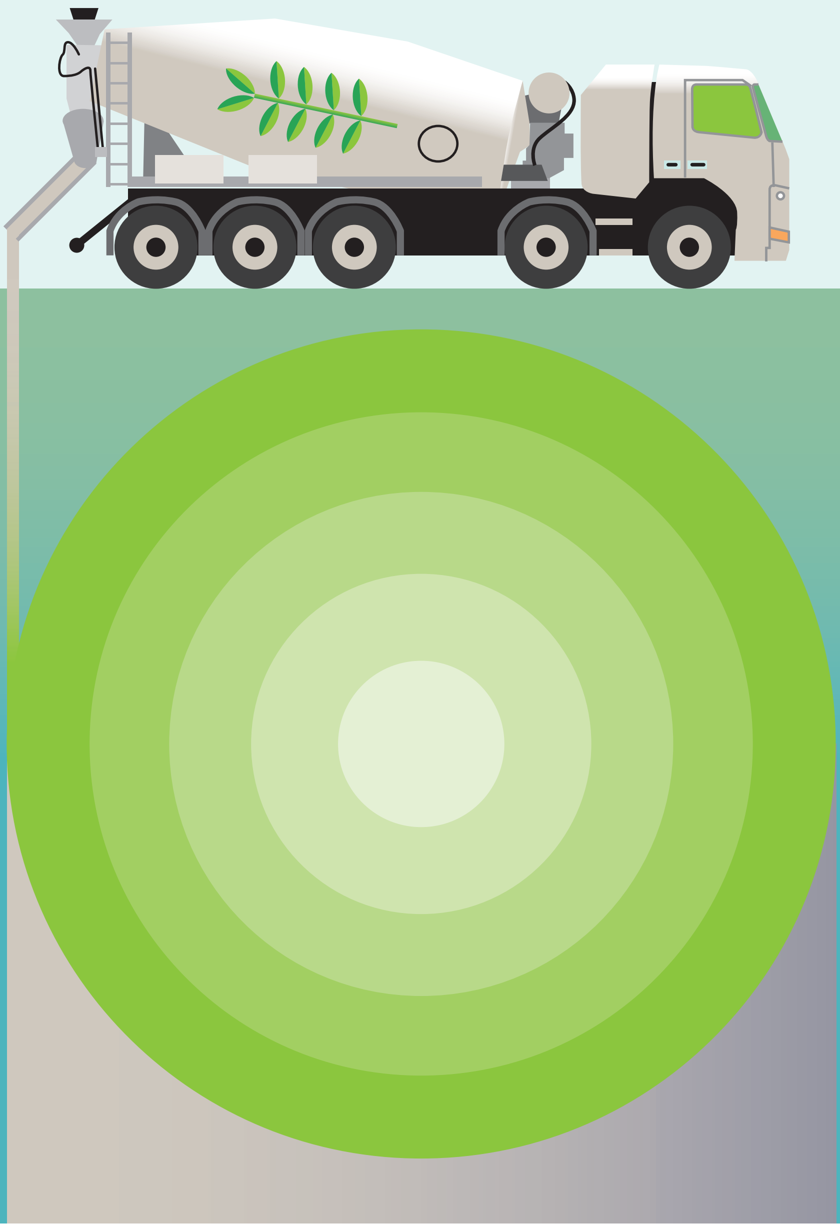
# Cementing the global net-zero transition



Prepared by Climate Bonds Initiative.

## Contents



### Table 1. Policies impacting the cement industry across the value chain[1]

| UPSTREAM | MIDSTREAM | DOWNSTREAM |
|---|---|---|
| **Low-carbon energy and infrastructure** | **Low-carbon production processes** | **Increase demand for low-carbon cement & concrete and enhance its circularity** |
| Accelerate renewable energy deployment | Establish carbon contracts for difference | Implement green public procurement |
| Ensure strategic and 1.5°C-aligned CCS infrastructure for the cement industry | Mandate credible transition plans at the entity-level | Improve waste management and circular economy requirements |
| | Strengthen carbon pricing with a reformed framework against the risk of carbon leakage | Scale up off-take agreements |
| | Guide green investment through standards and sector-specific criteria and taxonomies | Establish a "green window" for zero/near-zero carbon cement |

