Cement

RAISING AMBITIONS, REDUCING EMISSIONS

ecocem

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Foreword

If ever proof were needed that we face a climate emergency, this year has provided it. For some, it was a case of record temperatures, raging wildfires and droughts; for others it was floods of biblical proportions. For all, it is proof of the tragic and mounting costs of unchecked global warming.

The consequences of inaction are far-reaching. The Intergovernmental Panel on Climate Change points to the need to reduce greenhouse gas emissions by 48% by 2030. This is less than eight years away. UN Secretary General, Antonio Guterres, has said: "Preventing irreversible climate change is the race of our lives." With global energy and industrial emissions topping 36 billion tonnes in 2021 and heading in the same direction this year, global warming is running faster than our responses are.

Action cannot be postponed on the presumption that some miraculous technological fixes lie just around the corner. Halving emissions by 2030 is possible with today's technology. Doing so is a matter of will, pace and scale.

The cement industry accounts for over 7% of global emissions – some 2.5 billion tonnes. Cement is the critical ingredient in concrete, already the most used substance on earth after water, and expected to become even more widely deployed, as urbanisation continues across the globe.

There is a clear and urgent need to decarbonise this industry. To date, however, efforts to address cement emissions have focused on energy efficiency and, lately carbon capture, utilisation, and storage (CCUS) – whereby producers capture the carbon on site and transport it to places where it can be used or buried. When and if this technology matures, it will undoubtedly help the cement industry to address the IPCC's long-term carbon reduction goals.

But, in the near term, CCUS faces multiple challenges. It is hugely expensive, will only be suitable for a small number of cement plants, is commercially unproven and unlikely to be available for wide roll-out until the mid-2030s. In the meantime, CO_2 emissions will continue to rise and the pressure to act will intensify.

Most of the CO_2 in cement and concrete comes from the production of clinker, the critical ingredient in traditional cement; the glue that binds concrete together and is responsible for over 90% of concrete's carbon footprint. Accordingly, focusing on the root cause of cement and carbon emissions can bring dramatic results. Low-clinker cement and concrete technologies could decarbonise the cement and concrete industries by over 50% over the next decade without excessive cost – and they are already available. Shifting to these low-carbon alternatives could reduce the cement industry's emissions by up to 1.6 billion tonnes, equivalent to 4% of global emissions – almost 60% of the EU's CO_2 emissions.

These technologies need to be industrialised, incentivised, and rolled out without delay because acting early matters. Yet, despite their dramatic and short-term potential impact, these processes remain largely unsupported by public policy and funding. This needs to change.

CCUS can be a valuable part of the cement industry's longer term decarbonisation strategy but if this high-emitting sector is to play a meaningful role in global carbon reduction targets now and during the remainder of this decade, then public policy support and funding for a range of significant additional solutions is not only warranted but essential.

The cement industry has traditionally been averse to change, but the winds of change are blowing. The pathway to decarbonisation requires creative leadership, a firm resolve to act, and the full exploitation of technological and scientific know-how we now have. Only then, can we deliver the transformation required to support the cement industry, serve the wider common good and safeguard our planet.

This report offers a timely update on the state of the cement nation and the opportunities available to the industry to accelerate decarbonisation.

PAT COX
CHAIR OF ECOCEM

FORMER PRESIDENT OF THE EUROPEAN PARLIAMENT 2002–2004

Executive summary

The cement industry accounts for over 7% of global emissions – some 2.5 billion tonnes.

Climate change is widely recognised as the most pressing issue facing society today. The world is heating up, suffering is acute and there is a growing awareness that we need to act decisively now before we lose control.

Targeted action is most likely to deliver results. Of the 36 billion[1] tonnes of greenhouse gas emitted in 2021, three-quarters was generated by four sectors: heating and electricity, transport, steel and iron production and cement production. Cement alone generates around 2.5[2] billion tonnes of CO_2 annually, more than aviation, shipping and long-haul trucking combined. If it were a country, the cement industry would equate to India, the third biggest polluter in the world, after China and the US.[3]

Yet, even as other industries make tangible strides towards a low-carbon future, emissions from the cement industry are going the other way, more than doubling between 2000 and 2020.[4] With the World Economic Forum (WEF) estimating that demand for cement could increase by 45% by 2050,[5] urgent action is imperative.

Why is cement in such demand? Because cement is the main ingredient of concrete and concrete is used in infrastructure and construction projects across the world. But cement is a major emitter of CO_2. As awareness of its environmental impact increases, the cement industry is facing intense and growing challenges from stakeholders, including customers, capital providers and regulators. Its social licence to operate may even be called into question.

There is a way forward, however. Breakthrough technological advances offer significant hope that the industry can move to a path of rapid decarbonisation, far faster than could have been imagined even a few years ago.

Shifting to renewable energy helps but it does not go far enough. This leaves two major options for cement producers if they are to hit EU targets and reduce emissions by 55% by 2030.[6] First, capture as much of the carbon produced as possible through carbon capture, utilisation and storage (CCUS) technology. Second, reduce the volume of emissions produced to begin with by creating scalable, low-carbon cements.

Whilst CCUS will undoubtedly play a major role in any industrial decarbonisation strategy, it is not a panacea. It will not work in every location. It will almost certainly require extensive taxpayer support. And it will take years to become fully operational. The technology remains immature, and it will add huge cost and disruption to an industry as low cost and fragmented as cement. Indeed, it has been noted that CCUS could cost more than $500 billion to install, with associated expenditure taking the bill to almost $800 billion, over twice the value of the industry's entire asset base.[7]

Low-carbon cements have been available for decades. The technology behind them involves a reduction in clinker, the central ingredient in cement and the one that generates most of its emissions. Widespread adoption of these low-carbon cements has been hampered to date by their inability to scale up or by their technical performance. However, recent advances in cement technology, concrete technology and chemical admixtures, offer an opportunity to substantially reduce the amount of clinker needed by cement manufacturers, whilst maintaining both output and quality. Indeed, such cements could, in the near term, reduce the carbon footprint of traditional cement by more than 1.6 billion tonnes a year, equivalent to some 4% of global emissions, without excessive cost or disruption to the cement manufacturing processes.

Drastically reducing CO_2 output at source will give the cement industry time to refine and develop CCUS technology, and research other carbon-reducing options too.

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[1] https://www.iea.org/reports/global-energy-review-co2-emissions-in-2021-2
[2] https://www.iea.org/reports/cement
[3] IEA, Global Energy Review https://www.iea.org/reports/global-energy-review-co2-emissions-in-2021-2
[4] Statista https://www.statista.com/statistics/1299532/carbon-dioxide-emissions-worldwide-cement-manufacturing/
[5] WEF Net Zero Industry Tracker 2022
[6] https://eur-lex.europa.eu/legal-content/EN/HIS/?uri=CELEX:52021PC0551
[7] WEF Net Zero Industry Tracker 2022

But, this low-clinker, low-carbon cement needs support on three fronts to deliver against its potential.

- First, financial: CCUS for cement plants has received an estimated €600 million[8] in grants and funding from the EU's Innovation fund alone. Scalable low-carbon cement technologies have received little or nothing. They would benefit hugely from financial support to drive further research and development and demonstrate their effectiveness on the ground.

- Second, regulatory: standards and regulations around cement and concrete are understandably rigorous but they are also highly complex and act as an obstacle to innovation and progress. If they were modified and updated, low-clinker cement could be in use before 2025.

- Third, sector buy-in: no technology can deliver results unless it is used by the industry for which it has been developed. This technology could be rapidly deployed by cement producers the world over. Those in the vanguard are already keen to use it. The more adopters there are, the quicker the industry can achieve its emissions targets.

Today, governments and policymakers are at a crossroads with respect to cement decarbonisation. As they consider how best to hit near and long-term decarbonisation targets, there is clear evidence from other high-emitting sectors that a multi-channel approach is likely to prove most effective, helping the cement industry to decarbonise faster, more simply and at substantially lower cost. With strong stakeholder support, cement producers can rapidly decarbonise. They can save time, save money and prove that even this hard-to-abate industry can contribute to a better future for all.

