

EMBODIED CARBON CALCULATOR GUIDE NZ V1.1

OCTOBER 2022

DRAFT

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

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

Change Log

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1 INTRODUCTION

This document provides a how-to guide for use of the *Embodied Carbon Calculator NZv1.1* ('the Calculator') developed by the New Zealand Green Building Council (NZGBC) and thinkstep-anz. The Calculator is a tool built in Microsoft Excel that can be used to support projects seeking ratings under the *Green Star – Design & As-Built NZv1.1* 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 Reduction Assessment (Credit 19.1) of *Green Star – Design & As-Built NZv1.1*.
- Long-term Carbon Storage (Credit 19.3) of *Green Star – Design & As-Built NZv1.1*.
- NZGBC's *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 NZGBC's *Green Star NZ Embodied Carbon Methodology* ("the Embodied Carbon Methodology").

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

The Calculator, this document and NZGBC's *Green Star NZ Embodied Carbon Methodology* are intended to align with MBIE's Building for Climate Change (BfCC) programme (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 BfCC programme as it develops.

1.1 Credit 19.1 Upfront Carbon Reduction Assessment

Credit 19.1 of *Green Star – Design & As-Built NZv1.1* requires that all buildings achieve a reduction in upfront carbon for the building to be awarded a star rating. In addition, projects must also demonstrate that Whole-of-Life Embodied Carbon is no higher than that of the Whole-of-Life Embodied Carbon of the Reference Building to show there is no burden shifting to other phases of the building's life.

For projects demonstrating a 30% reduction in upfront carbon emissions or greater (4, 5 or 6 points), the calculations should comply with quality assurance requirements by meeting one of the following two options:

- Option A: The report is produced by an LCA Certified Practitioner, subject to organisational quality assurance, which has been certified in accordance with ISO9001.
- Option B: The report is produced by an Experienced Individual and is peer reviewed by an LCA Certified Practitioner or independent Experienced Individual.

To demonstrate compliance, projects can either:

- Calculate upfront carbon using the Embodied Carbon Calculator, or
- Calculate upfront carbon by modelling the proposed building following the methodology of the 19.2 Comparative Life Cycle Assessment for modules A1 – A5.

1.2 Credit 19.3: Long-term Carbon Storage

Credit 19.3 of *Green Star – Design & As-Built NZv1.1* 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. Note that storage of carbon is excluded as an upfront carbon emissions reduction method in 19.1 Upfront Carbon Reduction Assessment; however, is valid in credit 19.3.

The separation of carbon emissions from carbon removals is in line with the latest consultation documents produced by the New Zealand Government under its draft Building for Climate Change policy framework.

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

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 11).
7. Alternative tools (chapter 12).

2 DEFINITIONS

2.1 Building-Related Terms

Proposed Building: The building works to be rated under *Green Star – Design & As Built NZv1.1* 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 warm shell includes the whole substructure, superstructure and building envelope. 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.

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.

2.2 Project-Related Terms

Project: The same as Proposed Building.

External Works: This includes external carparks, driveways, hard landscaping, external walls and fences, and external drainage. It excludes soft landscaping.

Shared Site: Projects where only some of the buildings on the site will be assessed using the Calculator. Shared Sites are common in precinct-style developments.

Sole Occupant Site: Projects where all buildings on the site will be assessed together.

Practical Completion: The point in a building project when the contracted works have been completed, except for any minor outstanding works, and when possession is transferred to the owner of the building.

2.3 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 CO₂ 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.

2.4 Stages of a Building's Life Cycle

European standards (EN 15978:2011, prEN 15978:2021 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 Figure 1. Only those modules relevant to Whole-of-Life Embodied Carbon are shown.

