

Decarbonising the Foundations

Exploring Opportunities for
Decarbonisation in the Cement Sector

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FOR PROFESSIONAL INVESTORS ONLY

Introduction

The cement industry stands as both a cornerstone of modern civilisation and one of the most challenging sectors to decarbonise. Cement forms the binding agent in concrete, the most widely used construction material after water, creating the literal foundations of our hospitals, homes, bridges, and critical infrastructure. However, this essential role comes at an environmental cost, with the industry responsible for approximately 7–8% of global anthropogenic CO₂ emissions.

As the world confronts the climate crisis while continuing to develop essential infrastructure, the decarbonisation of cement represents not just an option but an urgent necessity for achieving global climate targets.



Rebecca Sly
Research & Engagement Analyst



Oshadee Siyaguna
Head of Stewardship



Cement Emissions in Context

The cement industry's contribution to global greenhouse gas emissions places it among the most carbon-intensive sectors worldwide. **Global cement manufacturing produced approximately 1.6 billion metric tonnes of CO₂ in 2022–2023, representing about 7–8% of total anthropogenic emissions.** To contextualize this impact, if the cement industry were a country, it would rank as the world's third or fourth-largest emitter of carbon dioxide, surpassing the annual emissions of most nations.¹

While cement is an important part of sustainability due to its critical role in resilient infrastructure, it has an outsized and hard-to-abate carbon footprint. It is due to this footprint that cement has become a priority sector in climate policy. Cement is explicitly captured within the EU's core carbon pricing mechanisms—the internal Emissions Trading Scheme (ETS) and the Carbon Border Adjustment Mechanism (CBAM)—which together are reshaping the economics of cement production and trade. Under the EU ETS, cement plants must buy and surrender allowances for each tonne of greenhouse gas they emit, directly linking kiln emissions to a rising carbon cost and strengthening the financial case for low carbon technologies such as clinker substitution, alternative fuels, and CCUS. CBAM extends a comparable carbon price to imports of carbon intensive materials, including cement, so foreign producers face similar carbon costs to EU producers, limiting carbon leakage and reinforcing the commercial imperative for decarbonisation rather than relocation of facilities. In combination, EU ETS and CBAM seek not only to cut emissions within the EU but to anchor a durable price signal that supports deep decarbonisation of cement in line with the EU's broader "Fit for 55" climate objectives. This framework creates a first-mover advantage for European cement producers who invest early in decarbonisation, as they benefit from operational experience with low-carbon technologies, enhanced regulatory certainty, and preferential access to EU markets where carbon intensity increasingly determines competitive position.

Conversely, producers in regions with weaker climate policies face mounting barriers to EU market access and risk stranded assets as global carbon pricing mechanisms expand.

Process emissions account for approximately 60–65% of total cement CO₂ emissions, arising from the calcination of limestone (calcium carbonate, CaCO₃) during clinker production. When limestone is heated to temperatures exceeding 1,450°C in cement kilns, it chemically decomposes into lime (calcium oxide, CaO) and carbon dioxide in an unavoidable chemical reaction. This process releases approximately 0.78 kg of CO₂ per kg of lime produced. **Thermal emissions comprise the remaining 35–40%**, resulting from the combustion of fossil fuels required to generate the extreme temperatures necessary for calcination.

The dominance of process emissions makes cement uniquely challenging to decarbonise compared to other industrial sectors. While thermal emissions can potentially be reduced through fuel switching and electrification, process emissions are chemically unavoidable when using traditional limestone-based cement production methods. This fundamental constraint positions carbon capture technologies as essential for achieving deep decarbonisation in the sector.

Current demand trajectories compound these challenges. Global annual concrete production is forecast to increase from 14 billion m³ today to 20 billion m³ by mid-century,² driven by continued urbanisation and infrastructure development, particularly in developing economies.

Under current production practices, this growth would see CO₂ emissions from the sector soar to 3.8 billion tonnes per year, making urgent decarbonisation efforts even more critical for global climate goals.³

¹World Economic Forum (2024) 'Cement is a big problem for the environment. Here's how to make it more sustainable.' Available at: <https://www.weforum.org/stories/2024/09/cement-production-sustainable-concrete-co2-emissions/> (Accessed: 16 October 2025)

²Energy Transitions Commission (2020) Mission Possible: Reaching net-zero carbon emissions from harder-to-abate sectors - Sectoral Focus: Cement.