## List of acronyms

**CBAM** Carbon border adjustment mechanism

**CCfD** Carbon Contracts for Difference

**CCS** Carbon capture and storage

**CCU** Carbon capture and usage

**CEF** Connecting Europe Facility

**CEMBUREAU** European Cement Association

**CLT** Cross-laminated timber

**$CO_2$** Carbon dioxide

**DNSH** Do No Significant Harm

**EOR** Enhanced oil recovery

**ETS** Emissions Trading System

**EU** European Union

**GCCA** Global Cement and Concrete Association

**GPP** Green public procurement

**GSS** Green, social and sustainability

**IEA** International Energy Agency

**IIGCC** Institutional Investors Group on Climate Change

**IMF** International Monetary Fund

**IPCC** Intergovernmental Panel on Climate Change

**KPI** Key performance indicator

**LEILAC** Low Emissions Intensity Lime And Cement

**MSW** Municipal Solid Waste

**NGEU** Next Generation EU

**PCIs** Projects of Common Interest

**PSF** Platform on Sustainable Finance

**RED** Renewable Energy Directive

**RRF** Recovery and Resiliency Facility

**SLB** Sustainability-linked bond

**TEG** Technical Expert Group

**TEN-E** Trans-European Networks for Energy

**TSC** Technical screening criteria

**UNFCCC** United Nations Framework Convention on Climate Change

**UNIDO** United Nations Industrial Development Organisation

**UoP** Use of Proceeds

**WB** World Bank

# 1. Context

## Introduction

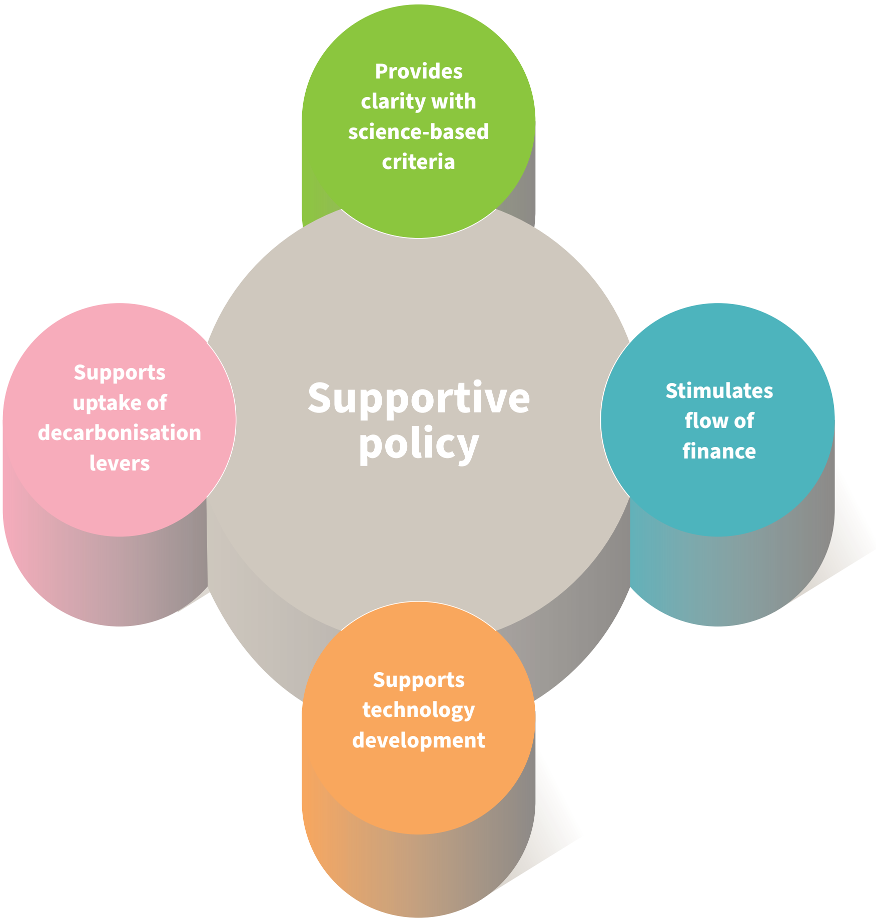
**Climate change is a global emergency that goes beyond national borders, requiring international cooperation.** The 2015 United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement aiming to limit the average global temperature rise to 1.5°C is a testament to this. Currently, 195 out of 198 Parties to the UNFCCC are Parties to the Paris Agreement.[2]

Despite commitments to the Paris Agreement, limiting global warming to 1.5°C is beyond reach without immediate and deep emissions reductions across all sectors. To achieve this limit, all sectors of the economy must decarbonise rapidly, reducing emissions by nearly half by 2030 and to net zero by 2050. As of November 2022, around 140 countries had stated or considered net-zero targets, representing about 90% of global emissions.[3]

**Cement production accounts for around 7% of global emissions and it is the second largest global industrial emitter after steel.**[4] Achieving the goals of the Paris Agreement will be impossible without decarbonising sectors such as cement and yet, the carbon intensity of global cement production has only slightly decreased in recent decades, and it is significantly behind a Paris-aligned pathway.[5]

For cement and other industrial sectors (known as hard-to-abate), the barriers to decarbonisation are much higher than others due to technological, economic, or socio-political reasons. The decarbonisation of cement is not just a technological challenge but also a financial and political one. It will require a new range of decarbonisation levers that are identified and guided through sector criteria, financed by the financial sector and promoted and de-risked with policy support.

**Policy will impact the adoption of all these levers – technological or financial.** This short paper provides an easy-to-implement guide to these policy levers available to policymakers and governments around the world.




## Sustainable finance markets are a critical financing tool

Labelled debt (green, social, sustainable, sustainability-linked and transition bonds – GSS+) has grown from a conceptual idea to a major global market. Climate Bonds recorded cumulative aligned GSS+ volume of USD4.2tn by the end of the first half of 2023.[6]

Given their forward-looking key performance indicators (KPIs), sustainability-linked bonds (SLBs) are inherently transition focused. SLBs represent an opportunity for entities to link their net-zero targets with access to sustainable finance. However, many early examples of SLBs and transition bonds have raised concerns about greenwashing in the market because the targets were not material or ambitious.[7] There are other concerns about the relevance and reliability of targets which are set by the issuing entity and are therefore difficult to benchmark against peers or wider goals such as the Paris Agreement targets.

**Around USD4.3bn SLBs have been issued in the cement sector in 2020-2023 (as of June 2023).** Despite the growth of these instruments, their potential has not been fully exploited in hard-to-abate sectors.

### Heidelberg Materials SLB and its potential alignment with Climate Bonds cement Criteria

**Heidelberg Materials** issued its first SLB in January 2023.[15] The EUR750m deal had a coupon rate linked to $CO_2$ emissions per tonne of cementitious material up to 2026 and 2030. Heidelberg Materials aims to reduce $CO_2$ emissions (scope 1) to 400 kg/t of cementitious material by 2030, around 30% below 2021 levels.[16]

This could be in line with Climate Bonds cement Criteria threshold of 463 kg $CO_2$ emissions (scope 1 and 2)/t of cementitious material by 2030 (see Annex).[17]

**Less than 2% of SLBs issued have originated from entities operating in the cement sector.**[8] In part, the potential of SLBs is not being exploited due to the lack of standards and particularly sector-specific criteria. The Criteria developed by Climate Bonds allow investors to verify the Paris alignment of SLBs more easily.

## The role of standards and sector-specific criteria

Climate Bonds has designed science-based guidance at individual sector level. This can assist stakeholders to identify companies, assets and projects following 1.5°C-aligned pathways and support informed investment decisions consistent with Science Based Targets initiative (SBTi) and the Transition Pathway Initiative (TPI) approaches.[9]

In the absence of formal consensus by governments or industry bodies, the wide variety of actions, targets and commitments emerging from industry players may not align with a 1.5°C future. Risks include investing in projects to extend the life of high-emitting assets that could rapidly become stranded.

Several pathways for cement decarbonisation have been modelled.[10] These are based on different scenarios and assumptions and vary depending on the regional focus. Consequently, the paths differ but provide a valuable indication of the potential to reduce greenhouse gas (GHG) emissions and the role of low-carbon technologies.

The cement sector transition to a 1.5°C-aligned pathway will be achieved by implementing a mix of technologies in both existing and new facilities.