[8] https://climate.ec.europa.eu/system/files/2022-03/c_2022_1571_annex_en.pdf


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Section 1
Heating up

In 1938, the British engineer Guy Callendar showed that temperatures had risen over the past century, at the same time as CO_2 emissions had increased. His conclusion – that the two were linked – was widely dismissed. At the time, annual carbon emissions were just over 4 billion tonnes. By the time the Intergovernmental Panel on Climate Change (IPCC) was formed, 50 years after Callendar's findings, annual carbon emissions had soared more than fivefold to 22 billion tonnes. Today, annual emissions are more than 36 billion tonnes, having stubbornly exceeded 30 billion tonnes for the past 15 years.[9]

Rapid growth in emissions, rising temperatures and increasingly frequent 'weather events' have prompted a profound shift in sentiment and in April of this year, the IPCC issued a stark warning: global greenhouse gas emissions need to fall by 48%[10] in the next eight years, if the world is to limit global warming to 1.5°C. And CO_2 emissions need to reach net zero by 2050 in order to stabilise global temperatures.

In the words of IPCC co-chair, Jim Skea: **"It's now or never if we want to limit global warming to 1.5°C. Without immediate and deep emissions reductions across all sectors, it will be impossible."**

Ambitious targets have been set in response: the European Union aims for a 55% reduction in emissions by 2030, compared to 2005. The US aims to halve emissions over the same timeframe.[11]

Among the highest emitting sectors of the economy, some have made considerably more progress than others. Global investment in the renewable energy sector reached a record $366 billion in 2021;[12] the cost of renewable energy has fallen dramatically and take-up of technologies such as wind and solar power has been extensive.

The transport sector has made tangible progress too. Investment in the electrification of transport was a record $273bn in 2021.[13] More than 70% of global rail activity was powered by electricity or hydrogen in 2020, while electric cars are gaining rapidly in popularity, accounting for almost 10% of new car sales last year.[14]

But certain sectors are lagging. Carbon emissions from iron and steel and cement production doubled between 2000 and 2020, far outpacing every other sector of the economy.[15]

The transition to electricity-based production methods is already underway in many US and European steelmakers, but cement makers face a far greater challenge. Only 33% of their emissions relate to energy usage: the remaining 67%[16] are generated by a chemical reaction that takes place within the production process itself. Even if the industry transitioned entirely to renewable energy, it would still be a major emitter. To deliver a 48% reduction in emissions by 2030 and reach net zero by 2050, more must be done.

[9] Source: Global Carbon Project
[10] IPCC Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.carbonbrief.org/in-depth-qa-the-ipccs-sixth-assessment-on-how-to-tackle-climate-change/
[11] The United States Department of State. The Long-Term Strategy Of The United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050, November 2050. https://www.whitehouse.gov/wp-content/uploads/2021/10/US-Long-Term-Strategy.pdf
[12] Source: European Innovation Council (2022 Investment Trends) and BloombergNEF
[13] European Innovation Council (2022 Investment Trends) and BloombergNEF
[14] IEA
[15] IEA
[16] Washington State Industrial emissions Analysis – cement case study July 2021 https://uploads-ssl.webflow.com/5d8aa5c4ff027473b00c1516/6187eb9c1f28f854f87eb2d2_Washington%20State%20Industrial%20Emissions%20Analysis%20Green%20Cement%20Case%20Study%20July%2030%2C%202021%20Draft.pdf

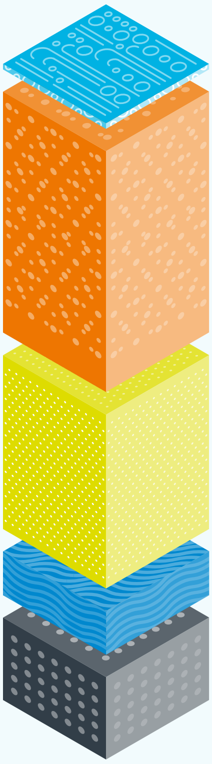
Section 2
Why cement matters

Demand for cement is driven principally by its use in concrete, the most consumed substance on earth, after water.[17]

Concrete, a unique, low-cost, durable substance has revolutionised our world over the past 200 years,[18] becoming the cornerstone of modern infrastructure. Concrete is used in almost every part of the built environment: from homes to hospitals; roads to railways; offices to industrial warehouses, and power stations to renewable energy sites.

And concrete would not exist without cement. Cement is the glue that makes concrete the most resilient, easy to use and effective construction material in the world.

CONSTITUENT PARTS OF CONCRETE



When mixed with water, cement hardens, binding together sand and aggregates to form concrete.

Demand for concrete is fuelled primarily by population growth, urbanisation and even the green transition, where every new megawatt of onshore wind power requires around 1,700 tonnes of concrete.[19] And demand is accelerating. The world will build the equivalent of an entire New York City every month over the next four decades.[20]

Cement itself is now the world's largest manufactured product by mass.[21] Annual production exceeds 4 billion tonnes,[22] equivalent to over 0.5 tonne of cement for every person on the planet. To put this in context, according to a 2018 report some 8.3 billion tonnes of plastic had been produced over the last 70 years.[23] Cement makers take just two years to create that volume of material. Ongoing demand for this fundamental material is expected to foster a 45% increase in cement production to over 6 billion tonnes per annum by the early 2050s.[24]

Yet cement has a major issue. It is the source of around 2.5 billion tonnes of carbon emissions annually,[25] and, if it were a country, it would be the third biggest producer of emissions after China and the USA.

[17] United Nations Environmental Programme, Eco-efficient cements: Potential economically viable solutions for a low-CO_2 cement-based materials industry, 2017
[18] Irish Cement | History of Cement
[19] Why Europe needs a comprehensive carbon capture and storage strategy: Clean Air Task Force
[20] That's a lot of Cement and Steel: Bill Gates, Gates Notes, February 2019
[21] United Nations Environmental Programme, Eco-efficient cements: Potential economically viable solutions for a low-CO_2 cement-based materials industry, 2017
[22] US Geological Survey
[23] https://www.unep.org/news-and-stories/press-release/line-sand-global-commitment-eliminate-plastic-pollution-source
[24] https://www3.weforum.org/docs/WEF_NetZero_Industry_Tracker_2022_Edition.pdf
[25] https://www3.weforum.org/docs/WEF_NetZero_Industry_Tracker_2022_Edition.pdf