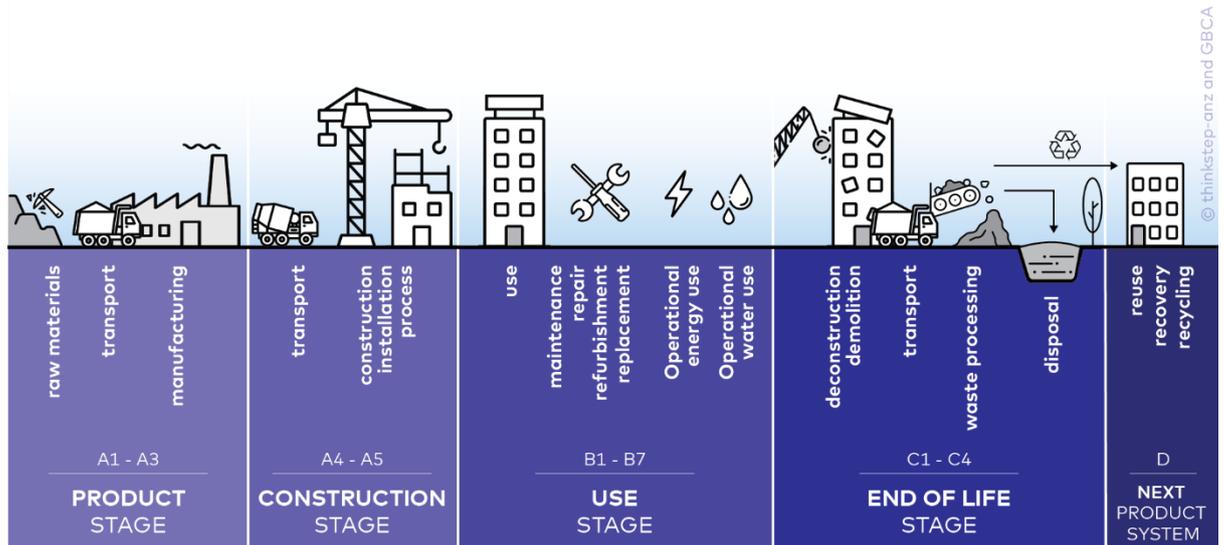


Figure 1: Stages of a building's life cycle (as per EN 15978)

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

Module 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.

Module 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.

2.5 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).

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), operational water use (module B7) and fugitive emissions of refrigerants (module B1). In corporate carbon footprinting, these emissions are known as scope 1 and scope 2 emissions.

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. Depending on the standard followed, it may include or exclude module D (benefits and loads beyond the system boundary).

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 (CO₂e) 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 or GWPL): 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 CO₂ into biomass from all sources except native forests (CEN, 2019, section C.2.4). GWP-stored should be a negative number, as it is a removal of CO₂ 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:

- 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 timber 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 LCA NZ, 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 include 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 Table 1. 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

Building element	Inclusion within <i>Green Star Design & As-Built</i>	Inclusion within <i>Net-Zero Upfront Carbon</i>
Facilitating Works	Yes	Yes
Substructure	Yes	Yes
Superstructure	Yes	Yes
Internal Finishes	Yes	Yes
Fittings, Furnishing, and Equipment	No	No
Services	Yes	Yes
Prefabricated Buildings and Building Units	Yes	Yes
Work to Existing Buildings	Yes	Yes
External Works	Areas for vehicle traffic to be reported separately, but not part of the target	Yes

For more detail, see:

- Appendix A within the Embodied Carbon Methodology.
- “Scope of Analysis” 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 the *Embodied Carbon Methodology*).

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 "Existing Building" sheet, refer to section 10.5.

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 that are not part of delivered building products.
- Glues, sealants, caulking compounds and filling compounds used in small quantities throughout the building and not part of delivered building products. (This exclusion does not apply to mortars, block filling concretes and sealants used in membrane roofs.)
- Doorknobs, door hinges, light switches, power sockets and other minor fittings.

Modules B1 (direct emissions) and 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 of Analysis" 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 is addressed in *Green Star Design & As Built NZv1.1* through Credit 15, Greenhouse Gas Emissions. Operational water is addressed through Credit 16, Potable Water.