**Scientific standards, such as the Climate Bonds Standards and sector-specific eligibility Criteria,** will guide investment in credible transition activity and provide asset owners with the right path to decarbonise existing facilities or switch to new low-carbon cement production plants. Policymakers can also utilise them in setting regulations and incentives for sector decarbonisation.[11]

**Ensuring that capital flows towards net zero-aligned projects is an essential piece of the puzzle to decarbonise cement.**[12] The Climate Bonds Standard and Certification Scheme is an easy-to-use screening tool that provides a clear signal to investors and intermediaries on the climate integrity of Certified Climate Bonds. This can be used to screen assets and capital projects so that only those with climate integrity will be certified through their contribution to climate mitigation, and/or to adaptation and resilience to climate change. The Climate Bonds Criteria also include cross-cutting criteria addressing other impacts by setting qualitative measures such as specific criteria for the use of biomass or hydrogen as a fuel, waste-derived fuels and carbon capture and storage (CCS) technologies, as well as Adaptation and Resilience requirements, see Annex.[13]

**In April 2023, Climate Bonds expanded its Standards and Certification Scheme.** It now also allows for the Certification of non-financial corporates, assets, and sustainability-linked instruments. The cement sector criteria also include a pathway that can enable Certification of an entity (a cement company or part of a company) and any debt instruments issued by them including SLBs.[14]

# 2. Cementing the net-zero transition: key decarbonisation options and investment requirements

## Understanding cement sector emissions

**Concrete is the second most-used substance in the world after water, and cement production accounts for around 7% of worldwide $CO_2$ emissions,** see box.[18] If global cement manufacturing were a country, it would be the third-largest emitter on the planet, after China and the United States of America.[19] Cement also releases the most emissions per dollar of revenue, around 6.9 kg of $CO_2$/USD, much higher than iron and steel (1.4 kg), oil and gas (0.8 kg), and chemicals (0.3 kg).[20]

Cement is a key input into the supply chain of many industries, especially construction and infrastructure. Therefore, decarbonisation of cement production processes is a critical enabler to the transition of these sectors and achieving their emissions reduction targets. Cement is also a crucial component of installations providing renewable energy, such as wind turbines and hydroelectric dams.[21]

The cement making process consists of several steps. Over 80% of emissions occur in the kiln and preheater/precalcinator, see the red box in Figure 1.[22] These emissions are linked to the current production process and can be broadly separated into combustion and non-combustion emissions.[23]

**Non-combustion emissions (calcination process) account for around 60% of the direct emissions in the production process.** They do *not* result from fuel combustion but from chemical reactions in the clinker calcination process.[24]

**Importantly, these emissions cannot be reduced by substituting fuels.** This is very different from other industrial processes where the bulk of process emissions relate to fuel use, see Climate Bonds A Green Future for Steel, for comparison.[25]

**Most of the remaining $CO_2$ emissions are fuel combustion emissions (about 30%).** Fossil fuels (predominantly coal), biomass or alternative fossil and mixed wastes are burnt to reach high temperatures to make clinker – the main constituent of cement – in a kiln at around 1450°C.

### Cement vs concrete

Even though the terms cement and concrete are often used interchangeably, they are two different materials. Cement is a fine powder and a key ingredient in concrete production.[43] Concrete, a mixture of cement, water, and aggregates (both coarse and fine), is the second most-used substance in the world after water.

### Climate Bonds Initiative and the net-zero transition

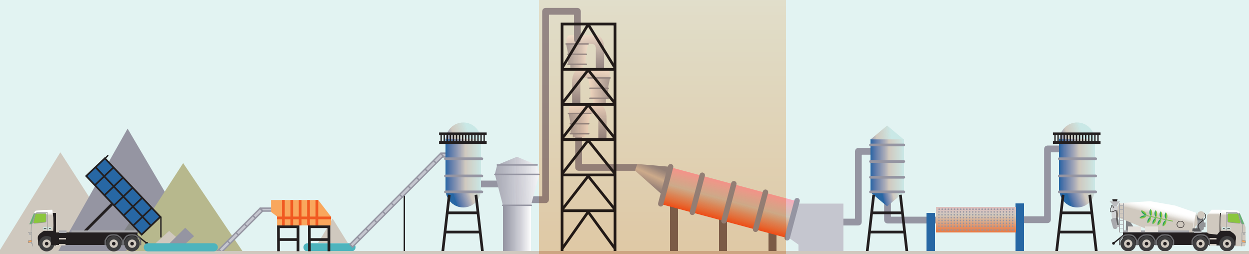
Climate Bonds has embarked on an ambitious transition programme to provide the industrial pathways, sustainable finance standards, policies, and investment guidance required to deliver credible transition in the hard-to-abate sectors.

The financial markets must implement the results of this work to support the decarbonisation of the cement sector. This paper follows Climate Bonds *A Fork in the Road for the Global Steel Sector*.[44] These policies are complemented by the Climate Bonds sustainable finance criteria for the cement sector published in 2022.[45] In April 2023, Climate Bonds expanded its Standards and Certification Scheme to the certification of non-financial corporates, assets, and sustainability-linked instruments.[46]

Climate Bonds also published policy guidance on the net-zero transition of the European steel and cement sectors, as well as a comprehensive toolkit of 101 policy levers available to governments, regulators, and central banks to facilitate the transition to net zero.[47]

### Figure 1. Cement making process

**Raw materials, energy, and resources** | **Clinker and cement manufacturing**



| | Quarry | Crusher | Transport | Raw mill | Kiln and preheater/ precalcinator | | Cooler | Cement mill | Logistics | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Energy,** mega-joule/ton | 40 | 5 | 40 | 100 | | 3150 | 160 | 285 | 115 | **3895** |
| **$CO_2$ emissions,** kilogram/ton | 3 | 1 | 7 | 17 | 479 Calcination process | 319 Fossil fuel combustion | 28 | 49 | 22 | **925** |

Source: https://www.mckinsey.com/industries/chemicals/our-insights/laying-the-foundation-for-zero-carbon-cement#cement

Cement is a crucial input for many industries and is inevitably part of a low-carbon future.[26] It will therefore need substantial technological and financial investment to be able to play its role in achieving a zero-carbon future.

**The cement sector is at an early yet critical stage in the transition to net zero.** Energy intensity has gradually decreased over the past decades due to dry-process kilns and efficiency improvements. However, fossil fuels still provide over 90% of energy input and this share needs to decrease to around 60% by 2030 in a net-zero scenario.[27]

The overall carbon intensity of global cement production is well behind a Paris-aligned pathway.[28] It amounted to 656 kg $CO_2$/ton of cement in 2019 and this will need to decrease by almost half by 2030 to reach a Paris-aligned pathway target of 360–370 kg $CO_2$/ton.[29]

**Global cement production levels have remained stable in recent years** (around 4,300 Mt of cement were produced in 2021).[30] In 2021, China accounted for around 55% of the world's cement production, followed by India at 8%.[31]

**Cement demand is expected to rise steadily in the coming decades**, by almost 50% by 2050.[32] There is large regional variation in this increased global demand. The highest demand increase is expected to occur in India, Latin America, and Africa due to population growth, urbanisation, and infrastructure development.[33] Such an increase is estimated to more than offset the long-term decline in cement demand in China, resulting in a higher demand for cement in 2030 in a business-as-usual scenario.[34]

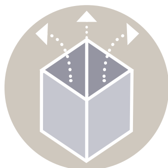
**Aligning with a net-zero scenario will require global cement production to remain stable until 2030** and therefore major improvements in energy and material efficiency, as well as the use of alternative building materials, are needed.

