THE NEW WAY FORWARD

Built

TAKING ACTION ON **EMBODIED CARBON**

The integral role contractors can play in driving down carbon emissions for the property industry.

SEPTEMBER 2021

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The New Way Forward

This report contains three specific calls to action for the property industry and shares upfront carbon data from 10 Built projects.

A note on terminology: throughout this report we use the terms design and construct partner as well as head contractor and builder. Whilst not completely interchangeable, we're referring to the general contractor that takes over design from 30–70% of design development to complete the design with the consultant team. It is through harnessing this ability to work through design and procurement that the greatest embodied carbon savings can be made.

Executive summary

This paper shares our learnings so far around how best to reduce upfront carbon in construction and the five critical steps to follow to achieve this on any project.

As more of the property industry takes action on meeting and exceeding sustainability targets in buildings, we've seen the materials supply chain and processes that enable us to calculate upfront carbon begin to evolve.

While significant gains have been made in how we reduce operational carbon in our buildings through energy efficiency and renewable energy supply, there is less progress and transparency when it comes to reducing the upfront embodied carbon.

We, as head contractors, occupy a privileged position in our ability to address upfront carbon across the industry. We act as a critical link within the broader supply chain – a lynchpin between clients and their aspirations and the materials that bring these to life.

By engaging the industry and bringing design and construct partners onboard to reduce upfront carbon, and amassing industry knowledge together, we increase capacity to set and achieve higher reduction targets.

5 steps for action to reduce embodied carbon on any project:

1. Make upfront carbon reduction a success factor from the start.
2. Ask your design and construct partner to own the lifecycle assessment (LCA) and upfront carbon model as early as practicable in their engagement.
3. Use best practice methodologies to measure savings.
4. Track upfront carbon emissions as you would costs – at every stage.
5. Share your data with the industry to build a body of knowledge.

A call to action for the industry

As an industry we're more powerful when we work together to find solutions to reduce carbon emissions. This paper highlights the immediate steps that actors in our industry can take to get there quickly, such as:

1

Clients specifying upfront carbon reduction as a key success factor for the project team. This will leverage the creativity of the architect and structural engineer to challenge the status quo in design and start the project on a strong carbon reduction footing.

2

Clients empowering the builder to own the upfront carbon model. This will drive further improvements in design and incentivise procurement decisions that leverage the builder's supply chain links to prioritise lower upfront carbon products.

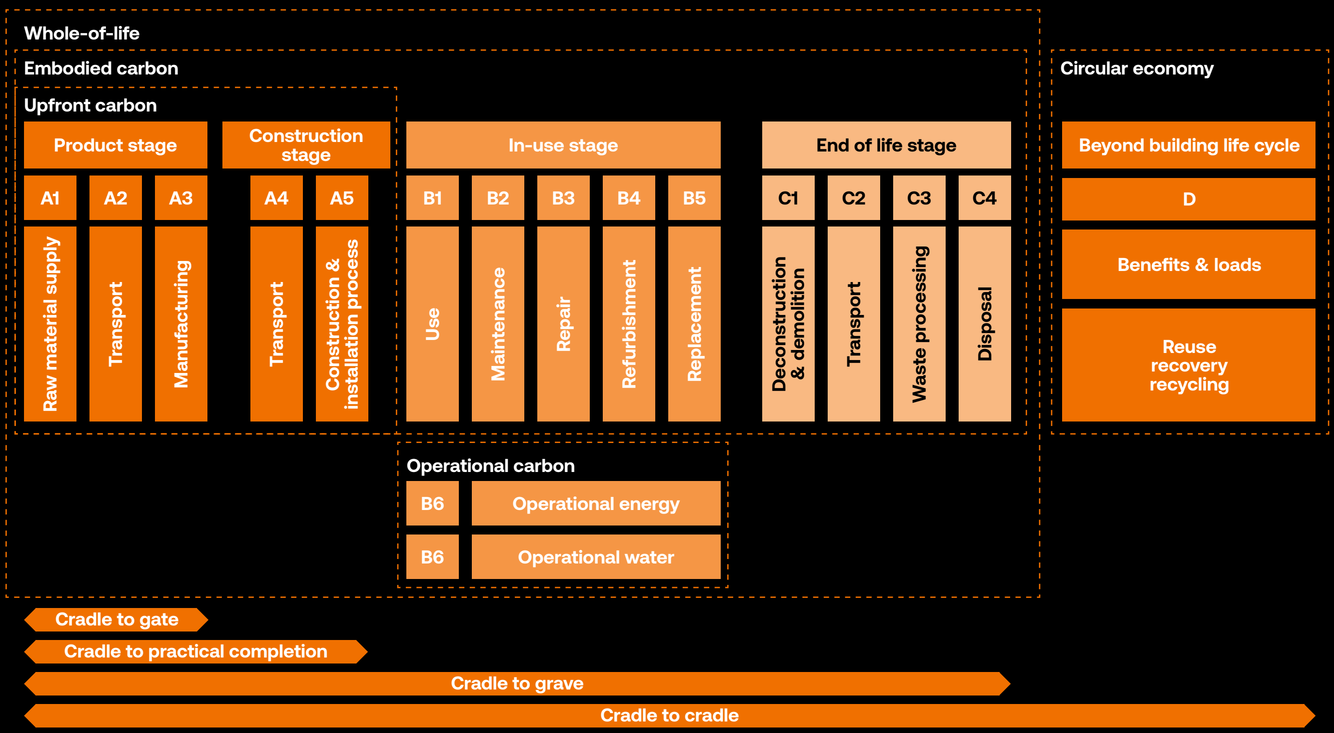
3

Industry setting benchmarks for good performance based on Australian life cycle inventory data. When we can define what good upfront carbon performance looks like for a range of building typologies, industry can start setting targets to motivate the entire supply chain towards carbon reduction.

Carbon emissions fact sheet: A snapshot of the building and construction sector.

GLOBALLY	39% of global carbon emissions come from building construction and operations[1]	28% come from operations[2]	+ 11% come from embodied carbon including upfront carbon[3]
MATERIALS	Typically, 65% of the building's overall upfront carbon emissions are from substructure and superstructure[4]	30% to 40% reductions in cement content can be achieved at nil performance impact and minimal cost	
BUILT	74,429 tonnes of upfront carbon (A1-A5) saved over 10 projects	Built's upfront carbon reduction of 74,429TCO₂e is equivalent to the total upfront carbon in a reinforced concrete building of 40 storeys and 110,000m² GFA	

Life cycle modules



[1] https://www.worldgbc.org/news-media/global-status-report-2017
[2] https://architecture2030.org/buildings_problem_why/
[3] https://www.worldgbc.org/embodied-carbon
[4] https://www.leti.london/ecp

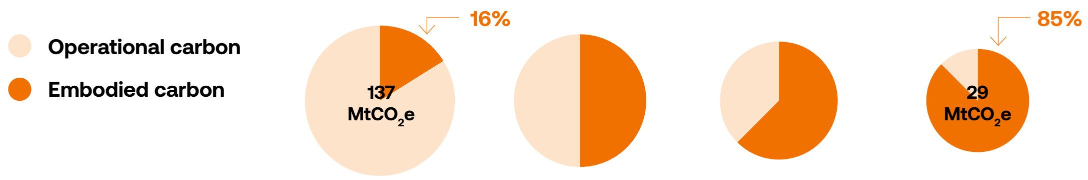
The Intergovernmental Panel on Climate Change advises that drastic cuts to all carbon emissions are required to slow global warming – and the building industry is at a critical crossroads.

