Green Star Net Zero Ready Buildings

Baseline Analysis, Pathway Setting and Target Feasibility

Prepared for New Zealand Green Building Council
Prepared by Beca Limited

18 December 2024

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Contents

Executive Summary

The New Zealand Green Building Council (NZGBC) engaged Beca to assist in determining baseline performance and setting decarbonisation trajectories for upfront embodied carbon and operational carbon (energy use).

This report summarises the research undertaken to identify possible pathways aligned with a "Net Zero" approach for new buildings. It describes the proposed pathways identified through a 'top-down' approach from a 1.5-degree aligned trajectory for the sector, and compiles the 'bottom-up' analysis undertaken to determine the practical feasibility of aligning operational energy and upfront embodied carbon caps.

The final 'Net Zero Ready' pathway upfront embodied carbon and operational energy reduction requirements are as follows:

Typology	Operational energy reduction	Upfront carbon reduction			
	All years	**2024**	**2026**	**2028**	**2030**
Office	53%	31%	45%	53%	61%
Other		26%	38%	45%	55%

1 Research Summary

Three existing methodologies for buildings alignment with a 1.5 degree-aligned "Net Zero Carbon" pathway were reviewed and compared. These were:

- The Science-Based Targets Initiative (SBTi) draft Buildings methodology.
- The Carbon Risk in Real Estate Monitor (CRREM) Operational pathways methodology.
- The BRANZ carbon budget for NZ Buildings research / methodology.

The review of these methodologies identified several key areas for making judgement calls when undertaking carbon budget or target decisions. These assumptions and key decisions are summarised below.

Budget allocation. It was acknowledged by NZGBC that there are inherent ethical, socio-political and scientific values embedded in different approaches to selecting and apportioning carbon budgets to countries and sectors. These require a consistent or coherent approach, and there are equally as many assumptions to be made about the future state or scenarios. To be consistent with other national and international approaches for similar applications, it was decided to follow the grandfathering approach used by the SBTi. The target reductions are highly sensitive to the budget allocation method used.

Energy Use Intensity (EUI) targets. There are several viable methodologies for setting EUI targets for buildings which were reviewed. The CRREM approach was preferred. A wide range of potential future NZ specific electricity grid emissions profiles were investigated. The differences in target outcomes where not significant when compared to annual target reductions. The decision was made to directly align with the CRREM energy reduction targets.

Validation. The NZGBC acknowledged the need for ongoing validation of past assumptions, and correction to the methodology if need be. The NZGBC intends to align with SBTi and CRREM updates to their respective tools in future iterations.

Timing of emissions – embodied carbon. For upfront embodied carbon emissions, the NZGBC decided an average time of two years between registration and practical completion was reasonable. This length of time determines the target reduction for any given year of registration, as the emissions are assumed to occur in the year of practical completion.

Timing of emissions – operational energy. For operational carbon emissions, the approach suggested in the feasibility study was not adopted by the NZGBC. This proposed energy targets on the basis of an average reduction over a 15yr period. However, it was observed that there was only a minor difference between the average 15yr reduction targets (50% @ 2026) and the post-2030 steady state reduction target (53%). Therefore for simplicity, the NZGBC decided to adopt a 53% reduction target for all building types, for all years.

Growth of building sector. The expected rate of growth of the building sector (in m^2 per year) is already accounted for in the carbon budgets allocated to the building sector, in all of the methodologies assessed. As the research established the New Zealand building market future projections of growth aligned closely to those used in the SBTi and CRREM methodologies, the NZGBC decided no further changes were required at this stage to the assumptions of sectoral growth. This assumption will need to be revisited periodically to ensure the targets remain appropriate.

2 Analysis Summary

2.1 Operational energy

2.1.1 EUI baselining and target-setting

The operational emission study took existing Green Star energy models and updated them to current v1.1 GHG ‘Reference Building’ models. This primarily involved upgrading the fabric and HVAC systems to new Clause H1 (2022) minimum standard efficiencies. This regulatory minimum was agreed with the NZGBC as a suitable baseline for new building operational efficiency.

Modelling was conducted for four different building typologies, to provide a broad scope of project conditions. The projects tested included an office in Tauranga, a school in Christchurch, an industrial warehouse in Tauranga, and a hospital in New Plymouth. Whilst the absolute performance of these buildings may not be representative, they are able to provide insight into “typical performance” that can be used to understand the practicality of improving energy performance.

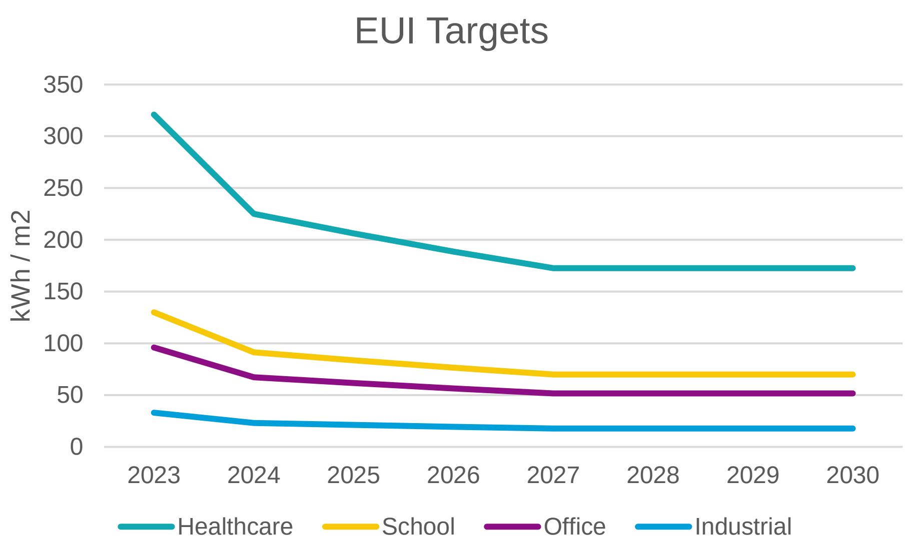
The modelling included all major typical energy end uses, including space heating, space cooling, hot water heating, ventilation fans, ancillary fans, pumps, indoor lighting, outdoor lighting, and lifts.

The table below presents the building Energy Use Intensity (EUI) for each modelled building.

Project	v1.1 Reference EUI ($kWh/m^2/y$)
Office	86 (4.5 Star NABERSNZ*)
Warehouse	42
School	113
Hospital	367

*base build when excluding tenant lighting consumption

The target EUIs associated with the SBTI and CRREM operational carbon reduction pathway are as follows:



The following table summarises the ‘top-down’ percentage reductions identified as being aligned with a 1.5-degree-aligned pathway for buildings. These are the reductions required to be achieved in the year of design, assuming a 15-year period before systems upgrades / replacements trigger new targets. This also shows the long-term reduction targets for each typology.

Typology	Energy reduction targets			Long Term Targets	
	2024	2026	2028	2030	2030 - 2050
Office	46%	50%	52%	53%	53%
School	46%	50%	52%	53%	53%
Industrial Warehouse	45%	49%	51%	52%	52%
Hospital	41%	44%	46%	46%	46%

The following key decisions and assumptions were adopted by the NZGBC to move forward with the feasibility study.

Baseline year selection. Several options were discussed for operational energy baseline setting. The decision was made by the NZGBC to keep this consistent with the Green Star GHG ‘Reference building’, i.e. regulatory minimum standard per 2022 Clause H1. Therefore, 2023 was selected as the baseline year for both operational energy and upfront embodied carbon reduction pathways, being the first full calendar year in which designs adopted the H1 standard.

Building typology selection. To cover the majority of building types registered or certified under Green Star, four typologies were selected. Alternative or one-off ‘special’ projects (such as civic or cultural buildings) are expected to follow the same reduction pathway.

2.1.2 Feasibility analysis

Our top-down energy baselining research showed that depending on the typology, between 46% and 53% reduction in operational energy is required to be considered aligned with a science-based target.

The feasibility study report found that:

- These targets are practically feasible for most Office and School buildings.

- Industrial warehouse buildings would generally struggle to achieve this level of performance (coming in at ~40%) but can readily achieve the target through the provision of Solar PV (due to large roof availability).
- Few hospital buildings would be able to practically achieve this level of performance without sacrificing level of service. There is significant variability in hospital use (hours, level of service), and reducing energy consumption beyond 30% will be challenging for most healthcare buildings.

The following key decisions or assumptions were made by the NZGBC based on the feasibility study.

Typology specific targets. As the percentage reduction targets for the energy intensity were similar across typologies, for simplicity, NZGBC decided to adopt a single reduction pathway. This pathway was based on the office typology CRREM EUI reduction targets, resulting in a target reduction of 53% compared to a 2023 baseline.

Time-varying reduction targets. As the difference between a 15yr average target and the long-term energy reduction targets was marginal (max. 7% diff.) it was decided that a single reduction target for all dates of project registration was appropriate.

Healthcare and highly serviced buildings. The feasibility study identified that hospitals, and potentially other highly serviced buildings, are unlikely to be practically able to achieve the reductions identified. NZGBC have specified that these buildings may request special conditions to achieve a slightly lower percentage reduction target.

Grid decarbonisation. It was decided that no allowance for grid decarbonisation beyond that already assumed within the CRREM energy reduction targets would be embedded into the EUI reduction targets. We confirmed this was a conservative approach through analysis of future grid scenarios. We note that grid futures are uncertain and this can be updated when there are revisions to the pathway over time.

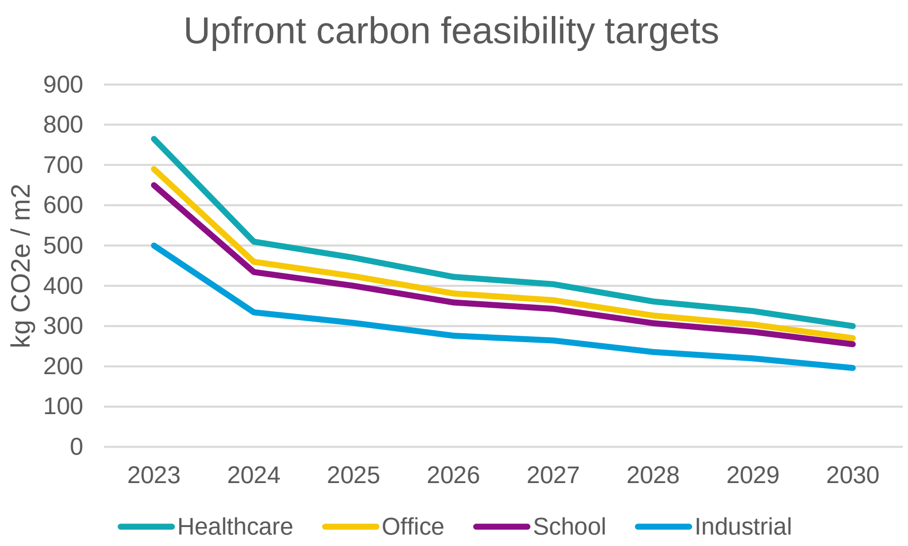
2.2 Upfront embodied carbon

2.2.1 Baselining and target-setting

Setting upfront carbon baselines for this research was solely for the purpose of testing the feasibility of the proposed decarbonisation pathways. Therefore while the buildings used to set baselines are fairly typical of their sector, they are not representative of the sector as a whole. Past detailed life cycle assessments of buildings in New Zealand in the four typologies identified resulted in the following baselines identified for this study:

	Healthcare	School	Office	Industrial Warehouse
Upfront Carbon	765 $kgCO_2e / m^2$	650 $kgCO_2e / m^2$	690 $kgCO_2e / m^2$	500 $kgCO_2e / m^2$

The top-down upfront embodied carbon intensities associated with the SBTi draft Buildings tool are as follows:



The following table summarises the final 'top-down' percentage reductions identified as being aligned with a 1.5-degree aligned pathway for buildings. These are the reductions required to be achieved in the year of design, assuming a 2-year average programme between design and practical completion.

Typology	Upfront carbon reduction			
	2024	**2026**	**2028**	**2030+**
Office	31%	45%	53%	61%
School	26%	38%	45%	55%
Industrial Warehouse	26%	38%	45%	55%
Hospital	26%	38%	45%	55%

Baseline year and intensity. For consistency between the operational and embodied carbon pathways, a 2023 baseline year was selected. For the purposes of establishing baseline carbon intensities, building upfront carbon assessments from 2020 to 2023 were used, as it was agreed there have been minimal functional changes in design and construction methods for a number of years. This is also in alignment with the SBTi approach which allows up to 3 years of prior data for embodied emissions baselines to be set.

2.2.2 Feasibility analysis

The bottom-up analysis undertaken for feasibility of upfront carbon reduction targets identified showed that each typology is able to achieve the current (2024) level of reduction required from the 'top-down' analysis, based on current technologies and practices. For school buildings this will likely require the replacement of traditional materials with timber, but other buildings can achieve this based on traditional materials with low carbon procurement. Some level of timber design (or innovative structural solutions) may be required to provide further reductions as the targets progress through the years, depending on the extent of decarbonisation of the supply chain.

Specific to each project, and not able to be well captured in this feasibility study, are those decisions which are reliant on the good judgement of the design team, and in particular the structural engineer. Undertaking optioneering in early design to select systems which are the most materially efficient, and finding innovative means of meeting the brief, will also be options which are available to design teams seeking to reduce upfront carbon emissions.

The following table presents the feasible reductions determined from the ‘bottom-up’ analysis for different building typologies, based on currently available technologies and materials, to inform the targets.

Typology	Upfront carbon reduction	
	Traditional materials	Timber
Office	35%	55%
School	30%	40%
Industrial Warehouse	50%	60%
Hospital	35%	40%

Supply chain decarbonisation. The NZGBC confirmed that baseline material carbon intensities will remain the same throughout time even as the supply chain decarbonises[1]. This is in recognition of the fact that a large proportion of upfront embodied carbon reductions in the building sector required by the 1.5° pathway are expected to be from material process decarbonisation, rather than from changes in design approach.

3 Integration into Green Star Buildings

This report provided NZGBC with an understanding of decarbonisation feasibility and the reduction pathways aligned to a 1.5-degree future. The research provided the NZGBC with sufficient information to decide final performance requirements for the Net Zero Ready Pathway in Green Star Buildings, for operational energy and upfront embodied carbon reductions.

Subsequent to input provided by the Expert Reference Panel (ERP) for Materials, the NZGBC have published these targets under Credit 21, Upfront Carbon Emissions, and Credit 22, Energy Use.