³World Economic Forum (2024) 'Cement is a big problem for the environment. Here's how to make it more sustainable.' Available at: <https://www.weforum.org/stories/2024/09/cement-production-sustainable-concrete-co2-emissions/> (Accessed: 16 October 2025)

Cement and Sustainable Development

Cement is indispensable to sustainable development because it underpins the built environment that enables progress across most Sustainable Development Goals, from water and sanitation to education, health, energy, and resilient cities. As the most widely used material after water, concrete's availability, durability, and cost-effectiveness make it a critical resource for delivering essential infrastructure at the scale required for inclusive growth and climate resilience. UNOPS has identified that the built environment supports society in reaching 92% of the 169 SDG targets, and concrete is foundational to those assets, from water systems to transport networks and housing.⁴

Cement directly delivers core public goods by forming the structure of hospitals and clinics, schools and universities, water treatment plants and sewers, roads and bridges, affordable housing, and the foundations for renewable energy. These assets are not optional amenities; they are the enabling hardware of development that allows services to be delivered safely, reliably, and at scale in both urban and rural settings.

- **Health:** Water, sanitation, and hygiene infrastructure built with concrete is central to preventing infections, reducing diarrhoeal disease, and enabling resilient health systems and universal health coverage. This infrastructure in health care facilities is essential to infection prevention and control, maternal and newborn outcomes, and emergency response, which hinges on reliable built infrastructure.
- **Water and sanitation:** Dams, reservoirs, treatment plants, pipelines, and wastewater systems are built with concrete due to its strength, durability, and scale, directly enabling SDG 6 targets on safe water and sanitation. These systems are the backbone of public health and environmental protection, reducing pollution and safeguarding ecosystems when properly managed.

- **Transport:** Roads and bridges constructed with concrete reduce travel times and costs, increasing market access and service delivery to remote communities, with robust evidence that rural road investments reduce poverty and raise employment. Road access improves school completion, health service access, and household incomes through multiple channels, including lower transport costs and diversified livelihoods.
- **Clean energy:** The transition to renewables depends on concrete for wind turbine foundations, hydropower structures, and grid facilities, anchoring the expansion of affordable and clean energy systems. Most onshore wind turbines use cast-in-place reinforced concrete spread footings, and offshore structures increasingly leverage concrete for durability and lifecycle performance.

While cement production is a significant contributor to global GHG emissions, **the material's physical properties are indispensable for climate change adaptation.** Concrete, the principal end product of cement, exhibits the high strength, durability, and resilience required to protect communities and infrastructure from the escalating impacts of a changing climate. Its applications in climate adaptation are extensive and include the construction of hard coastal defences such as sea walls to mitigate the effects of sea-level rise, and the creation of robust buildings and emergency shelters capable of withstanding extreme weather events. The thermal mass of concrete can also contribute to moderating the urban heat island effect, while permeable concrete designs can manage extreme precipitation, thereby reducing flood risk. As climate-related hazards intensify, concrete's role in establishing a resilient built environment becomes increasingly critical.

⁴United Nations Office for Project Services (UNOPS) (2021) Nature-based Infrastructure.

Carbon Emissions Footprint Across the Cement Life Cycle

Emissions in cement production are heavily concentrated in specific stages of the manufacturing process, with over 90% of total emissions arising from a single critical phase. Understanding this distribution is essential for identifying the most impactful decarbonisation interventions and investment priorities.

Raw material quarrying and preparation contributes approximately 3% of total cement plant emissions. At this initial stage, emissions stem primarily from fuel consumption in quarrying machinery, transportation vehicles, and electricity usage for crushing and grinding equipment. While representing a small fraction of total emissions, efficiency improvements and electrification at this stage can contribute to overall emission reductions.

Pyroprocessing represents the heart of cement production and accounts for approximately 92% of total plant emissions. This stage involves feeding raw materials into massive rotary kilns where two critical processes occur simultaneously. The calcination process involves the chemical decomposition of limestone, releasing large quantities of CO₂ as an unavoidable byproduct when calcium carbonate breaks down into calcium oxide at temperatures exceeding 1,450°C.

Simultaneously, thermal combustion of fossil fuels provides the substantial energy required to achieve these extreme temperatures, generating additional CO₂ emissions beyond those from the chemical process itself.

Finish grinding and blending accounts for approximately 4% of total plant emissions, arising primarily from electricity consumption for high-energy grinding processes and material handling equipment. The carbon intensity of this stage depends significantly on the electricity grid's emission factor and presents opportunities for emission reductions through renewable energy procurement.

Transport and logistics contribute the remaining 1% of emissions through diesel consumption in heavy-duty trucks, rail transportation, and loading operations. While representing the smallest fraction of total emissions, the distributed nature of cement consumption means that transportation choices can influence the overall carbon footprint for specific applications.



Decarbonisation Levers in Detail

Achieving the International Energy Agency's Net Zero by 2050 scenario, according to some estimates, requires the cement sector to reduce emissions intensity by over 90%.⁵ This ambitious target necessitates the simultaneous deployment of multiple complementary decarbonisation strategies, each addressing different aspects of the production process and value chain.

