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What are Green Cement and Concrete?

Definitions from Standards, Initiatives, and Policies around the World

Ali Hasanbeigi and Adam Sibal

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Executive Summary

The cement and concrete industry is one of the most energy- and carbon-intensive industries worldwide. The cement industry accounts for around 7% of global CO_2 emissions with a global production volume of 4.1 billion tonnes of cement and 14.0 billion m^3 of concrete produced in 2020. In the concrete production process, the creation of cement is responsible for approximately 88% of the CO_2 emissions through the direct emissions in the calcination step and fuel combustion. Demand growth is anticipated in the sector globally despite a slowdown in many countries, including China, as demand in developing nations continues to grow. Since 2015, the emissions intensity of cement production has increased globally despite slowing slightly to a 1% increase in 2022. The IEA estimates that the emissions intensity of cement production needs to reverse its current trend and see an annual emissions intensity decrease of 4% through 2030 to remain on track for the world to reach the target of the Paris Climate Agreement.

In decarbonizing the global cement and concrete industry, standards, protocols, initiatives, and government policies have a significant role to play. In recent years, major growth has been seen in the number of standards, protocols, initiatives, and policies focused on decreasing the emissions from cement and concrete production. An additional level of complexity is introduced into the current efforts to decarbonize the cement and concrete industry whereby the standards, protocols, initiatives, and policies tend to focus on either the producers of cement and concrete, the demand side of cement and concrete procurement, the finance and funding side or some combination thereof. However, through the sheer number of standards, protocols, initiatives, and policies and the variation and complexity in features, target audience, assessment boundaries, targets, pathways, requirements, reporting, certifications, and validation procedures, there has not yet been a cohesive report that compiles the information in one place to support industry, government, and other stakeholders in achieving the goal to decarbonize the cement and concrete industry.

In this report, "What are Green Cement and Concrete?", we aim to address this information gap and bring together a summary of the current major standards, protocols, initiatives, and government policies focused on reaching the goal of green/low-carbon cement and concrete production and decarbonization of this sector. Additionally, we provide a clear indication of whether a standard, initiative, or policy directs its focus on the cement and concrete producers, the demand side of cement and concrete, procurement, and/or the finance and funding sectors.

We assessed five different standards and protocols (e.g. WRI's GHG Protocols for Cement, Climate Bonds Initiative's Criteria for Climate Bonds for the Cement and Concrete Industry), fifteen different initiatives and benchmarks (e.g. Industrial Deep Decarbonization Initiative (IDDI), Science Based Target Initiative for Cement (SBTI), First Movers Coalition Initiative, and the ConcreteZero Initiative) and several selected policies from some of the world's largest cement and concrete producing countries/regions (i.e. the EU, U.S., China, India, Japan, South Korea, and Canada). We also review the whole lifecycle building embodied carbon policies currently enacted in various countries, U.S. states, and cities.

We additionally present a first-of-its-kind cross-comparison matrix that compiles the currently disaggregated standards, protocols, initiatives, and policies' key information into one table to aid industry, government, non-government organizations, and academia in quickly comparing major standards, protocols, initiatives, and policies that are currently in place or soon-to-be-released at the time of writing this report. This in-depth review of the global standards, protocols, and initiatives related to the decarbonization of the global cement and concrete industry also investigates the cement and concrete market focus areas (Table 1). Each of these is discussed in detail in the body of this report

Table 1. Summary of the focus of the current cement and concrete industry standards, protocols, and initiatives.

Cement and Concrete Market Focus Area	Count of Relevant Standards, etc.	Examples
Producers Only	13	WRI GHG Protocols, Science Based Targets Initiative, IEA Concrete Sustainability Council
Demand Only	3	IDDI, First Mover's Coalition, ConcreteZero
Finance Only	2	Climate Bond's Initiative, Climate Action 100+
Producer & Demand	1	Mission Possible Partnership

As can be seen in the table, there are a significant number of standards, protocols, and initiatives that focus on cement and concrete producers and to a significantly lesser extent on the demand and finance side. Additionally, we find that there is a lack of agreement on the definition of green cement and concrete across the standard, initiative, and policy landscape. The current lack of agreement may lead to confusion in the market for both producers and consumers of cement and concrete as well as policy makers about what green/low carbon cement and concrete are. A summary comparison of the definitions adopted by various standards, protocols, initiatives, and polices is summarized in Table 2 for cement and Figure 1 for concrete.

Table 2. Emissions intensity definition for cement as stated by standards, protocols, initiatives, and policies with stated numerical quantity targets

Standard / Initiative / Policy Name	Emissions intensity target defined as low carbon/ near zero(tonnes of CO e/tonne of cement)	Further Classifier
Climate Bonds Initiative	0.437 & 0.58	For new production facilities and companies respectively
IEA and IDDI	0.04 – 0.125	Clinker ratio utilized (0%-100%)
First Movers Coalition	0.184	
U.S. General Services Administration IRA Requirement	0.751	
New York (USA) Buy Clean	0.411	
Colorado (USA) Buy Clean	1.112	

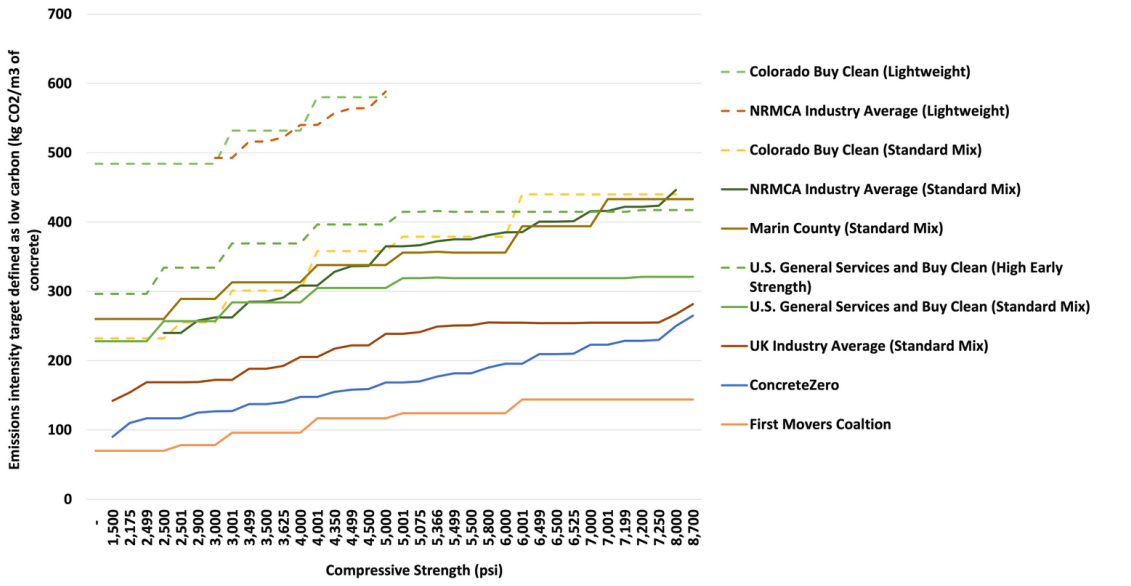

Figure 1. Emissions intensity definition for concrete at varied compressive strengths for standard, high early strength, and light weight mixes as stated by standards, protocols, initiatives, and policies with stated numerical quantity targets. Lightweight and high early strength concretes are denoted with dashed lines.

For cement, these definitions also differ in that only the IEA and IDDI (who adopted the IEA framework) consider the clinker ratio utilized, as shown in Table 2. IEA classification of green cement set one of the lowest CO_2 intensity levels compared to other standards and initiatives. For concrete, the First Movers Coalition has set the most ambitious targets for low-carbon concrete followed closely by the ConcreteZero Initiative. It should be noted however that the lowest definitions of low-carbon concrete adopted by ConcreteZero targets 30%, 50%, and 100% of concrete procurement under this threshold by 2025, 2030, and 2050 respectively while the First Movers Coalition requires 10% of the procurement to fall under their target values while other requirements apply to all procurement.

Additionally, of the definitions of low carbon concrete, all of the standards, initiatives, and policies have adopted a stepwise emissions intensity increase as compressive strength increases, except for ConcreteZero.

Also shown in Figure 1, many of the policy requirements for procurement of low carbon concrete set by the U.S. General Services Administration and Inflation Reduction Act (IRA) requirements and those of many state and county levels policies follow closely with or exceed the U.S. national average concrete emissions intensities.

Additionally, some standards, protocols, initiatives, and policies have no set target number stated. Others such as the Science Based Targets Initiative, Climate Action 100+, and Concrete Sustainability Council utilize a relative approach to an industry baseline. Some align closer with the Paris Agreement's 1.5 °C target, while others do not (see Table 5). There are also apparent differences in the disclosure requirements and verification processes across the board.

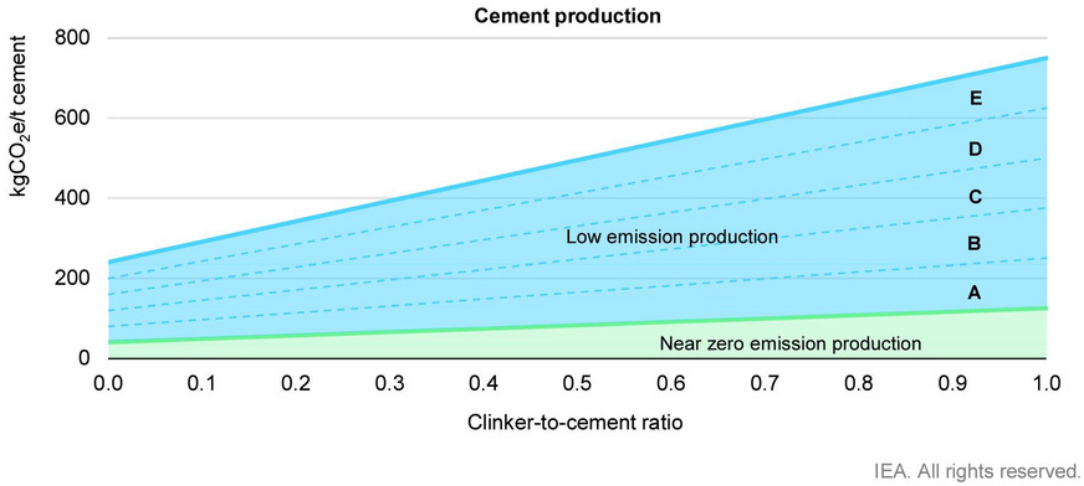

Figure 2. IEA's near zero emission cement production threshold as a function of the clinker ratio and proposed classification system (IEA 2022a).

This report also finds that the policies of the world's major cement and concrete-producing countries vary significantly. For example, the U.S., Canada, and Japan have stated targets of obtaining net zero cement and concrete production by 2050 and China by 2060. India has a goal to reach carbon neutrality in 2070.

To obtain these goals, individual nations can drive down their cement and concrete industry emissions by implementing Green Public Procurement (GPP) programs with emissions intensity thresholds for the cement and concrete they procure, as is being done currently in the U.S. and many of its states (California, New York, and Colorado) with planned GPP programs more broadly in development in Canada for cement and concrete.

We find that in many of the nations assessed in this study, the primary emissions reduction policies are being carried out through energy efficiency legislation, as seen in India, Japan, South Korea, and China. Nations can additionally implement other policies and regulations and/or incentive programs to lower their cement and concrete production emissions intensities through the adoption of technologies and measures such as material efficiency, fuel switching to low/no-carbon fuels, decreasing clinker ratios, increased utilization of supplemental cementitious materials, and CCUS.

Upon completing a thorough analysis of the various cement and concrete industry decarbonization standards, protocols, initiatives, and policies the following four key focus areas were identified as crucial to meeting Paris Agreement Goals and decarbonizing the cement and concrete industry.

- A standard, protocol, initiative, or policy should be aligned with the Paris Agreement 1.5°C target. Deep decarbonization of the cement and concrete industry is crucial to achieving the Paris Agreement target.
- Standards, protocols, initiatives, and policies should consider Scope 1, 2, and 3 emissions and provide clear boundary definitions for the calculation of their emissions guidelines. This will allow the industry to move forward consistently in achieving the deep decarbonization targets.
- Definitions of green/low carbon cement and concrete should be harmonized to limit confusion for producers, consumers, and policy makers.
- The reliability and availability of product- and plant-level data should be increased, which will be very important to continue to monitor the progress of the industry and help in the identification of areas for improvement to achieve deep decarbonization. It should be noted that cement and concrete companies and plants and most governments collect and have all the data needed to comply with the requirements of the standards, protocols, initiatives, and policies listed in this report, although such data and information may not be publicly available.

Our study shows that there are several standards and protocols and many initiatives and policies related to the decarbonization of the cement and concrete industry. These standards, protocols, initiatives, and government policies often serve different purposes and address different segments or aspects of the cement and concrete value chain.

Some target the demand side, while others target the supply side of the cement and concrete value chain. Some may be targeted toward the finance community, while some are for green public procurement policies. Therefore, it may not be possible to only have one standard for all purposes these initiatives and policies are trying to serve.

In addition, given the different contexts in which the cement and concrete industry operates in different countries, it is impractical to assume that a single standard would be used in all countries for all purposes around the world. Instead, we may need a few high-quality standards and protocols that are aligned with each other as much as possible. It is imperative that these few standards and protocols communicate and coordinate with each other to align their requirements and reduce the burden on the cement and concrete industry and other stakeholders such as policy makers as much as possible. Also, it is critical to bring developing countries' perspectives into decarbonization standards and initiatives.

In Chapter 2 of this report, we present a first-of-its-kind cross-comparison matrix that compiles the currently disaggregated standards, protocols, initiatives, and policies key information into one table to help industry, government, non-government organizations, and other stakeholders quickly compare major standards, protocols, initiatives, and policies currently in place or soon to be released at the time of writing this report.

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1. Introduction

The cement and concrete industry is one of the most energy- and carbon-intensive industries worldwide. The cement industry accounts for around 7% of global CO_2 emissions with a global production volume of 4.1 billion tonnes of cement and 14.0 billion m³ of concrete produced in 2020 (GCCA, 2023a). In the concrete production process, the creation of cement is responsible for approximately 88% of the CO_2 emissions through the direct emissions in the calcination step and fuel combustion (Marceau et al., 2007). Demand growth is anticipated in the sector globally despite a slowdown in many countries, including China, as demand in developing nations continues to grow. Since 2015 the emissions intensity of cement production has increased globally despite slowing slightly to a 1% increase in 2022. The IEA estimates that the emissions intensity of cement production needs to reverse its current trend and see annual emissions intensity declines of 4% through 2030 to remain on track for the world to reach the 1.5°C target of the Paris Climate Agreement as shown in Figure 3 (IEA, 2023).

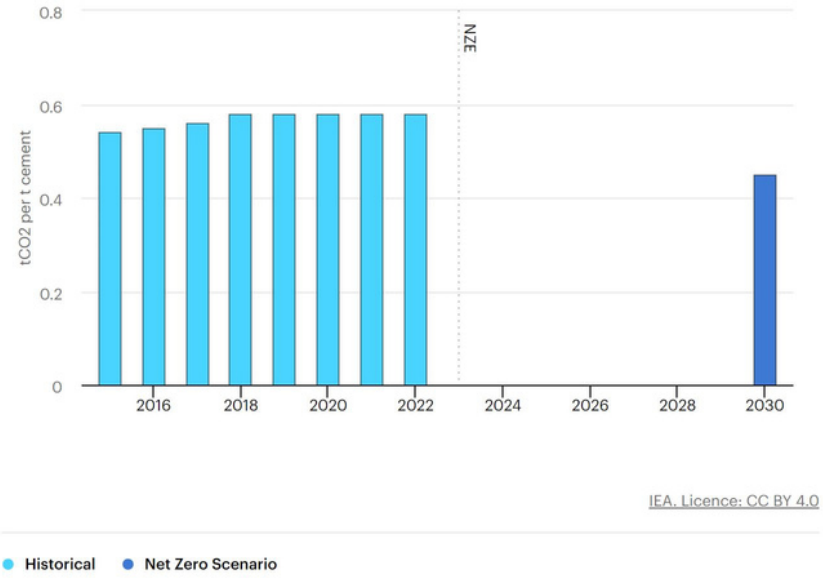

Figure 3. Cement emissions intensity reduction required by 2030 according to the IEA's Net Zero Scenario (IEA, 2023).

In addition to technological, material, and process advancements in decarbonizing the global cement and concrete industry, standards, protocols, initiatives, and government policies have a significant role to play. In recent years, major growth has been seen in the number of standards, protocols, initiatives, and policies focused on decreasing the emissions from cement and concrete production.

However, through the sheer number of standards, protocols, initiatives, and policies and the variation and complexity in features, assessment boundaries, targets, pathways, requirements, reporting, certifications, and validation procedures, there has not yet been a cohesive report that compiles the information in one place to support industry, government, and academia in achieving the goal to decarbonize the cement and concrete industry.

The World Trade Organization (WTO) also recognizes the current proliferation and fragmentation of steel sector decarbonization efforts that can be easily drawn in comparison to the current cement and concrete sector as seen in this report. The WTO states that the current landscape creates uncertainty for producers, increases transaction costs, and risks trade frictions. The WTO also stresses the importance of promoting coherence and bringing developing countries' perspectives into decarbonization standards and initiatives.

Standards should be globally relevant and technology-neutral, science-based and ambitious, have well-understood boundaries and scope, and ensure transparency in monitoring, reporting, and verification. The right methodologies enable accurate information and comparisons across products, processes, and technologies and deliver confidence in net zero claims. It is also important to develop the right methodologies for decarbonization standards in situations where governments decide to incorporate them into their domestic regulations (WTO 2022).

In this report, "What are Green Cement and Concrete?", we aim to address this issue and bring together a summary of the current major standards, protocols, initiatives, and selected government policies focused on reaching the goal of low-carbon cement and concrete production and decarbonization of the industry. We assessed five different standards and protocols, fifteen different initiatives and benchmarking studies, and selected policies from some of the world's largest cement and concrete-producing nations. For each analyzed standard, protocol, initiative, and policy we provide details wherever applicable on the:

- definition of green or low-carbon cement and concrete,
- emissions boundary/scope,
- site or product level emissions definition,
- proportionality to the clinker ratio and/or cement class,
- use of the full life cycle assessment (LCA) approach or environmental product declaration (EPD),
- numerical targets set,
- timelines,
- demand, producer, or finance side push of the initiative, standard, or policy
- consistency with the Paris Agreement 1.5°C target
- disclosure and reporting requirements
- reporting verification and enforcement
- who developed the standard or initiative
- who is using or participating in the standard or initiative
- the development status

For the policy section of this report, we also discuss the status of government initiatives and regulations as well as the progress of national organizations and companies' efforts and goals of decarbonization of the cement and concrete industry and the status of cement and concrete's inclusion in green public procurement policies.

In the report, we additionally present a first-of-its-kind cross-comparison matrix that compiles the currently disaggregated standards, protocols, initiatives, and policies' key information into one table to aid industry, government, non-government organizations, and other stakeholders in quickly comparing major standards, protocols, initiatives, and policies currently or soon to be released at the time of writing this report.

2. Summary of Standards, Protocols, Initiatives, and Policies

Each of the various cement and concrete greenhouse gas (GHG) emissions standards, protocols, initiatives, and policies has varied characteristics and requirements. In this document, standards are referred to as something set up by authority or by general consent as a rule for measuring, and initiatives are new plans or processes to achieve a goal or solve a problem. Of the standards, protocols, initiatives, and policies studied in this report, each has a different market focus area. They are designed to target the cement and concrete demand side, the cement and concrete producers, the finance sector, or the regulatory/green public procurement side. Of the standards and initiatives covering GHG emissions in the cement and concrete industry, there is a significantly larger number that focuses exclusively on the production side, while the demand and finance sides have just three and two initiatives respectively, outlined in Table 3.

Table 3. Summary of the focus of the current cement and concrete industry standards, protocols, and initiatives.

Cement and Concrete Market Focus Area	Count of Relevant Standards, etc.	Examples
Producer Only	13	WRI GHG Protocols, Science Based Targets Initiative, IEA Concrete Sustainability Council
Demand Only	3	IDDI, First Mover's Coalition, ConcreteZero
Finance Only	2	Climate Bond's Initiative, Climate Action 100+
Producer & Demand	1	Mission Possible Partnership

There are also differences in boundary definitions and the inclusion of Scope 1, 2, and 3 emissions, whether site level or product level emissions are considered as well as if a full life cycle assessment (LCA) or a more formalized LCA in the form of environmental production declaration (EPDs) is required. We also find that some standards, initiatives, and policies either apply exclusively to cement (8) or concrete (7) or consider both (13).

A cross-comparison matrix between the different standards, initiatives, and policies on these matters is presented in Table 5. The numerical emissions intensity targets/definition of green cement or concrete for each of the standards, protocols, initiatives, and policies differ as summarized in Table 4 and Figure 4.

Table 4. Emissions intensity definition for green cement and concrete as stated by standards, protocols, initiatives, and polices with stated numerical quantity targets.

Standard/Initiative/Policy Name	Emissions intensity target defined as low carbon/near zero (tonnes of CO_2 e/tonne of cement)	Further Classifier
Climate Bonds Initiative	0.437 & 0.58	For new production facilities and companies respectively
IEA and IDDI	0.04 – 0.125	Clinker ratio utilized (0%-100%)
First Movers Coalition	0.184	
U.S. General Services Administration IRA Requirement	0.751	
New York (USA) Buy Clean	0.411	
Colorado (USA) Buy Clean	1.112	

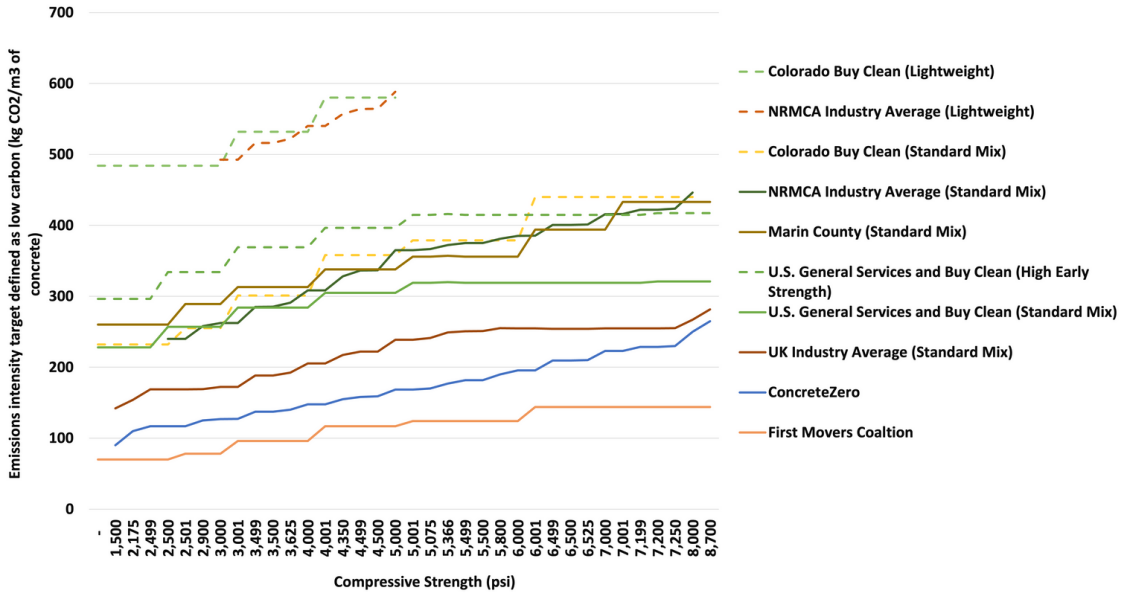

Figure 4. Emissions intensity definition for concrete at varied compressive strengths for standard, high early strength, and light weight mixes as stated by standards, protocols, initiatives, and policies with stated numerical quantity targets. Lightweight and high early strength concretes are denoted with dashed lines.

For cement, these definitions also differ in that only the IEA and IDDI (who adopted the IEA framework) consider the clinker ratio utilized, as shown in Table 4. IEA classification of green cement set one of the lowest CO_2 intensity levels compared to other standards and initiatives.

It should be noted however that the lowest definitions of low-carbon concrete adopted by Concrete Zero targets 30%, 50%, and 100% of concrete procurement under this threshold by 2025, 2030, and 2050 respectively while the First Movers Coalition requires 10% of the procurement to fall under their target values while other requirements apply to all procurement. Additionally, of the definitions of low carbon concrete, all of the standards, initiatives, and policies have adopted a stepwise emissions intensity increase as compressive strength increases, except for ConcreteZero.

Also shown in Figure 4, many of the policy requirements for procurement of low carbon concrete set by the U.S. General Services Administration and Inflation Reduction Act (IRA) requirements and those of many state and county levels policies follow closely with or exceed the U.S. national average concrete emissions intensities.

In general, for both cement and concrete, there is a lack of agreement on the definition of green cement and concrete across the standard, initiative, and policy landscape as is demonstrated in Table 4. Additionally, some standards, protocols, initiatives, and policies have no set target number stated. Others such as the Science Based Targets Initiative, Climate Action 100+, and Concrete Sustainability Council utilize a relative approach to an industry baseline. Some align closer with the Paris Agreement's 1.5 °C target, while others do not (see Table 5). There are also apparent differences in the disclosure requirements and verification processes across the board. Table 5 on the following pages outlines these differences in a cross-comparison matrix.

The purpose of the cross-comparison matrix development is to provide a first-of-its-kind overview of all of the key elements of the major standards, protocols, initiatives, and selected policies relating to the cement and concrete industry that are discussed in more detail in the body of this report.

Table 5: Cross comparison matrix for the standards, protocols, initiatives, and policies discussed in this report.

