thinkstep anz

Embodied Carbon and Circular Economy review

Summary Report 2023

Created by thinkstep-anz for City of Sydney



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Executive summary

Why City of Sydney commissioned this report

The City of Sydney wants to improve the decisions it makes about circular economy and embodied carbon in its operations. You engaged thinkstep-anz to review and summarise documents about circular economy and embodied carbon in the built environment.

The aim of the review was to identify the documents that were most useful, the situations and audiences the documents apply to, and how best you can implement their recommendations. We reviewed a mix of practical guidance, technical guidance and tools and/or metrics that you can use when you develop and procure building and infrastructure projects.

What we did



Stage 1 involved collating documents and reviewing them at a high-level to:

- confirm whether the document could be useful to you
- describe briefly the contents of the document and why (or why not) it might apply to your operations
- recommend whether to include the document in our detailed review (Stage 2).

From the original 73 documents, we shortlisted 14 documents to review in detail.



At Stage 2 we reviewed the shortlisted documents in detail. Our aim was to uncover this information:

- Metrics and tools that are available to measure circularity and embodied carbon.
- Practical guidance that is available to include embodied carbon and circularity in specifications.
- Potential cost/time implications for projects seeking to set embodied carbon and circular economy targets.
- What needs to happen at each stage of the project lifecycle to measure and reduce embodied carbon and build in circularity
- Current examples of industry targets or projects that have successfully reduced embodied carbon or built circularity into their projects.
- Opportunities to connect embodied carbon and circular economy on projects and trade-offs between the two.
- The documents that contain extra resources that might support you.

What we found

These are the main themes of the documents:



The literature summarises metrics and tools (with supporting examples) available to help you develop a strategy. The challenge is to understand which of these tools applies to which project. We recommend a phased approach when implementing tools.



Projects are successfully reducing embodied carbon and incorporating circular economy strategies. The more projects are willing to share data and strategies with industry the better.



Engaging early with contractors and suppliers is essential to meet embodied carbon and circular economy targets.



Some documents provide step-by-step practical guidance to address embodied carbon and circular economy on projects, from the conceptual phase through to operation and maintenance.



Examples of tools for product circularity include the Material Circularity Indicator (MCI) and the Circular Transitions Tool (CTI). For building circularity they include *The Circular Buildings Toolkit* by Arup and the recently published *The Circular Built Environment Playbook* by the World Green Building Council.



Examples of embodied carbon tools include Life Cycle Assessments (LCAs), Environmental Product Declarations (EPDs), the GBCA's upfront carbon emissions calculator and the upcoming NABERS embodied carbon calculator.



Projects need to be approached 'holistically' and topics viewed together.



Noting the above, these factors are important: the context, system (including the project's desired outcomes) and trade-offs between full circularity and other indicators such as embodied carbon.

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1. Introduction

The City of Sydney is trying to improve decision-making around circular economy and embodied carbon relating to their own operations. To support this, they engaged thinkstep-anz to review and summarise several documents relating to embodied carbon and circular economy in the built environment. The intent of the review was to provide recommendations on how useful each document is to the City of Sydney, when it would be useful, for which audience, and how recommendations could be implemented. The documents included a mix of practical guidance, technical guidance, and tools and / or metrics that can be used when developing and procuring for building and infrastructure projects.

1.1. Stage 1 and Stage 2 reviews

The project was broken down into two stages. Stage 1 involved collating a long list of documents and conducting a high-level review of each. The intent of stage 1 was to create a long list of approximately 40 documents. The search was informed by knowledge gained from previous projects, the reference sections of currently available resources, and looking at work published by our industry contacts.

A total of 73 documents were reviewed in total for Stage 1 and each document was reviewed to assess the applicability for the City of Sydney according to the following criteria:

- Whether or not the document might be useful to the City of Sydney's objectives.
- A brief description of the contents of the document, and why (or why not) it might be applicable to the City of Sydney.
- A recommendation for its inclusion in the Stage 2 Detailed Review.

A review meeting was held between thinkstep-anz and the City of Sydney to finalise the list of documents for inclusion in Stage 2. All the documents reviewed in Stage 1 will be supplied in a compressed file to the City of Sydney for future reference. The Stage 1 excel spreadsheet is appended in Annex A as a separated electronic file and Annex B includes a summary of the Stage 2 document review.

Stage 2 of the project involved a detailed review of the prioritised documents. The review aimed to assess:

- Metrics and tools that are currently available for measuring circularity and embodied carbon.
- Practical guidance that is available to support including embodied carbon and circularity in specifications.
- Potential cost/time implications for projects seeking to set embodied carbon and circular economy targets.
- What needs to happen when in the project lifecycle?
- The examples that currently exist in industry of targets, or projects that have successfully reduced embodied carbon or incorporated circularity into their projects.
- Synergies and trade-offs between embodied carbon and circular economy on projects.

- The documents that contain additional resources that might support the City of Sydney.

The findings of the detailed review of short-listed documents are synthesised in this report, and an associated presentation for the City of Sydney.

2. Synthesis

The literature review showed opportunities for the City of Sydney to achieve lower embodied carbon and specify more circular products and materials. These outcomes can be achieved through collaboration between project teams and their supply chains.

The synthesis and recommendations only relate to the City's own operations, assets and properties, covering elements in the City's control, and how they could influence their own procurement spend, tenants, and suppliers. Therefore, the literature review covered aspects relating to the following operational aspects:

- Asset renewal and maintenance of:
- Commercial buildings, including office and retail.
- Community buildings, including heritage buildings, community centres, childcare centres, libraries, sporting facilities, aquatic centres.
- Council buildings, including works depots.
- Parks and related infrastructure.
- Road infrastructure, including cycleways and footways.
- Other public domain infrastructure (e.g., seating, lighting, other furniture, signage).
- Stormwater drainage systems.
- Fit-out/strip-out of commercial buildings and community buildings as listed above.
- Major contract areas:
- IT equipment
- Facilities management
- Park and playground equipment

The City's Environmental Strategy 2021-2025 includes targets for carbon, water, and waste within operations, some of which report to have been met or surpassed, e.g. landfill diversion. Guidance and insight from the literature review will assist to inform further developments of the goals and targets moving beyond 2025.
Note: The synthesis is based only on the documents reviewed in Stage 2 as per the project brief. Where relevant additional insights are provided from alternative sources and referenced as such.

2.1. Overarching themes

The documents included in the Stage 2 detailed review covered three main categories:

- Practical guidance on embedding circularity and embodied carbon targets into project plans and specifications.
- Technical guidance on how to measure and report on embodied carbon and circularity.
- Measurement guidance on tools and metrics currently available in the market for the City of Sydney to use.

Table 2-1 contains a breakdown of the documents by category.

Table 2-1 Document Categories

Category	Document
Practical Guidance	→ Circular Buildings Toolkit → The circular built environment playbook → Circular Economy Metrics: Case Studies for NSW → Zero Carbon Industry Plan: Rethinking Cement → Australian buildings and infrastructure: Opportunities for cutting embodied carbon → Embodied Carbon: Developing a client brief → Taking Action on Embodied Carbon → A practical guide to upfront carbon reductions for new buildings and major refurbishments
Technical Guidance	→ Embodied Carbon & Embodied Energy in Australia's Buildings → The Material Circularity Indicator – Methodology
Tool Specific Guidance	→ Green Star Buildings Upfront Carbon Emissions credit → Green Star Performance Upfront Carbon Emissions credit → NABERS Embodied Emissions Technical Report → Material Circularity Indicator Tool

2.1.1. Key takeaways by document category

Practical Guidance

- → Embedding both embodied carbon and circular thinking into projects requires approaching projects holistically.
- → Engage with suppliers and contractors early in a project. Encourage open discussion and sharing of ideas around all areas of sustainability so you can understand what trade-offs and synergies exist in the project.
- → Embodied Carbon should be incorporated into a project's strategy as early as possible, ideally before concept design.
- → Establishing a benchmark and setting a reference case will usually happen at tender design.
- → Track upfront carbon emissions at each stage of the project to ensure you are on track.
- → Third party product certifications can help with specifying low embodied carbon materials. Certification schemes recognised through the GBCA's Responsible Products Framework are a good starting point.
- → Review embodied carbon strategies and forecast impacts throughout the project at the same time you review costs to ensure you stay on track. Work with suppliers on what low Portland cement blends are available for your project.
- → When reducing embodied carbon in a project, cost implications can come from supply chain barriers.
- → Low carbon concrete can take longer to set and develop strength although industry innovation is reducing the setting times.
- → Using unknown or new materials in a project will add time and risk for contractors.

