Concrete policies to underpin the cement transition

Prepared by Climate Bonds Initiative.

Contents

1. Summary 3

2. Introduction 5

Methodology 6

3. The importance of the cement sector 7

Global cement emissions 7

The EU cement industry 8

Understanding cement sector emissions 9

Transition pathways for cement 9

The urgency of investing in low-carbon cement 13

Sustainable Finance Markets are a critical financing tool 13

4. Policy levers for the European cement sector 15

Policy recommendations 16

Upstream policies 16

Midstream policies 18

Downstream policies 23

5. Conclusions 26

6. Annex: the cement making process 27

Endnotes 28

Table 1. Key policies to decarbonise the entire EU cement 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.Summary

The cement sector is the second-largest industrial emitter globally and it accounts for around 4% of the EU's CO_2 emissions.

The cement industry contributes significantly to CO_2 emissions. It is the second-largest industrial emitter, accounting for approximately 7% of global CO_2 emissions, and demand for cement is predicted to increase.[2] Cement is a critical input for many activities, including buildings and infrastructure, and is a key material in the net-zero transition.

30% of EU cement kilns are estimated to reach end of life and need reinvestment by 2030.[3]

This decade offers a perfect opportunity to invest in the cement net-zero transition in Europe. Cement assets' lifetimes reach up to 60 years and the investment choices that cement companies make now 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 high economic losses.[4]

Given the size and emissions of the cement sector, its transition is essential for the EU to meet its 2050 climate neutrality target. Policymakers should act immediately to guide industry and investors onto a climate-aligned pathway for cement and support informed investment decisions consistent with a net-zero cement investment approach.

The investments needed by 2030 to align with a Paris-aligned transition pathway are estimated to be relatively low.

The investments needed for the EU cement sector to meet 2030 targets represent around 20% of annual maintenance CAPEX.[5] At the individual plant level, the additional investment needs are not very large. For example, an estimated EUR246m of additional investment is required to build a 3 Mt-capacity cement plant with carbon capture in Germany. This would meet around 10% of the country's annual average production.[6]

At the system level, however, there are challenges in rapidly scaling up these investments across a huge number of locations. The need to achieve deep emissions reductions by 2030 means that scale and speed are critical.

The capital spending needed to transition the global cement industry could reach USD70bn annually between 2030 and 2040.[7] The global cement industry will need to invest USD16bn annually on top of business-as-usual investments to transition to net zero.[8]

Around USD3.7bn sustainability-linked bonds (SLBs) have been issued in the cement sector in 2020-2023 (as of February). The cement sector represented less than 2% of SLBs issued so far. Despite the growth of these financial instruments, their potential is not being fully exploited in this sector. Emerging standards and sector-specific criteria, such as those developed by Climate Bonds Initiative, can support the growth of these instruments in hard-to-abate sectors such as cement.[9]

Policy support is crucial to the decarbonisation of hard-to-abate industries such as cement.

Technologies and solutions are available today which can kickstart the cement sector transition while emerging ones can complete the picture.

These nascent technologies can be supported by Carbon Contracts for Difference. These improve their investment potential and long-term offtake certainty. Off-take agreements can also lower the risk of producing low-carbon cement.[10]

Strong policy instruments are needed to support the EU cement industry transition to net zero. These policies apply to different parts of the cement industry value chain: upstream, midstream, and downstream, see Table 1.

Strong demand signals will provide confidence for companies to invest in the transition to green cement production.

Public procurement can drive the market for green cement. The EU has set green public procurement (GPP) criteria, but these are only voluntary. Introducing mandatory criteria in line with the Green Deal would enable preferential spending to be embedded in governmental budgets. Aligning GPP standards with the EU Taxonomy will ensure consistency of green public investment.

The cement industry has not been subject to the full price of carbon pollution under the EU-ETS; improving price signals under the EU-ETS would support the investment case for decarbonisation.

The EU Emissions Trading System (ETS) is one of the main EU policies to address climate change and reduce emissions. It works on the cap-and-trade principle; within this cap, companies buy or receive allowances that they can trade with each other.[11] Free emission allowances cover up to 100% of cement industry emissions under the ETS, due to carbon leakage concerns – the risk of relocation to avoid pricing with the EU cement production becoming uncompetitive with lower-cost, higher-emissions imports.

Meanwhile, cement imports to the EU-27 quadrupled between 2016 and 2021, from less than 2% of total cement production to more than 10%.[12] The Carbon Border Adjustment Mechanism (CBAM) will address this, and free allowances could be phased out for sectors covered by the CBAM by at least 2030.

CCS will play a significant role in the cement sector transition, but it needs to meet specific criteria to be a credible decarbonisation option.

Carbon capture and storage (CCS) will play an important role in reducing CO_2 emissions from the cement industry, notably the emissions that occur as a result of the chemical reaction needed to make cement, irrespective of the energy source. Around 60% of the direct emissions in the production process do not result from fuel combustion, but from chemical reactions in the clinker calcination process.[13] CCS in cement should address these emissions that cannot otherwise be abated, rather than prolong fossil fuel combustion.

Europe takes the lead on CCUS initiatives in the cement sector. 56% of cement industry planned CCUS projects are in Europe.[14] Policymakers can ensure the strategic application of CCS and favour priority sectors to ensure it is reserved for sectors with limited decarbonisation options and for emissions that cannot be prevented, such as in the cement industry. CCS technologies will need to use low-carbon electricity and meet technical criteria for the transport of CO_2 and underground permanent geological storage of CO_2 in the EU Taxonomy.[15]

2.Introduction

Cement is a crucial input for many industries, including construction and infrastructure, and inevitably part of a low-carbon future. However, it is currently very high carbon and will need significant technological and financial investment 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. While progress is accelerating, the carbon intensity of global cement production has only slightly decreased in recent decades, and it is significantly behind where it needs to be on a Paris-aligned pathway.[16]

The 2015 United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement is a testament to the global determination to limit increasing global temperatures to 1.5°C. 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.

However, only a few economic activities currently operate at or near zero emissions. Most sectors require substantial financing, clear guidance, and a framework of supportive policies to transition to net zero. Decarbonisation pathways are less obvious for hard-to-abate sectors such as cement, steel, and chemicals. Greater attention is now being given to these hard-to-abate sectors, and detailed decarbonisation plans and pathways are available or are being published, showing that feasible low/zero-emission solutions are possible within a reasonable timeframe. The European Union (EU) has led the way with the ambitious Green Deal strategy and the Fit for 55 Policy Package. The challenge is not only in developing the technology but also in overcoming financial and political barriers. The suite of EU policies and legislation supporting the net-zero transition must be coherent, mutually reinforcing, and rapid enough to meet climate targets.

This paper aims to support the EU in defining the necessary policy framework for financing the transition. While primarily focused on the EU context, many of the policy tools and recommendations apply globally. This is particularly relevant as most European cement producers operate on a global level. European cement companies own about 60% of the cement and lime production capacity in the United States, and they have large manufacturing facilities across the world.[17]

The decarbonisation pathways used in this paper follow both the EU's climate targets (2050 climate neutrality and 2030 55% emission reduction target), Intergovernmental Panel on Climate Change (IPCC) guidance and the 2021 International Energy Agency (IEA) Net Zero Roadmap. The 2022 IPCC Working Group III report, forewarned that without immediate and deep emissions reductions across all sectors, limiting global warming to 1.5°C is beyond reach.[18]

Investing in the transition of hard-to-abate sectors presents a unique opportunity for the EU to continue to lead on the climate agenda by supporting the development of innovative technologies and scaling up renewable energy. Failure to seize this opportunity and continue business as usual will risk missing vital climate targets and expose the EU to higher physical climate risks. It would also lock in billions of euros of stranded assets and a disorderly and chaotic transition, exposing the real and financial economies to transition risks and possible financial crises.

Climate Bonds Initiative (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 is part of a series focused on the policies and regulations needed in the EU to facilitate the flow of finance necessary for the transition; see Climate Bonds' "Accelerating the Fossil Gas Transition to Net Zero" and "A Green Future for Steel".[19] These policies are complemented by the Climate Bonds sustainable finance criteria for the cement sector published in 2022.[20]

This paper aims to address the following critical questions:

How can the EU facilitate a green future for cement through policy and sustainable finance frameworks?

How can the EU utilise its policy levers to facilitate and catalyse a green future for cement?

Section 3 summarises the size, emissions contribution, sustainable finance instruments, technologies, and challenges to the transition of the European cement sector.

Section 4 examines how policymakers can ensure the credibility of this transition, drawing on existing EU policy and strategies and recommending how these can help to deliver a credible transition.

Methodology

This policy paper aims to support the EU in defining the necessary policy framework for financing the transition to net zero in the cement sector. It is based on an analysis of existing EU policies and a literature review of cement transition policies. It is supported by an assessment of the European cement sector, including a summary of the technologies and solutions that can deliver deep emission reduction.

EU policies relevant to the sectoral transition were identified and analysed against the Climate Bonds Credible Transition Principles and the decarbonisation pathways set out by the IEA and other international organisations to assess their sufficiency in facilitating the sector's transition.[21] Particular attention was paid to the Fit for 55 policy package, which aims to deliver rapid decarbonisation in the next decade, including the European Emissions Trading System and Carbon Border Adjustment Mechanism. A literature review informs the policy suggestions.

Several policy recommendations and decarbonisation pathways for the cement sector have been identified by public and private sector stakeholders including IEA, EU institutions, International Monetary Fund (IMF), World Bank (WB), United Nations Industrial Development Organisation (UNIDO), CEMBUREAU, Global Cement and Concrete Association, NewClimate Institute, Agora Energiewende, and the work of the EU Platform on Sustainable Finance.

3. The importance of the cement sector

Global cement emissions

The cement sector is a major contributor to carbon dioxide (CO_2) emissions. The steel and cement industries are the largest global industrial emitters, accounting for around 8% and 7% of global CO_2 emissions respectively, and demand for these products is expected to rise, see Figure 1.[22] Concrete, a mixture of cement, water, and aggregates (both coarse and fine), is the second most-used substance in the world after water, see Box 1. If global cement manufacturing were a country, it would be the third-largest emitter on the planet, only after China and the United States of America.[23] Cement also releases the most emissions per dollar of revenue, around 6.9 kg of CO_2/USD, much higher than iron and steel, oil and gas, and chemicals, respectively 1.4, 0.8 and 0.3 kg of CO_2/USD, see Figure 2.[24] The cement industry is also responsible for around 4% of the EU's total CO_2 emissions.[25]

Cement is also integrated into the supply chain of many industries, including construction and infrastructure. The decarbonisation of cement production processes is critical to these sectors' transition and achieving their emission reduction targets. Cement is a key material to reaching the EU climate neutrality objective as it is a crucial component of installations providing renewable energy, such as wind turbines and hydroelectric dams.[26]

The EU cement industry

The EU is the world's third-largest cement manufacturer. In 2020, the EU-27 accounted for 4% (171.5 Mt) of world cement production, after China and India at 57.2% and 7.0%, respectively, see Figure 3.[27]

In the EU, the sector directly employs approximately 38,000 people, with millions more employed in the construction industry.[28]

Box 1. Cement vs concrete

Even though the terms "cement" and "concrete" are often used interchangeably, they are two different materials. Cement is a fine powder substance key ingredient in concrete production. Concrete is a mixture of cement, water, and aggregates, that make up between 60% and 75% of such a mixture.[30] Concrete has been used for a long time; historic examples include the Colosseum.[31]

More than 25 different types of common types of cement exist today and can be grouped into five categories and three strength classes which describe its reactivity.[32]