		Sectoral Coverage	Type	Cement Sector Side	Emissions Boundaries		Site/Product Level	EPD/LCA is Required/Encouraged	Disclosure	
No.	Standard/Initiative/Policy/Country Name				Boundary Defined	Scope's Included			To Standard Body	Public
1	World Resource Institute's GHG Protocol for cement and concrete	Cement and Concrete	Standard/Protocol	Producer	X	Scope 1 & 3	Site/Company and Product	No		
2	Climate Bonds Initiative's Criteria for Climate Bonds for the Cement and Concrete Industry	Cement	Standard/Protocol	Financial	X	Scope 1, 2, & 3	Product	No	X	Encouraged
3	ISO 19694-3 Stationary source emissions — Determination of greenhouse gas emissions in energy-intensive industries — Part 3: Cement industry"	Cement	Standard/Protocol	Producer	X	Scope 1, 2, & partial 3	Product	Yes		
4	ISO 14067:2018 – Carbon Footprint of Products	Cement	Standard/Protocol	Producer	X	Scope 1 & 2	Product	No		
5	Global Cement and Concrete Association "GCCA Sustainability Guidelines for the monitoring and reporting of CO2 emissions from cement manufacturing	Cement	Standard/Protocol	Producer	X	Scope 1, 2, & partial 3	Site/Company and Product	No	X	Consolidated data published
6	Industrial Deep Decarbonization Initiative (IDDI)	Cement	Intiative	Demand and GPP	X	Scope 1, 2, & partial 3	Product	Yes	X	X
7	Science Based Target Initiative for Cement	Cement	Intiative	Producer	X	Scope 1, 2, & partial 3	Site/Company and Product	No	X	X
8	First Movers Coalition Initiative: Cement and Concrete	Cement and Concrete	Intiative	Producer		Scope 1 & 2	Product	No	X	X
9	Climate Group's ConcreteZero Initiative	Concrete	Intiative	Producer		Not stated	Product	No	X	Ananymously
10	Climate Action 100+ for Cement Initiative	Cement	Intiative	Financial	X	Scope 1 & 2	Site/Company and Product	No	X	
11	IEA's Definition of Low-Carbon Cement	Cement	Intiative	Producer	X	Scope 1, 2, & partial 3	Product	No		
12	Mission Possible Partnership's Concrete Action for Climate (CAC)	Cement and Concrete	Intiative	Pro, Demand, and Financial		Scope 1, 2, & partial 3	Product	No		
13	National Institute of Standards and Technology Low Carbon Cements and Concretes Consortium	Cement and Concrete	Standard/Protocol	Producer		Not stated	Undefined yet	No		
14	Concrete Sustainability Council	Cement and Concrete	Intiative	Producer		Not stated	Product	No	X	
15	National Ready Mix Concrete Association's Life Cycle Assessment of Ready-Mixed Concrete benchmark report	Concrete	Benchmark	Producer	X	Scope 1, 2, & partial 3	Product	Yes	X	Consolidated data published
16	U.S. General Services Administration IRA's Low-Embodied Carbon Concrete Standards Material Requirement	Cement and Concrete	Intiative and Policy/Regulation	Producer and GPP		Not stated	Product	Yes	X	Not stated
17	Carbon Leadership Forum's North American Material Baselines – Cement and Concrete	Cement and Concrete	Benchmark	Producer	X	Scope 1, 2, & partial 3	Product	Yes		
18	Marin County's Low Carbon Concrete Code	Cement and Concrete	Policy/Regulation and Benchmark	Producer and GPP		Scope 1, 2, & partial 3	Product	Yes	X	
19	The Concrete Centre's UK Concrete Industry Sustainability Performance Report	Concrete	Benchmark	Producer		Scope 1, 2, & partial 3	Product	No		
20	Low Carbon Concrete Group's Low Carbon Concrete Roadmap	Concrete	Initiative and Benchmark	Producer		Scope 1, 2, & partial 3	Product	Yes	X	Consolidated data published
21	European Union Green Public Procurement and Other EU-Level Standards	Concrete	Policy/ Regulation	Producer, Demand, and GPP		Scope 1, 2, & partial 3	Product	Yes	X	X
22	United States Federal Buy Clean Inititative	Concrete	Policy/ Regulation	Producer, Demand, and GPP		Not stated	Product	Yes	X	Not stated
23	Buy Clean Program in U.S. States	Cement and Concrete	Policy/ Regulation	Producer and GPP		Not stated	Product	Yes	X	
24	Whole Lifecycle Building Embodied Carbon Policies	Cement and Concrete	Policy/ Regulation	Producer, Demand, and GPP		Varied	Site	Yes	X	
25	Canada Green Public Procurement	Cement and Concrete	Policy/ Regulation	Producer, Demand, and GPP		Not stated	Product	Yes	X	
26	China National Level and Industry Led Initiatives	X	Policy/ Regulation	Producer, Demand, Financial, and GPP		Not stated	Site/Company and Product	No	X	X
27	Japan National Level and Industry Led Standards	Cement and Concrete	Policy/ Regulation	Producer, Demand, and GPP		Not stated	Site/Company and Product	Yes	X	X
28	South Korea's National-Level and Industry-Led Standards	Cement and Concrete	Policy/ Regulation	Producer, Demand, and GPP		Not stated	Site/Company and Product	No	X	X
29	India National Level Standards and Industry Led Initiatives	Cement and Concrete	Policy/ Regulation	Producer, Demand, and GPP		Not stated	Site/Company and Product	Yes	X	X

Table 5 (Continued): Cross comparison matrix for the standards, protocols, initiatives, and policies discussed in this report.

		Targets & Modeling					Verification & Enforcement			Status	
No.	Standard/Initiative/Policy/Country Name	Numerical Target Stated	Numerical Target	Additional Target Qualifier	Is the target 1.5°C Compatable?	CO_2 accounting & reporting method	Verification	Enforcment Mechanism	Certification Granted	Current Status	Announced Updates
1	World Resource Institute's GHG Protocol for cement and concrete				Not explicetly stated	GHG Protocol	None			Released	
2	Climate Bonds Initiative's Criteria for Climate Bonds for the Cement and Concrete Industry	X	**New Steel Facilities:** 0.437 t CO_2/t cement **Operational Prior to 2022:** Installation, upgrade, or optimization of various equipment/processes as shown in **Table X** of the report **Criteria for Companies:** 0.58 tCO2/tcement	Ratchet Up Timeline & Tiered Emissions Intensity	YES	EN 19694-3, GHG Protocol	Third Party		X	Released	Every 3 years minumum
3	ISO 19694-3 Stationary source emissions — Determination of greenhouse gas emissions in energy-intensive industries — Part 3: Cement industry"				Not explicetly stated	CO2 and Energy Accounting and Reporting Standard for the Cement Industry Version 3	None			Released	
4	ISO 14067:2018 – Carbon Footprint of Products				Not explicetly stated		None			Released	
5	Global Cement and Concrete Association "GCCA Sustainability Guidelines for the monitoring and reporting of CO2 emissions from cement manufacturing				Not explicetly stated	ISO/EN 19694-3	Third Party	X		Released	
6	Industrial Deep Decarbonization Initiative (IDDI)	X	**Near zero emission cement:** 0.04-0.125 t CO_2e/ t cement (0%-100% clinker) Utilizes the IEA definitions and A-E ranking for low emissions cement	Clinker to Cement Ratio Proportional & Tiered Emissions Intensity	YES	Not explicitly stated	None		X	In Development	X
7	Science Based Target Initiative for Cement	X	**Sectoral Decarbonization Approach:** Convergence towards a common emissions intensity target **Absolution Contraction Approach:** Linear 4.2% emission reduction per year or 42% by 2030 Also includes company specific targets	Ratchet Up Timeline	YES	GHG Cement CO2 Protocols v3.0 and WBCSD Cement Sector Scope 3 GHG Accounting and Reporting Guidance	Standard Body		X	Released	X
8	First Movers Coalition Initiative: Cement and Concrete	X	**Near zero cement:** 0.184 t CO_2e/t cement **Near zero concrete:** 70 - 144 kg CO_2e/m^3 for stength classes 1 - 8,000 psi Members commit to procurring 10% of their cement/concrete as near-zero by 2030	Compressive Strength Proportional	YES	Not explicitly stated	None		X	Released	
9	Climate Group's ConcreteZero Initiative	X	Commit to procuring 30%, 50%, and 100% near-zeroconcrete by 2025, 2030, and 2050 respectively Near zero concrete defined by the **Low Carbon Concrete Group "B"** level of =90 - 260 kg CO_2e/m^3 for strength classes C8/10 to C50/60	Compressive Strength Proportional	Not explicitly stated	Low Carbon Concrete Group	None		X	Released	X
10	Climate Action 100+ for Cement Initiative	X	Emission intensity compared to IEA Beyond 2°C scenario. **Significant distance to alignment:** >36% deviation **Moderate distance to alignment:** 15%-36% deviation **Aligned or close to being aligned:** <15% deviation	Tiered Emissions Intensity	2°C	GHG Protocols	Third Party		X	In Development	
11	IEA's Definition of Low-Carbon Cement	X	**Near zero emission cement:** 0.04-0.125 t CO2e/ t cement (0%-100% clinker)	Clinker to Cement Ratio Proportional & Tiered Emissions Intensity	YES	Not explicitly stated	None			Released	
12	Mission Possible Partnership's Concrete Action for Climate (CAC)				YES	Not explicitly stated	None			In Development	
13	National Institute of Standards and Technology Low Carbon Cements and Concretes Consortium				Not explicitly stated	Not explicitly stated	None			In Development	
14	Concrete Sustainability Council		Emissions intensity reduction relative to country/region baseline **1 Star:** 30% reduction **2 Star:** 40% reduction **3 Star:** 50% reduction **4 Star:** 60% reduction		Not explicitly stated	Not explicitly stated	Third Party	X	X	Released	
15	National Ready Mix Concrete Association's Life Cycle Assessment of Ready-Mixed Concrete benchmark report		**U.S. concrete average:** 240 - 588 kg CO2e / m^3 for 2,500 - 5,000 LW psi class	Compressive Strength Proportional	Not explicitly stated	ISO 14040:2006 and ISO 14044 for LCAs and ISO 21930:2017 for EPDs	None			Released	
16	U.S. General Services Administration IRA's Low-Embodied Carbon Concrete Standards Material Requirement	X	**Cement:** 0.751 t CO_2e / t cement **Standard Mix:** 228 - 321 kg CO_2e / m^3 for 2,499-7,200 psi **High Early Strength:** 296 - 417 kg CO_2e / m^3 for 2,499-7,200 psi	Compressive Strength Proportional	Not explicitly stated	EPDs	None			Released	
17	Carbon Leadership Forum's North American Material Baselines – Cement and Concrete		**North America cement average:** 0 589 - 0.922 t CO_2e / t cement (varies by cement product) **U.S. concrete average:** 240 - 588 kg CO_2e / m^3 for 2,500 - 5,000 LW psi class **Canadian concrete average:** 179 - 486 kg CO_2e / m^3 for 15-80 MPa class (varies by region)	Compressive Strength Proportional	Not explicitly stated	Data from PCA, NRMCA, and Canadian regional EPDs	None			Released	
18	Marin County's Low Carbon Concrete Code	X	**Portland Cement Utilization:** 362 - 629 lbs / yd for concrete strength 2,500-5,000LW psi **Concrete:** 260 - 675 kg CO_2e / m^3 for concrete strength 2,500-5,000LW psi	Compressive Strength Proportional	Not explicitly stated	Not explicitly stated	Standard Body			Released	
19	The Concrete Centre's UK Concrete Industry Sustainability Performance Report		**UK standardized concrete mix average:** 72.5 kg CO_2e / t concrete		Not explicitly stated	Not explicitly stated	None			Released	Yearly
20	Low Carbon Concrete Group's Low Carbon Concrete Roadmap			Compressive Strength Proportional & Tiered Emissions Intensity	Not explicitly stated	BS EN 156431 BS EN 158042 and BS EN 167573	None		X	Released	
21	European Union Green Public Procurement and Other EU-Level Standards	X	50% voluntary GPP target. 20% in Poland, <50% France and Latvia, 100% in The Netherlands	Ratchet Up Timeline	<2°C	Not explicetly stated	None	X		Released	
22	United States Federal Buy Clean Inititative	X	**Standard Mix:** 242 - 414 kg CO_2e / m^3 for 2,499-6,500 psi **High Early Strength:** 314 - 524 kg CO_2e / m^3 for 2,499-6,500 psi **Lightweight:** 462 - 540 kg CO_2e / m^3 for 2,499-5,599 psi	Compressive Strength Proportional	<3°C	Not explicitly stated	None			Released	
23	Buy Clean Program in U.S. States	X	**New York Cement:** 0.9060 lb CO_2 / lb cement **New York Cement Utilization:** 300- 400 lbs / yrd^3 **New York SCM Utilization:** 30% minimum **Colorado concrete:** 232 - 580 kg CO_2e / m^3 for 0-5000LW psi **Colorado cement:** 1.112 kg CO_2e / t cement	Compressive Strength Proportional	Not explicitly stated	EPD (ISO 14025)	Standard Body	X		Released	X
24	Whole Lifecycle Building Embodied Carbon Policies	X	**Denmark:** Buildings larger than 1,000 m^2 - 12 kg CO_2/m^2/year **France:** Single-family homes - 640 kgCO_2/m^2 Multi-family homes: 740 kgCO_2/m^2 **Netherlands:** Residential buildings > 100 m^2 - 0.8 EUR/m^2/yr Office buildings > 100 m^2 - 1 EUR/m^2/yr **California:** Varied approaches detailed in section 5.4		Not explicitly stated	Varied	Varied	X		Released	
25	Canada Green Public Procurement	X	Reduce embodied carbon by 30% in 2025 and net-zero by 2050	Ratchet Up Timeline	<4°C	EPD, , wbLCA, LCA2	Standard Body	X		Released	X
26	China National Level and Industry Led Initiatives	X	Emissions peaking in 2030 and net-zero by 2060	Ratchet Up Timeline	NO	Not explicitly stated	Standard Body	X		Released	X
27	Japan National Level and Industry Led Standards	X	46% reduction by 2030 comapred to 2013, net-zero by 2050	Ratchet Up Timeline	<3°C	Eco Leaf EPD	Standard Body	X		Released	X
28	South Korea's National-Level and Industry-Led Standards	X	40% below 2019 levels by 2030 and carbon neutrality by 2050	Ratchet Up Timeline	<4°C	Not explicitly stated	Standard Body	X		Released	
29	India National Level Standards and Industry Led Initiatives	X	Carbon neutrality by 2070	Ratchet Up Timeline	<3°C	Not explicitly stated	Standard Body	X		Released	

3. Low-Carbon Cement and Concrete in Standards and Protocols

In this chapter, the world's most utilized standards for quantifying the emissions and/or emission intensity of cement and concrete are discussed. Standards are referred to as something set up by authority or by general consent as a rule for measuring these emissions. Each standard was reviewed and summarized to present its respective emissions scopes and boundaries, emission intensity targets if one is set, reporting requirements and verification procedures, constituency, and development status.

3.1 World Resource Institute's GHG Protocol for cement and concrete

The GHG Protocol established comprehensive global standardized frameworks to measure and manage GHG emissions for private and public sector operations, value chains, and mitigation actions. The "CO_2 and Energy Accounting and Reporting Standard for the Cement Industry" (Protocol) set a framework for GHG intensity calculation methods (WBCSD, 2011).

Features

The Protocol for cement focuses on carbon dioxide (CO_2), emissions and states that other criteria pollutants from cement production are considered negligible due to the relatively low CH_4 emissions due to the high temperatures of kilns, historic data on N_20 emissions indicate low emission levels however the main underlying reason is that most voluntary and mandatory reporting schemes are currently restricted to CO_2. Within the scope of the Protocol, cement companies must include the emissions from the following:

- Clinker production, including raw material quarrying and preparation;
- Grinding of clinker, additives, and cement substitutes such as slag, both in integrated cement plants and stand-alone grinding stations;
- Additional fuel use for on-site power generation; and
- Preparation or processing of fuels or fly ash in own installations (WBCSD, 2011).

Figure 5 demonstrates the scope and boundaries of the Protocol for cement.

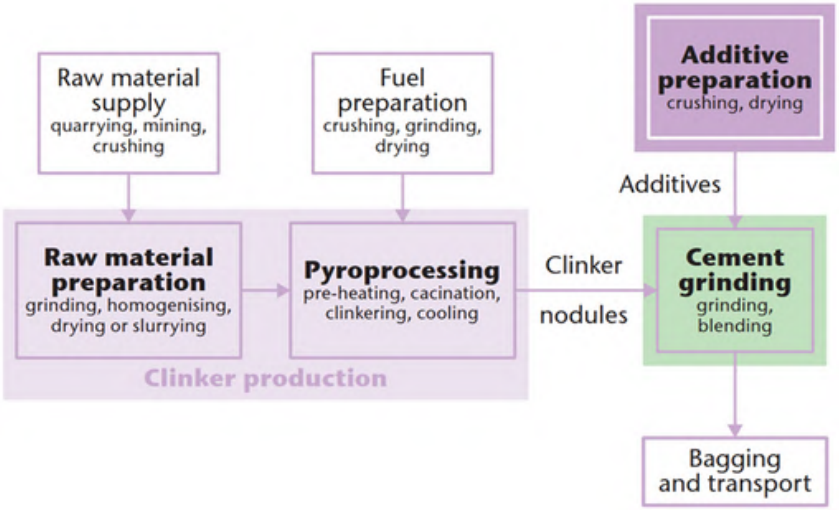

Figure 5. CO_2 emissions sources included in the GHG Protocol for cement (WBCSD, 2011).

WRI allows for both organizational and operational boundaries to be drawn in their calculations where organizational boundaries for ownership of the emissions can be set based on the company's percentage equity share in the asset or the financial control/operational control. A company with financial control, defined as having financing control to direct both the financial and operational policies of an asset, reports 100% of the emissions. The same is true for a company with operational control because it has full authority to influence operating practices at the facility.

Operational boundaries for the facility include Scope 1 emissions and direct emissions from sources that are owned or controlled by the company, for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc. However, biomass-derived sources are not required to be quantified and are instead suggested in the Protocol to be reported separately. Scope 2 emissions are considered in the Protocol for Cement, which are the emissions associated with purchased electricity. Scope 3 emissions are only considered for the indirect emissions of purchased clinker. Emissions sources that are not included in the Protocol include CO_2 from company-owned off-site transport fleets, CO_2 from the combustion of wastewater, and CH_4 and N_2O emissions.

The Protocol for cement utilizes a Tier structure to estimate a facility's emissions that evolve from industry-wide to company/site-specific as it escalates from Tier 1 to 3, however, only Tiers 1 and 2 are considered for the Protocol. The Tier structure selected for each emissions source should be selected to be the most accurate representation of the facility but remain the same to avoid double counting.

The Tiers are outlined below.

- Tier 1: Tier 1 methods estimate emissions by multiplying production data, such as the volume of fuel used or cement produced, by an industry-specific default emission factor.
- Tier 2: Tier 2 methods require less general data. For instance, a Tier 2 emission factor might reflect the typical industrial practices within a specific country, whereas a Tier 1 factor constitutes a global default value. Facility-specific data are not considered Tier 2. Tier 2 data might be available from national statistical agencies or industry associations (WBCSD, 2011).

Targets, Pathways, and Requirements

The Protocol does not set a numerical target or timelines for cement or any other products and specifically does not set a "one size fits all" materiality threshold. This instead can be set by other GHG programs/initiatives discussed in other sections of this report. There are no additional reporting requirements that include the disclosure or social impact criteria for WRI GHG Protocols (Greenhouse Gas Protocol, 2022a)

Disclosure, Reporting, Enforcement, and Quality Control

There are no direct reporting requirements or quality verifications as the WRI and WBCSD are not regulating bodies themselves, however, the guidelines may be used by regulating bodies and any other entities interested in GHG accounting and reporting (Greenhouse Gas Protocol, 2022a)

Constituency

The GHG Protocol was developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) alongside governments, industry (such as Norsk Hydro, Tokyo Electric, and Shell), NGOs (such as the WWF, Pew Center on Global Climate Change, and The Energy Institute), businesses and other organizations. The GHG Protocol is funded by 68 different companies, organizations, and government bodies across various sectors. As of 2016, 92% of Fortune 500 companies directly or indirectly utilized the GHG Protocol (Greenhouse Gas Protocol, 2022a; Greenhouse Gas Protocol, 2016; Greenhouse Gas Protocol, 2022b).

Standards Development Status

The "CO_2 and Energy Accounting and Reporting Standard for the Cement Industry" Version 3 was published in May of 2011 which superseded the "CO_2 Accounting and Reporting Standard for the Cement Industry" Version 2 published in June of 2005 and the original Protocol Version 1 published in 2001. The updated Protocol Version 3 takes account of the further extended experiences with the application of Protocol Version 2 and its evaluation for several years by many cement companies worldwide and in the CSI Getting the Numbers Right project (GNR). As reporting of energy (fuels, power) data is important for the calculation of CO_2 emissions, the name of the protocol was amended to Cement CO_2 and Energy Protocol (WBCSD, 2011).

3.2. Climate Bonds Initiative's Criteria for Climate Bonds for the Cement and Concrete Industry

The Climate Bonds Initiative is an international organization working to mobilize global capital for climate action by developing the Climate Bonds Standard and Certification Scheme. This work empowers organizations with tools and knowledge to navigate, influence, and instigate change. Within the Climate Bonds Initiative are the Climate Bonds Standard and Certification Scheme and The Cement Eligibility Criteria which are designed to be an easy-to-use screening tool that provides a clear signal to investors and intermediaries on the climate integrity of Certified Climate Bonds. The criteria outlined in the Standard and Certification Scheme sets climate change benchmarks for that sector that are used to screen assets and capital projects so that only those that have climate integrity, either through their contribution to climate mitigation and/or to adaptation and resilience to climate change, will be certified. Certification ensures that the bonds and loans are consistent with the 1.5°C warming limit in the Paris Agreement. The following can be certified under the criteria (Climate Bonds, 2023a; 2023b):

- Use-of-Proceed (UoP) bonds financing decarbonization measures (e.g., retrofits)
- UoP bonds financing cement production facilities (i.e., assets and activities)
- Assets not linked to any specific financing instrument (cement production facilities)
- Entities (cement production companies) and Sustainability Linked Debt (SLD) instruments issued by those entities

Features

The criteria cover assets and activities involved in the production of cement and companies that operate such assets or activities. The scope boundaries begin at the quarrying of limestone and end at the final blended cement product. Within a Fixed System Boundary, applicants are responsible for reporting on all emissions within the same boundary, irrespective of ownership of various processes and regardless of whether they are an integrated or non-integrated producer. The production of fly ash and blast furnace slag, concrete, and quarrying that is separate from a cement plant or is a pureplay quarry company is not within the scope. Entities out of the scope include pureplay concrete producers, pureplay quarrying companies, and pureplay clinker production companies. Emissions intensity should be accounted for in terms of tons of CO_2 per ton of cementitious product or ton of cement equivalent where cementitious product is defined as clinker, cement, and cement products produced by the reporting company.

Figure 6 demonstrates the boundary to be considered, in which Issuers must take into account the contributions from all the processes involved in the production of their cement that are shown within the fixed boundary irrespective of whether they represent Scope 1 and 2 emissions and Scope 3 emissions up to point of the finished cement for the reporting company (Cement criteria). Scope 1 emissions are the burning of fossil fuels to heat kilns, calcination emissions, emissions from alternative fuels and raw materials, and on-site power generation. Scope 2 emissions including the purchase of electricity, steam, heat, or cooling (Climate Bonds, 2023b).

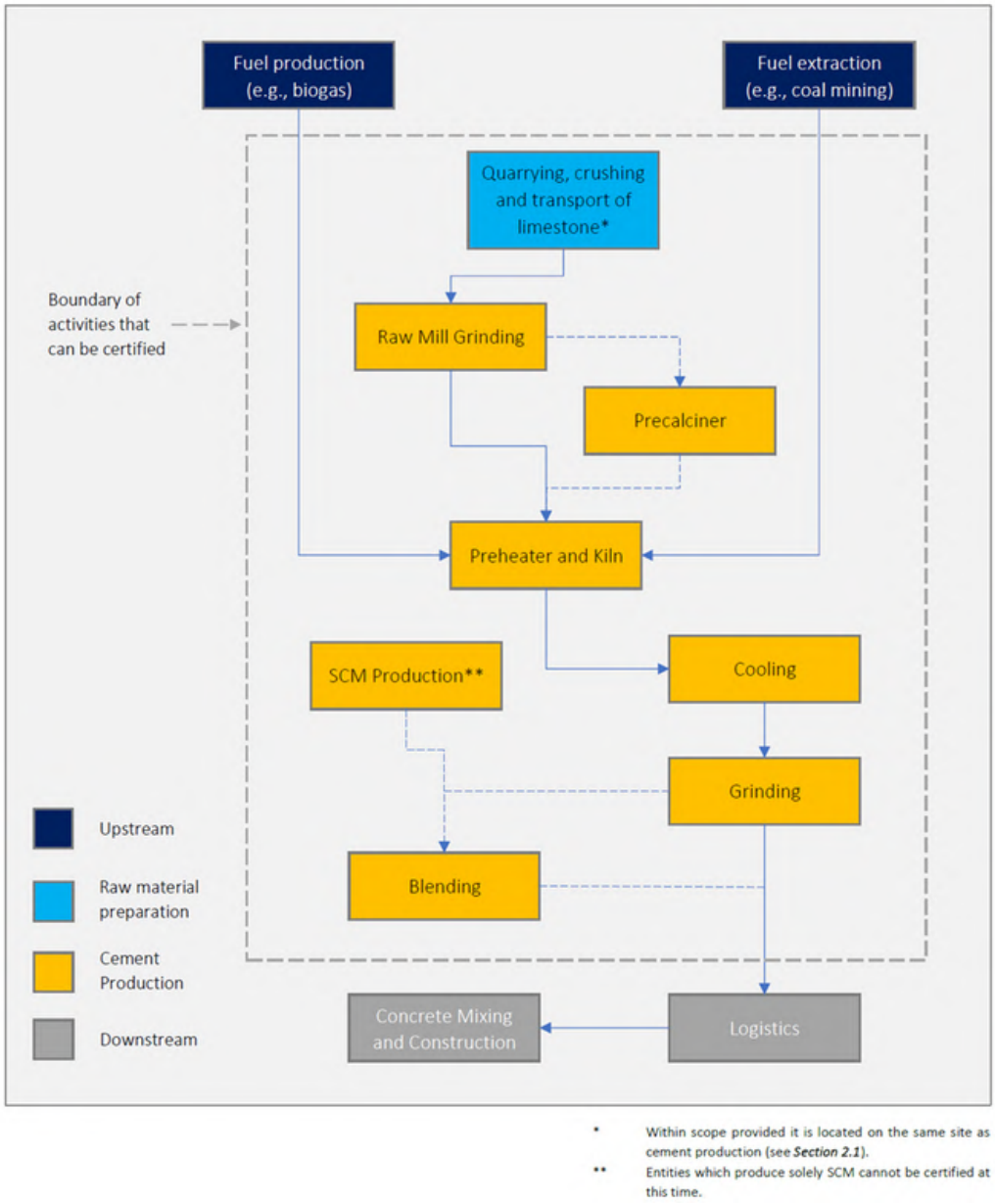

Figure 6. Fixed System Boundary for emissions intensity calculations for the Cement Eligibility Criteria of the Climate Bonds Standard and Certification Scheme (Climate Bonds, 2023b).

