KPMG

Tackling embodied carbon

within Australia's construction and infrastructure sector

October 2023

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Executive summary

As Australia and the rest of the world transition to a net zero economy, there is growing scrutiny surrounding the contribution of the infrastructure industry to global carbon reduction targets. While the focus has typically been on the operational aspects of infrastructure, the embodied carbon within an infrastructure project is also making a significant contribution to emissions.

Globally, the current embodied carbon proportion of an infrastructure asset is 22 percent of an asset's total carbon emissions, with operational emissions accounting for the remaining 78 percent.

Strategies for reducing operational emissions are being successfully implemented through a range of initiatives, including renewable energy supply, low carbon transport and construction equipment.

The focus has now turned to embodied carbon.

Efforts to understand, measure, reduce and mitigate embodied carbon have commenced and are at different stages across the globe. A more coordinated effort is required in Australia to meet the challenge of a net zero economy. In order to do this, a combination of policy and frameworks, as well as low-carbon construction methodologies will be needed to drive a comprehensive approach.

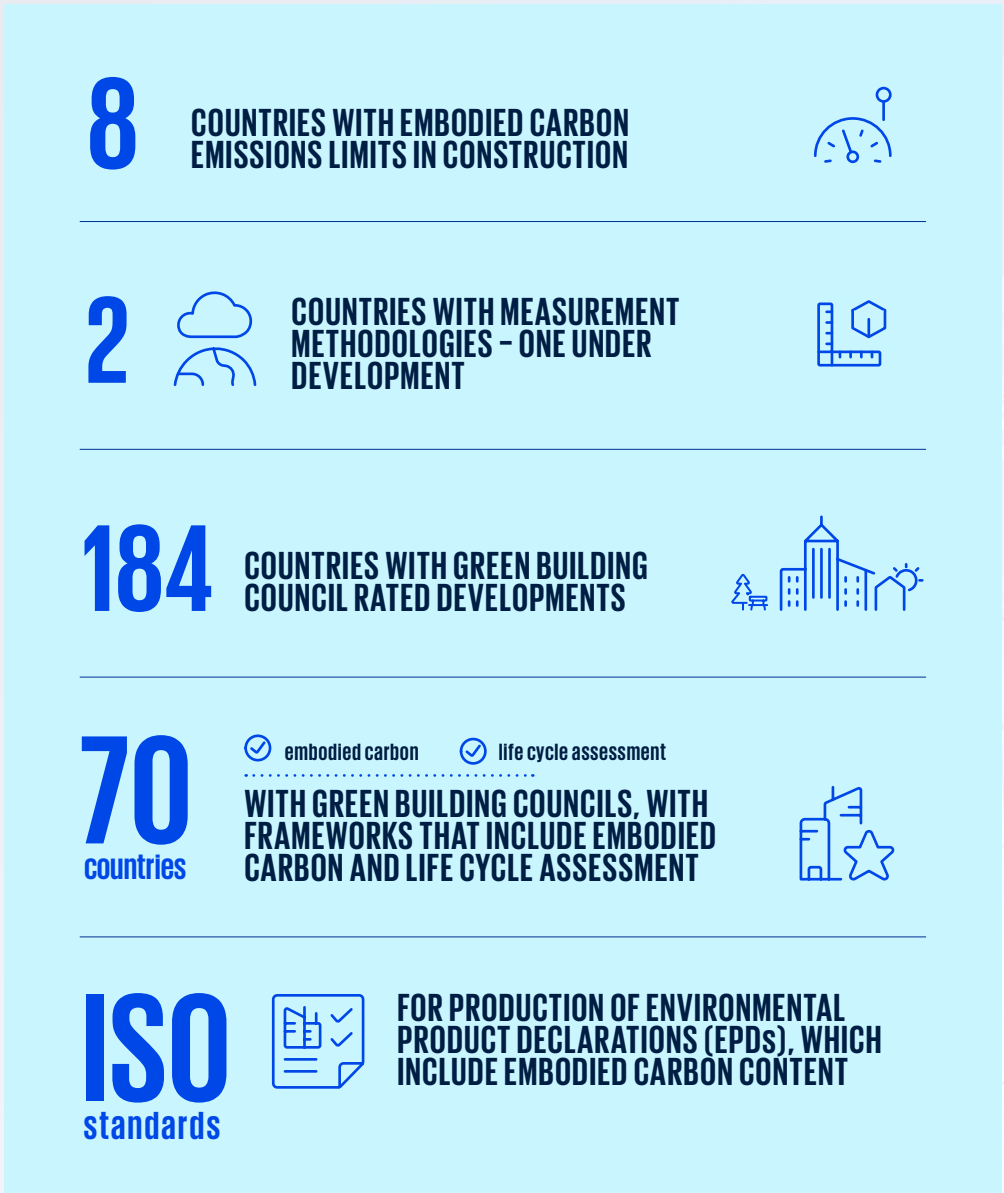
In this publication we explore:

- how the increasing need for infrastructure will see significant growth in the construction sector to 2050
- what embodied carbon is, how it is measured and why it should be managed
- initiatives globally and in Australia to address embodied carbon
- examples outlining how embodied carbon is already being addressed in infrastructure and property construction projects, using the PAS 2080 principles of build nothing, build less, build clever and build efficiently – as supported by the Green Building Council, the Infrastructure Sustainability Council, Australian Constructors Association and Consult Australia
- our views on accelerating a reduction in embodied carbon, including where in the process initiatives need to be considered and what stakeholders are involved.

Framework mapping

Currently, policy frameworks vary across the globe. One of the common factors that promote and incentivise consistency among development projects includes the presence of Green Building Councils, which have led the way in the property sector with rating tools that include embodied carbon and life cycle assessment (refer to Section 1). Processes and methodologies developed in the property construction sector can be applied in the infrastructure sector to tackle the embodied carbon challenge.

FIGURE 1. FRAMEWORKS ACROSS THE GLOBE



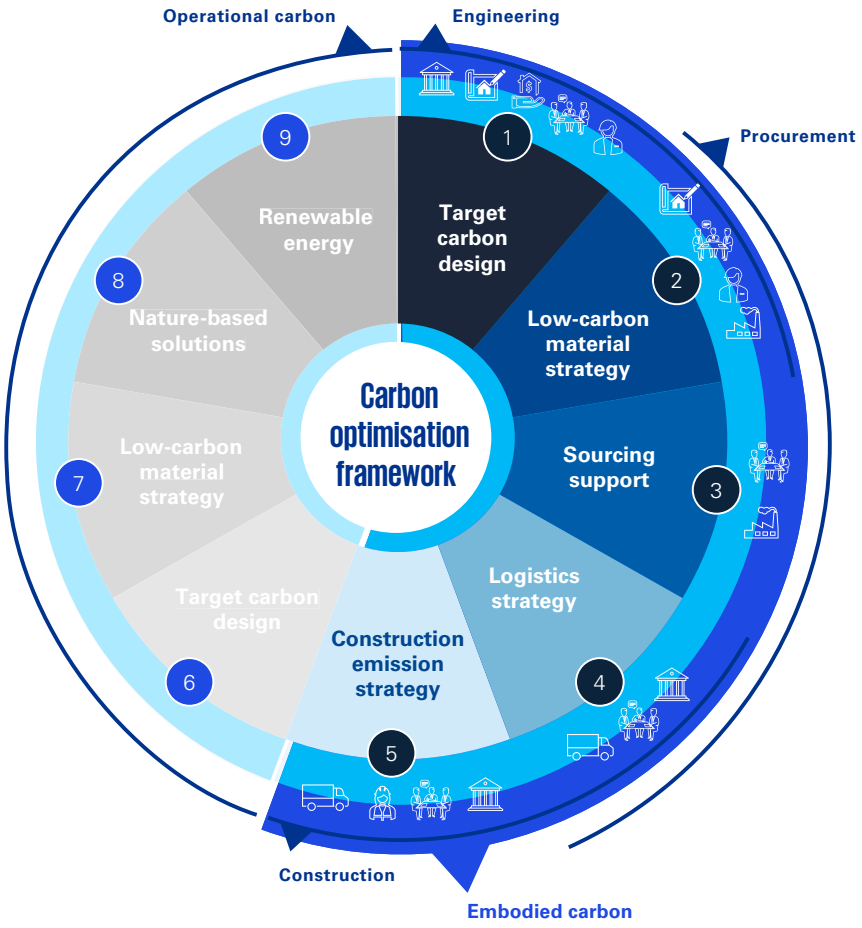
CONSTRUCTION METHODOLOGIES

To effectively address embodied carbon, the World Green Building Council (WGBC) outlines the following potential activities, in order of carbon footprint, with 'build nothing' having the smallest footprint. Established methodologies and technology are available to implement this framework.

FIGURE 2. WGBC ACTVITIES FOR TACKLING CARBON EARLY

POTENTIAL IMPACT OF TECHNOLOGY SOLUTIONS TOWARDS LOW CARBON CONSTRUCTION

At the heart of reducing embodied carbon emissions is improving productivity and efficiencies in the construction process. Each stakeholder has a role to play; from standardising measurement and targets, to collaborating on new materials and construction methodologies. This figure shows the carbon optimisation framework and the stages leading to construction. Key stakeholders that can influence embodied carbon reductions are shown at each stage.



Legends

Policymakers/ Government Bodies	Architects/ Engineers
Tenants/ Corporates	Contractors/ Subcontractors
Investors/Lenders/ Funds	Asset Owners/ Developers
Supplier/Manufacturer/ Vendors	Transporter/ Freight Forwarders

ACCELERATING THE CHANGE

A suite of additional measure will be key to further accelerating the reduction of embodied carbon, including, but not limited to:

LEADERSHIP COMMITMENT

Whilst we see strong commitment from leaders across the industry, whole of industry collaboration will support broader adoption on carbon-conscious development and commitment to build low-carbon assets which will unlock innovation and drive more value.

INCENTIVISING CONTRACTORS/ SUPPLIERS

Both owners and tenants should structure contracts that incentivise project suppliers or contractors to use low-carbon material and collaborate to achieve project carbon emissions goals.

INDUSTRY COLLABORATION

Cross collaboration is warranted between stakeholders in various dimensions. Designers or engineering firms, prevailing OEMs should collaborate with agencies that can provide software platforms to assist in the design of low-carbon assets.

EXPLORING TRANSPORT ALTERNATIVES

Modes of transport must be considered to minimise emissions from this stage of the life cycle. That may include adopting the use of electric vehicles, sourcing materials locally to minimise transport distances and choosing less carbon intensive transport methods where fuel use is currently unavoidable.

GREEN CONSTRUCTION

Using electric machinery and equipment helps reduce emissions during site construction. Currently, the usage of conventional fuel constitutes 10-15 percent of emissions from a construction project. Companies need to set a pathway to fossil fuel-free construction with a focus on renewable diesel and the electrification of construction equipment and machinery.

INTEGRATING WITH GLOBAL INITIATIVES

Backward integration with global initiatives such as green steel and green cement is required for providing green alternatives at incremental costs. Owners/designers/developers need to create substantial demand for low-carbon projects, leading to the market price correction of such material.

TECHNOLOGY

Leveraging technology such as KPMG's Asset Impact tool to allow for tracing of building materials and enable the reporting of GHG emissions, giving asset owners transparency around embodied carbon in a building or asset.

Foreword

A staggering 40 percent of the world's carbon emissions derive from the built environment, and in Australia, embodied carbon emissions are expected to increase by 65 percent by 2050.[1,2] At such scale, reducing embodied carbon is an integral lever to limit global warming. The infrastructure sector, construction industry and related key input industries like steel, cement, and aluminium have a critical role to play.

In March 2023, the Intergovernmental Panel for Climate Change (IPCC) issued a grim warning to the world in its sixth synthesis report (AR6), that there is a rapidly closing window of opportunity to secure a liveable and sustainable future for all. Limiting global temperature increase to 1.5°C will require unprecedented effort across all sectors.

The construction sector is undergoing a remarkable surge in growth, with infrastructure playing a vital role in supporting expansion across all nations for the foreseeable future. As the sector adapts to this accelerated growth, it faces significant implications for carbon emissions, including both embodied and operational carbon.

As we collectively work towards net zero, project developers and asset owners need to actively manage emissions across the entire asset life cycle, including the construction and end-of-life phases.

KPMG is ready to partner with our clients to develop and implement carbon reduction strategies.

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Partner – National Property, Construction & Logistics Lead

1 Climate Group (2023), Built Environment, https://www.theclimategroup.org/built-environment

2 CEFC (2021), Australia's opportunity to cut embodied carbon in buildings and infrastructure, https://www.cefc.com.au/media/media-release/huge-potential-australia-s-opportunity-to-cut-embodied-carbon-in-buildings-and-infrastructure

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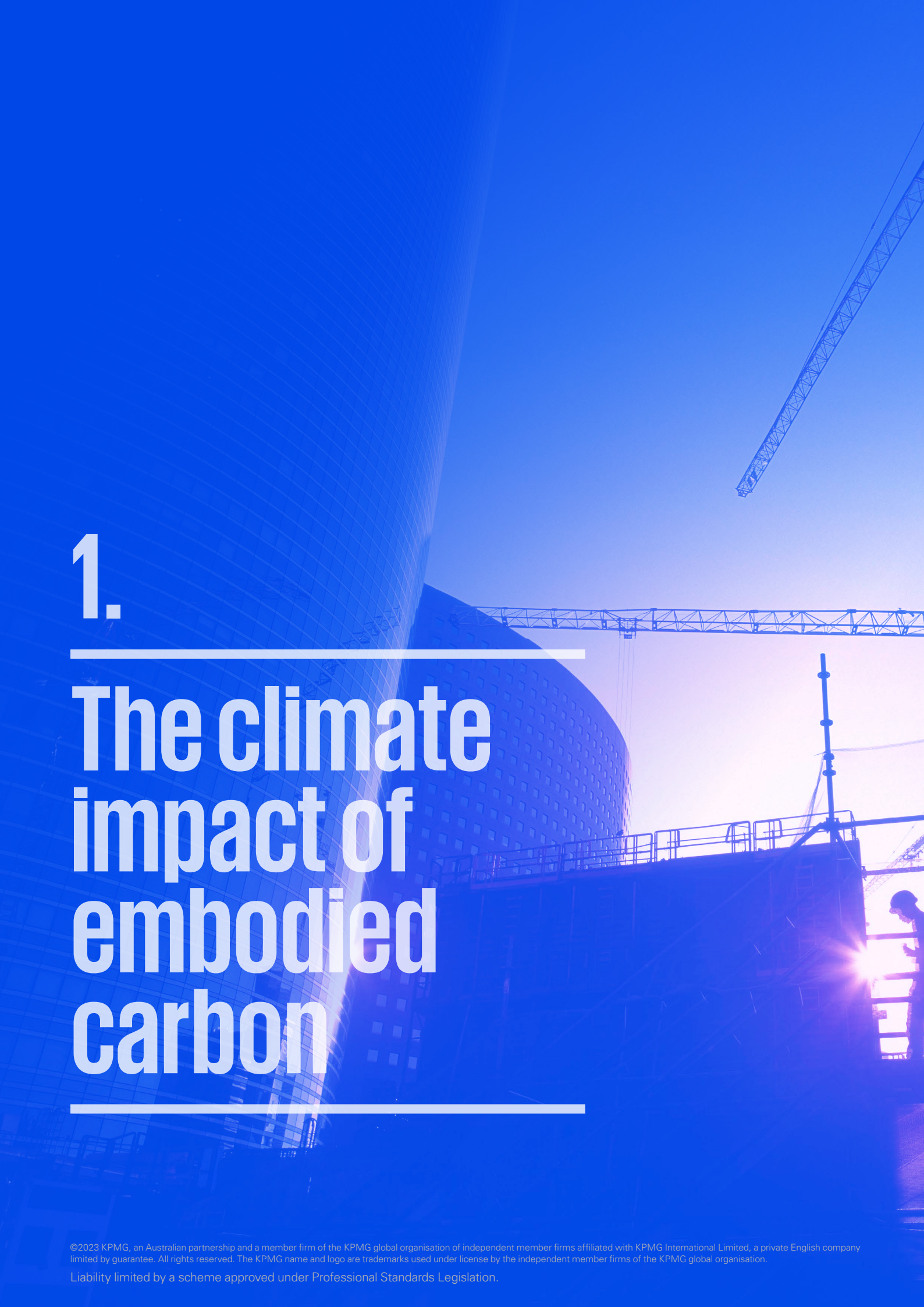


1.