Furthermore, additional key decisions by the NZGBC following workshops and engagement were as follows.

Alignment to 6-star. To avoid confusion between the requirements of Green Star Buildings, and the requirements of the Net Zero Ready pathway, the NZGBC decided that only 6-star buildings would have to follow the pathway. This is aligned with the NZGBC’s approach to having 6-star buildings represent world-leading buildings.

Updating Green Star targets. For simplicity, a single set of targets was adopted by the NZGBC to bring in the research from the Net Zero Ready buildings into the Green Star Buildings Credits. These targets are aligned with key points along the 1.5 degree reduction pathway curve, although as noted above, 4-star and 5-star buildings targets for any given year do not align to the Net Zero Ready pathway targets.

Providing recognition. Buildings which opt to follow the Net Zero Ready pathway and achieve the target reductions identified will be rewarded in the Green Star Buildings tool. The NZGBC have determined that following this pathway also gives building owners the ability to claim a Net Zero Ready building.

Net Zero Ready versus Net Zero. There always remains uncertainty about the exact amount of carbon emissions from a building, both in the embodied and operational carbon space. Also, until all of these emissions (and any removals) have occurred, a Net Zero status cannot be guaranteed. Therefore, the NZGBC made the decision to call this pathway a Net Zero Ready pathway. This reflects the intent of the building owner to align to Net Zero principles, while acknowledging the difference.

[1] Note: The feasibility studies were undertaken prior to the research and publishing of the material GWP baselines by the NZGBC in November 2024. Different material baseline GWPs were used in the feasibility study. It is expected that the available reductions through material procurement are lower than presented here, particularly for structural steel.

A

Appendix A – Research Report

Green Star v1.1 Net Zero Aligned Buildings

Baseline Analysis and Pathway Setting

Prepared for New Zealand Green Building Council
Prepared by Beca Limited

23 February 2024

Disclaimer:

This report was prepared for the New Zealand Green Building Council and presents the findings of research and analysis undertaken to inform future decisions about the Net Zero Ready pathway.

Workshops with the NZGBC and their Expert Reference Panel, has led to analysis updates and augmented these findings. These reports may not reflect the final targets and approach found in the Green Star Buildings guideline.

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Revision History

Revision Nº	Prepared By	Description	Date
0	Tavis Creswell-Wells and Phoebe Moses	For information	8/01/24
1	Phoebe Moses	Additional commentary on BRANZ methodology	23/02/24

Document Acceptance

Action	Name	Signed	Date
Prepared by	Phoebe Moses		8/01/24
Reviewed by	Scott Smith		23/02/24
Approved by	Scott Smith		23/02/24
on behalf of	Beca Limited		

Contents

Executive Summary

The New Zealand Green Building Council (NZGBC) have engaged Beca to assist in determining baseline performance and setting decarbonisation trajectories for embodied and operational carbon.

This report summarises the research undertaken to identify possible pathways aligned with a "Net Zero" approach for new buildings, the operational energy analysis and baselining, and the upfront carbon baselining. Proposed pathways (identifying percentage reduction targets) are recommended for the next stage of undertaking feasibility studies.

Pathways to Net Zero

Three existing methodologies for buildings alignment with a 1.5 degree-aligned "Net Zero Carbon" pathway were reviewed and compared. These were:

- The Science-Based Targets Initiative (SBTi) draft Buildings methodology.
- The Carbon Risk in Real Estate Monitor (CRREM) Operational pathways methodology.
- The BRANZ carbon budget for NZ Buildings research / methodology.

The review of these methodologies identified 4 (no.) key areas for making judgement calls when undertaking carbon budget or target decisions:

1. **The approach taken to allocating a portion of the global carbon budget to a sector or a country.** There are many ethical, socio-political and scientific variables at play which require a consistent or coherent approach, and there are equally as many assumptions to be made about the future state or scenarios.
2. **Deciding on how to set EUI targets for buildings.** There are several viable methodologies – one aligned with the CRREM approach, and two alternatives to make it more NZ-specific. At this stage, we recommend proceeding to the next stage of the study using the CRREM reduction targets as tests for the feasibility studies, while assessing the other pathways in more detail.
3. **The approach for ongoing validation of past assumptions** and correction to the methodology if need be. We recommend the NZGBC align with SBTi and CRREM updates to their respective tools.
4. **Target setting in the year of design.** Past discussions with NZGBC indicate that a period of three years may be suitable to account for the year in which emissions are released.

Operational energy modelling and analysis

The operational emission study took existing Green Star energy models and updating them to current v1.1 GHG 'Reference Building' models. This primarily involved upgrading the fabric and HVAC systems to new Clause H1 (2022) minimum standard efficiencies. This regulatory minimum was agreed with the NZGBC as a suitable baseline for new building operational efficiency.

Modelling was conducted for four different building typologies, to provide a broad scope of project conditions. The projects tested included an Office in Tauranga, a School in Christchurch, an Industrial warehouse in Tauranga, and a Hospital in New Plymouth. Whilst the absolute performance of these buildings may not be representative, they are able to provide insight into "typical performance" that can be used to understand the practicality of improving energy performance.

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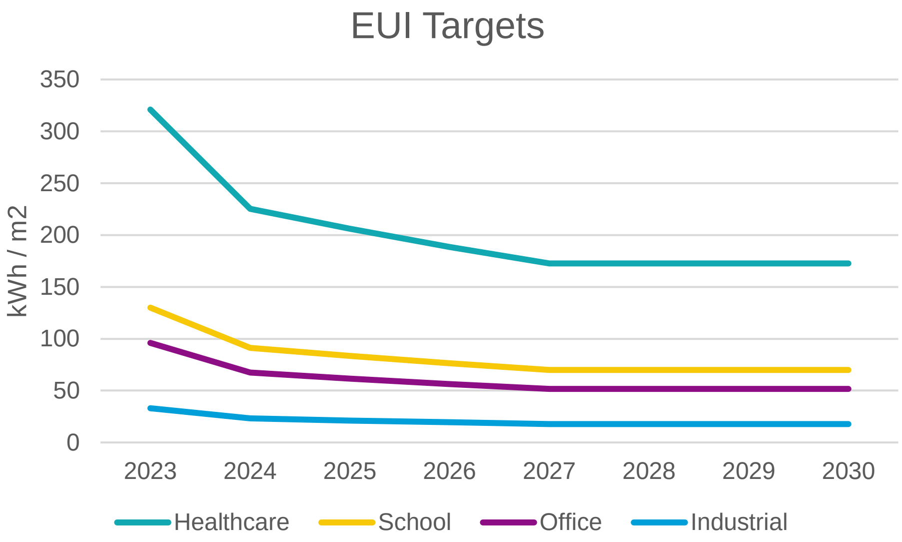
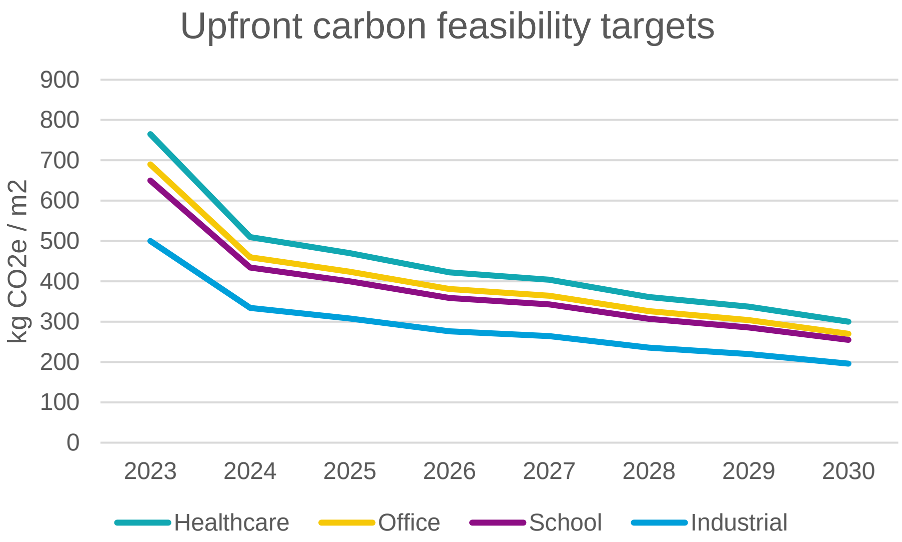


Upfront carbon baselining and pathways

Setting upfront carbon baselines for this exercise is solely for the purpose of testing the feasibility of the proposed decarbonisation pathways. Therefore while the buildings used to set baselines are fairly typical of their sector, they are not representational of the sector as a whole. Past detailed life cycle assessments of buildings in New Zealand in the four typologies identified resulted in the following baselines identified for this study:

	Healthcare	School	Office	Industrial Warehouse
Upfront Carbon	765 $kgCO_2e / m^2$	650 $kgCO_2e / m^2$	690 $kgCO_2e / m^2$	500 $kgCO_2e / m^2$

The upfront carbon targets associated with the SBTI draft Buildings tool are as follows:



Limitations

Absolute carbon figures provided in this study relate to specific designs / data sets and may not reflect the performance of other buildings. The purpose of this study is to establish baseline figures which can be placed against percentage reduction trajectories. The practicality of these target emission levels can then be tested against current decarbonisation strategies and projections of supply chain and grid decarbonisation.

SBTi Trajectories are for organisations not individual assets. Whilst targets can be downscaled to individual assets this assumes that all assets within that organisational boundary are aligned. Any claims that an individual building is aligned with a science-based target should highlight this assumption.

Next Steps

- Agree underlying growth and emissions assumptions to further develop trajectories
- Agree target setting timeframes and methodology
- Undertake analysis of emissions reduction feasibility

1 Pathways to Net Zero

At a high level, the IPCC have recommended that global warming is kept to within 1.5 degrees above pre-industrial levels. This enables a theoretical calculation of a remaining carbon “budget” – emissions which can still be released into the atmosphere (without having an equal and opposite quantity absorbed).

Decarbonisation “pathways” use these budgets in order to derive progressive actions towards a future state. As New Zealand (and many other global entities) is aiming for Net Zero by 2050, the assumed “future state” of emissions at and beyond 2050 is Net Zero. There are infinite means to get to Net Zero Carbon globally by 2050, all of which are reliant on some assumptions about the future’s ability to offset or otherwise create negative carbon emissions.

Generally, well regarded global pathways to Net Zero assume that none of these negative carbon emissions are available until 2050. All of the approaches discussed below follow that same principle, of considering a total carbon budget through to 2050 without reliance on negative emissions before the end date.

All approaches to setting carbon targets for specific sectors or activities follow roughly the same approach:

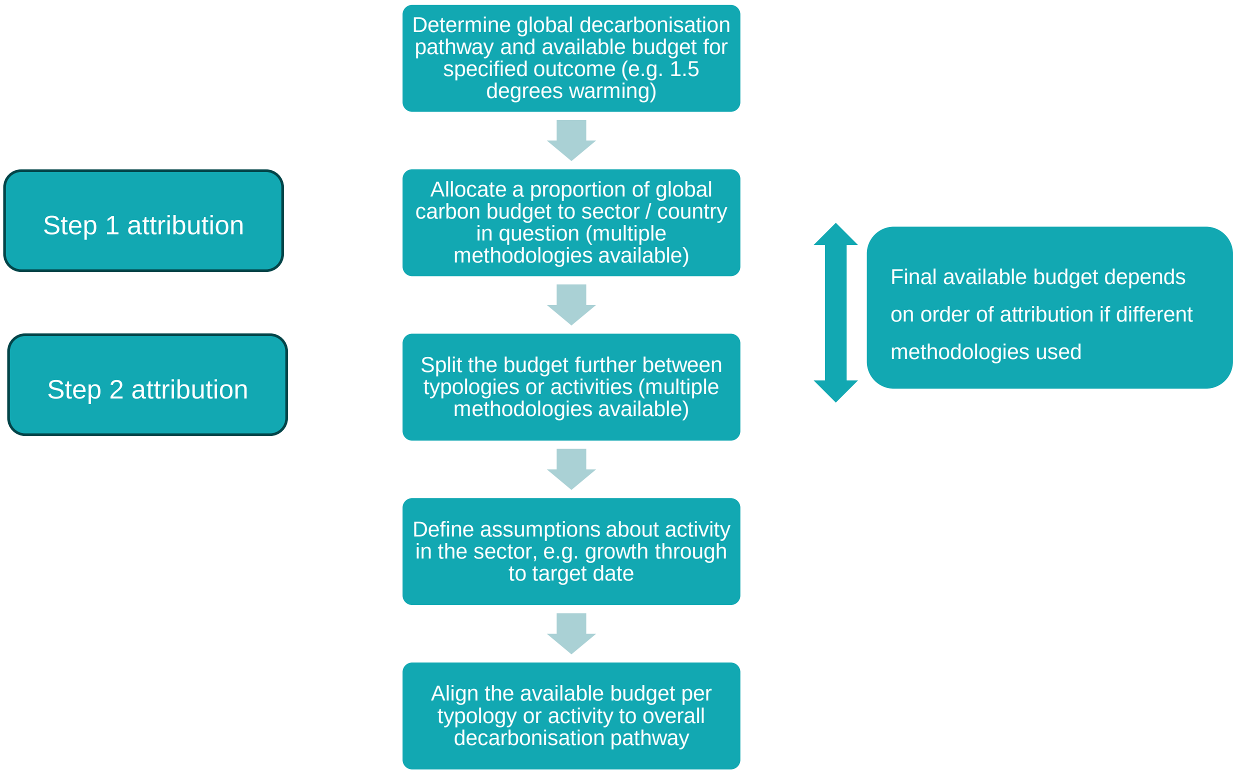


Figure 1: Decarbonisation pathway setting

The following sections summarise the approaches and key points of several different options for pathway definition for Net Zero Aligned New Zealand Buildings.

