GREEN STAR EMBODIED CARBON CALCULATION GUIDE

MAY 2025

This guide is to be used for Credit 21 Upfront Carbon Emissions in Green Star Buildings NZ, Credit 19 Life Cycle Impacts in Green Star – Design & As-Built NZ v1.1 and for the Net Zero Upfront Carbon Standard.

greenstar

NZGBC
TE KAUNIHERA HANGANGA TAUTAIAO

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This document is updated regularly. It can be found at www.nzgbc.org.nz/.

Change Log

Release	Date	Description of changes
v0.1	13/10/2022	Draft for consultation
v1.0	01/05/2023	Revised version following consultation
V2.0	06/05/2025	Incorporates all Green Star specific content from the Methodology and includes references to Green Star Buildings NZv1.0

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1 INTRODUCTION

This document provides a how-to guide for use of the *Embodied Carbon Calculator* ('the Calculator') developed by the New Zealand Green Building Council (NZGBC) and thinkstep-anz. It also provides guidance on how Embodied Carbon targets are set in Green Star including definitions of a reference building and use of alternative calculation tools.

The Calculator is a tool built in Microsoft Excel that can be used to support projects seeking ratings under the *Green Star* rating tool and the *Net-Zero Upfront Carbon Standard*.

The intended audiences for this document are building projects that want to use the Calculator for:

- Upfront Carbon Emissions (Credit 21) and Other Carbon Emissions (Credit 24) of *Green Star Buildings NZ*.
- Upfront Carbon Reduction Assessment (Credit 19.1) and Long-term Carbon Storage (Credit 19.3) of *Green Star – Design & As-Built NZv1.1*.
- NZGBC's forthcoming *Net-Zero Upfront Carbon Standard*.

Other users are welcome to use the Calculator and this guidance; however, NZGBC makes no warranties of any kind regarding its use or the results calculated. The quality of the results depends primarily on the quality of the input data entered and the appropriateness of the emission factors selected.

For information regarding the underlying methodology behind the Calculator, refer to the *NZGBC Embodied Carbon Methodology*.

The Calculator provides results for upfront carbon and whole-of-life embodied carbon only. As a result, it cannot be used for multi-indicator Life Cycle Assessment (e.g., Credit 26 of *Green Star Buildings NZv1.0* and Credit 19.2 of *Green Star – Design & As-Built NZv1.1)*. Projects seeking to comply with the LCA credits in *Green Star* must use a third-party building LCA software tool and then paste their results into the *Life Cycle Impacts Calculator* to calculate the points awarded.

The Calculator, this document and the *NZGBC Embodied Carbon Methodology* are intended to align with MBIE's *Whole-of-Life Embodied Carbon Assessment: Technical Methodology* (MBIE, 2022). The reader should be aware that all three documents/tools will likely evolve over time to reflect user feedback and to continue to align with MBIE's Climate Change work programme as it develops.

This is intended to be a living document that evolves as experience with embodied carbon grows.

1.1 Upfront Carbon Reduction

Credit 21 of *Green Star Buildings NZ* and Credit 19.1 of *Green Star – Design & As-Built NZv1.1* require that buildings achieve a reduction in upfront carbon to be awarded a star rating.

To demonstrate compliance, projects can either:

- Calculate upfront carbon using the *Embodied Carbon Calculator*, or
- Calculate upfront carbon following the Life Cycle Impacts credit within *Green Star* for modules A1 – A5. Stored biogenic carbon (GWP-stored) must be reported separately from GWP-total following section 4.2.1 of the *NZGBC Embodied Carbon Methodology*.

For projects seeking to demonstrate large reductions in upfront carbon emissions (as defined within the rating tool), one of the following options must be used:

- 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 and is peer reviewed by an LCA Certified Practitioner or independent Experienced Individual.

1.2 Long-term Carbon Storage

Green Star rewards the long-term storage of carbon previously removed from the atmosphere and stored in the fabric of the building during its operating life. This is to encourage the use of materials which have intrinsic carbon storage properties, for example, wood/biomass.

Long-term storage is defined as a forecasted period of at least 50 years.

Relevant credits:

- Credit 24 of *Green Star Buildings NZ*
- Credit 19.3 of *Green Star – Design & As-Built NZv1.1*

1.3 Structure of This Document

This document is structured as follows:

1. Definitions of key terms (chapter 2).
2. Scope of assessment (chapter 3).
3. When to use the Calculator (chapter 4).
4. An overview of the Calculator (chapter 5).
5. How to select data (chapter 6)
6. How to use the Calculator (chapters 7 to 14).
7. Targets, including how to define the Reference Building (chapter 15)
8. Calculating points (chapter 17).
9. Alternative tools (chapter 17).
10. Offsetting demolition works (chapter 18).

2 DEFINITIONS

2.1 Building-Related Terms

Proposed Building: The building works to be rated under *Green Star* or the *Net-Zero Upfront Carbon Standard*. This includes all buildings and any ancillary areas such as parking, landscaping and shared facilities.

Reference Building: A hypothetical building to be compared to the Proposed Building. The Reference Building may be an Actual Reference Building or a Standard Practice Reference Building.

Actual Reference Building: A building constructed in the last five years that is similar to the usage, construction and operation of the Project.

Standard Practice Reference Building: A hypothetical building that represents standard contemporary construction and operation practices.

Warm Shell: The whole substructure, superstructure and building envelope. For commercial buildings: 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. For all other buildings: services, floor coverings, wall coverings and ceiling coverings are included throughout.

Tenant Improvements: Tenant Improvements includes additions to the building beyond the Warm Shell. This includes, but is not limited to, kitchenettes, internal partition walls and doors, cabinets and loose furniture.

External Works: This includes external carparks, driveways, hard landscaping and external walls. It also includes land use change across the whole site on which the building is located. It excludes other forms of infrastructure (e.g., water and wastewater infrastructure) and soft landscaping.

Building Material: A single material used in a building. Examples include concrete, steel and timber.

Building Product: Either a single Building Material or an assembly of Building Materials designed to be used in a building. An example is an electrical cable, which consists of one or more cores – itself a material that conducts electricity (copper or aluminium) encased in a material that insulates electricity (e.g., PVC or XLPE) – and then enclosed within a protective jacket (e.g., PVC, XLPE or polyurethane).

Building Element: An assembly of Building Products that together constitute an important part of a building. Building Elements may be functional (e.g., a roof, wall, floor or foundation), aesthetic (e.g., a decorative façade) or designed for occupant comfort (e.g., acoustic wall/ceiling lining). Building products may be assembled into a building element either on the building site (on-site fabrication) or at a separate facility (off-site fabrication).

2.2 Area Measurements

Gross Floor Area (GFA): The total floor area inside the building envelope, measured to the outside face of external load-bearing walls. The definition of the New Zealand Institute of Quantity Surveyors (NZIQS, 2018, p. 1) is applied, as quoted below:

> *The gross floor area is measured over all the external walls of the building, over partitions, columns, internal structural or party walls, stair wells, lift wells, ducts, enclosed roof top structures and basement service areas. All exposed areas such as balconies, terraces, open floor areas and the like are excluded.*
>
> *Generally, projections beyond the outer face of the external walls of a building such as projecting columns, floor slabs, beams, sunshades and the like shall be excluded from the calculation of gross floor areas.*

Where the outer face of the external walls of a building are not regular vertical surfaces, the overall measurements shall be taken at floor levels and a note made of the vertical profile of the wall line.

Where mezzanine floors occur within a structure the gross floor area of this mezzanine shall be added to all other complete floor areas and become a constituent part of the gross area.

Rentable Area: The total floor area under the control of the tenant, including space which may be unusable. Rentable Area is generally measured to the internal face of perimeter walls and windows. It includes unusable floor area (e.g., columns and internal partition walls) and amenities (kitchens, toilets, lift lobbies, etc.), so long as these areas are under the tenant's direct control. All common areas are excluded from this measure, as are the thicknesses of external walls and intertenancy walls. For a full definition, please see the *Guide for the Measurement of Rentable Areas* (PCNZ & PI, 2023).

Net Lettable Area (NLA): See Rentable Area.

Gross Internal Area (GIA): The total floor area inside the building envelope, measured to the inside face of external walls.

External Works Area (EWA): The total surface area of external works captured within the scope of the assessment. It includes areas on the site covered by pavements, hardstands, covered walkways and hard landscaping. It excludes all areas that are not covered by hard surfaces (e.g., grassed areas and gardens), the surface area occupied by the building itself, and all areas that are not within the site boundary. Only new construction should be captured in the measured area. The area occupied by existing hard landscaping on the site should not be included.

2.3 Stages of a Building's Life Cycle

European standards (EN 15978:2011, prEN 15978-1:2021 and EN 15804+A2:2019) and international standards (ISO 21931-1:2022 and ISO 21930:2017) divide the life cycle of a building into modules, as shown in **Error! Reference source not found.**. Only those modules relevant to Whole-of-Life Embodied Carbon are shown.

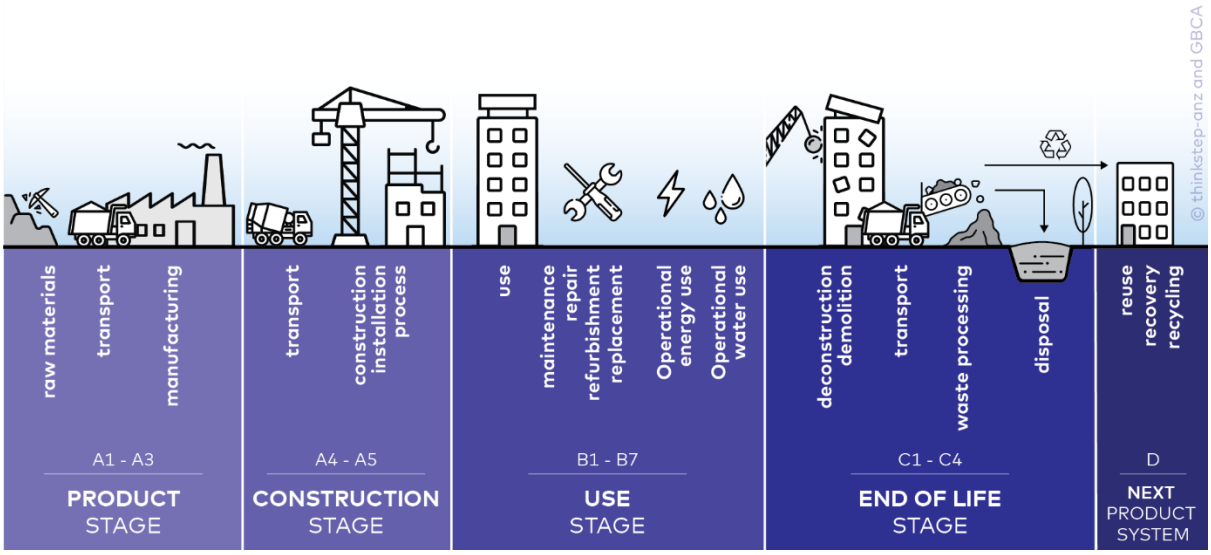


Figure 1: Stages of a building's life cycle (as per EN 15978)

Stage A: The production of materials (modules A1-A3), transport of materials to the construction site (module A4) and construction of the building (module A5).

Stage B: Building maintenance and renovation (modules B1-B5), operational energy use (module B6) and operational water use (module B7). Newer standards introduce optional module B8 for building-related activities by users not covered in modules B6 or B7, e.g., transportation of people to work.

Stage C: The end of a building's life, including demolition (module C1), transport of waste materials off-site for processing (module C2), waste material processing for recycling (module C3) and disposal of those materials that cannot be recycled (module C4).

Module D: Benefits and loads beyond the building's life cycle. More specifically, Module D includes credits for avoided production of primary materials or avoided generation of energy. Module D can also include exported utilities from the building, which is defined as Module D2 by newer standards.

2.4 Carbon-related Terms

Carbon Emissions: Emissions of greenhouse gas(es) to the atmosphere. Examples include combustion of fossil fuels and greenhouse gases released from chemical reactions.

Carbon Footprint. The sum of carbon emissions and carbon removals over a full or partial product life cycle. Equivalent to GWP-total (see below).

Carbon Removals: Removals of greenhouse gas(es) from the atmosphere. Examples include removal of CO_2 from the air by plants during photosynthesis and by cement-containing materials during carbonation.

Carbon Storage: The storage of carbon captured from the atmosphere for a period of time, resulting in the temporary reduction in the concentration of greenhouse gases in the atmosphere.

Emission Factor: The Carbon Footprint of a product related to a declared unit, e.g., cubic metres.

2.5 Types of Carbon Footprint

Upfront Carbon: Carbon emissions caused by the production of materials, transport of materials to the construction site and construction of the building(s), prior to the building(s) being occupied (modules A1-A5). Only gross emissions are declared, excluding removals (see GWP-stored).

Use Stage Embodied Carbon: Carbon emissions associated with materials and processes needed to maintain the building during use such as for maintenance, repair or refurbishments (modules B1-B5).

Operational Carbon: The carbon emissions associated with energy used to operate the building (module B6) and operational water use (module B7).

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-C4).

Whole-of-Life Embodied Carbon: Carbon emissions associated with materials and construction processes throughout the whole lifecycle of a building, excluding operational energy use and operational water use (modules B6 and B7, respectively). This includes Upfront Carbon, Use Stage Embodied Carbon, and End-of-Life Carbon, but not Operational Carbon. Module D (benefits and loads beyond the system boundary) is excluded from the main calculation and must be reported separately.