The climate impact of embodied carbon

An increasing population and a need for infrastructure

The global population recently crossed the 8 billion mark and is estimated to reach approximately 9.7 billion by 2050.[3] In Australia, the population is expected to increase to just over 40 million from its current level of just over 27 million across the same period.[4]

The population growth nationwide will exert immense strain on existing infrastructure, necessitating the expansion of housing, workplaces, and infrastructure to accommodate burgeoning communities. The construction of new buildings and infrastructure will lead to heightened carbon emissions, rendering the objective of limiting global temperature increases to 1.5°C unattainable unless substantial alterations are implemented immediately.

The significant consequences of climate change on our population and infrastructure, such as flooding, droughts, and intensified heatwaves, also has considerable effects on our assets and public health and needs to be considered during development activities.

INCREASE IN INFRASTRUCTURE

The most recent Federal Budget allowed for a $120 billion rolling 10-year infrastructure pipeline.[5] Infrastructure Australia has published that currently funded projects include major road projects, rail projects, dams and pipelines, power projects and university campuses.[6] A significant number of unfunded projects are also present on the Infrastructure Priority List, with 34 proposals added to the list in 2022.[7] This represents a significant financial investment, but also significant amounts of construction in infrastructure, including civil works and construction of assets.

INCREASE IN HOUSING

Australia faces a housing shortage as demand surpasses available stock. The COVID-19 pandemic has disrupted labour and material supplies, and poor weather conditions have contributed to construction delays. Approximately 28,000 dwellings were delayed in 2022.

As well as the backlog of construction activities, projections indicate that the number of households will increase from 10.7 million in 2022 to 12.6 million in 2033. This will require the construction of 1.8 million dwellings over the course of 10 years.[8]

This is being recognised at a state level. For example, in June 2023, the Commonwealth took steps to improve access to housing by encouraging and incentivising the construction of additional homes, including more social housing.[9]

3 United Nations News. (2022). Global perspective Human stories News Brief 11 July 2022. https://news.un.org/en/audio/2022/07/1122292

4 Australian Bureau of Statistics. (2018). Population Projections, Australia 2017 (base)- 2066. https://www.abs.gov.au/statistics/people/population/population-projections-australia/latest-release

5 Budget 2023-24: Strengthening Australia's $120 billion infrastructure pipeline | Ministers for the Department of Infrastructure

6 Infrastructure Australia. (2023). Infrastructure Priority List. Search the Infrastructure Priority List | Infrastructure Australia

7 Infrastructure Australia. (2023). Infrastructure Priority List. Search the Infrastructure Priority List | Infrastructure Australia

8 National Housing Finance and Investment Corporation. (2023). State of the Nation's Housing Report 2022 -23

9 NSW Govt Media Release – The Premier, Minister for Housing, Minister for Planning and Public Spaces – June 15, 2023).

With current projections estimating a construction shortfall of 134,000 dwellings over five years and a planning system in which development approval processing times has blown out from 69 days on average in July 2021 to 116 days in March 2023, the NSW Government has realised that it needs to take proactive steps to reduce this shortfall.

As a result, the NSW Government will improve the planning system to incentivise residential housing developers that include at least 15 percent affordable housing in their plans. This one announcement alone will result in an increase in spending and investment in infrastructure and construction over the next five years.

Coupled with the commitment to a 50 percent reduction in greenhouse gas emissions by 2030, it is clear the construction industry will come under increased pressure to do more, more efficiently, and with less emissions.

INCREASE IN COMMERCIAL BUILDINGS

To support the increase in population, additional commercial buildings will be required to provide services and workplaces to the population. The Commercial Building Baseline Study 2022[10] provides statistics for the number and use of commercial buildings across Australia. Commercial buildings cover a wide range of asset types, including offices, retail assets, industrial assets, warehousing, factories, transport buildings, entertainment and recreation buildings, short term accommodation buildings (e.g. hotels and resorts), education buildings and aged care buildings. The study estimates that the floor area of commercial buildings will increase from just over 820 million m^2 in 2020 to just over 1.3 billion m^2 in 2050. This represents an increase of 58 percent in commercial building floor area, requiring a significant amount of construction activity.

Expected growth in the global construction industry by 2050[11]

The global construction industry is expected to grow from AU$15 trillion in 2022 to AU$52 trillion by 2050, with a compound annual growth rate (CAGR) of ~4 percent. It is expected to surpass the manufacturing sector in the current decade, with its estimated growth to reach around 29 percent of the global GDP. This includes the construction of new assets as well as the restoration and renovation of aged infrastructure assets that make up about 25 percent of the overall construction activity.

In Australia, the construction industry generates nearly AU$360 billion in revenue each year, 9 percent of Australia's gross domestic product (GDP).[12] Further, the industry is expected to realise a CAGR of more than 5 percent from 2023 to 2028.[13]

Overall, the strategy to reduce embodied carbon will be unique to the infrastructure landscape in each country.

10 Department of Climate Change, Energy, the Environment and Water, Commercial Building Baseline Study 2022

11 https://resources.oxfordeconomics.com/hubfs/Future%20of%20Construction_Full%20Report_FINAL.pdf

12 Infrastructure Australia. (2023). Infrastructure Priority List. Search the Infrastructure Priority List | Infrastructure Australia

13 Mordor Intelligence. (2022). The Australian Construction Market is anticipated to register a CAGR of more than 5% during 2023 – 2028 – Market Size, Share, Forecasts, and Trends Analysis Report by Mordor Intelligence.

What is embodied carbon?

Different types of carbon emissions are described using three scopes. Scope 1 emissions represent those directly emitted by an organisation where an organisation directly burns a fuel. Scope 2 emissions are direct emissions, typically relating to the purchase of electricity. Scope 3 emissions are all emissions outside the direct operational control of an organisation. Scope 3 emissions are produced in the supply and delivery of goods and services in the design, construction, maintenance, and ultimate disposal of our business operations. They are typically described as upstream or downstream emissions. Upstream emissions, being those required to manufacture or construct a product such as an asset, typically relate to the extraction and production of materials, transportation and the construction process itself. Downstream activities relate to emissions associated with use and the end of life of a product and include the use of the sold products and services, maintenance of the product and end-of-life disposal of the product.

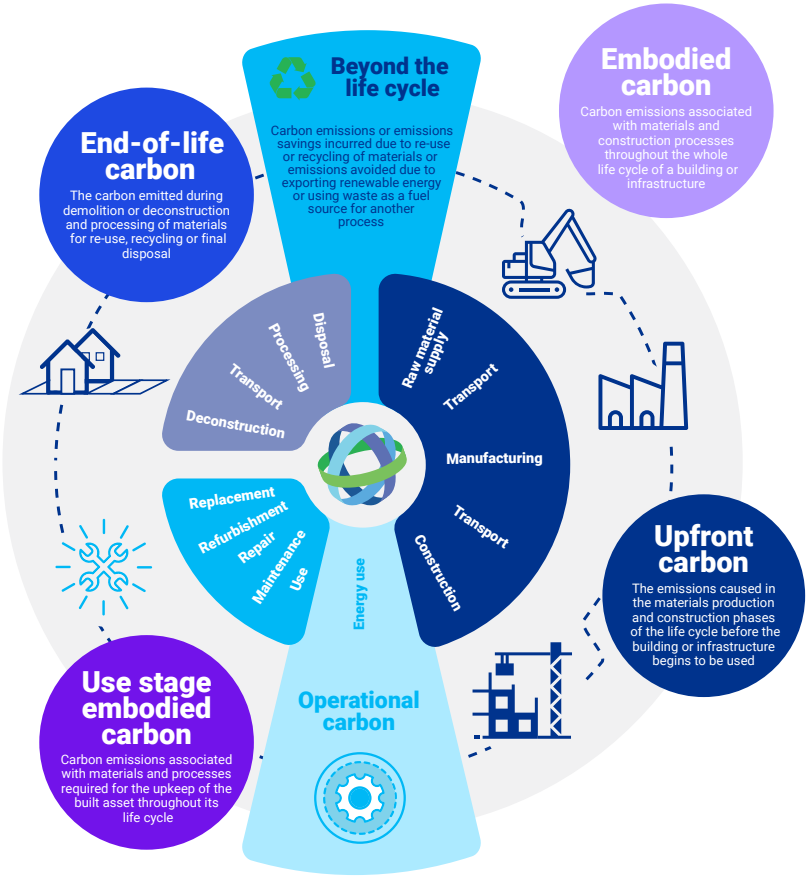
These emissions require transparency across suppliers and contractors, to account for the production and transport of goods and services delivered as part of a project.

When calculating the embodied carbon of a project, we are focused on Scope 3 emissions. Projects need to account for the entire emissions impact of the goods and services received, working collaboratively with suppliers to source and procure low-carbon materials.

The World Green Building Council defines embodied carbon as: 'Carbon emissions associated with material and construction processes throughout the whole life cycle of a building or infrastructure.'

Figure 3 illustrates the life cycle of an asset, highlighting the corresponding stages, which includes the upstream and downstream emissions of an asset. The process progresses from the manufacturing of components to the end of the asset's life. The World Green Building Council's definition of embodied carbon encompasses the four stages depicted in the diagram, excluding operational energy use.

FIGURE 3. PROJECT LIFE CYCLE HIGHLIGHTING ALL STAGES[14]



[14] World Green Building Council. (2019). Bringing Embodied Carbon Upfront. https://worldgbc.org/article/bringing-embodied-carbon-upfront/

How do you measure embodied carbon?

WHAT IS A LIFE CYCLE ASSESSMENT (LCA)?

A life cycle assessment (LCA) is a systematic analysis of potential environmental impacts of products, process, or services throughout their complete life cycle.[15]

The inclusion of LCA in Green Star rating tools encourages construction and building project teams to conduct comprehensive assessments throughout a project's lifespan, showcasing better performance in various impact categories while minimising the negative trade-offs. The LCA also acts as a credit which can be used to enhance both demand and accessibility of life cycle data, while also strengthening the industry's ability to conduct project comparisons based on life cycle assessments.

The LCA initiatives are designed to evolve and become more comprehensive over time, influenced by data obtained from Green Star Projects and major changes from consultation with industry partnerships.[16]

ENVIRONMENTAL PRODUCT DECLARATION (EPD)

The current standard method of measuring embodied carbon in products is using Environmental Product Declarations (EPDs) – declarations of the ecological impacts of a specific product over its lifetime. These are defined in the International Standard ISO 14025 and called a Type III declaration. The aim of the declaration is to 'qualify environmental information on the life cycle of a product to enable comparisons between products fulfilling the same function'. The EPD methodology has been sourced from the Life Cycle Assessment tool from the ISO 14040 series. This includes defining the product, undertaking a life cycle assessment study, creating the EPD and having it verified and published.

To aid in consistency in EPDs, Product Category Rules provide guidance on life cycle scope and methodology for similar products in the same category. This allows comparison of products of the same category to inform consumers of the impact of using different products.

For example, companies manufacturing reinforcing bar and mesh, such as the Australian Reinforcing Company (ARC) and Infrabuild, have produced independently verified EPDs for these products, providing details of the materials' impacts against consistent categories across all stages of the product life cycle, allowing consumers to make informed procurement choices. Global Warming Potential (GWP) is a key indicator relevant to embodied carbon in these EPDs and provides the potential of greenhouse gases – such as carbon dioxide – to increase absorption of heat reaching Earth's atmosphere, intensifying the natural greenhouse effect. This measure, provided in kg CO_2 equivalent, indicates the embodied carbon contribution per tonne of reinforcing if the product was to be incorporated into a project.[17, 18]

While efforts have been made to ensure some consistency, there is currently no global harmonisation of Product Category Rules and EPDs, with different regions having different standards.

One limiting factor of EPDs is that the International Standards are relatively recent in their preparation, with ISO 14025 first published in 2000 and ISO 14040 in 1997. Any materials produced prior to this are unlikely to have an EPD or an equivalent life cycle assessment that includes embodied carbon. This means that determining the embodied carbon of older building stock is extremely difficult.

[15] Sphera. (2020). What is Lifecycle Assessment. https://sphera.com/glossary/what-is-a-life-cycle-assessment-lca/

[16] Green Building Council of Australia. (2023). Lifecycle assessment (LCA) and Environmental Product Declarations (EPD). https://new.gbca.org.au/life-cycle-assessment-lca-and-environmental-product-declarations-epd/

[17] The Australian Reinforcing Company. (2022). Environmental Product Declaration, SP-00858_ARC-Reinforcing-Bar-Mesh-EPD_2022.pdf (epd-australasia.com)

[18] InfraBuild. (2022). Environmental Product Declaration. SP-00857_Reinforcing-Bar-and-Mesh-EPD-InfraBuild-Reinforcing_2022.pdf (epd-australasia.com)

The importance of reducing embodied carbon

From 2020 to 2050, embodied carbon will be responsible for almost half of new construction emissions.[19] For example, in high-performance new buildings in Australia, embodied carbon represents 45 percent of whole-life carbon emissions.[20] Unlike operational carbon, which can be reduced over time with energy-efficient measures and renewable energy sources, embodied carbon emissions are generally locked in once the asset is built.

