slattery

# Embodied water: An untapped source of emissions reductions

March 2023

slattery

# Embodied water: An untapped source of emissions reductions

Up to 38% of a building's lifecycle water consumption can occur before anyone ever turns on a tap. Fresh Slattery research suggests tackling this hidden water footprint – known as 'embodied water' – can save our most precious natural resource and drive down emissions.

## Introduction

Although around 70% of the Earth's surface is covered in water, just 2.5% of that is fresh water – and of that just a fraction is easily accessible and available for use. The rest is locked away in glaciers, ice caps, permafrost or underground aquifers.

We are left with less than 0.5% of the Earth's fresh surface water, and that is distributed unevenly across the globe.

Australia, the world's driest inhabited continent, has always been a land of droughts and flooding rains. But our variable climate patterns are becoming harder and harder to predict, with extreme droughts and floods no longer 'once in a 100 year' events.

As our population grows, so does our water consumption. Australia's water usage increased by 25% between 2019 and 2021 alone (ABS, 2020). A massive 85% of that water was supplied to industry.

## What is embodied water?

Large quantities of water are consumed during the process of growing and extracting raw materials, to manufacture and transport products, and during construction. This water is known as **embodied water.**

Until recently, the sustainability narrative was focused on the operations story.

Green Star has rewarded water-wise design for two decades, and the Green Building Council of Australia estimates a Green Star building consumes 51% less water than the average Australian building (GBCA, 2019). Architects and engineers routinely integrate rainwater harvesting, greywater systems, and water-efficient fixtures and fittings into designs.

Similarly, facility management teams continue to focus on water-efficient operations. The average NABERS Water rating has risen from 3.4 stars in 2010 to 4.8 stars in 2022 as consumption is measured and managed, and equipment optimised (NABERS, 2022). Building users are being educated to turn off taps and report leaks.

While these efforts are laudable, little attention has been paid to the water used at other stages of the building lifecycle. This is reflected in the scant data and lack of peer-reviewed research papers that could help us understand the size of the challenge – and the size of the opportunity.

One full life-cycle assessment of an Australian residence, conducted in 2014, determined that 38.2% of water was consumed before operations (Stephan and Crawford 2014). As green design and smart management drives down water consumption during the operational phase, our attention turns to the water used at other stages of the lifecycle.

Recent and rapid developments across the industry to tackle embodied carbon demonstrate how the issue of embodied water could evolve in just a few short years. Embodied water could become a spotlight issue even faster as the industry looks to reduce emissions at speed and scale.

> "Slattery analysis finds that, on average, 92% of embodied water is consumed during the product stage – and that the materials with the highest embodied water are also the highest in embodied carbon."



slattery

## Looking at water through a new lens

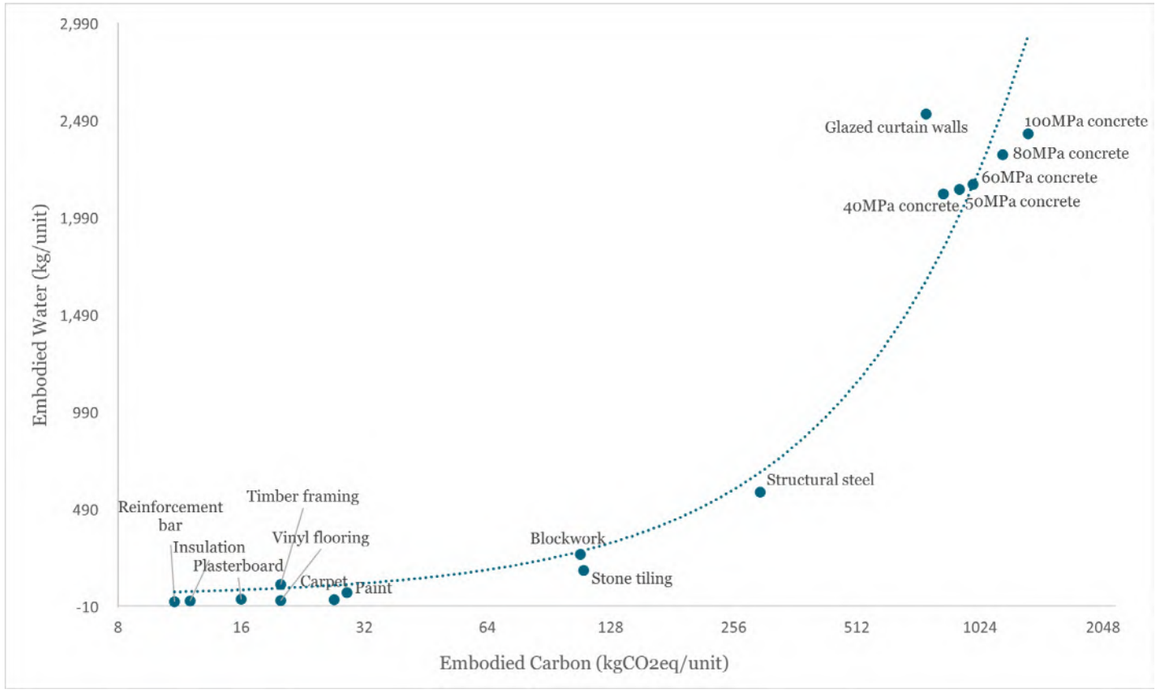
As Australia's property and construction industry continues its collective decarbonisation journey, the concept of embodied carbon is gaining traction. Some property and construction leaders are beginning to quantify their hidden carbon footprint – and as they do, they have an opportunity to look at water through a new lens.