Meeting new cement demand with fossil-based facilities would likely result in long-term carbon lock-in and stranded assets (due to their long-life cycle), threatening jobs and putting the Paris-aligned pathway out of reach.[35] Cement asset lifetimes reach up to 60 years and the investment choices made by cement companies will create long-lasting path dependencies, well beyond 2050. By investing in technologies that are consistent with a net-zero scenario they can avoid stranded assets and the risk of facing high economic losses.[36]

Table 2. Key decarbonisation options for the cement industry[48]

| | Short term | Medium and long term |
|---|---|---|
| **Non-combustion levers** | Maximise the use of alternative binders | Improve clinker-to-cement ratio |
| | | Implement carbon capture & storage technologies (CCS) |
| **Combustion levers** | Maximise energy efficiency | Adopt low-carbon electricity and solar thermal energy |
| | Substitute fossil fuels with alternative fuels such as waste-derived | Use low-carbon hydrogen as an alternative fuel |

## Technologies and solutions are available today that can kickstart the transition while emerging ones can complete the picture



**Approximately 60% of the total $CO_2$ emissions of the cement manufacturing process come from chemical reactions**, while most of the remaining $CO_2$ is produced by fuel combustion, see Figure 1. Key decarbonisation options can therefore be divided into these two groups; see Table 2 and Climate Bonds paper Concrete policies to underpin the cement transition for a more detailed overview of these levers.[37]

Some of these options are more likely to be implemented in the short term and continue being developed and implemented in the following years, while other technologies are estimated to need more time to achieve maturity.

To address non-combustion emissions, the key levers discussed to date include carbon capture technologies, improving clinker-to-cement ratios and the use of alternative binders. These are supported by the IEA Net Zero Scenario which estimates the need to capture around 180 Mt of cement emissions by 2030, compared to the 0.1 Mt currently captured, and for the clinker-to-cement ratio to fall 1% annually by 2030 reaching 0.65 by 2030.[38]

For combustion levers, maximising energy efficiency and substituting fossil fuels with alternative fuels can help achieve emissions reductions in the next few years. Further research is needed to determine and test the use of electrification, solar thermal energy, and green hydrogen to deliver further reductions in the cement making process.

While these are the levers that are envisaged today, for many hard-to-abate sectors, there will be new technology developments emerging which may completely change the sector, and policy should be supportive of these. Pilot projects are being developed around the world to test and scale up new and emerging technologies to address both combustion and non-combustion emissions, see box below.

In addition, reducing the use of cement through material substitution can be another option to achieve the net-zero transition. In some applications, cross-laminated timber can substitute cement, steel and other carbon-intensive materials traditionally used in construction.[39]

**Massive investment is needed to develop and roll out low-carbon production technologies to transform the global cement sector.** The transition is supported by government emissions reduction goals and associated policies. There is a narrow window to implement the policies required for the cement sector to transition to net zero.

Financial flows need to be aligned with a Paris-compatible scenario, avoid lock-in, and be in place for the next investment cycle considering the longevity of cement assets (up to 60 years). The cement industry is very capital intensive. **The capital required to transition the global cement industry could reach USD70bn annually between 2030 and 2040** (double current levels).[40] This includes building new low-carbon production capacity and renovating existing plants with technologies such as CCS. Other studies forecast an additional investment of USD16bn annually on business-as-usual to transition to net zero.[41] The sustainable debt market could unlock the financing needed for cement companies that commit to ambitious targets and can develop credible transition plans.

The cost premium of low-carbon concrete in construction projects is difficult to generalise and can vary widely across regions. **However, given that concrete represents around 5% of a typical building, a green premium on concrete will not significantly increase the final cost of a new building**.[42] Even in a high-estimate scenario where low-carbon concrete costs 50% more than conventional concrete, the cost implication for a new building would be less than 3%.

## Low-carbon cement projects

**LEILAC** (Low Emissions Intensity Lime And Cement) started in 2016 to pilot a breakthrough technology to cut emissions while maintaining competitiveness.[49] It successfully piloted direct separation at the HeidelbergCement plant, which captures non-combustion $CO_2$ emissions. The second phase – **LEILAC2** – started in 2020, with funding from Horizon 2020 and the industry. It is aimed at becoming operational by 2023 and implementing large-scale demonstrations by 2025. This facility also plans to demonstrate the use of less carbon-intensive heat sources for calcination, such as electricity.

**Norcem**, the leading Norwegian supplier of cement is conducting research into carbon capture applications for cement manufacturing. Its project at the plant in Brewik is currently on track and aims to become operational by 2024.[50]

**VTT Decarbonate** developed an electric kiln which can replace fossil-based alternatives in the cement making process, while also integrating it with carbon capture technologies.[51] The project is in Finland and successful trials were completed in 2021–2022.

**Brimstone**, based in the United States, has announced the development of a new cement making process that sources lime from calcium silicate rocks rather than limestone, avoiding process emissions during the calcination process and producing a magnesium-based waste product that can absorb emissions from fuel combustion.[52] According to Brimstone, this would be less expensive than standard production methods and chemically equivalent to Portland cement clinker. The project is still in its early phase and in 2022 Brimstone announced plans to establish a first-of-its-kind demonstration facility in the United States before scaling up its process.[53]

**Synhelion** aims to decarbonise industrial processes with high-temperature solar heat. With concentrated solar power, a mirror array concentrates solar radiation onto a receiver. Concentrated radiation becomes high-temperature process heat exceeding 1500°C. Synhelion and Cemex plan to construct a carbon-neutral cement plant using concentrated solar power, combined with CCS, and started this project in 2019.[54]

**Cambridge Electric Cement** came up with an innovative process converting construction and demolition waste to cement over molten steel using an electric arc furnace, which is usually used to recycle steel scrap. The related Cement 2 Zero project aims to demonstrate this process: recycling concrete to create a slag-forming addition which could replace high-quality cement.[55] In other words, this project aims to combine steel and cement recycling in a single process which, when powered by renewable energy, could produce zero/near-zero emissions cement.

# 3. Policies to ensure a credible transition

**The decarbonisation of hard-to-abate industries will need strong policy support.** Robust policy instruments and supply chain coordination are required to support the cement industry's transition to net zero. These policies apply to different parts of the cement industry value chain: **upstream** (low-carbon energy and infrastructure), **midstream** (low-carbon production processes), and **downstream** (increasing demand for low-carbon cement and enhancing its circularity).

