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CapitaLand
DEVELOPMENT

Mapping the Embodied Carbon of Concrete in Singapore

Concrete Data for Concrete Action

February 2026

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Singapore’s ability to align public actors, foster collaboration and a creates an opportunity to demons regional and international leader

Foreword

The climate crisis is forcing a fundamental rethink of how we build and urbanise. **The building sector accounts for almost 40% of global CO_2 emissions – approximately 28% from operations and 12% from materials.** (1) Concrete, steel, and aluminium together represent nearly half of industrial emissions worldwide.

Concrete has long been central to the progress of many nations, shaping early housing estates and defining skylines. Today, as the focus expands from operational carbon – the emissions linked to building use – to embodied carbon produced by construction processes and materials, it is clear the sector needs to rethink how buildings are financed, designed, and delivered.

This transformation must be consciously embedded across the value chain. Supply and demand stakeholders, policymakers, financiers, academics, and consultants each play a role in reshaping practices and accelerating adoption of lower carbon solutions.

In Singapore, concrete remains a strategic material for the built environment. Its decarbonisation is essential to ensure national competitiveness and long-term resilience, as the nation works toward its Green Plan 2030 and net zero 2050 commitments.

This report supports the establishment of Singapore’s market benchmark for the embodied carbon of concrete, providing a shared reference point for industry, finance, and policy.

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Leveraging the collective strength of CapitaLand Development and Climate Group's global ecosystem of partners and collaborators, this effort demonstrates how industry leadership can catalyse market transformation, accelerate the transition to lower carbon construction, and provide a blueprint for regional and global adoption.

Singapore's ability to align public and private actors, foster collaboration and act at scale creates an opportunity to demonstrate both regional and international leadership. This report is therefore more than a snapshot of the present situation, it is also a call to action: for designers and builders to adopt lower carbon practices; for suppliers to expand alternatives; for financiers to support transition pathways; and for policymakers to embed progress in consistent standards.

Singapore has often turned constraints into strengths. The decarbonisation of concrete can be the next example – demonstrating how partnership and pragmatism can position the nation as a global leader in sustainable construction.

Giovanni Cossu
Head of Sustainability
CapitaLand Development

Foreword

Driving climate action fast requires people to come together with a shared purpose. For collaboration to succeed, it must be built on common definitions, consistent measurements and a clear understanding of how each actor can affect the change they want to realise.

That understanding is not just a destination, but a journey – one we can take together to accelerate action on concrete decarbonisation.

The current commercial reality for all those involved must also be acknowledged as central to this journey without losing sight of the cost of inaction: increased risks from extreme weather and rising sea-levels driven by climate change.

It has been an honour to be part of this journey in Singapore, in partnership with CapitaLand Development, – meeting with key market leaders to help shape a common view of the embodied carbon of concrete being used.

This is a springboard for Singapore to translate the ambition of its corporate and public sector leaders into actions to drive down concrete's embodied carbon. While Singapore doesn't produce its own concrete constituents domestically, it can still set the pace of concrete's decarbonisation trajectory in Southeast Asia. Sending a clear demand signal – embedded in national roadmaps and reinforced by near-term organisational decarbonisation targets – can

unlock the investment and innovation needed to transform supply chains.

Market benchmarking is more than a technical exercise. It supports target setting by depicting what ambitious, yet achievable, near-term reductions in the embodied carbon of concrete are possible in Singapore. It also acts as a catalyst, enabling ambition to be measured, action to be aligned, and for Singapore to demonstrate the leadership the region, and the world, urgently needs.

Mike Peirce
Executive Director of Systems Change
Climate Group

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List of Abbreviations

Abbreviation	Definition
ACI	American Concrete Institute
BCA	Building and Construction Authority (Singapore)
CCS	Carbon Capture and Storage
CEM I	Ordinary Portland Cement (OPC), pure clinker-based cement
CEM II	Portland composite cement with partial clinker substitution
CEM III	Blast furnace cement with high GGBS content
CO_2e	Carbon dioxide equivalent (standardised unit for GHGs)
EF	Emission Factor
EPD	Environmental Product Declaration (third-party verified LCA for a product)
GCCA	Global Cement and Concrete Association
GGBS	Ground Granulated Blast-furnace Slag (a low-carbon cementitious material)
GHG Protocol	Greenhouse Gas Protocol (corporate GHG accounting standard)
GRESB	Global Real Estate Sustainability Benchmark
GWP	Global Warming Potential (impact metric used in LCAs/EPDs)
ICE	Inventory of Carbon & Energy
IDDI	Industrial Deep Decarbonisation Initiative (UNIDO-led)
IEA	International Energy Agency
IIGCC	Institutional Investors Group on Climate Change
ISSB	International Sustainability Standards Board
KPI	Key Performance Indicator (implied in procurement/targets context)
LCA	Life Cycle Assessment
LCC	Low-Carbon Concrete

Abbreviation	Definition
LCCG	Lower Carbon Concrete Group (UK)
LCMH	Low Carbon Materials Hub (company hosting Australia concrete EPD data)
MB	Market Benchmark (of the Embodied Carbon of Concrete)
MECLA	Materials & Embodied Carbon Leaders' Alliance (Australia)
MPa	Megapascal (concrete strength unit)
$MtCO_2e$	Million Tonnes of CO_2 equivalent
NCCS	National Climate Change Secretariat (Singapore)
OPC	Ordinary Portland Cement (CEM I)
PCF	Product Carbon Footprint
PCR	Product Category Rules (EPD/LCA rules for a product category)
PCAF	Partnership for Carbon Accounting Financials
PPVC	Prefabricated Prefinished Volumetric Construction
RFI	Request for Information (data collection template)
SC	Steering Committee (project governance group)
SCI	Singapore Concrete Institute
SCM	Supplementary Cementitious Material (e.g. GGBS, fly ash, calcined clay)
SGBP	Singapore Green Building Product (SGBC Certification Scheme)
SGBC	Singapore Green Building Council
TCFD	Task Force on Climate-related Financial Disclosures
TAG	Technical Advisory Group (project expert group)
UNIDO	United Nations Industrial Development Organization

Executive Summary

Concrete is the backbone of Singapore's built environment: its urban skyline a testament to the versatility and performance of this ubiquitous material. As the country implements its Green Plan 2030 and accelerates toward its net zero 2050 goal, the embodied carbon of concrete stands out as a strategic priority for decarbonisation.

This report presents a market benchmark for the embodied carbon of concrete in Singapore: a snapshot of the carbon intensity of concrete used in 2024. It provides a quantitative foundation for industry-wide collaborative action and informs the development of policy and financial instruments to support lower carbon material and process innovation, supply chain resiliency and competitiveness.

The First Singapore Market Benchmark

The Singapore Market Benchmark, Figure 1, provides the volume weighted average (yellow), minimum (green), and maximum (red) embodied carbon values across six concrete strength grades supplied in the Singapore market in 2024.

The Singapore Market Benchmark:

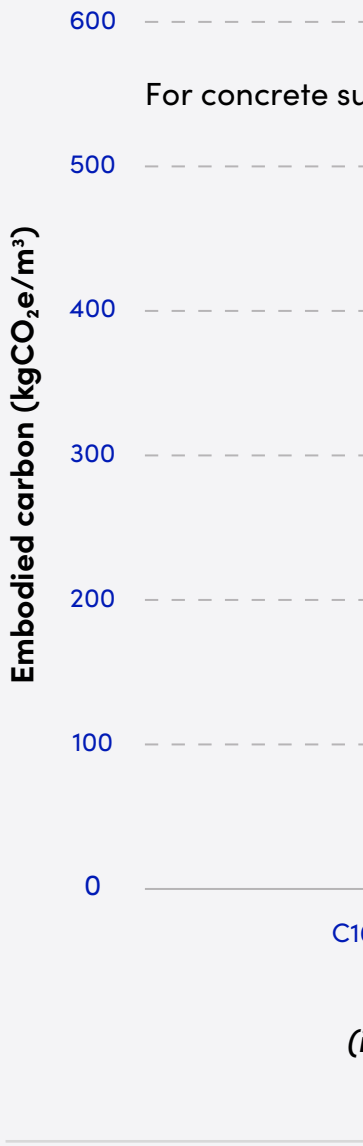
- Clarifies what constitutes lower carbon concrete compared to the market average.
- Establishes a baseline reference for tracking progress and setting targets.
- Supports procurement, policy, and finance decisions with robust data.

While Singapore's volume weighted average embodied carbon lies closer to the upper range, the wide spread in the data reflects the varying pace at which different stakeholders are transitioning to lower embodied carbon of concrete. This highlights significant opportunities for accelerating sector-wide improvement, particularly by encouraging the broad middle players to adopt lower embodied carbon solutions, driving down the average values.

The report demonstrates how market benchmarks can guide the specification and procurement of concrete in Singapore when applied alongside static rating or certification systems, such as those of the Global Cement and Concrete Association (GCCA) and Singapore Green Building Council (SGBC).

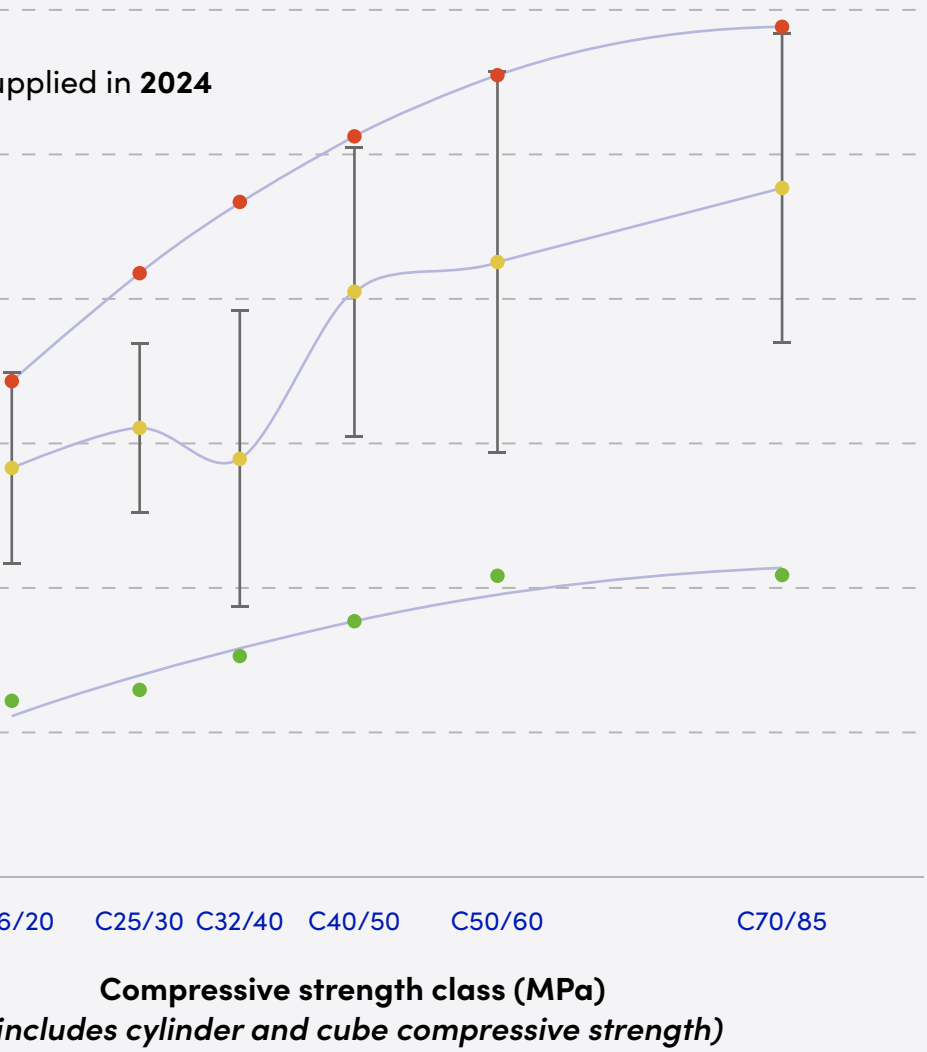
The report outlines a transparent methodology for collecting and analysing the best available data, offering a consistent template for future updates. For other markets, the report showcases how significant data availability and quality challenges were addressed and serves as a useful reference for replication.

Figure 1: The Singapore
of Concrete based on 20



Why Concrete
Singapore's Cl

Market Benchmark for the Embodied Carbon
24 data.



- Maximum embodied carbon
- Volume weighted average embodied carbon
- Minimum embodied carbon

Notes: This Market Benchmark represents the best available data on the embodied carbon (LCA stages A1 to A3) of ready-mix normal weight concrete poured or placed in Singapore in 2024 based on an estimated 68% of the market. While data from precast concrete is included, given the limited sector coverage, the Singapore Market Benchmark is not recommended for making inferences about the precast concrete sector. Note that the achievable embodied carbon will depend on a variety of concrete performance requirements in addition to compressive strength, as well as the market availability depicted in the Market Benchmark.

Matters for imate Goals

Singapore's urban and geographic context drives high per-capita concrete consumption, at over 11 million m^3 annually or 1.9 m^3 per capita per year. Singapore's upstream concrete emissions, estimated as part of this research, at 3.7 $MtCO_2e$, are equivalent to 6% of national emissions.

While concrete's emissions primarily sit outside the Singaporean national inventory, its dominance in built environment organisations' carbon footprints presents as an increasing need to coordinate action on tackling these emissions.

Strategic Value for Stakeholders

The Singapore Market Benchmark is designed as an **annual exercise** to track the evolution of embodied carbon in concrete, generating insights that enable the progressive refinement of certification tools and ensure their long-term market impact.

It aims to catalyse action across the concrete value chain:

02

Regulators and policy makers can align standards and track progress.

01

Concrete users, such as clients, consultants and contractors, can benchmark performance, engage suppliers, and specify carbon targets.

04

Financiers can assess climate risk, inform green finance, and support transition pathways.

03

Concrete suppliers can differentiate products, validate claims, and guide innovation.

Barriers and Opportunities to Lowering the Embodied Carbon of Concrete for Singap

Barriers

- Lack of common understanding of what is meant by 'lower carbon' or 'green' concrete.
- Limited environmental data hindering fair comparison of concrete products and increasing risk of inadvertent greenwashing.
- Knowledge gaps among consultants, designers, contractors, and developers regarding lower carbon concrete materials and products, and how best to use them.
- Opaque pricing deterring uptake of these lower carbon concrete solutions unless specifically required on a project.

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Extensive stakeholder engagement (see contributor list) was a critical part of the research behind the data collection effort, and in identifying the following key barriers and opportunities for advancing lower carbon concrete in Singapore.

Opportunities

Immediate Opportunities

- Unite the Singapore concrete value chain in its intent to reduce embodied carbon.
- Realise efficiency gains through optimising the use of concrete and cement.
- Reduce transport-related emissions through sourcing materials closer to Singapore and prioritising low-carbon logistics.
- Demonstrate intent by establishing specific decarbonisation targets and trajectories for concrete, including at a project, organisational or national level.
- Identify and support scaling of innovation and efficiency gains across the concrete value chain.

Near-Term Opportunities

- Increase resiliency of supply chains by scaling new-to-Singapore but established alternative SCMs.
- Foster innovation and industry competitiveness by advancing novel lower carbon and near-zero carbon concretes.
- Create demand certainty for lower carbon materials by including them as requirements in private and public procurement frameworks.

Five Recommendations for Action

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	Concrete Demand Side	Regulators and Certifie
01 **Use the Singapore Market Benchmark...**	To evaluate embodied carbon performance and align concrete procurement and specification with best practice.	As a baseline reference and track progress agai a concrete decarbonisa roadmap for Singapore.
02 **Choose lower embodied carbon concrete ...**	By specifying SGBP Tick 3 or better and phasing out 100% CEM I based concrete.	By increasing the weigh SGBP Tick 3 or better co in the Green Mark Certification Scheme.
03 **Grow and diversify the supply and use of lower carbon concrete constituents...**	Through setting embodied carbon decarbonisation targets for concrete used or specified, and through partnering on trials for innovative lower carbon materials.	By expediting approval for introducing new con products to the market supporting the collabor testing and trials involve
04 **Improve the measurement of the embodied carbon of concrete...**	By specifying and collecting granular data on as-used concrete and its embodied carbon.	By supporting consisten concrete environmental well as providing a data emission factors for mar participants to use in mi design-based calculatio
05 **Activate Singapore's concrete community - domestic and international...**	By joining networks (ConcreteZero, SGBC and the like) to develop internal knowledge and capability, and support implementation.	By positioning Singapor regional leader, raising benchmarks in the SGB Certification Scheme to aligned with internation frameworks, and hostin platforms for knowledge and maintenance of the Singapore Market Benc

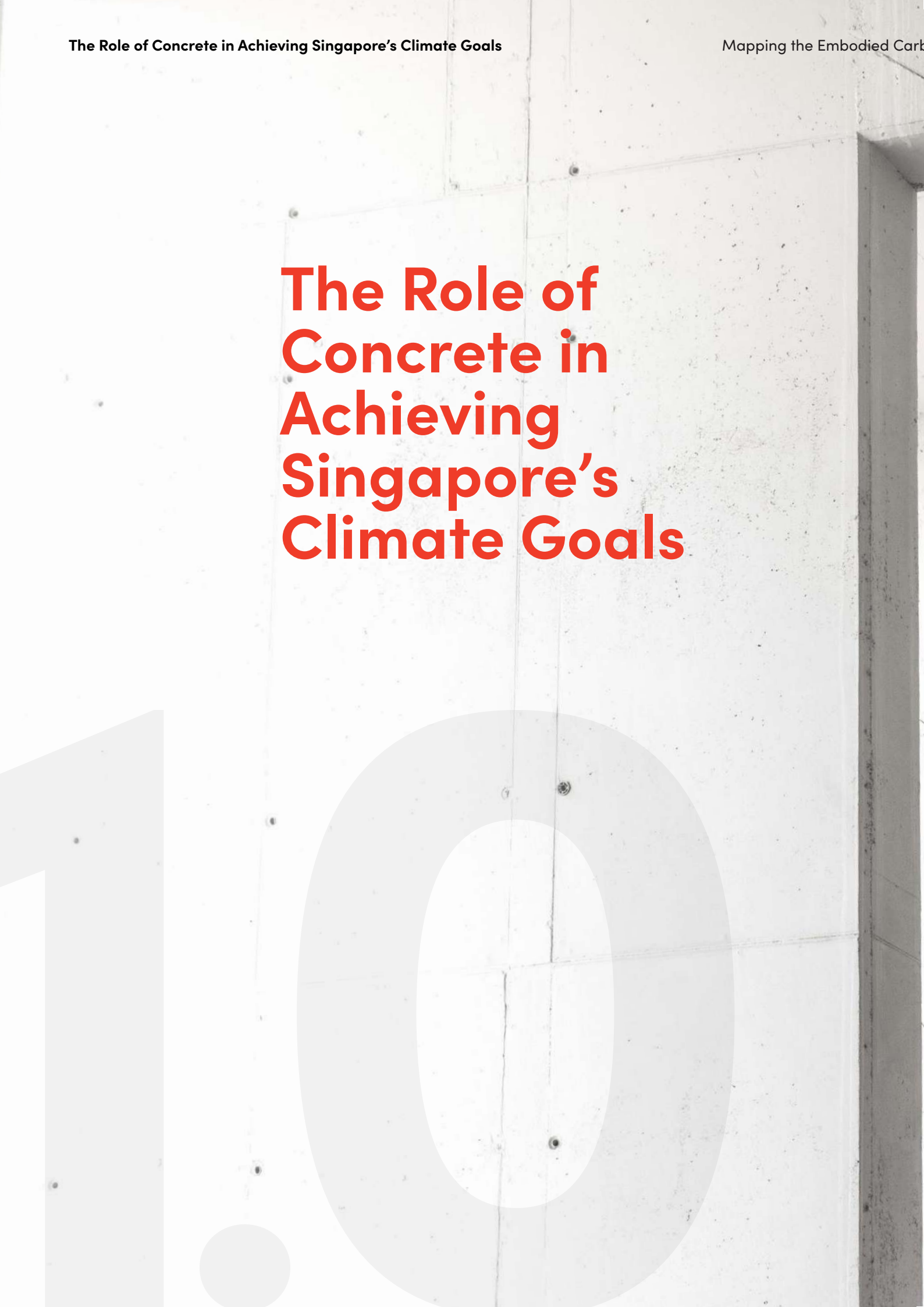
apore's leadership on concrete decarbonisation catalyse regional transformation, strengthen ly chain resilience, and position the nation as a al frontrunner in sustainable construction.

