Cement Criteria

Development of Eligibility Criteria under the Climate Bonds Standard & Certification Scheme

Acknowledgements

Climate Bonds gratefully acknowledges the Technical and Industry Working Group members who provided their time and expertise during the development of these Criteria. Members are listed in ***Appendix A*** at the end of this document. Special thanks are given to ***Cyrille Dunant***, the lead specialist coordinating the development of the Criteria through the Technical Working Group.

Revision	Date	Summary of Changes
Rev. 0.1	22 February 2022	Issued as Draft for Public Consultation
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Definitions

Applicant: The term or name for any potential bond issuer, or non-financial corporate entity that might seek certification under the Cement Criteria.

Climate Bonds Initiative (Climate Bonds): An investor focused not-for-profit organisation, promoting large-scale investments that will deliver a global low carbon and climate resilient economy. Climate Bonds seeks to develop mechanisms to better align the interests of investors, industry and government to catalyse investments at a speed and scale sufficient to avoid dangerous climate change.

Climate Bonds Standard (CBS): A screening tool for investors and governments that allows them to identify green bonds the proceeds of which are being used to deliver climate change solutions. This may be through climate mitigation impact and/or climate adaptation or resilience. The CBS is made up of two parts: the parent standard (CBS v3.0) and a suite of sector specific eligibility Criteria. The parent standard covers the certification process and pre- and post-issuance requirements for all certified bonds, regardless of the nature of the capital projects. The Sector Criteria detail specific requirements for assets identified as falling under that specific sector. The latest version of the CBS is published on the Climate Bonds website.

Climate Bonds Standard Board (CBSB): A board of independent members that collectively represents $34 trillion of assets under management. The CBSB is responsible for approving (i) Revisions to the CBS, including the adoption of additional sector Criteria, (ii) Approved verifiers, and (iii) Applications for Certification of a bond under the CBS. The CBSB is constituted, appointed, and supported in line with the governance arrangements and processes as published on the Climate Bonds website.

Climate Bond Certification: allows the applicant to use the Climate Bond Certification Mark in relation to that bond. Climate Bond Certification is provided once the independent CBSB is satisfied the bond conforms with the CBS.

Clinker: an intermediate product in cement manufacture. It is made from the decarbonisation of limestone before it is melted (a term called sintering) and then rapidly cooled.

Clinker factor: the percentage of clinker in cement.

Concrete: a material produced by mixing cement, water and gravel where the cement acts as a binder making up about 15% of the total.

Critical interdependencies: The asset or activity's boundaries and interdependencies with surrounding infrastructure systems. Interdependencies are specific to local context but are often connected to wider systems through complex relationships that depend on factors 'outside the asset fence' that could cause cascading failures or contribute to collateral system benefits.

Green Bond: A green bond is a bond of which the proceeds are allocated to environmental projects or expenditures. The term generally refers to bonds that have been marketed as green. In theory, green bonds proceeds could be used for a wide variety of environmental projects or expenditures, but in practice they have mostly been earmarked for climate change projects.

Industry Working Group (IWG): A group of key organisations that are potential applicants, verifiers and investors convened by Climate Bonds. The IWG provides feedback on the draft sector Criteria developed by the TWG before they are released for public consultation.

Investment Period: The interval between the bond's issuance and its maturity date. Otherwise known as the bond tenor.

Ordinary Portland Cement (OPC): cement made from 95% of ground clinker and 5% gypsum.

Supplementary Cementitious Material (SCM): material that can act as a partial substitute for clinker in cement.

Technical Working Group (TWG): A group of key experts from academia, international agencies, industry and NGOs convened by Climate Bonds. The TWG develops the Sector Criteria - detailed technical criteria for the eligibility of projects and assets as well as guidance on the tracking of eligibility status during the term of the bond. Their draft recommendations are refined through engagement with finance industry experts in convened Industry Working Groups (see below) and through public consultation. Final approval of Sector Criteria is given by the CBSB.

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1. Introduction

1.1 Overview

This document serves as a reference document to the Criteria Document for Cement. The purpose of this document is to provide an overview of the key considerations and issues that were raised during development of the Cement Criteria and provide the rationale for why requirements were chosen and set.

The Criteria were developed through a consultative process with TWGs and IWG, and through public consultation. The TWGs comprised academic and research institutions, civil society organizations, multilateral banks and specialist consultancies whereas IWGs are represented by industry experts as well as potential applicants and investors. A 60-day period of public consultation offers the opportunity to any member of the public to comment on the Criteria. This document aims to capture these various dialogues and inputs and substantiate the reasoning behind the Cement Criteria.

This document begins with an introduction to the challenges in financing a low carbon and climate resilient world and the role that bonds can play in meeting this challenge, particularly through the standardisation of green definitions. This is followed by ***Section 2*** which is an introduction to the cement sector and the implications of climate change on the sector in terms of both emissions and climate risks. ***Section 4*** synthesizes the discussions arising from the TWGs, IWGs, and public consultation and presents the resulting Criteria that have been finalized and published by CBI.

Supplementary information available in addition to this document include:

1. Cement Criteria document: the complete Criteria requirements.
2. Cement Frequently Asked Questions (FAQ's)
3. Cement Criteria Summary of Public Consultation: all feedback received from public consultation including responses.
4. Climate Bonds Standard V3: the umbrella document laying out the common requirements that all Certified Climate Bonds need to meet, in addition to the sector-specific Criteria (V3 is the most recent update version).[1]
5. Climate Bonds Standard & Certification Scheme Brochure: an overview of the purpose, context and requirements of the Climate Bonds Standard & Certification Scheme.

For more information on the Climate Bonds Initiative and the Climate Bond Standard & Certification Scheme, see www.climatebonds.net/standards. For the documents listed above, see www.climatebonds.net/standard/cement

1.2 Funding the goals of the Paris Agreement

The current trajectory of climate change, expected to lead to a global warming of 2.7-3.1°C by 2100,[2] poses an enormous threat to the future of the world's nations and economies. The aim of the Paris Agreement is to limit warming to a global average of no more than 2°C higher than pre-industrial levels by the end of the century, and ideally no more than 1.5°C. The effects of climate change and the risks associated even with a 2ºC rise are significant: rising sea levels, increased frequency and severity of hurricanes, droughts, wildfires and typhoons, and changes in agricultural patterns and yields. Meeting the more ambitious 1.5ºC goal requires a dramatic reduction in global greenhouse gas (GHG) emissions.

At the same time, the world is entering an age of unprecedented urbanisation and related infrastructure development. Global infrastructure investment is expected to amount to USD 90 trillion by 2030, more than the entire current infrastructure stock.[3]

To ensure sustainable development and avoid dangerous climate change, this infrastructure needs to be low-carbon and resilient to physical climate impacts, without compromising the economic growth needed to improve the livelihoods and wellbeing of the

[1] This will become v4.0, expected Q1 2023.
[2] According to Climate Tracker, under current policies we could expect 2.7 – 3.1ºC: http://climateactiontracker.org/global.html
[3] The Global Commission on the Economy and Climate (2018), 'Unlocking the Inclusive Growth Story of the 21st Century: Accelerating Climate Action in Urgent Times': https://newclimateeconomy.report/2018

world's poorer citizens. Ensuring that the infrastructure built is low-carbon raises the annual investment needs by 3–4%.[4] Climate adaptation needs add another significant amount of investment, estimated at USD 280–500 billion per annum by 2050 for a 2ºC scenario.[5]

1.3 The role of bonds

Traditional sources of capital for infrastructure investment (governments and commercial banks) are insufficient to meet these capital needs; institutional investors, particularly pension and sovereign wealth funds, are increasingly looked to as viable actors to fill these financing gaps.

Capital markets enable issuers to tap into large pools of private capital from institutional investors. Bonds are appropriate investment vehicles for these investors as they are low-risk investments with long-term maturities, making them a good fit with institutional investors' liabilities (e.g., pensions to be paid out in several decades).

Bond financing works well for low-carbon and climate-resilient infrastructure projects post-construction, as bonds are often used as refinancing instruments. Labelled Green Bonds are bonds with proceeds used for green projects, mostly climate change mitigation and/or adaptation projects, and labelled accordingly. The rapid growth of the labelled green bond market has shown in practice that the bond markets can provide a promising channel to finance climate investments.

The Green Bond market can reward bond issuers and investors for sustainable investments that accelerate progress toward a low-carbon and climate-resilient economy. Commonly used as long-term debt instruments, Green Bonds are issued by governments, companies, municipalities, commercial and development banks to finance or re-finance assets or activities with environmental benefits. Green Bonds are regular bonds with one distinguishing feature: proceeds are earmarked for projects with environmental benefits. Green Bonds are in high demand and can help issuers attract new types of investors.

A green label is a discovery mechanism for investors. It enables the identification of climate-aligned investments even with limited resources for due diligence. By doing so, a green bond label reduces friction in the markets and facilitates growth in climate-aligned investments.

Currently Green Bonds only account for less than 0.2% of a global bond market of USD 128 trillion.[6] It is forecast that sustainable bonds (green, social, and sustainability bonds) will account for 8 to 10 per cent of global bond issuance in 2021[7]. The potential for scaling up is tremendous. The market now needs to grow much bigger, and quickly.

In recent years there has been a noticeable rise in other types of sustainable labelled debt, including the issuance of so-called 'behaviour-based finance agreements'[8]. These include Sustainability-Linked Bonds (SLBs) which are receiving high levels of interest from sectors that traditionally have not issued green bonds. The International Capital Market Association defines SLBs as any type of bond instrument for which the financial and/or structural characteristics can vary depending on whether the issuer achieves predefined sustainability or ESG objectives. It is a forward-looking performance-based instrument with a flexible structure. Entities that issue SLBs can set key performance indicators (KPIs) which are aligned with their sustainability strategies. It allows the issuer to set more general, overarching sustainability goals, rather than being tied to financing specific projects like solar power plants or green buildings[9].

SLBs or green loans do not tie bond proceeds directly to assets or activities but rather finance general corporate purposes. It should thus be a priority for such financial instruments to link to green definitions along with additional principles for KPIs, transition plans and measurable action. This will be crucial for sectors and entities that tend to avoid use-of-proceeds[10] bond issuance yet need to decarbonise in line with the Paris Agreement like all other sectors. Relevance to the cement sector is discussed in more depth in ***section*** Deals already seen in the sector***2.5***.

[4] The Global Commission on the Economy and Climate (2016), 'Better Growth, Better Climate': http://newclimateeconomy.report/2016/wp-content/uploads/sites/2/2014/08/BetterGrowth-BetterClimate_NCE_Synthesis-Report_web.pdf
[5] UNEP (2018), 'Adaptation Gap Report 2018': file:///C:/Users/12035/Downloads/AGR_2018.pdf
[6] www.icmagroup.org/regulatory-policy-and-market-practice/secondary-markets/bond-market-size
[7] www.afr.com/companies/financial-services/green-bonds-to-hit-850b-in-2021-20210205-p56zzn
[8] https://cementamericas.com/2021/10/21/cement-and-sustainable-finance/
[9] www.nnip.com/en-INT/professional/insights/articles/sustainability-linked-bonds-a-viable-alternative-for-green-bonds
[10] Hight emitting sectors have traditionally not issued green bonds due to a lack of consensus on whether they can be truly 'green'. So-called 'Transition bonds' have been issued to explore a label that better reflects the nature of decarbonising these sectors. However, even these have been met with some scepticism.

1.4 Introduction to the CBS

Activating the mainstream debt capital markets to finance and refinance climate friendly projects and assets is critical to achieving international climate goals, and robust labelling of green bonds is a key requirement for that mainstream participation. Confidence in the climate objectives and the use of funds intended to address climate change is fundamental to the credibility of the role that green bonds play in a low carbon and climate resilient economy. Trust in the green label and transparency to the underlying assets are essential for this market to reach scale but investor capacity to assess green credentials is limited. Therefore, Climate Bonds created the Climate Bonds Standard & Certification Scheme, which aims to provide the green bond market with the trust and assurance to achieve the required scale.

The Climate Bonds Standard & Certification Scheme is an easy-to-use tool for investors and applicants to assist them in prioritising investments that truly contribute to addressing climate change, both from a resilience and a mitigation point of view. It is made up of the overarching CBS detailing management and reporting processes, and a set of Sector Criteria detailing the requirements assets must meet to be eligible for certification. The Certification Scheme requires applicants to obtain independent verification, pre- and post-issuance, to ensure the bond meets the requirements of the CBS.

Existing Sector Criteria cover solar energy, wind energy, marine renewable energy, geothermal power, buildings, transport (land and sea), biofuel production, forestry, agriculture, waste management and water infrastructure. In addition to cement, additional Sector Criteria currently under development include Basic Chemicals and Steel. Criteria are available at www.climatebonds.net/standards/sector-criteria.

1.5 Process for Sector Criteria Development

The CBS has been developed based on public consultation, road testing, and review by the Assurance Roundtable (a group of verifiers) and expert support from experienced green bond market participants. The Standard is revisited and amended on an annual basis in response to the growing green bond market. Sector specific Criteria, or definitions of green, are developed by TWG made up of scientists, engineers, and technical specialists. Draft Criteria are presented to IWG before being released for public comment. Finally, Criteria are presented to the CBSB for approval (see diagram below).

