DECARBONIZATION PATHWAYS

Decarbonizing Cement Plants:

How Can Industry Leaders Meet Publicly Stated Emissions Commitments?

BLACK & VEATCH

More goes into infrastructure than most might think, but you can't miss the difference it makes in the world. Our Decarbonization Pathways content series helps our clients stay ahead of the curve so they can progress relevant and effective decarbonization strategies and help the world transition to net zero.

The cement industry is a leading emitter of carbon dioxide (CO2) emissions. The sector produces around 2.5 Gigatons (Gt) of CO2 emissions per year, about 7 percent of the world's total, according to the Global Cement Association. What's more, cement is a key component in concrete, the second-most consumed resource in the world after water. With continued rapid urbanization and global population growth, demand for this critical component is unlikely to slow.

At the same time, intensifying pressures from investors, customers and governments to lower carbon emissions — alongside the commercialization and increasing maturity of numerous enabling technologies such as renewable energy and energy storage — is driving the cement industry to urgently reset decarbonization roadmaps and implementation plans. The International Energy Agency proposes that the industry decrease annual emissions by 3 percent through 2030 to meet global 2050 targets for net-zero emissions.

If the cement industry is to truly embrace decarbonization targets, cement producers will need to identify sustainable pathways that balance the adoption of decarbonized solutions while maintaining competitive advantages and supporting company growth.

This is a universal challenge facing business leaders in every industry: how to decarbonize profitably, effectively and sustainably. According to Black & Veatch's 2021 Corporate Sustainability Goal Setting and Measurement Report, more than 80 percent of large corporations (with revenues over US$250 million) had set greenhouse gas emissions targets. Yet, 25 percent of their CEOs admitted to not knowing how they would achieve these targets.

Multiple Decarbonization Pathways

There are multiple decarbonization opportunities cement producers can explore across the entire value chain. Decarbonization opportunities exist in quarrying, crushing, transportation, raw meal preparation, calcination, kiln firing, storage and distribution.

A first step on the journey to realizing effective decarbonization is to understand a company's impact on the global carbon cycle across different scopes of carbon emissions.

The Greenhouse Gas Protocol defines Scope 1 carbon emissions as direct emissions from owned or controlled sources. Indirect emissions from the generation of purchased energy is classified as Scope 2 emissions. Scope 3 emissions are indirect emissions that are produced from sources not owned or controlled by the company.

On average, for cement producers, the largest volume of direct carbon emissions occurs through in-plant processes and fuel firing, accounting for 80 percent to 90 percent of the process carbon emissions. In addition, indirect carbon emissions occur through electricity use, accounting for about 5 percent to 10 percent of emissions, while non-plant activities and transportation across the value chain contribute about 5 percent to 10 percent of CO2 emissions.

Cement Production Plant Processes

Quarrying and Crushing

Cement plants are usually located close to limestone quarries, key raw material source

Raw materials are crushed and transported to plant

Non-Plant CO_2 Emissions: **5-10%**

Preparation of "Raw Material"

Key raw materials mixed to form homogenous mixture and crushed to fine powder, raw meal

Indirect CO_2 Emissions: **5-10%** *(mostly electricity)*

Processing

Pre-heating with kiln exhaust

Pre-calcination and rotary kiln for clinker formation

Conversion of limestone to lime releasing CO2 & further heating to temperatures around 1400-1450 C by direct fuel fire to form clinkers

Direct CO_2 Emissions: **80-90%** *(Process & Fuel Firing)*

Post Processing

Cooling to 100 C

Blending with other materials: gypsum, fly ash, slag, etc.

