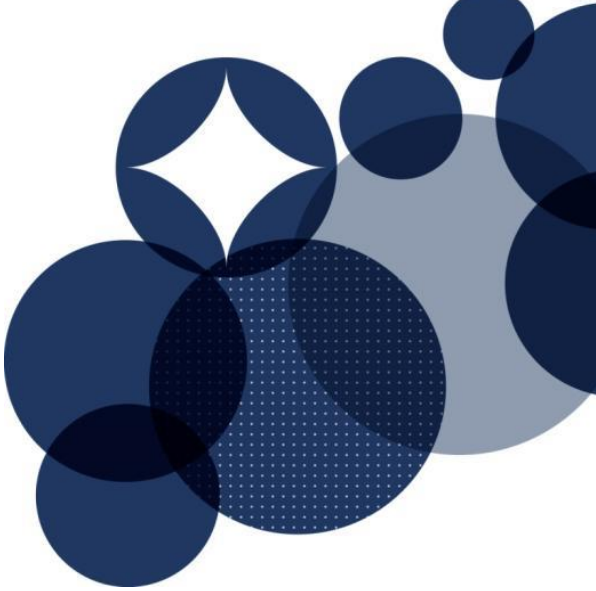

GREEN STAR NZ EMBODIED CARBON METHODOLOGY

MAY 2023

greenstar

NZGBC
TE KAUNIHERA HANGANGA TAUTAIAO

Document Information

For information on this document, please contact:

New Zealand Green Building Council
(09) 379-3996
greenstarnz@nzgbc.org.nz

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

Change Log

Release	Date	Description of changes
v0.2	15/07/2022	DRAFT for discussion
v0.3	14/10/2022	Revised DRAFT for consultation
v1.0	01/05/2023	Final version following consultation

Use of Trademarks

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

Intellectual Property Rights & Confidentiality

Table of Contents

1 INTRODUCTION

This document provides an overview of the core methodology and calculation requirements for:

- Upfront Carbon Reduction Assessment (Credit 19.1) in *Green Star Design & As-Built NZ v1.1*.
- The standalone *Net Zero Upfront Carbon Standard*.

Elements of this methodology (e.g., the definition of the reference building) can also be applied to the Comparative Life Cycle Assessment Credit (Credit 19.2) of *Green Star Design & As-Built NZ v1.1*. For this credit, please also refer to the *Life Cycle Impacts Calculator Guide*.

This document describes the requirements for both upfront carbon and whole-of-life embodied carbon. *Green Star Design & As Built NZ v1.1* awards points based on a reduction in upfront carbon. A minimum reduction in upfront carbon of 10% is required to achieve a Green Star rating. Whole-of-life embodied carbon must be reported but it is not part of the points calculation.

This document describes the underlying methodology behind the calculations within the *Embodied Carbon Calculator* (the "Calculator"), to enable organisations to apply the same methodology within their own tools and calculators. This document is not a how-to guide on the use and application of the Calculator. This information is contained within the separate *Embodied Carbon Calculator Guide* (the 'Calculator Guide').

The Calculator, this document and the Calculator Guide are intended to align with MBIE's Building for Climate Change (BfCC) programme (MBIE, 2022), even though BfCC is not yet final at the time of publication.

This document is structured as follows to outline:

1. Definitions of key terms.
2. A description of the scope of NZGBC's upfront carbon and whole-of-life embodied carbon methodology.
3. A description of the methods used to calculate various carbon footprints in alignment with NZGBC's methodology.
4. Appropriate selection of data to align with NZGBC's methodology.
5. Reporting requirements for NZGBC's certification programmes.
6. An indication of relevant upfront carbon targets.

Within this document, 'carbon' and 'carbon emissions' mean carbon dioxide equivalent and include all sources of greenhouse gas emissions. Carbon dioxide equivalent is calculated using the Intergovernmental Panel on Climate Change's (IPCC's) Global Warming Potential indicator over a 100-year time horizon (GWP100).

1.1 Reference Standards

This methodology is based on European standards for building life cycle assessment, EN 15978:2011 (CEN, 2011) and prEN 15978-1:2021 (CEN, 2021), and the international standard for product carbon footprinting, ISO 14067:2018 (ISO 2018). It contains additional guidance specific to upfront carbon and whole-of-life embodied carbon assessments as used in NZGBC's suite of rating tools.

All references to rating tools refer to NZGBC-owned rating tools for use in New Zealand.

1.2 Design Principles

This methodology is based on the following design principles:

- **Polluter pays:** The polluter should bear the environmental cost of carbon pollution caused by their activities.
- **Precaution/conservativism:** Where there is uncertainty in data, worst-in-class values should always be used as a conservative approach. This provides an incentive to get better data, as better data should reduce the carbon footprint of the building.
- **Additionality:** Improvements must go over-and-above business-as-usual. The methodology should not seek to reward behaviour which would happen anyway, on average.

1.3 Use of this Methodology

The intended audiences for this document are:

- Project teams applying the Upfront Carbon Credit (Credit 19.1) and/or Comparative Life Cycle Assessment Credit (Credit 19.2) in *Green Star Design & As-Built NZ v1.1*.
- Project teams applying for a rating under the *Net Zero Upfront Carbon Standard*.
- Tool developers seeking to implement the *Green Star NZ Embodied Carbon Methodology* in their own LCA/carbon calculator tools.

This methodology accompanies the *Embodied Carbon Calculator Guide* and *Net Zero Upfront Carbon Standard*. The reader should be aware that all three documents will likely evolve over time to reflect user feedback and to continue to align with MBIE's BfCC programme as it develops.

This methodology may be applied at any point in the building design life cycle, from early concept design through to delivery of the finished building. Use at the concept stage is encouraged to help drive lower carbon outcomes. However, the precision of the data will necessarily be lower at this early stage. Final Built submissions under *Green Star Design & As-Built NZ v1.1* and the *Net Zero Upfront Carbon Standard* must be based on the actual materials used in construction of the finished building. Actual material quantities must be auditable through invoices from material suppliers and contractors.