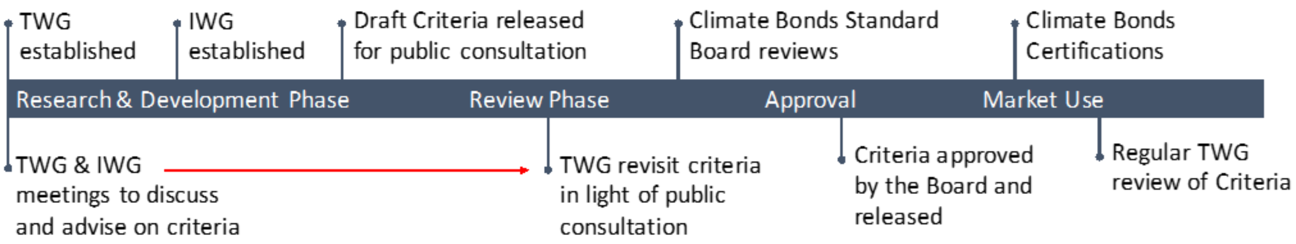

Figure 1. Criteria Development Process

1.6 Structure of this document

This document supports the Cement Criteria. It captures the issues raised and discussed by the TWG, as well as the arguments and evidence in support of the Criteria. It is structured as follows:

- *Section 2* provides a brief overview of the sector, its current status, trends and role in mitigating and adapting to climate change.
- *Section 3* outlines the objectives and principles. It states that assets and activities must pass 3 sets of requirements to be eligible for certification: (i) mitigation requirements; (ii) demonstration of alignment with the transition pathway; and (iii) adaptation, resilience and other environmental and social requirements.
- *Section 4* describes the rationale behind the criteria, including the mitigation component, adaptation and resilience (A&R) component, and entity transition.

1.7 Revisions to the Criteria

Criteria will be reviewed on a regular basis. At this point the TWG will take stock of the bond deals that are printed in the early stages as well as improvements in methodologies and data that can increase the climate integrity of future deals. As a result, the Criteria are likely to be refined over time, as more information becomes available. Certification will not be withdrawn retroactively from bonds certified under earlier versions of the Criteria.

2 Sector Overview

2.1 What is cement?

Cement is the binder used to make concrete. It is used in conjunction with water which starts the chemical reaction, gravel (called aggregates) to provide structural strength and sand to make it workable and add volume. When the gravel is omitted, the resulting product is called mortar. Although concrete and mortar are the end-use products with cement constituting only about 10% of the final mass, almost all of the emissions in this process are due to the cement production.

Cement is the second-most-consumed product globally after water. It is a product with exceptional attributes for its use, combining great robustness, flexible use, and low price. Many industries exist alongside the cement industry producing various additives to tailor the behaviour of cement, making it flow better, or harden slower or faster. About half of all the cement in the world is in buildings, with the rest used for infrastructure including roads, railways and energy facilities[11].

Most cement produced today is called Portland cement. It is produced by thermally decomposing (heating) limestone at high temperatures c.1400 °C in a process called calcination. This splits the limestone (calcium carbonate) into lime (calcium oxide) and carbon dioxide. It is this chemical reaction that accounts for 60% of the overall CO2 emissions produced in cement production (often referred to as the 'process emissions'). Once combined with a small amount of clay it is termed clinker. The clinker produced is cooled rapidly, ground, mixed with gypsum and other mineral additives.

Portland cement reacts with water to form so-called hydrates. Some of the hydrates form the solid skeleton that holds concrete or mortar together. Part of the Portland cement can be substituted by other mineral additions which will also produce hydrates in conjunction with the cement, although these substitution products are themselves inert in water. This mix is called a blended cement or binder. The most used substitution products are ground granulated blast furnace slag, a by-product of the steel industry, and fly ash, a by-product of coal burning. These products make the cement not only cheaper, but also stronger and more durable.

Cement products vary by type and grade which specify key characteristics. Many differing national and international standards exist across countries, but cement types generally indicate the end use of the cement and certain additives. For example, according to the European Standard EN-197, CEM I is pure Ordinary Portland Cement (OPC), while CEM III is OPC mixed with a certain amount of blast furnace slag. The grade of cement indicates the strength of the concrete produced after 28 days in Megapascals (mpa). The grades are 32.5, 42.5 and 52.5 (sometimes written 33, 43, 53). Nomenclature further distinguishes between cements with early strength gain vs normal or slow strength gain[12]. These strength grades of cement also differ in certain environmental impacts[13]. However, cement grades are proxies for these impacts. The most proximate factor is the clinker quality (in turn influenced by reactivity and burnability)[14].

Cement is very cheap, and therefore produced almost always close to where it is used, as transportation costs are significant. As such, many cement production facilities are also located on the same site as or close to a limestone quarry. The typical lifespan of a cement kiln is 30 – 50 years[15]. New kilns are therefore predominantly built in places where market growth potential will be experienced. Typically, much of the original equipment is replaced or upgraded.

2.2 Future of cement

The last decades or so were marked by an explosion in the production of cement in China, although this may have peaked.

[11] IEA Energy technology perspectives report p215 - https://iea.blob.core.windows.net/assets/7f8aed40-89af-4348-be19-c8a67df0b9ea/Energy_Technology_Perspectives_2020_PDF.pdf
[12] www.eabassoc.co.uk/cement-type-grades.php
[13] www.sciencedirect.com/science/article/abs/pii/S0921344916301549#:~:text=Cement%20with%20different%20strength%20grade,52.5%20RMPa%20strength%20grade%20cement.
[14] www.sciencedirect.com/science/article/pii/S1026918520300421#bib0016
[15] https://iea.blob.core.windows.net/assets/7f8aed40-89af-4348-be19-c8a67df0b9ea/Energy_Technology_Perspectives_2020_PDF.pdf

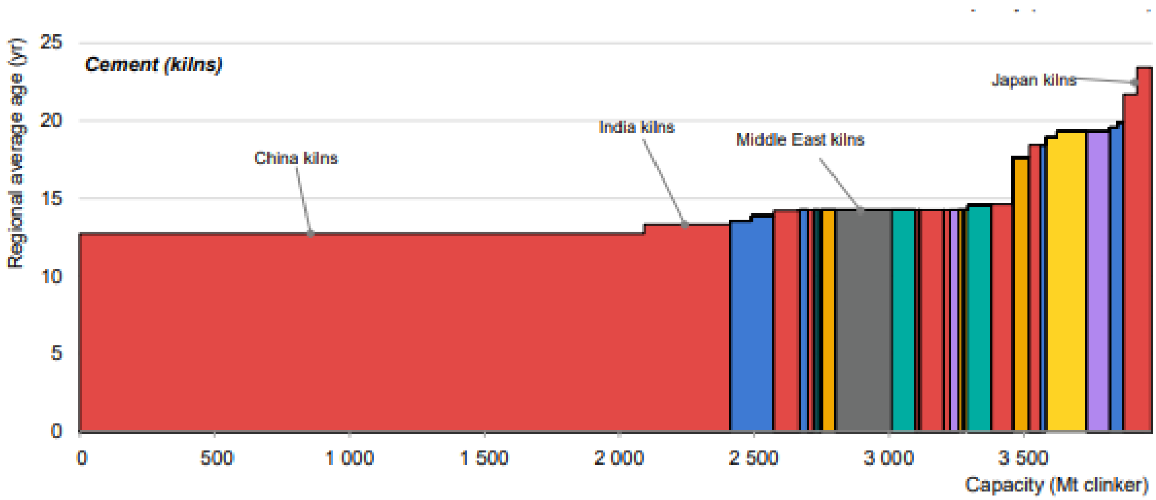

Figure 2. Age of plants by region (IEA Energy Technology Perspectives, 2020)

In the next decades, a similar explosion is expected in India, and staggered across the African continent. Production in developed economies is stagnant or declining. Cement production depends on the presence of abundant amounts of limestone. As limestone is a very common rock this has never been a limitation, but this may change. For example, Africa has less limestone than the other continents, and this may change the economics of cement production in the future. It is currently produced as locally as possible, with transport a significant fraction of the cost. In the future, it is expected that Portland clinker will be transported more to grinding/blending sites where its usefulness will be maximised depending on local demand. Given its performance characteristics and low cost, it is likely to remain the construction material of choice, though in some local areas alternatives may emerge such as cross laminated timber (CLT).

Alternative binders have been proposed to limit the climate impact of cement, but most of them rely on increasing the amount of substitution materials to close to 100%, using chemical activators. Unfortunately, the substitution materials are from highly polluting industries, whose continued operation is incompatible with climate goals (primary steel production and coal burning). Further, these products are already currently exploited to the limit to substitute cement, and finally, the chemical activators typically have worse emissions than the cement they aim to replace. Alternative chemistries, based, for example on MgO, are unlikely to replace any significant fraction of the market. Calcium Aluminate cements have excellent properties, and are commonly used in refractory applications, yet hold, a full century after their discovery, perhaps 1% of the market. Further, these alternate chemistries are still based on carbonated raw materials and suffer from the same problems as Portland.

The cement industry is changing. New types of production facilities are emerging alongside the common integrated quarry-kiln-grinding-blending facility. Some producers procure clinker and grind and blend it themselves. Some cementitious products harden under CO_2 atmospheres and allow for the integrated production of unreinforced precast elements with very low embodied carbon. Calcined clays, because of the considerable potential production volume may allow a global lowering of the clinker factor. All these things should fall under the scope of the criteria, to help transform the cement industry.

Mitigation options aim therefore to improve as much as possible the use of the Portland component of cement. Although much of the research is focussed on the development of new supplementary cementing materials (SCM), a key limitation to the replacement levels which can be obtained with poorly reactive (or unreactive) SCMs is the reactivity of the Portland itself. Indeed, new substitution materials are emerging, still using the activating properties of Portland. These are mostly calcined clays in combination with ground limestone which allow much larger substitution levels than currently practised, as well as, locally, rice husk ash. For example, current state of the art replacement using calcined clay is 55%, with 65% in the near future. But with highly reactive Portland, the replacement ratio could reach 85%.

Well underway also is the improvement of the thermal process: heat recovery, pre-calcining using recovered heat, using dry processes instead of wet are all the norm in the developed world, with the rest of the world well under way to catching up. There is also a large effort, mostly in Europe, to increase the use of biofuels and other alternative fuels. This requires better burners and control software but promises lower combustion emissions. However, the high temperatures required for the clinkering process make electrification of kilns very difficult.

Much of the thermal power required for the clinkering is taken by the decarbonation of limestone. Therefore, recycling cement would save not only the decarbonation emissions, but also some of the heat. Unfortunately, there is currently no capacity to take concrete from demolition sites and separate it in aggregates and cement paste at scale, although some start-ups have started looking at this. The temperature requirement would remain the same, however, and electrification would therefore still be very difficult.

Much of the possible carbon savings can come from better structural design, and better use of cement in concrete. These strategies will lead to a decline in the production of cement yet will also drive its quality upwards: the economics of cement manufacturing may well evolve towards higher value and lower volume. In all cases, a stronger, higher quality Portland component offers more flexibility to meet whatever the future market needs.

2.3 Cement and climate change

Cement production is responsible for a quarter of all industry CO2 emissions, generating significant levels of man-made greenhouse gas emissions[16]. This is because of the huge amounts used: in 2020, 4.3Gt of cement were produced. Compared to other industrial materials, however, the carbon intensity per unit of production of cement is low.

Meanwhile, cement production combines the problem of unavoidable chemical emissions from the decarbonation of limestone (about two-thirds of total emissions, so-called 'process emissions') and the high process heat requirements ('thermal emissions'). Further, replacement at scale is very hard to achieve due to cement's relatively low carbon intensity per unit of production. Cement is also a key ingredient to enabling other sectors to transition to a low-carbon economy: it is needed for wind and nuclear power, it is a necessary ingredient in infrastructure, and it will be used in vast quantities to build the cities of the future. It is, however, easy and cheap to lower the embodied carbon of a tonne of cement by using it more efficiently – through more efficiency in clinker, in cement and in concrete.

There is considerable industry interest in developing carbon capture solutions to manage the carbon emissions in a different way. Cement is a largely local product, but the few carbon capture projects in operation today rely on the proximity to depleted oil and gas fields (or saline formations) and all the industrial infrastructure around them. Whilst there are no viable options to fully decarbonise cement, adoption of the latest technologies and approaches offers the potential to reach perhaps 80-85% decarbonisation. These Criteria thus firstly focus on this decrease in emissions. Regular reviews of Criteria then consider the latest technological developments that can close the remaining gaps.

In addition to being a source of CO_2 emissions, concrete can also act as a carbon sink. Recarbonation (absorption of CO2 by concrete) is a slow process that occurs in concrete where lime (calcium hydroxide) in the cement reacts with carbon dioxide from the air and forms calcium carbonate. At the end of their useful life, buildings and infrastructure (reinforced concrete structures) are demolished. If the concrete is then crushed, its exposed surface area increases, and this increases the recarbonation rate. The amount of recarbonation is even greater if stockpiles of crushed concrete are left exposed to the air prior to reuse.[17]

2.4 Investment need

The International Energy Agency in its Technology Roadmap for the Cement Industry[18] lists four key emissions mitigation levers that will hence requirement investment for the industry to align with the Paris Agreement:

1. Improving energy efficiency
2. Switching to alternative fuels
3. Clinker substitution
4. Emerging and innovative technologies

Bonds are used to both finance new projects and refinance existing projects. As such, globally bond investment will need to support all of these levers. However, regionally, this will vary. Many of the most forward-thinking cement manufacturers have already implemented energy efficiency measures and their focus now is on the innovative approaches currently in the early phase of development. Other manufacturers may still have energy efficiency improvement options available to them if active in regions with older plants, for example, in Europe or North America (see ***Figure 2***). Similarly, certain regions already see high levels of alternative fuel use while there remains high potential for substitution in others.