Figure 1. Industry sector share of global CO_2 emissions, 2017

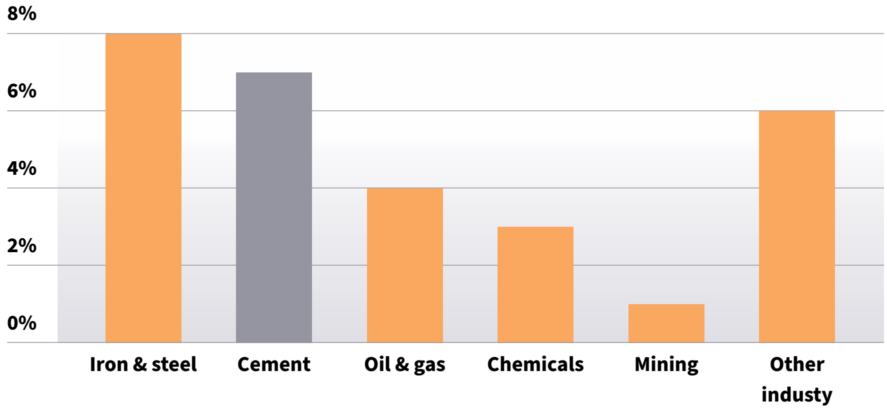


Figure 2. Emissions per dollar of revenue in selected sectors (kg of CO_2/USD)

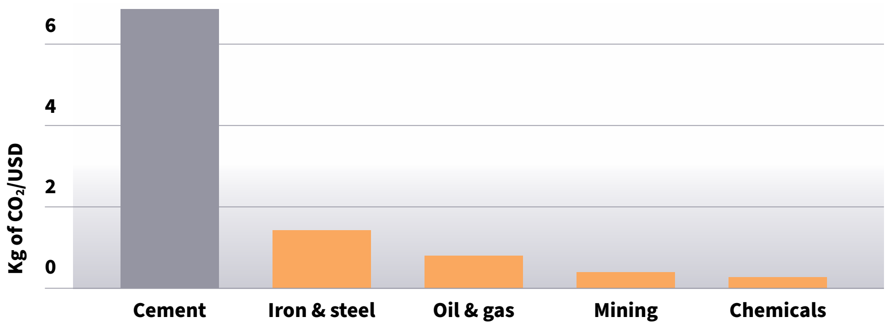


Figure 3. Share of global cement production in selected countries and regions, 2020

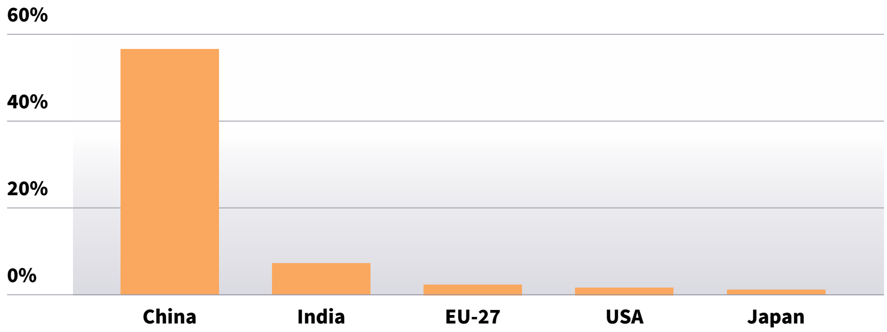
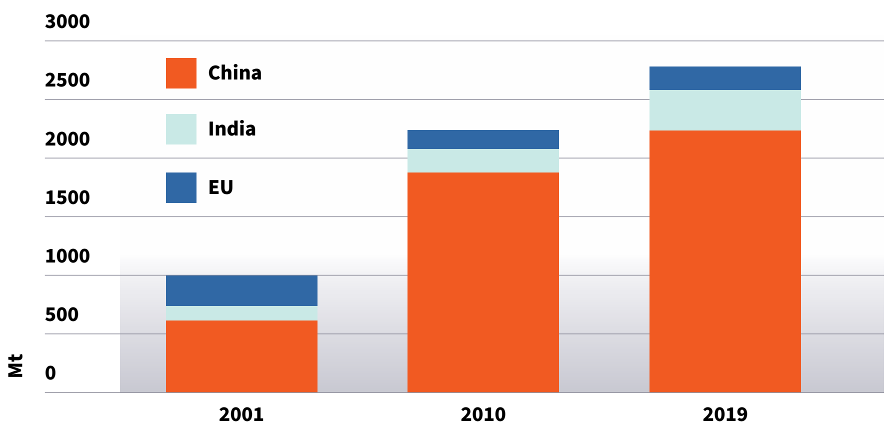


Figure 4. Total cement production in China, India and the EU in 2001, 2010 and 2019 (mt)



Total cement production in the EU fell substantially in the last two decades, from 225.6 Mt in 2001 to 182.1 Mt in 2019 (19% decrease), while global cement production grew over this period, particularly in China and India. The global cement industry is driven by constantly increasing demand, especially for the construction of housing and infrastructure. The total cement production in China grew from 661 Mt in 2001 to 2300 Mt in 2019, while, over the same years, India witnessed growth from 102.9 Mt to 320 Mt, see Figure 4.[29]

Table 2. Main EU cement-producing countries[71]

Country	Cement production in 2019 (Mt)	Share of EU-27 production (%)
Germany	34.2	19.8%
Italy	19.2	11.1%
Poland	18.5	10.7%
France	16.5	9.5%

Understanding cement sector emissions

The cement making process consists of several steps (see Annex for more information), as detailed in Figure 5. For the purposes of reducing emissions, the most important steps are in the red box below.

Given that over 80% of emissions are related to the kiln and preheater/precalcinator as above, these processes are the focus of this paper. Similarly, in the EU, about 90% of emissions are linked to the current production process and can broadly be separated into two categories:[33]

- **Non-combustion emissions (calcination process):** around 60% of the direct emissions in the production process do not result from fuel combustion, but from chemical reactions in the clinker calcination process – when limestone is calcinated in the kiln.[34] In other words, these cannot be reduced by substituting fuels. This is very different to other industrial processes where the bulk of process emissions relate to fuel use.
- **Fuel combustion emissions:** most of the remaining CO_2 emissions (about 30%) are produced by fuel combustion to make clinker, which is the main constituent of cement and is produced in a kiln at around temperatures of 1450°C. The high temperatures are achieved by burning fossil fuels (predominantly coal), biomass or alternative fossil and mixed wastes.

Transition pathways for cement

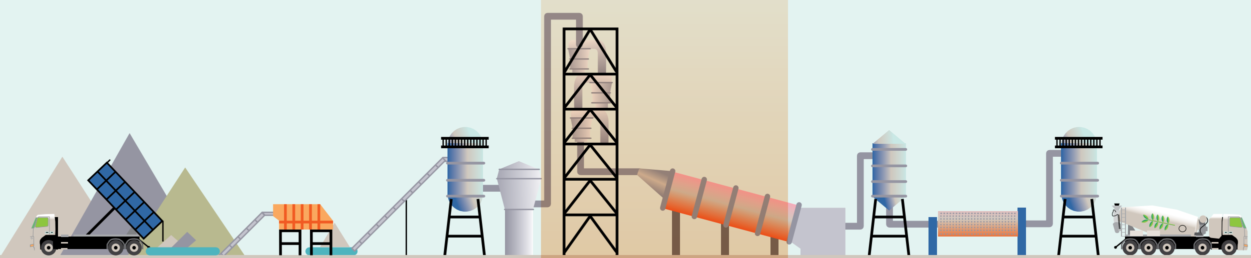
While the transition of the cement sector is, undoubtedly, a huge challenge, the good news is that there are technologies and solutions available today which can kickstart the transition while emerging ones can complete the picture. There are costs associated with each technology, but costs with continuing business as usual will result in increased investment risk and stranded asset risk.

Several studies and pathways for cement decarbonisation have been modelled based on expert knowledge of the production process as described above. Each of these pathways is based on different scenarios and assumptions and varies depending on the regional focus. The pathways differ but provide a useful indication of the potential to reduce GHG emissions and the role of low-carbon technologies. This section analyses the pathways to transitioning the European cement sector by 2050. Particular attention is paid to the studies carried out by IEA, EU, Agora Energiewende, NewClimate Institute, Material Economics, Global Cement and Concrete Association (GCCA) and the European Cement Association (CEMBUREAU).

As mentioned above, approximately 60% of the total CO_2 emissions of the cement making process come from chemical reactions, while most of the remaining CO_2 is produced by fuel combustion. Key levers for decarbonisation can therefore be divided into these two groups. Moreover, reducing the use of cement through material substitution represents another lever to help achieve the sector's net-zero transition. Indeed, in some applications, cross-laminated timber (CLT) can substitute cement, steel and other carbon-intensive materials traditionally used in construction. Barriers such as the lack of standardisation need to be addressed. CLT currently has a low market share of less than 0.1% of homes in this sector, and there is the potential for this to increase to 20-60%.[35] The global CLT market could reach a compounded annual growth rate of 13.2% between 2021-2026, reaching a global market size of USD2.7bn, and USD1.5bn in the EU.[36]

Figure 5. 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

Non-combustion levers

Improving clinker-to-cement ratio

As noted, making clinker accounts for over 80% of cement production emissions. Reducing the amount of clinker that goes into cement even by a few percent can have a big impact.

In 2017, Europe's clinker-to-cement ratio was 77%. This indicates that alternative materials, such as granulated slag from blast furnaces and fly ash from coal-fired power plants, replaced around 20% of the clinker on average. The cement industry is aware that the phase-out of fossil fuels would limit the availability of fly ash (now 10% of total replacements) and reduce slag usage (now 33% of total substitutes). However, other materials, such as natural pozzolans, limestone, and burned oil shale, already account for 21% of total substitutions, and non-traditional alternatives like calcined clay and silica are being evaluated. More studies are being conducted to examine these alternatives and how they may be utilised in the future.[37] CEMBUREAU is targeting to move from an average of 77% to 74% clinker in cement by 2030 and to move to 65% by 2050.[38] The NewClimate Institute envisages an average clinker-to-cement ratio of 60% in the EU cement sector by 2050.[39]

Implementing carbon capture & storage technologies (CCS)

CCS is the process of capturing, transporting, and storing CO_2 to prevent its release into the atmosphere, see Box 2. CCS will play a role in reducing CO_2 emissions from the cement industry, notably the around 60% of emissions associated with limestone calcination for which there is no other foreseeable mitigation technology in conventional production processes.

This means that compared to other hard-to-abate sectors such as steel, cement production is likely to rely on CCS to a greater extent because of difficulties in avoiding process emissions – see Climate Bonds Initiative's policy paper, "A Green Future for Steel", for comparison.[40]

The IEA estimates that CCS in the cement industry will need to significantly increase by the end of this decade, for the world to be on track to achieve the net-zero transition by 2050.[41] CEMBUREAU estimates that, by 2050, the use of carbon capture technologies will reduce European cement CO_2 emissions by 42%.[42]

While commercial CCS technologies applications in the cement industry are mostly in the early stages of development, they are expected to come to a commercial scale in the coming years.[43]

Europe has taken the lead in carbon capture investment in the cement sector. A total of 56% of planned global cement capacity with carbon capture is in Europe. In particular, European companies, LafargeHolcim and Heidelberg Cement are responsible for 73% of global carbon capture projects in the sector.[44] EU-specific policy recommendations on carbon capture are addressed in the policy section, see 5.3.

