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Embodied Emissions Technical Report

On behalf of NABERS

Document Approval and Revision

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Purpose and structure

This technical analysis aimed to develop a framework for a NABERS Embodied Emissions Tool.

Through this technical analysis, NABERS sought to:

- Understand how to **measure** embodied emissions.
- Understand how to **verify** embodied emissions.
- Understand how to **benchmark** buildings, including key building characteristics to understand and methodologies to apply.
- **Test and validate** the proposed approach with stakeholders.

The report is structured in the following way:

- Chapter 1 **introduces** the project.
- Chapter 2 describes the **approach and methods** used for the **technical analysis**.
- Chapter 3 defines **key terms** through a review of international standards for life cycle assessment and carbon footprinting.
- Chapter 4 presents a review of **international best practice** based on green building rating tools and governments targeting embodied carbon.
- Chapter 5 presents **the framework** for embodied carbon developed **for this project**, containing 13 guiding questions to be resolved.
- Chapters 6 to 18 present the 13 **key questions used to guide the stakeholder workshops**.
- Annex A presents a review of existing **embodied carbon policies and rating tools**.
- Annex B presents a review of past building **LCA and carbon footprinting studies**.

Based on the responses to these guiding questions in the initial framework, NABERS has developed 10 proposals. A mapping between the NABERS proposals and the original guiding questions is provided in Table 1-1 below.

The table follows the NABERS report structure, lists the 10 NABERS proposals outlined in the NABERS report, and provides hyperlinks to the corresponding technical sections to help readers find the sections of the report which are of most interest or relevance to them.

Table 1-1: Mapping between NABERS proposals and guiding questions

Section 1: Scope of the NABERS Embodied Emissions Tool		Page
Eligible projects	**Proposal 1** – Only new buildings and major refurbishments are eligible to certify → *Chapter 15 – Should the tool cover major refurbishments and demolition?*	78
The life cycle stages included	**Proposal 2** – Include only upfront emissions (A1-A5) → *Chapter 10 – Which life cycle stages will be included?*	47
Treatment of demolitions	**Proposal 3** – Emissions from demolitions are excluded → *Chapter 15 – Should the tool cover major refurbishments and demolition?*	78
The elements of the building construction included	**Proposal 4** – Cold shell is the default building scope → *Chapter 9 – Which parts of the building are included?*	41
The environmental indicators included	**Proposal 5** – Only carbon emissions will be included → *Chapter 12 – Will it assess carbon only or full LCA?*	60
Section 2: Calculation method		**Page**
The allowable emissions data	**Proposal 6** – NABERS will encourage verified product specific emissions data and will apply conservative defaults where no emissions data is available. → *Chapter 16 – Will it cover process LCA, hybrid LCA, or both?* → *Chapter 17 – Should the tool use a hierarchy of preferred data?* → *Chapter 15 – Should the tool cover major refurbishments and demolition?*	84 90 78
Treatment of building products with stored carbon or carbon neutral certification	**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. → *Chapter 13 – Will stored biogenic carbon be considered?* → *Chapter 14 – Will carbon offsets be considered?*	64 71
Section 3: Benchmarking		**Page**
Benchmarking methodology	**Proposal 8** – A statistical analysis of Bill of Quantities data is the preferred approach to creating whole of building benchmarks. → *Chapter 18 – How will we set benchmarks?* → *Chapter 11 – Which functional or declared unit will be used?*	95 53
Section 4: Certification process		**Page**
How projects progress to certification	**Proposal 9** – Projects receive certification following practical completion with some options to review progress along the way. → *Chapter 6 – Who submits the rating to NABERS?* → *Chapter 7 – When does certification occur?* → *Chapter 8 — How is auditing managed?*	27 32 36
Section 5: Future development		
Roadmap for future development	**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.	N/A

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1. Introduction

1.1. Introduction

This report accompanies a public consultation by the National Australian Built Environment Rating System (NABERS), titled “NABERS Embodied Emissions Consultation Paper” (NABERS report). It provides the technical analysis and recommendations that underpin the proposals put forward by NABERS for their planned Embodied Emissions tool.

The NABERS report provides the context for this analysis.

1.2. Project background

NABERS is adding embodied emissions to its suite of building ratings

NABERS is designed to be a simple, reliable rating system for a building’s environmental performance. As of 2022, NABERS ratings are available for building energy use, building water use, building waste production, and indoor environment.

NABERS have identified a market need to rate the embodied emissions of buildings. This need was validated through a **market feasibility analysis** run by NABERS and Meld Studios from October 2021 to March 2022. This analysis considered the views of 156 people from 92 organisations across Australia using workshops and interviews.

The outcome of the market feasibility analysis described the desired NABERS Embodied Emissions Tool as follows:

> *Measuring, benchmarking and verifying base building emissions from new buildings and major refurbishments to the point of construction completion.*

This report provides the technical basis for a tool for embodied emissions

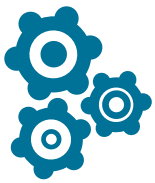
This report aims to provide the details and process of the technical research and analysis undertaken. It forms the basis of the recommended tool proposed by NABERS.

The NABERS embodied emissions tool must deliver the objectives in Table 1-1 and the market needs in Table 1-2. The objectives are the requirements of NABERS itself and State/Territory/Federal Governments. The market needs reflect what the market said it wanted through the market feasibility analysis. Collectively the objectives and market needs are the lens through which the elements of the tool need to be assessed. While all market needs are important, Impactful (which encapsulates all three objectives) and Consistent were both considered to be non-negotiable.

Table 1-1: Objectives for the NABERS Embodied Emissions Tool

	Support behaviour change to **urgently reduce embodied emissions**.
	Focus primarily on **measurement**, **verification**, **benchmarking** and **disclosure**.
	Start by **solving targeted problems now**, rather than waiting to solve all problems in embodied emissions.

Table 1-2: Market needs for the NABERS Embodied Emissions Tool

	**Impactful** To be impactful the tool should help drive behaviour change that leads to a real reduction in embodied emissions.
	**Consistent** To produce reliable outputs the tool should use a consistent approach. This includes assumptions, system boundaries, calculation methodology and data sources.
	**Collaborative** To avoid market confusion and ensure widespread adoption, the tool should align with existing tools and systems where this helps NABERS achieve its Objectives. This includes existing NABERS tools, other green tools/schemes such as Green Star and Climate Active, and international systems, where relevant.
	**Trusted** To build trust in the results of the NABERS tool it needs to have a robust, transparent process with third party-verified results.
	**Streamlined** The tool should be streamlined to minimise effort and costs to expand NABERS' reach.
	**Meaningful** The outputs of the NABERS tool need to be easy to understand and create fair comparisons between buildings.

1.3. Introduction to the Technical Analysis

NABERS engaged thinkstep-anz in April 2022 to complete the Technical Analysis portion of the NABERS Embodied Emissions project alongside the work of NABERS and Meld Studios. The Green Building Council of Australia (GBCA) was a key stakeholder and partner in this process, to ensure good alignment between the two rating systems.

Through this technical analysis, NABERS sought to:

- Understand how to **measure** embodied emissions
- Understand how to **verify** embodied emissions
- Understand how to **benchmark** buildings, including key building characteristics to understand and methodologies to apply
- **Test and validate** the proposed approach with key stakeholders

This analysis:

1. **Engaged with additional stakeholders** via interviews, including more building products manufacturers and their associations (15 of 16 interviews were of this type)
2. **Presented an initial concept** for the Embodied Emissions Framework using a series of 10 workshops with industry stakeholders
3. **Sought feedback on the initial concept** during the workshops and via a follow-up survey
4. **Presented a revised concept** following stakeholder feedback
5. **Tested the revised concept** with key stakeholders
6. **Prepared a final report** for NABERS (this report)

As part of the process, NABERS engaged two Supporting Consultants to make sure the developed solutions were feasible. The Supporting Consultants were Edge Environment and UNSW in collaboration with The Footprint Company. The process with the Supporting Consultants was thorough, collaborative and congenial. NABERS and all consultants agree on the position represented in this report. This agreement was partly based on developing a roadmap that shows how the NABERS Embodied Emissions Tool would be reviewed and could evolve over time to incorporate elements that were seen as important but could not be included in the first version.

NABERS is proposing a tool for embodied emissions

The NABERS consultation paper presents a proposed Embodied Emissions Tool, based on the initial framework presented here. This report reflects the technical analysis that supported the development of the proposed tool.

An initial framework for embodied emissions has been developed

thinkstep-anz developed an initial framework consisting of 13 questions to help guide the workshops (Figure 1-1). We grouped the questions into five categories: certification process, scope of building, calculation method, underlying data, and benchmarks.

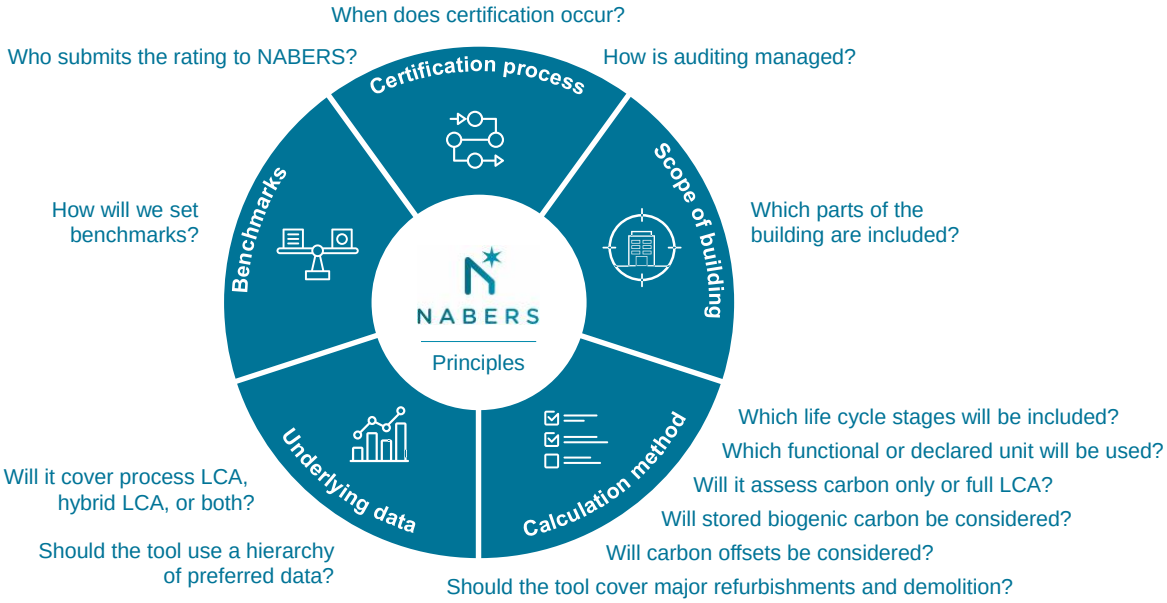


Figure 1-1: Questions to resolve in developing a NABERS Embodied Emissions Tool

We developed the initial framework in this report by applying the following process for each question:

- Problem statement
- Early feedback from market
- Literature / policy research
- Options available
- Review of options against the NABERS Embodied Emissions Tool market needs
- Recommendation presented for stakeholder feedback
- Feedback from stakeholder workshops
- Revised recommendation

2. Approach used for technical analysis

We conducted the technical analysis in six key stages:

1. Understand the key topics to be resolved
2. Develop an initial proposal to resolve each topic
3. Test the initial proposals with key stakeholder groups
4. Revise the proposals based on the feedback
5. Test the revised proposal with key stakeholder groups
6. Prepare final recommendations for NABERS (this report)

Each stage is described further below.

2.1. Understand the key topics to be resolved

To develop a tool for embodied emissions, it was first necessary to have a clear understanding of the issues that needed to be resolved by the tool. These issues were identified in three main ways:

1. The outputs and detailed notes from the market feasibility analysis
2. A global scan of existing embodied emissions frameworks/tools (Chapter 4 and Annex A) and literature (Annex B)
3. Additional interviews

The additional interviews were conducted primarily with building product manufacturers. While building product manufacturers were part of the market feasibility analysis, it was seen as important to include a larger sample and to understand not only what they wanted from the NABERS Embodied Emissions Tool, but also any risks the tool might pose to their business in the medium- to long-term. While not a target market for the NABERS Embodied Emissions Tool, Australian building product manufacturers could be affected by any market adjustment due to increased demand for low carbon building materials.

We conducted half-hour interviews with the following organisations (grouped by sector) to supplement the market feasibility analysis.

- Cement and concrete:
    - Cement Concrete & Aggregates Australia (CCAA) (part of a group interview)
    - Cement Industry Federation (CIF) (part of a group interview)
    - Hanson
    - Holcim
    - Wagners
- Metals:
    - Australian Steel Institute
    - BlueScope Steel
    - InfraBuild
    - Australian Aluminium Council

- Wood products:
    - Australian Forest Products Association (AFPA) (part of a group interview)
    - Softwood Chamber (part of a group interview)
    - Timberlink (part of a group interview)
    - Wood Products Victoria
    - Engineered Wood Products Association (EWPA)
    - Xlam
- Building products (excluding cement/concrete, metals and wood products):
    - Building Products Industry Council (BPIC)
    - Etex
    - Brickworks

2.2. Develop an initial proposal to resolve each topic

The outcome of the previous stage was a framework composed of 5 categories and 13 questions to be resolved (which will be described further in Chapter 5).

For each question, the following process was applied:

- **Problem statement:** What is the issue to be resolved?
- **Feedback from market:** What can be learnt from the market feasibility analysis and subsequent interviews?
- **Literature/policy research:** What can be learnt from exploring international frameworks and research on embodied carbon?
- **Options available:** What options are available to solve the problem, based on market feedback and the literature/policy research?
- **Review of options against NABERS market needs:** How does each option compare when reviewed against the six NABERS market needs?
- **Recommendation:** Which option (or options) are recommended?

The review of options against the NABERS market needs was done using a traffic light system. Green means that the option meets the principle, amber means that the option can meet the principle if certain conditions are met and red means the option does not meet the principle.

Before being presented to stakeholders, the initial set of recommendations was tested with the Supporting Consultants and the Steering Group. Modifications were made to both the recommendations and the presentation of the recommendations prior to the workshops.

2.3. Test the initial proposals with key stakeholder groups

We tested the initial proposals with stakeholders during a series of 10 two-hour workshops. All workshops were run virtually via Microsoft Teams. We did not provide any materials in advance; instead, the first half of the workshop was a presentation of the draft NABERS Embodied Emissions Tool to ensure everyone had the same information and the second half was focused on discussing the tool – first in general, then topics that were seen as most relevant to that stakeholder group by thinkstep-anz, NABERS and Meld Studios. Stored

biogenic carbon and carbon offsets were discussed with all stakeholder groups to seek feedback on each of the five potential solutions presented at the meeting.

Feedback was taken and recorded in three ways:

- A moderated meeting chat through Microsoft Teams. The chat was open through the whole meeting, with stakeholders encouraged to post thoughts, questions and ideas during the presentation and subsequent discussion.
- Verbal discussion during the second half of the workshop. The meetings were recorded so that they could later be transcribed (anonymously).
- Feedback questionnaire following the meeting.

Table 2-1 shows the stakeholder groups and stakeholders invited to each workshop. Not all stakeholders were able to attend the workshops at the scheduled time. For most workshops, stakeholders were sent a copy of the slides, a recording of the session (with the discussion removed) and the questionnaire, allowing them to provide feedback later if they wished to. A GBCA representative attended most of the workshops to demonstrate support and alignment with the project and its direction.

Table 2-1: Stakeholder workshops in round 1

Stakeholder group	Stakeholders invited to participate	
Metals	• BlueScope Steel • InfraBuild • Australian Steel Institute (ASI)	• Steel Reinforcement Institute of Australia (SRIA) • Australian Aluminium Council
LCA Experts	• Australian Life Cycle Assessment Society (ALCAS) • eTool • EpiC (University of Melbourne) • Life Cycle Strategies • Lendlease Group (LCA team)	• Evah Institute • Global GreenTag • Good Environmental Choice Australia (GECA) • Climate Active
Cement & Concrete	• Holcim • Hanson (Heidelberg Cement) • Boral • Cement Concrete & Aggregates Australia (CCAA)	• Cement Industry Federation (CIF) • Adelaide Brighton (Adbri) • Hallett Concrete
Wood Products	• Wood Solutions • Hyne Timber • Timberlink Australia • Engineered Wood Products Association of Australasia (EWPAA)	• Wood Products Victoria • Xlam • AKD Softwoods • New South Wales Department of Primary Industries

Stakeholder group	Stakeholders invited to participate	
Government, Industry Peak Bodies & Standards Bodies	• City of Melbourne • BASIX • Yarra City • Department of Customer Service • Infrastructure Sustainability Council (ISC) • Royal Institution of Chartered Surveyors (RICS) • Department of Planning and Environment (DPE) • City of Sydney • NSW Architects • Circular Economy CCS • Materials & Embodied Carbon Leaders' Alliance (MECLA) • Australian Institute of Architects Climate Action and Sustainability Taskforce (AIA CAST)	• Australian Institute of Quantity Surveyors (AIQS) • Australian Industry Group (Ai Group) • Australian Architects Declare • Building Products Industry Council (BPIC) • Standards Australia • Australian Building Codes Board (ABCB) • Green Building Council of Australia (GBCA) • Australian Circular Economy Hub (ACE Hub) – Planet Ark • New Zealand Ministry for Business, Innovation and Employment (MBIE)
Other Building Products	• Brickworks • Knauf Insulation • CSR • Nu-rock • Etex	• Interface • Shaw Contract • Alex Fraser • Kingspan Insulated Panels • Wagners
Architects, Engineers & Quantity Surveyors	• Simpson + Wilson Architecture • Arup • Grimshaw • MDA Australia • Slattery • KPMG • Dsquared Consulting • Northrop • WSP	• Floth • Fitzpatrick Partners • Turner & Townsend • Cundall • Aurecon • LCI Consultants • Australian Institute of Refrigeration, Air conditioning and Heating (AIRAH)
Construction Companies	• Built • John Holland • Laing O'Rourke • Hutchinson Builders • Probuild	• BuildCorp • Multiplex • Western Sydney Airport • Fulton Hogan
Owners, Developers & Investors	• Frasers Property • Charter Hall • Lendlease Group • ANZ • Mirvac • Goodman Group • Property NSW • Stockland	• GPT Group • Clean Energy Finance Corporation (CEFC) • MA Financial • Queensland Investment Corporation (QIC) • Commonwealth Bank Australia (CBA) • AMP

Stakeholder group	Stakeholders invited to participate	
NABERS Steering Committee Subcommittee	• Property Council of Australia (PCA) • Chartered Institution of Building Services Engineers (CIBSE) • Australian Institute of Architects (AIA) • Facility Management Association (FMA) • Green Building Council of Australia (GBCA)	• International Building Performance Simulation Association (IBPSA) • SA Government • Department of Climate Change, Energy, the Environment and Water

An optional feedback questionnaire was sent to participants following the workshop. We received 36 responses. While each stakeholder category was represented, the number of responses was not evenly distributed by stakeholder category.

2.4. Revise the proposals based on the feedback

We revised the proposals based on stakeholder feedback and presented them in a draft technical analysis report. NABERS, GBCA and the Supporting Consultants provided feedback on the proposals.

We then updated proposals in response to the feedback and held another review workshop with the Supporting Consultants. At the conclusion of that workshop, all parties were generally supportive of the recommendations made. Including a roadmap for future tool development was seen as an important way to capture ideas from stakeholders that could not be addressed at launch.

2.5. Test the revised proposal with key stakeholder groups

We held another round of six stakeholder workshops, where NABERS presented the 10 proposals from the NABERS Embodied Emissions Consultation Paper. There were two workshops for project team members, plus bespoke workshops for cement and concrete, timber, metals and general building products.

The workshops revealed a high level of support for all proposals. Many stakeholders commented on how the proposals had evolved to a position that was more favourably viewed by industry.

The workshops provided the opportunity for clarifications and important feedback on nuances and considerations which are important in later tool development. There were no strenuous objections raised in these workshops that required the proposal to be changed.

2.6. Prepare final recommendations for NABERS

This report is the final phase of the Technical Analysis prior to public consultation. It documents the technical basis for the content of the final NABERS proposals presented for public consultation. Refer to Table 1-1 on page 4 for how the content of this report links to the NABERS proposals.

Later sections of the report are structured around the questions investigated in the Technical Analysis. This report includes both the proposal presented at the original workshops for each key question, and the final proposal based on the rounds of stakeholder feedback received.

3. Embodied carbon definitions and standards

NABERS tools measure the sustainability performance of buildings in operation, including energy efficiency, water efficiency, waste management and their associated emissions. Through the NABERS tools, many buildings have achieved reductions in operational carbon emissions. However, emissions also arise from manufacturing the building products used to construct the building, transporting these products to site, constructing the building, maintaining the building, and finally demolishing the building. These emissions are collectively known as “embodied emissions” or “embodied carbon”.

This report adopts the World Green Building Council (WorldGBC) definition of embodied carbon as “carbon emissions associated with materials and construction processes throughout the whole life cycle of a building or infrastructure” (WorldGBC, 2019, p. 5). Carbon emissions are calculated as the “sum of greenhouse gas emissions and greenhouse gas removals in a product system, expressed as CO_2-equivalent (CO_2e) and based on a life cycle assessment using the single impact category of climate change” (ISO, 2018).

3.1. Embodied carbon versus upfront carbon

Across a building’s life cycle, there are three main areas of consideration for carbon:

- Operational carbon, often considered as part of energy efficiency measures and the subject of the NABERS Energy rating.
- Embodied carbon, which relates to carbon across the building’s life cycle other the operational carbon.
- Carbon beyond the life cycle, which is related to circular economy and intersystem considerations.

Embodied carbon is the focus of this work. It can be broken down into three parts, as shown in Figure 3-1 (WorldGBC, 2019, p. 6):

- Upfront carbon: “The [carbon] emissions caused in the materials production and construction phases (A1-5) of the life cycle before the building or infrastructure begins to be used.”
- Use stage embodied carbon: “[Carbon] emissions associated with materials and processes needed to maintain the building or infrastructure during use such as for refurbishments [(B1-B5)].”
- End of life carbon: “The carbon emissions associated with deconstruction/demolition (C1), transport from site (C2), waste processing (C3) and disposal (C4) phases of a building or infrastructure’s life cycle which occur after its use.”

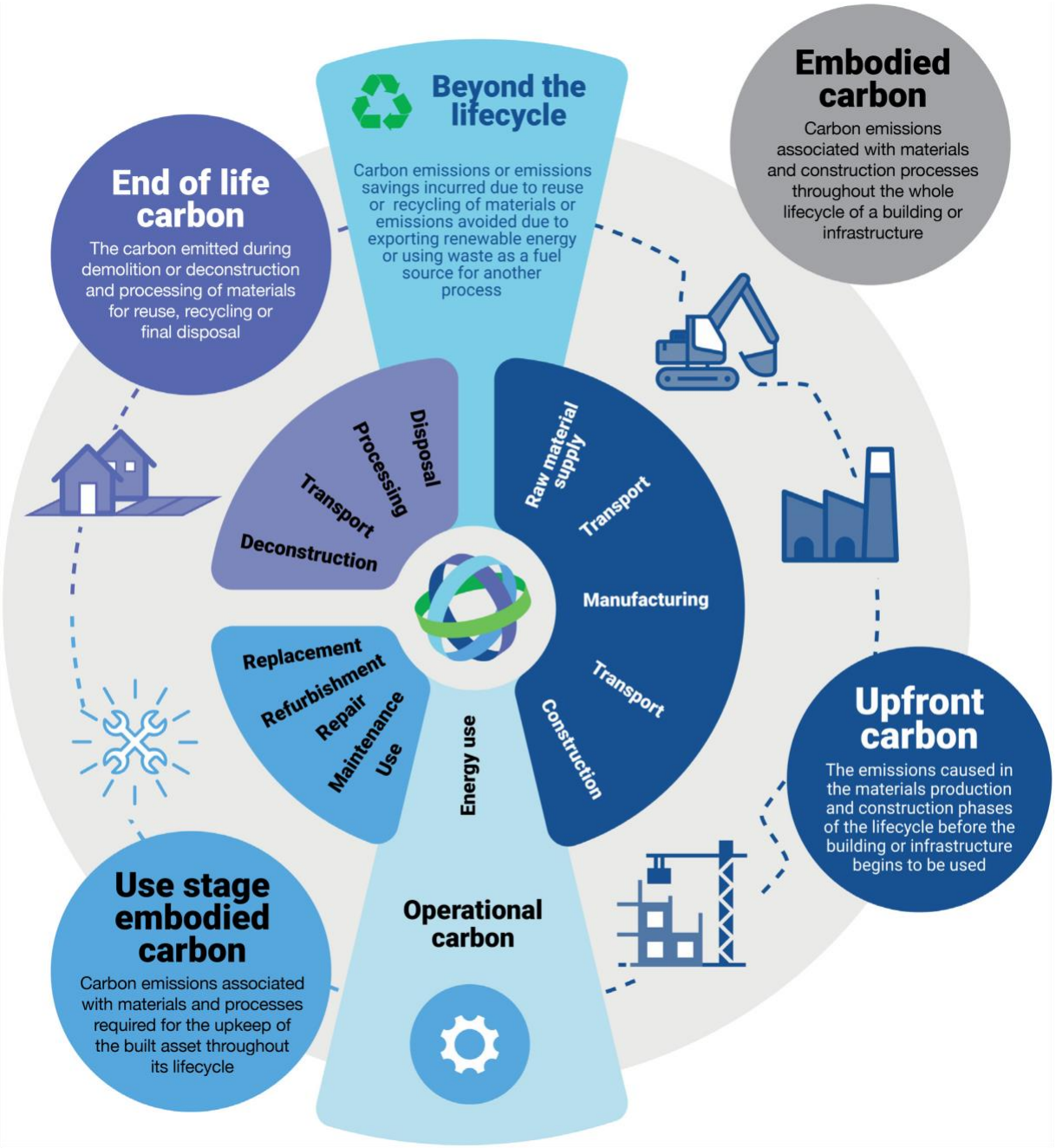


Figure 3-1: Embodied, upfront, use stage, and end-of-life carbon – reproduced from (World Green Building Council, 2019)

The life cycle stages included within each term are shown in Figure 3-2. The naming convention applied by WorldGBC follows European standards EN 15804 and EN 15978 for building products and whole buildings, respectively. Modules A1-5 focus on manufacture of the building products (A1-3), transport to site (A4) and installation (A5), modules B1-7 focus on emissions during the building's operating life (including maintenance and repair), modules C1-4 focus on end-of-life, and module D focuses on credits for avoided production of primary (virgin) materials in future product life cycles due to recycling or reuse.