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 Design & As Built NZv1.1* 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 Design & As Built NZv1.1*. 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 RICS Elemental Standard Form of Cost Analysis, 4th Edition (RICS, 2012), these non-physical elements are:

- Employer's Requirements
- Main Contractor's Cost Items
- Main Contractor's Overheads
- Main Contractor's Profit
- Consultant's Fees
- Main Contractor's Pre-Construction Fees
- Main Contractor's Design Fees
- Other Development/Project Costs
- Design Development Risks
- Construction Risks
- Employer Change Risks
- Employer Other Risks

4 WHEN TO USE THE CALCULATOR

The Calculator can be used for:

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

The Calculator cannot be used for Credit 19.2 Comparative 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 Upfront Carbon credit of *Green Star – Design & As Built NZ v1.1* and the *Net Zero Upfront Carbon Standard*.

4.1 Use of the Calculator Through the Design Process

For compliance with *Green Star – Design & As-Built NZv1.1* 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 an engineer's estimates.

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 m² NLA. It is part of a retail precinct with 100,000 m² of total NLA and 140,000 m² 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 Design & As-Built NZv1.1

The Calculator returns the results of the upfront carbon assessment, but not the Green Star points. To calculate the points achieved for *Green Star – Design & As Built NZv1.1*, copy the ‘Summary results’ section from the ‘Output – Results’ sheet of the Calculator (Table 2) 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.

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

Summary results (kg CO ₂ e)			
Result (kg CO ₂ e)	Absolute	Per m ²	Credit
Upfront carbon footprint (A1-A5)	245,724	205	19.1
Whole of life embodied carbon (A-D)	208,574	174	19.1
Upfront long-term stored carbon	-37,950	-32	19.2
Demolition impacts that must be offset	68,402	57.00	19.1
Vehicle trafficable surfaces	0	0.00	

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.
- **Base-building certification.** Projects must calculate and offset upfront emissions for all building elements included within the base building (warm shell).
- **Tenant improvements.** Projects must calculate and offset upfront emissions for improvements conducted by, or on behalf of tenants within their contracted area. 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”.

5 OVERVIEW OF CALCULATOR

5.1 Colour Coding

The first sheet of the Calculator, “Read Me”, describes how the Calculator should be used. The colour coding in Figure 2 indicates optional and required data inputs. A cell with a red marker in the top-right corner indicates that a comment is available.

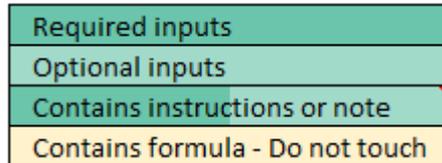


Figure 2: Colour coding of optional and required data inputs

All sheets that take data inputs have the prefix ‘Input –’. Exceptions are the ‘Custom emission factor data’ 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 3 below:

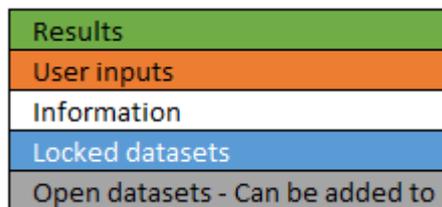


Figure 3: Colour coding of sheets

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 2.5 and section 2.6. 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.

5.2 Progress Bar

The progress bar shown in Figure 4 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 4: Progress bar

5.3 Calculation Methodology

5.3.1 Modules A1-A3 (Upstream Emissions of Materials)

Upstream emissions of materials (modules A1-A3) are based primarily on data from the BRANZ CO₂NSTRUCT 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 emission factor data' sheet.

Carbon footprint results are split into the following four indicators (defined in section 2.6):

- Climate change potential – Total (GWPT) [kg CO₂ eq.]
- Climate change potential – Fossil (GWPF) [kg CO₂ eq.]
- Climate change potential – Biogenic (GWPB) [kg CO₂ eq.]
- Climate change potential – Stored (GWPS) [kg CO₂ eq.]

5.3.2 Upstream Transport

Upstream transportation is calculated based on data provided in the 'Nearest city' and 'Distance from city' fields in the 'Input – Project Data' 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 'Input – Project Data' sheet.

5.3.3 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 'Input – Project Data' 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

5.3.4 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.

5.3.5 Transport to Waste Processing

All materials are assigned emissions from 50km 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.

5.3.6 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.

5.4 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 'Input - 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.

6 SELECTING DATA

6.1 Types of Data Needed

Two types of data are needed to complete a carbon footprint of a building project:

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 CO₂NSTRUCT Database.