The Cement Eligibility Criteria of the Climate Bonds Standard & Certification Scheme also provides examples of the activities within a facility that could be certified for a cement maker as shown in Figure 7.

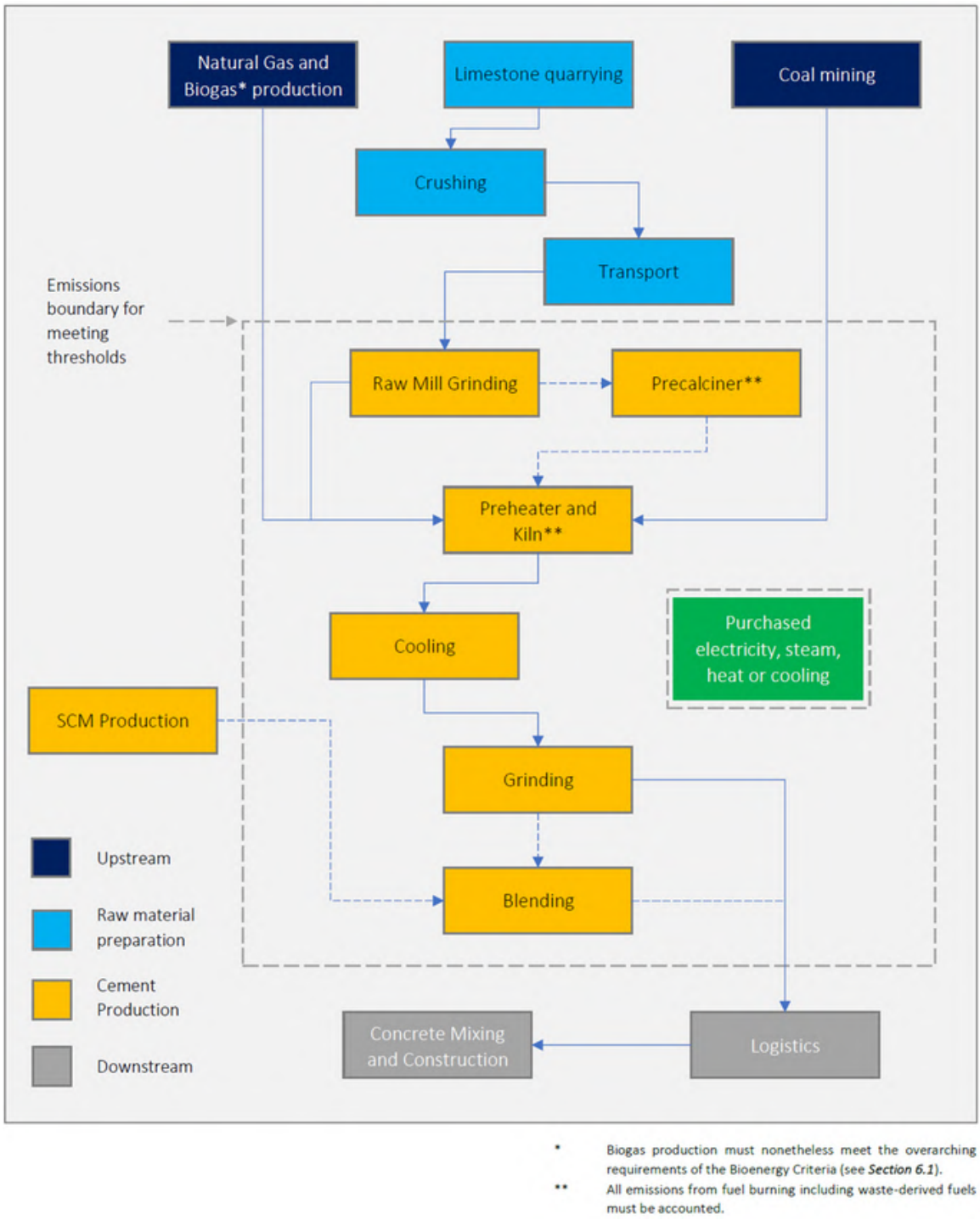

Figure 7. Example of emissions boundary for a cement producer (Climate Bonds, 2023b).

The Cement Eligibility Criteria of the Climate Bonds Standard & Certification Scheme also provides detailed requirements for facilities utilizing biomass, hydrogen, waste-derived fuels, and CCUS that are detailed in the Version 1.2 document.

Targets, Pathways, and Requirements

The GHG emissions assessment should follow the GHG Protocol on a product-level basis. The Climate Bonds Standard and Certification Scheme has set a target for the emission intensity of cement products that decrease over time, as shown in Figure 8 in the Cement Production Facilities section (Climate Bonds, 2023b).

The Climate Bonds Standard and Certification Scheme has different requirements that must be met depending on whether a new facility, an existing facility, or a whole company is applying. These requirements are discussed in detail below.

Cement Production Facilities

The emissions intensity at the time of writing this report is required to be 0.437 tonnes CO_2 per tonne of cementitious product and falls to zero by 2050 for certification of entire cement production facilities. The yearly emission intensity threshold is also presented in a tabular format in The Cement Eligibility Criteria of the Climate Bonds Standard & Certification Scheme Version 1.2.

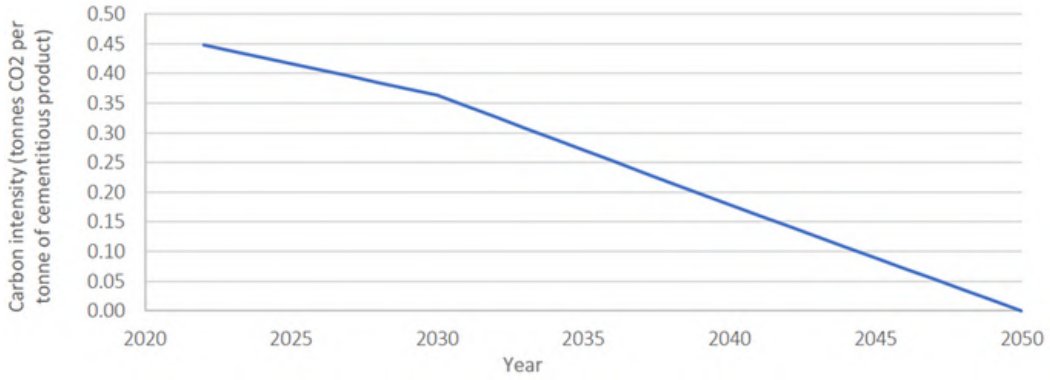

Figure 8. Decarbonization trajectory requirements for cement production facilities in Climate Bonds Initiative's Cement Criteria (Climate Bonds, 2023b).

The emissions intensity is adjusted based on a correction factor accounting for the cement class in each year as shown in Table 6.

Table 6. Correction factors for the emissions intensity based on cement class under The Cement Eligibility Criteria of the Climate Bonds Standard & Certification Scheme (Climate Bonds, 2023b).

Cement class	Correction Factor
32.5	1.18
42.5	1.00
52.5	0.87

The facility must calculate the average facility-level emissions intensity over the time of certification and demonstrate that it meets the threshold at the time of certification and commit to three yearly assessments to ensure it is meeting the new yearly threshold requirements. For facilities producing multiple cement classes, a weighted average is used to apply the correction factor (Climate Bonds, 2023b).

These facilities must also follow an Adaptation and Resilience Checklist that is further detailed in The Cement Eligibility Criteria of the Climate Bonds Standard & Certification Scheme.

Cement Production Facilities Operational Prior to 2022

For facilities operational prior to 2022, mitigation criteria have been set to allow improvements in the emissions mitigating (decarbonisation measures) intended to not lock in technologies that may impede the future decarbonization of the cement industry. These measures are broken down into those that automatically meet the mitigation component and those that are eligible subject to meeting measure-specific criteria. The requirements for these mitigation components are shown below in Table 7 (Climate Bonds, 2023b).

These measures must also follow an Adaptation and Resilience Checklist that is further detailed in The Cement Eligibility Criteria of the Climate Bonds Standard & Certification Scheme (Climate Bonds, 2023b).

Table 7. Eligibility criteria for cement production facilities in operation prior to 2022 under the Climate Bonds Standard and Certification Scheme (Climate Bonds, 2023b)

Mitigation Component	Automatic or Criteria Required
Installation, upgrade, and operation of precalciners	Automatic
Installation, upgrade, and operation of heat recovery systems.	Automatic
Installation, upgrade, and operation of digitized control equipment or infrastructure.	Automatic
Installation, upgrade, and operation of testing equipment.	Automatic
Electrification of heat	Automatic
Installation, upgrade, and operation of equipment dedicated to calcined clay use in cement production as distinct from clinker.	Automatic
Installation, upgrade, and operation of equipment dedicated to processing legacy or historic fly ash and blast furnace slag, extant from power plants that no longer exist	Automatic
Installation, upgrade, retrofit, and operation of measures that achieve emissions savings equivalent to the emissions decrease for facilities between the start year of the bond and the end year	Criteria
Installation, upgrade, and operation of carbon capture and storage equipment where the average capture rate across all point sources is greater than 70% of total emissions, and where the criteria for transport and storage components are met by the applicant	Criteria
Installation, upgrade, and operation of carbon capture, storage, and utilization processes that utilize CO_2 either through curing carbonation, mineralization of CO_2 in concrete waste, or production of recyclable products	Criteria
Infrastructure revamps, or modifications of equipment needed for the production of cement using hydrogen as a fuel where the criteria for hydrogen are met by the applicant	Criteria

Criteria for Companies and Sustainability-Linked Debt

For investments that are intended for the transition of an entire company or entity Level 1 and Level 2 certifications are available. Level 1 "Aligned" certifications are for companies that currently meet the emissions intensity qualification shown in Figure 9 as the average of its current and near-term future production facilities, while Level 2 "Transitioning" certifications are for companies that are not currently meeting the emissions intensity qualification but their future Performance Targets align with the thresholds by then end of 2030 and will continue to meet them after that date. Additional details on other qualifications to meet the Level 1 and 2 requirements can be found in the referenced Cement Eligibility Criteria of the Climate Bonds Standard & Certification Scheme. Sustainability-Linked Debt, loans, or bonds in which the interest rate charged is set based on meeting specific sustainability criteria such as emissions intensity in this case under specific timeframes, also falls under the same levels categorizations. CBI provides guidance to its partners for Sustainability Linked Debt, however, CBI itself does not provide this capital to companies (Climate Bonds, 2023b).

The emission intensity is assessed at a portfolio level with a slightly higher threshold than for individual facilities as shown in Figure 9.

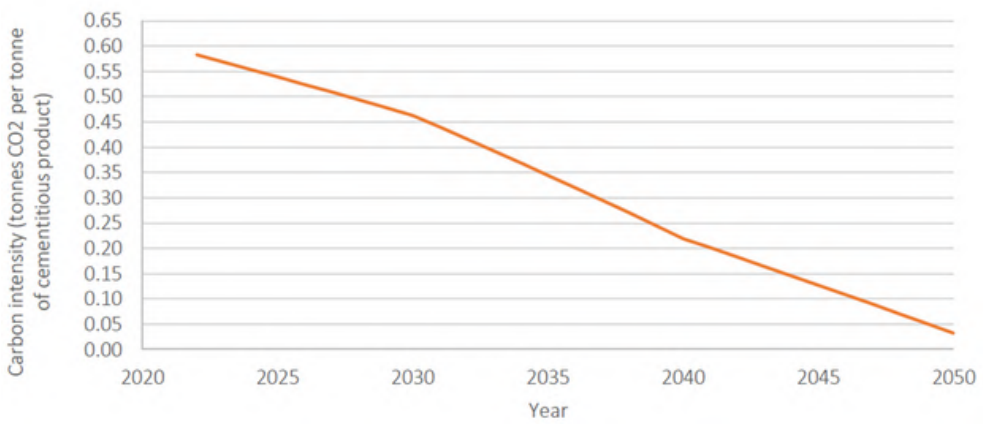

Figure 9. Decarbonization trajectory requirements for cement production portfolios in Climate Bonds Initiative's Cement Criteria (Cement Requirements).

Disclosure, Reporting, and Quality Control

To demonstrate compliance for each of the types of certifications, a plan must be provided with evidence of the decarbonization measures that have been/will be implemented. Additionally, a contract or agreement with a certified auditor demonstrating the emissions intensity must be approved over the term of the bond such that its performance meets those required in the previous sections. For facilities, this frequency is required three times per year and for entities and sustainability-linked debt, the frequency is every three years (Climate Bonds, 2023b).

Constituency

The Climate Bonds Initiative and the Climate Bond Standards Scheme are funded by grants from nonprofit and public organizations, revenue from public sector project contracts, and subscription fees from its partners. Some of the major funders include the EU's Horizon 2020, Inter-American Development Bank, The Rockefeller Foundation, and the Climate Works Foundation. The Climate Bonds Initiative has 108 partners including IHS Markit, Citi, and Nasdaq (Climate Bonds Initiative, 2009).

Standards Development Status

The current public version of the Climate Bonds Standard Version 4.0 was released in April 2023 and supersedes Version 3.0 launched in December 2019 and was preceded by the Climate Bond Standards V2.1 released in January 2017 and V2.0 released in December 2015. Updates to the Climate Bonds Standard are based on feedback from green finance markets stakeholders, issuers, verifiers, and partners and are reviewed at least every three years. (Climate Bonds, 2023a; 2023b).

The Cement Eligibility Criteria of the Climate Bonds Standard & Certification Scheme Version 1.2 was released in April 2023 to incorporate revisions from the Climate Bonds Standard Version 4.0 update. Sector-specific criteria for the cement industry under the Climate Bonds Standard and Certification Scheme are determined through a multistakeholder engagement process including a technical and industry working group convened and managed by Climate Bonds. The technical working group is made up of 11 members including numerous university professors and faculty, the European Bank for Reconstruction and Development, RMI, and TNO. The 19-member industry working group includes Pimco, JSW Cement, UBS Asset Management, Credit Suisse, PWC, and PCS to name a few. The criteria are subject to public consultation before final review and approval by Climate Bonds (Climate Bonds, 2023a).

3.3 ISO 19694-3 Stationary source emissions — Determination of greenhouse gas emissions in energy-intensive industries — Part 3: Cement industry"

ISO 19694-3:2023 provides a harmonized methodology for calculating the GHG emissions from the cement industry. The standard sets a framework for quantifying both the direct and indirect emissions associated with the production of cement on a plant, company, country or region, or international basis (ISO, 2023). ISO 10694-3 is a part of the ISO 19694 series that sets a common method for measuring, testing, and quantifying GHG emissions for sector-specific industry sectors (ISO, 2021).

Features

The scope of ISO 19694 includes the following direct and indirect GHG emissions sources:

Direct emissions from:

- calcination of carbonates and combustion or organic carbon-containing materials;
- combustion of kiln fuels;
- combustion of non-kiln fuels;
- combustion of fuels for on-site power generation;
- combustion of carbon contained in wastewater.

Indirect emissions from:

- generation of purchased electricity consumed in the organizations owned or controlled equipment;
- purchased clinker

ISO 19694-3 refers to GHGs as CO_2, carbon monoxide (CO), methane (CH_4), and nitrous oxide (N_2O) primarily for the cement industry. Figure 10 shows the boundaries of the emissions considered for cement producers within the secondary boxes (ISO, 2023).

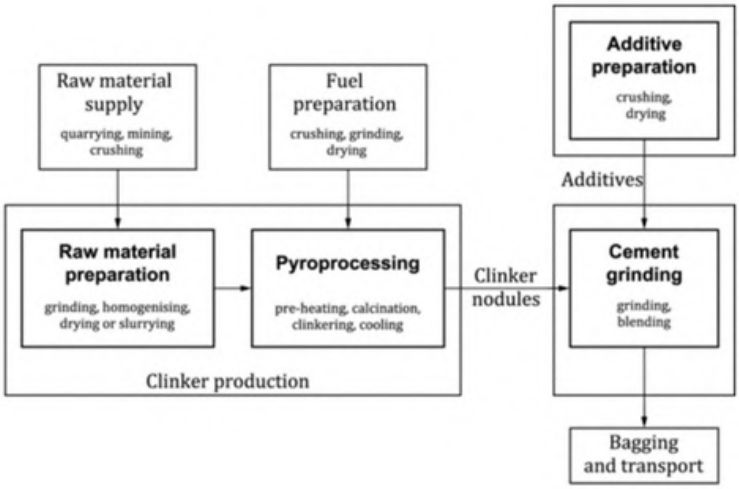

Figure 10. GHG emissions boundary for cement production considered under ISO 19694-3 (ISO, 2023).

The CO_2 emissions from the calcination of raw materials utilize a default value of 525 kg CO_2 per tonne of clinker that can be adjusted based on the exact chemical composition of the products or raw materials entering the kiln. Organic carbon in raw materials is typically low, however, companies that consume large quantities of fly ash or shale may have higher emissions from organic carbon than the standard provides a framework for accounting (ISO, 2023).

The emissions accounting methodology from fuels for kiln operation aligns with that of the CO_2 and Energy Accounting and Reporting Standard for the Cement Industry Version 3 formerly developed by the World Business Council for Sustainable Development, Cement Sustainability Initiative, and the WRI that is now under the GCCA since 2018. This method relies on determining the amount of raw meals consumed in the kiln system (ISO, 2023).

Targets, Pathways, and Requirements

ISO 19694 does not set any specific targets for the carbon intensity of cement as it solely sets a framework for quantifying the intensity of products. Additionally, ISO 19694 does not assess any social or economic aspects or impacts, or any other environmental aspects and related impacts potentially arising from the life cycle of a product. There are also no direct reporting mechanism requirements to ISO, however, a standardized reporting framework is provided.

Constituency

ISO is an independent, non-governmental international organization with 167 national standards bodies. ISO was founded in 1946. Individuals or companies cannot become ISO members but instead can participate in standardization work. As such ISO 19694 received input from numerous interested parties and technical experts to further build on the standards outlined in the document.

Standards Development Status

Preparation of ISO standards is carried out through ISO technical committees that each member body has the right to be represented in. International organizations, governmental and non-governmental also take part in the development of the standards in liaison. ISO 19694-3 was specifically prepared by the Technical Committee ISO/TC 146/SC1 "Stationary source emissions".

3.4 ISO 14067: 2018 – Carbon Footprint of Products

ISO 14067:2018 specifies principles, requirements, and guidelines for the quantification and reporting of the carbon footprint of a product (CFP), in a manner consistent with International Standards on life cycle assessment (LCA) (ISO 14040 and ISO 14044). Requirements and guidelines for the quantification of a partial CFP are also specified. The standard itself is not sector-specific, but it is developed for every sector. The sector-specific application requires the development of dedicated product category rules (PCRs). ISO 14067 is housed in a family of similar standards providing clarity and consistency for quantifying, tracking, reporting, and validating or verifying GHG emissions and removals to support sustainable development through a low-carbon economy (ISO, n.d.-a; n.d.-b; 2018)

Features

ISO 14067 provides a framework for determining the carbon footprint of an individual product that can be applied to industrial cement processes. The first step is to define the "goal and scope definitions" from a technical perspective with relative assumptions followed by a second phase, "life cycle inventory analysis" quantifying the GHG emissions themselves, which can then be further expressed as Global Warming Potential (GWP) in the third stage.

The primary focus is on emissions associated with the production of cement products including the direct emissions as well as the upstream emissions from mining, production, and transport of the input materials to cement production. Co-products that can replace products from other industries can also be accounted for in taking credit for prevented emissions. For example, avoiding the use of virgin raw materials in another process allows benefits to the emissions calculations (ISO, 2018; Suer et al., 2021).

Targets, Pathways, and Requirements

ISO 14067 does not set any specific targets for the carbon intensity of cement products as it solely sets a framework for quantifying the emission intensity of products. Additionally, ISO 14067:2018 does not assess any social or economic aspects or impacts, or any other environmental aspects and related impacts potentially arising from the life cycle of a product. There are also no direct reporting mechanism requirements under ISO 14067, however, Chapter 7 of the standard sets reporting standards. A sample of the reporting requirements is provided below, however, the standard itself should be referenced for full details (ISO, n.d.-a; n.d.-b; 2018; Suer et al., 2021)

- GHG emissions and removals are linked to the main life cycle stages in which they occur, including the absolute and the relative contribution of each life cycle stage;
- GHG emissions and removals arising from fossil carbon sources and sinks
- The study report should include a sensitivity check of the significant inputs and an assessment of the influence of alternative use profiles and end-of-life scenarios on the final result.
- Cut-offs
- Description of the data
- Scope
- System boundary
- Description of significant unit process
- Result of the life cycle interpretation including conclusions and limitations

Constituency

ISO is an independent, non-governmental international organization with 167 national standards bodies. ISO was founded in 1946. Individuals or companies cannot become ISO members but instead can participate in standardization work. As such the 2018 version of ISO 14067 received input from numerous interested parties and technical experts to further build on the standards outlined in the document (ISO, 2017).

Standards Development Status

Preparation of ISO standards is carried out through ISO technical committees that each member body has the right to be represented in. International organizations, governmental and non-governmental also take part in the development of the standards in liaison. The ISO 14067:2018 was specifically prepared by Technical Committee ISO/TC 207, Environmental Management, Subcommittee SC 7, Greenhouse gas management, and related activities. ISO 14067:2018 was preceded by ISO/TS 14067:2013 (ISO, n.d.-a; n.d.-b; 2018).

3.5 Global Cement and Concrete Association "GCCA Sustainability Guidelines for the monitoring and reporting of CO_2 emissions from cement manufacturing"

The Global Cement and Concrete Association (GCCA) developed the GCCA Sustainability Guidelines for the monitoring and reporting of CO_2 emissions from cement manufacturing to support the sector in reducing the emissions from cement production. These guidelines cover monitoring and reporting of CO_2 emissions as well as energy consumption, specify protocols, and provide Key Performance Indicators (KPIs) for the cement industry (GCCA, 2018).

Features

The GCCA guideline is consistent with ISO/EN 19694-3 and utilizes a mass balance on the outputs (clinker, cement, dust) and inputs (fuels, raw materials) of cement plants combined with emissions factors to determine direct CO_2 emissions from cement production. The approach covers all cement plant CO_2 emissions from the main stack and other emission points. Table 8 shows which Scope 1, 2, and 3 emissions are covered and which are not (GCCA, 2018).

Table 8. Sources of direct and indirect emissions covered by the GCCA guidelines (GCCA, 2018).

	Direct/Indirect	Source	Scope	Covered
1	Direct	Calcination of carbonates, and combustion of organic carbon contained in raw materials.	1	Yes
2	Direct	Combustion of kiln fuels related to clinker production a. Combustion of conventional fossil fuels b. Combustion of alternative fossil fuels and mixed fuels with biogenic carbon content c. Combustion of biomass fuels and biofuels (including biomass wastes).	1	Yes
3	Direct	Combustion of non-kiln fuels (e.g. hot gas generator, dryers) a. Combustion of conventional fossil fuels b. Combustion of alternative fossil fuels and mixed fuels with biogenic carbon content c. Combustion of biomass fuels and biofuels (including biomass wastes).	1	Yes
4	Direct	Combustion of fuels for on-site power generation.	1	Yes
5	Direct	Combustion of the carbon contained in wastewater.	1	No
6	Indirect	Emissions related to the electrical power consumed from external power production.	2	Yes
7	Indirect	Emissions related to clinker purchased.	3	Yes
8	Indirect	Emissions related to business travels.	3	No
9	Indirect	Emissions related to the production, preparation and transport of (alternative) fuels outside the company.	3	No

The GCCA guidelines also provide a methodology for quantifying gross and net emissions when recovered waste such as alternative fuels and raw materials are utilized that may produce higher direct emissions than traditional fossil fuel sources but may displace indirect GHG emissions at landfills or incineration plants. This methodology is outlined in Table 9 (GCCA, 2018).

Table 9. GCCA guidelines for determining gross and net emissions from cement production (GCCA, 2018).

Total direct emissions	–	Emissions from pure biomass and from the biogenic carbon content of mixed fuels	=	Fossil direct emissions
Fossil direct emissions	–	Emissions from on-site power production	=	Gross emissions
Gross emissions	–	Emissions from alternative fossil and non-biogenic content of mixed fuels – Comparable benchmark emissions for external heat transfer	=	Net emissions

Targets, Pathways, and Requirements

The GCCA guidelines' KPIs require the quantification of four metrics. The first two are the total gross and net direct CO_2 emissions in metric tonnes per year. The GCCA guidelines also require reporting of the net and gross specific CO_2 emissions in kg per tonne of cementitious material. Specific target values of these metrics are not provided in the GCCA guidelines (GCCA, 2018).

The GCCA Sustainability Charter that the Guidelines were developed under also assesses the following pillars that fall outside of these guidelines.

1. Health and Safety
2. Climate Change and Energy
3. Social Responsibility
4. Environment and Nature
5. Circular Economy

Under the GCCA Sustainability Charter, GCCA members must implement sustainability initiatives across all of these pillars, report on their performance to the KPIs, and set targets for improvement in each pillar (GCCA, 2022).

Disclosure, Reporting, and Quality Control

The GCCA requires independent verification and publication of data and targets. The GCCA collects the data annually through a third party and communicates the data publicly in a consolidated format with a particular focus on the KPIs. Member companies' targets are required to be publicly available. The GCCA audits its members every five years to ensure compliance with the GCCA Sustainability Charter (GCCA, 2022).

Constituency

The GCCA is a CEO-led organization run by cement industry leaders. The GCCA has 41 members including Cementos Argos, CEMEX, Holcim, Heidelberg Materials, and Titan Cement group, and its members account for 80% of the global cement industry volume outside of China. The GCCA has 28 affiliate members including the cement associations from many of the world's largest cement production nations including the USA, Brazil, Canada, and Mexico (GCCA, 2023).

Standards Development Status

The GCCA guidelines were developed as part of the GCCA Sustainability Charter in 2018 while the GCCA Sustainability Framework Guidelines were most recently published in 2022. The GCCA has also published a 2050 Cement and Concrete Industry Roadmap to Net Zero Concrete in 2021.

4. Low-Carbon Cement and Concrete in International Initiatives

In this chapter, many of the world's largest cement and concrete decarbonization initiatives are assessed. These initiatives target either cement and concrete producers/suppliers, users, or even the financial sector. Each initiative was reviewed and summarized to present its respective emissions scopes and boundaries, emission intensity targets if one is set, reporting requirements and verification procedures, constituency, and development status.