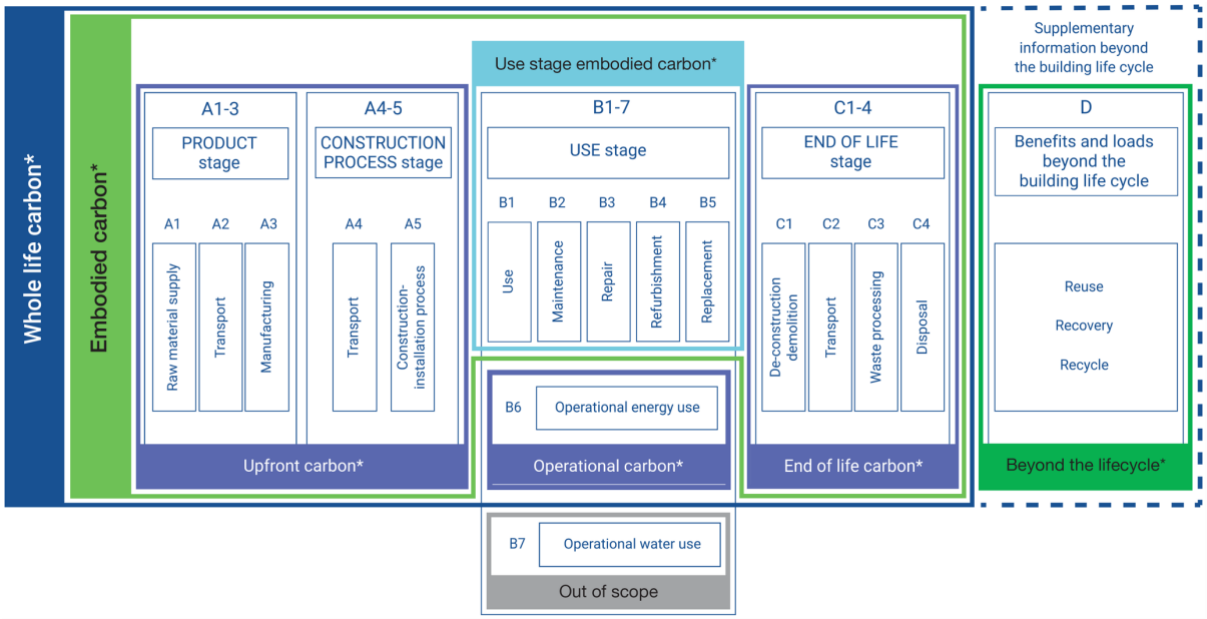


Figure 3-2: Terminology and related life cycle stages – reproduced from (WorldGBC, 2019)

Some stakeholders do not believe that the term “embodied carbon” is appropriate because it could be taken to mean “stored carbon” (see section 13.2), which is a very different concept. In this context, “embodied carbon” is used in a similar way as “embodied energy” and “embodied water”, i.e., the upstream impacts in the supply chain required to produce something and not the carbon/energy/water inherent in the product.

3.2. LCA versus carbon footprinting

Life cycle assessment (LCA) is the “[compilation] and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle” (ISO, 2006a). The LCA method inherently tries to prevent burden shifting – from one time to another, from one place to another, and from one environmental compartment (air, soil, freshwater, saltwater, etc.) to another. As such, LCA always considers multiple footprints: a carbon footprint, a water footprint, a waste footprint, etc.

A **carbon footprint (CF)** is an LCA using Global Warming Potential (GWP) as the sole indicator (ISO, 2018). Both methods share the same framework and approach – the key difference is that LCA considers multiple environmental indicators whereas a CF only considers climate change (as measured through GWP).

Importantly, the ISO standards for LCA (ISO 14040 and ISO 14044) and carbon footprinting (ISO 14067) provide a framework for conducting LCA and carbon footprint studies of any product or service. As a result, detailed product-specific rules are needed to be able to make fair comparisons between LCA or CF studies.

3.3. Gross and net carbon emissions

Both stored biogenic carbon and carbon offsets, including those associated with carbon neutral certified product, are compensation mechanisms that allow for removal – or avoidance – of greenhouse gases. This can be considered as a negative carbon footprint (i.e., a reduction in atmospheric greenhouse gases). As such, it is important to distinguish the **gross carbon footprint** – the direct emissions caused by burning fossil fuels, chemical process emissions, and land use change – from the **net carbon footprint**, which is the gross carbon footprint minus carbon removals.

3.4. Building LCA and building product EPD standards

European standard EN 15978 (CEN, 2011) is currently the best known and most widely cited standard for building LCA (see Table A-1 in Annex A). Its sister standard EN 15804 (CEN, 2019) has been used to create more than 12,000 Environmental Product Declarations (EPDs) for building products worldwide (Anderson, 2022). EN 15804 provides a set of rules, known as Product Category Rules (PCR), for creating EPDs. An EPD is an LCA independently verified against a given PCR.

Importantly, both standards use the same modular structure so that the quantity of each building product installed in a building can simply be multiplied by the impact per unit from an EPD and then added up to get to the building total. (Calculating the total life cycle impacts of the building also requires accounting for energy and water use during construction, construction waste, operational energy use, direct on-site emissions from combustion of fossil fuels and refrigerant leakage, and maintenance/repair/refurbishment.)

EN 15978 and EN 15804 helped to define the modular structure of life cycle stages now used across most building LCAs (Figure 3-2). This structure breaks the life cycle of the building into **life cycle stages** (A-D) and then **life cycle modules** (A1-A5, B1-B6, C1-C4 and D).

It is important to recognise that:

- **These standards are deliberately broad**, and they require specific implementing measures for truly comparable results. They are intended to cover the full life cycle environmental performance of a building across multiple environmental indicators. They are not specific to carbon, nor to embodied carbon.
- **The concept of upfront carbon was not well defined** at the time the original standards were published. To give some context, the World Green Building Council's *Bringing Embodied Carbon Upfront* report was published in 2019 (WorldGBC, 2019), 8 years after the first version of EN 15978 was published.
- **Treatment of stored biogenic carbon and carbon offsetting was not considered** at the time the original standards were published. EN 15978:2011 does not mention stored biogenic carbon or carbon offsetting. The international standard for carbon footprinting of products – ISO 14067 – was only published as a Technical Specification in 2013 and as a full standard in 2018 (ISO, 2018). Treatment of stored biogenic carbon came later through EN 16485:2014 and then EN 15804+A2:2019.

- The original standards specified how to report the results of a building LCA in a modular way, but not how to add the numbers together to get to a single score. The standards even go further than this, with EN 15978:2011 specifically precluding adding the numbers together at all, stating that “results shall be presented separately for all the building life cycle stages and for module D” (CEN, 2011, section 12.6).

3.4.1. Changes to standards

EN 15804+A1 (CEN, 2013) has been revised as EN 15804+A2 (CEN, 2019).The new version is similar to the old one, but there are several important changes, e.g., in the choice of environmental indicators, and in how the carbon footprint of bio-based materials such as wood is accounted for.

A revised version of EN 15978 is currently in draft form (CEN, 2021). The draft standard continues the same modular structure from the original, with a few additions: A0 for pre-construction activities, B8 for building user activities, and D2 covering benefits from exported utilities, such as electricity.

The draft revision of EN 15978 does provide some clearer guidance on what to expect from the revised standard (CEN, 2021, section 13). If implemented, the changes may allow whole-of-life embodied carbon (calculated as the sum of modules A1-A5, B1-B5, C1-C4 and excluding module D) to be presented as a separate figure, but not upfront carbon.

The draft version of EN 15978 (CEN, 2021) also:

- Requires stored biogenic carbon to be reported separately in kg carbon stored.
- Splits Global Warming Potential into GWP-total = GWP-fossil + GWP-biogenic + GWP-luluc, where GWP-luluc is GWP from land use and land use change. (GWP-total can be reported so long as the component parts are also available.)
- Does not allow carbon offsets.

4. Embodied carbon policies and rating tools

We reviewed international embodied carbon policies and rating tools to understand what is happening globally and whether or how NABERS should respond. “Table A-1: Summary of standards, policies and rating tools considered” and accompanying explanation is provided in Annex A.

The insights can be summarised as follows (ordered in the same way as in Table A-1 on page 109):

- **Scope of life cycle modules:** No consistency between tools. Upfront carbon (A1-A5) was typically the minimum scope, though two standards allowed for products (A1-A3) only in some cases. Many standards required whole-of-life embodied carbon.
- **Scope of building:** No consistency between standards. The foundation (substructure) and superstructure were always in scope, and usually the envelope too. Beyond this, there were significant differences in approach.
- **Functional/declared unit:** The three most common were:
- kg CO_2e/m^2
- kg CO_2e/m^2/year
- kg CO_2e/building

  There was little consistency between the measure of area. Standards used a mix of Gross Floor Area (GFA), Gross Internal Area (GIA) and heated area.
- **Achievement assessment:** Most tools use an upper limit or cap, typically per m^2, though a few used a reference building approach with a percentage reduction.
- Stored biogenic carbon: Always excluded for upfront carbon and sometimes reported separately. Often included for whole-of-life embodied carbon.
- **Carbon offsets:** Always **excluded** from the base calculation, except for *Green Star Buildings*. *Green Star Buildings* treats certified carbon neutral products from approved schemes as having zero impact but does not allow for carbon offsetting at the building level (GBCA, 2021).
- **Uncertainty factors:** Few standards explicitly mention whether they apply uncertainty factors for lower quality data. The Netherlands uses an uncertainty factor of 30% for its lowest tier of acceptable data quality. Finland uses 20% in example calculations, but it is unclear if this is the final value that will be used, as the policy is not yet law.
- **Standards:** Virtually all tools follow **EN 15978** and/or its sister standard EN 15804.
- **Data sources:** All tools except Green Star Buildings followed a process LCA approach, typically relying on EPD data. Most national tools provided a database, and some also provided a LCA calculator tool built on this database.

5. Initial framework used for workshops

The initial framework for embodied emissions shown Figure 5-1 was used in stakeholder workshops to develop the NABERS Embodied Emissions Tool. It comprises five areas and 13 guiding questions (listed in Figure 5-1).

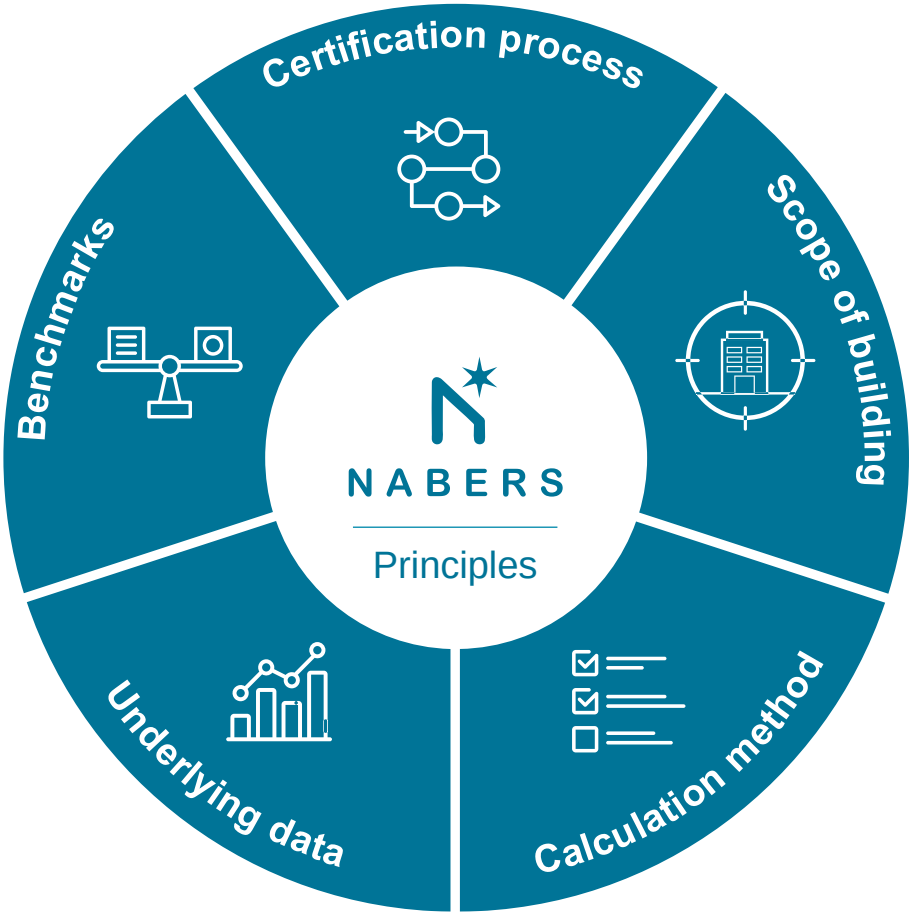


Figure 5-1: NABERS Embodied Emissions Tool

The six NABERS market needs of Impactful, Consistent, Collaborative, Trusted, Streamlined and Meaningful (refer to Table 1-2) are represented at the centre of the tool. The NABERS market needs were used to guide decision-making through the tool development and consultation process.

Under the five sections are 13 key questions that must be addressed through the development of the NABERS Embodied Emissions Tool (see Table 5-1).

Table 5-1: Questions to be addressed through development of the NABERS Embodied Emissions Tool

Section	Question
Certification process	Who submits the rating to NABERS?
	When does certification occur?
	How is auditing managed?
Scope of building	Which parts of the building are included?
Calculation method	Which life cycle stages will be included?
	Which functional or declared unit will be used?
	Will it assess carbon only or full LCA?
	Will stored biogenic carbon be considered?
	Will carbon offsets be considered?
	Should the tool cover major refurbishments and demolition?
Underlying data	Will it cover process LCA, hybrid LCA, or both?
	Should the tool use a hierarchy of preferred data?
Benchmarks	How will we set benchmarks?

The remainder of this report sets out to address these 13 questions, with one chapter per question. Each chapter is structured as per section 2.2, with additional commentary on feedback from stakeholders and the Supporting Consultants.

The review of options against the NABERS market needs was done using a traffic light system. Green means that the option meets the principle, amber means that the option can meet the principle if certain conditions are met, and red means the option does not meet the principle.

6. Who submits the rating to NABERS?

This stakeholder engagement topic relates to:
NABERS Proposal 9: Projects receive certification following practical completion with some options to review progress along the way.

6.1. Problem statement

Who in the project is responsible for sourcing and entering the data?

Historically, building LCA and building carbon footprinting was performed by a small number of LCA and carbon footprinting specialists – typically either external consultants or internal consultants embedded within large firms in the construction industry. These studies were performed in LCA expert tools, such as SimaPro and GaBi – tools that are not specific to building LCA and require specialist training. In the last 3-5 years, a much wider range of building professionals have started performing LCAs of buildings, enabled by software tools focused specifically on LCA of buildings, e.g., eTool, One Click LCA, Tally and EC3.

While this transition is both welcome and necessary for LCA and carbon footprinting to grow and to become embedded in decision-making, it also carries risk, as the people using the tools are now less familiar with LCA methods, such as assessing the quality of input data, performing mass balance checks, and critically evaluating outputs from the software tools. At the same time, quantity surveyors and building estimators may be better placed than LCA practitioners to understand how much material should go into a specific building design, which is a key part in getting a reliable result from an LCA or carbon footprint.

The crux of this question is whether submission of the data entered into the NABERS Embodied Emissions Tool should be limited to a small group of specialists or opened to a wider pool of construction industry professionals with suitable training.

6.2. Early feedback from market

Early market feedback showed support for allowing a Quantity Surveyor (QS) with NABERS training to enter the data. However, this was dependent on the simplicity of the final NABERS Embodied Emissions Tool, and the details of the training and verification requirements.

Selected quotes:

- “A QS can put the numbers in but a third-party review with the rigour we expect from the NABERS, to make sure they are sanity checked and consistent – only an LCA person can do that.” – *Developer/Owner*
- “If the rules are well defined and set then the QS could do it.” – *Engineer/Architect/QS*

- "Someone who is recognised by NABERS as being qualified to make that final certification." – *Constructor*
- "There will be a massive shortage of people who can do LCAs and EPDs. You will need to do a massive training program to be able to have enough people to do the work." – *Manufacturer*

6.3. Literature / policy research

Green building rating tools typically have requirements for their building LCA credits. For example, *Green Star Buildings* from the GBCA requires that (GBCA, 2021, pp. 169-171):

> *The LCA report must comply with quality assurance requirements by meeting one of two options:*
>
> ***Option A***
>
> *The report is produced by an LCA Certified Practitioner*
>
> *Subject to organisational quality assurance, which has been certified in accordance with ISO9001.*
>
> ***Option B***
>
> *The report is produced by an Experienced Individual*
>
> *Peer reviewed by an LCA Certified Practitioner or independent Experienced Individual*
>
> *[Where]*
>
> ***Experienced individual***
>
> *An individual who has produced, co-produced and/or independently reviewed at least five LCA studies of buildings or building products in accordance with ISO 14040/14044, within the past three years.*

None of the national frameworks for embodied carbon in Chapter 4 have requirements regarding who submits the data as far as the authors could tell. This is possibly because most are mandatory and so they cannot be overly restrictive. Instead, they tend to provide a single software tool, or a group of approved software tools with a common database, to help structure the data entry and to limit the selection of emission factors to preapproved data sources only (typically from EPDs).

6.4. Options available

We identified three options for data entry following the initial review.

Option 1: Quantity Surveyor only

In Option 1, only a trained Quantity Surveyor could submit the data for the Embodied Emission Tool to NABERS.

A QS has access to material quantities at the building level and is responsible for costing non-material related activities (e.g., excavation). Embodied carbon is a natural extension of

their work as cost estimators. However, for projects that would not normally employ a QS, this requirement would increase the cost of the project.

Option 2: LCA Expert only

In Option 2, only a trained LCA expert could submit the data for the Embodied Emission Tool to NABERS.

LCA experts understand LCA and carbon footprinting methodology and are ideally placed to evaluate data inputs, to choose appropriate emission factors, and to critically evaluate the results coming from an LCA tool.

An “LCA expert” might be limited to Life Cycle Assessment Certified Practitioners (LCACPs) and “experienced individuals” as per Green Star. LCACP certification requires the person to sign a code of conduct and to pass a 3.5-hour exam on LCA theory and practice. The exam is set by the American Center for LCA (ACLCA) and LCACP is a joint certification with the Australian LCA Society (ALCAS) and LCA New Zealand (LCANZ).

This option would always increase the cost of the project as an LCA expert would not normally be employed to work on a building project. There are also a limited number of LCA experts in Australia, with only 28 registered on the ALCAS website as of November 2022.

Option 3: Any qualified professional with training in NABERS embodied emissions

In Option 3, any qualified professional with the appropriate training could submit the data for the Embodied Emission Tool to NABERS.

While this option is the most scalable, NABERS would need to ensure that calculator tools and training courses have been well developed to minimise errors. For example, in-built error checking to reduce data entry could be necessary, together with automated pre-checking of the results to reduce outliers before allowing the results to be submitted.

6.5. Review of options against NABERS market needs

Table 6-1 Review of options against NABERS market needs for "Who submits the rating to NABERS?"

Principle		Quantity Surveyor Only	LCA Expert Only	Any Qualified Professional with training in NABERS embodied emissions
Impactful	• Urgent behaviour change • Big wins first	**?** QSs are not employed on all project types, potentially creating duplication of effort	**✗** There are currently too few LCA experts to be able to scale this to the national level	✓ Relatively easy to scale up once appropriate training and tools are developed
Consistent	• Results are reproducible no matter who calculates them	**?** Has the potential to be consistent, but this will likely be determined by the tools and standards more than the person submitting the rating.	**?** Has the potential to be consistent, but this will likely be determined by the tools and standards more than the person submitting the rating.	**?** Has the potential to be consistent, but this will likely be determined by the tools and standards more than the person submitting the rating.
Streamlined	• Quick and easy to use	**?** This approach could be streamlined, depending on the tool(s) and standard	**?** This approach could be streamlined, depending on the tool(s) and standard	✓ This approach would require the best tools, so would likely be the most streamlined
Collaborative	• Considers existing methods/standards • Considers what others are doing, e.g., Green Star • Works alongside other NABERS tools • Tries to link with existing work	✓ Well aligned with standards such as ICMS 3, which seek to integrate cost and carbon footprinting (ICMS, 2021)	✓ Best aligned with Green Star	✓ Consistent with other NABERS tools and national embodied carbon rating systems in other countries
Trusted	• People have faith in the framework	**?** Trust will depend on the quality of the results	**?** Trust will depend on the quality of the results	✓ NABERS manages who is a qualified assessor
Meaningful	• Easy to understand	✓ Meaningful if well communicated	✓ Meaningful if well communicated	✓ Meaningful if well communicated

Key	✓ Yes, option meets principle	**?** Option can meet principle if certain criteria are met	**✗** No, option does not meet principle

Based on the analysis in Table 6-1:

- Option 3: “Any qualified professional with training in NABERS embodied emissions” is the preferred option. This option is scalable to create impact, provided that the calculators and training courses are well developed to minimise errors.
- Option 1: “Quantity Surveyor only” can meet all NABERS’ market needs; however, QSs are not employed in all project types. This may create duplication of effort, increase overall project costs, and reduce uptake overall.
- Option 2: “LCA Expert only” was the least preferred option. There are currently too few LCA experts to be able to scale this to a national level.

6.6. Recommendation presented for stakeholder feedback

We recommended allowing data to be submitted by a qualified professional (e.g., Quantity Surveyor) who has been trained to follow the standard. Under this recommendation the Standard would need to be clear to try and limit the variability between building LCAs. An algorithm in the calculator would also be used to check for potential errors.

6.7. Feedback from stakeholders

Feedback from stakeholders (both verbal and via the survey) shows strong support for allowing data to be entered by a qualified professional who has received appropriate training in following the NABERS standard. While feedback indicated strong support for the recommendation, comments in the survey reinforced the need for an appropriate NABERS training program to be implemented.

6.8. Revised recommendation

Maintain this recommendation as-is. The recommendation was generally well received although some participants did comment that many building professionals (including quantity surveyors) may not be able to critically evaluate if the data they were entering was sufficiently complete. It was also noted that different building stakeholders can provide different quantities for the same building. For example, a quantity surveyor may provide different figures than an estimator in a construction firm. To ensure consistency in the data being provided, it will be important to have clear documentation, good training, and a highly structured software tool which can automatically detect common data entry errors (e.g., missing reinforcing steel in reinforced concrete, unit errors, etc.).

This has implications for NABERS being able to approve the use of third-party software tools, e.g., eTool or EC3. These tools will need to implement the same algorithms or equivalent protection mechanisms to ensure that consistency can be achieved.

Several stakeholders commented that the original Option 1 should have been more open. Specifying QSs only was too narrow. Construction company estimators would be equally well suited to this task and may even have a better idea of the true quantities used in projects as they are closer to the construction process.

7. When does certification occur?

This stakeholder engagement topic relates to:
NABERS Proposal 9: Projects receive certification following practical completion with some options to review progress along the way.

7.1. Problem statement

At which stage of the building life cycle can embodied emissions best be audited?

Incorporating low-carbon design criteria into early design is often considered to be one of the most effective ways of achieving significant reductions in carbon footprint. However, the data needed to calculate embodied emissions (material choices, material quantities, construction waste rates, construction energy, etc.) at this early stage is also necessarily incomplete, making auditing difficult. At later stages, auditing is easier (because material choices have been made, material quantities have been specified, etc.), though the design is now locked in, meaning that there is no further room left for decarbonisation.

7.2. Early feedback from market

Early market feedback endorsed:

- An *optional* independent design review (mandated for those with a Commitment Agreement). Stakeholders indicated that around 70% of the way through design may be most useful as this would allow time for builders and suppliers to provide input.
- An "as built" certification post practical completion.

Selected quotes:

- “Post construction verification is important because substitutions can occur.” – *Government*
- “Your concrete mixes can change because ‘Oh, we need to accelerate now, so we can’t use that super high fly ash mix.’”- *Builder*
- “There is a real risk of [the building] changing a lot between concept and detailed design.” – *QS/Engineer*
- “The developer may want to attract a buyer or tenant, so there may be a place for external verification at DA approval or tender stage where it’s not required, but the project’s team design needs to be verified so the developer could go public with the commitment.” – *QS/Engineer/Architect*

7.3. Literature / policy research

Within the Australian context, Green Star (both the older *Green Star - Design & As Built* and the newer *Green Star Buildings*) require an as-built rating but allow a design rating (provided that the as-built rating follows). Other major green building rating tools internationally – such as LEED and BREAM – follow a similar approach or allow the as-built rating only.

7.4. Options available

We identified four options for certification timelines.

Option 1: Design Stage Only

The design rating would occur during or after detailed design completion and would be based on design drawings. This option benefits from being a powerful way to influence behaviour throughout the design and construction process. However, the available material specifications and quantities would not be sufficient to allow for a robust certification.

Option 2: As-Built Stage Only

The as-built rating would occur after practical completion of the building and would be based on the materials and quantities in the actual building. All claims made would need to be auditable (via schedules, invoices, EPDs, etc.). This option benefits from the availability of accurate data allowing for a robust certification. However, influence over behaviour change is reduced unless preparation for certification can be well integrated into the design process.

Option 3: Design Review Optional, As-Built Certification Mandatory

Option 3 features a mandatory as-built certification, with an optional independent design review. This option was intended to provide a best of both worlds scenario, allowing early influence over behaviour changes, while also ensuring data is accurate enough to ensure a robust certification. Under this scenario, all projects would need to achieve an as-built certification following practical completion. Projects could also opt-in to an independent design review at the detailed design stage, though this would not be mandatory, unless a Commitment Agreement had been signed.

Option 4: Design Review Mandatory, As-Built Certification Mandatory

Option 4 is like Option 3 but would mandate the independent design review and as-built certification.

7.5. Review of options against NABERS market needs

Table 7-1: Review of options against NABERS market needs for "When does certification occur?"

Principle		Design Rating Only	As-Built Rating Only	Design Optional, As-Built Mandatory	Design Mandatory, As-Built Mandatory
Impactful	• Urgent behaviour change • Big wins first	✓ Focuses on early design where the biggest wins can be made	**?** Design is locked in. Can be mitigated by good design process.	✓ Allows focus on early design where the biggest wins can be made	✓ Focuses on early design where the biggest wins can be made
Consistent	• Results are reproducible no matter who calculates them	✗ The data are not of high enough quality to enable consistent results	✓ High quality data, enabling reproducibility	✓ High quality data, enabling reproducibility	✓ High quality data, enabling reproducibility
Streamlined	• Quick and easy to use	✓ Single submission and auditing process	✓ Single submission and auditing process	✓ Single submission mandated; design submission discretionary	✗ Requires an additional submission and an additional certification
Collaborative	• Considers existing methods/ standards • Considers what others are doing, e.g., Green Star • Works alongside other NABERS tools • Tries to link with existing work	✗ The data are not of high enough quality to enable consistent results	✓ Links well with Green Star and other green building rating tools	✓ Links well with Green Star and other green building rating tools	✓ Links well with Green Star and other green building rating tools
Trusted	• People have faith in the framework	✗ Building data not easily verifiable at the design stage, reducing trust	✓ High quality data (actuals) used, helping to build trust	✓ High quality data (actuals) used, helping to build trust	✓ High quality data (actuals) used, helping to build trust
Meaningful	• Easy to understand	✓ Meaningful with good communication	✓ Meaningful with good communication	✓ Meaningful with good communication	✓ Meaningful with good communication

Key	✓ Yes, option meets principle	**?** Option can meet principle if certain criteria are met	✗ No, option does not meet principle

Based on the analysis in Table 7-1:

- Option 3: “Design Review Optional, As-Built Certification Mandatory” is the preferred option, meeting all NABERS criteria.
- Option 2: “As-built Only” is also a preferred option. While the impact of the option is potentially diminished by not certifying at the design stage, this can be mitigated by good processes within project teams to forecast an as-built rating
- Option 4: “Design Review Mandatory, As-Built Certification Mandatory” scores well against the NABERS market needs but is less streamlined than the other options due to requiring two certification stages.
- Option 1: “Design Rating Only” fails to meet three of the market needs (Consistent, Collaborative, Trusted) and is not recommended.

Note: Option 4 was not presented to stakeholders during the workshops, as it was considered too similar to Option 3.

7.6. Recommendation presented for stakeholder feedback

We recommended allowing both ‘design’ and ‘as-built’ certifications:

1. The as-built certification would be *mandatory* and based on the materials and quantities in the actual building and must be verifiable (via schedules, invoices, EPDs, etc.).
2. The design review would be *optional*, based on design drawings, and time limited. It would allow developers to market a building as having an Embodied Emissions Commitment Agreement (or similar).

Under this recommendation, all buildings must have an as-built certification, but they can also have a time-limited independent design review.

7.7. Feedback from stakeholders

Feedback from stakeholders (both verbal and via the survey) showed strong support for mandating an as-built certification among all stakeholder groups. The optional independent design review was also generally well received, though not quite as positively as the as-built certification.