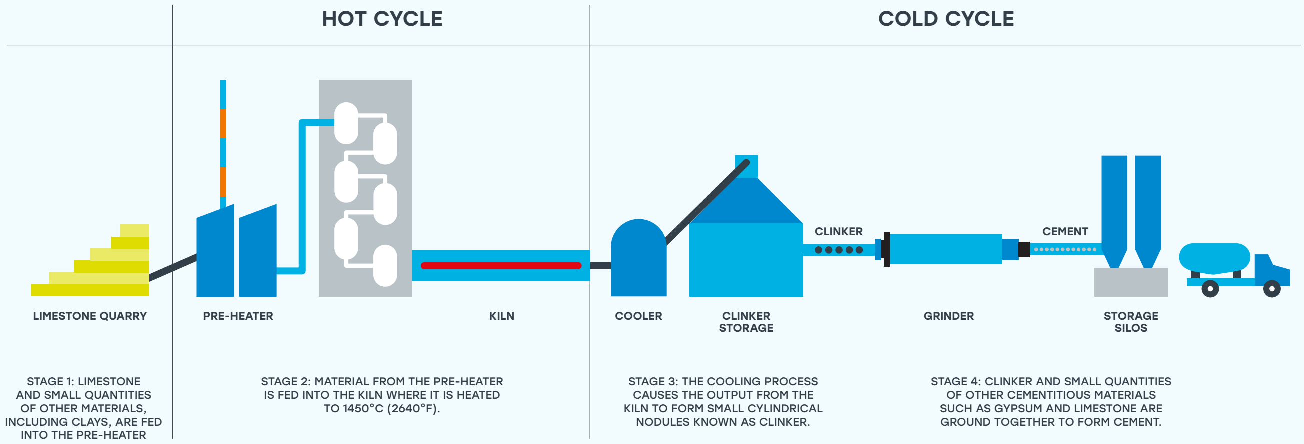
Section 3
Cement production

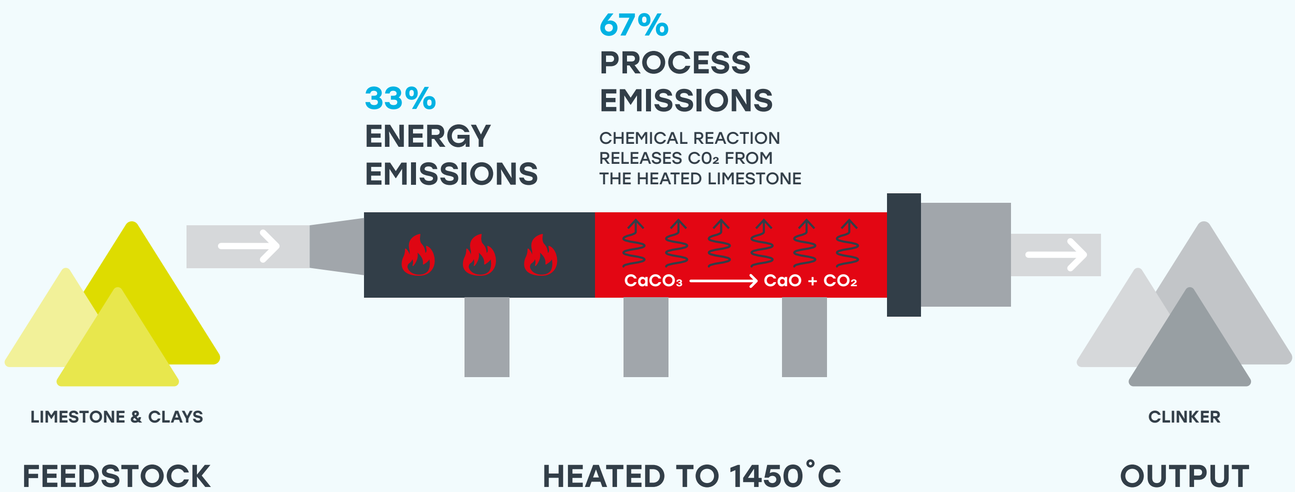
Cement production is well established, highly effective, and has barely changed since it was first developed nearly 200 years ago. The process comprises two stages, the 'Hot Cycle' and the 'Cold Cycle'.

During stage one, the Hot Cycle, a mixture of calcareous materials (e.g., limestone) and siliceous materials (e.g., clay) is heated in a rotary kiln to temperatures of around 1,450°C. At this point, the mixture is transformed into a reactive, semi-finished product called clinker, the key component in cement. Given its high temperature requirements, making clinker is one of the most energy-intensive industrial processes.

During stage two, the Cold Cycle, clinker is ground in a mill with other ingredients such as gypsum, and so-called supplementary cementitious materials. Together, these create the final product, a cementitious powder which hardens when it is mixed with water.

The unavoidable chemical reaction that occurs during the transformation of the limestone and clay mixture to clinker, known as calcination (process emissions), together with the energy required to achieve the necessary kiln heat and operate mechanical components (energy emissions), result in an immense carbon footprint: approximately 0.8 tonnes of CO_2 is released for every tonne of clinker produced.[25]





[26] Global Cement and Concrete Association, 2019 data.

On average, process emissions represent two-thirds of all cement emissions, with energy emissions making up the balance. As such, even a shift to 100% renewable energy, would only address approximately one-third of the industry's emissions.

Sonya Bhonsle, Global Head of Value Chains and Regional Director Corporations at global disclosure specialist, CDP:

"In its current form, the industry is not compatible with the commitments made at COP21 in Paris to limit global warming to 1.5°C. As the majority of the sector's emissions are inherent to its production process, the cement industry must make fundamental changes in order to reach net-zero."

THE DILEMMA

The world relies heavily on cement. Alternatives to cement – and concrete – are certainly considered by businesses and individuals looking for a cleaner solution. But each comes with its own set of challenges. Wood, for example, is often cited – and sometimes deployed – as an alternative to concrete; but replacing just 25% of cement used in construction with timber would require cutting down a forest 1.5 times the size of India every year.[27]

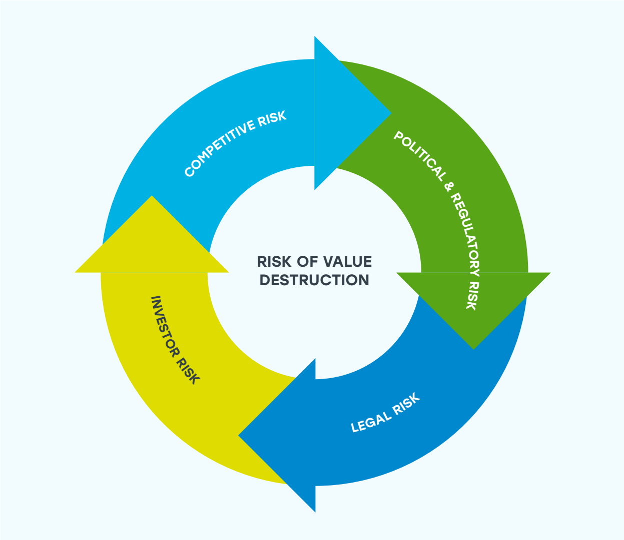
There is no real alternative to cement. Already extensively deployed in developed economies, cement now has a vital role to play in emerging markets, helping developing nations to build the infrastructure they need so they can create flourishing and economically secure societies.

Today, however, change is afoot. Fiscal regimes are changing, investor attitudes are changing, customer and societal demands are changing. As one of the largest industrial emitters in the world, the cement industry is under increasing pressure to decarbonise. In such an environment, cement production cannot continue in the same vein as it has in the past.

[27] Source: Climate action in the cement industry: Bellona

Section 4
Current trends, future consequences

To align with the Paris Climate Accords, cement producers need to decarbonise at pace. To date, they are lagging behind. The gap between global emission targets, and the planned rate of decarbonisation in the cement industry, could have grave consequences. Cement industry emissions have actually doubled since 2000. The Global Cement and Concrete Association (GCCA) is aiming for 20% reductions by 2030. Cembureau (the representative organisation of the cement industry in Europe), forecasts a reduction of just 15% in cement's carbon footprint between 2017 and 2030. Even long-term roadmaps fall substantially short of net-zero unless external factors are taken into account.



Stakeholders across the value chain are increasingly concerned about climate change; they recognise the need for urgent action, and they are reluctant to accept the status quo. The risks for cement manufacturers are multifaceted.

POLITICAL

As concerns mount around climate change, politicians are under pressure to address voters' fears by pushing for action from heavy emitters.

Sonya Bhonsle, CDP:
"Policymakers and regulators have an important part to play in accelerating action in the industry."

Across the political spectrum, there is a growing recognition of the need for collective action. In August, the US signed the ground-breaking Inflation Reduction Act, the EU's Green Deal has received widespread support, and COP events and initiatives are increasingly high profile. Simultaneously, political affiliations are changing. The Green Party now holds a share of power in six European countries,[28] including Germany, the industrial powerhouse of Europe.

As political preferences shift, environmental agendas are likely to gain greater prominence, putting heavy emitters under increasing pressure. In the words of McKinsey: 'Governments are now increasingly asking for environmental impact assessments before deciding whether to commit funding. As public scrutiny of CO_2 emissions increases, the risk remains that cement players could be "shamed," similar to oil and gas or mining companies in the past.'[29]

FISCAL

Taxation is one of the most effective tools in policymakers' armoury: legislative trends suggest they are not afraid to use it.

The EU has been a pioneer in this space, introducing the Emissions Trading System (ETS) in 2005 – a carbon market that puts a price on industry emissions. The price of carbon credits within the system has soared in recent years, from around €25 per tonne of CO_2 in 2019, to approximately €76 per tonne in November 2022 this year. Heavy industry has been largely protected from the European ETS to date, and cement producers are no exception, with 87% of their emissions covered by free carbon allowances in 2021.[30]

But the EU is now scaling up its ambitions with the Fit for 55 packages, a parcel of measures designed to reduce European carbon emissions by at least 55% by 2030. It is expected that

[28] How Green Politics are Changing Europe, 2021, BBC https://www.bbc.com/news/world-europe-58910712
[29] McKinsey: Laying the Foundation for zero-carbon cement
[30] The EU Transaction Log

free carbon allowances under the ETS will be phased out completely by 2035 at the latest under this package, in favour of the Carbon Border Adjustment Mechanism (CBAM), a system which will leave heavy industries fully exposed to carbon tariffs.