Evaluation of novel technologies, alternative fuels and clinker substitution options will require investment alongside potential exploration of alternative building materials such as wood-based solutions. Though outside the scope of these criteria, investment

[16] www.sciencedirect.com/science/article/pii/S2590332221005339#bib8
[17] https://circulareconomy.europa.eu/platform/en/good-practices/cement-recarbonation
[18] https://iea.blob.core.windows.net/assets/cbaa3da1-fd61-4c2a-8719-31538f59b54f/TechnologyRoadmapLowCarbonTransitionintheCementIndustry.pdf

could also support ideas for increasing the percentage of CO2 that can be sequestered in carbon cured concrete from the 5% possible today, to potentially 30%. These products could be sold at a premium as a 'green concrete'.

Globally, cement demand is set to increase between now and 2050[19], making capital markets crucial to meeting this demand. Cement investment will already be driven by a global infrastructure deficit, with an estimated USD94tn of infrastructure investment needed from 2016 to 2040, mainly in developing countries[20]. This aligns with the regions projected to experience the greatest increase in cement demand.

Running a fully decarbonised cement industry could amount to less than 0.07% of global GDP in 2050, or less than USD250bn per annum[21]. Moreover, lower renewable energy costs, improved demand-side management and future technological development could help further reduce this cost.

2.5 Deals already seen in the sector

Bondholders have a key role to play in decarbonising the cement industry as, on average, bonds make up 52% of the financing mix of the 21 largest cement companies, as shown in ***Figure 3***. This is therefore an active market for the cement sector, with the potential for high impact through setting Climate Bond criteria such as these.

Due to the difficulty in identifying truly green assets and projects in heavy industry (i.e., those already aligned with a net zero economy), historically these sectors have not seen issuances of green bonds. Green bonds are asset-linked and therefore earmark funds (or use-of-proceeds) for specific disclosed assets or projects. Transition bonds emerged more recently as an alternative use-of-proceeds bond instrument but have attracted a mixed reception around their environmental credentials[22]. The cement sector instead sees general corporate purpose bonds as the norm for fixed income instrument use in the market. This leaves the borrower to use the bond proceeds how they see fit without disclosing how those proceeds are specifically used.

[19] www.iea.org/reports/technology-roadmap-low-carbon-transition-in-the-cement-industry
[20] https://cdn.gihub.org/umbraco/media/1528/170724-mr-outlook-final-pdf.pdf
[21] www.energy-transitions.org/publications/mission-possible-sectoral-focus-cement/#download-form
[22] www.environmental-finance.com/content/news/beef-giant-issues-controversial-sustainable-transition-bond-framework.html

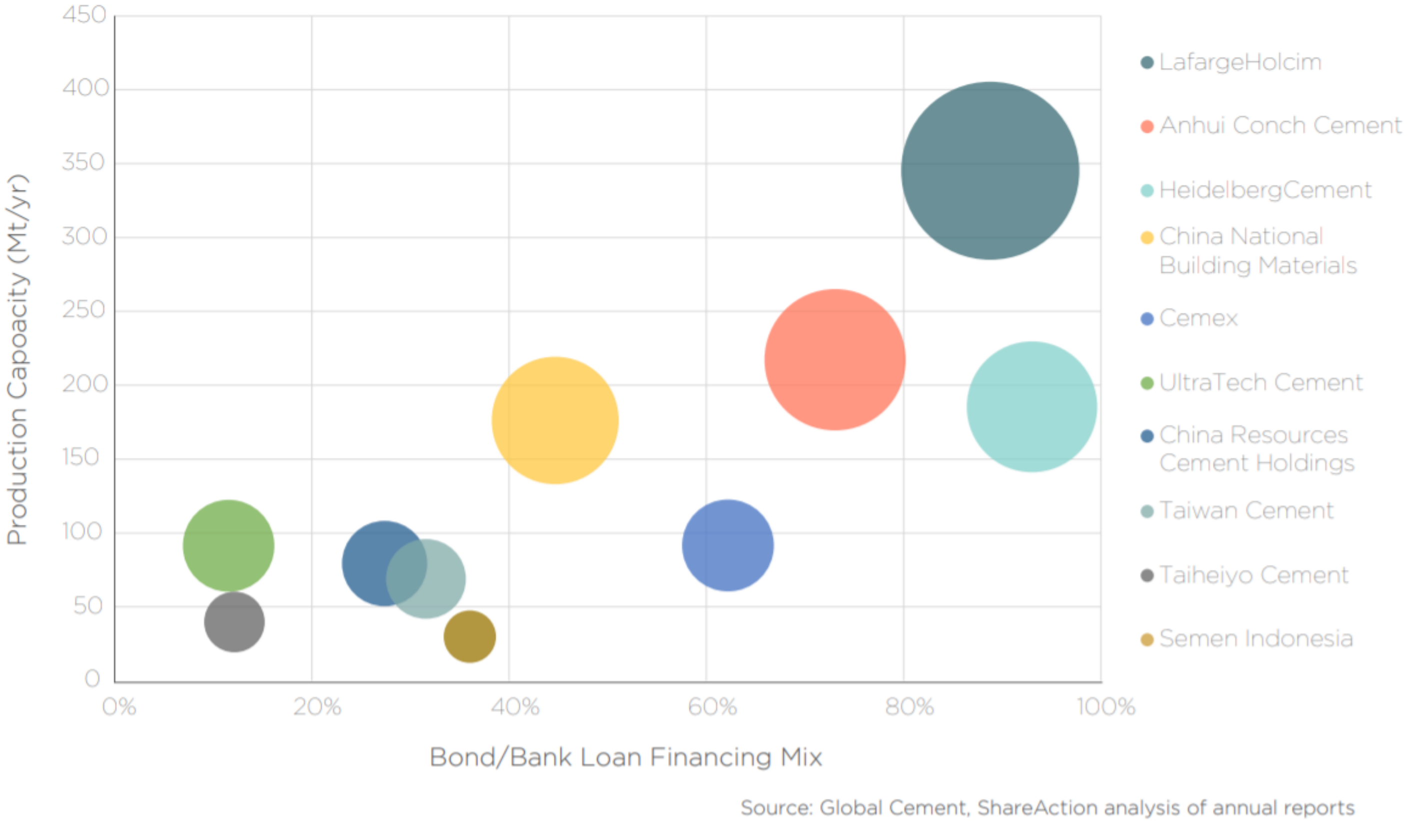

Figure 3. Financing mix of the largest cement companies according to production capacity.

Thus far (/at time of writing), USD2.6bn of SLBs have been issued by five cement companies across six countries, which can prove to be valuable case studies for future entity-level criteria. They vary in the scope and ambition of environmental objectives linked to their bond structure, yet all but one issuer thus far has used CO2 emissions per tonne of cementitious material as their key metric. While examples of SLBs and other sustainable debt instruments are considerably fewer than for other sectors, they may prove an increasingly popular option for cement companies moving forward.

A notable leader in cement SLBs is Lafarage Holcim, who has issued USD1.6bn of SLBs across four issuances as of Jan 2022. These have been tied to KPIs in emission intensity and freshwater usage intensity. Thus far, they also have the most ambitious emissions intensity targets among their SLB-issuing peers, aiming for 475 kg CO2/ton cementitious material.

Table 1. Examples of recent notable deals in the cement sector.

Issuer	Year	Description	Credentials
Votorantim Cimentos	2019	USD290m sustainability-linked loan agreement, including KPIs related to alternative fuel usage, clinker-to-cement ratio, and net CO2 per tonne of cement[23].	Sustainalytics Second Party Opinion
	2021	BRL450m 2026 sustainability-linked bond tied to achieving 548kg net CO2 per tonne of cementitious material by 2025, and an alternative fuel usage proportion of 29.4% by the same date.	Bureau Veritas Second Party Opinion

[23] https://cementamericas.com/2021/10/21/cement-and-sustainable-finance/

Issuer	Year	Description	Credentials
		This performance-linked format however didn't use a coupon step-up, but instead a discount on it's redemption premium.	
CEMEX	2020	CEMEX released a Sustainability-Linked Financing Framework in 2021, outlining its approach for issuing new sustainability-linked finance agreements. This framework includes three KPIs: net CO2 per tonne of cement, clean electricity consumption and alternative fuels rate[24]. Amended loan agreement amounting to USD3.2bn and incorporating five sustainability-linked metrics including reduction of net CO2 emissions per cementitious product and power consumption from green energy in cement[25].	Sustainalytics Second Party Opinion
Holcim	2020	EUR850m 2031 sustainability-linked bond with a coupon of 0.5% maturing in 2031. The structure is tied to the company's target to reach 475 kg net CO2 per ton of cementitious material by 2030, representing a reduction of 17.5% from a 2018 baseline.[26] Includes coupon step-up of 75bps if target not met.	ISS ESG Second Party Opinion
	2021	USD100m 2031 sustainability-linked bond with a coupon of 2.80% issued under the same Sustainability-linked Finance Framework as it's 2020 issuance. Includes coupon step-up of 1.50% if target is not met.	
	2022	CHF425m sustainability-linked bond issued in two tranches maturing in 2026 and 2032. Issued under updated Framework including the previous target, with the addition of a 2025 target of 520 kg CO2/t. cem. and a target to reduce freshwater intensity by 17.5% by 2025. Coupon step-ups of 37.5bps for the 2026 issuance and 75bps for 2032.	
Ultratech Cement	2021	USD400m sustainability-linked bond. The Sustainability Performance Targets linked to this bond entail a 22.2% reduction in CO2 intensity (kg CO2 e/ton produced) compared to a 2017 baseline by 31 March 2030. The coupon will step up by 75bps if the company misses its sustainability target. The reduction target and time frame yields a roughly 1.7% annual reduction target.[27]	ISS ESG Second Party Opinion

[24] https://cementamericas.com/2021/10/21/cement-and-sustainable-finance/
[25] www.cemex.com/-/cemex-takes-the-lead-in-green-financing-and-successfully-extends-facilities-agreement
[26] www.esgtoday.com/lafargeholcim-launches-building-materials-industry-first-sustainability-linked-bond/
[27] www.climatebonds.net/files/reports/cbi_susdebtsum_h12021_02b.pdf

3 Principles and Boundaries of the Criteria

3.1 Guiding Principles

The objective of CBI has been to develop Cement sector criteria that can maximize viable bond issuances with verifiable environmental and social outcomes. This means the Criteria need to balance the following objectives:

- They form a set of scientifically robust, ambitious and verifiable targets and metrics; and:
- They are usable by the market, which means they must be understandable for non-scientific audiences, implementable at scale, and affordable in terms of assessment burden.

The Criteria should:

- Enable the identification of eligible assets and projects (or use of proceeds) or entities or companies (general corporate purposes) related to cement investments that can potentially be included in a Certified Climate Bond.
- Deploy appropriate eligibility Criteria under which the assets and projects or entity can be assessed for their suitability for inclusion in a Certified Climate Bond.
- Identify associated metrics, methodologies and tools to enable the effective measurement and monitoring of compliance with the eligibility Criteria.

Given that a number of protocols relevant to cement already exist (see ***section 4.3***), the TWG has taken care not to reinvent the wheel, but rather draw from these existing protocols and guidance.

Subject to meeting the eligibility criteria in the following sectors, the following can be certified under these criteria:

- Use-of-Proceed (UoP)[28] bonds financing decarbonisation measures (e.g., retrofits).
- Use-of-Proceed (UoP) bonds financing cement production facilities (i.e., assets and activities).

The following can be certified following the update of the Overarching Climate Bonds Standard to v4.0[29]:

- Assets not linked to any specific financing instrument (cement production facilities).
- Entities (cement production companies) and Sustainability Linked Bonds (SLBs) issued by those entities.

Each subset of criteria may share common requirements, pathways or metrics but require different demonstrations of compliance. The following sections will make distinction between the guiding principles for certifying assets and activities (***section 3.1.1***), and the hallmarks for transition for entities and companies (described in ***section 3.1.2***).

3.1.1 Guiding principles – asset and activity certification

The Cement Criteria are made up of two components, both of which need to be satisfied for assets to be eligible for inclusion in a Certified Climate Bond. These are as follows:

1. Climate Change Mitigation Component – addressing whether the asset or project is sufficiently 'low GHG' to be compliant with rapid decarbonisation needs across the sector.
2. Climate Change Adaptation and Resilience Component – addressing whether the facility is itself resilient to climate change and furthermore not adversely impacting the resilience of the surrounding system. This encompasses a broad set of environmental and social topics.

[28] Use-of-Proceed (UoP) is used as shorthand throughout this document for a variety of targeted finance instruments, including green loans, repos, and asset-backed securities. Annex 1 of the Standard v3.0 details the full list of instruments that can be certified.
[29] Expected in Q1 2023.

Table 2. Key principles for the design of Climate Bond Standard Sector Criteria

Principle	Requirement for the Criteria
Ambitious	Compatible with meeting the objective of limiting global average warming to a 1.5ºC temperature rise above pre-industrial levels set by the Paris Agreement.
Material	Criteria should address all material sources of emissions over the lifecycle. Scope 1 & 2 emissions should be addressed directly and scope 3 considered.
No offsets	Offsets should not be counted towards emissions reduction performance.
Resilient	To ensure that the activities being financed are adapted to physical climate change and do not harm the resilience of the system them are in.
Scientifically Robust	Based on science not industry objectives.
Granular	Criteria should be sufficiently granular for the assessment of a specific project, asset or activity. Every asset or project to be financed must comply.
Globally consistent	Criteria should be globally applicable. National legislation or NDC's are not sufficient.
Aligned	Leverage existing robust tools, methodologies, standards.
Technology neutral	Criteria should describe the result to be achieved.
Avoid lock-in	Avoid supporting development that may result in long term commitments to high emission activities.

