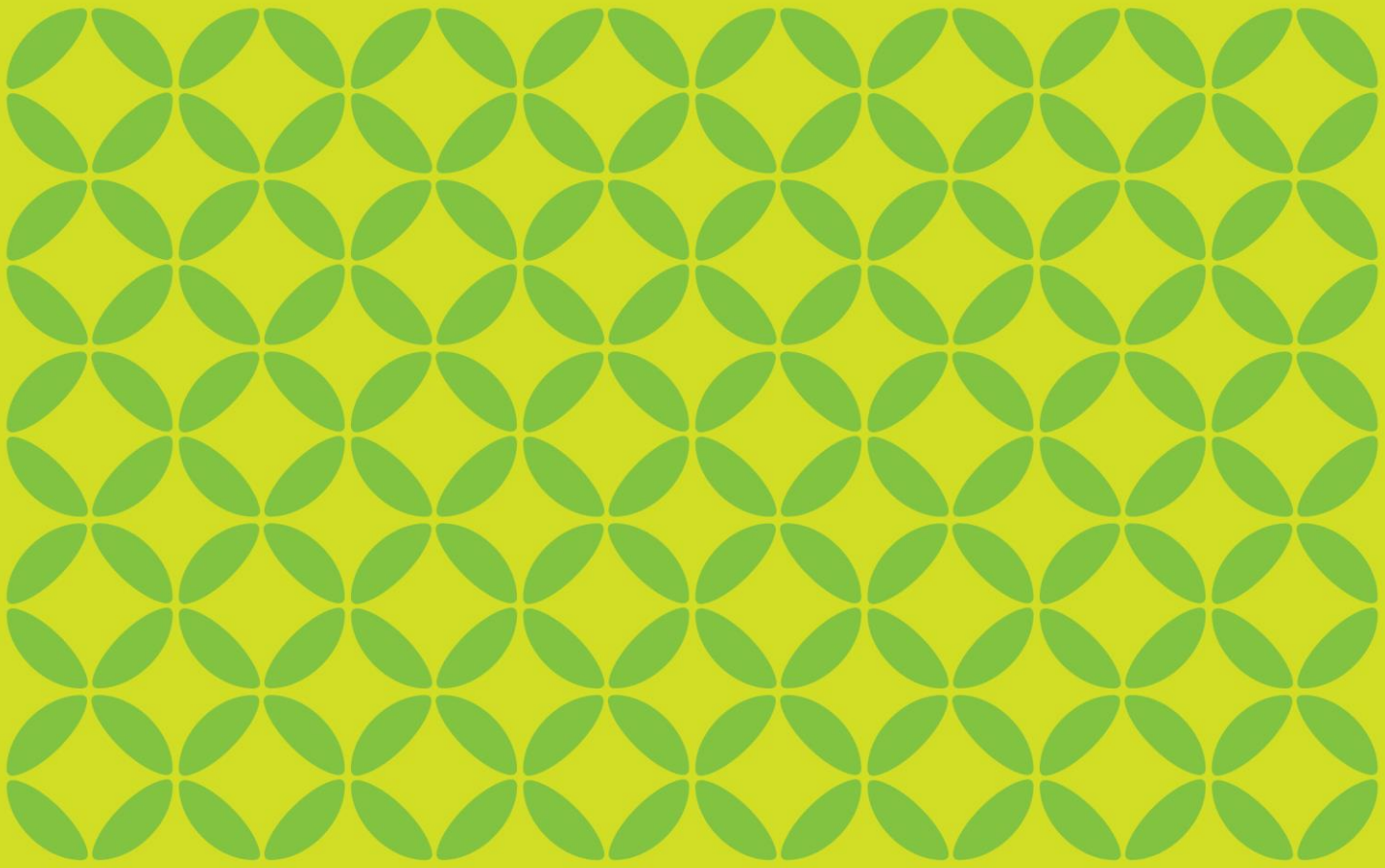
greenstar

Upfront Carbon Emissions calculation guide – interim

Guidance on calculation methods for the Upfront Carbon Emissions and Life Cycle Impacts credits



Interim Version 1

6 December 2022

Green Building Council Australia

Building a sustainable future

Version control

Version	Date	Description of changes
Interim v1	2 December 2022	Initial release – Interim Guide

Use of trademarks

All third-party trademarks are the property of their respective owners. All third-party trademarks referenced in this document are used in an editorial fashion and not to the detriment of the trademark holders.

Intellectual property rights and confidentiality

Acknowledgements

This guide was developed in conjunction with thinkstep-anz. We thank them for their expertise, advice, and insights.

We want to thank our funding partners Lendlease, NSW Government and Sustainability Victoria.

Thanks also to the many individuals that provided input on the reference specifications.

Table of contents

About this guide

Upfront Carbon Emissions Calculation Guide

This document sets out the basis on which a project's upfront carbon emissions modelling should be completed when the intent is to compare a reduction to a typical building in Australia.

To help provide a higher level of comparability and certainty in upfront carbon calculation, this guide:

- Defines upfront carbon and provides background for why it matters
- Outlines the scope of inclusions and exclusions in an upfront carbon calculation
- Provides options for reducing upfront carbon emissions
- Defines default *Reference Project*'s materials

This document contains interim guidance to assist project teams and will be superseded by an expanded and updated version in early 2023. It is provided to industry for use, testing and feedback purposes. It is also provided for use by Green Star registered projects.

Guidance specific to Green Star is highlighted in green. All are encouraged to follow this guidance when calculating upfront carbon emissions.

Information relevant to Green Star registered projects

The methodology in this guide must be applied when using either the Upfront Carbon Emissions Calculator or a Life Cycle Assessment in Green Star.

In addition, the following credits are affected by the contents of this guide:

Life Cycle Impacts: This guidance shall be used to define the *Reference Project* for the Life Cycle Impacts credit where the results are used for the Upfront Carbon Emissions credit. Where this occurs, the Life Cycle Assessment results shall be used to determine the points awarded, based on the Climate Change impacts reduction for Modules A1 to A5.

Other Carbon Emissions: The Exceptional Performance pathway of the Other Carbon Emissions credit requires the offsetting of the Upfront Carbon Emissions from Modules A1 to A5, as calculated under the Upfront Carbon Emissions credit and using this Guidance.

Energy Use: The *Reference Project* systems defined for the purposes of this credit should match the building fabric requirements for the *Reference Project* systems as specified in the Energy Use credit.

Applicability to Green Star projects

Projects registered before the date of publication of this document may use alternative approaches where previously approved by the GBCA.

Projects registered after December 2022 must use the version of the guide current at the time of registration or the most current version at their discretion.

Reference specifications should not change substantially between versions of this guide, however if you believe your project has been substantially affected by changes, please submit a Technical Question.

Feedback

GBCA welcomes feedback on the scope of the reference specifications and guidance provided. Feedback can be lodged here.

Definitions

Upfront Carbon Emissions

The carbon emissions caused before the building begins to be used, i.e., during manufacture of building products, transport of building products to site and construction of the building (EN 15978 Modules A1 to A5).

Embodied Carbon

Carbon emissions associated with materials and construction processes throughout the whole life cycle of a building. This includes Upfront Carbon, Use Stage Embodied Carbon, and End of Life Carbon, but not Operational Carbon.

Use Stage Embodied Carbon

Emissions associated with materials and processes needed to maintain the building during use such as for maintenance, repair or refurbishments (EN 15978 Modules B1 to B5).

End of Life Carbon

The carbon emissions associated with deconstruction/demolition, transport from site, waste processing and disposal phases of a building's life cycle which occur after its use (Modules C1 to C4).

Operational Carbon

The emissions associated with energy used to operate the building (Module B6). Operational water (Module B7) is also often included as part of Operational Carbon.