To understand the untapped potential of embodied water, Slattery's Carbon Planning team benchmarked and compared the embodied water and embodied carbon of common building materials to understand the association between the two. Here's what we found...

### Embodied water by material

The Australian Life Cycle Inventory Database (AusLCI) provides industry-averaged data on the environmental impacts of a wide range of Australian products and services. Using AusLCI data, our analysis found that common building materials – especially concrete, glass, aluminium and steel – are the most water-intensive materials, and also those with the highest embodied carbon.

**Figure 1:**
Embodied water and embodied carbon of common building materials




**Note:** A logarithmic scale is used to reflect the wide variation between low and high embodied water and carbon materials.


> “Not all materials that are high in embodied carbon are high in embodied water. Slattery’s research finds a correlation, rather than a causal relationship between embodied carbon and water.”

slattery

## Embodied water by material *cont.*

Large quantities of concrete and glazed curtain walls are common in new builds. The process of making glass involves melting raw materials at high temperatures – which generates significant carbon emissions – and water is used for cooling, cleaning, mixing, quenching and waste treatment. Depending on the glass being manufactured, up to 32.2 litres of water can be consumed per kilogram of glass produced (Crawford, 2022).

Cement, an essential ingredient of concrete, is produced at extremely high heats, generating around 7% of global emissions (Heincke, 2023). Cement production generates emissions through the chemical process of calcination, which breaks down limestone through extreme heat. Cement production is also water intensive. One study found concrete production was responsible for 9% of global industrial water withdrawals in 2012 (Miller, 2018).

If materials that are high embodied water are also high in embodied carbon, this means specifying low carbon materials has an additional advantage of reducing embodied water.

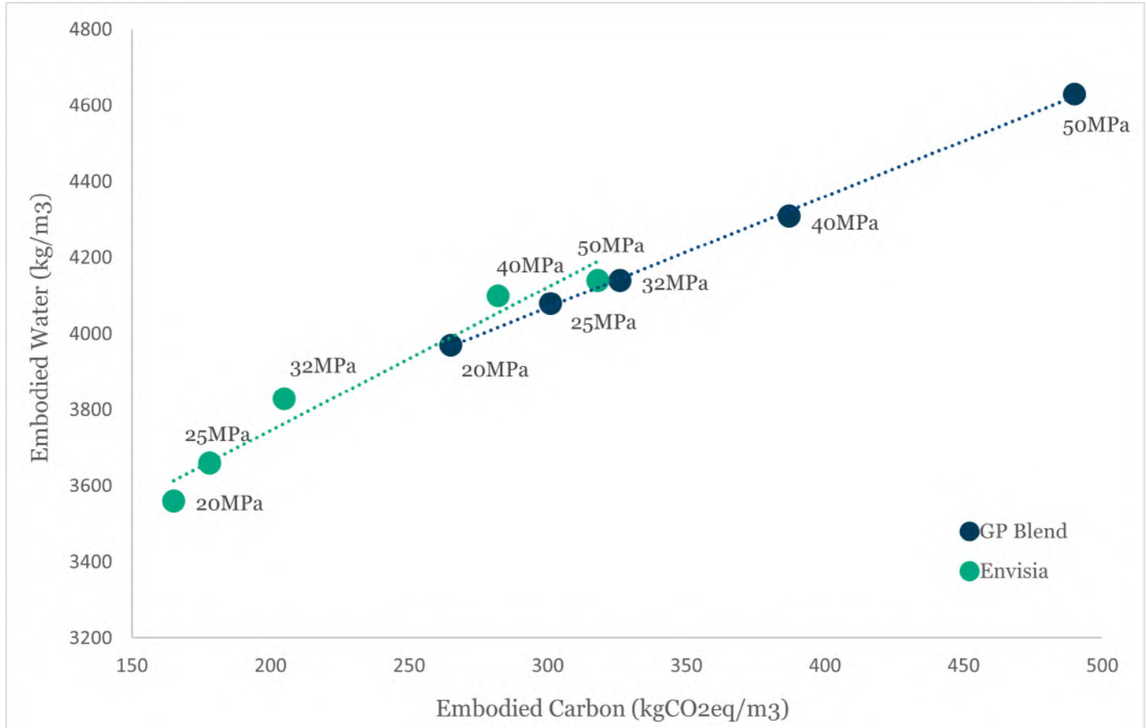
To drill down further, we compared the embodied water of two Boral concrete products: the normal general purpose blend and Envisia, a lower carbon concrete that uses 50% less cement. We found Envisia is not only lower in embodied carbon, but also reduces embodied water by around 10%. We suggest this is because Boral Envisia uses less cement, and therefore less water, in production.

