Green Building Council Australia

NZGBC
TE KAUNIHERA HANGANGA TAUTAIAO

Ngā wāhi pai ke atu, tūturu

Better places, proven

A practical guide to upfront carbon reductions

For new buildings and major refurbishments

December 2023

We're grateful to our colleagues at Green Building Council Australia and their partners for the Practical Guide to Upfront Carbon Reductions for the Australian market. It forms the reference for the creation of this version for Aotearoa New Zealand.

NZGBC
TE KAUNIHERA HANGANGA TAUTAIAO

The New Zealand Green Building Council represents more than 700 organisations across Aotearoa with a combined annual turnover of more than $40billion. Our vision is for all homes and buildings in Aotearoa to be green and sustainable, making healthier, happier New Zealanders.

Green Building Council Australia

Established in 2002, Green Building Council of Australia (GBCA) is the nation's authority on sustainable buildings, communities and cities. Our vision is for healthy, resilient and positive places for people.
Our purpose is to lead the sustainable transformation of the built environment. GBCA represents more than 550 individual companies with a combined annual turnover of more than $46 billion.

Technical partners

Beca

Beca is one of Asia Pacific's largest independent advisory, design and engineering consultancies. We create value through understanding and delivering successful solutions, exceptional service and our enduring relationships and use our skills and systems to empower innovation; helping our clients shape communities, optimise their assets and streamline their operations.

MOTT MACDONALD

Mott MacDonald has been contributing to projects in Australia for over 40 years and continues today with a range of complex engagements in transport, advisory, built environment, water and energy. As a leading multidisciplinary buildings consultant in Australia, we specialise in building structures and services, and engineering sciences.

We bring the advanced systems and infrastructure that you would expect from a 18,000 strong global organisation, realised in our Australia offering of 1,250 staff.

Principal partner

lendlease

Lendlease is proud to be principal partner of the Practical guide to upfront carbon reductions. As a global integrated real estate group, we draw on decades of experience and the latest thinking in development, design, placemaking, construction and investments to deliver iconic and inclusive places for everyone. We're a 1.5 degree aligned company and aim to create $250 million of social value by 2025. We have clear decarbonisation plans in place and we measure the positive impact we are making in communities around the world.

GBCA thanks Lendlease for their contributions in this guide, and for allowing the use of their "Low Embodied Carbon Guideline" which has informed various sections.

Funding partners

NSW GOVERNMENT

The National Australian Built Environment Rating Scheme (NABERS) is a world-leading national government program that provides simple, reliable and comparable sustainability measurements across multiple building sectors like offices, hotels, shopping centres and more. NABERS provides an annual rating for a building's efficiency in energy, water, waste or indoor environment quality. Over the last 20 years NABERS has proven that measurement leads to better management. Buildings that have obtained NABERS ratings for a decade achieve energy savings of 30-40% on average.

Sustainability Victoria

Sustainability Victoria's purpose is to transition Victoria to a circular, climate-resilient economy. Sustainability Victoria does this by contributing to achieving the Government's targets for 2025 and 2030 in recycling and net-zero emissions. We work together in partnership with our stakeholders in industry, business, entrepreneurs, research institutions, schools, households, individuals, community groups and governments within Victoria and across Australia. To achieve our goals, SV will lead and support industries on how we design, make, and use the products and materials in our economy.

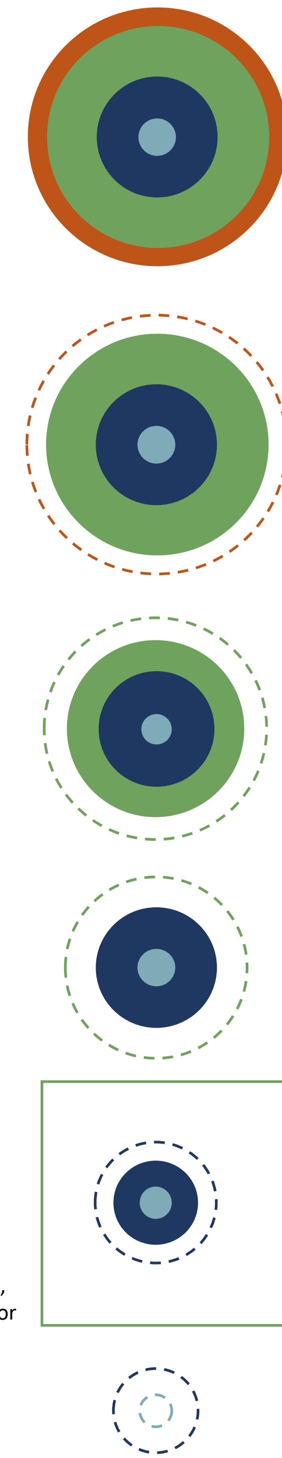
The information provided in this guide is for illustrative purposes only. In all cases, building owners are encouraged to consult with dedicated professionals to assist them in reducing upfront carbon emissions.

How to use this guide

This guide provides information on reducing upfront carbon emissions in new buildings and major refurbishments. The guide outlines steps to be taken during the design and construction process and offers solutions for common challenges. It is intended to be used alongside the embodied carbon methodology guide released in 2023.

Delivering Climate Positive Buildings

The diagram shows typical steps to decarbonise buildings. This guide covers how to reduce upfront carbon emissions. It addresses absolute reductions of carbon in the material production and construction processes. Separate guides[3] exist on making new and existing buildings fossil fuel free. We encourage you to apply these steps throughout your portfolio.



Standard building

Measure typical greenhouse gas (GHG) emissions due to energy use and construction, repair, maintenance & refurbishment and end of life.

Fossil fuel free

Eliminate natural gas for space heating, domestic hot water and cooking, both base building and tenants.

Highly efficient

Significantly reduce all building energy consumption through demand reduction, energy efficiency and effective controls.

Powered by renewables

Provide all electricity from 100% renewable sources – on-site and/or off-site.

Built with lower upfront carbon

Significantly reduce upfront carbon through material/product selection during design and construction.

This guide

Offset with nature[4]

After reducing all other GHG emissions as much as possible, procure credible nature-based offsets.

Legend

GHG EMISSIONS	USED FOR
Natural gas	Space heating, domestic hot water and cooking.
Electricity	Ventilation, cooling, lighting, pumps, small power, lifts, security, controls, and IT systems.
Other	Emergency (backup) power, and refrigerants.
Materials	Emissions from products, materials and activities for repair, maintenance and refurbishment.

Everything you wanted to know about upfront carbon (but were afraid to ask)

There are several terms and concepts that you should know about upfront carbon, including its definition, calculation, and significance.

What are upfront carbon emissions?

Upfront carbon emissions are produced during a building's material production and construction activities before its use.

Is it different to embodied carbon?

Upfront carbon is a tangible part of a building's embodied carbon, reflecting past actions rather than future projections.

What defines embodied carbon?

Embodied carbon includes upfront carbon (A1 to A5) and emissions from the use and end-of-life stages of a building (B1 to B5 and C1 to C4, respectively). It is defined in the EN 15978 Standard.[5]

How much of a problem is it?

Today, around half of a typical building's emissions occur during the upfront carbon stage[6] which cannot be changed once the building is constructed as these emissions are already spent and buildings become more operationally efficient.

What can I do about it?

To tackle upfront carbon, build with less, reduce and optimise virgin material usage, and use low-carbon materials and construction technologies.

How hard is it to reduce it?

Reducing upfront carbon is easiest during planning and early-stage design are where the largest reductions can be achieved with the least effort. As construction begins, options become more limited, and there is much less that can be done to reduce upfront carbon once the building is operational apart from upgrade or re-fit of elements.

How do I calculate it?

Calculating upfront carbon involves determining the amount of each material used in a building and multiplying it by the carbon content per unit of use. Material databases provide generic carbon information, whilst a product's Environmental Product Declaration (EPD) can offer product specific carbon content details.

Two main methods of calculation are comparison against a fixed benchmark or a Reference Project. Calculating against a reference requires defining both the reference and actual buildings.

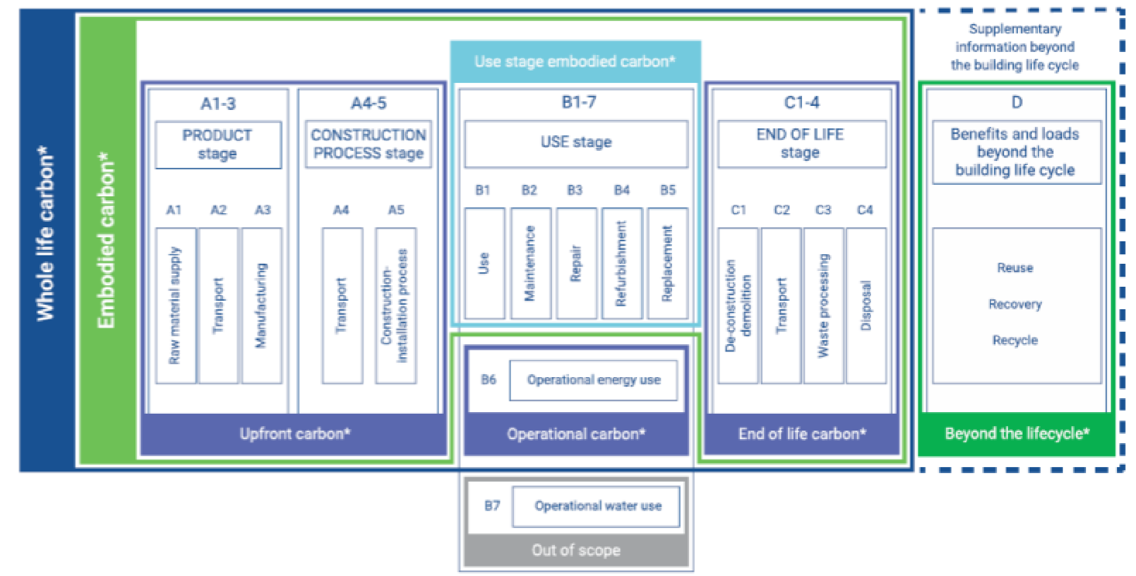


Figure 1: Embodied carbon over the life of an asset adapted from "Embodied Carbon in Green Star: Supporting Analysis" thinkstep-anz 2022

I heard that you can't trust calculations or compare buildings?

Assumptions in upfront carbon calculations can vary in scope, input data, and more. However, assuming the same conditions and if reviewed by a third party, comparisons between buildings should be relevant. The NZGBC Embodied Carbon Guidance released through 2022 and 2023, particularly the Embodied Carbon Methodology guide, will help reduce variability in assumptions and increase confidence in calculations and comparisons. Transparency in calculations and assumptions is paramount to enabling comparison.

Why not focus on whole life carbon or operating emissions?

To date, industry has focused on operational emissions. As we decarbonise the grid, upfront carbon emissions during design and construction become more impactful and cannot be reduced post building completion. Early design also offers the opportunity to maximise energy efficiency and reduce operating emissions.

Also, in Aotearoa New Zealand, electricity from the grid has lower emissions than typically seen elsewhere in the world - meaning embodied emissions are proportionately more impactful over a building's lifetime than in other countries.

Although it's essential to consider other emissions, doing so should not come at the expense of upfront carbon or operations, which are more easily influenced early on. Reducing other embodied carbon emissions is also vital, but reducing upfront emissions has a greater impact on a building's carbon footprint today.

How is upfront carbon addressed by Green Star?

Green Star has requirements for all projects to reduce their upfront carbon to obtain a rating. Green Star uses a reference building comparison. Once enough building benchmarks are obtained, comparison against real life benchmark data will be allowed.