Estimates suggest that this new mechanism will add an estimated €12 billion of carbon taxes per annum by 2035 to the European cement industry,[31] or more than €90 per tonne of clinker produced.

While Europe is leading the way in taxing carbon, other jurisdictions have followed suit, or are planning to do so, including the UK, Korea, Canada, certain US states and China, which established the basis of a carbon tax system in 2021.

FINANCIAL

Environmental concerns have become a central issue for the providers of capital. Under pressure from policymakers, regulators and end-customers, many debt and equity providers are turning their backs on heavy-emitting industries, in effect driving up the cost of capital.

The Global Fossil Fuel Divestment Commitments Database tracks fossil fuel divestment commitments made by institutions globally. Their 2021 report showed that 1,485 institutions, with assets of over $39.2 trillion (greater than the combined annual GDP of the USA and China), have committed to fully or partially divest from fossil fuels.[32]

Over 117 banks, representing $70 trillion[33] in assets, have committed to align lending and investment with net-zero emissions by 2050, under the UN-convened Net-Zero Banking Alliance. In achieving their ambition, the signatory banks have each set intermediate targets for 2030 or sooner.[34]

The Science Based Targets Initiative (SBTi) has also turned its focus onto the cement industry. Established to drive change across the corporate sector, the SBTi recently issued a guidance report so that cement producers and users, including construction businesses, can set science-based targets in line with 1.5°C.[35] Its rationale – the cement sector is the third-largest industrial energy user and the second largest industrial CO_2 emitter in the world.

While some institutions tend to push for change behind the scenes, activist investors are more vocal, and seek to engage directly with companies to drive change – and those advocating for climate action are growing in number. US hedge fund, Engine No. 1, exemplifies the trend, with three seats on the Exxon board and a mandate for a future free of fossil fuels.[36]

In response to investor concerns, some cement producers appear to be divesting assets as a method of reducing their global carbon footprint, selling subsidiaries in emerging markets and using the resultant cash to drive decarbonisation efforts closer to home or, indeed, reinvesting the capital into products outside of cement production altogether. Such asset sales have provoked censure in some quarters, with critics suggesting that disposals do not resolve the larger issue of emissions, and in fact may aggravate the problem over the longer term.[37]

The pressure on heavy industry will likely continue to intensify over the coming decade, as investment bank Jefferies explains:
'We expect investors to become increasingly aware of the diverse range of low-carbon investment opportunities in Europe and the resilience it brings to portfolio construction.'[38]

[31] Based on a price of €120/t of CO_2 and Cembureau's projected clinker factor per tonne of cement.
[32] Divestment Database https://divestmentdatabase.org/report-invest-divest-2021/
[33] Members – United Nations Environment – Finance Initiative (unepfi.org)
[34] Net-Zero Banking Alliance https://www.unepfi.org/net-zero-banking/
[35] https://sciencebasedtargets.org/sectors/cement
[36] Engine No.1 https://engine1.com/transforming/articles/exxon-mobil-one-year-later
[37] Washington Post Companies Should Go Green Abroad, Not Just at Home – The Washington Post
[38] Jefferies: ESG Research – The Thirty Years' War on Carbon

COMPETITION

In such a period of transition, failure to adapt opens up opportunity for competitors. The cement sector has long been dominated by well-established major players, but a changing market can create new openings for nimble-footed pioneers. The signs are already apparent. Breakthrough Energy, a $2bn investment fund founded by Bill Gates, has invested in a number of companies developing ground-breaking low-carbon cement technologies, including established players such as Ecocem, and start-ups, including Brimstone and CarbonCure.

Hoffmann Green Cement Technologies was established in 2014. Five years later, it listed on the Euronext Growth exchange at a market capitalisation of €240m.

Perhaps, however, the biggest potential source of competitive concern for cement producers could be their number one customer – the concrete industry. This industry is likely to come under increasing pressure to decarbonise, as its customers, construction firms and the real estate sector more broadly, strive to reduce their environmental footprint. If the cement industry cannot provide the solutions that concrete producers require, they may seek their own solutions, even sourcing raw materials and blending low-carbon cements and concretes themselves.

Low-carbon cement and concrete producers may also find themselves at a significant advantage, as incumbent cement operators face mounting costs from carbon taxes. Unlike traditional producers, innovators will be able to offer materials that are cost-effective, simple to use and in compliance with end-customers' increasingly stringent environmental targets.

LEGAL

Climate litigation is on the increase, as individuals, investors and NGOs turn to the courts to try and accelerate change at a corporate and even national level.

More than 2,000 climate litigation cases have been recorded around the world, almost 500 of which were filed between 2020 and the first half of 2022.[39]

In May 2021, a Dutch court ruled that Royal Dutch Shell must cut its CO_2 emissions by 45% compared to 2019 levels.[40]

Baltimore state is currently suing ExxonMobil, BP, Chevron and other oil groups, claiming they deceived the public about the dangers associated with their fossil-fuel products.[41]

And in the first major climate action against a cement producer, residents of an Indonesian island started legal proceedings in 2022 seeking payment for both damages and the development of flood defences.[42]

The policy report **Global trends in climate change litigation: 2022 snapshot** notes that cases are now being filed against a more diverse range of corporate actors and suggests: "While future trends are hard to predict with certainty, the increase in litigation against agricultural companies may suggest that other high emitting sectors such as heavy-duty industry (e.g. steel and cement), textiles, shipping and aviation may be the next targets for litigants".[43]

The cement industry will need to navigate a variety of challenges in the coming years as momentum builds towards greener economies. Two points are clear however: the industry will come under increasing scrutiny and the risks associated with being a major polluter will increase. To prepare, the industry must act now.

[39] Global trends in climate change litigation: 2022 snapshot, Joana Setzer and Catherine Higham
[40] https://uitspraken.rechtspraak.nl/inziendocument?id=ECLI:NL:RBDHA:2021:5339
[41] Reuters https://www.reuters.com/legal/litigation/baltimore-gets-venue-win-climate-case-against-exxon-bp-2022-04-07/#:~:text=(Reuters)%20%2D%20A%20federal%20appeals,to%20take%20a%20second%20look
[42] https://www.theguardian.com/world/2022/jul/20/indonesian-islanders-sue-cement-holcim-climate-damages
[43] Global trends in climate change litigation: 2022 snapshot, Joana Setzer and Catherine Higham

Section 5
Options

Clinker production is the primary source of emissions in cement and concrete: for every tonne of clinker produced, 0.8 tonnes of CO_2 are emitted.

The proportion of clinker per tonne of cement varies from region to region – as high as 89% in the US;[44] as low as 66 per cent in China;[45] around 77% in Europe.[46] On a global average however, the so-called clinker factor is around 74%, yet it is responsible for approximately 90% of cement's carbon footprint.