Reducing the Clinker-to-Cement Ratio

Since clinker production generates the majority of cement emissions, **reducing the clinker content in final cement products represents an effective and commercially mature decarbonisation lever available today.** This approach involves substituting portions of clinker with supplementary cementitious materials (SCMs) that provide similar binding properties while significantly reducing carbon intensity.

The strategy involves blending cement with materials such as ground granulated blast-furnace slag (GGBS) from steel production, fly ash from coal power generation, natural pozzolans, calcined clay, and limestone. These materials can partially replace clinker while maintaining or even enhancing concrete performance characteristics, with modern cement standards allowing for clinker substitution rates of 35–50%.

Holcim has successfully commercialised its ECOPlanet range of green cement products, which achieve lower CO₂ footprints primarily through reduced clinker factors. The company has incorporated clinker reduction as a central component of its 2030 emissions reduction targets, demonstrating the commercial viability of this approach.

Heidelberg Materials operates a state-of-the-art facility in Ghana that pioneers the use of calcined clay, setting new standards for CO₂-reduced cement production. The company claims that with calcinated clay, they have the potential to reduce the carbon footprint of the finished product by up to 40%.

However, the industry faces significant supply constraints for traditional SCMs. European consumption of blast furnace slag is projected to decline from 13 million tonnes in 2020 to just 4 million tonnes by 2050 due to steel sector decarbonisation. Similarly, fly ash availability will decrease from 3 million tonnes to less than 1 million tonnes as coal power plants phase out. This supply constraint is driving investment in alternative SCMs, including calcined clays, recycled concrete fines, and other innovative materials.⁶

⁵Cavalett, O., Cherubini, F. & Olsson, O. Deployment of bio-CCS in the cement sector: an overview of technology options and policy tools. IEA Bioenergy Task 40/45, December 2021.

⁶CEMBUREAU (2024) Clinker Substitution in the Cement Industry: Frequently Asked Questions. Brussels: The European Cement Association.



Decarbonisation Levers in Detail (cont'd)

Switching to Alternative Fuels

Replacing conventional fossil fuels with lower-carbon alternatives addresses the thermal emission component of cement production while contributing to circular economy principles by utilizing waste materials that would otherwise require disposal.

Cement kilns can efficiently combust various alternative fuels due to their high operating temperatures (1,450–1,500°C), long residence times, and alkaline environment. Common alternative fuels include biomass materials such as waste wood and agricultural residues, municipal solid waste, refuse-derived fuels (RDF), industrial waste including scrap tires and waste oils, and sewage sludge.

European cement producers lead in alternative fuel adoption, driven by regulatory frameworks and carbon pricing mechanisms.

Heidelberg Materials has achieved thermal substitution rates exceeding 30%, at the Edmonton cement plant in Alberta, Canada, the company achieves an alternative fuel rate of 50%.⁷ The company targets alternative fuel in the fuel mix to 45% and the proportion of biomass up to 20% by 2030.

Analysis of alternative fuel impacts shows varying CO₂ reduction potential depending on fuel type and biogenic content. Co-processing of waste oil represents the highest potential for CO₂ emissions reduction (1–7% sector-wide abatement), while sewage sludge and scrap tires offer 1–5% reduction potential. The effectiveness depends critically on the biogenic carbon content and lifecycle emissions profile of specific fuel sources.

Carbon Capture, Utilisation, and Storage (CCUS)

For an industry where process emissions dominate the carbon footprint, **CCUS technologies are widely recognised as the only viable path to achieving near-zero emissions**. CCUS development has progressed rapidly from research concepts to full-scale commercial deployment, representing a critical breakthrough for sector decarbonisation.

CCUS systems capture CO₂ from cement kiln flue gas streams, concentrate and purify the captured CO₂, and either permanently store it in deep geological formations or utilise it as feedstock for other industrial processes. Several capture technology approaches are being deployed, including post-combustion capture using amine-based solvents, direct separation technologies that isolate process CO₂ from combustion emissions, and oxyfuel combustion systems that produce concentrated CO₂ streams.

Heidelberg Materials' Brevik plant in Norway represents a landmark achievement as the world's first full-scale carbon capture facility at a cement plant. The facility captures 400,000 tons of CO₂ annually—approximately 50% of the plant's total emissions—using Aker Solutions' Advanced Carbon Capture technology. Captured CO₂ is transported via the Northern Lights project for permanent geological storage in the North Sea, demonstrating the complete CCUS value chain at commercial scale.⁸ In total, the company has 2 operational projects, 2 at final decision, 7 at advanced development stage and 3 at the technology pilot stage.

⁷Heidelberg Materials (2025) Annual and Sustainability Report 2024. Heidelberg: Heidelberg Materials.

⁸Heidelberg Materials (2025) World premiere: CCS cement facility opens in Norway marks new era of sustainable construction.