4.1 Industrial Deep Decarbonization Initiative (IDDI)

The Clean Energy Ministerial Industrial Deep Decarbonization Initiative (IDDI) is a coalition of public and private organizations that are working to stimulate demand for low-carbon industrial materials including cement and concrete. The work of the IDDI focuses on standardizing carbon assessments, establishing public and private sector procurement targets, incentivizing investment in low-carbon product development, and designing industrial guidelines (UNIDO, n.d.). The IDDI has three focus areas:

- Establishing an approach for collecting data and reporting on low and near-zero-emission steel, cement, and concrete, including embodied carbon.
- Harmonizing global standards to allow for comparability and define low and near-zero-emission steel, cement, and concrete.
- Agreeing globally recognized targets and best practices for the public procurement of low and near-zero emission steel, cement, and concrete (IDDI, 2023b).

Features

Under the IDDI, government entities may commit to the following pledge levels;

Level 1: Starting no later than 2025, require disclosure of the embodied carbon in cement/concrete and steel procured for public construction projects.

Level 2: In addition to Level 1, starting no later than 2030, conduct whole project lifecycle assessments for all public construction projects, and, by 2050, achieve net zero emissions in all public construction projects.

Level 3: In addition to Levels 1 and 2, starting no later than 2030, require procurement of low-emission cement/concrete and steel in public construction projects, applying the highest ambition possible under national circumstances.

Level 4: In addition to Levels 1, 2, and 3, starting in 2030, require procurement of a share of cement and/or crude steel from near zero emission material production for signature projects (IDDI, 2023a).

The product level emissions are accounted for on a tonnes of CO_2 e per tonne of cement basis and include a whole project lifecycle assessment that follows international standards, or national standards where they exist. The definition for near-zero and low-emissions cement is in line with the IEA definitions outlined in "Achieving Net Zero Heavy Industry Sectors in G7 Members", which provides a sliding scale based on the clinker-to-cement ratio and includes a categorization of low-emissions cement products ranked based on their emissions intensity. The boundaries for cement emissions intensity calculations are consistent with those proposed by the IEA and are discussed in further detail in the IEA's Achieving Net Zero Heavy Industry Sectors in the G7 Members section of this report (IDDI, 2023c).

Targets, Pathways, and Requirements

Consistent with the IEA's definition for near-zero cement, the threshold of 0.04 tonnes of CO_2e per tonne of cement for a clinker-to-cement ratio of zero is utilized by the IDDI. For cement produced with a 1.0 clinker-to-cement ratio, this threshold slides to 0.125 tonnes of CO_2 equivalent per tonne of cement. Additional quantification of "low emissions" cement is also provided on the same scale with a ranking from A-E based on the product's emissions intensity. (IDDI, 2023c)

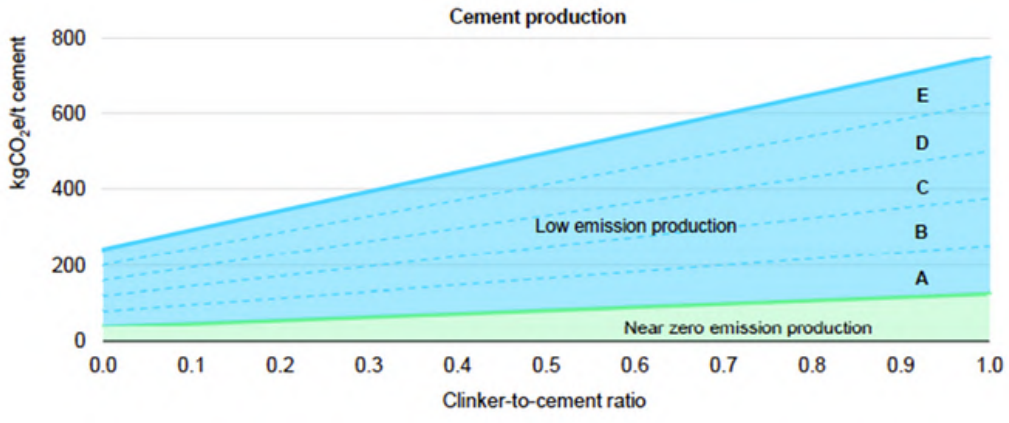

Figure 11. IEA's near zero emission cement emissions intensity threshold as a function of the clinker-to-cement ratio and proposed classification system as adopted by the IDDI (IEA, 2022a).

Disclosure, Reporting, and Quality Control

Under the IDDI Pledges, the disclosure for cement and concrete includes the cement in ready-mix concrete and the cement in prefabricated concrete blocks. The requirement for material and project-level disclosure should be included in procurements for design services starting no later than 2025. Beginning in 2025, the disclosure will be demonstrated with Type III Environmental Product Declarations (EPD), or other independently verified LCA reports, covering the same aspects as the EPD. By 2030, disclosure requirements will be based on the Product Category Rule agreed upon across IDDI members (IDDI, 2023c).

Subject to their Pledge level, at the end of this year, signatories will need to have the reporting mechanisms and infrastructure developed internally to enable sufficient reporting back to the IDDI. In the near term, reporting requirements will be based on tracking the number of nations that have committed to the Pledge and the status of these nations in terms of ambition level. IDDI does not mention independently verifying the reported data (IDDI, 2023c).

Constituency

The IDDI is coordinated by the United Nations Industrial Development Organization (UNIDO) and is co-led by the United Kingdom and India with additional members including Germany, Canada, Japan, Saudi Arabia, Sweden, the United Arab Emirates, and the United States. The IDDI also includes a collation of related initiatives and organizations including Mission Possible Platform, the ConcreteZero Campaign, The Climate Group, the Leadership Group for the Industry Transition, and the World Bank (UNIDO, n.d.).

Standards Development Status

Three technical working groups (WG) bring together the government, private sector, and leading expert organizations to support the development of IDDI (IDDI, 2022b). The groups and their responsibilities are outlined below.

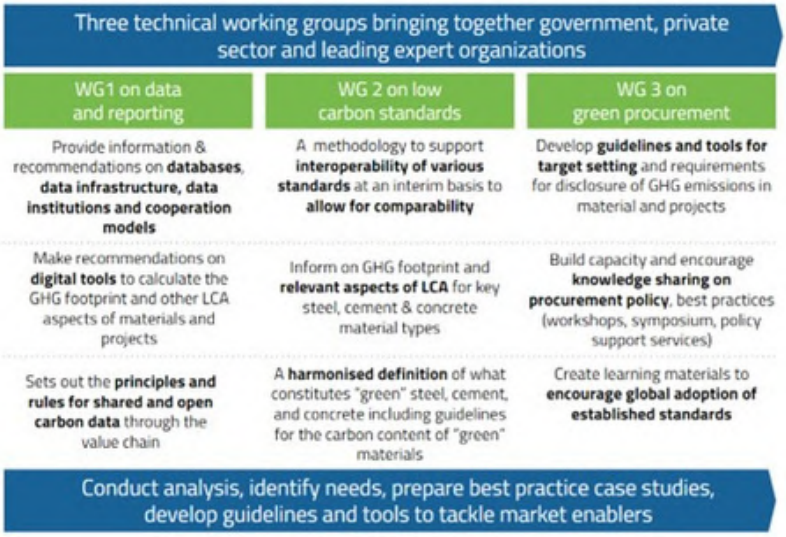

Figure 12. IDDI's development process, working groups, and responsibilities for WG (IDDI, 2022b).

These WGs kicked off in February of 2022 with the development of recommendations on GPP target reduction by 2030 and additionally work iteratively to develop recommendations, guidelines, learning materials, tools on GPP, low carbon definitions, and data reporting for embodied carbon. IDDI is under continued development and refinement to develop guidelines for harmonized product standards and definitions of low- and near-zero cement and concrete, cement and concrete, and is working towards a standardized, digitized methodology for reporting on embodied carbon through entire value chains. A full timeline presented by IDDI through the end of 2023 is presented below in Figure 13 (IDDI, 2023b).

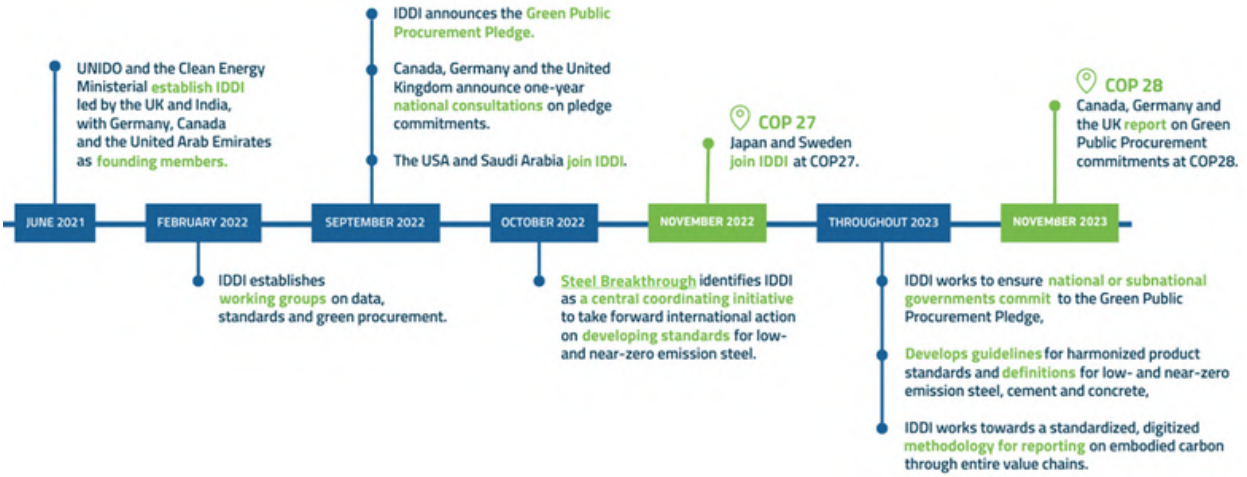

Figure 13. IDDI development timeline and process (IDDI, 2023b)

4.2 Science Based Targets Initiative for Cement

The Science Based Targets Initiatives (SBTi) provides a clearly-defined path to reduce emissions in line with the Paris Agreement goals for various sectors. Targets are considered 'science based' if they are in line with the latest climate science deemed necessary to meet these goals. SBTi developed science-based target-setting methodologies, tools, and guidance for cement companies and other stakeholders such as construction businesses to help companies understand and set near- and long-term science-based targets required to meet the 1.5°C goal of the Paris Agreement (SBTi, 2023a).

Features

For the cement industry, the SBTi published a 2.0°C pathway ("sector guidance") in 2015 and several companies have already made commitments based on this pathway. The Cement Science-Based Target Setting Guidance for 1.5°C was released in September of 2022. The Net-Zero Standard Framework under SBTi requires near-term (5-10 year) emission reduction targets to be in line with 1.5°C targets, long-term targets to reduce emissions to a residual level in line with 1.5°C scenarios by no later than 2050, and neutralization of those residual emissions when the company has achieved their long-term target through permanent removal and storage of carbon from the atmosphere. SBTi recommends companies take action to mitigate their emissions beyond their value chain by, for example, purchasing high-quality, jurisdictional Reducing Emissions from Deforestation and Forest Degradation (REDD+) credits or investing in direct air capture and geologic storage (SBTi, 2022a).

The 1.5°C Cement Science-Based Target Setting Guidance also provides specific guidance for different types of cement and concrete producers, namely: companies producing clinker and cement, companies producing clinker cement and concrete, companies producing only concrete, and other potential users of the cement pathway including construction companies (SBTi, 2022a).

Under the 1.5°C Cement Science-Based Target Setting Guidance, companies must demonstrate that their emissions per ton of cementitious product or cement show sufficient ambition in line with 1.5°C targets. This can be achieved through three approaches: the Sectoral Decarbonization Approach (SDA) also known as the "sector-specific intensity convergence" approach, or the Sector Carbon Intensity Pathway approach. The SDA is suitable for homogenous sectors that have a dedicated pathway and should not be used by companies that do not produce clinker and should be used by companies whose clinker production emissions make up 5% to 95% of Scope 1 emissions.

Under the SDA a 2050 target is set assuming all companies converge to the same emissions intensity level and Science-Based Targets (SBTs) are set in the near term of 5 to 10 years. The steepness of a company's curve is determined by its distance from the convergence target as demonstrated in Figure 14 below (SBTi, 2022a).

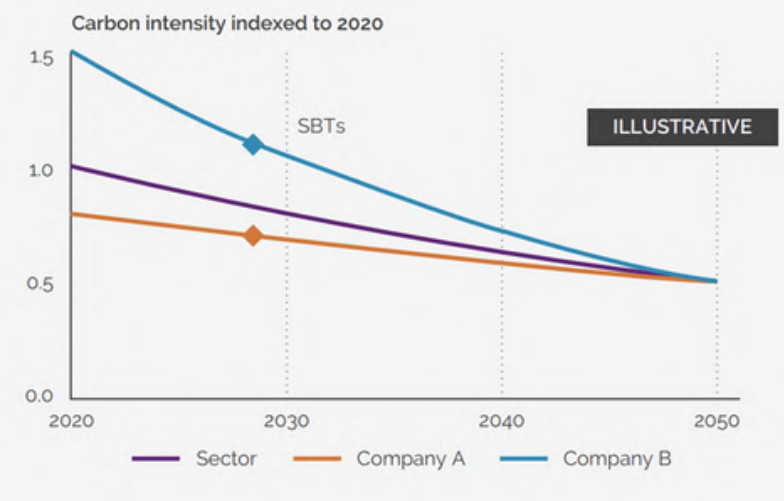

Figure 14. Illustrative example of the SDA where the emissions intensity must converge with the sector emissions intensity (SBTi, 2022a).

The absolute contraction approach is most suitable for sectors without a specific pathway and requires a minimum annual linear reduction of 4.2% or a 42% reduction over 2020-2030.

The boundaries to be considered in calculations of Scope 1 and 2 emissions are consistent with those discussed earlier in this report. Scope 3 emissions should be determined utilizing the WBCSD Cement Sector Scope 3 GHG Accounting and Reporting Guidance specifically on the cement sector (SBTi, 2022a).

Targets, Pathways, and Requirements

For near-term targets, at least 95% of Scope 1 and 2 emissions must be included. If Scope 3 emissions are 40% or more of total emissions, a Scope 3 target is required. Additionally, a Scope 3 near-term target covering the purchase of cement and clinker is always required. In all other cases, targets for Scope 3 emissions are recommended. Long-term (net-zero) targets must include 95% of Scope 1 and 2 emissions and 90% of Scope 3 emissions (SBTi, 2022a)

A company wishing to submit to the SBTi must do the following:

- Commit: submit a letter establishing your intent to set a science-based target
- Develop: work on an emissions reduction target in line with the SBTi's criteria
- Submit: present your target to the SBTi for a complete validation
- Communicate: announce your target and inform your stakeholders
- Disclose: report company-wide emissions and track target progress annually

SBTi requires that companies submit their targets at a company-wide level including their subsidiaries and include all relevant GHG emissions. The verification of the company-level commitments is based on the averages required of the whole industry globally. SBTi's team of experts independently reviews and verifies a company's submission and validates it against their science-based criteria to determine if it is in line with the SBTi (SBTi, 2022a).
This report provides a summary of the requirements stated in the 1.5°C Cement Science-Based Target Setting Guidance. Additional details can be found in the referenced guidance document.

Constituency

As of April 2023, 2,602 companies across numerous sectors have committed to science-based targets, of which 1,787 have net-zero commitments and 4,961 are taking action to meet the Paris Agreement targets (SBTi, 2023b). Concerning the cement industry, the 1.5˚C Sector guidance was developed through an Expert Advisory Group of technical experts from stakeholder organizations and companies including Cemex, Holcim, HeidelbergCement, the Global Cement and Concrete Association (GCCA), the European Climate Foundation, and Cementos Argos (SBTi, 2023a). Many other cement manufacturers have joined SBTi including JSW Cement, JK Cement, Titan Cement Group, Votorantim Cimentos, GRH, Oyak, and Boral to name a few (SBTi, 2022b).

Standards Development Status

In October 2021 SBTi launched a project with the aim of developing a 1.5°C sector guidance built on the previously developed SDA methodology. The process for revision included the following:

- Integration of new pathways in SBTi's target-setting tool to help cement companies model GHG emission-reduction targets consistent with the ambition required to limit warming to 1.5°C.
- Guidance for setting 1.5°C-aligned science-based GHG emission reduction targets for the production of cement.
- Incorporation of 1.5°C-aligned sector-specific benchmarks into the SBTi Target Validation Protocol to enable third-party validation of 1.5°C-aligned targets for cement production

A month-long public consultation period was held for the Cement Science Based Target Setting Guidance and Tool before the revision and release of the current 1.5°C version in September of 2022 (SBTi, 2023a).

4.3 First Movers Coalition Initiative: Cement and Concrete

The First Mover Coalition is a global initiative harnessing the purchasing power of companies to work towards decarbonizing the aluminum, aviation, chemicals, concrete, shipping, steel, and trucking industries along with funding innovative carbon removal technologies by its members committing in advance to purchasing a proportion of their industrial materials from suppliers using near-zero or zero carbon solutions (First Movers Coalition, 2022c; 2022a).

Features

For the cement and concrete industries, The First Movers Coalition has set a product level CO_2e threshold per ton of cementitious product that includes Scope 1 and 2 emissions as defined from modules A1, A2 and A3 lifecycle analysis (cradle-to-gate) as per EPD standards for Portland cement/ready mix concrete (First Movers Coalition, 2023).

Targets, Pathways, and Requirements

The First Movers Coalition has set a threshold of fewer than 0.184 tonnes of CO_2e emitted per tonne of cement. For near-zero concrete, Table 10 demonstrates the emissions intensity definition by specified compressive strength (First Movers Coalition, 2023).

Table 10. The First Movers Coalition's concrete emissions intensity requirements to meet the definition of near-zero emissions concrete for different specified compressive strengths (First Movers Coalition, 2023).

Specified compressive strength (f'c in psi)	Embodied carbon (kg CO_2e/m^3)
0 - 2500 psi	70
2501 - 3000 psi	78
3001 - 4000 psi	96
4001 - 5000 psi	117
5001 - 6000 psi	124
6001 - 8000 psi	144

Members commit to purchasing or specifying volumes of near-zero emissions cement / concrete by 2030. Construction and engineering firms set a target that at least 10% of their annual cement/concrete procurement inclusive of any supply chain management (SCM) by 2030 meets or exceeds the above definition of near-zero emissions and excludes fossil-based SCM by 2035. Real estate, developers, and advisory firms set a target to ensure that at least 10% of the annual volume of cement/concrete procured by 2030 meets or exceeds the same near-zero target and excludes fossil-based SCM by 2035 (First Movers Coalition, 2023).

Disclosure, Reporting, and Quality Control

The First Movers Coalition does not explicitly enforce adherence to a member's commitment due to the voluntary nature of the commitment. Progress towards commitments will however be reported through a State of the First Movers Coalition published report. The First Movers Coalition does not explicitly comment on conducting validation of a member's self-submitted progress report (First Movers Coalition, 2022b).

Constituency

The cement and concrete sector commitment framework was launched at COP27 in Share el-Sheikh. The First Movers Coalition is a public-private partnership launched by the U.S. State Department and the World Economic Forum and is supported by the U.S. Department of Commerce. The coalition includes 10 government partners with India, Sweden, and Japan serving as Steering Board Partners and the United States of America as the Co-Chair. Breakthrough Energy is the Primary Implementation Partner that brings together private and public partners to advance technology deployment and provide reporting and analytics to measure progress. Carbon Removal Partners include Breakthrough Energy Catalyst, Carbon Direct, Frontier, and South Pole. Boston Consulting Group serves as the Knowledge Partner supporting the formulation of sectoral commitments and working with members to support the delivery of commitments.

Sixteen organizations and NGOs serve as the Design Committee providing input to the sectoral commitments including the IEA, Rocky Mountain Institute, and the Climate Group. The First Movers Coalition has 55 total members (First Movers Coalition, 2022b; d; e).

Standards Development Status

The Design Committee for the cement and concrete commitment sector included the Concrete Action for Climate Initiative (Mission Possible Partnership) and the GCCA. At the time of writing this report, there are no published plans to revise the guidelines for the cement and concrete industry (First Movers Coalition, 2023; 2022b).

4.4 Climate Group's ConcreteZero Initiative

ConcreteZero is a global initiative aimed at driving market demand for net zero concrete. Organizations that join ConcreteZero make a public commitment to procure 100% net zero concrete by 2050, with two interim commitments of using 30% low-emissions concrete by 2025 and 50% by 2030. This sets out a clear and immediate pathway to meet the net zero target. Targeting net zero concrete from the demand side of the supply chain gives this initiative the potential to have a significant impact on investment, policy, manufacturing, and production in the sector. By harnessing their collective purchasing power and influence, concrete purchasers are sending a demand signal to shift global markets and policies toward responsible production and sourcing of concrete (ConcreteZero, 2023a)

Features

ConcreteZero members will be either organizations that use or procure concrete, including public procurement bodies, architects, designers, structural engineers, and specifiers of concrete, or companies involved in the concrete supply chain at any stage after the production of concrete.

The minimum commitment criteria include;

- Baseline commitment: Commit to report the volume and carbon intensity of concrete consumption.
    - Reported data must include actual and planned specifications and consumption
    - The following data must be submitted to ConcreteZero: strength class, carbon intensity, volume, year/month delivered, and country of origin.
- 2025 interim commitment: procuring 30% of total concrete consumption, meeting carbon intensity no greater than the ConcreteZero Low Embodied Carbon Concrete Threshold
- 2030 interim commitment: procuring 50% of total concrete consumption, meeting carbon intensity no greater than the ConcreteZero Low Embodied Carbon Concrete Threshold
- 2050 interim commitment: procuring 100% of total concrete consumption, meeting carbon intensity no greater than the ConcreteZero Low Embodied Carbon Concrete Threshold (ConcreteZero, 2023c)

Targets, Pathways, and Requirements

The ConcreteZero Low Embodied Carbon Concrete Threshold is defined as concrete with a GHG intensity of less than or equal to the A benchmark rating utilized by the Low Carbon Concrete Group (LCCG) defined in Figure 15 below that utilizes a sliding scale according to the specified strength class of concrete.

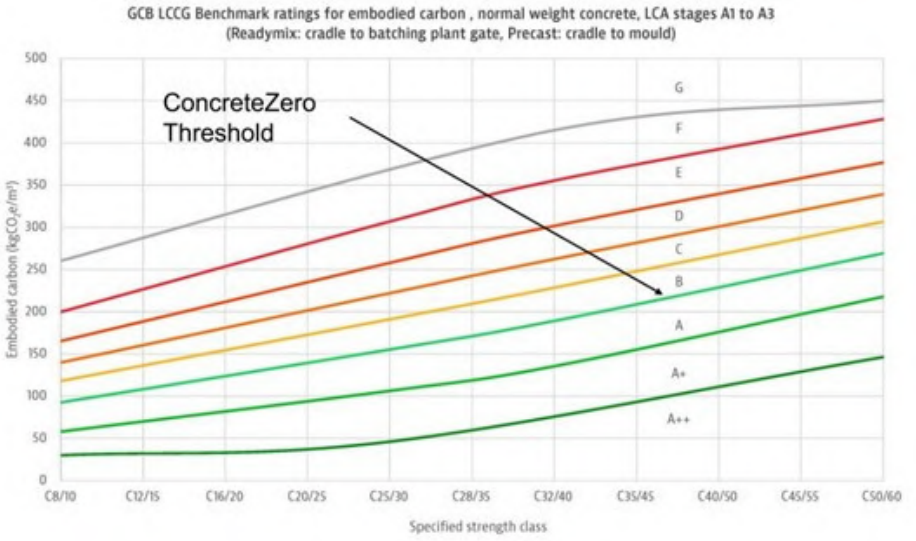

Figure 15. ConcreteZero Low Embodied Carbon Concrete Threshold (ConcreteZero, 2023c).

Submission of annual reports to the Climate Group are required to show an organization's progress towards their ConcreteZero commitment that must include summaries of the quantity and embodied carbon of concrete produced. Companies committing to Concrete Zero must self-report the strength class, carbon intensity, volume, year/month delivered, and the concrete of origin (ConcreteZero, 2023c).

Organizations have the option to review their commitment on an annual basis and adjust it in line with their corporate targets providing it always meets the minimum criteria. ConcreteZero members will be actively encouraged to increase their interim commitment if possible (ConcreteZero, 2023c).

Disclosure, Reporting, and Quality Control

ConcreteZero will report only anonymized total consumption from its reported members annually. There is no mention of further quality control of the reported data by ConcreteZero (ConcreteZero, 2023c).

Constituency

ConcreteZero is an initiative run by the Climate Group and ConcreteZero and is in partnership with WorldGBC. At the time of this report, 30 organizations have joined ConcreteZero including AKT II, EDGE Consulting Engineers, Clancy Group, and Multiplex Construction Europe to name a few (ConcreteZero, 2023a)

Standards Development Status

The most recent version of the ConcreteZero "Campaign overview and commitment framework" was published in February of 2023. In this document, ConcreteZero discusses that the commitment criteria and language may change over time to reflect up-to-date information. Changes to the framework will be decided in discussion with ConcreteZero members ahead of adoption (ConcreteZero, 2023c).

4.5 Climate Action 100+ for Cement Initiative

Climate Action 100+ is an investor-led initiative to ensure the world's largest corporate greenhouse gas emitters take necessary action on climate change. 700 investors, responsible for over $68 trillion in assets under management, are engaging companies in improving climate change governance, cutting emissions, and strengthening climate-related financial disclosures. Climate Action 100+ has become the largest-ever global investor engagement initiative on climate change, with growing influence and impact. 166 focus companies have been selected for engagement, accounting for up to 80 percent of corporate industrial greenhouse gas emissions (Climate Action 100+, 2022a).

The Climate Action 100+ Net Zero Benchmark assesses the performance of the focus companies against their emissions reduction, governance, and disclosure and presents a key measure of corporate progress on climate action and the move to achieve net zero emission by 2050 and their alignment with the Paris Agreement goal to limit global temperature rise to 1.5°C (Climate Action 100+, 2022c).

Climate Action 100+ has released Global Sector Strategies for the electric utility, steel, food and beverage, and aviation industries, and is developing a trucks and diversified mining Global Sector Strategy. A cement and concrete Global Sector strategy has not yet been developed by Climate Action 100+, however, 11 cement companies have been selected for engagement, representing a market capitalization of $181 billion (Climate Action 100+, 2023).