2.6 Calculation of Carbon Footprint

Global Warming Potential (GWP): The heat absorbed by greenhouse gases in the atmosphere, measured as carbon dioxide equivalent. Carbon dioxide equivalent (CO_2e) is calculated using the Intergovernmental Panel on Climate Change's (IPCC's) Global Warming Potential indicator, typically using a 100-year time horizon (GWP100), with the latest version being from the IPCC's Sixth Assessment Report (AR6).

GWP-fossil (GWP-f or GWPF): Net of:

- Carbon emissions from non-biogenic sources, e.g., combustion of fossil fuels and emissions from chemical processes (reported as a positive number), and
- Carbon removals from non-biogenic sources, e.g., through carbonation of cement (a negative number).

GWP-biogenic (GWP-b or GWPB): Net of:

- Carbon emissions from degradation of biomass via incineration, landfill, composting, or an accounting adjustment (reported as a positive number), and
- Carbon removals through formation of biomass during photosynthesis (a negative number).

GWP-luluc (GWP-l, GWPL, GWP-LULUC or GWPLULUC): Carbon emissions and removals from Land Use and Land Use Change (LULUC) describes changes in carbon stocks, such as soil carbon. EN 15804+A2:2019 does not allow negative numbers (e.g., net sequestration of carbon in the soil) and instead requires these to be set to zero.

GWP-stored (GWP-s or GWPS): The GWP avoided by removals of CO_2 into biomass (CEN, 2019, section C.2.4). GWP-stored should be a negative number, as it is a removal of CO_2 from the atmosphere. In EPDs following EN 15804+A2, there will be a statement of "Biogenic carbon content in product". To convert this to GWP-stored, multiply by -44/12 to convert stored elemental carbon to equivalent carbon dioxide.

GWP-total: The total carbon footprint is calculated differently for Upfront Carbon and Whole-of-Life Embodied Carbon. For Upfront Carbon, GWP-stored must be excluded and declared separately following ISO 14067 because the calculation is a partial carbon footprint. For Whole-of-Life Embodied Carbon, GWP-stored must be included because end-of-life emissions are included, i.e., the system boundary is complete.

- Upfront Carbon = GWP-fossil + GWP-luluc + (GWP-biogenic-GWP-stored).
- Whole-of-Life Embodied Carbon = GWP-fossil + GWP-luluc + GWP-biogenic

Long-term Carbon Storage: Long-term storage of carbon previously removed from the atmosphere into the fabric of the building. Long-term is defined as a forecasted period of at least 50 years. For long-term carbon storage arising from wood sources, the wood is required to be certified by either Forest Stewardship Council (FSC), Programme for the Endorsement of Forest Certification (PEFC), or a PEFC-endorsed system.

2.7 Conduct and Review of LCA Studies

Competent LCA Practitioner: Any person who is an Experienced Individual or an LCA Certified Practitioner.

LCA Certified Practitioner: A person who is qualified as an “LCA Certified Practitioner” by LCANZ, ALCAS, ACLCA, or another similar scheme.

Experienced Individual: An individual who has produced, co-produced and/or independently reviewed at least three LCA or carbon footprint studies of buildings or building products in accordance with EN15804/EN15978 and either ISO14040/14044 or ISO14067 within the past three years.

Independent Experienced Individual: An Experience Individual who is:

- Not employed in a full-time or part-time role by the commissioner or practitioner of the LCA study.
- Not the practitioner of the LCA study.

- Not involved in defining the scope or conducting the LCA study.
- Has no direct or indirect incentive or interest linked to the outcome of the LCA study.

2.8 Environmental Impacts of Products

Carbon Footprint of Product (CFP): A method for the quantitative evaluation of the carbon footprint of a product or service system through its life cycle. Standardised by ISO 14067:2018.

Environmental Product Declaration (EPD): Document containing data on the potential environmental impacts of a product or service calculated using LCA following a set of Product Category Rules. An EPD must be independently verified as compliant with ISO 14025:2006 and a relevant PCR and published by an EPD programme operator.

Life Cycle Assessment (LCA): A method for the quantitative evaluation of the potential environmental impacts of a product or service system through its life cycle. Standardised by ISO 14040:2006 and ISO 14044:2006.

Product Category Rules (PCR): A specific set of rules for completing an LCA of a particular product category and publishing an EPD. Only EPDs conducted according to the same PCR are comparable. The two main PCR documents for building products are EN 15804 and ISO 21930.

3 SCOPE

3.1 System Boundary

The following activities are **included**:

- Manufacture of building products (Modules A1-A3).
- Transport of building products, formwork and construction machinery to/from site (Module A4).
- On-site construction activities, such as operation of cranes and excavators, and the manufacture, transport and disposal of any wasted building products (Module A5).

The following activities are **excluded**:

- Manufacture of machinery and other capital goods.
- Transport of staff to and from the construction site.
- Energy used off-site for professional services.

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

3.2 Building Elements

Building elements that are part of the Warm Shell must be included within the scope of assessment up to the point of Practical Completion, as outlined in **Error! Reference source not found.**. Those projects applying for the *Net-Zero Upfront Carbon Standard* must also include External Works and all permanently installed Tenant Improvements (but excluding fittings, furnishings and equipment).

Table 1: Building elements in scope of assessment

Masterspec CBI Level 1	Included in scope?
1 General	**No**
2 Site	**Yes**
3 Structure	**Yes**
4 Enclosure	**Yes**
5 Interior	**Partial** (refer to '**Error! Reference source not found.**')
6 Finish	**Partial** (more detail may be reported separately)
7 Services	**Yes** (see default values in **Error! Reference source not found.** on page **Error! Bookmark not defined.**)
8 External	**No** (but **must be reported separately**)

For more detail, see:

- Appendix A within the *NZGBC Embodied Carbon Methodology*.
- 'Scope' sheet within the Calculator.

3.3 Demolition and Reuse of Existing Building(s)

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, if a 35-year-old building was demolished, projects would be required to account for 75% of upfront carbon emissions.

Projects which require demolition of an existing building as a result of it not being fit-for-purpose (e.g., due to earthquake damage, or a significant lack of NZ Building Code compliance) are able to be

excluded from offsetting demolition works. This is to be justified clearly in the submission and agreed upon with NZGBC via a Technical Question.

Both the upfront emissions of the demolished materials (modules A1-A3) and the demolition process (modules C1-C4) must be offset through the purchase of carbon credits that meet the requirements of approved carbon neutral certification schemes (see chapter 18).

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

For further information relating to the use of the Calculator's in-built 'ExistingBuild' sheet, refer to section 13.5.

3.4 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 5% of each module (A1-A3, A4-A5, B1-B5, C1-C4 and D) 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% threshold would be crossed. These smaller items include but are not limited to:

- Individual screws, nails and other fasteners used on-site that are not part of delivered building products (and should therefore be captured in that product's carbon footprint).
- Glues, sealants, caulking compounds and filling compounds used in small quantities throughout the building and not part of delivered building products. (This exclusion does not apply to mortars, block filling concretes and sealants used in membrane roofs.)
- Doorknobs, door hinges, fasteners for openable windows, light switches, power sockets and other minor fittings.
- Skirtings, architraves and flashings.

Module B2 (building maintenance, including washing and repainting) can also be excluded, unless there is a reason to believe the 5% threshold would be crossed.

3.5 Exclusions

Several elements are excluded from the Calculator due to low environmental relevance or inclusion elsewhere. For a full list of exclusions, please refer to the 'Scope' sheet in the Calculator.

3.5.1 Operational Energy and Water Usage

Operational energy (module B6) and operational water (module B7) are excluded from the Calculator because they fall within the definition of Operational Carbon. Operational energy and operational water are addressed in other credits within *Green Star*.

3.5.2 Additional Building Services for Installed Equipment

In some cases, additional building services (power cables, ventilation equipment, etc.) may be required for the equipment installed in the building (computers, medical equipment, etc.). The purpose of *Green Star* is to rate buildings fairly and comparably, but not the equipment inside them. Where additional building services are needed for the equipment in the building (rather than the people in the building), these can be excluded from the analysis as they effectively become part of the Tenant Improvements.

For example, a data centre requires considerable extra power cabling and HVAC equipment to power and cool the computers inside the data centre. The HVAC equipment and power cabling beyond that required to run the core building services (for the offices and common areas) can therefore be excluded from *Green Star*. Only the HVAC equipment and power cabling needed for a comparably sized warehouse-type building would need to be included in the *Calculator*.

Note that this exemption does not apply to the *Net-Zero Upfront Carbon Standard*, where all permanently installed equipment must be included.

3.5.3 External Works

Some external works are excluded from the scope of analysis. These are:

- Soft landscaping
- External fixtures
- Fencing, railings, and walls
- External services

3.5.4 Non-Physical Items

Non-physical elements are excluded from the scope of analysis as their environmental impacts occur outside of the mandatory system boundary set by EN 15978. Based on the categories in Masterspec's CBI classification system, these non-physical elements are:

- Contract negotiation
- Drawings
- Specifications
- Documentation
- Establishment
- Project management
- Financial administration
- Site investigation

4 WHEN TO USE THE CALCULATOR

The Calculator can be used for:

- *Green Star Buildings NZ* Credit 21 Upfront Carbon Emissions.
- *Green Star – Design & As-Built NZv1*.1 Credit 19.1 Upfront Carbon Reduction Assessment and Credit 19.3 Long-term Carbon Storage.
- NZGBC's *Net-Zero Upfront Carbon Standard*.

The Calculator cannot be used for multi-indicator Life Cycle Assessment. A third-party LCA tool must be used instead.

The Calculator should be used more than once where:

- Both a Proposed Building and a Reference Building are assessed to calculate a percentage reduction.
- When the *Net-Zero Upfront Carbon Standard* is being applied but there are significant differences in the inclusions and exclusions between the credit within *Green Star* and the *Net Zero Upfront Carbon Standard*.

4.1 Use of the Calculator Through the Design Process

For compliance with *Green Star* and the *Net-Zero Upfront Carbon Standard*, the carbon footprint must be calculated following practical completion of the project.

However, given that both programmes require upfront carbon reduction targets to be met, Projects are strongly encouraged to use the Calculator at early design stages so that upfront carbon can be assessed early and tracked against targets. A projected assessment using the Calculator could be based on quantities from a previous building and/or estimates from architects/engineers/surveyors.

4.2 Occupancy and Allocation

Projects must disclose whether the project is the sole occupant of a site (Sole Occupant Site) or part of a larger, shared site (Shared Site). This information shall be used to identify which shared building elements must be included within the scope of assessment.

Where a building is part of a Shared Site, 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. All buildings within the Shared Site applying for ratings to the NZGBC must use the same allocation method for each shared element for consistency.

Example:

- 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.

4.3 Upfront Carbon in Green Star

The Calculator returns the results of the upfront carbon assessment, but not the Green Star points. To calculate the points achieved for *Green Star*, copy the 'Results for Green Star' section from the 'Results' sheet of the Calculator (Table 2) and paste this into the 'Upfront Carbon' sheet of the *Life Cycle Impacts Calculator*. When using the Reference Building approach, you will need to run the Calculator twice (once for the Reference Building and once for the Proposed Building) and paste in two sets of results tables.

Table 2: Summary results to be copy-and-pasted for the points calculation

Results for Green Star (kg CO_2e)			
Result (kg CO2e)	Absolute	Per m^2	Credit
Upfront carbon footprint (A1-A5) inside the drip-line	**203,560**	**170**	**19.1**
Upfront carbon footprint (A1-A5) outside the drip-line	5,710	5	n/a
Upfront long-term stored carbon	**-73,204**	**-61**	**19.3**
Demolition carbon footprint that must be offset	162,902	136	19.1
Whole of life embodied carbon (A-C) [EN 15804+A2]	305,655	255	n/a
Whole of life embodied carbon (A-D) [EN 15804+A2]	234,662	196	n/a
Whole of life embodied carbon (A-C) [EN 15804+A1]	251,103	209	n/a
Whole of life embodied carbon (A-D) [EN 15804+A1]	180,110	150	n/a

4.4 Net-Zero Upfront Carbon Standard

Projects pursuing the *Net-Zero Upfront Carbon Standard* can use the Calculator to display conformance. Projects shall demonstrate:

1. Total (gross and net) projected upfront carbon emissions.
2. Total (gross and net) upfront carbon emissions at practical completion of project.
3. Reductions in upfront carbon emissions that comply with relevant reduction targets.

A minimum reduction in upfront carbon is required to achieve certification against the Standard.

Projects are required to select and disclose the scope of building elements included within their application:

- **Whole-building certification.** Projects must calculate and offset upfront emissions for all building elements included within the base building and tenant improvements. This incorporates any permanently installed building elements which are not included in the scope of base building certification and relevant to the tenant's space.
    - Wherever non-generic items that are not included within the tenant improvements sheet are incorporated into tenant improvements, applicants shall agree with Green Star Assessor as to the appropriate approach taken, aligning with guidance set out in section 6.4 "Adding Custom ".
- **Base-building certification.** Projects must calculate and offset upfront emissions for all building elements included within the base building (warm shell).

5 OVERVIEW OF CALCULATOR

5.1 Opening the Calculator File

The Calculator is a macro-enabled Excel file. The use of macros (VBA code) can trigger a security warning in Excel which may prevent the file from being opened or which may allow the file to be opened with macros disabled. If the file can be opened with macros disabled, it will still function; however, this will disable the protection of editable cells, allowing you to accidentally cut-and-paste or drag-and-drop cells which may lead to calculation errors within the file.

Depending on your operating system and version of Excel, you may need to follow different steps to get the file to open with macros enabled:

1. If you see a red “Security Risk” message upon opening the file for editing in Excel,

right-click on the file and choose “Properties”. In the “General” tab, check “Unblock” next to the security message “This file came from another computer and might be blocked to help protect this computer.” See Figure 2 below.