NZGBC encourages use of the Calculator throughout the building design and development process to help minimise the carbon footprint of the project.

6.2 Data Quality

6.2.1 Building Quantities

The 'Input data quality' selection is mandatory for all lines. This column contains a dropdown menu as shown below in Figure 5:

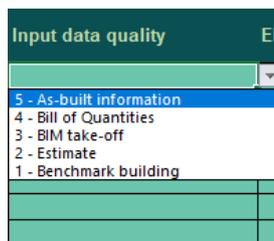


Figure 5: Input data quality dropdown example

This column is specifically related to where you sourced the material quantities. Options are:

- **5 - As-built information:** As-built information is the highest quality level. It applies to information gathered or validated after construction. It must be able to be validated against verifiable documents, such as invoices from building product suppliers and contractors.
- **4 - Bill of Quantities:** A Bill of Quantities (BoQ) or cost plan is a full schedule of material quantities prepared by a costing specialist such as a quantity surveyor or an estimator within a construction firm. While BoQ data is accurate, it may not necessary be updated following construction.
- **3 - BIM take-off:** Data from Building Information Modelling (BIM) is assigned average data quality. BIM can yield both highly accurate and less accurate material quantities depending on how consistently building elements have been coded throughout the building model.
- **2 - Estimate:** At estimate must be specific to the project. The estimate can be made by any relevant building professional.
- **1 - Benchmark building:** The lowest form of data quality is the use of data from a different building – or set of buildings – and scaled to represent the project (e.g., scaled by m²).

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). The column 'Is this a proxy?'

6.2.3 Minimum Data Quality

For building quantities, the following minimum data quality is required to achieve a rating:

- ≥80% as-built information for *Green Star – Design & As Built NZv1.1*.
- ≥95% as-built information for *Net Zero Upfront Carbon Standard*.

For emission factors, 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 23) 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 CO₂NSTRUCT Database for most material emission factors. Accompanying the CO₂NSTRUCT 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 CO₂NSTRUCT Database.

Fuels and transport calculations rely on Manatū Mō Te Taiao's (Ministry for the Environment's) publicly available emission factors from 2022.

Data inputs will be updated annually to maintain accuracy and relevancy.

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

The following preference hierarchy must be applied when choosing emission factors:

- **Product-specific emission factor:** Emission factors that apply to the specific product used in the building shall be used wherever they are available. These emission factors should be:
 - **Producer specific**
 - The emission factors 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.
 - **Independently verified**, following either of the following two 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 section 4.1.1 of the *Embodied Carbon Methodology*). Only product carbon footprints can be accepted, not organisational carbon footprints.
 - Life Cycle Assessments, compliant with EN 15804+A1, EN 15804+A2 or ISO 21930.
- **Generic value 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 in section 4.1.1 of the *Embodied Carbon Methodology*.
 - Generic data, e.g., AusLCI, ecoinvent, 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 remove stored biogenic carbon (GWP-stored) from GWP-total. For guidance, see section 3.2.1 of the *Embodied Carbon Methodology*.
 - Take the highest GWP-total value and use this as the proxy within the Calculator.
 - 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 to the upper quartile, forming an upper fence. All values above this upper fence can be excluded. Take the highest GWP-total of the emission factors remaining and use this as the proxy value within the Calculator.

Table 3: Emissions factor data quality hierarchy¹

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) 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 section 4.1.1 of the *Embodied Carbon Methodology*. 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 this 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 emission factor data' (Figure 6). Please add a new row for each custom material.

		
Green Star Embodied Carbon Calculator		
Component name	Material	Category
Concrete surface finishing	Concrete	Substructure
Propping	Steel	Substructure

Figure 6: 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 0% to 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 CO₂e):** 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 CO₂e):** 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., $GWP-f = GWP-t - GWP-s$.
- **GWP-b (kg CO₂e):** 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 CO₂e):** 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 CO₂e):** 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 $(1 - \text{water content}) * (\text{biogenic carbon content of dry matter}) * (-44/12)$. 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 $-1.65 \text{ kg CO}_2\text{e/kg} = (1-0.1)*(0.5)*(-44/12)$. 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/m³):** 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).
- **EF data quality:** Select one of the options below. Some numbers are deliberately missing as they will be automatically chosen when the user selects if the emission-factor they have selected is for the product used or is a proxy.
 - 1 - Product-specific EPD
 - 2 - Sector-average EPD
 - 4 - Peer-reviewed LCA or CFP
 - 7 - Unreviewed LCA or CFP
 - 9 - Input-output LCA or hybrid LCA

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 "Input – ..." sheets.