Grinding by mills

Storage in silos & packaging

Indirect CO_2 Emissions: **5-10%** *(mostly electricity)*

Transportation

Distribution of cement to customers

Other transportation requirements throughout value chain and operations

Non-Plant CO_2 Emissions: **5-10%**

Average emissions across the cement production value chain are indicative only

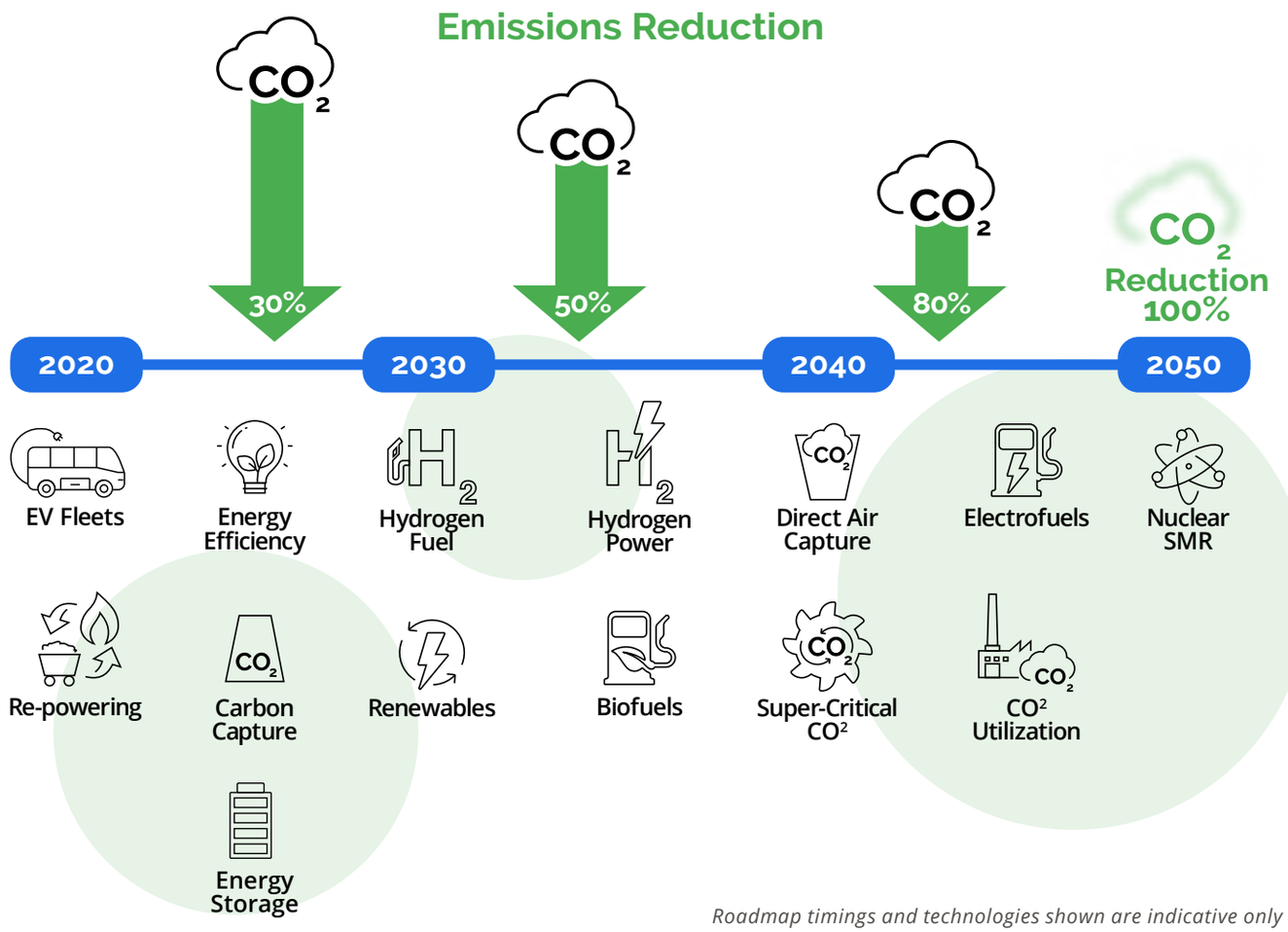
Decarbonization initiatives across these processes are difficult and require planning horizons that span decades and consider multiple current and emerging technology maturity pathways and cost curves. Alongside timing, affordability and effectiveness, any decarbonization initiative must align with cement producers' sustainable commitments and goals, continually evolving expectations of key stakeholders, as well as unique business operations and asset conditions.

Exploring Carbon Capture, Utilization and Storage

Many large cement industry players have started to invest in carbon capture, utilization and storage (CCUS) technologies to support the reduction of process emissions. At scale, CCUS offers the industry a compelling pathway to lowering carbon emissions.

CCUS technologies vary in application, and many are yet to reach full-scale commercial application. Several pilots are underway across the world, including some undertaken by the world's largest cement producers, to explore both the storage of CO2 in underground reservoirs as well as utilization in alternative product development to generate additional revenues.

LafargeHolcim Group, for example, has launched more than 20 CCUS projects across North America and Europe using multiple technologies as pilots to commercialize CCUS for widespread applicability. Anhui Conch Cement has a 50,000 million tons per year (MTPY) amine-based CO2 capture plant in Anhui selling liquid carbon dioxide to customers.



Roadmap timings and technologies shown are indicative only

Other Decarbonization Strategies

In addition to CCUS technologies, another decarbonization pathway is to add biomass and/or waste materials into the fuel mix to begin a transition to lower-carbon intensive fuels and eventually to zero-carbon processes.

Understanding this pathway and, for example, the potential of hydrogen or other long-term carbon-free emissions technologies is critical. Today's decisions on existing technology must be made in the context of what's emerging. Otherwise, cement producers risk the consequences of getting locked into a costly technology path dependency.

Other initiatives that can reduce carbon emissions include:

- reducing the proportion of clinker in the cement by using blended cement ratios and alternate binding materials
- adopting zero-emissions transportation such as electric or hydrogen fuel cell fleets for cement distribution and
- replacing fossil fuel with green electricity for power throughout the manufacturing process

Each of these pathways may offer more promising emissions reductions and operations gains over the near-term compared to tackling the intensive kiln process that may have limited effectiveness if addressed in the context of today's technology options.

Agile decarbonization roadmaps that assess existing and emerging technologies will guide cement producers to make the investments at the optimal time to realize their emissions reduction commitments.

Let's Talk

To turn energy and environmental challenges facing the cement industry into opportunities, cement producers need effective decarbonization roadmaps that better manage limited budgets and complex regulations and provide a more certain return on investment. Black & Veatch's decarbonization toolbox helps clients achieve cost-effective, significant decarbonization by avoiding the consequences of getting locked into technology path dependency; analyzing the emerging technology mix, and road mapping low-risk paths for GHG reduction; and providing objective assessments of emerging tech maturity and commercial viability.

Let's find ways to help you, too.