A diverse variety of carbon capture methods, with varying degrees of technological readiness, are being evaluated internationally to lower costs. These include:

- **LEILAC (Low Emissions Intensity Lime And Cement)** started in 2016 to pilot a breakthrough technology to cut emissions while maintaining competitiveness.[45] 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.
- **The CLEANKER project** is aimed at designing, constructing, and operating a demonstration system that will capture the CO_2 from a portion of the flue gas of a cement plant in Italy operated by Buzzi Unicem.[46]
- **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.[47]

Box 2. CCS and CCUS technologies

Once captured, carbon storage can be stored in closed systems (geological storage under the ground) or re-used in other applications.[72] For this document, CCS refers specifically to closed systems since these have the largest storage life spans.[73]

The use of captured carbon (CCU) remains a controversial area. This is mainly because if the CO_2 is used to create, for example, a fuel, it will be immediately released into the atmosphere when the fuel is burned. Additional restrictions are included in Climate Bonds criteria around CCU, particularly for the end product, which is only **considered as transitional when the CO_2 is used for the manufacture of durable products** (e.g., construction materials stored in buildings or recyclable products, e.g., PET) and not for enhanced oil recovery (EOR) and the production of other forms of fossil energy sources. This is particularly relevant, as more than 70% of the CO_2 captured today is used to extract more oil through EOR.[74]

Climate Bonds Initiative's sector criteria are technology-agnostic, so long as the technology can deliver the promised emissions reductions. Criteria also tend not to include in scope early-stage technology or Research and Development initiatives. As such, the transport and storage of CO_2 must be demonstrated for it to be certified.

Maximising the use of alternative binders

Alternative binders could reduce emissions from cement manufacture, particularly from process emissions and sometimes thermal energy requirements.[48] They are currently in various phases of development and rely on raw materials or mixtures that differ from those used to make concrete.[49] There are several types of these alternatives with the potential to save CO_2 by lowering the quantity of limestone in the formulation and requiring less energy.[50] However, because types of cement have varied different characteristics, they can only be utilised for specific applications.[51] CEMBUREAU has targeted a 2% reduction in process CO_2 emissions by 2030 and 5% by 2050. According to the association, these represent conservative estimates, as they consider potential limits in the application of some of these cement alternatives and the time needed for market acceptance and the development of standards and sector-specific criteria.[52]

Several alternative binding materials are commercially available, although their usage has been confined to niche applications. Recent research by Solidia Technologies on an alternative binding material with the potential for very low emissions – carbonation of calcium silicates – resulted in the launch of a first commercial venture in 2019.[53] Continued innovation might lead to the development and advancement of new opportunities for using various alternative binding materials.[54]

Fuel combustion levers

Maximising energy efficiency

Clinker manufacturing is an energy-intensive process requiring raw materials to be heated to 1450°C and accounting for 35-40% of the cement industry's CO2 emissions.[55]

European cement kilns are already efficient, as around 90% of European plants already rely on efficient dry thermal processes.[56] Therefore, the thermal efficiency of only certain European kilns can still be improved by converting preheater and other kiln types to pre-calciner kilns and by recovering heat from the cooler to provide up to 20% of the cement plant's electricity demand.[57] CEMBUREAU is targeting a 4% improvement in thermal efficiency by 2030.[58]

In 2017, electrical energy accounted for 13% of overall energy consumption and 6% of total CO_2 emissions from cement manufacturing. Changes to the preheater design on the kilns and enhanced grinding can increase electrical efficiency. Even though today's electrical energy consumption levels are relatively low, they are expected to quadruple by 2050 after implementing carbon capture technologies.[59]

Substituting fossil fuels with alternative fuels

Fuel emissions account for 35-40% of total CO_2 emissions from cement production. Reducing emissions from fuel use requires the use of alternative fuels. European and global cement use two main alternative fuels: waste and biomass.

In 2017, alternative fuels accounted for 46% of overall kiln fuel demands in Europe, of which biomass accounted for 16%.

If the resources are locally accessible, the cement industry states that there are no technological barriers to increasing the usage of alternative fuels to more than 90%. Several plants have reached that level due to favourable policies (e.g., policies discouraging landfill disposal), as well as public and investment support. Examples include Schwenk Cement's Allmendingen, in Germany, and LafargeHolcim's Retznei, in Austria, both of which utilise up to 100% alternative fuels and 12% alternative raw materials.[60]

Co-processing plays an important role in waste management in local communities and municipalities, particularly for those materials that are not recyclable, using waste as a fuel provides an important disposal technique and simultaneously reduces emissions from landfill methane.

CEMBUREAU targets to reach 60% alternative fuels containing 30% biomass in 2030 and 90% alternative fuels with 50% biomass by 2050.[61] The NewClimate Institute envisages an average substitution rate of 70% by 2040, with 50% biomass and 20% waste.[62]

While incinerating various waste streams for energy poses high GHG emissions and environmental impacts, it is a potential way for cement production to decarbonise its fuel-related emissions, provided that specific additional requirements are met. Considering the waste hierarchy, the waste management sector must move towards better reuse and recycling schemes, waste prevention and – across the economy – better product design. However, the reality is that large quantities of waste are still produced globally. Burning this waste in waste incineration plants carries risks. However, burning this waste in cement plants has distinct characteristics which can minimise or even completely remove the pollution and human health risks carried by burning Municipal Solid Waste (MSW) in incineration facilities.[63]

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. Climate Bonds acknowledges that 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 Low Carbon Cement Criteria.

Waste-derived fuels can be considered in line with Climate Bonds Criteria only when all waste of recycling potential has been removed before burning in line with the waste hierarchy, following the Climate Bonds Waste Management Criteria.[64] Moreover, MSW must remain a transition fuel and is considered as such only until 2035.[65] Finally, continuous monitoring of non-GHG pollutants must be demonstrated to align with Climate Bonds Criteria by industry best-practice guidance and publicly disclosed.

Adopting electrification and solar thermal energy

Electrification is a key part of the decarbonisation of all parts of industry. Electrification of industrial processes can minimise fuel demand and lower CO_2 scope 1 emissions (and scope 2 if using low-carbon electricity).

While the opportunity is great, the challenge is a big one – it is exceedingly challenging to reach the high kiln temperatures needed using electricity instead of fossil fuels. Electrification is therefore not on the immediate investment horizon, but further research will be needed to determine how an electric cement manufacturing process may operate.[66]

The CemZero project, which aims to electrify cement production in Sweden, completed a feasibility study in 2019 that demonstrated electrified cement production is technically feasible and probably cost-competitive with alternative ways to significantly reduce emissions. Studies on constructing a pilot plant are ongoing for the activity.[67] Other projects are also being developed, including innovation towards developing fully solar-driven cement plants.[68]

Using green hydrogen as an alternative fuel

In a decarbonised future, hydrogen is one of the candidate gases that could be utilised to replace or partially replace coal and fossil gas. There are several varieties of hydrogen, such as blue, pink, grey, and green, that have been classified based on the environmental credentials of the various manufacturing methods, Climate Bonds' "Accelerating the Fossil Gas Transition to Net Zero" expands on this.[69] In particular, green hydrogen has the potential to be utilised as a combustion fuel in a cement kiln without the CO_2 emissions associated with conventional fuels and biomass.

The availability of green hydrogen at the volumes required by the cement industry will depend on the availability of sufficient amounts of renewable energy (to produce green hydrogen), specialised transport and storage infrastructure, as well as the required changes to cement assets. Hydrogen has not been tested in the cement-making process. The usage of hydrogen may have an impact on the physical components of the kiln system, such as fuel mass fluxes, temperature profiles, heat transfer, and plant safety. Feasibility studies are being conducted to determine the viability of using hydrogen in a cement kiln system.[70]

The urgency of investing in low-carbon cement

The transition of the cement sector is critical to meeting the EU pledge to reach climate neutrality by mid-century. This will require huge investment to develop and roll out low-carbon cement-making technologies for an overall transformation of the global cement sector.

To understand the policy levers available, it is critical to understand a few important aspects of cement and investment. The cement industry is capital intensive, with the cost of establishing a cement production plant equalling around three years' turnover.[75] Kilns are a significant long-term investment for cement companies. It is difficult for manufacturers to adjust to changes in demand or to comply with new energy- or emission-related legislation. The cement manufacturing process is also very energy intensive.[76]

Lifetimes of cement assets reach up to 60 years meaning that both the reinvestment and location choices that cement companies will make during the coming years will create long-lasting path dependencies. Considering the 2050 EU climate neutrality target, this means that all major investments must be focused on technologies that can operate in a net-zero scenario to avoid stranded assets, the premature shutdown of existing plants, and high economic losses.[77]

The capital spending needed to transition the global cement industry could reach USD70bn annually between 2030 and 2040 – doubling from current levels. These estimates include the costs to build new low-carbon production capacity and renovate existing plants with innovative technologies, such as CCUS.[78] The global cement industry will need to invest USD16bn annually on top of business-as-usual investments to transition to net zero.[79] However, on average, the investments needed for the EU cement sector to reach 2030 targets represent around 20% of annual maintenance CAPEX.[80] Policymakers must, therefore, guide industry and investors onto a climate-aligned pathway for cement and support informed investment decisions consistent with a net-zero cement investment approach.

Substantial retrofits before the assets reach the end of their life are not always technologically or economically feasible meaning that it is critical that those assets reaching their end of life are the highest priority for low carbon. However, as noted above, the investments needed by 2030 to align with a Paris-aligned transition pathway are estimated to be relatively low. At the individual plant level, the additional investment needs are not large. For example, an estimated EUR246m of additional investment is required to build a 3 Mt-capacity cement plant with carbon capture in Germany. This would meet around 10% of the country's annual average production.[81] At the system level, there are challenges in rapidly scaling up these investments across a huge number of locations. The need to achieve deep emissions reductions by 2030 means that scale and speed are critical.

The good news is that 30% of EU cement kilns are estimated to reach their end of life and need reinvestment by 2030.[82] This means that the next few years are a critical point for the industry – as a third of the industry receives significant investment, it is critical that this is green – and retrofitting is as green as possible to lock in substantial emissions reduction into the longer term.

Sustainable Finance Markets are a critical financing tool

Sustainable finance instruments facilitate investment in Paris-aligned projects and have shown significant growth. Climate Bonds databases captured USD863.4bn of green, social and sustainability (GSS) bonds, sustainability linked bonds (SLBs), and transition bonds in 2022.[83]

Global transition finance, including bonds and loans, could contribute up to USD1tn annually, or 30% of the estimated USD3tn per year required to meet net-zero emissions over the next 30 years.[84] Transition finance instruments broaden the sustainable finance market, enabling participation by high-emitting sectors such as cement. These could outgrow the green bond market by the mid-2020s.[85]

Given their forward-looking key performance indicators (KPIs), 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, and in some cases had been achieved or almost achieved before the instrument had been priced.[86] 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. While the market has seen impressive growth, it has often been difficult to assess the impact and ambition of each bond.