7.8. Revised recommendation

The recommendation was revised slightly to:

1. The rating would an as-built certification. It would be based on the materials and quantities in the actual building. Quantities must be verifiable, via schedules, invoices, EPDs, etc.
2. An independent design review would be optional. However, it would be mandatory for those projects with a Commitment Agreement. It would be based on design drawings and used as a predictor of the as-built certification.

8. How is auditing managed?

This stakeholder engagement topic relates to:

NABERS Proposal 9: Projects receive certification following practical completion with some options to review progress along the way.

8.1. Problem statement

How is auditing of the rating managed? Which supporting documents are required? Who is qualified to audit the rating?

8.2. Early feedback from market

Early feedback from the market was that the audit process needs to be:

- **Streamlined** to avoid any unnecessary additional costs.
- **Account for actual quantities and actual materials** used in construction. Value engineering is common and can lead to building products that were initially specified being substituted for cheaper alternatives prior to construction. These alternative products may have a different carbon footprint and this needs to be picked up.

Stakeholders used various terms for what NABERS call auditing: “review”, “peer review”, “verification”, “checking” and “validation”. The international standards for LCA (ISO 14044) and product carbon footprinting (ISO 14067) both use “critical review”, while the international standard for EPDs (ISO 14025) uses “verification”.

Selected quotes:

- “Verification is important – ensure that what has been specified is used.” – *Building Product Manufacturer*
- “Do you need a third-party verifier, or can you self-verify then have a third-party certifier at the end? Make sure you are not adding too much paperwork and cost.” – *Engineer/QS*
- “It’s fine for the Quantity Surveyor to be the certifier as all they are doing is checking quantities and related information (e.g., invoices). They are not modelling anything. The calculations are very straightforward.” – *GBCA*

8.3. Literature / policy research

The GBCA requires peer review of LCA studies under Green Star. For other embodied carbon rating systems, there was relatively little information available about auditing.

The NABERS terminology above will be used for the remainder of this chapter.

NABERS' terminology will be used for the remainder of this chapter. NABERS (2018, p. 3) provides the following auditing procedure for its rating tools:

> *The NABERS Program routinely undertakes two types of audit. A Level 1 Audit is conducted on 100 per cent of NABERS rating applications. It is a quality assurance process undertaken by NABERS Technical Officers to ensure that an Assessor has correctly completed the rating form (NABERS Rate), has made no apparent errors in data entry, and has correctly applied the Rules for Collecting and Using Data (the Rules) to the data entered. A Level 1 Audit is required to certify a rating but does not check the accuracy of the data entered or evaluate the Assessor's application of the Rules in collating that data.*
>
> *A Level 2 Audit is conducted on five per cent of NABERS ratings by NABERS Auditors working with the National Administrator. The Level 2 Audit is a quality assurance peer review process that delivers a complete re-rating of the building using the documentation relied upon by the Assessor in conducting the original rating. It verifies that a NABERS Accredited Assessor has used accurate and documented data, and has complied with the NABERS Rules, Rulings, processes and procedures when undertaking the NABERS rating. A Level 2 Audit ensures that the correct rating result has been determined, and assesses the performance of NABERS Assessors based on their understanding, interpretation and application of the Rules.*

8.4. Options available

We identified three options for managing auditing.

Option 1 – Audit all ratings in detail, including checking schedules and invoices

A detailed Level 2 Audit would be performed for all ratings. This would include repeating the rating using the documentation provided, plus documentation checks (of invoices, schedules, EPDs, Climate Active declarations, etc.) to ensure the information submitted is plausible. This option is the most robust, but also the most labour intensive.

Option 2 – Audit a sample of ratings, covering all outliers and a share of other ratings per category

A sampling approach would be utilised covering all outliers (either too low or too high) and a share (e.g., 5%) of other ratings per category. A well-constructed sample can help ensure the provision of good quality data for a lower investment. This option aligns with NABERS' current practice.

Option 3 – Self-declaration

Project teams undertake their own validation and self-declare the results. Only the NABERS Level 1 Audit would be conducted. There would be no Level 2 Audit or further verification.

8.5. Review of options against NABERS market needs

Table 8-1: Review of options against NABERS market needs for "How is auditing managed?"

Principle		Detailed audit of all ratings	Use a sampling approach	Self-declaration
Impactful	• Urgent behaviour change • Big wins first	**?** Potential to be impactful if it can be streamlined	✓ Scalable and streamlined to encourage uptake	✗ Scalable but may not deliver quality results, ultimately limiting impact
Consistent	• Results are reproducible no matter who calculates them	✓ Highest chance of consistency in results	**?** Potential for consistency with a well-defined sampling approach	✗ Unlikely to lead to consistent results based on variability in past LCA studies
Streamlined	• Quick and easy to use	**?** Users must be able to easily supply needed documentation to be easy to use	**?** Users must be able to easily supply needed documentation to be easy to use	✓ Quick and easy to use
Collaborative	• Considers existing methods/standards • Considers what others are doing, e.g., Green Star • Works alongside other NABERS tools • Tries to link with existing work	✓ Aligns with Green Star, where the LCA credit requires third-party review	✓ Aligns with existing NABERS approach	✓ Aligns with national rating systems in other countries
Trusted	• People have faith in the framework	✓ Consistent, high-quality data will build trust	**?** A well-defined sampling approach leading to high-quality data will build trust	✗ Will not build trust without independent auditing or verification
Meaningful	• Easy to understand	✓ Meaningful with good communication	✓ Meaningful with good communication	✓ Meaningful with good communication

Key	✓ Yes, option meets principle	**?** Option can meet principle if certain criteria are met	✗ No, option does not meet principle

Based on the analysis in Table 8-1:

- Option 1: “Detailed audit of all ratings” is a preferred option, having the ability to meet all NABERS market needs. It would build trust but may not be scalable.
- Option 2: “Use a sampling approach” is also a preferred option, having the ability to meet all NABERS market needs.
- Option 3: “Self-declaration” does not meet the NABERS market needs and is not a preferred approach.

8.6. Recommendation presented for stakeholder feedback

We recommended the following for stakeholder feedback:

- Auditing should be performed by specially trained Quantity Surveyors, perhaps with LCA expert support at the start.
- In the short-term, option 1 (audit all) should be used.
- In the long-term, option 2 (audit a sample) should be used.

8.7. Feedback from stakeholders

Feedback from stakeholders (both verbal and via the survey) showed that there was support for auditing to be undertaken by a specially trained Quantity Surveyor; however, many stakeholders questioned why this should be limited to QSs only and that construction estimators and qualified LCA practitioners would also be suitable.

The feedback showed support for using a detailed audit process in the short-term before moving into a sampling approach longer-term; however, not everyone agreed with this approach. A selection of comments from the survey highlight this:

- “This is the way it seems to be moving overseas – that a trained quantity surveyor undertakes the verification.” – *Building Product Manufacturer*
- “QS isn't the only group that understands. While they might know a BoQ, doesn't mean they understand the materials impacts. The range of proof will incur decent costs. Focus on the big items.” – *Architect/Engineer*
- “Verification should be by NABERS Accredited Assessor trained for the task. Everything should be audited in detail. The LCA/EC industry is larger than I think NABERS thinks it is, and is far from being adequately trained or audited. Quantity surveyors are not trained for this. I'm not clear on the ongoing focus on QS as the resource for this exercise.” – *Architect/Engineer*
- “Should be a similar process to NABERS Energy. Level 1 audit, where basic questions are asked and basic checks are done. Level 2 audit on a 5% to 20% share of submissions that goes into much more detail. Verifying all in detail is not practical.” – *Constructor*

The Supporting Consultants were generally supportive of auditing being undertaken by a suitably qualified professional.

- “We agree with the option of any qualified professional (with a background in building and infrastructure construction) with training in NABERS embodied emissions.”

- “We also agree with the staged approach with short term verification of all ratings and the option long term to transition to sampling.”

However, some concern was expressed about the current low experience level in the industry which resulted in clarification of the audit process as follows:

- Data entry and submission done by a qualified NABERS Embodied Emissions Assessor.
- Design rating (optional): Independent Design Review Panel. (Like NABERS Energy Commitment Agreement process.)
- Early certifications: audit of the data entered by an independent professional for every assessment. This would be a check of data entered and source data, like a typical LCA review/verification process. This might not involve a full redo of the rating (i.e., might not be a full Level 2 Audit) and could be thought of as a Level 1.5 audit.
- Long term: the usual NABERS practice of Level 1 Audit (completeness check) for all ratings and a Level 2 Audit ("redo") for a sample of the ratings.

8.8. Revised recommendation

We revised the recommendation as follows:

- **Auditing should be performed by a suitably qualified professional** with knowledge relevant to building carbon footprinting. The auditor must be able to critically evaluate input data (i.e., quantities) for completeness, decide whether the emissions factors chosen are appropriate and understand if results are reasonable. A suitably qualified professional would likely have a background as a quantity surveyor, building estimator, LCA specialist, or product carbon footprinting specialist. NABERS will likely need to build up a resource of rules of thumb from the beginning to assist with achieving consistency.
- **Auditing requires documentation of the main materials and products used in the building, as constructed.** Documentation includes invoices, schedules, EPDs, Climate Active product neutral certificates, etc.
- **Documentary evidence will be limited to the big-ticket items only.** The Bill of Quantities for a building will often contain hundreds of line items. Providing evidence (e.g., invoices) for all items would be very time consuming. Thresholds will be used to limit the items for which documentation is required. E.g., documentation must be provided for items that contribute, say, ≥80% of the building’s material costs.
- **In the short-term, audit all ratings in detail** to build up capacity within industry and to provide feedback where the quality is not high enough.
- **In the long-term, audit ratings** in line with NABERS standard practice.

9. Which parts of the building are included?

This stakeholder engagement topic relates to:
NABERS Proposal 4: Cold shell is the default building scope.

9.1. Problem statement

To what extent should we include or exclude the following:

- Structure
- Foundation
- Envelope
- Building services
- Groundworks
- Fitout
- Furnishings

For each part of the building, there is the option to include it, exclude it, or to approximate it (to ensure completeness but without detailed measurement for now).

9.2. Early feedback from market

Early market feedback identified a risk of becoming too complicated and technical when identifying the scope of the rating. The feedback noted that the scope of the rating will need to be well defined and ensure consistency across the buildings being rated.

Selected quotes:

- “What degree of scope of building elements is considered? Will fit-out and building services be in scope? If they are included, how far does this go? And then how do you calculate it? This quickly becomes quite technical and complicated.” - *Building Product Manufacturer*
- “My opinion is it's everything that's in the contract scope. Everything that has been built. So, if it’s a NABERS base building rating, it's everything that was delivered as part of the base building contract. And typically that includes building services and you can make significant changes in embodied carbon just by selecting services differently.” – *Designer*
- “It’s everything from the concrete in the building (you do maybe 80% or 90% cut off and call it a day). And when you do that though the long tail is very long; but actually most of the emissions are on the structure and envelope.” – *Standards Body*
- “Be really careful about going down rabbit holes because…very quickly, you'll be into what type of desk or what you're using in internal partitions. And that's really not moving the dial where steel and concrete really are.” – *Developer/Owner*

- "Your concrete, steel, aluminium, precast, and then your engineered timber type solution. So, they are all part of the priority aspects of it. And then there are obviously lots of other second order priorities, services and other solutions." – *Developer*

9.3. Literature / policy research

Annex A shows little consistency between different ratings tools and policies, though most require at least the foundation, superstructure and envelope (façade) as a minimum scope.

9.4. Options available

Four options were identified – three from the GBCA's *Fitout Scope: Guidance for Cold Shell, Warm Shell and Integrated Fitouts* (GBCA, 2020) – and a final one covering everything.

Option 1 – Cold Shell

"Finishes and services are not installed. A **tenancy with an unfinished interior,** with no HVAC services beyond the riser (or core or rigid duct), and without lighting, plumbing, ceilings, floor finishes (or with a set down to allow for future provision of floor finishes), interior partitions or walls." (GBCA, 2020, p. 5)

This option covers all big-ticket items and is the easiest to implement. Data access is easy as the lead developer is always responsible for delivering the cold shell. The interior fit-out (including services) is largely independent of the shell and so is excluded.

Option 2 – Core & Shell

"Where the developer's scope of works is the design and construction of the base building. **Finishes and services are applied to common areas only.** A range of other construction and fit out works are left to be completed before the building is occupied." (GBCA, 2020, p. 5)

Core & Shell is relatively easy to implement but has the risk of being less consistent than the other options (when compared to an absolute benchmark), as the extent of the "Core" may vary from building to building.

Option 3 – Warm Shell

"Finishes and services are applied to common areas. **Tenancies are delivered with ceilings, floor coverings and lighting systems; and ducts from air supply and return risers, electrical and hydraulic services are installed above the ceiling from the riser throughout the tenancy areas.**" (GBCA, 2020, p. 5)

Warm Shell has the potential to provide greater consistency than Core & Shell, as the scope of the fit-out varies less from building to building. However, it will need a well-defined calculation approach to ensure consistency between projects and to deal with data gaps (as there is very little carbon footprint data available for building services). Projects attempting to resolve these data gaps would also likely spend considerably more time than if the scope was Cold Shell only.

Option 4 – Complete

The rating covers the entire scope of the building including the structure, foundation, envelope, building services, groundworks, and all fitouts and furnishings.

Comparison

A comparison of the options is provided in Table 9-1 using the building element categorisations from RICS (2021).

Table 9-1: Comparison of building scopes

Scope of building (RICS classification)	Cold Shell	Core & Shell	Warm Shell	Complete
0 Facilitating Works	X	X	X	X
1 Substructure	X	X	X	X
2 Superstructure	X	X	X	X
3 Internal Finishes		Common areas	X	X
4 Fittings, Furnishings and Equipment				X
5 Services	Base build	Base build	X	X
6 Prefabricated Buildings and Building Units	X	X	X	X
7 Work to Existing Building	X	X	X	X
8 External Works				X
9-13 Non-physical items				

Another consideration was the inclusion of external car parks, irrespective of building scope. This is to enable fair comparison between buildings with integrated (internal) car parks, which are part of the cold shell, and external car parks, which would normally be excluded.

9.5. Review of options against NABERS market needs

Table 9-2: Review of options against NABERS market needs for "What parts of the building are included?"

Principle		Cold Shell	Core & Shell	Warm Shell	Complete
Impactful	• Urgent behaviour change • Big wins first	✓ Can be implemented immediately	✓ Can be implemented immediately	✓ Can be implemented immediately	× Risk of getting lost in the details; not focused on the big wins first
Consistent	• Results are reproducible no matter who calculates them	✓ Will provide consistent outcomes with a well-executed tool	× Hard to achieve consistency as the extent of the "core" varies from building to building	✓ Will provide consistent outcomes with a well-executed tool	× Hard to achieve consistency due to the depth of the data required
Streamlined	• Quick and easy to use	✓ The most streamlined option as the least data is required	**?** Can be easy to use with a well-defined calculation approach	**?** Can be easy to use with a well-defined calculation approach	× The detail required for this option makes it hard to streamline well
Collaborative	• Considers existing methods/ standards • Considers what others are doing, e.g., Green Star • Works alongside other NABERS tools • Tries to link with existing work	**?** Variations of this approach are used globally	**?** Variations of this approach are used globally	**?** Variations of this approach are used globally	× Approach is not often used globally
Trusted	• People have faith in the framework	✓ Has the potential to be trusted	✓ Has the potential to be trusted	✓ Has the potential to be trusted	✓ Has the potential to be trusted
Meaningful	• Easy to understand	✓ Has the potential to be meaningful	✓ Has the potential to be meaningful	✓ Has the potential to be meaningful	✓ Has the potential to be meaningful

Key	✓ Yes, option meets principle	**?** Option can meet principle if certain criteria are met	× No, option does not meet principle

Based on the analysis in Table 9-2:

- Option 1: “Cold Shell” is a preferred option, with the potential to meet all NABERS market needs.
- Option 3: “Warm Shell” is also a preferred option as it can meet all NABERS market needs, although a well-defined calculation approach will be required to ensure consistency.
- Option 2: “Core & Shell” scores well against most NABERS market needs but is less consistent than the other approaches (when compared to an absolute benchmark) as the “core” varies from building to building.
- Option 4: “Complete” fails to meet four of the market needs (Impactful, Consistent, Streamlined, Collaborative) and is not recommended.

9.6. Recommendation presented for stakeholder feedback

We recommended that clients should be able to choose either **cold shell** or **warm shell** as the most suitable option will depend on the project. Separate benchmarks would be developed for each and exterior works like car parks would likely be included in some way (especially for retail).

9.7. Feedback from stakeholders

Feedback from stakeholders (both verbal and via the survey) show a reasonable degree of support for allowing either cold shell or warm shell. The Supporting Consultants considered there was risk in limiting the scope to cold shell only, i.e., excluding potentially significant sources of embodied carbon in fitout and internal finishes, maintenance, repair, refurbishments and replacements.

Those not supportive of this measure (“don’t like it” or “can’t live with it”) commented:

- “Currently the proposed BASIX material index covers only cold shell, but we are keen to shift to warm shell moving forward. We do not see it feasible to provide a choice for proponents to commit to cold or warm shell, as they are likely to choose the easier way forward – essentially gaming the system.” – *Government/Standards*
- “Given the choice, a client will go with the easier option. Suggest it is set in which cases cold or warm shell are applicable.” – *Building Product Manufacturer*
- “NABERS has a unique opportunity to transform a very broad supply market for goods and services. The function of removing embodied carbon from the supply chain is common across all procurement functions allowing the rules and the tool to be applied to the broadest set of projects.” – *LCA Experts*
- “This raises an issue about what the definitions of cold shell versus warm shell are. Some parts of a project/ building are warm shell, whereas other parts are more cold shell and thus there will be mixed cold and warm shell within the one project/ building.” – *Architect/Engineer/QS*
- “There are a big range of cold to warm ranges. Simplify it by just focusing on cold shell for the immediate time period.” – *Architect/Engineer/QS*

The final workshop discussions had some focus on the contribution of car parks and whether they should be part of the rating or not. Some stakeholders were of the opinion that buildings should not be unfairly penalised for a need for car parks, and to include them was to not have apples-to-apples comparison.

9.8. Revised recommendation

We revised the recommendation to:

- Specify a single **minimum scope for each building type**.
- **Cold shell** would be the default option, with warm shell or other building scope only used if there was a good reason cold shell could not be applied.

Specifying cold shell has the following advantages:

- Simplifies data collection by focusing on the big-ticket items.
- Improves cost-effectiveness of the tool by limiting the data collection effort required – it enables a simple, streamlined approach.
- Provides better consistency, due to a narrower scope.
- Improve accessibility of data, as the lead developer/constructor always builds the cold shell.
- Limit issues with refurbishment, as not much of the cold shell will ever be replaced.

NABERS could indicate to the market that it wants to move to warm shell and, ultimately, fitout, but the short-term goal is to start somewhere and try to build trust and familiarity with a simpler (and the most cost-effective) tool before broadening it. As such, we recommend that NABERS include an extension to warm shell and fitout in the roadmap for future consideration.

Car parks should either have both internal and external car parks included, or both excluded. It is recommended that NABERS investigate this further during the data analysis for benchmarking.

10. Which life cycle stages will be included?

This stakeholder engagement topic relates to:
NABERS Proposal 2: Include only upfront emissions (A1-A5)

10.1. Problem statement

Which life cycle stages should be included in the calculation method? Are we interested in upfront emissions, whole-of-life emissions, or whole-of-life emissions including operational emissions? Are benefits from recycling and reuse included or excluded?

10.2. Early feedback from market

Early feedback from the market suggested that stakeholders were split, with some preferring a whole-of-life approach as it ensures the building is viewed holistically, and others wanting to focus on upfront emissions only because this focuses on the present, simplifies the analysis, and simplifies the communication.

Selected quotes:

- "We just want it to be fair, that is our primary concern. Not trying to get a leg up, just don't want to be unfairly disadvantaged. We feel the whole of life best represents fairness across different types of materials." – *Building Product Manufacturer*
- "Award for upfront carbon with requirement for calculation of whole-of-life carbon (no worse than benchmark) could be an option." – *Building Product Manufacturer*
- "The different life cycles are an equal consideration, especially end of life." – *Constructor*
- "Most embodied carbon emissions are going to be in A1 to A3." – *Standards Body*
- "… my upfront carbon on this new piece of commercial or industrial real estate is this. And then I'm able to report on what my financed emissions are in a very nice tidy way. And then I would look to them, promote that in my annual report" – *Investor*

10.3. Literature / policy research

Annex A shows little consistency between different ratings tools and policies, though most require at least A1-A5 as a minimum scope.

Prasad et al. (2021, p. 33) make an important observation about data quality, which is directly linked to NABERS' "Consistency" principle:

> *The scope for embodied carbon assessment for buildings in this guide is limited to the upfront stage (A1-A5). As the construction industry's capacity to achieve quality, consistency and completeness for upfront embodied carbon assessment increases, there will be a basis for extending benchmarks to life cycle stages B (refurbishment) and C (end of life).*

> *The problem of comparability in life cycle cost planning in engineering and cost management fields is well known. The reliable estimating, modelling and scenarios of life cycle cost of complex products (such as buildings and infrastructure) is limited and highly uncertain (in both scale and timing) owing to the individual nature of assumptions with limited information at the early stage. Unless mandatory life cycle operating (B1); maintenance (B2,3) and renewal/replacement (B4,5) inputs and cycles for every aspect of a building or infrastructure are defined, any result is subject to uncertainty and limited to the opinion of the study proponent.*

It is worth noting that BRANZ in New Zealand has done this through its whole-building whole-of-life assessment framework, CO_2NSTRUCT Database and calculator tools. These resources are freely available and could be adapted to the Australian context should a whole of life carbon approach be adopted.

10.4. Options available

Seven combinations of life cycle stages were originally considered:

1. Building products only (modules A1-A3)
2. Building products + transport (A1-A4)
3. Upfront carbon to practical completion (A1-A5)
4. Embodied carbon without recycling credits (A-C, excl. B6 & B7)
5. Embodied with recycling credits (A-D, excl. B6 & B7)
6. Life cycle carbon without recycling credits (A-C)
7. Life cycle carbon with recycling credits (A-D)

The following options were eliminated:

- “Building products only (A1-A3)” does not account for the impact of transport and therefore does not provide a level playing field for local and imported products.
- “Building products + transport (A1-A4)” as this considers the impacts of off-site prefabrication (which fall in A1-A3) but not on-site activities (A5), effectively disadvantaging prefabrication.
- Both options that include operational emissions (B6 and B7). The reason for excluding these options is that NABERS already provides widely used ratings for operational emissions. There is an option to require both operational and embodied ratings, or to for NABERS to display them side-by-side.

This left three options, as described below. All three options use “carbon” rather than “emissions” to align with common terminology and the recommendation in section 12.

Option 1: Upfront carbon to practical completion (A1-A5)

This option accounts for all upfront carbon to the point of practical completion. This includes:

- Building products and materials, and transportation of those materials to site (A1-A4).
- Construction of buildings, including the manufacture of products and materials wasted during construction, and subsequent end of life processing (A5).

Option 1 aligns with approaches taken by other green building certifiers globally (e.g., GBCA, ILFI). It is also the simplest and the most immediately impactful.

It also is well aligned with NABERS standard practice because:

- It uses actual measurable data to formulate a rating vs. assumptions around what will happen regarding the building into the future.
- The scope of what is measured is in the control of the developer seeking the rating.

Option 2: Embodied carbon (A-C, excl. B6 & B7)

This option expands on Option 1 by including: embodied carbon relating to building maintenance, repair, replacement, and refurbishment (B1-B5); and end-of-life including demolition, and transport and disposal of materials related to demolition (C1-C4).

Option 3: Embodied carbon with recycling (A-D, excl. B6 & B7)

This option expands on Option 2 by including recycling/reuse potential in future product life cycles.

10.5. Review of options against NABERS market needs

Table 10-1 Review of options against NABERS market needs for "Which life cycle stages will be included?"

Principle		Upfront carbon (to practical completion) (A1-A5).	Embodied carbon (A-C, excl. B6 & B7).	Option 3: Embodied carbon with recycling (A-D, excl. B6 & B7).
Impactful	• Urgent behaviour change • Big wins first	✓ Simple and impactful	**?** Future replacements are uncertain, so these are inherently a prediction.	✘ Not urgent. Incentivises recycling in 50+ years.
Consistent	• Results are reproducible no matter who calculates them	✓ Easiest to make consistent with a well-executed tool	**?** Potential for consistency with a well-executed tool	**?** Potential for consistency with a well-executed tool
Streamlined	• Quick and easy to use	**?** Can be easy to use with a good calculator	**?** Can be easy to use with a good calculator	**?** Can be easy to use with a good calculator
Collaborative	• Considers existing methods/standards • Considers what others are doing, e.g., Green Star • Works alongside other NABERS tools • Tries to link with existing work	✓ Links well with Green Star and other green building rating tools	✓ Most standards-compliant, e.g., prEN 15978:2021 (CEN, 2021)	**?** Aligns with several other embodied carbon ratings internationally, but least standards compliant due to inclusion of module D
Trusted	• People have faith in the framework	**?** Potential risk to trust due to exclusion of whole-of-life effects and circularity	**?** Potential risk to trust due to need to forecast replacements and building end-of-life	**?** Potential risk to trust due to need to forecast replacements and building end-of-life
Meaningful	• Easy to understand	✓ Meaningful with good communication. Easier to understand than the other options.	**?** Meaningful with good communication. Not as easy to understand as requires a degree of prediction.	**?** Meaningful with good communication. Not as easy to understand as requires a degree of prediction.

Key	✓ Yes, option meets principle	**?** Option can meet principle if certain criteria are met	✘ No, option does not meet principle

Based on the analysis in Table 10-1:

- Option 1: “Upfront Carbon (to practical completion) (A1-A5)” is the preferred option, having the potential to meet all NABERS market needs. Its biggest risk is to trust, due to exclusion of whole-of-life effects and therefore the potential to shift problems in time.
- Option 2: “Embodied carbon (A-C, excl. B6 & B7)” also has the potential to meet all NABERS market needs, but is more complicated and requires future project of replacement and end-of-life rates.
- Option 3: “Embodied carbon with recycling (A-D, excl. B6 & B7)” does not meet all NABERS prinicples and is not a preferred option.

10.6. Recommendation presented for stakeholder feedback

Our draft recommendation was to focus on upfront carbon (modules A1–A5) as it empowers urgent behaviour change, is the easiest option to use and understand, and aligns with the Green Star Buildings rating tool.

Our recommendation was also to consider mandating a whole-of-life embodied carbon calculation to demonstrate a “no regrets” strategy. This approach is used by the New Zealand Green Building Council.

Finally, we recommended mandating that embodied and operational ratings are always shown side-by-side for a given building. The absence of a rating is an indicator in itself.

10.7. Feedback from stakeholders

There was general support, with some caveats. Generally, stakeholders showed concern about reduced durability of buildings; however, these concerns were refuted by project teams, builders and developers.

Many building product manufacturers would prefer a focus on whole-of-life carbon, even including operational carbon (as this allows trade-offs between life cycle stages to be minimised). However, some said they would accept upfront carbon only provided monitoring of potential trade-offs was done from the start.

The Supporting Consultants agreed with a focus on upfront carbon (A1-A5); however, they noted that excluding life cycle stages could discourage uptake of products that have higher upfront carbon but longer lifespan/performance benefits.

10.8. Revised recommendation

We updated the recommendation as follows:

- **Focus on upfront carbon (modules A1-A5) within the rating.** This empowers urgent behaviour change, is the easiest option to use and understand, and aligns with the Green Star Buildings rating tool.
- **Include an automated calculation of whole-of-life embodied carbon using prescribed replacement and end-of-life rates.** This should be A-C and A-D, both

excluding B6 and B7 (and likely B1 too). NABERS should consider how a whole-of-life calculation can be used to track potential impacts of higher NABERS Embodied Emissions ratings on whole-of-life carbon emissions. It would not necessarily need to be included in the rating certificates and could instead be used by NABERS to check if projects targeting higher NABERS Embodied Emissions ratings are making significant trade-offs with whole-of-life carbon emissions.