Currently, the world emits ~50 billion tCO_2-e of carbon emissions annually, of which, ~11 billion tCO_2-e (22 percent) comes from embodied carbon emissions from new infrastructure and building development.

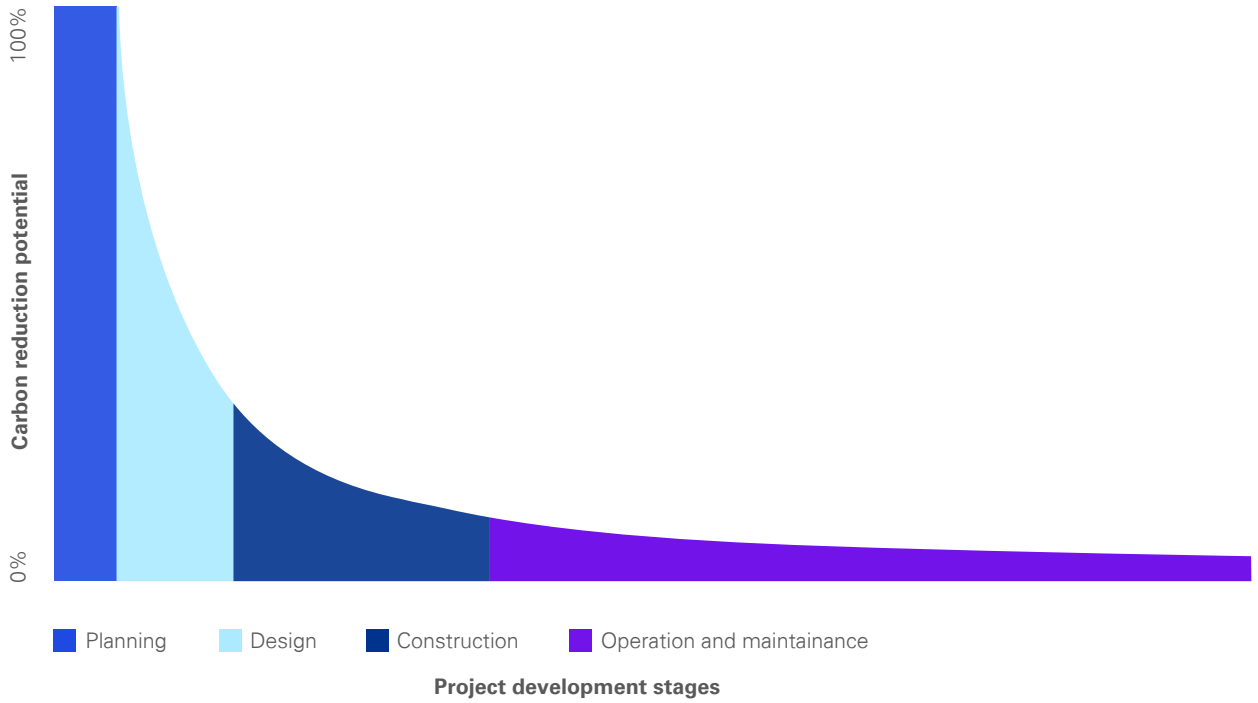
Studies have shown that embodied carbon can be reduced by between 24 percent and 46 percent through low-cost measures such as careful material selection and minimising material usage. This could equate to a reduction of up to 5 billion tCO_2-e embodied carbon emissions per year.[21]

Modern methods of construction have been developed that can be adopted to aid with this, including modular, prefabricated and precast building which focus on offsite construction, mass production and factory assembly.

The best potential to reduce embodied carbon emissions is by considering them in the planning and design phases of the project. This is the point where an organisation can determine if the asset needs to be built in the first place, what parameters require design, which can ensure the asset is not over-engineered, and what materials are required to complete the project.

Figure 4 shows the stages of a project and the phases where embodied carbon reduction is most effective. It shows that as a project progresses it becomes harder to reduce embodied carbon, and once the asset is built there is a baseline of carbon that cannot be physically reduced.

FIGURE 4. CARBON REDUCTION POTENTIAL ACROSS THE PROJECT DEVELOPMENT STAGES[22]



[19] World Green Building Council. (2019). Bringing embodied carbon upfront. https://worldgbc.org/article/bringing-embodied-carbon-upfront/

[20] Clean Energy Finance Corporation, the Green Building Council of Australia and the Infrastructure Sustainability Council. (2021). Opportunities for cutting embodied carbon

[21] Rocky Mountain Institute. (2021). Reducing embodied carbon in buildings Low-Cost, High-Value Opportunities

[22] World Green Building Council. (2019). Bringing embodied carbon upfront. https://worldgbc.org/article/bringing-embodied-carbon-upfront/

2.

Taking action on embodied carbon

Key initiatives – a global perspective

Various initiatives are being implemented worldwide to address embodied emissions. Some of these include:

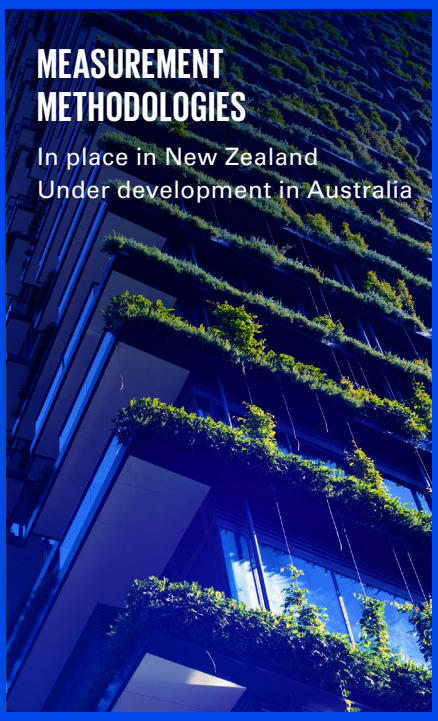
FIGURE 5. GLOBAL EMBODIED CARBON INITIATIVES

EMBODIED EMISSIONS LIMITS IN CONSTRUCTION

Currently in place in Finland, Sweden, France, the Netherlands, Switzerland, Canada and parts of the United States of America

184

Countries with Green Rated buildings



MEASUREMENT METHODOLOGIES

In place in New Zealand
Under development in Australia

PAS 2080 – MANAGING CARBON IN THE UK

Updated in 2023 to include the built environment and to integrate systems level thinking into the carbon management procedure

Number of countries with a Green Building Council

70

Regulatory and reporting frameworks as a catalyst for change

One of the best known global industry standards, the Science Based Targets initiative (SBTi) is a voluntary global program driving ambitious climate action through private companies by assisting them to create science-based reduction targets. SBTi is a partnership between the Carbon Disclosure Program (CDP), United Nations Global Compact, World Resources Institute (WRI), and World Wide Fund for Nature (WWF).

Over 4,000 private entities have set clearly defined pathways to reduce emissions in line with the goals of the Paris Agreement, including 83 organisations in Australia. In Australia, companies committed to the principles of SBTi or that have set targets include major real estate owners and managers, development companies and construction materials suppliers. The process of committing or setting targets involves a public commitment, the development of an emissions reduction plan, presentation of targets and annual tracking of performance.

Currently, SBTi is developing science-based target setting methodologies, tools, and guidance for companies in the building sector, specifically related to embodied emissions. The feedback process on the draft documents was open until July 2023. The document will now proceed to the finalisation stage.

Embodied carbon is increasingly the focus of policymakers around the world. For example, PAS 2080,[23] the standard for managing carbon in infrastructure in the UK, has been updated in 2023 expanding the scope to include the built environment and to integrate systems level thinking into the carbon management procedure. The aim of PAS 2080 is to manage carbon over the entire life cycle considering not just decarbonisation but resilience and environmental restoration. These actions have been included in the procedure to drive consistency in language and approach, reducing siloed working and consideration of assets alone. These additional lenses work to involve government, financial institutions, and the wider value chain to deliver the greatest decarbonisation impact with accuracy and consistency.

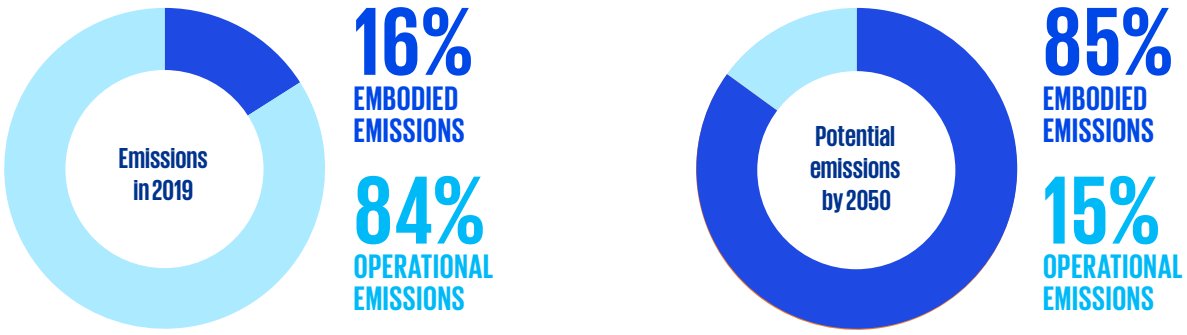
[23] Publicly available specifications

Key initiatives – an Australian perspective

Australia's building and construction industry traditionally focused on the operational energy of a building or infrastructure asset to reduce carbon emissions from the built environment. However, as the electricity grid decarbonises through increased penetration of renewable energies, the focus is shifting toward embodied emissions from construction materials. The Clean Energy Finance Corporation (CEFC) identifies great potential to cut emissions in the building sector by addressing embodied carbon from materials.

Figure 6 illustrates research undertaken by the Green Building Council of Australia (GBCA) in 2021, which estimates that embodied emissions represented 16 percent of the carbon footprint of buildings in 2019, with this ballooning to 85 percent in 2050 if no significant action is taken.

FIGURE 6. CURRENT AND FORECAST SHARE OF EMBODIED EMISSIONS IN THE TOTAL EMISSION FOOTPRINT OF BUILDINGS [24]



Industry has been pushing for movement in this area, and as a result, industry bodies and some government bodies have responded. With embodied emissions now being front and centre in the environmental agenda, leading industry and government bodies such as National Australian Built Environment Rating System (NABERS), the GBCA and the NSW Government are running working groups and developing frameworks, policy and incentives to provide standardisation and foster quick adoption of a diversity of initiatives to reduce upfront embodied emissions from construction projects. Figure 7 illustrates some of the key embodied carbon frameworks and drivers in Australia.

FIGURE 7. KEY FRAMEWORKS FOR EMBODIED CARBON EMISSIONS IN AUSTRALIA

[24] Green Building Council Australia. (2021). Embodied Carbon & Embodied Energy in Australia's Buildings.

CURRENT AUSTRALIAN POLICY FRAMEWORK

Initiatives have been put in place at a policy level to assist in addressing embodied carbon, however, measures that specifically highlight embodied carbon are limited, and there is currently an underlying assumption that decarbonisation of the entire economy will address the issue.

General climate policy

In 2022, the Australian Government passed the *Climate Change Act 2022* to strengthen their commitment to the Paris Agreement, by formally committing to net zero in 2050 and strengthening the 2030 target to a 43 percent reduction of greenhouse gas emissions compared to 2005 levels. While a significant component of the decarbonisation will come from decarbonising Australia's energy system into decarbonisation of the energy grid, increases in workforce capability, supply chain and project approvals timeframes have been recognised as significant components of ensuring a decarbonised Australia. Information from the Department of Climate Change, Energy, the Environment and Water indicates that while progress in the past has relied on lagging indicators, lead indicators will be developed to progress to net zero. This will include building resilience in supply chains and may require indicators higher up the supply chain.[25]

The government introduced the Safeguard Mechanism, to address specific industrial sectors that are high emitting. The recent amendments to the Safeguard Mechanism will regulate the top 215 emitters, which includes fossil fuel companies and big miners. In a lot of cases, these emitters are the producers of our local raw materials for construction, including steel, aluminium and cement production. This will work towards shifting construction products to a lower embodied carbon content. It is noted, however, that the Safeguard Mechanism only applies to Australian companies. There is an inherent risk in the construction industry that supply of materials will move offshore to cheaper products with a higher embodied carbon content.

The NSW Sustainable Buildings SEPP

The NSW Government has taken a key lead step in addressing embodied emissions from construction projects. In August 2022, the Sustainable Buildings State Environmental Planning Policy (SEPP) was issued to ensure new development in NSW is more sustainable and helps achieve the state's net-zero targets.

The new Sustainable Buildings SEPP is mandatory and comes into effect 1 October 2023. It contains provisions to tighten the sustainability requirements for residential development and introduce sustainability standards for non-residential development.

The Sustainable Buildings SEPP applies to any new building to be erected, or any refurbishment over $10 million located in NSW requiring planning approval after 1 October 2023.

To achieve planning approval, the new SEPP requires that new developments quantify the embodied carbon emissions attributable to the development along with a design that demonstrates other measures such as minimisation of construction and demolition waste and minimised use of onsite fossil fuels.

The new SEPP will become a key driver for the measurement and reporting of upfront embodied emissions from construction projects in NSW. Currently, the new SEPP only requires measuring and reporting of embodied emissions, with no requirement to meet any specific benchmark. However, it is anticipated that subsequent amendments will introduce benchmarks for each building class.

[25] Climate Change Authority. (2022). First Annual Progress Report

WHAT'S COMING?

With the fast-paced change of climate policy and regulation, the regulatory environment is constantly evolving. Here are some of the future policies in Australia that will shape requirements around embodied carbon.

Australian public infrastructure projects

In February 2023, Infrastructure Australia released the 'Guide to assessing greenhouse gas emissions (interim)'. The guidance has been developed in response to the *Climate Change Act 2022* and considers how Australia's greenhouse gas emissions reduction targets are considered in infrastructure proposals. Under the guidance, infrastructure proponents are required to provide information on greenhouse gas emissions as part of Infrastructure Australia's submissions. [26]

Over the next 12 months, Infrastructure Australia will consult and engage with federal, state and territory governments and key stakeholders to consider key issues to inform decision-making, including:

- business case approach to climate-related risks, emissions impacts and delivery outcomes for infrastructure
- methodologies and values for quantifying embodied emissions from infrastructure
- treatment of embodied, operational and enabling emissions in cost-benefit analysis
- considering carbon and environmental offsets as part of cost-benefit analysis
- forecasting the value and materiality of emissions over time
- deliverability considerations for abating carbon emissions and environmental impacts, in procurement and risk management frameworks for construction and operations.

The outcomes of this consultation will be formalised and embedded in the Infrastructure Australia Assessment Framework (the Assessment Framework).