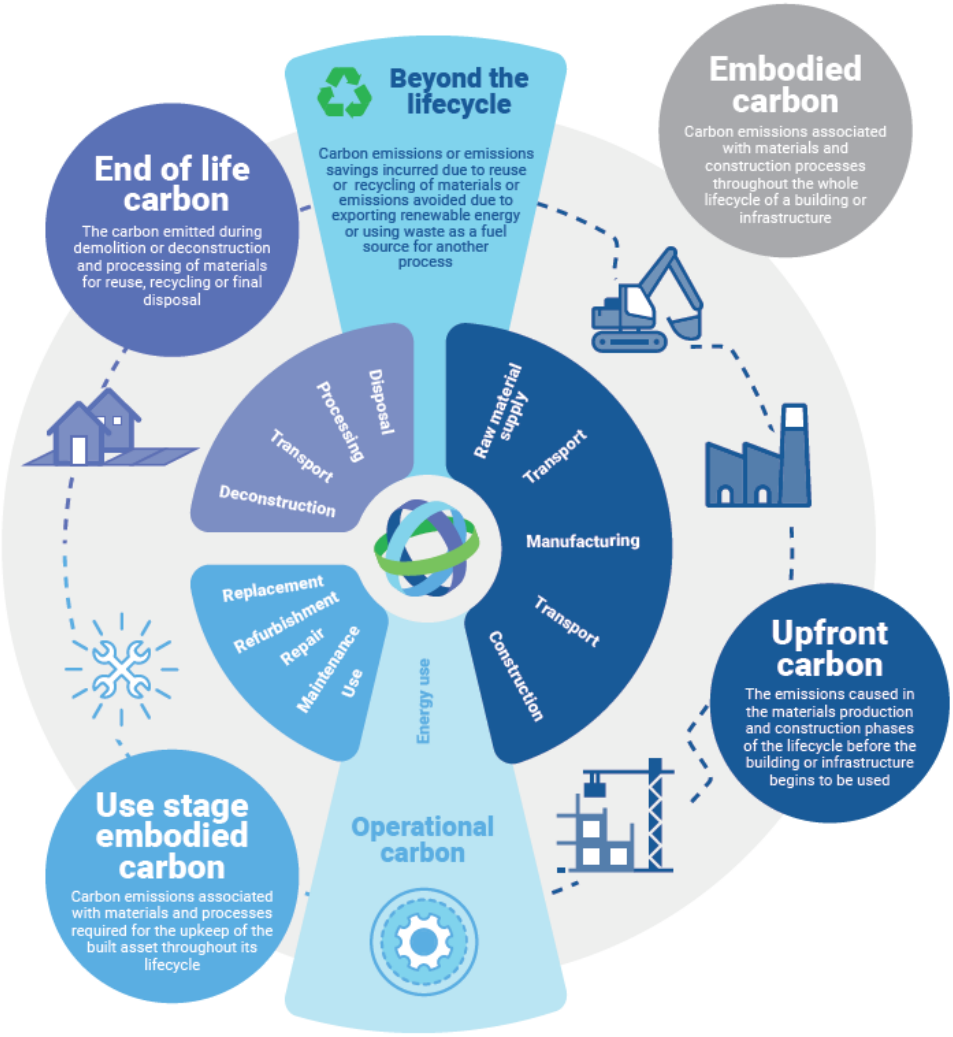


Figure 1 - Embodied carbon through a building's life cycle (World Green Building Council, 2019)

Life Cycle modules

The stages of a building's lifetime impacts as defined in EN15978 in Figure 2.

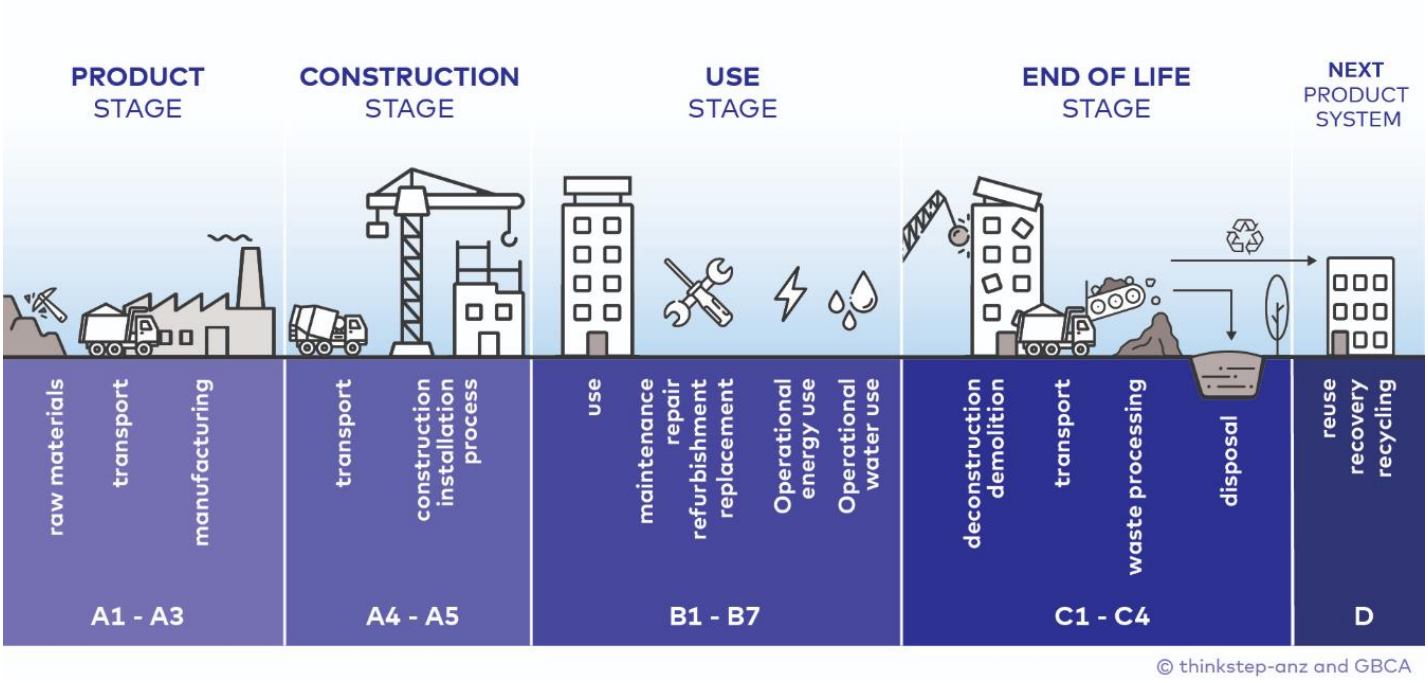


Figure 2 - Life cycle modules according to EN 15978

Green Star project scope

All areas and activities in a project that have been registered for Green Star. This includes all buildings and any ancillary areas such as parking, landscaping and shared facilities.

Proposed Project – Upfront Carbon

The building works to be rated by the *Green Star Buildings* rating tool, as designed and modelled by the project team as defined by the Green Star project scope.

Reference Project – Upfront Carbon

A hypothetical project of the same size, shape, location, floor area and glazing areas as the *Proposed Project*.

Why should we focus on upfront carbon emissions?

The built environment represents about 40% of all emissions worldwide. Of those emissions, approximately 11% is from construction materials. In Australia, that proportion is higher, with approximately 16% of all emissions from the built environment generated come from product and materials used in the construction and refurbishments of buildings, fitouts, and precincts. However, that figure is for the entirety of the built environment's impacts.

Of those emissions, the vast majority (about 80%) happen *upfront*. That is, they occur during the construction stage. In a typical new building this represents close to a quarter of the building's lifetime emissions. As the grid decarbonises, the proportion of *upfront carbon emissions* increases compared to its operating emissions. Furthermore, as these emissions are 'locked-in' during construction, they cannot change after the fact.

It is because of this that GBCA's Climate Positive Roadmap identified lowering upfront carbon emissions as a key element in ensuring we can decarbonise our built environment.

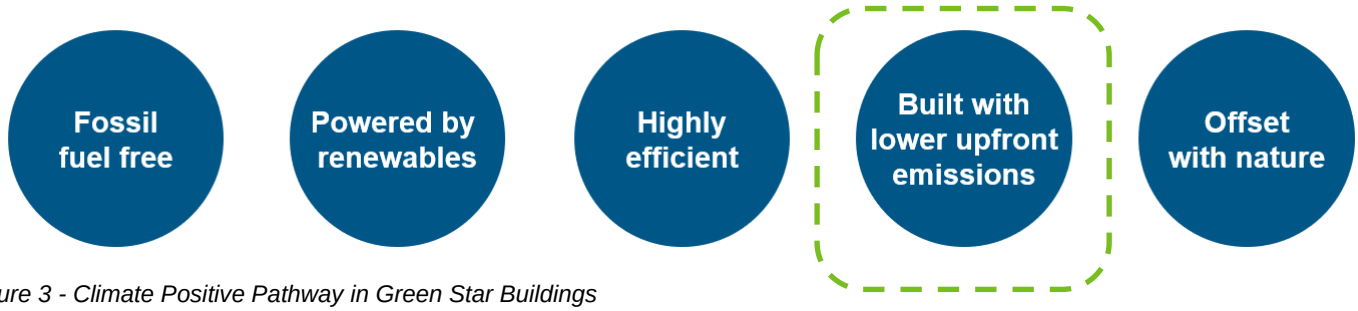


Figure 3 - Climate Positive Pathway in Green Star Buildings

How is upfront carbon treated in Green Star?