To accelerate decarbonisation, the report calls on stakeholders to (by 2026, 2027 and 2028):

2026 2027 2028

rs	Concrete Suppliers	Financiers and Investors
to develop, nst tion .	To ensure competitiveness of products on embodied carbon performance.	To assess the climate impact of investment opportunities in lower carbon concrete innovations and solutions.
ting of ncrete	By proactively educating customers on the performance and pricing of available lower carbon concrete products.	By incentivising better-than-average, lower carbon concrete supply and use thorough terms in financial products.
processes crete and ative ed.	Beyond GGBS and fly ash into more scalable alternatives such as limestone fines and calcined clay while also initiating work on other SCMs.	By developing and introducing dedicated finance products to encourage increased supply and use of concrete with lower carbon constituents.
cy of data as base of rket x ons.	By providing mix- or product-specific environmental data as standard to customers as well as for the development of future iterations of the Singapore Market Benchmark.	By requesting details of the embodied carbon of concrete in trade financing instruments where significant for the organisation.
e as a the P be more al g e sharing hmark.	By participating in cross-value chain platforms (SCI, ACI) domestically and in the Southeast Asian region.	By engaging in global networks (e.g., PCAF, GRESB) and sharing case studies to build the business case for transition finance targeting lower carbon concrete innovation and use.

The Role of Concrete in Achieving Singapore's Climate Goals



1.1 Concrete Use in Singapore

If concrete had a shop window to showcase its scalability and versatility, Singapore could well be th

In just six decades, Singapore has transformed into a major global commercial hub with a dense urbo shaped by its island geography and limited size. This context defines the distinctive characteristics of t market today and will shape how its use must evolve to support the nation's net zero targets. The relia concrete brings both opportunity and vulnerability, reflected in Singapore's geography, geopolitical p culture. Key characteristics of Singapore's concrete market include:

Material Imports and Resource Constraints:

With limited domestic limestone and sand resources, Singapore imports most raw materials for concrete, as well as finished concrete (precast) products, primarily from Malaysia, Thailand, Indonesia, and Japan. (2)

Durability Demands in a Tropical, Coastal Environment:

Singapore's tropical climate and coastal location require concrete mixes to be designed with enhanced durability and resistance (making them relatively more carbon-intensive than those used in other markets), ensuring performance under harsher exposure conditions than those typically encountered in temperate regions. Compounding factors of over-specification, over-design and over-delivery along the value chain may also contribute to a higher-than-necessary cement content in concrete, presenting an endemic challenge globally. (4)

Resource Efficiency Amid Import Dependence:

Heavy reliance on imported materials and the risks of supply chain disruptions have shaped Singapore's resource management strategies, including for concrete. For example, to curb over-specification and use of concrete, initiatives such as the Concrete Usage Index (CUI) were incorporated into the Green Mark Certification Scheme in 2008, setting limits on the amount of concrete used in buildings relative to floor area. (3)

Early Adoption of Recycled Aggregates:

High transport costs for importation of bulky aggregates accelerated the uptake of recycled alternatives, which are often sourced from construction and demolition waste. This has also helped address Singapore's waste disposal challenge.

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he concrete
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Note: In this report we refer to traditional cement, also known as CEM I cement, as Ordinary Portland Cement (OPC). OPC is the dominant type of binder used in concrete production globally. Most of the climate impact of concrete is associated with the production of a precursor of OPC called clinker.

High Per Capita Concrete Consumption:

Singapore's rapid pace of development drives concrete use to approximately 11.5 million m^3 annually, or 1.9 m^3 per capita. (5) By comparison, the global average per capita consumption of concrete is 0.5-0.6 m^3, underscoring Singapore's high concrete consumption relative to population size. (6)[1]

Centrally Planned and Phased Development:

Singapore's construction sector is defined by centrally managed and strategically phased development, a model that has consistently shaped, and will continue to shape the nation's concrete demand and use. (7)

Engaged and Enthusiastic Stakeholder Community:

120 organisations from across the built environment value chain signed the Singapore Green Building Council's Built Environment Embodied Carbon Pledge in 2021. Centred around broad-based actions on minimising material usage and opting for lower embodied carbon materials, the pledge demonstrates the industry's appreciation of, and readiness to collaborate on, the challenge of tackling embodied carbon. (9)

Singapore's import dependency, (2) high per capita consumption, and climate-driven durability demands make its concrete use both a vulnerability and an opportunity. Future decarbonisation strategies must address supply-chain resilience, recycling, and efficiency simultaneously.

[1] Calculations based on following sources: Singapore concrete volume data; (5) population of Singapore; (6) Global cement consumption (47) with assumption that average cement content in concrete is 300 kg/m^3; and current global population. (46)

1.2 The Singapore Green Plan 20 and Net Zero 2050 Commitmer

Singapore has set ambitious climate and sustainability targets under the Singapore Green Plan 2030, (12) and a national roadmap, the Singapore Green Building Masterplan 2021, was launched to drive deep decarbonisation and advance sustainable development. Structured around five key pillars, the plan includes a strong focus on greener infrastructure and buildings. **One of the key targets is to green at least 80% of Singapore's building stock (by gross floor area) by 2030, primarily through measures focused on raising minimum energy performance requirements for new and existing buildings.**

In 2022, Singapore strengthened its climate ambition by announcing a commitment to achieve net zero emissions by 2050, in line with the Paris Agreement. (13) As interim milestones, national carbon emissions are expected to

030
nt

reduce to around 60 $MtCO_2e$ by 2030 after peaking earlier; and further reduce to between 45 and 50 $MtCO_2e$ in 2035. (14)

This national policy framework provides the enabling environment for public and private sector leadership in shaping industry action towards progressively lower carbon alternatives and sustainable procurement practices. Building on the current national policy focus on operational carbon (energy consumption during building use), addressing embodied carbon represents the next critical frontier for comprehensive decarbonisation. Concrete has emerged as a priority for embodied carbon reduction due to its pervasive use, its contribution to the Scope 3 (indirect) emissions of concrete users, and the challenge of abating emissions from the high-temperature chemical processes necessary for OPC production. (15)

1.3 Concrete's Contribution to S Direct and Indirect Carbon Emi

Concrete is one of the most significant drivers of embodied carbon emissions in Singapore's expanding built environment. Most of the emissions impact originates outside Singapore, in its major trading partners for cement and, to a lesser extent, aggregates and sand. (16) Only some domestic concrete batching and casting is accounted for in Singapore's national emissions inventory.

Note: Upfront embodied carbon, cradle-to-gate emissions, or LCA stages A1-A3, are phrases used to refer to the emissions associated with upstream processes that go into making a product. (10) For concrete, these emissions make up the bulk of the emissions across its lifecycle and originate primarily in the production of OPC. (11) In this report, we exclusively refer to embodied carbon measured in $kgCO_2e$. Embodied carbon intensity is a phrase for embodied carbon normalised by unit volume i.e. $kgCO_2e/m^3$. This is what is plotted (against concrete strength) in market benchmarks.

The embodied carbon of cements, aggregates, and precast concrete products produced and manufactured abroad but used in local projects, contributes 3.7 $MtCO_2e$ of upstream indirect emissions in addition to what has been accounted for. This value for Singaporean concrete's indirect emissions (also known as Scope 3 emissions), was derived from this project, and is equivalent to 6% of Singapore's total direct emissions (see Section 4.1).

While the indirect emissions associated with concrete fall outside Singapore's official total direct emissions inventory, they are included in GHG Protocol–aligned disclosures of many private sector organisations, making them highly relevant for corporate accountability.

Note: Scope 3 emissior emissions, as defined i generally dominate (a involved in constructio initiative (SBTi), a volu and validate emissions targets wherever they

For developers, contract embodied carbon repres scrutinised categories of is becoming critical to m Real Estate Sustainabilit Sustainability Standards Climate-related Financia confidence and access t

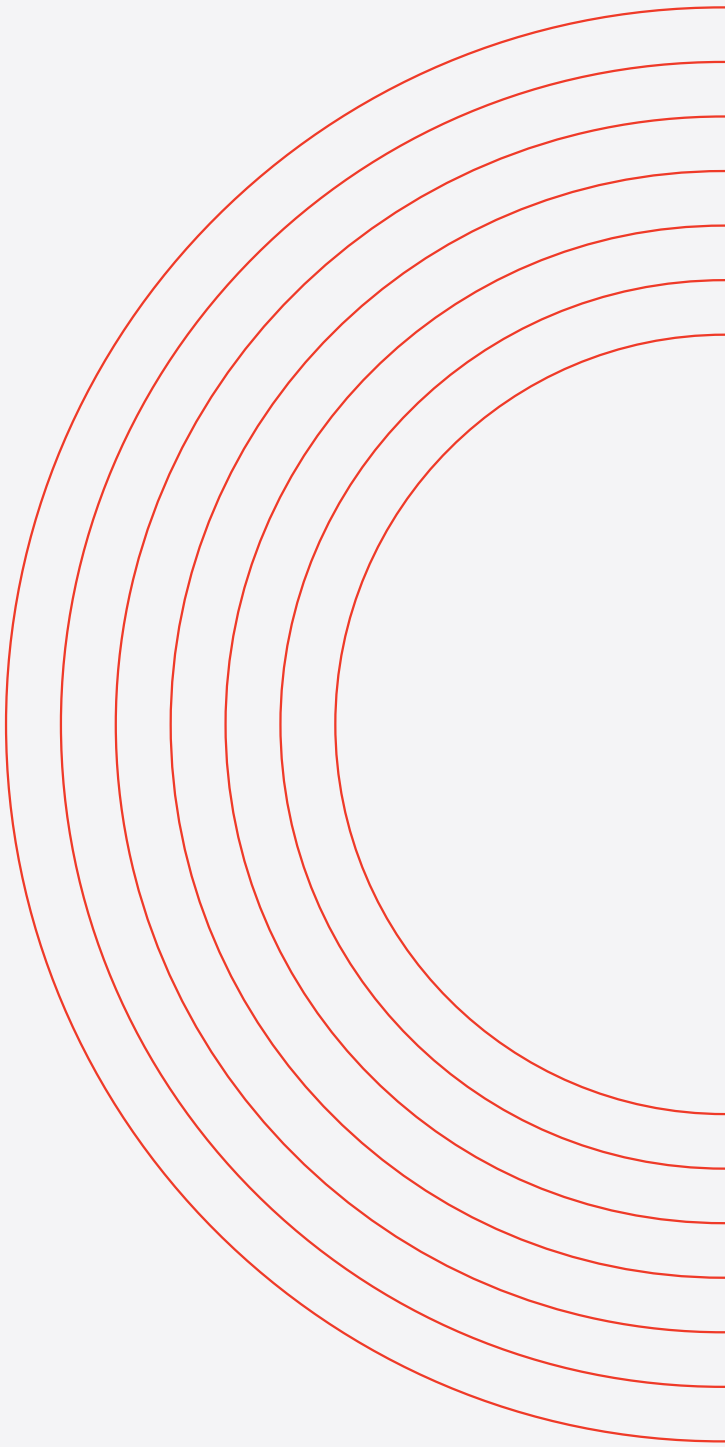
Singapore's reliance on i footprint to the decarbor Tackling the embodied c environmental imperativ supply-chain resilience, construction sector, and low-carbon transition of

Singapore's ssions

ns are non-electricity-related indirect
n the GHG Protocol. This class of emissions
t >80%) the carbon footprints of organisations
n projects. The Science Based Targets
ntary initiative supporting corporates to set
s reduction targets, requires Scope 3 emissions
exceed 40% of a company's footprint.

ors, and material suppliers, concrete's
sents one of the largest and increasingly most
f Scope 3 emissions. Managing these emissions
eet global reporting standards (e.g. the Global
y Benchmark (GRESB), International
Board (ISSB) and Task Force on
al Disclosures (TCFD)) and maintain investor
o international capital.

imports also ties its construction sector's carbon
nisation trajectories of regional suppliers.
carbon of concrete is therefore both an
ve and a strategic necessity, supporting
safeguarding competitiveness of the domestic
aligning Singapore's growth with the
its major trading partners.



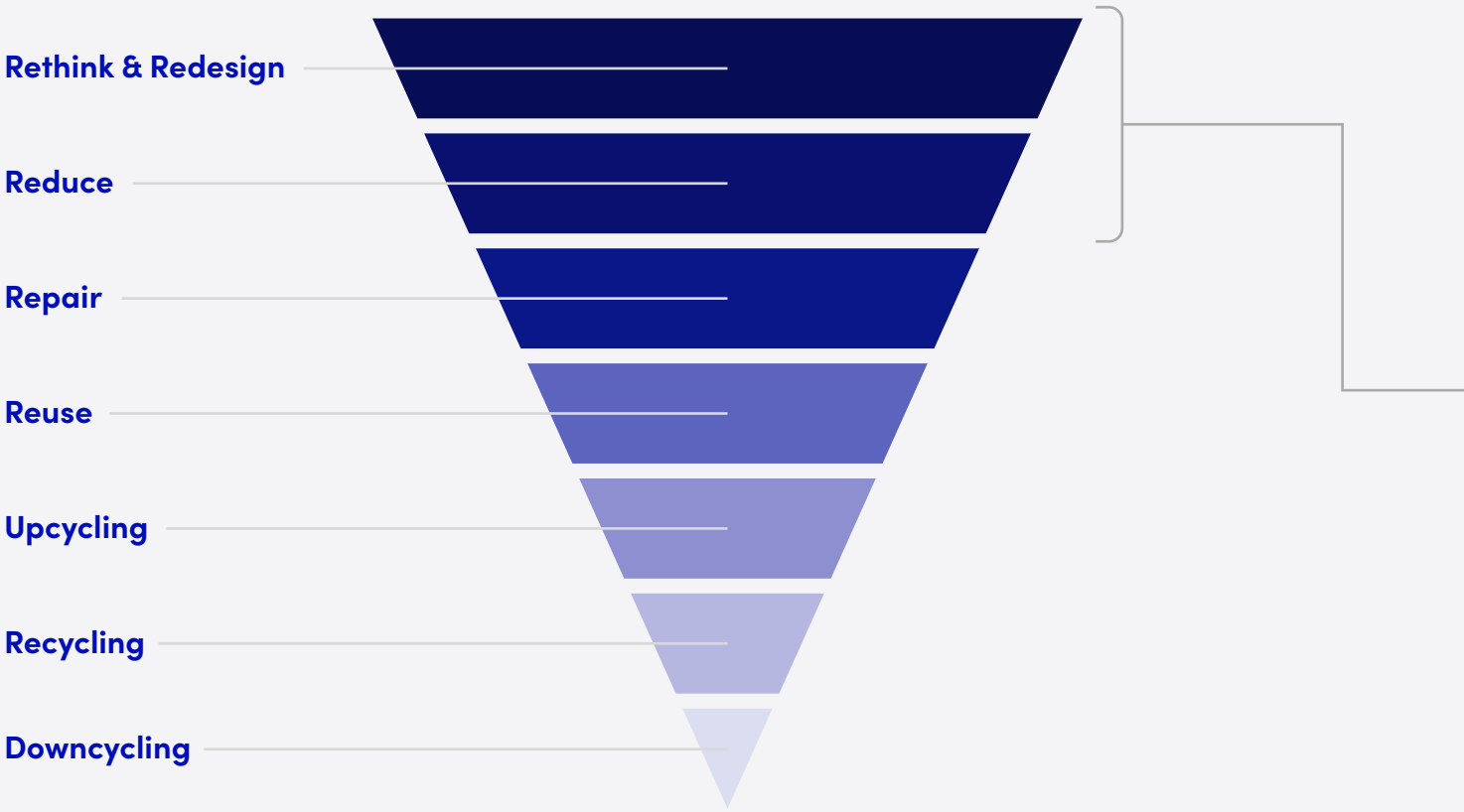
The Strategic Importance of a Market Benchmark for the Embodied Carbon of Concrete

This chapter defines a market benchmark for the embodied carbon of concrete and outlines its strategic value for Singapore as a whole, and for the stakeholder groups with key roles to play in realising a low-carbon concrete future.

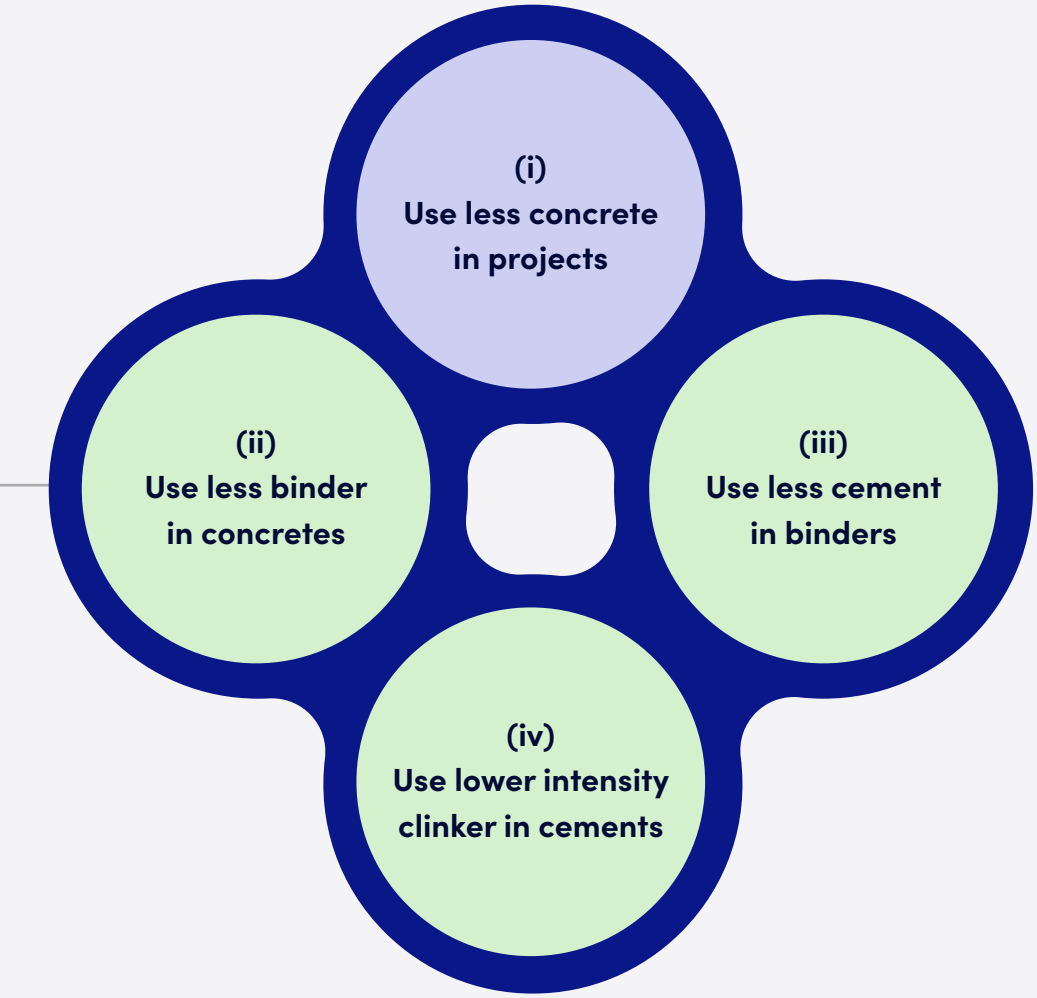
2.0

A holistic approach to tackling emissions associated with concrete has recently been presented in the World Green Building Council (WGBC) and the Circular Buildings Coalition's 'Cycling of Concrete Hierarchy' in Figure 2. (17) The prioritisation of "Rethink & Redesign" and "Reduce" at the top of the hierarchy reflects the reality that over 80% of concrete's lifecycle emissions are associated with upstream production processes, i.e. its embodied carbon. (11) Efforts to reduce the emissions impact of concrete therefore generally focus on (i) using less concrete, (ii) using less binder, (iii) using less OPC in the binder, and (iv) reducing the emissions intensity of clinker production. Market benchmarks, being based on embodied carbon intensity, primarily support strategies related to (ii)-(iv) and provide the ideal starting point for efforts to reduce concrete's emissions impact.