- **We recommend that embodied and operational ratings are considered together where possible** for a given building. While the timing of achievement of the two ratings will be different, the absence of an operational rating is an indicator in itself. NABERS should also evaluate if trade-offs are occurring between upfront carbon and operational carbon after there is sufficient data to check.

11. Which functional or declared unit will be used?

This stakeholder engagement topic relates to:
NABERS Proposal 8: A statistical analysis of Bill of Quantities data is the preferred approach to creating whole of building benchmarks.

11.1. Problem statement

What unit should the embodied emissions be presented relative to? Should it be per building, per m^2 of floor area, per m^2 of floor area per year, or something else entirely?

11.2. Early feedback from market

Early market feedback suggested a focus on square metres of floor area was the most appropriate approach. Some stakeholders preferred Gross Floor Area (GFA) as it covers the whole enclosed area of the building, including common areas. Others preferred Net Lettable Area (NLA) for offices and retail as this is the usable space that the building or precinct is designed to deliver. A small group of stakeholders preferred m^2/year to try to account for building durability; however, there was also recognition that it would be difficult to accurately forecast the life of the building as it depends on many factors. One stakeholder commented that a focus on floor area alone could lead to buildings with a smaller floor-to-ceiling height, which could artificially shorten the life of the building as trends change.

The GBCA has always used a reference building approach for the LCA credits in Green Star. This has the advantage of considering the specifics of the site, the building type and the client's brief. However, it has the disadvantage that the reference building can be gamed to make the reduction in carbon footprint look better than it is (by deliberate choice of a poor reference by project teams).

Selected quotes:

- "CO_2-equivalent per square metre" – *Developer/Owner*
- "GFA is probably a better one because it catches sort of everything. And that way you're using it across the board, across multiple projects." – *Constructor*
- "NLA tends to be reserved to commercial office buildings." – *Developer*
- "Kilograms of [carbon dioxide equivalent] per square meter per building typology, which is outlined beautifully in the LETI document…" – *Peak Body*
- "Embodied carbon is going to go one way relative to a square meterage versus a façade area … if you've got a deeper fatter floor plate with less façade and its more efficient than the gross." – *Project Team*

11.3. Literature / policy research

Annex A shows three different options are common for embodied carbon:

- kg CO_2e/m^2 is the most popular, though the measure of floor area differs by program.
- kg CO_2e/m^2/year is used in the Netherlands and Denmark and is proposed in Finland.
- kg CO_2e/building is used in Green Star and in Sweden (which requires reporting only, as opposed to a rating).

A core part of LCA is the concept of the "functional unit", defined by ISO 14044 as the "quantified performance of a product system for use as a reference unit" (ISO, 2006b, section 3.20). The functional unit aims to describe the need that the product (e.g., a building) is trying to meet (e.g., to provide shelter for people to live, work and play). By extension, the functional unit invites us to consider alternative ways of meeting that same need and whether those alternatives might have lower impact upon the environment. Importantly, "the functional unit shall be clearly defined and measurable" (ISO, 2006b, section 4.2.3.2).

All buildings provide some degree of shelter from the outside environment. Given that the climate in many cities and towns is either too hot or too cold for human habitation at certain times of year, many buildings (homes, offices, healthcare facilities, etc.) also provide conditioned indoor air that provides thermal comfort. A building will also need to provide a certain amount of space (both floor area and floor-to-ceiling height) for the need it is designed to meet (e.g., a home, an office, a warehouse). The functional unit also needs a time dimension to be truly measurable and comparable. For example, the functional unit for a warehouse might be "providing 5,000 m^2 of unconditioned internal floor area with a minimum clear operational height of 10 m and a floor designed to carry a forklift with a maximum axle load of 16 tonnes for 50 years".

A strict LCA approach therefore suggests a preference for m^2/year rather than m^2, as this allows the durability of the building to be considered. The challenge when considering upfront emissions only (as recommended in chapter 10) is that it covers the first part of the building's life cycle only, up to the point of practical completion. While it would still be possible to divide upfront emissions by an estimated building life in years, the upfront emissions would not include the maintenance needed to deliver this life.

While the question of m^2/year versus m^2 matters in theory, there is an open question as to whether it matters in practice. The reason for this is that the life of the building is difficult to predict from the outset. Research has shown that a building's actual life is not solely due to the quality of the design, or the durability of the materials chosen. While some buildings are demolished because of poor condition, many others are demolished because the current building no longer meets the needs of its present owners.

O'Connor (2004) found the following major reason for demolition given from a sample of 227 buildings demolished between 2000 and 2003 in Minneapolis–Saint Paul, USA:

- Area redevelopment (34.8%)
- Lack of maintenance (23.8%)
- Building no longer suitable for needs (22.0%)
- Fire damage (7.0%)

- Specific problem with structural or other material or system (3.5%)
- Improvements to bring to code too expensive (1.8%)
- Outdated appearance (0.9%)
- Socially undesirable use (0.9%)
- Changing land values (0.4%)
- Maintenance too expensive (0.4%)
- Other (4.6%).

In O'Connor's research, "Specific problem with structural or other material or system" was a small share of the total responses (3.5%). While it is possible that "Lack of maintenance" (23.8%) could also include some structural failures, the total would still be well under one-third even if all were structural failures, which seems unlikely.

Awano (2006) draws a distinction between "service life", which is the building's ability fulfil its function while meeting defined performance criteria (similar to "design life"), and "real life", which is the building's actual life in practice.

In a recent review of ongoing standardisation of service life prediction, Silva et al. (2022, p. 10) found that "obsolescence appears to occur, in the majority of the situations, before the physical deterioration of buildings and their components. This knowledge suggests that the current focus on the durability or longevity of the buildings should be rethought."

In the Australian context, Bullen and Love (2010) explored the theory of adaptive reuse and the reality of demolition in Perth. The authors argue that a considerable number of Perth's existing buildings will soon become redundant due to changing economic, social and sustainability needs. Owners are then faced with a question: adapt or demolish? They conclude that, "the jury appears to be still out on whether adaptive reuse is the most appropriate strategy for meeting the changing needs and demands of developers, occupiers and owners for exiting building stock in Perth."

Thomsen and van der Flier (2011) developed a helpful quadrant matrix for building obsolescence (Figure 11-1), with internal (endogenous) vs. external (exogenous) on the horizontal axis and physical vs. behavioural on the vertical axis.

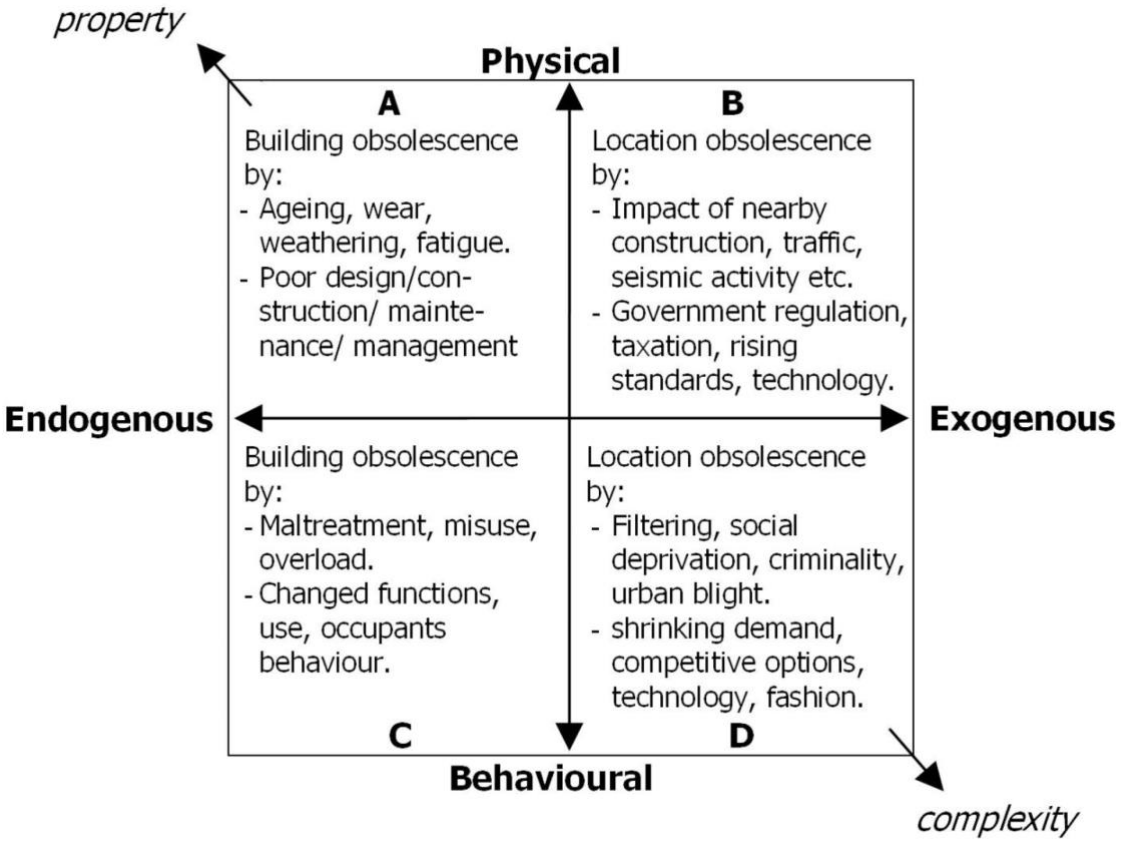


Figure 11-1: Matrix for building obsolencence – reproduced from (Thomsen & van der Flier, 2011)

O'Connor's (2004) conclusions are particularly relevant for this report:

> *In sustainable design, "durability" is increasingly being included on priority lists under the assumption that designing for longevity is an environmental imperative. However, this is unsupported in the absence of life cycle assessment and accurate lifespan predictions. In the worst case, designing for longevity can lead to design choices that are well-intentioned but, in fact, yield poor environmental results. For example, a building component with low embodied environmental effects, such as wood cladding, can be replaced many times before totalling the high embodied effects of a material such as brick. If the brick cladding ends up in landfill after 40 years of use, it was a poor choice on an environmental basis. The best environmental scenario for that brick is recovery at year 40, for re-use in another project. Rather than attempt to predict the future and design permanent structures with an infinite lifespan, we are probably better off in acknowledging our inability to make such predictions and instead design for easy adaptation and material recovery.*

11.4. Options available

Should carbon footprint (kg CO_2e) be presented…

1. per building?
2. per square metre of floor area?
    - gross floor area (GFA)?
    - net lettable area (NLA)?
3. per square metre per year?
    - gross floor area (GFA)?
    - net lettable area (NLA)?
4. per cubic metre of volume?
    - gross volume?
    - net lettable volume?

11.5. Review of options against NABERS market needs

Table 11-1 Review of options against NABERS market needs for "Which functional or declared unit will be used?"

Principle		Per building	Per m^2	Per m^2 per year	Per m^3
Impactful	• Urgent behaviour change • Big wins first	✓ Impactful and best consideration of context (site conditions, design constraints, etc.)	✓ Impactful as scales relative to the key thing building delivers: space	✖ Not focused on urgent behaviour change. Higher upfront emissions can be spread over time.	**?** May over-incentivise higher floor-to-ceiling spacing, which increases resource use per m^2
Consistent	• Results are reproducible no matter who calculates them	**?** Not consistent *unless* there is a standard library of reference buildings	✓ Consistent provided a standard floor area definition is used	✖ Most susceptible to gaming as expected life is very hard to predict	✓ Consistent provided a standard volume definition is used
Streamlined	• Quick and easy to use	**?** Would require a suite of standard reference buildings to be quick	✓ Easy to implement	✓ Easy to implement	✓ Easy to implement
Collaborative	• Considers existing methods/ standards • Considers what others are doing, e.g., Green Star • Works alongside other NABERS tools • Tries to link with existing work	**?** Used in Green Star, but not similar to other NABERS tools	✓ Not used in Green Star, but widely used worldwide and links well to NABERS existing rating tools	**?** Currently only used in Europe	✖ Not used anywhere in the world
Trusted	• People have faith in the framework	**?** Has the potential for gaming the reference building	✓ Calculations are clear provided a standard floor area definition is used	**?** Has the potential for gaming the building lifetime	✓ Calculations are clear provided a standard volume definition is used
Meaningful	• Easy to understand	✓ Easy to understand with good communication	✓ Easy to understand with good communication	✓ Easy to understand with good communication	✓ Easy to understand with good communication

Key	✓ Yes, option meets principle	**?** Option can meet principle if certain criteria are met	✖ No, option does not meet principle

Based on the analysis in Table 11-1:

- "Per m^{2}" is the preferred option, meeting all NABERS market needs.
- "Per building" is the next preferred option, having the potential to meet all NABERS market needs assuming that a suite of standard reference buildings was developed to enable it to scale without gaming.
- "Per m^{3}" is the next most preferred option, though it is not used anywhere else in the world (that the authors could find) and therefore would stand out as an outlier.
- "Per m^2 per year" is not recommended. It allows higher upfront emissions to be spread over time even though there is evidence to suggest that the inherent durability of the materials is not the main factor when determining a building's real life.

11.6. Recommendation presented for stakeholder feedback

We recommended to use **kg CO_2e per m^2 of floor area**. The measure of floor area might differ category to category but would always be consistent within a category. For example, it might be NLA for offices and retail, with GFA for others.

11.7. Feedback from stakeholders

Feedback from stakeholders (both verbal and via the survey) showed reasonably strong support for using kg CO_2e/m^2. There was some opposition to the inclusion of NLA as an option, with Developers and Constructors suggesting it should be limited to GFA only. The LCA Expert group had the strongest preference for kg CO_2e/m^2/year to account for building durability but acknowledged the limitations in estimating building lifetime.

One Supporting Consultant preferred NLA over GFA, on the basis that NLA aligns with current NABERS practice, better represents functionality and rewards resource efficiency.

11.8. Revised recommendation

No revised recommendation is made in this report. From a technical perspective, whether per m^2 GFA or NLA is used makes no material difference. Both include the same impacts, but they are normalised on a different basis. The main argument in favour of GFA is that the same metric can be applied to all building types. The main argument in favour of NLA is that it better serves the function that the building provides (to provide space to the tenant) and so is arguably superior as a functional unit (though the authors also see social value in providing common spaces, which would be treated as inferior if NLA was used).

The decision on GFA vs. NLA is left for NABERS to determine during the benchmarking analysis

12. Will it assess carbon only or full LCA?

This stakeholder engagement topic relates to:
NABERS Proposal 5: Only carbon emissions will be included.

12.1. Problem statement

Which environmental indicator(s) should be assessed? Should the tool be limited to carbon only? Should it include other commonly understood indicators such as water and waste due to trade-offs? Should it include a full suite of environmental indicators following EN 15978? Should it consider social issues like modern slavery?

Note: While "embodied emissions" is often used synonymously with "embodied carbon", this was not precisely defined at the start of this project and instead needed to be developed though through the process itself.

12.2. Early feedback from market

Early feedback from the market suggested that many stakeholders preferred carbon as a single environmental indicator to help focus the analysis. Others argued in favour of a multi-indicator LCA approach to help achieve balanced outcomes.

Selected quotes:

- "My request would be upfront carbon." – *Investor*
- "I think it is fair enough to be considering upfront carbon. These emissions are now. … Some of the products are in the building for a very long time." – *Manufacturer*
- "We are very mindful of delivering across the systemic and broader definition of sustainability and being mindful of those potential unintended perverse outcomes." – *Tool Maker*
- "I know your scope is only energy and emissions, but there's other environmental impacts that can occur. And that can be shifted if we're reducing emissions as well. So you can end up actually with worse outcomes in areas" – *Tool Maker*
- "Constraining the scope of the LCA leads to perverse outcomes." – *Constructor*

12.3. Literature / policy research

Most frameworks globally focus on embodied carbon and are therefore limited to greenhouse gas emissions only (see Table A-1 on page 109). However, LCA is designed to avoid shifting problems in time, in space, and between environmental compartments (e.g., GHG to water).

The *Life Cycle Impacts* credit within the GBCA's *Green Star Buildings* rating tool awards a 25% weighting to carbon footprint, a 25% weighting to water consumption, and a 10% weighting to each of the five remaining environmental indicators (GBCA, 2021). Following this logic, water could be seen as an important second indicator alongside carbon footprint.

Stakeholders also commented on the importance of designing for the circular economy. The Material Circularity Indicator (MCI) of the Ellen MacArthur Foundation is one possible measure of the circular economy that could be applied at the building level, though the actual end-of-life fate of the materials in the building is difficult to predict.

The fullest extent of environmental indicators that could be assessed is those found in EPDs. However, there is currently a transition taking place between EN 15804+A1:2013 and EN 15804+A2:2019 and these changes are not yet reflected in EN 15978 as the standard is still under revision. While the two versions of EN 15804 are substantially similar, there are differences in some of the environmental indicators. This affects acidification, eutrophication, summer smog and water deprivation potential. The last EPDs published under EN 15804+A1:2013 through EPD Australasia were registered on 28 February 2022 and will remain valid until 28 February 2027.

A focus on carbon footprint only makes things simpler. Carbon footprint is the only environmental indicator that is always assessed in LCA and EPD studies, and there are standards specific to carbon footprinting – ISO 14067 (ISO, 2018) at the international level and Climate Active within Australia. Hybrid LCA data is also often limited to carbon footprint only. These separate approaches provide another pathway to carbon footprint data in addition to EPDs.

The key question to be addressed is this: if the focus of NABERS Embodied Emissions is limited to carbon only, how can we ensure that this does not lead to burden shifting?

12.3.1. Options available

We identified three options:

1. Carbon footprint only
2. Small indicator set, e.g., carbon and water
3. All EPD indicators.

12.4. Review of options against NABERS market needs

Table 12-1 Review of options against NABERS market needs for "Will it assess carbon only or full LCA?"

Principle		Carbon footprint only	Small indicator set	All EPD indicators
Impactful	• Urgent behaviour change • Big wins first	✓ Focuses on the most immediate and significant environmental threat	**?** May create confusion about where energy should be focused	× Likely to create confusion about where energy should be focused
Consistent	• Results are reproducible no matter who calculates them	**?** Potential to be consistent if well executed.	**?** Potential to be consistent if well executed.	× Risk of inconsistency due to changes in EPD standards
Streamlined	• Quick and easy to use	✓ Least data required	× Extra data required and potential for complications	× Extra data required and potential for complications
Collaborative	• Considers existing methods/standards • Considers what others are doing, e.g., Green Star • Works alongside other NABERS tools • Tries to link with existing work	**?** Has the potential to algin with existing methodologies and green building tools	**?** Has the potential to algin with existing methodologies and green building tools	**?** Has the potential to algin with existing methodologies and green building tools
Trusted	• People have faith in the framework	**?** Has the potential to be trusted if well executed	**?** Has the potential to be trusted if well executed	**?** Has the potential to be trusted if well executed
Meaningful	• Easy to understand	✓ Easy to understand if well communicated.	× Multi-indicator studies are difficult to understand, and simple combined/weighted indicators may undermine trust.	× Multi-indicator studies are difficult to understand, and simple combined/weighted indicators may undermine trust.

Key	✓ Yes, option meets principle	**?** Option can meet principle if certain criteria are met	× No, option does not meet principle

Based on the analysis in Table 12-1:

- Option 1: “Carbon footprint only” is the preferred immediate option, having the ability to meet all NABERS market needs.
- Option 2: “Small indicator set” is the next preferred option but fails on Streamlined (due to the extra data needed) and Meaningful (due to the difficulty in interpreting multi-indicator studies).
- Option 3: “All EPD indicators” is a potential long-term option (in 5 years) but does not currently meet all NABERS market needs.

12.5. Recommendation presented for stakeholder feedback

We recommended **focusing on carbon footprint only for now**. Many other environmental indicators (e.g., acidification potential, summer smog, depletion of fossil fuels) will follow carbon footprint so long as there is a large share of fossil fuels in industrial heat and electricity.

EPDs are also in a transition phase between EN 15804+A1 and EN 15804+A2, with a change of environmental impact categories. This has limited effect on carbon, but does effect some other indicators. It is wise to wait until this settles out.

In future, consider expanding to the other environmental indicators, with a focus on water footprint first (following GBCA).

12.6. Feedback from stakeholders

Feedback from stakeholders (both verbal and via the survey) showed overall strong support for rating carbon only in the short-term, but comments suggest that the focus should be expanded to more environmental indicators in the next 1-3 years. A few survey responses – particularly from building product manufacturers – showed strong opposition to the recommendation and suggested that a more holistic approach should be considered.

12.7. Revised recommendation

Maintain this recommendation as-is. There is strong support for focusing on carbon for now with the view to expand to other environmental indicators in the future. Stakeholders noted that the carbon focus simplifies the certification process and provides a clear initial focus. However, the transition to other indicators should be transparent and well communicated to ensure people understand the direction the tool is taking. This should be considered at NABERS' first systematic evaluation of the methodology, in 3-5 years' time.

13. Will stored biogenic carbon be considered?

This stakeholder engagement topic relates to:

NABERS 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.

13.1. Problem statement

How should stored biogenic carbon be accounted for in the rating?

Stored biogenic carbon is carbon dioxide originally from the atmosphere that is stored (sequestered) in building materials. It is most commonly found in wood products. Trees absorb CO_2 from the atmosphere during tree growth. This CO_2 is converted into carbon compounds (cellulose, hemicellulose, lignin) that make up the structure of the tree. After harvesting, this stored CO_2 is banked temporarily in the building. For structural materials, "temporarily" will typically be a design life of 50 years or more.

13.2. Definitions

Biogenic carbon is "carbon derived from biogenic (plant or animal) sources excluding fossil carbon" (ISO, 2018). More specifically, biogenic carbon is carbon dioxide removed from the atmosphere through photosynthesis by living things that is then transformed into other carbon-based compounds and stored within a plant or animal – be it the trunk of a tree, or the wool of a sheep (through the sheep eating grass).

The process of removing carbon dioxide from the atmosphere helps to mitigate climate change. For short-lived products, such as food, stored biogenic carbon is typically released back to the atmosphere quickly, effectively cancelling out any net benefit. For long-lived products such as those used in buildings, this atmospheric CO_2 will often be stored within the building for several decades, and sometimes even hundreds of years. While this is a temporary effect, removing carbon dioxide from the atmosphere and storing it for several decades can help to buy time for further carbon reduction technologies and methods to be developed.

Biogenic carbon stored in wood products within buildings is governed by EN 16485:2014 (CEN, 2014), a partner standard to EN 15804+A1 (CEN, 2013). A new version is currently in preparation to partner with EN 15804+A2 (CEN, 2019), but it is not yet finalised.

13.3. Early feedback from market

Early feedback suggested differing views, though there was overall support for some form of separate reporting of fossil and biogenic carbon, as well as stored biogenic carbon.

Selected quotes:

- “If we need to state fossil and biogenic carbon separately that is okay … the information relating to the products needs to be complete.” – *Building Product Association*
- “I would like to see biogenic carbon included and fully recognised. Stored carbon is hugely important for our products.” – *Building Product Association*
- “Timber is quite a unique [product] because of the ability to suppress carbon as well. Now, EPD standards are requiring people to report that data separately: so sequestered carbon or the biogenic carbon separately from the production” – *Tool Maker*
- “The earlier we can consider alternative low embodied carbon products, such as timber and other low embodied solutions, then that can make a significant impact.” – *Developer*
- “[Regarding] biogenic carbon, both numbers should be included. EPDs show split between fossil and biogenic carbon. Also needs to look at whole-of-life. Look at it holistically and split them both.” – *Manufacturer*

13.4. Literature / policy research

Handling of stored biogenic carbon was not fully developed when the European standard for building LCA – EN 15978:2011 – was first published. The international standard for carbon footprinting of products – ISO 14067 – was only published as a Technical Specification in 2013 and as a full standard in 2018 (ISO, 2018). Treatment of stored biogenic carbon came later through EN 16485:2014 and then EN 15804+A2:2019.

These newer standards require accounting for stored biogenic carbon when the full product (or building) life cycle (manufacture + end-of-life) is accounted for, but do not allow it for a partial product/building life cycle (e.g., upfront carbon).

Presenting a simplified version of these standards:

- Stored biogenic carbon from sustainably managed forestry (i.e., certified by FSC/ PEFC/Responsible Wood) is treated as -1 kg CO_2e for every 1 kg CO_2 biogenic carbon sequestered into the finished product. The amount of CO_2 is calculated as the amount of biogenic C * (44/12), which is the mass ratio of CO_2 to C. Losses upstream (such as residues in the forest, sawdust from sawmilling, etc.) are not part of this calculation, as these are either waste products (where the uptake and release of biogenic CO_2 typically cancel each other out) or co-products (where the biogenic carbon is allocated to the co-product instead).
- Incineration of the product at end-of-life releases all of the stored biogenic carbon, effectively cancelling it out over the full building life cycle.
- Recycling or reuse of the timber product also effectively cancels out the stored biogenic carbon. This is an accounting rule and does not mean that the stored biogenic carbon is actually released to the atmosphere at this time. Instead, it is “passed” to the next product life cycle by treating it as an emission in the current life cycle, so the next life cycle can “reabsorb” the biogenic CO_2 from the atmosphere without a risk of double-counting between product life cycles.

- For landfill, any stored biogenic carbon that does not break down (which has been shown through research to be most of it) could historically be treated as carbon storage in EN 15804+A1. EN 15804+A2 now specifically requires any carbon stored after 100 years to be treated as if it is emitted to the air. This seems likely to be a political move to promote the circular economy as there is little scientific basis for this change.
- EN 15804+A2:2019 effectively cancels out all biogenic carbon over the full life cycle of the building (landfill, recycling, reuse, incineration). Only incineration is a real emission, while all the others are implemented for accounting reasons.

13.5. Options available

We identified five potential options:

Option 1 – Biogenic carbon is included in star rating at full amount

Carbon stored in products intended to have a long design life (e.g., structural elements) is accounted for in full, provided that these products come from a sustainably managed source (e.g., FSC or PEFC). E.g., use of 1 m^3 of kiln-dried sawn softwood would contribute -900 kg CO_2e/m^3 of stored carbon (as per the FWPA softwood EPD).

Option 2 – Biogenic carbon is included in star rating but discounted

Stored biogenic carbon is recognised at, say, 50% of its original value.

Example: If 1 m^3 of kiln-dried sawn softwood contributes -900 kg CO_2e/m^3 of stored carbon, perhaps -450 kg CO_2e/m^3 of this might be recognised.

These percentages could be arbitrary or set based on some measure of carbon leakage expected from carbon storage in products.

Option 3 – Biogenic carbon is included in star rating as separate scale

Fossil carbon emissions are treated separately to stored biogenic carbon and must reduce per star rating. A building's emissions must be lower than *both* a gross amount (excluding stored biogenic carbon) *and* a net amount (including stored biogenic carbon).

Option 4 – Biogenic carbon is excluded from star rating but reported separately

Products are recognised at their original fossil carbon emissions in the main star rating (i.e., stored biogenic carbon is excluded). The stored biogenic carbon is reported separately, e.g., 30% of the building's fossil carbon footprint has been "offset" (or "inset") through the use of stored biogenic carbon in the structure of the building.

Option 5 – Biogenic carbon is excluded from star rating and not reported

Stored biogenic carbon is not recognised under the rating system. The full fossil carbon emission of each product is counted in the main star rating. There is no separate disclosure of stored biogenic carbon within the rating system.

13.6. Recommendation presented for stakeholder feedback

No recommendations were made in the workshops as this was an item for discussion.

13.7. Feedback from stakeholders

Because this topic was expected to be contentious, none of the options were reviewed against the NABERS market needs until after the workshops. Instead, the five options were presented as equals and the floor was opened to stakeholders for their verbal feedback and then their written feedback via the questionnaire after the workshop.