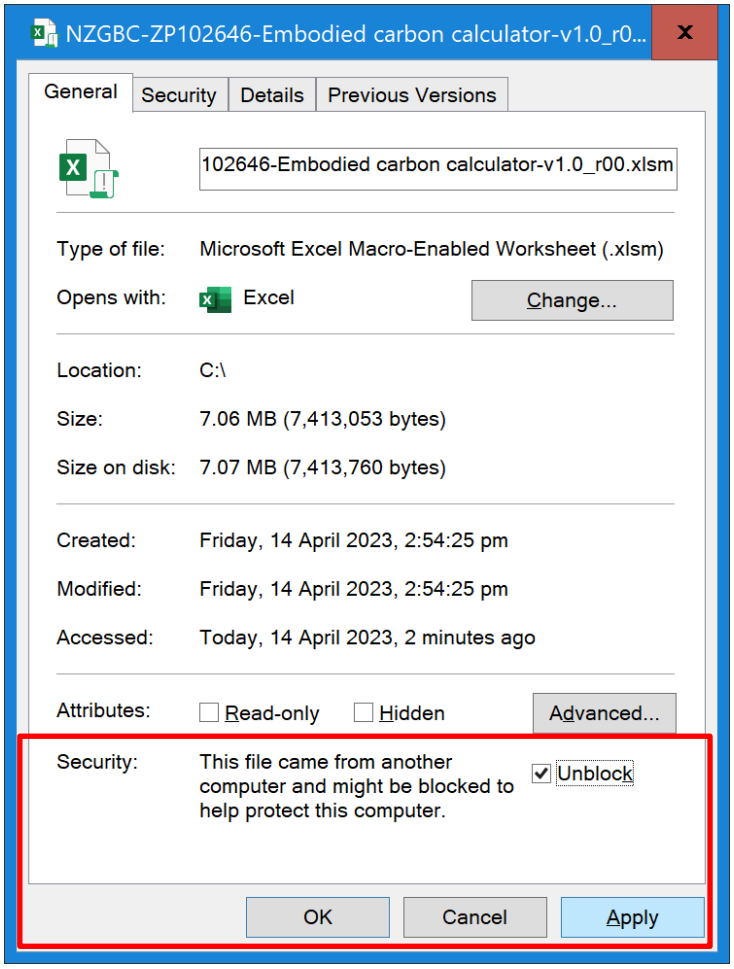
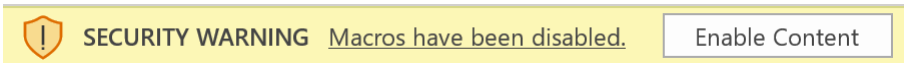


Figure 2: Unblock the file

2. If you see a yellow “Security Warning” message upon opening the file in Excel,



click “Enable Content” to enable macros within the file.

3. If you see a “Microsoft Excel Security Notice” pop-up box in Excel,

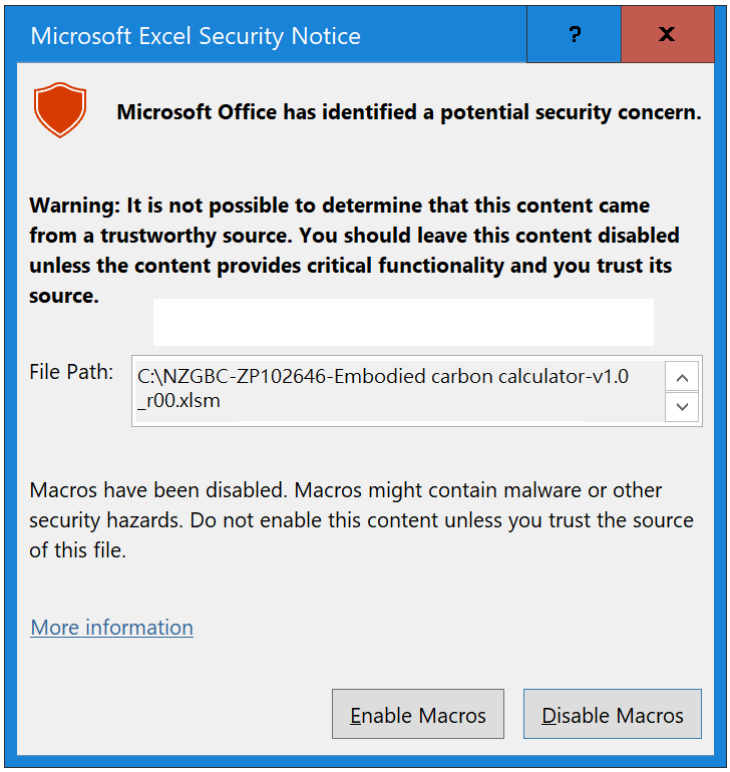


Figure 3: Enable macros

click “enable Macros” (Figure 3).

NZGBC can supply a version of the Calculator without macros if your organisation blocks them. However, this file cannot block the use of cut-and-paste or drag-and-drop automatically, meaning that it will be possible for you to break the formulas in the file accidentally.

5.2 Colour Coding

The first sheet of the Calculator, ‘Read Me’, describes how the Calculator should be used. The colour coding in Figure 4 indicates optional and required data inputs. A cell with a red marker in the top-right corner indicates that a comment is available.

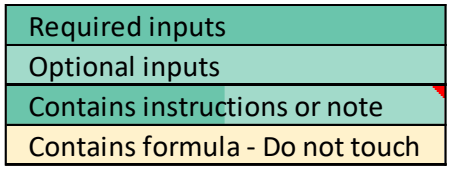


Figure 4: Colour coding of optional and required data inputs

All sheets that take data inputs (quantities) have the prefix ‘Q_’. Exceptions are the ‘Custom_EFs’ and ‘Assemblies’ sheets as these are not required to complete calculations but allow the user to expand on the Calculator’s database and aggregate multiple materials where commonly used assemblies are identified within the building.

Additionally, sheets are colour-coded as shown in Figure 5 below:

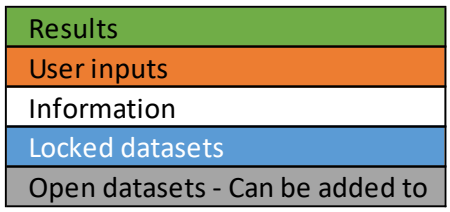


Figure 5: Colour coding of sheets

Only the orange colour sheets are required for the calculations. Sheets with the suffix '(NZUC)' are only required when following the *Net-Zero Upfront Carbon Standard*.

The outputs of the Calculator are displayed as different categories of carbon footprint / climate change as described in section **Error! Reference source not found.** and section **Error! Reference source not found.**. Outputs are displayed per phase of construction and dependent on the input data provided by the user, with modules derived from EN 15978:2011 and EN 15804+A2:2019.

5.3 Progress Bar

The progress bar shown in Figure 6 appears on all data input tabs. This shows the upfront carbon footprint at both the whole building level and per square metre of gross floor area. The graph then shows the contribution of the current module (e.g., the substructure) to the upfront carbon footprint.

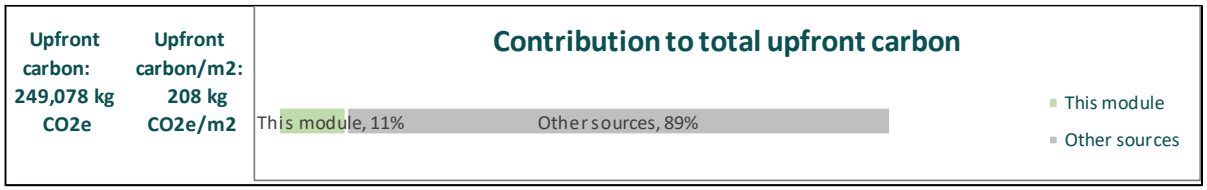


Figure 6: Progress bar

5.4 Calculation Methodology

5.4.1 Modules A1-A3 (Upstream Emissions of Materials)

Upstream emissions of materials (modules A1-A3) are based primarily on data from the BRANZ CO_2NSTRUCT Database, though the Calculator also includes custom data (largely from EPDs) supplied by NZGBC and thinkstep-anz. Users can also enter their own data in the 'Custom_EFs' sheet.

Carbon footprint results are split into the following four indicators (defined in section **Error! Reference source not found.**):

- Climate change potential – Total (GWPT) [kg CO_2 eq.]
- Climate change potential – Fossil (GWPF) [kg CO_2 eq.]
- Climate change potential – Biogenic (GWPB) [kg CO_2 eq.]
- Climate change potential – Stored (GWPS) [kg CO_2 eq.]

5.4.2 Upstream Transport

Upstream transportation is calculated based on data provided in the 'Nearest city' and 'Distance from city' fields in the 'Metadata' along with the chosen location selected in the 'Source' column in the material's row. The Calculator automatically determines the necessary travel distances by sea and road, multiplies it with the given tonnage of the material, and matches the tonne-km values with appropriate emission factors.

For the upstream transportation calculations to function properly, you must have filled in the ‘Nearest city’ and ‘Distance from city’ fields in the ‘Metadata’ sheet.

5.4.3 Replacement Over Building Service Life

Replacement of materials is calculated based on data on replacement rates per material group, sourced from BRANZ LCA datasheets. These datasheets provide data on typical service life (in years) per material group used in the building. Materials with a service life shorter than that of the building’s service life stated will be modelled with the necessary number of replacement cycles to cover the entire service life of the building. This will be rounded to whole number replacements. For example, if a material is calculated as being replaced 2.5 times, 3 replacements will be applied. Replacements are calculated covering the end-of-life stage of replaced components as well as the full upstream stage of the new components.

The following fields in the ‘Metadata’ sheet must be filled in for the replacement calculations to function properly:

- Building design life
- Estimated envelope life
- Estimated building service replacement cycle
- Estimated fixed interior replacement cycle

Note: Material replacement is not part of the upfront carbon calculation or the points calculation for Green Star.

5.4.4 Deconstruction

Deconstruction emissions are calculated using the average emissions per kg of deconstruction from Stevenson’s EPD No. S-P-03727 (Stevenson Concrete, 2022). This is applied to all materials. This functionality requires no data entry beyond that of upstream material data.

5.4.5 Transport to Waste Processing

All materials are assigned emissions from 50 km of road transport to end-of-life irrespective of end-of-life treatment(s). A Technical Question may be raised should a project provide evidence that transport is closer than 50 km to end-of-life treatment and this is important to the final carbon footprint. However, this choice will generally not have a significant impact on the carbon footprint of the building.

5.4.6 Waste Processing/Disposal/Recycling

There are no data entry requirements beyond that of upstream material data, as Whole-of-Life Embodied Carbon is used as a check rather than as the main output from the Calculator.

End-of-life scenarios are based on typical end-of-life fates from BRANZ’s LCA datasheets. BRANZ’s datasheets indicate a percentage split between landfill, recycling, incineration/energy recovery, and reuse per material type, also accounting for different uses in the building.

The end-of-life fates from BRANZ are then combined with end-of-life data from EPDs to calculate the relevant emissions.

5.5 Scaling by Estimated Completeness

Buildings are complicated and it will not be possible to include all elements within the Calculator. As such, the user must input the estimated coverage of each major part of the building (substructure, superstructure, envelope, etc.) in the ‘Completeness’ sheet. For any part of the building where the estimated completeness is less than 100%, its emissions are scaled up to ensure full coverage.

Completeness is judged by the percentage of material cost covered within the Calculator versus the actual (or estimated) project cost per major part of the building. This cost should be for the building products only, excluding transport to site, labour costs and subcontractor profit margins as these items are either modelled separately (transport to site) or excluded from the Calculator (labour and profits).

This scaling approach is applied to increase completeness where modelling cannot fully capture all the items in major part of the building. While this may be less needed for items with relatively few large components (e.g., the substructure), it becomes increasingly important for the envelope, fitout, and services where the variety and number of materials is much larger.

For the minimum coverage required to achieve a rating, please see section 6.2.1.

5.6 Use of Excel

The Calculator uses many dropdown menus within Excel. You can expand the dropdown menu by first selecting the desired cell and then either left-clicking the down arrow with your mouse or pushing Alt + Down Arrow on your keyboard.

6 SELECTING DATA

6.1 Types of Data Needed

Two types of data are needed to complete a carbon footprint of a building project (Figure 7):

1. **Building quantities:** The quantities of materials used in the building itself. (Within carbon footprinting, these quantities are often known as the activity data.)
2. **Emissions factors:** The carbon footprint per unit of material, energy or waste. The Calculator contains a database of emission factors, based largely on BRANZ's CO_2NSTRUCT Database.

Building quantities used in the final carbon footprint calculation shall be based on **actual quantities used in the building**, as can be validated from invoices and/or a schedule (such as a Schedule of Quantities / Bill of Quantities) that has been updated during or following construction to reflect the actual quantities and specific materials/products used in the finished building.

Building material quantities for in-progress carbon footprint calculations (including in all design stages) will need to be based on other quantity sources.