The case for reducing upfront carbon

Climate change, health and wellbeing, natural resource depletion, consumer preferences, investor demand - these are key issues that are impacting how we develop or refurbish buildings in our cities. Key to these challenges is how we transform our methods of construction to reduce and eliminate our upfront carbon.

The built environment represents about 40% of all emissions worldwide. Of those emissions[8], 10% comes from construction activities. In New Zealand, approximately 20% of our emissions emerge from the built environment, with around 10% embodied in building materials.

At a building level, upfront carbon emissions from materials and construction activities are around half of a building's lifetime emissions. While currently a slightly smaller proportion than a building's operating emissions, upfront emissions are spent on the day the building opens – they can never be changed.

As we move into a decarbonised world, buildings with lower upfront emissions are key to reducing our sector's emissions. These buildings are more attractive to investors as they demonstrate the developer and builder are responsible entities. Upfront carbon emissions are also being highlighted in sustainability reporting frameworks and initiatives, as they are considered part of an entity's scope 3 emissions. New draft guidance from the Science-based Targets Initiative (SBTI) also includes architects and engineers among those who need to consider embodied carbon emissions as part of their scope 3 reporting.

Lower upfront carbon emissions are in the spotlight in Aotearoa NZ, as the government (through MBIE's Building for Climate Change Programme) has signalled embodied carbon caps for buildings from 2026, with mandatory reporting from 2025 for all buildings submitting for building consent. MBIE will be developing these caps through industry partnership to collate existing building data.The External Reporting Board of NZ also requires mandatory disclosure of scope 3 emissions from constructing buildings for a range of entities across the country. In the business case for lowering upfront carbon emissions, the following factors can be considered:

- **Climate change**: Reducing the impacts of the built environment through decarbonising the sector. As operational carbon is reduced through renewable electricity and energy efficiency measures, embodied carbon emissions become the focus, representing a larger proportion of total emissions.[13]
- **Investor benefits:** Investors are looking for assets with a clear decarbonisation pathway. Lower upfront carbon buildings will have access to sustainable finance (Green Bonds and Loans), potentially at lower interest rates.[14] The rise of scope 3 reporting and its inclusion in corporate net zero targets means that upfront carbon is no longer an optional consideration.[15]
- **Tenant and consumer preferences**: Many organisations have set goals for decarbonising assets that they own or lease. By reporting on upfront emission reductions, organisations will be better informed about the spaces they occupy.

International and domestic policies driving upfront carbon action

IEA's zero carbon ready definition

In May 2021, the International Energy Agency released 'Net Zero by 2050: A roadmap for the energy sector'.[14] Within this report, the IEA set out its path for the building sector - Zero-carbon-ready buildings. In addition to zero-carbon-ready buildings being highly energy efficient sourcing renewable energy using an energy supply that will be fully decarbonised by 2050, the IEA recognises Scope 3 emissions, those in modules A1-A5 (the modules this guide addresses).

The IEA recommends building codes be adjusted to target net-zero emissions from material use in buildings.

External Reporting Board (XRB) climate-related disclosures

In October 2021, the Financial Sector (Climate-related Disclosures and Other Matters) Amendment Bill was passed. The XRB subsequently published the Aotearoa New Zealand Climate Standards, which are modelled off the TCFD reporting framework. Reporting entities include all large listed companies, building societies, managers of investment schemes, and some Crown financial institutions. [34] In response the NZGBC developed the Climate Scenarios for the Construction and Property Sector.

MBIE's Building for Climate Change Programme

BFCC was established in 2020, and released the Whole-of-life embodied carbon emissions reduction framework in the same year. From 2025, it is proposed that all buildings submitting for building consent will be required to report on their whole-of-life embodied carbon impacts, with A1-A5 emissions expected to be reported separately. Operational emissions will also be included in reporting requirements. From 2026, maximum caps will be introduced on embodied and operational carbon, with these progressively reducing through to 2030.

Carbon Neutral Government Programme

The CNGP is targeting carbon neutrality by 2025. The programme applies to all government owned and funded entities. Government procurement requires all new non-residential buildings with a capital value of over NZD $9M to obtain certification through an approved rating tool. At this time, the only approved tool for buildings is Green Star Design & As-Built - meaning relevant buildings will be required to achieve minimum reductions in up-front embodied carbon. This minimum reduction is currently 10% (or higher depending on the level of certification sought), and is set to increase incrementally over time.

The investor case for reducing upfront carbon

Net zero asset owners' alliance

Made up of institutional investors, the UN's Net Zero Asset Owner Alliance (NZAOA) is committed to transition their investment portfolios to net-zero by 2050 (or consistent with a 1.5C maximum temperature rise).

Specifically, members are tasked with engaging in financial services regulation and economic policy through climate policy engagement. Additionally, members pledge to steward the assets they control within their portfolio through corporate alignment due to the perceived "obstructive climate policy engagement" by investees which "can slow sectoral… decarbonisation and the transition to net zero". The net zero asset owners' alliance has called for scope 3 emissions to be considered.[18]

Taskforce for climate related financial disclosure (TCFD)

Created by the Financial Stability Board, the TCFD has been charged with recommending the information companies disclose to investors, insurance underwriters and lenders to help them assess and price climate related risks. TCFD guidance is now commonly used by boards of real estate companies, and guidance is expanding to note that scope 3 emissions are a key material risk that needs to be addressed.[19] The NZGBC Climate Scenarios for the Construction and Property Sector can be viewed here.

Market solutions driving change

Upfront carbon requirements in Green Star

The Green Star Design & As-built tool (v1.1) allocates a significant proportion of one credit to Upfront Carbon Emissions Reduction compared to a reference building. Projects seeking a rating under Green Star Design & As-Built (or Green Star Buildings when this is introduced) must reduce upfront carbon by at least 10% (Conditional Requirement). Higher ratings will require larger percentage reductions, and these minimum requirements will increase over time. By 2028, projects seeking a 6 star rating will be required to achieve minimum reductions of 40%. To assist with the carbon calculations, NZGBC has released a suite of guidance including an embodied carbon methodology guide and embodied carbon calculator. More information can be found in Green Star Design & As-Built Submission Guidelines.

NZGBC Net Zero Up-Front Carbon (Expected early 2024)

This certification will require mandatory minimum reductions in up-front embodied carbon compared to a reference building. Calculations from the Upfront Carbon Emissions credit in Green Star Design and As Built v1.1 may be used to inform this aspect of the certification. All remaining upfront embodied carbon emissions will be required to be offset using certified offset purchases. Biogenic sequestration is not included.

ILFI Net Zero Carbon certification

Projects seeking International Living Futures Institute Net Zero Carbon certification are required to achieve minimum 10% reduction on a reference building for upfront carbon reductions, as well as meeting an overall maximum upfront embodied carbon cap of 500 kg CO_2e / m^2. Remaining emissions may either be inset through biogenic sequestration / on-site renewable energy generation or offset through certified offset purchases.

What is a typical building's upfront carbon?

The upfront carbon of a building per square meter can vary greatly depending on several factors, such as the building materials used, the size and complexity of the building, and the location and climate. There are several studies that point to a range of expected emissions per square metre for multiple building types. These studies have been made across various countries, including Australia, and all point to similar numbers. The table below synthesises them and aims to provide a reference.

	$kgCO_2e/m^2$ GFA (A1-A5)	
	Low	**High**
Commercial	500	1000
Education (primary and secondary)	300	800
Education (tertiary)	750	1000
Health	500	1000
Industrial	350	500
Multi-unit residential	600	800
Public building	500	800

Table 1: The estimates developed for this table should be considered indicative. The values vary based on data sources, boundaries, scale, location and other factors.
To arrive at these figures, we considered the following studies:

- Slattery (2022)[7]
- ISTRUCTE (2022)[23]
- CLF (2017)[24]
- ARUP (2021)[25]
- Built (2021)[26]
- LETI (2022))[36]

It's important to note that these estimates are just a rough guide, and that the actual upfront carbon of a building will depend on a range of factors that are specific to the project. These numbers cannot be used to define reductions but can be used to test calculations against.

These estimates also do not account for any biogenic carbon, storage, or offsets.

Where is the upfront carbon?

In general, most of the building's upfront carbon is in the superstructure (suspended floors, structural walls, columns and beams), substructure (foundations, basement retaining walls and ground slabs) and envelope.

Prioritising these elements during design and material choice yields the highest opportunity to reduce upfront carbon.

Figure 2: Typical breakdown of construction upfront carbon in a new office building[6]

The lifespan of different building elements also vary with the superstructure and substructure being able to last the longest. By maximising the lifespan of the most carbon intensive elements, this reduces the need for replacement and additional upfront carbon emissions associated with new construction.

Transportation of products and materials

Heavy transport vehicles have proven difficult to decarbonise to date. However, the automotive industry has broadly started to electrify heavy commercial vehicles that will assist the built environment reducing the A4 module emissions for their projects. In addition to reduced carbon emissions, there are obvious benefits for developers and society with reduced air and noise pollution from these vehicles. [28]

Construction equipment emissions

Construction machinery and equipment, typically fueled by fossil fuels[5] are also a source of upfront carbon in construction. Fossil Free Construction requires the reduction of fossil fuels such as diesel, petrol and LPG to power site office, construction machinery and equipment. Electric Vehicles, and renewable fuels such as diesel and biofuels are options currently accessible to the sector as we move towards electrification.

Published last year, Lendlease and University of Queensland's report *Stepping Up the Pace: Fossil Fuel Free Construction* outlined a roadmap for removing fossil fuels from construction sites.[28]

How to measure upfront carbon?

Upfront carbon can be measured by determining the quantity of a specific product and its specific product emissions (modules A1 to A3) and the associated construction emissions (modules A4 to A5). The calculation is not complex, once all the information from the product's emissions is available.

A more comprehensive calculation can be done through a life cycle analysis (LCA) calculation. An LCA will provide more information than just upfront carbon and may yield valuable insights and potential opportunities for improving a building beyond upfront carbon reductions.

For projects that use building information modelling (BIM) tools, plug-ins allow live assessment of design changes on upfront carbon results. BIM can also be used to create 'digital twins' of buildings that provide a repository or bank of materials data, including material specification and emissions content.

Alternatively, upfront carbon assessments can be undertaken using a combination of quantity estimate data and product emissions factors from EPDs. These emissions factors can be found individually or compiled in databases such as BRANZ CO_2NSTRUCT, a New Zealand-specific database which is updated annually and is free to download. There are also many purpose-built LCA tools and software with embedded databases, one example being the NZGBC Green Star Embodied Carbon Calculator, which adapts the CO_2NSTRUCT database, and is also free to download.

There are many databases where you can find this information. When doing calculations, it is important to use aligned data sources to ensure comparability between results.

Measuring reductions in upfront carbon

The two accepted methods to calculate upfront carbon are:

- Comparison against a Fixed Benchmark
- Comparison against a Reference Project.

The fixed benchmark approach uses a direct comparison of a Proposed Project's upfront carbon rate against a benchmark relevant to the building's scale and function.

Under the Reference Project method, two upfront carbon calculations are compared; a Reference Project and a Proposed Project. The Proposed Project represents the current building design while the Reference Project is a hypothetical project that is similar in shape, scale, function and location but based on standard construction practices without attention to upfront carbon reduction.

The NZGBC has released a guide for calculating upfront carbon emissions reductions against a reference building. This guide:

- Outlines the scope of inclusions and exclusions in an upfront carbon calculation
- Provides options for reducing upfront carbon emissions
- Defines default Reference Project's materials and systems.