Table 3. Examples of SLB issuers in the cement sector

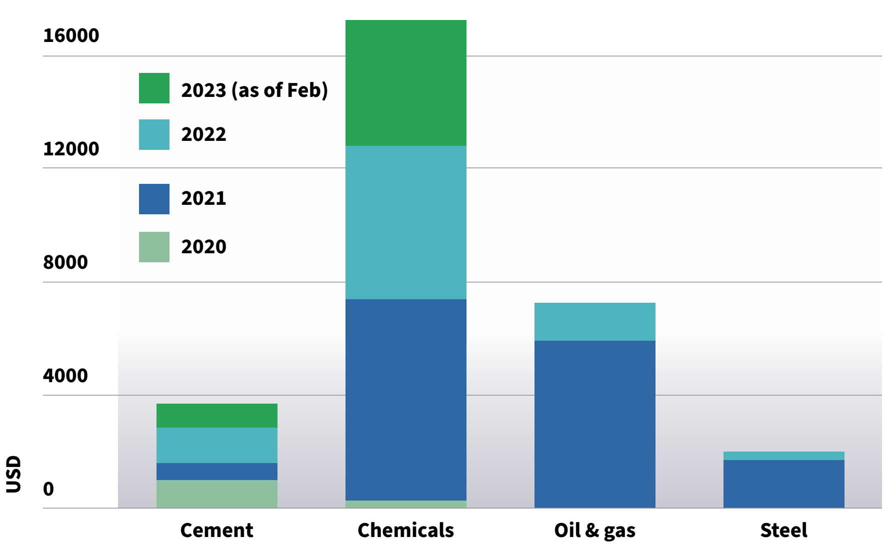
Issuer	Country	KPI Goal	KPI Deadline	Global estimated carbon intensity target on a Paris-aligned pathway[91]
GCC SAB de CV	Mexico	576 kg CO_2/ton cem. material	12/31/2030	360–370 kg CO_2/ ton of cement by 2030
Holcim US Finance Sarl & Cie SCS	Luxembourg	475 kg CO_2/ton cem. material	12/31/2030	360–370 kg CO_2/ ton of cement by 2030
UltraTech Cement Ltd	India	557kg CO_2/ton cem. material	3/31/2030	360–370 kg CO_2/ ton of cement by 2030
Votoratim cimentos	Brazil	548kg CO_2/ton cem. material	12/31/2025	360–370 kg CO_2/ ton of cement by 2030
Holcim Helvetia Finance AG	Switzerland	520 kg CO_2/ton cem. material	12/31/2025	360–370 kg CO_2/ ton of cement by 2030

Despite the growth of financial instruments like SLBs, their potential has not been fully exploited in hard-to-abate sectors. Around USD3.7bn sustainability-linked bonds have been issued in the cement sector in 2020-2023 (as of February), see Figure 6. The cement sector represented less than 2% of SLBs issued so far.[87] The top 10 cement producers, responsible for 40% of global production, do raise funding on the global bond markets.[88] There is, therefore, potential for the growth of sustainable finance instruments from the sector.

Such potential is not being exploited, in part, due to the lack of standards and particularly sector-specific criteria. Standards are now emerging, including the criteria developed by Climate Bonds (for the role of standards and taxonomies, see section 5.2) to allow investors to verify the Paris alignment of SLBs more easily.

The Investor Decarbonisation Initiative has urged cement businesses to establish science-based objectives, while the Institutional Investors Group on Climate Change (IIGCC) outlined investor expectations for net-zero emission targets in the cement industry in 2019. The World Economic Forum First Movers Coalition was announced at COP26. Its members are committed to investing in innovative clean technologies contributing to reaching the Paris Agreement's goals and harnessing the purchasing power of companies to decarbonise hard-to-abate sectors.[89] Cement and concrete sectors were included in the First Movers Coalition at COP27. Members of this initiative commit to at least 10% of their annual cement and concrete procurement meeting or exceeding the First Movers Coalition definition for near-zero emissions by 2030.[90]

Figure 6. SLBs issuances by selected sectors 2020-23



4. Policy levers for the European cement sector

In December 2019, the EU Commission presented the European Green Deal, a roadmap for making the EU's economy sustainable and the first climate-neutral continent by 2050. The EU Green Deal aims to transition the region to a clean economy while fighting climate change and social inequalities, and it includes a description of investment needs and financing tools.[92]

The European Climate Law, a central element of the EU Green Deal, sets a binding target of achieving climate neutrality by 2050. This requires current GHG emissions to drop substantially in the next decades. As an intermediate step towards climate neutrality, the EU has raised its 2030 climate ambition to cut emissions by at least 55% by 2030.[93] **The policy proposals to achieve these goals are known as the Fit for 55 package.**

To support the Fit for 55 package and economic recovery from COVID-19, the EU has earmarked EUR1.8tn in the 2021-2027 budget, including the Next Generation EU (NGEU) recovery package. The Recovery and Resiliency Facility (RRF), the most important part of the NGEU, makes EUR672.5bn of loans and grants available to EU Member States. At least 37% and 20% of investments must be allocated to the green and digital transitions, respectively.[94] The RRF represents a unique opportunity for the EU to rapidly advance its transition to a climate-neutral economy in line with the objectives of the Paris Agreement. European industry, including hard-to-abate sectors, can take advantage of this opportunity to finance the decarbonisation of their production processes through innovative technologies.

The decarbonisation of hard-to-abate industries will need significant policy support. The cement sector's transition to net zero needs to start in this decade. Several economic, technical, regulatory, and social barriers to achieving net zero in the cement industry can be identified, see right.[95]

Strong policy instruments and supply chain coordination are needed to support the cement industry's transition to net zero and overcome these barriers. The EU can support the transition of hard-to-abate sectors such as cement, through a strong and tailored policy framework. These policies apply to different parts of the cement industry value chain: upstream (low-carbon energy and CO_2 infrastructure), midstream (low-carbon production processes), and downstream (increasing demand for low-carbon cement and enhancing its circularity).

Economic barriers	Higher production costs and lack of sufficient incentives for low-carbon cement production (e.g., lack of effective carbon pricing) Lack of/uncertain demand for low-carbon cement and uncertain/ no price differentials Limited size of markets for low-carbon technologies needed for the sector's transition (e.g., CCS)
Regulatory barriers	Lack of harmonised standards and sector-specific criteria to guide green investment Insufficient policies supporting innovation in breakthrough technologies Uncertainties about changing regulations
Technical barriers	Limited investment in innovative technologies compared to other sectors Innovative technologies at early stages of development Lack of CO_2 transport and storage infrastructure
Social barriers	Lack of awareness of cement's climate impact Lack of societal acceptance for alternative materials substituting cement

Policy recommendations

UPSTREAM

1. Accelerate renewable energy and related infrastructure deployment. Renewable energy will play a significant role in decarbonising the cement sector.

2. Policymakers can ensure the strategic application of CCS and establish robust standards, preventing overreliance on these technologies and prioritising sectors such as the cement industry.

MIDSTREAM

1. Establish a Europe-wide market for CCfDs to facilitate private sector development of breakthrough technologies, especially during the incubator phase.

2. Mandate credible transition plans at the entity level, requiring granular and credible plans to achieve Paris alignment.

3. Phase out ETS free allowances for CBAM-covered sectors by 2030 at the latest, more rapidly than planned. The CBAM will help to mitigate carbon leakage concerns, removing the need for free allowances.

DOWNSTREAM

1. Implement GPP as a matter of urgency and establish a timeline for mandatory criteria aligned with the EU Green Deal.

2. Improve waste management and circular economy requirements. Reliance on fossil fuels can be reduced in the next years (up to 2035) by replacing them with alternative fuels and waste, provided additional requirements on carbon intensity and other pollutants are met.

3. Scale up off-take agreements, lowering the risk of investing in low-carbon cement production processes. Public authorities can green their procurement through off-take agreements.

4. Establish a green trade window – "zero tariffs on zero-carbon" products. Green cement could be a candidate for such a green window, compensating for CBAM's trade curtailments.

Upstream policies

Accelerate renewable energy deployment

Abundant low-carbon energy, especially renewable electricity, will play an important role in the cement sector transition. CCS technologies are energy intensive and will need to use **low-carbon electricity** (100g CO_2e/kWh declining lifecycle emissions threshold in the EU Taxonomy), see section 4.4.

Energy costs have a significant impact on hard-to-abate sectors. In particular, the cement industry is one with the highest share of energy costs in production costs – **more than 12%** in 2017 – double that of the steel industry.[96] As all economic 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.

One of the biggest challenges facing the energy transition is related to the fact that, in many cases, industrial energy demand is not located where renewable energy sources can be deployed at scale. This will put pressure on the grid infrastructure and must be addressed with long-range electricity transmission solutions. The regulatory framework needs to ensure that the cement industry has access to abundant and affordable low-carbon energy.

The **EU Renewable Energy Directive** (RED) was adopted in 2009 to deliver a minimum 20% share of renewable energy sources in EU final energy consumption by 2020. RED II was adopted in 2018 to deliver the EU objective of a minimum 32% share of renewables in final energy consumption by 2030. Meeting the more ambitious climate targets included in the EU Green Deal and European Climate Law requires significant modifications to EU energy policy. Therefore, a revised RED II has been proposed, strengthening RE targets to 40% by 2030.[97]

The revised RED II sets a new benchmark of a 1.1% annual increase in renewables use in industry, although this is not a binding target.[98] It also includes measures to **simplify administrative procedures and reduce bottlenecks**, for example by accelerating the permitting process. The proposal seeks to enable **EU energy systems to become more flexible**, making it easier to integrate renewables into the grid as efficiently as possible. The proposal also supports the **uptake of renewable hydrogen**, where electrification is more difficult.

In September 2022, the European Parliament adopted some amendments to the Commission's proposal, including a binding 45% renewables target by 2030 and an increased indicative target for renewables use in the industrial sector to 1.9%.[99]

As the cement industry is highly energy-intensive, the revised RED II will impact cement companies, particularly regarding electricity and hydrogen use. Current investments will determine the structure of the EU infrastructure for the coming decades. Directing these investments towards the infrastructure necessary for the clean energy economy is an important element of transition policymaking.

In November 2022, the European Commission released a new temporary emergency regulation to accelerate the deployment of renewable energy sources. This regulation is set to apply for one year and aims to cover the time needed for the RED II revision's entry into force. It includes specific measures, such as immediate simplification and accelerated permitting for certain solar installations and the repowering of renewable energy power plants. The regulation also grants renewable power plants the status of overriding public interest to eliminate bottlenecks in new permitting procedures.[100]

The Green Deal Industrial Plan (GDIP) was presented by the European Commission on 1 February 2023.[101] It aims to increase the competitiveness of the EU net zero-aligned industry and accelerate its transition. Under the plan, the EU Commission aims to simplify support for renewable energy deployment by accelerating permitting procedures, extending deadlines to complete projects, and modernising grid infrastructures.

Ensure strategic and 1.5°C-aligned CCS application

Carbon capture & storage technologies, as noted, will 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 emissions that cannot otherwise be abated.

In 2020, the European Commission adopted a proposal revising the 2013 regulation on Trans-European Networks for Energy (TEN-E) which specifically encompasses CO_2 transport and storage. The TEN-E Regulation focuses on developing cross-border infrastructure in the continent to deliver EU energy policy objectives, including the security of supply, energy efficiency and sustainable growth. A significant part of the TEN-E Regulation is the Projects of Common Interest (PCIs). The PCI list is updated every two years, and those projects can receive EU financial support under the Connecting Europe Facility (CEF).[102] In November 2021, the EU Commission published the 5th PCIs list, including six CO_2 network projects.[103] Projects included on the PCIs list benefit from some advantages, including:

- **streamlined permit granting procedures;**
- **improved, faster, and better streamlined environmental assessment;**
- **a single national competent authority coordinating all permit granting;**
- **a procedure allowing for the allocation of investment costs;**
- **eligibility for financial assistance under the CEF.**[104]

The new TEN-E Regulation entered into force in June 2022 and eliminates support for new fossil gas and oil projects, mandates sustainability requirements for all PCI projects and aims to shorten the permit-granting procedure.[105]

The low-carbon cement industry will likely rely on CO_2 networks, and the revised TEN-E Regulation will impact cement companies' business. Investment in these networks will determine infrastructure availability for the coming decades. Supportive policies, such as the accelerated permitting of PCIs, can favour priority sectors such as the cement industry, to ensure CCS tackles emissions that cannot be prevented.