- It should be possible to reduce cement content in concrete mixes up to 30-40% without any cost implications on a project.
- Through data sharing and sharing of experiences in industry we can start to understand the true trade-offs between decisions.

Technical Guidance

- Embodied carbon emissions are often measured by undertaking a Life Cycle Assessment. Process LCA was identified as the industry's preferred approach during the NABERS consultation process.
- Upfront carbon for a building can be calculated by multiplying the quantity of a specific product and its specific product emissions, adding all product emissions together (modules A1 to A3), plus the associated construction emissions (modules A4 to A5).
- The top six materials that contribute to embodied carbon in building and infrastructure projects are asphalt, concrete, steel, aluminium, clay bricks/tiles, and plasterboard.

Tool Specific Guidance

- Assess which tool would be most useful and understand that there is likely going to be a phased approach to implementation.
- Work with suppliers and internal team to familiarise both with the tool selected.
- Phase in using the tool and monitor adoption.

2.2. Project life cycle

The literature review provided insights into project lifecycles for building and infrastructure development, including where and how to use circular and embodied carbon metrics to measure and report against set targets.

Examples in the literature included that are (or could be) used as standard requirements. Noting that these would need to be familiarised with suppliers and internal teams (including procurement teams) prior to inclusion in specifications.

This review focussed on building and infrastructure projects (including roads) and not general procurement of goods and services; however, many of the principles can be applied across goods and services too. Figure 2-1 provides a simplified schematic of the project lifecycle for building and infrastructure projects. The figure has been drafted from the documents reviewed and not necessarily from one source.

The complexity of the project life cycle will depend on the type, value, and duration of the project. It will also be influenced by project-specific targets and aspirations[1]. Cost will be a factor when determining which of the strategies to implement for which project. Some

[1] GBCA. 2023. A practical guide to upfront carbon reductions: For new buildings and Major refurbishments. https://gbca-web.s3.amazonaws.com/media/documents/a-practical-guide-to-upfront-carbon-reductions.pdf

projects are managed internally, and others will be outsourced to contractors or suppliers. The City of Sydney will therefore need to take a phased and targeted project approach initially to understand the cost and time implications for the requirements specified.

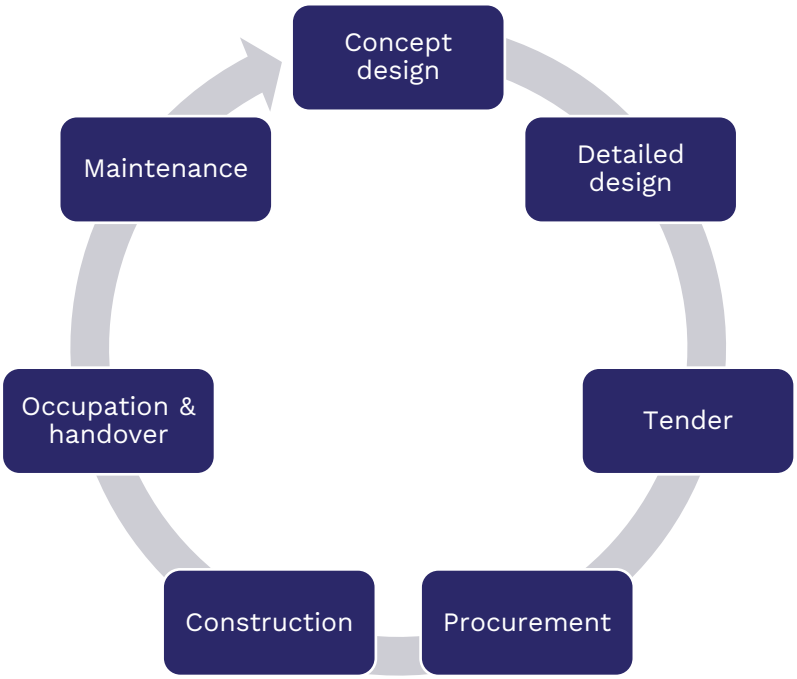


Figure 2-1: Simplified building and infrastructure project cycle (Source: thinkstep-anz)

Concept Design

The concept design phase is important to understand the overarching needs, options, costs and ideas about the proposed project. Many of the documents reviewed highlighted the importance of this stage of the design process as an opportunity to understand where the most impact can be had early in the process.

- The “build nothing” consideration - review what opportunities are available to retain existing structures and/or facades, furnishings etc.
- Where retention is not an option, adopt low-carbon and circular approaches in material/product selection and design.
- Consider the projects targets, including circular aspirations or lower embodied carbon. Record the intentions to measure and report selected targets and communicate these to all members of the project team.
- If the budget allows commission an assessment to determine the circularity and embodied carbon study of the initial design. This will highlight hotspots, where early changes could be made in the project design and will provide a useful point of comparison for later in the project.
- Understand where the critical decision points are for the project. These critical decision points also affect commercial teams including subsequent phases. The design and material choices will affect layout and product specifications which, in turn, affect aesthetics, comfort, durability and saleability.

Figure 2-2 provides a snapshot from the UK GBC (2019) of strategies to be considered at the conceptual design phase and implemented at each stage of the project lifecycle including examples for furnishing and fit-outs.

Additional circular principles to be discussed in the conceptual design phase beyond reuse (including refurbishing and repurpose) include:

- Design buildings and infrastructure for optimisation (including longevity; flexibility; adaptability, assembly, disassembly and recoverability)[2].
- Standardisation or modularisation (e.g., using standard designs to enable future recovery of elements)
- Products as a service and leasing (including proactive maintenance; alternative payment options for the service, e.g., lighting)
- Design and construct responsibly (including using low impact materials, using recycled content or secondary materials, designing out waste)

[2] Optimisation can refer to buildings, infrastructure or products specifically, e.g. modular buildings; or using glass as a sand replacement in road construction; or office furnishings that are designed and built to last.

Lifetime strategy and tactics

Table 2. *Sets out examples of the lifetimes of different elements and 'layers' of the building and the different strategies and tactics that can be applied.*

		Short life components		Long life components	
	Lifespan	0-5 years	5-10 years	20-30 years	30-300 years
	Example components	Internal finishes, furniture	Internal partitions, ceilings, floors, local services	Building services	Sub-structure, structure, floors, fabric
	Overall strategy	Match material to lifespan, design for disassembly and return to manufacturer	Design for reconfiguration, use modular systems	Design for maintenance, replaceability, remanufacture	Long life, loose fit Adaptable to different uses Temporary buildings designed to be relocatable
Principles and examples of application	Designing in layers	Ensure finishes allow access to services	Non-structural partitions	Services to be accessible and replaceable	Avoid interdependency of structural frame and facade
	Lean design	Inherent finishes	Exposed soffits Modular tea points	Design out systems	Lightweight structures
	Design out waste and use of reclaimed materials/ components	Remanufactured furniture; remanufactured paint	Reclaimed glass partitions	Modular systems, offsite manufacture to reduce site waste Challenge supply chain to provide remanufactured equipment	Offsite manufacture Standardised components Select grids that optimise material efficiency
	Partnership models and return to manufacturer	Lease components or arrange for return to manufacturer	Design interiors that can be reconfigured or disassembled	Leasing service arrangements for items such as lifts and lighting	Select elements that can be reused or returned to manufacturer
	Materials selection	Use biological materials that can be composted at end of life or certified products (e.g. C2C / Natureplus)	Use partitions made from bio -composites Use certified products (e.g. C2C / Natureplus)	Use plant and equipment that can be remanufactured Fabric ductwork	Structural elements with recycled content Certified facade systems
	Design for disassembly	Use furniture and fittings designed for disassembly	Dry-lay floor tiles Relocatable partitions	Equipment and distribution systems that are modular	Structure and facade that is designed with reversible mechanical fixings

Figure 2-2 Screenshot regarding circular economy guidance for construction clients. (Source: Extract from page 20, UKGBC, 2019[3]).

[3] UK GBC. 2019. Circular Economy Guidance for construction clients: How to practically apply circular economy principles at the project brief stage. https://www.ukgbc.org/wp-content/uploads/2019/04/Circular-Economy-Report.pdf. This document was not part of the formal review, however this table was considered to have important insights for the purpose of this project.

Detailed design

Detailed design requires more information and testing of assumptions from the earlier stages. This is where it is important that there is alignment with the project team regarding any communicated targets and monitoring requirements. It is also a further opportunity for identifying further innovation within the project.