Features

The Climate Action 100+ categorizes assessments into two types of indicators, Disclosure Framework Indicators that evaluate the adequacy of corporate disclosure, and Alignment Assessments that evaluate the alignment of company actions with the Paris Agreement goals. The Disclosure Framework utilizes public and self-disclosed data from companies to assess companies against the following 10 indicators:

- Net-zero GHG Emissions by 2050 (or sooner) ambition
- Long-term (2036-2050) GHG reduction target(s)
- Medium-term (2026-2035) GHG reduction target(s)
- Short-term (up to 2025) GHG reduction target(s)
- Decarbonization strategy
- Capital alignment
- Climate policy engagement
- Climate governance
- Just Transition [Beta]
- TCFD disclosure

These indicators are further broken down into sub-indicators which can be further broken down into individual metrics. A score is awarded for each indicator and sub-indicator. The scores are not aggregated to an overall score and no ranking of companies occurs. Details on the sub-indicators and metrics can be found in the source cited. For the cement industry specifically, Scope 3 emissions are not considered applicable in the Net Zero Benchmark assessment (Climate Action 100+, 2022d).

The Alignment Assessments are broken down as follows:

Capital Allocation Alignement (CTI)

Primarily focuses on the oil and gas and electric utility focus companies and does not apply to cement (Climate Action 100+, 2022d).

Climate Policy Engagement Alignement (InfluenceMap)

InfluenceMap's alignment assessments provide detailed analyses of corporate climate policy engagement and the alignment of company climate policy engagement actions (direct and indirect via their industry associations) with the Paris Agreement goals. Their assessments cover all focus companies (Climate Action 100+, 2022d).

Capital Allocation Alignment (2DII)

The alignment assessments analyze companies' planned economic outputs and associated emissions intensities relative to selected climate change scenarios. The emissions intensities are calculated per tonne of product. Asset-backed company-level data for the cement sector is used to derive production values for each physical plant. Scope 1 and Scope 2 emissions for the production of both cement are considered. Scope 3 emissions are excluded. The company-level emission intensity is calculated as the weighted average of its production plant, with the weighting based on the production capacity of each plant (21 Investing Initiative, 2022).

A comparison of current production to International Energy Agency (IEA) 10-year scenario targets for emissions is conducted. The companies' emissions intensities targets are compared to the IEA Beyond 2°C Scenario (B2DS) and the percent improvement required to converge with the scenario is determined. The focus company is graded as having "significant distance to alignment with B2DS" if there is a greater than 36% negative deviation, "moderate distance to alignment With B2DS" if there is a 15-36% negative deviation, and "aligned or close to being aligned with B2DS" if the is less than a 15% deviation (21 Investing Initiative, 2022).

Climate Accounting and Audit (Provisional) (CTI and CAAP)

The Climate Tracker Initiative (CTI) and the Climate Accounting and Audit Project (CAAP's) alignment assessment evaluates whether a focus company's accounting practices and related disclosures and the auditor's report thereon, reflect the effects of climate risk and the global move towards a 2050 (or sooner) net zero emissions pathway and the Paris Agreement goal of limiting global warming to no more than 1.5°C. This assessment covers all focus companies and is considered provisional (Climate Action 100+, 2022d).

Targets, Pathways, and Requirements

As discussed previously, Climate Action 100+ has not yet developed a Global Sector Strategy for the cement industry, however, 11 companies have been assessed and each was rated as having a significant distance to NZE for emissions intensities ranging from 0.63 to 0.72 tonnes of CO_2 per tonne of cement (Climate Action 100+, 2023).

Constituency

The Climate Change Action 100+ was launched in December 2017 and is made up of 5 regional investor networks: Asia Investor Group on Climate Change (AIGCC), Ceres, Investor Group on Climate Change (IGCC), Institutional Investors Group on Climate Change (IIGCC) and Principles for Responsible Investment (PRI) and is supported by a global steering committee. The global steering committee establishes initiative strategic priorities, governance, and infrastructure and also reviews companies that have been subject to corporate action and decides on a case-by-case basis if they should be removed from the focus list.

A technical working group brings together selected organizations that assess companies' preparedness for the transition to a net-zero emissions economy and have provided technical expertise along with company-specific research and analysis to inform initiative progress tracking. The technical advisory group is made up of the following organizations: 2 Degree Investing Initiative, Carbon Tracker, InfluenceMap, and Transition Pathway Initiative. Funding is supplied by contributions from participating partners such as ClimateWorks Foundation, Children's Investment Fund Foundation, Laudes Foundation, and Sea Change Foundation (Center for Climate Aligned Finance, 2022a).

From the cement industry, at the time of writing this report, 11 cement-producing companies have been focused on by Climate Action 100+ and they are (Climate Action 100+, 2022b):

- Abri Limited
- Anhui Conch Cement Company Ltd.
- Boral Ltd.
- Cemex S.A.D de C.V
- CRH Plc
- Dangote Cement Plc
- Grupo Argos S.A
- HeidenberCement AG
- Holcim Ltd.
- Martin Marietta Materials
- Ultratech Cement Ltd.

Signatories with Climate Action 100+ commit to the following actions:

- Implement a strong governance framework that clearly articulates the board's accountability and oversight of climate change risk;
- Take action to reduce greenhouse gas emissions across the value chain, consistent with the Paris Agreement's goal of limiting global average temperature increase to well below two degrees Celsius above pre-industrial levels, aiming for 1.5 degrees. Notably, this implies the need to move towards net-zero emissions by 2050 or sooner; and
- Provide enhanced corporate disclosure in line with the final recommendations of the Task Force on Climate-related Financial Disclosures (TCFD) and sector-specific Global Investor Coalition on Climate Change (GIC) Investor Expectations on Climate Change guidelines (when applicable), to enable investors to assess the robustness of companies' business plans against a range of climate scenarios, including well below two degrees and improve investment decision-making (Climate Action 100+, 2022e).

Standards Development Status

Climate Action 100+ launched in 2017 at the One Plant Summit in Paris with an initial list of 100 focus companies and 225 signatories. Since then the initiative has frowned to include 700 investors with 166 focus companies that account for 80% of the world's corporate CO_2 emissions. The initiative's Net-Zero Company Benchmark was formally released in March of 2021 assessing the world's largest corporate GHG emitters on their progress in the transition to net zero. The Global Sector Strategies workstream launched in August of 2021 with the first sector, steel, being published at that time. Since then, updates have been made to the benchmarks, and new rounds of assessments are released yearly (Climate Action 100+, 2022b).

4.6 IEA's Definition of Low-Carbon Cement

The International Energy Agency (IEA) published definitions for near-zero cement production in their 2022 Achieving Net Zero Heavy Industry Sectors in the G7 Members Report. This report focuses on the implementation of policies aimed at drastically lowering CO_2 emissions from heavy industries in G7 countries and beyond. The report summarized the numerous current standards and definitions of near-zero cement and proposed a common definition for the industry that is in line with the IEA's Net Zero Emissions by 2050 Scenario (IEA, 2022a).

Features

The IEA provides a product-level definition for near-zero cement emissions intensity in tonnes of CO_2 emissions per tonne of cement produced. The boundaries for quantifying the IEA's near-zero cement definition emissions include the direct emissions below:

- Fossil fuel use in clinker production
- Fossil fuel use in alternative cement constituent production
- Calcination emissions

Indirect emissions within the boundary of the definition include:

- Imported electricity, heat, and hydrogen including the fossil fuel emissions associated with their production
- Fossil fuel supply, including the emissions associated with their production, processing, and transportation
- Raw material supply including the emissions associated with the extraction, beneficiation, and transportation of limestone.

The boundary broadly encompasses clinker production, the production of alternative cement constituents, and the grinding that takes place before and after the kiln. Mining and transportation of the main raw materials for cement production are also included. Production of alternative cement constituents such as ground granulated blast furnace slag or fly ash is not included in the boundary. The boundary ends downstream of the grinding process and excludes concrete manufacture. Direct methane and nitrous oxide emissions are not included in the boundary. Figure 16 developed by the IEA provides a representation of the boundaries for their definition of near-zero cement (IEA, 2022a).

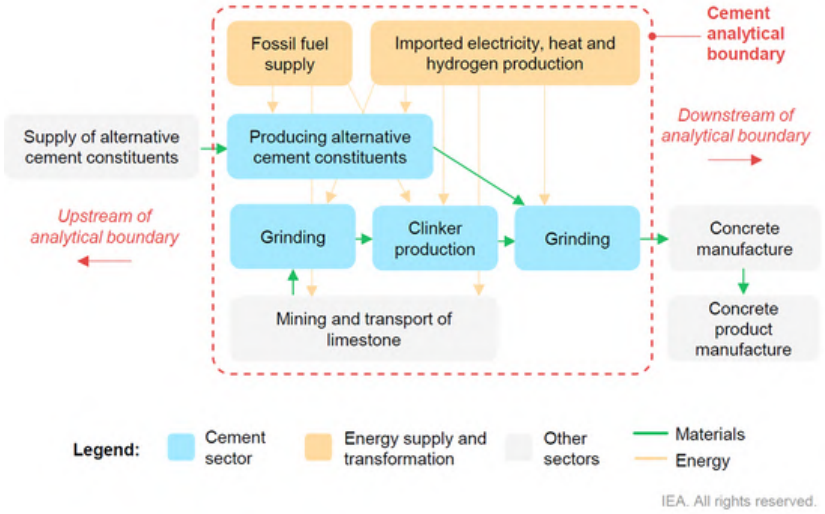

Figure 16. IEA's analytical boundary for defining near zero emission cement production (IEA, 2022a).

The IEA's threshold definition for near-zero cement utilizes a sliding scale proportional to the percentage of clinker used in the cement production process, discussed further below.

Targets, Pathways, and Requirements

The IEA sets an emissions threshold of 0.04 tonnes of CO_2e per tonne of cement for a clinker-to-cement ratio of zero utilized by the IDDI. For cement produced with a 1.0 clinker-to-cement ratio, this threshold slides to 0.125 tonnes of CO_2 equivalent per tonne of cement. In addition to the definition of near-zero cement, the IEA has also proposed a mechanism for classifying the cement product from Class A to E based on the carbon intensity of the product and the clinker ratio. Figure 17 demonstrates the IEA's proposed sliding scale for defining near-zero cement and the classification system (IEA, 2022a).

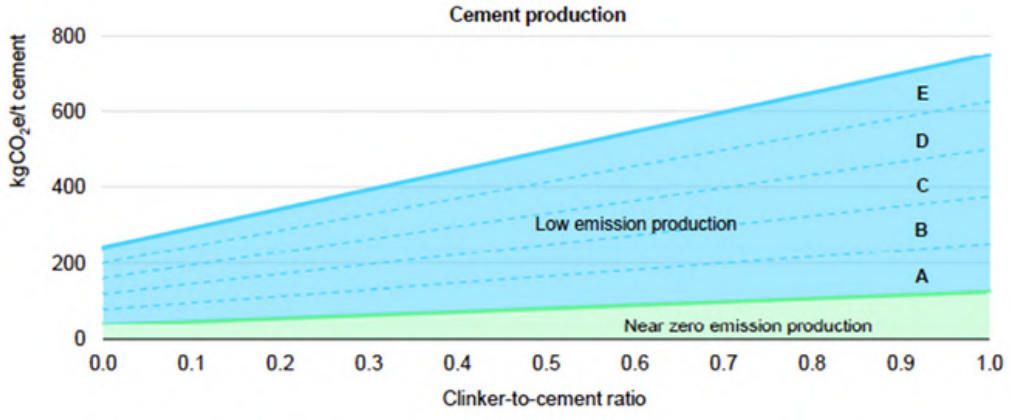

Figure 17. IEA's near zero emission cement production threshold as a function of the clinker ratio and proposed classification system (IEA, 2022a).

As the IEA has only proposed a definition for near-zero cement, there are no other requirements to meet this definition that consider other environmental or social impacts. The modeling utilized by the IEA for their definitions utilizes the GHG Protocol definitions for Scope 1, 2, and 3 emissions. The modeling is also compatible with the IPCC's guidelines and ISO standards (IEA, 2022a).

The IEA does not grant certification of their near-zero cement definition and therefore requires no disclosure, reporting, enforcement, or quality control to meet their proposed definition (IEA, 2022a).

Constituency

The IEA is made up of 31 member countries including the United States, Japan, France, Australia, and Germany with 8 association countries including China, Brazil, and South Africa. Additionally, there are 3 accession countries; Chile, Columbia, and Israel (IEA, 2022b).

Standards Development Status

The definition for near zero cement was developed by the IEA internally. In the Achieving Net Zero Heavy Industry Sectors in G7 Members Report, the IEA states that the current definition for neat zero cement will serve as forming the basis for product or project-focused definition establishment in future work. At the time of writing this report, there is no public statement on changing the current definition (IEA, 2022a).

4.7 Mission Possible Partnership's Concrete Action for Climate (CAC)

Mission Possible Partnership's Concrete Action for Climate (MPP CAC) aims to put the global cement and concrete industry on a path to net zero by 2050 with a focus on cross-industry and multistakeholder collaboration to ensure the supply and manufacturing of cement and concrete in line with global climate goals, increase demand for low-carbon cement and concrete by helping design and advocate for appropriate policy levers, and encourage full supply chain circularity. MPP CAC has goals to increase coalition-building efforts across the built environment value chain, launch a transitions strategy for net-zero cement and concrete, facilitate increased use of waste as byproducts as alternative and raw materials, increase reuse of concrete and use of demolished concrete, drive public and private demand for sustainable cement and concrete, and establish metrics for the resilience of buildings and infrastructure (Mission Possible Partnership, 2023)

Features

The MPP CAC is following a four-step approach to achieve these goals:

- Convene a critical mass of ambitious industry leaders and agree on a shared vision for sector decarbonization.
- Leverage existing analysis to develop a sector-specific, viable, high-ambition roadmap to net zero emissions by 2050 that will be a collaborative exercise with the industry and other stakeholders.
- Develop commitments to action that tie specific actions in line with the net-zero roadmap milestones, thereby embedding the roadmap in corporate strategies.
- Build the market infrastructure needed to track and support the ongoing implementation of these ambitious commitments via metrics, standards, and toolkits, as well as the rigorous implementation of best-practice public disclosure.

The MPP CAC provides a platform for stakeholders to align on a net-zero transition pathway for the industry and shape a favorable environment for investment in decarbonization. The MPP CAC is organized under 6 multi-stakeholder workstreams outlined below (Mission Possible Partnership, 2021):

1. Supply-side commitments

    - Showcase industry commitments and demonstrate progress/actions of the industry on net zero commitments.

2. Demand Signals

    - Propose terms for a buyers club and launch pledges, commitments, or principles for private sector buyers.
    - Identify countries, cities, and municipalities with green public procurement principles or guidelines.

3. Finance Engagement

    - Develop a financing/roadmap with conditions to enable investment into the concrete sector to achieve net zero.
    - Explore transition and climate-aligned finance opportunities.

4. Policy Engagement

    - Highlight policies that would enable sectoral transition based on the GCCA net-zero roadmap.

5. Innovation and Technology

    - Define focus technology innovation areas across the value chain, identify energy transition opportunities, and promote pilots and networks

6. Circular Solutions

    - Optimize circular economy solutions across value chains with a view on the whole ecosystem

Targets, Pathways, and Requirements

The MPP CAC supported the development of "The GCCA 2050 Cement and Concrete Industry Roadmap for Net Zero Concrete". The MPP CAC itself does not require individual reporting or disclosure of emissions data and has not at this time set its own targets or pathways but instead collaborates with the GCCA (Mission Possible Partnership, 2021).

Constituency

The Energy Transitions Commission, RMI, the We Mean Business Coalition, and the World Economic Forum launched the Mission Possible Partnership (MPP) in 2021 to accelerate the decarbonization of industries representing 30% of global emissions. The MPP CAC is co-led by the World Economic Forum and the GCCA and Members of the MPP CAC include the 40 member companies of the GCCA.

The Leadership Group for Industry Transition and Energy Transitions Commission additionally provides support to the MPP CAC workstream along with value chain players, service providers, government officials, and financial service officers (Mission Possible Partnership, 2021).

Standards Development Status

Following the GCCA Roadmap in late 2021, key milestones are targeted for 1, 3, 5, and 10 years including a high-ambition project by 2030 such as a first commercial-scale net zero project. The MPP CAC is actively engaging with the cement and concrete industries to provide continued support towards net zero goals (Mission Possible Partnership, 2021).

4.8 National Institute of Standards and Technology (NIST) Low Carbon Cements and Concretes Consortium

The National Institute of Standards (NIST), an agency of the United States Department of Commerce, established the Low Carbon Cements and Concretes Consortium to support the development of common measurements and standards related to low-carbon cement and concrete (NIST, 2023).

Features

The initial focus of the consortium is to evaluate, develop, and standardize methods to characterize and quantify the carbon in low-carbon cement and concrete. The consortium has a later goal to evaluate the suitability of current measurement standards to measure the material, mechanical, structural, and durability of these low-carbon cements and/or develop new testing methods to help enable acceptance of low-carbon cements and concretes in the marketplace. The four primary goals of the consortium are to:

- Evaluate the suitability of current ASTM standards to measure carbon, including specifically measuring carbon in cement, concretes, and the associated starting materials such as aggregates.
- Accurately measure the amount of carbon uptake by a material during CO_2 -curing processes. Validate the robustness and repeatability of the measurement method.
- Use these measurements as a foundation to propose tests(s) that can be standardized through the ASTM consensus process.
- Evaluate the applicability of current material, mechanical, structural, and durability tests used for cements and concretes to new low-carbon cements and concretes. If needed, develop new tests or point out why old tests are not needed to help enable acceptance of these new materials in the marketplace (NIST, 2023).

Targets, Pathways, and Requirements

The consortium does not mention specific emissions targets that represent low-carbon cement and is instead working to foster acceptance and quality standards for low-carbon cement to replace existing carbon-intensive cement and concrete products (NIST, 2023).

Disclosure, Reporting, and Quality Control.

NIST itself is not a governing body and instead works with industry, academia, and government to identify and address measurement and standards needs that are accepted by consensus instead of inforced. Those participating in the consortium are not required to contribute funds or fees and their proprietary information is protected. The consortium instead asks for samples of low-carbon cement concretes, and aggregates from its members (NIST, 2023).

Constituency

NIST has cross-disciplinary expertise in engineering, and the physical, information, chemical, and biological science and acts as a neutral convener between industry, standards development organizations, federal labs, universities, public workshops, and interlaboratory comparability testing. The Low Carbon Cements and Concretes Consortium is made up of 34 members as of April 2023 including industry members like Argos and Hedelber Materials, academic institutions such as UCLA, MIT, and Georgia Tech, and government entities such as the U.S. Army Corps of Engineers and the Department of Transportation (NIST, 2023).

Standards Development Status

The NIST Low Carbon Cements and Concretes Consortium was announced on the U.S. Federal Register in June of 2022 (NIST, 2022). The project status is currently listed as “ongoing” however, no updates or findings have been released as of June 2023 (NIST, 2023).

4.9 Concrete Sustainability Council

The Concrete Sustainability Council (CSC) created a certification system for responsibly sourced concrete and additionally promotes and demonstrates concrete as a sustainable building material. The CSCs primary goals and objectives are to demonstrate how operators are minimizing impacts through responsible sourcing, raise awareness of the positive attributes of concrete, report on agreed goals and targets, be recognized by global sustainable certification systems, and be financially valued in green government procurement policies (CSC, 2022a).

Features

The CSC's certification includes the complete concrete supply chain including cement producers, aggregate suppliers, and concrete manufacturers. Ready mix concrete and precast concrete plants that produce fresh concrete can receive a "CSC Certification", while cement and aggregate suppliers can receive a "CSC Supplier Certificate". Generally, the certification applies to concrete plants, cement plants, and aggregate quarries. The structure of the certification for a concrete plant is that 15% of its score is derived from its aggregate supply, 25% from its cement supply, and 60% is based on the concrete. For each aggregate, cement, or concrete facility a Bronze, Silver, Gold, or Platinum Certification can be awarded. Figure 18 illustrates the certification structure for a concrete plant (CSC, 2022f).

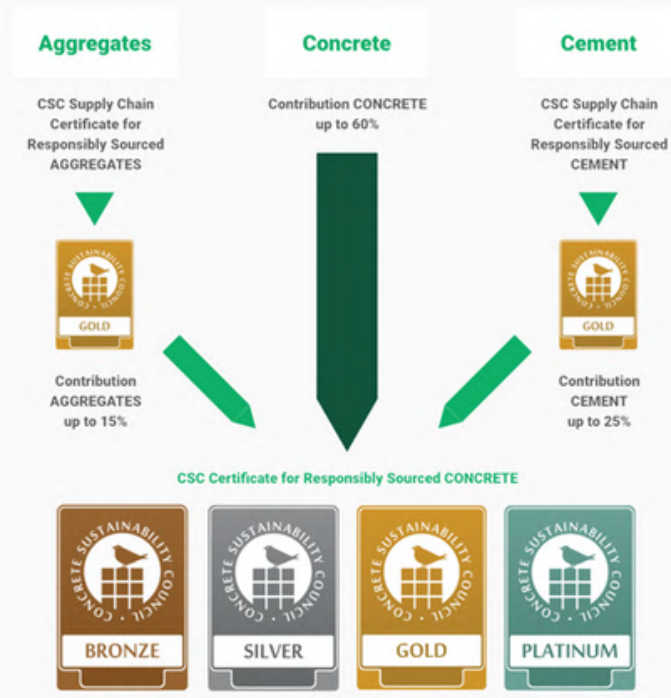

Figure 18. Concrete plant certification structure under the CSC (CSC, 2022f).

There are four categories for which a facility is assessed including management, environment, social topics, and economics, with varied weights depending on whether a facility produces aggregate, cement, or concrete. Each facility type also has varied score thresholds for each of the Bronze, Silver, Gold, or Platinum qualifications (CSC, 2022f).

For GHG emissions that fall under the Environmental category of the CSC Certification, there is no specific emissions target stated, however, in the self-assessment tool, points are awarded for measuring, reducing, and reporting GHG emissions targets as well as demonstrating that targets are science-based and being met. Points are also awarded in the section for utilizing LCAs and producing EPDs (CSC, 2022f).

External to the CSC Certification, the CSC released a CO_2 Module that is a voluntary add-on to the main CSC Certification for concrete facilities. This module is intended to increase transparency and credibility for marketing of low CO_2 concrete. This module grants stars to the CSC Certification label from 1 to 4 stars depending on the CO_2 intensity in kg CO_2 per m^3 of concrete reduction compared to a country/regional level baseline as determined by a Regional System Operator that is clustered by strength classes (CSC, 2022b). The CSC provides additional modules including the "R-Module" focusing on the use of recycled aggregates and an innovation credit that rewards additional points for innovative practices/products or solutions in the responsible sourcing of concrete (CSC, 2022c,e).

Targets, Pathways, and Requirements

Awarding of stars under the CSC's CO_2 Module is determined as 1 star for a 30% emissions intensity reduction compared to the baseline and a 40%, 50%, and 60% reduction for 2, 3, and 4 stars respectively. These specific emissions intensity values are not explicitly quantified in the CSCs publicly available documentation, however (CSC, 2022b).

In order to receive a certificate from the CSC, several prerequisites must be met regarding; Ethical and Legal Compliance, Human Rights, Indigenous People's Rights, Environmental and Social Impact, and Traced Materials. The CSC's certification then includes categories for management, environment social, and economic sustainability with various subsectors that are incorporated into the overall score for a facility that then determines the Bronze, Silver, Gold, or Platinum ranking (CSC, 2022f).

Disclosure, Reporting, and Quality Control

In order to obtain certification by the CSC, companies must gather and submit their own documentation that is then audited and certified by a Certification Body that has a license agreement with the CSC. The CSC then reviews the audit for quality control. If a certificate is granted, the certificate is valid for three years before recertification is required (CSC, 2022a).

Constituency

The CSC is made up of several committees including an Executive Committee that is responsible for all CSC activities and stakeholder engagement; a Technical Committee responsible for the CSC technical manual, registration, and certification; an Innovation Committee that qualifies a process or solution as innovative at a regional and/or global level; an Advisory Committee that guides the CSC's work and potential new areas of focus and content of the certification. These committees are largely made up of industry representatives including representatives from Heidelberg Cement, Holcim, and Buzzi Unicem along with other representatives from organizations like the GCCA and academia (CSC, 2022d).

As of June 2023, the CSC has 25 members from industry and other organizations including HOLCIM, Federton Confindustria, Kiwa, Titan, Betonhuis, and the National Ready Mixed Concrete Association to name a few. The CSC additionally has two listed sponsors; Güterschutz Beton and KTI (CSC, 2023).

CSC has been recognized as a responsible sourcing certification system for concrete, cement, and aggregates by the Building Research Establishment Environmental Assessment Method (BREEAM), By DNGB, and by Envision, a US infrastructure certification (CSC, 2022a).

Standards Development Status

The CSC was founded in November 2016 after several years of work led by the Cement Sustainability Initiative within the World Business Council for Sustainable Development. At the time of writing this report, no changes have been announced to the CSC‘s certification system (CSC, 2022a).

4.10 National Ready Mix Concrete Association's Life Cycle Assessment of Ready-Mixed Concrete benchmark report

The National Ready Mix Concrete Association (NRMCA) represents and serves the ready-mixed concrete industry in the United States (U.S.) promoting and educating ready-mix concrete as a building material. The organization works with U.S. state associations on promotion and regulatory issues. The NRMCA's Architecture 2030 Challenge was started in 2012 to reduce embodied carbon from the built environment to net zero by 2050 in support of the 1.5°C Paris Agreement goals. This challenge asks architects to specify products with carbon footprints 35% below industry average in 2015 and increasing to 50% below industry average by 2030. Under this challenge, the NRMCA has conducted an industry-wide EPD development and has developed a Benchmark Report with voluntary participation from its members.

Features

The MRMCA Benchmark Report titled "A Cradle-to-Gate Life Cycle Assessment of Ready-Mixed Concrete Manufactured by NRMCA Members – Version 3.2" utilizes ISO 14040:2006 and ISO 14044 for LCAs and ISO 21930:2017 for EPDs. The report covers 72 ready mixed concrete product ranges across the NRMCA members' production. The boundary of the assessment scope includes the following, additionally represented in Figure 19:

- Raw material supply (upstream processes): extraction, handling, and processing of the raw materials and intermediate component products as well as fuels used in the production of concrete.
- Transportation: transportation of all input materials and fuels from the supplier to the gate of the concrete plant.
- Manufacturing (core process): the energy used to store, move, batch, and mix the concrete and operate the concrete plant as well as the transportation and processing of wastes from these core processes (NRMCA et al., 2021).