With construction expected to double the world's building stock by 2060, there's an urgent need to change how we design, build, use, and refurbish our buildings, if we're to seize the opportunity to contribute significantly to the solution.[5]

Of these overall carbon emissions, 28% come from operations, what it takes to heat, cool, light and power buildings; while the remaining 11% comes from embodied carbon, including 'upfront' carbon.[6]

As the current trend of grid electricity decarbonisation gathers pace, the relative percentage of a building's upfront carbon will grow.

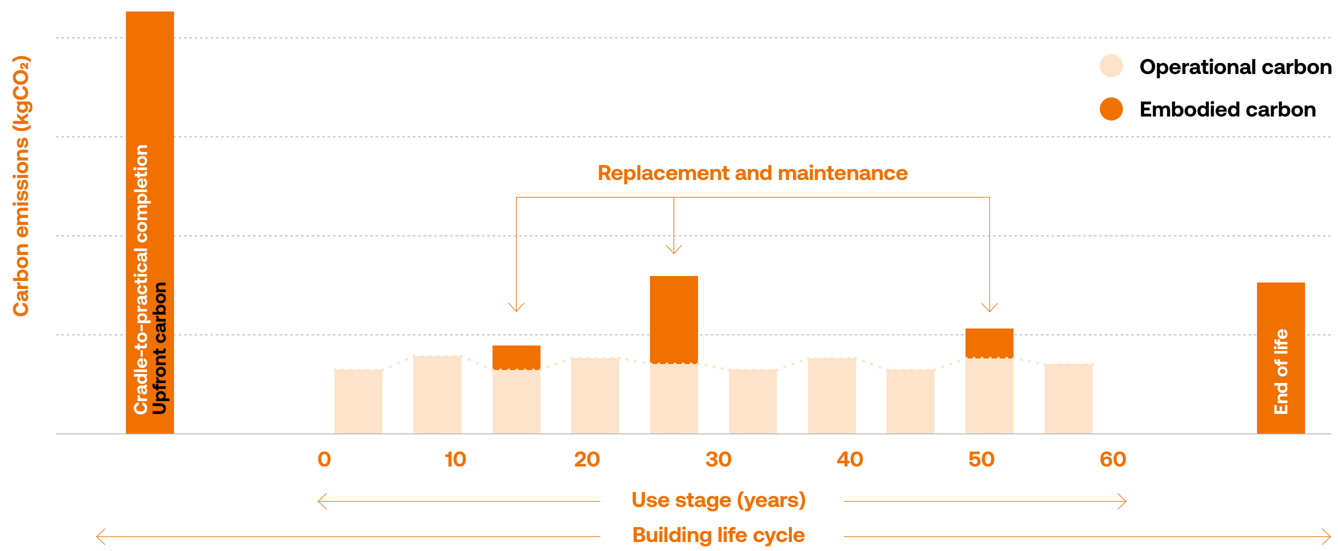
Upfront carbon refers to the manufacture, transport and installation of materials used in building projects, also known as the A1 to A5 or cradle-to-practical-completion emissions. Reducing these emissions is now a crucial next step for the building and construction industry – one that requires a collective effort.



Carbon emissions from Australia's building stock from 2019 to 2050[7]

[5] https://architecture2030.org/buildings_problem_why/
[6] https://www.worldgbc.org/news-media/WorldGBC-embodied-carbon-report-published
[7] https://new.gbca.org.au/news/gbca-news/gbca-and-thinkstep-release-embodied-carbon-report/

Emission breakdown of a building's life cycle



Source: Embodied Carbon Primer | LETI

Some of the most high-profile sustainability projects in Australia are starting to shine a light on upfront carbon. The new Atlassian headquarters, due for completion in 2025, made headlines when it committed to targeting a 50% embodied carbon reduction.

Executive summary

Image Source: Scion

The Scion Innovation Hub in New Zealand clearly communicated their

ZERO

embodied carbon outcome and data as part of the key project information.

How your head contractor can drive reductions:

By asking a design and construct partner to calculate upfront carbon associated with design options, clients gain greater transparency into the impact of each build. This process aligns with a strong value engineering approach which should be applied to maximise the financial opportunity on a project.

In the UK, material inefficiencies of up to 50% are common, so clearly more can be done to reduce cost and upfront carbon.[8] Clients who consider upfront carbon as another critical measure of a project's success will reap the benefits of producing a more sustainable building that, by avoiding carbon-intense materials, can also cost less to build.

It's a win-win for everyone.

[8] https://www.istructe.org/IStructE/media/Public/Resources/istructe-how-to-calculate-embodied-carbon.pdf

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What we've learned so far

As a design and construct partner, we appreciate:

1

what a life cycle assessment (LCA) is and how to leverage it to drive positive outcomes.

2

where the greatest opportunities lie for reducing upfront carbon.

3

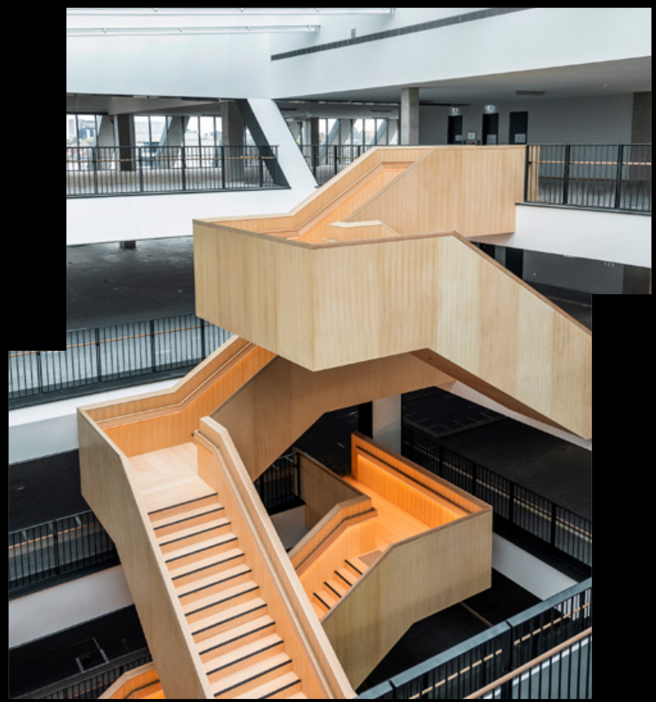
how to engage supply chain partners to deliver better outcomes.

4

how to wrap a carbon factor metric into value engineering exercises.

5

how best to communicate upfront carbon savings to clients.