Decarbonisation Levers in Detail (cont'd)

Holcim has committed CHF 2 billion gross CAPEX to CCUS projects, with seven full-scale European projects awarded grants by the EU Innovation Fund. These projects aim to produce 8 million tons of near-zero cement and capture around 5 million tons of CO₂ annually by 2030.⁹ The company's GO4ZERO project in Belgium aims to capture nearly all CO₂ from its plant by 2029, representing a near-complete decarbonisation of cement production at that facility.¹⁰

Heidelberg Materials' broader project pipeline includes advanced development initiatives in Bulgaria (ANRAV), Germany (GeZero), and Sweden (Slite CCS), with multiple projects receiving EU Innovation Fund support.¹¹ The GeZero project is scheduled for operation in 2029 and will model solutions for inland industrial sites not in close proximity to coastal storage options.

While CCUS deployment requires substantial capital investment, with high green premiums for cement with CCUS, supportive policy frameworks including EU ETS carbon pricing and innovation funding are improving project economics and accelerating deployment timelines.

Energy Efficiency and Alternative Production Processes

Beyond the primary decarbonisation levers, the industry continues to pursue energy efficiency improvements and explore breakthrough technologies that could fundamentally transform cement production processes. Energy efficiency measures span kiln system upgrades (transitioning to dry-process kilns with preheater systems), waste heat recovery systems that can capture up to 30% of otherwise wasted energy, grinding optimisation, and advanced process control systems. While offering more modest emission reductions compared to other levers, these improvements provide immediate, implementable solutions that reduce both costs and emissions.

Research and development efforts also focus on novel cement chemistries and alternative production processes. Brimstone has developed processes to produce standard Portland cement using calcium silicates instead of limestone, potentially eliminating process emissions while achieving carbon-negative production when combined with concrete carbonation effects.¹² Various other companies are exploring bio-cement production, synthetic limestone production from captured CO₂, and electrochemical production methods, with cement majors increasingly investing in technology partnerships.

⁹Holcim (2024) Carbon capture, utilization and storage. Available at: <https://www.holcim.com/what-we-do/green-operations/ccus> (Accessed: 16 October 2025).

¹⁰Holcim (2024) GO4ZERO CCUS project. Available at: <https://www.holcim.com/what-we-do/green-operations/ccus/go4zero> (Accessed: 16 October 2025).

¹¹Heidelberg Materials (2025) CCUS: more future with less CO₂. Available at: <https://www.heidelbergmaterials.com/en/sustainability/we-decarbonize-the-construction-industry/ccus> (Accessed: 16 October 2025).

¹²Brimstone (2025) Technology. Available at: <https://www.brimstone.com/technology> (Accessed: 16 October 2025).



How Investors Can Accelerate Decarbonisation

Given the essential nature of cement for global infrastructure development and the technical challenges of sector decarbonisation, **divestment strategies alone cannot deliver the real-world emission reductions necessary to meet climate goals.** The interconnected nature of cement production means that excluding high-emission activities from investment portfolios merely transfers these activities to other capital providers without addressing underlying emission sources.

Active engagement emerges as the most effective strategy for investors to drive meaningful decarbonisation outcomes while maintaining exposure to a sector that will remain critical for economic development. Successful engagement requires sophisticated understanding of technical decarbonisation pathways, clear objective-setting, and sustained commitment to monitoring progress over multi-year timeframes.

In our view engagement should utilise a rigorous evaluation framework informed by leading practice principles, including the PRI's Active Ownership 2.0. The approach should consider the achievement of beneficial outcomes for long-term investors by contributing to change via real-world outcomes.

Credibility and Ambition

A robust strategy must first be credible, grounded in comprehensive coverage of material issues and supported by transparent, unbiased assumptions. It should consider broader transition implications, including workforce and community impacts. Building on this foundation, we expect ambition that is contextual to the sector. Targets must be comprehensive—spanning short, medium, and long terms—and fully integrated into incentive structures to prevent unintended consequences where other metrics might undermine climate goals.

Reality of Implementation

Ambition must be matched by reality. Evidence that decarbonisation is not just a strategic intent but an operational reality, supported by sufficient resourcing, capability, and aligned capital expenditure. Effective board oversight and the integration of climate analysis into core governance and risk processes.

The Role of Influence

Finally, policy engagement is a pre-eminent indicator of genuine commitment. Given the critical role of policy in driving decarbonisation, companies must demonstrate that their influence activities—direct and indirect—support rather than delay climate action. For companies with revenue tied to emissions-intensive activities, this requires a higher burden of proof: clear rebuttal of any presumption of delay, transparent reporting of policy positions, and strict board governance over lobbying activities.