The typical sources of information (in order of preference) are:

Product specific EPD	A verified and standardised document, compliant with ISO14025, that provides transparent information on a product's lifecycle carbon footprint, water consumption, energy use, and other relevant impacts. Appendix C provides more information. EPD-Australasia has a repository of most current industry and product specific EPDs released in Australia and New Zealand. The EC3 database contains many more international EPDs which may be applicable to imported products.
Industry specific EPD	As above, but for a class of products from multiple manufacturers. It should be noted that this EPD only applies to the products and participants listed within. Because it is for multiple manufacturers, it reflects an average, so some products may have higher emissions. An example of this is the Wood Processors and Manufacturer's Association of New Zealand joint EPD for a range of timber product suppliers.
Generic material data	Product emissions factors derived from generic data and modelling. Some of the data in BRANZ's CO_2NSTRUCT database is generic, while others are from product- or industry- specific EPDs. Other LCA tools and software such as One Click LCA and eTool have access to international generic databases such as ecoinvent, GaBi, AusLCI or envirodec as well as EPDs.
Literature data	Derived from information from input-output or hybrid LCA studies, this provides information on the product class, which might be useful when the product selection is unknown.

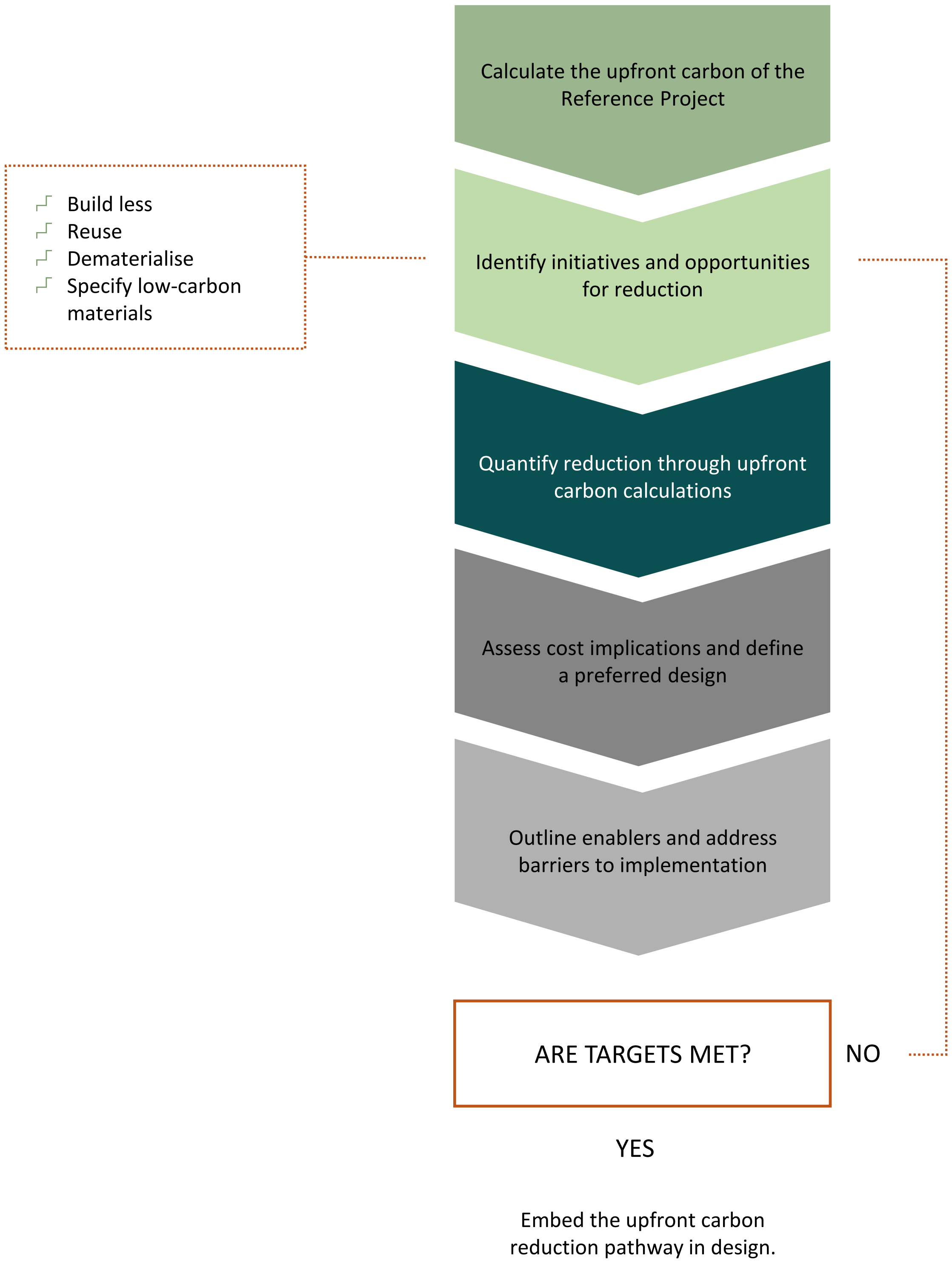
Reducing carbon at each stage of the process

Addressing upfront carbon emissions from the earliest stages of a project allows for the implementation of effective strategies that reduce the overall environmental impact. Calculating upfront carbon is something that should be done multiple times during the development of the project. Doing so allows progress to be compared against targets.

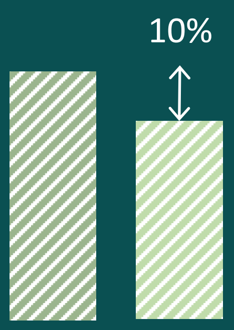
Stage	Potential reduction	Calculation certainty	Options available	Things to consider	Data used
Feasibility and Brief	100%	Lowest	Re-use an existing building, or maximise the reuse of existing building components, with a focus on retaining structure and envelopes. For new buildings, adopt low-carbon design approaches in material selection and design options.	Identify components with the highest carbon contribution, likely in the substructure, superstructure and envelope and major services. Answer the key question: How much new space is needed? Consider how the building re-use may integrate with a seismic upgrade, or conversely, if the extent of seismic upgrade required offsets the benefit of building reuse.	Calculations are likely to use more generic material data, as specific materials will not be selected yet. Future calculations can be compared against this stage, but be careful that the emissions reductions aren't occurring due to changing data sources.
Design		Low	Optimise the shape and design of the building, reduce the quantity of materials, and increase modularity and future adaptability.	This stage offers an opportunity to reduce complexity in the design and save carbon. Consider the shape and volume of the new building and specify low carbon materials.	As the design is refined, calculations should be updated regularly to reflect changes.
Tender		Medium	Look for opportunities to reduce the carbon in the structure and envelope. Seek innovative solutions in the tender with a focus on low-carbon materials. Ask specifically for the tender response to calculate carbon alongside the price. Collaborate with suppliers and contractors to further reduce the project's carbon footprint throughout the supply chain.	Set out clear guidelines for contractors to respond to in the calculations, as depending on how they're calculated, they may get a lower result without providing a benefit. There are still opportunities to reduce carbon in materials, future construction practices, and options for suppliers and contractors to offer innovative solutions.	The calculations should require product-specific EPDs where known, with industry-wide EPDs or robust general databases to supplement them. Where possible this information should be included within the BIM model for the project.
Construction		High	The implementation of efficient construction practices, such as just-in-time delivery, use of low-carbon construction equipment and renewable fuels, contributes to lowering the project's carbon emissions. This is also a key time to ensure transport and construction process emissions are monitored and reduced. The construction stage offers the opportunity to reduce fossil fuel use on-site.	With targets set, continue reviewing during construction. As suppliers are selected and product-specific EPDs are sourced, update the calculation. This process should be repeated when any changes occur to monitor and confirm alignment with reduction targets.	There should be bills of quantities for all materials at this stage and a robust upfront carbon calculation that should be able to be confirmed against targets. The BIM model should continue to be updated.
Handover	0%	Highest	Whilst handover marks the end of the project, strategies such as design for disassembly or reuse will help reduce the upfront carbon of future refurbishment or maintenance projects.	The builder should collect all final quantities and EPD information and make them available for final documentation.	At this point, a final calculation is done, and reviewed against targets.

Developing upfront carbon targets

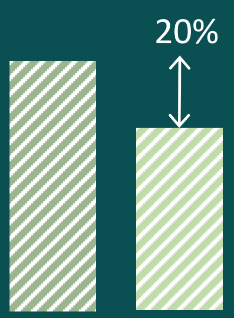
The first step is for you to set out your targets. This is an iterative process, and the earlier you start, the higher the potential for reductions.



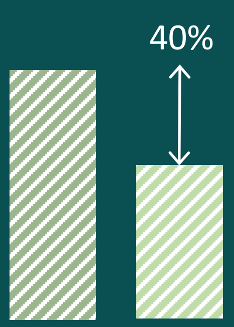
What reduction targets should you aim for?



A 10% reduction is challenging for many new-build building typologies. It generally requires material substitution for low-carbon options, either through the use of timber or procurement of low-carbon steel and / or concrete. There are often, but not always, cost premiums associated with these options. This level of reduction is the minimum reduction that must be achieved by all projects targeting Green Star certification[35], with 5 Star increasing to 15% less from January 2024 and 4 star increasing to 15% less from 2026.



A 20% reduction will require more than procuring low-carbon versions of the same material. More collaboration is needed between stakeholders to unlock further use of low-carbon products or dematerialise the building through optimisation of building form and structural systems. From 2024, projects targeting 6 Star Green Star will be required to meet this target, as well as 5 Star Green Star from 2026.



A 40% reduction is ambitious but achievable. Building on the above, this reduction can be achieved by reusing existing buildings or by using reused components or low carbon materials as part of all new building elements.

Achieving 40% reduction results in full points allocation from the Upfront Carbon Reduction credit (6 points).

Getting to zero upfront carbon today

Decarbonising the built environment requires reducing upfront carbon and compensating for any remaining emissions.

Reduce as far as practicable, then compensate

According to the Intergovernmental Panel on Climate Change (IPCC), limiting global warming to 1.5°C requires rapid and far-reaching reductions in emissions, while at the same time, noting the importance of addressing remaining emissions through carbon-removal activities.[30]

The Science Based Targets Initiative (SBTi) emphasizes the reduction aspect as well prior to compensation activities. The Corporate Net-Zero Standard[31] emphasises that companies must prioritise reducing emissions within their own operations and value chains. Offsetting and compensation activities, such as carbon offsets can be used to address residual emissions, but these must be separated from reduction efforts.

The Buildings Sector Science-Based Target Setting Guidance makes clear what expectations are on each player in the buildings industry to take responsibility for associated emissions.

At this point, it is not likely that a building can reduce its upfront carbon emissions to zero without compensation activities like carbon offsets.

The role of biogenic carbon and offsetting

Biogenic carbon refers to the carbon absorbed and released by living organisms, such as trees. For products like timber, this carbon can be considered stored on site, in the building. Carbon offsetting is a method of compensating for emissions by funding projects that remove emissions from the atmosphere.[A]

The uncertainties around ownership of the carbon drawdowns associated with forestry means that the NZGBC does not currently allow including biogenic carbon sequestration as an equivalent offset. Also, carbon is potentially only stored over the lifetime of the building, meaning the permanence of the carbon reduction is in question (a core principle of offsetting).

Keeping track of your emissions

According to the Royal Institution of Chartered Surveyors (RICS) Whole of Life Carbon Standard,[32] it is best practice to keep reduction calculations separate from compensation calculations. This approach ensures that efforts to reduce emissions are not conflated – while the carbon balance account is maintained, both actions serve distinct purposes.

Both reduction and compensation strategies are essential in addressing upfront carbon emissions in buildings. While reduction is the primary objective, compensation through carbon offsets plays a vital role in taking responsibility for remaining emissions. It is crucial to keep these strategies separate in order to accurately track progress and maintain transparency.