Tender

This phase broadly refers to all elements within the tender stage including when the tender documents are drafted prior to calling for bidders to respond. This is where specifications and requirements of the project need to be clear enough for all bidders to be able to respond in a standardised way.

Specifications for embodied carbon or circularity may not be relevant for all projects, so the following will need to be reviewed for applicability.

- If including embodied carbon as a specification, submissions should include calculations and results. Prior to any publicly available benchmarks or standardised tools, a useful method can be to set up a project specific benchmark that represents conventional construction (i.e., for buildings, infrastructure or materials) using the following principles:
  - Ensure the project uses a legitimate reference case – one that would proceed if upfront carbon reduction was not a key driver
  - Similar construction methods
  - Similar site constraints
  - Similar building typology (if a building project, but relevant for infrastructure too)
- Requirement for data updates as the project progresses

The following provides additional criteria for consideration:

- Assessment boundary and study period: For example, the boundary may be cradle to completed construction, cradle-to-grave, or cradle-to-transfer of ownership etc. The study period could be 10 years, 20 years, 30 years, 60 years etc.
- Assessment scope: For example, the full project; structural components only; fit-out only; earthworks, demolition, all construction materials, construction operations and maintenance only. Please note that the NABERS embodied carbon rating tool currently in development preferred scope will be cold shell.
- Assessment standards and calculation methodology: Be sure to specify if the project is seeking certification through a rating tool like Green Star. Life Cycle Assessments should comply with ISO 14040 and 14044. Where EPDs are specified, they should comply with EN 15804 and be verified to ISO 14025. The GBCA and NABERS have released an interim guide for upfront carbon emissions calculations (Please refer to Section 4 Resource Library).
- Data and tools: Specify preferred data sources or calculation tools. Product-specific EPDs are becoming more accessible, with industry-wide EPDs or robust general databases being used if they are unavailable[4]. Currently the EPiC database is

[4] GBCA. 2023. A practical guide to upfront carbon reductions: For new buildings and major refurbishments. https://gbca-web.s3.amazonaws.com/media/documents/a-practical-guide-to-upfront-carbon-reductions.pdf

commonly referred to and used as a source, however, there are some uncertainties with the current data set. Other industry bodies are working on alternatives which will provide updated data sets that should be available within the next year. Therefore, should the data be used in the interim, ensure to include a qualifying statement including the reference.

Construction

The construction phase (broadly intended here to mean physical construction, refurbishment etc) should include continuous monitoring against the specifications included in the tender documents, e.g. (1) if the specifications have included embodied carbon, then continue updating the upfront carbon measurements as construction progresses to keep the project on track, (2) monitoring of the materials being supplied against circularity indicators provided in the tender submission. Should the project be managed internally, the above examples can still be applied.

Handover and Operations

Handover in this instance will also include maintenance, as the City of Sydney will usually continue to own and operate or lease out the asset, so there is an ongoing ownership or oversight role.

If the project was a design and construct, then operations and ongoing monitoring should be against the initial design and construction. This would include ongoing reporting on efficiency but also in terms of preventative maintenance, repair and ongoing leasing of products and services.

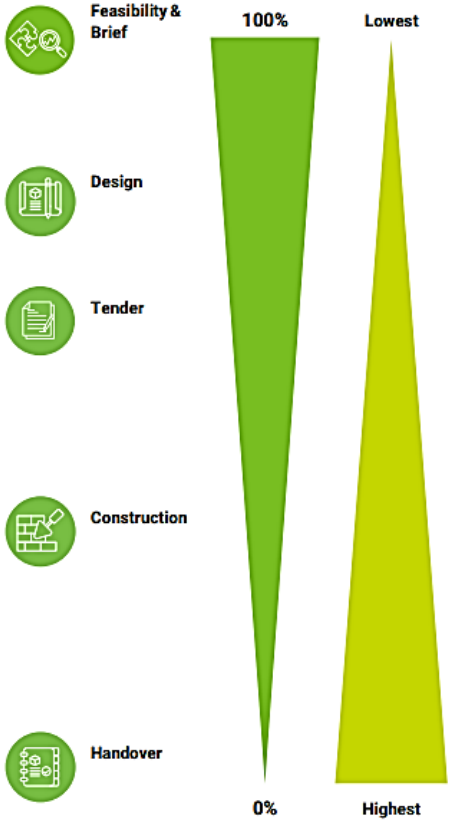
Presenting the results: The tender brief should state how the results are to be presented. It could also request a list of reduction strategy suggestions[5].

The following figures provide examples of where carbon (Figure 2-3 and Figure 2-4) can be reduced throughout the different project stages and where circular economy principles can be included throughout (Figure 2-5).

[5] UK GBC. 2017. Embodied carbon: Developing a client brief. https://www.ukgbc.org/wp-content/uploads/2017/09/UK-GBC-EC-Developing-Client-Brief.pdf

Reducing carbon at each stage of the process

Addressing upfront carbon emissions from the earliest stages of a project allows for the implementation of effective strategies that reduce the overall environmental impact. Calculating upfront carbon is something that should be done multiple times during the development of the project. Doing so allows progress to be compared against targets.



Stage	Potential reduction	Calculation certainty	Options available	Things to consider	Data used
Feasibility & Brief	100%	Lowest	Re-use an existing building, or maximise the reuse of existing building components, with a focus on retaining structure and envelopes. For new buildings, adopt low-carbon design approaches in material selection and design options.	Identify components with the highest carbon contribution, likely in the substructure, superstructure and envelope and major services. Answer the key question: How much new space is needed?	Calculations are likely to use more generic material data, as specific materials will not be selected yet. Future calculations can be compared against this stage, but be careful that the emissions reductions aren't occurring due to changing data sources.
Design			Optimise the shape and design of the building, reduce the quantity of materials, and increase modularity and future adaptability.	This stage offers an opportunity to reduce complexity in the design and save carbon. Consider the shape and volume of the new building, and specify low carbon materials.	As the design is refined, calculations should be updated regularly to reflect changes.
Tender			Look for opportunities to reduce the carbon in the structure and envelope. Seek innovative solutions in the tender with a focus on low-carbon materials. Ask specifically for the tender response to calculate carbon alongside the price. Collaborate with suppliers and contractors to further reduce the project's carbon footprint throughout the supply chain.	Set out clear guidelines for contractors to respond to in the calculations, as depending on how the calculate, they may get a lower result without providing a benefit. There are still opportunities to reduce carbon in materials, future construction practices, and options for suppliers and contractors to offer innovative solutions.	The calculations should require product-specific EPDs where known, with industry-wide EPDs or robust general databases to supplement them. Where possible this information should be included within the BIM model for the project.
Construction			The implementation of efficient construction practices, such as just-in-time delivery, use of low-carbon construction equipment and renewable fuels, contributes to lowering the project's carbon emissions. This is also a key time to ensure transport and construction process emissions are monitored and reduced. The construction stage offers the opportunity to reduce fossil fuel use on-site.	With targets set, continue reviewing during construction. As suppliers are selected and product-specific EPDs are sourced (where available), update the calculation. This process should be repeated when any changes occur to monitor and confirm alignment with reduction targets.	There should be bills of quantities for all materials at this stage and a robust upfront carbon calculation that should be able to be confirmed against targets. The BIM model should continue to be updated.
Handover			Whilst handover marks the end of the project, strategies such as design for disassembly or reuse will help reduce the upfront carbon of future refurbishment or maintenance projects.	The builder should collect all final quantities and EPD information and make them available for final documentation.	At this point, a final calculation is done, and reviewed against targets.

Figure 2-3 Option for Embodied Carbon Reduction at each project stage. Taken from a practical guide to Upfront Carbon Reduction. Page 13. (Source: GBCA. 2023. A practical guide to upfront carbon reductions: For new buildings and major refurbishments. https://gbca-web.s3.amazonaws.com/media/documents/a-practical-guide-to-upfront-carbon-reductions.pdf).



Figure 2-4 Taken from Acting on Embodied Carbon (Source: Built, 2021[6]).