We did not expect agreement going into this process; instead, we were hoping to identify the least-worst option as a compromise position to try to build some degree of consensus.

Feedback from stakeholders (both verbal and via the survey) show mixed responses for all options. There was at least a handful of “can’t live with it” responses for all five options, though option 3 stood out as the least-worst option.

Stakeholder comments included:

- “It would be a perverse outcome to fail to recognise the long term stored carbon in wood products. Timber construction could be a significant contributor to reducing embodied emissions and a failure to encourage this would be a serious failure in the rating tool.”
- “Similar to NABERS Energy where green power is reported separately, report biogenic and carbon offset separately to not lose focus on driving down embodied carbon.”
- “Either the 3rd or 4th one, it’s a line ball in terms of which way you want to promote these type of materials.”
- “Potential for significant temporal misalignment between time of harvest and regrowth sequestration rates despite FSC or sustainable forest management practices.”
- “Life Cycle Assessment does not consider financial transacted implications of carbon ownership rights does not validate whether there is an existing third-party claim over stored carbon – it only indicates the amount of carbon sequestration that has resulted.”
- “Capturing the benefits of stored biogenic carbon is extremely important however if it is included there must be a safeguard (cap) to ensure that overuse of material is not inadvertently encouraged.”

The Supporting Consultants saw merit in including biogenic carbon, however wanted it reported as a separate indicator as its CO_2 reabsorption is not accepted in upfront carbon (A1-A5) scope.

- “A further alternative could be for biogenic carbon emissions and offsets to form part of a ‘offset carbon indicator’, in a similar manner to NABERS Renewable Energy Generation and Purchasing for operating ratings.”

13.8. Feedback from NABERS

NABERS Energy with GreenPower has not seen significant uptake, with only 13% of NABERS Energy ratings in FY22 including a GreenPower component. Feedback from stakeholders included that it was confusing and did not drive behaviour change. This was because it did not transparently display the performance of buildings and the effort to reduce the impact of the building through efficiency measures versus compensation measures. As a result, NABERS is winding back the NABERS Energy with Green Power Rating and introducing a separate indicator – the Renewable Energy Indicator – which transparently shows efficiency and renewable energy performance side-by-side.

The Material Recovery Score in the NABERS Office Waste rating works in a similar way. It is an additional measure that was introduced into the rating calculation to measure the quality of end-of-life (or circular economy) outcomes. Again, feedback from stakeholders was that it is confusing, therefore limiting its impact. Inclusion within the rating score means that there is no transparent display of the circular performance of the building. NABERS will be trialling a separate indicator for the new NABERS Public Hospitals Waste product to enable a transparent display of circularity. The intention is to then roll this out to the NABERS Office Waste product.

13.9. Review of options against NABERS market needs

Table 13-1 Review of options against NABERS market needs for "Will stored biogenic carbon be considered?"

Principle	Included in star rating at full amount	Included in star rating but discounted	Included in star rating as separate scale	Excluded from star rating but reported separately	Excluded from star rating and not reported
Impactful	**?** Drives behaviour change towards materials that store carbon; may not reduce fossil carbon	**?** Drives behaviour change towards materials that store carbon; may not reduce fossil carbon	**?** Designed to drive behaviour change; however, NABERS experience is that it will create confusion	**?** Incentivises fossil carbon reduction; may drive improvements in stored carbon if the indicator is valued by the market	**?** Incentivises fossil carbon reduction; does not incentivise stored carbon
Consistent	✓ Results reproducible with a clear Standard	✓ Results reproducible with a clear Standard	✓ Results reproducible with a clear Standard	✓ Results reproducible with a clear Standard	✓ Results reproducible with a clear Standard
Streamlined	✓ Easy to implement	✓ Easy to implement	✓ Easy to implement	✓ Easy to implement	✓ Easy to implement
Collaborative	✗ Does not comply with ISO 14067; may double-count sequestration	✗ Does not comply with ISO 14067; may double-count sequestration	✓ Complies with ISO 14067 due to separate reporting	✓ Complies with ISO 14067 due to separate reporting	✓ Complies with ISO 14067 due to the fact this is a partial life cycle
Trusted	✗ Fossil carbon emissions may not always reduce; potential for double-counting may erode trust	✗ Fossil carbon emissions may not always reduce; potential for double-counting may erode trust	✓ Fossil carbon emissions will always reduce with higher star ratings	✓ Fossil carbon emissions will always reduce with higher star ratings	✓ Fossil carbon emissions will always reduce with higher star ratings
Meaningful	**?** The same star rating can be achieved through either fossil carbon reduction or adding more stored carbon	**?** The same star rating can be achieved through either fossil carbon reduction or adding more stored carbon	**?** Still a single star rating, but the calculations in the background are more complicated	✓ NABERS experience with other ratings is that this is the most meaningful way to present results	✓ Easy to understand with good communication

Key	✓ Yes, option meets principle	**?** Option can meet principle if certain criteria are met	✗ No, option does not meet principle

Based on the analysis in Table 13-1:

- Option 4: “Stored biogenic carbon is excluded from the star rating but reported separately” is the preferred option and able to meet all market needs.
- Option 5: “Excluded from star rating and not reported” is similarly preferred based on the NABERS principles; however, it was not preferred by stakeholders.
- Option 3: “Included in star rating as separate scale” is the next most preferred option; however, NABERS’ experience is that this type of composite rating has not worked for NABERS Energy and NABERS Waste.
- Options 1 and 2 both fail on at least one of the NABERS market needs and are therefore not recommended.

13.10. Recommendation

We recommended:

- Option 4 “Stored biogenic carbon is excluded from the star rating but reported separately”.
- **Only biogenic carbon from sustainably managed sources** (e.g., with FSC or PEFC certification) **or from recycled/reused sources** can be recognised. This helps to avoid inadvertently creating demand for unsustainable forestry practices, which can also have perverse carbon outcomes.
- **Only biogenic carbon for products with a design life of >20 years can be included.** While 20 years is arbitrary, this timeframe is set to represent long-term storage and to try to avoid materials disposed of as part of regular churn within the building. (ISO 14067:2018 uses a minimum timeframe of 10 years for long-term carbon removals.) Typically speaking, products with a design life of >20 years will include all bio-based materials included in the structure of the building and it may also include some types of bio-based cladding and non-structural interior elements.
- Stored biogenic products in engineered wood products and other composite wood products can be accounted for, provided it meets the points above.

We recommend this approach because:

- It guarantees a reduction in fossil carbon as the star rating progresses, helping to build trust in the NABERS Embodied Emissions Tool.
- **It is standards compliant.** Gross emissions are reported separately to removals.
- **It provides transparency** on the proportion of fossil carbon emissions that have been compensated via carbon offsets.
- **It allows stakeholders to set targets** based on strategies that match their objectives.
- It aligns with the new Renewable Energy Indicator within NABERS Energy.
- It provides an incentive for the use of stored biogenic carbon in building materials, which is important as it drives immediate action in this decade.

We recommend that both NABERS and wood product manufacturers advocate for stored biogenic carbon to be accounted for in decision-making alongside the final star rating.

14. Will carbon offsets be considered?

This stakeholder engagement topic relates to:

NABERS 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.

14.1. Problem statement

How should carbon offsets be accounted for in the rating?

Should they be included in some way or excluded entirely? Should carbon offsets at the product level be treated equally to carbon offsets at the building level?

Carbon offsets neutralise fossil carbon emissions. By allowing them, manufacturers in hard-to-abate sectors such as primary steel and ordinary Portland cement can take some action on climate change now (at a cost) while they wait for low-carbon technology to mature.

Conversely, including carbon offsets can create the perception of doing nothing and buying your way out of trouble, potentially reducing trust in the tool. They are also not allowed in base calculations by standards for LCA (following ISO 14044) and carbon footprinting (following ISO 14067).

14.2. Definitions

A **carbon offset** "is a unit of carbon dioxide-equivalent (CO_2e) that is reduced, avoided, or sequestered to compensate for emissions occurring elsewhere." (Goodward & Kelly, 2010)

Like stored biogenic carbon, carbon offsets help to mitigate climate change. Unlike stored biogenic carbon, where atmospheric carbon dioxide is stored in the building itself, carbon offsets occur off-site and typically have no direct connection to the building itself.

"**Carbon neutral** means reducing emissions where possible and compensating for the remainder by investing in carbon offset projects to achieve net zero overall emissions" (Climate Active, 2020, p. 2). This is illustrated in Figure 14-1. A product that has achieved carbon neutrality is then referred to as a carbon neutral product or net-zero carbon product.

Within the Climate Active framework, certified carbon neutral products can be used to reduce the emissions that must be offset to achieve a carbon neutral building. They must abide by the Climate Active rules of reducing emissions first before compensating for the remainder with qualifying carbon offsets.

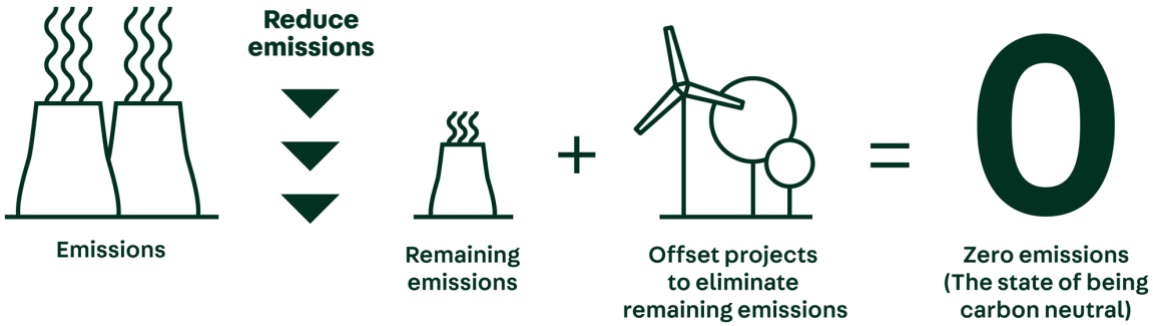


Figure 14-1: The process of carbon neutrality – reproduced from Climate Active (2020)

14.3. Early feedback from market

Selected quotes:

- "Carbon offsetting should not be included in the base calculation of emissions. If it is utilised it should be an add-on, and you should see what is being [directly] contributed as a product." – *Building Product Manufacturer*
- "There should be an ability [to target a high NABERS rating] by purchasing good quality offsets … aligning with the Climate Active carbon neutral approach." – *Engineer/QS*
- "We're offsetting as the last resort." – *Designer*
- "How you handle offsets? Maybe you have them at the start, but ratchet them back?" – *Manufacturer*
- "[For Climate Active certification] you can't just buy offsets and that's all you do. It requires a plan and commit to reductions and drive that." – *Manufacturer*

14.4. Literature / policy research

Carbon offsets are not allowed in base calculations by the standards for LCA (ISO 14044) and carbon footprinting (ISO 14067). They are also not allowed in the base calculation as part of an EPD.

As can be seen in Table A-1 on page 1091, *Green Star Buildings* was the only standard in our review that allowed carbon offsets. Importantly, *Green Star Buildings* specifically restricts carbon offsets to the product level and does not allow building-level offsets.

Climate Active Product Certification does recognise offsets in purchased products from compliant programs given that its goal is to achieve carbon neutrality.

While carbon offsets may seem like a way for industry to buy its way out of trouble and not take any real action on climate change, it is worth noting that:

- Good quality **carbon neutral product certifications** such as Climate Active always **require a carbon reduction plan** and ongoing emissions measurement so that the business reduces its emissions as much as it can before offsetting. Where a business' emissions are hard-to-abate, they are at least visible, tracked and continually reducing to the extent possible as technology matures.

- A reduction in carbon footprint **at the building level** does not automatically translate to a reduction in carbon footprint **at the global level**. Careful consideration must be given to any demand-related mechanisms as there is a risk of unintended consequences (e.g., putting increased pressure on local building product manufacturers) while also not reducing – or even increasing – global greenhouse gas emissions.

14.5. Options available

We identified five options, as described below.

Option 1 – Carbon offsets are included in star rating at full amount

Certified carbon neutral products are recognised at 0 kg CO_2e at the building level.

Option 2 – Carbon offsets are included in star rating but discounted

Certified carbon neutral products are recognised at, say, 50% of their original value.

Example: A certified carbon neutral product that released 100 kg CO_2e fossil carbon to the atmosphere might be counted as 50 kg CO_2e at the building level.

These percentages could be arbitrary or set based on some measure of carbon leakage expected from offsets (if any), for example.

Option 3 – Carbon offsets are included in star rating as separate scale

Fossil carbon emissions are treated separately to offsets and must reduce per star rating. A building's emissions must be lower than *both* a gross amount (excluding offsets) *and* a net amount (including offsets).

Option 4 – Carbon offsets are excluded from star rating but reported separately

Certified carbon neutral products are recognised at their original fossil carbon emissions in the main star rating (i.e., offsets are excluded). The carbon offsets purchased for building products are reported separately, e.g., 30% of the building's fossil carbon footprint has been offset through the purchase of certified carbon neutral products.

Option 5 – Carbon offsets are excluded from star rating and not reported

Certified carbon neutral products are not recognised under the rating system. The full fossil carbon footprint of these products is counted in the main star rating (i.e., offsets are excluded). There is no separate disclosure of these offsets with the rating system.

14.6. Recommendation presented for stakeholder feedback

We didn't make any recommendations in the workshops as this was an item for discussion.

14.7. Feedback from stakeholders

Because this topic was expected to be contentious, none of the options were reviewed against the NABERS market needs until the completion of the workshops. Instead, the five options were presented as equals and the floor was opened to stakeholders for their verbal feedback and then their written feedback via the questionnaire after the workshop.

We did not expect agreement going into this process; instead, we were hoping to understand the impacts to identify the solution most aligned with the objectives and market needs and build some understanding of the rationale for our decision making.

Feedback from the stakeholders (both verbal and via the survey) show mixed responses for all options. There was at least a handful of “can’t live with it” responses for all five options, though options 3 and 4 stand out as the least-worst options. The relatively high number of neutral responses could be as a result of stakeholders not feeling equipped to understand and provide a judgement based only a small amount of information

Selected stakeholder comments:

- “Offsets are important and can be hugely beneficial. Reporting offsets separately provides an incentive to optimise the design and retains a pathway to get to net zero while we decarbonise materials.”
- “Focus should be on absolute reduction (and spending money on achieving this rather than offsetting).”
- “Offsets need to be included to be realistic about improving embodied carbon. There needs to be financial incentives for commercialisation of new technologies like green steel or geopolymer concrete. I believe there should be a roadmap to eventually [wean] off the need for offsets (perhaps by say 2030-2040). However, there should also be the recognition that offsets aren't as preferable to the real thing.”
- “I'm one that thinks carbon offsets are just the way developers/clients use financial means to rid of climate problems.”
- “Carbon offsets are a path for operations continuing to work on reducing carbon but where there is currently no technology for renewable energy to be used. However, offsets must be under a rigorous credible scheme such as Climate Active.”
- “I do not see an issue in including in the calculation method provided that the carbon neutral certification is above legitimate and robust (ie. climate active). It encourages material manufacturers to firstly reduce their emissions, and then secondly offset the remaining emissions.”
- “Like the old GreenPower rating. It’s not the headline, but there for people to see. Focus on reducing the impact, then the offset.”

The Supporting Consultants expressed some concern that carbon offsetting could devalue the NABERS rating system and recommended that offsets be reported separately if at all. They acknowledged that offsets provide emissions reduction pathways while the sector transitions and agreed that recognising offsets that align with Climate Active or similar programs **(but report separately)** is a balanced solution.

- “Agree that there is no reward for carbon offsets if the gross upfront carbon performs poorly.”

- “Carbon offsets at the individual material or building level must be considered to align with Climate Active and other “carbon neutral” programs to provide the broadest range of low-cost pathways to reduction.”
- “Excluding offsets but report separately is probably the balanced middle ground.”

14.8. Feedback from NABERS

Refer to section 0.

14.9. Review of options against NABERS market needs

Table 14-1 Review of options against NABERS market needs for "Will carbon offsets be considered?"

Principle	Included in star rating at full amount	Included in star rating but discounted	Included in star rating as separate scale	Excluded from star rating but reported separately	Excluded from star rating and not reported
Impactful	**?** Drives behaviour change (assuming Climate Active or similar used) but may not reduce fossil carbon	**?** Drives behaviour change (assuming Climate Active or similar used) but may not reduce fossil carbon	**?** Designed to drive behaviour change; however, NABERS' experience is that it will create confusion	**?** Incentivises fossil carbon reduction; may drive an increase in carbon offsets if the indicator is valued by the market	**?** Incentivises fossil carbon reduction; may drive an increase in carbon offsets if the indicator is valued by the market
Consistent	✓ Results reproducible with a clear Standard	✓ Results reproducible with a clear Standard	✓ Results reproducible with a clear Standard	✓ Results reproducible with a clear Standard	✓ Results reproducible with a clear Standard
Streamlined	✓ Easy to implement	✓ Easy to implement	✓ Easy to implement	✓ Easy to implement	✓ Easy to implement
Collaborative	✗ Does not comply with ISO 14067	✗ Does not comply with ISO 14067	✓ Complies with ISO 14067 and EN 15804+A2 due to separate reporting	✓ Complies with ISO 14067 and EN 15804+A2	✓ Complies with ISO 14067 and EN 15804+A2
Trusted	✗ Fossil carbon emissions may not always reduce; perception of buying our way out of the climate emergency	✗ Fossil carbon emissions may not always reduce; perception of buying our way out of the climate emergency	✓ Fossil carbon emissions will always reduce with higher star ratings	✓ Fossil carbon emissions will always reduce with higher star ratings	✓ Fossil carbon emissions will always reduce with higher star ratings
Meaningful	**?** The same star rating can be achieved by either fossil carbon reduction or buying more products with offsets	**?** The same star rating can be achieved by either fossil carbon reduction or buying more products with offsets	**?** Still a single star rating, but the calculations in the background are more complicated	✓ NABERS experience with other ratings is that this is the most meaningful way to present results	✓ Easy to understand with good communication

Key	✓ Yes, option meets principle	**?** Option can meet principle if certain criteria are met	✗ No, option does not meet principle

Based on the analysis in Table 14-1:

- Option 4: “Carbon offsets are excluded from the star rating but reported separately” is the preferred option and able to meet all market needs.
- Option 5: “Excluded from star rating and not reported” is similarly preferred based on the NABERS principles; however, it was not preferred by stakeholders.
- Option 3: “Included in star rating as separate scale” is the next most preferred option; however, NABERS’ experience is that this type of composite rating has not worked for NABERS Energy and NABERS Waste.
- Options 1 and 2 both fail on at least one of the NABERS market needs and are therefore not recommended.

14.10. Recommendation

We recommend:

- Option 4: “Carbon offsets are excluded from the star rating but reported separately”.
- Carbon offsetting should only be permitted through a mechanism of carbon neutral certified building products, not at the building level.
- **Carbon neutral certified products** will be recognised through a program such as Climate Active. Carbon offsets purchased directly by a manufacturer (and not through a carbon neutral certification program) will not be recognised. This ensure that the manufacturer has an active **emissions reduction strategy** in place as well as using **quality offsets**. NABERS plan to recognise other carbon neutral product certification schemes where they are assessed as delivering similar outcomes to Climate Active.

We recommend this option because:

- It guarantees a reduction in fossil carbon as the star rating progresses, helping to build trust in the NABERS Embodied Emissions Tool.
- **It is standards compliant.** Gross emissions are reported separately to removals.
- **It provides transparency** on the proportion of fossil carbon emissions that have been compensated via carbon offsets.
- **It allows stakeholders to set targets** based on strategies that match their objectives.
- It aligns with the new Renewable Energy Indicator within NABERS Energy.
- **It provides an incentive for the use of carbon offsets for building materials**, which is important as it drives immediate action in this decade while also providing a pathway for manufacturers in hard-to-abate sectors an opportunity to continue to sell their products while they work on next-generation technology.

We recommend that both NABERS and manufacturers in hard-to-abate sectors advocate for carbon offsets to be accounted for in decision-making alongside the final star rating.

15. Should the tool cover major refurbishments and demolition?

This stakeholder engagement topic relates to:
NABERS Proposal 1: Only new buildings and major refurbishments are eligible to certify.
NABERS Proposal 3: Emissions from demolitions are excluded.
NABERS Proposal 6: NABERS will encourage verified product specific emissions data and will apply conservative defaults where no emissions data is available.

15.1. Problem statement

How should major refurbishments and demolition of existing buildings be treated? What constitutes a significant enough refurbishment that it would be eligible for a NABERS rating? Should there be a minimum amount of works undertaken? Should demolition of relatively new structures be disincentivised?

15.2. Early feedback from market

Early feedback from the market was that refurbishment should be incentivised as one of the primary strategies for decarbonisation.

Selected quotes:

- "It would be great if [the framework] isn't just for new construction – if it can be adaptable for major retrofits as well." – *Developer/Owner*
- "We have a few major refurbishments as well where … it would be good to integrate market needs on how to reduce embodied carbon in the way we delivered those works." – *Developer/Owner*
- "We actually did a full life cycle assessment on the project. It's a good reuse story, we've re-lifed a building. So we reused the structure and the side of the building, which was basically equivalent to 13.3 years of operational energy savings." – *Tool Maker*
- "Encouraging refurbs as opposed to demolitions with the aim of… lowering embodied carbon" – *Policy Maker*

15.3. Literature / policy research

One of the best strategies to reduce embodied carbon is *not* to build something (by reusing something that already exists). While it is not always possible to reuse an existing building (see section 11.3), reuse should be encouraged wherever it is practical.

Green Star Buildings treats reused elements as zero carbon (except for any emissions associated with reprocessing them to be suitable for reuse) and has the following requirements for demolition (GBCA, 2021, p. 135):

Offsetting Demolition Works

Where an existing building less than 30 years old has been fully or partially demolished for construction, an embodied carbon calculation must be completed for the demolished portion and these emissions offset.

Where the existing building is between 30 to 50 years old, the contribution must be calculated and discounted at 10% for every two additional years past year 30.

Beyond 50 years, there are no requirements.

15.4. Options available

The early feedback from the market was that reuse should be incentivised. To try to address this, major refurbishments were considered in the same category as new builds. We considered the following two options

Option 1: Retained building elements are burden free

- Retained building elements are assigned zero impact (except for the carbon footprint of reprocessing them for reuse, if required).
- Demolition is excluded as it is considered part of the previous building's life cycle.

This approach aligns with international standards, such as EN 15978 in that the building's life cycle is considered in a logical sequence, with the end-of-life grouped with its start-of-life, even though this may have been several decades ago. The life cycle of the new building starts after demolition of the old building is completed following the "polluter pays principle" common in LCA and EPDs (i.e., the original building must pay the environmental cost for its own disposal).

Option 2: Retained building elements are assigned zero impact beyond a certain age

- Retained building elements are zero impact beyond a certain age (except for the carbon footprint of reprocessing them for reuse, if required).
- Pro-rate the embodied carbon of existing building elements whose age is less than their expected life to avoid gaming (for cold shell elements only).
- E.g., existing 40-year-old building (expected life of structure = 50 years, façade = 30 years). Structure reused and façade replaced. Structure treated as 10/50 of original impact with no pro-rated impact for the old façade.
- The pro-rated embodied carbon would apply regardless of whether the item was reused or disposed of
- Emissions from demolition included in the new building's life cycle.

The logic of this approach is that a building site in a city forms a continuous chain between one building and the next. The previous building cannot be responsible for its own demolition carbon footprint because that is the choice of its current owner, and it may happen decades after the original building was constructed. The current owner is in control of the site and building and so they are responsible for choosing whether the building is knocked down and

rebuilt, or whether certain elements (such as the foundation and superstructure) are retained.

Pro-rating is built in to avoid gaming. Because new builds and major renovations would share the same rating scale under this approach, there is a risk that a developer takes possession of a building that is, say, 10 years old, replaces the curtain wall and interior fit-out and then applies for a NABERS Embodied Emissions rating. If this were allowed, they would almost certainly attain a 6-star rating, even though the reused building elements still had many years of service life remaining.

15.5. Review of options against NABERS market needs

Table 15-1: Review of options against NABERS market needs for "Should the tool cover major refurbishments and demolition?"

Principle		Retained building elements are burden free	Retained building elements are burden free beyond a certain age
Impactful	• Urgent behaviour change • Big wins first	**?** Strong incentive for reuse, but open to gaming where relatively new buildings are refurbished to achieve a high NABERS rating, possibly contributing to churn.	✓ Strongest incentive to reuse existing building elements
Consistent	• Results are reproducible no matter who calculates them	✓ Most reproducible because there is no need to pro-rate reused elements	**?** There is a risk of inconsistency if the design life used for pro-rating is different, so design lives would need to be standardised
Streamlined	• Quick and easy to use	✓ Simple method that is easy to apply	**?** Requires additional calculations to support pro-rating calculations
Collaborative	• Considers existing methods/standards • Considers what others are doing, e.g., Green Star • Works alongside other NABERS tools • Tries to link with existing work	✓ Aligns with existing standards for LCA	**?** Links to *Green Star Buildings*, but lower alignment with international standards for LCA
Trusted	• People have faith in the framework	**?** Potential for gaming through reuse	✓ Framework provides a significant incentive for reuse and a significant disincentive to demolish an existing building
Meaningful	• Easy to understand	✓ Easy to understand	**?** Harder to understand due to pro-rating

Key	✓ Yes, option meets principle	**?** Option can meet principle if certain criteria are met	✘ No, option does not meet principle

Based on the analysis in Table 15-1:

- Both options are preferred, potentially meeting all NABERS market needs.
- Ultimately, we have recommended Option 2 “Retained building elements are burden free beyond a certain age” for the primary reason that Option 1 appears open to gaming and a lack of standardisation.

15.6. Recommendation presented for stakeholder feedback

The following recommendation was presented at the workshop:

- **Assign zero impact for elements older than their expected life**
- Pro-rate the embodied carbon of existing building elements whose age is less than their expected life to avoid gaming (for cold shell elements only)
- E.g., existing 40 y.o. building (expected life of structure = 50 y., façade = 30 y.). Structure reused and façade replaced. Structure treated as 10/50 of original impact; no impact for old façade.

15.7. Feedback from stakeholders

There were concerns about the proposal from Constructors and Developers verbally during the workshops. The main comment from the workshop was that they believed all reuse should be treated as zero emissions, irrespective of the age of what was being reused. In their view, reuse must be encouraged as much as possible, without any caveats.

Demolition was seen as part of the previous building’s life cycle (aligning with international standards, such as EN 15978) and they didn’t believe that historic embodied carbon should be pro-rated and applied to the new building’s life cycle. There were concerns about rezoning and changing client needs, etc.

From the workshop, two Developers commented that major refurbishment should be its own category, rather than being rated alongside new-build or knock-down + rebuild; however, this was advocated for by other participants and did not come through in the survey responses.

Stakeholder comments included:

- “Focus should be on incentivising reuse rather than penalising demolition. Retained building elements can already be incentivised by being incorporated burden free.”
- “Maybe a solution to avoid gaming is building can only renew their NABERS EC rating every 10 years. Also, if a developer elects to retain the bulk of the building in its refurbishment then this isn't gaming, its low EC design.”
- “Incentivising reuse is a must to transition to a circular economy. Reuse reduces embodied carbon.”
- “I question whether any existing building demolition should be considered. … Surely a building that reuses existing structure would already realise EC benefits over a building that was 100% new structure - is that not reward enough?”

The Supporting Consultants were eager to see the incentivisation of refurbishment in the NABERS Embodied Emissions Tool. They felt that Option 1: all re-use should be treated as

zero emissions as a simple and effective method of establishing one of the strongest incentives for refurbishment in a rating system internationally. A minimum 10-year period between rating applications was supported.

- “This is a vital consideration. Perhaps the best way to reduce embodied emissions is through refurbishment, and certainly the largest and easiest reductions are made by reusing what we already have.”
- “The incentivisation of refurbishment is important to support the impactful principle. As such, we feel new builds and major renovations should share the same ratings.”