6.5 Adding Custom Assemblies

Custom assemblies are reusable building elements that aggregate multiple materials together. This could be one m² 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 m² 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 'INPUT - PROJECT DATA' 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.

Please note that the selection 'Stage of design' under 'Project information' 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.

8 THE 'INPUT - CONSTRUCTION ENERGY' SHEET

The 'Input – Construction 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 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. 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 aggregated information for all contractors is not available, please *either* fill any gaps in your own data with conservative approximations *or* use the following default values:

- Diesel: 4.5 L/m²
- Petrol: 0 L/m²
- Electricity (grid): 37 kWh/m²
- Electricity (on-site renewables or green power): 0 kWh/m²
- Natural gas: 0 kWh/m²

These default values come from One Click LCA and have been used in a range of other studies, e.g., (Arup & WBCSD, 2021).

Note: A later sheet 'Input – Construction Energy (NZUC)' 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 – Design & As Built NZv1.1) to be included. This sheet has the same structure as 'Input – Construction Energy'.

9 MATERIAL INPUT SHEETS

This guidance covers the general function of the following sheets:

- ‘Input – Site Preparation’
- ‘Input – Substructure’
- ‘Input – Superstructure’
- ‘Input – Envelope’
- ‘Input – Fitout’
- ‘Input – Services’
- ‘Input – Formwork’
- ‘Input - Tenant Improve. (NZUC)’
- ‘Input - External works (NZUC)’

This chapter provides detail on how to input data to the input sheets above. Each sheet follows a similar structure, as shown in Figure 7. 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	Component ID	Assembly name	Component name
Slabs		Foundation - Ground beam/strip footing	Concrete
Slabs		Foundation - Ground beam/strip footing	Reinforcing

Figure 7: Example material input sheet (Substructure pictured)

9.1 Adding Additional Rows

As the Calculator is intended to work for any sized building, all material inputs sheets allow for creating unlimited rows downwards. To create new rows, simply input any quantity in a cell directly beneath the last table row; this will automatically expand the table to include this row. Alternatively, right click on the last row of the table and select ‘Insert > Table row beneath’.

9.2 The ‘Category’ Column

This column relates the specific row towards one of the sub-classifications of the building module, i.e., in the ‘Substructure’ module, the available sub-classifications are ‘Slabs’, ‘Piles’, ‘Retaining walls’, and ‘Other’. It is important to group the data correctly using this column as this will relate to the completeness calculations later in the modelling. While these options may not always suit the input data, stay consistent with how your economic data is grouped as that will feed into the calculations in the ‘Input – Completeness’ sheet.

9.3 The 'Component ID', 'Assembly name', and 'Component name' Columns

These columns do not have a function within calculations. They should be used as follows:

- The 'Assembly name' column denotes assembly names for the pre-entered, generic assemblies in the particular building module.
- The 'Component ID' and 'Component name' columns are included for project teams to be able to link items entered into the Calculator to items from their Bill of Quantities / Cost Plan.

Using these columns will assist both the user and verifier to keep track of what each row is representing.

9.4 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.

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.

9.5 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.

9.6 The 'Source' Column

This column is used to indicate where your material was sourced from. The dropdown menu contains some of the most common countries/cities for sourcing material but may have gaps for your modelling. If the required country/city is not available in the dropdown, please select the geographically closest alternative. E.g., if your material was sourced from Uruguay, Brazil will be the closest alternative.

Source proxies can be documented with an Excel 'note' or written into the 'material description' column.

9.7 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' LCA datasheets will be used in its place.

This percentage is *additional* to your entered amount i.e., 10 tonnes of concrete with 20% waste input is equal to 10 tonnes of concrete + 2 tonnes of construction waste, totalling 12 tonnes of concrete.