All new Green Star rating tools include or will include an *Upfront Carbon Emissions* credit. This credit seeks to reduce the upfront carbon emissions when compared against a benchmark or a reference building in Australia. Remaining upfront carbon emissions also has a bearing on the *Other Carbon Emissions* credit, because for all upfront carbon that is not reduced, this credit encourages the procurement of nature-based offsets to compensate for these emissions. Both credits can be found in the *Positive* category.

Any project seeking to get a rating under Green Star Buildings must reduce its upfront carbon by at least 10% (*Minimum Expectation)*. Those seeking higher ratings must achieve at least a 20% reduction (*Credit Achievement* worth 3 points). Over time, the requirements increase to have all future registered projects to meet a 40% reduction (*Exceptional Performance* worth an additional 3 points).

To demonstrate compliance, project teams can either:

- **Model the *Proposed* and *Reference Project* following the methodology of the *Life Cycle Impacts* credit for modules A1 to A5.** The models must comply with the requirements in this Guidance, and specifically include modelling of Modules A4 (transport to site) and A5 (construction impacts).
- **Complete the Upfront Carbon Emissions calculator. The GBCA's *Upfront Carbon Emissions calculator* uses Modules A1 to A3 to calculate compliance**. Calculation of Modules A4 and A5 is not included in the calculator, and therefore it may not be used to claim compliance with the *Exceptional Performance* criteria, as outlined in the Upfront Carbon Emissions credit. Note that for the Other Carbon Emissions credit, an alternative pathway to calculate estimated Modules A4 and A5 emissions is provided.

More information can be found in Green Star Buildings v1 Submission Guidelines.

Interdependence with other Green Star credits

Responsible Structure, Responsible Envelope, Responsible Systems and Responsible Finishes

Some information collated to calculate upfront carbon emissions may also assist project teams in making claims under the above-mentioned credits. In particular, Environmental Product Declarations, Climate Active certifications or similar are recognised under the Responsible Products Framework.

Calculating upfront carbon emissions reductions

There are two methods that are accepted for calculating upfront carbon emissions reductions:

- Comparison against a fixed benchmark
- Comparison against a *Reference Project*

This guide is to be used when doing a comparison against a reference project.

A note on fixed benchmarks in Australia

GBCA and NABERS are collaborating on developing an aligned method for calculating upfront carbon emissions reductions against a fixed benchmark. This is expected to be released in late 2023. A consultation process will be running from December 2022 to February 2023. Upon the release of this aligned method and fixed benchmarks, GBCA will amend Green Star Buildings to allow for such method to be accepted. Regardless, an approach against a reference building will continue to be accepted under certain circumstances.

Comparison against a Reference Project

To compare against a *Reference Project*, a consulting team will do two sets of upfront carbon emissions calculations, one for the *Proposed Project* and one for the *Reference Project*.

The *Proposed Project* is defined as the project as designed and built by the project team. A *Reference Project* is a hypothetical project of the same size, shape, location, floor area and glazing areas as the *Proposed Project*. The aim of the *Reference Project* is to provide a point of comparison for reductions against, by developing a building that could have been built in place of the *Proposed Project* provided no work was done to reduce its upfront carbon emissions.

Therefore, both the *Proposed Project* and *Reference Project* must share the same:

- Life cycle stages and system boundary
- Calculation methodology
- Data sources and data hierarchy
- Declared units
- Site work boundary
- Building elements boundary
- Size, scale, volume, and function
- Shared elements
- Cut-off rules
- Assumptions on carbon sequestration, carbon neutral products, and carbon offsets
- Considerations for demolition and reuse of existing buildings

The *Reference Project* can differ on the following from the *Proposed Project* to show reductions in upfront carbon as shown in the following sections:

- Reusing existing building elements or site infrastructure
- Improvements through iterative design processes
- Building material choices and quantities
- Transport emissions
- Construction emissions

There are other considerations that can vary between the *Proposed* and *Reference Projects*. These are outlined later in the guide.

Life cycle stages and system boundary

The system boundary follows EN 15978:2011 (CEN, 2011) and EN 15804:2012+A2:2019.

The following activities are **included:**

- Modules A1-A3: Carbon emissions from the manufacture of products and materials used in the building.
- Module A4: Transport of building products to site.
- Module A5: Site preparation works and construction of the building. This includes:
  - On-site construction activities, such as operation of cranes, excavators, and building site services, and the manufacture, transport and disposal of any wasted building products.
  - Energy (primarily diesel and electricity) used in construction machinery or site offices on the building site.
  - Manufacture, transport, and end-of-life treatment of materials that become construction waste.
  - For greenfield developments, this module also includes the carbon impacts of land use change (calculated at the date of purchase).

The following activities are **excluded:**

- Manufacture of machinery and other capital goods.
- Transport of staff to and from the construction site.
- Electricity used off-site for professional services.
- Pre-construction activities, such as land acquisition and design (Module A0).

Please note:

- Both lists are intended to be illustrative and are not exhaustive.
- The exclusions above are aligned with a process-based life cycle assessment approach, e.g., *PCR 2019:14 Construction Products* from the International EPD System (IEPDS 2022, section 4.3.2) as used within EPD Australasia.

Calculation methodology

All carbon footprint calculations shall be performed using Global Warming Potential over a 100-year time horizon (GWP100) in line with ISO 14067:2018 (ISO, 2018). The most recent characterisation factors from the Intergovernmental Panel on Climate Change (IPCC) should be used where possible. At the time of writing, the IPCC Sixth Assessment Report (AR6) contains the most recent factors (IPCC, 2021). However, GWP100 factors following older assessment reports may also be used.

Following EN 15804:2012+A2:2019, the total carbon footprint – **GWP-Total** – is the sum of three constituent parts:

- GWP-Fossil: Carbon footprint arising from fossil sources.
- GWP-Biogenic: Carbon footprint arising from biogenic sources (net of emissions and removals).
- GWP-LULUC: Carbon footprint due to land use and land use change.

Biogenic carbon stored in materials can only be included up to the point of neutralising GWP-Fossil and GWP-LULUC to make GWP-Total = 0. This is discussed further below in “Assumptions on carbon sequestration, carbon neutral products and carbon offsets”.

Data sources and data hierarchy

Two types of data are needed to complete the carbon footprint:

1. Building quantities: The quantities of materials used in the building itself and the quantities of materials and energy used in the construction of the building. Within life cycle assessment, these quantities are often known as the activity data.
2. Emissions factors: The carbon footprint per unit of material, energy or waste.

The following preference hierarchy must be used for emission factors:

- Product-specific emission factor: Emission factors that apply to the specific product used in the building shall be used wherever they are available. These emission factors should be producer and region specific, and independently verified. A product specific Environmental Product Declaration (EPD) is preferred, with an industry specific EPD following as preference.
- Generic value from database: Where a product-specific emission factors is unavailable, an appropriate generic material from an LCA tool may be selected. The type of generic data being used should be considered – it should be either process LCA-based (like EPDs) or hybrid LCA-based (like EPiC Database data), but the two should not be mixed for the same type of product, otherwise this may lead to inconsistent results.
- Generic value from global literature scan: Where neither of the previous two options are possible, a generic emission factor from literature may be used, using the worst value found for the correct product type.

The data used for each building element must be from a similar source for both the *Proposed Project* and the *Reference Project*. For example, the EPiC Database used in the Upfront Carbon Emissions calculator can be used for the same building element (e.g., structural framing) in both the *Proposed* and *Reference Project*s, or EPD data can be used in both, but they are not to be mixed. It is possible to use a mix of process LCA data and hybrid LCA data within the same study, but it must be used for different building elements (e.g., process LCA for structural framing and hybrid LCA for building services).

Declared units

The declared unit for upfront carbon emissions is **kg CO_2e/m^2 GFA**, which is kilograms of carbon dioxide equivalent per square metre of Gross Floor Area (GFA).

The Australian Institute of Quantity Surveyors' definition of GFA is applied. GFA is the sum of "Fully Enclosed Covered Area" and "Unenclosed Covered Area", as defined below (AIQS, 2013, Appendix A, Part 2).