Figure 2: Embodied carbon reduction strategies supported by Market Benchmarks, in [green], depicted against the Cycling of Concrete Hierarchy. (17)



Note: The production of clinker (a precursor of OPC) requires high temperatures (~ 1450 °C) achieved using a mixture of fossil and waste-derived fuels and involves a chemical reaction that is responsible for ~60% of the associated CO_2 emissions. Strategies to reduce the emissions intensity of clinker focus on emissions reduction mechanisms, such as switching to lower carbon fuels and improving kiln efficiency and eliminating the emissions through Carbon Capture and Storage (CCS).



2.1 What is a Market Benchmark for the Embodied Carbon of Concrete?

A market benchmark provides an annual snapshot of the embodied carbon of concrete produced for a specific market, based on real project data. It captures the variation in embodied carbon emissions across similar strength concretes within a particular timeframe. When regularly updated, market benchmarks provide a dynamic picture of how market-level embodied carbon of concrete changes over time, reflecting the impact of any changes in the supply and demand for concrete.

Market benchmarks reflect the full, representative distribution of the embodied carbon of concrete's intensity differentiated by strength. They capture the carbon intensity of concrete actually used in a market, rather than mixes that are available but whose real-world uptake is unknown.

The definition of the market boundary is an essential attribute of a market benchmark. Depending on market share and available data, a market benchmark may include or exclude different sub-groups of concrete (e.g. lightweight vs. normal weight, or ready-mix vs. precast) or may combine data across these categories.

Early iterations of market benchmarks face common challenges around data availability and consistency. Nevertheless, the experience of other markets (see Appendix A) suggests that producing a market benchmark can benefit both immediate decision-making and signal the need for improved industry-wide data collection and management practices.

2.1.1 How the Embodied Carbon of Concrete Market Benchmarks Complement Rating and Certification Systems

The last few years have seen a concerted international push to establish international frameworks for measuring, defining, rating and certifying the embodied carbon of high-impact materials including concrete. The ability to consistently and effectively refer to the embodied carbon of materials and compare between products and across markets is widely recognised as supporting meaningful collaboration and cooperation globally, an important precursor to scaling lower carbon technologies and accelerating embodied carbon reductions.

Note: For concrete, this global push for rating and definition harmonisation is being spearheaded by the UN's Industrial Development Organization's Industrial Deep Decarbonisation Initiative (IDDI), the Cement and Concrete Breakthrough Agenda, the International Energy Agency's (IEA) Working Party on Industrial Decarbonisation, and the Global Cement and Concrete Association (GCCA).

The focus of this international effort is on fixed, static definitions and rating systems, supporting the interoperability of measurement and certification systems globally. Market benchmarks for embodied carbon of concrete, capturing as they do the actual status in a specific market, are both complementary and additive to these international efforts.

For example, the GCCA has developed a static Global Rating System for Concrete as shown in Figure 3. (23) Market-level corrections to the rating system can be applied, as has been done for the UK, to address differences in carbon accounting practices between markets.

The most relevant certification system for embodied carbon of concrete in Singapore is the Singapore Green Building Product (SGBP) certification scheme developed by the Singapore Green Building Council, which is a tiered tick rating system for the embodied carbon of concrete, as shown in Figure 3.

Overlaying market benchmarks onto these static systems supports identification of which rating levels, for the market in question, most effectively drive reductions in the embodied carbon of concrete over time.

Used together, market benchmarks and static certification and rating systems provide a mutually reinforcing mechanism for effective long-term decarbonisation planning and the identification of actionable embodied carbon reduction opportunities.

Note: Using market be
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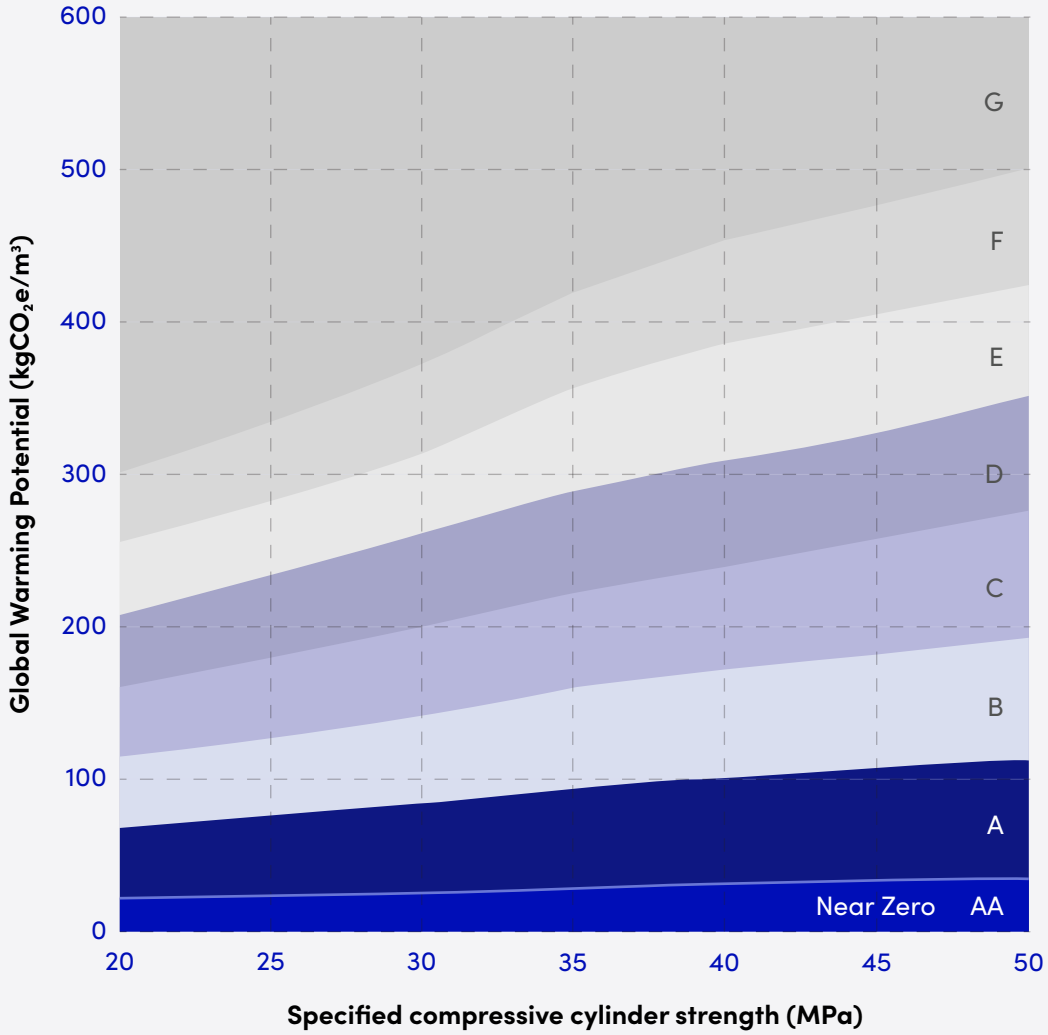
currently based on unc
benchmarks are ideal
realising the benefits s

Figure 3: (LHS) The GCCA's Global Rating System for Concrete and (RHS) SGBC's Singapore Green Building Product Certification Scheme



Rating	
1-tick	
2-tick	
3-tick	
4-tick	

Note: The criterion for the Sing
It is updated periodically; stak

*The concrete compressive str
Megapascals (MPa), (16) and

nchmarks to compare the embodied carbon of concrete in different markets is not hose developed using similar approaches (the UK and Singapore market benchmarks) are derlying data that is too different to support like-for-like comparison. Instead, market for aligning internal stakeholders around the truest possible picture of their own market and et out in Sections 2.3 and 2.4.

Global Warming Potential (GWP) for A1 to A3 ($kgCO_2e/m^3$)					
C16/20* & below	**C25/30**	**C32/40**	**C40/50, C45/55**	**C50/60**	**C58/70 & above**
≤ 280	≤ 340	≤ 400	≤ 450	≤ 500	≤ 540
≤ 260	≤ 310	≤ 370	≤ 415	≤ 460	≤ 500
≤ 235	≤ 280	≤ 330	≤ 375	≤ 410	≤ 455
≤ 210	≤ 250	≤ 300	≤ 340	≤ 370	≤ 410

gapore Green Building Product (SGBP) rating system is accurate as of October 2025. keholders are advised to check with SGBC for any updates.

rength notation used here includes both the compressive cylinder strength in d the compressive cube strength in MPa. (20)

2.2 The Benefit of Market Benchmarks for Reducing the Embodied Carbon of Concrete

Meaningful progress on concrete decarbonisation is based on two critical foundations:

(i) A robust understanding of the embodied carbon of concrete

Achieving deep reductions requires clarity on both the current embodied carbon profile of concrete in use and the levels required for net zero alignment. Market benchmarks establish a baseline reference providing all key stakeholders (see full list in Section 2.4) with a credible starting point from which to assess performance and chart a pathway to net zero.

(ii) An empowered cross-sectoral community

Transitioning to lower carbon concrete demands collaboration among designers, producers, policymakers, and financiers operating within a supportive regulatory and financial environment. Market benchmarks provide a common reference from which to anchor clear definitions, ensure measurement consistency, and develop a shared understanding of current and required embodied carbon of concrete performance.

2.3 How Singapore Can Benefit from a Market Benchmark for the Embodied Carbon of Concrete

Concrete is central to construction in Singapore with the sector expected to remain stable through to 2029. (24) Any emissions reductions will therefore need to be realised through improvements in concrete use efficiency, and its embodied carbon intensity.

The correlation between lower carbon concrete solutions and supply chain diversification can also benefit the nation. Singapore's leadership on this topic, and especially the establishment of a robust demand signal for lower carbon products, could catalyse innovation and investment in lower carbon concrete supply across the Southeast Asia region.

A market benchmark can help Singapore track progress over time and assess the effectiveness of concrete decarbonisation interventions. It may also help identify performance gaps and highlight areas where the largest carbon savings can be achieved.

The market specificity of the market benchmarks is necessary because of the unique context in different markets, such as their climatic and geographic conditions, current concrete practices, ability to access lower carbon solutions in the near- to mid-term, the presence of voluntary or legally-binding net zero commitments, industry make-up and capacity, and the regulatory landscape.

2.4 How Key Stakeholder Groups Can Leverage the Singapore Market Benchmark

The Singapore Market Benchmark supports the implementation of concrete decarbonisation at both national and project levels. It is designed not only as a measurement tool, but also as a catalyst for systemic transformation across the value chain.

Developed through consultation with Singaporean stakeholders, the benchmark is guided by five strategic drivers:

01 Market Transparency

Consolidates fragmented datasets into a single credible reference, promoting transparency. Builds market confidence by distinguishing genuinely lower carbon options.

02 Procurement Alignment

Provides an objective basis for tender requirements, harmonising expectations across owners, designers, contractors, and suppliers. Creates a level playing field and strengthens demand for verified lower carbon products.

03 Financing Enablement

Validates ambition of lower carbon products and projects, reducing uncertainty for investors. Supports the development of sustainability-linked finance instruments and informs eligibility criteria for incentives, channelling capital into decarbonisation.

04 Innovation Signal

Reveals the current performance spectrum and recognises first movers, encouraging industry to shift from “wait-and-see” to continuous innovation. Gives suppliers confidence that their efforts will be rewarded.

05 Policy Integration

Provides the evidence base for regulatory design, from mandatory limits to enhancements of voluntary schemes (e.g., BCA Green Mark, SGBP Certification). Ensures coherence between procurement, policy, and national climate goals.

While these drivers are common across all stakeholder groups, their use and benefits vary as outlined
The following tables offer a strategic checklist for stakeholders to make the most of the Singapore Ma

	Use the benchmark to
 **Concrete Users** (Developers, Contractors, Designers, Clients)	○ Inform project and/or organisational carbon targets. ○ Assess project and/or organisation's performance. ○ Assess supplier performance and to engage suppliers on their plans for lower carbon solutions.
 **Regulators and Certifiers** (e.g., BCA, SGBC)	○ Acquire a market-level view of concrete's embodied carbo ○ Validate carbon claims of products in the market ○ Develop a baseline reference to inform and monitor progre against a material-specific decarbonisation pathway.
 **Concrete Suppliers** (Ready-Mix and Precast)	○ Assess mix designs against the market as a whole ○ Assess the relative embodied carbon performance of innov new-to-market lower carbon concrete materials and soluti ○ Engage the upstream supply chain on the importance of high-quality, supply chain-specific embodied carbon data, especially for OPC.
 **Financiers and Investors**	○ Inform embodied carbon thresholds for targeted transition finance products. ○ Assess the relative climate benefits of investment opportun related to lower carbon concrete innovation or expansion. ○ Improved embodied data availability and quality stemmin market benchmarking to support internal disclosure requir

below.
rket Benchmark.

	Using the benchmark
	○ Aids strategic portfolio decarbonisation planning and demonstrates sustainability leadership. ○ Improves visibility of organisational and project level data on embodied carbon of concrete. ○ Supports procurement and tender comparisons across suppliers and products.
n. ess	○ Current embodied carbon performance, as well as the size of the opportunity to decarbonise concrete, can inform design and ambition-levels of policy instruments such as the Green Mark scheme. ○ Provides an evidence base against which to evaluate claims of absolute or relative embodied carbon benefits. Also, in conjunction with the SGBP Certification, precludes the need for ambiguous phrases like 'Low Carbon Concrete' and 'Green Concrete'. ○ Supports a market-level view of concrete's emissions impact that can be integrated into sectoral and national decarbonisation strategies.
vative ions. ,	○ Supports market differentiation and the substantiation of lower carbon concrete claims. ○ Provides clarity on innovation pathways for reducing the embodied carbon of concrete being marketed. ○ Supports robust data, which in turn inspires greater customer confidence in the lower carbon credentials of products and prepares for potential future regulatory requirements.
ities g from ements.	○ Builds confidence that thresholds set will contribute to embodied carbon reductions in the market. ○ Enhances investor confidence in the market need for expanding the supply of lower carbon concrete solutions. ○ Improves management of climate-related financial risk, specifically in activities reliant on emissions-intensive concrete.

Case Study

SGBC's Singapore Green Building Product Certification Scheme: Enhancing Low-Carbon Concrete Adoption through Product Rating and Certification

The Singapore Green Building Council (SGBC) administers the Singapore Green Building Product (SGBP) Certification Scheme to provide benchmarks on environmental performance of building products. (25), (26) The scheme uses ratings based on 1 to 4 ticks, and provides an accessible reference point to help procurers differentiate between different levels of product environmental performance. To accelerate the adoption of lower carbon concrete in Singapore, product ratings for ready-mix concrete were introduced in 2011. Certification criteria has been updated regularly in the intervening years to align with industry developments.

The rating system addresses the industry's growing need for transparent and standardised evaluation of embodied carbon in construction materials. SGBC's objective was to embed carbon performance into mainstream procurement by offering a credible, performance-based certification. Importantly, certified products contribute points toward a project's Green Mark certification, reinforcing the commercial value of sustainability-aligned procurement. Products with certifications valid for two years are listed in real-time on a public directory for easy verification and transparent comparisons. This certification is recognised under the Building and Construction Authority's (BCA) Green Mark scheme and strengthens the role of certified products in meeting industry decarbonisation goals for buildings.

Case Study

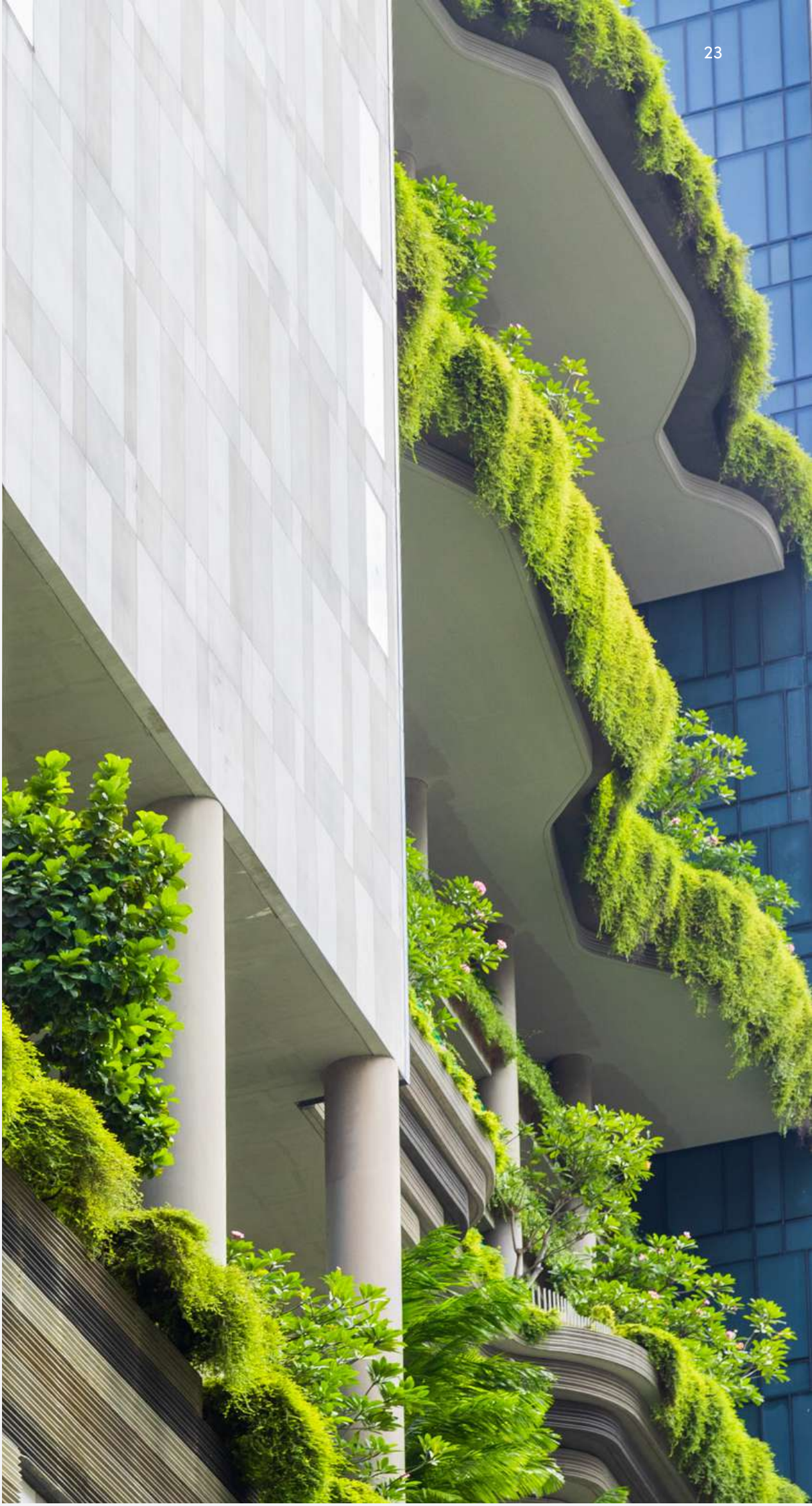
Starting January 2026, to ensure robustness and credibility, the SGBC will mandate that all manufacturers submit third-party verified Environmental Product Declarations (EPD), the GWP reported in the EPDs will be used as the key metric for evaluation, amongst other sustainability requirements. This requirement enhances consistency and rigour in embodied carbon assessments. To reduce redundancy and streamline certification, manufacturers are allowed to use the "representative product" approach, aligned to the Product Category Rules (PCR) of EPDs to report carbon footprint for concrete mixes within the same strength class. Concrete mixes with GWP values within 10% deviation from the declared GWP of the representative product GWP will be accepted for evaluation.

The initiative delivers benefits across the value chain, ensuring manufacturers gain market visibility and clarity on how to improve their sustainability profile; designers and specifiers have a reliable reference point for making carbon-conscious decisions; and building owners can use certified products to strengthen their projects' environmental credentials.

As the market evolves, SGBC intends to periodically review and adjust rating thresholds, ensuring they remain aligned with decarbonisation targets. Alongside this, SGBC is expanding its education and awareness programmes to equip stakeholders across the supply chain with the knowledge needed to accelerate LCC adoption.

This case study demonstrates how a voluntary but strategically aligned certification framework enables scalable adoption of low-carbon materials. The SGBC's integration of carbon performance into the SGBP Certification Scheme, in close alignment with the Green Mark, provides a replicable model for embedding sustainability into national building standards and procurement systems.