1.1 SBTI Buildings

The Science-based targets initiative defined what a 1.5-degree aligned decarbonisation pathway looks like for organisations in 2019. In 2023 they released draft guidance, methodology and a tool for determining what this pathway looks like for the buildings sector. Key points summarised below:

- SBTI worked with CRREM and Ramboll to determine operational and embodied pathways respectively.
  - SBTI operational pathways align fully with CRREM (and therefore GRESB) reduction targets.
  - Ramboll had previously developed 1.5 degree upfront embodied carbon pathways for buildings in the EU – SBTI brought them on to do global pathways.
- First target setting method: sector-specific intensity convergence, used for large sectors including buildings sector (previously known as the Sectoral Decarbonisation Approach or SDA). Budgets are not directly split by proportion but instead a factor of mitigation potential, sectoral growth and dependency on population and economic growth.
  - Intensity convergence refers to how targets are set, assuming all companies converge to the same point by 2050. Used for most in buildings. Assumes the average will be median reduction rate.
- SBTI uses grandfathering to set sectoral pathways for the buildings sector (i.e. current proportions of global emissions from building sector determine final proportions at target date).
  - Near term targets are in line with 1.5 degree - 5-10 years maximum from current year.
  - Long-term targets are to residual levels, no later than 2050 (gross emissions only).
- Other method: Absolute contraction. Expects all companies reduce at linear rate through to 2030. Only used for some in buildings who have a forecast low or no growth rate, or who are moving from new developments to maintaining an existing portfolio.
- Global growth estimation 75% increase 2020-2050 for buildings based on the CRREM growth pathway.
  - Majority of growth assumed to be in emerging markets – developed markets such as NZ assumed to have slowing floor area growth.

1.1.1 SBTI In-use emissions pathway (refer also CRREM)

General Comments

- Differentiates performance targets based on use and location - includes an NZ area. Top-down downscaling.
  - Pathways both for carbon and energy intensity
  - Includes scope 1, 2, 3 sources - straightforward intensity KPIs (per sqm). Tenant emissions from buildings must be included. Must use location based accounting approach for disclosures for buildings scope 2.

Target Setting Process

- Step 1 - looks at global decarbonisation budget through to 2050. Deriving real estate share, based on growth rates etc.
- Step 2 – disaggregates to country-specific decarbonisation pathways using SDA to derive location-based targets and property type targets (usually SDA is used to differentiate by sector, but CRREM and SBTi justify use of SDA for country-based disaggregation based on similar reasoning). All converging at 0 in 2050, all pathways collectively add up to budget.

- CRREM methodology discusses possible modifications to the growth factor used to take equity considerations into account when using the SDA process to differentiate budgets by countries – no modification made for this iteration but doesn't rule it out for the future.
- Data used appears old (2007 for building stock) and for average house size refers to Australian data (for resi / commercial splits).

- Step 3 – defines use-type specific decarbonisation pathways, with defined kWh/m2 starting values, use-type specific energy mix (e.g. percentage future energy mix for office buildings gas vs grid electricity). Uses weighted emissions factor in base year to calculate kg CO_2e / m^2 / yr.
  - Uses MFE EFs published in 2020 based on 2018 inventory to define starting point for carbon pathways.
  - Grid decarbonisation scenarios are based on global IEA data – assuming full grid decarbonisation by 2040. Therefore not linked to NZ-specific grid decarbonisation.
- Step 4 (CRREM only) - derives EUI pathway (kWh / m^2 / yr) based on projected emission factors through to 2050.
  - The projected emissions factors are based on IEA energy 'targets' – not defined in IEA report, derived by CRREM from renewable energy budgets available to the buildings industry.
  - Energy targets calculated taking into account possibilities and limits of energy efficiency in different climate zones, and heating and cooling degree days.

1.1.2 SBTI Embodied emissions pathway

<u>General Comments</u>

- Performance targets only differentiated by building typology – only a global upfront carbon pathway has been provided to date.
  - Further workstreams plan to disaggregate pathways by location similar to operational pathways.

<u>Target Setting Process</u>

- Step 1 – looks at global decarbonisation budget through to 2050. Derives full construction sector activity share, based on Exiobase database (Multi-regional input-output model provides information on environmental impacts of economic activities across regions and sectors). Covers A1-A5, B1-B5.
  - It is unclear if the Exiobase database covers New Zealand specifically.
- Step 2 – downscales from full construction to construction of buildings. Used a review of economic productivity covering US, EU, China, Africa to determine 53% of construction activity related to buildings.
  - Not NZ-specific – proportional allocation between building and non-building construction would impact NZ building construction budget.
  - Still covers Modules A1-A5 and B1-B5.
- Step 3 – downscales to building typologies (skips regional downscaling / allocation). Still top-down at this stage using a "comprehensive review of embodied carbon in buildings".

    - Difference between residential and non-residential embodied carbon emissions intensity used to proportionally allocate between residential and “other” building typologies, with “other” further disaggregated using global building stock data for “office”, “retail” and “other”.
    - NZ situation not reflected in this ratio.
- Step 4 – excludes impacts of renovation (i.e. cover new buildings, Modules A1-A5 only).
    - Pathways are steeper including renovation.
    - There is an unexpected step change in the pathways which include renovation, around the 2030 mark. No commentary on SBTI what this is from.
- Step 5 – aligns final downscaled shares by building typology with a 1.5 degree global pathway with little-to-no overshoot.
    - This pathway is the median of a large number of pathways developed by AR6 Scenario Database for 1.5 degree target.
    - SBTI have developed specific pathways for material production sectors cement and steel, as well as ‘other sectors’, transport and electricity and heat generation. These are integrated into the buildings pathway based on their relative contributions to building emissions (using 2019 baseline). The aggregate of these is used to determine the weighted reduction percentage for construction relative to 2020 (on an absolute contraction basis). Through to 2030, minimal assumed reliance on decarb of sector.

Table 5.8. Weighted reduction percentage for construction relative to 2020

	2025	2030	2035	2040	2045	2050
Reduction percentage	-15%	-31%	-52%	-73%	-85%	-97%

Figure 2: Table from SBTI buildings embodied carbon methodology indicating absolute contraction of combined construction emissions sources through to 2050

- Step 6 – divide budget pathway (annual allowable emissions) for each sector by the total projected built area of each typology, to estimate target upfront carbon intensities through to 2050, using pre-defined starting points for intensity based on bottom-up LCAs (almost 500 for non-resi).
- Downscaling approach: did three methods. The main approach used grandfathering but did sensitivity study on two other approaches (equal per capita – most comparable to BRANZ approach, and economic value added approach).
    - The draft guide contradicts and swaps around reference to these alternative pathways further down same section – unclear which results in 35% reduction in budget and which in 10% reduction.
- Includes up to “Category A fit out” – similar scope to NZGBC “warm shell” fit out.
- In the accompanying tool – choosing a base year further on than 2020 provides proportionately adjusted pathways.

1.1.3 Key points for consideration - SBTI

- SBTs not intended to be used to assess performance of an individual asset.

1.2 CRREM operational pathways

Carbon Risk and Real Estate Monitor translates Paris Agreement 1.5 and 2 degree scenarios to decarbonisation pathways for the property sector, to enable benchmarking and consider asset stranding in risk assessments. An update was released in 2023 to align with the SBTI Buildings methodology and decarbonisation pathways. Key points are summarised below:

- Operational only (fully aligned to SBTi operational – worked together – same process as SBTi Operational pathways). Also fully aligned to GRESB.
- Updates to pathways include:
    - Updated IEA and IPCC data, which projects most absolute reductions to be in the years 2030-2040 (rather than between now and 2030).
    - Updated to use 2020 as base year, to align with SBTI (was previously 2018).
    - Excludes transmission and distribution losses (change from 2018), to be consistent with SBTI approach.
    - EUI pathway methodology changed to reflect actual building energy consumption (including consumption of on-site renewables) to incentivise efficiency-first approach. But renewables still incentivised for carbon pathways.
- Updated pathway reflects global reality that sector is not decarbonising as fast as it needs to – therefore to keep same sectoral budget, the pathway is now more aggressive. However – as the new pathway excludes T&D losses – the curve actually looks quite similar to beforehand. Other upstream power usages also not included – only building consumption.
- More detailed information on other GHGs (i.e. refrigerants) available so conservative add-on for Module B1 was reduced.
- Adjusted pathways for real growth to 2020 compared to projected growth (reduced).

Figure 8: Global building sector CO_2-only intensity pathways (excluding vs. including T&D-losses) [22]

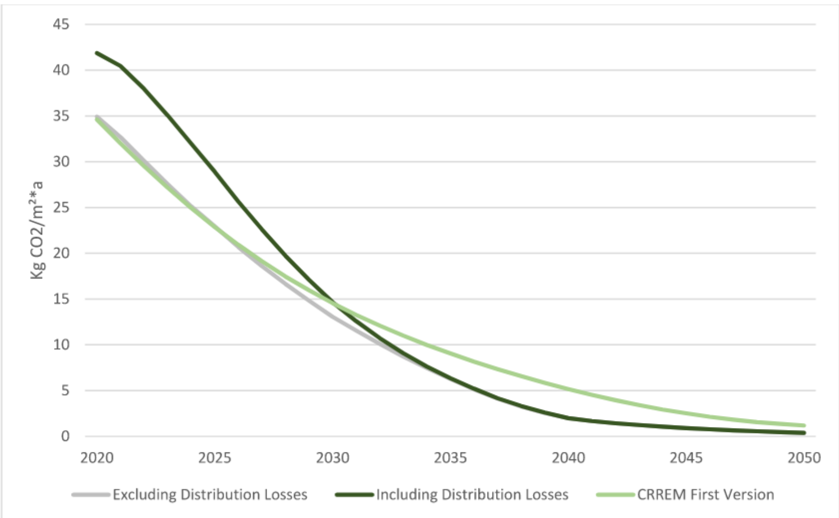


Figure 3: Graph from CRREM new baseline report describing global reduction pathways

- Assigns a ‘stranding year’ based on current asset intensity combined with grid decarbonisation, overlaid on 1.5 or 2 degree curve

- Translating to targets – can set year of expected stranding
- Only 1.5 degree curve aligns with SBTI, not the 2 degree curve
- Assets required to target both energy consumption and carbon intensity to avoid stranding.

- Sets "Energy targets" for different asset types in different countries / locations. These energy targets take into account possibilities and limits of energy efficiency in different climate zones, and heating and cooling degree days.
  - Note that the energy targets, when multiplied by the projected country grid emissions factor for that year, do not equate to the GHG pathway figures (i.e. there is a shortfall). CRREM makes it clear assets also need to meet the GHG intensity targets for the respective year – with the shortfall being made up by renewables (presumably on-site).
  - This is based on IEA assumptions around renewable energy budgets available for the real estate industry in 2050.
  - **Choice for NZGBC** – to align with CRREM approach (limited by assumed practicality/grid emissions) or align with SBTi carbon targets translated to energy consumption using more specific NZ context.
- Pathways / targets available for operational carbon (GHG), operational carbon (CO_2 only), and operational energy (kWh / m^2 / yr)
  - Methodology states the CO_2 -only curve developed by request of the SBTi – however the SBTI methodology is all in CO_2e (i.e. including other GHGs) – appears this was to differentiate Module B1 (refrigerant) from Module B6 (building energy), and to ensure users not reporting refrigerant emissions have their own pathway.
- Asset or portfolio based – no limitation on use.
- Is clear that the purchase of renewable energy certificates may not be accounted for when using the CRREM tool as they do not increase amount of renewable energy in the grid.
- Provides a "carbon value at risk" indicator (CVaR) to compare stranding risk of multiple assets – calculated based on total carbon "costs" and "savings" through to 2050, with a user defined discount rate to assess net present value.
- CRREM methodology document has a much larger section than SBTi documentation covering equity considerations.
  - Different growth is the only equity consideration taken.
  - If countries have national carbon budgets derived on a per capita basis, or an alternative basis other than grandfathering, then sectors other than real estate need to contribute more to the national decarbonisation.
  - Notes distributing budgets on a per capita basis for buildings is not suitable – as buildings in different climate zones already have different energy demand requirements.
  - Recommends an equity adjustment should be built in when all NDCs globally have been decided and the global distribution has been solved at a political level.

1.3 BRANZ Carbon budget for buildings

BRANZ undertook a study in 2021 which extended past research looking at absolute sustainability of buildings in the residential sector, to also cover non-residential building types. One of the primary purposes of the study was to assess how sensitive the carbon budget for buildings is in New Zealand when considering variable input parameters. The study does not identify a pathway for reduction, but instead nominates an allowable carbon budget for buildings through to 2050 (growth-adjusted) and identifies whole-life carbon intensities which, if all buildings built between now and 2050 were to meet, align to a 1.5 degree budget. Absolute reduction targets are based on global carbon budgets to 2050.

Target Setting Process

- Step 1 – use equal per capita sharing to allocate New Zealand's portion of the global carbon budget in line with a 1.5 degree warming limit.
- Step 2 – use grandfathering approach to distribute the NZ carbon budget to the buildings sector (in-use and construction).
    - Base year of 2012 for sectoral contributions.
- Step 3 – split embodied and operational carbon contributions, to determine operational and embodied budgets.

General Comments

- Assumes all buildings are net zero beyond 2050.
- New build office carbon footprint exceeded carbon budget by factor of 5.3 (236tCO2e total for 'average' building, or 208kgCO2e / m2, with a current estimated 'average' carbon footprint of 1108kgCo2e / m2). All buildings between now and 2050 assumed to have the same carbon budget, or average between now and 2050 to be 208kgCO2e / m2.)
    - Budgets are combined operational and embodied carbon.
    - There is no pathway proposed to match the budget – determining a decarbonisation pathway from this research is possible however and could be looked at in the next stage as a comparison to the SBTi / CRREM approach. Figure 4 shows this indicatively.
    - Estimated upfront carbon budget within whole-life budget is ~70kgCO2e / m2 for non-residential buildings, using the BRANZ allocation of embodied to operational carbon of a 35% / 65% ratio. Note this was the ratio used by BRANZ to describe the expected source of emissions from now to 2050, including existing buildings. The source for this is unclear but may come from a referenced paper written in 2020 which applied an absolute sustainability assessment to residential buildings in NZ. If so, it will not be representative of the non-residential buildings sector.
- Modules B1, B2 and B4 not included in scope – different to SBTi.
- Only shell + core (sensitivity study included biogenic, Module D, and MEP and TI). Different scope to SBTi – which also includes select fitout elements.
- 60 year service life assumed when calculating whole-life energy.
    - Annual carbon intensity for in-use carbon can be derived from the building budget identified. This could be aligned with grid decarbonisation to identify an in-use emissions pathway for CO_2 only, and compared to the CO_2-only pathway from CRREM.
- Grid decarbonisation - assumes MBIE "reference" energy scenario for grid decarbonisation, sensitivity study on '100% renewable". Is NZ-specific unlike the CRREM.
- Many sensitivity studies were undertaken, most changes considered resulted in lower carbon budgets available for buildings.