In terms of the many complex and interconnected environmental and social issues that should be assessed under these Criteria, the following points are noted:

- The Climate Bonds Standard is focused on climate impacts – including low GHG-compatibility (mitigation) and climate adaptation and resilience. Defining resilience can be challenging. However, it is clear that many topics which have been a part of environmental and social assessments for a number of years overlap significantly with the resilience of affected populations and ecosystems and their ability to adapt to climate change.

- One of the goals of the Climate Bonds Standard is to bring transparency and consistency to the evaluation of Green Bonds and other labelled debt. By including some ESG factors in the Criteria, we can ensure this outcome is delivered. In this way, investors and other stakeholders are not in the position of attempting to independently assess and interpret issues using ESG frameworks of varying and/or unknown quality and completeness in respect of these highly inter-connected and complex factors.

3.1.2 Guiding principles – entity and SLB certification

The nature of certifying whole entities, companies and Sustainability Linked Bonds requires a thorough ruleset and set of principles that go beyond those for assets and activities. This is to ensure that the entity truly merits certification having taken a view of its KPIs, transition plan, and planned action.

To this end, the Climate Bonds Initiative proposed 5 Hallmarks for Transition. These are discussed in greater detail in the paper 'Transition Finance for Transforming Companies'[30] and illustrated in ***Figure 4***. They build on and incorporate the transition principles proposed in the paper 'Financing Credible Transitions'[31]. Those transition principles are as follows:

- In line with 1.5-degree trajectory
- In line with establish science
- Offsets don't count
- Technological viability trumps economic competitiveness
- Action, not pledges

[30] www.climatebonds.net/transition-finance-transforming-companies
[31] www.climatebonds.net/transition-finance/fin-credible-transitions

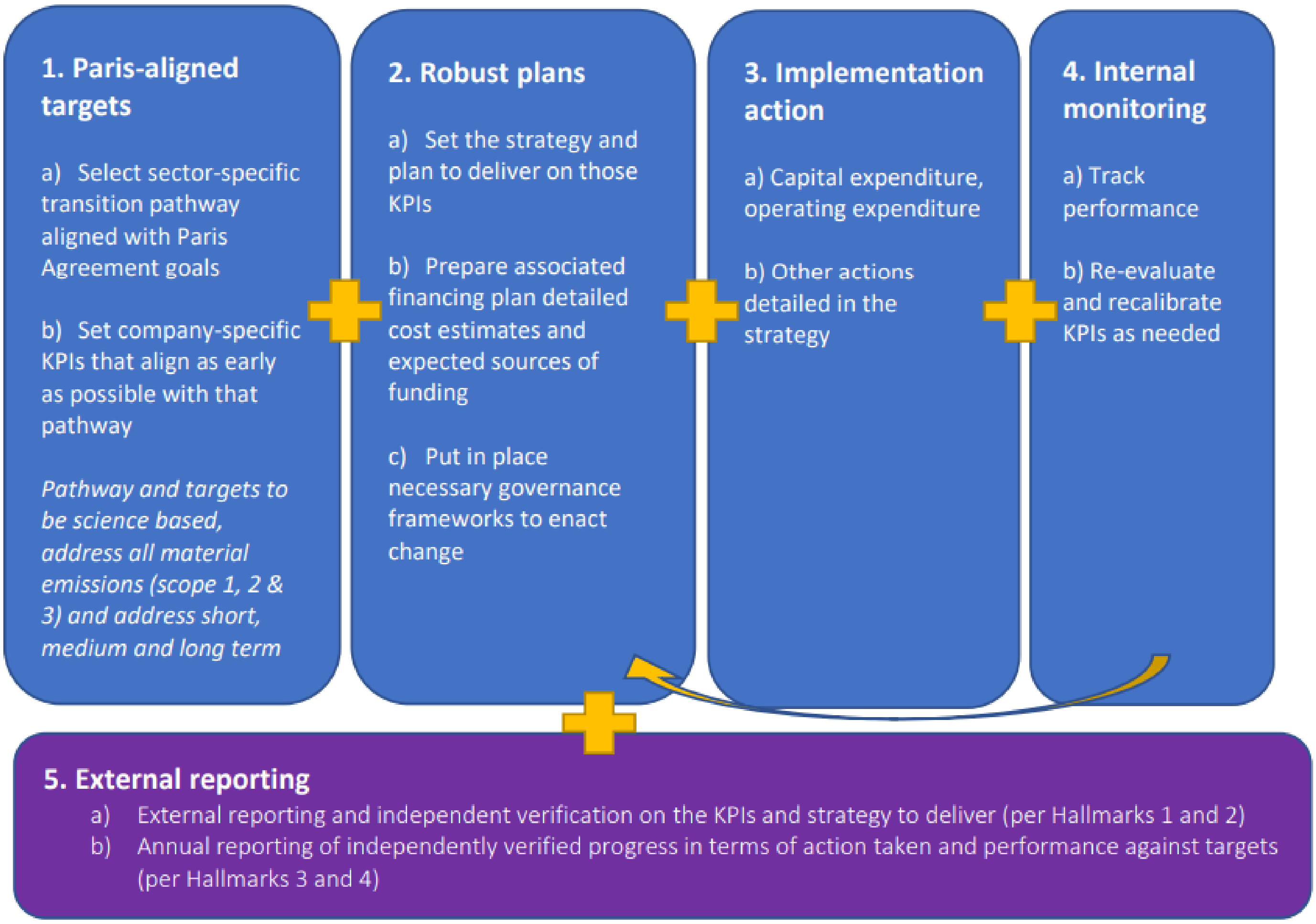

Figure 4. The Hallmarks of a credibly transitioning company

These Criteria address the first Hallmark in *Figure 4*. That is, they set the sector specific transition pathway for cement production at a company level, which companies must link to their KPIs if issuing SLBs. This transition pathway meets the principles set out in this section. As for the remaining four Hallmarks, they are met by the applicant providing a robust transition plan and evidence of planned action and internal monitoring that will allow KPIs to be met and the transition plan to be fulfilled.

External reporting underpins all other Hallmarks, but with distinctions from previous sector criteria. Criteria for entities must be forward-looking in nature, setting robust requirements for ambitious KPIs and also ensuring as best as possible that companies will meet those KPIs, thus meriting the certification label. However, there is always the risk that some KPIs may not be met. External reporting will therefore also need to cover when these KPIs are not met and whether the applicant will suitably compensate for this.

The additional requirements for certification of an entity, particularly those covering Hallmarks 2 – 5, will be released for public consultation in 2022. Upon finalisation, they will complete the requires necessary for a cement company to be certified.

4 Discussion and eligibility criteria

4.1 Overarching considerations

The purpose of the Cement Criteria, like all Sector Criteria developed for the Climate Bonds Standard & Certification Scheme, is to certify assets, projects and entities that are aligned with a low carbon economy and are climate resilient. Overarching principles and considerations for alignment with these objectives apply to all cement production measures, assets and activities, and entities within scope and are discussed in this section.

4.1.1 The overarching principles of the Cement Criteria

These criteria aim to identify the most ambitious emissions pathways for cement production facilities, while also identifying specific measures that should be prioritised alongside. However, this is while simultaneously pushing for higher quality of cement, which can in turn indirectly reduce emissions. It is easy and cheap to lower the embodied carbon of a tonne of cement by diluting it. This is not a future-proof strategy for decarbonisation, as future needs may require stronger, less diluted cement, and the availability of SCMs is not guaranteed. Therefore, the criteria focus on improvements to the production and use of the Portland component of cement. Alternative cement chemistries, if they emerge as solid contenders, will have to match the performance characteristics or requirements of the Portland they displace.

These criteria also reflect the need for new facilities to be state-of-the-art and for retrofits which reduce the emissions of existing facilities during their remaining lifetime without creating lock-in of assets incompatible with further decarbonisation.

In addition to the principles discussed in chapter 3, these criteria aim to ensure certified bonds truly meet the ambitious mitigation objectives in line with holding temperature increases ideally to 1.5ºC above pre-industrial levels. The Cement TWG strongly believes that emerging technologies and strategies available to the industry today can deliver those objectives.

4.2 Choosing the scope of criteria

4.2.1 Scope of activities – what activities can theoretically be certified?

As the name suggests, these criteria focus on cement as the product and sector in scope. This covers all stages of the production of blended cement, from the quarrying of limestone to the blending of OPC with SCMs.

Upon mixing the blended cement with sand, gravel and other additives, this becomes concrete and therefore is not within scope. It is accepted that there is considerable overlap between the cement and concrete industries. Many companies produce both products. Moreover, there is high potential for further emissions reductions across these industries when dealing with concrete. Material efficiency can reduce the demand for concrete and thus emissions, while recarbonation takes place when the concrete has set[32]. Despite these aspects, for practical reasons the boundary of activities is limited to cement and not concrete.

A wider scope of activities would undoubtedly be more time-consuming. There is an acute need to rapidly decrease the emissions of industrial sectors in order to avoid catastrophic climate change. Focusing on cement means a tool for the market will be available more quickly, allowing certifications to speed up progress in the sector. Crucially, this does not mean the concrete and construction sector will never be the focus of Climate Bonds sector criteria. Such criteria could address these additional opportunities further down the line.

During the development of the criteria the option to lower the clinker factor using fly ash and slag was considered and discounted. It is not that the used of this material should be discouraged. However, as a specific measure to reduce emissions or make future commitments to but that they are not future-proof, and not 1.5ºC-compatible as they arise as a by-product of the coal and steel industries. Therefore, their supply is expected to reduce in the future, and they cannot be part of a long-term decarbonisation plan.

[32] The GCCA Roadmap to Net Zero lays out these additional dimensions when including concrete in focus.

4.2.2 Scope of emissions – what emissions need to be accounted for when meeting mitigation thresholds?

In light of the scope of activity of the Cement Criteria, the most material emissions are the focus for demonstrating compliance for practical reasons. Due to their comprising an extremely small proportion (around 1%) of overall cement production emissions[33], quarrying and transportation emissions are outside of the scope of emissions. In other words, eligible facilities (or mitigation measures into those facilities) may be directly connected to a quarry, or with transport activities taking place, onsite, but the emissions of these stages are not counted towards meeting thresholds.

There are implications for emissions accounting by setting the scope as such. The TWG noted that the Getting the Numbers Right (GNR) database managed by the Global Cement and Concrete Association (GCCA) is the industry standard for GHG accounting and reporting. Importantly, the demonstration of compliance with the mitigation requirements of these criteria falls within the scope of reporting for the GNR database, with the exception of cement grade (discussed in ***section 4.3.3***).

Note that if the cement plant being financed has an onsite quarry, the Adaptation & Resilience component must address this aspect of the facility as it does the rest.

4.2.3 Scope of entities – what about companies?

Currently, not all companies operating along the cement supply chain can be certified under the Cement Criteria. This depends on their business activity. Entity certification requires forward looking transition strategies that will incorporate all emissions within scope as per the section above. Certain companies engaged solely in one supply chain stage cannot robustly promise (yet) that their overall emissions will continuously meet the pathway out to 2050. The main example of this would be a pureplay clinker production company. This company may produce and sell clinker to downstream companies that then produce the finished cement. Pureplay quarrying entities are similarly out of scope, but for different reasons (a full range of criteria for mineral extraction is needed first). Future iterations of these criteria will seek to incorporate these corporate structures in the cement supply chain.

Only companies operating solely as cement producers (i.e., 'pureplay' companies) – as distinct from concrete producers[34] – can be certified. This is because of the fact criteria do not yet exist for concrete production or construction, which are usually the other main activities of companies in this sector. A certified company might have integrated cement production as its sole activity, or it may own a subsidiary company that solely produces cement. These cases would be within scope for entity certification.

4.3 Determining mitigation criteria for the Cement Criteria

The mitigation requirements are based on a strategy to be part of an economy that is net zero by 2050. It is not currently possible to achieve zero carbon cement due to the limitations of today's technologies but that may change over time. However, considerable abatement can be achieved through focusing on the carbon intensity of binders, which, linked to improvement in concrete technology and structural design, promise abatement of emissions of perhaps 95% with today's technologies, without requiring CCS or novel chemistries.

The following sections lay out the rationale for the mitigation requirements set out in the Cement Criteria.

4.3.1 Choosing the emissions pathway for cement companies

Like every sector of the economy, the cement sector needs to decarbonise its activities to align with the objectives of the Paris Agreement. How fast and by when can be portrayed as a transition pathway. Some cement plants may already perform below this pathway today, while others will require retrofits or best available technologies to get there. Equally, some cement companies are aligning their activities with such a transition and those that are doing so with a clear plan could potentially achieve Climate Bonds certification. In line with the principles that govern how criteria are developed, Climate Bonds sector criteria align with material already in existence where it is consistent in approach and recognised by many stakeholders. One such area is to adopt transition pathways already developed through a high degree of scrutiny from academia and industry experts such as that developed by the Science Based Targets Initiative (SBTi) and the Transition Pathway Initiative.

[33] www.mckinsey.com/industries/chemicals/our-insights/laying-the-foundation-for-zero-carbon-cement
[34] That may also produce cement and aggregate.