A. It is recommended to use high-quality carbon removal offsets. The NZGBC has published interim guidance around the types of offsets which are appropriate to use in the Embodied Carbon Calculator Guide (2023).

Roles in the project lifecycle

The below stakeholders have important roles to play in reducing upfront carbon through the lifecycle of a project. The graphic on the next page outlines these roles in more detail.

Investors
Invest in buildings with improved lifespans through refurbishment and reuse, and that deliver credible reductions in upfront carbon.

Developers
Increase utilisation of existing buildings through refurbishment and reuse, avoiding demolition. Rethink the size and shape of new buildings. Promote the use of different materials.

Authorities
Require all developments subject to planning approval to measure and report upfront carbon. Adopt recognised performance standards to set reduction targets. Ensure standard specifications feature low carbon options.

Professional Services
Help define the brief to deliver upfront carbon reductions. Work collaboratively to design and specify low upfront carbon buildings. Advocate for net zero buildings.

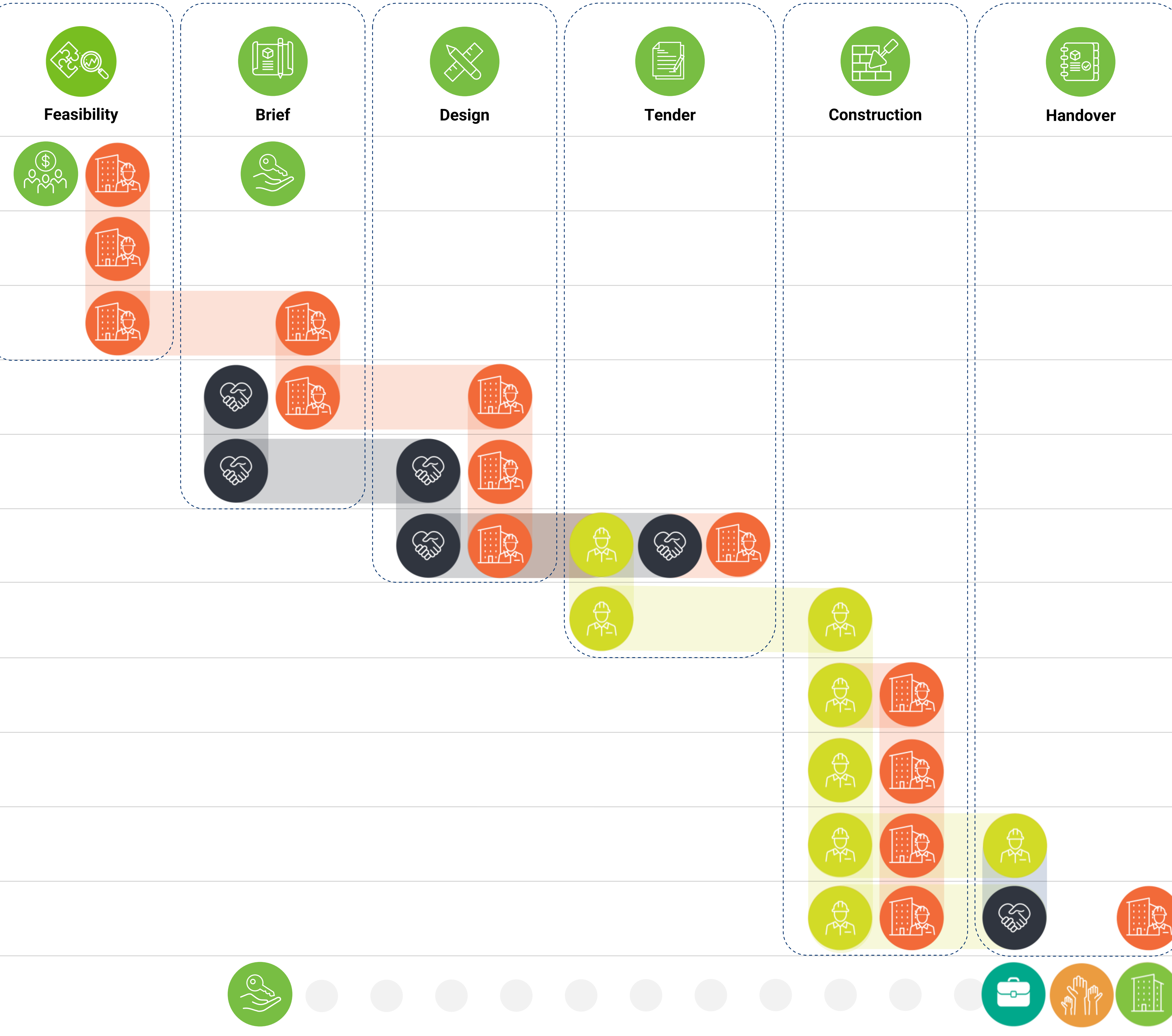
Builders & Trades
Facilitate supply chain transformation in collaboration with trades. Track and report upfront carbon. Have an action plan to reduce upfront carbon.

Leasing Agents
Advocate for low upfront carbon buildings with the developer, prospective tenants and occupants, and purchasers. Demonstrate benefits.

Tenants & Occupants
Choose to lease or occupy refurbished and reused buildings, and buildings that demonstrate a credible reduction in upfront carbon.

Owners
Promote benefits of low upfront carbon buildings and seek to own buildings that have been refurbished and reused, and are low upfront carbon buildings.

The lifecycle of the project in one page



Prevent

- Set a vision for upfront carbon reduction for your organisation
- Introduce upfront carbon targets into your site feasibility studies
- Where possible, select sites with suitable ground conditions that require no/minimal demolition or can reuse existing buildings, avoiding new construction

Reduce & Optimise

- Develop a brief with clear targets and expectations for your development and site
- Develop design options against targets, and quantify potential further reductions
- Select a preferred option seeking further analysis to look for more reductions
- Optimise further by streamlining components and using low carbon materials

Deliver

- Deliver a plan for lean construction and deconstruction, rules for substitutions and waste reduction
- Electrify site construction vehicles and offices. Utilise Heavy Duty EVs for transport of products and materials to site
- Record materials, transportation, on-site energy, water, waste, and collect EPDs
- Complete the construction stage calculations to confirm performance

Encourage

- Require low upfront carbon buildings and fitouts in your leasing practices

Feasibility

Feasibility is critical as the decisions and targets related to upfront carbon are decided here.

Stakeholders

Questions

- Can the project reuse any or all of an existing building?
- What are the project's targets for upfront carbon reduction?
- What can be done to get there?

Opportunities

- Prefer sites with buildings that can be reused to avoid demolition and new construction
- Avoid sites with complex ground conditions

Deliverables

- A Vision Statement for the project, highlighting ambitions including upfront carbon
- A performance brief with measurable upfront carbon reduction targets for the project
- Identification of options to retain or reuse existing assets
- Feasibility recommendations with measurable upfront carbon reduction targets (against a Reference Project or similar), recommendations for reuse (where possible)
- Ambition for a performance based brief to enable substitutions for products or materials that have the same outcomes
- Communication strategy to ensure these ambitions are shared throughout the project lifecycle
- Budget for the inclusion of low embodied carbon materials and products
- Identity innovation opportunities

Before the next stage you should:

- Complete a 'hot spot' upfront carbon analysis for the design brief. This will assist in identifying where initiatives will realise the most valuable reductions in upfront carbon and underpin preparation of an upfront carbon reduction pathway.

Brief

A finalised brief sets the objectives for the project's deliverables and clarifies the roles of the project team. This is a vital for setting clear goals through to construction.

Stakeholders

Questions

- How to ensure practices to reuse building elements?
- How to identify further opportunities through the lifecycle?
- How does the team manage change as more details become clear through the project?

Opportunities

- Challenge the brief: are there any further opportunities for reducing carbon?
- Does the brief encourage innovation? Invite recommendations for practices or technology from the team's experience.

Deliverables

- A design brief with a whole of building, measurable upfront carbon target that includes:
  - The boundary or scope of the target
  - What is included and what is excluded
  - The data and/or methodology used to establish the target
  - A description of the main assumptions used to establish the Reference Project
- Schedule of pre-approved materials, products, and assemblies
- Budget for processes, products and materials
- Where demolition can't be avoided, develop a circular deconstruction strategy that identifies options for material recovery and reuse in the project or for use off site.

Before the next stage you should:

- Ensure targets are challenging, but achievable, to ensure the design team is engaged in the process.

Comparing strategies to reduce and compensate upfront carbon emissions

From retaining an asset to building a new one, the opportunities to reduce upfront carbon emissions vary based on your chosen strategy. To the right is an indicative comparison available per strategy chosen. In all cases, specific site conditions will vary, and consultant advice should be sought.

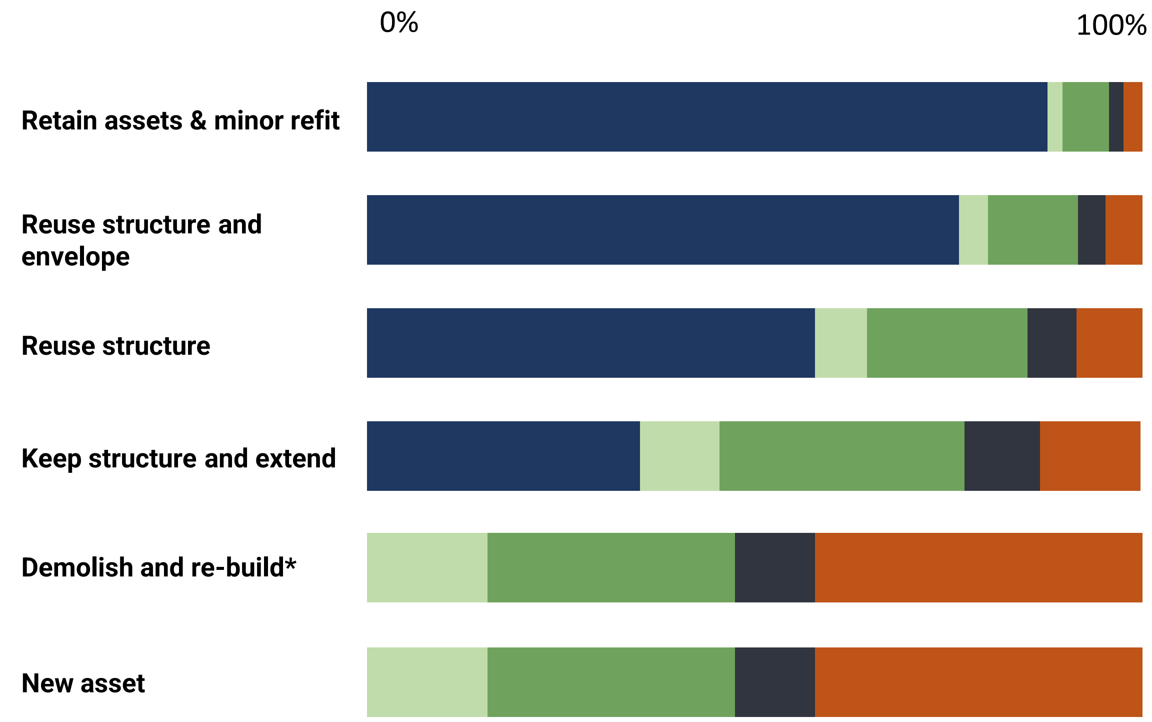
In general, the best strategies for eliminating or reducing upfront carbon emissions will prefer the retention or reuse of existing assets. Reusing a building instead of demolishing and replacing it offers the maximum guaranteed emissions savings. Refurbishment is also typically quicker than new construction so there are financial savings from this strategy as well.