- Assumed 76% increase in office building floor area through to 2050 (net) – BRANZ didn't do any sensitivity studies on growth, however this growth assumption aligns with the growth assumptions used by SBTi and CRREM (75% growth).

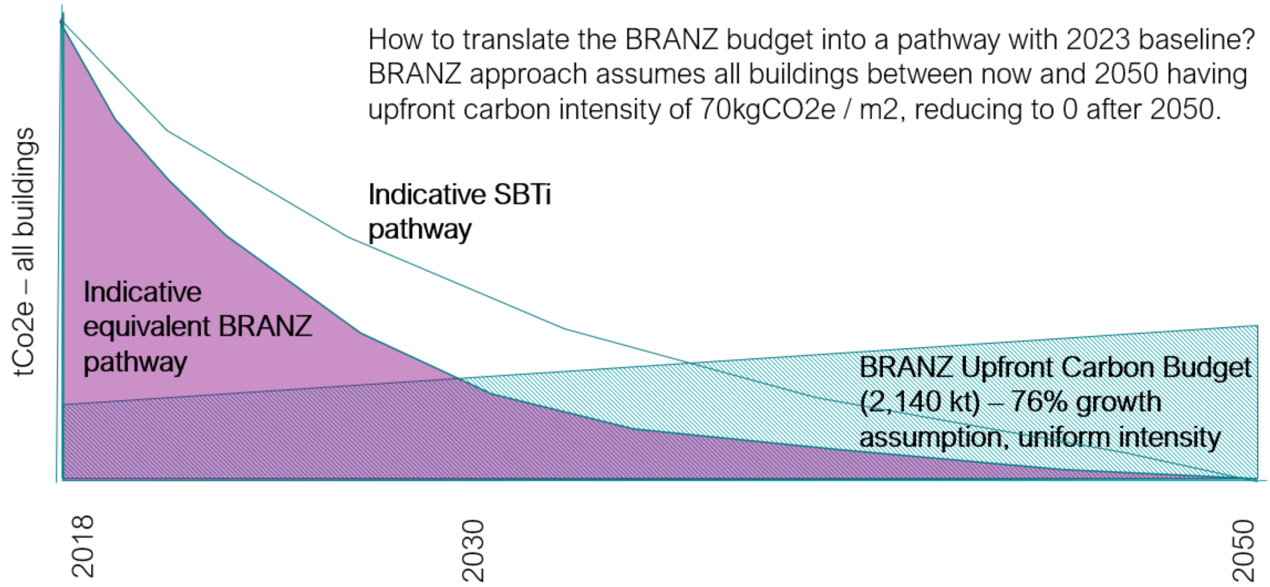


Figure 4: BRANZ Pathway

1.4 Discussion

- **Budget allocation -**
  - National budget allocation **-** There is a mix of approaches – SBTI uses grandfathering only (because their upfront carbon is not regional, it's global). Dutch GBC and BRANZ both use "equal per capita" method to allocate national budget. NZ's NDCs and domestic budgets have been set using grandfathering approach, but this also has had quite a lot of criticism. IPCC do not endorse grandfathering for setting country-level budgets.
  - Oxfam report calculates different methodologies for setting the NZ NDCs – a 67% reduction on 2005 levels by 2030 for "grandfathering" (budget ~2.5x higher than "equal per capita"), an 81% reduction on 2005 levels using "equal per capita". "Population and overuse" model shows >100% reduction by 2030. Climate Action Tracker allocates a minimum % reduction by 2030 of 45% from 2005 to be compatible with Paris Agreement.
  - Sectoral budget allocation – consistent use of grandfathering approach, most of the debate around budget allocation comes when it's allocating to people / nations.
  - SBTi calls itself a science-based target methodology, CRREM points out (interesting point of tension) that allocating future emissions is inherently political, and not scientific. Any decision on future allowable emissions will need to justify their approach on an equity basis (even if it is to say that no equity considerations were taken).
- **Future state vs present state:**
  - Resetting growth assumptions – CRREM undertook with update, reasonable to assume that as time progresses, resetting growth assumptions (both for future growth, and for growth which occurred in real time since previous update) should happen.

  - Timing of emissions – as discussed with the NZGBC, target emissions are for the year in which those occur. Making an assumption about the typical length of time between design and construction will enable targets to be set during the design.
- **Grid decarbonisation**
  - CRREM uses a global grid carbon intensity reduction pathway, applied to all country-specific baselines, to calculate their EUI reduction pathway. This is non-specific to NZ.
  - Other NZ-specific grid decarbonisation pathways are available - note if it the pathway selected is less ambitious than the pathway outlined by CRREM, there is a risk that the overall carbon budget will be exceeded.
- **Energy targets**
  - Option to use the CRREM energy targets – these have been set with a global approach (i.e. with an understanding of global renewable energy budget and carbon budget), HDD and CDD in specific country.
  - Another option is to set energy targets for new buildings (translated to percentage reductions from baseline) directly equivalent to the GHG targets (while following NZ-specific grid decarbonisation scenarios, and assuming buildings are built fossil-fuel free). This makes no allowance for on-site renewables in meeting the overall “net zero” GHG pathway.
  - A third option is to set specific energy targets in a similar manner to CRREM – based on what is realistically possible with specific building types, and making assumptions around on-site renewables in the property industry through to 2050. The risk here is that if this is less conservative than the CRREM approach, or if it is not carefully calculated to exactly meet the NZ-specific carbon budget identified, this may no longer be within the allocated carbon budget for NZ.

1.5 Recommendation

If a single upfront carbon pathway for all building typologies is adopted, we recommend the global “Office” pathway reduction from the SBTI methodology is selected as this is the most conservative (i.e. highest carbon reduction outcome.

If a single operational energy pathway for all building typologies is adopted we recommend the NZ-specific “Healthcare” pathway reduction from the SBTI / CRREM methodology is selected. Of the three options for setting energy targets described above, we propose beginning with the in-built CRREM EUI targets for the feasibility study stage, but undertaking a study in parallel which looks at the other two potential pathways in more detail.

We also recommend that a period of three years is adopted when setting targets to ensure that targets set in the year of design reflect the target emissions in the year of construction. Therefore the proposed pathways elsewhere in this report have described percentage reduction targets from at least 3 years from the current year (2024).

We recommend this is reviewed against BRANZ in-use CO_2 allowances as a sensitivity study.

2 Operational energy modelling and analysis

2.1 Introduction

The operational emission study took existing Green Star energy models and updating them to current v1.1 GHG 'Reference Building' models. This primarily involved upgrading the fabric and HVAC systems to new Clause H1 (2022) minimum standard efficiencies. This regulatory minimum was agreed with the NZGBC as a suitable baseline for new building operational efficiency..

Modelling was conducted for four different building typologies, to provide a broad scope of project conditions. The projects tested included an Office in Tauranga, a School in Christchurch, an Industrial warehouse in Tauranga, and a Hospital in New Plymouth. Whilst the absolute performance of these buildings may not be representative, they are able to provide insight into "typical performance" that can be used to understand the practicality of improving energy performance.

The modelling included all major typical energy end uses, including space heating, space cooling, hot water heating, ventilation fans, ancillary fans, pumps, indoor lighting, outdoor lighting and lifts.

2.2 Reference model constants

Below is a basic description of the changes that were made to all models to convert them from previous Green Star iterations to the current v1.1 Reference Model state.

- Fabric efficiencies (insulation/R-value) set to the H1/AS2 minimum values for the relevant climate zones.
- All heating sources changed to boilers at 90% efficiency.
- All cooling sources changed to chillers with curve efficiencies of EER 2.985 and IPLV 4.1.
- Heat recovery included in systems >1000L/s outdoor air, at 60% sensible efficiency.
- Economizers added to ventilation systems with capacity >2,500L/s.
- Fan efficiencies for duties >1000 l/s to follow H1/VM3 Section 4.2. Fans <1000 l/s @ 0.65 W/l/s. Fan motor efficiencies set to 90%. Fan system efficiencies typical around 54%, depending on duties.
- Pump efficiencies to follow H1/VM3 and same pressure drops as Proposed models.
- The airside HVAC system architecture is specific to each of the buildings modelled and based on the as-designed systems.

Healthcare

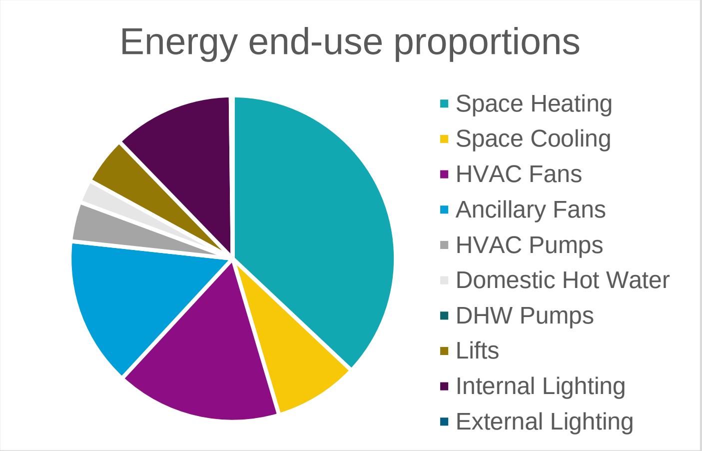
Large multi-story Hospital in New Plymouth, approx. 22,000m².

HVAC system: 14 separate HVAC systems are utilized to serve the various spaces and uses of the building. Each one includes an AHU, AHU heating and cooling coils, economizer, and heat recovery (40% sensible efficiency). Conditioning is predominantly distributed via FCUs CAV and VAV systems. Atrium spaces are naturally ventilated.

Resulting performance:

- Energy consumption: 6,133,330 kWh/yr; 321 kWh/m²/yr.
- Emissions: 25.1 kgCO_2/m²/yr.

Energy Consumption (kWh/m²/yr)	
Space Heating	119
Space Cooling	27
HVAC Fans	53
Ancillary Fans	48
HVAC Pumps	13
Domestic Hot Water	7
DHW Pumps	0
Lifts	15
Internal Lighting	39
External Lighting	1
Total	**321**



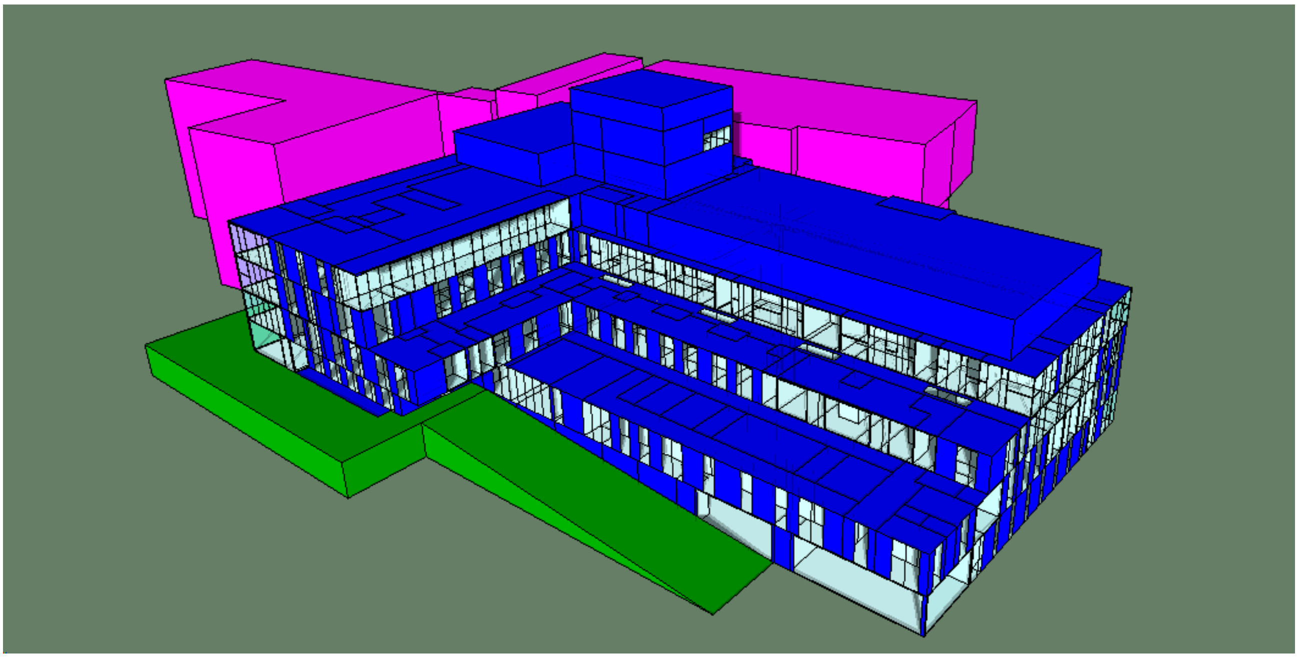


Figure 2.1. Screen shot of the Hospital building energy model.

School

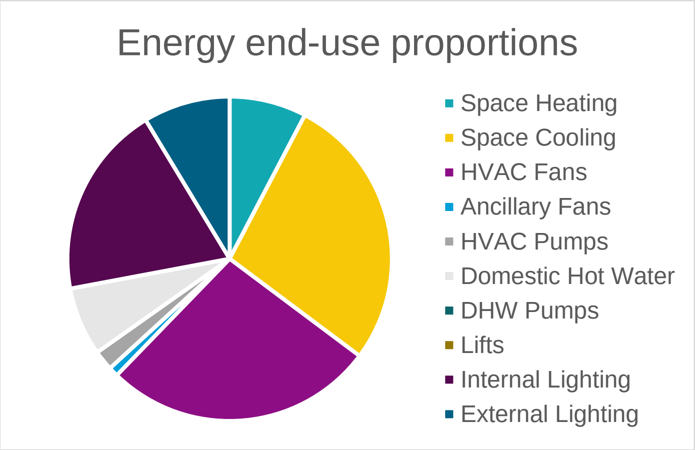
Single-story school in Christchurch, approx. 1,500m^2.

HVAC system: Modelled (as per Green Star reference definition) with a 4-pipe fan coil unit system.

Performance

- Energy consumption: 147,036 kWh/yr; 130 kWh/m^2/yr.
- Emissions: 10.1 kgCO_2/m^2/yr.