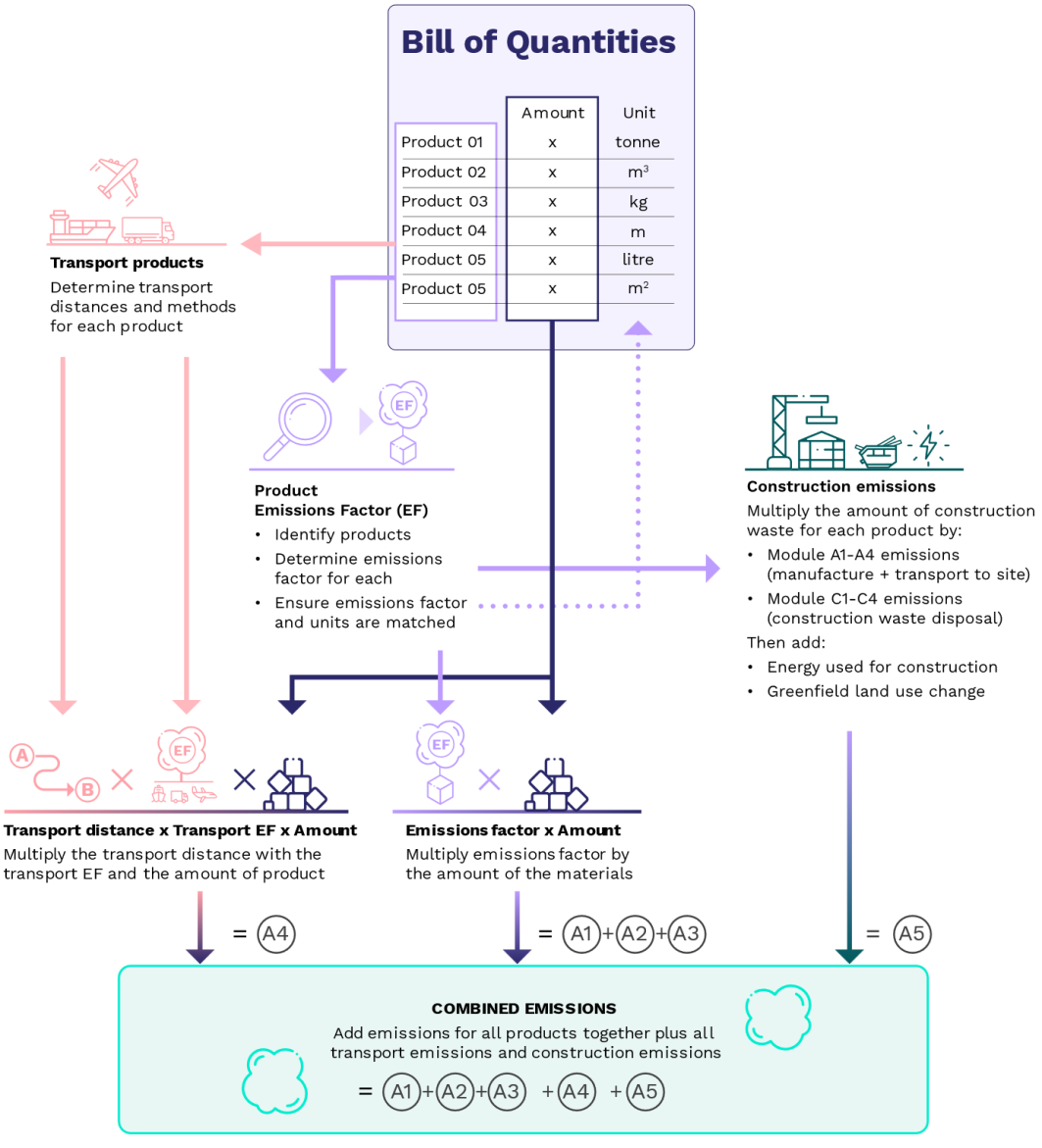


Figure 7: Calculating upfront carbon from building quantities and emission factors

6.2 Data Quality

6.2.1 Building Quantities

The following minimum data quality is required to achieve a rating:

- ≥80% as-built information for *Green Star*.
- ≥95% as-built information for *Net Zero Upfront Carbon Standard*.

6.2.2 Emission Factors

Data quality is assigned automatically for the data built into the Calculator, though it must be defined manually for custom data inputs (see next section).

There is no minimum requirement to achieve a rating as the process for choosing emission factors is designed to be conservative where there is uncertainty (i.e., to err on the side of overestimating emissions). While the Calculator does calculate a data quality score automatically, this is just used as a sense-check. A weighted quality score of 6 (medium data quality) or below (see Table 3 on page 27) is considered good, while a weighted quality score of 2 or below is considered excellent. This score is calculated by multiplying the quality score for each emission factor used (Table 3) by its contribution to the final Upfront Carbon of the building project.

6.3 Built-in Emission Factors, Replacement Cycles and End-of-Life Data

The Calculator draws on the BRANZ CO_2NSTRUCT Database for most material emission factors. Accompanying the CO_2NSTRUCT database are BRANZ's publicly available data on construction site waste, building materials replacement cycles, and building end-of-life. All additional datasets are mapped using the material categories from the CO_2NSTRUCT Database.

Fuels and transport calculations rely on Ministry for the Environment's (Manatū Mō Te Taiao's) publicly available emission factors.

End-of-life calculations predominantly use end-of-life emissions intensities from representative EPDs, supplemented with more generalised calculations to fill gaps.

6.4 Adding Custom Emission Factors

6.4.1 How to Choose Data

Table 3 defines a data quality hierarchy for selecting emission factors. This hierarchy must be applied when selecting emission factors for building products.

The highest quality emission factor available for a given building product must always be used. Where an emission factor at the highest quality level is not available for your chosen building product, continue moving through Table 3 from top to bottom until an emission factor is identified.

The list below provides a step-by-step approach to apply Table 3:

- **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:
    - **Product specific**
        - The emission factor must apply to the correct product. The specific product name – or an easily identifiable product range – must be clearly stated.
    - **Producer specific**
        - The emission factor should be specific to the manufacturer who makes the product.
        - Where a sector-wide value is used that includes a variation range, the highest value within the range shall be selected.
    - **Region specific**
        - Where a supplier makes the same product in multiple regions, the data should reflect manufacture in the region where the actual product used is manufactured.
        - If the source of supply is unknown and the supplier declares a range of values, the worst-in-range value shall be used.
    - **Time specific:**
        - The emission factor should ideally be within its declared period of validity.
        - Emission factors with no period of validity, or which are outside their declared period of validity, may still be used unless the manufacturer is known to have moved to a higher carbon process. (Emissions generally fall over time, meaning that older declarations are usually more conservative.)
        - Declarations for products not yet on the market can be used in early stage assessments but should not be used for as-built assessments unless it was clear that the product was available and supplied at the time of construction.
    - **Independently verified**, following any of the following approaches:
        - Environmental Product Declarations (EPD) following ISO 14025 and either EN 15804 or ISO 21930 and registered with an independent EPD system.
        - Carbon Footprint of Product (CFP) compliant with ISO 14067:2018 or PAS 2050:2011 from approved programmes / certification schemes (see chapter 18). Only product carbon footprints can be accepted, not organisational carbon footprints.
        - Life Cycle Assessments (LCAs) following EN 15804 or ISO 21930.
- **Generic value built into the Calculator:** Generic emission factors for key materials shall be used from Appendix B of the NZGBC Embodied Carbon Methodology, if available, where there is no product-specific emission factor. These values are built into the Calculator.

- **Generic value from global literature scan:** Where there is no suitable emission factor using either of the previous two approaches, a generic emission factor may be used. The data quality hierarchy in Table 3 shall be applied as follows:

  Working from the top to the bottom of Table 3 (noting that this process will likely start from priority 5, as priority 1-4 emission factors should have already been identified in the steps above):

  - Identify all relevant emission factors using both a local and global scan. A relevant emission factor is one for the same or similar product type used in the building, but may be based on generic data (database or literature) or a different country of manufacture to that actually used.

    This scan should include:

    - All major EPD programmes, e.g., EPD Australasia, International EPD System, BRE, IBU, UL Environment, etc. For Australasian EPDs, check https://epd-australasia.com/ and https://www.globalgreentag.com/epd-program.html. For European EPDs, check https://www.eco-platform.org/epd-data.html.
    - All carbon footprint certification schemes recognised in chapter 18.
    - Generic data, e.g., AusLCI, ecoinvent and Sphera/GaBi databases. A good central repository is the Global LCA Data Access (GLAD) network: https://www.globallcadataaccess.org/search.
  - If no suitable emission factors are found, move down a row in the table to the next priority level and start scanning for new emission factors.
  - If one or more suitable emission factor(s) exist, convert them to the same unit (e.g., tonnes) and report stored biogenic carbon (GWP-stored) separately from GWP-total. For guidance, see section 4.2.1 of the *NZGBC Embodied Carbon Methodology*.
  - If there are many results and some appear to be outliers, use the Interquartile Range (IQR) method to exclude these outliers. To apply the IQR method, calculate the upper and lower quartiles of the dataset. Calculate IQR as (upper quartile) minus (lower quartile). Multiply IQR by 1.5 and add this value to the lower quartile, forming a lower fence, and to the upper quartile, forming an upper fence. All values below the lower fence and above the upper fence can be excluded from the dataset.
  - Take the following value and use this as the proxy within the Calculator:
    - For the Proposed Building, use the highest GWP-total.
    - For the Reference Building, use the median GWP-total.

Table 3: Emission factor data quality hierarchy[1]

Order of Priority	Emission factor data quality / precision	Origin of emission factor / data
1	Excellent (product-specific)	**Verified** EPD[2] or CFP[3] for **specific product** with the **specific country of manufacture** reflecting the product installed in the building.
2	High (product-specific)	**Verified** EPD[2] or CFP[3] for **sector average product** with the **specific country of manufacture** reflecting the product installed in the building.
3	Medium (product-specific)	**Verified** EPD[2] or CFP[3] for **the specific product** (specific or sector average) with a **different country of manufacture** to the product installed in the building.
4	Medium (product-specific)	**Peer reviewed** LCA[4] or CFP[4] for the **specific product** (specific or sector average), **regardless of country of manufacture,** not published by an independent programme operator
5	Medium (proxy product)	**Verified** EPD[2] or CFP[3] for **a similar product** (specific or sector average) to the product installed in the building **regardless of country of manufacture**
6	Medium (proxy product)	**Peer reviewed** LCA[4] or CFP[5] for a **similar product** (specific or sector average), **regardless of country of manufacture,** not published by an independent programme operator
7	Low (generic data)	**Unreviewed** LCA or CFP results for the **specific product** accounting for the **specific country of manufacture** using a mix of primary data from the manufacturer and **generic data from databases**, e.g., from ecoinvent, GaBi or AusLCI.
8	Low (generic data)	**Unreviewed** LCA or CFP results for a **similar product** using a mix of primary data and **generic data from databases**, e.g., from ecoinvent, GaBi or AusLCI, **regardless of country of manufacture**.
9	Low (IO data)	**Input-output LCA** or **hybrid LCA** data, either for New Zealand or for a country that has significant manufacturing capacity for this product type.

[1] Table based on the concept of BRANZ's data quality hierarchy (BRANZ, 2021) and MBIE's *Technical Methodology* (MBIE, 2022) with product-specific data first, followed by proxy data for a similar product, followed by generic data. Adaptations have also been made to allow for a wider pool of data (i.e., also from product carbon footprints and life cycle assessment studies).

[2] Environmental Product Declarations must follow both ISO 14025 and either EN 15804 or ISO 21930. They must be independently verified and published with an EPD programme. Preference should be given to EPDs that are still valid; however, an EPD which has expired can still be used given that environmental performance generally improves over time due to improvements in manufacturing efficiency and grid decarbonisation.

[3] A Carbon Footprint of Product must follow either ISO 14067:2018 (preferred) and/or PAS 2050:2011. The study must be independently verified and registered with a carbon certification programme. Approved certification schemes are listed in chapter 18. These declarations will typically be published as a carbon neutral declaration; however, it is the gross carbon footprint prior to offsetting that is needed for the *NZGBC Embodied Carbon Methodology*. Only product carbon footprints, not organisational carbon footprints, can be accepted.

[4] A peer-reviewed Life Cycle Assessment must have been reviewed following ISO 14044. Preference should be given for studies that also follow EN 15804 or ISO 21930.

[5] A peer-reviewed Carbon Footprint of Product must have been reviewed following ISO 14044. Preference should be given for studies that also follow EN 15804 or ISO 21930.

6.4.2 How to Input Custom Data

Data should be entered in the sheet 'Custom_EFs' (Figure 8). Please add a new row for each custom material.

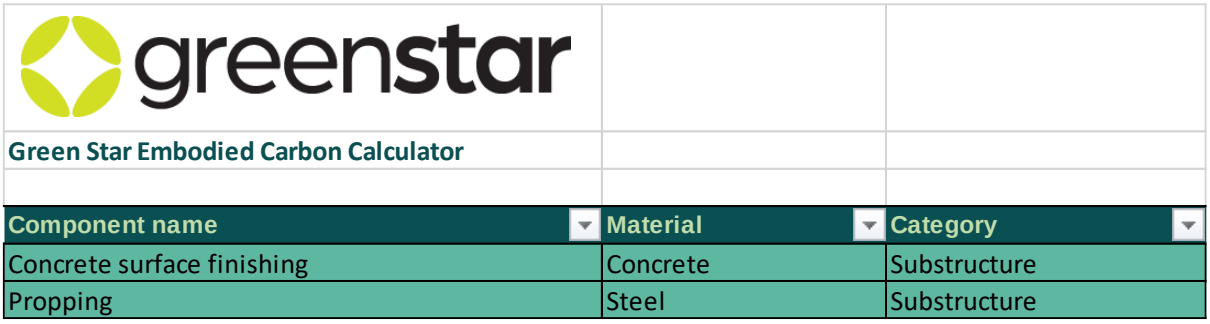


Figure 8: Data entry for custom emission factors

The following data must be entered:

- **Component name:** This is the name that will appear in the dropdown menus throughout the Calculator.
- **Material:** This is a material type grouping, e.g., concrete or steel.
- **BRANZ material class:** This class defines which construction and demolition waste statistics will be applied to the custom material. Please choose the closest matching category.
- **Origin:** Please enter the location where the last major manufacturing step occurs. E.g., if you buy the product from a New Zealand wholesaler, but it is manufactured in China then enter China in this box. If the country of supply is not in the list, please choose the country or region that is geographically closest to your supplier as this field is used for transport distances.
- **Waste:** This is the typical waste produced when installing this type of product. Common values are between 0% and 10%.
- **Replacement frequency (years):** This is the expected life of the building product before it needs to be replaced. This will be used in calculating whole-of-life embodied carbon. For structural elements, please enter a number between 50 and 100 years.
- **Unit:** This is functional or declared unit that the carbon footprint data is declared in, e.g., kilograms, tonnes, metres, square metres or cubic metres.
- **GWP-t (kg CO_2e):** This is the total carbon footprint, which is GWP-f + GWP-b + GWP-l. It might be reported as 'GWP-total' or 'Climate change – total', or sometimes simply as 'GWP' or 'Climate change'. In some studies, this is the only carbon footprint value reported. Depending on the standard followed, it may include or exclude GWP-b.
- **GWP-f (kg CO_2e):** This is the fossil carbon footprint. It might be reported as 'GWP-fossil' or 'Climate change – fossil'. It can be entered directly if it is separated (as required by EN 15804+A2:2019 and ISO 14067:2018). If it is not separated:
    - If the product is *not* from a biogenic source, assume GWP-f = GWP-t.