## Upstream policies

### Accelerate deployment of renewable energy and enabling infrastructure

**Abundant low-carbon energy and enabling infrastructure** – renewable electricity, $CO_2$ transport and storage, and green hydrogen, together with other levers – are necessary for the cement sector transition.

As all sectors will need to transition to a low-carbon economy, the cement industry will not be alone in needing greater access to abundant and affordable decarbonised energy.

**Accelerated deployment of renewable energy sources,** as well as related infrastructure, is needed to meet significant growth in demand which is estimated to increase by more than one-third by 2050.[56]

### Ensure strategic and 1.5°C-aligned CCS infrastructure for the cement industry

Carbon capture and storage technologies (CCS), as noted, are likely to play an important role in reducing $CO_2$ emissions from the cement industry, notably those emitted during limestone calcination.

**Importantly, carbon capture in cement is not a way to prolong fossil fuel combustion that can be replaced.** On the contrary, it should be focused on addressing the 60% of process-related emissions that cannot otherwise be abated. The IEA database captured one CCS project currently under construction – Norcem Brevik, see above– and 26 CCS planned to be operational by 2030 at the latest (as of March 2023).[57] These 27 projects are estimated to have an annual capture, transport and/or storage capacity of around 20 Mt $CO_2$.

**Policymakers can ensure the strategic prioritisation and application of CCS while establishing robust standards for infrastructure** and its related investments. Infrastructure development prioritisation schemes can include strategic infrastructure development for transporting $CO_2$ to storage sites. For example, $CO_2$ transport infrastructure is eligible for EU Projects of Common Interest (PCI) status, which grants projects accelerated permitting and potential financial assistance under the Connecting Europe Facility (CEF) budget for energy. PCIs are prioritised based on their net-zero contribution.[58] Supportive policies, such as accelerated permitting, can favour priority sectors to ensure CCS is reserved for emissions which cannot be prevented. This is vital to prevent overreliance on these technologies, as CCS cannot remove all emissions and has a limited impact on scope 2 and 3 emissions, which account for a significant proportion of carbon emissions from other sectors.

**Policymakers can also establish robust standards for $CO_2$ infrastructure.** They are key to ensuring high emissions capture efficiency rates, storage longevity, preventing $CO_2$ leakage at all stages of the process, and ensuring the CCS process uses low-carbon energy. CCS technologies will need to use low-carbon electricity (100g $CO_2e$/kWh declining lifecycle emissions threshold in the EU Taxonomy) and meet technical criteria on the transport of $CO_2$ and underground permanent geological storage of $CO_2$ in the EU Taxonomy to qualify as a low-carbon solution.[59]

Many of the world's cement kilns emit $CO_2$ on far lower scales than fossil gas processing facilities or thermal electricity generation.[60] This scale influences $CO_2$ capture costs, as capture costs per tonne normally increase as the magnitude of the $CO_2$ source decreases. As a result, cement kilns may have greater capture costs than other applications. Carbon Clean and Svante are two companies that have developed a capture technology that is well-suited for medium-scale applications, such as those in the cement industry.

## Midstream policies

### Establish carbon contracts for difference

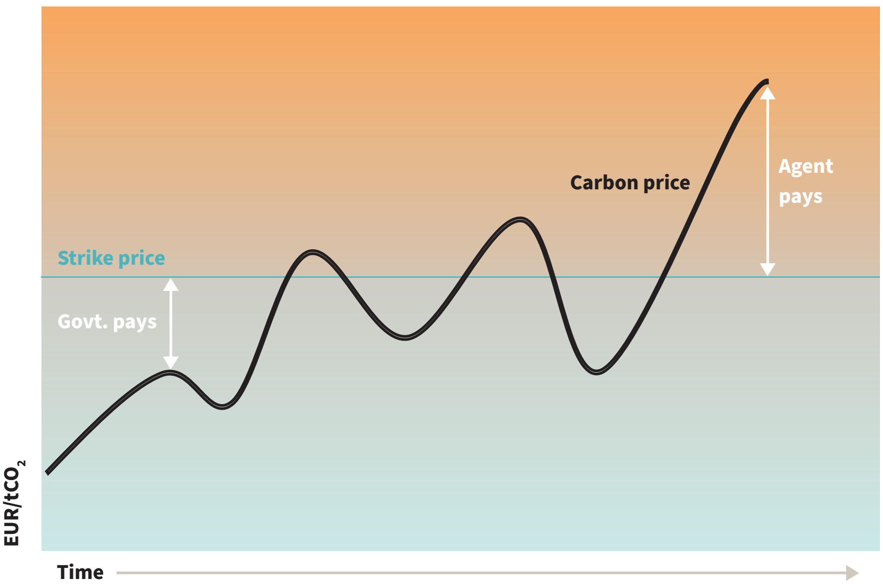
**Carbon contracts for difference (CCfDs) can facilitate the development of innovative and low-carbon technologies, especially during the incubator phase, providing long-term carbon price stability**.[61] However, being a subsidy-type instrument, CCfDs can be extremely expensive for public authorities, particularly in the first years.[62]

A CCfD is a subsidy agreement between a public authority and a company to finance a decarbonisation project. **The amount of subsidy depends on the difference between the carbon price in a specific context and the strike price**. This mechanism could be applied to de-risk investments in innovative and often more expensive decarbonisation technologies in the cement sector, and several governments are implementing such a scheme, see below.

In the case of a low-carbon cement project, a CCfD would be agreed between a public authority and a cement company whereby one of the two parties pays the difference between the carbon price and the strike price. This strike price can either be negotiated between public authorities and companies or through competitive tendering.

**The price agreed upon between a regulator and a company equals the carbon price necessary for the project to be economically profitable**, see Figure 2 referencing the EU carbon price. In this way, a stable carbon

Figure 2. Carbon contracts for difference




Source: https://climatestrategies.org/wp-content/uploads/2021/03/Carbon-Contracts_CFMP-Policy-Brief-2020.pdf price reduces investment risk in breakthrough technologies needed to transition hard-to-abate sectors, such as the cement sector.[63]

### Mandate credible transition plans at the entity-level

Several regulations are emerging with provisions including a transition plan outlining the strategy and plan that an entity will pursue to achieve Paris alignment. Transition plans are an increasingly important tool in strengthening the decarbonisation efforts of corporates across all sectors, including the cement industry. Mandating the existence of transition plans is one step towards making transition plans a facilitator of a credible and ambitious transition at the economic level. However, the mere existence of a transition plan will not achieve anything unless that plan is robust and is being implemented. Understanding the rigour and ambition of transition plans is an emerging field.