Energy Consumption (kWh/m^2/yr)	
Space Heating	10
Space Cooling	36
HVAC Fans	35
Ancillary Fans	1
HVAC Pumps	3
Domestic Hot Water	9
DHW Pumps	<1
Lifts	<1
Internal Lighting	25
External Lighting	11
Total	**130**



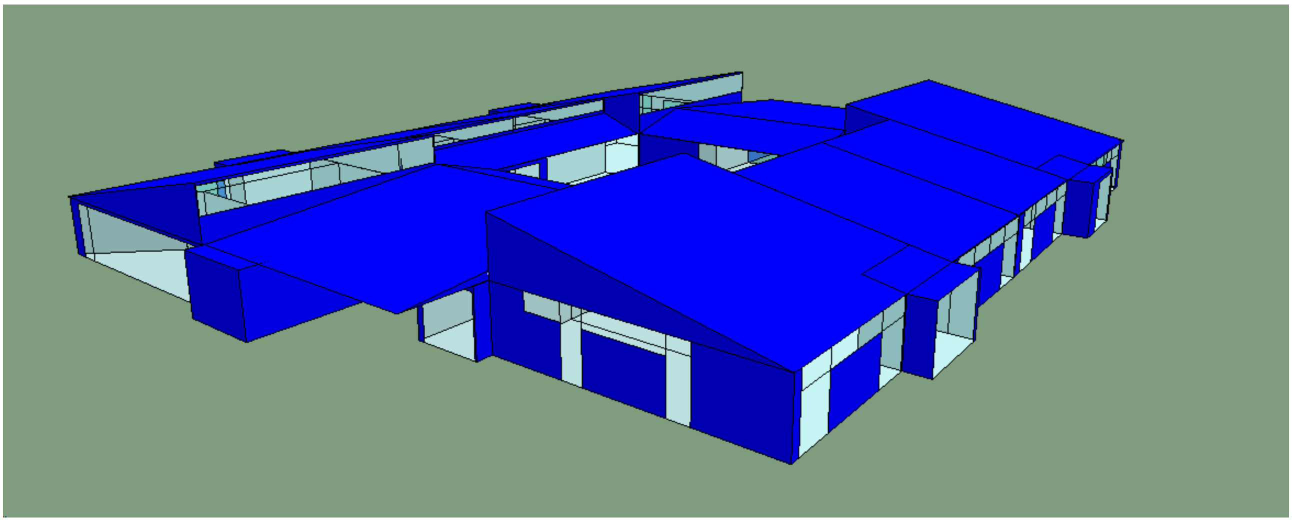


Figure 2.2. Screen shot of the school building energy model.

Commentary on Results

A Reference energy consumption of 130kWh/m^2/yr is relatively high compared to typical school design. This is because many schools utilise natural ventilation for summer-time comfort and provision of outdoor air. This is not governed by NZ Building Code energy performance requirements and the Green Star v1.1 Energy Consumption and GHG Emissions Calculation Guide.

Based on the energy use intensities listed above it is expected that a naturally ventilated school would have a baseline energy consumption of ~60kWh/m^2.

Office

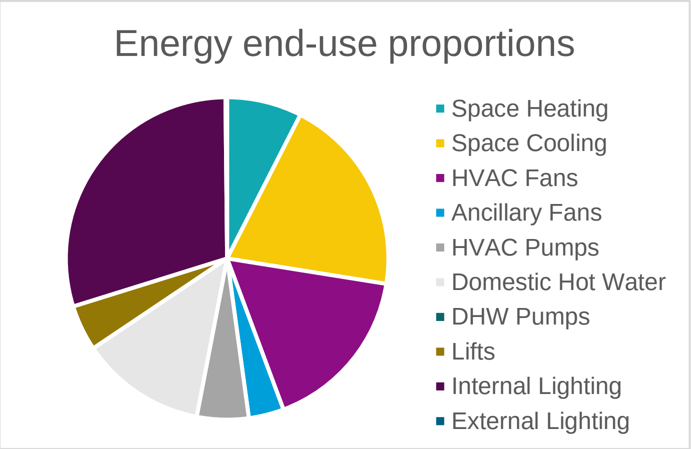
7-story tall office building in Tauranga, approx. 11,000m^2.

HVAC system: The main office areas of this building are served by two Direct Outdoor Air Systems (DOAS), using 4-pipe fan coils, and outdoor air via fan-coil terminal unit. Each system serves one half of the floorplate (East and West), up the height of the building.

Performance

- Energy consumption: 1,043,011 kWh/yr; 96 kWh/m^2/yr.
- Emissions: 7.5 kgCO_2/m^2/yr.
- Equivalent to a NABERSNZ 4.5 Stars rating.

Energy Consumption (kWh/m^2/yr)	
Space Heating	7
Space Cooling	19
HVAC Fans	16
Ancillary Fans	3
HVAC Pumps	5
Domestic Hot Water	12
DHW Pumps	<1
Lifts	4
Internal Lighting	28
External Lighting	<1
Total	**96**



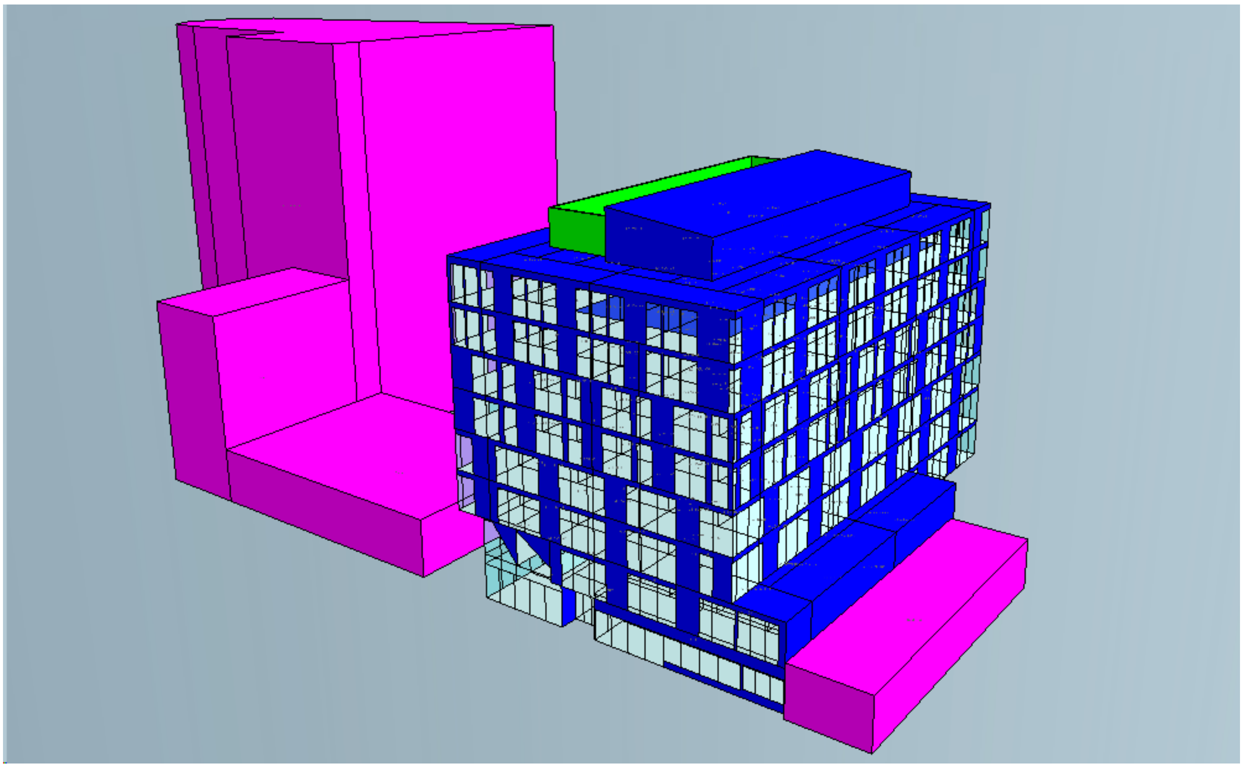


Figure 2.3. Screen shot of the Office building energy model.

Industrial warehouse

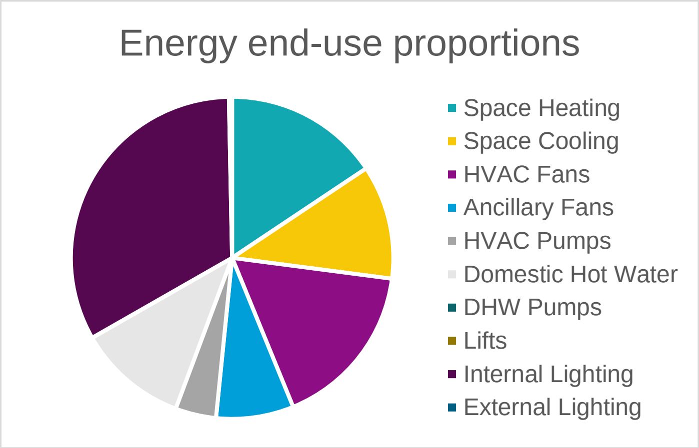
Single-story Warehouse in Tauranga, approx. 9000m².

HVAC system: The office areas of this building are served by Hybrid Variable Refrigerant Flow (HVRF) outdoor air units, via fan-coil terminal units. First floor administrative blocks are served by AHU1, with branches to three separate blocks. Ground floor office block and Ground floor kitchen each have their own HVAC systems. Heat recovery units are included in the non-kitchen AHUs. The warehouse areas are uncontrolled.

Resulting performance:

- Energy consumption: 307,410 kWh/yr; 33 kWh/m²/yr.
- Emissions: 2.6 $kgCO_2/m^2/yr$.

Energy Consumption (kWh/m²/yr)	
Space Heating	5
Space Cooling	4
HVAC Fans	6
Ancillary Fans	3
HVAC Pumps	1
Domestic Hot Water	4
DHW Pumps	<1
Lifts	<1
Internal Lighting	11
External Lighting	<1
Total	**33**



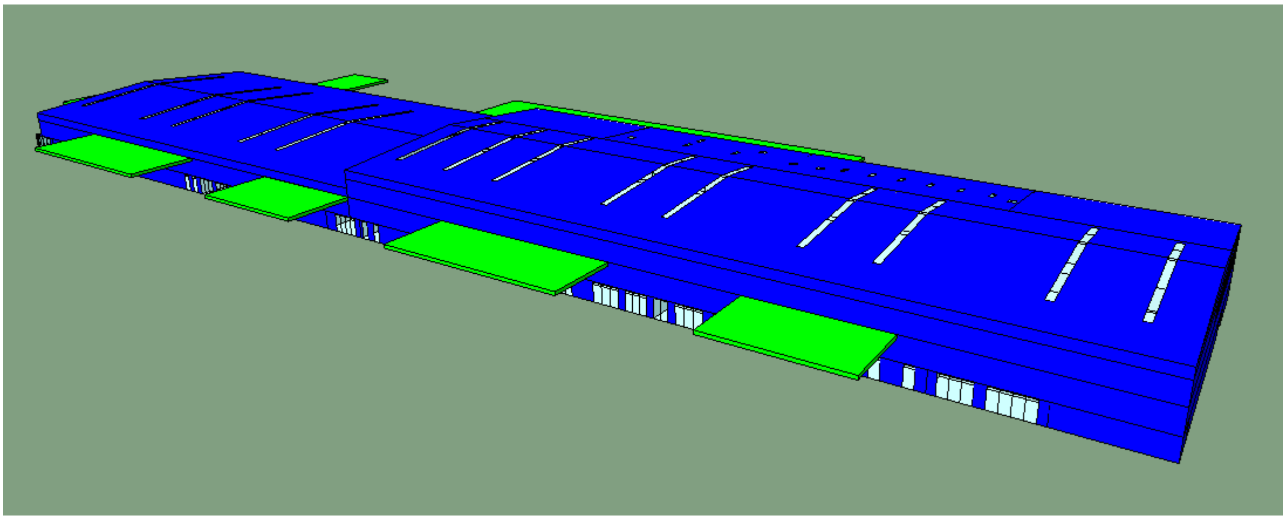


Figure 2.4. Screen shot of the Industrial warehouse building energy model.

2.3 Operational energy results summary and pathways

The table below presents the v1.1 Reference Building model total energy use intensity (EUI) results for each of the four buildings.

	Healthcare	School	Office	Industrial Warehouse
Operational energy	321 kWh/m²/yr	130 kWh/m²/yr	96 kWh/m²/yr	33 kWh/m²/yr

Table 1. Energy Results

2.3.1 Proposed pathways

The pathways below have been calculated following the percentage reductions in EUI identified in the CRREM tool for healthcare buildings in NZ.

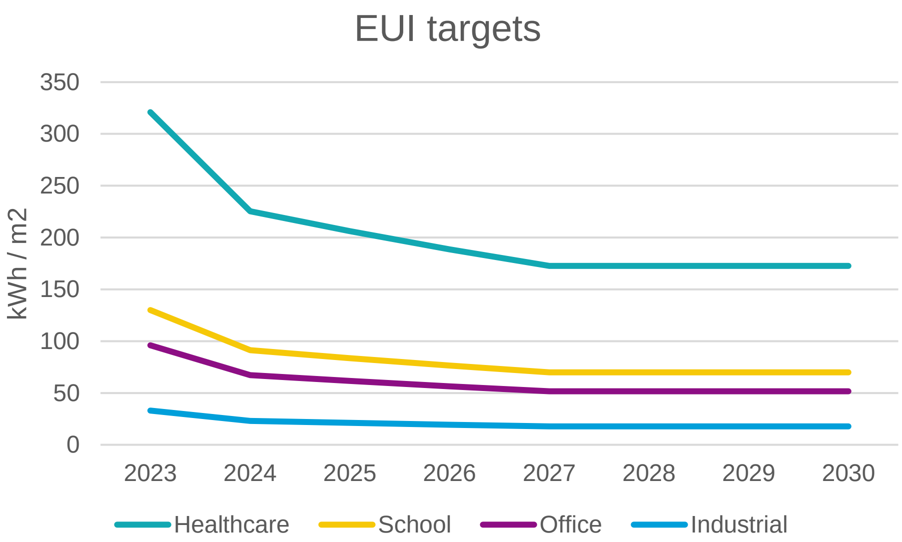


Figure 5: EUI targets by year of target setting

If we follow CRREM then the percentage reduction target caps out at a 46% with this being a final target from 2030 onwards (2027 for NZGBC assuming a 3yr design to operation lag).