Contributed by SGBC



Singapore Market Benchmark Methodology

Beyond the core aim of developing a market benchmark for the embodied carbon of concrete in Singapore, a key objective of this project is to present a replicable approach for developing market benchmarks that can serve as a practical starting point for other markets across Southeast Asia and beyond. For Southeast Asia, the interconnected supply chains and cross-border movement of materials like cement creates opportunities for regional alignment and coordinated decarbonisation efforts.

By providing a template to others, we aim to drive greater consistency across the sector and cascade the benefits being realised in Singapore, as well as in other markets such as the UK and Australia. These benefits include activating a cross-value chain community of relevant stakeholders and enhancing visibility of lower carbon concrete options currently available in the market.

This chapter outlines the methodology used to develop the Singapore Market Benchmark: a graphical representation of the embodied carbon intensity of concrete on the market in 2024, as a function of concrete strength. It includes reflections on the limitations of the approach and our learnings, while Appendix B presents a general framework that can guide similar benchmarking efforts in other markets.

3.1 Singapore Market Benchma

3.1.1 Stakeholder Mapping and Enga

Success factor:

Broad and Early Engagement

Early and rigorous engagement with
was critical to ensure sufficient data
Market Benchmark by these groups.

To guide the process, a Steering Committee co
Group (TAG) made up of concrete and market
representation was selected from:

Financial Institutions

Environmental Consultants

Academia

For a full list of all project contributors please s

rk Methodology

agement

a broad representation of relevant and influential stakeholder groups collection, build market acceptance, and eventual use of the Singapore

mprising senior representatives across the concrete value chain and a Technical Advisory experts were convened and met regularly throughout the project. Across both groups,

Developers

Contractors and Construction Firms

Construction and Engineering Consultancies

Concrete Ready-mix and Precast Suppliers

Regulators and Environmental Certification Providers

International Industry Bodies

ee the end of the report.

Success factor:

Leveraging Trusted Networks

The ability to mobilise and activate this diverse network was made possible by CapitaLand Development's established global relationships and influence in the local Singaporean market.

Surveys and one-on-one consultations were conducted with relevant stakeholders during Q2 and Q3 2025. These engagements helped identify both the barriers and opportunities for adoption. They also provided insights into current methodologies for measuring embodied carbon, the challenges faced in practice, and the local frameworks or tools currently in use.

In June 2025, an in-person workshop was organised to broaden industry engagement, update contributors on progress, and validate the trajectory of results collected so far. Attended by more than 60 representatives and featuring keynote addresses from leading international and domestic market experts, the workshop attendees tackled the subject of environmental data, including its availability, quality and value in decarbonisation decision-making.

Success factor:

Cross-sector Dialogue

The deliberate effort to break down silos, bringing producers into conversation with financiers, and engineers with regulators, created an engaging and insightful workshop that enriched the process and supported the derivation of cross-sectoral recommendations.

The stakeholder engagement set out above is a crucial element without which subsequent data collection would not have been possible. Securing the market's understanding, acceptance of ongoing maintenance requirements and widespread use of the resulting market benchmark were also key motivators for this engagement activity.

3.1.2 Data Collection Process

Two stakeholder groups, concrete suppliers and concrete users, were identified as having the best visi
concrete placed on the Singapore market. To maximise the amount of data for the Singapore Market
these groups became the focus of data collection efforts. Care was taken to avoid double counting, re
that we could receive data of the same concrete from different sources.

Success factor:

Building Supplier Buy-In for Data Sharing

Demonstrating the benefits of market
of data. For suppliers, the value lies in

- Efficiency gains from providing data
- Being able to assess their concrete
- Ensuring the Singapore Market Ben

Data on concrete held by concrete users is curr
only a secondary focus of our data collection e
anticipated that future market benchmarks wil

The data collected for this research falls into tw
(namely concrete compressive strength, embo
the quality and appropriateness of the core da

With guidance from the TAG, supplemented wi
Request for Information (RFI) was developed c
constituents and their countries of origin, binde

This RFI was shared, accompanied by a projec
manufacturers who collectively supply Singapo
meetings with 11 suppliers to further engage th

bility of the
Benchmark,
ecognising

t benchmarking to concrete suppliers was key to securing their contribution
n:

a once for this study rather than responding to numerous individual requests
against the market as a whole and substantiate lower carbon claims
chmark is representative of the market in which they operate

rently less complete and detailed than that held by concrete suppliers. As such, it was
efforts and was ultimately used only to validate the data provided by suppliers. It is
l be based on even wider supplier data.

wo categories: (i) the core data required to develop the Singapore Market Benchmark
died carbon, and volume placed on the market) and (ii) supporting data used to assess
ata (such as origin of constituent materials, cement type, and total binder content).

th direct feedback from a concrete supplier who volunteered to test it, a standard
overing information such as concrete strength class, embodied carbon, volume, mix
er content and type of projects the concrete was used in.

t overview, with 11 concrete ready-mix producers and 12 concrete precast
ore an estimated 88% of its concrete. This was followed up with one-to-one
em in the project and obtain any data they were ready to share.

Success factor:

Pragmatism in Designing the Request for Information

Adopting a pragmatic approach, both suppliers in the one-to-one calls, help completeness of the environmental d participation in a market where third- Singapore Market Benchmark, as dat

Some of the data requested, particularly the in this concern, all suppliers were assured that ar In certain cases, additional measures, includin non-disclosure agreements related to the raw

Upon receipt of data from the concrete supplie completeness and accuracy of the data provid compilation and calculation of the embodied c assumptions in their lifecycle assessment mode

All concrete suppliers provided their data grou for consistency in reporting. Instead of capturir constituent materials, their volumes and sourci understanding of this averaging process, or ide iterations of the Singapore Market Benchmark

h the design of the Request for Information and in the guidance shared with
bed increase supplier participation. Flexibility on the type, quality, format and
ata accepted was particularly important and supported increased
-party verified EPDs are not always available. In future iterations of the
ta quality improves, the approach should become more standardised.

nformation on concrete volumes, can be considered commercially sensitive. To address
ny data provided would be aggregated and anonymised in the development process.
g providing explicit assurances on the data management process and entering into
data, were necessary to secure their contributions.

ers, detailed follow-ups were conducted with additional questions to ensure
ed. This involved checking for data entry errors, clarifying their approach to data
carbon, and where relevant, requesting further details on emissions factors and
elling.

ped by product type and strength class before sharing. While this approach allowed
ng the emissions impact of batch-to-batch variation in individual concrete mix
ng, only pre-averaged values were received for use in market benchmarking. A better
eally, accessing the pre-averaged batch-to-batch data, could be targeted in future
to provide the best possible picture of Singapore's embodied carbon of concrete.

Table 1: Summary of supplier sample and the data collected and used to develop the market benchmark

	Indicator
Sample	Number of suppliers
	Number of suppliers
	Number of suppliers
	Of which are, ready-
	Number of consultan
	Number of data prov
Data collected	Number of data poin
	Of which, includes vo
	Volume of concrete re
	Volume of concrete e
	Volume reported or n
	Number of concrete s
Data used in the Singapore Market Benchmark	Number of concrete s
	Number of data poin
	Of which, includes vo
	Volume of concrete re
	Volume of concrete re

*Modelling included ex
significant supplier-pr

	Value
invited	23
engaged with	11
who provided data	7
mix providers	3
ts and engineers who provided data	2
iders who shared concrete volume information	6
ts reported	132
lume information	91
eported (m^3)	5.2 million
xtrapolated from reported data (m^3) *	3.9 million
modelled as % of total Singaporean market	80%
strengths reported on	17
strengths with sufficient data to include	6
ts reported at these strength classes	81
lume information	58
epresented (m^3)	7.7 million
epresented as % of total Singaporean market	68%

trapolation of supplier data from reported samples and was constrained using ovided contextual information on their product portfolio and market share.

3.1.3 Data Analysis and Developmer of the Singapore Market Benchmarl

All data received from suppliers, augmented with any additional insights, corrections or clarifications follow-up correspondence, was systematically logged and recorded. This dataset varied in completen guidance from the Technical Advisory Group (TAG), the dataset was refined to ensure only the most ap Key considerations included the availability of volume information, data quality and consistency, samp and, considering all these factors, the most appropriate way of presenting the Singapore Market Benc

Volume Information

All the data provided by consultants and engineers did not include information on the volume of material placed on the market in 2024 as this was beyond their visibility. Similarly, one supplier confirmed that its products were placed on the market but did not provide any volume information, citing the data's commercial sensitivity. These data points were included in informing the minimum and maximum embodied carbon values in the Singapore Market Benchmark but were excluded from the derivation of the volume weighted average.

A small number of suppliers provided partial volume information, covering only a selection of their 2024 production. Leveraging contextual information such as market share, representativeness of sample, and overall strength class distribution of concrete produced as provided by other suppliers, the omitted volumes were able to be modelled. This modelling was necessary to ensure the representativeness of the sample but should be minimised and ideally avoided in subsequent iterations of the Singapore Market Benchmark.

nt
k

obtained from the
ess and precision. With
ppropriate data was used.
le representativeness
chmark.

Data Quality and Consistency

There was a lack of alignment in the approaches used to measure or calculate the embodied carbon of concrete in Singapore.

Across the samples, we received embodied carbon data derived using carbon calculators as well as from EPDs. There was a range of methodology differences noted, including reference to five distinct emission factor databases (Singapore Building Carbon Calculator (SBCC), the One Click LCA tool, Ecoinvent v3.8 and v3.10, and ICE v4.0). Differences in the allocation of emissions associated with Ground Granulated Blast Furnace Slag (GGBS), the main supplementary cementitious material on the market, were also evident across the sample.

Despite the above limitations, observed variation in embodied carbon also correlated with real-world factors such as binder content and the distance travelled by the aggregates in reaching Singapore. The dataset represents the most comprehensive information currently available on the market and therefore was used to develop a first market benchmark for Singapore. The uncertainty introduced by inconsistencies within the data has been explicitly acknowledged and incorporated into both the presentation of the Singapore Market Benchmark and the guidance on its appropriate use by market participants.

Representativeness

From the outset of the project, particularly in engagements with concrete suppliers, it was emphasised that the objective of market benchmarking is to provide a representative view of the entire Singaporean concrete market. Only through a whole-market perspective can relative differences in embodied carbon performance be meaningfully identified.

To assess representativeness, high-level comparisons were made against industry estimates of the distribution of concrete types, concrete strengths, and ready-mix versus precast products. This analysis indicated that precast concrete, along with the cement types and strength classes prevalent in those products, were under-represented in the sample. It is also recognised that the self-selecting nature of supplier participation may have influenced the composition of this first iteration of the Singapore Market Benchmark.

Given these limitations, the Singapore Market Benchmark is presented at this stage as primarily applicable only to ready-mix concrete. It does not reflect precast concrete, including Prefabricated Prefinished Volumetric Construction (PPVC) products whereby entire rooms or large segmented modules are constructed off-site. These products represent a significant part of Singapore's concrete use as many private and public residential projects require the use of PPVC construction to reduce on-site activity and material waste.

Considering the role of precast concrete in Singapore, future iterations of the market benchmarks should prioritise addressing this gap. It is also notable that the UK market benchmark, despite being in its fourth year, has yet to cover representative volumes of precast concrete, underscoring the complexity of achieving full market coverage.

Selecting and Presenting Data for the Singapore Market Benchmark

The volume weighted market average was derived from data points associated with volume information, at concrete strengths where sufficient data existed to allow anonymisation through aggregation. This same data was used to calculate the standard deviation, also volume weighted, to represent the spread of embodied carbon data reported at each concrete strength.

The minimum and maximum embodied carbon at each concrete strength class were derived from the full dataset, including data points where no concrete volume was provided. Considering the limitations around sample size, its representativeness and the consistency of reported data, it was decided that the most appropriate format for the first Singapore Market Benchmark is a plot of the average (including standard deviation), alongside the minimum and maximum embodied carbon values by concrete strength.

Other market benchmarks have been represented using different formats, depending on the completeness and robustness of the underlying data. However, in the Singapore context, the use of banding, like in the UK market benchmark, was avoided to prevent confusion with the SGBP Certification Scheme and GCCA Global Rating System. This approach should be reviewed and evolved further in future years.

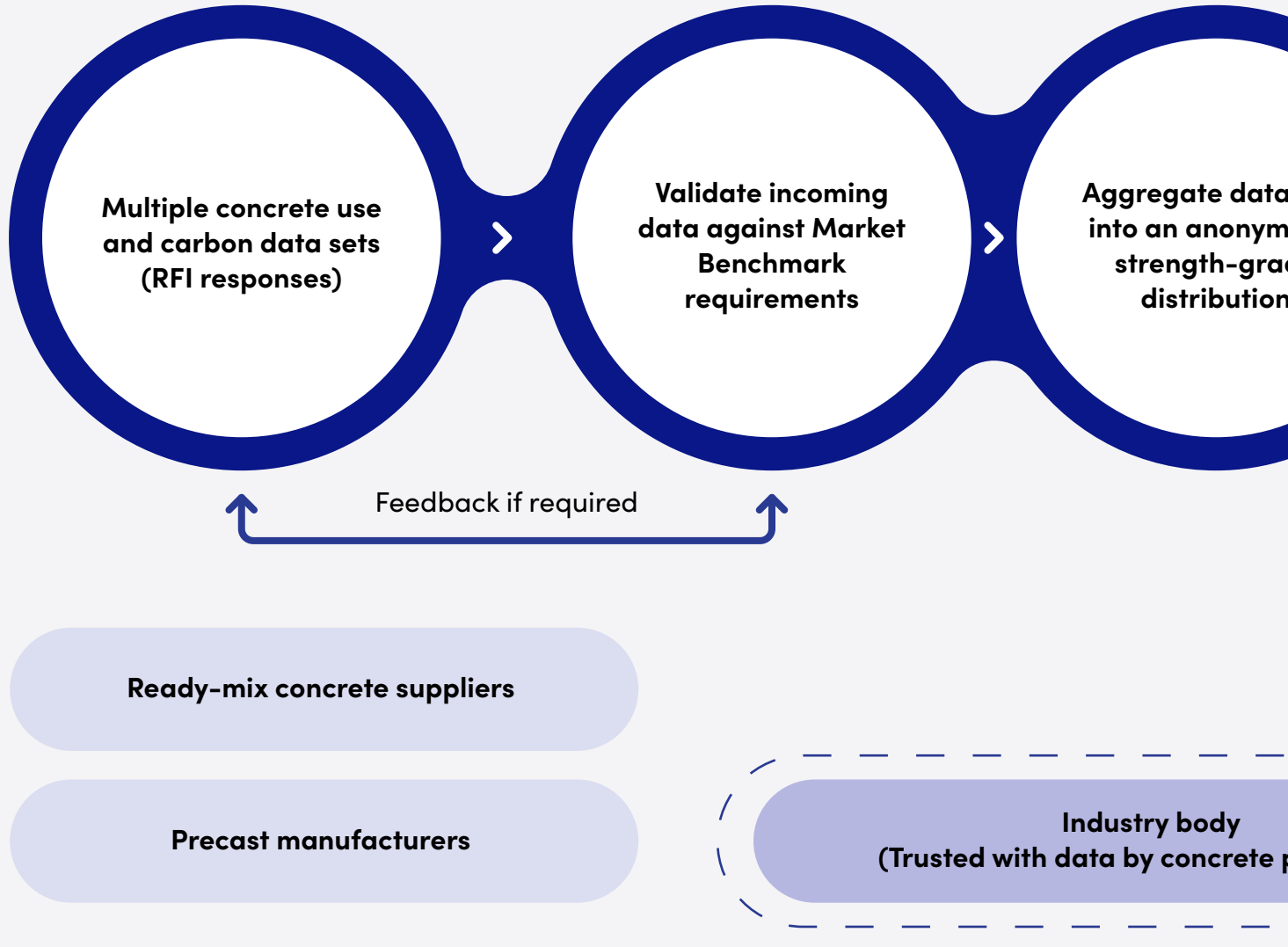
3.2 Learnings to Support the Re Future Market Benchmarking M

Find the Right Home for the Market Benchmark

From the outset of this pr long-term ownership an Market Benchmark. For t credible, market benchm to reflect evolving marke supply chains.

While many suppliers en with data, the hesitancy

Figure 4: Proposed generalised data collection and collation process for delivering market benchmar



efinement of Methodologies

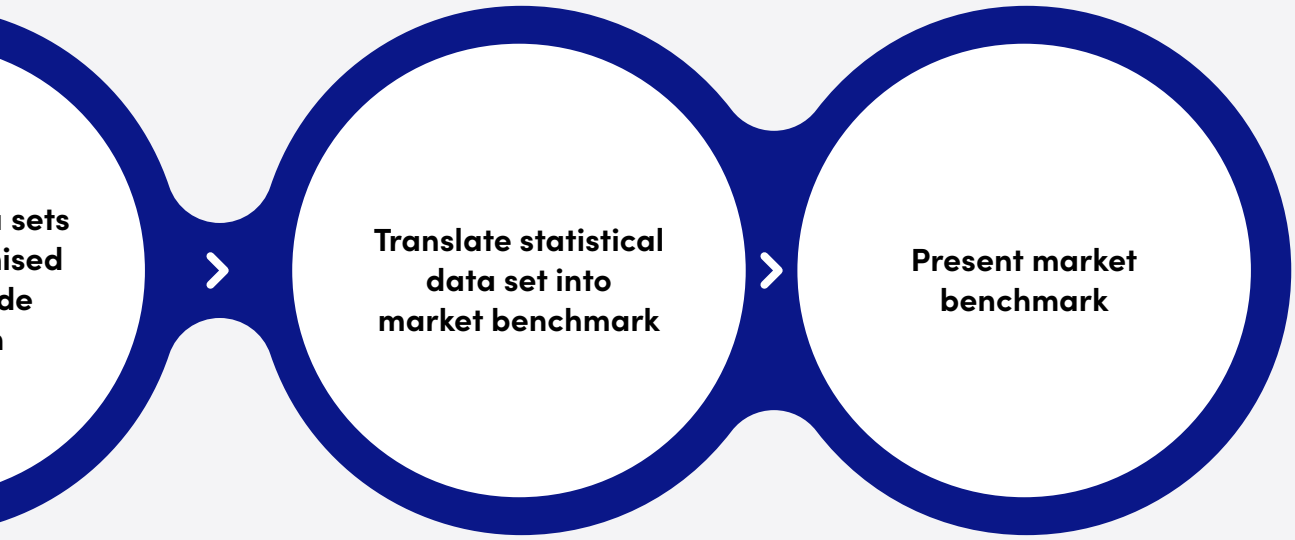
roject, consideration was given to
d maintenance of the Singapore
hem to remain both useful and
arks should be updated annually,
t practices, materials, and

gaged were extremely forthcoming
of some was also understandable.

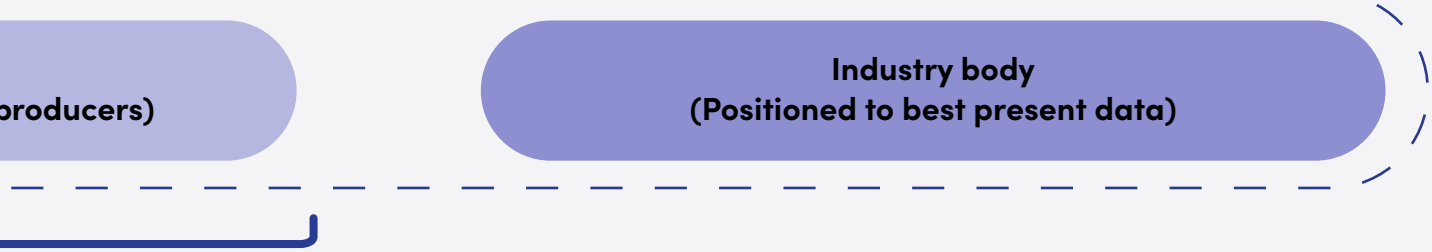
In Singapore, a neutral party like an institute of higher learning or a regulatory authority might be best placed to collect and manage this data on an ongoing basis, thereby ensuring both supplier confidence and its integrity.

The optimum process for collecting, collating, and interpreting the data and presenting it as a market benchmark will vary from market to market but can, at a high level, be summarised as set out in Figure 4.

ks for the embodied carbon of concrete



From the same or different organisations



Don’t Let Perfect Be the Enemy of Good

The accuracy, precision, granularity and availability of data on concrete and its embodied carbon are steadily improving globally. Over time, the market benchmark will evolve in response to these data improvements, changes in market coverage, and shifts in the embodied carbon of concrete itself.