Comparative Assessment of Leading Cement Players

For six of the largest global cement players, we now examine how far current emissions intensities, clinker and alternative fuel ratios, and disclosed CCUS pipelines align with stated 2030 and 2050 net-zero targets. This assessment provides a structured peer comparison of Holcim, Heidelberg Materials, CRH, Cemex, Buzzi and UltraTech, highlighting regional disparities, transition risks and implementation gaps, and translating our engagement framework into concrete, issuer-specific insights for investors.

Cement producers researched for this comparison (Holcim, Heidelberg Materials, CRH, Cemex, Buzzi and UltraTech) have all adopted 2050 net-zero goals and near-term intensity targets, but current performance around 525–595 kg CO₂/t cementitious product shows further work is required to reach sub-400–430 kg/t and similar objectives for 2030. Progress on alternative fuels and initial carbon capture projects is material for most companies and most advanced in Europe, yet sector-wide decarbonisation remains structurally dependent on accelerated clinker substitution, large-scale CCUS deployment, and enabling policy frameworks over the next two decades.

Summary Insights

- Current Scope 1 emission intensities for the peer group remain in the mid-500 kg CO₂/t cementitious product range, indicating that the sector is only part-way through the decarbonisation journey and must deliver double-digit percentage reductions within a single investment cycle to meet 2030 targets.
- Clinker ratios of roughly 69–77% confirm persistent dependence on conventional clinker chemistry, making process emissions from calcination the dominant and hardest-to-abate component of the carbon footprint.
- Alternative fuel use is established but uneven, with European-anchored players reaching around one-third thermal substitution while UltraTech remains very low, highlighting regional disparities in waste, biomass and regulatory support.

- All six companies have SBTi-validated 2050 net-zero commitments, but only a subset, notably Holcim and Heidelberg Materials, currently discloses robust evidence of large-scale CCUS projects aligned with those ambitions.
- Near-term (to 2030–2032) progress will be dominated by incremental optimisation of clinker factors, SCM use, alternative fuels and energy efficiency, with CCUS still concentrated in a few flagship plants.
- Long-term achievement of net-zero depends on widespread CCUS rollout across the kiln fleet, supply-constrained SCM scaling, capture of natural and accelerated carbonation sinks, and broader circular design in concrete use and end-of-life.

Detailed Analysis

Current Emissions Profile

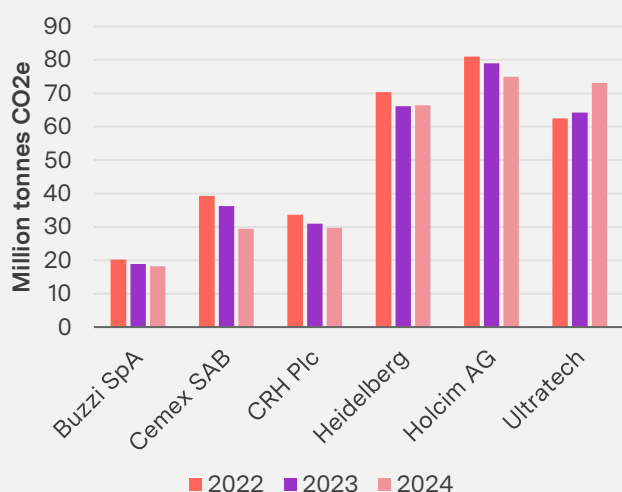
Direct Scope 1 intensities for the sample—Holcim, Heidelberg Materials, CRH, Cemex, Buzzi and UltraTech—cluster between about 526 and 556 kg CO₂/t cementitious product, with Buzzi higher at 593 kg CO₂/t, signalling that even best-in-class performance remains above the sector's own 2030 aspirations, for example Heidelberg's sub-400 kg CO₂/t and Cemex's sub-430 kg CO₂/t 2030 targets.

Clinker ratios remain elevated: mid-60s to low-70s for Holcim, Heidelberg, Cemex and UltraTech, and mid-70s for CRH and Buzzi, entrenching process emissions from calcination as the core decarbonisation challenge. At these clinker levels, even aggressive fuel switching and electricity decarbonisation cannot fully offset the chemical CO₂ released during clinker production, reinforcing the necessity of both clinker factor reduction and CCUS.

Alternative fuel rates around 30–37% for Holcim, Heidelberg, CRH, Cemex and Buzzi indicate meaningful but incomplete penetration of alternative fuels, while UltraTech's TSR of only 3.6% exposes a substantial regional implementation gap. This heterogeneity implies divergent carbon cost trajectories under tightening carbon pricing regimes and differing vulnerabilities to future regulatory or market constraints on fossil fuels.