Building Typology	**Percent reduction (CRREM)**	**Healthcare**	**School**	**Office**	**Industrial**
2023 EUI Baseline (kWh / m²)	***242***	***321***	***130***	***96***	***33***
2027 CRREM **(2024 "Net Zero Aligned" Target)**	**30%**	225	91	67	23
2028 CRREM **(2025 "Net Zero Aligned" Target)**	**36%**	206	83	62	21
2029 CRREM **(2026 "Net Zero Aligned" Target)**	**41%**	189	76	56	19
2030 CRREM **(2027 "Net Zero Aligned" Target)**	**46%**	173	70	52	18

2031 CRREM **(2028 "Net Zero Aligned" Target)**	**46%**	173	70	52	18
2032 CRREM **(2029 "Net Zero Aligned" Target)**	**46%**	173	70	52	18
2033 CRREM **(2030 "Net Zero Aligned" Target)**	**46%**	173	70	52	18

Table 2: Energy pathways

There are a number of assumptions made by CRREM around practicality and grid decarbonisation that may not be appropriate for NZ (and our baseline definition). This means the targets above could depart from SBTi carbon targets quite significantly.

As discussed with the NZGBC, we believe that an energy target based on a 15yr average (from point of practical completion) including NZ specific grid decarbonisation trajectories and the SBTi operational carbon budgets may be more appropriate.

This 15yr budget approach can be developed in line with testing the feasibility of achieving the energy efficiency targets if required.

3 Upfront carbon baselining and pathways

3.1 Baselines

For the purposes of the next phase of the study (assessing the feasibility of meeting targets), baselines for a range of building types were identified from past carbon assessments.

	Healthcare	School	Office	Industrial Warehouse
Upfront Carbon	765 $kgCO_2e / m^2$	650 $kgCO_2e / m^2$	690 $kgCO_2e / m^2$	500 $kgCO_2e / m^2$

Table 3: Upfront carbon baselines

3.1.1 Healthcare

The upfront carbon baseline for a healthcare building was based on an average figure from the reference designs (detailed design) for three recent healthcare buildings across New Zealand. The three buildings were different typologies and therefore briefly described below:

- Project 1: Predominantly single-storey structure with steel framing, masonry block walls, raft slab foundation
- Project 2: Complex multi-storey mental health facility with concrete and steel framing, concrete floors, curtain wall façade and piled foundations
- Project 3: More “typical” hospital building – multistorey steel frame and concrete floors, shallow foundations, curtain wall façade.

All of these projects had upfront carbon within 10% of each other, therefore the average figure is considered to be appropriate for whichever is used as the feasibility case study.

3.1.2 Schools

The upfront carbon baseline was based on the average of more than 15 bottom-up upfront carbon assessments undertaken for a range of typical school buildings in New Zealand using as-built material quantities. This included single-storey and multi-storey buildings for a range of purposes including administration / office, classroom teaching, sport & leisure, and specialist teaching.

For the feasibility assessment, one single school building will be used to test strategies. This will be a building which has the same upfront carbon as the average (or near to).

3.1.3 Office

The upfront carbon baseline for a typical office building was based on the reference design (detailed design) for a recent multistorey office building in New Zealand. The design is representative of a “Standard practice” office design (steel framing, concrete floors, piled foundations) and is consistent with other upfront carbon assessments we have undertaken for this building typology.

3.1.4 Industrial / warehouse

The upfront carbon baseline for a typical industrial warehouse building was based on an average figure from the reference designs (detailed design) for five recent typical warehouse buildings in Auckland. The design is representative of a “standard practice” warehouse design (steel portal frames, traditionally reinforced concrete slab, shallow foundations, profiled steel cladding) and is consistent with other upfront carbon assessments also recently undertaken for this building typology.

One of these projects will be chosen to assess the specific feasibility strategies in the next phase.

3.2 Proposed pathways

The table and figure below indicate the proposed percentage reduction pathway to align with a "Net Zero" carbon pathway. They also identify proposed targets for each typology which will be used during the feasibility study.

Building Typology	**SBTI – Office pathway reduction %**	**Healthcare**	**Office**	**School**	**Industrial**
2023 Upfront Carbon Baseline	***770***	***765***	***690***	***650***	***500***
2027 SBTI **(2024 "Net Zero Aligned" Target)**	**33%**	510	460	434	334
2028 SBTI **(2025 "Net Zero Aligned" Target)**	**39%**	470	424	400	308
2029 SBTI **(2026 "Net Zero Aligned" Target)**	**45%**	422	381	359	276
2030 SBTI **(2027 "Net Zero Aligned" Target)**	**47%**	404	364	343	264
2031 SBTI **(2028 "Net Zero Aligned" Target)**	**53%**	361	326	307	236
2032 SBTI **(2029 "Net Zero Aligned" Target)**	**56%**	337	304	286	220
2033 SBTI **(2030 "Net Zero Aligned" Target)**	**61%**	300	270	255	196

Table 4: Upfront carbon feasibility targets and reduction pathway

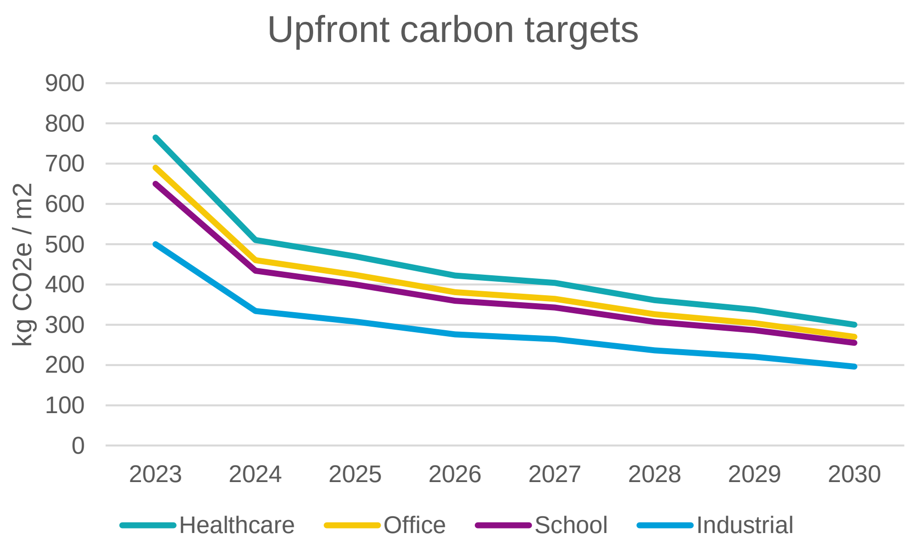


Figure 6: Upfront carbon targets by year of target setting

B

Appendix B –Feasibility Report

Green Star Net Zero Aligned Buildings

Target Feasibility

Prepared for New Zealand Green Building Council
Prepared by Beca Limited

8 April 2024

Disclaimer:

This report was prepared for the New Zealand Green Building Council and presents the findings of research and analysis undertaken to inform future decisions about the Net Zero Ready pathway.

Workshops with the NZGBC and their Expert Reference Panel, has led to analysis updates and augmented these findings. These reports may not reflect the final targets and approach found in the Green Star Buildings guideline.

Creative people together transforming our world

Revision History

Revision Nº	Prepared By	Description	Date
0	Simon Ellis and Phoebe Moses	For information	28/4/24

Document Acceptance

Action	Name	Signed	Date
Prepared by	Phoebe Moses / Simon Ellis		08/4/24
Reviewed by	Scott Smith		08/4/24
Approved by	Scott Smith		08/4/24
on behalf of	Beca Limited		

Contents

Executive Summary

The New Zealand Green Building Council (NZGBC) have engaged Beca to assist in determining baseline performance and setting decarbonisation trajectories for embodied and operational carbon.

This report focusses on analysis undertaken to determine the practical feasibility of aligning operational energy and embodied carbon caps with a Science Based Targets Initiative (SBTi) trajectory.

This report is supplementary to the *"Green Star v1.1 Net Zero Aligned Buildings_Rev1"* report which discusses the options and methodologies for setting trajectories and developing annualised targets which could be adopted by the NZGBC.

The following table presents the practically feasible reductions in energy consumption and upfront embodied carbon for each building typology.

Typology	Energy reduction	Upfront carbon reduction	
		Traditional	**Timber**
Office	50%	35%	55%
School	50%	30%	40%
Industrial Warehouse	40%	50%	60%
Hospital	30%	35%	40%

Operational energy

Our previous report identified that a 46% reduction in operational energy is required to be considered aligned with a science-based target. This report finds that:

- This is practically feasible for most Office and School buildings.
- Industrial warehouse buildings would generally fail to achieve this level of performance (coming in at ~40%) but can readily achieve the 46% target through the provision of Solar PV (due to large roof availability).
- Few hospital buildings would be able to practically achieve this level of performance without sacrificing level of service. There is significant variability in hospital use (hours, level of service), and reducing energy consumption beyond 30% will be challenging for most healthcare buildings.

Upfront embodied carbon

Our previous report identified a science-based pathway for embodied carbon reduction with an initial 33% reduction at 2027 (based on a 2023 baseline). It has been mooted that this 2027 emissions target be applied for the design year of 2024 (based on a nom. 3 yr programme from design to construction).

The feasibility numbers for upfront carbon reduction above show that each typology is currently able to achieve this level of reduction. For schools this will likely require the use of timber but other typologies can achieve this based on traditional materials with low carbon procurement. Some level of timber design (or innovative structural solutions) may be required to provide further reductions.

Next Steps

This report provides NZGBC with an understanding of decarbonisation feasibility. This needs to be mapped against the various pathway and target options previously issued. Decisions on grid and supply chain assumptions need to be taken. This then needs to be converted into a set of progressive compliance levels for the Green Star Buildings – Climate Positive Pathway.

1 Operational Energy Reduction

Previous work (refer *"Green Star v1.1 Net Zero Aligned Buildings_Rev1"* report) establishes the baseline building energy performance for 4 no. building typologies (office, school, industrial warehouse, hospital) when aligned to the NZGBC's Energy Consumption and Greenhouse Gas Emissions Calculation Guide v1.1. This is considered a suitable baseline for as-designed building energy performance.

Typology	v1.1 Reference EUI (kWh/m^2/y)
Office	86 (~4.5 Star NABERSNZ*)
School	113
Industrial Warehouse	42
Hospital	321

*base build rating when excluding tenant lighting consumption

The Carbon Risk in Real Estate Monitor (CRREM) operational pathways (which are aligned to SBTi and broadly adopted for this exercise) incorporate a feasibility factor which limits the maximum operational energy reduction to 46% from baseline. This is factor is applied to operational performance (as opposed to modelled design), is not broken down into specific typologies, and does not take account NZ specific baseline definitions or improvement practicalities.

To establish the practicality of energy reduction measures in the NZ context, incremental improvements in building systems (envelope, services, energy generation etc) were modelled.

The following practically achievable energy efficiency initiatives have been implemented on the four building typologies:

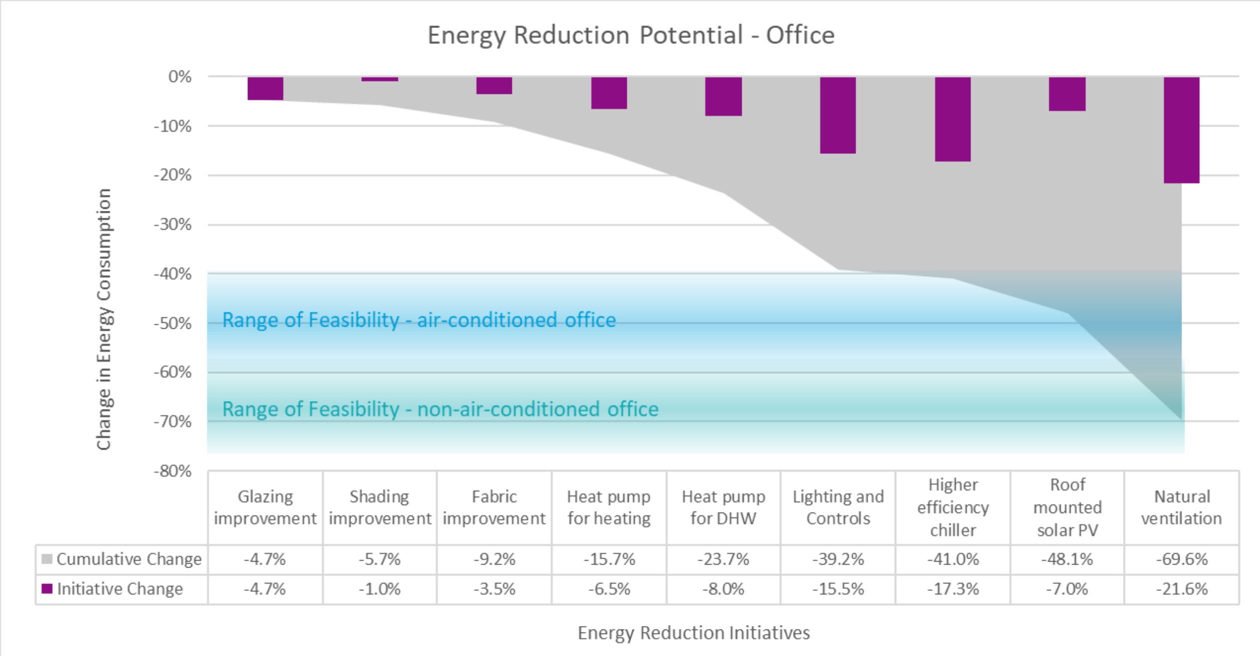
- Improved glazing solar performance
- Introduction of external shading devices
- Increased building insulation performance
- Heat pump used for heating energy
- Heat pump used for domestic hot water demands
- Improved lighting efficiency and controls
- Increased chiller efficiency
- Implementation of building mounted Solar PV
- Use of natural ventilation for passive building cooling

The following sections detail the impact of various initiatives for each typology. This is accompanied with commentary on practicality and other considerations when setting practical targets across the typology.

It should also be noted that the energy improvements presented are for a representative building only. It may not describe the level of achievability for all building locations, orientations, forms etc. To support a decision on the extent of energy improvement required by the NZGBC we have included feasibility ranges which show (qualitatively) the possible level of energy performance for these initiatives when considering different contexts.