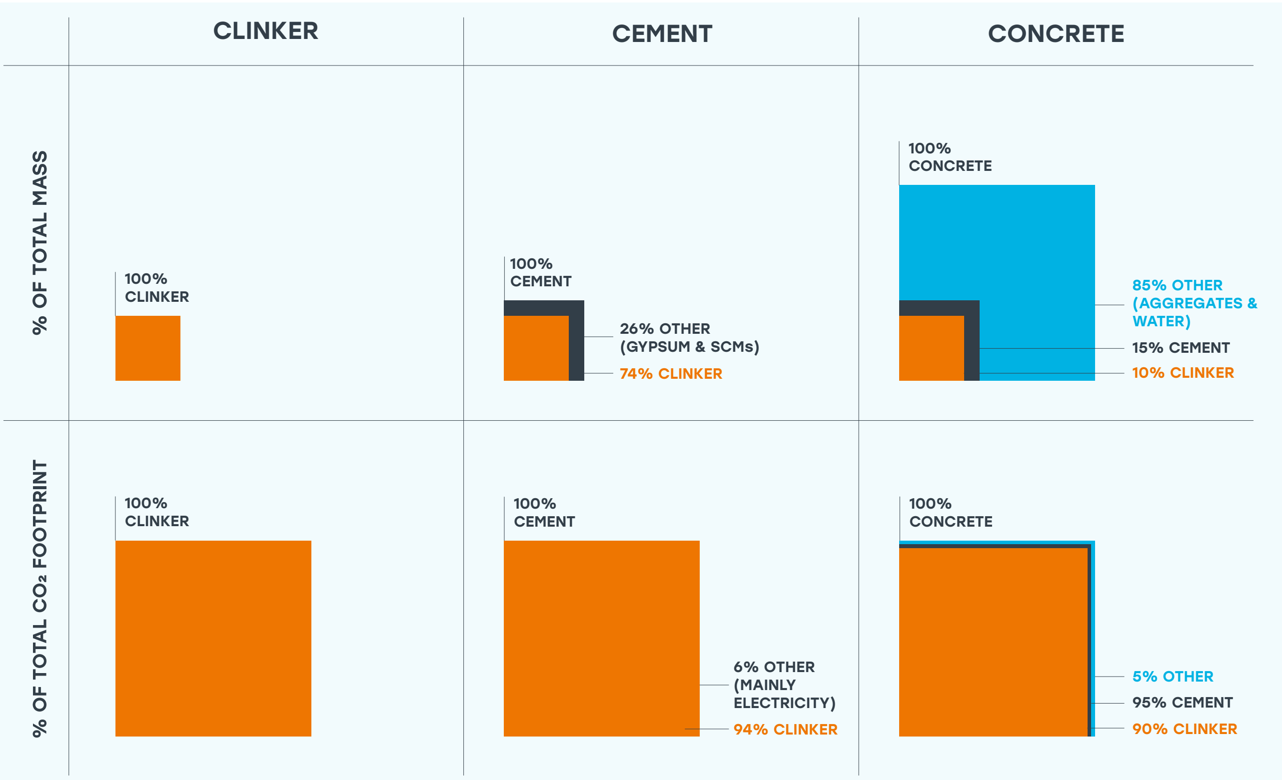
When cement is mixed with aggregates, sand and water to form concrete, clinker is just 10% of the mass of overall constituents, but it is responsible for 90% of concrete's carbon footprint.

Approximately one third of clinker-related emissions occur as a result of energy emissions, arising from the heating of kilns and operation of the mechanical machinery. A great deal of commentary has focused on technologies available to minimise this aspect of clinker production. Mitigating measures such as alternative fuel use, kiln efficiency and electrification of processes and transport are now widely deployed within cement manufacturing. Whilst much of the low-hanging fruit has been plucked, there remains some potential in reducing these emissions further.

However much work is done to reduce energy emissions, clinker-related emissions, known as process emissions, remain a key issue. Process emissions are the result of a chemical reaction that occurs when limestone, subjected to intense heat with other raw materials, calcines (or decomposes) into quicklime, the key component of clinker. This process creates an unavoidable release of CO_2.

Given the very nature of clinker production, there are only two realistic ways to radically decarbonise the cement sector:

- Capture as much of the CO_2 emitted as possible through the implementation of carbon capture utilisation and storage (CCUS) technologies and supporting infrastructure.
- Produce less CO_2 in the first instance by manufacturing cements with lower levels of clinker content – known as clinker substitution.



[44] Global Cement and Concrete Association
[45] https://www.iea.org/reports/cement
[46] Global Cement and Concrete Association

THE RELATIVE MERITS OF CCUS AND LOW-CARBON CEMENTS

Developing and implementing CCUS technologies

Carbon capture technology aims to capture carbon emissions directly from the production process and separate CO_2 from other gases.

CO_2 capture technology has been used since the 1920s to separate marketable gases from the rest.[47] More recently, investment in CCUS is being driven by the oil and gas industries, as well as cement, iron and steel, and chemical production, in the push for decarbonisation.

Once it is separated from other gases, the CO_2 is compressed, transported, and injected underground for permanent storage, or, reused within certain industries, including the concrete industry, to a small degree.

Many are hoping that CCUS will make a crucial contribution to global net zero targets, amid predictions that CCUS will capture 7.6 billion tonnes of CO_2 annually by 2050.[48]

There are a number of advantages in using CCUS to decarbonise the cement industry. In theory, the technology allows hard-to-decarbonise industries to continue to make their products unabated, on the assumption that the CO_2 released will be captured. Furthermore, carbon capture facilities could be implemented at industrial hubs, where multiple facilities could feed into the same unit, leading to economies of scale.

Attracted by the benefits of this technology, CCUS has been heavily prioritised by governments and the cement industry alike. Through the European Innovation Fund, the European Union has dedicated an estimated €600m to cement related CCUS projects over the past two years. And a major European cement manufacturer recently announced seven CCUS projects at a capital cost of €1.5bn by 2030.[49]

Expectations for CCUS are high. The GCCA (Global Cement and Concrete Association) has indicated that CCUS will be responsible for 36% of the cement industries' roadmap to net zero, although the technology is only expected to make a meaningful contribution beyond 2030.[50]

Clearly, CCUS has an important role to play in cement's ultimate decarbonisation. But it is not a panacea. Still in its infancy, the technology has yet to prove how effective it really will be.

According to the IEA: **"The story of CCUS has largely been one of unmet expectations."**[51]

The IEA estimates that global capacity of CCUS needs to reach 1.6 billion tonnes of CO_2 by 2030 to be on target for net-zero emissions by 2050. Yet, in 2021, just over 40 million tonnes of CCUS capacity existed globally, with capacity added at a rate of less than three million tonnes per annum over the previous decade.[52] A 40-fold increase in capacity this decade seems ambitious, even to the technology's most ardent supporters.

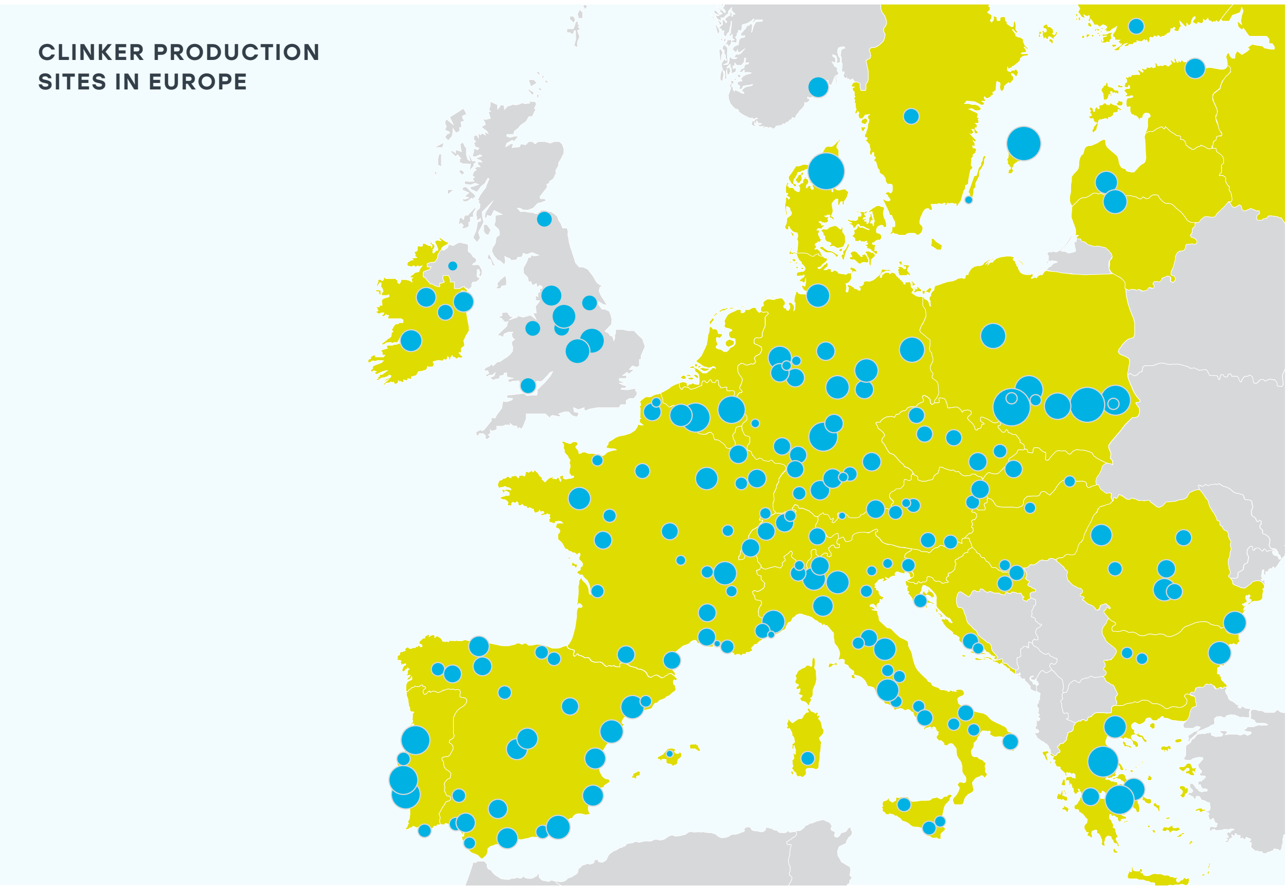
[47] IEA GHG Technology Collaboration Programme https://ieaghg.org/docs/General_Docs/Publications/Information_Sheets_for_CCS_2.pdf
[48] IEA, Net Zero by 2050, May 2021 https://www.iea.org/reports/net-zero-by-2050
[49] Heidelberg Capital Markets Day 2022 Capital Markets Day 2022 | Heidelberg Materials.
[50] GCCA-Concrete-Future-Roadmap-Document: https://gccassociation.org/concretefuture/wp-content/uploads/2021/10/GCCA-Concrete-Future-Roadmap-Document-AW.pdf
[51] IEA, Energy Technology Perspectives, 2020, Special report on Carbon Capture Utilisation and Storage, 2020
[52] Carbon Capture in 2021: Off and running of another false start, IEA.