9.8 The 'Estimated completeness %' Column

This column takes a percentage input representing the line item's coverage (by cost) of its total sub-category in the building module. This allows the user to indicate the total coverage of the sub-category over multiple lines and enables extrapolation of the remaining quantity.

E.g., if the user has modelled four different materials covering 25%, 50%, 10%, and 12% of the 'External Solid Walls' sub-category each, this will indicate to the Calculator that 97% of the 'External Solid Walls' sub-category is covered. This information is then used to extrapolate the remaining 3% based on the 97% existing coverage.

10 OTHER DATA INPUT SHEETS

10.1 The 'Input – Completeness' sheet

This function of this sheet is to calculate the completeness of each building module, and 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 and align the categorisation used in this sheet with the 'estimated completeness %' inputs in the material input sheets. 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).

10.2 The 'Input – Trafficable surfaces' 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.

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).

10.3 The 'Input – Concrete 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.

10.4 The 'Input – construction 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).

10.5 The 'Existing building' 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 do 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.

11 RESULTS

Two sheets are provided for the LCA results:

- ‘Output – Results’
- ‘Output – Additional results’

11.1 The ‘Output – Results’ Sheet

The main results of the Calculator are presented in the ‘Summary results’ table (Figure 8):

- **Upfront carbon footprint (A1-A5):** This is used to award points for Credit 19.1 of *Green Star – Design & As Built NZv1.1*.
- **Whole-of-life embodied carbon footprint (A-D):** This is used to ensure that burdens have not been shifted from upfront carbon to whole-of-life carbon under Credit 19.1 of *Green Star – Design & As Built NZv1.1*.
- **Upfront long-term stored carbon:** This is used to award points for carbon storage following 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.
- **Vehicle trafficable surfaces:** This is the carbon footprint of vehicle trafficable surfaces, such as uncovered carparks, driveways and hardstands. This carbon footprint falls outside of the dipline and is therefore outside of the scope of the main upfront carbon assessment. However, it is a reporting requirement under *Green Star – Design & As Built NZv1.1*.

			
Green Star Embodied Carbon Calculator			
Summary results (kg CO₂e)			
Result (kg CO₂e)	Absolute	Per m²	Credit
Upfront carbon footprint (A1-A5)	472,383	394	19.1
Whole of life embodied carbon (A-D)	394,979	329	19.1
Upfront long-term stored carbon	-19,800	-17	19.3
Demolition carbon footprint to offset	398,175	332	19.1
Vehicle trafficable surfaces	89,145	74.29	n/a

Figure 8: 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 – Design & As Built NZv1.1*, 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 9). 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 CO2e)			
Life Cycle Module	GHG emissions	GHG removals	GHG total
A1-A3 (building products)	427,070	-19,800	407,270
A4 (transport of products to site)	26,008	0	26,008
A5 (construction)	19,306	0	19,306
B1 (direct emissions)	0	0	0
B3-B5 (materials replacement)	0	0	0
C1 (deconstruction/demolition)	198	0	198
C2 (transport of scrap off-site)	2,113	0	2,113
C3 (waste processing for recycling)	5,015	0	5,015
C4 (landfill and incineration)	1,804	0	1,804
D (benefits and loads beyond the system boundary)	1	-86,506	-86,505
Total Upfront	472,383	-19,800	452,583
Total Embodied	481,515	-106,306	375,208

Figure 9: 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 10 below for upfront carbon.