[6] Built. 2021. Taking Action on Embodied Carbon. https://www.built.com.au/news/taking-action-on-embodied-carbon/

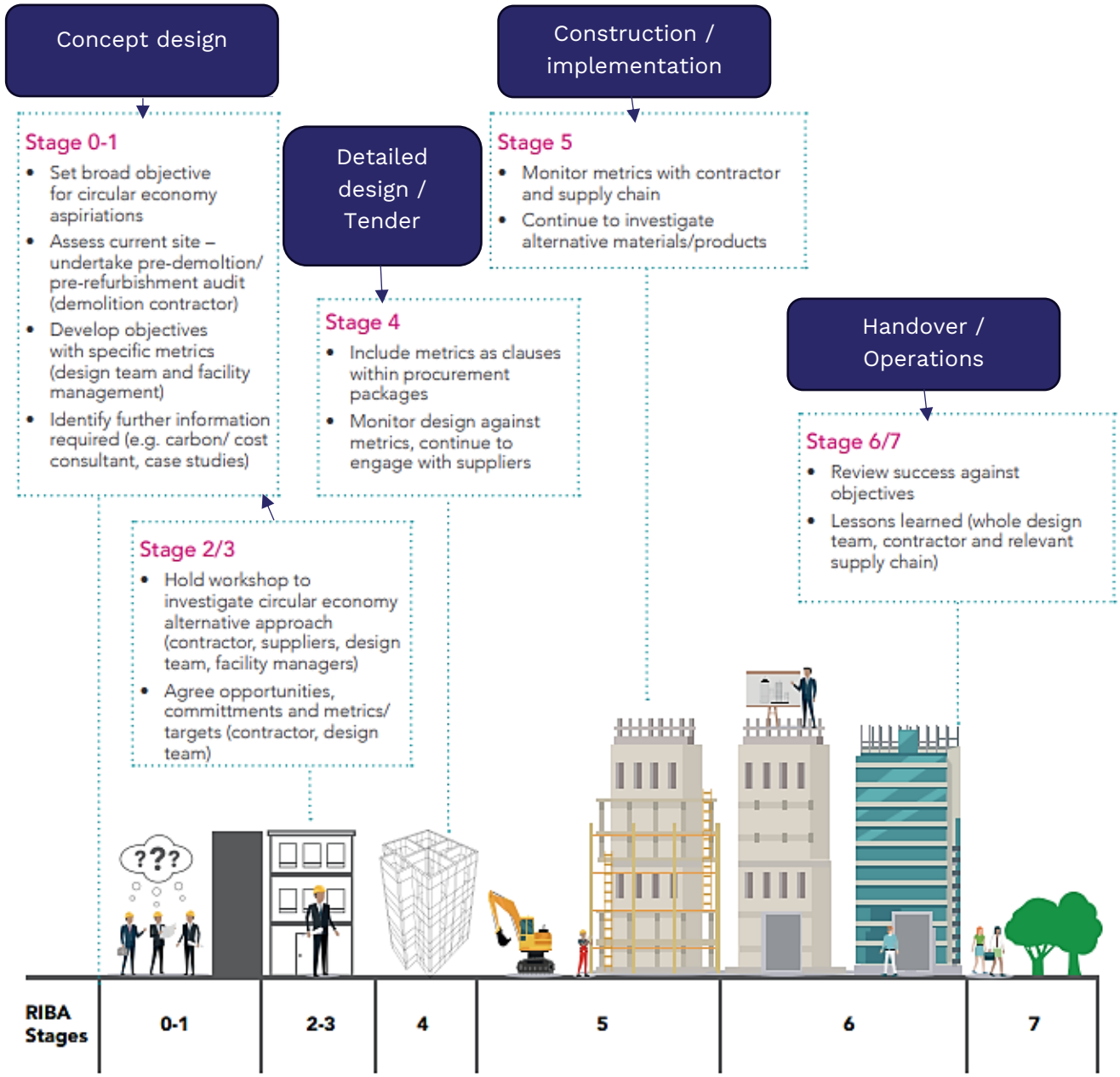


Figure 2-5: Methods and stages to include circular economy principles linked to project cycles (adapted from UK GBC, 2017[7])

[7] UK GBC. 2017. Embodied carbon: Developing a client brief. https://www.ukgbc.org/wp-content/uploads/2017/09/UK-GBC-EC-Developing-Client-Brief.pdf

2.3. Cost/time implications for projects

There will always be a cost/time implication for new methods initially, and project teams might be wary of reducing embodied carbon or including circular design. The literature provided examples where using these approaches realises a positive gain despite upfront cost (financial or time wise). In the Taking Action on Embodied Carbon report[8], Built identify that they are regularly able to achieve a 30-40% reduction in Portland cement content with no cost implications or performance impact on the project.

Other findings include:

- Uncertainties in the supply chain can have significant implications for project budgets. Maintaining collaborative relationships with suppliers and contractors can help mitigate this.
- Some low carbon concretes can have longer setting times than traditional mixes. However, the Rethinking Cement document[9] suggests that geopolymer concrete has the same setting time as traditional concrete.
- Upskilling of contractors to use materials that they are not familiar with can have time implications for projects.

2.4. Metrics and tools

Whilst there are numerous metrics and tools to calculate embodied carbon and understand circularity, there are a few well respected and often used metrics and tools that can and should be used (refer to 2.4.1).

As a starting point, the City of Sydney could include the need for products and materials that have achieved a third-party certification demonstrating a commitment to contributing to low-carbon and circularity goals. Metrics such as the NABERS Embodied Emissions Tool due for release in 2024, could be included in specifications for building and infrastructure projects and materials (refer to 2.4.1).

A library or database of suppliers and materials should be initiated in the interim that includes the following information:

[8] Built. 2021. Taking Action on Embodied Carbon. https://www.built.com.au/news/taking-action-on-embodied-carbon/

[9] Zero Carbon Australia. 2017. Zero carbon industry plan: Rethinking cement. https://bze.org.au/wp-content/uploads/2020/12/rethinking-cement-bze-report-2017.pdf

- Lifecycle Analysis (LCA) and Environmental Product Declaration (EPDs)[10]
- Third party assessed accreditation, e.g., Cradle2Cradle certified[11]; Global GreenTag[12]; Good Environmental Choice Australia.[13]

2.4.1. MCI, CTI and upfront carbon

Measuring and reporting on material and product circularity is becoming more topical beyond LCAs, EPDs and environmental eco label certifications. The Material Circularity Indicator (MCI) and the Circular Transition Indicator Tool (CTI) are the best examples of tools in use out of the many that exist.

Material Circularity Indicator (MCI)

The MCI developed in collaboration with the Ellen MacArthur Foundation, is a measure of how circular a product is. The calculator uses MCI to assign a value to a product. MCI has a scale of 0 to 1.

- 0 to <0.1 is the worst score, with the product use or functional life less than industry average
- 0.1 is a fully linear product with a utility or use similar to the industry average (bad score)
- 1 indicates a fully circular product (best score)

Linear means a 'take-make-dispose' model. Circular economy models are things like refillable milk bottles or jeans you can rent.

MCI tracks material flows from virgin stock, to use and eventual reuse. Its focus is on the materials going in and the waste coming out along each step of a product's lifecycle, including a product's utility.

Examples of a simplified MCI tool can be found here and example of a company using MCI within their EPD, e.g. Infrabuild, here.

Circular Transitions Indicator (CTI)

The CTI, developed by the World Business Council for Sustainable Development (WBCSD) provides help to businesses in different industries worldwide to measure and improve their circular performance by supporting and guiding companies through the Circular Transition Indicators process.

[10] A product that has conducted an LCA and then an EPD does not mean that the product is a more sustainable product, but it does provide information and data about the product to assist decision-making. Australasia EPDs are publicly available at EPD Australasia as well as many other sites.

[11] A list of certified products can be found here.

[12] A list of certified products can be found here.

[13] A list of certified products can be found here.

The tool structures data and calculates outcomes, supporting businesses in taking tangible actions toward circularity goals. It also supports users to reach out to internal stakeholders and value chain partners for data requests that avoid confidentiality issues.

Several case studies where the CTI tool has been used can be found here.

Upfront carbon emissions

The GBCA has developed an upfront carbon emissions calculator and calculator guide to support projects targeting the Upfront Carbon Emissions credit in Green Star Buildings. The calculator uses data from the Environmental Performance in Construction (EPiC) Database[14]. It is a simple calculator for projects not conducting a life cycle assessment and determines the emissions from Modules A1 to A3 (Cradle to gate), refer to Figure 2-6. The calculator needs to be accessed through the GBCA's online platform.