Moreover, of the circa 2.5bn tonnes of CO_2 emitted by the cement industry annually, none has been captured using CCUS to date.[53] While pilot projects are under way at a limited number of cement facilities, several obstacles stand in the way of a successful roll-out of CCUS at scale:

- **Timing**: CCUS is in its infancy as a technology and, while there are high hopes that it will mature over the coming decade, it is as yet unclear when that will be. By current estimates, it is unlikely to be utilised at scale in developed nations until the mid-2030s at the earliest, leaving billions of tonnes of emissions unchecked in the meantime.

- **Cost**: It has been estimated that installation, capturing, processing and storing CO_2 could cost €75–€145 per tonne of CO_2,[54] more than doubling the cost of producing cement. That makes CCUS a high-cost solution for a low-cost commodity.

- **Fragmentation**: As a low-cost commodity, it is rarely economical to transport cement further than 300km.[55] As a result, the world is heavily populated with clinker production facilities. There are over 200 clinker production sites[56] compared to less than 30 steel blast furnace sites.[57] To roll-out CCUS and related infrastructure to so many dispersed clinker facilities would be a significant and time-consuming undertaking. Furthermore, the initial capital outlay to put in place CCUS infrastructure is significant – potentially costing the same as a new cement production facility.[58] Whilst some major cement manufacturers may be able to rationalise these costs, smaller players will not. That gives rise to multiple questions as to how these facilities would be funded, not only in wealthy continents like Europe or North America, but at a global level, where capital is far less abundant.



[53] Net Zero by 2050, A Roadmap for the Global Energy Sector, IEA.

[54] Q3 2021 Aker Carbon Capture Investor Presentation – Cost based on 25 year levelised cost calculation, discounted at 7.5%.

[55] Cembureau, key facts and figures https://cembureau.eu/about-our-industry/key-facts-figures/

[56] Global Cement Report – 14th Edition

[57] Eurofer

[58] Cembureau, key facts and figures https://cembureau.eu/about-our-industry/key-facts-figures/

- **Logistics**: Given the geographically fragmented nature of clinker plants, transporting large volumes of carbon from these sites is difficult, Pipelines would need to be laid underground, almost certainly creating numerous objections from landowners. And international borders would need to be crossed, creating further potential issues. CCUS appears to be best suited to sites close to ports, allowingeasier access to shipping and offshore storage in exhausted oil or gas fields. To that end, the French national roadmap for decarbonising the cement sector states that only 20% of production facilities would be suitable for CCUS.[59] As Professor Vaclav Smil, Distinguished Professor Emeritus in the Faculty of Environment at the University of Manitoba notes, mass scale carbon capture of over 1 gigaton of gas per year: **"Would necessitate the creation of an entirely new gas-capture-transportation-storage industry that every year would have to handle 1.3–2.4 times the volume of current US crude production, an industry that took more than 160 years and trillions of dollars to build."**[60]

- **Leakage**: There are further concerns too. Most oil and gas wells are secured with concrete produced using Portland cement, which forms a protective sheath around the wells themselves. The most widely used cement in the world, Portland cement is robust and resilient, but concerns have been raised as to its CO_2 resistance. Research carried out at the Technische Universität of Munich, for example, suggests that Portland cement is not fully resistant to CO_2, creating a risk of leakage. This would have widespread consequences, even though the oil wells are far from land.

- **Utilisation**: Some companies are exploring re-carbonation – where CO_2 is deliberately re-absorbed into concrete and other construction materials under controlled conditions. Other initiatives include using CO_2 to create synthetic fuels; capturing CO_2 to cultivate algae and convert it into animal feed and taking CO_2 emitted from cement production for use in food and drink manufacturing. Whilst these are positive shifts, most initiatives are at an early stage and may not be sufficiently developed to move the dial as 2030 approaches.

- **Scope**: CCUS is expected to capture and store less than half the emissions produced by the cement industry. The GCCA forecasts that 1,370Mt CO_2 is forecast to be captured and utilised/stored by 2050,[61] half of today's annual output. A minuscule amount is expected to be captured over the course of this decade.

Overall therefore, while CCUS is a promising initiative that will play an important role in the ultimate decarbonisation of the cement industry, the technology will not be a silver bullet.

It will be expensive, disruptive to current processes and difficult to implement in a heavily fragmented industry, such as cement. It makes sense therefore to urgently seek out solutions that cut cement's emissions profile at the point of production, by reducing the amount of clinker required during the process itself. This would minimise reliance on CCUS, to the benefit of producers, their customers and society more broadly.

Dr Johann Plank, Professor of Chemical Building Materials at the Munich Institute of Technology: **"If CO_2 is released, it will change the PH of the sea water, which could have a significant impact on ocean life. Furthermore, the oceans continuously absorb substantial quantities of CO_2. If leakage occurs, then that capacity will be compromised. I believe that Portland cement should not be used for carbon capture and storage wells because this cement can be corroded and is ultimately completely decomposed by CO_2. Hence leakages might occur in the future and that would be a disaster."**

[59] Feuille de Route de la Filière Ciment, Conseil National de l'Industrie
[60] How the world really works: a scientist's guide to our past, present and future
[61] GCCA Concrete Future Roadmap
https://gccassociation.org/concretefuture/wp-content/uploads/2021/10/GCCA-Concrete-Future-Roadmap-Document-AW.pdf

Developing low clinker, low carbon cements

Clinker, an energy and carbon intensive cementitious material, is the primary cause of emissions in cement production. By substituting clinker with lower energy and lower carbon intensive cementitious materials, the carbon footprint of cement reduces. These other materials are known as supplementary cementitious materials (SCMs). The higher the percentage of SCMs in the final cement product, the more cement's carbon footprint is reduced.

SCMs include any other cement component that is not clinker. An integral component of the final cement, these materials can be split into two distinct categories – reactive binders and fillers.

- **Reactive binders** – these are cementitious materials with hydraulic properties which act similarly to clinker: they react when they come into contact with water, eventually hardening and binding the constituents of concrete together.
- **Fillers** – these are non-reactive materials which are used to "fill-out" the cement blend, reducing the amount of reactive binder within the overall cement blend.