Policymakers can ensure the strategic application of CCS and favour priority sectors to ensure it is reserved for sectors with limited decarbonisation options and for emissions that 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 & 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 green.[106]

Midstream policies

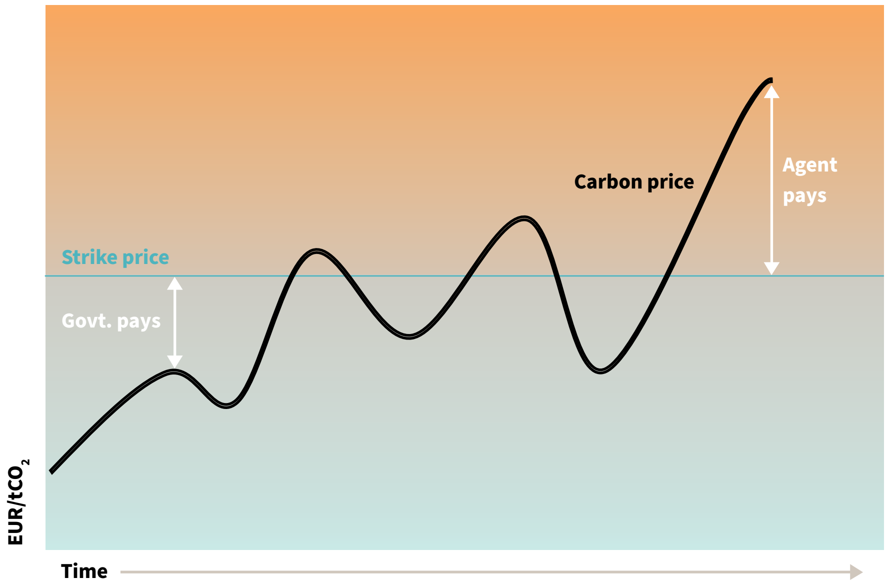
Establish carbon contracts for difference

Carbon contracts for difference (CCfDs) can facilitate the private sector development of breakthrough technologies, especially during the incubator phase.[107] As a result of the EU-ETS review agreed upon in December 2022, CCfDs will be implemented at the EU level through the Innovation Fund to provide support to decarbonisation projects and provide certainty to investors.[108] 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.[109] As part of the plan, the EU Commission announced that it aims to encourage hydrogen adoption and electrification in industrial sectors by implementing carbon contracts for difference 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.

A contract for difference (CfD) is an agreement between two parties whereby one agrees to pay the other the difference between the value of a commodity (its market price) and a specific value agreed upon by the two parties (the strike price), see Figure 7.[110] Hence when the agreed price is higher than the market price, the first party is obliged to pay the difference to the other one. In the case of a two-way CfD, the second party would be required to pay the difference in the reverse situation where the strike price was lower than the market price. Such contracts provide long-term price stability to support the large-scale development of nascent technologies, especially more sustainable production processes. However, CfDs can be extremely expensive for public authorities as a subsidy-type instrument.[111]

A CCfD represents a subsidy agreement between a regulator and a company to finance a decarbonisation project. The amount of such subsidy depends on the difference between the carbon price in a specific context (in the case of the EU, the average ETS price) and the strike price. The price agreed upon between a regulator and a company equals the carbon price necessary for the project to be economically profitable. In this way, a stable carbon price reduces investment risk in breakthrough technologies needed to transition European hard-to-abate sectors, such as the cement sector.[112]

Figure 7. Carbon contracts for difference



Source: https://climatestrategies.org/wp-content/uploads/2021/03/Carbon-Contracts_CFMP-Policy-Brief-2020.pdf

CCfDs are awarded to emissions reduction efforts. However, CCfDs should avoid incentivising incremental change and, even if a supported project can reduce cement production emission intensity, it needs to be on a Paris-aligned pathway. Technologies allowing for deep emission reduction should be favoured to avoid carbon lock-in.[113]

Similar schemes have been implemented in some EU Member States. Germany plans to implement pilot CCfDs to promote green hydrogen in the steel and chemical sectors.[114] In 2022, the German government published a call for expression of interest in CCfDs, to support innovative technologies contributing to the decarbonisation of the hard-to-abate sectors, including cement.[115] Elements of the Dutch Stimulation of Sustainable Energy Production and Climate Transition (SDE++) could be incorporated into CCfDs, as the two share commonalities. The SDE++ is the newest version of the SDE+, which has been in place since 2013 to support renewable energy generation projects (in 2021, a budget of EUR5bn was available).[116] The scope of the SDE+ was extended in 2020 and the new SDE++ includes other technologies – renewable heat, renewable gas, green hydrogen production and CCUS. Such a scheme provides organisations with a subsidy equal to the difference between the cost of the technology and the market price of the products delivered. Projects compete in auctions to be granted an SDE++ subsidy, which is awarded for 12-15 years.[117]

CEMBUREAU has outlined how investments in low-carbon technologies will require innovative forms of funding, such as CCfDs, especially considering the sector's long-term investment cycles.[118]

Mandate credible transition plans at the entity-level

Several EU 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 plotting out and strengthening the decarbonisation efforts of corporates across all sectors. 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 transition plans' quality 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.[119] These embody the credibility, clarity, and transparency necessary to create an active market, see Figure 8. This ground-breaking 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.

Figure 8. 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

5. External reporting

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

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

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

Strengthen carbon pricing to drive action

Carbon pricing 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 carbon pricing's value 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.

However, while carbon pricing can improve the economic case for green investments, other policies are required to overcome inertia, uncertainty, and demand issues. Carbon pricing must be introduced alongside other measures to ensure speed of transition, as markets are not solely driven by price. Carbon pricing should be seen as a supportive mechanism for other regulations and subsidies, as seen in the Fit for 55 package which will prevent overreliance on pricing to enable the transition.

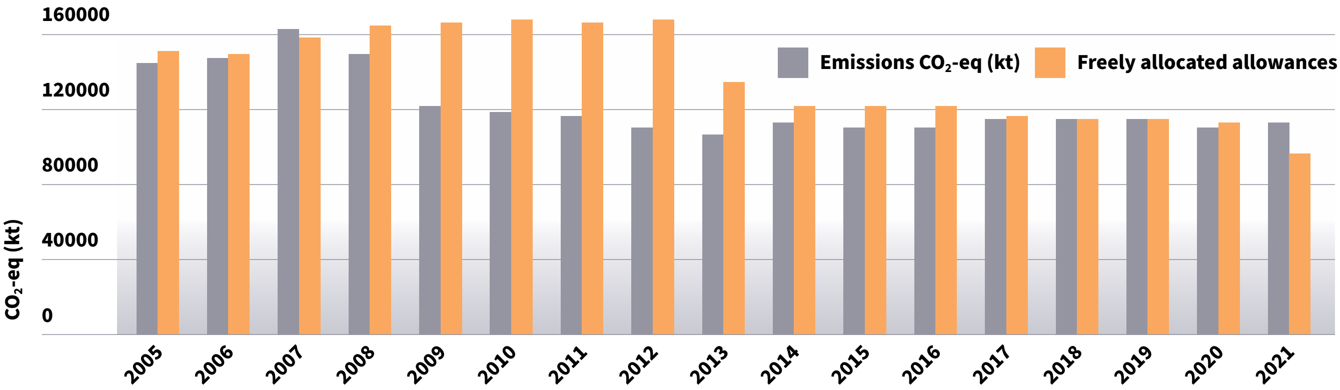
The EU Emissions Trading System is the world's first and biggest international emission trading system. It represents one of the main EU policies to address climate change and the cost-effective reduction of GHG emissions. The ETS works on the cap-and-trade principle; within this cap, companies buy or receive allowances that they can trade with each other.[120] It currently covers energy-intensive industries, fossil fuel power generation and commercial aviation.[121]

The ETS is designed to limit emissions, letting the market set a price and enable the most cost-efficient methods of cutting carbon emissions. However, this creates price uncertainty, particularly given changes in reductions of allowances.[122]

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 2023.123 The ETS covers the CO_2 emitted during cement clinker production which surpassed 160 Mt in 2007 and has then been stable at under 120 Mt in the last decade. However, the EU cement industry has not been subject to the full price of carbon pollution under the ETS due to concerns about carbon leakage and EU cement production becoming uncompetitive with lower-cost, higher-emissions imports.124 Under the ETS, sectors such as cement that are exposed to the risk of carbon leakage are still eligible to receive free allocation of up to 100%, see Figure 9.

In December 2022, EU institutions reached an agreement on the ETS review which was proposed by the Commission in 2021: emissions in the ETS sectors must be cut by 62% by 2030, compared to 2005 levels.[125] More funds to support the development of innovative technologies will be made available: the Innovation Fund will increase from 450 to 575 million allowances and the Modernisation Fund will be increased by an auctioning of an additional 2.5% of allowances. Moreover, all national revenues collected from auctioning ETS allowances will need to be allocated to climate-related activities.

Figure 9. EU-27 ETS emissions from cement clinker production and freely allocated allowances, 2005-2021 (kt CO_2-eq)



Reinforce the ETS with the CBAM

As the EU Commission seeks to phase out free allocations in this era of higher climate ambition, the Carbon Border Adjustment Mechanism (CBAM) was proposed by the EU Commission in 2021. 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. Such changes make the ETS and the CBAM more ambitious and bring some progress in levelling the playing field between EU and non-EU producers. The implementation of the CBAM – parallel to the ETS free allowances phase-out for CBAM-covered sectors – is only partially more ambitious than the initial Commission's proposal.[126] The CBAM will start applying in 2026 (after a transitional period from October 2023) and will be fully phased in from 2035, giving little incentive for emitters to decarbonise their production processes in the first years, as shown in Table 4.[127] The governance of CBAM will also be centralised, with the Commission in charge of most of the tasks to ensure a coordinated implementation at the EU level. Moreover, by 2025, the Commission will assess the risk of carbon leakage for goods produced in the EU intended for export to non-EU countries and, if needed, present a proposal to address this. Indeed, cement exported from the EU to regions with lower or no environmental policies might be disadvantaged as free allowances are reduced. No compensations or refunds for exporting goods covered by the CBAM to non-EU countries are included in the legislation. Nevertheless, the potentially negative impact on EU exports should not be underestimated.

Even though both the ETS review and CBAM introduction are being finalised, the **upcoming implementation will need to address some unanswered aspects**, such as how the methodology for indirect emissions, solutions for exporting CBAM-covered goods outside the EU, enlarging the scope to more products, and the use of revenues.

The CBAM will impose a border tariff on high-carbon cement imports, enabling the impact of an EU carbon price on EU cement production while retaining protection from lower-cost imports. The allocation of free allowances has been effective in addressing the risk of leakage. Still, it dampens the incentive to invest in greener production in the EU and non-EU countries.[128]

Cement is a high-volume material with a relatively low selling price. As a result, its trade is highly influenced by **transportation costs**. Cement imports from non-EU countries have traditionally been quite low, but there have been large shifts in the last few years. **Cement imports to the EU-27 quadrupled between 2016 and 2021**, from 2.4 Mt to 9.7 Mt, see Figure 10.[129] They represented less than 2% of total cement production within the EU-27 in 2016, but this level jumped to **more than 10% in 2020**.[130] This necessitates policymakers' continued attention to the regional implications of EU policy changes, such as the ETS reform and the CBAM introduction.