As it stands, there is no way to bypasss the process of evolution and maturation market benchmarks will undergo, especially in the early years. Drawing from the experience in the UK, the longest running market benchmark, the industry accepts these methodology-related shifts as a necessary part of maintaining a market benchmark based on the best available data and market leading analysis.[2]

While data limitations should not prevent the undertaking of market benchmarking efforts, it is important that the robustness of the underlying data are transparently presented and reflected in the guidance notes for using the market benchmark. This enables informed use of the market benchmark and provides direction for its enhancement in the future.

Be Clear on the Limitations of the Market Benchmark

Market benchmarks provide high-level overviews of the embodied carbon of concrete within a defined boundary, e.g. a country, as in the examples to date, a state or even a sector. While they are a useful resource, for all the reasons outlined in Section 2.4, improved market visibility often entails more detailed stakeholder questions about concrete’s embodied carbon and how to reduce it, which the market benchmarks alone can’t always answer.

To begin, a significant nuance is omitted in the two-dimensional representation of a market benchmark. Compressive strength is just one of many performance characteristics that influence decisions around concrete mix design. For example, more OPC can be used in concrete to shorten curing time and speed up project delivery. The ultimate compressive strength of the concrete may be the same as one that cures slower, but a higher OPC content leads to higher embodied carbon.

Note: Concrete specification is the process of selecting the appropriate concrete properties for a particular application and is a pivotal lever for concrete users to implement embodied carbon reductions. As set out in the recent ConcreteZero Guidance on this topic, lowering the embodied carbon of concrete requires a shift to a more collaborative approach with the whole project team having a role to play in its specification. (27)

Similarly, market benchmarks cannot inform how to avoid over-specifying the concrete used. If a higher than necessary compressive strength is specified for an element, say a floor slab or column, a market benchmark, based on data from concrete suppliers with little or no visibility on what their concrete is used for, will not be able to help.

Answering these detailed questions will only be possible with the maturation of concrete embodied data management across construction project teams. Recognising that granular, consistent data is necessary for identifying concrete users' carbon hotspots and opportunities to reduce embodied carbon, ConcreteZero has designed a reporting framework around the information needs of concrete users, thereby addressing this emerging market need.

Nevertheless, even though complementary data collection efforts will continue to evolve to provide more targeted information on tackling the embodied carbon of concrete, market benchmarks remain a valuable overview and means of monitoring and communicating progress at a whole-market level.

[2] For example, a decision to allocate more of the emissions from blast furnaces to GGBS using the economic allocation approach resulted in an uplift in reported embodied carbon that has fed into both the 2024 and 2025 UK Market Benchmarks.

Case Study

Unlocking Lower Carbon Conc Geneo through CapitaLand D Engagement with Multiple Ke

The Geneo project, a landmark life sciences and innovation cluster at Singapore Science Park, exemplifies how CapitaLand Development (CLD) has established a replicable model for advancing sustainable innovation in the built environment. (28) Its success was underpinned by three core enablers:

01 Clear Design Specifications

Sustainability requirements were embedded in the design brief from the outset, ensuring transparency and accountability across the project team.

02 Empowered Internal Champions

A dedicated CLD sustainability team catalysed the adoption of Carbon Mineralised Concrete (produced using the CarbonCure technology) and drove its effective implementation.

03 Cross-Sector Collaboration

Strong partnerships between private stakeholders and regulators validated the solution and demonstrated its feasibility for broader market adoption.

crete Innovation at evelopment's Early y Stakeholders

Anchored on these enablers, Geneo serves as a blueprint for the industry, showing how low carbon concrete can transition from pilot applications to scalable market solutions.

Carbon mineralised concrete technologies involve injecting and irreversibly reacting CO_2 into concrete during mixing, counteracting some of the emissions associated with concrete production, without negatively impacting its structural integrity. (29) Although proven internationally (primarily in North America and Europe), local regulations meant that its use in Singapore, and specifically for use in structural elements in the superstructure, required rigorous additional validation.

Early-stage consultation led by the internal champions focused on understanding the information needs of key stakeholders, namely,: Pan-United, the delivery partner for the CarbonCure concrete technology in Singapore; the main contractor; the project's structural Qualified Person (QP); the relevant regulator (BCA); and the Nanyang Technological University of Singapore (NTU).

The regulator requested confirmation of the QP's endorsement of the material for the specific application, of which the QP required additional performance-based testing to demonstrate compliance with the relevant structural standards. These tests were made possible through the advanced capabilities and services provided by NTU. With the QP's support, CLD successfully presented the case to BCA, ultimately securing regulatory approval for the use of the CarbonCure concrete technology for superstructure elements including both structural and non-structural elements, an important step towards for sustainable construction in Singapore.

This lower carbon concrete initiative was part of a broader sustainability strategy embedded in Geneo's design and delivery. The project, specifically 7 Science Park Drive, achieved BCA's Green Mark Platinum Super Low Energy certification and WELL Core Precertification, reflecting its dual commitment to environmental performance and occupant well-being. These certifications were instrumental in CLD securing two pioneering sustainability-linked loans (SLLs) totalling S$600 million from DBS and OCBC. (30)

Case Study

As part of the Geneo development, one of the flagship projects within the wider rejuvenation of the Singapore Science Park, a defining feature is **The Canopy** – a large, naturally ventilated public plaza that demonstrates how design can simultaneously address embodied and operational carbon emissions.

On the **embodied carbon** front, the structure incorporates Mass Engineered Timber (MET), achieving significant reductions compared to conventional materials while ensuring transparent accounting of the biogenic carbon stored within the timber.

On the **operational carbon side**, The Canopy is designed to minimise energy demand by harnessing natural ventilation, supported by ceiling fans, instead of relying on full air conditioning. This strategy is expected to substantially lower the building's Energy Use Intensity (EUI), particularly as air conditioning typically accounts for 40–50% of annual EUI in Singapore's commercial buildings. (31)

By combining innovative material use with passive design strategies, The Canopy not only reduces the project's carbon footprint but also serves as a flagship example of how sustainable architecture can enhance both performance and user experience.

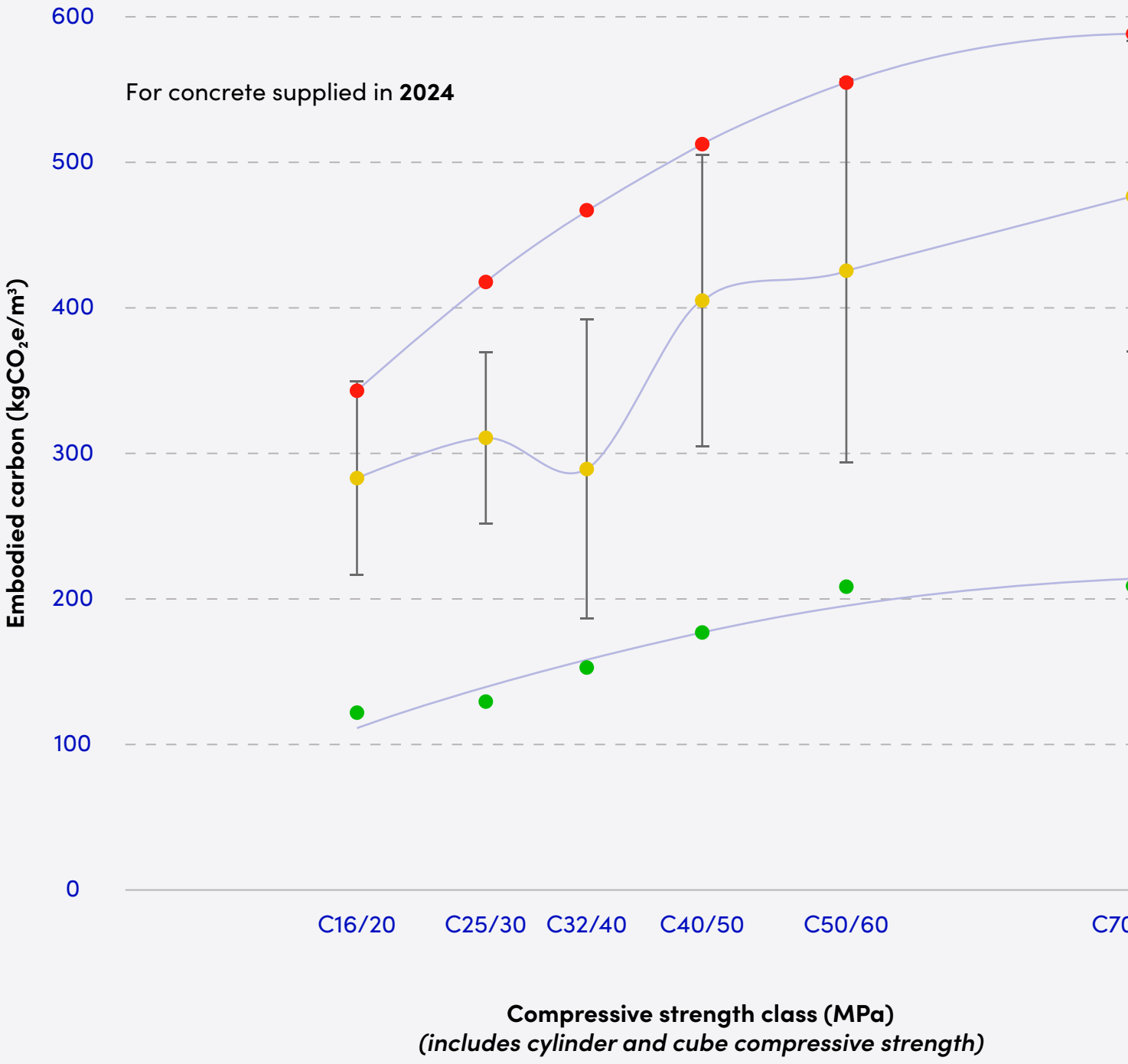
Geneo illustrates how internal leadership, technical rigour and stakeholder collaboration can drive meaningful change. By championing the CarbonCure concrete technology's adoption, CLD not only reduced the carbon footprint of its superstructure but also demonstrated that innovation in materials can coexist with regulatory compliance and commercial viability. The project's recognition through sustainability-linked financing further validates the business case for holistic sustainability where environmental performance and human-centric design converge to shape the future of urban development.

Key Findings & Insights

4.0

4.1 The Singapore Market Benc
for the Embodied Carbon of Co

Figure 5: The Singapore Market Benchmark for the Embodied Carbon of Concrete based on 2024 data.



hmark
ncrete

The first Singapore Market Benchmark for the Embodied Carbon of Concrete, based on data received through this research on concrete placed or poured in the market in 2024 is presented in Figure 5 and explained in the accompanying guidance notes.

- Maximum embodied carbon
- Volume weighted average embodied carbon
- Minimum embodied carbon

Notes: This market benchmark represents the best available data on the embodied carbon (LCA stages A1 to A3) of ready-mix normal weight concrete poured or placed in Singapore in 2024 based on an estimated 68% of the market. While data from precast concrete is included, given the limited sector coverage, the Singapore Market Benchmark is not recommended for making inferences about the precast concrete sector. Note that the achievable embodied carbon will depend on a variety of concrete performance requirements in addition to compressive strength, as well as the market availability depicted in the Singapore Market Benchmark.

Table 2: The data presented in the Singapore Market Benchmark

Data points ($kgCO_2e/m^3$)	C16/20*	C25/30
Proportion of concrete volume by strength class	7%	4%
Volume weighted average embodied carbon	283	311
Volume weighted standard deviation	66	59
Minimum embodied carbon	122	129
Maximum embodied carbon	343	418**

*The concrete compressive strength notation used here includes both the compressive cylinder strength in Megapascals (MPa), (16) and the compressive cube strength in MPa. (20)

**These values were modelled based on data at other strength grades of a CEM I-based concrete with aggregates imported over a particularly long distance

C32/40	C40/50	C50/60	C70/85
55%	17%	12%	5%
289	405	425	477
103	101	131	107
153	177	209	209
467	513**	555	589**

Interpreting the Singapore Market Benchmark

The maximum embodied carbon line (red) represents the highest embodied carbon of concrete reported being used in Singapore in 2024 for each concrete strength. Information provided with the data shows that these concretes use 100% OPC binders (CEM I), at relatively high proportions and with constituent materials, especially the heavy aggregates and sand, travelling a relatively long distance to market.

The minimum embodied carbon line (green) is the lowest embodied carbon concrete reported as being used in Singapore in 2024 for each concrete strength. These concretes use high proportions of lower-emissions-intensity Ground Granulated Blast Furnace Slag (GGBS), replacing 66-80% of the OPC (known as CEM IIIB based concretes). Carbon mineralisation processes are also available on the Singapore market, which can reduce the embodied carbon of concrete by circa 10%.

Note: While replacing CEM I with GGBS is effective at lowering the embodied carbon of concrete, the scalability of this approach is limited by the supply of GGBS, which is constrained by the fact that it is a by-product of blast furnace-based iron and steel production. Globally, GGBS is already a near fully utilised material for use in reducing clinker demand and for achieving other technical properties in certain concrete applications (e.g. reducing thermal cracking, especially in thick or deep concrete sections, and improving durability in harsh environments, such as marine structures and basements). Best practice guidance around the use of GGBS beyond technical requirements (i.e. for achieving carbon reductions) is that it should come from well-established supply chains, and be used in proportions cognisant of global constraints. (32)

The average embodied carbon line (yellow) is based on data where embodied carbon of concrete was shared along with information on the volume of that concrete supplied to the market. This allowed us to derive a volume weighted average and provide a more representative view of the market.

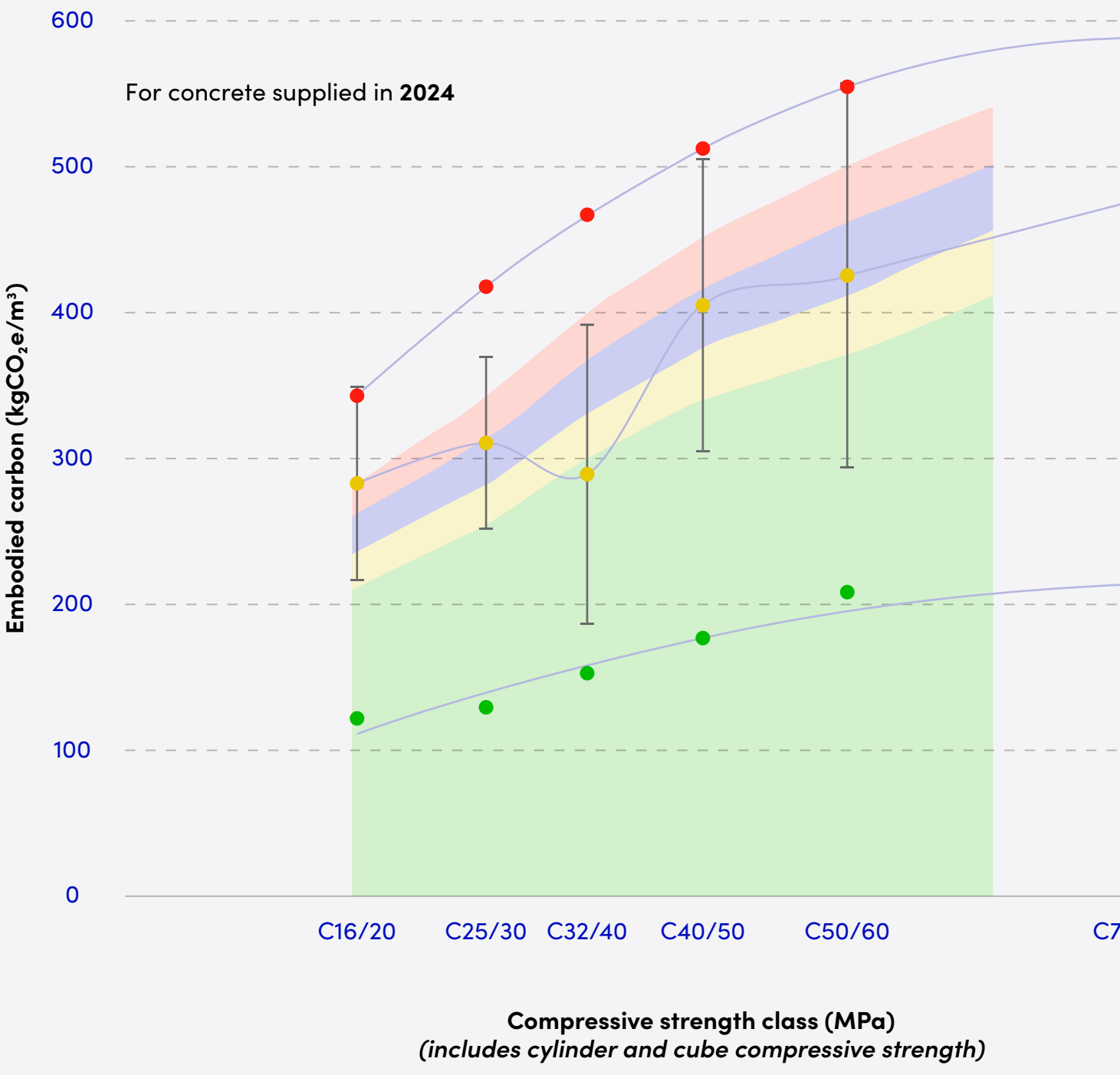
The positioning of the average and spread (standard deviation) of embodied carbon per concrete strength, nearer the maximum line than the minimum line, demonstrates that despite ongoing efforts, the current supply in Singapore is still concentrated at higher embodied carbon values, indicating substantial potential for improvement.

The average embodied carbon at C32/40 is notably lower than at other strengths because proportionally, more of the lower carbon CEM IIIB-based concretes were reported at this strength. This is especially significant as over half (55%) of the concrete represented in the Singapore Market Benchmark was C32/40. CEM IIIB based concrete's technical properties make it particularly well-suited to, typically high-volume, civil engineering projects with large element cross-sections, of which there were many ongoing in Singapore in 2024 (mass transit system and airport extension included). This example illustrates how current concrete applications in a market present in a market benchmark. Evolving concrete applications, as well as shifts in the embodied carbon of available supply, will be reflected in future iterations.

The standard deviation ranges shown are inconsistent across the concrete strengths depicted, a result of the varying number of data points used in their derivation. They are only presented to give an indication of the range of the concrete being placed on the market.

Interpreting the Singapore M
Relation to Other Rating and

Figure 6: The Singapore Market Benchmark for the Embodied Carbon of Concrete overlaid on the Singapore Green Building Product (SGBP) Green Tick Certification System (Red Zone = 1 Tick, Blue Zone = 2 Tick, Yellow Zone = 3 Tick and Green Zone = 4 Tick).