The amount of each ingredient varies slightly from region to region but in Europe, cement's average composition is around 74% clinker, 20% reactive binders and 6% filler material, usually ground limestone.[62]

To date, attempts to reduce cement's carbon footprint have focused on increasing the amount of alternative reactive binders[63] used, to reduce the percentage of highly polluting clinker. But these attempts face two key obstacles:

- **Scalability:** Ground granulated blast-furnace slag (GGBS) and fly ash are among the most widely used reactive SCMs today. But they are in limited, and declining, supply. GGBS is derived from blast furnace steel production, and fly ash from coal power energy generation, both of which are being partially or wholly phased out as part of the green transition.
- **Technical Maturity:** Whilst new SCMs have been developed, using widely available materials, most are at an early stage and require both investment and industry adoption if they are to be deployed at scale.

SUPPLEMENTARY CEMENTITIOUS MATERIALS (SCMs)

FILLER		ACTIVE NONPOZZOLANIC ADDITION	ACTIVE POZZOLANIC ADDITION	
NATURAL	ARTIFICIAL	ARTIFICIAL	NATURAL	ARTIFICIAL
Limestone	Marble powder	Granulated blast furnace slag	Pumice	Granulated blast furnace slag
	Concrete powder	Burnt shale	Tuff	Siliceous fly ash
		Calcareous fly ash	Diatomaceous earth	Metakaolin
			Opaline rock	Silica fume
			Moler	Agroforestry waste
			Gaize	Masonry waste
			Clays	Mixed C&DW
				Ornamental stone waste
				Paper sludge
				Bentonite
				Calcined clay
				Glass powder

[62] GCCA Data 2019
[63] Fillers and additions from industrial waste for recycled aggregate concrete, 2022. Cesar Medina Martinez, I.F. Sáez del Bosque, G. Medina, M. Frías, M.I. Sánchez de R

A Breakthrough Technology: High-Filler Cements

High-Filler Cements are a new departure for the cement industry. Unlike previous low-carbon initiatives, these products reduce the amount of clinker in cement by maximising the use of inert, low-carbon fillers. Whereas fillers typically account for around 6% of European cement, new technologies take that percentage up to around 70%, simultaneously reducing the clinker content from 74% to as little as 30%. Not only does this dramatically reduce cement's carbon footprint but it can do so without reducing the mechanical strength or durability of concrete.[64] The remaining clinker can even be partially substituted with low-carbon SCMs, further driving down cement's carbon footprint. Cement blends that incorporate 50% limestone filler, around 30% low carbon SCMs, and only 20% clinker or less are now proven.

Traditional cement generates approximately 600kg of CO_2 per tonne of cement.[65] High-filler, low-clinker cements can reduce that to just 150kg per tonne, an instant 75% reduction in cement's carbon footprint. Importantly too, the filler material used is generally limestone, a hugely abundant resource, so production can be scaled up in a way that no other low-carbon cement has achieved to date.

Cement is turned into concrete with the addition of sand, aggregates and water. The proportion of water used is critical. Use too much water and the concrete loses strength and becomes less durable. Use too little water and the concrete cannot be poured. Low-clinker, high filler cements have wrestled with this challenge, because they work best with much less water than traditional cement. However, significant research, coupled with developments in the chemical additives and concrete industries mean that this challenge can now be overcome. State-of-the-art High-Filler Cements can deliver concrete that uses very little water, flows well, develops strength quickly and retains all the performance and workability of traditional concrete.

[64] Fillers in cementitious materials – Experience, recent advances and future – Potential, 2018. (Authors… Vanderley M. Johna, Bruno L. Daminelia, Marco Quattronea, Rafael G. Pileggia

[65] IEA Cement Report, September 2022 https://www.iea.org/reports/cement

In short, there are several significant advantages to these technologies:

- **Low Carbon Footprint**: High-Filler Cements use as little as 20% clinker, blended with inert fillers and a range of low-carbon SCMs. This reduces cement's carbon footprint by more than 70%.
- **Scalability**: The main constituent of clinker is limestone, an abundant and easy to extract rock. Low-carbon cements have historically been made with SCMs, which are in limited and decreasing supply. Current High-Filler Cements are different because limestone filler is the largest single ingredient within the mix. This means they can be scaled to an exceptional degree.
- **Energy Security**: High-Filler Cements need as little as a third[66] of the amount of thermal energy used in the production of high clinker cements. They also need the same or less electrical energy. As a result, noxious gases such as SOx and NOx, and particulate emissions, are reduced by around 70%.[67]
- **Lack of Process Disruption**: High-Filler Cements bring little disruption to existing operations and processes within the cement and concrete industries, beyond some extra grinding and storage capacity. As such, additional capital expenditure required is likely to be minimal.
- **Cost**: Given that High-Filler Cements will often have lower energy requirements than traditional cement, they need little additional capital expenditure and deliver a substantial reduction in emissions, the cost: benefit analysis associated with them is compelling.
- **Water reduction**: Many parts of the world, including Southern Europe and large parts of the US, suffer from an increasing lack of water. High-Filler Cements can reduce, by as much as a half, the amount of water needed to produce concrete, a further environmental and societal benefit.
- **Availability in the short term**: Unlike most other decarbonisation technologies for the cement industry, high-filler, low-clinker cement technologies can be made available at scale in the short term. If widely deployed, these cements have the potential to reduce the cement industry's carbon footprint by up to 50% by 2030, reducing the substantial burden on other technologies, such as CCUS.

The UN Environmental Programme report[68] suggests that low-clinker cement technologies provide the clearest path to decarbonising the cement industry. They provide low cost, scalable and immediate solutions to a huge issue – clinker process emissions. And they do so whilst maintaining and even improving the technical performance of concrete, including its mechanical strength and durability.

[66] GCCA Data 2019.
[67] Assume 1,199g/t of clinker (NOx) and 302g/t of clinker (SOx)
[68] High-Filler Cements: Potential economically viable solutions for a low-CO_2 cement based materials industry, UN Environmental Programme

Section 6
Barriers

WHY POLICY MATTERS

The cement and concrete industries have traditionally been regarded as hard-to-abate. High-Filler Cements could allow them to change that status, reducing their carbon footprint at speed and at scale. Yet, there are concerns about the pace at which these new cements can proceed towards industrialisation. These concerns are not rooted in technical performance but, rather, in policy. Such concerns need to be addressed so that High-Filler Cements can make a meaningful contribution to global net-zero targets. Europe in particular has an opportunity to take a leadership role in this regard. The EU has been at the forefront of industrial decarbonisation in many sectors. But there is a danger that it will lag behind other administrations if policy changes are not enacted swiftly around the cement and concrete industries.

There are a number of areas where change could deliver tangible results and enable these technologies to contribute to decarbonising the cement industry.

CARBON TAX POLICY

It is now an accepted economic theory that if decarbonisation is to occur, carbon emissions need to have an associated cost through the "polluter pays" principle. This should encourage polluters to explore lower carbon ways of producing their products. However, even though there have been carbon tax policies in place in Europe since 2005, major industrial emitters have been largely shielded from carbon taxes through the free allocation of carbon credits.

The European cement industry has historically been seen in Europe as a carbon leakage risk. In other words, policymakers worried that if producers were taxed for their carbon emissions, they might relocate outside Europe or increase imports into Europe.[69] As a result, the industry has received billions of euros in free carbon allowances, essentially meaning it has avoided the bulk of carbon tax. In 2021, 87% of its carbon emissions were covered by free allowances,[70] avoiding over €5 billion in carbon tax.[71]

The distribution of free allowances to the industry is linked directly to the volume of clinker produced, so a significant reduction in clinker volumes would result in a reduction in free allowances. This has had the unintended consequence of providing a strong incentive to keep clinker levels high, even though clinker is the primary source of cement emissions. Many believe that free allowances have also discouraged the cement industry from exploring alternative ways to reduce their carbon footprint beyond CCUS.