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.

Project: The same as Proposed Building.

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.

External Works: This includes external carparks, driveways, hard landscaping, external walls and fences, and external drainage. It also includes land use change across the whole site. It excludes soft landscaping.

2.2 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 Figure 1. Only those modules relevant to Whole-of-Life Embodied Carbon are shown.

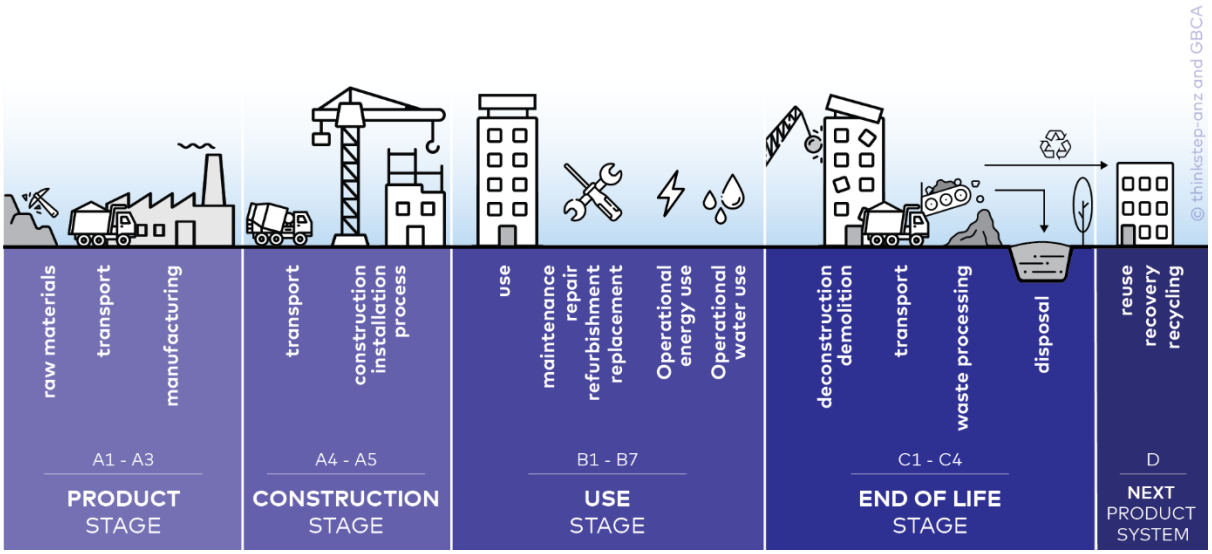

Figure 1: Stages of a building's life cycle (as per EN 15978)

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.

2.3 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 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.

2.4 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).

2.5 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 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 CO_2 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 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:

- 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.

2.6 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 Building Types

This methodology is primarily aimed at non-residential buildings, though it can also be applied to residential buildings. A building with multiple uses, such as an office with hotel and retail spaces, must be considered as one entity. In line with this approach, where fixed targets are used, these targets must be adjusted based on the share of each building type (see section 8.1.1).

3.2 Geographic Scope

This methodology is not country specific; however, all default values and some definitions are specific to Aotearoa New Zealand.

3.3 Life Cycle Stages

The following life cycle modules shall be included for **Upfront Carbon**:

- **A1-A3:** Building product manufacture
- **A4:** Transport of building products to site
- **A5:** Construction of the building and disposal of construction waste.

The following life cycle modules shall be included for **Whole-of-Life Embodied Carbon**:

- **A1-A5:** Upfront Carbon (as above)
- **B3-B5:** Use stage embodied carbon
- **C1-C4:** End-of-life embodied carbon

Results must also be calculated and reported for:

- **D:** Benefits and loads beyond the system boundary.

These modules come from EN 15978:2011 (CEN, 2011) and EN 15804:2012+A2:2019 (CEN 2019). Modules **B1** and **B2** are optional as they likely fall below the cut-off criteria. Modules **B6** and **B7** are excluded as they apply to operational carbon.

Only Upfront Carbon is considered for the points calculation within *Green Star Design & As-Built NZ v1.1*. Whole-of-Life Embodied Carbon must be calculated and reported separately for monitoring purposes, but it is not part of the points calculation.

3.4 Declared Unit

The declared unit for both Upfront Carbon and Whole-of-Life Embodied Carbon is **kg CO_2e/m^2 GFA**, which is kilograms of carbon dioxide equivalent per square metre of Gross Floor Area (GFA).

NZGBC's definition of GFA is applied:

> *The total floor area of all parts of a building that are permanently covered and can be protected from the elements. For purposes of Green Star, car parking (including under cover car parking) should not be included in the GFA, unless stated otherwise.*

Further guidance is provided by the New Zealand Institute of Quantity Surveyors (NZIQS, 2018, p. 1), with the notable difference that NZGBC does not allow car parking within the building's dripline to be considered:

> *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.

The project shall also report on Upfront Carbon and Whole-of-Life Embodied Carbon at a building-wide level, using kg CO_2e as the functional unit.

3.5 Building Elements

The building elements (Modules A1-A3) included within the carbon footprint shall:

- **Be part of the warm shell.** The warm shell includes the whole substructure, superstructure and building envelope. NZGBC defines warm shell as: “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.” (NZGBC, 2022, p. 7)
- **Be permanent.** This includes all building elements designed to be a permanent part of the building, including permanent walls (whether structural or non-structural) and fire doors. It excludes non-permanent walls, doors or kitchenettes installed as part of a tenant fit-out. Temporary installations required during site preparation or construction must be included.
- **Fall inside the dripline** of the building(s) under analysis. The dripline is the furthest outward projection of the building, typically the outside edge of the building’s roof.
- **Include ancillary buildings only if they provide core parts of the building services** required to deliver a warm shell.

External areas designed for vehicle traffic (car parks, hardstands, driveways, etc.) shall be reported separately. External areas are not part of the fixed benchmark at this stage.