We also recognise that design and construction decisions should not be based solely on upfront carbon savings.

After all, buildings need to stack up commercially and attract tenants. They need to comply with legislation and be structurally sound. An empty building is not getting a return on the investment in materials, nor is a building that is demolished well before its service life is up.

There are dozens of critical success factors within a project – and reducing upfront carbon should be one of them. When considering carbon emissions of any kind we suggest taking a holistic view when it comes to a building's overall impact.

It may be necessary to incur a higher upfront carbon cost in certain design decisions to drive higher overall performance throughout the building life cycle.

If a building with a triple-glazed façade has more upfront carbon than one with a single-glazed façade but will reduce energy use by 25%, then the triple-glazed façade option when considered within the whole building life cycle is a more sustainable choice.

Upfront carbon reductions should not necessarily be prioritised over other factors, such as energy efficiency or the health and wellbeing of occupants.

Understanding carbon emission reduction opportunities and how to achieve them

The head contractor's design team, alongside the architect and structural engineer, can often find opportunities to re-design the core, change layouts for a more efficient use of structural materials and even provide options for completely replacing materials, to identify cost and upfront carbon savings.

Concrete and steel typically make up the greatest proportion of upfront carbon in a building. Together with timber, these three materials offer the greatest opportunities for impact when it comes to reducing upfront carbon.

There are examples overseas of steel that offers a lower upfront carbon content, predominantly achieved through increased quantities of scrap steel and electric arc furnace manufacturing, that takes advantage of renewable power.

Significant material inefficiencies continue to plague new building delivery and initial efforts at reducing upfront carbon need to first focus on both the reduction in materials (especially concrete and steel), as well as the re-specifying of concrete mixes.

Built has delivered significant upfront carbon savings on projects where high cement content concrete mixes were replaced with lower cement content for savings in cost and carbon with no impact to the duration of the construction programme.

On a recent project, post-tensioned concrete floors were replaced with pre-cast concrete planks, reducing structural mass by 33% and enabling an overall upfront carbon saving of 31% against the tender design.

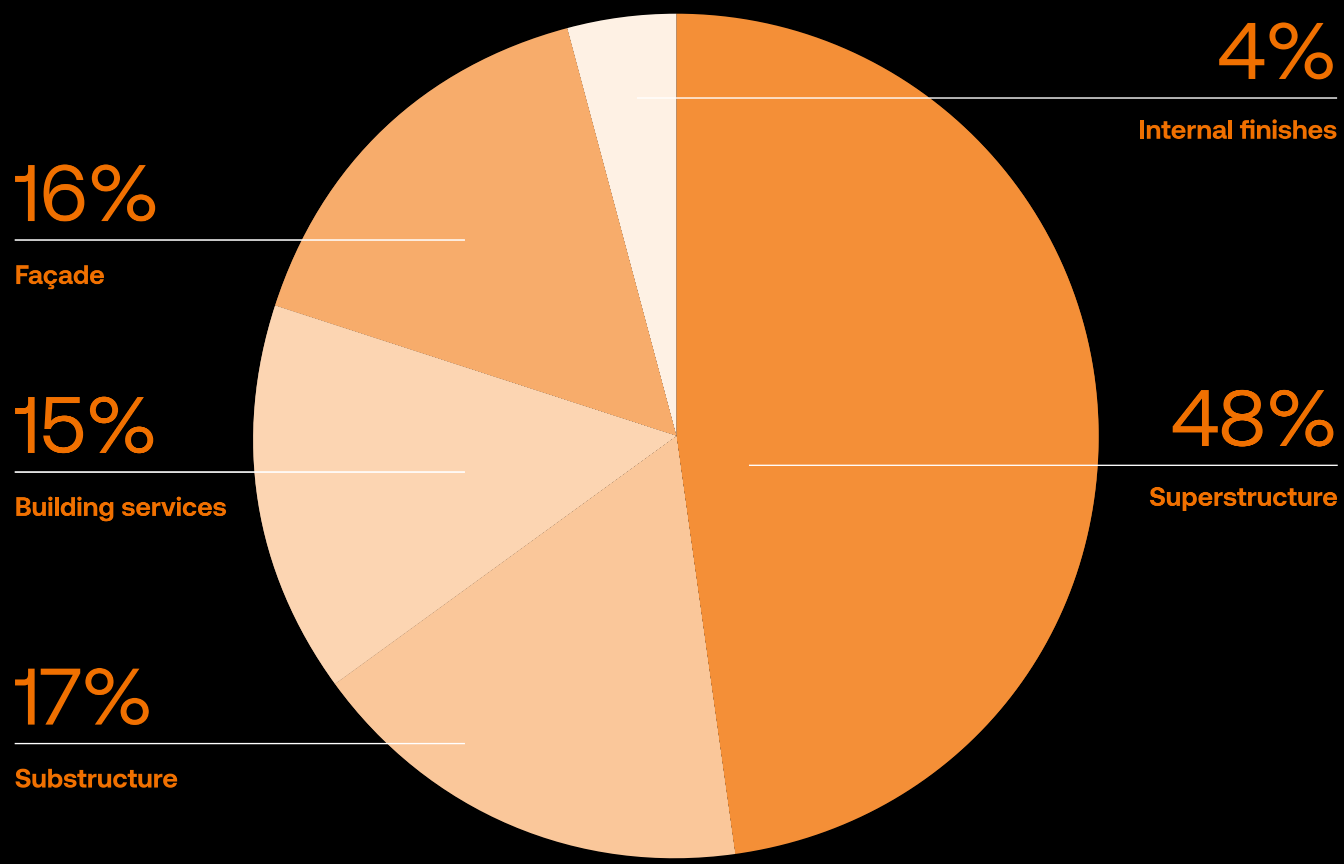
On a typical building, a concrete and steel substructure and superstructure will make up 65% of the building's overall upfront carbon emissions.

Following closely behind is the upfront carbon contribution from façade. Aluminium is a carbon intense material, and though limited opportunities to procure lower embodied carbon aluminium exist at this stage, re-designing façade systems to reduce aluminium provides an opportunity to pull upfront carbon out during design. A4 and A5 emissions benefits can also be realised through rationalised design as less material is transported to site and less fuel used to install the final quantity.

Whilst not one of the large opportunities for reduction, compared with the impacts of A1–A3, by considering the provenance and mode of transport of materials to site, contractors can reduce upfront carbon further by choosing materials with lower A4 Transport emissions.

Finally, by selecting certified renewable electricity sources and biofuels for construction site operation, the A5 Construction emissions can be addressed.

Rules of thumb – Upfront carbon emissions of a building by category (A1–A3)



Source: LETI

Making the most of life cycle assessments

Whilst the thrust of this paper is on using upfront carbon analysis to drive down embodied carbon in building projects, at Built we typically capture this metric as part of an overall project life cycle assessment (LCA).

There's additional value in an overall project LCA (assessing impacts from cradle to grave or cradle to cradle – see life cycle modules diagram on page 4) that you lose if only calculating the subset indicator of upfront carbon emissions, including:

1

Assessing embodied and operational carbon improvements or impacts with respect to each other and the context of the project's overall life cycle.