**Climate Bonds recommends that policymakers actively consider how they can strengthen the quality of transition plans if mandated.** To provide a structure and rigour around which transition plans can be analysed, Climate Bonds published Transition Finance for Transforming Companies which sets out Five Hallmarks that companies must adhere to when setting out an entity-wide transition plan for investors.[64] These embody the credibility, clarity, and transparency necessary to create an active market, see Figure 3. This guidance is also the first step in the Certification of the whole entity transition which will enable investors to preference investments based on the quality of the entity-level transition strategy and execution plan.

As regulations are tightening globally to reduce emissions and limit climate change, many cement companies have started to outline decarbonisation and net-zero targets, including Holcim, Heidelberg Materials, CEMEX, and UltraTech Cement.[65]

### Target underdeveloped decarbonisation technologies through R&D programmes

**Government research and development (R&D) financing will play a crucial role** in enabling nascent decarbonisation technologies to scale and reach economic viability. Such R&D programmes can specifically target technical challenges.

Some hard-to-abate sector decarbonisation technologies, including in the cement sector, are only at the pilot stage and their large-scale application still needs to be tested. Collaboration between public and private stakeholders and international cooperation will pool resources, improve the identification of R&D priorities, and strengthen knowledge exchange.

**There is no silver bullet currently available to achieve deep decarbonisation of the cement industry**. R&D programmes can help develop and scale breakthrough decarbonisation options in all industries, but the cement sector is particularly dependent on the emergence and scale up of innovative technologies.[66] For example, clinker substitution and replacement can be a potential growth area for R&D, together with kiln furnace electrification, new construction materials development and uptake of innovative solutions for recycling and reuse of cement and concrete.

## CCfDs in the EU, Germany, and Canada

As a result of the recently agreed EU-ETS review, CCfDs will be implemented at the EU level through the Innovation Fund to provide support to decarbonisation projects and certainty to investors.[90] Such a provision is in line with REPowerEU, a plan presented in May 2022 by the EU Commission to rapidly reduce dependence on Russian fossil fuels and fast-forward the green transition.[91] As part of the plan, the European Commission announced that it aims to encourage hydrogen adoption and electrification in industrial sectors by implementing CCfDs and dedicated REPowerEU windows to support a full transition of existing hydrogen production in industrial processes from fossil gas to renewables, as well as the transition to hydrogen-based production processes in new industrial processes.

In May 2022, the German government issued a call for expression of interest in CCfDs, to support innovative technologies contributing to the decarbonisation of the hard-to-abate sectors.[92] Draft funding guidelines for CCfDs have been recently published, including some specific eligibility requirements, such as the need for the project to align with Germany's 2045 climate neutrality target: each awarded project will have to meet specific GHG emissions thresholds in line with this target.[93] **In June 2023, the German government released its EUR50bn plan to decarbonise hard-to-abate sectors through CCfDs, with a particular focus on hydrogen.**[94]

In its 2023 Federal Budget, the Canadian government referenced CCfDs as a tool to give certainty on the carbon price, incentivise investment in low-carbon technologies, and support the transition of hard-to-abate sectors such as cement.[95]

Figure 3. Five Hallmarks of a Credibly Transitioning Company

**1. Paris-aligned targets**

- Select sector-specific transition pathway aligned with Paris Agreement goals
- Company-specific KPIs that align as early as possible with that pathway
- Science based, address scope 1, 2 & 3 emissions and address short, medium and long term

**2. Robust Plans**

- Set the strategy and plan to deliver on those KPIs
- Prepare associated financing plan detailed cost estimates and expected sources of funding
- Put in place necessary governance frameworks to enact change

**3. Implementation action**

- Capital expenditure, operating expenditure
- Other actions detailed in the strategy

**4. Internal reporting**

- Track performance
- Re-evaluate and recalibrate KPIs as needed

**5. External reporting**

**a.** External reporting and independent verification on the KPIs and strategy to deliver (per Hallmarks 1 and 2)

**b.** Annual reporting of independently verified progress in terms of action taken and performance against targets (per Hallmarks 3 and 4)

### Implement carbon pricing with an effective framework against the risk of carbon leakage

**Carbon pricing**, through a carbon tax or emissions trading scheme, is implemented to fix market distortions and capture the external costs of carbon emissions by charging emitters, either with a tax on emissions or a cap-and-trade system whereby sectors are allocated emissions allowances. Part of the value of carbon pricing is its technology neutrality, enabling the market to find the most cost-effective solutions to carbon-intensive activities. Carbon pricing can improve the business case for green technologies and incentivise efficiency gains by placing an economic value on emissions. To do so, prices need to be high enough to have a material impact and not be weakened by free emissions allowances, as is currently the case for the European steel sector. For the carbon price to encourage clean investment, it must be high enough to prompt action. Carbon price volatility will discourage green investment. However, carbon pricing alone cannot be relied on to drive transition. Other policies are required to overcome market failures and inertia, increase the green asset pipeline, and channel funding to transition the whole economy.

The cost of $CO_2$ emissions currently represents a fraction of total cement production costs in countries where carbon pricing is applied. However, the cost of carbon emissions will increase rapidly in the EU, as free carbon allowances (presently covering up to 100% of cement sector carbon emissions) under the EU Emissions Trading System (ETS) are withdrawn. The EU carbon price, established via the ETS, doubled in 2021 to EUR79.38 on 20 December and reached the EUR100/t $CO_2$ milestone in February 2023.[67]

**Concerns over carbon leakage**, the relocation of carbon-intensive industries to avoid pricing, have been a barrier to carbon price introduction. While many jurisdictions have provided free emissions credits to specific sectors, this weakens the price signal. The IMF has also proposed an international carbon price floor, suggesting a floor of USD25-75/$tCO_2$ by 2030, depending on their level of economic development.[68] This would provide long-term green investment certainty globally and help to address carbon leakage concerns.

**Carbon border adjustment mechanism** (CBAMs) are under discussion to address the risk of carbon leakage. A CBAM applies local carbon pricing to imports of carbon-intensive goods, accounting for any pricing used in the country of production. This can strengthen local carbon pricing, as industries no longer need to receive free allowances to ensure competitiveness. It also incentivises global action, as third countries might implement carbon pricing schemes to capture revenue. Turkey's chief negotiator at the COP26 climate summit declared that the EU's plan to introduce a CBAM was a factor in convincing Ankara to ratify the Paris Agreement.[69] In May 2023, EU institutions signed the CBAM regulation, which will enter into application in its transitional phase in October 2023.[70] In December 2022, EU institutions reached an agreement on the CBAM design: it will not only cover the sectors envisioned in the Commission's proposal (iron and steel, cement, aluminium, fertilisers, and electricity) but also hydrogen and other downstream products, as well as indirect emissions under certain conditions. Such changes make the CBAM more ambitious and bring some progress in levelling the playing field between EU and non-EU producers.[71] The CBAM will become effective in 2026 and will be fully phased in from 2035, giving little incentive for emitters to decarbonise their production processes in the first years.[72] Importers will start paying the CBAM financial adjustment in 2026. Several countries such as Canada and the UK are considering similar initiatives and a CBAM is already in place in California, where an adjustment is applied to certain imports of electricity.[73]

## Downstream policies

### Implement green public procurement

**The purchasing power of governments and other public bodies totals around USD11tn each year.**[74] Public procurement accounts for up to 40% of the global cement demand and represents a high share of consumption in critical industries for cement activities, such as construction and infrastructure.[75] Public procurement can also be a considerable incentive for developing a low-carbon cement market.