Evaluating existing material for adoption as criteria requires that the chosen pathway and underlying methodology meets certain criteria. For example, where possible it should:

- Be based on a robust methodology and stakeholder engagement
- Be aligned with an ambition level of limiting global warming to 1.5°C
- Be globally applicable, not based on regional data or standards
- Represent a level playing field for all stakeholders and geographies
- Be based on a carbon intensity of production metric
- Be specific to the cement sector and focus on cement production as the scope of emissions
- Provide a pathway out to 2050 at least, with intermediate points

The Climate Bonds Initiative and Cement TWG evaluated and rejected several pathways or benchmarks that held promise and are valuable methodologies in their own right but fail to meet at least one or more of the criteria above.

The chosen company pathway – The Science Based Targets Initiative (SBTi)

The SBTi Cement sector guidance[35] was chosen as the most suitable for cement company pathways. It is 1.5°C-aligned, being based on a Sectoral Decarbonisation Approach (SDA) reflecting robust International Energy Agency (IEA) modelling of sector-specific carbon budgets, taking into consideration the cost of decarbonising each sector. Other approaches to translating international emissions targets into company benchmarks have applied the same decarbonisation pathway to all sectors, regardless of these differences. Because the SDA is more effective at avoiding unrealistic and costly solutions in reducing emissions across sectors, it is preferable to other pathways[36].

It provides year-by-year thresholds to form a pathway to 2050 and is specific to the cement sector with cement production in scope. The pathway (which includes both scope 1 & 2 emissions) is similar to the TPI 1.5-degree pathway which also uses the SDA approach. However, the SBTi pathway was considered more appropriate because it reflects the scope of emissions considered most material by the TWG. Specifically, the pathway reflects that emissions from waste burning must be included. While scope 1 & 2 emissions are split into their own pathway, for simplicity these Criteria include them as one pathway, which is also an option in the SBTi guidance.

However, there is one key difference in terms of how CBI leverage SBTi's pathway in contrast to SBTi themselves, which is the convergence mechanism. In effect, the SBTi pathway represents the whole cement sector (starting at the *sectoral average* emissions intensity in 2020) reaching an endpoint in 2050. SBTi then validates company targets by using a tool that defines how all companies need to reach that point regardless of their starting point. As such, companies that are above the sectoral pathway could remain above it until 2050, at which point they meet the 2050 target. However, Climate Bonds considers the risk of companies not meeting this target too great, as this would risk overshoot of the carbon budget. Instead, Climate Bonds prefers to effectively 'frontload' company action in order to get every company onto the sectoral pathway as soon as possible. This will minimise the risk of some companies delaying action.[37] As such, despite the cement pathway for entities and SLBs being adopted from SBTi, being verified by SBTi cannot be used as demonstration of compliance with the Cement Criteria.

The Transition Pathway Initiative (TPI)

The Transition Pathway Initiative[38] was originally proposed as the adopted pathway as it was the pathway that originally met most of the above criteria[39]. It is also based on a Sectoral Decarbonisation Approach (SDA) and similar scenarios, thus making the pathways very similar in shape. The advantage of this is that there is a good consensus for what a 1.5-degree pathway looks like for the cement sector. As discussed above, the key distinction between TPI and SBTi is that TPI do not include waste fuel emissions in their pathway. In reality, this is immaterial to whether companies meet the pathway – by excluding waste burning emissions, the pathway becomes more ambitious because emissions from waste are not included in the underlying carbon budget. In any case, it is simpler for Climate Bonds to leverage the pathway that aligns with the chosen scope of emissions.

TPI also evaluate companies based on publicly disclosed data. However, they seemingly do not utilise a convergence tool as SBTi, meaning they instead focus on which companies are already on the pathway, and which have set targets that comply with that pathway. As such, TPI can serve as a valuable tool for determining what companies might initially meet the Cement Criteria based on their decarbonisation KPIs. TPI is thus a valuable tool for determining necessary ambition of cement companies. It should be

[35] https://sciencebasedtargets.org/resources/files/Cement-guidance-public-consultation.pdf
[36] SBTi goes further into the SDA here: https://sciencebasedtargets.org/resources/files/Sectoral-Decarbonization-Approach-Report.pdf
[37] This proposal, captured in the two-tier entity level criteria, is currently out for public consultation.
[38] www.transitionpathwayinitiative.org/sectors/cement
[39] Full description of the methodology behind the pathway can be found here: www.transitionpathwayinitiative.org/publications/76.pdf?type=Publication

considered that the TPI cement tool and Climate Bonds Criteria are aligned insofar as companies meeting the TPI carbon performance requirements *might* also meet the Climate Bonds cement company pathway.[40]

The GCCA 2050 Cement and Concrete Industry Roadmap for Net Zero Concrete

The GCCA released in 2021 a roadmap[41] for the cement and concrete industry to reach net zero by 2050. It is an ambitious initiative from these sectors to reduce their emissions in line with meeting the targets of the Paris Agreement. However, due to its focus on absolute emissions reduction, and on concrete as well as cement, meant that adopting this as a pathway would have meant extrapolation of part of the pathway when this may not have been its intended use. Furthermore, it is not based on an SDA approach as is the strength of the aforementioned pathways.

Other pathways evaluated

- Assessing Low Carbon Transition Initiative (ACT)
- IEA Net Zero by 2050 report[42]
- Cement Technology Roadmap for Brazil[43]
- One Earth Climate Model[44]
- McKinsey – Laying the foundation for zero-carbon cement[45]

4.3.2 Setting an emissions pathway for cement plants

A company is naturally comprised of a wide range of assets with differing emissions performance. Yet, despite higher emissions assets, the overall ambition of decarbonisation may be sufficient for 1.5-degrees. However, at a plant level, those certified as green must represent the highest level of ambition that ultimately drives a company's decarbonisation. As such, the TWG's view was that plants should represent the 'gold standard' compared to companies which take a more pragmatic (yet nonetheless ambitious) view of achieving the Paris Goals.

Similar to company pathways, a range of potential ideas were explored by the TWG to investigate:

a) What good performance looks like *today* for a cement plant
b) What good performance looks like *in 2050* for a cement plant
c) What the pathway is between those points

It was agreed early on by the TWG that a technology agnostic emissions intensity pathway (akin to the company level pathway) was necessary. This avoids the extremely contextual nature of cement decarbonisation. Regional, and even local, contexts of cement decarbonisation meant that setting specific criteria on clinker factor, fuel substitution, and other technology switches would be extremely difficult.

Few benchmarks exist that provide exactly the pathway needed for these criteria. As a result, various existing work was combined instead. These are discussed below.

The chosen starting point – the EU Taxonomy on Sustainable Finance

The EU Taxonomy on Sustainable Finance[46] (hereafter referred to as the EU Taxonomy) is a set of green definitions enshrined in EU law whereby all investors must disclose the extent to which their EU investments align with the EU Taxonomy. In other words, the Taxonomy lays out the criteria for EU investments to be referred to as 'green'.

It categorises criteria by economic activity. Therefore, the manufacture of cement is included in the EU Taxonomy[47]. It contains two thresholds that can be met for a cement manufacture activity to be making a significant contribution to climate mitigation. The

[40] This would need further analysis.
[41] https://gccassociation.org/concretefuture/wp-content/uploads/2021/10/GCCA-Concrete-Future-Roadmap-Document-AW.pdf
[42] https://iea.blob.core.windows.net/assets/beceb956-0dcf-4d73-89fe-1310e3046d68/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf
[43] www.globalcement.com/news/item/9102-snic-launches-cement-technology-roadmap-for-brazil
[44] www.uts.edu.au/research-and-teaching/our-research/institute-sustainable-futures/our-research/energy-futures/one-earth-climate-model
[45] www.mckinsey.com/industries/chemicals/our-insights/the-21st-century-cement-plant-greener-and-more-connected
[46] https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en#regulation
[47] It can be found in the Technical Annex here: https://eur-lex.europa.eu/resource.html?uri=cellar:d84ec73c-c773-11eb-a925-01aa75ed71a1.0021.02/DOC_2&format=PDF

TWG chose the cement threshold as the starting point for criteria, but as these are single thresholds, not pathways, they were not determined as suitable for criteria purposes. For extra context, the EU Taxonomy threshold for clinker production represents the average emissions of the top 10% most efficient cement manufacture installations in the EU. The threshold for cement production is formed by applying a clinker factor of 0.65 to this first threshold. The EU Taxonomy threshold for cement production is 0.469t CO2 per tonne of cementitious material, compared to the 2022 threshold value of the TPI pathway of 0.445t CO2 per tonne of cementitious material.

Distinct regional starting points

The TWG discussed the difficulty in determining an appropriate starting threshold for an eligible plant that was both ambitious and realistic for any region. The proposed starting point of the EU Taxonomy (0.469t CO2eq / t cement) was considered an unrealistic picture of best practice in non-EU regions. That is because the EU region has access to larger quantities of fly ash and blast furnace slag as SCMs, along with waste fuels. It was considered unfair to other regions such as Africa which do not have these industry by-products to reduce the footprint of the cement industry.

The second option was to find regional numbers that correspond to the EU Taxonomy. In other words, the top 10% most emissions efficient plants by each region which would better reflect regional contexts. However, several difficulties were encountered. Firstly, data accessibility is extremely limited. The GNR does not have plant-level data (and does not cover all global production in any case). Data for China – a key region – would be even more difficult to obtain. Secondly, even if plant level data existed by region, there would still exist the same problem raised by setting the EU Taxonomy threshold. Regions are relatively ambiguous units that would group countries with higher and lower performance. As such, there would always be countries having it easier or tougher than others.

It is important to note that there is a way the issue of regional context can be at least partially mitigated. To date, no cement company has issued a Use-of-Proceeds bond, which is where the plant-level criteria would be used (Use-of-Proceeds bonds finance specific assets). They have, however, issued Sustainability Linked Bonds, which are where the company-level criteria are used. The company-level criteria provide the grace period up to 2030 for companies not yet on the necessary pathway. This period of adjustment is where the criteria can recognise the regional contexts that may mean a company or producer is not yet on the global pathway but can adopt practices that will push it that way. Moreover, the below criteria for plant measures provide potential for certification of investments into reducing a plant's emissions. There is therefore still considerable opportunity for plants located in emerging economies to be certified.

Nonetheless, future iterations of criteria should continuously screen for new datasets that could achieve this. However, currently, data simply do not exist that would provide this level playing field.

A less ambitious starting point based on a high performing region

The TWG explored setting the emissions intensity threshold as that of the highest performing country average. This was because this would at least be based on accessible data and provides a more realistic idea of what good looks like today for cement production. However, this would be difficult to defend as robust or based on science. Moreover, it would not be a level playing field, with plants from the chosen country naturally being favoured.

Setting a pathway to 2050

With the starting point chosen, it was then decided to simply follow the trajectory set by SBTi and TPI in their respective company pathways, down to zero by 2050. The trajectory reflects the level of ambition required to reach net zero by 2050 and halve emissions by 2030. However, both pathways also reflect decadal differences in action taken by the sector. For example, 2030 – 2040 sees greater decarbonisation than 2020 – 2030 due to technology developments. It is thus logical that these trends extend to plants, not just companies (which are ultimately restricted by the same technological limits).

This endpoint reflects the expectation that, by 2050, every 'green' cement plant should be zero emissions, through technological breakthrough and maximising existing decarbonisation levers. However, it is acknowledged that zero-carbon cement is currently unachievable with existing technology. Continuous review of criteria will evaluate this 2050 endpoint and whether or not technology has evolved sufficiently for zero-carbon cement to be the green standard.

With the various realities discussed in mind, CBI proposes to use the only source of real emissions data available which is the EU Taxonomy. The trajectory of emissions reductions determined by the SDA (SBTi and TPI both have similar trajectories) is then applied to this starting point, to reach an end point of zero by 2050.

4.3.3 Accounting for cement strength as a proxy of clinker quality

The mitigation requirements are based on a strategy to be part of an economy that is net zero by 2050. It is not currently possible to achieve zero carbon cement due to the limitations of today's technologies but that may change over time. Nonetheless, considerable abatement can be achieved through focusing on the carbon intensity of binders, which, linked to improvement in concrete technology and structural design, promise abatement of emissions of perhaps 95% with today's technologies.

Based on this, the mitigation criteria proposed focus also on the quality (i.e., chemical reactivity) of the Portland clinker. By creating a higher chemical reactivity in cement, it enables a greater potential for adding SCMs and thus reducing the emissions per tonne of cement while keeping the same performance levels in use. This will enable future improvements both in activities downstream of clinker production as well as guaranteeing a production process which is compatible with the expected requirements of novel SCMs. At the same time, it is intended to rule out low quality cements with little overall mitigation benefit and safety issues.

Cement grades (i.e., the compressive strength) are not a perfect representation of clinker reactivity which is far more complex. However, it is easily testable across plants, and companies know the different cement products being produced across their operations. To balance the need for light touch monitoring and the requirement for future-proofing production, a correction factor has thus been computed for each strength class of the cement produced. This is a proxy measure of the quality of the Portland component of the cement and considers:

- its chemical reactivity (which results from the crystalline composition obtained in the kiln)
- the quality of the grinding.

Based on the dilution factor, it can be deduced that the average pure Portland cement which would be produced globally would be a 42.5 MPa (based on the European Standard EN-197[48]). Because of the necessity of decarbonising the Portland component, a discount on the carbon intensity is applied based on the clinker factor ranging from 0.87 for a 52.5 to 1.18 for a 32.5. In other words, if a higher cement class is being produced (e.g., 52.5), it is assumed that the clinker quality is greater and there has been more opportunity for SCM addition. As such, the multiplier of 0.87 applied to the thresholds results in a lower threshold. Vice versa, a low-class cement (e.g., 32.5) is assumed to have lower quality clinker and therefore, to maintain the same quality of performance, less SCMs can be added.