Buildings seeking to comply with the *Net Zero Upfront Carbon Standard* must also include:

- **All permanently installed building elements up until the point the building is occupied by the first tenant.** This includes items that may not last the life of the building, such as partition walls, additional cabling for tenants, kitchenettes, etc. It excludes non-permanent fittings and furniture.
- **External works.** This includes external carparks, driveways, hard landscaping, external walls and fences, and external drainage. It also includes land use change across the whole site (e.g., if a forest is cut down and replaced with a grassed area). It excludes soft landscaping.

A list of building elements included within the carbon footprint is provided in Table 1. A fuller list of inclusions and exclusions following the RICS building element classification is included in Appendix A: Detailed Scope of Building Elements. Where certain building elements are not clearly part of the warm shell or the fit-out, these elements must be included in the carbon footprint as a conservative approach.

Table 1: Building elements in scope of assessments

Building element	**Inclusion within *Green Star Design & As-Built***	**Inclusion within *Net-Zero Upfront Carbon***
Facilitating Works	**Yes**	**Yes**
Substructure	**Yes**	**Yes**
Superstructure	**Yes**	**Yes**

Internal Finishes	**Yes**	**Yes**
Fittings, Furnishing, and Equipment	**No**	**No**
Services	**Yes** (refer to 'Appendix A: Detailed Scope of Building Elements')	**Yes** (refer to 'Appendix A: Detailed Scope of Building Elements')
Prefabricated Buildings and Building Units	**Yes**	**Yes**
Work to Existing Buildings	**Yes** (refer to 'Appendix A: Detailed Scope of Building Elements')	**Yes** (refer to 'Appendix A: Detailed Scope of Building Elements')
External Works	**Areas for vehicle traffic to be reported separately**, but not part of the target	**Yes** (refer to 'Appendix A: Detailed Scope of Building Elements')

3.6 System Boundary

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

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 (unless these are likely to be material to the results), such as:
    - Manufacture of earthmoving equipment and cranes used for construction.
    - Manufacture of trucks used for transportation.
    - Manufacture of machinery used to manufacture building products.
    - (In all cases, emissions from operating machinery and vehicles must be included.)
- Transport of staff to and from the construction site.
- Electricity used off-site for professional services.

Please note:

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

3.7 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. (Sealants used in membrane roofs applied on-site must be included in the study.)

- Doorknobs, door hinges, light switches, power sockets and other minor fittings.

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.

4 CALCULATION METHODOLOGY

4.1 Carbon Footprint

All carbon footprint calculations shall be performed using Global Warming Potential over a 100-year time horizon (GWP100) in line with ISO 14067:2018 (ISO, 2018). The most recent characterisation factors from the Intergovernmental Panel on Climate Change (IPCC) should be used where possible. At the time of writing, the IPCC Sixth Assessment Report (AR6) contains the most recent factors (IPCC, 2021). However, GWP100 factors following older assessment reports and following EN 15804 may also be used.

The total carbon footprint – **GWP-total** – is the sum of three constituent parts:

- **GWP-fossil:** Carbon footprint arising from fossil sources.
- **GWP-biogenic:** Carbon footprint arising from biogenic sources.
- **GWP-LULUC:** Carbon footprint due to land use and land use change.

The components of GWP above (fossil, biogenic and LULUC) derive from EN 15804+A2. An additional indicator, GWP-stored, is introduced here specifically for Green Star as long-term stored carbon is rewarded separately within Credit 19.3 of *Green Star Design & As-Built NZ v1.1*.

GWP-stored is the GWP avoided by removals of CO_2 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 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.

Results must be calculated following EN 15804+A2

4.2 Upfront Carbon

Upfront Carbon shall be calculated as the sum of carbon emissions from:

- Modules A1-A3: Carbon emissions from the manufacture of products and materials used in the building.
- Module A4: Transport of building products to site.
- Module A5: Site preparation works and construction of the building. This includes:
    - The use of energy in machinery on-site for site preparation (e.g., site clearing and levelling) and construction (e.g., excavation for the foundation and erection of the building). If a previous building was present on the site, only include the work after the previous building(s) was (were) demolished and the materials for disposal have been put into skips or stockpiles for collection.
    - Production, transport and end-of-life treatment of materials that become construction waste.

The intention of the Upfront Carbon methodology is to calculate the gross carbon footprint. As such, the following must be excluded from the calculation:

- Carbon offsets. NZGBC's forthcoming *Net Zero Upfront Carbon Standard* addresses carbon offsets as part of building carbon neutrality.
- Stored biogenic carbon. This must be reported separately as GWP-stored (see section 4.2.1).

4.2.1 Removing GWP-stored for bio-based products

Depending on the standard followed, GWP-total and GWP-biogenic may either include or exclude GWP-stored for products that contain stored biogenic carbon. This methodology requires GWP-stored to be excluded from Upfront Carbon and reported separately. As such, GWP-stored must be manually removed if it is included.

Standards that require GWP-stored to be included are:

- EPDs produced to EN 15804+A2:2019

- EPDs produced to EN 15804+A1:2013 and EN 16485:2014
- EPDs, LCAs and CFPs produced to ISO 14067:2018

For other EPDs, LCAs and CFPs, GWP-stored needs to be assessed on a case-by-case basis. Where it is not explicitly stated in the study, a large negative carbon footprint (i.e., carbon removal) from cradle-to-gate and a large positive carbon footprint (i.e., carbon emission) at end-of-life normally indicates that GWP-stored is included.

Where GWP-stored is included in GWP-total and GWP-biogenic:

- GWP-total (Upfront Carbon) = GWP-total (as reported) - GWP-stored
- GWP-biogenic (Upfront Carbon) = GWP-biogenic (as reported) - GWP-stored

Where the GWP-stored is unknown, it can be calculated as (1 - water content) * (biogenic carbon content of dry matter) * (-44/12). Commonly, the biogenic carbon content of absolutely dry wood 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.