> ***Fully Enclosed Covered Area (FECA)***
>
> *The sum of all such areas at all building floor levels, including basements (except unexcavated portions), floored roof spaces and attics, garages, penthouses, enclosed porches and attached enclosed covered ways alongside buildings, equipment rooms, lift shafts, vertical ducts, staircases and any other fully enclosed spaces and usable areas of the building, computed by measuring from the normal inside face of exterior walls but ignoring any projections such as plinths, columns, piers and the like which project from the normal inside face of exterior walls.*
>
> *It shall not include open courts, light wells, connecting or isolated covered ways and net open areas of upper portions of rooms, lobbies, halls, interstitial spaces and the like which extend through the storey being computed.*
>
> ***Unenclosed Covered Area (UCA)***
>
> *The sum of all such areas at all building floor levels, including roofed balconies, open verandahs, porches and porticos, attached open covered ways alongside buildings, undercrofts and usable space under buildings, unenclosed access galleries (including ground floor) and any other trafficable covered areas of the building which are not totally enclosed by full height walls, computed by measuring the areas between the enclosing walls or balustrade (i.e. from the inside face of the UCA excluding the wall or balustrade thickness).*
>
> *When the covering element (i.e. roof or upper floor) is supported by columns, is cantilevered or is suspended, or any combination of these, the measurements shall be taken to the edge of the paving or to the edge of the cover, whichever is the lesser.*
>
> *UCA shall not include eaves overhangs, sun shading, awnings and the like where these do not relate to clearly defined trafficable covered areas, nor shall it include connecting or isolated covered ways.*

The scope of the building included in the assessment, as defined in this Guidance, is broader than the Gross Floor Area. This definition is provided to allow results to be normalised to a common unit.

Site work boundary

Site preparation and excavation (primarily the energy used in construction machinery) must be included where calculating Module A5.

Examples:

- Diesel used in excavators and on-site haul trucks when excavating a basement.

- Diesel and/or electricity used for cranes when erecting the building.
- Electricity used in any on-site offices during construction.

Emissions from demolishing a previous building and clearing the site of rubble are part of the previous building's life cycle. These emissions are not included in the A1-A5 calculations or the full Life Cycle Assessment, however effort should be made to maintain as much of an existing building as possible, particularly prior to the building's end of life (usually considered to be 50 years as a minimum). See below for best practice considerations when considering demolishing a building – while specific to Green Star, all are encouraged to follow the items below.

Green Star Guidance

The below guidance is stated in the Upfront Carbon Emissions credit. It is a separate requirement to the reduction in modules A1-A5.

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.

Where the existing building is between 30 and 50 years old, the contribution of embodied emissions shall be calculated and discounted at 5% for every additional year past year 30. For example, demolishing a 36-year-old building would require offsets to cover (100-6x5) = 70% of the calculated embodied emissions.

Following this, both the upfront emissions (modules A1-A3) of the demolished materials, and the demolition process (modules C1-C4), must be offset through the purchase of accepted carbon offsets. Acceptable types of offsets and offset schemes are listed in the GBCA's Climate Positive Buildings and our Net Zero Ambitions document available on the Resources portal of the GBCA website.

Projects which require demolition of an existing building because of it not being fit-for-purpose (e.g., due to fire damage, or a significant lack of Australian Building Code compliance) are able to be excluded from offsetting demolition works. This is to be disclosed and justified clearly in the submission and agreed upon via a Technical Question with GBCA.

Building element boundary

At minimum, all parts of the cold shell must be included within the scope of analysis. This includes:

- Substructure (foundations, ground-bearing slabs and basement retaining walls)
- Superstructure (suspended floors, structural walls, columns, and beams)
- Envelope (external non-structural walls and curtain walls)
- Core building services to the client connection point (e.g., the riser)

Where warm shell, or part thereof, is included in the contracted scope of works, these shall also be included, such as:

- Ceiling and wall systems
- Floor finishes
- Installed services
- Permanently installed fixtures, such as lighting, electrical, plumbing and joinery

There's additional guidance relevant for the *Proposed* and *Reference Project* related to solar PV, glazing and shading systems that must be considered.

Solar PV

Where the *Proposed Project* includes a solar PV system, it must equal or exceed the requirements for the solar PV system in the *Reference Project*. Where a solar PV system is not in the scope of the *Proposed Project*, it must not be included in the assessment of either *Project*, and consequently a reduction in upfront carbon cannot be claimed.

Glazing

The *Reference Project* should assume double glazing for improved thermal performance. Where the *Proposed Project* design specifies single glazing, the *Reference Project* shall be assessed using single glazing, and consequently a reduction in upfront carbon cannot be claimed.

Shading Systems

Shading systems (louvres/fins) are considered an optional design element for the purposes of the upfront carbon credit. As such, these systems may be included in the *Reference Project* if a shading system has been included to achieve the modelled energy performance for the *Proposed Project*. The shading arrangement should be similar in both Projects. Where shading systems have not been included in the *Proposed Project's* design, it must not be included in the assessment of either Project.

Size, scale, volume, and function

Both the *Reference* and *Proposed Project*s must have the same overall size, scale, volume, and function. In principle, the *Reference Project* and the *Proposed Project* must have the same:

- Structural requirements, such as:
  - Span
  - Overall building height
  - Vertical and lateral design loading
  - Durability
  - Fire Resistance
- Glazing
- Scale, particularly:
  - Gross Floor Area
  - Floor plate area
  - Number of stories
- Function
- Design Life
- Location
- Tenant requirements, particularly the same Net Lettable Area
- Aesthetics
- Site conditions, including underlying geology
- Planning constraints
- Orientation
- Season of construction

There is additional guidance in the section *Showing reductions in upfront carbon* on how the *Reference Project* can be adjusted to show improvements through design choices and material selection.

Shared elements

Where a building shares elements with other buildings, these shared elements must be apportioned (allocated) to the building under study in a way which reflects their use of these shared elements. Floor area – either Gross Floor Area (GFA) or Net Lettable Area (NLA) – should be used as the default method of allocation, unless there is a good reason to use a different method.

Examples:

- A retail store shares services (HVAC, waste disposal, toilets, car parks) with the wider retail precinct that it is a part of.
- The retail store has floor area of 1,000 m^2 NLA. It is part of a retail precinct with 100,000 m^2 of total NLA and 140,000 m^2 total GFA.
- The retail store should be allocated 1% (=1,000/100,000) of the shared services of the precinct. NLA is preferred to GFA in this context as otherwise the common areas of the precinct would receive some of the burden of the retail precinct despite these not being let by any tenant.

Green Star Guidance

All buildings within the precinct applying for ratings to the GBCA must use the same allocation method for each shared element for consistency.

Cut-off rules

This methodology follows EN 15978:2011 and EN 15804:2012+A1:2019. These standards require that data which are available must be included in the study. Where there are data gaps, up to a total of 5% of each module (A1-A3 and A4-A5) may be excluded, as measured by mass or energy.

In practice this means that smaller items can be excluded from the study, unless there is reason to believe that this 5% total threshold would be crossed. These smaller items include but are not limited to:

- Individual screws, nails and other fasteners that are not part of delivered building products.
- Glues, sealants, caulking compounds and filling compounds used in small quantities throughout the building and not part of delivered building products. (Sealants used in membrane roofs applied on-site must be included in the study.)
- Doorknobs, door hinges, light switches, power sockets and other minor fittings.

Green Star Guidance

Materials used in the Upfront Carbon calculator must capture at least 90% of physical materials and 90% of financial value of building products in addition to the rules above.

Assumptions on carbon sequestration, carbon neutral products and carbon offsets

While the following guidance is specific to Green Star, all are encouraged to follow the items below.

Green Star Guidance

Stored carbon (e.g., biogenic carbon sequestered by trees and other plants) can be accounted for up to the point of zeroing out the emissions of the product in which the stored carbon is found. Stored carbon from one product cannot be used to offset the emissions of another product. Stored carbon from biogenic sources may only be accounted for if the product is certified to FSC, PEFC or a PEFC-endorsed system (e.g., Responsible Wood).

Carbon neutral products: Products certified as carbon neutral by an approved program can be treated as having a carbon footprint of zero. Products must follow the Climate Active Carbon Neutral Standard for Products and Services. The Climate Active carbon neutral certification must be valid for the period when the product was purchased.

If a project seeks to use a different Standard, a Technical Question must be submitted to the GBCA justifying its equivalency. Additional schemes will be added once they become available and added as a FAQ on the GBCA's website.

Carbon offsets: Carbon offsets that are not linked to carbon neutral product certification cannot be considered other than for the purposes of offsetting demolition works, in line with the guidance in the Other Carbon Emissions credit.

Residual upfront carbon emissions beyond the Credit Achievement reduction target, and carbon emissions from demolition works, may be offset through verified offset schemes. Acceptable types of offsets and offset schemes are listed in the GBCA's Climate Positive Buildings and our Net Zero Ambitions document available on the resources portal of the GBCA website.