Comparative Assessment of Leading Cement Players (cont'd)

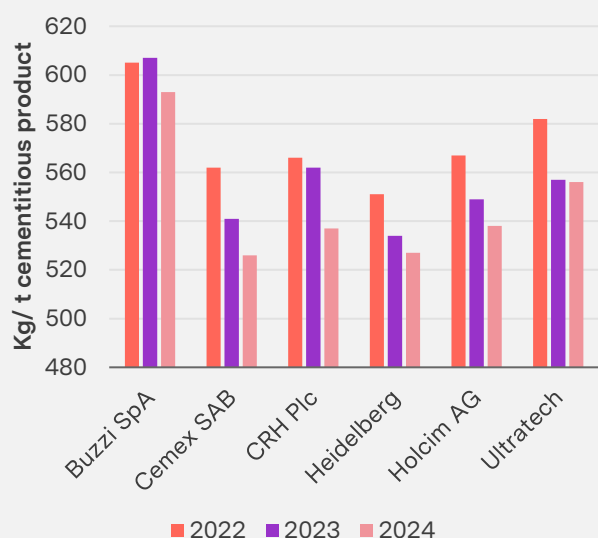
Absolute Scope 1 & 2 CO₂e Emissions



Source: company reported data. Note: Scope 1 is gross emissions; scope 2 emissions are reported in a mix of market and location across companies, however we consider the impact to be de minimis as scope 2 <10% of total scope 1 & 2 emissions.

As of 2024, on an absolute scale, Holcim, Ultratech and Heidelberg each produce over double the absolute scope 1 & 2 emissions than peers Buzzi, Cemex and CRH.

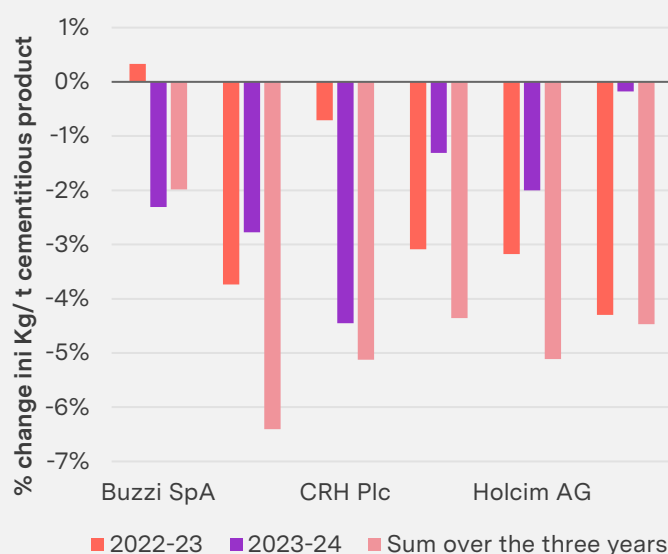
Scope 1 Emission Intensity



Source: company reported data. Note: Scope 1 intensity is net data relating solely to the cement part of the business.

As of 2024, Cemex and Heidelberg have the lowest intensities, with CRH and Holcim ranked 3rd and 4th. Ultratech and Buzzi lag the peer group, with intensities of 556 kg/t cementitious and 593 kg/t cementitious respectively.

Pct Change in Scope 1 Emissions intensity



Source: company reported data. Note: Scope 1 intensity is net data relating solely to the cement part of the business.

Over the last three years, Cemex, CRH, Heidelberg and Ultratech have reduced their emission intensity by between 6.4% (Cemex) and 4.4% (Ultratech), with Buzzi lagging the peer group with a 2 percentage point reduction.

Decarbonisation levers to 2030

Short- to medium-term targets are generally framed as 21–30% reductions in Scope 1+2 intensity or absolute emissions versus 2017–2021 baselines by 2030–2032, signalling alignment with a 1.5–2 °C pathway in directional terms.

Structural targets for clinker ratio and alternative fuel rates are central to these plans: Holcim aims for clinker below 68%, Heidelberg for 64%, and Cemex and Buzzi for roughly 65–68% by 2030, representing reductions of 3–12 percentage points from current levels.

Comparative Assessment of Leading Cement Players (cont'd)

In parallel, alternative fuel goals of around or above 50–55% for Heidelberg, Cemex and Buzzi imply roughly a doubling of alternative fuel penetration, with associated requirements for waste infrastructure, permitting and stable feedstock streams.

CCUS Deployment and Role

Holcim's CCUS pipeline—spanning projects in Romania, Greece, Belgium, Germany, Poland, France and Croatia with capture capacities in the 0.4–2 Mt CO₂ per year range—positions the company as a clear front-runner in integrating CCUS into its core asset base. These projects, scheduled to come online mostly between the late 2020s and early 2030s, signal a strategic bet that CCUS clusters and transport-storage infrastructure will mature sufficiently to support large-scale operation.