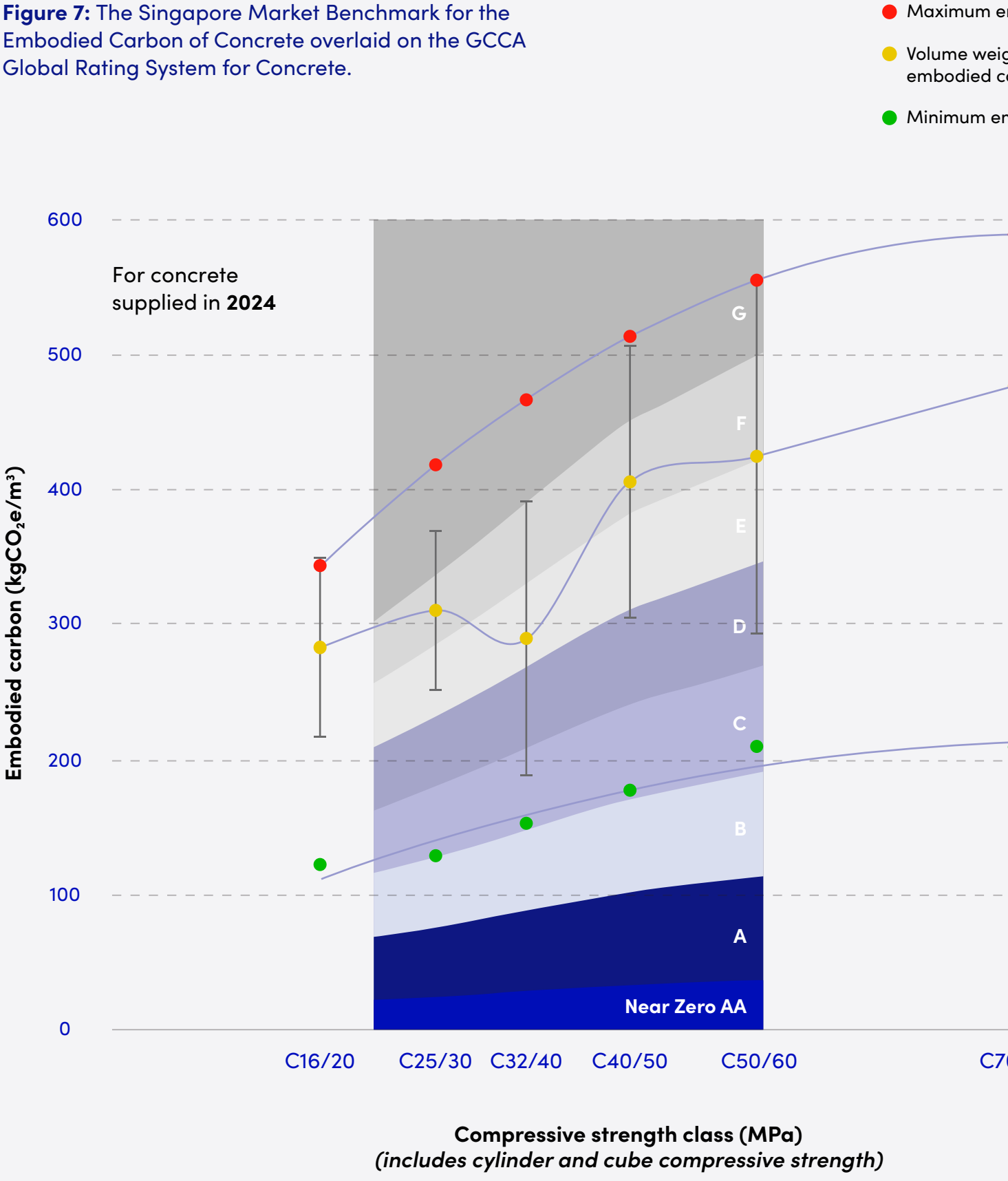
arket Benchmark in Certification Systems

- Maximum embodied carbon
- Volume weighted average embodied carbon
- Minimum embodied carbon

In Figure 6, the Singapore Market Benchmark has been overlaid on the Singapore Green Building Product (SGBP) Certification Scheme, the established system for differentiating concrete based on embodied carbon in the market. The average embodied carbon from the Singapore Market Benchmark data aligns roughly with the SGBP Certification Scheme's Green Tick ratings. In general, specifying and procuring certified concretes, especially those with Tick ratings 3 or 4, contributes to shifting the market average lower.

The overlay of the Singapore Market Benchmark and the SGBP Certification Scheme also indicates that the certification system would benefit from extending to lower embodied carbon values to support better differentiation of the lower carbon concrete on the market. In principle, to future-proof as well as signal direction of travel to the market, certification systems should align or support interoperability with globally recognised rating systems (e.g. that produced by GCCA) and should extend at least to near-zero or net zero carbon concrete.

Figure 7: The Singapore Market Benchmark for the Embodied Carbon of Concrete overlaid on the GCCA Global Rating System for Concrete.



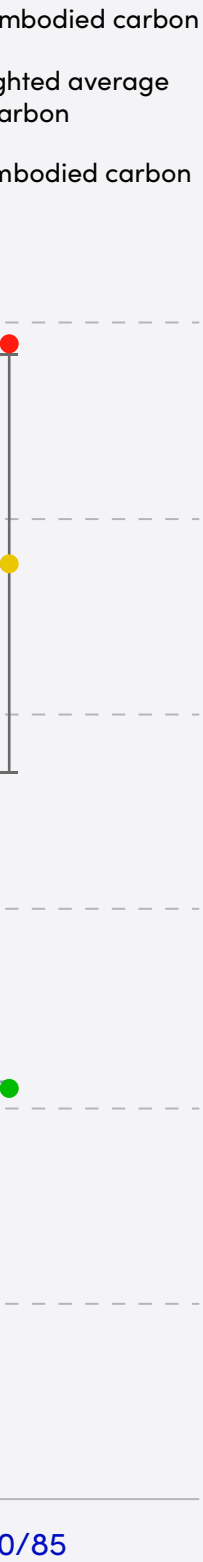


Figure 7 presents the overlay of the Singapore Market Benchmark onto the GCCA Global Rating System for Concrete. The weighted average embodied carbon emissions of Singapore concrete sits within Band E and F of this Rating System. The top of Band E corresponds to GCCA's Global Reference Threshold, described as "good practice Ordinary Portland Cement (CEM I/OPC)" and "good practice concrete mix designs", weighted by each country's cement output.

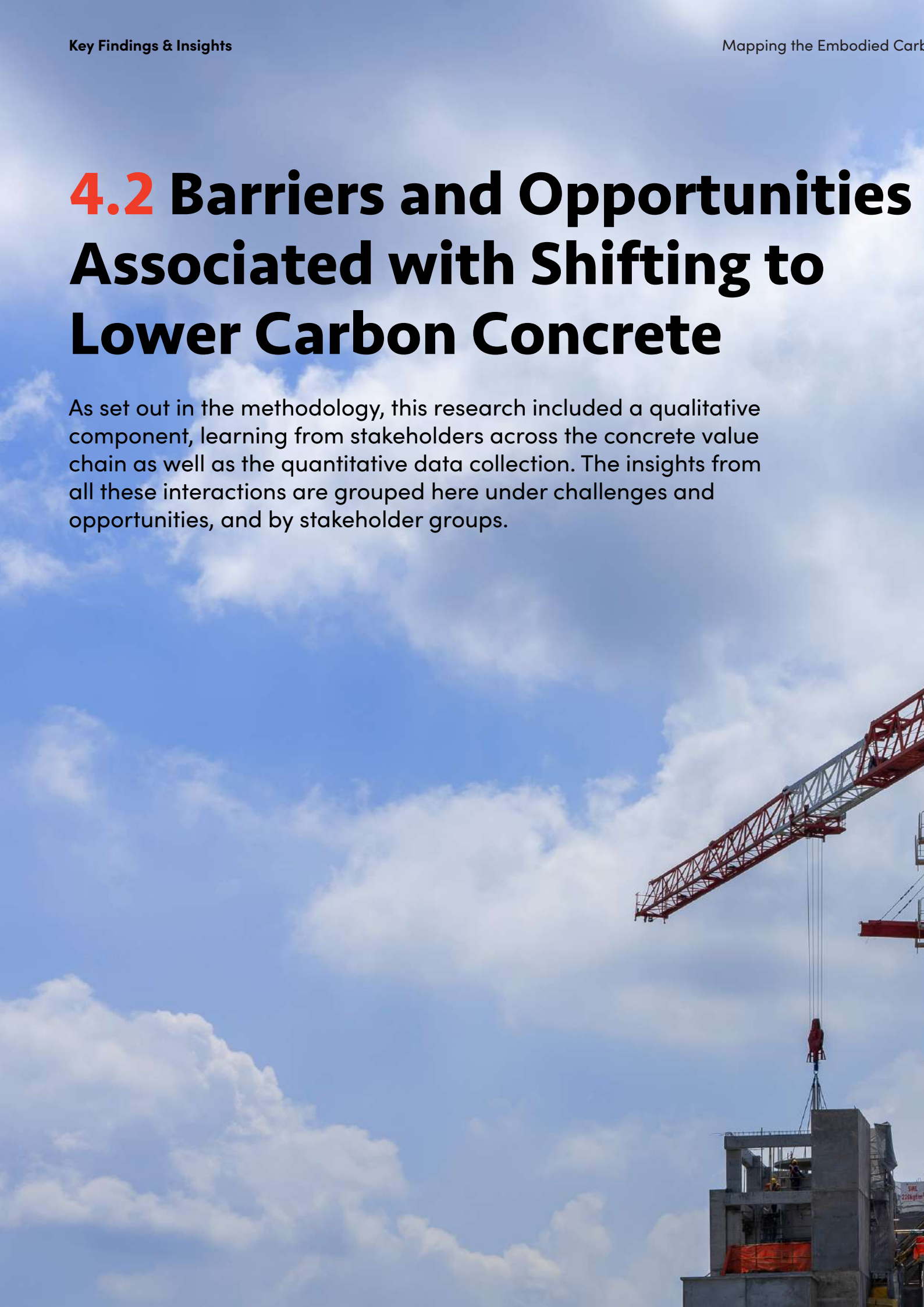
More positively, the average embodied carbon data presented in the Singapore Market Benchmark extends to Band E for C32/40 concrete, which is the most commonly utilised concrete, representing about 55% of the overall quantity sampled in the study, and the lowest carbon concrete available on the Singapore market can be rated C using the GCCA system. This demonstrates that concrete with embodied carbon lower than the GCCA's Global Reference Threshold is available for use in Singapore.

Using the Singapore Market Benchmark to Estimate the Carbon Impact of Singapore's Concrete Use

The data used to produce the Singapore Market Benchmark also allowed **the total embodied carbon to be calculated for the 11.4 million m³ of concrete used in Singapore in 2024: 3.7 $MtCO_2e$**. This represents an average embodied carbon intensity for Singapore's concrete of 329 $kgCO_2e/m^3$, across all strength grades, influenced by an average binder content of 428 kg/m^3. Average binder content was calculated by volume-weighting data from 7 suppliers, across 65 concrete mixes or products, representing 5.2 million m³ of concrete.

4.2 Barriers and Opportunities Associated with Shifting to Lower Carbon Concrete

As set out in the methodology, this research included a qualitative component, learning from stakeholders across the concrete value chain as well as the quantitative data collection. The insights from all these interactions are grouped here under challenges and opportunities, and by stakeholder groups.



4.2.1 Barriers to Moving Towards Lower Carbon Concrete

Common barriers reported by stakeholders included:

01
Lack of a common understanding of what is meant by “low-carbon” or “green” concrete

A broad challenge in the market is the absence of a unified definition of “low-carbon” or “green” concrete. These ambiguous phrases mean different things to different stakeholders, making it difficult to clearly communicate lower carbon concrete requirements, set credible project-level targets, and incorporate embodied carbon into financial instruments. The silver lining is the market-wide recognition of the SGBP Certification Scheme for concrete (see Figure 6), which, especially when used in conjunction with the Singapore Market Benchmark, can be referenced for more effectively communicating about the embodied carbon of concrete.

02
Limited and inconsistent environmental data preventing fair comparison of concrete products and increasing risk of inadvertent greenwashing

Producing mix or product-specific environmental product declarations (EPDs) is time and resource-intensive. Despite supplier’s best efforts, current EPDs reviewed as part of this research fall short of enabling robust product-to-product comparison due to variability in the underlying methodologies and assumptions employed.

Furthermore, the financial and technical challenges of obtaining EPDs are disproportionately higher for smaller businesses, contributing to uneven market participation and reinforcing competitive disadvantages. EPDs risk becoming a compliance burden rather than a market enabler.

Note: Within a certain product category, the composition of each batch of ready-mix concrete is tailored depending on its intended use (e.g. pumping distance) and the site conditions (i.e. temperature and humidity). Having EPDs to cover all possible compositions is cost-prohibitive, while product category-level EPDs do not have the batch-to-batch specificity end users value. As such there is growing interest internationally in the role Product Carbon Footprints (PCFs) may have in the future to support market access to robust mix- and product-specific information on the embodied carbon of ready-mix concrete.

Best practice concrete PCFs are calculated based on embodied carbon data from third-party verified concrete constituent EPDs, as well as transport and production associated emissions sourced from reputable market-specific databases (and follow the standard PCF guidelines set out in ISO 14067). The processes and calculations for generating PCFs can be third-party assured, but the third-party verification of each individual calculation (as is the case for EPDs) can be avoided. However, currently, variability in the PCFs in Singapore limits their usefulness. As such, EPDs remain the most robust source of concrete environmental data available.

03

Gaps in designer, contractor and developer knowledge of lower carbon concrete materials and products, and how to best utilise them

Data availability and technical tools alone will not transform the market. The whole project team has a role to play in reducing embodied carbon of concrete and needs to be equipped with the skills and knowledge to apply themselves to this sector-wide challenge. Lack of experience with the performance characteristics of lower carbon concrete, notably its 'early strength gain', is a particular concern for contractors and Qualified Persons (QPs).

Targeted training, structured knowledge exchange, and early collaboration between developers, suppliers, contractors, and regulators will be essential. Building this shared capacity and trust will ensure consistent application of new tools and ensure that the benefits of the transition to lower carbon materials are experienced by everyone.

04

Opaque lower carbon concrete pricing deterring uptake of these solutions unless specifically required on a project

Developers and contractors reported persistent cost perceptions as a key barrier, particularly in projects where sustainability outcomes are not incentivised or mandated. Many remain cautious, assuming lower carbon products will increase costs. While suppliers indicated that cost premiums for the established GGBS and fly ash-based concretes have narrowed.

4.2.2 Opportunities to Move Towards Lower Carbon Concrete

Opportunities to reduce the embodied carbon of concrete have been grouped into those that can be progressed immediately and those that can be realised in the near term, or 2 to 3 years.

Immediate Reduction Opportunities:

Realise efficiency gains through optimising the use of concrete and cement

Project teams should look to avoid concrete over-consumption (using too much) and over-specification (using material that exceeds performance requirements) for emission reductions of more than 20%, according to the GCCA's 2050 Roadmap. (33)

Based on the same reference, an additional 10% of emissions savings can be achieved through measures including mix optimisation. Given the range of binder contents we saw reported as part of this research, between 370 and 480 kg/m^3 for the most common concrete strength (C32/40), the potential savings in Singapore could be even greater than this.

Note: Binder is the term used to describe materials including OPC that act to bind the other main ingredients in concrete, sand and aggregates, together when activated by water. Other binders, also known as supplementary cementitious materials (SCMs) include ground granulated blast furnace slag (GGBS), fly ash, calcined clay, silica fume, limestone fines, pozzolans and some other industrial by-products. Crucially, all these have lower embodied carbon than OPC and can be used to achieve various desirable concrete performance characteristics when used appropriately. In general, good practice use of lower carbon SCMs should not increase the overall binder content in the concrete. Alternative binder systems, some of which don't include any OPC, are also in development globally. (34)

Ireland is an example of a market that, instead of setting GWP based targets, has decided to mandate the use of a minimum percentage of SCMs in the concrete procured on public projects. (35)

Support scaling of innovation and efficiency gains across the concrete value chain

Use existing grant-like mechanisms as vehicles to support innovation and diversification of lower carbon concrete materials, to address barriers associated with the upfront cost of trials, testing, and LCAs, which represent a significant risk to suppliers. This could include the Built Environment Accelerate to Market Programme, (36) the Open Innovation Network, (38) or Enterprise Singapore. (39)

Reduce transport-related emissions through shortening supply chains

From the EPDs reviewed as part of this research, we learnt that Singapore's import reliance is particularly evident in the emissions impact of transporting bulk materials. The transportation of sand and aggregates for use in concrete in Singapore can contribute over 100 $kgCO_2e/m^3$ to the overall embodied carbon of the material. Minimising haulage distances, improving logistics efficiency, and promoting lower carbon transport modes (e.g. electric or alternative-fuel vehicles) could deliver significant reductions. Initiatives such as Jurong Port Authority's RMC ecosystem, an example of strategic co-location and integration of supply chains, may also contribute to reducing concrete's overall transport-related emissions.

Demonstrate intent by establishing specific decarbonisation targets for concrete

This report furnishes stakeholders in the Singapore market with enough information to develop near- and medium-term targets for their concrete decarbonisation. In 2022, ConcreteZero used a similar level of information from the UK's first Market Benchmark to establish a time-bound decarbonisation commitment that all members sign up to. These targets can then be operationalised by introducing embodied carbon criteria into procurement frameworks and linking them to overarching sustainability targets and communication strategies.

Scaling new-to-Singapore, but established, alternative SCMs

Secure investment, source materials, test, trial, seek approval, pilot, and build the market for materials to displace increasing amounts of the emissions-intensive OPC, and the supply-constrained GGBS and fly ash. Near-term focus should be on materials with a track record in other markets such as limestone fines and calcined clays. This opportunity is also recognised in the BCA's recently published draft Built Environment Decarbonisation Technology Roadmap, where four of the priority technology solutions are associated with reducing binder content and displacing OPC in concrete. (40)

Near-Term Opportunities for Reducing the Embodied Carbon of Concrete in Singapore are:

Advancing novel concretes

Commercialised lower carbon concrete materials cannot get Singapore, or any other nation, the whole way to net zero. It is imperative that near-zero and net zero embodied carbon concrete technologies are financially supported and fostered by the industry. (34) The regulatory framework needs to be developed in step with these technical advances, including technical standards and construction regulations. Guidance for innovative concrete solution providers on the technical specifications required in Singapore, published by the BCA earlier this year, supports these efforts. (41)

For this, Singapore could draw on its previous experience championing recycled aggregates, including at a national policy level. Singapore is now widely recognised as a global leader in circular construction practices and as a frontrunner in construction and demolition waste management. (42)

Incorporating lower carbon concrete requirements into private and public procurement as well as sustainability-linked finance instruments

Under the Building Control (Environmental Sustainability) Regulations, new buildings and existing buildings undergoing major retrofitting are required to meet minimum environmental sustainability standards. This includes recognition of sustainable construction measures, such as the use of CEM II to V types of cementitious materials and certified sustainable products like those with SGBP certification. This creates an established mechanism through which increasingly ambitious targets for embodied carbon—both for whole buildings and individual materials—could be introduced.

Additionally, Singapore has introduced environmental sustainability-related considerations as part of government construction tender evaluation for projects with estimated procurement value above $50 million. This approach provides firms with opportunities to differentiate themselves. Those who have demonstrated sustainable practices stand higher chances of being awarded projects. Building on these provisions could help create clear signals on the importance of low-carbon construction and provide avenues for firms to differentiate themselves in this area.

Existing sustainability-linked finance instruments are a ready vehicle, and can be leveraged further, to incorporate embodied carbon requirements into the lending and investment criteria for those along the concrete value chain.

Case Study

Linking Supply Chain Finance with Susta Performance in Construction: DBS X San Sustainability Linked Supplier Payment S

Reducing embodied carbon in the built environment requires coordinated action beyond the developer level. While corporate sustainability-linked loans and green bonds support top-level commitments, the majority of construction emissions and operational practices sit within fragmented contractor and supplier networks. Working capital access, capability gaps and uneven ESG maturity often limit the pace of change across this upstream ecosystem.

Against this backdrop, DBS Bank (Hong Kong) and Sanfield (Management) Limited launched a sustainability-linked Supplier Payment Services (SPS) programme — described as the first of its kind in Hong Kong's construction industry. The programme links supplier payment services with sustainability-related performance targets, supporting ESG considerations within supply chain financing. (43)

Under the structure, Sanfield may recommend eligible suppliers and subcontractors for early payment through DBS. Financing terms are linked to suppliers' performance against sustainability-related indicators established by Sanfield. These include ESG disclosure, safety performance, waste reduction, adoption of innovative technologies and carbon emissions reduction. Suppliers demonstrating progress may become eligible for early payment under the program, strengthening cash flow certainty.

While the programme is not explicitly framed as an embodied carbon facility, its design is relevant to value-chain transition because construction emissions are influenced by upstream practices across subcontractors and suppliers. By linking working capital access to sustainability-related performance indicators, the SPS mechanism ties financing outcomes to progress against these targets.

From a Climate Group or broader built environment decarbonisation perspective, this model illustrates an evolution in sustainable finance: moving beyond project-level certification and corporate-level commitments toward mechanisms that encourage sustainability-related performance across supplier ecosystems. In sectors such as construction — where SMEs play a central role — access to timely payment and competitive financing terms can be a mechanism to encourage progress while supporting liquidity needs.