Below is the method used to calculate the correction factors

The relationship between the strength of a cement and its dilution is thus:

- Expected strength = 20+90*(clinker factor - 0.47)
- With the strength in MPa.

The aim is to not penalise the production of higher strength cement, which has the potential for higher substitution in the future. We therefore calculate the expected emissions of a cement produced under current world emissions (based on GCCA data) diluted or concentrated to reach 32.5 and 52.5 MPa respectively.

The global average cement grade is 42.5, with an intensity of 649g CO2eq / t cement (similar to the GCCA global average if transport and quarrying are included). *Diluting* the cement from a clinker factor of 0.72 (the global average) to 0.61 would reduce the strength of the cement produced to 32.5, and the emissions to 550 kg/t. *Concentrating* the cement to a clinker factor of 0.83 would yield a cement of strength 52.5 and emissions 748 kg/t.

In doing this, only the dilution has altered. Clinker quality has not changed, and so these three cements should have the same CO2 rating. Determining the ratios, we find that the correction factors are:

Table 3. Correction factors according to cement grade/class, with emissions intensity references

Cement Grade	Emissions intensity	Correction factor
32.5	550	1.18
42.5	649	1.00
52.5	748	0.87

[48] https://datis-inc.com/blog/what-is-en-197-1-standard/#:~:text=EN%20197%2D1%20Scope,-EN%20197%2D1&text=This%20European%20Standard%20defines%20and,furnace%20cements%20and%20their%20constituents.

Substitution with *reactive* materials will then cause a reduction in strength lower, in proportion, than the emissions abated. Therefore, this practice is not disfavoured by the correction factor. On the contrary, the more reactive the substitution, the more favourable the practice becomes. This is intended to achieve the objective of encouraging improvements in cement blending with reactive substitutes.

It was determined that the correction factors could not be applied to cases where applicants were meeting the facility-level pathway through the average emissions intensity threshold for the bond tenor. This is route (a) in section 4.2.3 of the Criteria Document. Any given facility can significantly alter the cement grade being produced even daily, let alone yearly. As such, it is impossible to verify a facility's emissions once at the point of certification with its current cement grade produced, and then assume that will remain the case for the bond tenor. This would provide a potential loophole for facilities producing higher strength cement at first, resulting in a lower emissions intensity, but for the rest of the certification term it produces lower strength cements. Ideally, the correction factors would be applied equally across the Criteria, with no discrepancies in the methodology. However, in this initial version, the trade-off was made to ensure a level-playing field and not create any loopholes or shortcuts to certification.

4.3.4 Distinctions in criteria between new and old production facilities

New and existing production facilities are subject to the same criteria and thus level ambition. If a whole facility is being certified, there is no reason that an existing facility should be seen as green simply because it is older. However, the TWG strongly held the view that there should still be ample opportunity for existing assets to improve their climate performance over their operating life. As such, while there are no distinctions between new and existing plants, bonds can certify measures that achieve these aims for existing infrastructure.

Equally, considering the lifetime of most cement plants, it is important to avoid the lock-in of certain technologies that do not deliver the sufficient emissions reductions considering that most new plants built today will still be online in 2050.

For sectors such as Steel, there should be a clear preference for new plants to be constructed using Electric Arc Furnace technology and which recycle scrap steel (secondary steel). This means building new plants using traditional Blast Oxygen Furnace technology should be encouraged only under strict conditions. For Cement, on the other hand, few if any technologies exist today for cement plants that could radically replace the burner or kiln systems used. The best burners and kilns from a decarbonisation perspective today are those that can burn the most types of fuels. In other words, they may be able to burn fossil fuels, but they can also burn alternative fuels such as biofuels, waste-derived fuels and, possibly in the future, low carbon hydrogen.

4.4 Determining eligible mitigation measures

The following sections detail the measures determined as eligible under these Criteria. They represent measures (capital investments) that can be financed by green bonds, providing they meet the relevant eligibility criteria. They are distinct from certifying a whole production facility. This includes automatically eligible mitigation measures, and measures that must meet certain conditions to be certified.

Automatically eligible measures are seen as 'do-no-harm' measures. In other words, while they may not deliver huge emissions savings on their own, they will never increase emissions and can lead to significant savings if bundled with other measures. It recognises that existing cement plants must also be retrofitted as best as possible with measures that bridge the gap until deeper decarbonisation measures are delivered. Conditionally eligible measures may be measures that appear beneficial from a mitigation perspective, yet additional checks and balances are needed to ensure that they do deliver the emissions reductions promised.

4.4.1 Heat Recovery Systems

Heat recovery systems always yield thermal efficacy improvements. Therefore, these systems are always eligible measures under the mitigation requirements of these criteria. They are also one of the most cost-effective measures for cement plants to implement.

4.4.2 Digitisation of control measures

Control equipment and software allow for the efficient burning of a wide range of fuel with no loss of quality in production. Similar to other sector criteria (for example the Electrical Grids and Storage Criteria), it is assumed that digitization of such processes can only lead to improvements not only in efficiency, but in the ability to more closely control cement quality and the addition of SCMs.

4.4.3 Testing equipment

Testing equipment can be used for continuous monitoring of production and evaluation of the raw meal. This is expected to always improve production quality as well as future flexibility and therefore is an automatically eligible measure under the mitigation criteria.

4.4.4 Precalciners

Precalciners for many plants represent the final step towards maximum efficiency and always yield large thermal efficacy improvement. As such, they are automatically eligible measures under the mitigation criteria.

4.4.5 Electrification of heat

Roughly a third of cement production emissions come from the burning of fuel to heat the kiln. Currently, no commercially available technologies exist that can deliver zero emission fuel in this process. However, two routes that may one day deliver this are low carbon hydrogen, and electrification of heat. Electrification of heat already holds much promise in the Steel sector. However, for cement this is extremely difficult to achieve. This is due to the high temperatures required in the kiln and the lack of conductive material within that makes achieving those temperatures technically challenging.

As such, electrified kilns are not technically feasible on a large scale and industry leaders foresee them playing a small role from only 2040 onwards. Nonetheless, these Criteria recognize that zero emissions fuels should be encouraged in the cement sector and will be necessary beyond waste fuels and biofuels. Therefore, despite being extremely early stage for these technologies, the Cement Criteria view them as automatically eligible if a plant or company can implement the technology commercially.

It is important to note that tackling fuel emissions still leaves most cement production emissions untouched. CO_2 will continue to be emitted through the calcification process even with zero emissions fuel. Therefore, other levers will still be crucial to explore to decarbonise the full range of emissions in the sector.

4.5 Other mitigation measures

The following are potential mitigation measures in cement production that cannot be certified in and of themselves. This may be because:

- Determining their contribution to emissions reduction is difficult.
- They are not a capital investment (i.e., a physical asset) but rather procurement of a material that decreases emissions overall.

4.5.1 Separation of grinding and blending

Grinding is the stage of cement production where the clinker is ground into a fine powder that can then be blended with other SCMs to make the finished cement product. In general, improvements in grinding technology produce higher efficiencies. This is because grinding increases the surface area and thus, the reactivity and quality of the product. It is also possible to electrify grinders for energy efficiency improvements. However, it is difficult to estimate beforehand the improvement a grinder will yield to the quality of production. As such, improvements to grinders are not automatically eligible. Rather, they must demonstrably deliver emissions reductions in line with the pathway or be part of an eligible plant.

Blending of cement can occur both in the grinder and separately. The installation of a separate blender allows more flexibility and better control of quality in the production. However, as above this may not guarantee lower emissions.

4.5.2 Supplementary Cementitious Materials (SCMs)

Lowering the clinker factor of cement is frequently cited as one of the most important (and feasible) decarbonisation levers for the sector. Currently the most common SCMs globally are coal fly ash and blast furnace slag, by-products of the coal and steel industries. While the TWG support their use as SCMs in order to reduce emissions, there of course a strong view that these criteria should not overly rely on them. Coal power, and blast furnace processes in steel, must be phased out if the Paris goals are to be met. As such, these SCMs will be in increasingly short supply. The TWG thus decided that companies including increased future use of these in meeting pathways is not accepted. This ensures that future emissions reductions are future proofed. This does not penalise cements that use them today and are sufficiently low carbon.

Other SCMs hold great promise for maintaining high performance cement while decreasing clinker content. Calcined clays, limestone and silica fume all are cited as promising in this area. Today, the global average clinker factor lies around 0.72. Various reports surmise that this must decrease to 0.57 and possibly beyond in order to reach net zero[49].

Some SCMs are produced with calciners similar to clinker, notably calcined clays[50]. As such, this could be a measure that is certified if the production is indeed dedicated to SCMs. These criteria aim to encourage the production of such materials as a key mitigation lever. However, because they are produced similar to clinker, ultimately the applicant should be able to demonstrate that the final cement product meets the necessary thresholds in order to be certified.

4.6 General criteria for retrofits which sufficiently reduces emissions

The TWG have identified measures that automatically meet the mitigation requirements of these criteria (discussed in the previous sections). However, for measures not identified as such, other cement production equipment retrofits or installations can meet the mitigation requirements if they demonstrate an improvement of equivalent to the emissions decrease of the plant-level pathway during the term of certification. This would also allow the issuer to count the cost of the whole bundle of measures in the bond if these criteria are met.

These criteria intend to act as a catch-all criterion for measures which may be qualitatively difficult to evaluate, but on a case-by-case basis they may result in considerable emissions reductions, especially if combined with other measures.

4.7 Cross-cutting criteria

Cross-cutting criteria were developed for decarbonisation measures and strategies regardless of whether they are an individual measure or capital investment being financed, or part of an entire facility. As such, some of these fall under the conditionally eligible measures in the Criteria.

4.7.1 Biomass as a fuel

Currently, biofuels provide a significant proportion of the required thermal energy in cement plants. The substitution of fossil fuels in the cement sector is also complex. The potential for different alternative fuels (both in the short-term and the long-term) differs considerably across regions. As such, these criteria do not outright exclude biofuel use in cement plants.

However, the TWG agreed that there are well known risks associated with biofuel production, namely Direct and Indirect Land Use Change (dLUC and iLUC) as well as other environmental impacts. As such, these criteria add precautionary criteria around the sourcing of biofuels to ensure that:

1. The biomass has a sufficiently low emissions profile per unit of energy (MJ)
2. Production of the biomass has not resulted in LUC

[49] IEA Net Zero by 2050: https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf
[50] https://link.springer.com/article/10.1617/s11527-021-01807-6#Fig12

To do this, any biomass used must meet the requirements of the Bioenergy Criteria under the Climate Bonds Standard. Full rationale and requirements can be found in those criteria[51].

4.7.2 Hydrogen as a fuel

In addition to kiln electrification, hydrogen is a fuel source that could provide emissions free heat to a cement kiln, at least in the long-term. Like electrified kilns, heating a kiln using hydrogen is still being developed as a concept[52,53]. However, technically, it is closer to being achieved commercially. This is helped by the strong interest in the gas across all industrial sectors which is set to push prices down to competitive levels, such that by 2050 costs could be comparable to fossil gas[54]. Compared to the Steel and Chemicals industry, however, doubts still exist as to whether Hydrogen represents as big an opportunity for Cement. Again this links to the fact that fuel switching only partially addresses cement production emissions.

In any case, Hydrogen must first be produced using low carbon electricity for it to truly deliver as a zero-emission fuel. For this reason, additional requirements on lifecycle emissions of the Hydrogen being used are set. A hydrogen sector level pathway was not available at the time of finishing these criteria, subsequently, the approach used in the Basic Chemicals criteria was adopted and it is explained below.

The 2022 threshold is taken from the EU taxonomy[55]and the approach in setting such thresholds is based on the 10% best performing facilities in Europe during a given period. For the 2030 threshold, the projection was done using the SBTi cross-sectoral pathway method[56]. Afterwards, the life cycle GHG emission values for hydrogen produced from renewable energy and feedstock alternatives (biomass) projected by the Hydrogen Council[57] were taken as reference to set out the thresholds for 2040 and 2050. This projection reveals that achieving the thresholds adopted in these criteria is feasible.

The Climate Bonds Initiative is currently developing criteria for hydrogen. Once the hydrogen criteria are published, it shall supersede the requirements set in this section.

4.7.3 Waste-derived fuels

Summary

CBI acknowledges the valid concerns of incinerating various waste streams for the purposes of energy. 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 particular risk. 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 various Municipal Solid Waste (MSW) in incineration facilities.

Alternative Fuels and Raw Materials (AFR) more generally are currently the only technically viable option for fuel switching from fossil fuels. They tend to have lower emissions profiles than fossil fuels due to their biogenic fraction[58]. The primary objective of the Cement Criteria is to indicate cement production assets and activities that are aligned with a 1.5°C warming pathway. Cleaner fuel technologies are still under development. Supplementary Cementitious Materials (SCMs) should be strongly promoted but new cement blends are yet to become industry norm. Carbon capture technology will not prove its real potential for driving significant emissions cuts in the sector until 2030 onwards. In other words, deep decarbonisation of the sector will not be feasible until 2030 onwards. Halving emissions by 2030 is still a crucial aspect of keeping temperature increases to 1.5°C and thus emissions cuts must be front-loaded as much as possible. In the interim, therefore, emissions reductions must be enacted in all aspects of cement production. By excluding MSW as a potential fuel type, there is a real risk that cement plants would be unable to align with a 1.5°C warming pathway. That means a potential trade-off between the sector's climate goals, and its' pollution and circular economy impacts which can be mitigated.