Figure 10. EU-27 cement imports in 2016-2021 (mt)

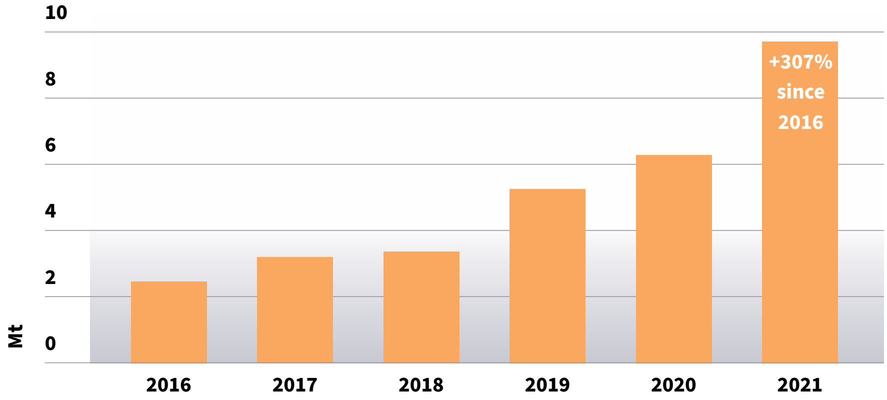


Table 4. ETS free allowances phase-out rate to CBAM-covered sectors

Year	ETS free allowances phase-out rate
2026	2.5%
2027	5%
2028	10%
2029	22.5%
2030	48.5%
2031	61%
2032	73.5%
2033	86%
2034	100%

The CBAM will apply to cement products – among others – imported into the EU and has significant implications for the cement industry. The main obligation lies with importers who need to declare and purchase CBAM certificates to cover the GHG emissions associated with the production of cement products. This sets a carbon price aimed at imports of non-EU products equivalent to the one paid by EU producers for making the same products. EU importers will be obliged to buy certificates related to the carbon price they would have paid if their imports had been produced within the EU. However, should EU importers demonstrate that they have already paid a carbon price to produce those goods in a non-EU country, this amount would be deducted.

To give private companies and non-EU countries enough time to test this new system, the CBAM will be implemented gradually and only for a few sectors.[131] Between 2026 and 2030, it is estimated that the cumulative impact of carbon pricing on the EU cement industry could total **EUR13bn**.[132] **The CBAM creates a strong incentive for producers to invest in low-carbon technologies now**. For the hard-to-abate sectors, including cement, the path forward is clear: a full green transformation is required to transition to net zero. Those that invest now to decrease emissions and plan to supply the cement required with the shortest possible environmental footprint will benefit from this competitive advantage.

One challenge facing the CBAM is its compliance with WTO and other international rules. In the view of the EU Commission, the CBAM design is in line with such rules, especially because EU importers will not have to buy certificates if they demonstrate that they have already paid a carbon price to produce the imported goods in a non-EU country. This incentivises **global action**, as non-EU countries might implement their carbon pricing schemes to capture revenue. In 2021, Turkey's chief negotiator at the COP26 climate summit declared that the EU CBAM was a factor in convincing Ankara to ratify the Paris Agreement.[133]

Guide green investment through standards and sector-specific criteria

In 2016, the EU Commission accepted a recommendation by the EU High-level Expert Group on Sustainable Finance to develop an **EU Sustainable Finance Taxonomy**. Its development has been supported by the work of the Technical Expert Group (TEG) and its successor, the Platform on Sustainable Finance (PSF). The Taxonomy Regulation entered into force in July 2020, with the first Delegated Act covering climate change mitigation and adaptation activities since 2022. The EU Taxonomy was developed as part of the wider EU

Sustainable Finance Strategy. Its primary use is to support the mandatory disclosure of sustainable investments and assets by investors, banks, and corporates in the EU.[134]

The Taxonomy will provide criteria for the contribution of activities to six environmental objectives, covering sustainable water use, circular economy, pollution prevention and biodiversity, climate mitigation, and adaptation. The Commission is also considering extending the scope of the Taxonomy to cover significantly harmful and low-impact activities and social issues. The work of the PSF will inform this.[135]

Agreeing on standardised criteria for high-emitting activities is fundamental for investors to understand what underpins a credible transition and for policymakers to incentivise the transition. Governments can draw from criteria to design regulations or recommendations for decarbonising a sector. The EU Taxonomy is particularly relevant because it is likely to be used for investments falling under its criteria that will be eligible for inclusion in green bonds Use of Proceeds (UoP) under the proposed **EU Green Bond Standard**. As the EU Taxonomy lays out long-term standards, it also encourages investment in innovative technologies and transition-friendly investments.[136]

The EU Taxonomy technical screening criteria (TSC) recognise the most climate-friendly production processes, which also comply with the Do No Significant Harm (DNSH) principle. The TSC provide clarity over GHG emission levels in cement production that are compatible with a 1.5°C-aligned production pathway (i.e., not currently near zero but aligned with a pathway). They, therefore, provide the endpoint for production, providing an objective for a transition pathway. Climate Bonds developed criteria for several sectors – those related to cement have recently been published – in its effort to design guidance for both issuers and investors around the globe on what credible transition activities in the cement sector look like.[137]

The EU Taxonomy will be very relevant to the cement industry. To meet the performance targets, substantial improvement and investment are required. This is because, out of the more than 150 European cement plants, **only 11% operate below the Taxonomy Technical Screening Criteria**.[138]

Climate Bonds has also launched the first **UoP and entity transition finance criteria for cement** (as well as other sectors, such as steel and basic chemicals), providing clear, credible, and specific guidance to both issuers and investors on the types of activities and investments that are aligned with a 1.5°C transition pathway.[139] However, entity-level instruments have fundamental differences from UoP ones, such as their much broader scope compared to the specific asset or activity scope of UoPs and their forward-looking nature.[140] The financial criteria are crucial to prevent greenwashing and provide confidence to the market that their investments are science-based. Thematic issuance from sectors such as cement, steel, and chemicals is expected to accelerate rapidly once the required standards and definitions are in place.

Box 3. EU Taxonomy Technical Screening Criteria for cement[162]

Activities with substantial contribution to climate change mitigation in the cement sector shall involve manufacturing one of the following products:

- **grey cement clinker** where the specific GHG emissions are lower than 0,722 tCO_2e per tonne of grey cement clinker;
- **cement from grey clinker or alternative hydraulic binder**, where the specific GHG emissions from the clinker and cement or alternative binder production are lower than 0,469 tCO_2e per tonne of cement or alternative binder manufactured.

Where CO_2 that would otherwise be emitted from the manufacturing process is captured for the purpose of underground storage, the CO_2 is transported and stored underground.

Downstream policies

Implement green public procurement

Public procurement accounts for up to **40% of the global demand for cement** and represents a high share of consumption in key industries, such as construction and infrastructure.[141] It can be a huge incentive for developing a green cement market favouring low-carbon products, gradually increasing demand at the EU level. It accounts for around 15% of the continent's GDP and represents a high share of European consumption in key cement-related sectors.

Green public procurement (GPP) can increase demand for decarbonised cement goods and its whole value chain.[142] The opportunity for GPP is huge and historically, public procurement has been a key lever to bring down emissions. For example, the City of Vienna saved EUR44.4m and over 100,000 tonnes of CO_2 between 2004 and 2007 through its EcoBuy programme.[143] The State of Berlin was able to reduce its GHG emissions by 47% through GPP in 15 product categories.[144]

GPP represents one of the 2023 EU Green Deal Industrial Plan's priorities, as the EU Commission aims to define requirements for net-zero products, using existing EU standards. This would promote a more predictable and uniform demand for such products. Moreover, the EU Commission intends to promote reciprocity for access to public procurement markets between EU and non-EU countries. This could lead to the decarbonisation of public procurement in non-EU countries, improving competition and ambition, as well as increasing demand for green products.

The challenge is in defining what should be bought. This is much simpler in a new technology like a solar PV panel but more challenging for a product like cement given that low-carbon cement is hardly distinguishable from high-carbon cement. A business-as-usual strategy exposes both companies and investors to several risks, and laggards are vulnerable to changes in climate policy. Government procurement is likely to increase demand for low-carbon cement.

Developing mandatory common criteria within the EU will ensure all Member States' green cement purchase is the same. This will prevent uneven intra-EU competition which could create a race to the bottom.[145] In the EU, GPP remains voluntary, meaning that each public authority can decide whether to follow the EU guidance. Still, it has the potential to drive demand for sustainable goods and services. The EU Commission and some Member States have defined some general guidance through national criteria on different sectors.[146]

In 2021, a coalition of governments and organisations, led by the United Kingdom and India, with current members including Canada, Germany, Saudi Arabia, the United Arab Emirates, and the United States, launched the new Clean Energy Ministerial "Industrial Deep Decarbonisation Initiative". Coordinated by the United Nations Industrial Development Organisation, this initiative aims to create market demand for low-carbon industrial materials, especially steel and cement.[147]

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.[148]

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.[149] However, **with fossil fuels reduction and then phase out, such materials will become rare, especially in the EU**.

After demolition, **concrete can be 100% recycled**, even though new materials need to be added to produce new concrete. 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. However, only around a third to two-thirds of Europe's construction and demolition waste is recycled today.[150]

Recycling clinker and cement is much more technically challenging.[151] In June 2022, Holcim announced the production of the world's first clinker made entirely of recycled minerals.[152] According to the company, the 100% recycled materials used range from wood ash to waste from mineral processing.

The European cement industry uses a considerable amount of waste and by-products, about 36 Mt per year, to replenish fuels and raw materials. In the EU, the industry substitutes secondary resources such as non-recyclable waste or biomass waste for **48% of its fossil fuel thermal energy usage**.[153]

In 2020, the EU Commission published a Communication on a new Circular Economy Action Plan, announcing a series of initiatives along the entire life cycle of products.[154] The Circular Economy Action Plan identifies cement as a priority thanks to its untapped potential for circularity.

CEMBUREAU highlighted that to phase out the usage of fossil fuels, the industry will need increased access to non-recyclable and biomass waste. Therefore, it advocated for policies that encourage waste shipment within the EU, discourage landfill disposal, and limit waste exports beyond the bloc.[155]

While incinerating various waste streams 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**. The waste management sector must move towards better reuse and recycling schemes, waste prevention and – across the economy – better product design. Burning alternative fuels and raw materials is not zero emissions and requires that all emissions released from waste burning are included in emissions calculations to comply with Climate Bonds Criteria thresholds – see section 4.4.[156]

Scale up off-take agreements to increase low-carbon cement demand

Policy instruments can lower the risk of low-carbon cement through **off-take agreements**.[157] 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. These advance purchase commitments carry a risk and public authorities can address it. Targeted R&D initiatives can provide CAPEX funding for innovative low-carbon technologies. Carbon Contracts for Difference reduce the OPEX risk of first movers, who have to deal with higher costs and uncertain carbon pricing levels. As stated above, public procurement is very relevant to the cement sector. Public authorities could green it through off-take agreements, increasing certainty on demand for future low-carbon cement while reducing their GHG emissions.

