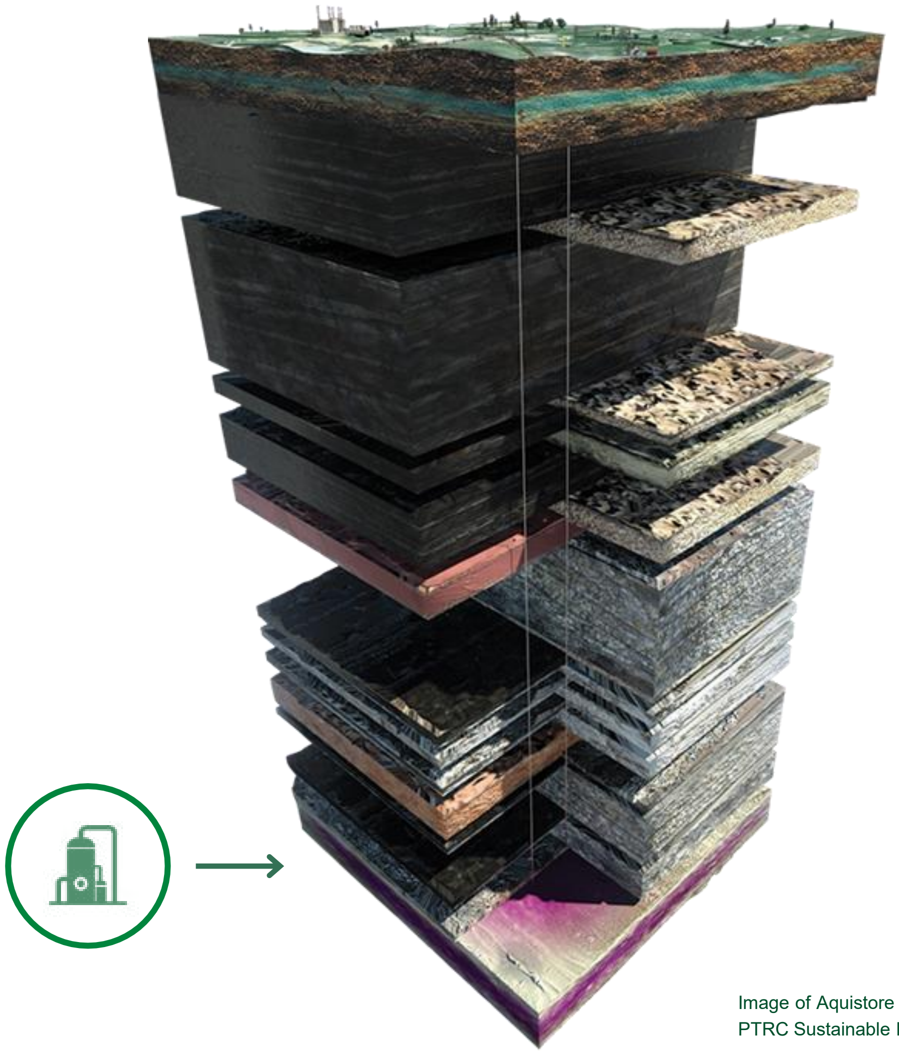


Image of Aquistore site courtesy PTRC Sustainable Energy

# Where Specifiers, Owners, Construction Professionals, Designers, and Stakeholders Fit In


## Changes to drive decarbonization

- Specify rigid concrete pavements improve vehicle fuel efficiency
- Concrete performance specifications – **Optimizes Mixes (PEM)**
  - Incentivize innovation
- In-place (non destruction testing) – maturity (reduce over-design)
- Work with industry to use Type IL and Type IT
  - PLC is becoming the norm in many markets
  - In 2022 PLC use saved over 1.8 million tons $CO_2$ in emission avoidance
- Allow/specify the use of recycled materials in mixes, i.e. RCA
- Educate design and construction community
- Account for natural carbonation process where $CO_2$ is absorbed by concrete, especially in Use and End of Life stages of LCA

# Thank You