For new buildings, and all other options, design optimisation strategies and material selection can yield up to a 50% reduction of whatever remaining carbon exists (depending which building components are reused or refurbished). The remaining emissions will need to be compensated. As yet, it is not possible to have a new zero upfront emissions building.

Benefit of Reuse in Green Star Design and As Built v1.1 and Green Star Buildings

Green Star Design and As Built v1.1 and Green Star Buildings reward the reuse of buildings or parts of buildings, as well as disincentivising demolition of assets before the end of their service life. For example, assets that demolish existing building elements will be required to fully or partially offset the emissions associated with those elements - if they have not yet reached their service life. On the other hand, buildings that reuse existing components are likely to gain significant points through upfront carbon reduction.

Potential impact of upfront carbon emissions strategies



* Demolishing a building carries with it a carbon debt from the embedded carbon in the previous building that should be considered and offset.

Emissions savings compared to a typical new building from:

- Reuse of existing building

Potential emissions savings from:

- Design optimisation
- Fossil-fuel free construction
- Material selection

Remaining emissions that must be compensated via:

- Nature based offsets

Concept Design

The early design stage allows assumptions to be tested and options to be worked through. The preferred concept will be one that meets the brief requirements and upfront carbon targets the best.

Stakeholders

Questions

Rationalise the design:

- Where in the build are opportunities for dematerialisation?

Optimise the design:

- How can we integrate reused or standardised elements?
- How can low carbon design initiatives be integrated into the concept?
- What are opportunities to design for disassembly?
- How can the building be designed to minimise damage from seismic events without compromising up-front carbon targets?

Opportunities

- Integrate existing buildings / elements into the design
- Align load bearing structural elements
- Reduce and/or even eliminate transfer structures
- Optimise the structural grid for low carbon materials
- Minimise substructure
- Challenge design margins

Deliverables

- Reference Project
- Alternative design options with measured upfront carbon impacts
- Upfront carbon roadmap
- Design stage upfront carbon calculation

Before the next stage you should:

- Identify if there is a possibility to standardise building elements, and design for disassembly.
- Identify material banks for components which could be reused as part of the deconstruction strategy.

Detailed Design

At this stage, there is a greater amount of information available about the design, enabling more accurate modelling and testing of assumptions from earlier stages.

Stakeholders

Questions

- Where in the build are opportunities for dematerialisation?
- How can we integrate reused or standardised elements?
- What are opportunities to design for disassembly?
- Where are opportunities for low carbon finishes, fittings and furniture?

Opportunities

- Fine tuning of carbon reduction with more finalised information
- Alignment with the project team with targets communicated and monitored
- More detailed understanding of opportunities for innovation within the build
- Focus on material selection and specify low carbon. (See Appendix B)

Deliverables

- Updated carbon reduction pathway
- Confirmed targets are deliverable
- Finalised scheme assessed, with upfront carbon calculated
- Collaborated with consultants and contractors to ensure bill of quantities are accurate and contingency ordering is minimised

Before the next stage you should:

- Finalise bill of quantities including performance specifications and reduced contingencies for materials

Design considerations in reducing a project's upfront carbon

Stage	Initiative	Consideration	Cost impact	Potential upfront carbon reduction
Feasibility	**Retain existing building**	Temporary support and/or structural strengthening may be needed during repair work adding some upfront carbon.	v	+++
Brief	**Adopt a regular building shape and arrangement**	Simple building forms enable simple structural design strategies, which will reduce the upfront carbon required to achieve the same building performance. Unlocks opportunities for reduced construction emissions.	$	++
	Passive design to reduce building services extent	Passive design may require additional material in the building envelope, consider against whole-life carbon considerations.	$	+
Concept design	**Reduce structural grid**	Larger amount of columns may impact a floor's spatial flow. Important to optimise columns, beams, and floor sizes to ensure total upfront carbon is lower.	$	++
	Reconsider basement levels	Impacts to lettable area may occur as services and amenities may need to be relocated.	$	++
	Use a braced steel frame rather than a moment frame	A braced steel frame may impact on views and daylight if not considered in the design.	$	+
	Use timber instead of concrete or steel for the superstructure	Use of timber may result in reduced floor to ceiling height and/or number of storeys, as well as reduced floor space due to larger columns being needed.	$$	+++
Detailed design	**Switch to higher grade strength steel to reduce steel quantity**	Higher strength steel does not always lead to smaller member sizes therefore the total upfront carbon may not be reduced – make sure to optimise.	$$	+
	Switch to lower grade strength concrete to reduce Portland cement	Larger volumes of concrete may be required with a lower grade mix for structural strength and durability purposes and may result in larger supporting structural elements and higher upfront carbon overall.	v	+
	Design for and specify low-GWP concrete, with alternative mixes	The concrete may take longer to cure impacting construction timelines. The concrete colour may be different. The concrete may have decreased workability, requiring additional considerations through construction.	$$	+
	Increase wall to window ratio to reduce aluminium framing	If the aluminium has recycled content, smaller glazing panels may yield less upfront carbon. Improved thermal performance and lower operational energy demand. Reduced views and daylight.	$	+
	Consider innovative ground floor slab design & build options	Fibre reinforced or post-tensioned slabs on grade.	$	+

Legend

Symbol	Meaning
$ (light green)	< 5% in savings
$ (green)	< 5% in cost
$$	5% to 15% in cost
v	Depends on circumstance
+	Low impact
++	Medium impact
+++	High impact

Tender

The tender, and its return, are the point where all requirements are finalised and communicated prior to being costed for construction

Stakeholders

Questions

DEVELOPER:

- How can we embed the carbon reduction requirements for the project?
- How can we evaluate tenders i.e. weighting for carbon reduction?

BUILDER:

- Can further reductions be made?
- Are there other materials or processes to assist?
- Can the brief be challenged further?

Opportunities

- At this stage, project teams should challenge the brief for any further opportunities to reduce carbon
- Does the brief encourage innovation? Invite recommendations for practices or technology from the team's experience

Deliverables

- Finalised documentation
- Detailed performance specifications including metrics and obligations for reporting
- Specified carbon metrics for products
- Expand the digital BIM environment to access material banks and map components for reuse
- Allow for seamless iterations with tendering builders to test and evaluate further optimisations
- Builder to develop a Construction Sustainability Report

Before the next stage you should:

- Align project team with the vision for the project
- Set out which metrics will be monitored and tracked, and how

Specifications

Specifications should include language that requires the builder to submit EPDs for all components considered and tracked for upfront carbon reduction. The EPDs should cover, at a minimum, the life cycle product stage, or modules A1-A3. Specifications should also call for the Contractor to submit a bill of quantities (BOQ) that provides products/materials itemised by application and type. Specifying material global warming potential (GWP), or carbon content, performance rather than prescriptive requirements (e.g. around cement substitutions) gives flexibility in the tender. Designers should consider appropriate limits and/or targets for material GWP intensity. The GWP for each item, based on EPDs, should also be included.

Digital solutions

Underpinning the specifications, an advanced building information model (BIM) should be provided. To support an effective knowledge transfer to the builder, it should:

- Label all new components and all relevant components that will be reused from an existing asset
- Facilitate BOQ extraction in a range of formats
- Detail GWP targets or ranges for all component types

Tender evaluations

The tendering builders should understand the established brief requirements, i.e., the functional brief requirements of the project and its upfront carbon reduction target. The specifications should provide room for the builders to innovate but be clearly performance based so that tenderers can make changes to materials or processes if the agreed metrics are met or exceeded. Builders work extensively with the trades and supply chain, are in a unique position to further optimise for upfront carbon reductions. The tender process should be designed to facilitate this interaction and incentivise improvement performance.

Construction

Once on site, it is important to ensure that monitoring and measurement is in place and that any variations to the design are checked with the principal for performance before substitutions are made.

Stakeholders

Questions

- How to track, monitor and report on agreed metrics?
- What is the process for product substitution to ensure targets are met?
- Can I reduce the carbon emissions from all construction activities by switching to renewables or fossil-fuel-free equipment?

Opportunities

- Access material banks for disassembled components for reuse and deposit into these banks with any resources that are surplus to requirements
- Use fossil-fuel free equipment, and renewable energy on-site[28]

Deliverables

- Construction Sustainability Report
- Induction workshop to align key suppliers/contractors with the roles, objectives and targets to reduce upfront carbon.
- Record of materials and transportation
- On-site energy consumption reporting
- EPDs for all relevant products
- Develop a detailed and comprehensive repository of data across the trades and supply chain that offers advanced reduction strategies
- Put forward advanced strategies that significantly improve reductions, and qualify the triple bottom line business case for their adoption
- Access material banks for disassembled components for reuse and deposit into these banks any resources that are surplus to requirements

Builder responsibilities

At this stage, the builder has the responsibility to deliver on the upfront carbon targets set by the principal. To deliver reductions, the builder must:

- Demonstrate capabilities, experience and strategies related to upfront carbon reporting and reduction and provide input on cost and program.
- Reconcile upfront carbon reduction performance against the upfront carbon roadmap - review and compare BOQs, EPDs, etc.
- Demand detailed environmental information from suppliers as standard to support comparative evaluation and selection, perform due diligence to ensure final products are as ordered or have the same properties, especially in respect to their embodied carbon.
- Procure renewable energy for site offices, and use low-carbon fuels or all electric equipment to reduce upfront carbon during construction activities. Also work with suppliers to reduce emissions from transport (See Appendix B).

Construction sustainability report

- The construction sustainability report covers construction to handover. The plan should be used as a measuring and management tool to ensure lean construction, material reuse, and waste reduction management.
- Estimation of the embodied carbon should be on a regular basis in order to understand how design and material selection affect the ultimate outcome. The number and timing of iterations must be agreed upon with the embodied carbon assessor.
- Construction-related upfront carbon reporting for the plan should be in appropriate units (e.g. $kgCO_2e$) and be reported regularly, with a final summary document provided at handover. Regular reporting is often important for Construction (A5) emissions so consider frequent, or monthly reporting, as needed.
- The construction sustainability report should include the upfront carbon estimates for any temporary works materials, on-site construction emissions, and materials waste. It should promote the integration of temporary works materials into permanent works or demonstrate reuse strategies to extend the life of these materials.

Handover

Once on site, it is important to ensure that monitoring and measurement is in place and that any variations to the design are checked with the principal for performance before substitutions are made.