In other hard-to-abate sectors, such as steel, off-take agreements have already been signed. In May 2022, some companies, including BMW Group, Electrolux, and Mercedes-Benz, pre-purchased approximately 1.5 Mt of green steel from H2 Green Steel. These off-take agreements for about 1.5 Mt per year for 5-7 years represent more than half of the anticipated first yearly production capacity of 2.5 Mt.[158] In particular, BMW signed two agreements with Salgizzer and H2GreenSteel that will supply over 40% of the steel required by the company's European plants and save around 400,000 tonnes of CO_2 emissions per year. BMW Group press plants in the continent process more than half a million tonnes of steel per year.[159]

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.[160]

Establish a green window – "zero tariffs on zero-carbon"

In addition to carbon pricing policies and measures against the risk of carbon leakage, a broad policy platform – **a green trade window** – would encourage the international flow of green goods, services, and capital.[161] Such a green window could entail reducing tariffs on environmentally friendly goods and services and products that are produced using green processes. Green cement – as well as green steel – would be a perfect candidate for such a green window: "**zero tariffs on zero-carbon**". This could compensate for CBAM's trade curtailments and stimulate green capital flows by reducing restrictions on capital destined for green or transition projects.

5. Conclusions

While there remains some uncertainty about the finer details of the Paris-aligned pathway to cement, technologies and criteria are emerging to provide market security in identifying Paris-aligned investments.

By 2030, 30% of EU cement kilns are expected to reach the end of their life and require reinvestment.[163] **This decade is therefore a pivotal moment in Europe's net-zero transformation**. Failing to transition the cement sector could threaten the EU pledge to reach climate neutrality by 2050.

There is an increasing realisation that the **investment requirement presents a unique opportunity** for the European economy to develop innovative technologies, achieve a rapid transition of a key hard-to-abate sector and become a front-runner in the emerging net zero-aligned economy.

The speed and success of the cement transition are now dependent on strong policy support. Policymakers define the conditions for a net-zero cement industry and play a significant role in choosing which pathways are chosen.

Policies need to be consistent and unified to boost demand for green cement, support investment in the transformation of cement companies and assets, and enable the scaling of new clean technologies.

As a result, the policy toolkit for this transition is broad, encompassing economy-wide standards and regulation, sector-specific support such as contracts for difference and green public procurement, and strategic legislation such as carbon pricing, circular economy, and CO_2 infrastructure.

6. Annex: the cement making process

Clinker, the main constituent of cement, is produced in a kiln, which heats limestone with other materials such as clay to around 1450°C.[164] This process is called calcination: the calcium carbonate (limestone) is transformed into calcium oxide (lime), and it reacts with the other materials, forming the clinker. The clinker is then cooled to a temperature between 100°C and 200°C. Grinding the clinker and mixing it with gypsum and other materials to make a fine powder is the last step in the cement making process.

The production of clinker can be divided into different stages: **quarrying raw materials, crushing, raw meal grinding, ᵖreheating, precalcining, clinker production in the rotary kiln, and cooling and storing** (see Figure 5 and Box 1).[165]

Cement plants are traditionally built near naturally existing materials such as limestone, which can be extracted from quarries. The raw material is then transferred to crushers. Following crushing, the raw materials are combined and processed to generate "raw meal".

A preheater is made up of a series of cyclones through which raw meal is passed by spinning hot flue gases in the opposite direction of the material flow. Thermal energy (heat) is recovered from hot flue gases in these cyclones, which has the advantage of preheating the raw meal before it enters the kiln, increasing process efficiency, and using less fuel.

Calcination is the process by which limestone is converted into lime. In current installations, some of the high-temperature reaction occurs in a "precalciner". The chemical degradation of limestone happens here, yielding **approximately 60% of the total CO_2 emissions** of the cement making process. **The remaining CO_2 is produced by fuel combustion.** Precalcined meal enters the kiln at about 1000°C. Raw materials then need to achieve temperatures of up to 1450°C. The hot clinker is then cooled and ground into cement. However, clinker can also be moved to other grinding facilities by truck, train, or ship.