- If the product is from a biogenic source (e.g., wood or paper) and you think it is unlikely that stored carbon is included within GWP-t (e.g., because GWP-t from A1-A3 is positive and not close to zero), assume GWP-f = GWP-t.
- If the product is from a biogenic source (e.g., wood or paper) and you suspect that stored carbon is included within GWP-t (e.g., because GWP-t from A1-A3 is negative), first remove GWP-s and then assume the remainder is GWP-f, i.e., GWP-f = GWP-t - GWP-s.

1. **GWP-b (kg CO_2e):** This is the biogenic carbon footprint. It might be reported as 'GWP-biogenic' or 'Climate change – biogenic'. It can be entered directly if it is separated (as required by EN 15804+A2:2019 and ISO 14067:2018). If it is not separated:
    - If the product is *not* from a biogenic source, assume GWP-f = GWP-t.
    - If the product is from a biogenic source (e.g., wood or paper) and you know it to be sustainably managed, assume GWP-b = GWP-s (see below for a calculation).

- **GWP-l (kg CO_2e):** This is the carbon footprint from land use and land use change (LULUC). It might be reported as 'GWP-luluc', 'Climate change (LULUC)' or 'Climate change – land use and land use change'. It can be entered directly if it is separated (as required by EN 15804+A2:2019 and ISO 14067:2018). If it is not separated, assume it is zero.
- **GWP-s (kg CO_2e):** For products made from fossil fuels and/or mined minerals, GWP-s = 0. For products that contain bio-based materials (e.g., wood and paper), this is biogenic carbon stored in the building product itself. In EPDs following EN 15804+A2, there will be a statement of 'Biogenic carbon content in product'. To convert this to GWP-stored, multiply by -44/12 to convert stored elemental carbon to equivalent carbon dioxide. Where GWP-s is unknown, calculate it as (1 - water content) * (biogenic carbon content of dry matter) * (-44/12). The biogenic carbon content of dry wood (0% water) is approximately 50%. Kiln-dried wood and air-dry paper typically have a water content of approximately 10%. As such, the carbon stored in a wood or paper product is typically approximately -1.65 kg CO_2e/kg = (1-0.1)*(0.5)*(-44/12). This value will vary where fossil-derived resins are used in addition to wood (e.g., in engineered wood products) and products with different water content.
- **Density (kg/m^3):** Density is required when the **Unit** is volume (cubic metres).
- **Area density (kg/m2):** Area density is required when the **Unit** is area (square metres).
- **Mass per m (kg/m):** Linear density is required when the **Unit** is length (metres).

Note: if you are intending to enter quantities in multiple different units for the same dataset, make sure to fill in the relevant conversions e.g., 'area density', 'density', or 'mass per metre'.

To use your new materials in the Calculator, select 'Custom_material' within the 'Material type' dropdown menu on most of the 'Q_…' sheets.

6.5 Adding Custom Assemblies

Custom assembles are reusable building elements that aggregate multiple materials together. This could be one m^2 of internal walls, for example. This can then be scaled up as needed.

When used in a material input sheet, this will be treated as a single row, scaled by the input amount.

The input structure and data requirements are aligned with the regular material input sheets for ease of use. Additionally, the assembly sheet includes the 'Assembly unit' column, allowing the user to specify the unit type for the assembly – such as m^2 or kg.

Important:

Where the assembly sheet differs from the material input sheets is that assemblies are comprised of multiple rows. Every row with the same name in ‘Assembly name’ will be treated together when used. This means that any number of rows can be combined by giving them the same name, but please make sure to copy/paste the name to avoid spelling mistakes – otherwise this could cause the assemblies to miss rows during use.

7 THE 'METADATA' SHEET

This sheet of the Calculator gathers data used for the following functions:

- Information required for Green Star submissions.
- Data required for general calculations.
- Data used for benchmarking and validation.

The input fields are a mix of open data inputs and dropdown menus.

As with all sheets, the colour coding defined in section 5 applies.

Fields of particular importance are:

- **Nearest city:** This controls transport distances and emissions in module A4.
- **Stage of design:** This affects the data entry requirements (which will update the colour coding accordingly). Indicating a design stage model will allow you to utilise the Calculator without inputting project data required for benchmarking and validation. This is intended to allow for exploring general trends in generic designs during the design phase of building planning. However, it should be noted that you may not submit a model that is in the design stage for certification.
- **Is this a reference building?** This field controls how general emission factors are selected when you specify a material category but not a specific material within the Calculator:
    - 'No' (i.e., the Proposed Building): The Calculator will automatically select the worst value in a specific class of values. For example, if you select Concrete > 40 MPa but do not select a specific concrete mix, the Calculator will select the *highest carbon* 40 MPa concrete (per kilogram of concrete). This is to encourage the project team to get better quality information and, ultimately, to choose a lower carbon alternative.
    - 'Yes' (i.e., the Reference Building): The Calculator will try to model market-average performance rather than worst-in-class performance. For example, if you select Concrete > 40 MPa but do not select a specific concrete mix, the Calculator will select the 40 MPa concrete with the *median* carbon footprint per kilogram of concrete.
- **Gross Floor Area (GFA):** This controls emissions calculations per square metre of floor area. Please see the definition of GFA within the *NZGBC Embodied Carbon Methodology*.
- **Was there an existing building on the site?** and **Age of previous building**. These two fields control whether carbon offsetting of a previous building is required. If there was a previous building that was demolished and it was under 50 years old then a full or partial offset for that building's embodied carbon emissions will be required.

8 THE 'LAND' SHEET

The 'Land' sheet is for GWP-LULUC, which is the carbon footprint due to land use and land use change. This sheet is only mandatory for greenfield developments where there is land use change. It does not need to be completed for brownfield developments since there is no land use change.

In general, land use change will only have a material impact on the carbon footprint results if a forest (plantation or natural) is cleared to build the building. Other forms of land use change are less significant because greenhouse gas modelling in New Zealand assumes that 'Settlement' (which is the default land use type for buildings, lawns, parking etc.) is equivalent to grassland/pasture.

When entering data:

- Area 1 is for land within the building's drip-line. This is the only land area which is included within the upfront carbon calculations.
- Areas 2-5 are for land use change that occurs on the site outside of the building's drip-line. These land use changes do not count for upfront carbon under *Green Star* but do count for *Net-Zero Upfront Carbon*.

The crop area is the age of the crop on the site. For example, for a 30-year-old forest, enter 30 years. The older the crop, the more carbon will be stored in that crop.

9 THE ‘COMPLETENESS’ SHEET

This function of this sheet is to calculate the completeness of each building module and to enable the Calculator to extrapolate the missing cost coverage by scaling the associated emissions. It is therefore very important to fill in the ‘Estimated percent of budget (%)’ column as accurately as possible. Importantly, this only refers to the cost of materials. All other costs (e.g., labour, transport to site, subcontractor’s profit margin) should be excluded from the calculation, as they are either included elsewhere within the Calculator (transport) or not part of the scope of assessment (labour and subcontractors’ profit margins).

10 THE ‘C_ENERGY’ SHEET

The ‘C_Energy’ sheet of the Calculator gathers aggregated energy and fuel data to calculate the emissions from site preparation and the construction process (module A5). These items are not split out following the Schedule of Quantities / Bill of Quantities / Cost Plan (e.g., as the amount of soil excavated) but are instead grouped together on this sheet.

Please enter data for *all fuels and electricity used on-site* in the construction and installation process. This data may be difficult to source as it must include fuel and electricity data from all trades and sub-trades in the construction process. Please *exclude* all fuel and energy used off-site, e.g., transporting staff to and from site, and energy used in the offices and vehicles of professional services firms.

If you do not have data for all fuels and electricity used on site, please leave the fields blank so that the default values are used instead.

Note: A later sheet ‘NZUC_Construction’ is also provided for users of the Net-Zero Upfront Carbon Standard. This allows additional energy required for tenant improvements (which are not part of the scope of Green Star) to be included. This sheet has the same structure as ‘C_Energy’.

11 THE ‘C_WASTE’ SHEET

This sheet calculates the cumulative proportions of construction waste that are destined for the different available end-of-life options per material category. This then allows the user to review the data and potentially override these proportions with their own waste data on a per-material category basis.

Note: You must document any reasoning for overriding these values as they are based on common practice in New Zealand and should only be replaced by data with higher accuracy. Documentation should be provided with relevant and adequate references (e.g., a site waste report based on weighed waste quantities per material type).

12 MATERIAL INPUT ('Q_') SHEETS

This guidance covers the general function of the following sheets:

- 'Q_SitePrep.'
- 'Q_Substructure'
- 'Q_Superstructure'
- 'Q_Envelope'
- 'Q_Fitout'
- 'Q_Services'
- 'Q_Formwork'
- 'Q_Ext.Works'
- 'NZUC_Improvements'
- 'NZUC_Ext.Works'

This chapter provides detail on how to input data to the input sheets above. Each sheet follows a similar structure, as shown in Figure 9. These sheets are designed for you to enter as many rows as necessary to cover each category of materials in the given building module. The label 'NZUC' indicates that a sheet is intended for compliance with the *Net-Zero Upfront Carbon Standard* only and is not needed for Green Star.

Green Star Embodied Carbon Calculator

Substructure

Category	Assembly name / notes	Component name
Slabs	Foundation - Ground beam	Concrete
Slabs	Foundation - Ground beam	Reinforcing

Figure 9: Example material input sheet (Substructure pictured)

12.1 The 'Category' Column

Please select a category from the drop-down menu. This column relates the specific row towards one of the sub-classifications of the building module within the 'Results' tab. E.g., in the 'Substructure' module, the available sub-classifications are 'Slabs', 'Piles, 'Retaining walls', and 'Other'.

12.2 The 'Assembly name / notes', and 'Component name' Columns

These columns are of do not have a function within calculations. They are intended to be used as follows:

- The 'Assembly name / notes' column is intended to be used where one entry spans more than one row. In this case, please enter the same assembly name in several rows (see e.g. Figure 10).
- The 'Component name' column is intended for the name/ID of an item within the assembly.

Using these columns will assist both the user and reviewer to keep track of what each row represents.

Category	Assembly name / notes	Component name	Material type	Subtype	Matching material - (Dependent on 'Material Type' selection)	Amount	Unit
Slabs	Ground beam	Concrete	Concrete	30_MPa	Concrete, 30 MPa, in-situ, no reinforcement, (OPC)	10	m3
Slabs	Ground beam	Reinforcing	Steel		Steel reinforcement, primary, bar (Pacific Steel)	1,500	kg

Figure 10: Example entry for reinforced concrete

12.3 The 'Material type', 'Subtype', and 'Matching material' Columns

These columns are used to select the most representative emission factor per modelled item.

The 'Material type' and 'Subtype' columns are used to pick a category of materials, or to select custom input emission factors and assemblies. The effect of selecting these (sub)types in the dropdown menus is to select a subset of data to be displayed in the 'Matching material' dropdown menu.

Not all materials have a 'Subtype'. If the 'Subtype' dropdown menu is empty, please move to the 'Matching material' column and select your desired material.

If your selection in the 'Material category' column is related to custom assemblies, only assemblies classified as belonging to your current building module will be available. See section 6.5 for information regarding the 'Custom assemblies' sheet.

Note: If you choose a 'Subtype' and/or a 'Matching material' and then later change the 'Material type', the old 'Subtype' and 'Matching material' will remain and will not be cleared automatically. To replace an existing row, you can either delete the row (right-click on the row to be deleted and select 'Delete > Table Rows'.

In this case, please proceed through the menus from left to right to override the old values, starting by selecting 'Material type' then 'Subtype' then 'Matching material'. The 'Unit' may also need to change

12.4 The 'Amount' and 'Unit' Columns

These columns are used to input the quantity of your material used. Make sure that the 'Unit' column dropdown reflects the quantity you are inputting in 'Amount'.

While some datasets contain conversions for different units (allowing for entry of different units), there are exceptions within the database. If your chosen unit does not have an available conversion factor, the unit selection will turn red, prompting you to select a different unit. E.g., conversions are not available when selecting 'unit' or 'linear metre' as your unit when having selected a concrete material.