1.1 Office building energy reduction

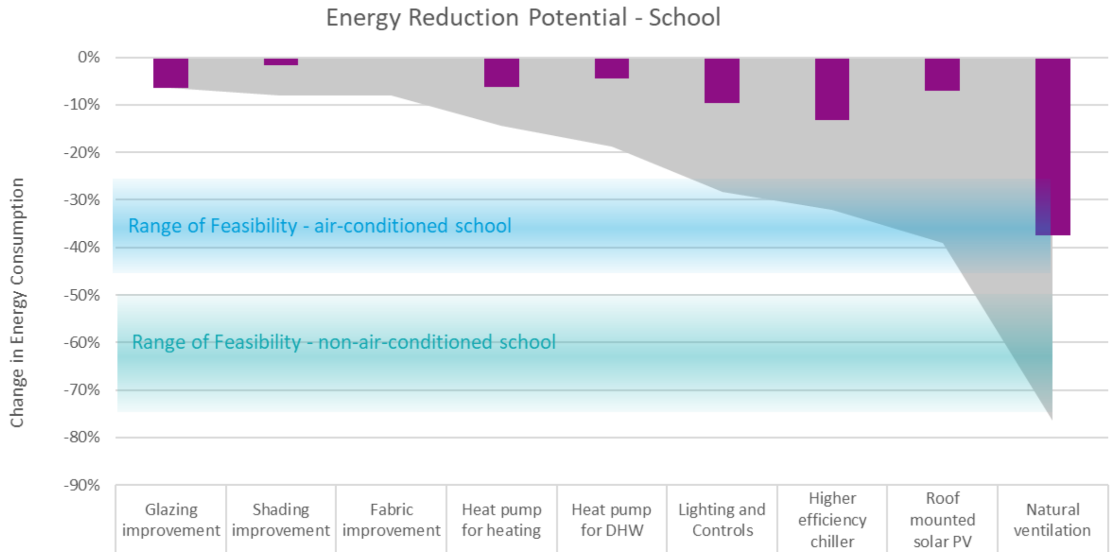
The following graph shows the impact of each initiative on building energy performance. This results in an overall reduction of up to 70% from the baseline building. This level of performance would require the use of natural ventilation for cooling which may reduce the level of service for the building (limiting feasibility).



We anticipate that most **office buildings could practically achieve a 50% reduction** on baseline energy consumption with levels of investment consistent with high performing building being designed today.

1.2 School building energy reduction

The following graph shows the impact of each initiative on building energy performance. This results in an overall reduction of up to 75% from the baseline building when utilising natural ventilation for cooling. Whilst this is considered standard for many school buildings, spaces such as administration blocks, technical teaching, computer labs, etc, may need air conditioning to function well.



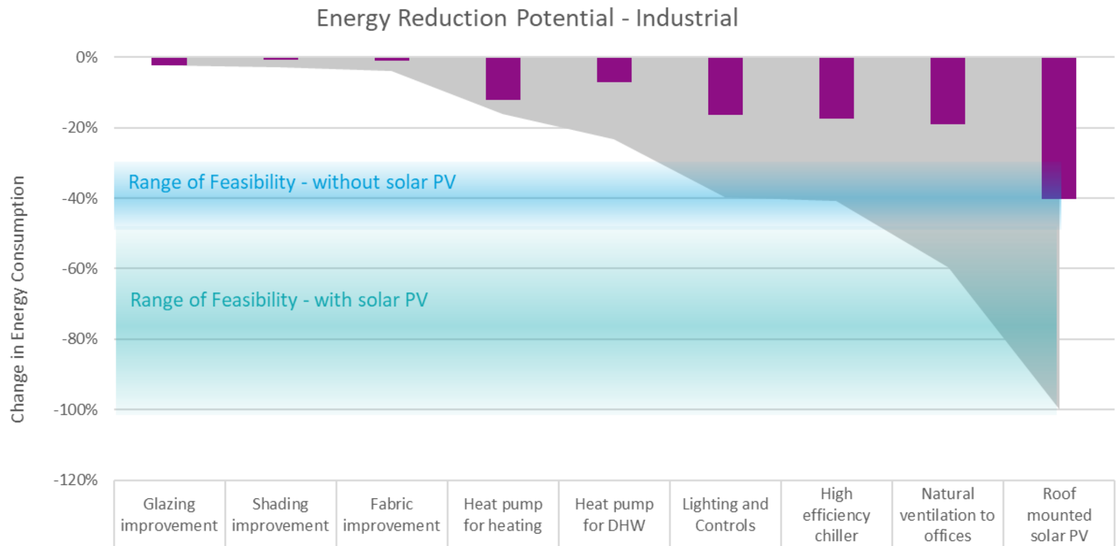
	Glazing improvement	Shading improvement	Fabric improvement	Heat pump for heating	Heat pump for DHW	Lighting and Controls	Higher efficiency chiller	Roof mounted solar PV	Natural ventilation
Cumulative Change	-6.3%	-8.0%	-8.0%	-14.3%	-18.7%	-28.4%	-32.0%	-39.0%	-76.4%
Initiative Change	-6.3%	-1.6%	-0.1%	-6.3%	-4.4%	-9.6%	-13.3%	-7.0%	-37.4%

We anticipate that **most school buildings could practically achieve a 50% reduction** on baseline energy consumption with levels of investment consistent with high performing building being designed today.

Buildings where air conditioning is required would likely be limited to a 35% reduction. Buildings which are naturally ventilated could practically achieve a 60% reduction when compared to an air-conditioned baseline.

1.3 Industrial warehouse energy reduction

The following graph shows the impact of each initiative on building energy performance. Due to the large amount of roof area available for onsite generation, it is feasible to achieve a 100% reduction on energy consumption. We have provided feasibility ranges for scenarios with and without solar generation.

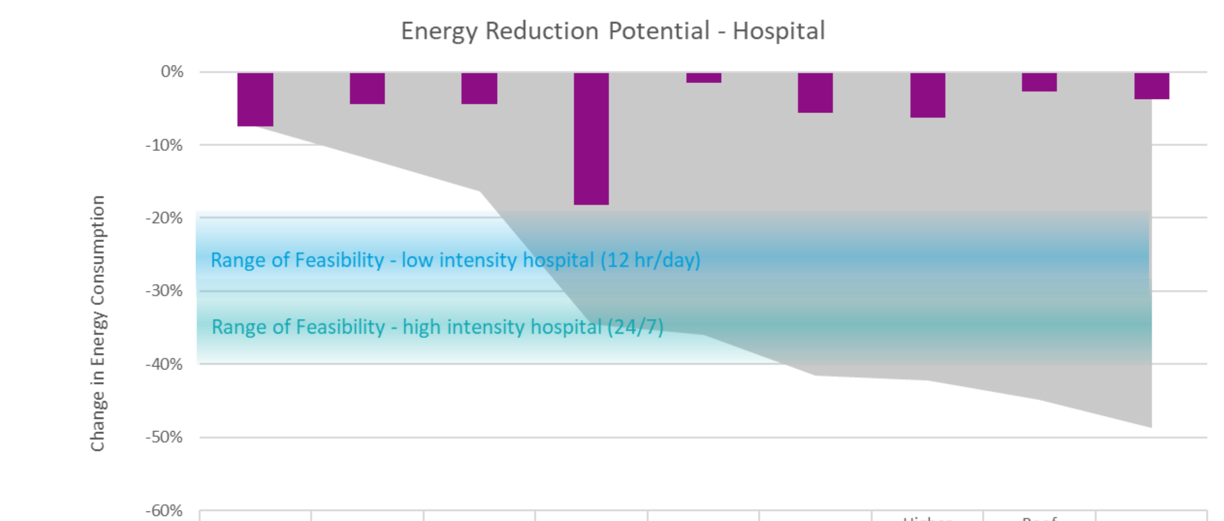


	Glazing improvement	Shading improvement	Fabric improvement	Heat pump for heating	Heat pump for DHW	Lighting and Controls	High efficiency chiller	Natural ventilation to offices	Roof mounted solar PV
Cumulative Change	-2.3%	-2.9%	-3.9%	-16.2%	-23.2%	-39.59%	-40.7%	-59.6%	-100.0%
Initiative Change	-2.3%	-0.6%	-1.0%	-12.3%	-7.0%	-16.4%	-17.5%	-18.9%	-40.4%

We anticipate that **most industrial warehouse buildings could practically achieve a 40% reduction** on baseline energy consumption without solar PV and with levels of investment consistent with a high performing building being designed today. Achieving the 46% presented in the CRREM pathways without PV would be challenging due to the relatively low energy demands associated with these building typologies.

1.4 Hospital building energy reduction

The following graph shows the impact of each initiative on building energy performance. Energy reduction through fabric improvements and heating efficiency are the most significant steps. This is likely due to the large heating demands associated with clinical healthcare facilities (due to high ventilation rates) and the long operating hours.



	Glazing improvement	Shading improvement	Fabric improvement	Heat pump for heating	Heat pump for DHW	Lighting and Controls	Higher efficiency chiller	Roof mounted solar PV	Natural ventilation
Cumulative Change	-7.5%	-11.9%	-16.3%	-34.5%	-36.0%	-41.6%	-42.2%	-44.9%	-48.7%
Initiative Change	-7.5%	-4.4%	-4.5%	-18.1%	-1.5%	-5.6%	-6.2%	-2.7%	-3.8%

Energy Reduction Initiatives

The practicality of achieving a given energy reduction target (%) will differ greatly depending on the level of service provided.

We anticipate that **most hospital buildings could practically achieve a 30% reduction** on baseline energy consumption. This may require some hospital buildings to invest in greater levels of building energy efficiency than current high performance design.

Achieving the 46% presented in the CRREM pathways would be challenging for many healthcare buildings.

1.5 Discussion of energy reduction findings

The analysis provided highlights the practically achievable levels of energy reduction achievable across building typologies. It represents the application of best practice energy efficiency initiatives, based on current technology and typical building design processes.

It will be technically possible for most buildings to exceed these reduction targets, but this will likely require either:

- a reduction in building level of service (occupant comfort, limitations on use),
- a significant increase in capital outlay, with investment in energy reduction initiatives that are not cost or carbon optimal when limited to sectoral impacts (i.e. not considering cross sectoral benefits).

2 Upfront embodied carbon reduction

Previous work (refer *"Green Star v1.1 Net Zero Aligned Buildings_Rev1"* report) establishes the baseline building carbon emissions for 4 no. building typologies (office, school, industrial warehouse, hospital) when aligned to the NZGBC's Embodied Carbon Methodology Guide v1.1. This is considered a suitable baseline for as-designed building upfront carbon performance.

Typology	Reference Building Emissions (kg CO2e/m2)
Office	670
School	650
Industrial Warehouse	550
Healthcare	1150*

*The reference Healthcare building used for this baseline for this study has changed. A more representative healthcare building became available during the course of this study and we consider this more representative of benefits for this sector.

To establish the practicality of carbon emission reduction measures in the NZ context, improvements in the procurement of more sustainable structural items were modelled for each building type.

The following practically achievable carbon reduction initiatives have been implemented on the four building typologies:

Option 1 – Low-carbon reinforcing steel

Option 2 – Low-carbon structural steel

Option 3 – Low-carbon concrete

Option 4 – Structural steel framing swapped for engineered timber structure

Option 5 – Raised concrete floors replaced with CLT engineered timber floors

These initiatives were chosen as they are deemed to be feasible and achievable for the construction industry to adopt into standard practice for many typical buildings.

It is recognised that the initiatives listed above cannot all be used in combination, (e.g. 2. Low Carbon Structural Steel and 4. Engineered timber structure). Therefore, two separate pathways have been analysed and presented.

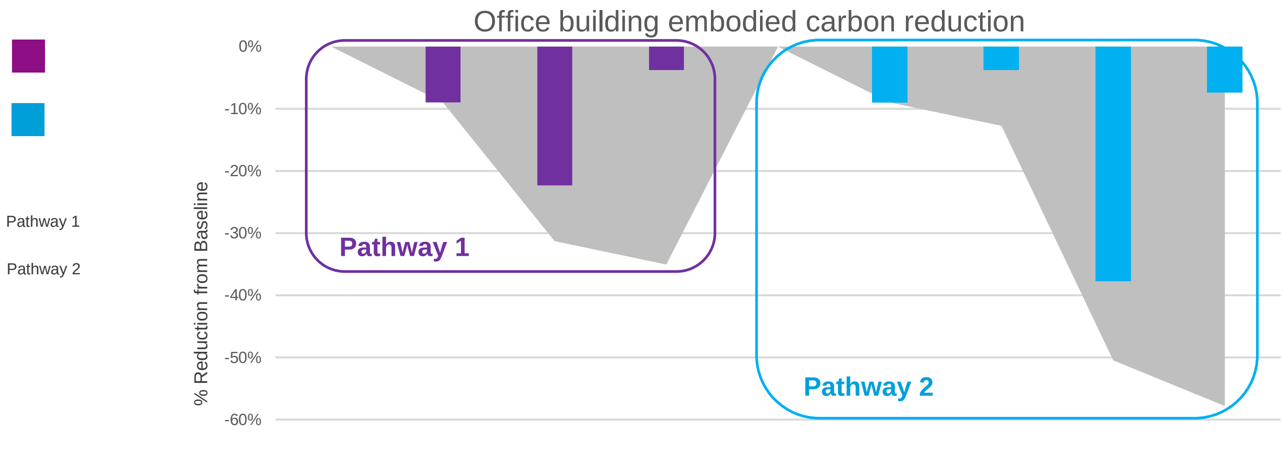
- Pathway 1 – Conventional concrete and steel structural design with low-carbon procurement
- Pathway 2 – Alternative engineered timber structure

The following sections detail the impact of various initiatives for each typology. This is accompanied with commentary on practicality and other considerations when setting practical targets across the typology.

It should also be noted that the upfront carbon improvements presented are for a representative building only. It may not describe the level of achievability for all building locations, types, structural requirements etc.

2.1 Office building embodied carbon reduction

The following graph shows the impact of each initiative on building upfront carbon emissions. Upfront carbon reduction through procurement of sustainable / efficient materials (such as converting the structural steel framing to engineered timber) results in the most significant reduction.



	Pathway 1 Baseline (Same as Reference Building)	Pathway 1 Option 1 - low carbon reinforcing steel	Pathway 1 Option 2 - Low carbon structural steel	Pathway 1 Option 3 - Low carbon concrete	Pathway 2 Baseline (Same as Reference Building)	Pathway 2 Option 1 - low carbon reinforcing steel	Pathway 2 Option 3 - Low carbon concrete	Pathway 2 Option 4 - Structural steel framing replaced with engineered timber	Pathway 2 Option 5 - Raised concrete floors replaced with CLT engineered timber floors
Cumulative change - pathway 1	0%	-9%	-31%	-35%	0%	-9%	-13%	-50%	-58%
Initiative change	0%	-9%	-22%	-4%	0%	-9%	-4%	-38%	-7%

We anticipate that most **office buildings could practically achieve a 35% reduction** on baseline upfront carbon with levels of investment consistent with a high performing building being designed today.