4.3 Whole-of-Life Embodied Carbon

Whole-of-Life Embodied Carbon (modules A-C) shall be calculated as the sum of carbon emissions from:

- Modules A1-A5: Upfront Carbon, as calculated in section 4.2 above.
- Module B1: Direct emissions from the building, which may be zero. This can also include carbon removals through carbonation of concrete where this can be shown to be significant. It excludes leakage of refrigerants from HVAC systems, as these are considered as an operational emission.
- Module B2: Emissions from maintenance of the building. This includes washing, repainting and repointing of mortar. This module can be excluded if it is believed to be below the cut-off rules.
- Modules B3 to B5: Repair and renovation of the building. This includes replacement of some or all building elements from the upfront carbon assessment. The carbon footprint of the individual building elements (including transport to site) must be calculated in accordance with EN 15978:2011 and EN 15804:2012+A2:2019. Disposal of the old building elements shall be calculated as for Modules C1 to C4 below.
- Modules C1 to C4: Demolition of the building, transport of building products to waste treatment and the waste treatment process (recycling, landfill, composting or incineration).

Whole-of-Life Embodied Carbon (modules A-D) shall be calculated as the sum of:

- Modules A-C (as above).
- Module D: Avoided impacts from recovery of building elements. Module D must be calculated and reported separately to other modules.

As with Upfront Carbon, carbon offsets must be excluded. Carbon offsets are used within NZGBC's *Net Zero Upfront Carbon Standard* instead.

4.4 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 upfront carbon calculation (incorporating modules A1-A3) must be completed for the demolished portion.

Where the existing building is between 30 and 50 years old, the contribution of upfront 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.

The upfront emissions of the demolished materials, and the demolition process (modules C1-C4), must be offset through the purchase of carbon credits that meet the requirements set out in the Calculator Guide.

For those projects required to offset existing building elements, the reused building elements may then be considered as having 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.

4.5 Buildings Within a Precinct

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

5 DATA REQUIRED PER LIFE CYCLE MODULE

5.1 Building Products (Modules A1-A3)

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

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

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 bill of quantities or cost plan) that has been updated during or following construction to reflect the actual quantities and specific materials/products used in the finished building.

For guidance regarding the selection of appropriate data, refer to chapter 6.

5.2 Transport to Site (Module A4)

The emissions of transporting building products, formwork and machinery to/from site and the empty return trip should be calculated by multiplying the total mass from a given location by the corresponding emission factors in Table 2. These emission factors are from the Ministry for the Environment (MfE, 2022) and are expressed in kilograms of carbon dioxide equivalent per tonne-kilometre of freight moved. (Alternative emission factors from an LCA database may also be used if preferred.) If multiple modes of transport are used (e.g., truck and ship), both should be calculated and the emissions summed together. Emissions do not need to be calculated product-by-product – what is important is the total tonne-kilometres of transport for each mode of transport.

Example:

- 2,000 kg of scaffolding is moved to the construction site from a warehouse at the start of the project. It remains on-site for the duration of the project, after which it is moved back to the same warehouse. The distance from the warehouse to the site is 30 km. The truck travels across an urban area in both directions.
- GWP-Total = (30 km + 30 km) * (2,000 kg / 1,000 kg/t) * (0.390 kg CO_2e/tkm)
- GWP-Total = 46.8 kg CO_2e

Table 2: Emission factors for transportation (source: MfE, 2022)

Transport mode	GWP-Total = GWP-Fossil (kg CO_2e/tkm)
Truck (urban delivery)	0.390
Truck (long-haul heavy truck)	0.105
Rail	0.027
Ship (containerised cargo)	0.046
Ship (break-bulk cargo)	0.030
Air (domestic)	4.494
Air (international – Australia and Pacific Islands)	2.302

Transport mode	GWP-Total = GWP-Fossil (kg CO_2e/tkm)
Air (international – long-haul)	1.019

5.3 Construction (Module A5)

Module A5 includes three main components:

- Manufacturing construction products that are wasted on-site (Modules A1-A3 + A4)
- Disposal of construction waste
- On-site construction impacts, including site preparation, excavation and erection of the building.

Default scrap rates and end-of-life fates per material type are included in **Error! Reference source not found.**. These values shall be used wherever project specific data is not available.

Default emissions from the use of energy for on-site construction is shown in Table 3. The emission factors are from the Ministry for the Environment (MfE, 2022). The electricity emission factor includes transmission and distribution losses.

The default values in Table 3 shall be used where site specific data is unavailable. Due to a lack of data, these values are based on OneClick LCA defaults as used in other studies (e.g., Arup & WBCSD, 2021). Where primary data are collected for the site, energy use must include all trades and subtrades over the duration of the project.

Note: Transport of construction equipment to and from site shall be included in Module A5.

Table 3: Emission factors for on-site construction

Energy source	Unit	Emission Factor (kg CO_2e/Unit)	Default (Unit/m^2)	Default (kg CO_2e/m^2)
Diesel	L	2.69	4.50	12.11
Petrol	L	2.46	0	0.00
Electricity	kWh	0.116	37.0	4.28
Total	**n/a**	**n/a**	**n/a**	**16.39**

Where construction takes place on a greenfield site, the effect of land use change (GWP-LULUC) must be considered. Only the land area that is transformed needs to be included in the calculation – if some of the land on the property remains in its original form then this should not be included.

5.4 Direct emissions (Module B1)

Module B1 (direct emissions from the building) includes:

- Any carbon emitted from building components during the life of the building, e.g., release of greenhouse gases from HFC blown insulation.
- Carbonation of concrete during the building's life (as a carbon removal).

Leakage of refrigerants from HVAC systems is excluded as this is considered to be an operational emission.

Module B1 can be assumed to be under the cut-off rules and therefore excluded from the study, unless there is a good reason to assume that it should be included.

5.5 Maintenance (Module B2)

Module B2 includes:

- Washing the building
- Repainting
- Repointing mortar.

Module B2 can be assumed to be under the cut-off rules and therefore excluded from the study, unless there is a good reason to assume that it should be included.

5.6 Repair, Replacement and Renovation (Modules B3 to B5)

Whole-of-Life Embodied Carbon calculations should use a building life of 50 years and the replacement rates specified in **Error! Reference source not found.**. Any deviations from this shall be justified and agreed with NZGBC via a Technical Question.