15.8. Revised recommendation

We changed the recommendation as follows to align with Option 1 and to try to address the comments raised by stakeholders:

- The purpose of NABERS Embodied Emissions is to **rate the embodied emissions of new buildings and major refurbishments**. A major refurbishment involves a major change to at least one element of the cold shell, e.g., replacement of the curtain wall.
- **New buildings and major refurbishments shall be rated on the same scale for a given building typology**. This is done to provide a significant incentive to reuse existing building elements during major refurbishments.
- **Demolition of a previous building on a given site shall be zero impact.** These emissions are associated with the previous building’s life cycle. The system boundary between the old building and the new building shall be drawn at the point after the previous building has been demolished and all rubble has been cleared. The new building is responsible for any earthworks and all construction from this point forward.
- **Any retained building elements shall be treated as zero-impact**, except for any emissions generated by repurposing those elements for reuse.

It is possible that ratings could be gamed by building owners submitting frequent minor refurbishments, which would result in most of the building being reused and therefore receive high ratings. It is recommended that either:

- A limit of one rating per ten years is applied, or
- The NABERS roadmap for future development includes a regular analysis of whether this practice has emerged.

Given that the scope proposed is currently cold shell, the risk of gaming is likely to be low, as refurbishment to the cold shell will almost always be major refurbishment. As such, the second option is appropriate until such issues arise, particularly if a change to warm shell scope occurs later. Where a building on a site is seriously damaged or not fit for purpose due to land rezoning, this limitation should not apply.

16. Will it cover process LCA, hybrid LCA, or both?

This stakeholder engagement topic relates to:
NABERS Proposal 6: NABERS will encourage verified product specific emissions data and will apply conservative defaults where no emissions data is available.

16.1. Problem statement

Which life cycle assessment / carbon footprint methodology – and ultimately which data sources – should be used as the basis of the calculations?

16.2. Early feedback from market

Australia has helped to pioneer the hybrid LCA approach and apply it to construction products. The University of Sydney, the University of New South Wales, and the University of Melbourne all have active research programs in input-output and hybrid LCA.

The use of the (hybrid LCA) EPiC Database from the University of Melbourne within the online calculator for the *Upfront Carbon Emissions* credit for *Green Star Buildings*, working groups within MECLA, and the work of The Footprint Company have all helped to bring forward a discussion that would probably otherwise have been had 5-10 years from now regarding the most appropriate method for LCA of buildings: should we use bottom-up process-based LCA (as used in EPDs and the Climate Active Products and Services Standard) or hybrid LCA (which combines process LCA and input-output LCA)?

Selected quotes:

- "Input-output and hybrid processes are not as transparent compared to EPD development. …There is no international standard or certification for it (like EPDs). It needs a PCR to provide railroad tracks for it. That process could take years*."* – *Building Product Association*
- "My main concern is that impacts are reported accurately and fairly. EPDs are the best demonstration of impacts." – *Building Product Manufacturer*
- "It would be a mistake to use one system in Australia when everyone else is using another one*."* – *Building Product Manufacturer*
- "If NABERS was to use a hybrid model (like EPiC but also others) as opposed to a process model based on international standards that are well understood within the industry that would be a major red flag*."* – *Building Product Association.*
- "If we use process analysis, it will be incredibly incomplete." – *Standards Body*
- "EPiC is a great bit of work but IO is for single country assessments, not individual building assessments. They have a use but not for products and buildings*."* – *Peak Body*

16.3. Literature / policy research

There are three different approaches available to calculate an LCA (Suh & Huppes, 2005):

1. Bottom-up, process-based LCA (“Process LCA”)
2. Top-down economy-wide input-output LCA (“IO-LCA”)
3. Hybrids of the two (“Hybrid LCA”).

Process LCA

The starting point for Process LCA is the unit process: a single process (typically a manufacturing process) that transforms inputs into outputs. Process LCA is the aggregation of these different unit processes to create an often-complex production chain. An inventory is compiled by summing together the resource use, energy use, and emissions incurred through every step in a product’s life cycle. This inventory is then multiplied by characterisation factors (emission factors) to calculate potential impacts on the environment, such as the product’s contribution to climate change.

Process LCA is the method typically used by companies to understand and reduce the impacts of their products and processes as it is highly specific to different production processes and supply chains. It is also the LCA method used for Environmental Product Declarations (EPDs).

Process LCA has the advantage of detail: it allows even small differences between products and processes to be investigated. Its key disadvantage is truncation error: Process LCA focuses on the inputs required to make a product, but it often cuts off second/third/n^{th}-order inputs, such as the capital goods (machinery and manufacturing plant) required to manufacture the products, the fuel required by the sales and marketing team to make client visits, the energy used in office blocks, and the many professional and service industries supporting the manufacturing process.

The significance of truncation error for NABERS is twofold:

1. If some sources of emissions are not counted, there is no incentive to reduce them.
2. If building owners wish to move forward to a net-zero carbon certification (which is outside of the scope of NABERS Embodied Emissions), they are likely not considering all emissions that are potentially attributable to the building.

IO-LCA

IO-LCA starts from the direct impacts of an entire economic sector and then adds indirect impacts through trade with other sectors (i.e., from purchased goods and services). Emission intensities (e.g., kg CO_2e per $) are calculated by dividing the direct and indirect emissions by the monetary value the sector contributes to the economy.

Data required for this method includes:

1. Economy-wide input-output (IO) tables, i.e., matrices showing transactions between sectors/industries within an economy, and
2. Industry-wide emissions data corresponding to these same sectors/industries.

IO-LCA has the advantage of completeness: by its very nature, it includes all interactions associated with a particular activity (from direct material and energy use through to banking and insurance). As a result, it is well suited to national LCA studies where the goal is to calculate the total emissions of an activity or sector without much breakdown of the results.

Hybrid LCA

Hybrid LCA includes any method which combines both Process LCA and IO-LCA. It is designed to help avoid truncation error while also disaggregating data far enough to enable sectors to be split so that sector-specific emissions can be allocated accurately. As such, Hybrid LCA is often regarded as the gold standard for LCA (Suh & Huppes, 2005; Lenzen & Crawford, 2009; Crawford & Stephan, 2013), though others highlight that careful interpretation is the most important aspect of any LCA study due to the inherent strengths and weaknesses of all methods (Rowley, et al., 2009).

To put the size of truncation error into perspective, the GBCA and thinkstep-anz (2021) calculated the difference between Process LCA and Hybrid LCA for the major materials in Australia's buildings to be 21% for the same system boundary (see Table B-3 on page 119).

While many LCA practitioners see Hybrid LCA as gold standard LCA method of the future, that is not the same as suggesting it is suitable for use in rating tools right now.

Global review of LCA methods used for embodied carbon

Green Star Buildings is the only major rating tool worldwide that we could identify using a hybrid LCA approach (see Table A-1 on page 1091). Even then, hybrid LCA (and specifically the EPiC Database) is only used for the GBCA's simple online carbon calculator. This calculator is not mandatory for achieving the points available (as the LCA pathway can also be used). Further, the highest points cannot be achieved using the calculator and the LCA pathway must be used instead.

16.4. Options available

We identified three options:

1. Process Life Cycle Assessment
2. Hybrid Life Cycle Assessment
3. Some of both, as appropriate.

IO-LCA was ruled out for final design because it does not have enough resolution to make meaningful choices. Consequential LCA (as opposed to attributional LCA) was similarly ruled out due to a lack of product-specific data.

16.5. Review of options against NABERS market needs

Table 16-1: Review of options against NABERS market needs for "Will it cover process LCA, hybrid LCA, or both?"

Principle		Process LCA	Hybrid LCA	Some of both
Impactful	• Urgent behaviour change • Big wins first	✓ Potential to encourage urgent behaviour change	✓ Potential to encourage urgent behaviour change	✓ Potential to encourage urgent behaviour change
Consistent	• Results are reproducible no matter who calculates them	✓ Potential for high quality data, enabling reproducibility. However, there is still a risk that users will cherry pick emission factors.	✖ Results are not reproducible due to multiple available methods and less standardisation than process LCA/EPDs.	✓ Potential for high quality data, enabling reproducibility. However, there is still a risk that users will cherry pick emission factors.
Streamlined	• Quick and easy to use	**?** Potential for ease of use if a good quality calculator is developed to cover data gaps.	✓ Well developed Standard will lead to ease of use.	✓ Well developed Standard will lead to ease of use.
Collaborative	• Considers existing methods/standards • Considers what others are doing, e.g., Green Star • Works alongside other NABERS tools • Tries to link with existing work	✓ Links well with Green Star and other green building rating tools.	✖ Not commonly used internationally but does align with the GBCA.	? Potential alignment with green building rating tools.
Trusted	• People have faith in the framework	✓ High quality data used, helping to build trust	✖ Stakeholder feedback indicates that approach is not trusted within the market.	**?** Use of process LCA has the potential to build trust.
Meaningful	• Easy to understand	✓ Meaningful with good communication. (Any LCA can be difficult to understand.)	✓ Meaningful with good communication. (Any LCA can be difficult to understand.)	✓ Meaningful with good communication. (Any LCA can be difficult to understand.)

Key	✓ Yes, option meets principle	**?** Option can meet principle if certain criteria are met	✖ No, option does not meet principle

Based on the analysis in Table 16-1:

- Option 1: “Process LCA” is a preferred option, having the potential to meet all NABERS market needs.
- Option 3: “Some of both” is also a preferred option, having the potential to meet all NABERS market needs.
- Option 2: “Hybrid LCA” does not meet the NABERS market needs for Consistent, Collaborative or Trusted and is not recommended.

16.6. Recommendation presented for stakeholder feedback

We presented two reccomendations for stakeholder feedback:

Reccomendation 1: Greater freedom for design teams at early design stages:

- IO-LCA could be used to provided general kg CO_2e/m^2 rates for early design where all you know is the type and the square metres of the building you want to design.
- Hybrid LCA could be used to provide average material category emission factors where you might have an early design with approximate material quantities.
- Process LCA of building archetypes could be built by NABERS and/or other organisations based on past upfront carbon ratings, and these can then be scaled by m^2 for similar building types (where “similar” might be a similar structural system, similar ground conditions, and a similar number of stories).

Recommendation 2: Process LCA preferred at as-built stage:

- Modules A1-A3: Process LCA as primary data; Hybrid LCA to fill gaps if needed.
- Module A4: Process LCA data for transport to site.
- Module A5: IO-LCA to fill gaps for on-site construction energy, but this could be replaced by Process LCA data for those companies that do collect on-site construction energy data from all trades and subtrades.

16.7. Feedback from stakeholders

Verbal feedback from the stakeholder workshops was overwhelmingly against using a mixed-methods approach. At all workshops, all stakeholders who spoke on this topic believed that the LCA method must be consistent throughout the design and construction process to get consistent results.

There was strong support for Process LCA (EPDs, Climate Active Product Certification, etc.) and much less support for Hybrid LCA. The major concern from stakeholders was that early-stage results and as-built results might not be aligned, and that the different methods might point design teams in the wrong direction at the start of the design process.

Multiple and varied stakeholders spoke strongly against the use of hybrid LCA data. Apart from a few LCA experts, no other stakeholder group raised concerns about the use of process LCA data.

Feedback from the questionnaire included:

- “Totally disagree with early design stage, should just be LCA/EPDs”

- “At built stage, it must be process LCA.”
- “A process-based LCA/EPD approach should be the preferred method adopted in any recommendations around product or building embodied carbon material impact assessment – this is the globally accepted approach and underpins EPDs.”
- “IO and Hybrid approaches have not been calibrated against the internationally standard approach which is process LCA based on EPDs. Investigations reveal that IO/Hybrid approaches in use yield results that can be misleading in terms of impacts of different material types, hence use early on could skew material choice in a way that would actually increase building impact.”
- “While using Process LCA (e.g. product specific EPDs) is preferred at the early design stage the use of a range of data will allow options to be explored more thoroughly. Concerns exists on using a mix of data types or how average material data may be determined for use. 2) Process LCA (e.g. product specific EPDs) at built stage should be used where available and supplemented by other data sources.”
- “Process LCA at as built stage has the option to use Hybrid LCA to fill gaps if needed Module A4. This is unacceptable to the building product sector because Hybrid is drawing its product embodied carbon data from the same public sources as the Process approach and will have the same gaps. If it is NOT acceptable to fill any such gaps with a lot of top-down info from Hybrid that is extraneous and not based on LCA/EPD international standards.”

The Supporting Consultants agreed on the use of Process LCA, particularly at the ‘as built’ stage. One consultant saw value in a combined method – suggesting that IO could be useful to support early-stage modelling.

- “[We] strongly agree with the revised recommendation to only use process LCA. It is then also consistent with EPDs, Climate Active etc.”

16.8. Revised recommendation

Propose to move to process LCA (EPDs, Climate Active, etc.) throughout. Overall, the feedback is strongly in support of a process LCA approach over a hybrid LCA or flexible, mixed-methods approach. Other methods will no longer be permitted.

A preference hierarchy should be implemented by NABERS to encourage product-specific process LCA data at the highest level.

Hybrid or IO-LCA data could be allowed where no valid process LCA data is available. It could be used on a cost or per m^2 basis to estimate the impacts of some elements such as building services until EPDs (or similar) become available.

17. Should the tool use a hierarchy of preferred data?

This stakeholder engagement topic relates to:
NABERS Proposal 6: NABERS will encourage verified product specific emissions data and will apply conservative defaults where no emissions data is available.

17.1. Problem statement

How should different types of emission factors be recognised within the NABERS Embodied Emissions Tool? Should all data be treated equally, or should penalty/ uncertainty factors be applied for less precise data to encourage production of better data?

17.2. Early feedback from market

Early feedback suggested a strong preference for:

- Verified data, helping to build trust.
- Recognising the difference between an EPD or Climate Active Product Certification that is specific to a particular product (or a group of products), and one that is used as a proxy for a product that does not have any verified, product-specific data.
- Encouraging suppliers to produce verified, product-specific data.

Selected quotes:

- “Data must be third party verified. If not, what is the mechanism to ensure the integrity of the data?” – *Building Product Manufacturer*
- “Be sure that you have quite rigorous requirements so that NABERS doesn't become a body that generates or uses unverified data” – *Tool Maker*
- “If everyone's talking the same language, everyone can pick up an EPD and rely on the data, compare apples with apples. That's really what people are looking for.” – *Constructor*
- “We actually are looking for real data from the suppliers, not average industry or an EPiC database or something.” – *Developer*
- “Disclosure of embodied carbon should have hierarchical methodology that allows for continuous improvement: 1. EPD verified with EPD Australasia, then 2. industry EPD with EPD Australasia, then 3. info coming from databases. That hierarchy will drive behaviour change that will reduce embodied carbon in the built environment.” – *Manufacturer*

17.3. Literature / policy research

There are many different types of data that could potentially be considered, such as:

- Producer-specific EPDs

- Industry-average EPDs
- Climate Active Product Certification (or equivalent international program)
- Process LCA databases (e.g., AusLCI, ecoinvent, GaBi)
- Producer-specific peer-reviewed LCA/CF data
- Producer-specific unreviewed LCA/CF data
- Hybrid LCA databases (e.g., EPiC, ICM)
- Any of the data types above that is used as a proxy for the product that is actually used in the building because there is no product data

17.4. Options available

We identified the following three options.

Option 1: Approved data only

No weighting is applied, but only data from approved sources is allowed (e.g., EPDs, Climate Active Product Certification, AusLCI, etc.).

Option 2: Minimum data quality score

Each emission factor is assigned a quality score based on the data source. A minimum aggregated quality rating is required at the building level to be able to qualify for a NABERS rating.

Option 3: Use a hierarchy of preferred data

Data from a wide variety of sources is allowed. A conservative approach is used to ensure uncertain data is worst-in-class (but not necessarily worst-in-the-world).

17.5. Review of options against NABERS market needs

Table 17-1 Review of options against NABERS market needs for "Should the tool use a hierarchy of preferred data?"

Principle		Approved data only	Minimum data quality score	Hierarchy of preferred data
Impactful	• Urgent behaviour change • Big wins first	✖ Minimal data available in the short term means option is not scalable	**?** Data is not representative of worst-case scenario so does not encourage manufacturers whose emissions are above average to publish data	✓ Potential to encourage urgent behaviour change through accurate, high-quality data
Consistent	• Results are reproducible no matter who calculates them	✓ High quality data, enabling reproducibility	✖ Bad quality data can be used to plug data gaps leading to low reproducibility	**?** Reproducibility would likely require a table or database of worst-in-class values
Streamlined	• Quick and easy to use	**?** Minimal data available in the short term may mean missing data for parts of buildings	✓ Well developed Standard will lead to ease of use	✓ Well developed Standard will lead to ease of use
Collaborative	• Considers existing methods/standards • Considers what others are doing, e.g., Green Star • Works alongside other NABERS tools • Tries to link with existing work	✓ Links well with Green Star and other green building rating tools	**?** Potential to be less standards-compliant than the use of gold-standard data from a more limited pool	**?** Potential to be less standards-compliant than the use of gold-standard data from a more limited pool
Trusted	• People have faith in the framework	✓ High quality data used, helping to build trust	**?** Potential for some degree of gaming using low quality data, lowering trust	✓ High quality data used, helping to build trust
Meaningful	• Easy to understand	✓ Meaningful with good communication	✓ Meaningful with good communication	✓ Meaningful with good communication

Key	✓ Yes, option meets principle	**?** Option can meet principle if certain criteria are met	✖ No, option does not meet principle

Based on the analysis in Table 17-1:

- Option 3: “Use a hierarchy of preferred data” is the preferred option, having the potential to meet all NABERS market needs.
- Option 1: “Approved data only” provides good outcomes but the lack of data availability in the short term means it is not an immediately impactful option.
- Option 2: “Minimum data quality score” may lead to some gaming of the results and is the least preferred option as a result.

17.6. Recommendation presented for stakeholder feedback

Apply a hierarchy of data, taking a conservative approach based on precision:

- Prioritise product-specific EPDs and Climate Active Product Certification.
- Use worst-in-average for industry-average EPDs.
- For everything else, take a conservative figure (worst of what you would actually use in the building) based on global scan of EPDs, LCAs, literature, hybrid LCAs.

The goal is to **encourage disclosure** at the product level.

17.7. Feedback from stakeholders

Stakeholders expressed a strong preference for third-party verified, product-specific data. EPDs were frequently named as the most preferred source of data across a wide variety of stakeholders.

Stakeholder feedback included:

- “There is an inbuilt incentive to use Product specific EPDs where these help a project achieve EC reductions. A hierarchy of data should be defined (and reviewed/enforced by an accredited professional) but it should not be weighted.”
- “To be clear, hybrid analysis should not be used. As suggested, please take the time to look at the data and make your own judgement!”
- “For conservative figure, assuming NABERS will provide these figures in the calculation tool? Otherwise, how does one determine the 'worst' figure?”
- “Should encourage people to use EPDs to push more suppliers to get EPDs….the challenge will be bespoke assemblies made of many products that are harder to EPD - e.g. how will facade assemblies or bespoke HVAC components achieve this? Who will decide what is the worst-in-industry EPD?”
- “Surely we want to encourage EPDs and the best way to do this is getting customers to ask for them. Incentivising EPDs seems to make sense (but could cause delays to new products). Would the EPiC database represent a reasonable material average if a EPD is not available? Any 'worst case' would need to be reasonable – e.g., almost all concrete has some level of cement substitution, using a worst possible case alternative wouldn’t make much sense.”

These comments predominantly support the proposed recommendation rather than refuting it. They may be reflective of the brief summary that was presented in the workshops, rather than a full presentation of the intent of the methodology.

- The reason for designing a system with conservative emission factors where you don't have product-specific data is to encourage manufacturers to produce these numbers, even if their emission factors are higher than the average.
- Industry-average EPDs are required to have a variability range and so the highest number can simply be selected from this range.
- As flagged by several stakeholders, NABERS (or a third party) would need to produce a database of worst-in-class emission factors to support consistency. However, if the scope of the tool is limited to cold shell (as per Chapter 9), the size of this database would be quite small and relatively easy to manage. Because the goal is worst-in-class, not average, this would need to be updated less frequently.
- The use of hybrid LCA data was only proposed in the case EPD or Climate Active Product Certification data were not available. Manufacturers or associations would have the ability to override the hybrid LCA data by producing an EPD. However, concerns expressed by some manufacturers indicate that where the most conservative assumption is required, this could lead to the use of hybrid LCA data for unspecified products, which is a worse-than-worst-case outcome compared to process LCA data.

The Supporting Consultants had different views on adopting a hierarchy of data sources, with one supporting the recommendation and the other opposing it on the basis that "precise" is a subjective concept. Part of the issue seemed to be that this question was initially framed as "Should data be weighted by its precision?" This question was rejected because weighting is often subjective and can lack scientific rigour. The guiding question was therefore revised to "Should the tool use a hierarchy of preferred data?" as this better describes the proposal, which is a stepwise method for selecting and using data rather than applying penalty/uncertainty factors to different types of data.

17.8. Revised recommendation

The recommendation is maintained with minor modifications. Hybrid LCA is allowed as one of the options for determining worst-in-class performance but only when no suitable process LCA data exists. Numerous stakeholders (particularly the wood industry) indicated that the values used in hybrid LCA are significantly different to their EPD data and represent a worse-than-worst case when representing generic wood products. Responses to other questions also indicated a strong preference for methodological consistency using process LCA data.

18. How will we set benchmarks?

This stakeholder engagement topic relates to:

NABERS Proposal 8: A statistical analysis of Bill of Quantities data is the preferred approach to creating whole of building benchmarks.

18.1. Problem statement

How should the benchmarks for each star rating be set before any LCA / carbon footprint studies have been run using the NABERS Embodied Emissions Tool?

NABERS would prefer to avoid a two-model (reference building) approach due to the potential for inconsistency and gaming. Rather, NABERS would like to set benchmark values to determine which star ratings get awarded. This will likely require hundreds of building carbon footprints per building type, all calculated using NABERS' own calculation method. Unfortunately, while thousands of LCAs of buildings have been conducted worldwide, they often use different data sources, different methods and different scopes. They are hard to reconcile into something that is internally consistent enough to support NABERS benchmarks.

18.2. Early feedback from market

Selected quotes:

- "The benchmarking needs to be kept at a whole of building level rather than for individual materials... including potential end of life impacts with release of embodied carbon, and also the life cycle length." – *Building Product Association*
- "There should not be any preclusion of materials on a maximum global warming potential limit. Builders must be able to choose the best product for their desired solution irrespective of the embodied carbon content. The market must be able to drive for the solution that they need." – *Building Product Manufacturer*
- "Statistically, to be able to get a benchmark, you need thousands of thousand data points, which [NABERS is] not going be able to collect in the next year." – *Designer*
- "First you have to do this big comparison of – I don't know – a hundred to 1000 buildings before being able to start forming some conclusions." – *Designer*
- "Because it's a commercial building buildings program, probably the place to start is where the highest intensities are and try to establish a benchmark for carbon embodied carbon." – *Developer/Owner*
- "I'm thinking that something that does both, that really does set that minimum, but encourages people to go as far as they can, would be really great from a regulatory perspective." – *Policy/Regulator*

- "What I need to know is how far we can stretch. We are thinking of 6 Green Star on one of our developments and don't know if 20% is a real stretch." – *Government*

18.3. Literature / policy research

A review of studies on embodied carbon (contained in Annex B) was undertaken to determine what – if any – absolute targets could be defined, especially given limited data available in the Australian context.

Key findings:

- Whole-of-life embodied carbon typically ranges between 350 and 1,200 kg CO_2e/m^2.
- The high variability in these figures is partly due to variability in the scope of the analysis, methodology (e.g., inclusion or exclusion of stored biogenic carbon) and underlying data. Nearly all historic studies have included the building structure and foundation, and most included the building envelope. Building services and fit-out were often excluded, though they can be highly relevant for whole-of-life embodied carbon given the number of replacement cycles over the building's life.
- The final use of the building (offices, apartments, education, etc.) seems to have little influence on upfront carbon, except in a few special cases. A notable exception may be for warehouses and industrial buildings, as their construction is considerably different to multi-storey buildings.
- Other variables (e.g., ground conditions) are often noted to have a significant influence and so it will be important to define meta-data for each building to ensure that enough datapoints are considered to work out which variables have the greatest influence on upfront carbon.

ICMS: Global Consistency in Presenting Construction Life Cycle Costs and Carbon Emissions defines meta-data common to all types of construction project, including site conditions (ICMS, 2021, Table 4), and specific data for buildings (ICMS, 2021, Table 5). The buildings table is shown in Table 18-1 below. It gives a long list of potential meta-data that could be narrowed down into a shortlist for statistical analysis.

Table 18-1: Project meta-data for buildings – content reproduced from (ICMS, 2021, Table 5)

Project Attributes	Values
Code	
Local functional classification standard	
name of standard	
code number of construction	
Works	
Functional type	residential | office | commercial | shopping centre | industrial | hotel | car park | warehouse | educational | hospital | airport terminal | railway station | ferry terminal | plant facility | other stated
Nature	new build | major adaptation | temporary
Grade (qualitative description to be read in conjunction with the location)	ordinary quality | medium quality | high quality

Project Attributes	Values
Hotel grade	international below 4-star | international 4-star | international 5-star | international over 5-star | local below 4-star | local 4-star | local 5-star | local over 5-star
Environmental grade	
grade and name of environmental certification	ISO 14001 | other stated
status	targeted | achieved | none
Principal design features	
structural (predominant)	timber | concrete | steel | load bearing masonry | other stated
external walls (predominant)	stone | brick/block | render/block | curtain walling | other stated
environmental control	non-air conditioned | air conditioning
degree of prefabrication	less than 25% | up to 50% | up to 75% | up to 100%, of Construction Costs
major prefabricated work	suites (inclusive of toilets, kitchens and the like) | standalone toilets, bathrooms, shower rooms and the like | standalone kitchens | classrooms | healthcare rooms | operating theatres | plant rooms, pipe ducts and the like | soundproof rooms | computer rooms | cold rooms | kiosks | balconies | corridors | staircases | other stated
Project Complexity	
shape (on plan)	circular, elliptical or similar | square, rectangular, or similar | complex
shape (vertical section)	circular, elliptical or similar | square, rectangular, or similar | complex
design	simple | bespoke | complex
method of working	sectional completion | out-of-hours working | confined working | other stated
Design life	(years)
Average height of site above or below sea level	above | below
	(m | ft)
Dimensions (overall length × width × height of each building to highest point of the building)	(m | ft)
Typical storey height (floor level to floor level)	(m | ft)
Other storey heights and applicable floors	(m | ft)
Number of storeys above ground (qualitative description to be read in conjunction with the location)	house | low rise | medium rise | high rise
Number of storeys above ground (quantitative)	specific number 0–3 | 4–7 | 8–20 | 21–30 | 31–50 | over 50
Number of storeys below ground	specific number

Project Attributes	Values
Area of external elevations (total area of external wall finishes, facade cladding and curtain walls, windows, doors, shop fronts, roller shutters, fire shutters, etc. on the external elevations including all surfaces of external railings, parapets and features, but ignoring the presence of canopies)	(m^2 | ft^2)
Project Quantities	
Site area (within legal boundary of building site, excluding temporary working areas outside the site)	(m^2 | ft^2)
Covered area on plan	(m^2 | ft^2)
Gross external floor area as IPMS 1 (EXTERNAL)	(m^2 | ft^2)
Gross internal floor area as IPMS 2 (INTERNAL)	(m^2 | ft^2)
Functional units	number of occupants | number of bedrooms | number of hospital beds | number of hotel rooms | number of car parking spaces | number of classrooms | number of students | number of passengers | number of boarding gates | production capacity (specifics to be stated) | other stated

18.4. Options available

We considered three options.