The DBS–Sanfield collaboration demonstrates how financial institutions and construction management firms can align supply chain financing with sustainability objectives. As the industry increasingly focuses on embodied carbon reduction and value-chain transparency, mechanisms that link financing to sustainability-related performance may

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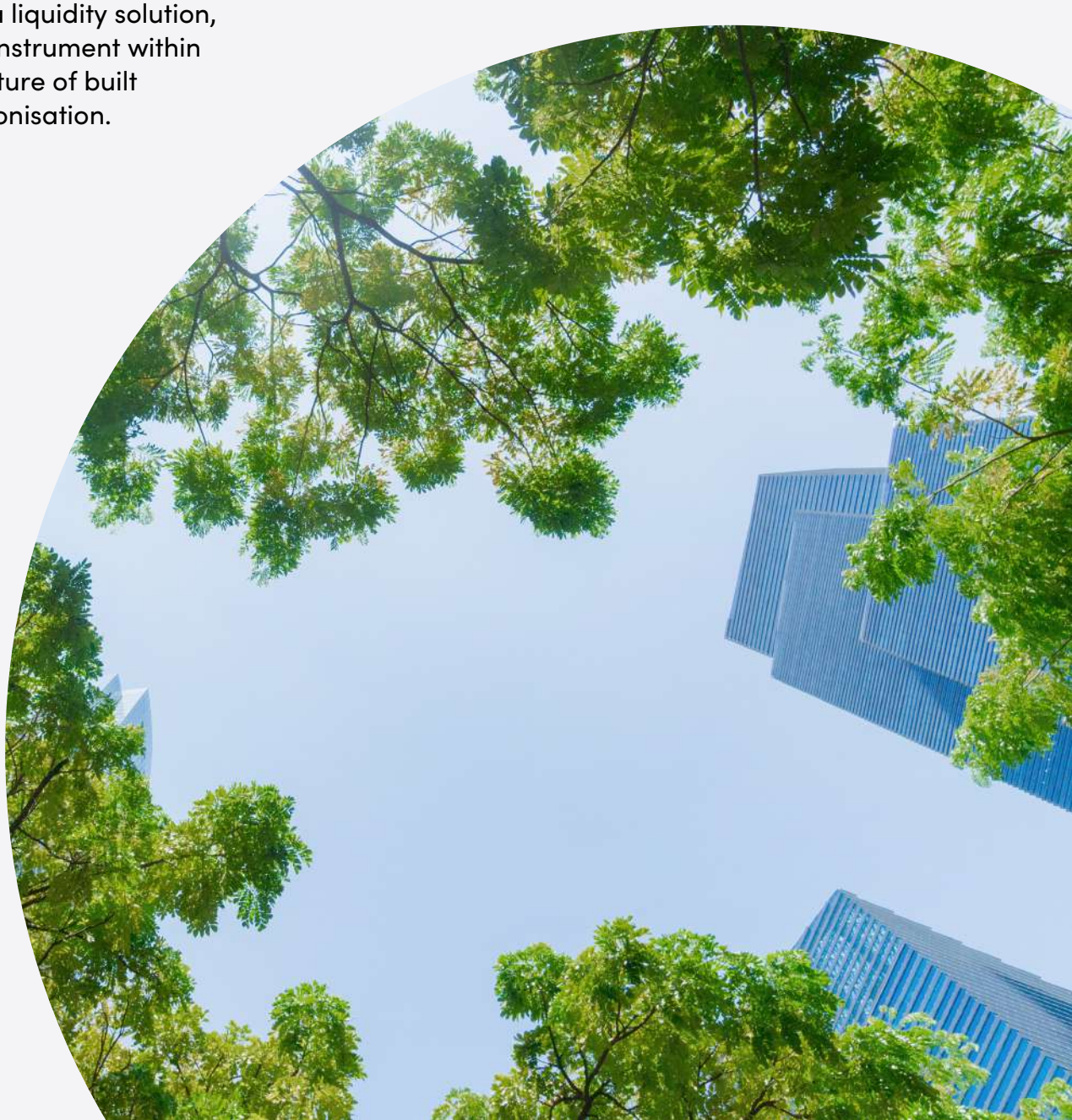
complement tools such as green building standards and supplier engagement programmes.

In this sense, supply chain finance can serve not merely as a liquidity solution, but as a reinforcing instrument within the broader architecture of built environment decarbonisation.

This case study is based on public sources and disclosures.



Recommendations for Industry & Policy Makers

5.0

01 Use the Singapore Market Benchmark

Use the Singapore Market Benchmark, a common view of Singapore's embodied carbon of concrete, to engage your stakeholders on the opportunity to lower concrete's embodied carbon.

Concrete Demand Side:

Use it to evaluate current embodied carbon performance, spot opportunities to reduce embodied carbon, and use concrete specification and procurement processes to shift demand towards lower carbon materials.

Concrete Suppliers:

Use it to build a shared understanding of what's possible, pinpoint where improvement is needed and ensure products' ongoing competitiveness on embodied carbon.

Regulators and Certifiers:

Use it as a baseline reference for developing a net zero concrete roadmap and for tracking progress against that roadmap.

Financiers and Investors:

Use it to assess the climate impact of investment opportunities in lower carbon concrete innovations and solutions.

02 Choose Lower Embodied Carbon of Concrete Today

Supply, procure, specify, and introduce financial incentives now for concrete with a better-than-average carbon impact (i.e. SGBP Certification Scheme's 3 Ticks or better).

Concrete Demand Side:

Avoid concrete based on 100% CEM I and, where possible, procure or specify SGBP Certification Scheme's 3 Ticks or better, signalling a clear preference for concrete that outperforms the market average. This helps significantly reduce upfront carbon emissions associated with construction, supporting broader decarbonisation and sustainability targets.

Concrete Suppliers:

Proactively educate customers on available lower carbon concrete products. Address hesitancy to scale the specification and use of lower carbon concretes by improving transparency on their performance and pricing.

Regulators and Certifiers:

Incorporate lower embodied carbon values in the SGBP Certification Scheme to better capture lowest carbon materials currently on the market and signal decarbonisation imperative more broadly. Encourage market-led innovation by weighting the scoring in the Green Mark Certification Scheme further in favour of lower carbon concretes and strongly incentivise pioneering efforts from early adopters and innovators that push the boundaries of low-carbon construction. Increase transparency on pricing by introducing index for a representative lower carbon product, potentially replacing the current index maintained for CEM I based products.

Financiers and Investors:

Incentivise the supply and use of better-than-average, lower carbon concrete at all stages of the concrete value chain. Include SGBP Certification Scheme's 3 Ticks or better in the criteria of sustainability-linked finance instruments for organisations where ready-mix concrete is a significant proportion of their carbon footprint.

03 Grow and Diversify the Supply and Use of Lower Carbon Concrete Constituents

Accelerate trials for lower carbon concrete chemistries in Singapore and incentivise robust Southeast Asian supply chains for alternatives to the constrained GGBS and fly ash. Prioritise diversification into proven alternatives such as limestone fines and calcined clay, while piloting emerging solutions to expand future options.

Concrete Demand Side:

Develop trials for lower carbon concrete with suppliers and academic researchers via structural projects and share learnings across the value chain. Where possible, use lower carbon concrete and signal strong demand by setting time-bound decarbonisation targets, e.g. ConcreteZero's commitment to using 50% low emission concrete by 2030. (44)

Concrete Suppliers:

Identify opportunities to grow and diversify lower carbon concrete alternatives in Singapore, especially proven materials such as limestone fines and calcined clays. Strengthen Southeast Asian supply chains through regional partnerships and reduce reliance on constrained materials.

Regulators and Certifiers:

Expedite and clarify approval processes for introducing new concrete products to the market. Facilitate collaboration between suppliers, users, and researchers, including through targeted innovation funding to test and demonstrate solutions and accelerate adoption at scale.

Financiers and Investors:

Develop and introduce dedicated finance products to encourage increased supply and use of concrete with lower carbon concrete constituents, drawing on established green finance frameworks.

04 Improve the Measurement for the Embodied Carbon of Concrete

Address the availability, consistency and granularity of the embodied carbon of concrete data to inform decision making, support collaboration, and unlock action along the whole value chain.

Concrete Demand Side:

Adopt the ConcreteZero approach to embodied carbon data management, collecting concrete mix design data and supply chain-specific data to distinguish reductions achieved through supply chain factors from those related to concrete mix selection and design.

Concrete Suppliers:

Prepare for a market expectation of mix- or product-specific, detailed and auditable embodied carbon data for concrete. This is critical for providing the other identified stakeholders with the information they need to decide and act on interventions to reduce embodied carbon of concrete.

Regulators and Certifiers:

Improve the consistency of the environmental data on Singaporean concrete, potentially by requiring specific PCR are complied with for EPDs and by providing a database of emission factors market participants can use to support comparability across mix design-based calculations.

Financiers and Investors:

Signal the growing importance of embodied carbon data for built environment financing and risk management by requesting it in trade financing instruments.

05 Activate Singapore's Concrete Community and Their Participation Domestic and International Embodi Carbon of Concrete Reduction Effor

Establish platforms to foster collaboration, direct lower carbon concrete interventions, monitor progress through maintenance of the Singapore Market Benchmark, and act as a conduit for the exchange of international best practice within Singapore.

Concrete Demand Side:

Join and leverage networks including professional member bodies and corporate initiatives (e.g. ConcreteZero and National Green Building Councils) to support collective action, knowledge sharing, and international collaboration focused on tackling embodied carbon of concrete.

Concrete Suppliers:

Join the cross-value chain initiative to further concrete decarbonisation in Singapore and establish systems to counteract commercial sensitivities in the maintenance of the market benchmark. Directly, or through an industry body such as the Singapore Concrete Institute (SCI) and American Concrete Institute (ACI), engage with the wider cement and concrete production sector, especially in the Southeast Asian region, to secure material supply to meet higher demand for lower carbon concrete in Singapore.

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Regulators and Certifiers:

Develop Singapore as a regional leader in low-carbon concrete. Formalise intent, expectations and ongoing mechanisms to support organisations and individuals to further concrete decarbonisation across Singapore. Also align, or support interoperability of local embodied carbon of concrete measurement frameworks i.e. SGBC's Singapore Green Building Product (SGBP) Certification Scheme, with international industry-led schemes, e.g. the GCCA Global Rating System.

Financiers and Investors:

Maintain Singapore's leadership on the topic of embodied carbon through exploring global networks such as PCAF, GRESB and IIGCC, where transition finance and financed emissions accounting best practices are being evolved.

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Appendix A:
Global Examples of the Embodied Carbon of Concrete Market Benchm

While this report presents the first market benchmark for the embodied carb
concrete in Singapore, the project team has drawn from the knowledge of, a
experience in developing similar outputs in other markets. The next pages ou
examples of existing market benchmarks in Australia and the UK while also r
there are likely further examples globally not reviewed here.

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UK

Name	Link to publication	First release
LCCG Market Benchmark	The UK Lower Carbon Concrete Group - LCCG Market Benchmark. (18) (19)	May 2022 (22)

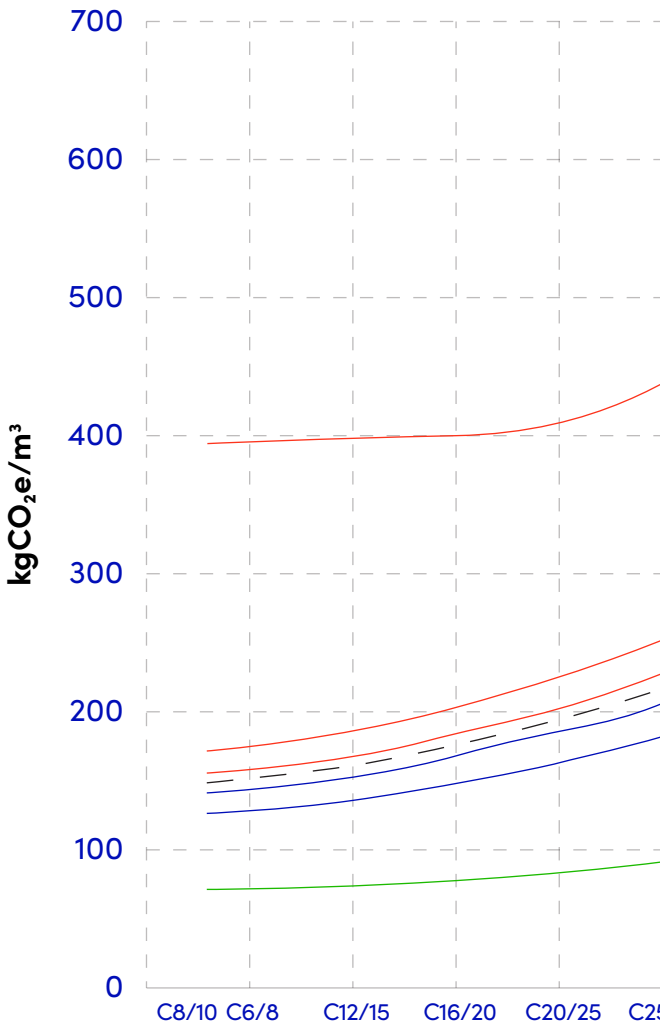
Methodology for collecting the data behind the market benchmark, including any changes over time	Methodology for representing
Current process: ○ The MPA gathers data from suppliers on concrete poured in the previous year. ○ Data is vetted by MPA for compliance, aggregated, anonymised and shared as a volume weighted statistical analysis with the LCCG. ○ LCCG uses the data to define the market benchmark. ○ (Additional data from ConcreteZero is used to refine the upper and lower boundaries of the chart) **Year 1 process:** ○ Initial benchmark based on carbon intensity information of recent UK mixes provided by five contractors and consultants.	UK Market Benchmark presente system that defines carbon clas numbered banding system (fro carbon concrete on the market highest) to differentiate from th static rating systems such as the System. Concrete with carbon l considered market-beating.

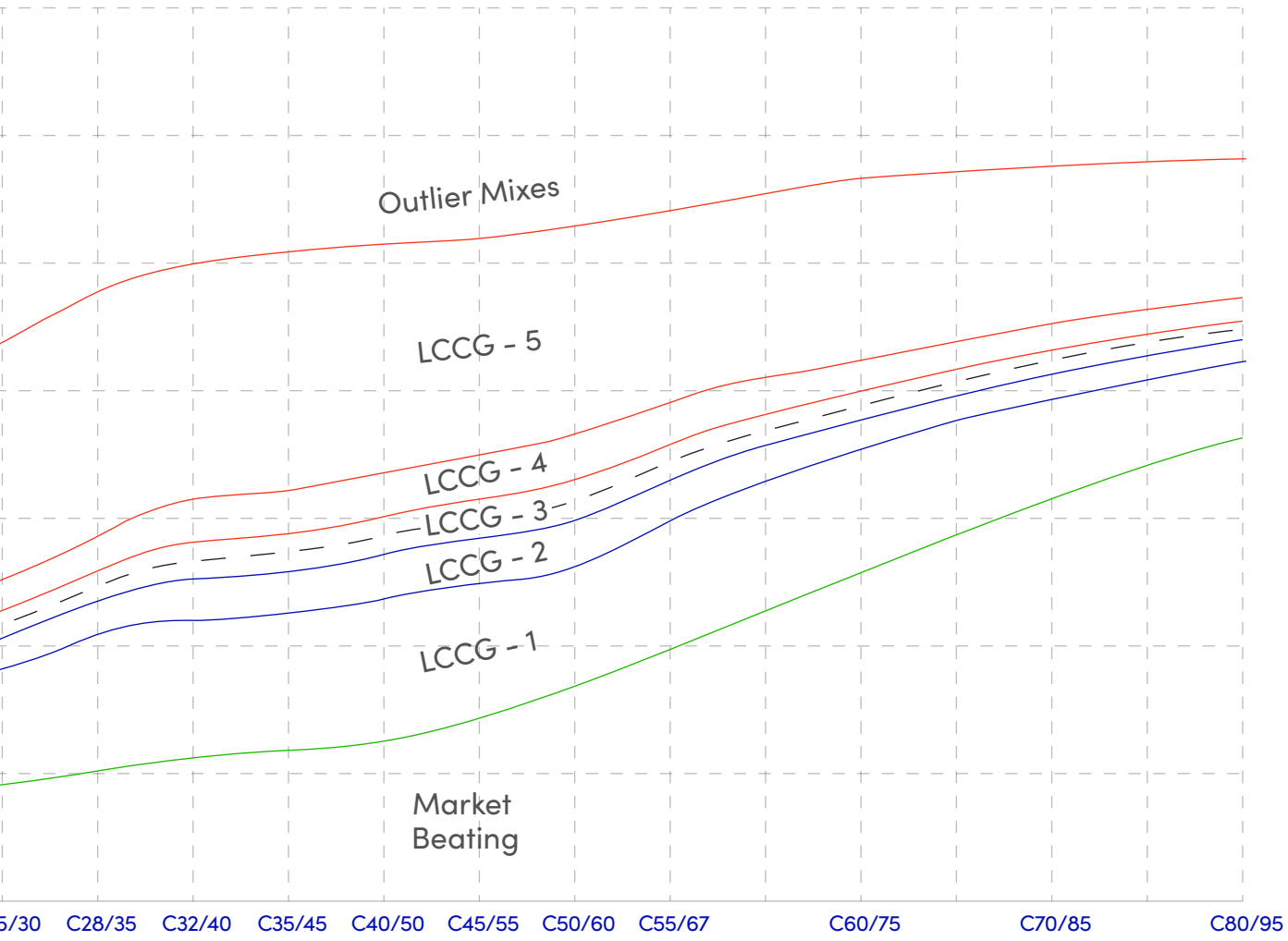
Update schedule	Governance, including any changes over time	Boundary definition, including any changes over time
Updated annually	The UK Lower Carbon Concrete Group (LCCG) produces the UK Market Benchmark. Data is gathered and anonymised by the Mineral Products Association (MPA), the trade association representing most UK concrete producers.	Normal weight, ready-mix concrete produced in the UK

the market benchmark	Outcome of approach
ed as a dynamic banding sses. Recent versions use a m LCCG-1.1 for the lowest to the LCCG-5.5 for the e lettered bands used in e GCCA Global Rating ower than LCCG-1.1 is	Provides a dynamic rating system that can be used directly for specification or assessment of concrete or to inform users on the availability of concrete within the bands of static rating systems. Supported the development of the ConcreteZero Low Embodied Carbon Concrete Threshold, allowing the industry to set intermediary targets on the way to net zero by 2050.

UK

Image of the latest market benchmark




2025
Outlier Mixes
LCCG - 5
LCCG - 4
LCCG - 3
LCCG - 2
LCCG - 1
Market Beating
5/30
C28/35
C32/40
C35/45
C40/50
C45/55
C50/60
C55/67
C60/75
C70/85
C80/95
Specified strength class

Australia

Name	Link to publication	First release
MECLA Embodied Carbon Classification Scheme for Australian Concrete	MECLA's Guide to Low-Carbon Concrete (20) (21)	April 2024

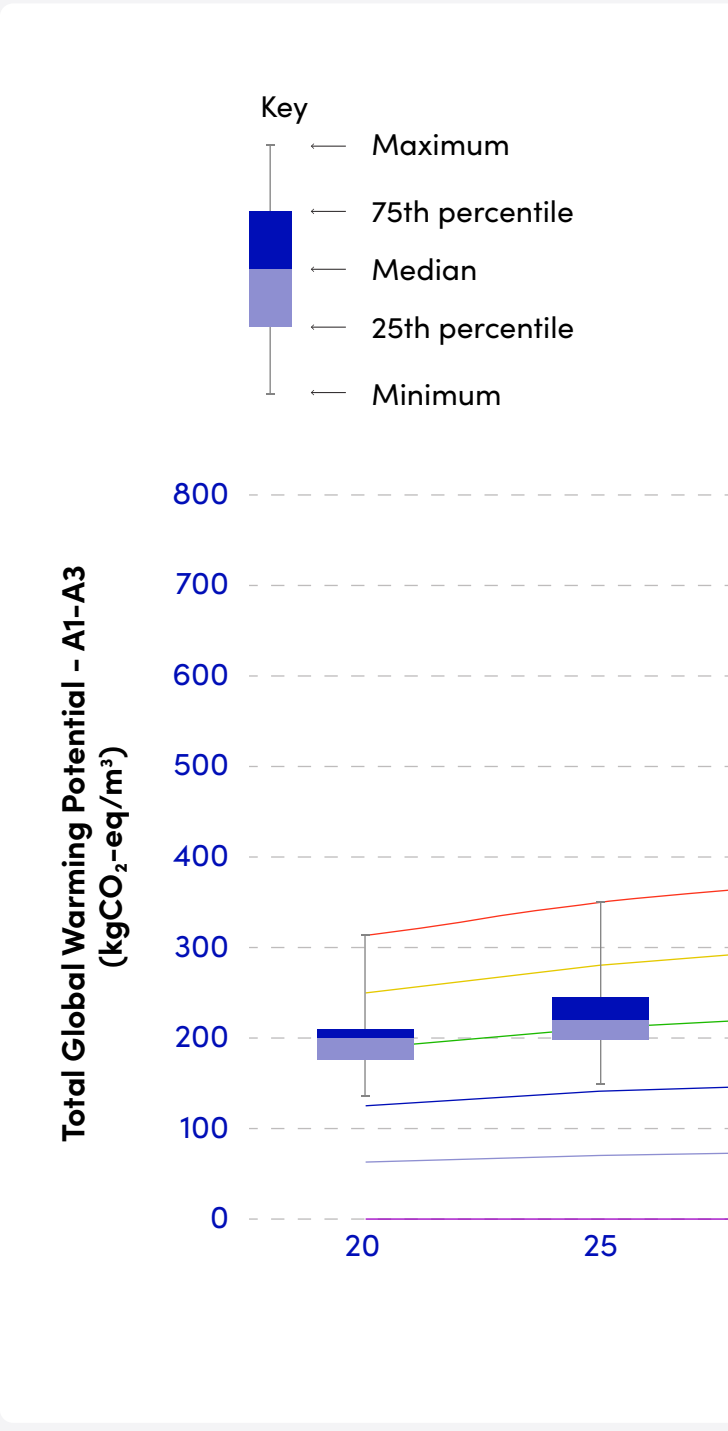
Methodology for collecting the data behind the market benchmark, including any changes over time	Methodology for representing
Version 1: ○ Uses Australian market-based EPD data sourced from open-access EC3 tool and cleaned for errors. **Version 2:** ○ To use live EPD data provided by Low Carbon Materials Hub (LCMH) and to be presented alongside dynamic and static rating systems.	**Version 1:** ○ Presented box and whisker p system based on the statistic available on the market. Stat available as well as for the w **Version 2:** ○ Expected to present box and the statistical distribution of E market along with options fo classification systems.