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[51] www.climatebonds.net/standard/bioenergy
[52] Hydrogen use in industry | Climate Solutions (frompollutiontosolution.org)
[53] Green hydrogen for grey cement - Cement industry news from Global Cement
[54] BNEF Long Form Template (Grid) (bloomberglp.com)
[55] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R2139
[56] SBTi (2015). SECTORAL DECARBONIZATION APPROACH (SDA): A method for setting corporate emission reduction targets in line with climate science. https://sciencebasedtargets.org/resources/files/Sectoral-Decarbonization-Approach-Report.pdf
[57] Hydrogen Council (2021). Hydrogen decarbonisation pathways. A life cycle assessment. Available at: https://hydrogencouncil.com/wp-content/uploads/2021/01/Hydrogen-Council-Report_Decarbonization-Pathways_Part-1-Lifecycle-Assessment.pdf
[58] See section below: 'The emissions profile of AFR' for full explanation

Nonetheless, considering the public feedback on MSW incineration in the cement sector, CBI introduced three additional criteria for waste-derived fuels. Firstly, emissions from waste burning are included in meeting thresholds. This ensures it is not simply assumed waste-derived fuels always has a lower emissions profile than fossil fuels when in fact this can vary. Secondly, a cut-off date is stipulated that MSW is accepted as an eligible fuel. This will clearly signal that it is a transition fuel rather than a long-term fuel solution, by which point cleaner alternatives should be ready. Finally, continuously monitoring of non-GHG pollutants must be demonstrated by the applicant in accordance with industry best-practice guidance, and publicly disclosed. Limits are also set on the various pollutants that are referenced by industry best practice guidelines[59].

The emissions profile of AFR

When burnt, AFR are not zero emissions. However, most AFR will have a biogenic fraction[60]. In accounting terms, biogenic carbon exists in a separate cycle to the carbon stored in fossil fuels. The carbon stored in biological material has been sequestered much faster than the carbon found in fossil fuels which is built up on a geological timescale. In other words, the CO2 released from AFR will be sequestered by biomass soon afterwards. Biogenic carbon is thus often regarded as zero emissions in LCA (depending on the source). When the focus is more closely on woody and agricultural waste, GHG advantage over fossil fuels is widely accepted[61, 62]. Rice husk waste, for example, is 100% biogenic in origin. For MSW, some assessments have indicated that about 20-40% of the carbon is derived from fossil sources, e.g., plastics[63]. As a result, MSW *can* result in lower emissions than fossil fuels depending on its biogenic fraction[64].

Side note – Bioenergy

Bioenergy used in cement production must also meet the Climate Bonds Bioenergy Criteria. This includes GHG thresholds and provisions to prevent Indirect Land Use Change (ILUC). Woody biomass (for example, forestry grown for bioenergy) is excluded from these criteria. By extension, cement production cannot use woody biomass as an eligible fuel. Woody biomass typically has the highest biogenic carbon emissions of biomass types due to the long rotation times and slow growing nature of the biomass.

MSW may equally have a relatively small biogenic fraction which means burning of the fuel does not result in emissions savings compared to fossil fuels. There is thus rationale for counting the emissions from burning AFR, also known as 'gross' emissions. The Science Based Targets Initiative (SBTi) requires emissions to be measured in such terms. Aligning with SBTi would result in a neutral view of MSW and their emissions must be accounted for in meeting thresholds as with any other fuel. Moreover, requiring AFR emissions to be counted would force cement producers to lean more on other decarbonisation levers such as SCMs in order to meet the criteria emissions thresholds.

One additional item of interest is the potential for cement emissions to become net positive when combined with CCS. A study by Fennell et al (2021)[65] explored how the biogenic fraction of MSW combined with CCS (which also captures process-related emissions from clinker production) can result in lower emissions compared to full hydrogen or electrified processes. However, it is not clear if this is preferable towards 2050, when ideally waste streams should be considerably minimised.

Timelines – MSW is a transition fuel

Cement production today is wholly reliant on fuel burning as a means of sourcing its energy. Typically, fossil fuels are used (81% of the global fuel mix), of which approximately 41% is pet coke and 46% is coal[66]. There are apparently no alternatives today for cement plants that do not involve burning a carbon-based fuel. Kiln electrification is only beginning to be explored, with no large-scale pilot plants yet built. There are still considerable technical barriers which must be overcome before a kiln can be heated to such high

[59] www.giz.de/en/downloads/giz-2020_en_guidelines-pre-coprocessing.pdf
[60] www.ieabioenergy.com/iea-publications/faq/woodybiomass/biogenic-co2/
[61] Liu et al (2017). Analysis of the Global Warming Potential of Biogenic CO2 Emission in Life Cycle Assessments. Available from: www.nature.com/articles/srep39857
[62] Agostini et al (2014). Carbon accounting of forest bioenergy. JRC.
[63] www.ieabioenergy.com/wp-content/uploads/2013/10/40_IEAPositionPaperMSW.pdf [Page 4]
[64] This is in line with the GHG Protocol methodology for the Waste Sector: https://ghgprotocol.org/sites/default/files/Waste%20Sector%20GHG%20Protocol_Version%205_October%202013_1_0.pdf
[65] Fennell, Davis and Mohammed (2021). Decarbonizing cement production. Joule 5, 1301–1311.
[66] According to the GCCA - https://gccassociation.org/sustainability-innovation/gnr-gcca-in-numbers/

temperatures without a conductive material (unlike for Steel)[67]. Green hydrogen holds much promise with expected price decreases and investment. However, how it can be used in cement kilns is still being determined and again is early stage[68]. This is because hydrogen combustion and the heat transfer (by radiation) in the kiln would differ significantly from fuels currently used. One feasibility study of a UK project investigating the potential for partially substitution of fossil gas with hydrogen concluded that a hydrogen flame's high heat in a burner alone might not make it suitable for clinker formation[69]. Note, even this is only looking at partial substitution – fuelling a kiln with 100% hydrogen is even more technically challenging.

CBI is nonetheless supportive of waste elimination through better design of products, and improved recycling and reuse schemes in line with the waste hierarchy. Clearly, if better options exist in the future which have better environmental credentials than MSW, they should be the only option. As such, the criteria set an initial cut-off year after which MSW is no longer accepted as an eligible fuel. This is proposed as 2035 onwards. Depending on progress made with other fuel technologies, this cut-off point could also be brought forwards in future criteria iterations.

In conclusion, while development of cleaner technologies must be accelerated, they are not market ready yet and action must be taken now to reduce emissions in cement production using all decarbonisation levers. The TWG view is that the cement production emissions pathways necessary for meeting 1.5-degree targets may be unattainable if fuel switching is not encouraged. Left only with fossil fuels or AFR, the TWG's view was that AFR should be viewed as an eligible transition fuel, with key caveats. Sector criteria are reviewed over time and thus can adapt in line with the latest science and understanding.

Circular Economy and the Waste Hierarchy

Circular economy is a key environmental objective, while a Paris-aligned economy also means zero waste. The EU Taxonomy include circular economy as an environmental objective for most economic activities. However, for Cement, there are no Do No Significant Harm (DNSH) criteria for circular economy. However, for DNSH Pollution Prevention and Control, it has the following:

'For manufacture of cement employing hazardous wastes as alternative fuels, measures are in place to ensure the safe handling of waste.'

There is then a more general reference to EU legislation to minimise pollutants such as heavy metals and dioxins. The Cement Criteria would seek to be more ambitious than this, even if the main remit of the criteria is Climate Mitigation and Adaptation & Resilience. The criteria require all waste of recycling potential to be removed prior to burning in line with the waste hierarchy. It is acknowledged this is challenging in many regions in terms of verification, but the burden will be on the applicant to demonstrate this. Robust justification will be required that no further recycling can take place of the waste to be burnt.

AFR is indeed normally contracted to a cement producer on a long-term basis. However, this should not 'lock-in' the creation of more waste as is sometimes speculated. It is implied that these contracts incentivise less recycling to provide more waste material. Because waste is always expensive to dispose of for a collector, the factors governing whether waste is recycled or burned is the cost of recycling rather than the price of waste paid for by the cement producer. By requiring all recyclable material to be removed from the waste prior to burning, this should in theory remove any possibility that a waste collector 'increases' the amount of waste being burned.

Non-GHG pollution

There is a risk from burning MSW in incineration plants is the presence of undesirable non-GHG pollutants. Several sources indicate that this risk is lowered due to key differences between the cement industry and the practice of waste incineration for electricity.

A cement kiln has many inherent features which makes it ideal for hazardous waste treatment: high temperatures, long residence time, surplus oxygen during and after combustion, good turbulence and mixing conditions, thermal inertia, dry scrubbing of the exit gas by alkaline raw material (neutralises acid gases like hydrogen chloride), fixation of the traces of heavy metals in the clinker structure, no production of by-products such as slag, ashes or liquid residues and complete recovery of energy and raw material components in the waste.[70]

Cement plants can thus destroy Persistent Organic Pollutants (POP's) to a destruction efficiency (DE) of greater than 99.9999969%. Additionally, leaching tests are generally carried out to prove there's no leaching in the final product. Cement kilns reach an average

[67] http://connectedenergysolutions.co.uk/the-challenge-of-decarbonising-the-cement-industry/#:~:text=It%20is%20currently%20not%20feasible,kiln%20temperatures%20required%20during%20clinkering.%E2%80%9D
[68] www.globalcement.com/news/item/11061-green-hydrogen-for-grey-cement
[69] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/866365/Phase_2_-_MPA_-_Cement_Production_Fuel_Switching.pdf
[70] http://synergies.pops.int/Resources/Shared/scripts/appPubKit/docs/06a-StockholmConvention-SuccessStories.English.pdf

of 1450ºC and 2000ºC at the flame while incinerators only reach 700ºC. Despite these safeguards in the process, the criteria should require appropriate filters for all waste processing, and appropriate management of filter dust that might contain heavy metals.

Nonetheless, to minimise these risks, additional criteria are in place that require continuous monitoring of non-GHG pollutants along with public disclosure of levels in plants. In addition, limits are defined for each pollutant. This is based on industry best practice guidelines, which in turn references EU legislation for permittable emissions[71]. Importantly, to create a level playing field, these additional criteria apply to any fuel being burned, including fossil fuels. This is because industry testing suggests that non-GHG emissions from AFR do not differ statistically from those of fossil fuels.

Referencing again industry best practice, special attention should be given to the mercury (Hg) content of materials used for clinker production and corresponding operational procedures due to the volatile nature of the metal. Unlike other pollutants, it is not retained in the kiln system and subsequently captured in the clinker matrix. Instead, it forms gaseous compounds that are only partially retained by condensation on the raw material in the raw mill and dust collector. To reduce Hg emissions, it is thus necessary to limit the Hg input from raw material and fuels into the kiln system. Hg emissions can be reduced by extracting filter dust during direct operation and feeding the filter dust to the cement mills. This is thus required in the criteria for all fuels.

4.7.4 Carbon Capture

CCS is the process of capturing (concentrating from diluted sources), transporting and storing CO_2 in order to prevent its release into the atmosphere. Carbon storage can be in open, closed or cycling systems[72]. Open systems include natural systems such as in biomass growth and soil. Closed systems include the geological storage in lithosphere or deep oceans and mineral formations. For the purposes of this criteria document, CCS refers specifically to closed systems as in geological storage since this is the one with the largest storage life span[73].

The technologies required for carbon capture are in early stages of development, but it is expected to make progress towards commercialisation. In addition, care should be taken in regard to the end use of the product generated from CO_2. This is mainly because if the CO_2 is immediately released into the atmosphere during end product use, the mitigation is unrealised. This means, additional restrictions are included for the end product, which should be a long-lasting or recyclable product so as to keep CO_2 in a loop.

Carbon capture and storage is currently the focus of large innovation and investment efforts in the cement sector. Few studies or models do not include CCS as a potential emissions reduction lever in their scope or projections. However, they may vary in how much weight is given to the technology. In any case, CCS will increasingly become a topic of conversation for the cement sector. Undoubtedly, the correct policy environment will be crucial to the technology reaching viability.

Climate Bond sector criteria are technology agnostic, so long as the technology can deliver the promised emissions reductions. Criteria also tend to not include in scope early-stage technology or Research and Development initiatives. As such, the transport and storage of the CO2 must be demonstrated in order for it to be certified. It is acknowledged that the scope of these criteria is limited in the opportunity given to carbon capture pilot projects. There is no doubt that such projects will need to take place and will require investment to do so. Future criteria may explore further opportunities for CCS projects as the understanding of CCS develops and the technology matures.

The EU taxonomy has set up criteria for CCS which has been adopted for the purposes of the Cement Criteria.

For simplicity, and due to the complexities around utilisation, Carbon Capture and Utilisation (CCU) is not within scope of these criteria. Future updates may include this, but the TWG noted that there are currently few applications for CCU in cement plants.

4.8 Cement recarbonation

Cement recarbonation refers to the process where part of the CO2 emitted during the cement production is re-absorbed by concrete in use through carbonation. Carbonation is a slow process that occurs in concrete where lime (calcium hydroxide) in the cement reacts with carbon dioxide from the air and forms calcium carbonate. At the end of their useful life, buildings and

[71] EU directive 2010/75 on industrial emissions

[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 CO2 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

infrastructure (reinforced concrete structures) are demolished. If the concrete is then crushed, its exposed surface area increases which in turn increases the recarbonation rate[74].