2

Using the LCA as a communication and decision-making tool to inform considerations around reducing the environmental impact of a project.

3

Learning from a range of LCA modelling indicators beyond embodied carbon and gaining metrics through which to make design decisions on issues such as land use, freshwater consumption, ecotoxicity and ground level ozone creation.

4

Skilling up the entire project team through LCA assessments, raising awareness around the impacts that material choices and design have on local and global eco-systems.

5

Gaining a substantial number of points within industry rating tools such as Green Star.

As more buildings take up 100% renewable electricity and operational carbon impact moves towards zero, it's also clear that upfront carbon emissions are increasing as a proportion of a project's overall carbon impact, which needs urgent attention.

Undertaking LCA modelling provides the perfect opportunity to review and reduce upfront carbon. Often undertaken when applying for Green Star ratings, completing an LCA offers insights to developers, designers and construction teams to benchmark and better understand their project.

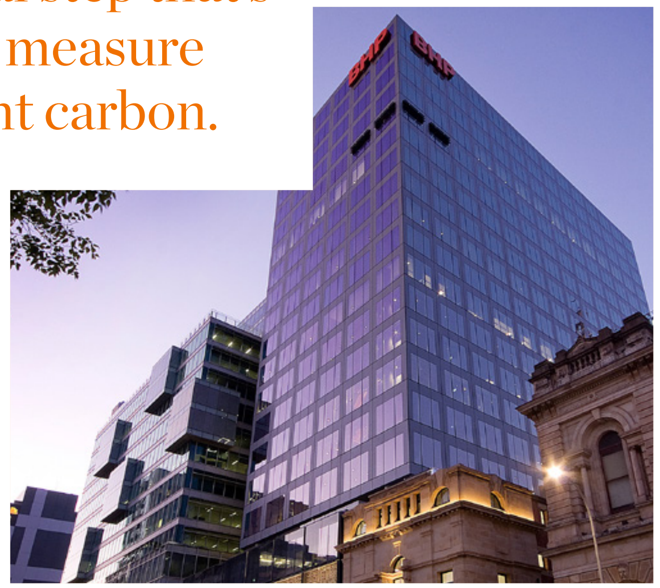
By zeroing in on the upfront component of carbon emissions in the assessment – and isolating these from all other environmental impacts – targets can be set and design can start to be incentivised to tackle this particular environmental imperative.

An effective way to capitalise on these opportunities is to make the design and construct partner responsible for delivering the project's LCA and upfront carbon analysis (see step two in 'A roadmap to achieving upfront carbon reductions' on page 21).

Head contractors can use the smarts of their design teams to drive materials reductions and claim the benefit within Green Star and other ESD rating tools as reduced upfront carbon.

How to create a credible "conventional" benchmark

Creating a benchmark or reference case to compare against is a critical step that's needed to enable a project to measure their improvements in upfront carbon.



Setting a benchmark for upfront carbon is unlike setting a benchmark for operational carbon. For operational carbon, there are clear standards of energy intensity per square metre that can be set and tools like NABERS Energy that normalise for location, size and occupancy, enabling different buildings to compare against one another.

With upfront carbon, project variables such as form, site conditions and quality can mean different benchmarks are appropriate for projects of a similar area. Consider the very different structural requirements for a 40,000m^2 project in the form of a 4-storey groundscraper versus a 20-storey tower.

Gauging the benchmark for your project, based on the upfront carbon of similar buildings, can assist with understanding the ballpark kgCO_2/m^2 benchmark figure the project should achieve.

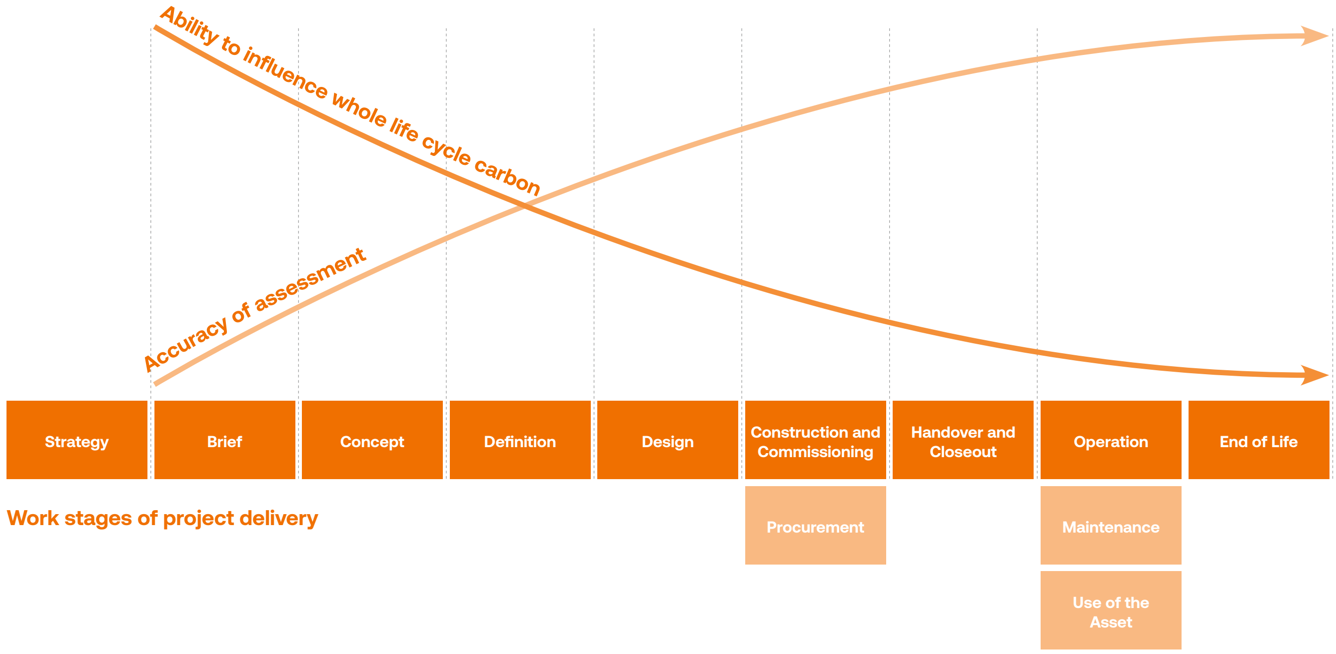
But it will not typically account for all project specific parameters.

A more useful method is to set up a project specific benchmark that represents conventional construction, by using the following principles:

- **similar construction methods**
- **the same site with the same constraints**
- **similar building typology**
- **similar levels of quality and amenity**
- **updated data as the project progresses**

While we've found the tender design is the most realistic and clear point in time to set a reference case – it's also true that if you consider upfront carbon even earlier, e.g. during concept design, you unlock the opportunity to realise a much greater reduction.