STATE-BASED EXAMPLES OF PUBLIC INFRASTRUCTURE PROJECT EFFORTS

Victoria

The Victorian Government, in a quest to reduce greenhouse gas emissions toward their net zero by 2045 target, has sought advice from Infrastructure Victoria on opportunities to reduce emissions of future public infrastructure investments.

Infrastructure Victoria will provide their final advice to government by September 2023, focusing on policy and guidelines to address emissions from Victoria's infrastructure at all stages of development, from investment, design and construction to maintenance, operation and end-of-life stages.

Key areas that will be addressed include:

- opportunities to achieve reductions in both embodied and operational emissions from future public infrastructure projects
- options to update the government's investment guidelines, procurement policies and tools to reduce emissions
- incentives for private sector to adopt low-carbon materials and processes
- enablers and barriers for decarbonising infrastructure delivery
- timing and stages to implement options.

In preparing advice for the Victorian Government, Infrastructure Victoria consulted with industry and received submissions from peak industry bodies such as the GBCA, the Materials and Embodied Carbon Leaders' Alliance (MECLA), and the Australian Steel Institute. This feedback will help define targets, policies, regulations, frameworks, and standards for emissions reductions across the state's future infrastructure projects.

New South Wales

The NSW Government is developing a Protection of Environment Policy (PEP) as a regulatory mechanism to mandate the measurement and eventual reduction of embodied emissions in infrastructure. Infrastructure NSW (INSW) and the NSW Environment Protection Agency (EPA) will conduct extensive industry consultation to inform the development of the PEP in 2023.

Under the PEP, public infrastructure projects will be required to further improve design and construction to reduce carbon and prioritise the use of low-carbon recycled or remanufactured materials. The PEP intends to foster a circular economy approach in the built environment, which could deliver $773 billion in direct economic benefits across Australia over 20 years and reduce emissions by 3.6 million tonnes per year by 2040. [27]

[26] Infrastructure Australia evaluates business cases for nationally significant investment proposals for inclusion on the Infrastructure Priority List and assess proposals seeking more than $250 million in Australian Government funding.

[27] NSW Environment Protection Authority. (2023). NSW kickstarts decarbonisation and circular design in infrastructure. https://www.epa.nsw.gov.au/news/media-releases/2023/epamedia230224-nsw-kickstarts-decarbonisation-and-circular-design-in-infrastructure-nsw

This follows the release of the Decarbonising Infrastructure Delivery Discussion Paper in October 2022 by INSW. The paper provided guidance to reduce embodied emissions from public infrastructure, outlining principles and actions to promote reductions from early project development stages. In February 2023, the NSW Minister for Infrastructure, Rob Stokes, mandated the measurement of carbon costs in business cases for future NSW Government infrastructure projects. This decision aims to drive down emissions and costs, as part of the government's efforts to address climate change and transition towards a more sustainable and environmentally friendly economy.

South Australia

The South Australian Government introduced independent statutory authority Green Industries SA (GISA) in 2004, under the *Green Industries SA Act 2004*. The authority acts as an enabler and driver of change, supporting development of the circular economy through diverse collaborations and partnerships which improve productivity, resilience, resource efficiency and the environment. [28]

GISA aims to keep South Australia at the forefront of green innovation in waste management, resource recovery and the circular economy. It also aims to increase economic growth for South Australia by reducing waste and pollution, improving business practices and efficiencies and building South Australia's competitive edge and resilience. This includes building the state's capability and resilience in the area of disaster waste management. [29]

GISA is driving circular economy outcomes specifically targeting embodied carbon, including the encouragement of:

- certification schemes such as Green Star and Climate Active on new projects, placing a stronger emphasis on embodied emissions which will increase over time, increasing demand for materials and products sourced as part of a circular economy model
- the inclusion of embodied carbon into new zero-emissions targets for both government and private organisations, in relation to the development of major projects.

Further, the SA Department for Environment and Water (DEW) is currently developing a net-zero program for SA Government agencies, which is expected to start driving emission reduction initiatives related to SA Government's emissions inventory. It is expected that government projects will increasingly focus on emissions associated with capital works projects (embodied carbon) and the built environment, as well as goods and services used in buildings and facilities. [30]

INDUSTRY STANDARDS

NABERS embodied emissions framework

The National Australian Built Environment Rating System (NABERS) identified that measuring and managing embodied emissions in buildings, despite being a huge challenge, needs to be tackled if Australia is to achieve its net-zero emissions target by 2050.

Acknowledging the absence of a consistent method in Australia for measuring and reporting embodied emissions, NABERS collaborated with industry and government stakeholders to assess market feasibility and perform a technical analysis for the creation of a NABERS Embodied Emissions framework. A crucial insight from the industry was the urgent need for a national standard to measure, compare, and establish reduction targets for embodied emissions in buildings.

In response, NABERS is developing a national framework to allow building owners to set robust and measurable targets for reducing embodied emissions in buildings, enhance transparency and reporting to investors, and enable organisations to set embodied carbon targets for the buildings they will occupy. This framework will help increase the demand for low-carbon design practices and construction materials from the construction industry, creating a common language for embodied carbon emissions in Australia.

[28] Government of South Australia. (2023). Green Industries SA. https://www.greenindustries.sa.gov.au/

[29] Government of South Australia. (2023). Circular Economy SA Government Financing Authority https://www.safa.sa.gov.au/

[30] Government of South Australia. (2023). Circular economy in South Australia's built environment, https://www.greenindustries.sa.gov.au/

NABERS is currently consolidating and responding to public consultation undertaken on the following 10 key proposals to inform the development of the embodied emissions framework:

- **Proposal 1** – Only new buildings and major refurbishments will be eligible to certify.
- **Proposal 2** – Only upfront emissions will be included.
- **Proposal 3** – Emissions from demolitions are excluded.
- **Proposal 4** – Cold shell is the default building scope.
- **Proposal 5** – Only carbon emissions will be included.
- **Proposal 6** – NABERS will encourage verified product-specific emissions data and will apply conservative defaults where no emissions data is available.
- **Proposal 7** – Stored carbon and carbon-neutral products will be disclosed on NABERS Rating Certificates via a Carbon Removal Indicator. They will not be recognised within the star rating on the certificate.
- **Proposal 8** – A statistical analysis of Bill of Quantities data is the preferred approach to creating whole-of-building benchmarks.
- **Proposal 9** – Projects receive certification following practical completion with some options to review progress along the way.
- **Proposal 10** – A Roadmap for Future Development of the tool, providing visibility over proposals that are likely to increase in scope, to increase the impact of the tool over time.

The Green Star rating system

The Green Building Council of Australia (GBCA) operates the Green Star rating system, Australia's leading voluntary rating system for sustainable buildings. The Green Star rating system promotes embodied carbon reductions and rewards Green Star projects that demonstrate improvements over conventional buildings.

All new Green Star rating tools include an Upfront Embodied Emissions credit with the aim to reduce upfront carbon emissions of Green Star rated buildings. The Green Star credits currently allow two methods to demonstrate best practice in upfront embodied emissions. The first method is to use a life cycle assessment (LCA) to compare the proposed building against a reference building built to minimum code requirements. Improvements demonstrated over the reference building determine the number of points achieved under the credit.

The second method allowed in Green Star is to complete the GBCA's upfront carbon emissions calculator which considers environmental footprint of materials from raw extraction, transportation and manufacturing.

The GBCA and NABERS are collaborating on developing an aligned method for calculating upfront carbon emissions reductions against a fixed benchmark, expected to be released in late 2023. The GBCA will amend the Green Star credits to allow fixed benchmarks as an acceptable method. Regardless, an approach against a reference building will continue to be accepted under certain circumstances.

Infrastructure Sustainability Council and the IS Rating Scheme

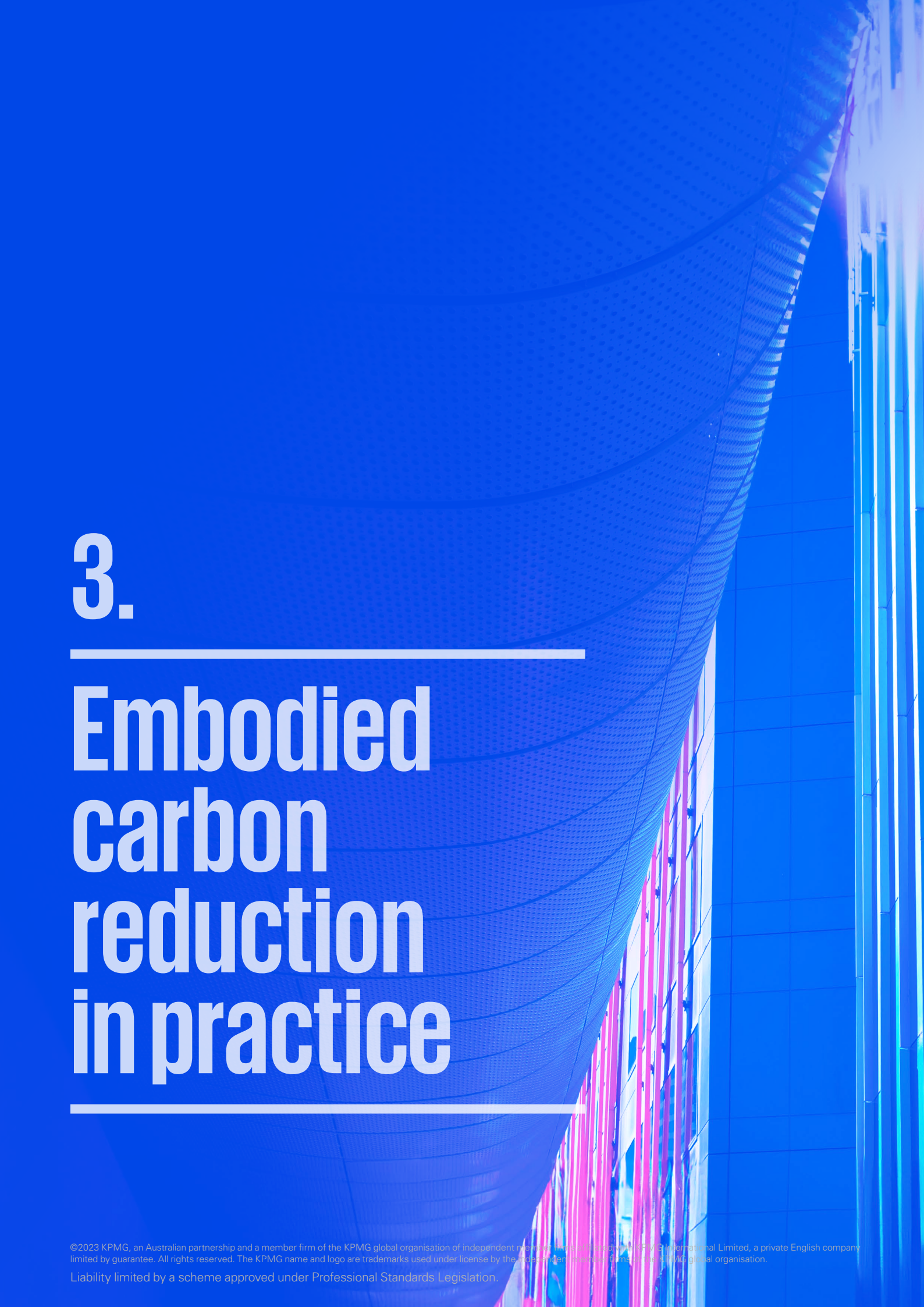
The Infrastructure Sustainability Council is a member based peak body focused on ensuring all infrastructure delivers social, cultural, environmental and economic benefit. The key mechanism for this is the Infrastructure Sustainability (IS) Rating Scheme. The IS Rating Scheme is a collection of 6 rating tools providing benchmarks and assurance at every stage of an assets lifecycle, planning, design, construction and operations. The tools can be utilised on infrastructure projects, assets, portfolios or networks. The rating tool and scheme is voluntary and used across Australia and New Zealand.

Currently there are 393 projects and assets under rating with a total Capex of $282.4 billion. The tool promotes the upfront consideration and inclusion of sustainability, rather than an operational reflection.

We welcome the recent announcement from the Minister for Climate Change and Energy, The Honourable Chris Bowen MP, regarding the commitment from the Australian Government to develop decarbonisation plans for six sectors, which includes the built environment.

3.

Embodied carbon reduction in practice



Learning from successful executed strategies

For many years, strategies to reduce embodied carbon have been implemented, such as utilising local resources, minimising material usage and employing responsible materials. These approaches can significantly decrease embodied carbon levels.

Our ability to influence embodied emissions is greatest during the planning and design of a project. The business case process is therefore the best vehicle to embed consideration of embodied carbon in the early stages of the project life cycle.

Until recently, business cases in Australia have focused mostly on operational carbon emissions from new infrastructure and monetisation of these impacts was only common for investments specifically targeting emissions abatement. To support a transition towards net zero emissions, all investment decisions for new infrastructure should consider the impact on carbon emissions across the full asset life cycle.

In a business case, this requires:

- assessing whether opportunities to reduce embodied carbon are a strategic fit with government policy and strategic direction and their contribution to net zero targets
- exploring and capturing varying approaches to minimise or abate emissions. A critical first step in this process is developing a plausible base case scenario that reflects expected outcomes if the opportunities being considered are not implemented. This is not necessarily the same as a do-nothing scenario
- estimating and monetising embodied carbon as part of the options appraisal process (using a cost-benefit analysis framework)
- considering opportunities for further reduction in embodied carbon once the preferred option is selected, for example through the design, construction methodology and procurement approach.

To effectively address embodied carbon, the PAS2080 principles identify the following potential actions, ranked by their carbon reduction impact:

1. **Build nothing** – determine if there are alternatives to building, such as repurposing existing assets or amending ways of using space.
2. **Build less** – optimise the use of existing assets, to retrofit for greater utilisation.
3. **Build clever** – use the design process to optimise material usage and low carbon materials.
4. **Build efficiently** – ensuring that design consideration converts into construction practices, with low-carbon technologies employed with an aim to eliminate waste in construction.

The principles of reducing embodied carbon are closely tied to the principles of a circular economy, which aims to keep material in use at its highest value for the longest period. This involves transitioning away from the extraction of resources, which is a significant component of embodied carbon, to the regeneration of resources. [31]

Utilising the World Green Building Council's design processes to minimise embodied carbon, the following strategies serve as examples for reducing emissions.