GBCA and NABERS are currently consulting on a future aligned method to calculating upfront carbon emissions reductions. This consultation includes questions on how carbon sequestration, carbon neutral products, and carbon offsets should be treated. Until amended, the guidance above will apply to all Green Star registered projects.

Showing reductions in upfront carbon

Reusing existing building elements or site infrastructure

Reused building elements are considered to have a carbon footprint of zero in the new project. Only additional activities – such as reprocessing and transporting of materials – needs to be included within the upfront carbon calculation.

Project teams that reuse an existing building – in whole or in part – may assume new construction in the *Reference Project* for the reused parts of the building(s) and a carbon footprint of zero in the *Proposed Project*.

Improvements through iterative design processes

The *Reference Project* is a hypothetical building that represents standard contemporary construction and operation practices. As noted earlier in the guide, the *Reference Project* must have the same size, scale, volume, and function.

However, to allow for improvements and reductions in upfront carbon through design efficiencies and better material selection, the *Reference Project* is to be measured at the stage referred to as Detailed Design / Technical Design[1]. Any changes from that point onwards are only considered for the *Proposed Project*.

In some cases, the *Reference Project* can be based on earlier stages in the design process. To be considered, clear evidence should exist to demonstrate that embodied carbon reduction was part of the decision-making process, and part of the reason for the changes. Examples of evidence include:

- An original contract specification that has been altered.
- A minuted / traceable decision-making process where the original design was altered to reduce the embodied carbon.,

Green Star Guidance

Project teams wanting to claim a change between the *Reference* and *Proposed Project* of any of the above on the basis of a deliberate low-carbon design strategy must submit a Technical Question to the GBCA with evidence to support the claim.

Building material choices and quantities

Building quantities used in the final carbon footprint calculation for the *Proposed Project* shall be based on **actual quantities used** in the building and its construction, as can be validated from invoices and/or a schedule (such as a bill of quantities or cost plan) that has been updated during or following construction to reflect actual material/product use in the finished building.

Building quantities used for the *Reference Project* must be calculated using the quantities calculated as per the Detailed Design / Technical Design stage, or where justified, and earlier stage selected above.

The material choices for the *Reference Project* shall be based on present-day, business-as-usual construction methods, not the worst available.

Templates for defining the material choices used for the *Reference Project* are provided in the section ‘Defining materials for use in the Reference ’. They are defined for different classes of buildings.

Guidance for Green Star Projects

The project may vary the material choices in the tables as the GBCA recognises that all buildings and all building sites are different. In the case of significant changes, the project can submit a Technical Question to the GBCA for clarification. Minor variations should be justified through a short report provided by the principal architect and engineer for the project in the Green Star submission.

[1] As defined in the Australian National Building Specification (NATSPEC, 2022) or Royal Institute of British Architects’ Plan of Work 2020 (RIBA, 2020) respectively.

Where the design of a building must meet additional requirements that are not allowed for in Table 1 to Table 4, the project can submit a Technical Question to the GBCA to apply to use an alternate set of *Reference Project* materials. The Technical Question must include justification of the additional requirements (e.g., special building type such as a stadium or hospital, geological conditions, cyclone rating).

Transport emissions reductions

Transport to site (Module A4)

The emissions of transporting building products, formwork and machinery to/from site should be calculated by multiplying the total mass from a given location by an appropriate emission factor for the correct mode of transport (truck, ship, diesel train, etc.) within the LCA tool used. Emissions do not need to be calculated product-by-product – what is important is the total tonne-kilometres of transport for each mode of transport.

Example:

- 2,000 kg of scaffolding is moved to the construction site from a warehouse at the start of the project. It remains on-site for the duration of the project, after which it is moved back to the same warehouse. The distance from the warehouse to the site is 30 km. The truck travels across an urban area in both directions. Assume an emission factor of 0.128 kg CO_2e/tkm.
- GWP-Total = (30 km + 30 km) * (2,000 kg / 1,000 kg/t) * (0.128 kg CO_2e/tkm)
- GWP-Total = 15.4 kg CO_2e

Sample emission factors are provided below in Table 1. Project teams can use these emission factors to calculate Module A4 emissions in both their *Reference Project* and *Proposed Project.* Project teams can also use the factors below for their *Reference Project* and the emission factors of their chosen LCA tool or data sources for the *Proposed Project*.

Table 1: Freight emission factors

Freight type	Carbon footprint per tonne-kilometre (kg CO2e/tkm)	Source
Air, domestic	1.86	AusLCI v1.38
Air, international	1.65	AusLCI v1.38
Rail	0.0240	AusLCI v1.38
Van, 3.5t gross weight	1.54	AusLCI v1.38
Truck, 3.5 to 16t gross weight	0.216	AusLCI v1.38
Truck, 16 to 28t gross weight	0.128	AusLCI v1.38
Truck, 28t gross weight	0.0719	AusLCI v1.38
Truck, 40t gross weight	0.0686	AusLCI v1.38
Ship, container ship	0.0161	Defra (2022)
Ship, bulk carrier	0.00354	Defra (2022)

Construction emissions reductions

Module A5 includes four main components:

- Manufacture of construction products that are wasted on-site (Modules A1-A3 + A4).
- Disposal of construction waste (Modules C1-C4).
- On-site construction emissions (energy use in construction machinery and site offices).
- Emissions due to land use change for greenfield sites (calculated at the date of purchase).

Disposal of construction waste

Sample emission factors are provided below in Table 2. Project teams can use these emission factors to calculate disposal of construction waste emissions in both their Reference Project and Proposed Project. Project teams can also use the factors below for their Reference Project and the emission factors of their chosen LCA tool or data sources for the Proposed Project. The waste fates come from the National Waste Database 2020 (DECCEEW 2020), while the waste percentages come from BRANZ (BRANZ 2021).

Table 2: Construction waste rates and fates for selected construction materials

Product	Waste %	Fate of construction site waste (% material by mass)		
		Recycling	Energy Recovery	Landfill/ Cleanfill
Aluminium	1%	100%	0%	0%
Asphalt	4%*	100%	0%	0%
Bricks	5%	99%	0%	1%
Concrete (in-situ)	4%	100%	0%	0%
Concrete (precast)	0%	n/a	n/a	n/a
Glass	1%	68%	0%	32%
Plasterboard	23%	75%	0%	25%
Steel	1%	100%	0%	0%
Timber	10%	43%	7%	50%

* based on in-situ concrete as no data available

On-site equipment and site offices emissions

For the *Reference Project*, the same number, type, and capacity of equipment as used for the *Proposed Project* must be used. However, it can be assumed that construction equipment for the *Reference Project* uses fossil fuels for power, where that is typically used. Where the equipment would typically use electricity, the standard grid factor for the location can be used as well.

Site office energy consumption for the *Reference Project* is assumed to be at the location grid factor, or if fossil fuels are used, at the relevant emissions factor as of the date of use.

The *Proposed Project* can show improvements through switching to all-electric equipment and fossil fuel alternatives as well as via the use of GreenPower or Renewable Energy Purchases.

Defining materials for use in the Reference Project

The tables in this section aim to show where current typical construction practices lie. They are to be used to calculate *Reference Project* upfront carbon emissions. The default material type specified aims to represent the predominant material type used for a given building element on the Australian market at the time of publication. This is a deliberate simplification as many buildings will use a mixture of materials for the same building element. The project team may vary the material choices in the tables as buildings and all building sites can be different but should take care to have strong justification for doing so.

The structure of the tables is based on the building element categories in the *Elemental Standard Form of Cost Analysis, 4th Edition* from the Royal Institution of Chartered Surveyors (RICS, 2012).