Option 1: Simulation using QS data

Get quantity data for thousands of Australian buildings built in the last 5-10 years (across all key building categories of interest) from one or more quantity surveyors. Run all data through the calculation method to calculate the benchmarks.

Option 2: Bands from public data

Multiple possible methods. One method: define building types, estimate typical material quantities for each building type, match materials to the full range of emissions factors for that material, calculate a range of results. Determine “average” performance based on national averages for each material type. The range determines the other stars.

Option 3: Data first, benchmark later

Start with a trial period. Invite projects to submit their quantity data first, but without providing a NABERS rating. Collect data for thousands of buildings. Calculate and roll out benchmarks as a second step. (This is the approach being proposed by the NZ Government.)

18.5. Review of options against NABERS market needs

Table 18-2: Review of options against NABERS market needs for "How will we set benchmarks?"

Principle		Simulation using QS data	Bands from public data	Data first, benchmark later
Impactful	• Urgent behaviour change • Big wins first	✓ Allows internally consistent data to be built up quickly	**?** While data could be built up quickly, there is the potential for it to be inconsistent, leading to poor benchmarks	✗ Could take >1 year to compile enough data and buildings cannot be given a star rating during this time
Consistent	• Results are reproducible no matter who calculates them	**?** There could be variability in data between QSs	**?** Benchmarks may not be internally consistent at first due to data variability	✓ Most consistent as based on the data actually submitted for a rating
Streamlined	• Quick and easy to use	✓ Easy to use	✓ Easy to use	✓ Easy to use, but does not give an immediate star rating during data collection
Collaborative	• Considers existing methods/standards • Considers what others are doing, e.g., Green Star • Works alongside other NABERS tools • Tries to link with existing work	✓ Aligns with others NABERS tools	✓ Aligns with others NABERS tools	✗ Does not align with other NABERS tools in that a rating cannot be produced initially
Trusted	• People have faith in the framework	✓ Potential for trust if well executed	**?** Potential for poorer data quality to undermine trust	✓ Gold standard data quality as based on real project data, as submitted
Meaningful	• Easy to understand	✓ Meaningful with good communication	**?** Benchmarks may not be internally consistent initially	✓ Meaningful with good communication

Key	✓ Yes, option meets principle	**?** Option can meet principle if certain criteria are met	✗ No, option does not meet principle

Based on the analysis in Table 18-2:

- Option 1: “Simulation using QS data” is the preferred option, having the potential to meet all NABERS market needs.
- Option 2: “Bands from public data” is the next most preferred option, having the potential to meet all NABERS market needs, but carrying the risk of internal inconsistency due to limitations of data in the public domain.
- Option 3: “Data first, benchmark later” offers the best data quality, but is the least preferred option as NABERS would not be able to launch a rating tool initially and would instead have to run a long-term pilot to gather enough data to be able to produce benchmarks. During this pilot, projects would be able to receive a carbon footprint, but not a rating.

18.6. Recommendation presented for stakeholder feedback

Simulation using QS data was recommended at the workshops as that was seen as the most likely option to yield a reliable set of benchmarks in the short-term, provided that building carbon footprints are calculated using the same set of emission factors and calculation methods as will be used to assess the NABERS rating in the market. One “watch out” is to review data from several different surveyors and builders to ensure that it is comparable.

18.7. Feedback from stakeholders

The main comment raised about this topic during the workshops was that Constructors and Developers felt that QS data was likely to underestimate real quantities in the building. They therefore had concerns if the quantities would be appropriate.

Selected stakeholder quotes:

- “'Simulation from QS data' is absolutely not going to yield the most reliable set of benchmarks quickly. Depending on the dataset used, the method of measurement and even the calculator tool used, historic results are all over the place and aren't reliable for benchmarking. Benchmarks should be built using early adopter projects in the Pilot phase. The development of benchmarks will be slower, but they will be more accurate and also defendable to industry interrogation.”
- “You will get much better data from construction company estimators than from Quantity Surveyors.”
- “As an initial approach, it is a starting point but should be clear that the benchmarks would be refined as data improves and revised based on this review.”
- “My caution would be that many QS's only have $ allowances for building services and finishes that bear no relationship to their carbon content. In my opinion, QS info is really best for concrete, steel and aluminium only (i.e. structural quants only). It will be misleading for other materials especially fitout related (which you have noted may not go beyond a warm shell).”

- “Will the QS data have enough detail? For example will it include transport emissions? To what extent can LCA data collected for Green Star Design & As Built be leveraged?”

The intention of this recommendation was to use QS data on material quantities (not pre-calculated carbon footprints from QSs) together with any building/site meta-data available and to calculate internally consistent embodied carbon footprints using the NABERS Embodied Emissions Tool. If enough building carbon footprints could be run using this method, it would then be possible to use statistical analysis to determine what the key variables affecting embodied carbon are and where the break points in the data are.

The Supporting Consultants considered benchmarks to be essential however disagreed on the methodology for establishing them. Once consultant pointed out that the key success of NABERS operational benchmarks has been its use of empirical data, and that there appears to be sufficient industry-buy in for gathering the relevant embodied carbon data. It was also pointed out that building typology does influence embodied carbon and building classification and subclassification must be considered.

- “We feel the setting of benchmarks is an essential process, and will require time and resources to get right and build consistency and trust.”
- “We also agree that while thousands of building scale LCA and embodied carbon studies exist, they are fundamentally incompatible due to differences in method, inclusions / exclusions, etc.”

18.8. Revised recommendation

Maintain the recommendation largely as-is, but consider if a buffer factor (e.g., 10%) could be added on top of the QS data. This suggestion needs to be further sense-checked with Constructors and Developers. Data could also be collected from construction estimators and compared to QS data for a selection of real buildings to give further assessment and validation of the buffer factor.

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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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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 Embodied carbon policies & rating tools

The Netherlands was the first country in the world to require whole-building LCA for non-Government buildings, required from 2013 after having previously been attempted without success (due largely to industry opposition) in 2003 (Zizzo, et al., 2017). Other countries have since implemented their own policies, though each has their own focus.

Table A-1 presents a review of:

- Three voluntary standards:
  - *Green Star Buildings v1.0* in Australia.
  - The International Living Future Institute's *Embodied Carbon Guidance*, as used in its *Zero Carbon Certification*, *Core Certification*, etc.
  - *Green Star Design & As Built NZ v1.1* in New Zealand.
- Seven national programs – some legislated and some as proposed legislation: the Netherlands, France, China, Denmark, Finland, Sweden, and New Zealand.
- Two city-level programs: LETI in London and the City of Vancouver.

While not an exhaustive list, it includes:

- All European countries that had embodied carbon emissions regulations in place for privately-owned buildings as of early 2022: Netherlands, France, Denmark, Finland and Sweden (Petersen, 2022). (Other European countries have regulations in place that target government buildings specifically, e.g., Germany.)
- Relevant green building rating tools with a specific focus on carbon, not only LCA (which has historically been the focus of major tools such as LEED and BREEAM).
- Relevant policy in the Asia/Pacific region, covering existing policy in China and proposed policy in New Zealand.
- Well-known guidance documents from the UK: LETI (2020; 2021), which builds on RICS (2017).

Table A-1: Summary of standards, policies and rating tools considered

From	GBCA	ILFI	NZGBC	Netherlands	France	China	Denmark	Finland	Sweden	New Zealand	Vancouver	London/LETI
Standard/Law/ Policy	**Green Star Buildings v1.0A**	**Embodied Carbon Guidance**	**Green Star Design & As Built NZ v1.1**	**Building Decree 2012**	**Decree No. 2021-1004 / RE2020**	**GB/T 51366-2019 and GB 55015-2021**	**National Strategy for Sustainable Construction**	**Roadmap to low-carbon building**	**Climate declaration for buildings**	**Building for Climate Change**	**Climate Emergency Action Plan**	**Embodied Carbon Primer**
Type	Rating tool	Rating tool	Rating tool	National policy	National policy	National policy	National policy	National policy	National policy	National policy	City policy	Voluntary policy
Mandatory?	Voluntary	Voluntary	Voluntary	Mandatory	Mandatory	Mandatory	Mandatory from 2023	Mandatory (if approved)	Mandatory	Mandatory (if approved)	Mandatory by 2030	Voluntary
Year in force	2020	2019	2022	2013	2022	2022	2023	Mid-2020s	2022	2024	2030	2020
Reference	(GBCA, 2021)	(ILFI, 2019)	(NZGBC, 2022)	(Stichting NMD, 2022; Netherlands, 2022)	(France, 2021)	(MHURD, 2019; SAC, 2021)	(DHPA, 2021)	(FME, 2019)	(Sweden, 2021; IVL, 2022)	(NZ, 2021)	(Vancouver, 2020, Appendix K)	(LETI, 2021; LETI, 2020)
Applicable building type	All applicant projects	All applicant projects	Non-residential buildings	Residential and offices with floor area >100m^2	Individual houses, collective housing, offices, education	Residential and public buildings	New buildings >1,000 m^2	Not yet specified	Most permanent buildings	All buildings	All buildings	All applicants
Performance rating type	10% reduction as minimum; more points if higher	Maximum of 500 kg CO_2e/m^2	10% reduction as minimum; points if higher	Mandatory at national level	Mandatory at national level	Mandatory at national level	Mandatory at national level	Mandatory (if approved)	Mandatory	Mandatory (if approved)	Mandatory at regional level	Letter-banded (A+ to G)
Scope of life cycle modules	A1-A5 (upfront carbon) or A1-A3 if using GBCA calculator	A1-A5 (upfront carbon)	A1-A5 (upfront carbon) with check against embodied	A1-A3 *or* A1-A5, B1-B5, C1-C4, D	A1-A5, B2-B5, C1-C4, D (embodied carbon)	A-D	?	A1-A5, B3-B4, B6, C1-C4, with module D separate	?	Not yet specified	A1-A5, B2-B5, C1-C4	A1-A5 (upfront carbon)
Scope of building*	SFE	SFEI required, BGW optional	SFEBIG	Varies based on building typology	Varies by context	?	?	SFEBIG	SF?	SFEBI required, GW optional	SFE	SFEBI
Declared unit	kg CO_2e/building	kg CO_2e/m^2 for threshold achievement	kg CO_2/m^2 GFA	€ as weighted score across all EPD indicators	kg CO_2e/m^2	kg CO_2e/m^2 GFA	kg CO_2e/m^2/year	kgCO_2e/m^2/year heated net area	kg CO_2e/building and kg CO_2e/m^2	Not yet specified	Not yet specified	kg CO_2e/m^2 GIA
Achievement assessed against	Reference building	Reference building	Absolute value and reference building	Absolute value (cap)	Absolute value (cap)	% difference to 2016 code compliance	Absolute value (cap)	Likely absolute value (cap)	Not required yet – declaration only	Absolute value (cap)	% difference to 2018 baseline	Absolute value (cap)
Biogenic carbon?	Excluded	Yes, required to report on	Excluded	Yes, for whole-of-life calculations	Included	?	?	Yes	?	Not yet specified	?	Excluded for upfront; reported for whole-of-life
Allow offsets (Y/N)	Y (product level, not building level)	N for threshold; Y for net-zero	N	N	N	N	N	N	N	Not yet specified	Not yet specified	N
Uncertainty factors (Y/N)	N	N	?	Y – 30%	?	?	?	Y? – 20%	?	Not yet specified	Not yet specified	?
Data sources	Hybrid LCA or Process LCA	Process LCA	Process LCA	Process LCA	Process LCA	Appears to be Process LCA	Process LCA	Process LCA	Process LCA	Process LCA is likely	Process LCA is likely	Process LCA
Standard(s) followed	EN 15978	EN 15978	EN 15978	EN 15804, with EN 15978	EN 15978	Similar to EN 15978	EN 15978	EN 15978	EN 15978	EN 15978	EN 15978 is referenced	EN 15978
Underlying database	EPiC or own database	Named LCA tools, e.g., eTool	BRANZ CO_2NSTRUCT	milieudatabase.nl	INIES.fr	Annex D to the standard	LCAbyg.dk as LCA tool	co2data.fi	BM tool and database	Likely BRANZ CO_2NSTRUCT	n/a	Not specified

* S = Superstructure, F = Foundation, E = Envelope, B = Building Services, I = Interior (floor/wall/ceiling coverings, dividing walls), G = Groundworks, W = External Works

Annex B Research on embodied carbon

B.1. Global data from meta-analyses of building LCAs

Thousands of LCAs and carbon footprints for buildings have been completed worldwide since the 1990s. Several authors have compiled databases of past building LCA studies, notably the Carbon Leadership Forum (CLF, 2017) and Röck, et al. (2020). While not specific to Australia, these studies still provide a valuable baseline and aid understanding of the data available and its variability, which ultimately is to assist in determining the feasibility and specifics of absolute targets for upfront carbon.

B.1.1 "Embodied Carbon Benchmark Study" of the Carbon Leadership Forum

The Carbon Leadership Forum compiled a database of over 1,000 building LCAs published between 1990 and 2016 through its *Embodied Carbon Benchmark Study* (CLF, 2017). Where it was reported in the study, the CLF compiled both the upfront carbon and the whole-of-life embodied carbon.

Several important observations can be drawn from this study:

- The range of results reported for each building type was considerable – often greater than the range of results between building types. This suggests standardisation of the calculation method and underlying data is very important to be able to draw meaningful comparisons.
- The median upfront carbon emissions of a building were typically less than 500 kg CO_2e/m^2 gross floor area (GFA), regardless of the scope of assessment, the number of stories, the floor area, the region, etc.
- The final use of the building (offices, apartments, education, etc.) seems to have little influence on upfront carbon, except in a few special cases, notably parking buildings and public order buildings (though both have a small sample size in the CLF study). Importantly, the above are observations, not firm conclusions. As a meta-analysis, the CLF compiled studies with different system boundaries, different reference year, different data quality, etc. As such, it is possible that scope differences between each underlying carbon footprint have led to some of these observations.

It is worth considering that the CLF study is somewhat of a self-selecting sample. The LCAs which were included had to have been published to be considered, and, as such, only those buildings which were attempting some level of sustainable outcome were available for consideration. Furthermore, it is unlikely that environmentally impactful buildings were included, as these LCAs might not have been conducted in the first place or, if they were, they might have chosen not to publish. Another noteworthy feature of the results was that for most analyses, the mean was consistently higher than the median, implying there were a reasonable number of buildings which had greater upfront carbon emissions and sat high on the impact scale.

The remainder of this section cuts the CLF data in different ways. In each case:

- The data are shown on a box and whisker chart. The box shows the lower quartile, median, and upper quartile. The whiskers show the minimum and maximum values.
- The “X” over the chart shows the mean (average) value.
- The values in the square brackets next to each category header indicate the number of samples included for that category in the CLF database.
- All charts in this section are based on the underlying data from the CLF report, not from the report itself.
- Outliers, renovations, and entries that were partly incomplete were all excluded.

Figure B-1 shows upfront carbon for new-build construction (i.e., excluding renovation) by high-level building category. In general, residential buildings have a slightly lower carbon footprint than commercial buildings. There are too few data points for the other building categories (non-commercial and industrial) to make any useful observations about them.

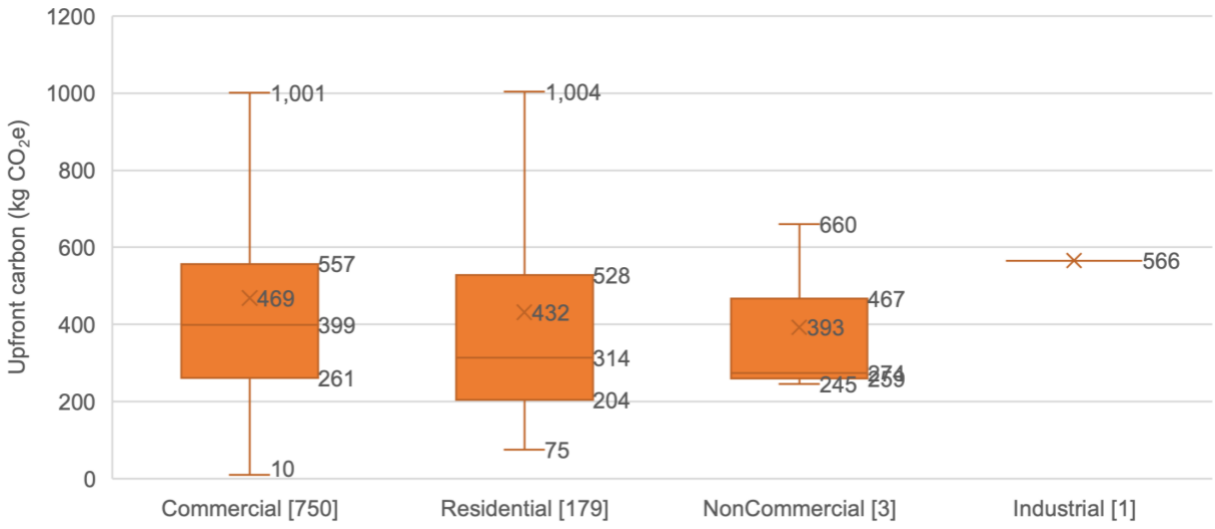

Figure B-1: Upfront carbon for new build construction by building category – data from (CLF, 2017)

Figure B-2 presents CLF data for non-residential buildings only (i.e., commercial, non-commercial, and industrial buildings) broken down by their specific use case. The variability in results within a given use case often exceeds the difference between each use case, though there are notable exceptions (parking buildings have a particularly low carbon footprint, while public order and mixed-use buildings have a particularly high carbon footprint). In most use cases, the median carbon footprint is between 350 and 500 kg CO_2e/m^2 GFA. The mean typically exceeded the median, with nearly all between 380 and 600 kg CO_2e/m^2

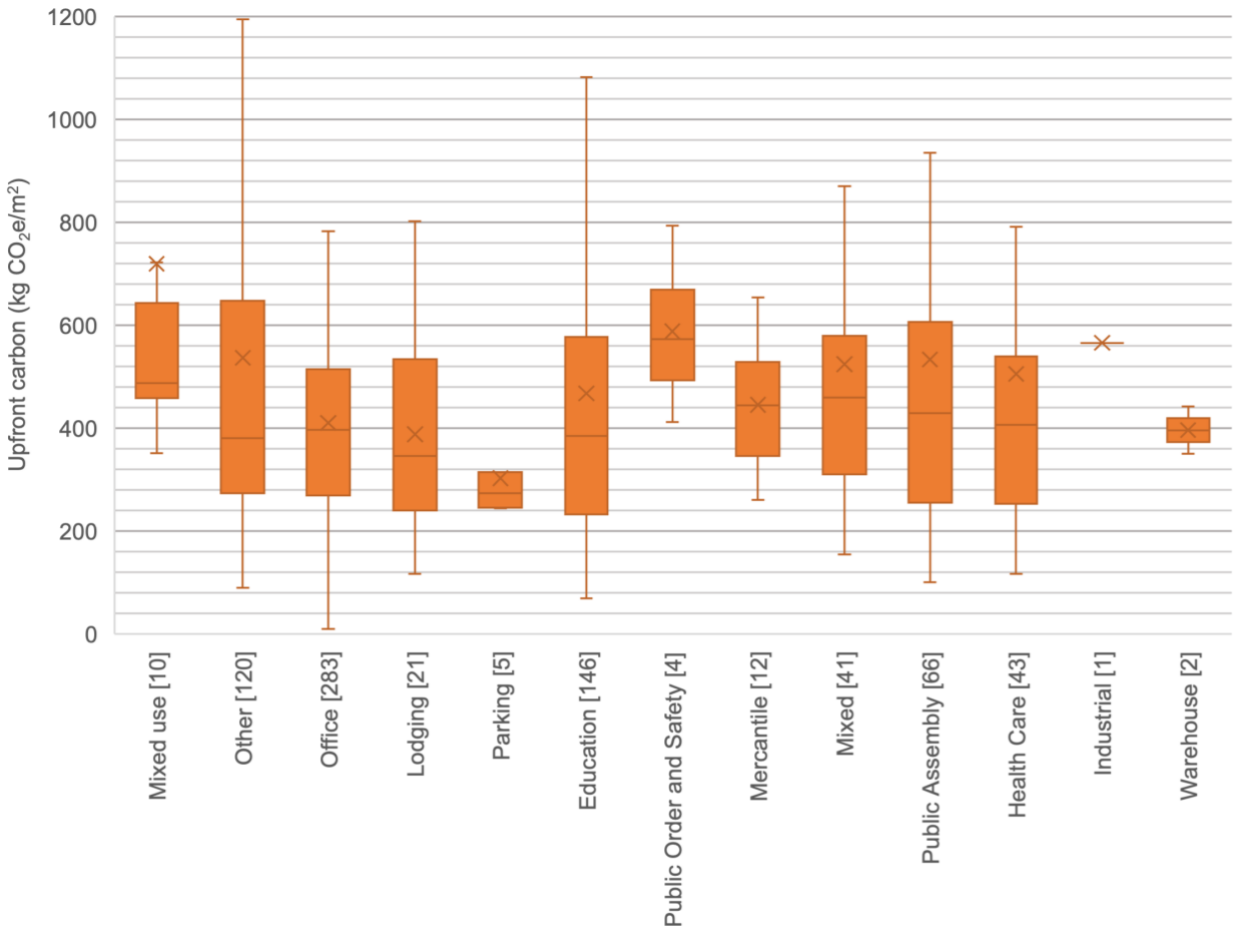

Figure B-2: Upfront carbon for non-residential new-build construction by use – data from (CLF, 2017)

Figure B-3 presents CLF data for non-residential buildings broken down by region. The Asia-Pacific region has a higher carbon footprint per square metre (median = 465 kg CO_2e/m^2) than most of the other regions studied, though not by a large margin (except for North America, whose median upfront carbon was 320 kg CO_2e/m^2).

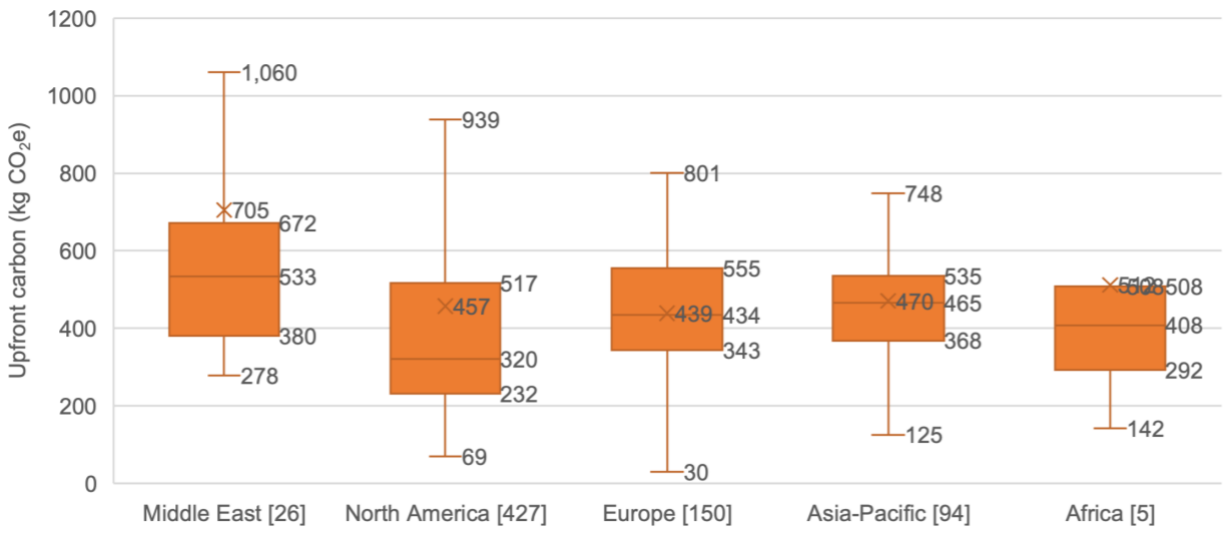

Figure B-3: Upfront carbon for non-residential new-build construction by region – data from (CLF, 2017)

Figure B-4 presents CLF data for non-residential buildings broken down by scope of assessment. S = Structure, F = Foundation, E = Enclosure, and I = Interior. All other things being equal, increasing the scope of assessment should increase the emissions per square metre. This is not what is observed in Figure B-4. Instead, S, SF, SEI and SFEI all have a similar median, with the SFE category standing out as an outlier. Once again, this chart highlights the importance of having consistent data quality and a consistent system boundary when making comparisons between buildings.

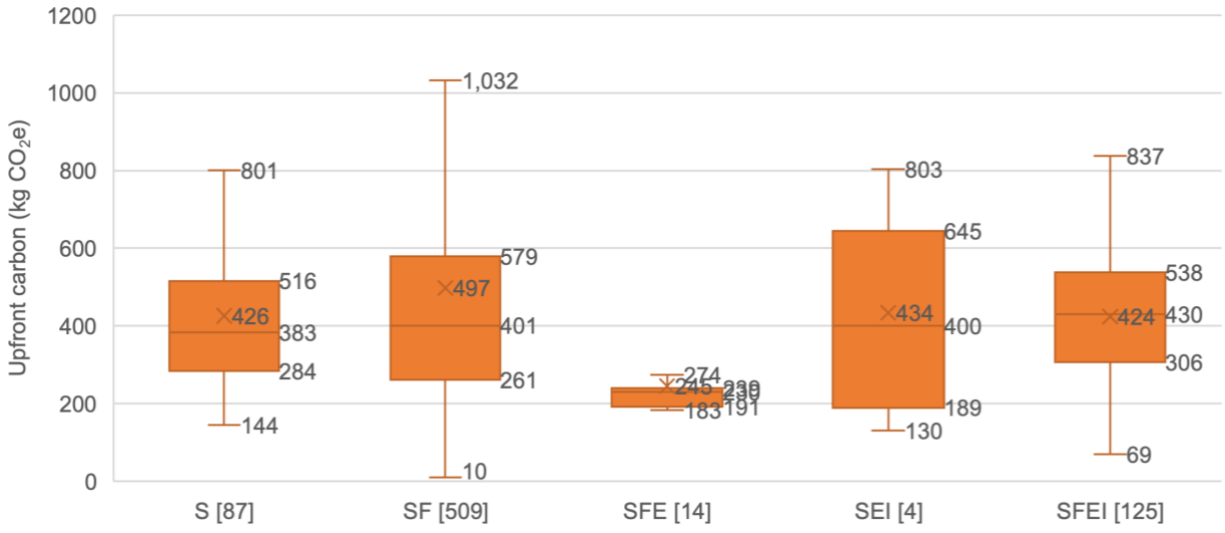

Figure B-4: Upfront carbon for non-residential new-build construction by scope of assessment – data from (CLF, 2017)

Figure B-5 presents CLF data for non-residential buildings broken down by floor area. (The reason for the strange groupings is because the ranges have been converted from square feet to square metres.) It is difficult to see a clear trend for these buildings, except perhaps that buildings with floor area from 466 to 4565 m^2 have a higher-than-average carbon footprint per square metre compared to buildings smaller and larger than them. As previously mentioned, variability in data and system boundary between studies (even within the same group) is likely to be a key determinant of variability between studies.