Not all materials that are high in embodied carbon are high in embodied water. Slattery’s research finds a correlation, rather than a causal relationship between embodied carbon and water.

Not all data can be used with 100% confidence either. There are still some gaps in carbon data, and even larger gaps in the data needed to make sound decisions about embodied water.

When it comes to quantity surveying, the devil is always in the detail. It is important to understand how different materials, required in vastly different quantities, can influence the embodied water outcome. For example, while one unit of a particular material may be considerably lower in embodied carbon or water than an alternative, the quantity required may reduce its appeal and sustainability impact.

**Figure 2:**
Low-carbon concrete makes embodied water savings




**Note:** The embodied water (y-axis) and upfront embodied carbon (x-axis) of Boral Normal GP Blend and Low-carbon Envisia embodied water product, based on Boral Victoria Region Environmental Product Declaration (EPD), for LCA Stages A1-A3.

## Embodied water by activity

Life Cycle Assessments, or LCAs, assess the environmental impact of materials, products and services across their entire lifecycle. While LCAs are primarily used as a tool to measure and offset carbon emissions, fresh water usage is calculated in this analysis.

We found most embodied water can be attributed to LCA stages A1-3 (product stage) with minimal contributions from A4 (transport stage) and A5 (construction stage).

Across our benchmarks, an average of 92% of embodied water is used during raw materials extraction and product manufacturing (Figure 3). Despite this, the construction industry's focus has been on sustainable water use on construction sites (A5) and on the use stage (B7).