5.7 Building End-of-Life (Modules C1 to C4 and D)

Whole-of-Life Embodied Carbon calculations should use the assumptions provided in **Error! Reference source not found.**. Any deviations from this shall be justified and agreed with NZGBC via a Technical Question.

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 CO_2NSTRUCT Database.

6.2 Building Quantities

The following preference hierarchy must be applied to select building quantities:

- **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.
- **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.
- **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.
- **Estimate:** At estimate must be specific to the project. The estimate can be made by any relevant building professional.
- **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 m^2).

The "estimate" and "benchmark building" data categories are suitable for early design stages. However, projects submitted for rating should be based on "as-built information" to the greatest extent possible.

6.3 Emission Factors

The following preference hierarchy must be applied to select 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 (EPDs) 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 **Error! Reference source not found.**). 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 from database:** The BRANZ CO_2NSTRUCT Database and the list of generic emission factors for key materials in Appendix B: Generic Emission Factors shall be used as the core database where there is no product-specific emission factor.
- **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 4 shall be applied as follows:

  Working from the top to the bottom of Table 4 (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 **Error! Reference source not found.**.
        - 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 as per section 4.2.1.
    - 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 4: Emissions 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) 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 **Error! Reference source not found.**. 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, may 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 align with the system boundary of EN 15804 or ISO 21930.

6.4 Minimum Data Quality Required

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

- ≥80% as-built information
- ≤5% based on estimates and/or benchmark buildings (or, if no data exists, cut off as per section 3.7)
- The remainder can be based on a BoQ or BIM take-off.

This percentage shall be calculated as the share of material cost covered by the project, excluding non-material costs such as labour, profit margins and taxes. If labour and margins cannot be excluded from some line items, they should be included for all line items. In both cases, exclude the cost of land and non-physical items, such as professional services and taxes.

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).

7 REPORTING

7.1 Reporting Methods

As MBIE's Building for Climate Change programme continues to evolve, there will be greater expectations for new projects in New Zealand to report on upfront carbon emissions, whole-of-life embodied carbon emissions and operational emissions.

Projects are encouraged to report in alignment with MBIE's Building for Climate Change Methodology as well as to demonstrate compliance with relevant NZGBC standards.

Those projects using the Calculator to demonstrate compliance with upfront carbon reduction targets within Credit 19 are required to report on only upfront carbon emissions associated with building elements in scope (i.e., modules A1-A5 and the "GHG emissions kg CO_2e/building" column in Table 5).

Those projects using the Calculator to demonstrate compliance with upfront carbon requirements within the *Net-Zero Upfront Carbon Standard* are required to report on upfront carbon emissions for modules A1-A5 below for those building elements in scope of assessment. Refer to the *Net-Zero Upfront Carbon Standard* and relevant pathway for the building elements in scope of assessment. Projects are required to report on any greenhouse gas removals separately to emissions (i.e., modules A1-A5 in all columns in Table 5 and Table 6 below).

Those projects using the Calculator to report on upfront carbon emissions in alignment with MBIE's Building for Climate Change programme are required to report on all life cycle modules in the below table. Greenhouse gas emissions and greenhouse gas removals must be reported separately.

Reporting is required both at the whole building level and at the gross floor area (GFA) level (m^2).

Table 5: Whole building reporting requirements

Life Cycle Module	GHG emissions (kg CO_2e/building)	GHG removals (kg CO_2e/building)
A1-A3 (building products)		[i.e., long-term storage of carbon within building products]
A4 (transport of products to site)		
A5 (construction)	[i.e., onsite fuel/energy use during construction]	
B2 (maintenance)	[can be omitted as likely below cut-off criteria]	[can be omitted as likely below cut-off criteria]
B3+B4+B5 (materials replacement)		
C1 (deconstruction/demolition)		
C2 (transport of scrap off-site)		
C3 (waste processing for recycling)		
C4 (landfill and incineration)		
D (benefits and loads beyond the system boundary)		

Table 6: Gross Floor Area reporting requirements

Life Cycle Module	GHG emissions (kg CO_2e/m^2)	GHG removals (kg CO_2e/m^2)
A1-A3 (building products)		[i.e., long-term storage of carbon within building products]
A4 (transport of products to site)		
A5 (construction)	[i.e., onsite fuel/energy use during construction]	
B2 (maintenance)	[can be omitted as likely below cut-off criteria]	[can be omitted as likely below cut-off criteria]
B3+B4+B5 (materials replacement)		
C1 (deconstruction/demolition)		
C2 (transport of scrap off-site)		
C3 (waste processing for recycling)		
C4 (landfill and incineration)		
D (benefits and loads beyond the system boundary)		

7.2 Reporting Units

Reporting shall be split into the following categories:

- Upfront Carbon inside the dripline: kg CO_2e per m^2 GFA **and** kg CO_2e total (i.e., two values)
- Upfront Carbon including External Works: kg CO_2e per m^2 GFA **and** kg CO_2e total (i.e., two values)
- Stored Carbon inside the dripline: kg CO_2e per m^2 GFA **and** kg CO_2e total (i.e., two values)
- Whole-of-Life Embodied Carbon inside the dripline: modules A-C **and** modules A-D, following EN 15804+A2 **and** EN 15804+A1, kg CO_2e per m^2 GFA **and** kg CO_2e total (i.e., eight values)

Reporting for *Net Zero Upfront Carbon Certification* shall also declare (reported on separately to above):

- Upfront Carbon in External Works: kg CO_2e per m^2 GFA **and** kg CO_2e total (i.e., two values)
- Whole-of-Life Embodied Carbon in External Works: kg CO_2e per m^2 GFA **and** kg CO_2e total (i.e., two values)

7.3 Carbon emissions and removals

The reporting of carbon removals, such as long-term stored carbon within materials and benefits beyond the system boundary (i.e., Module D), must be accounted for and reported upon separately to carbon emissions. In alignment with MBIE's Building for Climate Change, reports should present a high-level summary differentiating between carbon emissions and removals. An example of this is displayed below. [1]