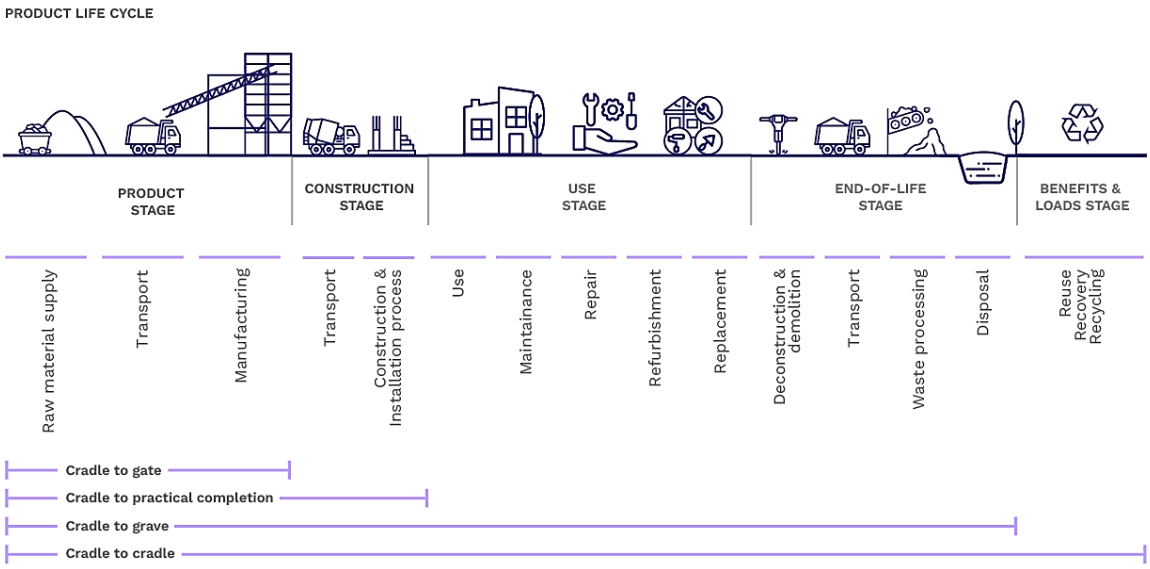


Figure 2-6: LCA Product life cycle. Modules A1-A3 refers to "cradle to gate" assessments (Source: thinkstep-anz)

The calculator provides the following information:

- Guidance on meeting requirements of the Upfront Carbon Emissions credit
- Reduction in upfront carbon emissions
- Results for the Upfront Carbon Emissions credit
- Upfront carbon emissions of the existing building(s), retained building, and demolition works

With funding from the NSW government, NABERS are developing, a rating system for measuring, benchmarking, and certifying embodied emissions in new buildings and major

[14] Environmental Performance in Construction (EPiC) Database (www.epicdatabase.com.au) Crawford, R.H., Stephan, A. and Prideaux, F. (2019) Environmental Performance in Construction (EPiC) Database, The University of Melbourne, Melbourne.

refurbishments across Australia. NABERS are working in partnership with key stakeholder groups to design a rating system that is simple and reliable. The NABERS Embodied Emissions tool will be designed to be aligned with other widely used building sustainability schemes, such as Green Star.

The tool is expected to be available for use in about 12 months, in 2024.

2.4.2. Circular procurement

The report authored by Circular Australia and UTS (2022) state that Green Public Procurement (GPP)[15] is already used in many cases and is a metric used to measure the share of green procurement by governments. To be effective, GPP requires the inclusion of clear and verifiable sustainability criteria for products and services in the public procurement process. The calculation includes using GPP criteria as a ratio of total procurement volume or value. This metric can be reported in % or in absolute figures.

Shifting to more circular procurement examples include leasing of uniforms, car sharing, office stationery and supplies (especially in construction, building fit outs & transportation sectors)[16].

In the construction sector this refers to the reuse and recycling of building materials such as concrete, elimination of harmful substances and pollution, energy efficiency and preparing for end-of-life design for disassembly.

In the infrastructure and transport sectors this refers to road construction, street lighting and procurement for transport, including cars, carsharing, e-bikes, electric buses, and ambulances.

An example of an approach to circular procurement is the use of glass as a sand replacement for virgin sand (refer to Box 1). This case study is an example of a collaborative approach and one in which the City of Sydney is a contributing partner. There may be additional opportunities for other materials that could be considered, perhaps in terms of the reuse of building materials across municipalities, or the storage of materials etc.

[15] Circular Australia and UTS. 2022. Circular Economy Metrics: Case studies for NSW. https://circularaustralia.com.au/wp-content/uploads/2022/11/Circular-Economy-Metrics-Case-Studies-for-NSW-Nov-22.pdf

[16] *Circular Australia and UTS. 2022. Circular Economy Metrics: Case studies for NSW.* https://circularaustralia.com.au/wp-content/uploads/2022/11/Circular-Economy-Metrics-Case-Studies-for-NSW-Nov-22.pdf

Box 1:
Paving the Way to Sustainable Roads Southern Sydney Regional Organisation of Councils (SSROC) generates 71,000 tonnes of municipal glass waste annually, of which approximately 65% is recycled locally. Paving the Way is a 16 council-led procurement of asphalt with recycled crushed glass as a substitute for natural sand, creating a local market for kerbside glass and driving regional infrastructural investment. The initiative has created a local closed-loop market for approximately one-third of participating councils' domestic glass collections (80 million glass bottle equivalents per year), reduced greenhouse gases, and driven essential infrastructural development and job creation through a large-scale procurement of asphalt with recycled crushed glass (RCG) as a substitute for natural sand.

The largest council-led procurement of its kind in NSW, aggregated demand from 16 participating Sydney councils and Transport for NSW, through parallel market approaches, have doubled statewide demand for RCG. An innovative contract model reports on sustainability KPIs and an innovation clause is facilitating next-generation materials. The Sustainable Pavements contract resulting from the procurement commenced on 1 July 2021. Some of the anticipated results are:

- A scalable and replicable framework for end-to-end engagement, analysis, procurement, contract, and communications.
- Creation of a local market for all remaining recoverable domestic glass in SSROC equivalent to 80 million glass bottles/year.
- Triple bottom line cost-benefit analysis indicates $1.19 of value generated for every $1 invested in the initiative.
- Reduction in greenhouse gas emissions by approximately 1,900 tonnes per annum
- Reduced interstate transportation of used glass.
- Together with TfNSW, doubled state-wide demand for RCG.

(Source: Circular Australia and UTS. 2022. Circular Economy Metrics: Case studies for NSW. https://circularaustralia.com.au/wp-content/uploads/2022/11/Circular-Economy-Metrics-Case-Studies-for-NSW-Nov-22.pdf - Document 34 in the Stage 1 & 2 Review)

2.5. Practical guidance

Examples of practical guidance from the various documents are presented below and hyperlinked for ease of reference.

Refer to : Circular economy guidance for construction clients: How to practically apply circular economy principles at the project brief stage | UKGBC

→ This guidance is designed to enable construction clients to include more ambitious circular design and construction principles in project briefs for non-domestic built assets. This is achieved by addressing the common commercial obstacles that clients

may encounter and providing practical support and evidence to assist them in setting clear circular objectives for their construction projects.
- The guidance also aims to ensure that the construction supply chain can effectively deliver circular economy goals and that budget, project management, and timescale risks are all minimised and mitigated.
- This guidance is directed at construction clients who are writing project briefs which are looking to pursue circular economy principles in their developments.

Refer to: A Practical Guide to Upfront Carbon Emissions | GBCA

- Provides information on reducing upfront carbon emissions in new buildings and major refurbishments. The guide outlines steps to be taken during the design and construction process and offers solutions for common challenges.

Refer to: Embodied Carbon: Developing a Client Brief | UKGBC

- Step-by-step guidance on how to address embodied carbon in a client brief, including example wording.

Refer to: Taking Action on Embodied Carbon | Built

- Step-by-step guidance on how Built as Head Contractors approach meeting embodied carbon targets in buildings. Refer especially to chapters 2 and 3.
- Provides useful resources and guidelines and tools for use (refer to page 41).

2.6. Synergies and trade-offs

Synergies and trade-offs are mentioned frequently in the literature. Overarching messages from the literature include the following:

- Embedding both embodied carbon and circular thinking into projects requires approaching projects holistically.
- Engage with suppliers and contractors early in a project and encourage open discussion and sharing of ideas around all areas of sustainability so you can understand what trade-offs and synergies exist in the project.
- Through data sharing and sharing of experiences in industry we can start to understand the true trade-offs between decisions.

2.7. What good practice examples are there in industry?

SubStation No. 164, Sydney and 4 Parramatta Square, Parramatta

Located in Sydney and Parramatta, SubStation No. 164 and 4 Parramatta Square are two very different Built projects that each achieved significant upfront carbon reductions through different strategies.