TACKLE CARBON EARLY ACCORDING TO WGBC

[31] Office of Energy and Climate Change & NSW Treasury. (2023). Circular design guidelines for the built environment

Build Nothing

By using existing buildings, carbon introduced through the construction process is eliminated. Existing infrastructure can be repurposed with low levels of investment to achieve a sound environmental outcome and an almost complete reduction in carbon potential. The 'build nothing' approach requires a questioning of need, and the exploration of alternative options, such as the adaptive use of assets (i.e. using the same building for multiple purposes at the same time, such as a school which also acts as a community space), encouraging the re-use of fit-outs between tenants where possible (e.g. hospitality fit-outs used by multiple sequential businesses), and embracing flexible working (to reduce the need for new offices, and maximise the utility of existing spaces). [32]

SCHOOL INFRASTRUCTURE NSW SHARED USE AGREEMENTS[33]

School Infrastructure NSW (SINSW) provides opportunities for its assets to be used collaboratively for multiple purposes. Through shared use arrangements with government agencies, local councils, sporting organisations and not-for-profits, facilities such as halls, libraries and sporting fields can be shared with the wider community outside of school hours, removing the need for new facilities to be built.

SINSW collaboration opportunities available include:

- Joint Use Arrangements, which are entered into between the department and another party to share the costs of building and maintaining a new school asset such as a sporting facility that can be shared by both the relevant school and the community outside of hours.
- Community Use Arrangements, which are entered into between the department and another organisation for access to school facilities outside of hours.
- Share Our Space (SOS) School Holiday Activities, which are run during the school holiday SOS program in outdoor school areas and involve the department entering into an agreement with organisations to hold free activities.

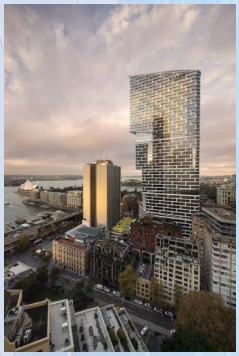
[32] ISOA, Climate Works Australia & Asbec. (2020). Reshaping Infrastructure: for a Net Zero emissions Future.

[33] School Infrastructure NSW. (2023). https://www.schoolinfrastructure.nsw.gov.au/

Build Less

Utilising existing assets and conducting refurbishments and upgrades can decrease embodied carbon emissions, as the primary structure is already in place. This approach minimises the need for new materials, reducing the overall environmental impact.

QUAY QUARTER TOWER[34]



Quay Quarter Tower was constructed by Multiplex in 2022. The tower is located on the site of the 50 Bridge street, a 46-storey building that was built in 1972. The building has a 6 Star Green As Built Rating by the Green Building Council of Australia.

One of the unique aspects of the design was to retain the original core of the building and construct the new tower around it. The development retained 65% of the original building's existing floorplates and structure and 98% of the original structural walls and core. This equates to a saving of approximately 12,000 tonnes[35] of embodied carbon and an estimated construction time saving of almost a year. Additionally, this approach saved on demolition costs and shortened the construction program by 13 months.

500 BOURKE STREET[36, 37]

ISPT have elected to refurbish the commercial office building at 500 Bourke Street, Melbourne, rather than demolish the structure and build from new. While the refurbishment still involves a significant financial investment of $130 million, the environmental savings from the project are significant. The project is expected to be completed in mid-2023 and includes retention of the main structure and facade.

The life cycle assessment of the project indicates that 57,000 tonnes of CO_2-e will be saved, including 40,000 tonnes from retaining the structure.

[34] Photo credit – Wikipedia. (2022). Quay Quarter Tower. https://en.wikipedia.org/wiki/Quay_Quarter_Tower

[35] Multiplex. (n.d). Quay Quarter Tower ACAA Technical Paper

[36] MECLA. (n.d). 500 Bourke St Case Study. https://mecla.org.au/wp-content/uploads/2022/06/500-Bourke-Street-Aurecon.pdf

[37] Photo credit – N. Dorgan & M, Ogg. (2022). Former Probuild development 500 Bourke revived with $150m redesign

Build Clever

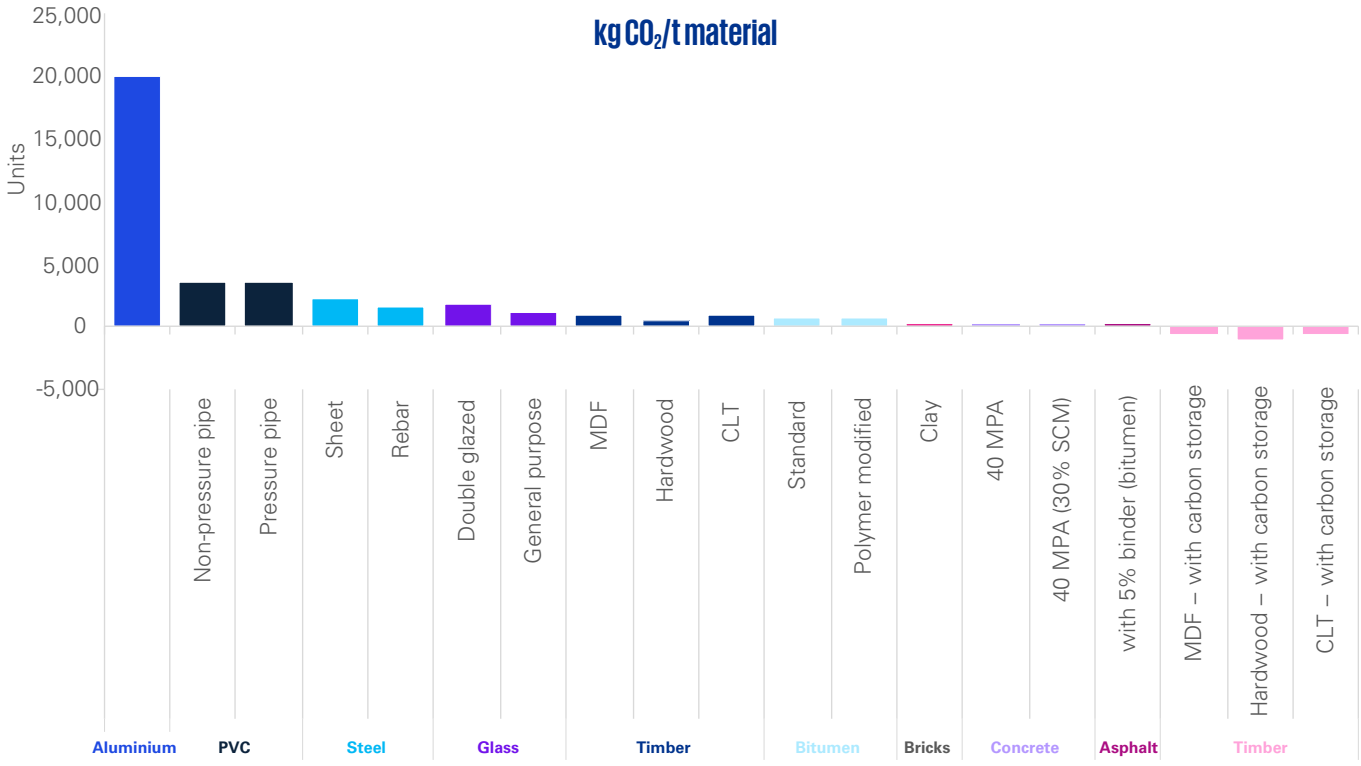
The increasing use of technology can rapidly generate options for optimising material use in projects. By carefully selecting materials, products with lower embodied carbon can be utilised, either through more efficient manufacturing processes or by choosing locally sourced materials that require less transportation

THE IMPACT OF CONSTRUCTION MATERIALS

Concrete, steel, and aluminium are amongst the key carbon contributors for a typical construction project. These materials typically add up to more than two-thirds of the total embodied carbon emission. In concrete, 90 percent of emissions are from cement production and use. Cement is the second most consumed material[38] and contributes 7 to 8 percent of global carbon emissions. To put this into perspective, if concrete were a country, it would rank third in the world after China and the USA.[39] The cement industry currently produces around 4 billion metric tonnes of cement annually and is expected to produce 6 billion metric tonnes by 2050.[40] Steel contributes around 7 to 9 percent of global emissions. Approximately half of the emissions from concrete and steel provide materials for the construction industry.[42]

Figure 8 shows the typical amount of carbon dioxide produced to make 1 tonne of material. It shows that aluminium is the most carbon intensive typical construction product, with 20,000 kg CO_2 per tonne. While the graph shows that concrete is relatively low on the list of materials, the volume of material used must be considered in determining the amount of embodied carbon captured in a structure.

FIGURE 8. CARBON DIOXIDE PRODUCTION PER TONNE OF MATERIAL PRODUCED [42]



[38] J. Watts. (2019). Concrete the most destructive material on earth. The Guardian

[39] BBC News. (2018). Climate Change: The massive CO2 emitter you may not know about. https://www.bbc.com/news/science-environment-46455844

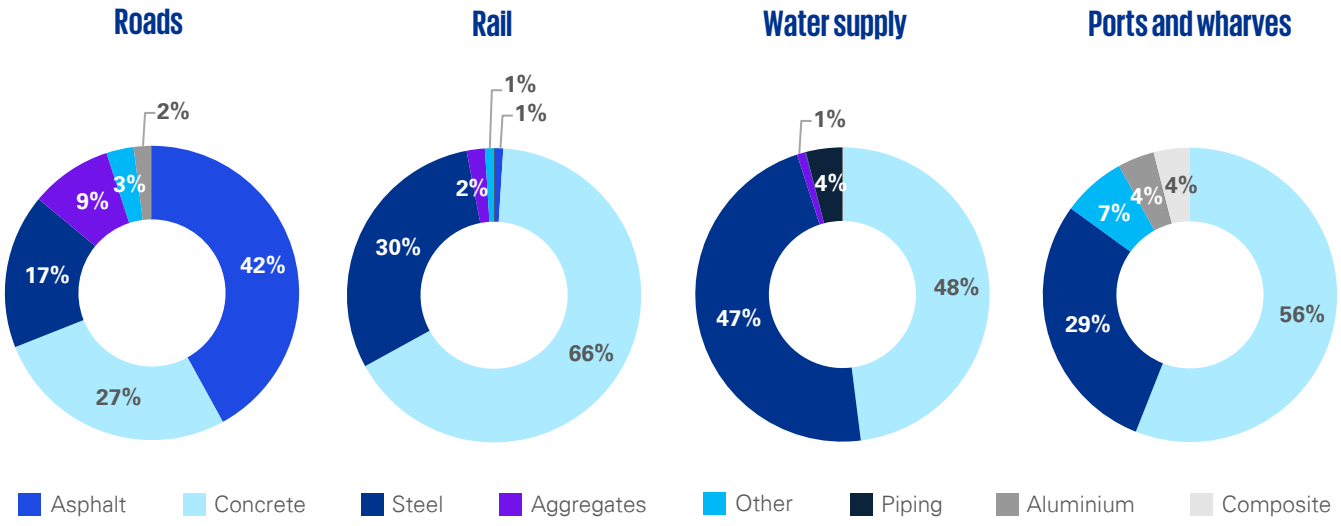
[40] F. Harvey. (2021). Cement makers across world pledge large cut in emissions by 2030. The Guardian.

[41] International Energy Agency. (2020). GlobalABC Roadmap for Buildings and Construction 2020 – 2050

[42] Clean Energy Finance Corporation. (2021). Australian Buildings and Infrastructure: opportunities for Cutting Embodied Carbon

Figure 9 shows the typical split of embodied carbon by material for infrastructure projects.

FIGURE 9. INFRASTRUCTURE EMBODIED CARBON BY MATERIAL AND PROJECT[43]



The pie charts in Figure 9 show that the most significant materials contributing to embodied carbon in infrastructure projects are concrete, steel and asphalt. While other materials have a large carbon footprint per tonne of material, they are used in lower volumes and have lower overall weight in a project.

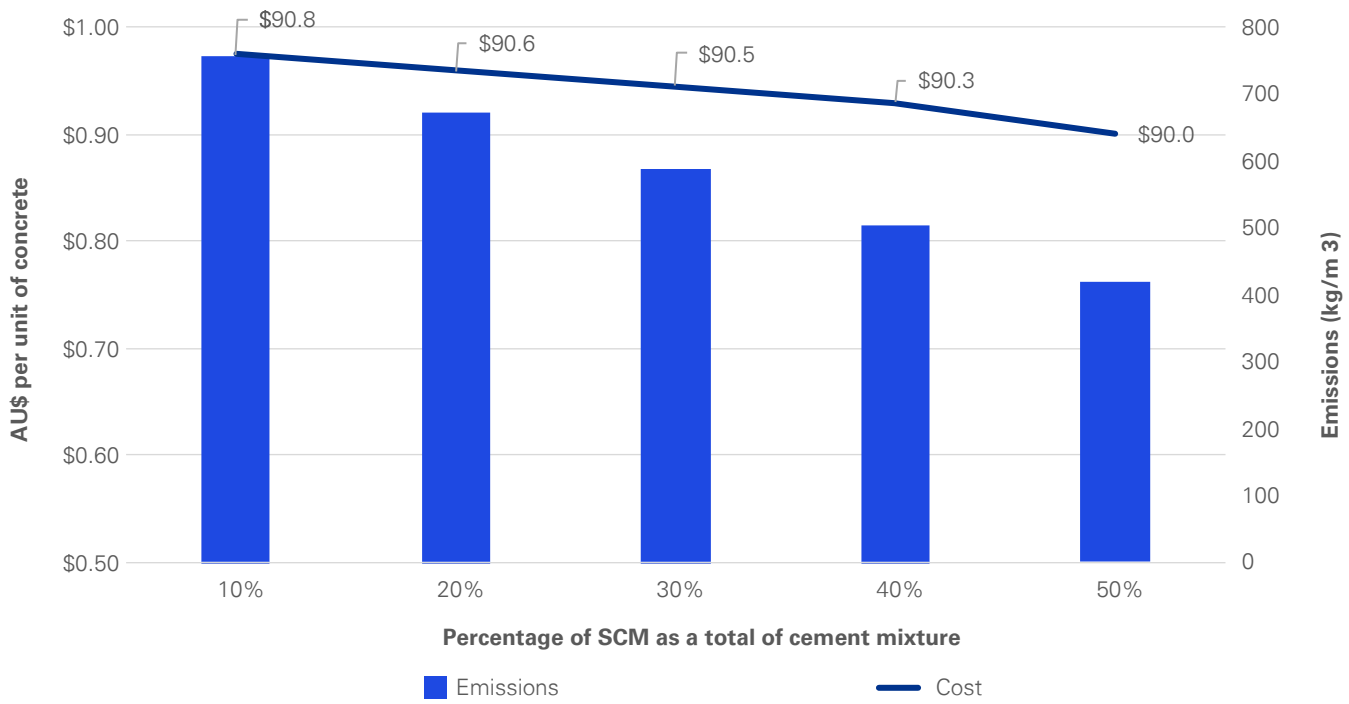
[43] Clean Energy Finance Corporation. (2021). Australian Buildings and Infrastructure: opportunities for Cutting Embodied Carbon

USE OF SUPPLEMENTARY CEMENTITIOUS MATERIAL (SCM) IN AUSTRALIA

KPMG's Deal Advisory and Infrastructure (DA&I) team has investigated the role of innovative cement technologies in reducing emissions and life cycle cost. A clear example of this is Supplementary Cementitious Material (SCM) which consists of a partial replacement of Portland cement and includes materials that would otherwise be industrial waste products, such as fly ash, blast-furnace slag and silica fume.