Stakeholders

Questions

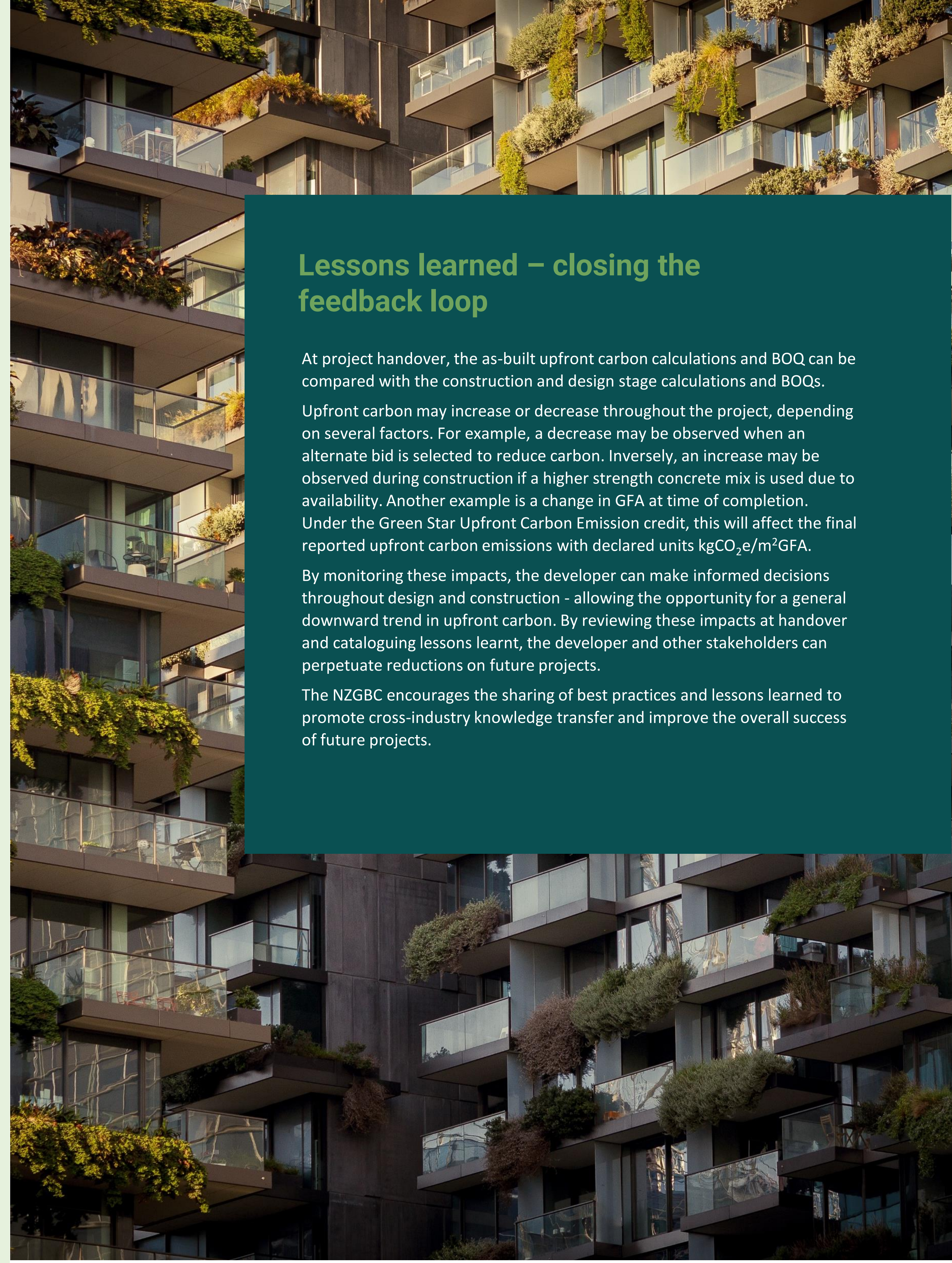
- How to capture outcomes?
- How to improve performance in future?

Opportunities

- Lessons learned
- Set standard upfront carbon reduction targets/benchmarks and identify opportunities for more ambitious reductions
- Demonstrate a strong correlation in design, construction and as-built performance

Deliverables

- Finalised construction carbon plan
- Final As-Built BOQ and compiled EPDs
- As-built upfront carbon calculations
- Building User's Guide and Building Logbook with upfront carbon targets and reduction strategies



Lessons learned – closing the feedback loop

At project handover, the as-built upfront carbon calculations and BOQ can be compared with the construction and design stage calculations and BOQs.

Upfront carbon may increase or decrease throughout the project, depending on several factors. For example, a decrease may be observed when an alternate bid is selected to reduce carbon. Inversely, an increase may be observed during construction if a higher strength concrete mix is used due to availability. Another example is a change in GFA at time of completion. Under the Green Star Upfront Carbon Emission credit, this will affect the final reported upfront carbon emissions with declared units $kgCO_2e/m^2GFA$.

By monitoring these impacts, the developer can make informed decisions throughout design and construction - allowing the opportunity for a general downward trend in upfront carbon. By reviewing these impacts at handover and cataloguing lessons learnt, the developer and other stakeholders can perpetuate reductions on future projects.

The NZGBC encourages the sharing of best practices and lessons learned to promote cross-industry knowledge transfer and improve the overall success of future projects.

Case Study: UoA B201

Building typology
High-rise, multi-storey

Location
Tāmaki Makaurau, Auckland

Sector
Education

Developer
The University of Auckland

Builder
Hawkins

Procurement
Traditional

Key influences

Key outcomes
Reuse of existing structure designing out ceilings

The B201 Redevelopment is a 22,000m^2 major refurbishment project consisting of the adaptive re-use and 50-year extension of life for the University of Auckland's B201 campus for Education and Social Work.

This project was awarded the highest ever Green Star New Zealand 6 Star rating.

The B201 project was born from a desire for the University's estate to set a positive example and be leading the way in terms of sustainability in Aotearoa. The building had been scheduled for a simple refurbishment pending full replacement in ten to fifteen years-time - despite undergoing a raft of remedial work over the decades it had reached end-of-life status with mechanical and building services no longer fit-for-purpose, poor environmental performance, and a seismically poor deteriorating heavy concrete façade.

Building 201 reduced upfront carbon (Modules A1-A5) by 32.5% when compared to an equivalent new building.

The University chose to take this opportunity to turn this poorly performing building into an example of how adaptive reuse can be transformative and as good, or better, than demolition and replacement.

The heavy concrete precast façade was removed, and the new façade - a lightweight high-performing curtain wall - installed in its place, not only vastly improving the thermal performance and internal comfort, but reducing the overall weight of the building. This reduced weight, along with targeted, minimally invasive structural strengthening, enabled the conversion of the rooftop of one of the towers into new floor area, for a larger plantroom and laboratory space.

The large external courtyard on top of an underground lecture theatre space was transformed into a light and airy central atrium, with mass timber beams forming a lightweight roof above the main entrance.

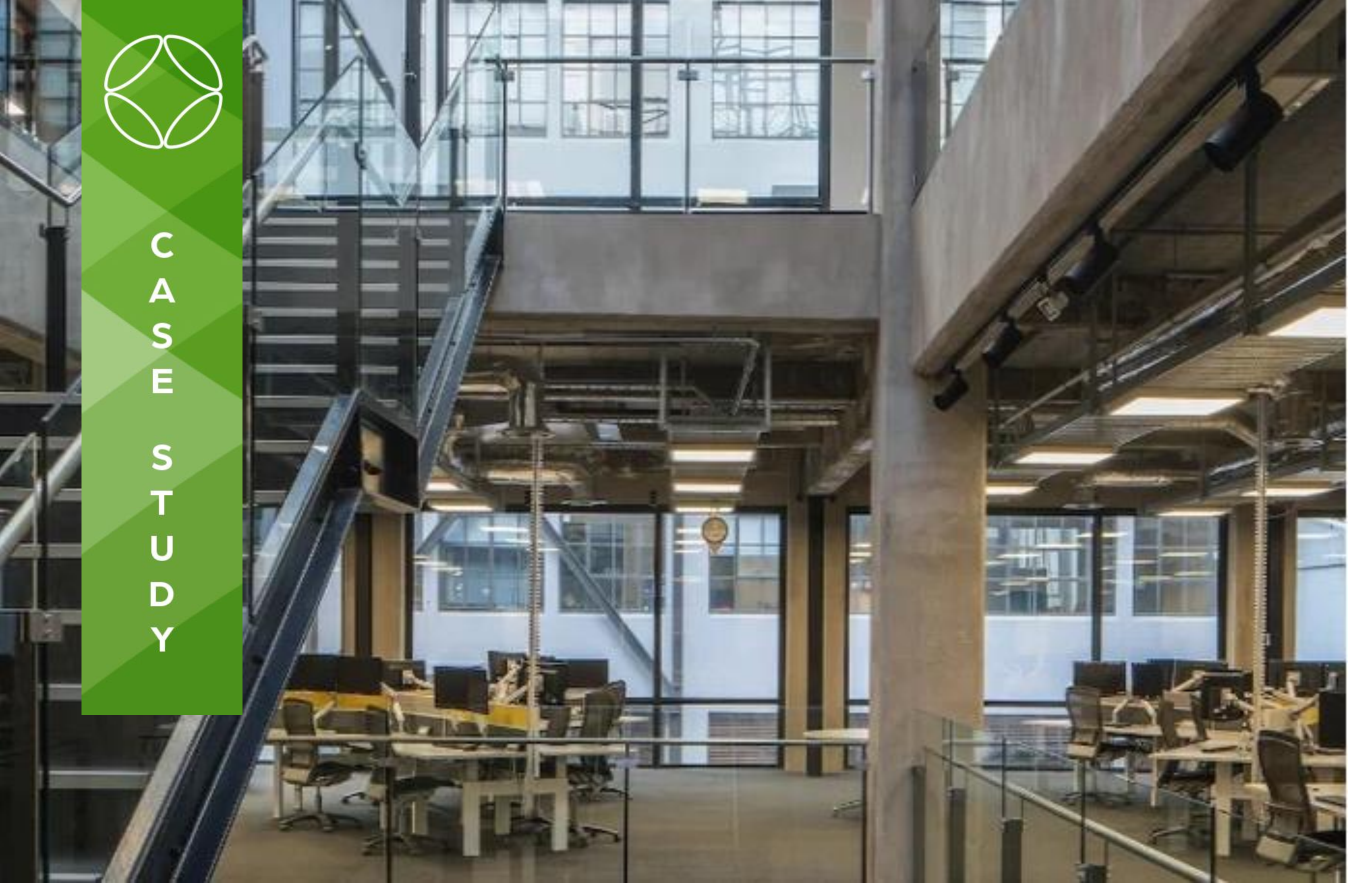
The Reference Project was defined as a new building with the reused structural elements assuming new construction, with the concrete strength and volume reflecting the existing structure and modern emissions factors.

The key innovations enabling the upfront carbon saving included:

- Removal of existing heavy, poorly performing façade and replacing with lightweight high performing façade
- Targeted use of fibre-reinforced polymer for its high strength-to-weight ratio, enabling super-lightweight strengthening of key structural elements
- Specification of aluminium from New Zealand, produced using renewable electricity
- Designing out ceilings over public areas and circulation routes
- Minimising new building services in atrium area through designing for natural ventilation.

ABOVE: B201 University of Auckland, 6 Green Star Design and As Built v1.0 Design Review Rating

> To achieve the highest score awarded since the inception of the New Zealand Green Building Council's design rating - 93 points - is an awesome achievement and an exciting milestone.
>
> SIMON NEALE | Director of Property Services - University of Auckland



Case Study: 80 Willis (Intergen Building)

Building typology
High-rise, multi-storey

Location
Te-Whanganui-a-Tara, Wellington

Sector
Commercial

Developer
Maurice Clark

Builder
McKee Fehl Constructors

Procurement
Design & Construct

80 Willis (now known as the Intergen Building or Press Hall) featured the adaptive reuse of a heritage building. The building was constructed in 1923 as the press hall for The Evening Post, and has now been fully refurbished, retaining much of the existing structure and façade in the upgrade.

This required an extensive structural strengthening exercise, with new concrete shear walls, FRP-wrapped columns and new steel columns to prevent collapse of the floor during a seismic event.

Replacing the building glazing with new low-e glazing, along with upgrading the roof and remainder of the thermal envelope, resulted in a high-performing building with reduced energy consumption and operational carbon emissions - proving that adaptive re-use isn't just saving upfront carbon to spend it over the rest of the buildings' life.

Press Hall is now an A grade office space with a thriving eatery and laneway beneath. The success of the adaptive reuse was recognised through several national property awards.

LEFT: 80 Willis St
(Intergen Building)
5 Green Star Office Built

> Creating a modern and dynamic site which preserves and celebrates much of the original form, structure and heritage lies at the heart of this redevelopment.
>
> Matt Fraser, Project Manager at McKee Fehl Constructors

Key influences

Key outcomes
Retained structure and materials

Life Cycle Assessment

- This was the first building in New Zealand to undertake a Life Cycle Assessment for Green Star, using the BRANZ LCA-Quick software to establish whole-life project carbon savings.
- The analysis determined that the building had saved 75% in upfront (A1-A5) emissions associated with the building structure and enclosure, about 2,000 tCO_2e.