12.5 The 'Source' Column

This column is used to indicate where your material/product was sourced from. Please choose the location that the last major manufacturing step takes place. For products that are imported into New Zealand, please enter the location of the original manufacturer, not the location of their local representative's warehouse. In the context of Green Star, packaging does not count as a manufacturing step. E.g., if a product is manufactured in China, but shipped in bulk to New Zealand and then individually wrapped in Auckland, please enter 'China' as the source.

Please note:

- 'Local' should be used for products that are manufactured in the city where the building is constructed.
- Please select the geographically closest alternative if the required country/city is not available in the dropdown menu. E.g., if your material was sourced from Uruguay, please select Brazil as the geographically closest alternative. Use of proxy locations can be documented using a

note in Excel; however, transport distances will generally not have a significant impact on the building's overall carbon footprint when using sea, rail or truck freight.

12.6 The 'Waste % input' Column (Optional)

While this column is not a required input, it will allow you to specify the construction waste per line-item. If this column is left empty, a default construction waste figure from BRANZ's LCA datasheets will be used in its place.

This percentage is:

- Additional to the amount you entered.
- Calculated as a percentage of the output amount, not the input amount.
- Counted in module A5, not module A1-A3, in line with EN 15804 and EN 15978.

For example, 10 tonnes of concrete with 10% waste input would be calculated as 10 tonnes of concrete in module A1-A3 plus 1 tonne of concrete waste in module A5, totalling 11 tonnes of concrete manufactured.

13 OTHER DATA INPUT SHEETS

13.1 The 'Q_Services' Sheet

Building services are difficult to model due to a lack of available data. The Calculator contains several in-built services carbon footprints that can be used in place of real data. The use of these datasets is strongly encouraged while carbon footprint data on building services improves.

To find these datasets, select "Building_services" from the "Material type" drop-down menu. You will see the following three options:

- Building services, low-rise residential (proxy)
- Building services, mid-rise and high-rise (excl. vertical transport) (proxy)
- Building services, warehouse and industrial (excl. vertical transport) (proxy)

Please select the appropriate option for your project. Assuming that your building can solely be grouped as one of the categories above, please enter the total floor area of the building in the "Amount" column (which can also be entered as "=A_GFA") and select the "Unit" to be "m²". An example is shown in Figure 11 below where the building can best be represented by three different types of building services, each of which covers 1,000 m² of gross floor area.

Material type	Subtype	Matching material - (Dependent on 'Material Type' selection)	Amount	Unit	Emission factor used (GWP fossil)
Building_services		Building services, low-rise residential (proxy)	1,000	m²	40.000 kg CO2e/m² (selected EF) - 25.81% of module.
Building_services		Building services, mid-rise and high-rise (excl. vertical transport) (proxy)	1,000	m²	75.000 kg CO2e/m² (selected EF) - 48.39% of module.
Building_services		Building services, warehouse and industrial (excl. vertical transport) (proxy)	1,000	m²	40.000 kg CO2e/m² (selected EF) - 25.81% of module.

Figure 11: Example of selecting generic building services emission factors

It is important to note that these general building services factors exclude:

- Vertical transport services, such as elevators and escalators.
- On-site photovoltaic installations.

These should be modelled separately and added on top of the general building services figure above.

For projects wanting to model building services in detail, please refer to CIBSE's TM65ANZ standard for guidance (CIBSE, 2022a) and the related DT65ANZ Embodied Carbon Calculator (CIBSE, 2022b). The generic factors for building services should only be replaced where the project can ensure that it models at least 80% of the mechanical, electrical and plumbing services (by material value) and uses a scaling factor in the 'Completeness' tab to quantify any missing portion.

13.2 The 'Q_Formwork' Sheet

This sheet behaves in the same way as the other 'Q_' sheets with two important differences:

- The 'Uses' column allows you to enter the number of use cycles for the formwork. For single-use items, please enter a value of 1. Where you do not have specific data, please use:

- Timber formwork (light duty): 1 use cycle
- Timber formwork (heavy duty): 3 use cycles (Laleicke, et al., 2015)
- Steel scaffolding: 10 use cycles (Laleicke, et al., 2015)
- Bamboo scaffolding: 3 use cycles (Laleicke, et al., 2015)

- All transport distances are multiplied by 2 when the use cycles exceed 1. This accounts for the return transport leg, assuming a return-to-base (rather than peer-to-peer) transport model.

13.3 The 'Q_Ext.Works' Sheet

This sheet is designed to enter information about the trafficable surfaces (carparks, driveways, hardstands, etc.). While this information is not within the dripline of the building and therefore not strictly within the scope of assessment, it is included for reporting purposes given that some building types (e.g., retail) will almost always include vehicle parking spaces or hardstands.

This information is mandatory to allow NZGBC monitor if there are any trade-offs between trafficable surfaces inside the dripline of the building (e.g., covered carparks in the basement of a multi-storey building) versus those that are outside of the dripline (e.g., uncovered carparks).

13.4 The 'Carbonation' Sheet

This sheet is designed to allow the user to enter any carbon dioxide removed from the atmosphere during concrete carbonation, either during the building's life or at the end of the building's life. The carbon dioxide stored should be calculated separately and then copied into this sheet. Appropriate documentation must be supplied to support the numbers entered.

13.5 The 'ExistingBuild' Sheet

For all projects in which there is already an existing building, this sheet allows the user to calculate the mandatory offsets associated with the demolition and/or reuse of (parts of) the existing building.

The emissions associated with the demolition of the existing building is calculated through approximated quantities of selected materials combined with their proportions to end-of-life fates. The sheet is already set up with all required materials and should therefore not be modified beyond adding quantities and end-of-life data. Please also ensure that the proportions to end-of-life scenarios adds up to 100% exactly. Non-empty proportions that do not add up to 100% are highlighted with red text.

14 RESULTS

Two sheets are provided for the LCA results:

- 'Results'
- 'Results_Detail'

14.1 The 'Results' Sheet

The main results of the Calculator are presented in the 'Summary results' table (Figure 12):

- **Upfront carbon footprint (A1-A5):** Calculates points for Credit 21 of *Green Star Buildings NZ* and Credit 19.1 of *Green Star – Design & As Built NZv1.1*. These credits only account for upfront carbon within the dripline.
- **Upfront long-term stored carbon:** Calculates points for carbon storage following Credit 24 of *Green Star Buildings NZ* and Credit 19.3 of *Green Star – Design & As Built NZv1.1*.
- **Demolition carbon footprint to offset:** If there was an existing building on the site that was younger than 50 years at the time of demolition, this is the carbon footprint that must be offset, either fully or partly depending on building's age.
- **Whole-of-life embodied carbon footprint (A-C):** This is used as a sense-check to help ensure that burdens have not been shifted from upfront carbon to whole-of-life. It includes EN 15804 modules A, B and C (i.e., it excludes credits from reuse and recycling). It is not part of the points calculation for *Green Star*.
- **Whole-of-life embodied carbon footprint (A-D):** This is used as a sense-check to help ensure that burdens have not been shifted from upfront carbon to whole-of-life. It includes EN 15804 modules A, B, C and D (i.e., it includes credits from reuse and recycling). It is not part of the points calculation for *Green Star*.

greenstar

Green Star Embodied Carbon Calculator

Summary Results

Results for Green Star (kg CO_2e)			
Result (kg CO2e)	**Absolute**	**Per m^2**	**Credit**
Upfront carbon footprint (A1-A5) inside the drip-line	**203,560**	**170**	**19.1**
Upfront carbon footprint (A1-A5) outside the drip-line	5,710	5	n/a
Upfront long-term stored carbon	**-73,204**	**-61**	**19.3**
Demolition carbon footprint that must be offset	160,318	134	19.1
Whole of life embodied carbon (A-C) [EN 15804+A2]	304,467	254	n/a
Whole of life embodied carbon (A-D) [EN 15804+A2]	225,222	188	n/a
Whole of life embodied carbon (A-C) [EN 15804+A1]	282,930	236	n/a
Whole of life embodied carbon (A-D) [EN 15804+A1]	203,685	170	n/a

Figure 12: Summary results table

The Calculator returns the results of the upfront carbon assessment, but not the Green Star points. To calculate the points achieved for *Green Star*, copy the 'Summary results' section from the 'Output – Results' sheet of the Calculator and paste this into the 'Upfront Carbon' sheet of the *Life Cycle Impacts Calculator NZv1.1*. When using the Reference Building approach, you will need to run the Calculator twice (once for the Reference Building and once for the Proposed Building) and paste in two sets of results tables.

A greater level of results breakdown is provided in the 'Results for MBIE's Building for Climate Change' table (Figure 13). This table splits the results into greenhouse gas emissions (positive numbers) and greenhouse gas removals (negative numbers) for the stages that happen now (modules A1-A5) versus those that happen in the future (modules B-D), as per the current guidance from MBIE. This table may be revised as MBIE further clarifies its requirements for Building for Climate Change.

Results for MBIE's Building for Climate Change (kg CO_2e)	**EN 15804+A2**		
Life cycle module	**GHG emissions**	**GHG removals**	**GHG total**
A1-A3 (building products)	175,566	-73,204	102,362
A4 (transport of products to site)	8,688	0	8,688
A5 (construction)	19,306	0	19,306
B1 (direct emissions)	0	0	0
B3-B5 (materials replacement)	98,252	0	98,252
C1 (deconstruction/demolition)	65	0	65
C2 (transport of scrap off-site)	690	0	690
C3 (waste processing for recycling)	50,947	0	50,947
C4 (landfill and incineration)	24,157	0	24,157
D (benefits and loads beyond the system boundary)	2	-79,247	-79,246
Total upfront carbon (A1-A5)	**203,560**		**203,560**
Total embodied carbon (A-C)	**377,671**	**-73,204**	**304,467**
Total embodied carbon (A-D)	**377,673**	**-152,451**	**225,222**

Figure 13: Results for MBIE's Building for Climate Change

The Calculator also includes several charts to help visualise the results. An example is presented in Figure 14 below for upfront carbon.

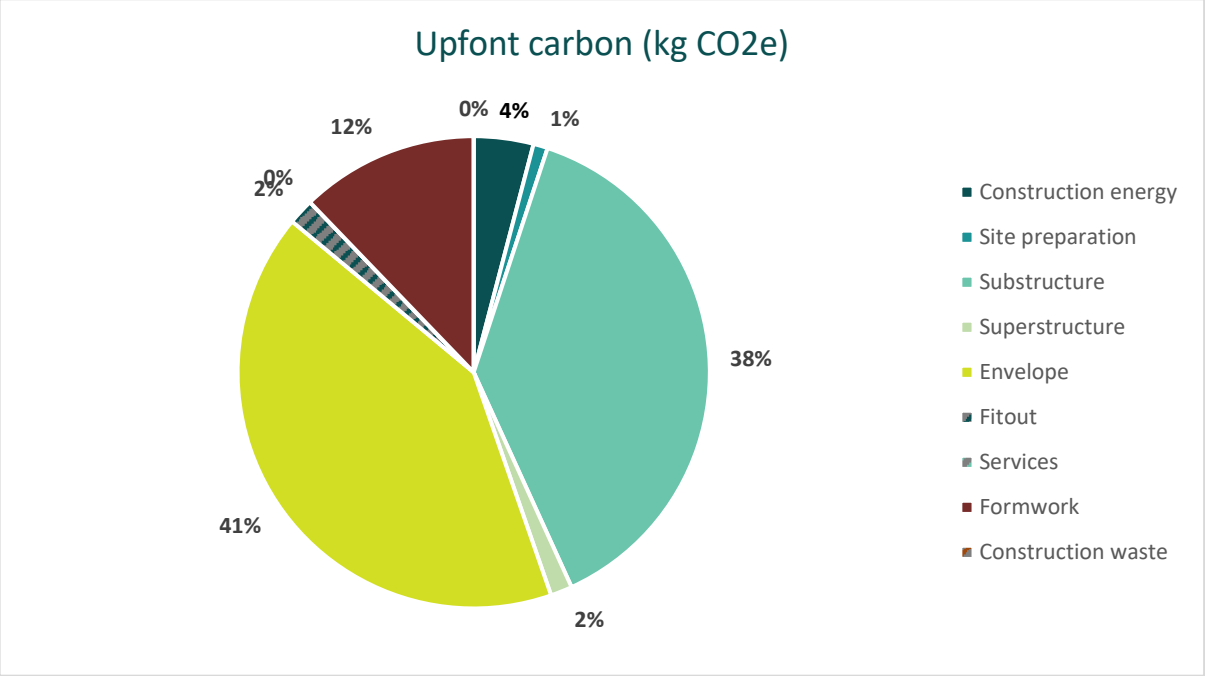


Figure 14: Chart showing contributions to upfront carbon

A detailed breakdown of carbon footprint results is available in Figure 15 below. The emissions breakdown has the following two axes:

- **Building modules** (rows) correspond to each of the major 'Q_*' sheets (substructure, superstructure, etc.), allowing the user to see which parts of the building are contributing the most towards the total carbon footprint.
- **Life cycle modules** (columns) correspond to the life cycle modules defined in section **Error! Reference source not found.**. The results are summarised in the 'Upfront carbon' and 'Embodied whole-of-life' columns to the right, with one set showing whole-building and the other set showing per m^2 results.