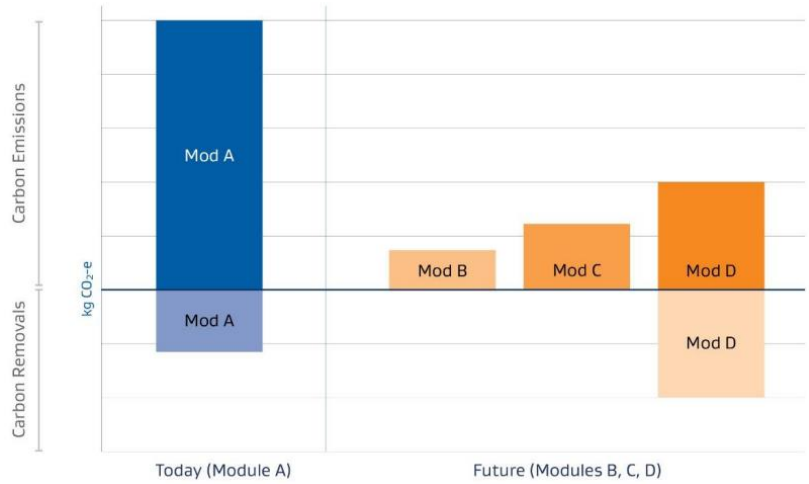

Figure 7-1: Reporting of carbon emissions and removals (MBIE, 2022)

[1] Obtained from MBIE's 'Whole-of-Life Embodied Carbon Assessment: Technical Methodology' document.

8 TARGETS

Two pathways will be possible in future:

1. Absolute Value Pathway (section 8.1)
2. Reference Building Pathway (section 8.2)

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.

8.1 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 7 and Table 9, 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 7: Targets for Upfront Carbon

	Reduction vs national average	Mid- to high-rise buildings	Warehouse-type buildings	Low-rise buildings	Residential-type buildings
Baseline (2022)		[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 8: 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 (2022)		[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

8.1.1 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).

8.2 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 standard contemporary construction and operation practices (i.e., a business-as-usual design). The reference building shall be agreed through consultation with structural, mechanical, electrical, and architectural professionals.

The choice of Reference Building must be justified to show that it represents the business-as-usual design that would likely have been constructed at the site had the project not chosen to pursue a Green Star rating.

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 burden of proof to demonstrate the Reference Building is appropriate lies with the project team. In general, there are four levels (from the least to the highest burden of proof):

1. The **same material quantities** are used for both the Reference Building and the Proposed Building. The only differences are differences in the level of cement replacement in concrete, recycled content in metals and sourcing of key materials (e.g., sourcing of aluminium in the façade).

   In this case:

   a. The reduction in environmental impact comes solely from intra-material substitution, i.e., replacing.one material with a lower carbon version of the same material category – concrete with low-carbon concrete, steel with low-carbon steel, timber with low-carbon timber, etc.

   b. The only documentation required from the project team is the material quantities used (to demonstrate that they are the same for both the Reference Building and the Proposed Building) and the specific materials used for both buildings.

2. The same building with **partial material replacement**. Examples might include replacement of the mid-floors in a high-rise building (reinforced concrete vs composite steel decking vs cross laminated timber), or the replacement of structural beams (steel vs. reinforce concrete vs. engineered timber).

   In this case:

   a. The reduction in environmental impact may come from a combination of intra-material substitution (point #1 above) and inter-material substitution (this point).

   b. In this case, either the standard material choices in Table 9 to Table 12 must be used for the Reference Building or the project team must supply a letter or report from a structural engineer declaring what the most likely ‘business as usual’ material specification would have been.

3. **Significant material replacement with the same floor area, exterior shape and building orientation.** In this case the same building form is adopted but the structural materials differ significantly. For example, changing from one structural system (reinforced concrete, steel-framed, engineered timber or stick timber) to another for a large portion of the building.

   In this case, the same requirements as point #2 above apply; however, the project team will likely need to place greater reliance on a structural engineer and/or quantity surveyor to provide the alternative material quantities for the Reference Building. In either case, a signed letter or report is required.

4. **A different building.** The project team must provide documentation of early-stage upfront carbon assessments and justify that reducing upfront carbon was a significant factor in changing the building’s design. If you wish to pursue this option, please first submit a Technical Question to NZGBC.

The tables in this section (Table 9 to Table 12) should 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 at the time of publication, as used for a specific element in each building type. This is a significant simplification of reality because building specifications differ based on the project and the site, and many buildings will use a mixture of materials for the same building element. While these specifications should guide the default material choices for the Reference Building, deviations are allowed provided they are justified. The greater the deviation from these tables, the stronger the justification should be.

Where the design of a building must meet additional requirements that are not allowed for in Table 9 to Table 12, the project can submit a Technical Question to NZGBC to apply to use an alternate set of materials for the Reference Building. The Technical Question must include justification of the additional requirements (e.g., based on geological conditions, cyclone ratings, or similar). The Reference Building specification shall be based on typical present-day business-as-usual construction methods, rather than the worst available.

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 9.
- **Warehouse-type buildings**: Table 10.
- **Low-rise buildings**: Table 11.
- **Residential-type buildings**: Table 12.

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 9: 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 10: 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 11: 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 12: 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.

8.2.1 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.