Reference Project Definition

The reference building used for the assessment was a BRANZ standard reference building, of a similar sized mixed-use building in Christchurch with post-tensioned LVL frames and walls.

CASE STUDY

Case Study: Weiti Care Home

Building typology
Low-rise

Location
Tāmaki Makaurau, Auckland

Sector
Aged Care

Developer
Metlifecare

Builder
NZ Strong

Procurement
ECI

The Weiti Care building is the first care facility in Aotearoa to achieve a 6 Green Star Design certification. It showcases what sustainability can look like in the context of a high-dependency residential unit.

Upfront carbon is reduced in the building through the selection of cross-laminated timber panels for floor, wall and frame construction. The extensive use of mass timber not only has relatively low emissions from production and fabrication, but also reduces the building weight. This has flow-on effects for upfront carbon, reducing the amount of concrete required for the building foundations.

Metlifecare also placed a large emphasis on offsite manufacture and pre-fabrication of as much of the building as possible. The use of pre-fabricated elements has dramatically driven down the amount of waste on site, reduced on-site activity and labour, and promoted a healthy work environment.

Reduced waste is important not only from a resource conservation perspective, but also from an upfront carbon perspective. The less material required to build a product, the fewer emissions associated with the production.

The prefabrication process also enabled low emissions through onsite activity - energy and fuel use on site (Module A5) is directly associated with the duration of construction and the type of plant required to construct the building. With a focus on offiste manufacture and lightweight building materials, the speed and efficiency of the build reduced this carbon impact.

> This project was intended to be built smarter, faster, safer, quieter and more efficiently than traditional construction.
>
> Michael Lisowski - Metlifecare Head of Delivery

LEFT: Weiti Care Home, 6 Green Star Design & As Built - Design Review

Key influences

Key outcomes
Low carbon materials, reduced site waste, reduced site activity, lightweight superstructure

The upfront carbon of the build was reduced by 45% compared to a reference building - with a total upfront carbon intensity of 210kg CO_2e / m^2.

Key embodied carbon reduction strategies included:

- Lightweight superstructure materials.
- Low embodied carbon primary structural materials
- Reduced foundation size due to lightweight superstructure
- Offsite manufacture and prefabrication reducing site waste

Reference Project Definition

The reference building used for the upfront carbon assessment was an equivalent steel and concrete design with the same functional requirements and layout.

What's next?

Upfront carbon is one of the critical challenges of our time. As the market matures, benchmarks are refined, and low carbon materials and processes enter the market, this guide will continue to be updated.

Where can I get more information?

The following organisations are working to drive reductions in upfront carbon emissions in New Zealand.

- **New Zealand Green Building Council**, which represents 700+ members, including individual companies with a collective annual turnover of more than $40 billion. The NZGBC collaborates with industry to drive whole life carbon reductions and net zero outcomes through Green Star and the Embodied Carbon Methodology guide.
- **Building for Climate Change (BFCC)**, the Ministry of Business, Innovation and Employment's (MBIE) programme committed to reducing emissions from the built environment in NZ. Has produced standardised guidance on the methodology around embodied carbon calculations.
- **Building Research Association NZ (BRANZ)**, a multi-faceted, science-led organisation who develops practical solutions that improve New Zealand's building performance. BRANZ has developed several free-to-access tools which enable calculation of up-front carbon emissions on building projects, as well as a standardised database of material emissions factors for New Zealand.
- **Structural Engineering Society NZ (SESOC)**, a professional membership body who provides access to resources for structural engineers seeking to understand and reduce up-front embodied carbon on projects.
- **Toitū**, a team of scientists and business experts who come together to protect the ecological and economic future of Aotearoa New Zealand. Toitū lead positive change through a system of robust environmental programmes and certifications, giving businesses science-based tools, actions and evidence they need to make real change.
- **Aotearoa New Zealand Architects Declare**, a network of architectural practices committed to addressing the climate and biodiversity emergency. Part of the International 'Built Environment Declares' movement, provides access to practice guides for architects to reduce their climate change impacts.

International organisations

- **Materials and Embodied Carbon Leadership Alliance,** The Materials & Embodied Carbon Leaders' Alliance (MECLA) is an alliance that brings together the drive to reduce embodied carbon in the building and construction industry, MECLA is determined to transform the building and construction sector to reach Net-Zero emissions.
- **Royal Institution of Chartered Surveyors** (RICS), a professional body based in the UK with standards in the land, property and construction sectors worldwide. RICS has developed the Whole Life Carbon Assessment for the Built Environment 1st Edition (November 2017). It provides a framework for assessing the carbon emissions of a building over its lifecycle.

Information for product manufacturers

Information on product-level emissions can be found in the following. These resources can also help product manufacturers on their journey to understand and disclose their emissions.

- **Chartered Institution of Building Services Engineers (CIBSE)**, has long been active on the topic of climate change mitigation and adaptation, and linking it to building performance. CIBSE has produced the TM65 guide, Embodied carbon in building services: A calculation methodology (2021), providing guidance on how to use environmental product declarations (EPDs) to assess the embodied carbon of building services equipment; and where not available, it provides guidance on how to estimate embodied carbon.
- **EC3** is an American free and easy-to-use database of digital, third-party verified Environmental Product Declarations (EPDs). EC3 includes EPDs for Australasian and international products. It focuses on the upfront supply chain emissions of construction materials.
- **EPD Australasia** is a regional partner of the International EPD® System with over 1,800 EPDs now published from businesses in 37 countries. EPD Australasia registers and publishes Environmental Product Declarations (EPDs) and Climate Declarations.

Appendix A: Valuable terminology

Biogenic carbon emissions	Biogenic carbon emissions originate from biological sources such as trees and soil.
Carbon dioxide equivalent	Carbon dioxide equivalent (CO_2e) is a unit of measurement that is used to standardise the climate effects of various greenhouse gases.
Carbon footprint	A carbon footprint is the total greenhouse gas (GHG) emissions caused by an individual, event, organisation, service, place or product, expressed as carbon dioxide equivalent (CO_2e).
Carbon neutral	Climate neutrality refers to the concept of an individual or organisation achieving a balance between the emissions of greenhouse gases and the absorption of these gases by natural processes, resulting in net zero emissions. This can be achieved by reducing carbon emissions, carbon offsetting, or a combination of both. In New Zealand, carbon neutrality is defined by the New Zealand government through the Ministry for the Environment (insert reference: Guidance for voluntary carbon offsetting, 2020).
Carbon sequestration	Capturing and storing carbon dioxide from the atmosphere, for example by establishing forests. The long-term effect of a forest as an ecosystem will make a much larger impact than planting individual trees.
Cradle to cradle	Describes a material or product that is recycled into a new product at the end of its life, so that ultimately there is no waste.
Cradle to gate	Describes a material or product from resource extraction to the factory gate, before it is transported to the next step in the construction process stage.
Cradle to grave	Describes a material or product from raw materials extracted and processing, through each stage of manufacturing, transport, product use, and ultimately, disposal.
Embodied carbon	Emissions associated with building construction, including those from extraction, transport, manufacture and install of materials and products, as well as the use and end-of-life emissions associated.
Environmental product declaration (EPD)	A certified public summary of a product's environmental impact over its life cycle. Based on international standards and independently verified, it is widely recognised by industry and governments.
Environmental, Social and Governance (ESG)	A set of standards for measuring a businesses or organisation's sustainability and ethical impact. ESG criteria are increasingly popular as a way for consumers and investors to evaluate companies they want to engage with.
Gate to practice completion	A term used in life cycle assessments to describe a material or product being transported from the factory gate to the construction site and being installed through the building's construction.

Global Warming Potential (GWP)	GWP is used in the life cycle assessment to quantify the climate impact in GHG emissions of materials and products. It is useful in defining performance targets or ranges in CO_2e for materials and products.
Global Warming Potential Total (GWPT)	The sum of GWP from fossil fuels (GWPF), biogenic sources (GWPB) and land use and land use change (GWPL) as defined in EN 15804:2012+A2:2019.
Green finance	Loans and other financial products and services that encourage industries and organisations to adopt sustainable practices, both environmental and social.
Greenhouse gases	Gases that trap heat in the atmosphere.
ISO (International Organisation for Standardization)	An independent, non-governmental, international organisation that develops standards to ensure quality, safety, and efficiency of products, services, and systems.
Life cycle assessment (LCA)	Measurement method that quantifies the environmental impacts of a product, service, or organisation over its life cycle and value chain. It is a science-based, whole-systems approach to understand and address environmental issues.
Net zero emissions	Reducing direct (scope 1) and indirect emissions (scope 2) of a business or organisation's activities, and its value chain emissions (scope 3) to zero or to a residual level that is consistent with a 1.5°C-aligned pathway (see Paris Agreement). Residual emissions must be compensated for.
Paris Agreement	A legally-binding international treaty on climate change adopted by more than 190 countries in 2015. Its goal is to limit global warming to well below 2°C, preferably to 1.5°C, compared to pre-industrial levels.
Emissions scope	Scope 1 emissions are direct emissions that occur from sources that are controlled or owned by an organisation. Scope 2 emissions are indirect emissions associated with buying electricity or thermal energy. Scope 3 includes all other emissions that occur in a company's value chain.
Taskforce for Climate-related Financial Disclosures (TCFD)	An international organisation created in 2015 to develop consistent climate-related financial risk disclosures for use by companies, banks, and investors in providing information to stakeholders.
Triple bottom line	Evaluation of a business, organisation or investment across social, environmental and financial performance. This economic analysis method considers direct and indirect benefits of decisions and investments.
Value chain	A business model that describes the full range of activities needed to create a product or service.

Appendix B: Carbon in materials

The high emitting elements in a building are the superstructure, substructure and envelope, due to the carbon intensive materials used. Figure 2 highlights the main building elements and the common materials that are used. A higher variety of materials are used in services and finishes however both elements have less information readily available.

Project teams should consider the best use of various materials to make the most of their relative benefits.

It is important to note that the building sits within a wider system, and early design choices around site selection and location may unlock enabled or avoided emissions, which should be considered alongside the upfront carbon emissions of the building itself.

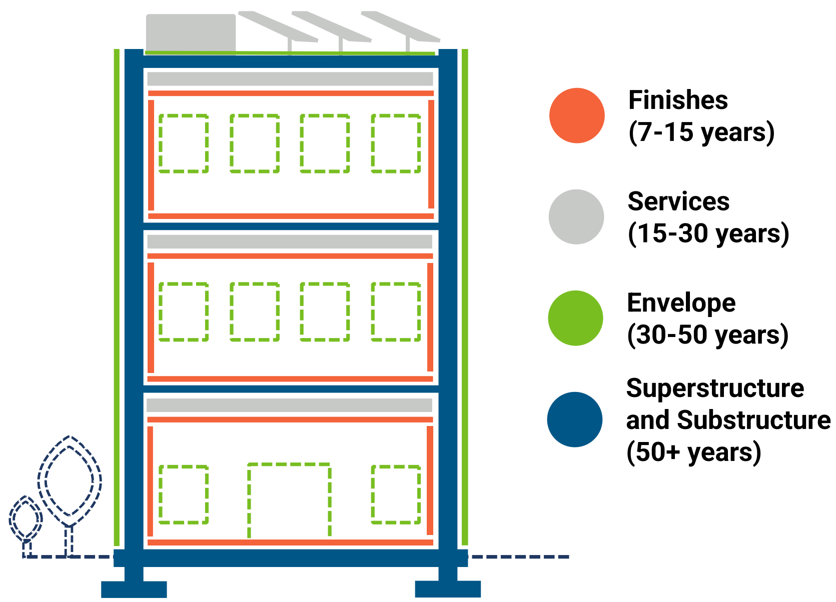


Figure 2: Building elements and their typical lifespan (source: Adapted from Brand, S., 1994, How Buildings Learn: What Happens After They're Built)

STEEL

Traditional Steel is produced in a blast furnace using coke and is a major contributor to upfront carbon. Recycled steel can be processed within an Electric Arc Furnace (EAF). Just such a furnace is planned for the Glenbrook plant meaning that New Zealand made steel will decarbonise over the coming decade. When specifying steel, consider**:**

- Sourcing steel from Sustainable Steel Council (SSC) certified sites or at least from SSC members or members of similar schemes.
- Specifying high strength steel – this may enable reductions in the quantity of steel and the project's upfront carbon.
- Focusing on incorporating re-used members.
- Where relevant, specifying steel produced using low carbon emissions-intensive processes or renewable energy.