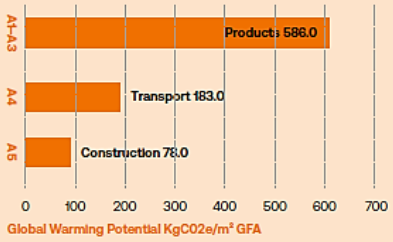
SubStation No. 164, Sydney



This project achieved a 21% reduction in upfront carbon emissions which was primarily accomplished through the following strategies:

- Substantial retention of the existing brick façades, walls, floors and columns. Heritage floors were used as formwork for the concrete floor topping which also enabled the required fire ratings to be achieved.
- An integrated design process between the design team and Built's design managers and structural engineer consultant.
- Structural efficiencies were found that enabled the deletion of a main column and reductions in structural walls.
- Concrete mixes with an average 44% cement replacement were used.

21% reduction in upfront carbon emissions



SubStation No. 164 is a boutique project that features the adaptive re-use of two heritage buildings. With 7,659m² commercial Net Lettable Area (NLA), it consists of a steel structure, that supports a striking seven-level, triple glazed curvilinear glass extension atop the restored buildings so that it seems to float above the streetscape.

The heritage buildings include a 110-year-old timber and brick warehouse and the last DC Electricity substation operating in Sydney completed in 1927. Both buildings lay unoccupied for over 30 years making their renovation and re-lifing a testament to sustainable development.

4 Parramatta Square, Parramatta



4 Parramatta Square is a new post-tensioned, reinforced concrete tower with approximately 70,000m² commercial NLA over 33 storeys and provides office accommodation for three NSW Government agencies. Developed by Walker Corporation, it is located beside Parramatta train station and within the Parramatta Square urban redevelopment.

This project achieved a 33% reduction by employing the following strategies:

- Structural rationalisation removed 2,300m³ of concrete at various strength mixes and shifted higher strength concrete into lower strength mixes, including reducing 100MPa concrete by 23,000m³, replaced with 65MPa, 50MPa and predominantly 40MPa mixes.
- Structural rationalisations removed 2,000 tonnes of reinforcing steel from the tender design.
- Average cement reduction of 32% across all mixes.
- Replacement of chilled beam mechanical system with low-temp VAV saving 33 tonnes of copper and 13 tonnes of black steel pipework and the aluminium and steel in 3,170 chilled beams.
- Rationalisation of curtainwall façade modules from 1200mm to 1800mm, saving 33% of the aluminium mullions or 60 tonnes of high embodied carbon aluminium.

33% reduction in upfront carbon emissions

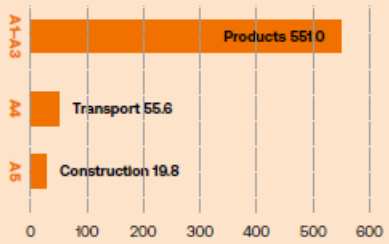


Figure 2-7 Screenshot from Taking Action on Embodied Carbon. Page 37. Source: (Built, 2021).



Figure 4.4: Precast footpath sections made from Zeobond's E-Crete at Salmon St Bridge, Port Melbourne



Figure 4.5: Retaining walls made from Zeobond's E-Crete at Swan St Bridge, Melbourne



Figure 4.6: Pavement made from Zeobond's E-Crete at Thomastown Recreation and Aquatic Centre.



Figure 4.7: E-Crete precast panels at Melton Library

Case study: Geopolymer concrete helps win national award

The use of geopolymer concrete in precast panels helped get a Melbourne library a five star Green Star rating in 2014. It was the first time that geopolymer precast panels used in a structural setting have ever been awarded innovation points towards a Green Star rating in Australia.

Zeobond's E-Crete product was used in precast panels, footpaths and in-situ works in the Melton Library and Learning Hub, in Melbourne's north-west.

More than 30 precast 40 MPa E-Crete panels make up the exterior of the building.

The building won multiple awards in 2014, including the Master Builders Australia National Environment and Energy Efficiency Commercial Building Award.

Figure 2-8 Screenshot from Rethinking Cement report. Source: (Beyond Zero Emissions, 2017, page 30).

Case Study: 25 King Street

Building typology
High-rise, multi-storey

Location
Brisbane, QLD

Sector
Commercial

Developer
Lendlease

Builder
Lendlease

Procurement
Design & Construct

Key Influences

Key outcomes
CLT and Glulam structure and finishes

Average 40% Portland cement reduction

At 52 metres tall and 14,965 m² of office NLA spread across 10 floors, 25 King Street is Australia's largest commercial office building constructed with Cross Laminated Timber (CLT) and glue laminated timber (Glulam). As part of the $2.9 billion renewal of the Brisbane Showgrounds in Bowen Hills QLD, the project sits within one of Australia's biggest urban renewal initiatives. Now home to its engineering team Aurecon, it holds many sustainability ratings including a 6 star Green Star Design and As-Built rating, NABERS 6 star office energy, 4.5 star water and 3.5 waste ratings and Carbon Neutral certification for base building and a Platinum WELL Shell and Core rating.

The project team wanted a building that would visibly express sustainability and engineering. Since concept stage, upfront carbon emissions and decision to build with timber was established.

25 King Street reduced upfront carbon within Modules A1 –A3 by 38.7% when compared to a reference building

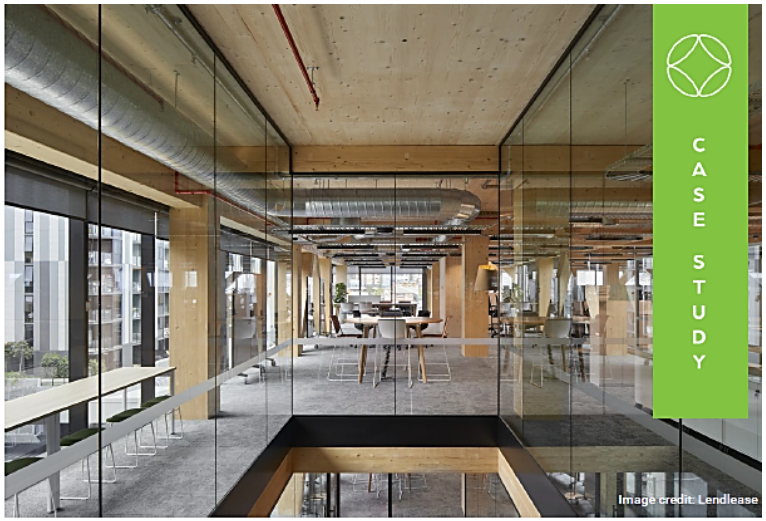
The key upfront carbon reduction design initiatives at 25 King Street included:

- Engineered timber was used in lieu of carbon intensive concrete and steel for structural columns and beams
- Minimalist internal finishes with CLT cladding and flooring with no suspended ceilings systems throughout
- 40% reduction in overall Portland Cement use

A Life Cycle Inventory was established from the building cost plan, preliminary bill of quantities and site construction bill of materials, as well as drawings, specifications, environmental product declarations and the like, using the GaBi Professional + Extension Database. The scope for upfront carbon was Modules A1 to A3.

The Reference Project comprised of a standard concrete/steel construction, while the Proposed Project was of a Cross Laminated Timber (CLT) and Glulam structure. The structural design of the two cases is consistent, using a post and beam construction, however the physical quantities of structural materials (concrete and steel compared with CLT and Glulam) vary between the Reference Project and the Design Case. These quantities of structural materials have been determined for both the Reference and Design Cases by engineering and cost planning experts and the bill of quantities. Where data was unavailable, the study uses estimated inputs based on similar projects.

The focus on sustainability within design attracts more and higher quality tenants and lower vacancy risk. 25 King Street offers high-end office space with strong lease covenants. Its tenants, as reported by IIG, have been attracted by 25 King's amenity, innovation and overall quality, including the extensive use of engineered timber to drive environmental performance.



> 25 King has set a new benchmark for sustainability, occupant wellbeing and building performance. A low carbon, low waste and highly energy efficient building that also puts health and wellbeing at the heart of its design.
>
> ANN AUSTIN | Head of Sustainability – Australia, Lendlease

Figure 2-9 Screenshot from a practical guide to upfront carbon reductions. Source: (GBCA, 2023, page 36).

3. Recommendations and next steps

The literature review has provided a host of information on the current thinking for circular economy and embodied carbon considerations in building and infrastructure projects. The review is the result of a particular moment in time and developments within the circular economy and embodied carbon space are evolving. In Australia the landscape is changing, with the establishment of the Circular Economy Ministerial Advisory Group to guide Australia's transition to a more circular economy by 2030[17]; and embodied carbon initiatives and subsequent measurement tools being developed by NABERS[18].