Building Life Cycle Information Modules															
Product stage			Construction Process stage		Use stage							End-of-life stage			
Raw Material supply	Transport	Manufacturing	Transport	Construction/Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	De-Construction/ Demolition	Transport	Waste processing	Disposal
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4

Figure 19. Boundary of the NRMCA's LCA report (NRMCA et al., 2021).

In this approach, for concrete mixing that occurs in the truck mixers, a portion of the energy that would fall under section A4 in this report, is considered under the Manufacturing section to account for mixing that would otherwise have occurred at a central mixing plant. The LCA methodology accounts for impacts per cubic meter (NRMCA et al., 2021). To account for the vast range of potential concrete mixtures and specifications, the assessment specifies six different compressive strengths and eight different mixture compositions for each to arrive at the assessment of 72 products. A full list of covered products can be found in the referenced report (NRMCA et al., 2021).

Targets, Pathways, and Requirements

The NRMCA's LCA study identified that the emissions intensity for concrete in the U.S. average range from 0.240 to 0.588 tonnes of CO_2e per m^3 of concrete across the 2,500 to 5000LW psi 28-day compressive strength regime as shown in Figure 20.

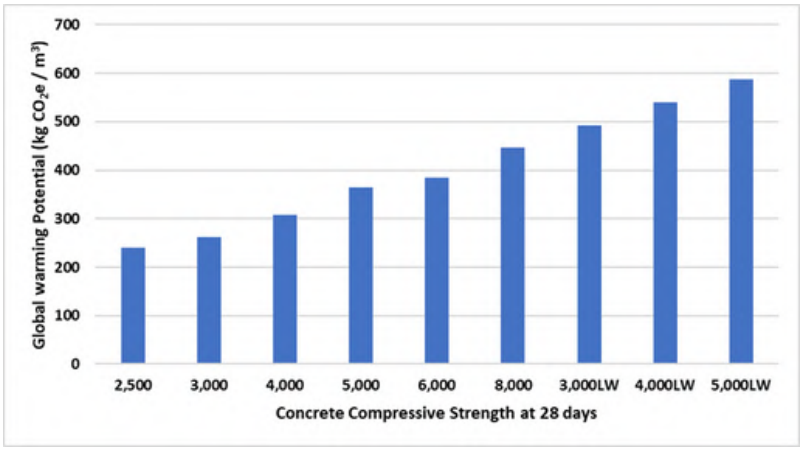

Figure 20. NRMCA's LCA national average emissions intensity of various concrete compressive strengths (NRMCA et al., 2021).

Across this regime, a company would need to produce concrete in its given compressive strength class 50% less than the value shown in Figure 20 for its respective compressive to be considered under the Architecture 2030 Challenge. Within the LCA, the emissions intensities are also quantified by region and can be found in the referenced report.

Disclosure, Reporting, and Quality Control

Data for the LCA was acquired through a voluntary survey of NRMCA members on production, transportation, and fuel use, and values for the LCA impacts were derived from various data sources further detailed in the referenced report and an average electricity source breakdown across the NRMCA study participants (NRMCA et al., 2021).

Constituency

The NRMCA is an industry lead organization with members from across the U.S. ready-mix concrete industry and supply chain. Participants in the executive committee, board of directors, and officers represent companies such as Holcim, CalPortland Co, American Ready Mix, Manatt's Inc, Chaney Enterprises, and Holiday Rock Co. to name a few (NRMCA, 2023c). The NRMCA is sponsored by Euclid Chemical, Chryso, GCP, Master Builders Solutions, and Sika (NRMCA, 2023b).

Standards Development Status

The NRMCA was founded in 1930 to advocate for the ready-mix concrete industry (NRMCA, 2023a). The LCA report version 3.2 builds upon version 1 utilizing 2013 data, version 2 utilizing 2015 data, and successive yearly updates to Version 3 since 2019 before the release of the current version 3.2 in 2021 (NRMCA et al., 2021).

4.11 U.S. General Services Administration IRA Low-Embodied Carbon Material Requirement

The U.S. General Services Administration (GSA) provides workplaces by constructing, managing, and preserving government buildings and by leasing and managing commercial real estate (U.S. GSA, 2013). The GSA is an independent agency of the U.S. government and is responsible for purchasing and distributing supplies to government agencies (U.S. GSA, 2020). The GSA oversees approximately $75 billion in annual contracts (U.S. GSA, 2022a). Following the signing of the Inflation Reduction Act in August 2022, and the U.S. Environmental Protection Agency (EPA) released an Interim Decision in December of 2022, the GSA published the requirements for cement and concrete to qualify for IRA funding (U.S. GSA, 2023).

Features

The GSA U.S. General Services Administration Interim IRA Low Embodied Carbon Material Requirements cover various construction materials including concrete, cement, asphalt, steel, and glass (U.S. GSA, 2023).

Targets, Pathways, and Requirements

Contractors must provide a product-specific Type III EPD for each concrete mix design specified for a project according to NSF International's product category rule for concrete and must conform with ISO 14025 and ISO 21930. If the provision of concrete under these limits is impractical, then the GSA's limits for cement may be applied. Additionally, the entire construction assembly, including rebar, qualifies for funding if at least 80% of the assembly's total cost or total weight meets these requirements. The emissions intensity requirements are shown in Tables 11 and 12 (U.S. GSA, 2023).

Table 11. Gobal warming potential limits of concrete set by the GSA Low Embodied Carbon Concrete Standard (U.S. GSA, 2023).

	GSA IRA Limits for Low Embodied Carbon Concrete - May 16, 2023 (EPD-Reported GWPs, in kilograms of carbon dioxide equivalent per cubic meter - $kgCO_2e/ m^3$)		
Specified concrete strength class (compressive strength [f'c] in pounds per square inch [PSI])	**Top 20% Limit**	**Top 40% Limit**	**Better Than Average Limit**
≤2499	228	261	277
3000	257	291	318
4000	284	326	352
5000	305	357	382
6000	319	374	407
≥7200	321	362	402
Add 30% to these numbers for GWP limits where high early strength[1] concrete mixes are required for technical reasons.			

Table 12. Global warming potential limits of cement set by the GSA Low Embodied Carbon Concrete Standard (U.S. GSA, 2023).

GSA IRA Limits for Low Embodied Carbon Cement - May 16, 2023 (EPD-Reported GWPs, in kilograms of carbon dioxide equivalent per metric ton - $kgCO_2e/ t$)		
Top 20% Limit	**Top 40% Limit**	**Better Than Average Limit**
751	819	858

For concrete, high early strength mixes are discouraged due to their higher emissions intensity, however, if they are required, the emissions intensity cannot exceed 30% of the emissions intensity of the same respective compressive strength for concrete.
The GSA also requires the submission of the ENERGY STAR Energy Star Performance score for the cement plant, including the plant name, location, and the data period of the Energy Performance Score at the time of purchase (U.S. GSA, 2023).

The EPA's Determination in December of 2022 stated that the global warming potential of the best performing 20% as stated in the Cradle-to-Gate Life Cycle Assessment of Ready-Mixed Concrete Report – Version 3.2 analysis (July 2022) (see section 4.10 of this report) meets the requirements for low carbon concrete. The top 40% are required if materials from the top 20% are not available, and must be the industry average if the 40% is not available. The GSA limits further build upon this framework (U.S. EPA, 2022).

Disclosure, Reporting, and Quality Control

The GSA requires that the EPDs for the cement be submitted to the GSA for every concrete mix batch design including the type and volume. In the standard, there is no statement on whether or how the submitted information is disclosed or quality controlled (U.S. GSA, 2023).

Constituency

The GSA was established in 1949 by President Harry Truman. The agency provides workspace to more than 1 million U.S. federal civilian employees and oversees the preservation of 480 historic buildings. The GSA receives 1% of its budget from U.S. congressional appropriations with the majority of the GSA's operating costs being recovered through the products and services it provides (U.S. GSA, 2020).

Standards Development Status

The GSA initial standards for the procurement of concrete in nationwide GSA construction, modernization, and paving projects in March of 2022 (U.S. GSA, 2022a). The GSA Low Embodied Carbon Concrete Standard was revised and updated in September 2022 (U.S. GSA, 2022b). Then further set the requirement for IRA applicable emissions intensity limits in May 2023 (U.S. GSA, 2023). To develop the standards, the GSA worked with federal agencies, trade associations, nonprofits, and local government agencies and received input from 130 industry respondents through a market survey (U.S. GSA, 2022a).

4.12 Carbon Leadership Forum's North American Material Baselines – Cement and Concrete

The Carbon Leadership Forum's (CLF) mission is to eliminate embodied carbon in buildings, materials, and infrastructure by informing policy, improving tools and data, and building community. The CLF conducts research on decarbonization pathways with material experts, NGOs, industry partners, and industry and crowdsources and disseminates their findings. The CLF also brings together engineers, contractors, material suppliers, building owners, policymakers, and associations through environments toward this common decarbonization goal. Supporting decarbonization initiatives is also a primary objective of the CLF (Carbon Leadership Forum, 2023b).

Features

The CLF published the "2023 Carbon Leadership Forum North American Material Baselines" which provide a snapshot of the state of EPDs and presents the CLF Baselines representing an estimate of industry-average GHG emissions for construction materials manufactured in North America, including cement and concrete. For cement, the CLF reports values in kg of CO_2e per ton of cement obtained from the Portland Cement Association (PCA) shown in Table 13 (Waldman et al., 2023).

Table 13. Global warming potential values for cement products in North America utilized by the CLF (Waldman et al., 2023).

Category	Product Type	Description	CLF Baseline GWP (kg CO_2e per declared unit)	Declared Unit	Method	Additional Life Cycle Stages See Appendix	Data Sources and Notes
CONCRETE							
Flowable fill Appendix B3	Flowable fill	Normal weight mixes for compressive strengths: 100 psi, 150 psi, 200 psi, 500 psi, and 1000 psi	none	1 m3	–	☐	No adequately representative data source.
Shotcrete Appendix B4	Shotcrete	Normal weight mixes for compressive strengths: 3000 psi, 4000 psi, 5000 psi, 6000 psi, and 8000 psi	none	1 m3	–	☐	No adequately representative data source.
Cement grout Appendix B5	Cement grout	Normal weight mixes for compressive strengths: 2500 psi, 3000 psi, 4000 psi, 5000 psi, and 6000 psi	none	1 m3	–	☐	No adequately representative data source.
Cement Appendix B6	Portland cement	Portland cement that conforms to ASTM C150 (USA) and/or CSA A3001 (Canada); includes a range of subtypes	922	1 metric ton	Industry	☐	PCA. (2021). Environmental product declaration - Portland cement.
Cement Appendix B6	Blended hydraulic cement	Per ASTM C219 and specified in ASTM C595, ASTM C1157, AASHTO M 240, or CSA A3001; includes a range of blended cement subtypes	742	1 metric ton	Industry	☐	PCA. (2021). Environmental product declaration - Blended hydraulic cement.
Cement Appendix B6	Portland-limestone cement	Conforms to ASTM C595 Type IL (USA) or Type GUL (Canada); limestone content is >5% and ≤15% by mass	846	1 metric ton	Industry	☐	PCA. (2021). Environmental product declaration - Portland-limestone cement.
Cement Appendix B6	Masonry Cement	Per ASTM C219 and specified in ASTM C91 or CSA A3002; includes multiple subtypes	589	1 metric ton	Industry	☐	PCA. (2021). Environmental product declaration - Masonry cement.

For concrete, the emissions intensity values are reported for the U.S. nationally and by region (obtained from the NRMCA LCA Report/EPDs) as well as by Canadian province (obtained from province-wide product EPDs) in kg CO_2e per m^3 of concrete. These reported values utilized by the CLF are shown in Tables 14 and 15.

Table 14. Global warming potential values for concrete products in the U.S. broken down by compressive strength, regionally, and nationally utilized by the CLF (Waldman et al., 2023).

	2500 psi (17.2 Mpa)	3000 psi (20.7 MPa)	4000 psi (27.6 MPa)	5000 psi (34.5 MPa)	6000 psi (41.4 MPa)	8000 psi (55.1 MPa)	LW 3000 psi (20.7 MPa)	LW 4000 psi (27.6 MPa)	LW 5000 psi (34.5 MPa)
Pacific Southwest	257	279	323	378	401	456	500	546	594
Pacific Northwest	235	261	316	386	408	487	518	575	632
Rocky Mountains	232	255	301	358	379	440	484	532	580
South Central	226	245	286	336	356	409	468	510	555
North Central	241	264	312	372	394	460	487	537	591
Southeastern	247	268	309	360	382	435	478	521	562
Great Lakes	232	255	303	363	383	452	499	551	603
Eastern	240	264	314	378	399	472	517	573	628
National	240	262	308	365	385	446	492	540	588

Notes: All values are Baseline GWP (kg CO_2e / m^3).

Data Source: NRMCA. (2022). *National and regional LCA benchmark (industry average) report - v3.2*

Table 15. Global warming potential values for concrete products in Canada broken down by compressive strength and province utilized by the CLF (Waldman et al., 2023).

		15 MPa	20 MPa	25 MPa	30 MPa	32 MPa	35 MPa	40 MPa	45 MPa	50 MPa	55 MPa	60 MPa	70 MPa	80 MPa
British Columbia	w/ AEAs	–	193.86	230.52	269.83	285.31	310.51	344.04	355.65	345.16	402.11	421.88	–	–
	w/o AEAs	179.42	194.73	219.7	258.92	272.44	293.75	329	335.06	359.49	376.56	400.43	–	–
Alberta	w/ AEAs	–	273.04	318.42	368.87	396.85	409.82	426.88	464.66	488.29	466.27	–	–	–
	w/o AEAs	–	260.95	306.32	334.47	313.61	328.02	418.44	–	447.4	–	–	–	–
Saskatchewan	w/ AEAs	–	–	312.83	346.17	379.55	417.21	441.57	473.78	–	–	–	–	–
	w/o AEAs	–	–	296.06	317.39	338.27	358.43	414.04	458.41	–	–	–	–	–
Manitoba	w/ AEAs	–	203.52	229.86	252.54	277.07	297.58	308.87	361.69	395.93	–	–	–	–
	w/o AEAs	–	202.25	223.41	245.92	–	268.42	289.75	333.45	367.01	–	–	–	–
Ontario	w/ AEAs	–	227.16	260.64	292.72	326.46	334.49	361.65	379.45	456.93	–	–	–	–
	w/o AEAs	–	220.29	254.05	264.38	264.38	295.46	326.25	349.88	335.76	354.67	361.25	354.42	–
Quebec	w/ AEAs	–	278.1	298.87	342.52	362.8	393.24	396.62	413.72	410.8	–	444.71	–	–
	w/o AEAs	–	263.8	287.42	307.09	–	345.4	364.24	381.16	404.38	–	424.74	–	485.72
Atlantic	w/ AEAs	–	343.96	360.99	394.38	438.78	447.25	474.19	528.55	551.01	–	–	–	–
	w/o AEAs	–	336.63	354.02	379.12	–	422.25	449.16	501.86	536.01	–	580.21	–	–

Notes: All values are Baseline GWP (kg CO_2e / m^3). Canadian ready-mixed concrete industry EPDs provide multiple baseline mixes per strength value in some cases. Where available, CLF included baseline values for one mix with air-entraining admixtures (AEAs), and one without.

Data Source: Concrete BC. (2022). *Concrete BC member industry-wide EPD for ready-mixed concrete*; Concrete Alberta (2022). *Concrete Alberta member industry-wide EPD for ready-mixed concrete*; Concrete Saskatchewan. (2022). *Member industry-wide EPD for ready-mixed concrete*; Concrete Manitoba. (2022). *Member industry-wide EPD for ready-mixed concrete*; Concrete Ontario. (2022). *Member industry-wide EPD for ready-mixed concrete*; Association Béton Québec. (2022). *Member industry-wide EPD for ready-mixed concrete*; Atlantic Concrete Association. (2022). *Member industry-wide EPD for ready-mixed concrete.*

Targets, Pathways, and Requirements

The CLF does not demonstrate a target emissions intensity for low carbon cement or concrete in the "2023 Carbon Leadership Forum North American Material Baselines" nor do they discuss any pathways or requirements. The report serves as a communication of current emissions intensities of building materials in North America (Waldman et al., 2023).

Disclosure, Reporting, and Quality Control

The "2023 Carbon Leadership Forum North American Material Baselines" does not discuss gathering information from direct companies that would require disclosure. The values obtained in the study are obtained from publicly available EPD information. The CLF did review the quality of the information provided in the EPDs and did not report making changes to the values presented in the report for cement and concrete (Waldman et al., 2023).

Constituency

The CLF is run out of the College of Built Environments at the University of Washington with a board represented by academics, national lab members, NGO representatives, and built environment industry members (Carbon Leadership Forum, 2023b). The CLF has 57 sponsors of various support levels. Amazon is in the highest tier of sponsorship, while from the cement and concrete industry and its supply chains, companies like Carbon Cure, the American Institute of Architects, the NRMCA, Sellen, and Central Concrete Supply Company are in the upper tiers of sponsors (Carbon Leadership Forum, 2023a).

Standards Development Status

The "2023 Carbon Leadership Forum North American Material Baselines" superseded the 2021 version that reported the average, high, and achievable target emissions intensities of cement and concrete products however, the 2023 version did not provide such targets (Carlisle et al., 2021). At the time of writing this report, there was no public announcement of the planned release of future material baseline report, although based on previous timelines, an update is likely in coming years.

4.13 Marin County's Low Carbon Concrete Code

Marin County is a county in the U.S. state of California located on the San Francisco Bay that has developed programs to promote renewable energy, address climate change, encourage green building, recognize green businesses, and implement energy efficiency projects in County schools, special districts, and cities and towns (Marin County, 2022). Marin County adopted the world's first building code that limits carbon emissions from concrete through their Low Carbon Concrete Requirements enacted in November 2019 (Ehrlich, 2019).

Features

The Marin County Low Carbon Concrete Code focuses on maintaining adequate strength and durability for the intended application while reducing embodied carbon. The code covers concrete placed in its jurisdiction and covers replacing Portland cement with supplementary cementitious materials, minimizing the amount of cement in mixes, selecting aggregate, and changing the requirements for how quickly concrete has to cure. The code excludes precast concrete (Ehrlich, 2019). Based on the minimum specified compressive strength of concrete, the code sets limits for the maximum Portland cement content in lbs/yd^3 and maximum embodied carbon in kg CO_2e per m^3 verified by EPDs (Marin County, CA, 2019).

Targets, Pathways, and Requirements

The required cement utilization and embodied carbon limits as outlined in the Marin County Low Carbon Concrete Code are shown in Table 17.

Exceptions can be applied for high early-strength concrete up to a 30% increase from the values shown in Table 17. Cement content can be increased proportionally by providing an EPD for the cement that demonstrates a carbon intensity of less than 1,040 kg of CO_2e per tonne (Marin County, CA, 2019).

Table 17. Marin County Low Carbon Concrete Code's cement and embodied carbon limits per minimum specified compressive strength (Marin County, CA, 2019).

	Cement limits for use with any compliance method 19.07.050.2 through 19.07.050.5	Embodied Carbon limits for use with any compliance method 19.07.050.2 through 19.07.050.5
Minimum specified compressive strength f'_c, psi (1)	Maximum ordinary Portland cement content, lbs/yd^3 (2)	Maximum embodied carbon, kg CO_2 e/m^3, per EPD
up to 2,500	362	260
3,000	410	289
4,000	456	313
5,000	503	338
6,000	531	356
7,000	594	394
7,001 and higher	657	433
up to 3,000 light weight	512	578
4,000 light weight	571	626
5,000 light weight	629	675
Notes (1) For concrete strengths between the stated values, use linear interpolation to determine cement and/or embodied carbon limits. (2) Portland cement of any type per ASTM C150 or ASTM C595.		

Disclosure, Reporting, and Quality Control

Before issuing building permits, applicants are required to submit a completed low-carbon concrete compliance form that is reviewed by the County for compliance with the code. Batch certificates and/or EPDs must also be submitted demonstrating this compliance following the placement of the concrete. Exemptions can be applied for if there is a lack of commercially available material, the cost of achieving compliance is disproportionate to the overall cost of the project, or if the historic integrity of a listed structure is impaired by compliance with the code (Marin County, CA, 2019).

Constituency

The work behind the Marin County Low Carbon Concrete Code was in part funded by the Bay Area Air Quality Management District Climate Protection Grant Program. The Code was developed through government, engineer, architect, academia, the Carbon Leadership Forum, concrete industry representatives, regional stakeholders, and the U.S. Green Building Council (Ehrlich, 2019).

Standards Development Status

The Marin County Low Carbon Concrete Code was adopted in November 2019. Enforcement of the code was deferred during the COVID-19 pandemic with enforcement resuming on January 1, 2023.

4.14 The Concrete Centre's UK Concrete Industry Sustainability Performance Report

The Concrete Centre offers material, design, and construction guidance, with the goal of helping individuals involved in the design, use, and performance of concrete to realize its full potential. The organization provides the design community with published guidance, seminars, courses, online resources, and industry research to support their understanding and utilization of concrete (The Concrete Centre, 2023a).

The Concrete Industry Sustainable Construction Strategy was adopted in 2008 by various manufacturers and sector associations in the UK concrete industry. This commitment encompassed sectors such as aggregate, cement, GGBS, fly ash, admixtures, ready-mixed concrete, and precast concrete (The Concrete Centre, 2023b).

Features

Over the course of 12 years, annual performance reports have been published, highlighting the industry's dedication to implementing a unified framework for reporting and continuously striving for improvement. A key strategic objective was also to effectively communicate and educate both colleagues and customers about these sustainability efforts (The Concrete Centre, 2021). Additionally, the performance report serves as a benchmark against the industry's 30% CO_2 emissions reduction target set in 2012 (The Concrete Centre, 2012). The newest and 13th edition of the Concrete Industry Sustainability Performance Report covering 2019 data highlights that the UK concrete industry has achieved a 29.3% reduction in the embodied carbon of a standardized mix of concrete at 72.5 kg of CO_2e per tonne of concrete, down from 102.6 in 1990 (The Concrete Centre, 2021).

Targets, Pathways, and Requirements

At the time of writing this report, a revised Concrete Industry Sustainable Construction Strategy has been published, however, a target has been set to achieve net zero emissions by 2050 with a target of achieving beyond net zero emissions through methods like electrification, transport efficiency, use of low carbon cements and concretes, fuel switching, CCUS, carbonation, and thermal mass utilization. A detailed outline of this pathway is shown in Figure 21 with relative contributions compared to 2018 values (The Concrete Centre, 2020).

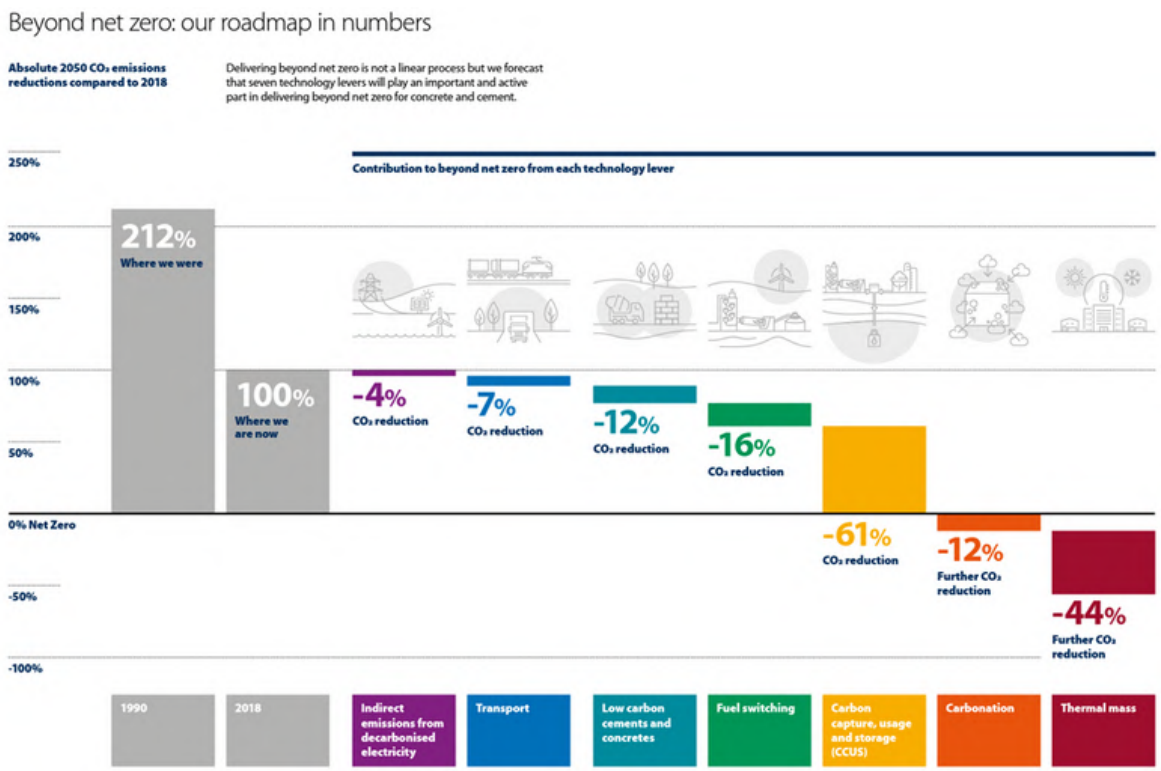

Figure 21. The Concrete Centre's roadmap to beyond net zero for the UK concrete industry (The Concrete Centre, 2020).

Disclosure, Reporting, and Quality Control

To develop its benchmarking reports, The Concrete Centre obtains data from various sector associations, including the British Ready Mix Concrete Association and MPA (The Concrete Centre, 2020).

Constituency

The Concrete Centre is made up of team members with backgrounds in concrete, construction, engineering, architecture, and sustainability. The Concrete Centre has 31 U.K. member companies across the concrete supply chain including Cemex UK, Aggregate Industries, Meyers Group, and Quattro UK (The Concrete Centre, 2023a,c,d). The founders include Aggregate Industries, Brett Group, CEMEX, Hanson UK, Marshalls plc, and Tarmac (The Concrete Centre, 2020).

Standards Development Status

The Concrete Centre's "Concrete Industry Sustainability Performance Report" has been updated yearly for the last 12 years with the most recent report published in 2021 assessing 2019 year data.