Ability to influence carbon reduction across the different work stages of project delivery



Source: UK-GBC EC Developing Client Brief.pdf (ukgbc.org)

Short of continuing to develop two different sets of designs – actual and conventional – it's important for the industry to settle on a methodology for creating realistic benchmark designs that match the actual design in terms of resolution.

For example, you can't compare a building designed to a tender level of detail with a building designed to a concept level of detail, as more detail in a project design equates to more materials to which carbon is attributed.

This can become murky when a project has a concept design that's traded out a carbon-intense material like concrete for an upfront carbon-sink like timber, for the benefit of the upfront carbon emissions outcome.

What we recommend is that the client consider upfront carbon emissions from the earliest stage of concept (see step one in 'A roadmap to achieving upfront carbon reductions' on page 21) and document a legitimate reference case building – one that would be built if upfront carbon reduction was not a key driver.

That way, by considering whether a timber building would always have been a timber building or whether it might have been a post-tensioned reinforced concrete building, the project team can then record the benefit of changing from concrete to timber.

As the construction team is appointed and they continue to refine the design further, there are continued benefits – by pulling out more materials and finding opportunities for increased value within the design and identifying lower upfront carbon materials.

Challenging the supply chain

The issue of carbon emissions in the building and construction industry is bigger than any one of our companies. And we can't fix this alone. If we want to enable a shift towards lower upfront carbon materials in the building industry, we need to work together.

The upfront carbon on a recent Built DFMA prototype was modelled at

80%

less than conventional construction.

The sustainability movement has relied on collaboration. It's a hallmark of the industry that it has always brought competitors together to solve problems that are greater than what any individual company can achieve.

In Australia, during the height of 2020's COVID lockdown, more than 30 organisations and companies – including Built – came together virtually to establish a coalition called the Materials and Embodied Carbon Leaders' Alliance (MECLA).[9]

The group's intent is to decarbonise Australia's construction materials industry. MECLA is working to increase demand for products such as mass timber, re-used and recycled materials as well as lower upfront carbon steel, concrete and aluminium.

As substructure, superstructure and façade make up the bulk of upfront carbon, targeting these materials offers the lion's share of opportunity in decarbonising the construction of buildings.

[9] https://www.wwf.org.au/what-we-do/climate/mecla#gs.4qy1m5

Shifting the supply chain

Less than a decade ago, concrete suppliers were still charging a premium for 'Green Star' mixes or concrete mix designs that reduced a proportion of cement to meet the criteria in the Green Star Concrete credit.

High embodied carbon cement was replaced with special blends of industrial waste product that would otherwise be landfilled, incurring only nominal increases to cure times which could be accommodated in the construction programme through thoughtful planning.

To gain a Green Star Concrete point, a minimum of 30% cement, averaged across the project's concrete mixes, had to be replaced.

These days, rather than targeting a specific percentage reduction (as nominated in the prescriptive pathway for concrete in Green Star), we're more likely to ask a concrete supplier to maximise the quantity of waste product in their mixes – up to the point where no cost is added to the concrete supply price.

Because we take a life cycle assessment performance approach to the Green Star materials credits, the benefit of a 25% average cement reduction can be valued within the project's rating. Compared to the prescriptive approach, no points are awarded until a 30% average cement reduction is achieved.

Over the last few years, we've found concrete suppliers more willing to increase the cement replacement across their mixes without impacting price.

During procurement ask your supplier about options they can offer to reduce upfront carbon

30–40%

Cement reductions on building projects achievable without being charged a premium

We now regularly manage to reduce the cement content by an average of 30% to 40% without adding cost to the concrete supply package. We account for that upfront carbon savings in the project LCA and Green Star or LEED submission.

Cement reductions of 50% to 60% are notionally achievable but attract cost premiums due to the research and development investment recuperation by the companies developing these high-performance concrete mix designs.

This is supply chain evolution in action. As demand increases, companies grow in their sophistication to supply the market with what it needs to achieve carbon reductions and create lower impact buildings.

Importantly, suppliers are now producing environmental product declarations (EPDs) that disclose the carbon factors of their most popular concrete mix designs, providing transparency for industry participants to make decisions based on the best carbon outcome as well as price and strength characteristics.

TAKING ACTION ON **EMBODIED CARBON**

A roadmap to achieving upfront carbon reductions

Step 1

Make upfront carbon reduction a success factor from the start

To achieve the best outcome when it comes to reducing upfront embodied carbon, we recommend incorporating carbon reduction aspirations from the earliest phase of concept design – as one of the early critical success factors in the project brief.

That means for every stage of design, procurement and delivery, where upfront carbon is considered: it drives action and becomes a metric within the overall project plan for which the project team remains accountable.

Recent examples in Sydney where this method has been successfully deployed include the Barangaroo Precinct and forthcoming Atlassian building. By setting an upfront embodied carbon target from the outset, the project team is incentivised to investigate and deliver on these savings throughout the delivery of the project.

Atlassian Building, Sydney

Step 2

Ask your design and construct partner to own the LCA and upfront carbon model as early as practicable in their engagement

By having ownership over the design and upfront carbon model, a design and construct partner is best placed to continuously review the design solutions put forward and drive the project towards the goal of achieving upfront carbon reductions.

While upfront carbon may have been considered at the design stage, it needs to be considered repeatedly throughout the entire build, particularly when engaging subcontractors and suppliers, and even through to taking on tenants.

In office buildings, integrating tenant fitout designs within the delivery of a base building can have significant reductions in the upfront carbon associated with cutting voids, carpet, ceiling grid and tiles and other finishes that might be applied by base building only to be removed by the incoming tenant.

A proactive builder should understand the unique position they hold within the overall supply chain – and appreciate their ability to drive positive upfront carbon outcomes, from a design resolution and materials procurement standpoint.

Working with a design and construct partner has additional benefits in that they'll bring design changes to the client that result in better value and a building that achieves all of its project brief requirements at a lower cost and with lower upfront carbon emissions.

Step 3

Use best practice methodologies to measure savings

A design and construct partner should understand best practice when it comes to calculating and communicating upfront carbon, and how to influence the supply chain, by working with the whole-of-industry to create more demand for environmental product declarations (EPDs) and alternative materials.

As more buyers of construction materials use product EPDs to compare the upfront carbon content of like-for-like products, more informed decision-making based on upfront carbon impact can be made.

Our principles for clear communication around upfront carbon in buildings include:

- **Stating the scope of all elements that are included in the assessment (as a minimum, substructure and superstructure).**
- **Defining the boundaries of the upfront carbon emissions calculations (e.g. A1–A5).**
- **Specifying the embodied carbon data used (either from an EPD or a library) for both reference case and actual (these should be the same).**
- **Identifying from where the quantities used in the calculation have been sourced (e.g. Bill of Quantities).**
- **Clarifying the functional unit for the project (e.g. Net Lettable Area, Gross Floor Area, no. of occupants).**

[10] https://www.istructe.org/IStructE/media/Public/Resources/istructe-how-to-calculate-embodied-carbon.pdf

"Transparency of calculation scope is key to enabling meaningful comparisons and discussions with the design team."[10]

Step 4

Track upfront carbon emissions as you would costs, at every stage

Throughout the design process there are particularly influential inflection points where the decisions made will materially impact the building's performance over its life cycle, including upfront carbon.