SCM maintains similar structural performance to traditional Portland cement at replacement rates of up to 50 percent. These replacement rates can equate to a reduction of approximately 3 million tonnes of carbon dioxide per annum in Australia. SCM's structural properties coupled with its low emissions present a significant opportunity for the Australian construction industry, one that our clients are beginning to enthusiastically embrace. As SCM continues to be adopted as viable material for use in concrete mixes, KPMG's desktop analysis of recent literature has highlighted that the use of SCM is positively correlated with a reduction in total life cycle cost. The environmental and financial benefits of increasing SCM use are summarised in Figure 10.

FIGURE 10. VARYING LEVELS OF SCM IMPLEMENTATION IN CONCRETE MIXES AND THEIR RESPECTIVE BENEFITS TO COST AND CARBON DIOXIDE EMISSIONS[44]



[44] I.M. Chethana S. Illankoon, Vivian W.Y. Tam, Khoa N. Le, & J.Y. Wang. (2018). Journal of Cleaner Production. Lifecycle costing for obtaining concrete credits in green star rating system in Australia

USE OF RECYCLED MATERIALS

The use of recycled materials is increasing in construction projects, particularly in the infrastructure space. This has the potential to significantly reduce the amount of virgin materials required in a project and can lead to significant embodied carbon savings. As well as recycling materials into cement, as shown above, other common materials using recycled content include asphalt and aggregates. While contamination of recycled products can be an issue, local governments have introduced greater controls in this area and the industry itself is realising the benefits of tighter controls.

ROZELLE INTERCHANGE AND WESTERN HARBOUR TUNNEL (WHT) ENABLING WORKS NSW[45]

Currently underway, the Rozelle Interchange and Western Harbour Tunnel Enabling Works is one of the largest infrastructure projects in Australia. John Holland and CPB Contractors Joint Venture (JHCPB) have enacted several initiatives to reduce the embodied carbon footprint of their construction activities, including the replacement of traditional reinforcing steel in R53 General works with recycled plastic fibres. The project has committed to a 15 percent reduction in material consumption across the project.

[45] Clean Energy Finance Corporation. (2021). Opportunities for cutting embodied carbon Industry Report. https://www.cefc.com.au/media/ovrkk5l3/australian-buildings-and-infrastructure-opportunities-for-cutting-embodied-carbon.pdf

EMBODIED CARBON IN METALS

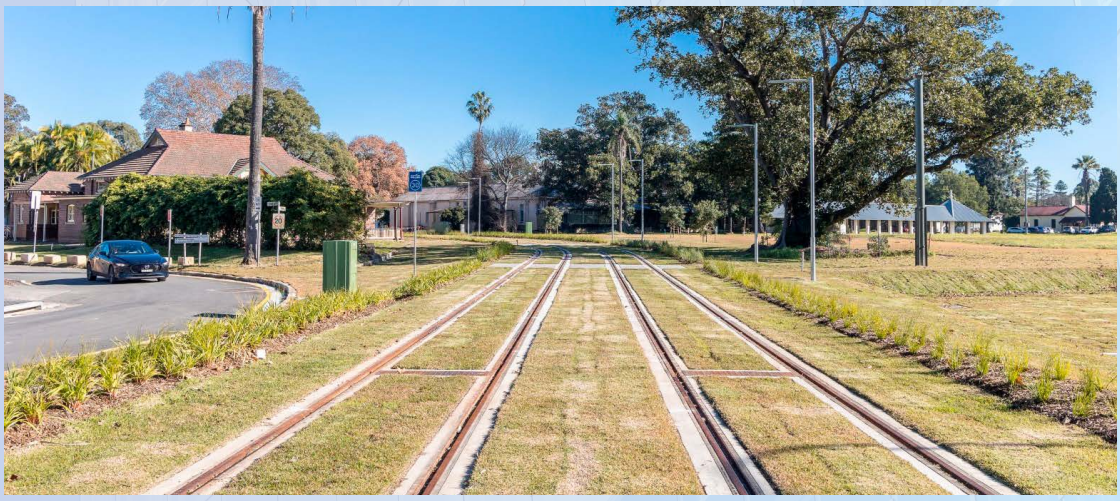
Significant investment is currently being made into green steel technologies. Generally, the technologies being investigated aim to replace traditional coal-based blast furnaces with non-fossil fuel furnaces. They have focused to date on hydrogen as a replacement fuel, with production already occurring in Sweden. Another method of producing green steel is recycling used steel in electric furnaces.[46]

Advances are also being made in material engineering to produce lighter weight steel that is as strong as conventional steel. By having less weight, the materials use less raw material and energy to produce and use less energy to transport, crane, and handle.[47] This can lead to reduction in embodied carbon of up to 33 percent.[48]

Lower carbon aluminium is available in various countries, including Norway, where aluminium is manufactured using renewable energy, typically hydroelectricity. Recycled aluminium is available in several countries including Australia, with Tomago Aluminium now producing this material locally. The re-smelting of used aluminium uses only 5 percent of the energy required to produce virgin aluminium.[49]

PARRAMATTA LIGHT RAIL[50]

The Parramatta Light Rail Infrastructure Works were completed in August 2022. The project provides a light rail line from Westmead to Carlingford, featuring 16 stops. It was registered with the Infrastructure Sustainability Council in 2019 and the Infrastructure Works package achieved some significant reductions in embodied carbon from a 28 percent reduction in material use through the project. This includes re-use of heavy rail components, as well as using recycled materials in concrete, asphalt and aggregates. Material reductions contributed to an overall cumulative reduction in CO2-e of 76,000 tonnes.



[46] CSIRO. (2022). Steeling ourselves: How Australia can support the transition to net-zero steel
[47] Infrastructure Magazine. (2020). New Viribar 750 fitment is sustainable and easy to substitute
[48] Infrastructure Sustainability Council. (n.d). InfraBuild's Journey to Making Sustainable Steel
[49] Materials & Embodied Carbon Leaders' Alliance (MECLA). (2022). Low Emissions Aluminium
[50] Infrastructure Sustainability Council. (2022). Parramatta Light Rail Stage 1 Infrastructure Works – As Built

IMPACT OF TRANSPORTATION

For material and equipment transportation in construction projects, fuel consumption is the key source of emission, which varies on the mode of transport and the type of carrier. For major projects, a substantial amount of fuel is consumed for the transportation of building materials and equipment across domestic and international routes.

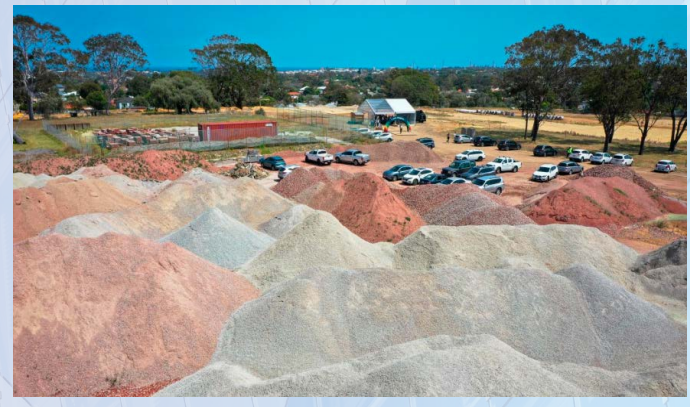
In the Australian construction industry, the economic value of the materials used is approximately $75 billion.[51] Around $10 billion is being imported, with 60 percent of that originating from China. The import of bricks alone amounted to $10.3 million in 2020,[52] coming from Italy, Spain, Denmark, United Kingdom, China and another eight countries. With a significant import of ceramic goods from Italy, Spain and India, a substantial portion of materials found on our construction sites have travelled immense distances at considerable cost.

Much of Australia's concrete and timber supplies are imported, and in the case of timber there is currently no price signal to drive local uptake.

Manufacturing in Australia does not come without its own challenges. Whilst the carbon intensity of electricity supply will reduce relatively quickly, transport emissions are the next key focus areas given the large size of the country.

Given the absence of a universal carbon price, Australia is reliant upon the Safeguard Mechanism, targeting high emitting industries, as well as procurement policies to promote the purchase of locally supplied low-carbon materials.

DEVELOPMENTWA[53]



DevelopmentWA acquired a high school from the state government and transformed this into residential called OneOneFive. As part of the project, all the existing structures were demolished and materials able to be recycled were crushed and made available for re-use. This resulted in 10,385 tonnes of material diverted from landfill, which was almost 86 percent by weight. 86 percent of the re-use material was re-used onsite, with only 10 percent being taken offsite for recycling purposes. This resulted in a saving of 662,000 kg CO2 and 1,000 fewer truck movements to transport the material. Lessons learnt from the project included requiring a holistic approach and commitment to the circular economy and the need for a clear understanding.

[51] Clean Energy Finance Corporation. (2021). Opportunities for cutting embodied carbon Industry Report. https://www.cefc.com.au/media/ovrkk5l3/australian-buildings-and-infrastructure-opportunities-for-cutting-embodied-carbon.pdf

[52] World Integrated Trade Solution. (2020). Australia Ceramic building bricks imported by country in 2020

[53] Materials & Embodied Carbon Leaders' Alliance (MECLA). (n.d). Case Study: Development WA Building Circularity

MINING SECTOR LEADING THE CHARGE WITH ELECTRIC FLEET[54]

A diversified resources mining company has recently acquired a fleet of electric mining vehicles for use, as part of its push to achieve net-zero emissions by 2050.
As the first models begin to arrive on Australian shores, KPMG understands that several major mining competitors are considering the rollout of electric plant and equipment to meet their net-zero targets. This avenue of reaching net zero is further enabled by the recent releases of electric utility vehicles by Toyota, including the Hilux and Landcruiser. The replacement of a single diesel utility vehicle with an electric equivalent can save up to 3 tonnes of carbon per year in usage alone.

The US EPA states that some studies have shown that carbon emissions from the manufacture of an electric vehicle are higher than those of a fuel vehicle with an estimated 9 percent of emissions of a fuel car attributed to manufacturing and 17 percent in an electric vehicle. However, over the life of a vehicle, carbon emissions from an electric vehicle remain lower than fuel vehicles.[55]

[54] Green Vehicle Guide. (2023). 2020 Toyota Hilux. Individual Vehicle | Green Vehicle Guide
[55] Electric Vehicle Myths | US EPA

Technology in construction

The KPMG Global Construction Survey 2023 identified that digital technology is one of the largest avenues for owners and engineering and construction firms to implement innovative solutions in the construction process, including around ESG and embodied carbon. The most successful outcomes come from implementing a combination of available and tested technologies. However, one of the barriers to implementation of technology appears to be the return on investment, which for technology is realistically a three to five year horizon, rather than the short-term returns that are expected. Cultural barriers are also present, which make implementing new technology more difficult, as well as the different priorities of owners versus constructors.

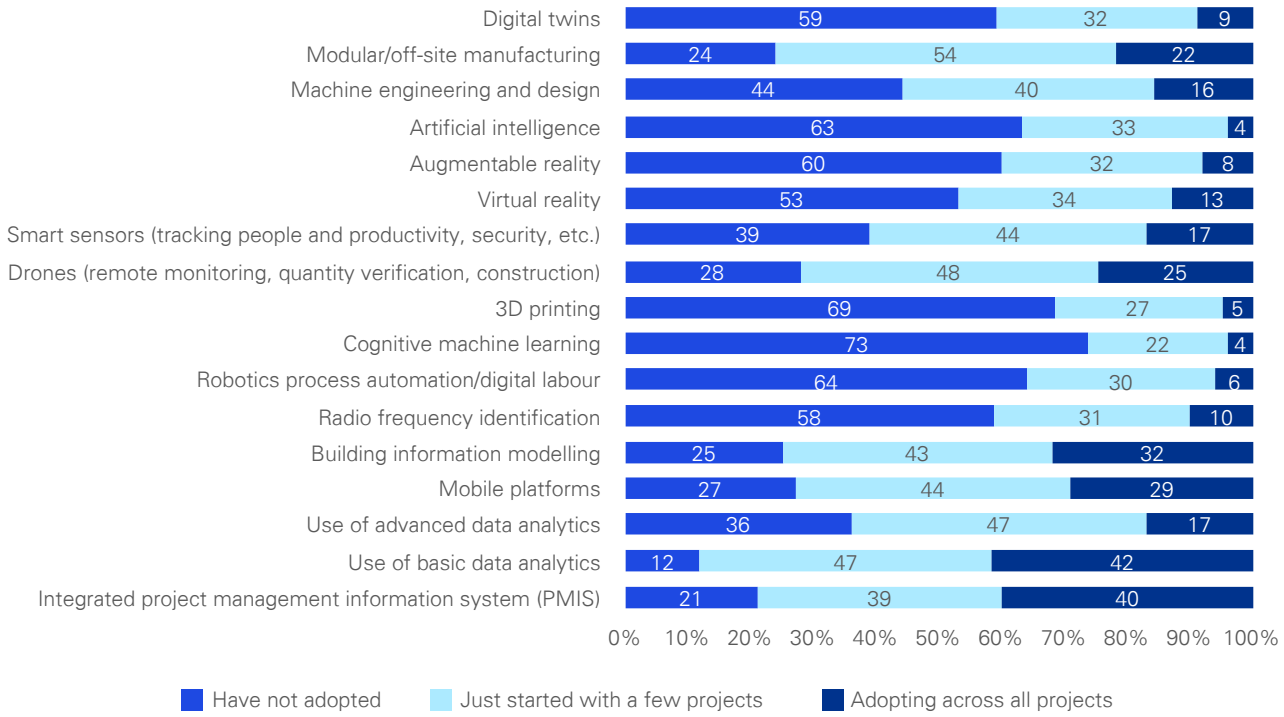
The KPMG survey showed that established industry players are already using integrated project management information systems (PMIS), building information modelling (BIM) and advanced data analytics. There is further growth in the use of digital twins, artificial intelligence (AI), virtual and augmentable reality (VR/AR), 3D printing and robotics process automation (RPA). Successful implementation of the technologies requires investment in education for teams.

Managing embodied carbon through technology will require increased adoption of tools and platforms.