4.15 Low Carbon Concrete Group's Low Carbon Concrete Roadmap

The Low Carbon Concrete Group (LCCG) is a part of the Institution of Civil Engineers (ICE) under their Green Construction Board. The LCCG released the "Low Carbon Concrete Roadmap" in 2022 to examine how the infrastructure industry can use the latest tools, technologies, and materials to continue using concrete while working towards a zero-carbon future. The roadmap's focus is particularly on the UK concrete industry (LCCG, 2022a). In 2023 The Concrete Centre published a 2023 updated Embodied Carbon of Concrete -Market Benchmark focused on concrete emissions intensity in the UK.

Features

The structure of the 2022 roadmap first sets benchmarks and benchmark ratings for the production of concrete and additionally provides insight into decarbonization pathways for using and making concrete that focus on knowledge transfer, design and specification, supply and construction, optimizing existing technology, adopting new technology, and CCUS. The roadmap is concluded with a section covering the next steps in decarbonizing the industry and presenting several decarbonization scenarios (LCCG, 2022b).

In the 2023 market benchmark report roadmap's benchmarking, the embodied carbon associated with concrete production in a batching plant or precasting facility is considered to cover LCA stages A1 to A3 similar to the approach outlined in the NRMCA LCA. The LCA follows BS EN 156431 (superseded by EN 17472 as of March 2022), BS EN 158042, and BS EN 167573. Concrete reinforcement, finishes, etc. are excluded from the scope and assume the use of Portland cement without SCMs.

Carbon intensity benchmark ratings are determined according to the distribution of data obtained in the UK from the British Ready-mixed Concrete Association as well as member companies based on a kg CO_2e per m^3 basis by strength class (LCCG, 2022b).

Targets, Pathways, and Requirements

The LCCG provides benchmark rankings for embodied carbon that fall into the rankings from A++ to F by strength class presented in Figure 22.

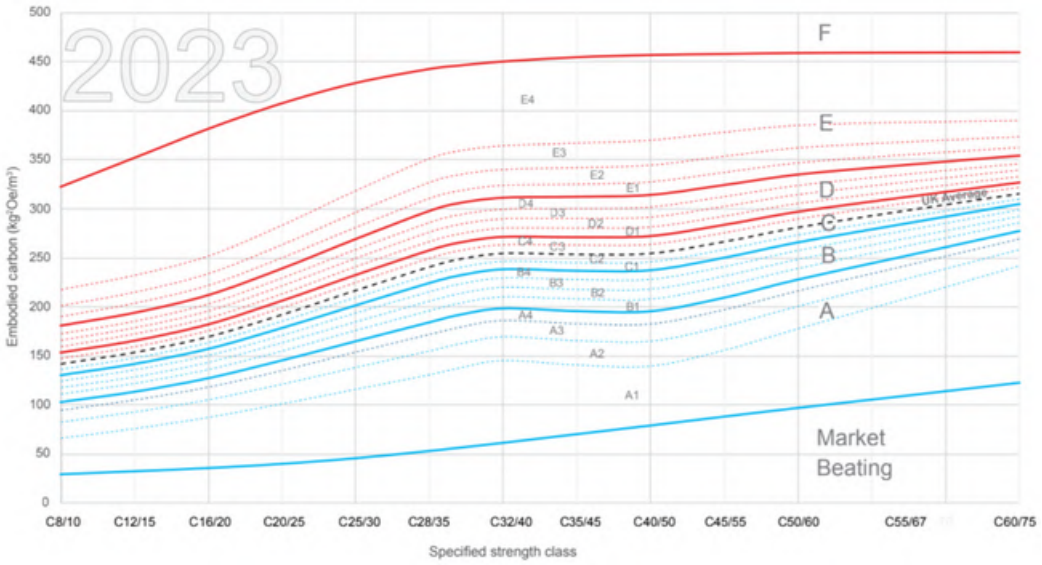

Figure 22. LCCG's benchmark ratings for embodied carbon, normal-weight concrete, for LCA stages A1-A3 (ready-mix: cradle to batching plant gate; precast: cradle to mold) (LCCG, 2022b).

In these benchmarks, a specific target is not presented for each strength class, however, and the ratings simply reflect the distribution of the current emissions intensity of UK concrete by strength class. For example, A++ reflects an emissions intensity below that of benchmarked concretes while A+ represents the top 5%, A represents the best 5%-20%, and so on. Each A-F classification is further broken down into increments of 5% (LCCG, 2022b).

Disclosure, Reporting, and Quality Control

The LCCG states that there should be required public reporting of the as-constructed benchmark ratings and requires submission of concrete strength and carbon data to keep the benchmark current. The roadmap does not mention quality control of the data by the LCCG (LCCG, 2022b).

Constituency

The LCCGs Low Carbon Concrete Roadmap is by members from the concrete and cement industries, academia, and engineers represented by CEMEX, AMCRETE UK, The Concrete Centre, and the University of Leeds to name a few. The roadmap has been endorsed by the Construction Leadership Group. The Green Construction Board, ICE, The Institution of Structural Engineers, and MPA The Concrete Centre (LCCG, 2022b).

Standards Development Status

The LCCG states that updates to the benchmark will be required, however, there is currently no stated update timeline.

5. Low-Carbon Cement and Concrete in National and Regional Policies

There are other cement and concrete industry decarbonization policies in these countries and regions discussed below which were not included in our discussion explicitly. This analysis mainly focuses on GPP in countries and regions where they exist as an example of how low-carbon cement and concrete are defined in those policies. The purpose of this review was not to include every cement and concrete decarbonization policy; however, a sample of the cement and concrete industry decarbonization policies enacted in different countries or states is briefly included.

5.1 European Union Green Public Procurement and Other EU-Level Standards

Collectively the European Union's 27 member countries are one of the largest producers of cement and concrete in the world, and in 2015 had the 7th highest emissions intensity of cement-producing nations at approximately 0.62 tons of CO_2e per ton of cement produced. In the same time frame, the EU ranked the 6th highest in terms of energy intensity with about 3.7 GJ per ton of clinker produced (Hasanbeigi & Springer, 2019). It is estimated that 4% of the EU's CO_2 emissions are from the cement industry with a target to reduce GHG emissions by 55% by 2030, and a goal to be climate neutral by 2050 (European Commission et al., 2023).

Within the EU, public procurement accounted for 2.3 trillion euros at approximately 19% of GDP in 2018. The majority of EU member states have adopted a voluntary approach to GPP; however, Austria, the UK, and the Netherlands have introduced mandatory green procurement for their central governments. In France, green procurement is mandated for selected product groups. Voluntary approaches tend to be more common in decentralized countries, leaving as much autonomy as possible to the sub-central government level (Hasanbeigi et al., 2019).

The EU GPP criteria are based on available scientific information and data (including eco-labeling), a life-cycle approach, and stakeholder engagement. The EU criteria contains two levels of stringency: one which is designed for ease of use while reducing key environmental concerns, and comprehensive criteria, which are more ambitious requirements for agencies that want to go further in supporting environmental and innovation goals the EU has set a voluntary target of at least 50% of procurement following GPP criteria.

Many countries have set their own targets, ranging from as low as 20% in Poland to less than 50% in France and Latvia to as high as 100% in the Netherlands. In some countries, green procurement's scope and targets have not been set (Hasanbeigi et al., 2019).

For the cement and concrete industry, GHG emissions are regulated through the EU Emissions Trading System (EU ETS), however, the cement industry has historically been receiving a free allocation of emission allowances to prevent carbon leakage that is planned to be phased out between 2026 and 2033. Despite a rise from 25 EUR/tCO_2 in 2020 to nearly 100 EUR/tCO_2 in 2022 in the carbon price in the ETS, the free allocation has largely shielded the cement industry from incentivizing decarbonization investments, however, higher prices will begin to incentivize decarbonization of the industry. The EU has also passed a Carbon Border Adjustment Mechanism (CBAM) in May of 2023 that will begin its transitional phase in October of 2023 that ensures imports of cement to the EU face the same carbon prices of domestically produced cement (European Commission, 2023), (European Commission et al., 2023).

Features

The European Union supports the use of project-level analysis in GPP criteria based on a point system. Points can be awarded based on the improvement of life cycle assessment (LCA) performance in comparison with business as usual or competing designs. A weighting system is applied to combine various LCA indicators including global warming potential (GWP), depletion potential of the stratospheric ozone layer (ODP), and acidification potential of soil and water (AP) into an overall score. In the absence of an LCA, the GWP from a carbon footprint (CF) assessment can be used. In the absence of both, points can be calculated from proxy data such as the reduction of CO_2 equivalent emissions from the transportation of materials and recycling of demolition waste (European Commission 2022). Environmental product declarations (EPDs) are also a key source of this information and serve as a reporting mechanism for product-level emissions intensity for products. The EU is leading the way in EPD development and utilization globally (Hasanbeigi et al., 2019), (Hasanbeigi et al., 2021).

Within the EU, The Netherlands has the most robust GPP system covering 45 product groups and monetizes the environmental impacts of their production. A software program called DuboCalc quantifies the life cycle environmental effects of materials and energy that are used to compute an environmental cost indicator. In this system, procurers can set a maximum cutoff for this indicator above which a supplier becomes ineligible or procurers can subtract a monetized value below the standard from the bids. The Netherlands also utilizes a five-runged CO_2 performance ladder for products and subtracts a monetized value from a bid based on the rung classification of the material (Krupnick, 2020).

5.2 United States Federal Buy Clean Initiative

The United States of America was the world's 4th largest producer of cement in 2021 and is the 5th largest total emitter of CO_2 from cement production in 2021 (Our World in Data, 2023). The emissions intensity of U.S. cement production was ranked the highest of all nations, behind Italy, at approximately 0.80 tons of CO_2 emissions per ton of cement produced in 2015.

The U.S. high emissions intensity during cement production can largely be attributed to the addition of SCMs during concrete production rather than cement production as is more common in other countries around the world. The U.S. also had the highest energy intensity of all major cement-producing nations at approximately 3.9 GJ per ton of clinker produced (Hasanbeigi, 2022) in 2019. The U.S. is the world's largest importer of cement and imported 161 million metric tons of cement in 2021 (Hasanbeigi et al., 2021), (Hasanbeigi et al., 2022).

To spur the development of low-carbon construction materials made in America, the Biden-Harris administration announced the Federal Buy Clean Initiative in September of 2022. The initiative will prioritize the purchase of key low-carbon construction materials covering 98% of the materials purchased by the U.S. Federal Government. Which, steel, glass, concrete, and asphalt material production in the U.S. account for 50% of industrial emissions.

The Federal Buy Clean Initiative includes the Bipartisan Infrastructure Law, Inflation Reduction Act, and the CHIPS and Science Act all aimed at increasing low-carbon manufacturing in the U.S.. The initiative builds on the Buy Clean commitments made by the administration earlier in 2022 which included standing up the Federal Buy Clean Task Force (The White House, 2022).

The U.S. Federal government is the largest direct purchaser in the world and in the U.S. approximately 46% of the total nation's s concrete consumption was utilized in public construction projects in 2018. (The White House, 2022) (Hasanbeigi et al., 2021). In the U.S., public procurement accounts for 12% of the GDP, and 18% of the nation's emissions can be attributed to public construction projects.

It is estimated that the Buy Clean Initiative could directly reduce 1-5 million tonnes of CO_2 emissions from the cement industry alone with the potential to reach up to 39 million tonnes of CO_2 emissions reduction in indirect impacts as U.S.concrete manufacturing companies decarbonize to meet federal government project demands (Hasanbeigi et al., 2021).

Features

The Federal Buy Clean Initiative is focused on steel, concrete, asphalt, and flat glass and has several key features outlined below:

Prioritizing the purchase of materials that have lower levels of emissions

The Federal Government will purchase key construction materials when they have fewer GHG emissions associated with their manufacturing, transportation, installation, maintenance, and disposal. The Buy Clean Task Force will provide instructions to agencies for integrating Buy Clean into federal procurement and funding processes (The White House, 2022).

Expanding lower-carbon construction materials used in federally funded projects

Buy Clean will also cover federally funded projects in addition to federal procurement. Under Buy Clean the Department of Transportation is developing an agency-wide Buy Clean policy and establishing an Embodied Carbon Workgroup (The White House, 2022).

Convening states to partner on Buy Clean

The Initiative is partnering with Federal and State governments to align state-based Buy Clean policies with federal incentives to expand the market for clean manufacturing. The partnership aims to share knowledge and build capacity for public construction projects that support U.S. manufacturing and lower carbon emissions (The White House, 2022).

Increasing data transparency through supplier reporting to help track and reduce emissions

The administration will expand the reliability, transparency, and verification of environmental product declarations (EPDs) including GHG emissions reporting for the supply chain production of these materials. The Initiative is partnering with the Environmental Protection Agency (EPA) and providing $100 million for program costs and $250 million for grants and technical assistance (The White House, 2022).

Launching pilot programs to advance federal procurement of clean construction materials

Pilot programs under the Buy Clean Initiative have been launched across the U.S. in partnership with regional contractors and subcontractors including engineering, architecture, and material firms. The pilot programs are also receiving technical support from the Department of Energy (DOE), EPA, and the United States Department of Agriculture (USDA) (The White House, 2022).

Targets, Pathways, and Requirements

Under the Buy Clean Initiative, the Buy Clean Task Force is developing a recommendation on policies and procedures to expand consideration of embodied emissions and pollutants of materials in federal procurement and funded projects. The group is identifying materials and pollutants to prioritize for consideration in Federal procurement and projects. Additionally, the group is working to increase the transparency of embodied emissions of products through supplier reporting and includes incentives and technical assistance to help U.S. manufacturers better report and reduce embodied emissions of their products (Federal Buy Clean Initiative | Office of the Federal Chief Sustainability Officer, 2021). The GSA is the primary concrete purchasing body for federal projects and set their initial targets for the Buy Clean Initiative in March of 2022, updated their requirements in September 2022, then further updated them in May of 2023. Additional details on the GSA requirements can be referenced in its respective section and tables of those requirements are provided herein for ease of reference.

Table 18. Global warming potential limits of concrete set by the GSA Low Embodied Carbon Concrete Standard.

	GSA IRA Limits for Low Embodied Carbon Concrete - May 16, 2023 (EPD-Reported GWPs, in kilograms of carbon dioxide equivalent per cubic meter - $kgCO_2e/ m^3$)		
Specified concrete strength class (compressive strength [f'c] in pounds per square inch [PSI])	**Top 20% Limit**	**Top 40% Limit**	**Better Than Average Limit**
≤2499	**228**	**261**	**277**
3000	**257**	**291**	**318**
4000	**284**	**326**	**352**
5000	**305**	**357**	**382**
6000	**319**	**374**	**407**
≥7200	**321**	**362**	**402**
Add 30% to these numbers for GWP limits where high early strength[1] concrete mixes are required for technical reasons.			

Table 19. Global warming potential limits of cement set by the GSA Low Embodied Carbon Concrete Standard

GSA IRA Limits for Low Embodied Carbon Cement - May 16, 2023 (EPD-Reported GWPs, in kilograms of carbon dioxide equivalent per metric ton - $kgCO_2e/ t$)		
Top 20% Limit	**Top 40% Limit**	**Better Than Average Limit**
751	**819**	**858**

In December 2022, the EPA issued an Interim Determination focusing on the interpretation of embodied carbon for cement/concrete, glass, asphalt, and steel. The Determination stated that the global warming potential of the best performing 20% as stated in the Cradle-to-Gate Life Cycle Assessment of Ready-Mixed Concrete Report – Version 3.2 analysis (July 2022) (see section 4.10 of this report) meets the requirements for low carbon concrete. The top 40% are required if materials from the top 20% are not available, and must be the industry average if the 40% is not available. The Determination also states that upstream cement manufacturing is required to provide an ENERGY STAR Performance Indicator. Additionally, concrete procured must have an EPD relying on specific data from the upstream cement plant (U.S. EPA, 2022). Through 2023, the EPA is working on setting a standardized Ecolabel for cement and concrete, however, the project is still in development at the time of writing this report (U.S. EPA, 2023).

Constituency And Development Status

Established under Executive Order (E.O.) 14057 on Federal Sustainability, the Buy Clean Task Force is co-chaired by the Federal Chief Sustainability Officer and the White House Office of Domestic Climate Policy The Task Force includes representatives from the Departments of Commerce, Defense, Energy, Homeland Security, Housing and Urban Development, Health, and Human Services, Interior, State, and Transportation; the Environmental Protection Agency; the General Services Administration; the National Aeronautics and Space Administration; the Veterans Administration; the White House Office of Management and Budget; and the White House Domestic Climate Policy Council. Together, the Task Force agencies account for 90% of all federally-financed and purchased construction materials. (Federal Buy Clean Initiative | Office of the Federal Chief Sustainability Officer, 2021).

5.3 Buy Clean Programs in U.S. States

Similar to the federal government, U.S. states are major purchasers of construction materials including concrete. It has been estimated that nearly one-third of all concrete used for construction in the U.S. is procured by state and local governments. Of these states, California has historically been one of the only states with a dedicated Buy Clean law that currently applies to steel, flat glass, and insulation materials, however, legislation to decarbonize concrete in California has been proposed. Several other U.S. states have also passed Buy Clean legislation into law for concrete/cement including New York, New Jersey, and Colorado. Legislation in Virginia and Illinois has been proposed in recent years but was not passed (Stashwick, 2022).

California

The state of California is a leader in establishing state green building regulations and standards for the United States of America and provides a model for other jurisdictions considering embodied carbon regulations (Hasanbeigi et al., 2019). Cement and concrete have not yet been added to the California Buy Clean Program, however, California introduced Senate Bill 596 in 2020 which was signed into law in 2021 that required cement producers to reduce their GHG emissions from cement production by at least 40% below 1990 levels by 2035 with a goal of achieving zero emissions by 2045. The bill also requires the California Air Resources Board (CARB) to establish interim targets for the reduction of GHG intensity of cement used within the state (CARB, 2021).

New York

In 2022, New York's Governor signed Executive Order 22 (EO 22) which included procurement commitments and guidelines that included the embodied carbon reduction in new construction that was further refined in New York City's Clean Construction Executive Order 23 (EO 23) These executive orders built upon the Low Embodied Carbon Concrete Leadership Act (LECCLA) passed in January of 2021 that convened an agency and industry stakeholder group to design a system for state agencies to award contracts that include the climate performance of the proposal. EO 22 required EPDs to be submitted at the bid stage for state-funded construction projects. New York State released its approved Lower Carbon Concrete specification applicable to concrete used for building and roadway construction (NRDC, 2022). These specifications require EPDs with a preference for batch-specific, over regional and industry averages. Where no EPD is provided the cement utilized must have a lb CO_2 per unit lb limit of 0.9060. The standard also sets a maximum Portland cement content of 400 lbs per cubic yard and 300 lbs per cubic yard for below-grade concrete uses.

The specification requires a 30% minimum total SCM by total weight of all cementitious materials. There are also additional aggregate requirements that can be seen for additional detail in the referenced specification (New York State Office of General Services, 2022).

New Jersey

In January of 2023, the state of New Jersey signed into law the New Jersey Low Embodied Carbon Concrete Leadership Act. This act focuses on public procurement in which New Jersey state agencies are the largest buyers of concrete in the state. Concrete producers who supply 50 yards of concrete for state-funded projects will be eligible to receive a tax credit of up to 8% of the total contract cost if they provide concrete for the project that is under a maximum CO_2 intensity value in kg of CO_2 per m^3 of concrete. The program begins in 2024 and at the time of writing this report, the threshold has not yet been made public. The funding for the tax credit is set at a $10 million per year cap and is issued on a first come first served basis and is limited to $1 million per applicant (NRDC, 2023).

Colorado

The Buy Clean Colorado Act (BCCO), signed into law in 2021, applies to state public projects with costs that exceed $500,000 issued by a Colorado government agency after January 1, 2024. The program is administered by the Office of the State Architect for construction projects and the Colorado Department of Transportation for horizontal construction projects and applies to the construction, alteration, repair, demolition, or improvement of any land, building, structure, facility, road, or bridge that is intended to promote public upkeep. Global warming potential thresholds are included for numerous materials including cement and concrete mixtures (Colorado Office of the State Architect, 2022). The thresholds for concrete and cement were issued in a draft version in June 2023 and are detailed in Table 20 below.

Table 20. Buy Clean Colorado Act global warming potential thresholds for cement and concrete (Colorado Office of the State Architect, 2023)

Material[1]	2023 OSA Updated Limits[2]
Asphalt and mixtures[3]	**1. Asphalt Mixtures** (1 metric ton): 85 kg CO2 eq.
Cement & Concrete Mixtures[4]	**1. ReadyMix Concrete** (in kgCO2e/m3 or kilograms of carbon dioxide equivalent per cubic meter)
	a. 0-2500 psi: 232
	b. 2501-3000 psi: 255
	c. 3001-4000 psi: 301
	d. 4001-5000 psi: 358
	e. 5001-6000 psi: 379
	f. 6001-8000 psi: 440
	g. Lightweight 0-3000 psi: 484
	h. LW 3001-4000 psi: 532
	j. LW 4001-5000 psi: 580
	2. Cement (in kgCO2e/t or kilograms of carbon dioxide equivalent per metric ton): 1,112

5.4 Whole Lifecycle Building Embodied Carbon Policies

In the building industry, embodied carbon refers to the GHG emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of building materials. This differs from operation carbon, defined as the GHG associated with a building's energy consumption. Approximately, 8% of the global carbon emissions result from the manufacturing of construction materials while operational carbon is expected to fall with increasingly lower carbon energy systems. Embodied carbon limit policies have recently gained traction in several countries, U.S. states, and cities discussed further in this section. Embodied carbon limits additionally target material efficiency in the design of projects and material substitution, beyond the carbon intensity of the materials (Carbon Leadership Forum, 2020). While some approaches have targeted net-zero or net-zero capable buildings, only policies with specific targets that consider embodied carbon of materials are detailed herein.

Countries

Denmark

The Danish government adopted a requirement to calculate a building's climate footprint and to comply with a whole life carbon (WLC) metric. The regulation applies to buildings larger than 1000 m². Buildings less than 1000 m² must conduct a WLC measurement but are not required to comply with limit values. The current regulation requires the inclusion of both embodied and operational carbon emissions. In 2023 the limit is set as 12 kg CO_2/m² /year and will decrease to 10.5, 9, and 7.5 kg CO_2/m²/year in 2025, 2027, and 2029 respectively (Steinmann et al., 2022).

France

The French Réglementation environnementale (RE2020) came into force in 2022 and applies to new construction of residential buildings, office buildings, and education buildings. The regulation sets mandatory limits separated by operation and embodied carbon however the limits are not standardized and are adjusted to every specific building according to a set of coefficients. The limit also reduces over time. The limits for single-family and multifamily homes however are outlined in Table 21 (Steinmann et al., 2022).

Table 21. WLC limits for single-family and multi-family homes overtime for RE2020 (Steinmann et al., 2022).

	Single-family homes	Multi-family homes
2022-2024	640 kgCO2/m2	740 kgCO2/m2
2022-2024	530 kgCO2/m2	650 kgCO2/m2
2028-2030	475 kgCO2/m2	580 kgCO2/m2
From 2031	415 kgCO2/m2	490 kgCO2/m2

Netherlands

In 2018 The Netherlands set a regulation requiring the mandatory calculation of the Environmental Performance of Buildings that applies to new residential buildings and office buildings larger than 100 m². The approach taken differs from others discussed in this section in that the Environmental Cost Indicator is determined in which the outcome of a Life Cycle Assessment (LCA) is translated into a monetary value by assigning a monetary value to environmental impact categories and the damage associated with a certain type of emissions. In 2021 the limit for residential buildings was set at 0.8 EUR/m²/yr and 1 EUR/m²/yr for office buildings (Steinmann et al., 2022).

U.S. States

California

The California Green Building Standards Code, CALGreen, was first introduced in 2008 with voluntary measures that have since evolved into more detailed voluntary and mandatory requirements for whole building embodied carbon detailed in Figure 23 below effective in 2024. Under CALGreen compliance can be demonstrated through either of the three approaches shown (Bantock, 2023).

CALGreen's

Proposed Mandatory and Voluntary Carbon Reduction Measures for Non-Residental Buildings

	Existing Voluntary	Mandatory 50,000 sq ft (project aggregate)	Tier 1 50,000 sq ft (project aggregate)	Tier 2 50,000 sq ft (project aggregate)
Building Reuse	75% of the structure and enclosure to be reused.	45% of structure and enclosure to be reused.	75% of the structure and enclosure to be reused.	75% of the structure and enclosure to be reused, AND 30% of interior non-structural elements to be reused.
Whole Building Lifecycle Assessment (WBLCA)	10% reduction from baseline	10% reduction from baseline	15% reduction from baseline	20% reduction from baseline
Prescriptive Approach		175% of IW-EPD GWP limits; concrete 130% of ready-mixed GWP values	150% of IW-EPD GWP limits; concrete 130% of ready-mixed GWP values	IW-EPD GWP limits; concrete 130% of ready-mixed GWP values

Figure 23. CALGreen's whole building embodied carbon requirements (Bantock, 2023).

Cities

Toronto, Canada

In the Canadian city of Toronto, for the first time in a jurisdiction in North America, a cap on embodied carbon in new city-owned buildings was set in May of 2023. The emissions intensity for these buildings was set at 350 kg of CO_2e per m^2 with a voluntary limit of 250 CO_2e per m^2. The requirement is currently optional for privately owned new buildings, however, it may become mandatory but no clear timeline has been set for such change (Mantle Developments, 2023). Proposed 2024 caps are shown in Figure 24.

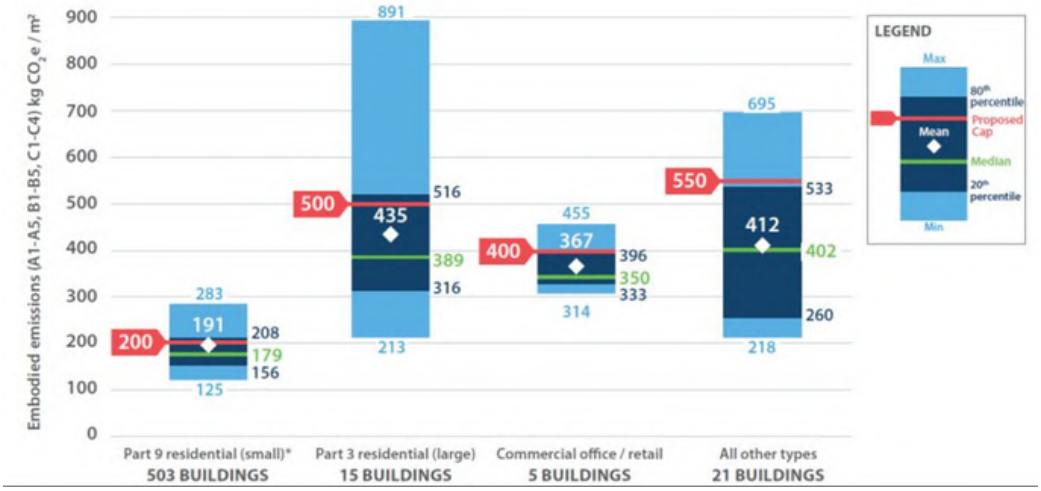

Figure 24. Proposed whole building embodied carbon emissions caps for Toronto in 2024.