When cement production does become fully exposed to carbon taxes (as a result of CBAM), customers and consumers will almost certainly look for substitute products. Why? Because cement is an inelastic product meaning that, unless substitutes are available, increased production costs associated with carbon taxes could be passed onto the customer with no guarantee of any commensurate decarbonisation. If consumers are to be offered an alternative to paying for high clinker, high carbon, high-cost cement, low-cost alternatives need to be brought to market. And this is where standards and regulations have a key role to play.

[69] Carbon Market Watch https://carbonmarketwatch.org/2014/08/29/carbon-leakage/
[70] European Union Transaction Log
[71] EU transaction log and based on an average 2021 price of €54/t of CO_2

STANDARDS AND REGULATIONS

From constructing a house to building a major dam, certain characteristics are essential, in particular safety, and structural integrity. For good reason therefore, rigorous attention is given to both cement and concrete standards across the world. Europe is a global leader in this space, with many developing nations accepting and adopting EU construction standards.[72]

Cement and concrete standards are often particularly prescriptive in nature, setting out exactly what ingredients, and in what proportion, each ingredient can be used in the production process. These standards have proved invaluable, not only ensuring the durability and longevity of structures, but also bringing conformity and a sense of familiarity to engineers.

However, in a generation where technical development is rapid, standards, such as those for cement and concrete, can lag behind innovation and act as a barrier to widespread adoption of the latest and best available technology.

In Europe, changing standards is a bureaucratic and often-protracted process. Cement and concrete standards are no exception. Cements across Europe are largely controlled by a harmonised standard (a European standard adopted by all member states). For a newly developed cement to be included in the cement standard, it must not only successfully complete extensive performance testing, but also undergo a protracted process whereby the relevant authorities must agree the necessary amendments to the existing standard. Historically, such a process has taken as long as 10 years.

Tiffany Vass of the International Energy Agency (IEA) identified this as an area that would benefit from a change in approach: **"Governments may need to change or develop regulations to foster technology uptake. Shifting from prescriptive to performance-based design standards, for instance, would enable greater uptake of lower-carbon blended cements and cements that include alternative binding materials."**

Recognition in the European cement standard, however, is not sufficient for a cement to be automatically used in concrete. Concrete is regulated by its own separate standard which, to add complication, is a non-harmonised standard (a European recommendation that can be amended as required by each member state through a national annexe). While only a recommendation and not legally binding, nearly all concrete producers comply with the European concrete standard as adopted in their respective countries, primarily since insurance cover is not possible when operating outside the relevant country concrete standard.

Like the cement standard, any cement approved by the concrete standard requires further testing to demonstrate its performance in concrete.

As concrete standards are non-harmonised, before a cement can be used across the EU within concrete, each of the 27 EU member states must individually recognise that cement in their national annexe to the European concrete standard. This has clear consequences for High-Filler Cements. Even though they are ready for deployment and can dramatically reduce cement emissions, market acceptance is hampered by the very standards that aim to protect society.

This situation has attracted criticism from several quarters. Justin Wilkes, executive director, Environmental Coalition on Standards (ECOS): **"Ultimately, the standardisation system is broken."**

Other jurisdictions have taken different approaches to the issue of standardisation. The US, for example, has introduced a standard for performance-based cements, which sets out the performance requirements of a cement, rather than dictating its exact ingredients. Other possible approaches include a fast-track process that recognises when new cements are using raw materials already included in the existing cement standards.

Given the EU's status as a standard-setter, there is now an opportunity to address the barriers

[72] The Eurocode map, European Union, 2017.

created by standards from the past and deliver standards that are fit for the future. But action is needed. As Justin Wilkes point out: **"The EU wants to be seen as a standards-maker, not a standards-taker."**

Philippe Babey, former general manager, LafargeHolcim: **"Policy is the biggest stumbling block. If standards changed, it would give more space to alternatives."**

FUNDING

Significant funding is available in the developed world to support the green transition. Europe has committed billions, including €38 billion[73] under the Innovation Fund alone, while the US has committed $369 billion. Government funding has been a force in driving change in other industries such as the energy sector. Under the European Emissions Trading System emissions from the combustion of fuels for example, fell 35% from 2013 to 2020,[74] while energy consumption remained virtually unchanged across the EU.[75]

The energy sector has derived clear benefits from funding across multiple clean energy production processes. Logic would suggest that multiple potential solutions should also be supported in a bid to decarbonise cement, a major and complex industrial sector.

Nevertheless, it appears that multiple governments and supra-governance have focused almost exclusively on CCUS, singling out this technology as the solution to cement's carbon challenges. Since the inception of the Innovation Fund, five CCUS projects associated with the cement industry have been awarded grants; none has been awarded to low carbon substitutes. It appears too as if policy is centred on the decarbonisation of individual plants rather than the industry in general. Given the fragmented nature of the cement sector in Europe (and beyond), this could be regarded as a narrow-sighted solution, particularly when low-carbon substitute products are readily available and could be rapidly industrialised.

To facilitate a broader set of solutions, the level of funding available for industrial 'scale-ups' needs to be greatly increased. Often a hotbed of ideas and new technologies, scale-ups have ample opportunity to access funding for grants of between €250k to €5m. But industrialisation requires capital to the tune of €50m–€150m, in order to move technologies from the laboratory or testing site to full-scale commercialisation. Such funding is hard to find, yet the return on investment can be substantial.

This seems misguided. While CCUS units require funding for each individual structure, High-Filler Cements need to be proved at industrial scale just once, and subsequently incentivised, to proliferate. Such an approach could unlock private funding, encourage standards to move, drive rapid change and, most importantly, deliver a meaningful reduction in global emissions.

[73] https://climate.ec.europa.eu/eu-action/funding-climate-action/innovation-fund/what-innovation-fund_en#:~:text=The%20Innovation%20Fund%20will%20provide,support%20its%20transition%20to%20climate
[74] Eurostat European Environment Agency
[75] Eurostat

Conclusion

Something needs to be done.

Cement has a problem. The process is highly polluting, releasing more than 2.5 billion tonnes of CO_2 per year, responsible for more than 7% of global greenhouse gas emissions, and demand is growing. Something needs to be done.

Leading producers, innovators and external specialists believe there are two principal ways to reduce cement's carbon emissions.

- First, reduce the amount of clinker in cement.
- Second, capture the carbon and either use it or store it.

To date, policymakers and industry incumbents have focused on the second option. This will almost certainly play a key role in cement's long-term decarbonisation journey, but it has yet to yield meaningful results and there are many hurdles to overcome. Crucially too, this single-focus approach is not the way that change has been delivered in other high-emitting sectors.

In energy, public sector support and private sector enterprise have provided research and funding for a range of solutions – wind, solar, hydropower, nuclear and others. These efforts have delivered tangible results. Prices have fallen dramatically; usage has increased, and renewable energy now makes up a significant proportion of total usage in many parts of the world. The transport sector has also seen significant change, driven by wide-ranging research, development and financial backing.

The cement industry would benefit from similar dynamics – a multi-pronged approach that could collectively drive down emissions. Carbon capture, utilisation and storage cannot do it alone. Trade bodies know it. Producers know it. Investors know it. While the technology will have a major impact on emissions, it will cost almost $800 billion to implement, it will be logistically impractical for many plants and far too expensive for many more.

Low-clinker cement cannot single-handedly take the industry to net-zero either, at least not yet. But it is ready for adoption, it is cost-effective, easy to use, and could reduce cement producers' emissions by up to 1.6 billion tonnes of CO_2, equivalent to 4% of global emissions.

There is a risk that the cement industry is being incentivised not to change by the current approach to policy and funding. Indeed, they can be penalised for trying to decarbonise in many instances. Europe has so far led the way in driving environmental policy across numerous sectors of industry. As home to some of the world's largest cement producers, Europe is in a unique position to lead the way in the cement industry too. Widespread implementation of low-clinker cement could reduce emissions by 50% this decade alone, with further reductions before 2050. Combined with CCUS technology, net zero is not just in sight, it is an achievable goal.

In a scenario where rapid decarbonisation of the global economy is a must, failure is not an option. There needs to be shift in approach, a need to look beyond a single solution and consider all viable low-carbon options. Supportive policies and standards, balanced funding and a more dynamic standard-setting framework would present a real opportunity to drive down emissions from one of the most polluting sectors on the planet.

There is no time to lose.

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