For the purposes of this guide, the tables have been broken into four main categories based on four typical building typologies:

- **Mid- to high-rise buildings.** These buildings are typically five or more storeys. They are usually taller than they are wide. The primary structural system may be any combination of reinforced concrete, structural steel framing and mass timber. Building types in this category include office towers, residential apartment towers and large hospitals, for example National Construction Code (NCC) Class 2, 5 and 9 buildings. See Default specifications for mid- to high-rise buildings for reference materials.
- **Warehouse-type buildings.** These buildings are typically single storey with large spans and a large interior volume. They are much wider than they are tall. They may be designed for internal vehicle operation, e.g., forklifts, lift trucks and/or trucks. They are typically constructed using a portal frame over a reinforced concrete slab. Building types in this category include warehouses, logistics depots, large industrial buildings, large supermarkets and other large open-plan retail sites, for example NCC Class 6, 7 and 8 buildings. See Default specifications for warehouse-type buildings for reference materials.
- **Low-rise buildings.** These buildings are typically one to four storeys. They are usually smaller than warehouse-type buildings (above), but larger than residential-type buildings (below). They may have a combination of large open-plan areas and smaller enclosed areas. They may be constructed using a standard reinforced concrete frame or reinforced concrete tilt-up panels continuously supported on reinforced concrete strip footings. Building types in this category include shopping centres, indoor sports venues, schools, libraries, smaller supermarkets, smaller industrial buildings and smaller hospitals, for example NCC Class 6, 7 and 9 buildings. See Default specifications for low-rise buildings for reference materials.
- **Residential-type buildings.** These buildings are typically one to two storeys and have the smallest floor area of the four building types. Their construction resembles a detached residential house. They are typically constructed of timber stud or cold-form steel framing on a reinforced concrete slab. Building types in this category include medical practices, school buildings and extensions to the building types above, for example NCC Class 2, 3, 6 and 9 buildings. See Default specifications for residential-type buildings for reference materials.

Where a specific project is a combination of multiple building types (e.g., a retail complex which features both warehouse-type buildings and low-rise buildings), the most appropriate building type shall be used for each part of the project.

In the sections below, the following is used:

- **Virgin steel (primary steel)** refers to steel produced primarily from iron ore. The most common manufacturing route is to use a Blast Furnace to convert iron ore to pig iron and then a Basic Oxygen Furnace (BOF) to convert pig iron into steel. All virgin steel contains some recycled content, but virgin iron/steel makes up the bulk of the product.
- **Recycled steel (secondary steel)** refers to steel produced primarily from steel scrap. The most common manufacturing route is an Electric Arc Furnace (EAF). While steel scrap is the main raw material, other alloying elements – including virgin iron – may be used to achieve the desired alloy composition. As such, recycled steel does not always contain 100% recycled content. The emission factor used for the EAF's electricity should reflect the real electricity mix supplied to the furnace. If the source of the steel is unknown, assume production in Australia using average Australian grid electricity without Renewable Energy Certificates.
- **Virgin aluminium (primary aluminium)** refers to aluminium produced primarily from aluminium ore (bauxite). Production involves conversion of bauxite into alumina and then electrolysis of alumina to produce aluminium. The emission factor used for the smelter's electricity should reflect the real electricity mix supplied to the smelter. If the source of the aluminium is unknown, assume production in China using average Chinese grid electricity without Renewable Energy Certificates.
- **Recycled aluminium (secondary aluminium)** refers to aluminium produced from post-consumer recycled (secondary) sources. Aluminium scrap is put into a melting furnace and may then be further alloyed before being cast, extruded or rolled. Unlike steel, which always contains some recycled content, aluminium may have any recycled content from 0% to 100%.
- **Portland cement replacement** includes the use of any supplementary cementitious materials (SCMs) to replace ordinary Portland cement in concrete. These include, but are not limited to, fly ash, ground granulated blast-furnace slag, and silica

fume. Additionally, there is ongoing interest in the use of alternative cement products (such as Limestone-Portland cement) to improve concrete performance while also lowering the carbon intensity of concrete mix design.

Default specifications for mid- to high-rise buildings

Category 1	Category 2	Building element	Default reference materials
Substructure	Substructure	Foundation	Concrete: 50 MPa with 20% cement replacement 70kg/m3 for pad footings, 115kg/m^3 for pile caps and 230kg/m^3 for ground beams Design should align with recommendations provided by the project geotechnical engineer
		Ground-bearing slab	Concrete: 32 MPa with 20% cement replacement Reinforcing: Reinforcing bar/mesh made from conventional recycled steel at 50 kg/m^3 for slab on grade and 150 kg/m^3 for suspended ground slab
		Basement retaining walls	Concrete: 50 MPa with 20% cement replacement Reinforcing: Reinforcing bar/mesh made from conventional recycled steel at 110 kg/m^3
Superstructure	Frame	Columns Beams	Concrete: 50 MPa with 30% cement replacement for columns and beams Reinforcing: Reinforcing bar/mesh made from conventional recycled steel at 250-350kg/m^3 for columns and 220kg/m^3 for beams Structural steel: Universal beams/columns or welded beams/columns made from grade 300 or hollow sections made from grade 350 to 450 virgin structural steel
	Suspended Floors	Banded Slab Flat Slab Composite Slab	**Banded Slab generally for Commercial Office and Healthcare** Concrete: 40MPa with 20% cement replacement Reinforcing: Reinforcing bar/mesh made from conventional recycled steel at 90-110kg/m^3 OR Post tensioning with virgin steel tendons at 6kg/m^2 and reinforcing bar/mesh made from conventional recycled steel at 50kg/m^3 **Flat Slab generally for Residential** Concrete: 40 MPa with 20% cement replacement Reinforcing: Reinforcing bar/mesh made from conventional recycled steel at 80-100kg/m3 OR Post tensioning with virgin steel tendons at 5kg/m^2 and reinforcing bar/mesh made from conventional recycled steel at 35kg/m3 **Composite Slab** Steel deck made from 1mm thick virgin steel sheet, conventional recycled steel reinforcing mesh at 100-120kg/m^3.

Category 1	Category 2	Building element	Default reference materials
	Roof	Banded Slab Flat Slab Steel Roof	**Banded Slab generally for Commercial Office and Healthcare** Concrete: 40MPa with 20% cement replacement for banded slabs Reinforcing: Reinforcing bar/mesh made from conventional recycled steel at 90-110kg/m^3 OR Post tensioning with virgin steel tendons at 7kg/m^2 and reinforcing bar/mesh made from conventional recycled steel at 55kg/m^3 Roof covering: Precast concrete paving (60mm) **Flat Slab generally for Residential** Concrete: 40MPa with 20% cement replacement Reinforcing: Reinforcing bar/mesh made from conventional recycled steel at 80-100kg/m^3 OR Post tensioning with virgin steel tendons at 6kg/m^2 and reinforcing bar/mesh made from conventional recycled steel at 40kg/m^3 Roof covering: Precast concrete paving (60mm) **Steel Roof** Framing: Cold-formed steel purlins made from grade 450 virgin steel Cladding: Long-run virgin steel cladding with a base metal thickness of 0.42mm or 0.48mm, pre-painted over a zinc-aluminium metal coating.
	Stairs and ramps	Stairs and ramps	Concrete: 40 MPa with 20% cement replacement Reinforcing: Reinforcing bar made from conventional recycled steel at 125kg/m^3
	External walls	Structural external walls	Concrete: 50MPa with 30% cement replacement for walls Reinforcing: Reinforcing bar made from conventional recycled steel at 260kg/m^3 for gravity walls and 300 – 350kg/m^3 for shear walls Blockwork: 190mm concrete blocks, core-filled with 20MPa grout and conventional recycled steel reinforcing bar at 30kg/m^3 Finish: Cement render
		Non-structural external walls	Blockwork: 190mm thick concrete block, core-filled with 20MPa grout and conventional recycled steel reinforcing bar at 15kg/m3 Cold-formed steel frame made from grade 450 virgin steel Cladding: Aluminium cladding made from pre-painted virgin aluminium sheet with a base metal thickness of 0.5 mm.
	Windows and external doors	Curtain wall / façade	Curtain wall: double-glazed with a powder coated virgin aluminium frame (or equivalent NCC 2019 section J compliant façade design). Shading system: virgin aluminium extrusions mounted externally to a virgin aluminium frame

Category 1	Category 2	Building element	Default reference materials
	Internal walls and partitions	Structural internal walls	Concrete: 50 MPa with 30% cement replacement Reinforcing: Reinforcing bar made from conventional recycled steel at 260kg/m^3 for gravity walls and 300 – 350kg/m^3 for shear walls
		Non-structural internal walls	**All typologies:** Wall partitions: 13 mm plasterboard (painted) over cold-formed steel frame with steel furring channels made from grade 450 virgin steel Internal wall insulation: stone or glass wool. Paint: one coat water-based primer + two coats water-based top-coat. Blockwork: 190mm thick concrete block, core-filled with 20MPa grout and conventional recycled steel reinforcing bar at 15kg/m3 **Commercial office and healthcare:** Single-glazed partitions with aluminium frame
	Internal doors	Internal doors	Hollow core timber with steel jamb, painted. Steel fire door, painted.
Finishes	Wall finishes	Wall feature finishes	Wall tiles in bathrooms (5 mm and 10 mm)
	Floor finishes	Floor finishes	**Commercial office:** Nylon carpet tiles with rubber underlay ~80% of area, vinyl flooring ~20% of area Access floors: Cement core, steel pedestal ~80% of area **Residential:** Wool broadloom carpet ~20-30% of area, stone tiles on screed ~20--40% of area, solid timber floorboards ~20-40% of area
	Ceiling finishes	Ceiling finishes	**Commercial office:** Choose the most appropriate ceiling system: • Suspended metal panels (aluminium 0.6 mm) • Mineral fibre tiles • Plasterboard ceiling tiles (10 mm thick) **Residential:** Ceiling with set plasterboard on steel furring channels
Fittings, furnishings and equipment (FF&E)	Fittings, furnishings and equipment	Fittings, furnishings and equipment	**Commercial office:** Office joinery (communal kitchens, lockers, storage units) **Residential:** Built in joinery (cupboards and storage)