There is therefore further potential for emissions reduction in cement through increasing this recarbonation potential, along with recycling used concrete. Future criteria may explore the possibility of maximising these opportunities. However, currently there are uncertainties around the exact recarbonation rate of concrete. Existing pathways for cement production do not include this aspect, and there would be further questions on who the emissions savings would be attributed to – the cement producer, concrete producer or constructor.

Exciting new cement applications also exist which harden using CO2 as a replacement for water, further increasing the potential for carbon sequestration[75]. These criteria nonetheless aim to support these innovations where possible and acknowledge that future revisions to the criteria should continue to explore new opportunities such as these.

4.9 Adaptation and Resilience

The IPCC defines adaptation as: "The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects." [76].

The IPCC defines resilience as: "The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation." Capacity for adaptation and for resilience will depend on available assets and their distribution within a population as well as institutional infrastructure.

The Climate Resilience Principles further offers the below definition to inspire investors and issuer engagement: Climate resilience investments improve the ability of assets and systems to persist, adapt and/or transform in a timely, efficient, and fair manner that reduces risk, avoids maladaptation, unlocks development and creates benefits, including for the public good, against the increasing prevalence and severity of climate-related stresses and shocks.

Climate adaptation and resilience mitigation criteria are designed to ensure that a project itself is resilient to climate change and that it does not affect the resilience of other sectors. The development of the requirements for the A&R component was based on CBI's "Climate resilience principles" document[77]. ***Figure 5*** gives an overview of the six principles for resilience.

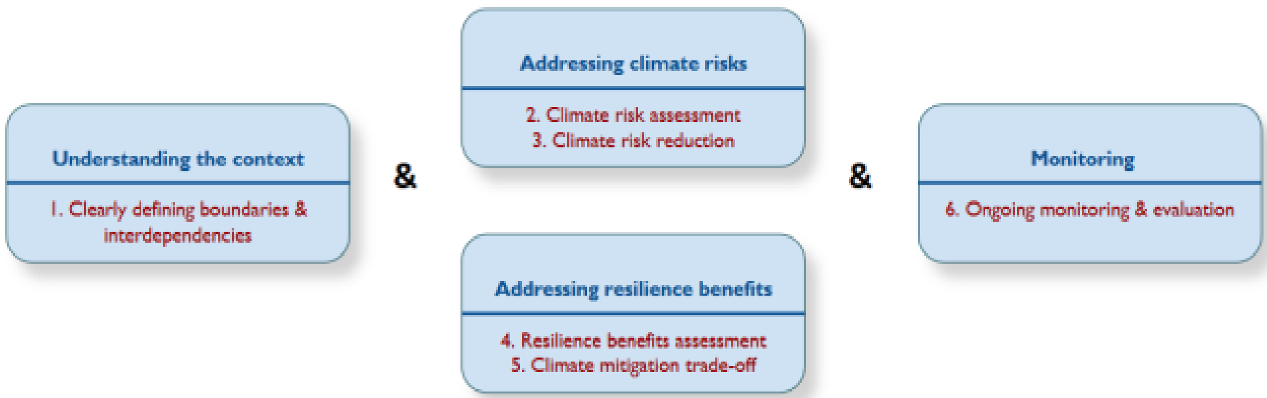

Figure 5. The Climate Resilience Principles

[74] https://circulareconomy.europa.eu/platform/en/good-practices/cement-recarbonation
[75] www.solidiatech.com/solutions.html
[76] Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability.Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field CB et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32. http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/ar5_wgII_spm_en.pdf
[77] CBI (2019). Climate Resilience Principles. A framework for assessing climate resilience investments. www.climatebonds.net/climate-resilience-principles

Although the principles provide a framework and serve as guidance for general aspects to consider, it is also recognised the challenges and limitations to assess the adaptation and resilience aspects in general. Such limitations include the lack of awareness of climate resilience benefits and a common language, robust data on climate risks and common methodologies for climate risk assessment, lack of capacity and interdependencies with other assets or actors in the supply chains. It is also acknowledged that A&R has inherent complexities which makes it harder to quantify and it can be very context specific, depending not only on location but also on the type of asset, the type of risk looked at, the level of severity and frequency of the risk, and so on. The frequency and magnitude of the impacts are commonly underestimated by companies.

Location: Appropriate geographic or other spatial boundaries for climate risk and benefits assessments for assets and activities in the sector was discussed as well as consideration of the broader system affected by those assets and activities. There are expected internal and external interdependencies between assets or activities in a given sector and between sectors (which become evident when a climate event results in a potential failure of value chains) but there can also be opportunities to maximise resilience benefit.

When developing criteria for setting the boundaries for assessment, it was proposed to separate the analysis as follows:

- Capital assets
- Production
- Logistics and supply (including raw materials, utilities and their distribution),
- Labour

Key infrastructure dependencies were identified with special relevance for the sector including water, gas, energy and other key utilities necessary to run the iron and steel production and keep the adaptation and resilience equipment and infrastructure operating during any outage arising from climate change events. All these infrastructure dependencies are to be included in the production element.

- **Timeframes**: Appropriate time horizons for climate resilience assessments need to be set for the assets and activities in scope. The criteria to base the time horizon for the assessments are set based on the typical lifetimes of assets in the sector which is 30 years on average (though it is recognised that some may last for 50 years or more).
- **Disclosure**: As part of the monitoring and evaluation principle, there are requirements for reporting and disclosing risks assessments. Currently there are a number of issues seen:
    - a lack of alignment or harmonisation as reporting is often undertaken on a voluntary basis
    - the level of completeness can be low which leads to accusations of greenwashing
    - the frequency for reporting and updating the assessment varies (recognising that the time horizons for revisiting the assessments will likely depend on the level of risk of a facility: low risk facilities can have long time horizons, and high-risk facilities short time horizons). Depending on the severity of the risk the time horizon can be set.

Other aspects to consider when setting the A&R requirements are listed as follows:

- **Identification of the key climate risks** – including hazards, exposures and vulnerabilities - likely to be experienced by assets and activities in that sector. Some insurance companies, such as FM global, can provide a useful source of data for risk assessments.
- **Models, methodologies and data sets** that would be most appropriate for determining likely physical climate risks to be faced in context for activities and assets in the sector.
- **Climate change risk measures and metrics** for assets and activities in the sector – e.g. how should assets and activities deal with these risks? How this could be evaluated?

Based on the discussions presented above, the assessment methodology includes a verification list that the verifier should complete when assessing an asset or project. It is recognised that this may not be complete, but is presented as the most robust available, given the complexities and several angles of the topic, and the lack of robust and more quantitative methodologies and tools.

Wider environmental and social risks are complex and interconnected and should be assessed under these Criteria, however the following points are noted:

- The Climate Bonds Standard is focused on climate impacts – including low GHG-compatibility (mitigation) and also climate adaptation and resilience. Defining resilience can be challenging. However, it is clear that many topics which have been a part of environmental and social assessments for a number of years overlap significantly with the resilience of affected populations and ecosystems and their ability to adapt to climate change.

- The most obvious example is the potential impact of climate change on hydrological conditions, and consequently water supply and local livelihoods. Another is climate change exacerbating ecological problems such as impaired species migration and algal blooms. Environmental and social impacts such as these, already complex and interconnected, become more so when climate change impacts and risks are taken into account, and there is a logic to addressing all key environmental factors, rather than trying to separate them out.
- The Climate Bonds Standard does not usually address primarily social impact issues, these were discussed but not considered within scope.

4.9.1 Practical requirements for this Component

Leverage existing tools

The knowledge and literature on adaptation and resilience impacts of steel production facilities is limited as this area is in its infancy. The A&R Component will require consideration of a highly complex and varied set of issues across the environmental and social spectrum for which data, methodologies and metrics may not be available. Qualitative methods based on verification lists or questionnaires have been proposed which can however be leveraged. It is not appropriate for Climate Bonds to commit resources to address these issues, and the guiding principle of simplicity shall be applied at this time. More robust criteria can be developed over time as more information is generated and integrated in the subsequent revisions of the Criteria.

However, it should be noted that existing methods do not always fully or explicitly cover the additional, often interrelated impacts connected to climate adaptation and resilience. Many of the risk assessments and management processes specified by existing guidelines will be a prerequisite for identifying A&R risks, but more may be needed to fully address them given that this is an emerging topic.

Minimise the assessment burden

In addition, there needs to be a balance between rigour and practicality. Any Criteria with a prohibitively expensive assessment burden will discourage certification. Any methodology adopted therefore need to avoid this.

A binary 'pass'/'fail' outcome rather than scores or grades

Certification decisions under the Climate Bonds Standard are binary – applicants are either certified or not. Therefore, the A&R Component needs to be framed in terms of pass/fail thresholds. Where an assessment tool provides scores or grades for a facility, consideration has been given to what threshold 'score' or result should represent a pass for the purposes of Climate Bonds Certification. It is important to note that applicants may put 'n/a' as 'not applicable' with suitable justification. Where an aspect of the requirements is not relevant to an applicant's asset or measure, it is not expected the applicant should provide evidence of meeting this.

Retrospective application

Finance raised in this sector may be for new, greenfield facilities, for retrofits or upgrades to existing facilities, or they may be a straight refinancing of an existing facility. Therefore, any proposal and associated approved assessment tool under this Component needs to be usable for both new and existing facilities.

This is not a straightforward issue; as in the case of refinancing, the facility may have been operating for a number of years. It may have been compliant with best practices in place at the time of its implementation but may not meet current best practice requirements. The selected methodology and tool will therefore need to be able to address and resolve any 'legacy issues' that may be identified.

Distinct requirements for measures and entire facilities

When the focus of certification is on a decarbonisation measure or bundle of measures, as compared to an entire production facility, adaptation risks and resilience impacts change. It is not considered proportionate to require a single measure being financed to also have to demonstrate A&R criteria are satisfied for the whole facility it is found in. As such, there are two separate A&R checklists: one for measures, the other for plants.

4.9.2 Existing tools and guidelines considered

A range of existing tools and guidelines with the most potential to be leveraged for the Steel Criteria are listed below.

Risk Assessment and Climate Scenarios

- The ISO 14091:2021 Adaptation to climate change – Guidelines on vulnerability, impacts and risk assessment standard offers guidelines for assessing the risks related to the potential impacts of climate change.[78]
- Risks can be characterised by the associated annual probability of failure or annual costs of loss or damage
- For risk assessment, the TCFD The Use of Scenario Analysis in Disclosure of Climate Related Risks and Opportunities is recommended.
- A broad range of models can be used to generate climate scenarios. Users should apply climate scenarios based on representative concentration pathway (RCP) 4.5 and 8.5 or similar / equivalent to ensure consideration for the worst-case scenario. (The IPCC 'Shared Socioeconomic Pathways' to develop potential temperature scenarios. SSP5-8.5 is the highest warming pathway, SSP3-7.0 the second highest and so on).
- The IPCC Sixth Assessment report also provides an indication as to how different temperatures impact the likelihood and severity of different climate impacts
- A framework for risk management for climate security. www.c2es.org/document/degrees-of-risk-defining-a-risk-management-framework-for-climate-security/
- Climate Change Risk Assessment Guidelines. www.ctc-n.org/system/files/dossier/3b/D4.2%20Climate%20change%20risk%20assessment%20guidelines.pdf

4.9.3 Adaptation and Resilience in the Cement Sector

The TWG held the view that the cement sector does not harbour acute climate adaptation and resilience (A&R) risks compared with other sectors, especially industrial ones. As such, the A&R criteria reflect the Climate Resilience Principles developed by Climate Bonds and the Adaptation and Resilience Expert Group (AREG)[79].

Due to the economic costs of transporting raw materials, cement plants are often located on the same site as a limestone quarry. This presents additional environmental risks when certifying bonds that finance such facilities. The TWG noted that quarries are often subject to strict planning permission processes and legislation requires prevention of adverse environmental impacts, particularly through rehabilitation requirements. However, Climate Bonds goes beyond this to ensure that in places where strict legislation is not in place, minimum safeguards prevent that no significant harm is done by the quarry to the surrounding system.

Following best practice industry guidelines, the requirements for A&R stipulate that the applicant must have a Quarry Rehabilitation Plan and Biodiversity Management Plan in place that covers these minimum safeguards. In the future, Climate Bonds may develop sector specific criteria for quarrying or mining which better covers these issues. However, the TWG also stressed that limestone quarrying is different from many other mining sectors. It does not result in the same environmental impacts.

[78] www.iso.org/standard/68508.html
[79] Climate Resilience Principles: A framework for assessing climate resilience investments. Climate Bonds Initiative. www.climatebonds.net/files/files/climate-resilience-principles-climate-bonds-initiative-20190917.pdf

Appendix A: TWG and IWG members

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TWG Observers:		
Estefania Marchan	Rocky Mountain Institute (RMI)	

All TWG and IWG participants were members of these organisations at the time of criteria development. However, some may have since moved organisations.

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Appendix B: Summary of Public Consultation

Due to their length and detail, all feedback received over the course of public consultation is presented in a separate document rather in an appendix here. This summary of public consultation includes responses and justifications as to why changes were or were not made in light of each comment. The summary can be located here[80], or on the Cement Criteria website.[81]

[80] Cement-Criteria-Public-Consultation-Summary-041022.pdf (climatebonds.net)
[81] Cement | Climate Bonds Initiative