It's important to take action in reducing upfront carbon at every juncture, when you engage an architect and structural engineer, even before working with a builder.

Engage the design and construct partner from the outset to manage carbon emissions tracking

How to track upfront carbon emissions at every stage

1 **Create a reference case for a new building that meets the project's brief using conventional construction materials and techniques.**

Set a target for upfront carbon reduction, comprised of targeted material reductions (design) and reductions from procurement decisions (purchasing).

2 **Consider whether any buildings or materials on the site can be re-used or repurposed to achieve the desired project outcome. Prolonging the life of embodied carbon in materials can form a significant reduction strategy.**

Measure how any building re-use benefits upfront carbon value in proposed case.

3 **Challenge project design consultants to come up with the most efficient form for the building's intended purpose. Can the project brief be achieved by doing less, reducing the works and associated upfront carbon?**

Measure how design options can reduce upfront carbon in proposed building and continually assess the upfront carbon associated with design iterations as a defining project success metric.

4 **Update the reference case to accommodate any changing requirements to the overall functional brief.**

5 **Incorporate the least carbon intense materials that will meet project requirements – timber provides an upfront carbon saving as it absorbs carbon whilst growing and locks it away in the structure.**

Measure how materials replacement benefits upfront carbon value in proposed building.

6 **Ensure the building partner aligns their work and value engineering with achieving and improving the project sustainability targets.**

7 **Challenge the building partner to rationalise design further and source the least carbon-intense materials available including consideration of transport emissions associated with the materials.**

Measure how materials replacement benefits upfront carbon value in proposed building.

8 **Update the upfront carbon as procurement and construction progresses to keep the project on track and ensure the project achieves the reduction target in its final built form.**

Measure your electricity and fuel usage noting that biofuels, including renewable diesel and renewable electricity use on the construction site offer savings in the A5 Construction module.

Step 5

Share your data with the industry to build a body of knowledge

We won't know what good upfront carbon performance looks like if we don't have data from the industry. Even though LCA modelling has been in use for decades, it's still not commonplace to run a model on every building project.

We still need more data to determine what's appropriate for a benchmark design, against which to log upfront carbon savings or reductions.

In Australia, the industry has had the AusLCI initiative produced by the Australian Life cycle Assessment Society (ALCAS) working on measuring the upfront carbon in materials.

While in New Zealand, the government has established the 'Whole-of-Life Embodied Carbon Emissions Reduction Framework' which initially requires whole-of-life embodied carbon of buildings to be reported (in $kgCO_2e/m^2$ of building) as part of the building consent process to generate a national database of data against which to benchmark.

In the UK a proposed amendment to UK Building Regulations 2010 called Part Z has been put forward by the construction industry that would compel projects to disclose their embodied carbon emissions. If enacted, Part Z would ensure that embodied carbon is assessed on all projects, as part of a comprehensive whole life carbon assessment.

As individual entities, we're hard-pressed to demonstrate market demand for low upfront carbon materials to contribute to their proliferation. It will take the collective effort of the industry to shift demand to lower embodied carbon materials.

With industry leaders like NABERS sharing data around the operational intensity of buildings, we envisage a body like the Green Building Council of Australia will one day be the ultimate wheelhouse for this data domestically, and be able to provide relevant benchmarks and clarity on what constitutes good upfront carbon performance for buildings.

Until then, measuring and tracking upfront carbon emissions will remain a challenge across the industry. Two materials may look identical, cost the same and perform to a similar standard but have an entirely different upfront carbon factor.

But if more Australian building developers and owners, builders, engineers and architects begin to develop their own data around LCA modelling and the materials they choose to reduce and replace, a broader industry-based body of knowledge will evolve.

The industry needs to move towards **a standard measurement and presentation of embodied carbon figures.**

Below are two examples of how this might look:

1

A1 — A5: 178 $kgCO_2e/m^2$ GFA

Sequestration: -102

Substructure and superstructure

2

A — C: 212 $kgCO_2e/m^2$ GFA

A1–A5: 76

(including sequestration)

Substructure and superstructure

A1–A5 upfront carbon (top) and A–C embodied carbon (bottom) for drawings, sketches or presentations.

Once the industry has a body of knowledge and standardised means of measuring and presenting data, **the industry will be able to set common benchmarks, compare projects and establish targets to drive best practice.**

Calculated savings on 10 completed projects

Below are calculated savings in upfront carbon on ten projects Built has delivered over the past six years. We've provided figures in $kgCO_2e/m^2$ GFA for A1–A5 modules (cradle to practical completion) including all building elements to show a comparable functional unit carbon intensity and percentage reduction over a reference case.

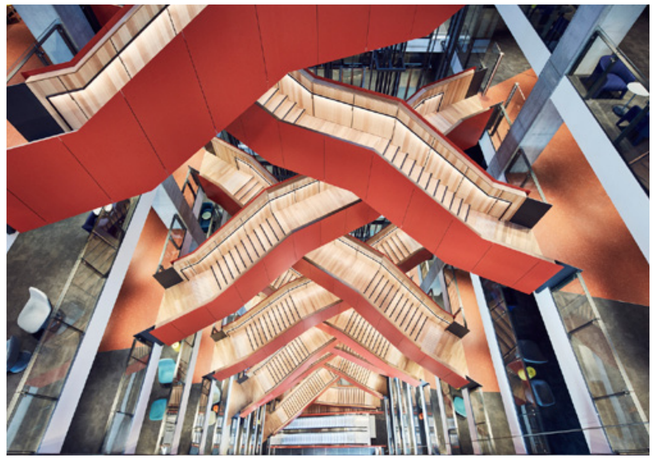
Data extracted from peer reviewed EN15978 eTool LCA models

4 Parramatta Square, NSW

GFA	**97,269 m^2**
$kgCO2e/m^2$ GFA	
Reference	**928.5**
Actual	**626.5**
Percentage reduction	**33%**

Savings initiatives

- Significant materials reduction in structure, façade and services
- 31% cement replacement across all concrete mixes



3 Parramatta Square, NSW

GFA	**59,918 m^2**
$kgCO2e/m^2$ GFA	
Reference	**1482.8**
Actual	**1354.9**
Percentage reduction	**9%**

Savings initiatives

- 31% average cement replacement across concrete mixes – minor structural rationalisations

6 & 8 Parramatta Square, NSW

GFA	**130,230 m^2**
$kgCO_2e/m^2$ GFA	
Reference	**827.5**
Actual	**674.5**
Percentage reduction	**18%**

Savings initiatives

- 31% average cement replacement across concrete mixes
- Reduced structure (11% less concrete, 15% less reinforcement steel, 5% less structural steel)

20 Martin Place, NSW

GFA	**23,007 m^2**
$kgCO2e/m^2$ GFA	
Reference	**808**
Actual	**483**
Percentage reduction	**40%**

Savings initiatives

- Retaining 5,500t existing structural steel
- 30% cement replacement across all concrete mixes