The scope of the project was to provide an overview of the 14 documents reviewed and propose how these may provide direction for the City of Sydney in the development of a strategy going forward.

Many tools, ideas and examples have been provided, but where should the City of Sydney start?

It is recommended that first steps should include areas of the supply chain where there is already familiarity about sustainable practices. This may be through procurement (i.e., products and materials). As a start, capture how many of these products have third party certifications to understand the maturity of the suppliers. In parallel, obtain additional assistance to identify which third party assessment certifications would be recognised by the City.

Building and infrastructure projects present great opportunities to test practices. The Bay Street East Depot project already includes ambitious embodied carbon and circular requirements. As Arup are involved with the Head Design Consultant, their experience could be leveraged to see what aspects of circularity and / or embodied carbon can be brought to the fore through the use of their Circularity Buildings Tool.

The projects pipeline should be reviewed to see which are still in the design phase and could be influenced. The City of Sydney could develop internal systems and methods of measuring, monitoring and/or managing both circularity and embodied carbon on their suite of projects at different lifecycle stages.

In closing, this literature review presents a snapshot of ideas that can be adapted and applied to the needs of the City of Sydney and the projects and assets being managed. It will require a phased approach and increasing awareness of the supply chain along the way along with measurement and monitoring progress.

[17] Department of Climate Change, Energy, the Environment and Water. 2023. Circular Economy Ministerial Advisory Grouphttps://www.dcceew.gov.au/environment/protection/circular-economy/ministerial-advisory-group#chair-professor-john-thwaites-am

[18] Nabers. 2021. NABERS Embodied emissions initiative. https://www.nabers.gov.au/publications/nabers-embodied-emissions-initiative

4. Glossary

Term	Definition
Circular economy	A circular economy is an economy that keeps products and materials in use, designs out waste and pollution and regenerates natural systems. It is a more resilient alternative to the traditional linear economy, sometimes referred to as a 'take-make-dispose' model.
Cradle to cradle	Cradle to Cradle Certified® is the global science-based standard for products that are safe, circular and responsibly made. The certification provides designers, manufacturers, and suppliers with a framework to continually improve what products are made of and how they are made.
Cradle to gate	Cradle to gate is an assessment of a partial product life cycle from resource extraction to the factory gate, before it is transported to the next step in the manufacturing supply chain. The use phase and disposal phase of the product are omitted in this case.
Cradle to grave	Cradle to grave assessments consider impacts of a product's life cycle, from the time natural resources are extracted and processed, through each stage of manufacturing, transport, product use, and ultimately, disposal.
DISER	Department of Industry, Science and Resources
GBCA	Green Building Council of Australia
NABERS	National Australian Built Environment Rating System
GECA	Good Environmental Choice Australia

Term	Definition
Ecolabel	An ecolabel is a mark or logo that can help consumers or other purchasers quickly identify products that meet specific environmental performance criteria. They range from an 'organic' sticker on an apple or a recycling number on packaging to a EPD of an entire train. They follow internationally recognised principles and provide information about a product or service in terms of overall environmental benefits, such as packaging, if it is recyclable and free of noxious ingredients. There are three kinds of environmental labels: Type I eco-labelling schemes with clearly defined criteria for products. These schemes award the label to products or services certifying against a science-based standard specific to their category, for example, furniture or cleaning services. Type II self-declared environmental claims for products and services where there are neither criteria nor labelling schemes. The standard defines and clarifies commonly used terms like 'eco-friendly', 'energy efficient' or 'organic'. Type III environmental declarations – or EPD that look at the environmental impact of a product using a life cycle approach.
Embodied Carbon	Emissions produced over the life cycle of a product, building or infrastructure project are generally put into two groups: operational emissions and embodied emissions. Operational carbon emissions occur during the use stage. They come from all the energy sources used to keep a building warm, cool, ventilated, lighted and powered. Embodied carbon emissions stem from the materials and products the building is made from and can occur right across the building's life cycle. Upfront embodied carbon emissions refer to emissions arising from manufacturing, transporting, and installing a product before it is used. Whole-of-life embodied carbon also includes carbon emitted for maintenance and end-of-life of a building or infrastructure project.
EPD	An Environmental Product Declaration is a certified public summary of a product's environmental impact over its life cycle. Based on international standards and independently verified, it is widely recognised by industry and governments.

Term	Definition
LCA	Life Cycle Assessment is a tool that measures the environmental footprint of a product or service over its life cycle and value chain. It provides information to help businesses understand, manage and communicate their environmental impacts. There are international standards that set out the principles and frameworks for LCA (ISO 14040), specify requirements and provide guidelines (ISO 14044). It is often referred to as life cycle analysis. The 'father of modern-day LCA', Jim Fava who coined the term 'life cycle assessment', prefers 'assessment' as it goes deeper than just analysing.
MCI	The Material Circularity Indicator (MCI) measures how 'circular' or reusable a product is. It follows circular economy principles and focuses on keeping materials in use for as long as possible, through repair and maintenance, reuse, refurbishment, remanufacture and recycling. The MCI has a scale of 0 to 1, with 0.1 indicating a linear process ('take-make-dispose') and 1 indicating a fully circular one. Systems like refillable milk bottles or jeans you can rent would likely score highly on MCI. Learn more with our free online MCI Calculator.
Scope 1, 2 & 3	Greenhouse gas emissions are categorised into three groups or 'Scopes' by the Greenhouse Gas Protocol. Scope 1 emissions are direct greenhouse emissions from sources that are controlled or owned by an organisation (e.g., emissions from fossil fuels used to operate boilers or company vehicles). Scope 2 emissions are indirect GHG emissions from the electricity, heat or steam an organisation buys. Scope 3 is where it gets more complicated. It includes all other emissions that occur in a company's value chain from employees' commuting, waste disposal, business travel and investments to all purchased goods and services.

For additional terms and words often used refer to thinkstep-anz's Sustainability Glossary

5. Resource library

The following documents and links are provided as additional sources of information. They provide additional tools that are freely available for use.

Better Buildings Partnership[19]. (2018). Pathways to net zero buildings tool[20]. https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fs3.ap-southeast-2.amazonaws.com%2Fcdn.sydneybetterbuildings.com.au%2Fassets%2F2018%2F06%2FPathways-to-Net-Zero-Buildings-Tool-BBP-Point-Advisory.xlsx&wdOrigin=BROWSELINK

City of Helsinki. (no date). Helsinki Green Area Factor Tool: User Manual for the Excel-based tool[21]. City of Helsinki, Urban Environment Division, FCG Design and Engineering Ltd. https://www.integratedstormwater.eu/sites/www.integratedstormwater.eu/files/final_outputs/helsinki_green_factor_tool_-_user_manual_final.pdf

Ellen MacArthur Foundation & Arup. (no date). Circular Buildings Toolkit – Workshop methodology & materials[22]. https://ce-toolkit.dhub.arup.com/workshop

Gibbons, O.P; Orr, J.J. (2022). How to calculate embodied carbon (Second edition)[23]. https://www.istructe.org/resources/guidance/the-structural-carbon-tool/

WBCSD. (2021). The business case for Circular buildings: Exploring the economic, environmental and social value[24]. https://www.wbcsd.org/Programs/Cities-and-Mobility/Sustainable-Cities/Transforming-the-Built-Environment/Resources/The-business-case-for-circular-buildings-Exploring-the-economic-environmental-and-social-value

[19] The Better Buildings Partnership represents a number of Sydney's leading commercial and public sector landlords, including partner members; AMP Capital Investors, Brookfield Properties, Charter Hall, City of Sydney, DEXUS Property Group, Frasers Property, The GPT Group, Investa, ISPT, Lendlease, Mirvac, Stockland, and University of Technology Sydney.

[20] A net zero pathways tool to visualize your climate action trajectory form now to 2050 developed by Point Advisory

[21] Excel based tool provides calculations of greening ratios and water sensitive design

[22] Provides an overview of how to conduct a workshop using the Circular Buildings Tool

[23] This document supports legislation by UK Parliament to achieve net zero carbon emissions by 2050 and forms a part of the response of The Institution of Structural Engineers to implement the necessary changes in the profession to respond to the climate emergency

[24] The report articulates the business case of pursuing circularity in the built environment consisting of the economic value alongside a broader value case, including environmental and social factors. It brings together qualitative and quantitative research identifying how circular practices can provide competitiveness in the marketplace and highlighting emerging evidence of economic value

6. Applicability and limitations

Restrictions and intended purpose

This report has been prepared by thinkstep-anz with all reasonable skill and diligence within the agreed scope, time and budget available for the work. thinkstep-anz does not accept responsibility of any kind to any third parties who make use of its contents. Any such party relies on the report at its own risk. Interpretations, analyses, or statements of any kind made by a third party and based on this report are beyond thinkstep-anz's responsibility.