Endnotes

1. https://static.agora-energiewende.de/fileadmin/Projekte/2020/2020_10_Clean_Industry_Package/A-EW_208_Strategies-Climate-Neutral-Industry-EU_Study_WEB.pdf
2. https://www.pnas.org/doi/full/10.1073/pnas.1821673116
3. A-EW_208_Strategies-Climate-Neutral-Industry-EU_Study_WEB.pdf (agora-energiewende.de)
4. A-EW_208_Strategies-Climate-Neutral-Industry-EU_Study_WEB.pdf (agora-energiewende.de)
5. https://www.spglobal.com/esg/insights/featured/special-editorial/decarbonizing-cement-how-eu-cement-makers-are-reducing-emissions-while-building-business-resilience
6. https://static.agora-energiewende.de/fileadmin/Projekte/2021/2021_10_DE_KIT/A-EW_259_Klimaschutzvertraege-Industrietransformation-Zement_WEB.pdf
7. https://www.mckinsey.com/capabilities/sustainability/our-insights/Spotting-green-business-opportunities-in-a-surging-net-zero-world/transition-to-net-zero/cement
8. https://www.weforum.org/reports/the-net-zero-industry-tracker/in-full/cement-industry/
9. https://www.climatebonds.net/market-intelligence
10. https://materialeconomics.com/publications/scaling-up-europe
11. https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets_en
12. https://cembureau.eu/media/ejohhq5c/global-cement-production-table.png https://ec.europa.eu/eurostat/databrowser/view/DS-059268__custom_3299031/default/table?lang=en
13. https://newclimate.org/sites/default/files/2020/12/SGCCC-EU-Cement-paper-NewClimate_Nov2020.pdf
14. https://ihsmarkit.com/research-analysis/carbon-capture-utilization-and-storage-ccus-is-the-technology.html
15. https://ec.europa.eu/sustainable-finance-taxonomy/activities/activity_en.htm?reference=5.12 https://ec.europa.eu/sustainable-finance-taxonomy/activities/activity_en.htm?reference=5.11
16. https://climateactiontracker.org/documents/1083/2022-10-26_StateOfClimateAction2022_kR0sbBZ.pdf
17. https://single-market-economy.ec.europa.eu/sectors/raw-materials/related-industries/non-metallic-products-and-industries/cement-and-lime_en
18. https://www.ipcc.ch/report/ar6/wg3/
19. https://www.climatebonds.net/files/page/files/cbi_gaspolicy_2022_01c.pdf https://www.climatebonds.net/resources/reports/green-future-steel
20. The Cement Criteria lay out the requirements that Cement production asset, projects must meet to be eligible for inclusion in a Certified Climate Bond and for companies on a credible transition path to issue transition labelled debt. The Criteria apply to manufacture and production of Cement and do not address other stages of the value chain. The Criteria contain Mitigation Requirements, and Adaptation & Resilience Requirements. Bonds and loans linked to these eligible assets and projects will be aligned with the Paris Agreement. https://www.climatebonds.net/standard/cement
21. Climate Bonds' Financing Credible Transitions paper established five principles for an ambitious transition (for an overview, see figure 10). These are designed to ensure the transition is science-led, ambitious and will reduce overall emissions by excluding the use of offsets. https://www.climatebonds.net/files/reports/cbi_fincredtransitions_final.pdf
22. https://www.pnas.org/doi/full/10.1073/pnas.1821673116
23. https://news.mit.edu/2019/carbon-dioxide-emissions-free-cement-0916
24. https://www.mckinsey.com/industries/chemicals/our-insights/laying-the-foundation-for-zero-carbon-cement#cement
25. https://publications.jrc.ec.europa.eu/repository/handle/JRC131246
26. https://cembureau.eu/media/kuxd32gi/cembureau-2050-roadmap_final-version_web.pdf
27. https://cembureau.eu/media/lnjpejs2/world-cement-production-in-2020-by-region.jpg
28. https://network.bellona.org/content/uploads/sites/3/2020/01/Factsheet-1_Cement_Industry.pdf
29. https://cembureau.eu/media/ejohhq5c/global-cement-production-table.png
30. https://cembureau.eu/media/drylkjo0/manufacturing-process-factsheet_update-jan2021.pdf
31. https://www.smithsonianmag.com/history/the-secrets-of-ancient-romes-buildings-234992/
32. https://cembureau.eu/media/drylkjo0/manufacturing-process-factsheet_update-jan2021.pdf
33. https://publications.jrc.ec.europa.eu/repository/handle/JRC131246
34. https://newclimate.org/sites/default/files/2020/12/SGCCC-EU-Cement-paper-NewClimate_Nov2020.pdf
35. A Study of the Viability of Cross Laminated Timber for Residential Construction (diva-portal.org)
36. https://www.imarcgroup.com/cross-laminated-timber-manufacturing-plant
37. https://cembureau.eu/media/kuxd32gi/cembureau-2050-roadmap_final-version_web.pdf
38. https://cembureau.eu/media/kuxd32gi/cembureau-2050-roadmap_final-version_web.pdf
39. https://newclimate.org/sites/default/files/2020/12/SGCCC-EU-Cement-paper-NewClimate_Nov2020.pdf
40. https://www.climatebonds.net/resources/reports/green-future-steel
41. https://www.iea.org/reports/cement
42. https://cembureau.eu/media/kuxd32gi/cembureau-2050-roadmap_final-version_web.pdf
43. https://co2re.co/FacilityData
44. https://ihsmarkit.com/research-analysis/carbon-capture-utilization-and-storage-ccus-is-the-technology.html
45. https://www.project-leilac.eu/about-leilac
46. http://www.cleanker.eu/the-project/project-contents
47. https://www.norcem.no/en/CCS_background
48. https://www.climateworks.org/wp-content/uploads/2021/03/Decarbonizing_Concrete.pdf
49. https://www.iea.org/reports/cement
50. https://www.chathamhouse.org/sites/default/files/publications/2018-06-13-making-concrete-change-cement-lehne-preston-final.pdf
51. https://cembureau.eu/media/kuxd32gi/cembureau-2050-roadmap_final-version_web.pdf
52. https://cembureau.eu/media/kuxd32gi/cembureau-2050-roadmap_final-version_web.pdf
53. https://www.aggbusiness.com/ab9/news/lafargeholcim-expands-reduced-co2-cement-offering
54. https://www.chathamhouse.org/sites/default/files/publications/2018-06-13-making-concrete-change-cement-lehne-preston-final.pdf
55. https://lowcarboneconomy.cembureau.eu/5-parallel-routes/energy-efficiency/thermal-energy-efficiency/
56. https://publications.jrc.ec.europa.eu/repository/handle/JRC131246
57. https://cembureau.eu/media/kuxd32gi/cembureau-2050-roadmap_final-version_web.pdf
58. https://cembureau.eu/media/kuxd32gi/cembureau-2050-roadmap_final-version_web.pdf
59. https://cembureau.eu/media/kuxd32gi/cembureau-2050-roadmap_final-version_web.pdf
60. https://cembureau.eu/media/kuxd32gi/cembureau-2050-roadmap_final-version_web.pdf
61. https://cembureau.eu/media/kuxd32gi/cembureau-2050-roadmap_final-version_web.pdf
62. https://newclimate.org/sites/default/files/2020/12/SGCCC-EU-Cement-paper-NewClimate_Nov2020.pdf
63. https://www.climatebonds.net/files/files/Cement-Background-Paper-Final-241022.pdf
64. https://www.climatebonds.net/files/files/Cement-Criteria-Document-Final-241022.pdf
65. https://www.climatebonds.net/standard/cement
66. https://www.iea.org/reports/cement
67. https://connectedenergysolutions.co.uk/the-challenge-of-decarbonising-the-cement-industry/
68. https://www.cemex.com/-/cemex-and-synhelion-achieve-breakthrough-in-cement-production-with-solar-energy
69. https://www.climatebonds.net/files/page/files/cbi_gaspolicy_2022_01c.pdf
70. https://cembureau.eu/media/uightfs0/16272-narrative-towards-zero-carbon-fuels-for-cement-manufacture_view-cement-sector.pdf https://www.globalcement.com/magazine/articles/1189-the-multiple-benefits-of-green-hydrogen-for-the-decarbonisation-of-cement-production https://www.cemnet.com/News/story/171323/the-potential-of-hydrogen-in-decarbonising-cement.html#:~:text=For%20it%20to%20be%20classed,used%20as%20renewable%2Dbased%20fuel. https://www.frompollutiontosolution.org/hydrogenuseinindustry
71. https://cembureau.eu/media/ejohhq5c/global-cement-production-table.png https://cembureau.eu/media/m2ugw54y/cembureau-2020-activity-report.pdf
72. Hepburn, C, Adlen, E, Beddington, J et al. (2019) The technological and economic prospects for CO_2 utilisation and removal. Nature, 575 (7781). pp. 87-97. ISSN 0028-0836
73. According to the IPCC, well-selected, well-designed and well-managed geological storage sites can maintain CO_2 trapped for millions of years, retaining over 99 per cent of the injected CO_2 over 1000 years. IPCC Special Report on Carbon Dioxide Capture and Storage, www.ipcc.ch/site/assets/uploads/2018/03/srccs_wholereport-1.pdf
74. https://ieefa.org/resources/carbon-capture-crux-lessons-learned
75. https://ec.europa.eu/growth/sectors/raw-materials/related-industries/non-metallic-products-and-industries/cement-and-lime_en
76. https://ec.europa.eu/growth/sectors/raw-materials/related-industries/non-metallic-products-and-industries/cement-and-lime_en
77. A-EW_208_Strategies-Climate-Neutral-Industry-EU_Study_WEB.pdf (agora-energiewende.de)
78. https://www.mckinsey.com/capabilities/sustainability/our-insights/Spotting-green-business-opportunities-in-a-surging-net-zero-world/transition-to-net-zero/cement
79. https://www.weforum.org/reports/the-net-zero-industry-tracker/in-full/cement-industry/
80. https://www.spglobal.com/esg/insights/featured/special-editorial/decarbonizing-cement-how-eu-cement-makers-are-reducing-emissions-while-building-business-resilience
81. https://static.agora-energiewende.de/fileadmin/Projekte/2021/2021_10_DE_KIT/A-EW_259_Klimaschutzvertraege-Industrietransformation-Zement_WEB.pdf
82. A-EW_208_Strategies-Climate-Neutral-Industry-EU_Study_WEB.pdf (agora-energiewende.de)
83. https://www.climatebonds.net/2023/01/2022-market-snapshot-and-5-big-directions-sustainable-finance-2023
84. https://www.spglobal.com/ratings/en/research/articles/210309-transition-finance-finding-a-path-to-carbon-neutrality-via-the-capital-markets-11864585
85. https://cib.bnpparibas/app/uploads/sites/2/2021/03/markets-360-brief-on-transition-bonds.pdf
86. https://capitalmonitor.ai/sector/energy-and-utilities/why-transition-bonds-have-failed-to-make-their-mark-so-far/
87. https://www.climatebonds.net/market-intelligence
88. https://shareaction.org/reports/decarbonising-cement-the-role-of-institutional-investors
89. https://www.weforum.org/first-movers-coalition
90. https://www.weforum.org/first-movers-coalition/sectors
91. https://climateactiontracker.org/documents/1083/2022-10-26_StateOfClimateAction2022_kR0sbBZ.pdf
92. https://ec.europa.eu/commission/presscorner/detail/en/ip_19_6691
93. https://www.consilium.europa.eu/en/policies/green-deal/euplan-for-a-green-transition/
94. https://ec.europa.eu/info/sites/default/files/swd-competitive-clean-european-steel_en.pdf
95. https://www.sciencedirect.com/science/article/pii/S0921344922001264
96. https://ec.europa.eu/info/sites/default/files/amendment-renewable-energy-directive-2030-climate-target-with-annexes_en.pdf
97. https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2021)698781
98. https://www.europarl.europa.eu/RegData/docs_autres_institutions/commission_europeenne/com/2021/0557/COM_COM(2021)0557_EN.pdf
99. https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-revision-of-the-renewable-energy-directive https://oeil.secure.europarl.europa.eu/oeil/popups/summary.do?id=1716331&t=e&l=en
100. https://ec.europa.eu/commission/presscorner/detail/en/ip_22_6657
101. https://commission.europa.eu/document/41514677-9598-4d89-a572-abe21cb037f4_en
102. https://fsr.eui.eu/the-ten-e-regulation/
103. https://ec.europa.eu/commission/presscorner/detail/en/ip_21_6094 https://www.euractiv.com/section/energy/opinion/the-flawed-black-box-deciding-europes-energy-infrastructure/
104. https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_6093
105. https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-revision-of-the-ten-e-regulation-for-energy-infrastructure
106. https://ec.europa.eu/sustainable-finance-taxonomy/activities/activity_en.htm?reference=5.12 https://ec.europa.eu/sustainable-finance-taxonomy/activities/activity_en.htm?reference=5.11
107. https://climatestrategies.org/wp-content/uploads/2021/03/Carbon-Contracts_CFMP-Policy-Brief-2020.pdf
108. https://www.europarl.europa.eu/meetdocs/2014_2019/plmrep/COMMITTEES/ENVI/AG/2023/02-09/ETS_final_text_EN.pdf
109. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&qid=1653033742483
110. https://www.pinsentmasons.com/out-law/analysis/contracts-for-difference-industry-cleantech
111. https://www.mdpi.com/2071-1050/13/22/12626/pdf
112. https://www.tandfonline.com/doi/full/10.1080/14693062.2020.1803040
113. https://www.tandfonline.com/doi/full/10.1080/14693062.2020.1803040
114. https://www.euractiv.com/section/energy/news/germany-plans-to-promote-green-hydrogen-with-e7-billion/
115. https://www.bmwk.de/Redaktion/DE/Publikationen/Klimaschutz/klimaschutzvertraege-bekanntmachung-des-interessenbekundungsverfahrens.html
116. https://english.rvo.nl/subsidies-programmes/sde
117. https://english.rvo.nl/subsidies-programmes/sde
118. https://cembureau.eu/media/w0lbouva/cembureau-2050-roadmap_executive-summary_final-version_web.pdf
119. https://www.climatebonds.net/transition-finance-transforming-companies
120. https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets_en
121. https://ec.europa.eu/clima/policies/ets_en
122. https://www.euractiv.com/section/energy-environment/news/eu-carbon-market-blurred-by-volatile-prices-and-speculationgreens-warn/?utm_source=piano&utm_medium=email&utm_campaign=9707&pnespid=puR5CSpcbr8XxOecvDm3SZfXrhX0RolzJLe5z.Bjtk1mrzSQy.4RAmuh69EcGIx1SgGur5tgJw
123. https://ember-climate.org/data/data-tools/carbon-price-viewer/ https://www.reuters.com/markets/carbon/europes-carbon-price-hits-record-high-100-euros-2023-02-21/
124. The "carbon leakage" expression refers to a situation that may occur in which, due to the high costs that some industries have to bury because of the EU climate policies, these companies might decide to transfer their production process where there are less strict ones. https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets/free-allocation/carbon-leakage_en
125. https://www.europarl.europa.eu/news/en/press-room/20221212IPR64527/climate-change-deal-on-a-more-ambitious-emissions-trading-system-ets
126. https://www.europarl.europa.eu/news/it/press-room/20221212IPR64509/deal-reached-on-new-carbon-leakage-instrument-to-raise-global-climate-ambition
127. https://www.europarl.europa.eu/news/en/press-room/20221212IPR64527/climate-change-deal-on-a-more-ambitious-emissions-trading-system-ets
128. https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3661
129. https://ec.europa.eu/eurostat/databrowser/view/DS-059268__custom_3299031/default/table?lang=en
130. https://cembureau.eu/media/ejohhq5c/global-cement-production-table.png https://ec.europa.eu/eurostat/databrowser/view/DS-059268__custom_3299031/default/table?lang=en
131. https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3661
132. https://foresightdk.com/the-revised-eu-ets-can-accelerate-the-decarbonisation-of-cement/
133. https://www.politico.eu/article/eu-carbon-border-adjustment-mechanism-turkey-paris-accord-climate-change/
134. https://www.climatebonds.net/2021/09/taxomania-international-overview

135. https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/overview-sustainable-finance/platform-sustainable-finance_en#activities
136. https://ec.europa.eu/info/sites/default/files/swd-competitive-clean-european-steel_en.pdf
137. https://www.climatebonds.net/standard/cement
138. https://foresightdk.com/eu-taxonomy-will-heavily-impact-the-cement-industry/
139. https://www.climatebonds.net/climate-bonds-standard-v4
140. https://www.climatebonds.net/climate-bonds-standard-v4
141. https://iap.unido.org/articles/consumers-can-play-central-role-decarbonizing-cement-and-steel
142. https://ec.europa.eu/info/sites/default/files/swd-competitive-clean-european-steel_en.pdf
143. https://ec.europa.eu/environment/gpp/benefits_en.htm
144. https://www.sei.org/wp-content/uploads/2023/02/green-public-procurement-eu.pdf
145. https://www.switchtogreen.eu/eu-green-public-procurement/
146. https://ec.europa.eu/environment/gpp/index_en.htm
147. https://www.unido.org/news/major-global-economies-announce-collaboration-drive-global-decarbonization-steel-and-cement
148. https://ec.europa.eu/eurostat/web/circular-economy#:~:text=What%20is%20the%20circular%20economy,minimising%20the%20generation%20of%20waste
149. https://www.nature.com/articles/d41586-022-00758-4
150. https://cembureau.eu/policy-focus/sustainable-construction/construction-demolition-waste/
151. https://newclimate.org/sites/default/files/2020/12/SGCCC-EU-Cement-paper-NewClimate_Nov2020.pdf
152. https://www.holcim.com/who-we-are/our-stories/recycled-clinker
153. https://cembureau.eu/media/s3xby5ye/doc-19910-cembureau-position-for-waste-shipment-regulation-revision-2021-09-10.pdf
154. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN
155. https://cembureau.eu/media/kuxd32gi/cembureau-2050-roadmap_final-version_web.pdf
156. https://www.climatebonds.net/files/files/Cement-Criteria-Document-Final-241022.pdf
157. https://materialeconomics.com/publications/scaling-up-europe
158. https://hydrogen-central.com/h2-green-steel-sold-1-million-tonnes-green-steel-customers/
159. https://www.climateaction.org/news/bmw-group-significantly-increases-use-of-low-carbon-steel-in-series-product
160. https://www.autostrade.it/documents/10279/49049770/ASPI_Sustainability_linked_financing.pdf/c271264e-7fb2-a123-1130-198b93c5c668?t=1671204433536
161. https://www.climatebonds.net/2021/09/carbon-pricing-climate-action-new-countdown-cop-policy-briefing
162. https://ec.europa.eu/sustainable-finance-taxonomy/activities/activity_en.htm?reference=3.7
163. A-EW_208_Strategies-Climate-Neutral-Industry-EU_Study_WEB.pdf (agora-energiewende.de)
164. https://cembureau.eu/media/drylkjo0/manufacturing-process-factsheet_update-jan2021.pdf
165. https://cembureau.eu/media/drylkjo0/manufacturing-process-factsheet_update-jan2021.pdf

Prepared by Climate Bonds Initiative.

Author: Fabio Passaro

Acknowledgements: Mark Alexander, Bridget Boulle, Lily Burge, Helen Burmeister, Zhi Cao, Chris Moore, Anna Nilsson, Vangelis Papakonstantinou, Juan Manuel Viver Gargallo, Kira West

Design: Godfrey Design, Joel Milstead