**Green public procurement** (GPP) can increase demand for decarbonised cement goods and for the whole value chain. The opportunity for GPP is huge and historically, public procurement has been a key lever to bring down emissions. The State of Berlin was able to reduce its GHG emissions by 47% through GPP.[76]

Aligning with Taxonomy criteria will ensure climate-alignment and consistency of sustainable investments. For example, the US government aims to spend 80% of its procurement funds with suppliers that have set targets for their scope 1 and 2 emissions by 2023. Major suppliers to the US federal government will be required to disclose their greenhouse gas emissions and climate-related financial risk.[77]

The development of mandatory criteria is key to effective implementation of GPP. In some jurisdictions, such as the EU and South Korea, GPP remains voluntary, meaning that each public authority can decide whether to follow this guidance.[78] However, even voluntary criteria can drive demand for sustainable goods and services. For example, the European Commission and some Member States have defined some additional general guidance through national criteria on different sectors.[79]

In 2021, a coalition of governments and organisations, led by the United Kingdom and India, with current members including Canada, Germany, Japan, Saudi Arabia, Sweden, the United Arab Emirates, and the United States, launched the new Clean Energy Ministerial Industrial Deep Decarbonisation Initiative (IDDI). Coordinated by the United Nations Industrial Development Organisation, this initiative aims to create market demand for low-carbon industrial materials, especially steel and cement. Governments are among the top buyers of construction materials such as cement. In fact, public authorities account for around 20-30% of global construction industry revenues.[80] Governments signing IDDI's Green Public Procurement Pledge are required to start using low-emission steel, cement, and concrete by 2030 for public construction projects, and monitor and disclose their embodied carbon emissions by 2025. At COP28 in November 2023, Canada, Germany, and the UK are expected to report on their GPP commitments.

### Improve waste management and circular economy requirements

A circular economy aims to maintain the value of products, materials, and resources by returning them to the product cycle at the end of their use, minimising waste generation.[81]

Fly ash from coal-fired power plants, blast-furnace slag and by-products of fossil-based primary steel manufacture can be used in cement production as supplementary cementing materials, replacing the clinker with more sustainable materials.[82] However, with fossil fuel reduction and then phase out, such materials will become rare.

**After demolition, concrete can be 100% recycled, although new concrete production requires additional materials.** This can decrease reliance on primary resources and reduce landfill waste. Recycled concrete is utilised as recycled aggregate in new concrete or other applications such as road building. The global construction and demolition waste recycling market was valued at around USD126m in 2019 and is estimated to reach around USD149m in 2027.[83] However, despite its potential, the level of recycling and material recovery of construction and demolition waste varies greatly across regions.

**Recycling clinker and cement is much more technically challenging.**[84] In June 2022, Holcim announced the production of the world's first clinker made entirely of recycled minerals.[85] According to the company, the 100% recycled materials used range from wood ash to waste from mineral processing.

**The cement industry substitutes secondary resources such as non-recyclable waste or biomass waste for its fossil fuel thermal energy usage.** While incinerating waste for energy poses a risk of high GHG emissions and environmental impacts, it is a potential way for cement production to reduce its fuel-related emissions, provided that specific additional requirements are met. This is especially relevant when considering the need to halve emissions by 2030 to reach the Paris Agreement goals and the fact that only a few alternatives exist today for fuel switching.

Burning alternative fuels and raw materials does not amount to zero emissions. Climate Bonds requires that all emissions released from waste burning are included in meeting the thresholds within the cement Criteria. Waste-derived fuels can be considered in line with Climate Bonds Criteria only when all recyclable waste has been removed before burning, following the Climate Bonds Waste Management Criteria.[86] Moreover, Municipal Solid Waste must remain a transition fuel and is considered as such only until 2035. Finally, continuous monitoring of non-GHG pollutants must be demonstrated to align with Climate Bonds Criteria and publicly disclosed. The waste management sector must move towards better reuse and recycling schemes, waste prevention and – across the economy – better product design.

### Autostrade per l'Italia Group and the use of green construction materials

In its Sustainability Financing Framework, **Autostrade per l'Italia Group**, Italy's leading toll road infrastructure operator, highlighted that it aims to reach its decarbonisation targets using green construction materials for all its infrastructural development projects. This shows the increasing appetite that end-user companies have for abating concrete and cement emissions.[96]

### Scale up off-take agreements

Policy instruments can lower the risk of low-carbon cement by enabling and scaling up off-take agreements.[87] These represent a future purchase commitment to buying a product, defining the specific terms of the contract several years in advance, therefore providing long-term demand certainty. However, these advance purchase commitments carry a risk for the buyer. As stated above, public procurement is very important to the cement sector. Public authorities could include green off-take agreements in their procurement, increasing certainty on demand for future low-carbon cement while reducing their GHG emissions.

### Establish a green window for the trade of zero/near-zero carbon cement

**In addition to carbon pricing policies and measures against the risk of carbon leakage, a broad policy platform, a green window, would encourage the international flow of green goods, services, and capital.**[88] Such a green window could entail reducing tariffs on environmentally friendly goods, services and products produced using green processes.

Cement world trade totalled USD14.8bn in 2021, compared to USD550bn for iron and steel, and experienced a 16.6% growth compared to 2020.[89] However, low-carbon cement would be a perfect candidate for such a green window: zero tariffs on zero-carbon. In 2018, the average tariff for cement was 7.77%, compared to 5.03% for steel.

This green window could compensate for CBAM-related trade curtailments and stimulate green capital flows by reducing restrictions on capital destined for green or transition projects.

# 4. Outlook

The cement industry is vital to the global economy. Cement is a crucial input for multiple industries such as construction and infrastructure and its inclusion in the transition to net zero is essential. Cement accounts for around 7% of global emissions, and is reliant on energy-intensive production processes dependent on coal.