Climate Change - Upfront Carbon (kg CO2e)					
Green Star	**A1-A3**	**A4**	**A5**	**Absolute**	**Per m^2**
Construction energy			19,306	19,306	16
Site preparation	7,873	874		8,747	7
Substructure	18,750	5,801		24,551	20
Superstructure	5,200	1,709		6,909	6
Envelope	95,742	304		96,046	80
Fitout	0	0		0	0
Services	48,000	0		48,000	40
Formwork	0	0	0	0	0
Construction waste			0	0	0
Total	**175,566**	**8,688**	**19,306**	**203,560**	**170**

Net-Zero Carbon	**A1-A3**	**A4**	**A5**	**Absolute**	**Per m^2**
Construction energy	0	0	0	0	0
External works	0	0	0	0	0
Tenant improvements	0	0	0	0	0
Construction waste	0	0	0	0	0
Additional	**0**	**0**	**0**	**0**	**0**
Total	**175,566**	**8,688**	**19,306**	**203,560**	**170**

Figure 15: Detailed upfront carbon results per life cycle stage and module, for both Green Star and Net-Zero Upfront Carbon

14.1 The ‘Results_Detail’ Sheet

The ‘Output – Additional results’ sheet provides an additional level of breakdown to split the carbon footprint by the major source of emissions: GWP-fossil, GWP-biogenic, GWP-luluc and GWP-total. GWP-stored is also included. Figure 16 shows the GWP-total results as an example.

EN15804+A2: Climate Change - Total (kg CO_2e)										
Green Star	**A1-A3**	**A4**	**A5**	**B1**	**B3-B5**	**C**	**D**	**Upfront carbon**	**Embodied whole of life (A-C)**	**Embodied whole of life (A-D)**
Construction energy			19,306					19,306	19,306	19,306
Site preparation	-57,081	874		0	0	65,665	-14,158	8,747	9,458	-4,700
Substructure	18,750	5,801		0	0	306	-7,344	24,551	24,857	17,513
Superstructure	-3,050	1,709		0	0	8,434	-1,178	6,909	7,093	5,915
Envelope	95,742	304		0	0	328	-56,565	96,046	96,374	39,809
Fitout	0	0		0	0	0	0	0	0	0
Services	48,000	0		0	98,252	1,126	0	48,000	147,378	147,378
Formwork	0	0	0					0	0	0
Construction waste			0					0	0	0
Recarbonation				0		0	0	0	0	0
Total (inside the drip-line)	**102,362**	**8,688**	**19,306**	**0**	**98,252**	**75,859**	**-79,246**	**203,560**	**304,467**	**225,222**
External works	5,710	0		0	0	2,045	-39	5,710	7,754	7,716
Land use change outside the drip-line	0			0				0	0	0
Total (including external works)	**108,071**	**8,688**	**19,306**	**0**	**98,252**	**77,904**	**-79,284**	**209,269**	**312,222**	**232,937**

Figure 16: Detailed whole-of-life carbon results per life cycle stage and module

15 TARGETS

Two pathways will be possible in future:

1. Absolute Value Pathway (section 15.1)
2. Reference Building Pathway (section 15.2)

At the time of writing, only the Reference Building Pathway may be applied. The Absolute Value Pathway will be introduced in the future once enough carbon assessments have been completed to allow meaningful benchmarking.

15.1 Absolute Value Pathway

It is envisaged that absolute targets will be set against four main categories of building:

- **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, hotels and large hospitals.
- **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.
- **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. The primary structural system may be any combination of reinforced concrete, structural steel framing and timber. Building types in this category include shopping centres, indoor sports venues, schools, libraries, some supermarkets, multi-level industrial buildings and smaller hospitals.
- **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 lightweight stick or truss framing (timber or steel), with some blockwork walls, on a reinforced concrete slab. Building types in this category include medical practices, school buildings and extensions to the building types above.

Targets will be set as kg CO_2e/m^2 GFA. Placeholder tables for the absolute targets for Upfront Carbon and Whole-of-Life Embodied Carbon for each building type are included in Table 4 and Table 6, respectively. **Absolute targets will only be developed once a representative sample of buildings have been submitted for Green Star ratings and so this pathway cannot yet be used.** It is possible that these four categories will change based on further analysis of the data that is submitted.

Table 4: Targets for Upfront Carbon

	Reduction vs national average	Mid- to high-rise buildings	Warehouse-type buildings	Low-rise buildings	Residential-type buildings
Baseline (2020)		[x] kg CO_2e/m^2	[x] kg CO_2e/m^2	[x] kg CO_2e/m^2	[x] kg CO_2e/m^2
Projects registered after 1st January 2022	10% below 2022 average	[x] kg CO_2e/m^2	[x] kg CO_2e/m^2	[x] kg CO_2e/m^2	[x] kg CO_2e/m^2
Projects registered after 1st January 2026	15% below 2022 average	[x] kg CO_2e/m^2	[x] kg CO_2e/m^2	[x] kg CO_2e/m^2	[x] kg CO_2e/m^2

Table 5: Targets for Whole-of-Life Embodied Carbon

	Reduction vs national average	Mid- to high-rise buildings	Warehouse-type buildings	Low-rise buildings	Residential-type buildings
Baseline (2020)		[x] kg CO_2e/m^2	[x] kg CO_2e/m^2	[x] kg CO_2e/m^2	[x] kg CO_2e/m^2
Projects registered after 1st January 2022	No worse than 2022 average	[x] kg CO_2e/m^2	[x] kg CO_2e/m^2	[x] kg CO_2e/m^2	[x] kg CO_2e/m^2
Projects registered after 1st January 2026	No worse than 2022 average	[x] kg CO_2e/m^2	[x] kg CO_2e/m^2	[x] kg CO_2e/m^2	[x] kg CO_2e/m^2

15.1.1 Adjusting Targets for Mixed-use Buildings

A single building may be of only one type, or it can be any combination of all four types. Where a building is a combination of types, the target value shall be adjusted by the share of floor area under each type.

Example:

- A retail complex has a 10,000 m^2 warehouse-type building attached to a 10-storey 10,000 m^2 tower. The combined GFA is 20,0000 m^2.
- If the target value for the warehouse-type building was 450 kg CO_2e/m^2 and the target for the office tower was 600 kg CO_2e/m^2, the target must be adjusted to 525 kg CO_2e/m^2 for the combined building, calculated as 600*(10,000/20,0000) + 450*(10,000/20,0000).

15.2 Reference Building Pathway

Projects that select the Reference Building Pathway shall demonstrate reductions in upfront carbon emissions in comparison to a Reference Building, as defined below. Two options are available to compare the project's upfront carbon footprint, where a Standard Practice Reference Building or an Actual Reference Building can be used to demonstrate reductions.

A. Standard Reference Building Pathway

The Standard Practice Reference Building is a hypothetical project that represents construction and operation practices (i.e., a business-as-usual design) circa 2020. The Reference Building is the reference point against which improvements are measured, hence why it must reflect a fixed point in time. The Reference Building shall be agreed through consultation with structural, mechanical, electrical, and architectural professionals.

Without strong justification to the contrary, the Reference Building and Proposed Building must have the same:

- Structural requirements
- Scale
- Function
- Location
- Tenant requirements
- Site conditions including underlying geology
- Planning constraints
- Orientation.

The tables in this section (Table 6 to Table 9) must be used to calculate upfront carbon emissions for the Reference Building. These tables aim to show the predominant material type on the New Zealand market circa 2020, as used for a specific element in each building type.

Where the material requirements in Table 6 to Table 9 are inappropriate for your project, you may submit a Technical Question to NZGBC to apply to use an alternate set of materials for the Reference Building. The Technical Question must include a justification (e.g., based on ground conditions, seismic risk, or similar). Please keep in mind that the Reference Building should reflect business-as-usual construction circa 2020.

The default material types for each building type are given in the tables below:

- **Mid- to high-rise buildings** (buildings with 5 or more levels): Table 6.
- **Warehouse-type buildings**: Table 7.
- **Low-rise buildings**: Table 8.
- **Residential-type buildings**: Table 9.

In the tables below:

- **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. In New Zealand, virgin steel is produced by converting iron sand to molten iron using rotary kilns and then to steel using a Klockner Oxygen Blown Maxhutte (KOBM) furnace.
- **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. New Zealand's only large-scale domestic EAF (at Pacific Steel) closed in 2016. As such, all steel manufactured in New Zealand is virgin steel. If EAF steel is used and the source 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. If the SCM content is unknown, assume 0% SCM as this is standard practice in New Zealand as of 2022 (though this is expected to change).

Table 6: Default reference building material specifications for mid- to high-rise buildings

Category 1	Category 2	Building element	Default reference materials
Substructure	Substructure	Foundation	Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 40 MPa. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar/mesh made from conventional virgin steel at 150 kg/m^3 for pad footings,150 kg/m^3 for pile caps and 230 kg/m^3 for ground beams. Design should align with recommendations provided by the project geotechnical engineer. If a different foundation system, with a different material specification, is appropriate for the Reference Building vs the Proposed Building, this is to be justified through a Technical Question as early as possible.
		Ground floor slab	Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 40 MPa. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar/mesh made from virgin steel at 150 kg/m^3 for walls.
		Basement retaining walls	Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 35 MPa. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar/mesh made from virgin steel at 250-350 kg/m^3. 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
Superstructure	Frame	Columns Beams	Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 35 MPa. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar/mesh made from virgin steel at 250-350 kg/m^3.

			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	**Precast concrete slab** Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 35 MPa for in-situ elements and 45 MPa for precast elements. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar/mesh made from virgin steel at 100-150kg/m^3 and prestressing to precast elements with virgin steel tendons at 7-10 kg/m^2 area. **Post-tensioned concrete slab (flat)** Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 40 MPa. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar/mesh made from virgin steel at 70-100kg/m^3 and post-tensioned strands to floor area with virgin steel tendons at 15 kg/m^2 area. **Composite slab** Same as that for the Proposed Building. OR: Steel deck made from 1 mm thick virgin steel sheet, and virgin steel reinforcing mesh at 100-120 kg/m^3 and concrete at 30 MPa with 0% cement replacement.
	Roof	RC Slab Roof Steel Roof	**Reinforced concrete roof systems:** Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 35 MPa for in-situ elements and 45 MPa for precast elements. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar made from virgin steel at 0.8 x the ##kg/m^3 rates given for the relevant system in 'Suspended Floors' above. 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 0.40mm or 0.55mm, pre-painted over a zinc-aluminium metal coating.
	Stairs and ramps		Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 30 MPa. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar made from virgin steel at 125 kg/m^3.

	External walls	Structural external walls	Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 40 MPa. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar made from virgin steel at 200-260 kg/m^3 for gravity walls and 300-350 kg/m^3 for shear walls. Blockwork: 190 mm concrete blocks, core-filled with 20 MPa grout and virgin steel reinforcing bar at 40 kg/m^3. Finish: Cement render.
		Non-structural external walls	Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 30 MPa for in-situ walls and 40 MPa for precast walls. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar made from virgin steel at 150 kg/m^3 for precast façade-only panels. Blockwork: 190 mm thick concrete block, core-filled with 20 MPa grout and virgin steel reinforcing bar at 20-30 kg/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 0.5 mm.
	Windows and external doors	Curtain wall / façade	Curtain wall: Double-glazed with a powder coated virgin aluminium frame. The glass thickness and window-to-wall ratio should be the same as for the Proposed Building, unless otherwise justified.
	Internal walls and partitions	Structural internal walls	Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 30 MPa for in-situ walls and 40 MPa for precast walls. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar made from virgin steel at 200-260 kg/m^3 for gravity walls and 300-350 kg/m^3 for shear walls.
		Non-structural external 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. Code minimum. Paint: one coat water-based primer + two coats water-based top-coat.

		Blockwork: 190 mm thick concrete block, core-filled with 20 MPa grout and virgin steel reinforcing bar at 20-30 kg/m^3. **Commercial office and healthcare:** Single-glazed partitions with aluminium frame.
	Internal doors	Hollow core timber with steel jamb, painted. Steel fire door, painted.
Finishes	Wall finishes	Wall tiles in bathrooms (5 mm and 10 mm)
	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	**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

Table 7: Default reference building material specifications for warehouse-type buildings

Category 1	Category 2	Building element	Default reference materials
Substructure	Substructure	Ground-bearing slab	Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 40 MPa. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar/mesh made from virgin steel at 80 kg/m^3. 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 0.40 mm or 0.55 mm, 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 0.40 mm or 0.55 mm 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 0.40 mm, pre-painted over a zinc-aluminium metal coating. **Warehouse with temperature control:** Sandwich panel constructed of galvanised virgin steel cladding (inside and outside) with 0.40 mm or 0.55 mm 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: 40MPa with 0% cement replacement Reinforcing bar/mesh made from virgin steel at 175 kg/m^3. Long-run steel cladding above.

	Windows and external doors		Double-glazed with a powder coated virgin aluminium frame. The glass thickness and window-to-wall ratio should be the same as for the Proposed Building, unless otherwise justified. 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. Code minimum. Paint: one coat water-based primer + two coats water-based top-coat.
	Internal doors		Hollow core timber with steel jamb, painted. Steel fire door, painted.
Finishes	Wall finishes		**Office area:** Wall tiles in bathrooms (5 mm and 10 mm)
	Floor finishes		**Warehouse area:** n/a (polished concrete assumed) **Office area:** Nylon carpet tiles with rubber underlay ~80% of area, vinyl flooring ~20% of area
	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)

Table 8: Default reference building material specifications for low-rise buildings

Category 1	Category 2	Building element	Default reference materials
Substructure	Substructure	Foundation	Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 40 MPa. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar/mesh made from conventional virgin steel at 150 kg/m^3 for pad footings,150 kg/m^3 for pile caps and 230 kg/m^3 for ground beams. Design should align with recommendations provided by the project geotechnical engineer. If a different foundation system, with a different material specification, is appropriate for the Reference Building vs the Proposed Building, this is to be justified through a Technical Question as early as possible.
		Ground floor slab	Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 40 MPa. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar/mesh made from virgin steel at 150 kg/m^3 for walls.
		Basement retaining walls	Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 35 MPa. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar/mesh made from virgin steel at 250-350 kg/m^3. 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
Superstructure	Frame	Columns Beams	Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 35 MPa. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar/mesh made from virgin steel at 250-350 kg/m^3. 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	**Precast concrete slab** Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 35 MPa for in-situ elements and 45 MPa for precast elements. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar/mesh made from virgin steel at 100-150kg/m^3 and prestressing to precast elements with virgin steel tendons at 7-10 kg/m^2 area.