Update schedule	Governance, including any changes over time	Boundary definition, including any changes over time
No specific update schedule. Version 2 to be issued shortly with plans for version 3 also in place.	The Embodied Carbon Classification Scheme for Australian Concrete is produced by the Materials Embodied Carbon Leaders' Alliance (MECLA)).	Concrete available for production in Australia including ready-mix and precast

the market benchmark	Outcome of approach
lots and a lettered rating al distribution of EPDs e level data views hole of Australia. whisker plots based on EPDs available on the r overlaying onto different	Enables users to understand the current availability of concrete on the market within the static rating bands. Dividing information down by state provides local information of availability.

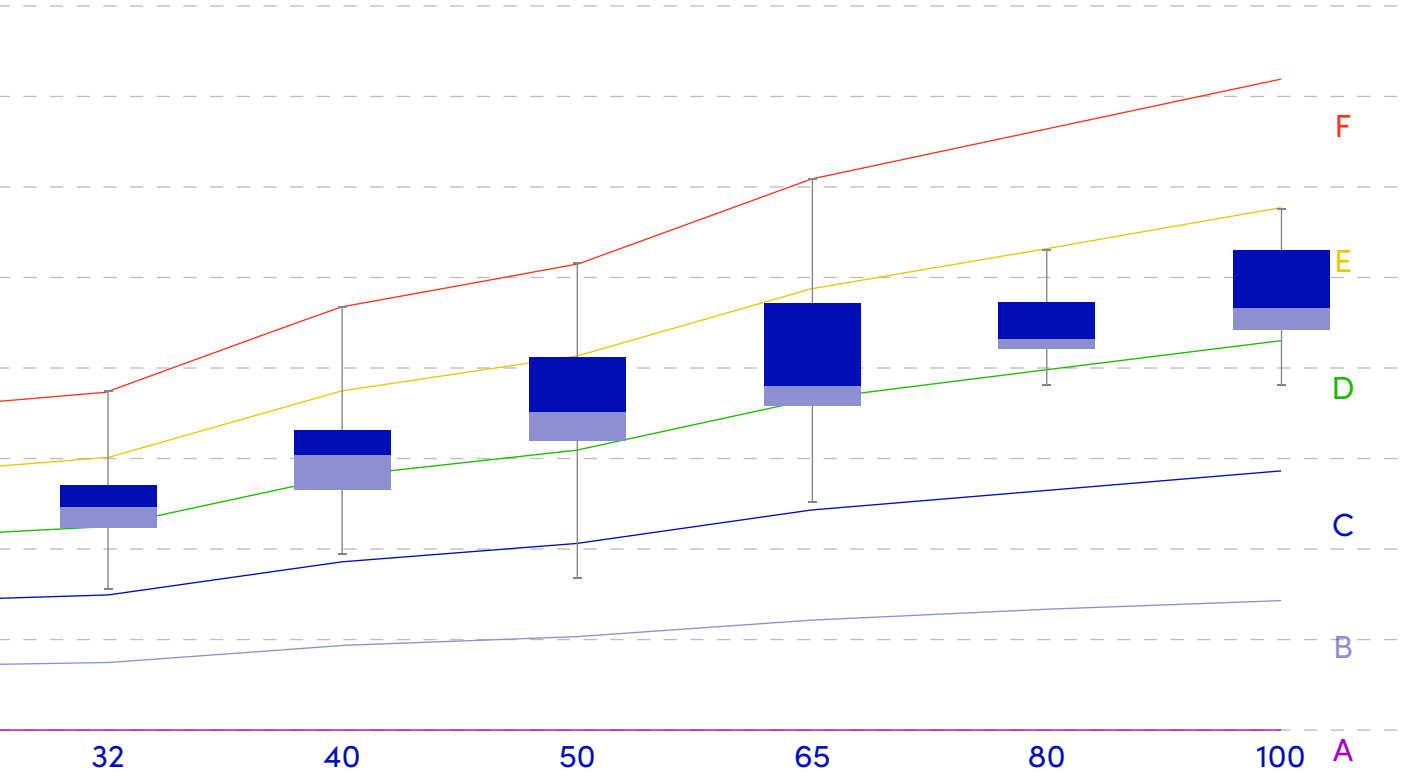
Australia

Image of the market benchmark



Note: This is a chart of Version 1 of the MECLA Embodied
Classification Scheme for Australian Concrete. Version 2
in December 2025 and can be accessed directly from th

Based on Australian EPD data
from between 2019 and 2023



Specified compressive design strength of concrete (MPa)

d Carbon
2 was released
heir website.

Appendix B:
General Framework for Developing a Market Ben

This report for the Singapore concrete market demonstrates multiple benefi in establishing a national concrete market benchmark as part of the drive to decarbonise the concrete industry. To extend the benefit of the work carried out in Singapore to other markets, Appendix B outlines steps necessary in establishing a benchmark to provide a platform for the development of furth benchmarks across the globe.

The guidance in this section is based on the experience gained in establishin current benchmarks. Although there are many commonalities in the concret industry globally, each market will have unique challenges and opportunitie As such, we would encourage anyone who is motivated to develop a concre benchmark within their own region to contact us for support.

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Initiating the Benchmark: Year 0

At the outset of establishing a benchmark, it is likely that the required concrete carbon data will be limited in nature, and where available will be calculated in different ways and available in multiple formats. There may well be no established forum for the relevant parties to convene and further barriers may well occur around commercial sensitivity and conflicting interests.

Therefore, although the output from this first stage of development is an initial market benchmark, the purpose and the work of this first year is a greater exercise of gathering the industry together to support the development of concrete carbon reporting and providing the platform for the benchmark to gain momentum and greater representation in the next year.

Although presented linearly, some of these actions are best carried out alongside each other to provide feedback loops of information to support the development of the benchmark.

Action:

Convene a core team to develop the initial benchmark:

- Ensure funding and time commitment are sufficient.
- Connect to the international experience of market benchmark development.
- Establish protocols to ensure impartiality in collecting and anonymity in handling the data.

Data analysis:

- Data analysis approaches will be dependent on the volume and quality of data supplied from the market.
- Be prepared in year 0 to be flexible in data analysis approaches to create a helpful representation of the embodied carbon of concrete on the market from a limited and imperfect data set.
- Ensure methodology and any limitations of the data is transparently reported.

Stakeholder mapping and engagement:

- Carry out an industry landscape mapping exercise to understand aspects of the concrete market, such as the stakeholders across the value chain, how much and what types of concrete are used in the market and the maturity of carbon reporting in the market.
- Establish a community of multiple stakeholders from across the concrete industry to engage with the development of the benchmark and support it to provide positive impact.
- Explore sources of concrete carbon data on which to base the first benchmark.

Data collection:

- Set the aspiration of the Market Benchmark to represent all the concrete used within the market boundary.
- Available data may be limited; therefore explore all potential data sources for carbon and concrete.
- Engage with and support those providing data to understand the basis of the data and any challenges they are facing in providing it.
- Use this opportunity to support data providers in improving the quality and volume of data available in preparation for updates to the benchmark in future years.

Report to promote action:

- Produce an industry-facing report presenting the benchmark.
- Include support from significant organisations within the market to provide backing.
- Frame the reporting of the benchmark as part of action to enable wider decarbonisation approaches within the market.
- Use the report to set the platform for future development and regular updating of the benchmark, and to establish it as a powerful decarbonisation tool in the market.

Identify the organisation(s) that can update and develop the benchmark in subsequent years:

- Depending on which organisations have initiated the market benchmark, it is worth considering who is best placed to provide updates in future years.
- Considerations for identifying the best-placed organisation(s) could include their position to handle commercially sensitive information, their independence and position of trust within the market, and their capability and funding for the role.

Consolidating the Benchmark: Years 1 to ~3

After the initial year, the focus turns to consolidating the benchmark within the market. This requires two main aspects. The first of which is to improve the quality and volume of data reported in the benchmark, and the second is to build the impact of the benchmark in reducing the embodied carbon of concrete used in the market.

Improving the Quality

Establish a standard set o criteria for data to be incl in the benchmark:

- This needs to be set at a level at which the m can respond, but also one which promotes improved carbon data reporting.
- The criteria may need to develop over seve years as carbon reporting matures.

Increase the volume of co reported in the benchmar percentage of the total co produced in the market.

- Continue to engage with existing data prov the percentage of their concrete on which t
- Expand the number of organisations repor benchmark through continued stakeholder

and Volume of Data reported:

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market

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viders to increase they report data.

ting to the engagement.

Increase the granularity and richness of data provided to the benchmark by moving towards reporting data:

- From individual concrete pours.
- For specific concrete mixes.
- Which includes additional information, such as location, element type, and performance criteria.

Develop a standardised process for data processing:

- Move towards a repeatable process on a regular cycle to embed the benchmark as part of the industry (see Figure 4 as an example).
- Establish additional quality assurance processes and build confidence with data providers and benchmark users.

Building the Impact of the Benchmark in Reduci the Embodied Carbon of Concrete:

Continue stakeholder engagement around the benefits of using the benchmark.

- Work with organisations to embed the benchmark as part of their sustainability strategies and integrate it into their project processes.

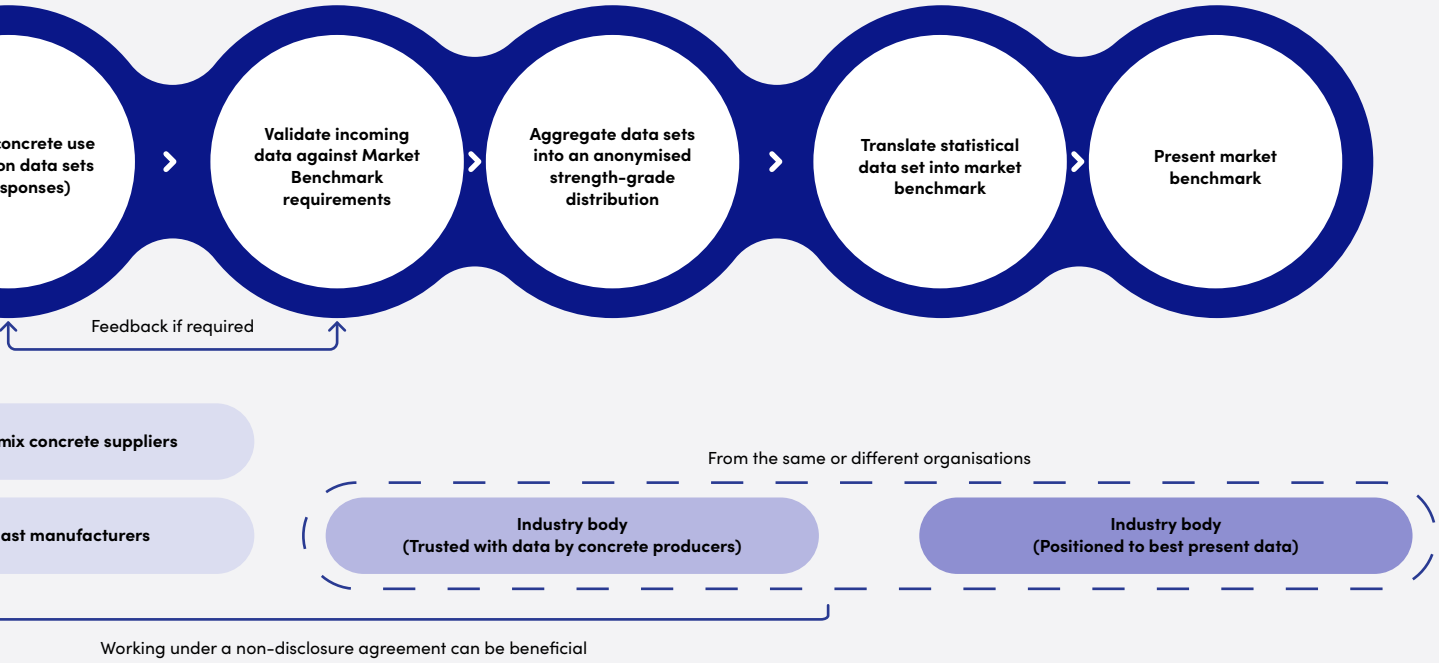
Share case studies demonstrating the impact of the benchmark. For example:

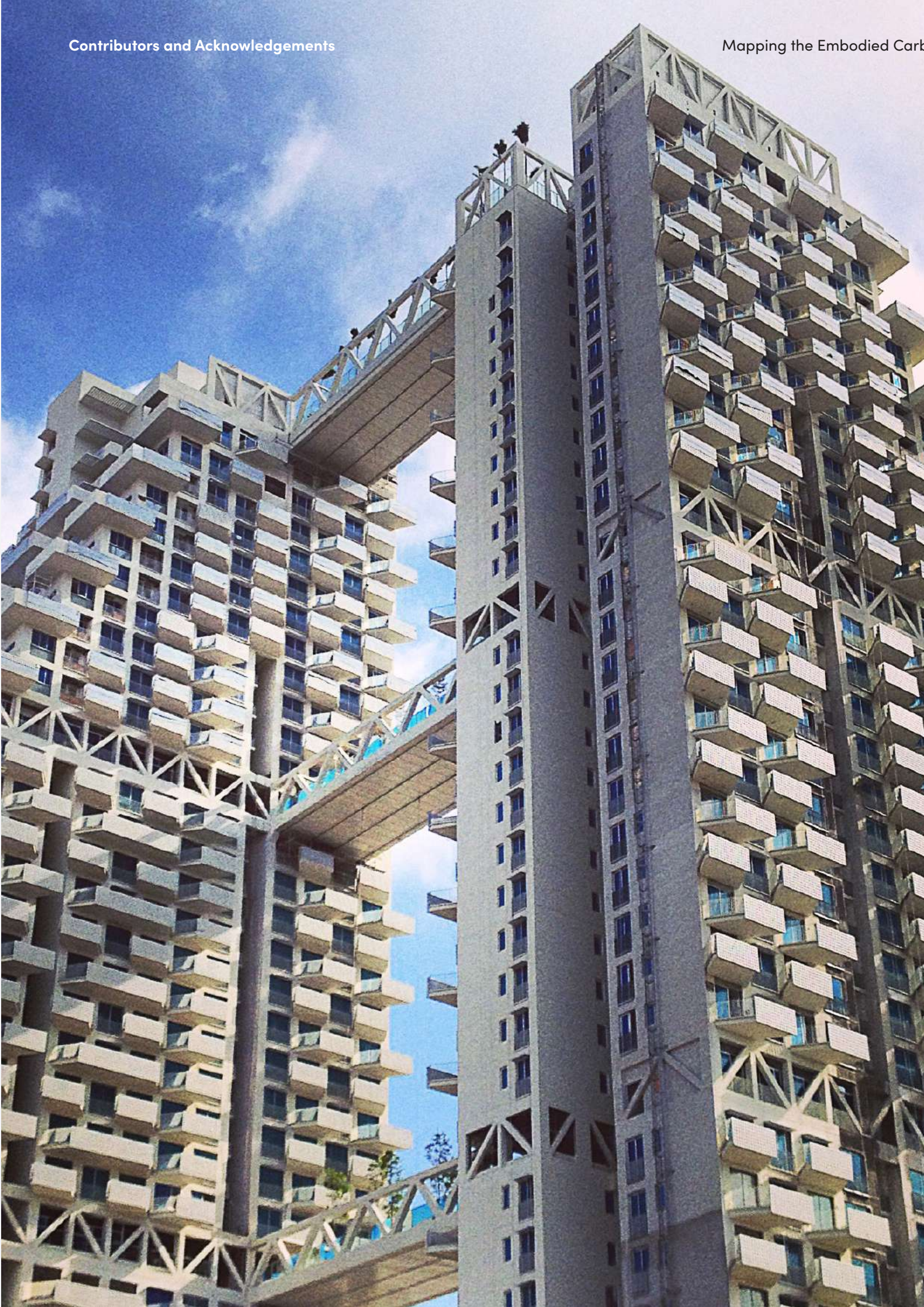
- Where organisations are using the benchmark to set strategic decarbonisation pathways.
- Where the benchmark has been used in project specifications to enable carbon reductions on projects.
- Where the benchmark has been used to demonstrate the embodied carbon of a concrete mix.

Figure 4: Propose

ng

ed generalised data collection and collation process for delivering market benchmarks for the embodied carbon of concrete





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Lead Organisations

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CapitaLand Development

Technical Advisory Group & Steering Committee

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Expedition Engineering
Global Cement and Concrete Association (GCCA)
Love Concrete Ltd
Mott MacDonald
National University of Singapore (NUS)
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Greyform Pte Ltd
Hong Leong Asia Ltd (HLA) - Building Materials Group
HPC Builders Pte Ltd
Integrated Precast Solutions
Island Concrete Pte Ltd
JTC Corporation
Keppel Ltd
KTP Consultants (Surbana Jurong)
LaSalle Investment Management
Mapletree Investment Pte Ltd
Pan-United Concrete Pte Ltd
Precast Concrete
Robin Village Development
Soilbuild Construction Group Ltd
Tiong Seng Contractors Pte Ltd
Woh Hup
World Green Building Council (WGBC)

International / Global Contributing Organisations

Climate Champions

International Renewable Energy Agency (IEA)

Institution of Structural Engineers (IStructE)

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About Climate Group

Climate Group is an international non-profit organisation on a mission to drive climate action fast. Our goal is a world of net zero carbon emissions by 2050, with greater prosperity for all. We focus on systems with the highest emissions and where our networks - both governments and businesses - have the greatest opportunity to drive change. For over twenty years, we've built large and influential networks, holding organisations accountable and turning their commitments into action. We share what we achieve together to show more organisations what they could do.

Climate Group's ConcreteZero is a global initiative that brings together pioneering organisations to create a global market for net zero concrete.

About CapitaLand Development

CapitaLand Development (CLD) is the development arm of CapitaLand Group, with a portfolio worth S$18.5 billion as at 30 September 2025. Focusing on its core markets of Singapore, China and Vietnam, CLD's well-established real estate development capabilities span across various asset classes, including integrated developments, retail, office, lodging, residential, business parks, industrial, logistics and data centres. Its strong expertise in master planning, land development and project execution has won numerous accolades including the Building and Construction Authority Quality Excellence Award and FIABCI Prix d'Excellence Award.

CLD aspires to be a developer of choice that goes beyond real estate development to enrich lives and uplift communities. It is committed to continue creating quality spaces for work, live and play in the communities in which it operates, through sustainable and innovative solutions.

As part of CapitaLand Group, CLD places sustainability at the core of what it does. As a responsible real estate company, CLD complements CapitaLand's businesses through its contributions to the environmental and social well-being of the communities where it operates, as it delivers long-term economic value to its stakeholders.

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CLIMATE GROUP
CONCRETEZERO

CapitaLand
DEVELOPMENT

The Climate Change Organisation (Climate Group) with
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CapitaLand Development Pte. Ltd. with UEN: 201109018N