**This decade is crucial to the cement sector transition and meeting net-zero commitments.** Cement demand is expected to rise steadily in the coming decades, by almost 50% by 2050. Meeting this new demand with fossil-based facilities would likely result in long-term carbon lock-in and stranded assets, threatening jobs and putting the Paris-aligned pathway out of reach. Cement asset lifetimes reach up to 60 years and the investment choices made by cement companies will create long-lasting path dependencies, well beyond 2050. By investing in technologies consistent with a net-zero scenario they can avoid stranded assets and the risk of facing high economic losses.

**Finance needs to flow to 1.5°C-aligned pathways and activities.** Massive investment is needed to develop and roll out low-carbon production technologies to transition the global cement sector: USD70bn annually between 2030 and 2040 (doubling from current levels). However, the sustainable debt market could absorb these investments and support cement companies that commit to ambitious targets and develop credible transition plans.

**The success of the cement transition relies heavily on strong policy support.** Policymakers can play a significant role in determining which pathways are taken. The Climate Bonds Sector Criteria for cement and this policy paper provide science-based guidance on what constitutes a Paris-aligned cement transition.

Policies must be coherent and aligned to encourage demand for low-carbon cement, facilitate investment in the transformation of cement companies and assets, and enable the scaling of innovative clean technologies. Therefore, this paper is wide ranging and includes different policy levers, see box.

| Decarbonisation levers | Policy levers | |
|---|---|---|
| | Lever-specific | Applicable to the whole sector |
| Maximise the use of alternative binders | | Scale up off-take agreements |
| Implement carbon capture and storage technologies (CCS) | Ensure strategic and 1.5°C-aligned CCS infrastructure for the cement industry | Establish a "green window" for the trade of zero/near-zero carbon cement |
| Maximise energy efficiency | | Implement green public procurement (GPP) |
| Substitute fossil fuels with alternative fuels such as waste-derived | Improve waste management and circular economy requirements | Establish carbon contracts for difference (CCfDs) |
| Improve clinker-to-cement ratio | | Mandate credible transition plans at the entity-level |
| Use low-carbon hydrogen as an alternative fuel | Accelerate deployment of renewable energy and related infrastructure | Guide green investment through standards and sector-specific criteria and taxonomies |
| Adopt low-carbon electricity and solar thermal energy | Accelerate deployment of renewable energy and related infrastructure | Target underdeveloped decarbonisation technologies through R&D programmes |
| | | Implement carbon pricing with an effective framework against the risk of carbon leakage |

# Annex: Climate Bonds Initiative Cement Criteria

Figure 4. Emissions pathways for cement production facilities and cement production companies (scope 1 & 2 emissions combined)

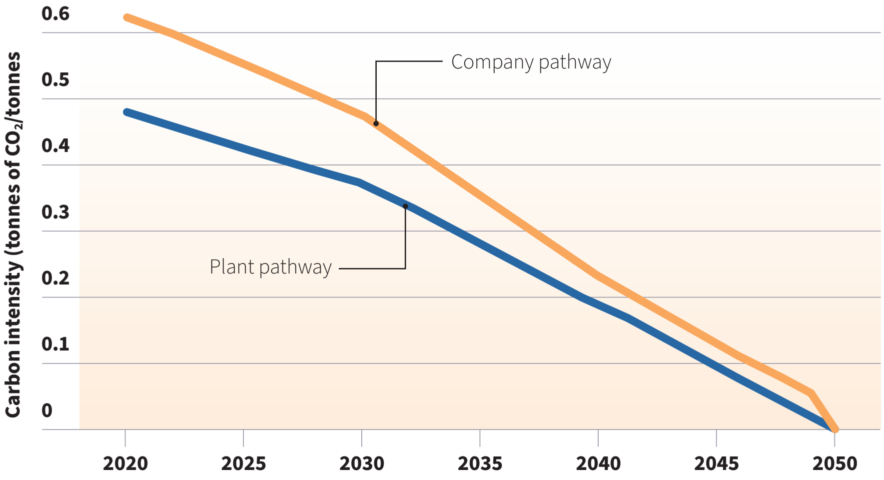



Table 3. Threshold values forming the emissions pathway for all cement production facilities[97]

| Year | Carbon intensity (t $CO_2$/t cementitious product) | Year | Carbon intensity (t $CO_2$/t cementitious product) | Year | Carbon intensity (t $CO_2$/t cementitious product) | Year | Carbon intensity (t $CO_2$/t cementitious product) |
|---|---|---|---|---|---|---|---|
| **2020** | 0.469 | **2028** | 0.384 | **2036** | 0.253 | **2044** | 0.107 |
| **2021** | 0.458 | **2029** | 0.374 | **2037** | 0.234 | **2045** | 0.089 |
| **2022** | 0.448 | **2030** | 0.363 | **2038** | 0.216 | **2046** | 0.071 |
| **2023** | 0.437 | **2031** | 0.345 | **2039** | 0.197 | **2047** | 0.054 |
| **2024** | 0.427 | **2032** | 0.326 | **2040** | 0.179 | **2048** | 0.036 |
| **2025** | 0.416 | **2033** | 0.308 | **2041** | 0.161 | **2049** | 0.018 |
| **2026** | 0.406 | **2034** | 0.289 | **2042** | 0.143 | **2050** | 0.000 |
| **2027** | 0.395 | **2035** | 0.271 | **2043** | 0.125 | | |

Table 4. Threshold values forming the emissions pathway for all cement production companies (scope 1 and 2)[98]

| Year | Carbon intensity (t $CO_2$/t cementitious product) | Year | Carbon intensity (t $CO_2$/t cementitious product) | Year | Carbon intensity (t $CO_2$/t cementitious product) | Year | Carbon intensity (t $CO_2$/t cementitious product) |
|---|---|---|---|---|---|---|---|
| **2020** | 0.616 | **2028** | 0.494 | **2036** | 0.320 | **2044** | 0.145 |
| **2021** | 0.597 | **2029** | 0.478 | **2037** | 0.295 | **2045** | 0.127 |
| **2022** | 0.583 | **2030** | 0.463 | **2038** | 0.270 | **2046** | 0.108 |
| **2023** | 0.568 | **2031** | 0.440 | **2039** | 0.245 | **2047** | 0.089 |
| **2024** | 0.554 | **2032** | 0.416 | **2040** | 0.219 | **2048** | 0.070 |
| **2025** | 0.539 | **2033** | 0.392 | **2041** | 0.201 | **2049** | 0.051 |
| **2026** | 0.524 | **2034** | 0.368 | **2042** | 0.183 | **2050** | 0.000 |
| **2027** | 0.509 | **2035** | 0.344 | **2043** | 0.164 | | |

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Prepared by Climate Bonds Initiative.





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