9 REFERENCES

- Arup & WBCSD (2021). *Net-zero buildings: Where do we stand?* Geneva: World Business Council for Sustainable Development.
- BSI (2011). *PAS 2050:2011: Specification for the assessment of the life cycle greenhouse gas emissions of goods and services*. British Standards Institution.
- BRANZ (2021). *CO_2NSTRUCT Database.* Porirua: Building Research Association of New Zealand.
- CEN (2011). *EN 15978:2011: Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method.* Brussels: European Committee for Standardization.
- CEN (2019). *EN 15804:2012+A2:2019: Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products.* Brussels: European Committee for Standardization.
- CEN (2021). *prEN 15978-1:2021: Sustainability of construction works – Methodology for the assessment of performance of buildings – Part 1: Environmental Performance.* Brussels: European Committee for Standardization.
- DNV GL (2018). *Emission-reduction potential of fossil- and emission-free building and construction sites*. Oslo: Climate Agency, City of Oslo.
- IEPDS (2024). *PCR 2019:14 Construction Products v1.2.* Stockholm: International EPD System.
- IPCC (2021). *Climate Change 2021: The Physical Science Basis.* Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, USA: Cambridge University Press.
- ISO (2018). *ISO 14067:2018: Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification.* Geneva: International Organization for Standardization.
- ISO (2019). *ISO 21930:2017: Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services.* Geneva: International Organization for Standardization.
- MBIE (2022). *Whole-of-Life Embodied Carbon Assessment: Technical Methodology*. Wellington: Ministry for Business, Innovation and Employment.
- MfE (2022). *Measuring emissions: A guide for organisations: 2022 summary of emission factors.* Wellington: Ministry for the Environment.
- NZGBC (2022). *Green Star – Design & As Built NZv1.0 Fitout Scope: Guidance for Integrated, Cold Shell and Warm Shell Fitouts.* Auckland: New Zealand Green Building Council.
- NZIQS (2018). *The Quantity Surveyor's Handbook.* 5th Edition. Wellington: New Zealand Institute of Quantity Surveyors.
- RICS (2012). Elemental Standard Form of Cost Analysis. 4th Edition. London: Royal Institution of Chartered Surveyors.

APPENDIX A: DETAILED SCOPE OF BUILDING ELEMENTS

Two tables are included, both following the building element classification of RICS (2012):

- Table 13 is for *Green Star Design & As Built NZ v1.1*
- Table 14 is for Net Zero Upfront Carbon Standard.

Table 13: Building elements in scope (by RICS categories) in the Upfront Carbon credit under Green Star Design & As Built NZ v1.1

Level 1	Level 2	Included?	Reason for exclusion	Notes
0 Facilitating Works	0.1 Toxic/Hazardous/Contaminated Material Treatment	YES		
	0.2 Major Demolition Work	NO	Previous building	Included in the previous building's life cycle and offset if needed (see section 4.4)
	0.3 Temporary Supports to Adjacent Structures	YES		
	0.4 Specialist Groundworks	YES		
	0.5 Temporary Diversion Works	NO	Below cut-off rules	Can be included as part of the categories above if likely to be material
	0.6 Extraordinary Site Investigation Works	NO	Below cut-off rules	Can be included as part of the categories above if likely to be material
1 Substructure	1.1 Substructure	YES		
2 Superstructure	2.1 Frame	YES		
	2.2 Upper Floors	YES		
	2.3 Roof	YES		
	2.4 Stairs and Ramps	YES		
	2.5 External Walls	YES		
	2.6 Windows and External Doors	YES		
	2.7 Internal Walls and Partitions	PARTLY		Only include permanent walls and partitions (i.e. part of warm shell). Non-permanent partition walls are out of scope.
	2.8 Internal Doors	PARTLY		Only include permanent doors (i.e. part of warm shell). Doors in non-permanent partition walls are out of scope.
3 Internal Finishes	3.1 Wall Finishes	YES		These must be included for the warm shell based on a likely scenario, even if not delivered under the contract

Level 1	Level 2	Included?	Reason for exclusion	Notes
	3.2 Floor Finishes	YES		These must be included based on a likely scenario, even if not delivered under the contract
	3.3 Ceiling Finishes	YES		These must be included based on a likely scenario, even if not delivered under the contract
4 Fittings, Furnishings and Equipment	4.1 Fittings, Furnishings and Equipment	NO	Not part of the warm shell	
5 Services	5.1 Sanitary Installations	PARTLY		Only include services delivered as part of the warm shell
	5.2 Services Equipment	NO	Included below	Major mechanical, electrical and plumbing (MEP) services are already split by category below
	5.3 Disposal Installations	YES		Only include services delivered as part of the warm shell
	5.4 Water Installations	YES		Only include services delivered as part of the warm shell
	5.5 Heat Source	NO	Include with HVAC	
	5.6 Space Heating and Air Conditioning	YES		Only include services delivered as part of the warm shell
	5.7 Ventilation Systems	NO	Include with HVAC	
	5.8 Electrical Installations	YES		Only include services delivered as part of the warm shell
	5.9 Fuel Installations	NO	Include with HVAC	Likely not applicable in a green building which are tending towards fully electric
	5.10 Lift and Conveyor Installations	YES		Only include services delivered as part of the warm shell
	5.11 Fire and Lightning Protection	YES	Below cut-off rules	
	5.12 Communication, Security and Control Installations	YES		Only include services delivered as part of the warm shell
	5.13 Specialist Installations	YES		Only include services delivered as part of the warm shell
	5.14 Builder's Work in Connection with Services	NO	Below cut-off rules	
6 Prefabricated Buildings and Building Units	6.1 Prefabricated Buildings and Building Units	YES		
7 Work to Existing Building	7.1 Minor Demolition and Alteration Works (Strip Out)	YES		
	7.2 Repairs to Existing Services	YES		
	7.3 Damp-Proof Courses/Fungus and Beetle Eradication	YES		