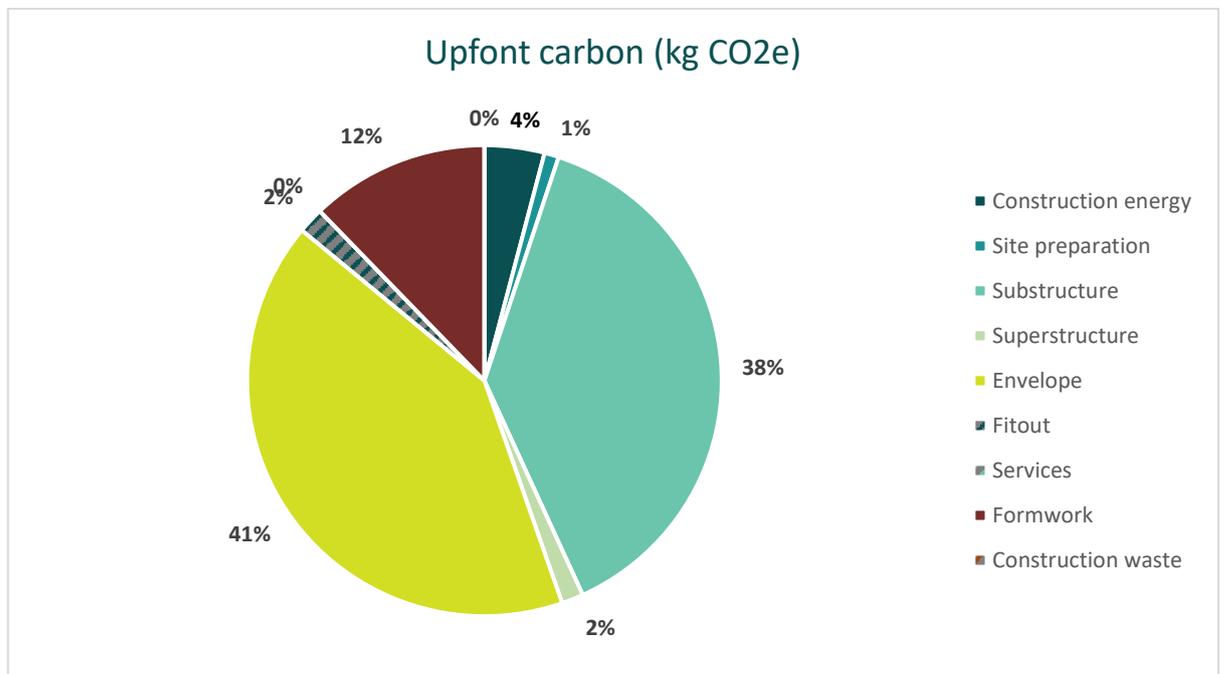


Figure 10: Chart showing contributions to upfront carbon

A detailed breakdown of carbon footprint results is available in Figure 11 below. The emissions breakdown has the following two axes:

- **Building modules** (rows) correspond to each of the major ‘Input’ 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 2.4. 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 m² results.

Climate Change - Upfront (kg CO2e)												
Green Star	A1-A3	A4	A5	B1	B3-B5	C	D	Upfront carbon	Embodied whole of life	Upfront carbon	Embodied whole of life	
Construction energy			19,306					19,306	19,306	16	16	
Site preparation	4,650	0		0	0	295	0	4,650	4,945	4	4	
Substructure	158,123	21,969		0	0	1,979	-33	180,092	182,038	150	152	
Superstructure	2,980	4,039		0	0	1,216	-2,753	7,019	5,482	6	5	
Envelope	195,330	0		0	0	540	-83,720	195,330	112,149	163	93	
Fitout	8,367	0		0	0	91	0	8,367	8,458	7	7	
Services	0	0		0	0	0	0	0	0	0	0	
Formwork	57,620	0						57,620	57,620			
Construction waste			0					0	0	0	0	
Total	427,070	26,008	19,306	0	0	4,122	-86,506	472,383	389,999	394	325	
Net-Zero Upfront Carbon	A1-A3	A4	A5	B1	B3-B5	C	D	Upfront carbon	Embodied whole of life	Upfront carbon	Embodied whole of life	
Total	427,072	26,008	19,306	0	0	4,122	-86,506	472,385	390,000	394	325	

Figure 11: Detailed upfront carbon results per life cycle stage and module, for both Green Star and Net-Zero Upfront Carbon

11.1 The ‘Output – Additional results’ 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.

12 ALTERNATIVE TOOLS

NZGBC's intention is to approve alternative tools that meet the requirements of the Embodied Carbon Methodology. As the Embodied Carbon Methodology and Calculator were developed in parallel, no alternative tools were approved as at the time of launch. However, 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.

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