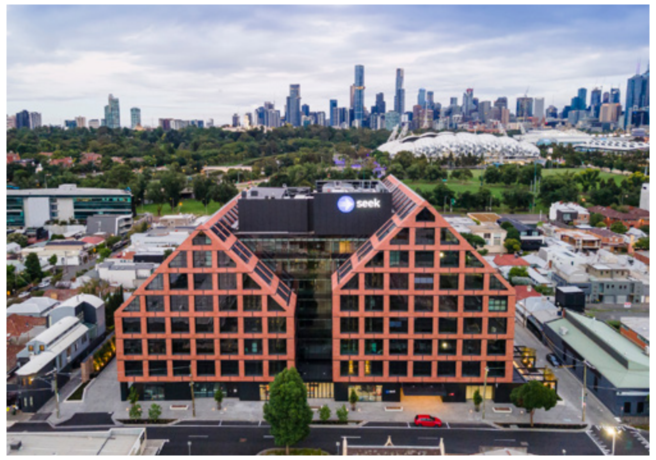
Barrack Place, NSW

GFA	**31,893 m^2**
$kgCO2e/m^2$ GFA	
Reference	**808**
Actual	**729**
Percentage reduction	**10%**

Savings initiatives

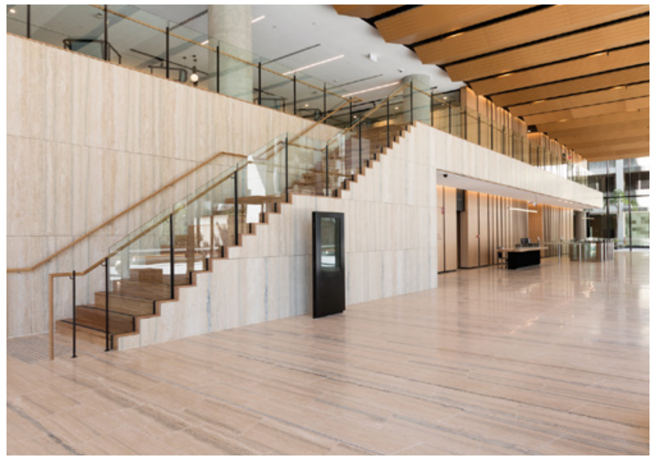
- 28% average cement replacement across concrete mixes

Calculated savings on 10 completed projects



60 Cremorne, VIC	
GFA	20,758 m²
kgCO2e/m² GFA	
Reference	952.8
Actual	914
Percentage reduction	4%

Savings initiatives
- 15% cement replacement in concrete
- Reinforcing mesh reduction



105 Phillip Street, NSW	
GFA	32,347 m²
kgCO2e/m² GFA	
Reference	605.9
Actual	417.1
Percentage reduction	31%

Savings initiatives
- 33% reduction in structural concrete and steel core and floors through pre-cast plank system
- Deleted ceiling finishes (exposed services in integrated fitout)

SubStation No. 164, NSW	
GFA	9,802 m²
kgCO2e/m² GFA	
Reference	1093
Actual	847
Percentage reduction	23%

Savings initiatives
- Retained structures of two 100+ year old buildings
- 44% cement replacement across concrete mixes

GPO Exchange, SA	
GFA	30,282 m²
kgCO2e/m² GFA	
Reference	564
Actual	520.5
Percentage reduction	8%

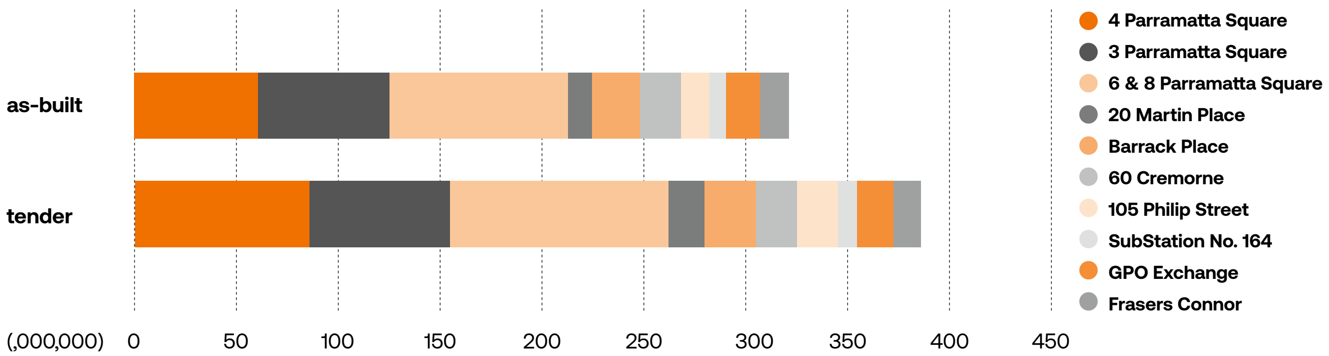
Savings initiatives
- 600m³ concrete reduction
- 22% cement replacement in concrete mixes

Frasers Connor Residential, Central Park, NSW	
GFA	18,018 m²
kgCO2e/m² GFA	
Reference	748
Actual	693
Percentage reduction	7%

Savings initiatives
- Reduced mechanical plant through connection to site-wide thermal plant in Central Park
- 30% cement replacement

These studies all compare completed projects to a reference case based on tender documentation. Reductions in upfront carbon from design initiatives incorporated pre-tender are not captured.

74,429 tonnes of upfront carbon saved over 10 projects



3

Real-world data: SubStation No. 164 + 4 Parramatta Square

Located in Sydney and Parramatta, SubStation No. 164 and 4 Parramatta Square are two very different Built projects that each achieved significant upfront carbon reductions through different strategies.

SubStation No. 164, Sydney

SubStation No. 164

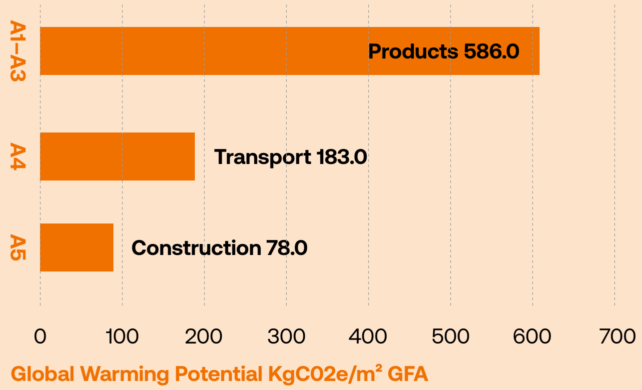
SubStation No. 164 is a boutique project that features the adaptive re-use of two heritage buildings. With 7,659m^2 commercial Net Lettable Area (NLA), it consists of a steel structure, that supports a striking seven-level, triple glazed curvilinear glass extension atop the restored buildings so that it seems to float above the streetscape.

The heritage buildings include a 110-year-old timber and brick warehouse and the last DC Electricity substation operating in Sydney completed in 1927. Both buildings lay unoccupied for over 30 years making their renovation and re-lifing a testament to sustainable development.