			Post-tensioned concrete slab (flat) Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 40 MPa. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar/mesh made from virgin steel at 70-100kg/m^3 and post-tensioned strands to floor area with virgin steel tendons at 15 kg/m^2 area. **Composite slab** Same as that for the Proposed Building. OR: Steel deck made from 1 mm thick virgin steel sheet, and virgin steel reinforcing mesh at 100-120 kg/m^3 and concrete at 30 MPa with 0% cement replacement.
	Roof	RC Slab Roof Steel Roof	**Reinforced concrete roof systems:** Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 35 MPa for in-situ elements and 45 MPa for precast elements. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar made from virgin steel at 0.8 x the ##kg/m^3 rates given for the relevant system in 'Suspended Floors' above. 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 0.40mm or 0.55mm, pre-painted over a zinc-aluminium metal coating.
	Stairs and ramps		Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 30 MPa. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar made from virgin steel at 125 kg/m^3.
	External walls	Structural external walls	Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 40 MPa. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar made from virgin steel at 200-260 kg/m^3 for gravity walls and 300-350 kg/m^3 for shear walls. Blockwork: 190 mm concrete blocks, core-filled with 20 MPa grout and virgin steel reinforcing bar at 40 kg/m^3. Finish: Cement render.
		Non-structural external walls	Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 30 MPa for in-situ walls and 40 MPa for precast walls.

			Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar made from virgin steel at 150 kg/m^3 for precast façade-only panels. Blockwork: 190 mm thick concrete block, core-filled with 20 MPa grout and virgin steel reinforcing bar at 20-30 kg/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 0.5 mm.
	Windows and external doors		Double-glazed with a powder coated virgin aluminium frame. The glass thickness and window-to-wall ratio should be the same as for the Proposed Building, unless otherwise justified. Steel roller shutter door(s).
	Internal walls and partitions	Structural internal walls	Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 30 MPa for in-situ walls and 40 MPa for precast walls. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar made from virgin steel at 200-260 kg/m^3 for gravity walls and 300-350 kg/m^3 for shear walls.
		Non-structural external 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: 190 mm thick concrete block, core-filled with 20 MPa grout and virgin steel reinforcing bar at 20-30 kg/m^3. **Commercial office and healthcare:** Single-glazed partitions with aluminium frame.
	Internal doors		Hollow core timber with steel jamb, painted. Steel fire door, painted.
Finishes	Wall finishes		Wall tiles in bathrooms (5 mm and 10 mm)
	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	**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

Table 9: Default reference building material specifications for residential-type buildings

Category 1	Category 2	Building element	Default reference materials
Substructure	Substructure	Foundation	Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 30 MPa. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar/mesh made from virgin steel at 70 kg/m^3 for pad footings and 200 kg/m^3 for ground beams Design should align with recommendations provided by the project geotechnical engineer
		Ground-bearing slab	Concrete: Same as that for the Proposed Building, but with 0% cement replacement. OR: 30 MPa. Reinforcing: Same as that for the Proposed Building. OR: Reinforcing bar/mesh made from virgin steel at 40 kg/m^3.
Superstructure	Suspended Floors		**Framing:** Treated engineered softwood timber or laminated veneer lumber (LVL) beams and joists or cold-formed steel joists. **Flooring:** Plywood or fibre-cement-sheet flooring
	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 0.40 mm, pre-painted over a zinc-aluminium metal coating 50% concrete/clay tile
	Stairs and Ramps		Treated engineered softwood timber or laminated veneer lumber (LVL) stringers and treads
	External walls		Framing: Treated softwood timber stud frame or cold-formed virgin steel frame with virgin steel strap bracing ⅓ face brick: 70 mm thick clay/concrete face brick. ⅓ long-run steel: Long-run virgin steel cladding with a base metal thickness of 0.40 mm, pre-painted over a zinc-aluminium metal coating. ⅓ fibre cement: 9-15 mm thick fibre cement panel. Insulation: Stone wool or glass wool. Code minimum.

	Windows and external doors	Double-glazed with a powder coated virgin aluminium frame. The glass thickness and window-to-wall ratio should be the same as for the Proposed Building, unless otherwise justified.
	Internal walls and partitions	Wall partitions: 13 mm plasterboard over either timber-stud or cold-formed steel-stud structural frame. Internal wall insulation: stone or glass wool. Code minimum. Paint: one coat water-based primer + two coats water-based top-coat.
	Internal doors	Hollow core timber with steel jamb, painted. Steel fire door, painted.
Finishes	Wall finishes	Wall tiles in bathrooms (5mm and 10mm)
	Floor finishes	Nylon carpet tiles with rubber underlay ~80% of area, vinyl flooring ~20% of area
	Ceiling finishes	Ceiling covering: 10 mm plasterboard Insulation: Stone wool or glass wool. Code minimum. Paint: one coat water-based primer + two coats water-based top-coat

B. Actual Reference Building Pathway

The Actual Reference Building Pathway is only applicable where data for a suitable existing building is available to project teams. Ideally, the existing building must have been constructed in the past 5 years. NZGBC recognises the limited availability of data within the New Zealand context. Project teams are encouraged to submit a Technical Question should a proposed actual reference building meet most, but not all the criteria listed in this section.

The age of the Reference Building is measured from the project's Green Star registration date.

The Reference Building and the Proposed Building shall have similar:

- Structural requirements.
- Scale.
- Function.
- Site conditions including underlying geology.

Where possible, the Reference Building and the Proposed Building shall have similar:

- Planning constraints.
- Number of storeys.
- Orientation.
- Season of construction.
- Tenant requirements.
- Aesthetics.

Comparisons should be made per square metre of gross floor area to account for differences in floor area between the Reference Building and the Proposed Building.

15.2.1 Other Considerations

Solar photovoltaic (PV) system

Where the Proposed Building includes a solar PV system, it must equal or exceed the requirements for the solar PV system in the Reference Building. Where a solar PV system is not in the scope of the Proposed Building, it must not be included in the assessment of either building, 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 should not be included in the Reference Building. Where you have opted to include a shading system to achieve the modelled energy performance for the Proposed Project and you believe this system should be included in the Reference Project, please submit a Technical Question to the NZGBC.

16 CALCULATING POINTS

The results from the *Embodied Carbon Calculator* must be pasted into the *Life Cycle Impacts Calculator* to calculate the points achieved under Green Star. The initial view of the *Life Cycle Impacts Calculator* is shown in Figure 17.

		REFERENCE		PROPOSED		IMPROVEMENT	
Result	**Unit**	**Absolute**	**Per m^2**	**Absolute**	**Per m^2**	**Absolute**	**Per m^2**
Upfront carbon footprint (A1-A5) inside the drip-line	kg CO_2e					0%	0%
Upfront carbon footprint (A1-A5) outside the drip-line	kg CO_2e					0%	0%
Upfront long-term stored carbon	kg CO_2e						
Demolition carbon footprint that must be offset	kg CO_2e						
Whole of life embodied carbon (A-C) [EN 15804+A2]	kg CO_2e					0%	0%
Whole of life embodied carbon (A-D) [EN 15804+A2]	kg CO_2e					0%	0%
Whole of life embodied carbon (A-C) [EN 15804+A1]	kg CO_2e					0%	0%
Whole of life embodied carbon (A-D) [EN 15804+A1]	kg CO_2e					0%	0%

Figure 17: Blank results table where results should be pasted

When using a reference building, paste the results from the *Embodied Carbon Calculator* into the left two blue columns, as shown in Figure 18.

		REFERENCE		PROPOSED		IMPROVEMENT	
Result	**Unit**	**Absolute**	**Per m^2**	**Absolute**	**Per m^2**	**Absolute**	**Per m^2**
Upfront carbon footprint (A1-A5) inside the drip-line	kg CO_2e	8,983,993	898			100%	100%
Upfront carbon footprint (A1-A5) outside the drip-line	kg CO_2e	53,444	5			100%	100%
Upfront long-term stored carbon	kg CO_2e	50,042	5				
Demolition carbon footprint that must be offset	kg CO_2e	0	0				
Whole of life embodied carbon (A-C) [EN 15804+A2]	kg CO_2e	10,780,792	1,078			100%	100%
Whole of life embodied carbon (A-D) [EN 15804+A2]	kg CO_2e	8,999,787	900			100%	100%
Whole of life embodied carbon (A-C) [EN 15804+A1]	kg CO_2e	10,123,423	1,012			100%	100%
Whole of life embodied carbon (A-D) [EN 15804+A1]	kg CO_2e	8,798,977	880			100%	100%

Figure 18: Results table after entering data for a reference building

Next, paste the results for your proposed building's *Embodied Carbon Calculator* output to the right two blue columns, as shown in Figure 19.

		REFERENCE		PROPOSED		IMPROVEMENT	
Result	**Unit**	**Absolute**	**Per m^2**	**Absolute**	**Per m^2**	**Absolute**	**Per m^2**
Upfront carbon footprint (A1-A5) inside the drip-line	kg CO_2e	8,983,993	898	7,988,998	799	11%	11%
Upfront carbon footprint (A1-A5) outside the drip-line	kg CO_2e	53,444	5	53,444	5	0%	0%
Upfront long-term stored carbon	kg CO_2e	50,042	5	852,500	85		
Demolition carbon footprint that must be offset	kg CO_2e	0	0	0	0		
Whole of life embodied carbon (A-C) [EN 15804+A2]	kg CO_2e	10,780,792	1,078	9,187,348	919	15%	15%
Whole of life embodied carbon (A-D) [EN 15804+A2]	kg CO_2e	8,999,787	900	7,923,424	792	12%	12%
Whole of life embodied carbon (A-C) [EN 15804+A1]	kg CO_2e	10,123,423	1,012	8,135,353	814	20%	20%
Whole of life embodied carbon (A-D) [EN 15804+A1]	kg CO_2e	8,798,977	880	6,871,429	687	22%	22%

Figure 19: Results table after entering data for both a reference building and the proposed building

The Green Star points for Credit 19.1 and Credit 19.3 will be calculated below the table, as shown in Figure 20.

Points Awarded For	Points Awarded
Mandatory achievement met?	**YES**
Points awarded for Credit 19.1	**6**
Points awarded for Credit 19.3	**0**
Innovation points for going beyond Credit 19.3	**0**

Figure 20: Green Star points calculation

17 ALTERNATIVE TOOLS

NZGBC's intention is to approve alternative tools that meet the requirements of the *NZGBC Embodied Carbon Methodology*. As the *NZGBC Embodied Carbon Methodology* and Calculator were developed in parallel, no alternative tools were approved as at the time of launch. Priority will be given to approve those tools that are already widely used within Green Star, such as BRANZ LCAQuick, eTool and One Click LCA.

18 OFFSETTING DEMOLITION WORKS

To offset the carbon embodied in a previous building (or buildings) that is (are) demolished:

- Sufficient carbon offset units must be purchased to offset the demolition works, as calculated within the 'ExistingBuild' sheet of the *Embodied Carbon Calculator*.
- All carbon offset units must have a vintage year later than 2012.
- All carbon offset units must be cancelled in a public registry in the name of the project (i.e., the building's address or building's name) and *not* the name of the construction company or building owner. This is to prevent double counting of offsets across projects.

Offsets may be claimed through any of the programmes listed below:

- Toitū
- Ekos
- Climate Active

Offsetting can also be done by the project itself or through another third party through the use of voluntary carbon offsets provided that only eligible offset units are used, namely:

- Certified Emissions Reductions (CERs) issued as per the rules of the Kyoto Protocol from Clean Development Mechanism projects, except for:
    - Long-term (lCERs) and temporary (tCERs), and
    - CERs from nuclear projects, the destruction of trifluoromethane, the destruction of nitrous oxide from adipic acid plants or from large-scale hydro-electric projects not consistent with criteria adopted by the EU (based on the World Commission on Dams guidelines).
- Removal Units (RMUs) issued by a Kyoto Protocol country for land use, land-use change and forestry activities under Article 3.3 or Article 3.4 of the Kyoto Protocol.
- Verified Emissions Reductions (VERs) issued by the Gold Standard, noting that:
    - Abatement recognised by the Gold Standard may be subject to the possibility of double counting; for example, where the abatement occurs in a host country or region that is affected by international or national emissions trading, cap and trade or carbon tax mechanisms. Please see the Gold Standard's Double Counting Guideline for full details.
    - Where the additionality of a VER is ensured through the cancellation of an Eligible Cancellation Unit (as defined by the Gold Standard), that VER is only eligible for use where the applicable Eligible Cancellation Unit would itself have been eligible.
- Verified Carbon Units (VCUs) issued by the Verified Carbon Standard.
- New Zealand emissions units (NZUs) from the New Zealand Emissions Trading Scheme (NZ ETS), provided that:
    - Only NZUs issued for permanent forestry are surrendered. No other type of NZU may be used.
    - All NZUs are voluntarily surrendered. NZUs that must be surrendered for a company to meet its obligations under the NZ ETS cannot be claimed.

This list of eligible carbon offset units comes from the *Climate Active Carbon Neutral Standard for Buildings* (Climate Active, 2022) with additions from Toitū (Toitū, 2022). As per the *Climate Active*

Carbon Neutral Standard for Buildings, this list may be updated as new information and new offset units become available. This may result in the addition of new offset units or the removal of existing offset units.

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