Category 1	Category 2	Building element	Default reference materials
Building services/MEP	Services	Plumbing	• Building plumbing • Hot water system (e.g., gas boiler) • Showers • Electric pump • Water tank
		Mechanical	As per existing GBCA Energy Use Calculation Guide – Table 62 (September 2021)
		Fire	Fire services
		Electrical	• Cables (communication and network) • Lighting • BMS and energy monitoring • Site power and electrical connection
		Solar PV	Panel: 350W monocrystalline panel made from virgin materials with 20% efficiency Framing: Mounting frame made from virgin aluminium
		Transportation	• Lift(s)/elevator(s) • Escalator(s) (if used)

Default specifications for warehouse-type buildings

Category 1	Category 2	Building element	Default reference materials
Substructure	Substructure	Ground-bearing slab and hardstand	Concrete: Slab thickness of 175 mm at 40 MPa with 10% cement replacement. Reinforcing: Reinforcing fibre made from conventional recycled steel at 35 kg/m^3. (Use of reinforcing mesh at a higher kg/m^3 is permitted provided the reasoning is justified and accepted by your Green Star Assessor.) Underground rainwater tank (if fitted): Same concrete type and reinforcing steel as above.
Superstructure	Frame	Portal frame	Universal beams/columns or welded beams/columns made from grade 300 virgin structural steel
	Roof	Steel Roof	**Warehouse without temperature control:** Framing: Cold-formed steel purlins made from grade 450 virgin steel. Cladding: Long-run virgin steel cladding with a base metal thickness of 0.42mm or 0.48mm, pre-painted over a zinc-aluminium metal coating. Translucent roof sheeting covering ~10% of the roof area. Roof internal lining: Laminated aluminium foil sarking and safety steel wire mesh. **Warehouse with temperature control:** Sandwich panel constructed of galvanised virgin steel cladding (inside and outside) with 0.42mm or 0.48mm base metal thickness and expanded polystyrene (EPS) insulation. If fire-rated, use polyisocyanurate (PIR) or mineral wool insulation instead.
	External walls	Bulk cladding	**Warehouse without temperature control:** Framing: Cold-formed steel girts made from grade 450 virgin steel. Cladding: Long-run virgin steel cladding with a base metal thickness of 0.42mm, pre-painted over a zinc-aluminium metal coating. **Warehouse with temperature control:** Sandwich panel constructed of galvanised virgin steel cladding (inside and outside) with 0.42mm or 0.48mm base metal thickness and expanded polystyrene (EPS) insulation. If fire-rated, use polyisocyanurate (PIR) or mineral wool insulation instead.
		Cladding for office areas and front façade	Precast Concrete Panels Concrete: 40 MPa with 10% cement replacement Reinforcing bar/mesh made from conventional recycled steel at 175 kg/m^3 Lifting lugs and dowel connections to be included. Long-run steel cladding above.
	Windows and external doors	Windows and external doors	Double-glazed with a powder coated virgin aluminium frame. Steel roller shutter door(s).

Category 1	Category 2	Building element	Default reference materials
	Internal walls and partitions	Non-structural internal walls	Wall partitions: 13 mm plasterboard over cold-formed steel frame with steel furring channels made from grade 450 virgin steel. Internal wall insulation: stone or glass wool. Paint: one coat water-based primer + two coats water-based top-coat.
	Internal doors	Internal doors	Hollow core timber with steel jamb, painted. Steel fire door, painted.
Finishes	Wall finishes	Wall feature finishes	**Office area:** Wall tiles in bathrooms (5 mm and 10 mm)
	Floor finishes	Floor finishes	**Warehouse area:** n/a (polished concrete) **Office area:** Nylon carpet tiles with rubber underlay ~80% of area, vinyl flooring ~20% of area
	Ceiling finishes	Ceiling finishes	**Warehouse area:** n/a (exposed ceiling) **Office area:** Choose the most appropriate ceiling system: • Suspended metal panels (aluminium 0.6 mm) • Mineral fibre tiles • Plasterboard ceiling tiles (10 mm thick) • Set plasterboard (13 mm thick)
Fittings, furnishings and equipment (FF&E)	Fittings, furnishings and equipment	Office joinery	Communal kitchens, lockers, storage units
Building services/MEP	Services	Plumbing	• Building plumbing • Hot water system (e.g., gas boiler) • Showers • Electric pump (if needed) • Water tank (if needed)
		Mechanical	As per existing GBCA Energy Use Calculation Guide – Table 62 (September 2021)
		Fire	Fire services

Category 1	Category 2	Building element	Default reference materials
		Electrical	• Cables (communication and network) • Lighting • BMS and energy monitoring • Site power and electrical connection
		Solar PV	Panel: 350W monocrystalline panel made from virgin materials with 20% efficiency Framing: Mounting frame made from virgin aluminium

Default specifications for low-rise buildings

Category 1	Category 2	Building element	Default reference materials
Substructure	Substructure	Foundations	Concrete: 40MPa with 20% cement replacement Reinforcing: Reinforcing bar/mesh made from conventional recycled steel at 70kg/m^3 for pad footings, 115kg/m3 for pile caps and 230kg/m^3 for ground beams Design should align with recommendations provided by the project geotechnical engineer
		Ground-bearing slab	Concrete: Slab thickness of 175 mm at 32 MPa with 20% cement replacement. Reinforcing: Reinforcing bar/mesh made from conventional recycled steel at 50kg/m3 for slab on grade and 150kg/m3 for suspended ground slab
		Basement retaining walls	Concrete: 40 MPa with 20% cement replacement Reinforcing: Reinforcing bar/mesh made from conventional recycled steel at 110kg/m^3
Superstructure	Frame	Columns Beams	Concrete: 40 MPa with 20% cement replacement for columns and beams Reinforcing: Reinforcing bar/mesh made from conventional recycled steel at 200 - 250kg/m^3 for columns and 200kg/m^3 for beams
	Suspended Floors	Banded Slab Flat Slab Composite Slab	**Banded Slab generally for Commercial Offices, Retail or Healthcare** Concrete: 40MPa with 20% cement replacement Reinforcing: Reinforcing bar/mesh made from conventional recycled steel at 90-110kg/m^3 OR Post tensioning with virgin steel tendons at 6kg/m2 and reinforcing bar/mesh made from conventional recycled steel at 50kg/m^3 **Flat Slab generally for Residential** Concrete: 40MPa with 20% cement replacement Reinforcing: Reinforcing bar/mesh made from conventional recycled steel at 80-100kg/m^3 OR Post tensioning with virgin steel tendons at 5kg/m$_2$ and reinforcing bar/mesh made from conventional recycled steel at 35kg/m^3 **Composite Slab** Concrete: 40MPa with 30% cement replacement. Composite Slab: Steel deck made from 1mm thick virgin steel sheet, conventional recycled steel reinforcing mesh at 100-120kg/m^3
	Roof	Banded Slab	**Banded Slab**