In parallel, the development of core products should be considered specifically for embodied carbon modelling and measurement, including BIM, digital twins, and data analytics platforms, which can be used for multi-scenario simulation. This will assist in embedding the concept of embodied carbon from the early stages of design, which will provide the most effective means of reducing the footprint of a project.

Figure 11 shows the levels of adoption for the below technologies, taken from the 2023 KPMG Global Construction Survey. This figure shows the total number of respondents, which includes owners and engineering and construction companies.

FIGURE 11. RATES OF ADOPTION FOR EACH OF THE NAMED TECHNOLOGIES[56]



[56] KPMG Global. (2023). 2023 Global Construction Survey: Familiar challenges – new approaches

It can be seen from the figure that the top five technologies adopted across all projects are the use of basic data analytics, PMIS, BIM, mobile platforms, and drones. The majority of the top five relate to design and project management activities, which allows them to be levers for embodied carbon management.

An interesting outcome from the 2023 Global Construction Survey was two areas which had not previously been assessed for their potential to deliver the greatest overall return on investment. They were the use of digital twins, which rose 11 percent, and offsite manufacturing, which rose 31 percent. Both technologies have significant scope to reduce embodied carbon in a project. The use of digital twins to form a baseline model and then a secondary model to assess scenarios that may reduce the embodied carbon of a building through different configurations, construction methods or material choices, can play a key role in future projects to design embodied carbon out of a project.

As well as looking at the design phase of a project to avoid embodied carbon, technology will be required to measure the embodied carbon being proposed for a project. Tools are available, including in Australia to assist with this process, which have the capacity to highlight areas of high embodied carbon and drive decisions on material selection to achieve better outcomes.

CASE STUDY

KPMG Origins Asset Impact[57]

KPMG Origins Asset Impact is a digital product focused on measurement, benchmarking, and reporting of embodied carbon and operational emissions in the built environment. Digital technology and high-quality data are at the heart of the construction industry's ability to calculate embodied carbon and manage operational emissions accurately and transparently despite the complexity of existing supply chains.

Government delivery agencies and major infrastructure providers are working through practical pathways to meeting state-based and national decarbonisation and net-zero commitments. The first step to understanding and reducing carbon emissions is measurement. With an initial focus on school projects, KPMG Origins Asset Impact was used to assess embodied carbon impact across the design and construction phases.

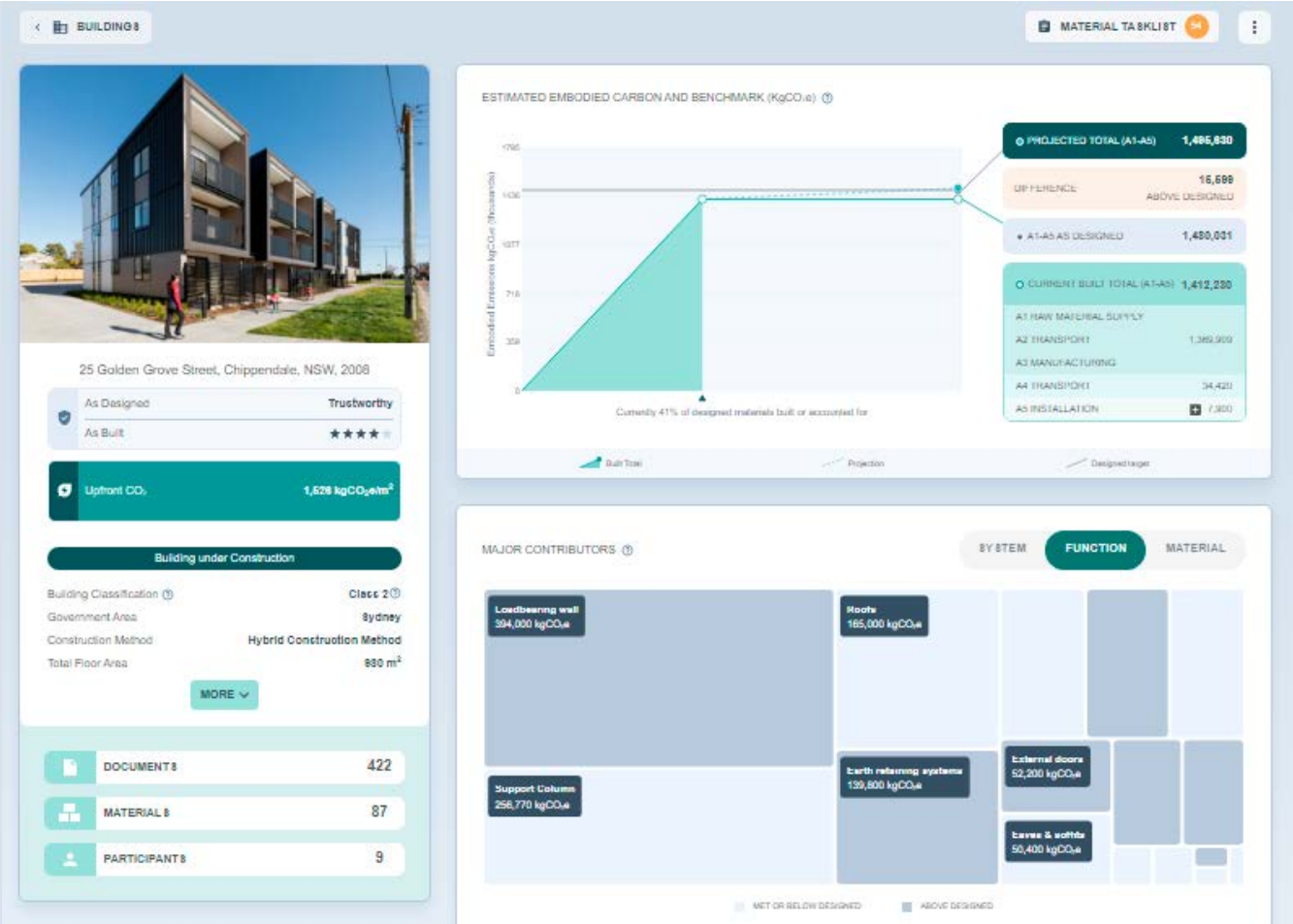
Measuring embodied carbon at the design phase enables organisations to understand the emissions impact early on at a time where material selection decisions are still available. KPMG Origins Asset Impact enabled infrastructure portfolio owners to understand the impact of building projects on their overall portfolio emissions as well as supporting decision-making around delivery using modern methods of construction. Refining inputs with the relevant design and sustainability consultants helps identify the most carbon-intensive elements and determine lower-impact alternatives. It also enables developers to specify embodied emissions targets to head contractors for delivery.

Verification of as built embodied carbon against the designs enables organisations to obtain an additional level of confidence that actual emissions are in line with design aspirations. KPMG Origins Asset Impact was used to update and refine inputs available at the design stage with more accurate and specific information on the materials used, such as quantities, sources, suppliers, transport distances and installation processes. Data captured at this stage enabled portfolio owners to access a breakdown across each building element and use the data for reporting and communication.

For organisations starting on the embodied carbon measurement journey, beginning with a simple project helps capture key learnings for future portfolio delivery decisions. Using KPMG Origins Asset Impact across multiple projects has highlighted key learnings:

- Understanding the data required to calculate embodied carbon is crucial for achieving accurate and reliable results. The project teams can understand how to collect and manage data on materials specifications, quantities, sources, transport distances and recycling rates.
- Incorporating data requirements into materials and contractor procurement is essential for ensuring data availability and quality. Understanding the required data helps inform procurement documents that specify data requirements for each material and contractor involved in the project. It also helps establish data collection processes and systems that facilitate data sharing and verification among different parties.
- Starting to capture embodied carbon data early enables project teams and portfolio owners in preparing for upcoming regulatory requirements around disclosure, reporting and benchmarking. Creating an early baseline will enable strategic decision-making around procurement and delivery in alignment with overall decarbonisation objectives.

[57] KPMG Origins. (2022). Asset Impact | Embodied Carbon



KPMG Origins Asset Impact helps organisations commissioning, designing and delivering construction projects to understand the data requirements, enable simple data collection from consultant and contractor teams, while enabling streamlined measurement and reporting of embodied carbon at the individual asset and portfolio level. This will drive their ability to meet current and future regulatory obligations as well as unlock sustainability-linked financing from banks and other financiers that are placing greater value on understanding Scope 3 financed emissions in their value chains.

Recently, KPMG Origins have been engaged with School Infrastructure New South Wales (SINSW), and the NSW Building Commissioner to work with property developers, architects, builders, and consultants to measure and report the embodied carbon for their projects. Under a NSW Government initiative, the Department of Education has been designing and building new schools using Modern Methods for Construction (MMC) to improve the efficiency, reduce the cost, and lower the embodied carbon emissions for these projects. To validate this strategy, KPMG Origins Asset Impact platform was utilised by the SINSW team to upload the required documents for an as-designed upfront embodied emissions calculation. Construction data was collated and uploaded to Asset Impact, and compared with the as-designed benchmark for Embodied Carbon. The insights provided by the data, presented in an easily accessible way have introduced greater transparency during the construction process, and allowed construction professionals and developers to make informed decisions about chosen materials and methods early in the construction process. A portfolio of four new schools is now using Asset Impact to further understand their embodied emission profiles and inform efficiencies. This portfolio approach is also providing data for benchmarking and comparing different materials and methods as the NSW Government initiative is further developed to inform sustainable practices for future works.

"Understanding the carbon associated with the building is going to be increasingly important, so any tool that can allow us to track that from very early on in the process all the way through to later on in life is going to be a good thing."

WILLIAM PAYNE
Chief Digital Officer, Mirvac

Building capability

One clear strategy for change involves the education and training of the next generation of workers in the construction industry. Educational pathways for construction professionals are opening, with emphasis on raising the overall education and training levels for people working in the industry, with the goal to improve the safety, efficiency, and quality of buildings in the future. The construction industry is historically slow at adopting new methods and technologies in order to address challenges faced with productivity, safety and quality. Historically, on average, construction companies have allocated 1.2 percent of their revenues to technology spend, compared to 3.5 percent average across other sectors.[58] Digitisation of existing methods and practices, including the adoption of digital technologies to measure and manage carbon emissions presents an enormous opportunity and challenge for the sector. Meeting the challenge head-on has been a focus of educators and trainers in the sector in recent times. Both private and public tertiary and vocational educators have invested in courses and syllabus to address this challenge, with the belief that real change can be made through training the next generation of construction professionals in new methods and technologies. One example includes:

– The Western Sydney University and the Centre for Smart Modern Construction (c4SMC), an industry collaboration initiative embracing smart technologies and processes in delivering a modern construction industry.

Build Efficiently

Building efficiently converts the design processes into construction practices and uses construction methods that minimise the use of carbon and produce less waste.

CONSTRUCTION METHODOLOGY

Next steps should focus on reducing fossil fuel use in the construction industry, which equates to approximately 6 percent of all global emissions. Electrification is underway with electric excavators, loaders, lifts, mobile cranes, and telehandlers all currently available. Studies have predicted that 60 percent of all construction equipment (by energy use) can be electrified by 2040.[59] Additionally, the total cost of electrified equipment over its life cycle is now lower than diesel-powered options.

However, significant progress is still required to electrify equipment before 2050. Subsequently, intermediate options such as renewable diesel, a fuel that emits 75 to 95 percent less than traditional diesel, have been developed. Existing equipment requires no modification to be used with renewable diesel, providing a competitive advantage against other alternative fuels. Renewable diesel is currently unavailable in Australia and is unlikely to occur without supportive policies and incentives by the Australian Government.

OFFSITE CONSTRUCTION

As mentioned in the technology section above, another method to reduce the energy associated with construction is to employ offsite construction techniques. This involves building components of a structure offsite, in a controlled environment. This allows efficiencies in methods, including the use of robotics to automate tasks, minimising waste production, as well as providing a controlled environment that is safer for workers. Constructed/built components are then transported to site for immediate installation, which can also reduce the time taken for installation and the amount of energy used in the construction process. Uptake of this technology is increasing, with the KPMG 2023 Global Construction Survey indicating 22 percent of survey respondents are already using offsite construction on all projects and 54 percent of respondents have started using the technology on some projects.

When looking specifically at the Australian responses, 25 percent of respondents indicated that they use this approach across all projects and 61 percent were starting to adopt the technology.

Offsite construction is becoming more common in the residential sector and sectors where building footprints are generally smaller, such as education facilities. Some elements of larger buildings can be incorporated, such as the use of bathroom or kitchen pods into residential apartments and hotels.

[58] Deloitte. (2019). Point of View on Digital Construction – The business case of incorporating digital technologies into the construction industry

[59] Lendlease & The University of Queensland. (2022). Stepping Up the Pace: Fossil Fuel Free Construction.

CASE STUDY

School Infrastructure volumetric and kit of parts construction[60]

School Infrastructure NSW has embraced offsite manufacturing to realise both reduced carbon emissions and time and cost improvements to deliver the school infrastructure across NSW. Drawing upon volumetric modules of classrooms, vertical riser and lift cores, manufacturing is completed offsite and installed as a complete unit once transported to its desired location.

Additionally, a kit of parts approach has been utilised where a standardised building component kit, similar to flat-pack furniture, is transported to site for easy assembly resulting in a reduced requirement for the use of heavy machinery and ultimately a lower carbon footprint.

[60] School Infrastructure NSW. (n.d). Modern methods of construction.