CONCRETE

Traditional concrete often contains Portland Cement which is the greatest contributor to its carbon emissions. Portland cement can be replaced by supplementary cementitious materials (SCMs):

- Fly ash, a coal combustion product. This is a good alternative however as coal power generation decreases, so will availability.
- Ground granulated blast furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam. GGBFS production is also decreasing as the industry moves towards electric arc furnaces.
- Microsilica (silica fume) is a by-product of producing silicon metal or ferrosilicon alloys in electric furnaces. It can typically only be added in small amounts to the concrete mix.

How to reduce the upfront carbon in concrete?

1. Define the correct strength and performance – When comparing design options, consider reduced concrete strength. To support Portland Cement reduction, engage with concrete suppliers to evaluate their standard mix options against performance requirements.
2. Specify low carbon concrete – Low carbon concrete mixes are vital to most reduction pathways. All specifications should require the builder to submit EPDs for all components. Specifications should also call for the builder to submit a BOQ that provides the projected concrete volumes, recycled content and GWP itemised by application and type.
3. Reduce and eliminate excess orders on site. This can be achieved through careful measurement of structure (or formwork) to minimise wastage.
4. Deliver the specified grade and no higher. Concrete strengths have diverse applications and costs; using higher strength concrete for low-grade applications compromises material efficiency and raises the carbon intensity of the project.

Action:

- Specify alternative binders and admixture.
- Put demand side pressure on suppliers to capture and sequester emissions from production.

TIMBER

Framing or mass timber elements (CLT, LVL, glulam) inherently have low levels of up-front carbon. When sourcing timber from overseas, it is important to review the processing emissions and transportation emissions to ensure assumptions around relative carbon reductions are relevant. In New Zealand, where our grid is largely renewable, these considerations are less significant.

How do you account for the biogenic benefits of timber?

As a bio-based material, timber can remove CO_2 from the atmosphere and store it for the lifetime of the building. This is called carbon sequestration. Engage with LCA practitioners and evaluate related guidance to correctly account for this in your project. Sequestered carbon is not included in up-front carbon reporting, it is only taken account of in whole-of-life embodied carbon assessments.

How do you reduce the up-front carbon in timber?

- Source timber from sustainably managed forests. The Programme for the Endorsement of Forest Certification (PEFC) and The Forest Stewardship Council (FSC) are both international, non-profit, non-governmental organisations that promote sustainable forest management. While these schemes may prevent illegal timber from being used in a project, it would be prudent for project teams to do their own due diligence.
- Explore opportunities with local structural timber suppliers wherever possible to reduce transportation impacts
- Design for deconstruction to maximise reuse
- Design for transportation to reduce the need for complex structural connections
- Design for efficient grid, loading and dematerialisation

How should you use timber?

- The Timber Design Society has a range of guides designed to enable designers to optimise the use of timber in various building typologies..

ALUMINIUM

Per kilogram of material, aluminium is a major contributor to upfront carbon. This is primarily due to the large amount of electricity used during the smelting process.

How do you reduce the upfront carbon in aluminium?

Two main types of low carbon aluminium products exist that reduce emissions in the smelting phase:

- Aluminium produced with renewable electricity
- Aluminium produced with a high recycled content (~75%)

Early engagement with suppliers to explore low carbon solutions that exist in their supply chain is key. In New Zealand, both of these low-carbon aluminium products are readily available in the market, however you need to be careful that this sourcing is guaranteed.

Action:

Adopt a circular economy approach to façade systems (where aluminium is most often found in buildings) with refurbishment and reuse, or renting façade modules from suppliers as part of a materials bank.

GLASS

Glass is a heavy carbon contributor for the envelope. Similar to aluminium, it also requires a high input of industrial heat in its manufacture.

How do you reduce upfront carbon in glass?

In the Australasian market, low carbon glass options are still emerging. However, European technology is developing solutions for the industry. In the short term, plans to incorporate glass with a 40% recycled content are being pursued. Long term solutions include electrifying manufacturing equipment and switching energy sources to renewable electricity and green hydrogen.

Action:

- Procure glass manufactured using renewable electricity and green hydrogen
- Specify high recycled content
- Adopt a circular economy approach to façade systems with refurbishment and reuse, or renting façade modules from suppliers as part of a materials bank

FINISHES

Finishes make up a smaller portion of upfront carbon; however they are the most often replaced through the building life-cycle and make up a large portion of module B4. Finishes provide a good opportunity for upfront carbon reductions with a wide range of product choices compared with other building elements.

Emissions are likely to be driven by two key aspects:

- Presence of high embodied carbon materials
- Volume of the finishes product (e.g. high volume products such as decorative ceilings and carpets are likely to contribute a greater portion of upfront carbon)

How do you reduce the upfront carbon in finishes?

It is recommended that the following principles are applied:

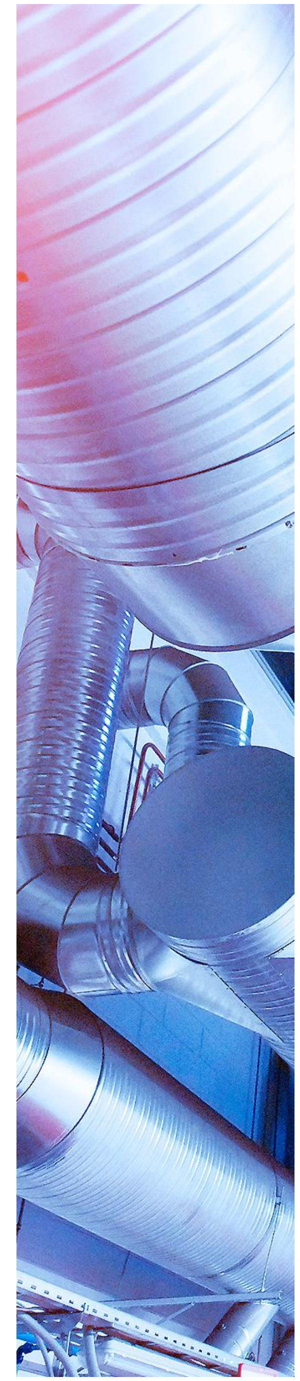
1. Where options exist, use less applied finishes or utilise the raw finish of the envelope or structure
2. Undertake an integrated fitout to minimise waste material
3. Ask suppliers for EPDs to make like for like comparisons between different products
4. Consider the longevity of the finish when specifying
5. Specify products with a high recycled content
6. Identify and preference suppliers that are using renewable energy sources in the manufacture of their products
7. Identify and preference suppliers with product stewardship or take back schemes. This acts to extend the life of products and keeps materials in use at a higher value for a longer time.

Action:

Reduce the use of finishes where possible.

Specify products made by renewable energy and with suppliers that offer product stewardship schemes.

BUILDING SERVICES



Any decision made to reduce upfront carbon needs to ensure that the operational energy performance is not impacted. The diversity of materials in building services, as well as the complexity of its supply chain, means that engagement with suppliers should be early to ensure building services equipment is both operationally efficient and low carbon.

Approximately half of the upfront carbon of mechanical and fire protection services can be attributed to steel. For electrical services, polyvinyl chloride (PVC) (~40%) and aluminium (~30%) make up the main portion. Hydraulic services are dominated by copper and polyethylene (each contributing ~35-40%).

BRANZ and Beca have recently released a study[33] on the embodied carbon impact of building services in NZ, using several residential and non-residential case studies.

How do you reduce the upfront carbon in building services?

Low carbon alternatives will generally rely on technologies and processes such as electric arc furnace produced steel, and high recycled content in aluminium and PVC. When and where the majority of the emissions occur (e.g., at a steel mill or aluminium smelter) are often not in the direct control of suppliers but sit further back in the supply chain. Because of this, it may be more efficient to signal demand and collaborate with suppliers. These changes will take time, so we need to start this conversation now.

The building services industry is relatively new to the upfront carbon conversation as, historically, building services focused on operational efficiency. However, as more buildings are electrified and the structure of buildings is decarbonised, the upfront carbon of building services will become increasingly important.

Action:

- Compare and specify building services products based on product-specific EPDs
- Preference suppliers that are working within their own supply chain to drive low carbon materials and increase recycled content
- Specify low GWP or natural refrigerant plant and equipment only
- Embed sensors in components that retain as-built data and support resource-rich material banks.

Appendix C: Environmental Product Declarations

ENVIRONMENTAL PRODUCT DECLARATIONS

To measure the embodied carbon of a material or product, the standard reporting mechanism is an Environmental Product Declaration (EPD). An EPD is a report that describes a material or product's environmental impact. It is analogous to a nutrition label, reporting a variety of health information. In this case, one of the important tracked "nutrients" is the product's GWP. EPDs are governed by industry-established Product Category Rules (PCRs) that document the reporting requirements and guidelines for a specific material or product type. They are typically updated every five years following a series of ISO standards. EPDs are commissioned by manufacturers or vendors to report their environmental impacts. The most credible EPDs are third-party verified, with a number of organisations providing this service to the industry. For vendors that have not yet created EPDs for their products, several trade organisations have created industry-average EPDs based on the average national data for those materials.

What is the best source of EPDs New Zealand?

The NZGBC recognises EPDs that are compliant with EN15804, EPD Australasia and the International EPD system.

Types of EPDs	PCR is third-party reviewed?	EPD is third-party review	Specific to a single product from a single supplier?	Standards followed?
Product-Specific Declaration	–	–	✓	• ISO 14044
Product-Specific Type III **PREFERRED**	✓	✓	✓	• ISO 14025 • ISO 14040 • ISO 14044 • ISO 21930 / EN 15804
Industry-Wide	✓	✓	–	• ISO 14025 • ISO 14040 • ISO 14044 • ISO 21930 / EN 15804

How do you compare EPDs?

Currently, EPD comparisons are not straightforward between different materials and products (e.g., concrete to steel to timber) because EPDs for specific materials are governed by different PCRs. While PCRs primarily focus on the product life cycle stage, they each make different assumptions, and in turn make it difficult to compare the data.

One example of this is the new version of EN 15804, released in 2019 and mandatory from mid 2022. The environmental indicators reported in an EPD following this updated standard are different, and use different units, to the previous iteration of the standard. This means EPDs from older versions of EN 15804 cannot be used in the same building LCA as EPDs from the new version of EN 15804.

EPDs of the same material or product, however, are generally comparable when following the same PCR. It is these "apples-to-apples" conditions that result in the most accurate comparison of carbon emissions.

Overall, while inconsistency and uncertainty exist with EPD data, it is the most accurate information available for measuring carbon emissions of materials and products. This data will be refined and improved over time with industry adoption.

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