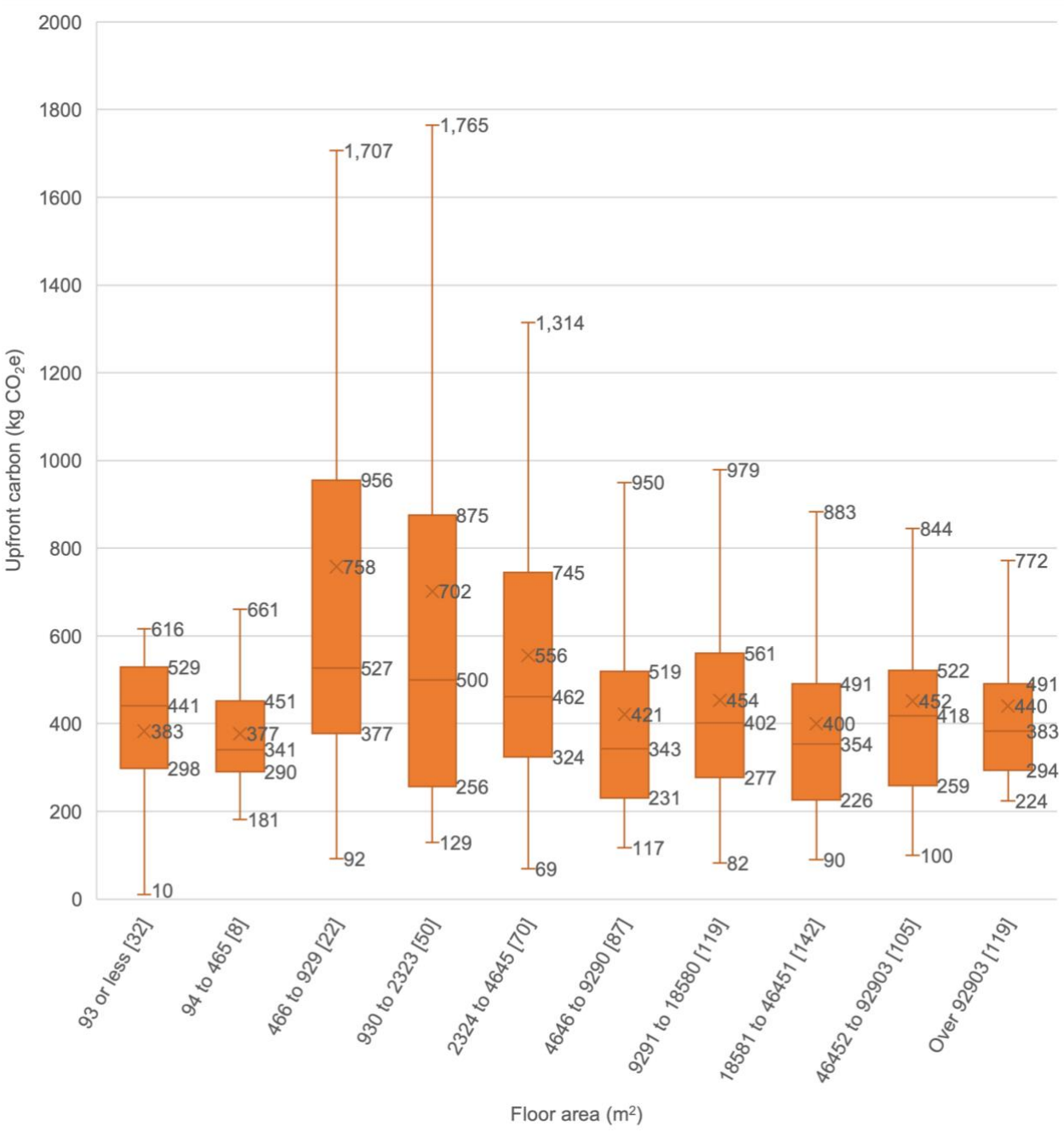

Figure B-5: Upfront carbon for commercial buildings by floor area – data from (CLF, 2017)

Figure B-6 presents CLF data for non-residential buildings broken down by the number of stories above ground level. There is little evidence from this chart that the height of the building plays a significant role in its carbon footprint per square metre.

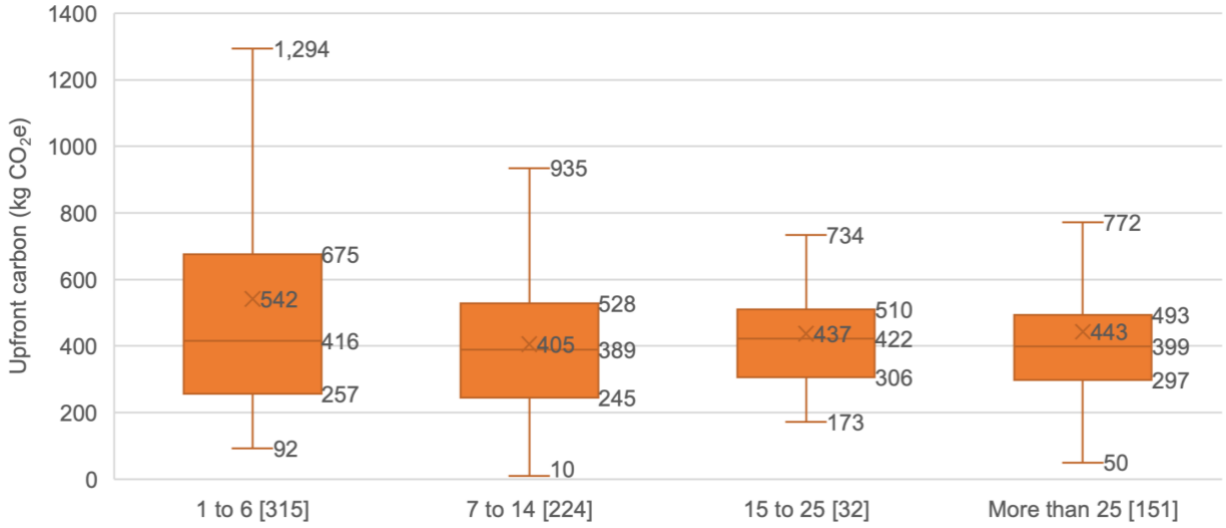

Figure B-6: Upfront carbon for commercial buildings by levels above ground – data from (CLF, 2017)

“Embodied GHG emissions of buildings” by Röck et al. (2020)

Röck et al. (2020) analysed over 650 building LCAs globally to investigate how significant embodied carbon is to the whole-of-life emissions of buildings. Röck et al.’s focus is embodied carbon, i.e., upfront carbon + use stage embodied carbon + end-of-life carbon.

Figure B-7 shows the contribution of embodied carbon (peach colour) and operational carbon (light blue colour) found in Röck et al. (2020) which annualises the results over 50 years. The embodied carbon per square metre of GFA constructed can therefore be calculated by multiplying the annual embodied carbon value provided in the paper by 50. By doing this, office buildings are calculated as having an embodied carbon value of 865 kg CO_2e per m^2 from an annualised value of 17.3 kg CO_2e/m^2/year. The average for all buildings is calculated as 364 kg CO_2e per m^2 from an annualised figure of 7.3 kg CO_2e/m^2/year.

One observation from Figure B-7 is that "new advanced" buildings can have higher embodied carbon, even though they have lower lifetime carbon on per annum basis. This has consequences when rating embodied carbon in isolation and highlights the potential for trade-offs between embodied (upfront) and operational carbon.

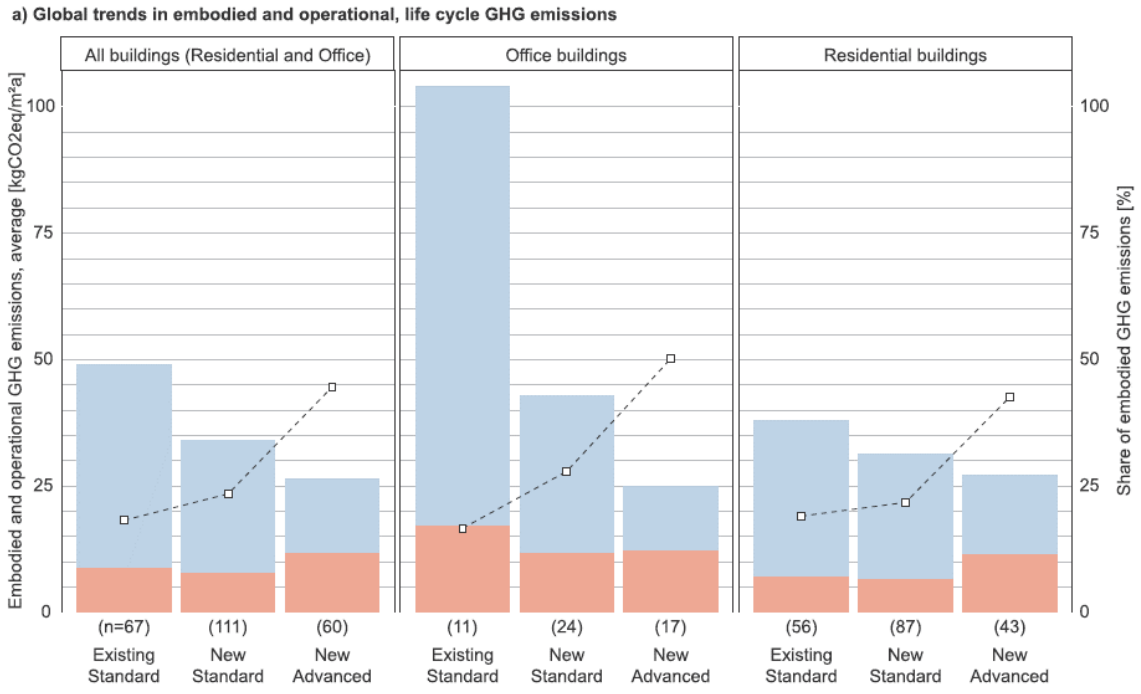

Figure B-7: Annualised embodied carbon and operational carbon of global buildings (50 year normalisation, gross floor area) – reproduced from (Röck, et al., 2020)

LETI's colour/letter bands for upfront and embodied carbon

The London Energy Transformation Initiative (LETI) has published a series of colour/letter rating bands that cover both upfront carbon and embodied carbon for several different building use cases (office, residential, education, and retail). These bands are shown in Figure B-8 correspond to the building scope described in Table B-2. The scope of the study can be broadly described as structure + foundation + envelope + services. Similar bands are now being used in some building LCA software tools, e.g., One Click LCA.

Upfront Carbon, A1-5 (exc. sequestration)

	Band	Office	Residential	Education	Retail
	A++	<100	<100	<100	<100
	A+	<225	<200	<200	<200
LETI 2030 Design Target	A	<350	<300	<300	<300
	B	<475	<400	<400	<425
LETI 2020 Design Target	C	<600	<500	<500	<550
	D	<775	<675	<625	<700
	E	<950	<850	<750	<850
	F	<1100	<1000	<875	<1000
	G	<1300	<1200	<1100	<1200

Embodied Carbon, A1-5, B1-5, C1-4 (inc. sequestration)

	Band	Office	Residential	Education	Retail
	A++	<150	<150	<125	<125
	A+	<345	<300	<260	<250
	A	<530	<450	<400	<380
RIBA 2030 Built Target	B	<750	<625	<540	<535
	C	<970	<800	<675	<690
	D	<1180	<1000	<835	<870
	E	<1400	<1200	<1000	<1050
	F	<1625	<1400	<1175	<1250
	G	<1900	<1600	<1350	<1450

All values in $kgCO_2e/m^2$ (GIA)

Figure B-8: Upfront and embodied carbon targets and colour/letter bands – reproduced from (LETI, 2021)

LETI argues that "for buildings that are currently in the design stage" (LETI, 2021):

- Average design achieves an E
- Good design achieves a C (LETI 2020 target)
- LETI 2030 design target achieves an A

When comparing upfront carbon from CLF (2017) to the top table in Figure B-8, an 'average' non-residential building (using the median or the mean) would fall into the C band. When comparing embodied carbon from offices in Röck et al. (2020) to the bottom table in Figure B-8, an average office building would also fall into the C band.

Table B-2: Scope of building included in LETI's colour/letter bands (LETI, 2020)

Level 1 Group element	Level 2 element	Level Sub element
1. Substructure	1. Substructure	1. Standard foundations
		2. Specialist foundation systems
		3. Lowest floor construction
		4. Basement excavation
		5. Basement retaining walls
2. Superstructure	1. Superstructure	1. Steel frames
		2. Space decks
		3. Concrete casings to steel frame
		4. Concrete frames
		5. Timber frames
		6. Other frames
	2. Upper floors	1. Floors
	3. Roof Coverings	1. Roof structure
		2. Roof coverings
		3. Specialist roof systems
		4. Rooflights, skylights and openings
	4. Stairs and ramps	1. Stairs and ramps structures
	5. External walls	1. External enclosing walls above ground floor level
		2. External enclosing walls below ground level
		3. Solar or rain screening
	6. Windows and external doors	1. External windows
	7. Internal wall and partitions	1. Wall and partitions (education only)
5. Services	5. Heat source	1. Heat Source
	6. Space heating and air conditioning	1. Central heating and cooling
		2. Local heating and cooling
		3. Local air conditioning
	6. Ventilation	1. Central ventilation
		2. Local ventilation
		3. Smoke extract or control
	9. Fuel installations and systems	1. Fuel Storage
		2. Fuel distribution systems
8. External works	2. Roads, paths and paving	1. Roads, paths and paving
		2. Special surfacing and paving

B.2. Embodied carbon in the Australian context

Understanding the total embodied carbon in Australia's buildings is made challenging by complex supply chains and a lack of data. The GBCA and thinkstep-anz (2021) used three LCA methods to approximate total embodied carbon in new buildings across Australia in 2019. This report found the total whole-of-life embodied carbon for an 'average' building in Australia was likely to lie between 369 and 824 kg CO_2e/m^2 GFA in 2019 (see Table B-3). The total greenhouse gas emissions in Table B-3 align well with a different calculation of 30 to 50 Mt CO_2e per year performed by the Clean Energy Finance Corporation (CEFC) and Edge Environment (2021) from Australian material production and trade data.

Table B-3: Embodied carbon in Australia's buildings in 2019 – adapted from GBCA & thinkstep-anz (2021)

	Total GHG (Mt CO_2e)	GHG intensity (kg CO_2e/m^2 GFA)	Share of national GHG emissions
Process LCA, calculated using Material Flow Analysis for the major materials in new-build construction for the base building (structure, foundation, façade)	21.5	369	3.9%
Hybrid LCA, calculated based on partially modified EPiC to align the process LCA values with the above	26.2	448	4.7%
IO-LCA, scaled from (Yu, et al., 2017) from 2013 using GFA constructed and covering the entire building industry, including building services and fit-out, and renovation as well as new-build	58.4	824	8.9%
Australian total	**565 excl. LULUCF**	**Calculated against 58.4 million m^2 built**	

These figures are an *average* of all building types, both residential and non-residential. Residential buildings in Australia typically have a lower carbon footprint per square metre GFA than non-residential buildings as there is a large market share of relatively low-carbon low-rise, lightweight, timber-framed buildings. Given that NABERS' focus is primarily on non-residential buildings, these detached residential buildings lower the average carbon footprint.

The analysis from the GBCA and thinkstep-anz (2021) found that non-residential buildings had roughly 50% more embodied carbon than the Australian average when using process LCA. As a simple approximation, assuming this ratio holds across all LCA methods, the total **GHG intensity of an 'average' non-residential building was likely to lie between 550 and 1,200 kg CO_2e/m^2 GFA in 2019**, depending on the scope of building elements included and the LCA method used. This range is also an average, with long, flat, portal-framed warehouses with relatively simple foundations being grouped with tall office towers with large foundations. As a rule of thumb, the taller you build on the same site, the greater the embodied carbon per m^2 because of the larger foundation and superstructure needed to

support that height. (The carbon benefits of a high-density urban form are not captured by this rule of thumb as it is specific to the carbon embodied in the building in isolation.)

The differences between the carbon footprints of different building types in Australia are highlighted by two other recent publications:

- Prasad et al. (2021) calculated the upfront carbon footprint (module A1-A5) of typical buildings by National Construction Code (NCC) class. Their analysis is presented relative to NLA (rather than GFA) and used a hybrid LCA approach and building data from The Footprint Company. While the method used in not directly comparable to the GBCA and thinkstep-anz work above it highlights significant differences between Class 1 (low-rise residential) and Class 2 (high-rise residential) and Class 5 (offices).
- Slattery (2022) calculated the upfront carbon (module A1-A5) of a range of common building types for which they were the quantity surveyor. Their analysis is presented relative to GFA (or total project area for landscaping projects) using a process LCA approach, using data from AusLCI and EPDs and conducted in the eToolLCD software. It includes sequestered biogenic carbon, though this is likely to have limited effect on the results for the types of buildings considered due to the common use of reinforced concrete and steel-framed construction. While the distinction between residential and other building types is not as distinct as in Prasad et al. (2021), this is likely because Slattery would not be involved in detached residential construction and so their results will likely cover mid-rise and high-rise residential developments only.

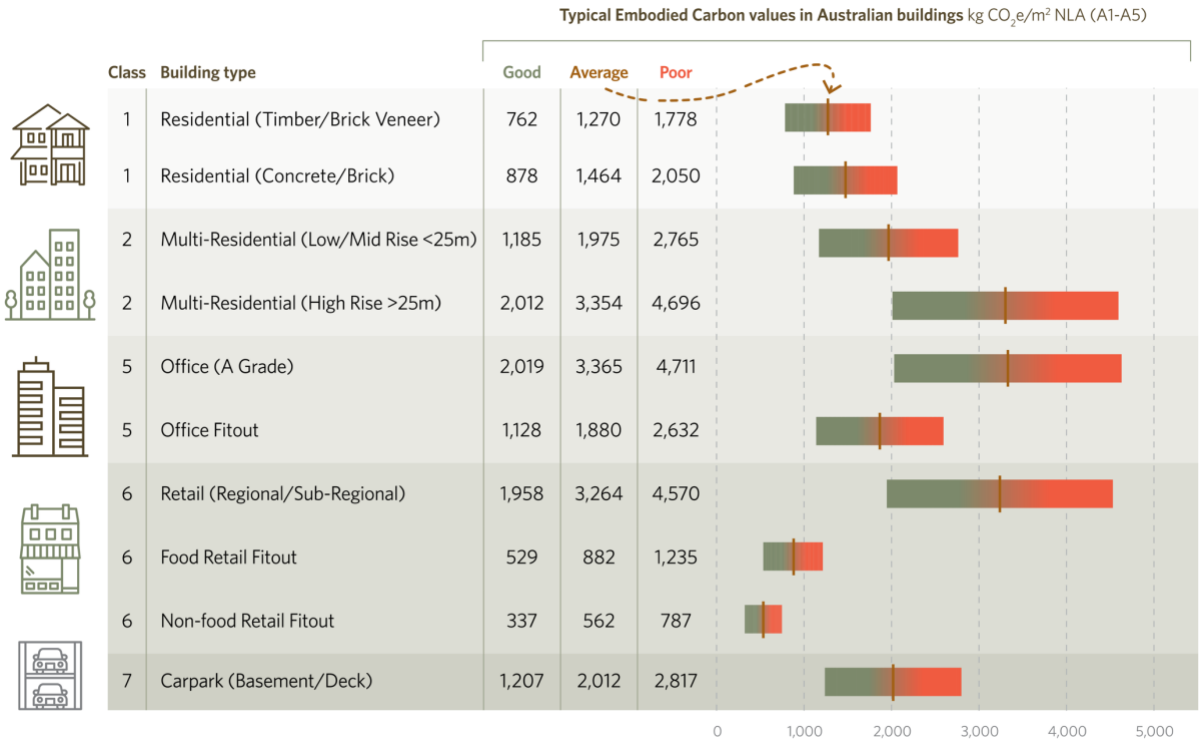

Figure B-9: Upfront carbon in Australian buildings, by NCC class – reproduced from Prasad et al. (2021)

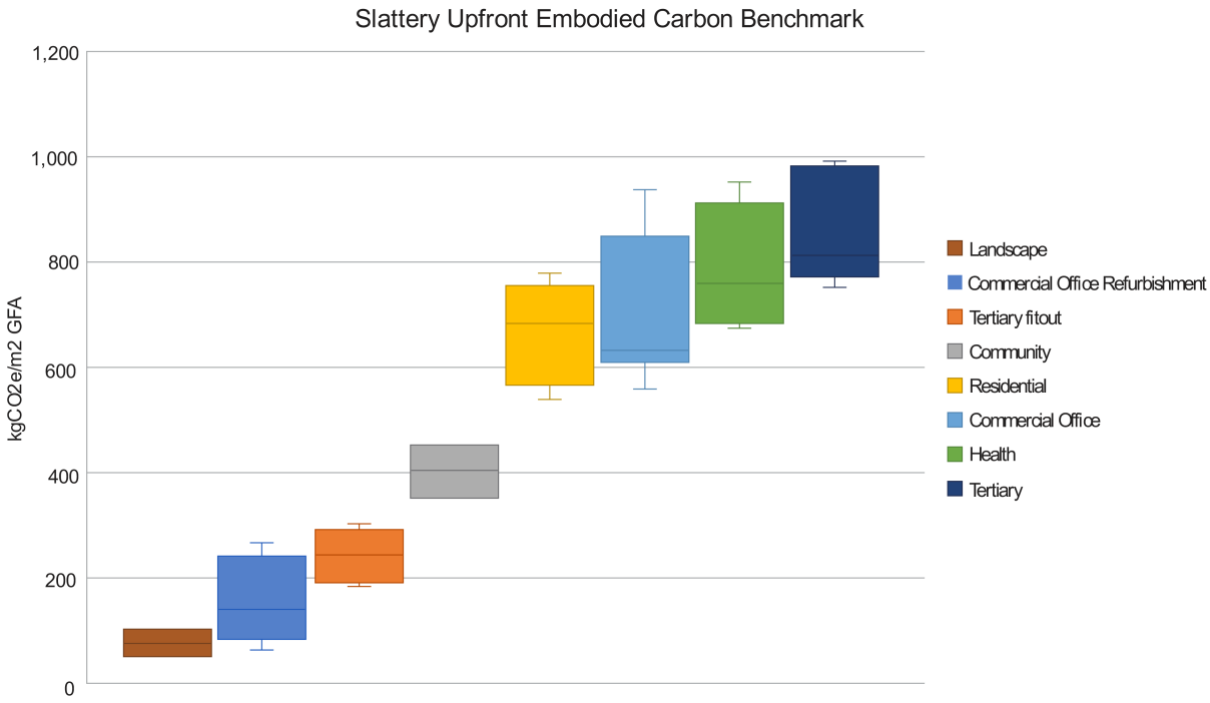

Figure B-10: Upfront carbon in Australia's buildings, by type – reproduced from Slattery (2022)

B.3. Embodied carbon per building element

Slattery (2022) indicate the following breakdown of upfront carbon for a typical project:

- *Substructure: 10-30% (depending on the extent of basements)*
- *Superstructure: 40-70%*
  - *Upper floors and columns: 30-50%*
  - *External walls, windows, and external doors: 8-25%*
- *Finishes: 4-8%*
- *Building services: 5-8%*

Importantly, these values are for upfront carbon to the point of practical completion (i.e., modules A1-A5). The low impact of finishes and building services is due partly to upfront carbon representing initial installation only. It does not cover repair and replacement through the building's life. While the structure of the building must last the life of the building, services and finishes are typically replaced ('churned') much more frequently due to a combination of wear-and-tear and changing interior design trends. Slattery's figures also do not include the full extent of the fit-out – only the finishes. Based on the box-and-whisker plots for refurbishment and fit-out, fit-out would likely add another 100 to 300 kg CO_2e/m^2 GFA.

Rodriguez et al. (2020) calculated the carbon footprint of Mechanical, Electrical, and Plumbing (MEP) services and Tenant Improvements (TI) per square metre of floor area for a selection of buildings. They found that:

- MEP accounts for 40 to 75 kg CO_2e/m^2 (average 60 kg CO_2e/m^2)
- TI accounts for 45 to 134 kg CO_2e/m^2 (average 90 kg CO_2e/m^2)

The embodied carbon of these items appeared to be roughly correlated to the mass, with approximately 70-80% of both mass and embodied carbon of MEP attributable to those elements considered to be mechanical (Rodriguez, et al., 2020). As such, when addressing upfront carbon, there is a case to include heavy items within the scope of building elements. Also notable was the impact of tenant improvements (finishes, furniture, and fixtures) on both upfront and embodied carbon.

These figures are important because while the structure and foundation of the building are expected to last the life of the building (typically 50 years or more), MEP and TI may be replaced much more frequently. Rodriguez et al. (2020) indicate that most MEP lasts only 15 years, though some components and materials may last up to 40 years.

Figure B-11 takes Slattery's median upfront carbon footprint for offices (635 kg CO_2/m^2 GFA) and removes 5-8% for building services and 4-8% for finishes. It then adds MEP and TI on top using Rodriguez et al.'s (2020) data. This chart assumes a building life of 50 years and replacement cycles of 25 years for MEP (i.e., one full replacement) and 10 years for TI (i.e., four full replacements). It also assumes 10% of the original impact of the Foundation, Structure and Envelope (FSE) over the building's life for maintenance, though this could be an underestimate if a full façade replacement was needed during the building's life.

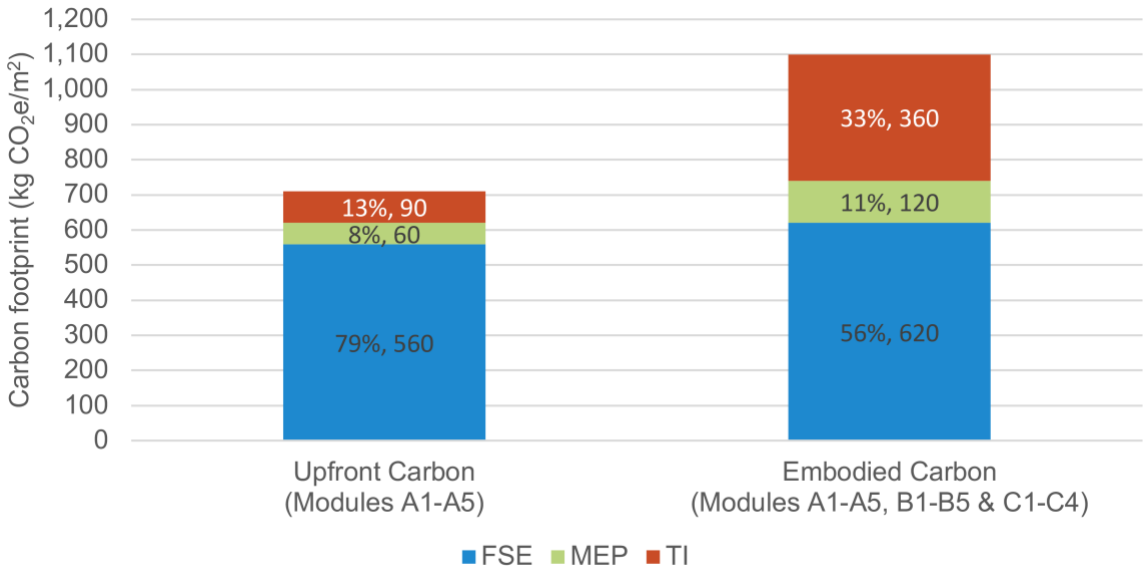

Figure B-11: Comparison of upfront carbon and embodied carbon for office buildings. FSE data is from Slattery (2022). MEP and TI data is from Rodriguez et al. (2020). Where: F=Foundation, S=Structure, E=Envelope; M=Mechanical, E=Electrical, P=Plumbing; TI = Tenant Improvements.

B.4. How much scope is there for decarbonisation?

Based on analysis of LCAs submitted to the GBCA, which compare a reference building to the final design, the CEFC and Edge Environment (2021) identified average reductions in embodied carbon of up to 15%, with significantly higher reductions in some projects. Importantly, these LCAs were submitted prior to the release of *Green Star Buildings*, which introduced a new credit for upfront carbon alongside the traditional credit for LCA.

The Upfront Carbon Emissions credit within *Green Star Buildings* gives an indication of what the GBCA believes is likely to be possible:

- A 10% reduction compared to the reference building is the minimum required to achieve Green Star.
- A 20% reduction qualifies for 3 of 6 points.
- A 40% reduction qualifies for the full 6 points.

Based on feedback from the market following publication of *Green Star Buildings*, the GBCA understands that achieving a reduction in upfront carbon of 40% is extremely challenging and that reductions of 40-50% likely represent best-in-class decarbonisation for non-residential buildings in 2022 (J. Chapa, personal communication, 7 June 2022).