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feedback@thinkstep-anz.com.

Legal interpretation

Opinions and judgements expressed herein are based on our understanding and interpretation of current regulatory standards and should not be construed as legal opinions. Where opinions or judgements are to be relied on, they should be independently verified with appropriate legal advice.

Annex A Stage 1 & Stage 2

Note: An excel spreadsheet is provided as a stand alone document in the shared folder with the document title "*City of Sydney-ZP103272-Annex A-Stage1-2.v1.0*"

Annex B Summary of Stage 2 documents reviewed

A brief high-level summary of the short-listed documents is provided in Table B-1. The intention is to provide an overview and not to pull any conclusions or recommendations. A total of 14 documents were reviewed as part of the detailed Stage 2 assessment.

Table B-1: Summary of Stage 2 documents

Document Title and Author	Summary
The circular built environment playbook (World GBC, 2023)	An inclusive view of the built environment including: • Reduction in consumption of materials and resources • Optimisation of lifespan for material and product use • Design for disassembly, reuse and recycling, and the elimination of all waste • Regeneration of nature. The Playbook refers to levers for change at varying stages of development, including planning through to operation. Additional aspects include centralized material database; Implementation of EPR; localizing the supply chain (and potential for storage of materials); challenge short term thinking, i.e., approaching from a circular economy perspective and not just referring to waste, resource recovery or recycling, as well as considering alternative circular business models etc.
Circularity Gap Report - Methodology (Circle Economy, 2023)	These metrics are too complex and too broad (i.e., global focus and planetary boundaries) for use in a local authority level or the constrained focus of this assessment. Aspects could be incorporated, however there are better metrics for this type of assessment.
Circular Economy Metrics: Case studies for NSW (2022) (Circular Australia and UTS)	Setting targets and a strategy will need to be developed. The strategy and associated targets could be linked to the City of Sydney's operational target commitments. Apply metrics to construction projects – e.g., Carbon dividend, Circular public procurement, different CE business models.

Document Title and Author	Summary
Circular Buildings Toolkit (Arup, current, live tool)[25]	The framework provides a "how to" guide following circular principles including: → Build nothing - (1) refuse new construction; → Build for long term value / use - (2) Increase building utilisation; (3) Design for Longevity; (4) Design for adaptability; (5) Design for disassembly; → Build efficiently - (6) Refuse unnecessary components; (7) Increase material efficiency; → Build with the right materials - (8) Reduce the use of virgin materials (using MCI); (9) reduce the use of carbon intensive materials (Embodied Carbon intensity); (10) design out hazardous materials/polluting materials.
Material Circularity Indicator Tool (Granta Design and Ellen MacArthur Foundation, 2019)	Product-focused and can incorporate company level - therefore could do a project-level MCI. The model relies on a Bill of Materials to build the data set. Can be used in combination with other tools, including LCA, EC, carbon, water, toxicity etc. The 2015 MCI did not include biological materials; however, the methodology was updated in 2019 to include biological materials (Materials like timber, hemp, cotton and kelp typically have great properties and a lower embodied carbon, their growth usually removing CO2 from the atmosphere). Potentially too time-consuming to use MCI by the City of Sydney - however, the City of Sydney could specify that products procured and used in City of Sydney infrastructure projects should be able to demonstrate the circularity either through a third-party assessment or through using the MCI calculations to provide an indication of the circularity. MCI could also be used at the project level, however noting that to calculate the MCI a full Bill of Materials (BoM) is required, and time would need to be factored in to conduct this assessment.

[25] The Circular Buildings Toolkit is free to use and open to all, and will remain a live, constantly updated resource, showcasing practical learnings from the latest circular projects around the world.

Document Title and Author	Summary
Embodied Carbon & Embodied Energy in Australia's Buildings (DISER, GBCA, thinkstep-anz, 2021)	For the best outcomes a combination of supply-side (emission reduction in manufacturing) and demand-side (using less products) action is needed. There are strong synergies between the circular economy and embodied carbon reduction. Even a 10% reduction in embodied carbon emissions in new commercial and residential buildings will contribute to avoiding at least 63.5 Mt CO_2e between 2022 and 2050.
Zero Carbon Industry Plan Rethinking Cement (The Zero Carbon Australia project | Beyond Zero Emissions, 2017)	The report contains industry wide targets for reducing Portland cement and moving towards high blend geopolymer cements. There are strong synergies with circularity as geopolymer cement can be used to utilise problematic waste. Strategies need to be built into projects pre-concept design and collaboration with suppliers is essential.
Australian buildings and infrastructure: Opportunities for cutting embodied carbon (CEFC & Edge Environment, 2021)	The report uses a limited definition of embodied carbon (A1-A4) to show a conservative view of reduction opportunities. Concrete and steel are identified as the biggest material contributors to embodied carbon. The report advocates for the use of offsets as part of a holistic, project-wide embodied carbon strategy. Good synergies with circular economy due to the focus on improved resource use and reduced waste.
Embodied Carbon: Developing a client brief (UK GBC, 2017)	Embodied carbon should be measured through LCA (note that the standards referenced in the report are UK centric). The report should be consulted in full when developing briefs as it provides step-by-step guidance and will be useful to City of Sydney team members who need to write project briefs and specifications.

Document Title and Author	Summary
Taking Action on Embodied Carbon (Built, 2021)	Upfront carbon should be included as part of an overall project LCA to get a holistic view of a building's performance. Developing good partnerships with the Head Contractor and suppliers will ensure the best outcomes. Currently Built achieve a 30-40% (on avg.) reduction in cement content by working with their suppliers, with no additional project costs.
Embodied Emissions Technical Report (NABERS & thinkstep-anz, 2022)	The NABERS tool is due for release in 2024 and the recommendations in the report suggest that the scope will be cold shell unless this is impractical. Life cycle stages will include A1-A5 and the tool will assess carbon indicators for now with others to be added down the line. Process LCA was the preferred measurement metric in consultation.
Green Star Buildings Upfront Carbon Emissions credit (GBCA, 2021)	Reductions of upfront carbon in Green Star Buildings are measured using the GBCA's upfront carbon emissions calculator. The methodology is covered in the Life Cycle Impacts credit of the tool.
Green Star Performance Upfront Carbon Emissions credit (GBCA, 2022)	The Upfront Carbon Emissions credit in Green Star Performance requires that there is a policy and process in place to address upfront carbon emissions for materials, products and services related to building refurbishment and maintenance activities.

Document Title and Author	Summary
A practical guide to upfront carbon reductions for new buildings and major Refurbishments (GBCA and Lendlease, 2023)	Provides detailed guidance on how to address upfront carbon throughout the life of a project from feasibility studies through to post practical completion handovers. The document also outlines the role each stakeholder will play in reducing upfront carbon through the project lifecycle.

thinkstep anz

About thinkstep-anz

We're an independent and award winning sustainability firm with offices in Australia and Aotearoa New Zealand - and a global reach.

Our team works with you to put sustainability at the heart of your business, to set you up to succeed and inspire you to keep achieving more.

We focus on what matters and use data to understand organisations and their impact. We provide practical resources and ideas that move you ahead.

We create value for organisations like yours, bringing our technical expertise and business know-how to help you tell your story. It's what we've done for the last 16 years.

Our services cover:

Product

- Life Cycle Assessment (LCA)
- Environmental Product Declarations (EPD)
- Circular Economy (CE)
- Cradle to Cradle (C2C)
- Material Circularity
- Water footprint
- Packaging

Carbon

- Carbon Footprint
- Scope 3 emissions
- Reduction strategy
- Carbon targets
- Science-based targets (SBT)
- Emission factors

Strategy

- Materiality assessment
- Green building
- Sustainable Development Goals (SDGs)
- Regenerative futures
- 3 Horizons
- Roadmaps
- Responsible procurement
- Benchmarking
- Workshops
- Business circularity

Reporting

- Climate risk (TCFD | XRB)
- Global Reporting Initiative (GRI) & Integrated reporting (<IR>)
- B Corp
- CDP

Communications

- Sustainability reports
- Case studies
- Board presentations
- Training
- Copywriting
- Infographics
- Media support

Software

- LCA for experts (GaBi)
- LCA calculator
- Material Circularity Indicator (MCI)
- Corporate sustainability (SoFi)
- MCI tool
- Excel carbon calculator

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