Category 1	Category 2	Building element	Default reference materials
		Flat Slab Steel Roof	Concrete: 40MPa with 20% cement replacement for banded slabs Reinforcing: Reinforcing bar/mesh made from conventional recycled steel at 90-110kg/m^3 OR Post tensioning with virgin steel tendons at 7kg/m^2 and reinforcing bar/mesh made from conventional recycled steel at 55kg/m^3 **Flat Slab** Concrete: 40MPa with 20% cement replacement Reinforcing: Reinforcing bar/mesh made from conventional recycled steel at 80-100kg/m^3 OR Post tensioning with virgin steel tendons at 6kg/m^2 and reinforcing bar/mesh made from conventional recycled steel at 40kg/m^3 **Steel Roof** Framing: Cold-formed steel purlins made from grade 450 virgin steel Cladding: Long-run virgin steel cladding with a base metal thickness of 0.42mm or 0.48mm, pre-painted over a zinc-aluminium metal coating.
	Stairs and Ramps	Stairs and Ramps	Concrete: 40 MPa with 20% cement replacement Reinforcing: Conventional recycled steel reinforcing at 125 kg/m^3
	External structural walls	Structural external walls	Concrete: 50MPa with 30% cement replacement for walls Reinforcing: Reinforcing bar made from conventional recycled steel at 180kg/m^3 for gravity walls and 250 – 300kg/m^3 for shear walls If precast, lifting lugs and dowel connectors to be included. Blockwork: 190mm concrete blocks, core-filled with 20MPa grout and conventional recycled steel reinforcing bar at 30kg/m^3 Finish: Cement render
		Non-structural external walls	Blockwork: 190mm thick concrete block, core-filled with 20MPa grout and conventional recycled steel reinforcing bar at 15kg/m^3 Cold-formed steel frame made from grade 450 virgin steel Cladding: Aluminium cladding made from pre-painted virgin aluminium sheet with a base metal thickness of 0.5mm.
	Windows and external doors	Windows and external doors	Curtain wall: double-glazed with a powder coated virgin aluminium frame. Shading system: virgin aluminium extrusions mounted externally to a virgin aluminium frame Steel roller shutter door(s).
	Internal walls and partitions	Non-structural internal walls	Wall partitions: 13 mm plasterboard over cold-formed steel frame with steel furring channels made from grade 450 virgin steel. Internal wall insulation: stone or glass wool.

Category 1	Category 2	Building element	Default reference materials
			Paint: one coat water-based primer + two coats water-based top-coat.
	Internal doors	Internal doors	Hollow core timber with steel jamb, painted. Steel fire door, painted.
Finishes	Wall finishes	Wall feature finishes	**Office area:** Wall tiles in bathrooms (5 mm and 10 mm)
	Floor finishes	Floor finishes	**Open-plan / warehouse areas:** n/a (polished concrete) **Office area:** Nylon carpet tiles with rubber underlay ~80% of area, vinyl flooring ~20% of area
	Ceiling finishes	Ceiling finishes	**Open-plan / warehouse areas:** n/a (exposed ceiling) **Office area:** Choose the most appropriate ceiling system: • Suspended metal panels (aluminium 0.6 mm) • Mineral fibre tiles • Plasterboard ceiling tiles (10 mm thick) • Set plasterboard (13mm thick)
Fittings, furnishings and equipment (FF&E)	Fittings, furnishings and equipment	Office joinery	Communal kitchens, lockers, storage units
Building services/MEP	Services	Plumbing	• Building plumbing • Hot water system (e.g., gas boiler) • Showers • Electric pump (if needed) • Water tank (if needed)
		Mechanical	As per existing GBCA Energy Use Calculation Guide – Table 62 (September 2021)
		Fire	Fire services
		Electrical	• Cables (communication and network) • Lighting • BMS and energy monitoring • Site power and electrical connection

Category 1	Category 2	Building element	Default reference materials
		Solar PV	Panel: 350W monocrystalline panel made from virgin materials with 20% efficiency Framing: Mounting frame made from virgin aluminium

Default specifications for residential-type buildings

Category 1	Category 2	Building element	Default reference materials
Substructure	Substructure	Foundation	Concrete: 32MPa with 20% cement replacement Reinforcing: Reinforcing bar/mesh made from conventional recycled steel at 70kg/m^3 for pad footings and 230kg/m^3 for ground beams Design should align with recommendations provided by the project geotechnical engineer
		Ground-bearing slab	Concrete: 32 MPa with 20% cement replacement. Reinforcing: Reinforcing bar/mesh made from conventional recycled steel at 40kg/m^3
Superstructure	Suspended Floors	Framing	Treated engineered softwood timber or laminated veneer lumber (LVL) beams and joists or cold-formed steel joists
	Roof	Roof	Framing: Treated softwood timber or cold-formed virgin steel truss 50% long-run steel: Long-run virgin steel cladding with a base metal thickness of 0.42mm, pre-painted over a zinc-aluminium metal coating 50% concrete/clay tile
	Stairs and Ramps	Stairs and Ramps	Treated engineered softwood timber or laminated veneer lumber (LVL) stringers and treads OR Concrete: 40 MPa with 20% cement replacement Reinforcing: Conventional recycled steel reinforcing at 125 kg/m^3
	External walls	External walls	Framing: Treated softwood timber stud frame or cold-formed virgin steel frame with virgin steel strap bracing ⅓ face brick: 110mm thick clay/concrete face brick. ⅓ long-run steel: Long-run virgin steel cladding with a base metal thickness of 0.42mm, pre-painted over a zinc-aluminium metal coating. ⅓ fibre cement: 9-15mm thick fibre cement panel. Insulation: Stone wool or glass wool
	Windows and external doors	Windows and external doors	Curtain wall: double-glazed with a powder coated virgin aluminium frame. Shading system: virgin aluminium extrusions mounted externally to a virgin aluminium frame
	Internal walls and partitions	Non-structural internal walls	Wall partitions: 13mm plasterboard over structural frame. Internal wall insulation: stone or glass wool. Paint: one coat water-based primer + two coats water-based top-coat.
	Internal doors	Internal doors	Hollow core timber with steel jamb, painted.

Category 1	Category 2	Building element	Default reference materials
			Steel fire door, painted.
Finishes	Wall finishes	Wall feature finishes	Wall tiles in bathrooms (5mm and 10mm)
	Floor finishes	Floor finishes	Nylon carpet tiles with rubber underlay ~80% of area, vinyl flooring ~20% of area
	Ceiling finishes	Ceiling finishes	Ceiling covering: 10mm plasterboard Insulation: Stone wool or glass wool Paint: one coat water-based primer + two coats water-based top-coat
Fittings, furnishings and equipment (FF&E)	Fittings, furnishings and equipment	Office joinery	Communal kitchens, lockers, storage units
Building services/MEP	Services	Plumbing	• Building plumbing • Hot water system (e.g., gas boiler) • Showers • Electric pump (if needed) • Water tank (if needed)
		Mechanical	As per existing GBCA Energy Use Calculation Guide – Table 62 (September 2021)
		Fire	Fire services
		Electrical	• Cables (communication and network) • Lighting • BMS and energy monitoring • Site power and electrical connection
		Solar PV	Panel: 350W monocrystalline panel made from virgin materials with 20% efficiency Framing: Mounting frame made from virgin aluminium

References

- Arup & WBCSD (2021). Net-zero buildings: Where do we stand? Geneva: World Business Council for Sustainable Development.
- AusLCI (2022). The Australian National Life Cycle Inventory Database (AusLCI) v1.38. Australian Life Cycle Assessment Society (ALCAS). https://www.auslci.com.au/ and https://www.alcas.asn.au/auslci
- CEN (2011). EN 15978:2011: Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method. Brussels: European Committee for Standardization.
- CEN (2019). EN 15804:2012+A2:2019: Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products. Brussels: European Committee for Standardization.
- CEN (2021). prEN 15978-1:2021: Sustainability of construction works – Methodology for the assessment of performance of buildings – Part 1: Environmental Performance. Brussels: European Committee for Standardization.
- Defra (2022). UK Government GHG Conversion Factors for Company Reporting 2022. London: Department for Environment, Food and Rural Affairs (Defra), UK Government.
- DNV GL (2018). Emission-reduction potential of fossil- and emission-free building and construction sites. Oslo: Climate Agency, City of Oslo.
- GBCA (2020). Green Star – Design & As Built Fitout Scope: Guidance for Cold Shell, Warm Shell and Integrated Fitouts. Sydney: Green Building Council of Australia.
- GBCA & thinkstep-anz. (2021). Embodied Carbon and Embodied Energy in Australia's Buildings. Sydney: Green Building Council of Australia and thinkstep-anz.
- IEPDS (2022). PCR 2019:14 Construction Products v1.2. Stockholm: International EPD System.
- IPCC (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, USA: Cambridge University Press.
- ISO (2018). ISO 14067:2018: Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification. Geneva: International Organization for Standardization.
- ISO (2019). ISO 21930:2017: Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services. Geneva: International Organization for Standardization.
- NATSPEC (2022). National Building Specification. Sydney. https://www.natspec.com.au/
- RIBA (2020). RIBA Plan of Work. London: Royal Institute of British Architects
- RICS (2012). Elemental Standard Form of Cost Analysis. 4th Edition. London: Royal Institution of Chartered Surveyors.
- WorldGBC. (2019). Bringing embodied carbon upfront: Coordinated action for the building and construction sector to tackle embodied carbon. Toronto: World Green Building Council