Heidelberg Materials already operates the Brevik facility in Norway, capturing about 400,000 t CO₂ per year and constituting the first industrial-scale CCUS installation in cement, with a German facility also operational. The company also has two projects at final decision; seven in advanced development and three in technology pilot. For example, they have taken a final investment decision at Padeswood in the UK to capture nearly all the plant's CO₂ emissions and is planned to be operational by 2029. This combination of operational experience and committed follow-on investment establishes Heidelberg as a benchmark for CCUS integration, including the development of net-zero product lines such as evoZero.

By contrast, CRH, Cemex, UltraTech and Buzzi reference CCUS in strategic terms or mention projects by name, however disclosure of technical or timetable detail appears embryonic, suggesting that their CCUS pathways are less mature.

Holcim CCUS Projects

- **Campulung, Romania:** Carbon Hub CPT01 project is set to deliver 2 million tons of near-zero cement annually from 2032 as the first full-scale onshore CCS in Eastern Europe.
- **Milaki, Greece:** The OLYMPUS project aims for 1 million tons of CO₂ captured annually and nearly 2 million tons of net-zero cement produced by 2029, leveraging advanced technologies.
- **Obourg, Belgium:** GO4ZERO is due to capture 1.1 million tons of CO₂ per year by 2028, setting a national benchmark.
- **Lägerdorf, Germany:** project will capture 700,000 tons per year by 2030–2035 using innovative technology.
- **Kujawy, Poland:** Holcim plans to capture 1.2 million tons of CO₂ annually by 2027 with full-chain CCS.
- **Le Teil and Martres, France:** Dual projects advance decarbonisation as part of a broader cluster strategy.
- **Koromačno, Croatia:** Project will achieve 400,000 tons CO₂ captured per year by 2028, with a focus on permanent offshore storage and the use of disruptive cryogenic capture technology.



Comparative Assessment of Leading Cement Players (cont'd)

Heidelberg Materials Projects

Operational

- Brevik CCS, Norway: Fully operational CCS plant at a cement works, described as the world's first industrial-scale CCS facility in the cement industry, enabled by strong government support and social acceptance in Norway.
- Cap2U, Lengfurt, Germany: Near-term CCU plant (targeted for 2025) that will capture CO₂ from cement production and purify it for reuse as a feedstock in manufacturing, including food and chemical applications.

Final investment decision / close to FID

- Padeswood CCS, UK: FID-stage project to add carbon capture at the Padeswood cement plant, linked to the HyNet North West transport and storage network and powered using hydrogen, with UK government funding supporting detailed planning.
- Edmonton, Canada: Near-FID project to build North America's first industrial-scale CCUS solution in cement, capturing CO₂ from the kiln and CHP plant and sending it via pipeline, in partnership with Enbridge, pending FEED completion and FID.

Advanced development

- ANRAV, Devnya, Bulgaria: First full-chain CCUS project in Eastern Europe, connecting Devnya Cement's capture facilities via pipeline to offshore storage under the Black Sea, co-developed with Petroceltic and backed by the EU Innovation Fund.
- GeZero, Geseke, Germany: Inland-site CCS concept supported by the EU Innovation Fund, combining capture at Geseke with interim transport solutions to move CO₂ to Wilhelmshaven and then offshore storage in the North Sea by around 2029.
- Slite CCS, Sweden: Project to fully decarbonise the Slite plant by 2030 with up to 1.8 million tonnes of CO₂ captured per year, increased biobased fuel use, and CO₂ shipped for storage under the North Sea after a completed feasibility phase.

- Anthemis, Antwerp, Belgium: Hybrid OxyCal unit combining oxyfuel and amine capture in a single system without a separate preheater tower, targeting more than 97% reduction in CO₂ emissions at the Antwerp plant.
- AirvaultGOCO₂, Airvault, France: Part of the GOCO₂ cluster, capturing CO₂ and piping it to Saint-Nazaire for liquefaction, shipping to North Sea storage, and partial use of the biogenic fraction for e-fuels production, with first capture aimed for 2030.
- Mitchell, Indiana, USA: Project to capture about 95% of CO₂ emissions from the modernised Mitchell plant and store it in an onshore reservoir in the Illinois Basin, currently in feasibility study with US DOE support.
- Rezzato-Mazzano, Italy: Capture project targeting over 95% emissions reduction at the Rezzato-Mazzano plant, using the Ravenna CCS hub in the Adriatic Sea as the storage site with support from Eni and Snam.
- Safi, Morocco: Large-scale CCU demonstration using captured CO₂ to grow microalgae for animal feed, already producing around 25 tonnes of dried microalgae per year on a 0.5-hectare site, with planned capacity expansion by 2026.