Level 1	Level 2	Included?	Reason for exclusion	Notes
	7.4 Façade Retention	YES		
	7.5 Cleaning Existing Surfaces	NO	Below cut-off rules	
	7.6 Renovation Works	NO	Included above	Specific forms of renovation are already provided above
8 External Works	8.1 Site Preparation Works	NO	Included above	Other forms of site preparation are already included in Facilitating Works
	8.2 Roads, Paths, Pavings and Surfacings	REPORT SEPARATELY	Not within the dripline	
	8.3 Soft Landscaping, Planting and Irrigation Systems	NO	Not within the dripline	
	8.4 Fencing, Railings and Walls	NO	Not within the dripline	
	8.5 External Fixtures	NO	Not within the dripline	
	8.6 External Drainage	NO	Not within the dripline	
	8.7 External Services	NO	Not within the dripline	
	8.8 Minor Building Works and Ancillary Buildings	NO	Not within the dripline	
9 Main Contractor's Preliminaries	9.1 Employer's Requirements	NO	Non-physical	
	9.2 Main Contractor's Cost Items	NO	Non-physical	
10 Main Contractor's Overheads and Profit	10.1 Main Contractor's Overheads	NO	Non-physical	
	10.1 Main Contractor's Profit	NO	Non-physical	
11 Project/Design Team Fees	11.1 Consultant's Fees	NO	Non-physical	
	11.2 Main Contractor's Pre-Construction Fees	NO	Non-physical	
	11.3 Main Contractor's Design Fees	NO	Non-physical	
12 Other Development/Project Costs	12.1 Other Development/Project Costs	NO	Non-physical	
13 Risk (Client's Contingencies)	13.1 Design Development Risks	NO	Non-physical	
	13.2 Construction Risks	NO	Non-physical	
	13.3 Employer Change Risks	NO	Non-physical	
	13.4 Employer Other Risks	NO	Non-physical	

Table 14: Building elements included and excluded (by RICS categories) in Net Zero Carbon Certification (changes from D&AB in bold)

Level 1	Level 2	Included?	Reason for exclusion	Notes
0 Facilitating Works	0.1 Toxic/Hazardous/Contaminated Material Treatment	YES		
	0.2 Major Demolition Work	NO	Previous building	Included in the previous building's life cycle and offset if needed (see section 4.4)
	0.3 Temporary Supports to Adjacent Structures	YES		
	0.4 Specialist Groundworks	YES		
	0.5 Temporary Diversion Works	YES		
	0.6 Extraordinary Site Investigation Works	YES		
1 Substructure	1.1 Substructure	YES		
2 Superstructure	2.1 Frame	YES		
	2.2 Upper Floors	YES		
	2.3 Roof	YES		
	2.4 Stairs and Ramps	YES		
	2.5 External Walls	YES		
	2.6 Windows and External Doors	YES		
	2.7 Internal Walls and Partitions	YES		All walls must be included, both permanent and non-permanent partition walls.
	2.8 Internal Doors	YES		All doors must be included.
3 Internal Finishes	3.1 Wall Finishes	YES		
	3.2 Floor Finishes	YES		
	3.3 Ceiling Finishes	YES		
4 Fittings, Furnishings and Equipment	4.1 Fittings, Furnishings and Equipment	NO	Not permanently installed in building	Items that are not permanently installed in the building (furniture, loose cabinets, rugs) are out of scope.
5 Services	5.1 Sanitary Installations	YES		Include all sanitary installations
	5.2 Services Equipment	NO	Included below	Major mechanical, electrical and plumbing (MEP) services are already split by category below
	5.3 Disposal Installations	YES		Include all disposal installations
	5.4 Water Installations	YES		Include all water installations

Level 1	Level 2	Included?	Reason for exclusion	Notes
	5.5 Heat Source	NO	Include with HVAC	
	5.6 Space Heating and Air Conditioning	YES		Include all space heating and air conditioning services
	5.7 Ventilation Systems	NO	Include with HVAC	
	5.8 Electrical Installations	YES		Include all electrical installations
	5.9 Fuel Installations	NO	Include with HVAC	Likely not applicable in a green building which are tending towards fully electric. Include if relevant.
	5.10 Lift and Conveyor Installations	YES		Include all lift and conveyor installations
	5.11 Fire and Lightning Protection	YES		
	5.12 Communication, Security and Control Installations	YES		Include all communication, security and control installations needed to support the building itself
	5.13 Specialist Installations	YES		Include all specialist installations needed to support the building itself
	5.14 Builder's Work in Connection with Services	YES		
6 Prefabricated Buildings and Building Units	6.1 Prefabricated Buildings and Building Units	YES		
7 Work to Existing Building	7.1 Minor Demolition and Alteration Works (Strip Out)	YES		
	7.2 Repairs to Existing Services	YES		
	7.3 Damp-Proof Courses/Fungus and Beetle Eradication	YES		
	7.4 Façade Retention	YES		
	7.5 Cleaning Existing Surfaces	NO	Below cut-off rules	
	7.6 Renovation Works	NO	Included above	Specific forms of renovation are already provided above
8 External Works	8.1 Site Preparation Works	NO	Included above	Other forms of site preparation are already included in Facilitating Works
	8.2 Roads, Paths, Pavings and Surfacings	YES		
	8.3 Soft Landscaping, Planting and Irrigation Systems	NO	Below cut-off rules	Very little data is available and modelling is complicated by plants sequestering biogenic carbon
	8.4 Fencing, Railings and Walls	YES		
	8.5 External Fixtures	YES		

Level 1	Level 2	Included?	Reason for exclusion	Notes
	8.6 External Drainage	YES		
	8.7 External Services	YES		
	8.8 Minor Building Works and Ancillary Buildings	YES		
9 Main Contractor's Preliminaries	9.1 Employer's Requirements	NO	Non-physical	
	9.2 Main Contractor's Cost Items	NO	Non-physical	
10 Main Contractor's Overheads and Profit	10.1 Main Contractor's Overheads	NO	Non-physical	
	10.1 Main Contractor's Profit	NO	Non-physical	
11 Project/Design Team Fees	11.1 Consultant's Fees	NO	Non-physical	
	11.2 Main Contractor's Pre-Construction Fees	NO	Non-physical	
	11.3 Main Contractor's Design Fees	NO	Non-physical	
12 Other Development/Project Costs	12.1 Other Development/Project Costs	NO	Non-physical	
13 Risk (Client's Contingencies)	13.1 Design Development Risks	NO	Non-physical	
	13.2 Construction Risks	NO	Non-physical	
	13.3 Employer Change Risks	NO	Non-physical	
	13.4 Employer Other Risks	NO	Non-physical	

APPENDIX B: GENERIC EMISSION FACTORS

Please see the “Database” sheet in the Embodied Carbon Calculator for a full table.