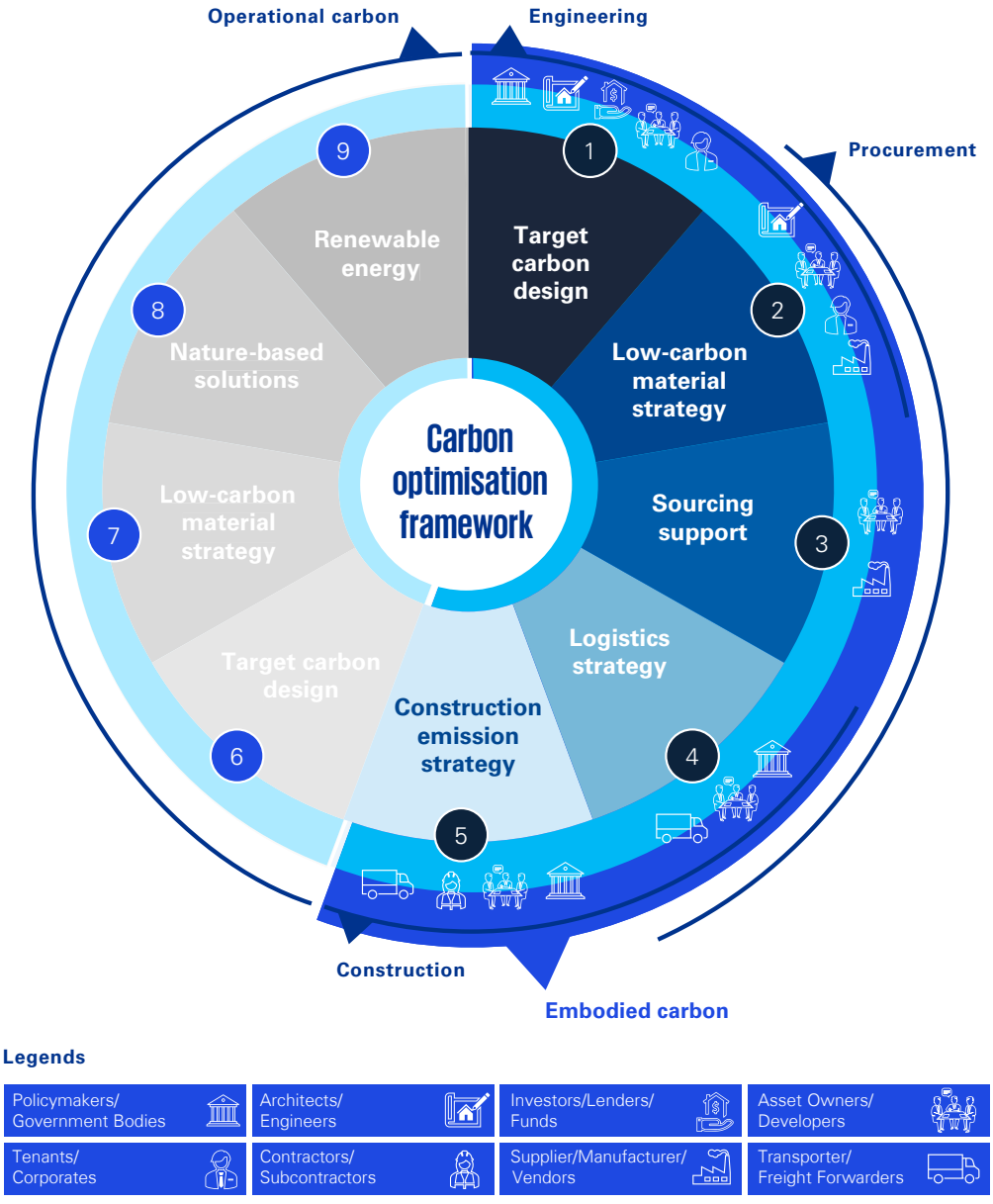
4.

Call to action from the construction industry

A cultural transformation is warranted from the construction ecosystem

At the heart of reducing embodied carbon emissions is improving productivity and efficiencies in the construction process. Each stakeholder has a role to play in enabling this; from standardising measurement and targets, to collaborating on new materials and construction methodologies. Figure 12 shows the carbon optimisation framework and the stages leading to construction. Key stakeholders that can influence embodied carbon reductions are shown at each stage.

FIGURE 12. POTENTIAL IMPACT OF TECHNOLOGY SOLUTIONS TOWARDS LOW CARBON CONSTRUCTION[61]



[61] Based on KPMG India analysis

Table 1 provides potential actions that can be taken by key stakeholders.

TABLE 1: ACTIONS FROM KEY STAKEHOLDERS TO REDUCE EMBODIED CARBON

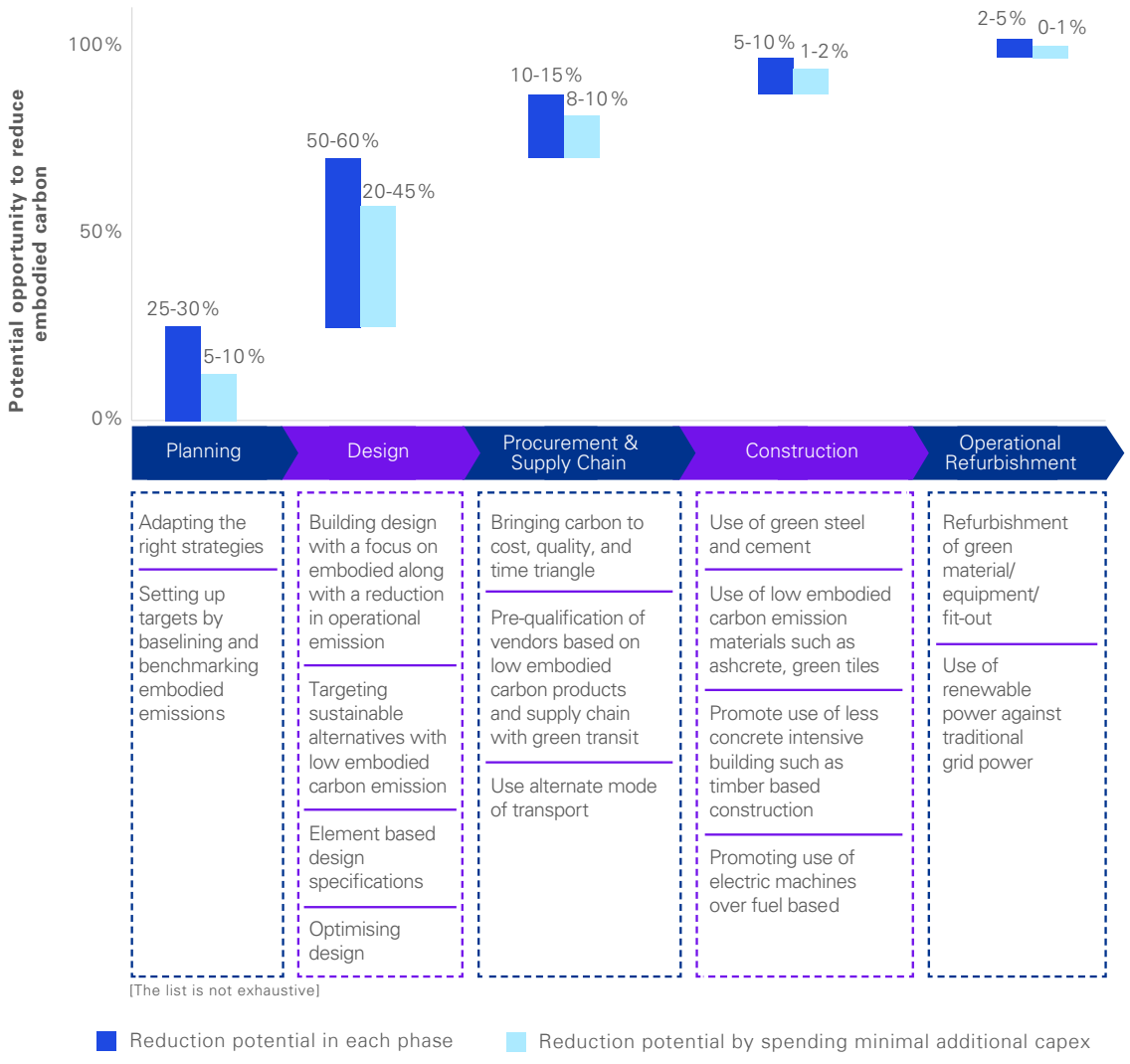
KEY STAKEHOLDERS	POTENTIAL ACTIONS
POLICYMAKERS AND GOVERNING BODIES 	– Continue the existing process of incorporating embodied carbon into policy. NSW is leading the way in requiring embodied carbon to be measured, with other states and territories needing to develop their own policy. – As standard measurement tools are developed, consider implementation of minimum performance standards. – Ensure that standard measurement tools include methods to calculate embodied carbon across the building life cycle, to ensure that appropriate decisions can be made on whether to refurbish or rebuild. This will require assessment of embodied carbon in existing buildings. – Provide frameworks to require EDPs to be produced, so that embodied carbon decisions can be made in projects.
INVESTORS/LENDERS/FUNDS 	– Include ESG investment criteria in investment decisions, including the need for low carbon projects. – Provide green loans and encourage low-carbon pathways, that includes embodied carbon, not just operational energy intensity. – Provide transition support to other stakeholders to create a highly sustainable infrastructure value. – Ensure due diligence before investments with respect to climate risks to avoid severe effects of the climate, thus bringing in monetary gains.
ASSET OWNERS/DEVELOPERS 	– Require low-carbon development and retrofits and enable processes aligned to the net-zero goals. – Promote the use of greener material across the built environment, including embodied carbon requirements in fit-out guides. – Collaborate with suppliers to reduce embodied emissions in products, for example, concrete mixes, aluminium facades and steel, to drive more demand for low embodied carbon products.
TENANTS/CORPORATES 	– Prefer low-carbon buildings over poorer performing buildings. – Ensure low embodied carbon materials are selected as part of fit-outs. – Report Scope 1, 2, and 3 not only for operational emissions but also for embodied carbon.
ARCHITECTS/ENGINEERS 	– Train staff on technologies to enable embodied carbon assessment and measurement. – Promote carbon modelling for the selection of suitable material. – Promote the selection of low-carbon sustainable material or alternative materials. – Collaboration with the stakeholders to encourage creation of sustainable low-carbon infrastructure.
CONTRACTORS/ SUBCONTRACTORS 	– Accelerate new technology adoption which promotes low embodied carbon due to installation and site transfers. – Build capability of staff to effectively use adopted technology. – Plan to decarbonise activities conducted, so that fuels are no longer used.
SUPPLIERS/MANUFACTURERS/ VENDORS 	– Plan to decarbonise activities so that fuels are no longer used, and energy consumed reduces. – Create emission databases and EDPs to assist customers in making informed decisions.
TRANSPORTERS/ FREIGHT FORWARDERS 	– Plan to decarbonise activities and fleets so that fuels are no longer used. – Create transparency across the supply chain. – Become agile to the market demands.

OVERCOMING THE INERTIA AND MAKING IT AFFORDABLE FOR CAPITAL PROJECT OWNERS

There exists a widespread notion of increased cost for carbon reduction in the industry. However, it is established that up to 46 percent of embodied carbon emissions can be curtailed in capital projects by additional spending of a mere 0.5 percent to 1 percent of capital expenditure.[62] When coupled with some of the efficiencies that technologies discussed can provide, reduced project timelines can also provide a compelling argument for decarbonising.

The industry can overcome this inertia through improved awareness around embodied carbon leading to structured policies and frameworks, initiatives, contracting process, and its monitoring. Additionally, net carbon reduction will require a collective change in mindset, leadership and governance across the life cycle of construction and infrastructure projects.

FIGURE 13. OPPORTUNITY TO REDUCE CARBON IN A PROJECT LIFE CYCLE WITH MARGINAL SPEND[63]



62 Rocky Mountain Institute. (2021). Reducing embodied carbon in buildings Low-Cost, High-Value Opportunities

63 Based on KPMG India analysis

ACCELERATING THIS CHANGE

A suite of additional measures will be the key to further accelerating the embodied carbon reduction, including but not limited to:

FIGURE 14. MEASURES TO FURTHER ACCELERATE THE EMBODIED CARBON REDUCTION[64]

LEADERSHIP COMMITMENT

Whilst we see strong commitment from leaders across the industry, whole of industry collaboration will support broader adoption on carbon-conscious development and commitment to build low-carbon assets which will unlock innovation and drive more value.

INCENTIVISING CONTRACTORS/ SUPPLIERS

Both owners and tenants should structure contracts that incentivise project suppliers or contractors to use low-carbon material and collaborate to achieve project carbon emissions goals.

INDUSTRY COLLABORATION

Cross collaboration is warranted between stakeholders in various dimensions. Designers or engineering firms, prevailing OEMs should collaborate with agencies that can provide software platforms to assist in the design of low-carbon assets.

EXPLORING TRANSPORT ALTERNATIVES

Modes of transport must be considered to minimise emissions from this stage of the life cycle. That may include adopting the use of electric vehicles, sourcing materials locally to minimise transport distances and choosing less carbon intensive transport methods where fuel use is currently unavoidable.

GREEN CONSTRUCTION

Using electric machinery and equipment helps reduce emissions during site construction. Currently, the usage of conventional fuel constitutes 10-15 percent of emissions from a construction project. Companies need to set a pathway to fossil fuel-free construction with a focus on renewable diesel and the electrification of construction equipment and machinery.

INTEGRATING WITH GLOBAL INITIATIVES

Backward integration with global initiatives such as green steel and green cement is required for providing green alternatives at incremental costs. Owners/designers/developers need to create substantial demand for low-carbon projects, leading to the market price correction of such material.

TECHNOLOGY

Leveraging technology such as KPMG's Asset Impact tool to allow for tracing of building materials and enable the reporting of GHG emissions, giving asset owners transparency around embodied carbon in a building or asset.

64 Based on KPMG India analysis

How KPMG can help

KPMG works closely with leading construction and government clients across the globe – and the clients they service – to develop and implement decarbonisation strategies and goals.

With a global network of specialists in climate change, decarbonisation and net zero transition, as well as expertise in technology, policy and industry sectors, we are uniquely positioned to bring together the experience and expertise needed to embed sustainability into an organisation's core business strategy and delivery on its transformation goals at speed.

KPMG in Australia supports clients with:

INFRASTRUCTURE LIFE CYCLE, GREEN STAR & ISC

Our teams have the ability to prepare upfront carbon calculations for life cycle stages associated with the product stage (raw material supply, transport and manufacturing) and construction process stage (transport and construction/installation process). We can provide comparisons to assist clients in choosing different material types. We contribute to Green Star and ISC documentation in projects.

CARBON IN BUSINESS CASE

KPMG has extensive experience in supporting clients make informed and evidence-based decisions on policy and infrastructure investments. This includes preparing business cases, and assessing options to identify the investments alternatives offering the optimised economic, social, environmental and cultural outcomes.

KPMG has advanced tools and techniques to quantify and monetise the embodied carbon in infrastructure across all stages of the asset life cycle that we continually update and refine in line with updated guidance from the federal and state governments. This will support decision-makers to understand the full extent of the costs and benefits of the investment options and make an informed decision that aligns with financial, economic, environmental and social objectives.

KPMG ORIGINS – EMBODIED CARBON CALCULATION FOR CONSTRUCTION

KPMG Origins Asset Impact is a market-led digital product that enables measurement, benchmarking and reporting of upfront embodied carbon.

Asset Impact was designed with the user in mind to remove the complexity associated with calculating embodied carbon in the built environment. The intent was to make the digital tool easy to use, allowing developers and construction professionals to easily upload data and generate relevant reports. The embodied carbon calculations performed by Asset Impact were developed in line with the GBCA's Green Star requirements and with the evolving NABERS framework (soon-to-become the Australian emissions measurement standard). KPMG Origins Asset Impact removes the complexity for construction professionals in calculating embodied carbon for their projects and is aligned with existing standards for calculating embodied carbon in construction.

Acknowledgements

We are grateful to KPMG India and our Australian team for their time and effort in developing this report.

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