Zurich, Switzerland

In 2008, Zurich committed to a 2050 target of 8.5 kg CO_2e/m^2 for life-cycle embodied carbon in residential buildings in a program known as the MINERGIE-ECO standards. Newly constructed buildings are required to meet this standard (Carbon Leadership Forum, 2020).

5.5 Canada Green Public Procurement

Canada produced 13.2 million tonnes of cement in 2019 and that cement has a CO_2 intensity of 0.771 tonnes of CO_2e per tonne of cement produced. (Hasanbeigi, 2022b). The Federal Greening Government Strategy announced in 2017 established a goal of net-zero emissions by 2050, including the procurement of goods and services). Canada's Greening Government Strategy for the government's property and fleet operations has committed to reducing absolute Scope 1 and Scope 2 GHG emissions by 40% by 2025 and by at least 90% below 2005 levels by 2050. On this emissions reduction pathway, the government will aspire to reduce emissions by an additional 10% every 5 years starting in 2025.

For materials like concrete, this pledge incorporates the disclosure of embodied carbon in structural materials by 2022, reducing the embodied carbon of structural materials by 30% starting in 2025, and conducting LCAs for entire assets by 2025 (Treasury Board of Canada Secretariat, 2020). Additionally, Canada has developed its 2030 Emissions Reduction Plan pledged to reduce its emissions by 45% from 2005 levels by 2030 (National Research Council Canada, 2022).

Canada spent approximately CA$ 218 billion (13% of GDP) on public procurement in 2020 and its large-scale purchasing power gives the government leverage in driving markets towards the development of low-carbon goods and services. In Canada, some elements of Buy Clean policy are already in place and 32% of public procurement was spent on cement products in 2018, the most of any material. The government will reduce embodied carbon starting in 2025 through the use of recycled and lower-carbon, material efficiency, and performance-based design standards, and conduct a whole building life-cycle analysis by 2025 for major projects.

In service of this, the government is building a repository of reliable emissions data through the Low Carbon Assets through Life Cycle Assessment (LCA2) initiative (Hasanbeigi et al., 2022b In 2021-2022, Canada also approved a CAD 1.3 billion project called the Buyers for Climate Action (BCA) that aims to establish a coalition of large green buyers to accelerate green procurement and supplier disclosure in areas such as net zero and climate-resilient buildings, low carbon construction materials, zero-emission fleets, and green information and communications technology (ICT) (Government of Canada, 2020). Canada additionally utilizes a carbon tax that has encouraged the cement industry to reduce its emissions (Marowits, 2021).

Features

Canada's LCA2 initiative has announced that it will develop important outputs that create a science-based approach to support the selection of materials and designs that offer the lowest carbon footprint while offering the lowest total cost of ownership. The outputs from this work will include infrastructure-specific LCA guidelines/tools, related procurement specifications, low carbon benchmarks, and a Canadian life cycle inventory (LCI) database. The initiative is focused primarily on buildings and at the time of writing this report, Canada has published the "National Guidelines for Whole-Building Life Cycle Assessment" in August of 2022.

The wbLCA dataset is intended to capture the full life cycle impact of a specific product. Environmental product declarations (EPDs) can also be utilized under this system and where an EPD does not account for the full life cycle ISO 21930:2017 Clause 5.5 provides details on the conditions that must be met before using that EPD in the LCA. At a minimum, the LCA for a project should report the global warming potential, acidification potential, eutrophication potential, smog potential as well as non-renewable primary energy. Full details of the required LCA methodology can be found in the cited guidelines (Canada, 2019; Bowick et al., 2022).

This work in 2023 evolved into the creation of region-based EPDs for cement produced in West, Central, and Eastern Canada. The methodology followed for the creation of these EPDs is the same as that followed by the NRMCA and outlined by the Carbon Leadership Forum. The results of these EPDs stated the emissions intensity of cement in Canada in each of the regions as shown in Table 22 for general use and Portland-limestone cement (National Research Council Canada, 2022).

Table 22. Canadian cement GWP in the West, Central, and East regions of Canada (National Research Council Canada, 2022)

Impact category and inventory indicators	Unit	West	Central	East
Global warming potential, GWP 100, IPCC 2013	kg CO_2 eq	796	854	898

Additionally, the LCA2 initiative developed EPDs for ready-mix concrete by region under varied compressive strengths for British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Atlantic regions. EPDs were also developed for various precast and prestressed concrete materials and masonry blocks (National Research Council Canada, 2022).

To provide an additional policy context for federal procurement of low-carbon concrete, the initiative also published a "Strategies for Low Carbon Concrete" report that focuses on various mechanisms to reduce the embodied carbon of concrete in reducing the clinker content, increasing SCM use, and material efficiency among others. In this report, a further summary of the emissions intensity of concrete in Canada was provided by concrete strength and mix type (Zizzo et al., 2021).

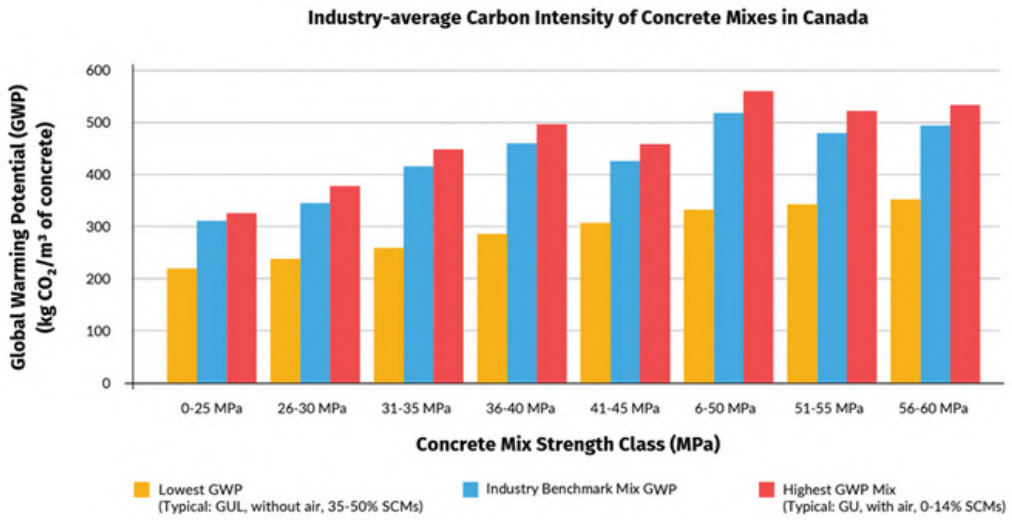

Figure 25. Industry Average GWP of Concrete Mixes in Canada by strength class and mix type (Zizzo et al., 2021).

The Canadian Government has also launched a Platform to Decarbonize the Construction Sector at Scale to support the development of new language for 2025 and 2030 codes to enable regulation of GHG emissions and embodied GHG emissions (National Research Council Canada, 2023b). Working with industry, academia, governments, and other stakeholders, the National Research Council of Canada has also developed a Low Carbon Built Environment Challenge aiming to accelerate decarbonization across the Canadian construction industry (National Research Council Canada, 2023a).

Constituency

Canada LCA2 initiative is led by Canada's Natural Resource Council (NRC) and is managed collaboratively with the NRC's Energy, Mining, and Environmental Research Centre and the Construction Research Centre. The initiative is being conducted through a collaboration between other federal departments, academia, non-government organizations, industry partners, and low-carbon asset experts (Canada, 2019).

5.6 China's National-Level and Industry-Led Initiatives

China accounted for 57% of global cement production in 2021 and is the largest producer and consumer of cement in the world. In China, cement production accounts for 13% of the country's carbon emissions and accounts for more than half of the industry's global emissions (RMI and China Cement Association, 2022). The emissions intensity of Chinese cement was among the lowest of major cement-producing nations in 2015, at 0.50 tons of CO_2e per ton of cement. This can largely be attributed to its newer cement plants that are more advanced and utilize more energy-efficient technologies than other nations like the U.S., as well as a significantly higher share of SCM utilization in its cement production. (Hasanbeigi & Springer, 2019). China publicly committed to its CO_2 emissions peaking in 2030 and reaching net zero by 2060 (Global Times, 2022).

National Initiatives

In November of 2022, China's Ministries of Industry and Information Technology, National Development and Reform Commission, of Ecology and Environment, and Housing and Urban-Rural Development launched the Carbon Peak Implementation Plan for Building Materials Industry that applies to the cement industry (IEA, 2023). By 2025, this plan requires a 3% reduction in the energy intensity of clinker production. The industry's emissions are to peak by 2030 under this plan (Global Times, 2022). These targets are to be achieved via several routes, one of which is through the elimination of energy-inefficient cement production, preventing construction of new cement production facilities, and capacity control measures. Additionally, the plan focuses on promoting electrification and replacement of coal-burning cement production facilities with natural gas, biomass, and renewables as well as technology innovation and reducing limestone use with recycled solid wastes (China Dialogue, 2022).

China established the world's largest Emissions Trading Scheme (ETS) in 2021 similar to that in the EU in response to the EU's Carbon Border Adjustments (Yin, 2023). At the time of writing this report, cement is not yet included in the ETS, however, it is estimated that it will be added to the China ETS sometime in 2023 (Busch, 2022).

In August of 2022, China's National Development and Reform Commission, the National Bureau of Statistics, and the Ministry of Ecology and Environment jointly issued the "Implementation Plan for Accelerating the Establishment of a Unified and Standardized Carbon Emission Statistical Accounting System" that will apply to the nation's cement industry. The proposed system aims to promote the establishment of a scientific, unified, and standardized carbon emission statistical and accounting system in China, consolidate the carbon emission data foundation, and improve the quality of carbon emission data (Guangming, 2022).

China also released the Green Bond Principles in 2022 which established a unified standard for green bond issuance that requires 100% of the funds to go towards the green project. The bonds may follow the Common Ground Taxonomy, developed by China and the EU, and the EU Taxonomy Climate Delegated Act and establish a domestic green bond issuing catalog (Yifan, 2022).

Industry Led Initiatives

China's cement industry sector stated its own goal of peaking emissions by 2023 which has been pushed by the Chinese government officially to 2030 (China Dialogue, 2022). Anhui Conch, one of China's leading cement producers has a target to reduce its emissions by 6% from 2017 levels to 790 kg of CO_2 per tonne of clinker and has already begun operation of one biomass-fueled plant in 2022 with the production of a second biomass-fueled plant underway (Dong et al., 2023). Additionally, Anhui Conch built the world's largest carbon capture facility for the cement industry which absorbs 50,000 tonnes of CO_2 each year (Murdoch, 2021).

GPP In China

China's GPP program prioritizes the following environmental and related goals: reducing air pollution, mitigating climate change, conserving energy, reducing hazardous substance use, protecting human health, protecting local environmental conditions, protecting natural resources, using resources efficiently, protecting soil, minimizing waste, conserving water, and reducing water pollution. GPP applies to all national, state/regional, and local public authorities. Central government institutions formulate the policy framework, and sub-central government entities procure supplies and services in accordance with the policies. All central government agencies are required to procure the products identified in the nine categories on the Energy Conservation Products (ECP) list. Products in other categories can be voluntarily procured from the ECP or environmental labeling products (ELP) list. In addition to governmental agencies at all levels, institutions and organizations that use public funds for procurement are required to prioritize purchasing products on China's ELP and ECP lists.

China has the largest total number of products certified for GPP – more than 93,000 products in 44 categories. 29 percent of all national-level public procurement followed China's GPP regulations. Of that, 80 percent was the procurement of energy-efficient and environmental labeling products. In terms of market impacts, the introduction of the ELP and ECP policies appears to have contributed to a significant increase in the number of companies manufacturing certifiable products. 14% of total governmental procurement expenditures in 2011 were on green products and services. Currently, however, there is no specific GPP requirement for cement or concrete products in China (Hasanbeigi et al., 2019).

5.7 Japan's National-Level and Industry-Led Standards

Japan has announced goals to achieve carbon neutrality by 2050 and is a major producer of cement producing 57 million tons annually across 30 plants owned by 17 different companies (Japan Cement Association, 2021). Cement production in Japan accounted for 8% of the nation's industrial emissions (Climate Action Tracker, 2023a). Japan is the 12th largest producer of cement in the world with reported energy intensity per ton of cement of 3,272 MJ in 2020 (Japan Cement Association, 2020). Japan has developed national-level policies and industry-led initiatives to support its decarbonization goals to cut GHG emissions by 46% by 2030 and net neutrality by 2050 (Climate Action Tracker, 2023a).

National Initiatives

Japan's Act on the Rational Use of Energy (Energy Efficiency Act) was first passed in 1979 and was revised multiple times through 2018. This act focuses on setting regulatory energy efficiency standards, and management standards, and sets targets for energy efficiency improvements. Under this act, facilities must improve energy efficiency by 1% on average annually. Energy efficiency benchmarks were established for the cement industry in a 2009 revision known as The Industry and Commercial Sector Benchmark System in which the benchmarks are set as that of the top 10-20% of performers in the cement industry in regards to energy intensity that then becomes the target for other industry members. The benchmark levels for the cement industry were amended in 2016. Japan's current target is to achieve an energy intensity of 3,104 MJ per tonne of cement by 2030. Under these energy efficiency regulations, companies must report their energy efficiency improvements and implementation of energy management systems. If a lack of effort is determined through this review guidance, publication of the company's name, and fines are imposed while high-performing companies are publicly praised (IEA, 2017a,b, & 2020b).

On February 10, 2023, Japan's Cabinet approved the "GX: Green Transformation Policy" Basic Plan. This plan was developed by the Ministry of Environment, Trade, and Industry (METI) to help Japan achieve its climate goals. One of the key components of the plan is the Green Transformation (GX) League, a voluntary baseline-and-credit system set to launch in April 2023. Over 600 companies, representing about 40% of national emissions, have indicated their intention to participate. The plan also includes a transition to a mandatory emissions trading system (ETS) from 2026, with the introduction of upper and lower price limits to stabilize the carbon price. By 2033, the ETS will shift from free allocation to auctioning (International Carbon Action Partnership, 2023).

Industry Led Initiatives

Under a major business association in Japan, Keidanren, business members joined the Commitment to Low-Carbon Society which is a voluntary action with monitoring obligations for GHG emissions under Japan's Plan for Global Warming Countermeasures. The organization also launched "Challenge Zero" in collaboration with the Japanese government which invites companies to submit strategies to decarbonize. The Japan Cement Association and its members have announced targets to cut cement sector emissions by 15% compared to 2030 levels (Climate Action Tracker, 2023a).

GPP In Japan

Japan is the pioneer, both in Asia and the world, in developing a GPP framework. Japan's policies and regulations to promote and implement GPP have been in place since the late 1980s, starting with the Eco Mark environmental labeling program.

The first edition of the "Basic Policy for the Promotion of Procurement of Eco-Friendly Goods and Services" (Basic Policy on Promoting Green Purchasing or Green Purchasing Law) appeared in 2001; the most recent version appeared in 2016. The law requires that government agencies apply green purchasing criteria when procuring products in a wide array of categories.

Japan's "Basic Policy Concerning the Promotion of Contracts considering reduction of GHG Emissions by the State and Other Entities" (Basic Policy on Promoting Green Contract or Green Contract Law) was adopted in 2007 with the most recent revision in 2014 and compliments the Act on Promoting Green Purchasing. This law requires government agencies and public institutions to follow green contracting requirements when purchasing electric power, automobiles, energy services, or building design services.

Following the 2001 adoption of the Act on Promoting Green Purchasing, the market share of environmentally friendly products increased in Japan. GPP is estimated to have reduced GHG emissions by 210,000 tons of CO_2 equivalent. Japan's green procurement list includes 246 items in 19 product categories (Hasanbeigi et al., 2019).

Japan maintains an Eco-Products database of information about products and services and their rating under the Green Purchasing Guidelines that the EcoLeaf label obtaining products can be listed under (Hasanbeigi et al., 2019).

For the cement and concrete industries, however, these products fall under the "public works projects" category although the GPP guidelines do not mention specific emission or energy intensity requirements. These guidelines are shown in Table 23.

Table 23. Japan GPP requirements for cement and concrete products (Japan Ministry of the Environment, 2019).

Material Type	Specification	Evaluation criteria
Blended Cement	Portland blast furnace cement	Portland blast furnace cement whose raw material contains more than 30% blast furnace slag.
Blended Cement	Fly-ash cement	Fly-ash cement whose raw material contains more than 10% fly-ash.
Cement	Eco cement	Cement that uses ashes resulting from incineration of city waste, etc. as the main ingredient. Cement contains no less than 500kg in dry weight of such waste material per 1 ton of final product.
Concrete and Concrete Products	Water permeable concrete	Water permeability of the concrete exceeds 1x10-2cm/sec

Notes: As for Portland blast furnace cement, materials that meet the standard of species B or species C based on JIS R 5211 fills this criteria. As for Fly-ash cement, materials that meet the standard of species B or species C based on JIS R 5213 fills this criteria. Eco-cement is to be used for concrete structures and concrete products that do not require high strength. As for Eco-cement, materials that meet the standard of JIS R 5214 fill this criteria. Water permeable concrete is to be used for areas that require rainwater to permeate but do not require high strength. As for Water-permeable concrete, material that meets the standard of JIS A 5371

5.8 South Korea's National-Level and Industry-Led Standards

South Korea is one of the world's largest cement producers producing approximately 50 million tons of cement each year (Statista, 2023). Industry contributed 7.5% of the national CO_2 emissions in 2022 (Climate Action Tracker, 2023b). In 2012 the Korean Ministry of Environment estimated that 40.9% of South Korean CO_2 industry emissions came from the cement industry (Andrew, 2018). South Korea has set goals of reducing national CO_2 emissions by 40% below 2019 levels by 2030 and reaching carbon neutrality by 2050 (Climate Action Tracker, 2023c). These targets are to be achieved through various national initiatives that are supported further by industry initiatives in the country.

National Initiatives

In 2015 South Korea launched its Korean Emissions Trading Scheme applicable to the cement industry which was expanded upon in 2020 to cover 73.5% of the national GHG emissions. This ETS program covers 685 companies in 69 subsectors. The requirement to participate in the ETS applies to companies emitting more than 125,000 tonnes of CO_2 per year and facilities emitting more than 25,000 tonnes per year including both direct and indirect emissions.

Initially, the share of offsets that a company could attribute to compliance with these emissions limits was 10% and has fallen to 5% following the Phase III implementation of the ETS in 2021 (International Carbon Action Partnership, 2022). Companies subject to the ETJ are also eligible for financial support to install energy-efficient equipment and processes. To meet the EU CBAM, South Korea is planning to launch Phase 4 of its ETS by 2026 (Climate Action Tracker, 2023c).

The primary enforced energy reduction program in South Korea that applies to the cement industry is the Target Management System established in 2010, in which companies that emit over 50,000 tonnes of CO_2e (or 15,000 tonnes of CO_2e for individual businesses) must submit their GHG and energy use numbers and consult with the government to set and implement improvement targets and report their status over 3 years (Korea Energy Agency, 2020). South Korea also has a required Reporting System of Energy Intensive Business Program that applies to the cement industry for facilities consuming more than 2000 tons of oil equivalent (toe). This program requires reporting of past and planned energy consumption (Korea Energy Agency, 2015a).

South Korea also has several voluntary energy efficiency improvement programs including the Energy Champion program, the Energy Intensity Reduction Agreement, and the Energy Management System (Climate Action Tracker, 2023b).

South Korea also tracks GHG reduction achieved by the Clean Development Mechanism (CDM), Korea Voluntary Emissions Reduction (KVER) program, and other voluntary reduction projects such as Verified Carbon Standard (VCS) projects. South Korea verifies GHG inventory of companies to help them strengthen their GHG management ability (Korea Energy Agency, 2015b). However, a specific industry-wide emissions intensity target for the cement industry in South Korea has not been published.

Industry Led Initiatives

Efforts were made from 2018 to 2020 to develop a unified method for capturing and transforming CO_2 to lower the cement industry's greenhouse gas emissions in South Korea. Before this, from 2015 to 2018, there was a project in place focused on developing CCU procedures, aiming to create high-grade precipitated calcium carbonate and liquified CO_2 within the cement industry (IEA, 2020a).

GPP In South Korea

South Korea was one of the first countries to integrate GPP in the Act on Development and Support of Environmental Technology in 1994. In South Korea GPP implementation is based on the collaboration of key actors: the Ministry of Environment (MoE), the Korea Environmental Industry and Technology Institute (KEITI), the Ministry of Economy and Finance (MOEF), and the Public Procurement Service (PPS). Cement and concrete are included in South Korea's GPP guidelines (UNEP, 2019), however, GHG emissions intensity is not currently included in the criteria for South Korea and instead focuses on contaminant reduction (Eun Ko & Kim, 2022).

5.9 India's National-Level Standards and Industry-Led Initiatives

India was the world's second-largest producer of cement in 2022 (IEA, 2023) and was second to China with the lowest emissions intensity per tonne of clinker produced in 2015 at approximately 0.55 tons of CO_2 eq. This can largely be attributed to its newer cement plants that are more advanced and utilize more energy-efficient technologies than other nations like the U.S. as well as a significantly higher share of SCM utilization in its cement production. India also had one of the world's best performances in energy intensity in 2015 of its clinker production at approximately 3.1 GJ per tonne of clinker (Hasanbeigi & Springer, 2019). In India in 2021, industrial processes, including cement and concrete production, accounted for 9% of the nation's overall GHG emissions and consumed 38% percent of the nation's largely coal-supplied (72%) electricity generation. Both the emissions from the industrial sector and its electricity consumption have grown by 4% and 5% annually respectively over the last 10 years. India's target is to achieve carbon neutrality by 2070 (Climate Action Tracker, 2023a).

National Initiatives

India's Perform, Achieve, and Trade (PAT) is the nation's primary policy mechanism to improve energy efficiency in the industrial sector including the cement industry. India's PAT was established in 2012 by the National Mission for Enhanced Energy Efficiency which reduces specific energy consumption in energy-intensive industries, with an associated market-based mechanism to enhance cost effectiveness through certification of excess energy saving which can be traded. For the cement industry, these improvements have largely been gained through the installation of waste heat recovery systems and vertical rolling mills. In the PAT program, energy saving certificates are awarded per 1 toe of energy saved over a threshold target that can be traded to those that did not meet their target. The PAT is enforced by fines against non-compliance plus the value of the energy that was not conserved. The first cycle of the PAT program was highly effective and reduced energy consumption by 5.3%, above the target of 4.1% from 2012-2015 (IEA, 2021), (Climate Action Tracker, 2023a).

In 2022 India amended its 2001 Energy Conservation Act, last amended in 2010, that regulates energy consumption by equipment, appliances, buildings, and industries including the cement industry. The amendment grants the government power to mandate determined amounts of non-fossil fuel energy use for the cement sector as well as others and also allows industries to buy renewable energy directly from the producers enabling renewable energy producers' price certainty. The 2022 amendment also granted the power to the government to establish a carbon trading scheme (The Energy Conservation (Amendment) Bill, 2022, 2023). At the time of writing this report, however, no timeline for the implementation of the powers outlined in this amendment has not been made public.

Industry Led Initiatives

The India Cement Manufacturers Association has stated that India's cement industry is perhaps the only sector in the country to have its own Low Carbon Technology Roadmap led by its major players in the industry. The roadmap set a target to reduce direct emission by 45% by 2050 compared to 2010 levels and suggest the industry is on track to achieve more than an 80% reduction.

Of the major players in the Indian cement industry, UltraTech Limited pledged to the Energy Productivity (EP100) program, aiming to enhance its energy productivity by 100% from its 2010 base year by 2035. Dalmia Bharat Limited has set an objective to power its operations entirely with renewable energy by 2030. ACC Limited and Ambuja Cements Limited have established Geocycle to ensure consistent waste supply for use as a substitute fuel, with the ambition of raising their Thermal Substitution Rate (TSR) beyond 20% by 2025.

HeidelbergCement Limited is committed to only producing blended cement. Shree Cement Limited and JK Cement Limited have committed to targets based on scientific research (India Cement Manufacturers Association, 2021).

GPP In India

Nationally, India currently does not have a GPP program relating to cement or concrete procurement nor has national targets for cement or concrete production emissions intensity goals. India does have general financing rules which are a set of guiding regulatory principles for public procurement focused on efficiency, economy, transparency, and promotion of competition. In 2011, India's Ministry of Environment and Forests formed a committee to develop GPP guidelines. A year later, the Government of India introduced the Draft Public Procurement Bill-2012, which states that the evaluation criteria for procurement may include: (a) price; (b) the cost of operating, maintaining, and repairing goods or works; and (c) the characteristics of the object being procured, such as the functional and environmental attributes.

In 2012 the Ministry of Micro Small and Medium Enterprises (MSME) passed an executive order mandating a 20% minimum procurement amount from micro and small enterprises where energy efficiency, GHG emissions reduction, re-use or recycling, energy conservation, reduction in the use of hazardous substances, protection of local environmental conditions and biodiversity, efficient waste disposal, and resource recovery are the main focus. (Hasanbeigi, 2022; Hasanbeigi et al., 2019).

In 1991, India launched a voluntary eco-labeling scheme called Eco-Mark that focused on both environmental and product quality criteria. Ecolabels and environmental standards are not commonly considered as part of the public procurement of products, works, and services in India's public sector, and the Eco-Mark label has so far not been widely adopted by manufacturers or buyers (Hasanbeigi et al., 2019). However, Godrej Construction – Godrej & Boyce Mfg. Co. Ltd. is the first ready-mix concrete manufacturer in India to adopt GreenPro certification for their ready-mix concrete products manufactured at Vikhroli, Ambernath, and Dhayari plants (Indian Cement Review, 2021). India's Nuvoco has had six ready-mix concrete facilities receive GreenPro certification as of 2022 (Nuvoco, 2023).

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