Large technology pilots

- LEILAC, Ennigerloh, Germany: EU-funded scale-up of direct separation technology for cement and lime, building a reactor at Ennigerloh four times larger than the Lixhe pilot to capture high-purity process CO₂ without extra heat input.
- ANRAV.beta, Devnya, Bulgaria: Pilot capture unit at Devnya to prove the new OxyCal technology and its scalability, with construction underway and a 12–24 month demonstration phase planned to de-risk the full ANRAV CCUS chain.
- catch4climate, Mergelstetten, Germany: Joint oxyfuel kiln demonstration with three other cement producers, constructing a semi-industrial plant at Mergelstetten to test low-energy oxyfuel capture and use part of the CO₂ for synthetic fuels like sustainable aviation kerosene.

Comparative Assessment of Leading Cement Players (cont'd)

Long-term positioning and transition risks

All six manufacturers commit to net-zero by 2050, typically across Scopes 1 and 2 and often Scope 3. Universal SBTi validation lends formal credibility to these pledges, but the heterogeneity in disclosed implementation plans means that not all trajectories are equally robust from an investor-risk perspective.

Structural constraints remain pronounced: the chemical nature of clinker production, high capital intensity and long asset lives limit the speed at which kiln technologies can be replaced or retrofitted. Delays in CCUS infrastructure, regulatory certainty or supportive policy (for example on waste fuel use and recognition of carbonation sinks) could leave significant portions of the kiln fleet stranded in a high-emissions equilibrium, jeopardising both 2030 milestones and 2050 net-zero trajectories.

Regional asymmetries are likely to persist, with European players benefiting from stronger policy drivers, carbon pricing and CCUS cluster development, while operators in emerging markets face more constrained waste-to-fuel systems and less mature carbon regulation.

This uneven playing field may reshape trade flows and competitive positioning in clinker, cement and concrete products, potentially triggering carbon-border adjustments or similar mechanisms as importing regions seek to protect decarbonising domestic industries.

Overall, the peer comparison portrays a sector that has clearly committed to deep decarbonisation and made measurable early progress, but that still sits at a notable distance from its own 2030 and 2050 targets and is exposed to the pace of CCUS scale-up and enabling policy. The companies that are already deploying large-scale CCUS and structurally re-engineering clinker ratios and fuel mixes appear best positioned for a disorderly transition scenario, while those at an earlier stage risk compressed timetables, higher marginal abatement costs and greater vulnerability to regulatory tightening.

Climate Transition Peer Comparison: Cement Manufacturers

Metric	Holcim	Heidelberg Materials	CRH	Cemex	Buzzi SpA	UltraTech Cement
Direct Emissions Intensity (per tonne)	538 kg CO ₂ net/t cementitious (2024)	527 kg CO ₂ net/t cementitious (2024)	537 kg CO ₂ net /t cementitious (2024)	526 kg CO ₂ net /t cementitious (Scope 1, 2024)	593 kg CO ₂ net/t cementitious (2024)	556 kg CO ₂ net/t cementitious (FY24)
Current Clinker Ratio	71.7% (2024)	69% (2024)	75.3% (2024)	71.8% (2024)	76.6% (2024)	69.6% (FY24)
Current Alt. Fuel Ratio (TSR)	31.7% (2024)	31% (2024)	35.7% (2024)	37% (2024)	30.3% (2024)	3.6% (FY24)
Current CCS Status (for details of project see below)	7 large-scale projects in execution	2 operational projects, 2 at final decision, 7 at advanced development stage and 3 in technology pilot stage	Part of 2030 decarbonisation strategy - no project information disclosed	Part of long-term strategy - no project information disclosed	Projects named (Nuda, Vernasca, Hercules), although no specific project information is disclosed	Part of long-term strategy - no project information disclosed
CLIMATE TARGETS						
Short/Medium-Term Targets	-26.2% gross S1+S2 GHG/t cementitious by 2030 (vs 2018)	<400 kg CO ₂ net/t cementitious (S1) by 2030	- 33.5% gross S1 & S2 GHG/ t cementitious product by 2030 (2021 base year)	<430 kg CO ₂ net/t cementitious (S1) by 2030; alt fuels at >55%, S2 per ton of cementitious at <24 kgCO ₂	Reduce S1+S2 intensity by 21.2% by 2030 (vs 2021)	-27% specific S1+S2 CO ₂ emissions/t by FY32 (vs FY17)
Long-Term Target	Net Zero GHG across value chain by 2050	Net Zero across S1, S2, S3 by 2050	Net Zero across S1, S2, S3 by 2050	Net Zero across S1, S2, S3 by 2050	Net zero by 2050	Net Zero concrete by 2050
SBTi Validation	Yes	Yes	Yes	Yes	Yes	Yes
Clinker Ratio Target	<68% by 2030	64% by 2030	No specific target with a timeline	68% by 2030	65% by 2030	No specific target with a timeline
Alt. Fuel Ratio Target	50% by 2030	>50% by 2030	No specific target with a timeline	55% by 2030	48% by 2030	No specific target with a timeline

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