This project achieved a 23% reduction in upfront carbon emissions which was primarily accomplished through the following strategies:

- Substantial retention of the existing brick façades, walls, floors and columns. Heritage floors were used as formwork for the concrete floor topping which also enabled the required fire ratings to be achieved.
- An integrated design process between the design team and Built's design managers and structural engineer consultant.
- Structural efficiencies were found that enabled the deletion of a main column and reductions in structural walls.
- Concrete mixes with an average 44% cement replacement were used.

23% reduction in upfront carbon emissions



4 Parramatta Square, Parramatta

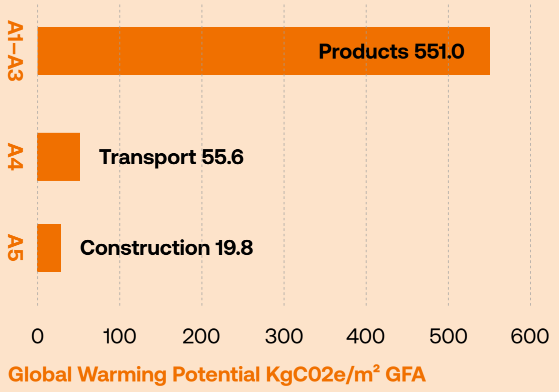
4 Parramatta Square

4 Parramatta Square is a new post-tensioned, reinforced concrete tower with approximately 70,000m^2 commercial NLA over 33 storeys and provides office accommodation for three NSW Government agencies. Developed by Walker Corporation, it is located beside Parramatta train station and within the Parramatta Square urban redevelopment.

This project achieved a 33% reduction by employing the following strategies:

- Structural rationalisation removed 2,300m^3 of concrete at various strength mixes and shifted higher strength concrete into lower strength mixes, including reducing 100MPa concrete by 23,000m^3, replaced with 65MPa, 50MPa and predominantly 40MPa mixes.
- Structural rationalisations removed 2,000 tonnes of reinforcing steel from the tender design.
- Average cement reduction of 32% across all mixes.
- Replacement of chilled beam mechanical system with low-temp VAV saving 33 tonnes of copper and 13 tonnes of black steel pipework and the aluminium and steel in 3,170 chilled beams.
- Rationalisation of curtainwall façade modules from 1200mm to 1800mm, saving 33% of the aluminium mullions or 60 tonnes of high embodied carbon aluminium.

33% reduction in upfront carbon emissions



Summary

It's difficult to compare these projects in terms of their sustainability outcomes equitably.

One of the main reasons is that the work done at SubStation No. 164 has the effect of extending the life of these 100+-year-old buildings by at least another 60 years or nearly tripling the LCA assumed design life.

When considering that fact, the impact of honouring the embodied carbon in these old concrete, steel, brick and timber buildings goes beyond the calculated 23% reduction in upfront carbon.

In these cases, LCA modelling was integral but not the only benchmark worth considering. The value of sharing these case studies is to show the considerable reductions in upfront carbon that can be achieved regardless of project scope and scale.

Useful resources

Useful resources

When starting out you can begin with a simple Excel spreadsheet

Take your material quantities from the Bill of Quantities and add the associated upfront carbon factor for each material – extracted from product EPDs or life cycle inventories – to calculate upfront carbon as a way to identify rough figures.

This will allow you to quickly zero in on the largest opportunities for upfront carbon reduction.

Here's a simple example:

Material	CO_2e factor (T/unit)	Quantity	A1 – A3 (TCO_2e)
Concrete 40MPa (m^3)	0.5481	5000	2,740.5
Structural steel (tonnes)	2.85	750	2,137.5
Reinforcing steel (tonnes)	1.58	1500	2,370.0
Curtainwall façade (m^2)	0.168	850	142.8
Total			7,390.8

Guidelines and tools

We've found **eTool** to be one of the most user-friendly LCA software tools available to the market. The advantage of eTool is that it allows us to constantly review our projects and assess them consistently while providing good analytics and reporting opportunities.

In the States, **Carbon Leadership Forum (CLF)** is pioneering research and gathering data to drive best practice, with member-led initiatives to "radically reduce and ultimately eliminate the embodied carbon in building materials and construction."[11]

In the UK, **London Energy Transformation Initiative (LETI)** has been working with industry groups to help address a lack of consistent measurements which leads to mis-aligned benchmarks. Released in 2020, LETI's Embodied Carbon Primer[12] is an excellent resource.

The Embodied Carbon Primer is designed to help companies understand where they should place technical parameters within embodied carbon analysis, and provides practical measures that can be taken to reduce embodied carbon in design and construction.

The table below is a collation of helpful guidelines and resources we have used to inform our processes at Built and ensure our work with upfront carbon and life cycle assessments is aligned with international best practice.

Embodied Carbon guidelines

- UKGBC Embodied Carbon developing a client brief
- LETI Embodied Carbon Primer
- Carbon Leadership Forum
- Institute of Structural Engineers

Australian Embodied Carbon Databases

- University of Melbourne Life Cycle Inventory
- University of New South Wales Integrated Carbon Metrics Life Cycle Inventory
- The Inventory of Carbon & Energy Database

Case Studies/ Benchmarks

- Embodied Carbon Benchmark Study
- LETI Embodied Carbon Target alignment

Reports

- Embodied Carbon & Embodied Energy in Australia's Buildings - GBCA
- Bringing embodied carbon upfront - WorldGBC

[11] https://carbonleadershipforum.org/wp-content/uploads/2019/11/Embodied-Carbon-Facts-and-Figures.pdf
[12] https://www.leti.london/ecp

About Built

Built

Built has the scale and certainty of a tier one construction company, with the culture and agility to stay ahead of change.

Proudly Australian and privately owned since 1998 we have grown to be a national diversified general contractor and one of Australia's largest private construction groups.

Our reputation is built on being the most responsive, client focused partner in the industry – a specialist team with extensive tier one and large corporate experience. From large scale new builds to complex refurbishments and intricate fitouts, we innovate and challenge industry conventions.

When you work with us, you work with a group of leaders on a mission to improve the way the world is built.

About the authors

Joe Karten

Joe is an industry leader in sustainability. He has visited some of the most sustainable buildings in the world and worked at the Green Building Council of Australia. Joe now heads up sustainability and social impact for Built, where he works with a team committed to improving the way the world is built.

Joe sets sustainability and social impact strategy, guides progress on live projects and contributes to industry think tanks and stakeholder groups to improve the Australian property industry's response to the environmental and social challenges we face.

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Clare Gallagher

Clare's career has focused on creating change in the built environment – working towards healthier buildings that use fewer resources and drive positive social and environmental outcomes.

She works with clients, integrating their values to inspire change and action on projects and delivering leading sustainability results. Her project highlights include SubStation No 164, Barrack Place, PCA 2020 Best Sustainable Development and 1 Malop St, Master Builder's 2019 Best Sustainable Project (VIC).

Clare's background is in architecture and she worked for the New Zealand Green Building Council prior to joining Built.

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