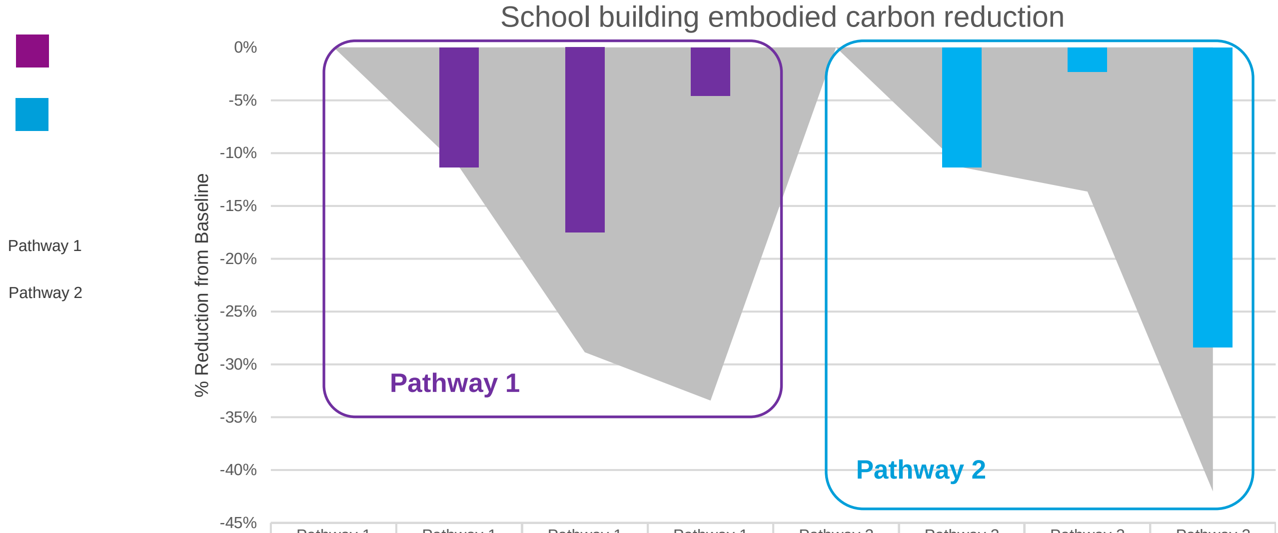
Pathway 2 offers an additional ~23% reduction in upfront carbon emissions compared to Pathway 1 (Total 58%). This is due to the additional reduction in material quantities in the foundations due to the lighter superstructure with all-timber framing and floors, for a typical tall midrise building.

The reference building used is a regular 8-storey office building in the North Island, with deep concrete foundations, a braced structural steel lateral system, structural steel gravity framing and a composite concrete floor on steel decking. The envelope is a fully unitized glazed curtain wall.

It is worth noting that some buildings may struggle to follow Pathway 2, particularly for taller buildings in regions of New Zealand with a very high seismic hazard. This may change in the future due to ongoing technological advancements in innovative seismic structural solutions, lower costs of timber, and more robust supply chains.

2.2 School building embodied carbon reduction

The following graph shows the impact of each initiative on building upfront carbon emissions.



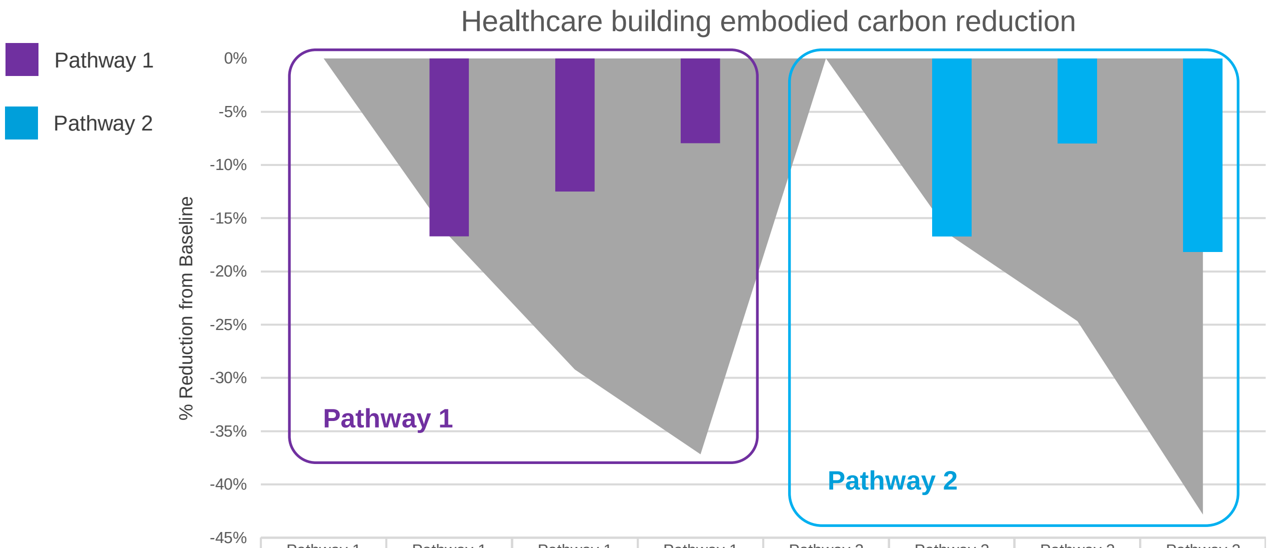
	Pathway 1 Baseline (Same as Reference Building)	Pathway 1 Option 1 - low carbon reinforcing steel	Pathway 1 Option 2 - Low carbon structural steel	Pathway 1 Option 3 - Low carbon concrete	Pathway 2 Baseline (Same as Reference Building)	Pathway 2 Option 1 - low carbon reinforcing steel	Pathway 2 Option 5 - Raised concrete floors replaced with CLT engineered timber floors	Pathway 2 Option 4 - Structural steel framing replaced with engineered timber
Cumulative change - pathway 1	0%	-11%	-29%	-33%	0%	-11%	-14%	-42%
Initiative change	0%	-11%	-18%	-5%	0%	-11%	-2%	-28%

We anticipate that most **school buildings could practically achieve a 30% reduction** on baseline upfront carbon based on an average school building, with levels of investment consistent with high performing building being designed today.

Pathway 2 offers an additional ~9% reduction in upfront carbon emissions compared to Pathway 1 (42% Total). The feasibility study for this typology has been performed on average data aggregated from multiple projects, therefore the reference case comprises a mix of typical construction typologies. Because a large number of school buildings are single-storey, many already use inherently lower-carbon construction techniques with lightweight timber framed walls as the primary load-resisting systems. These do not offer a reduction on reference, when compared to other typologies where timber construction is more novel. Therefore, additional opportunities to replace steel framing with timber framing are limited. In reality, the reductions identified above are likely to be higher for some typologies and lower for some typologies.

2.3 Healthcare building embodied carbon reduction

The following graph shows the impact of each initiative on building upfront carbon emissions.



	Pathway 1 Baseline (Same as Reference Building)	Pathway 1 Option 1 - low carbon reinforcing steel	Pathway 1 Option 2 - Low carbon structural steel	Pathway 1 Option 3 - Low carbon concrete	Pathway 2 Baseline (Same as Reference Building)	Pathway 2 Option 1 - low carbon reinforcing steel	Pathway 2 Option 3 - Low carbon concrete	Pathway 2 Option 4 - Structural steel framing replaced with engineered timber
Cumulative change - pathway 1	0	-17%	-29%	-37%	0%	-17%	-25%	-43%
Initiative change	0	-17%	-13%	-8%	0%	-17%	-8%	-18%

We anticipate that most **Healthcare buildings could practically achieve a 35% reduction** on baseline upfront carbon with levels of investment consistent with high performing buildings being designed today.

Pathway 2 shows an additional ~6% reduction in upfront carbon emissions compared to Pathway 1 (Total 43%). This is lower than what is available for an equivalent office building. The healthcare building selected is a smaller example of the healthcare typology (relevant to a great proportion of the stock), with a greater proportion of the emissions within the concrete slab and foundation elements. As these are not generally replaceable with engineered timber elements, opportunities within Pathway 2 are not as significant.

For large multistorey hospital buildings, a similar smaller reduction will be observed (compared to office typologies) because functional requirements of the space preclude the use of timber in most scenarios for flooring and framing.

2.4 Industrial warehouse embodied carbon reduction

Additional low-carbon initiatives are available due to the nature of a typical warehouse structure. As per the preferred hierarchy of low-carbon design, the first option in both pathways is to reduce the quantities of material on the project, before looking for sustainable alternatives to materials. Because of the unique nature of Warehouse buildings, the proportional impact of steel in the cladding and roof purlins has also been considered. Both of these elements are typically sourced out of New Zealand Steel Bluescope, and therefore will be available in the late 2020s with the 50% reduced carbon intensity signalled.

Option 1 – Innovative slab design

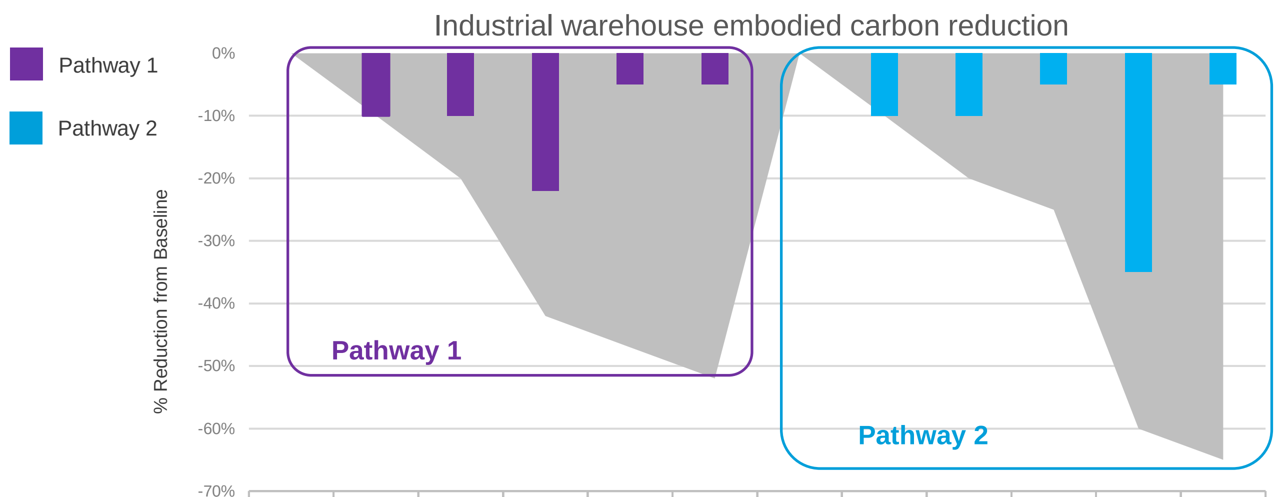
Option 2 – Low-carbon reinforcing steel

Option 3 – Low-carbon Structural Steel

Option 4 – Low-carbon Concrete

Option 5 – Structural steel framing replaced with engineered timber

Option 6 – Low-carbon light gauge steel plate and framing elements



	Pathway 1 Baseline	Pathway 1 Option 1 - Innovative structural slab design	Pathway 1 Option 2 - Low carbon reinforcing steel	Pathway 1 Option 3 - Low carbon structural steel	Pathway 1 Option 4 - Low carbon concrete	Pathway 1 Option 6 - Low-carbon light gauge steel plate and framing elements	Pathway 2 Baseline	Pathway 2 Option 1 - Innovative structural slab design	Pathway 2 Option 2 - Low carbon reinforcing steel	Pathway 2 Option 4 - Low carbon concrete	Pathway 2 Option 5 - Structural steel framing replaced with engineered timber	Pathway 2 Option 6 - Low-carbon light gauge steel plate and framing elements
Cumulative change	0%	-10%	-20%	-42%	-47%	-52%	0%	-10%	-20%	-25%	-60%	-65%
Initiative change	0%	-10%	-10%	-22%	-5%	-5%	0%	-10%	-10.0%	-5%	-35%	-5%

We anticipate that most **Industrial Warehouse buildings could practically achieve a 50% reduction** on baseline upfront carbon with levels of investment consistent with high performing buildings being designed today.

Pathway 2 shows an additional 13% reduction in upfront carbon emissions compared to Pathway 1 (Total 65%). Some larger industrial buildings may struggle to follow Pathway 2, particularly where interior functionality precludes the addition of intermediary supports to enable engineered timber portal frames.

2.5 Discussion of Carbon Emission reduction findings

Replacing all structural steel framing with engineered timber framing and (where applicable) upper concrete floors with equivalent engineered timber products are the greatest possible reduction opportunities for upfront carbon. However, this may not be practically achievable for all projects due to technical or financial limitations.

Strategies involving engineered timber design may have significant impacts on building form, structural layout, building height, and other design strategies which might introduce significant costs or result in a reduced level of service. There is also the risk of carbon leakage where site selection supports building decarbonisation but negatively impacts on urban form, density, or land utilisation.

Pathway 1, which typically focuses on the procurement of lower carbon equivalents of the same materials within a supply chain, is also not without risk. There is a great reliance placed on the ability of the builder and supply chain to provide the appropriate product at a price consistent with what has been assumed by the developer through design. This makes these strategies vulnerable to price-gouging or unexpected limitations in supply, if the demand for low-carbon products outstrips the ability of those producers to meet it.

Specific to each project, and not able to be well captured in this feasibility study, are those decisions which are reliant on the good judgement of the design team and in particular the structural engineer. Undertaking optioneering in early design to select systems which are the most materially efficient, and finding innovative means of meeting the brief, will also be options which are available to design teams seeking to reduce upfront carbon emissions.

3 Next Steps

This report provides NZGBC with an understanding of decarbonisation feasibility. This needs to be mapped against the pathways and targets previously issued. Decisions on any assumptions relating to grid decarbonisation and supply chain improvement need to be taken and converted into a set of progressive compliance levels within the Green Star Buildings – Climate Positive Pathways.

As these next steps are potentially iterative, we would recommend a 3-hr workshop to bring these elements together and finalise the settings.