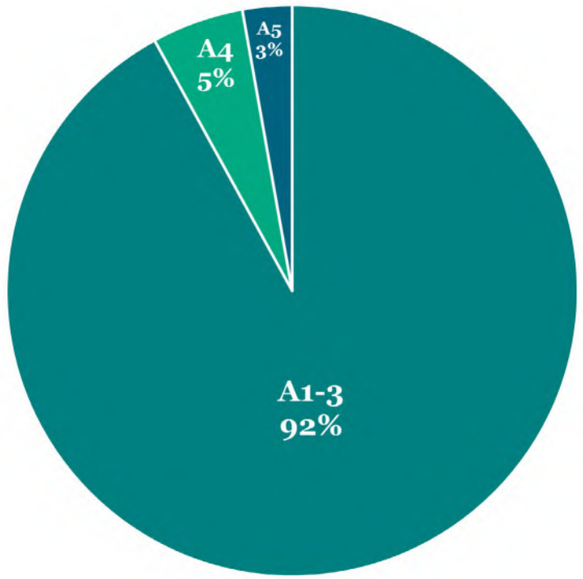



**Figure 4:**
Embodied water breakdown by Life Cycle Assessment (LCA) stages A1-3, A4 and A5

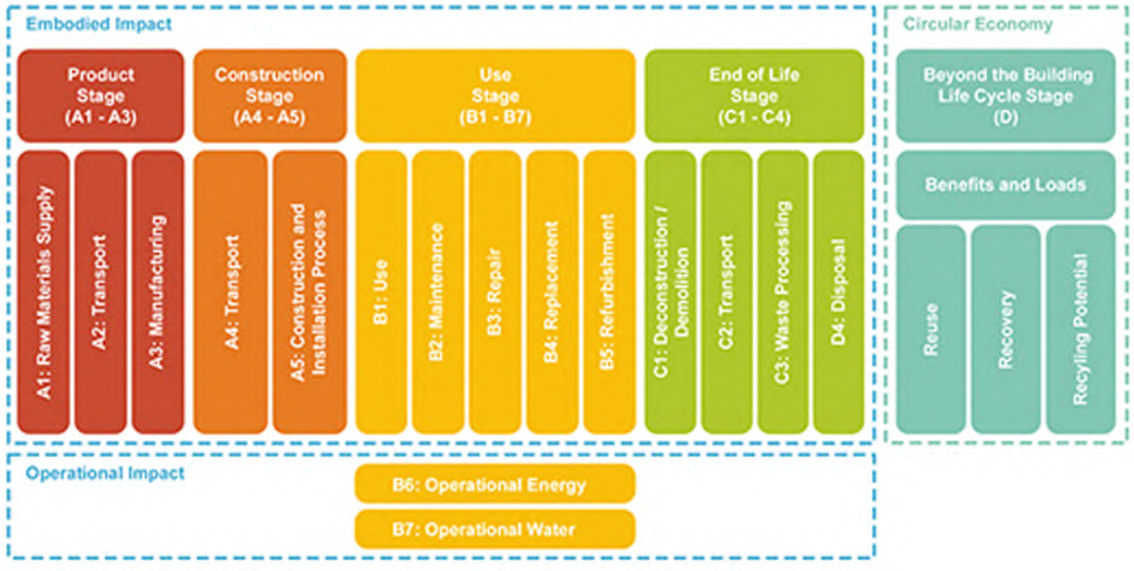



**Figure 3:**
Life Cycle Assessment (LCA) stages (Source: Overbey, 2021.)



slattery

## Embodied water by building type

We also analysed benchmarking data from a selection of 30 diverse new builds and refurbishments. This analysis, illustrated in Figure 5, found commercial, residential and health buildings have the largest embodied water footprints per square metre of gross floor area (GFA). On some projects this can be the equivalent to the water held in 114 Olympic-sized swimming pools.

To standardise the results and compare projects of varying sizes, we divide the total embodied water by the GFA. A typical new build project has large quantities of concrete, steel reinforcement, structural steel, aluminium and glazing. This explains why the health, commercial and residential sector benchmarks have relatively high embodied water.

Fitouts and refurbishments have lower embodied water, highlighting the embodied water saving opportunities that can be achieved by repurposing existing structures.

> "...this can be the equivalent to the water held in 114 Olympic-sized swimming pools."




**Figure 5:**
Comparison of embodied water (kg/m2 of GFA) by sector

## Obstacles and opportunities

There is a notable void in available data to accurately benchmark embodied water.

Crawford (2022) analysed common building materials in Australia and demonstrated, through a residential case study, that concrete and timber products have the largest embodied water footprints. Concrete, as mentioned earlier, uses vast quantities of water during manufacture. Timber, on the other hand, is used in large quantities in residential construction, and therefore has a larger embodied water footprint.

Crawford's case study considered the lifecycle of the house over a 50-year period, finding that the frequent replacement of internal finishes such as paint and carpet contributed the largest overall proportion of embodied water. This highlights the opportunity to reduce recurrent embodied water impacts by opting for longer-lasting products and materials.

Research undertaken by Deakin University of 17 non-residential buildings in Australia (McCormack et al., 2007) suggests that the embodied water impact is greater than the volume of water used throughout the building's operational life. Materials selection plays a major role in a building's embodied water, the research found. But this study, while valuable, did not calculate services, fixtures and fitments due to a lack of data availability. Large, high-rise buildings contain high quantities of service equipment, as well as fixtures and fitments in amenities and end-of-trip areas.

There is substantial variation between AusLCI embodied water figures and datasets employed in the academic studies to date. As mentioned earlier, there are also few peer-reviewed papers to draw upon. This highlights an opportunity to develop a nationally consistent framework to measure industry-averaged embodied water impacts.

With no nationally accepted methodology for conducting LCAs, outcomes and data quality can vary substantially. This is an impediment to accurate and comprehensive carbon emissions data, and also prevents us from quantifying and comparing embodied water impacts.

NABERS and the Green Building Council of Australia are currently collaborating with industry experts, including Slattery, to develop a national framework for embodied carbon emissions. This will set a common method to measure, benchmark and certify the upfront embodied carbon emissions of construction and building materials. Industry has identified an opportunity to extend this scope of work to capture other environmental impacts, such as water.

> "There is an opportunity to reduce recurrent embodied water impacts by opting for longer-lasting products and materials."




slattery

## Quick wins

With a clear correlation between high embodied carbon and water materials, strategies to reduce one environmental impact are likely to have a positive influence on the other.

Slattery's recommended approach is aligned with the ethos of our Carbon Planning Service – and that is to measure embodied carbon throughout the design process to identify and address those with the emissions-reduction potential.

By modelling and measuring embodied carbon impacts early in the project lifecycle – and then by making informed adjustments to a building's design – an embodied carbon reduction of around 10% can be achieved without an additional cost. By reducing embodied carbon, we believe there is likely to be a corresponding reduction in embodied water.

Sizeable opportunities to drive down emissions and reduce embodied carbon are found at the earliest stages of design, as core building components such as the substructure, structure and façade are locked in. The same is true for embodied water. For example:

**Build less**

- Dematerialise: Efficient design can reduce the volume and quantity of materials, like concrete and steel, without compromising building utility or value.
- Minimise: Consider minimising basements and excavation, and reuse what you can from buildings that may already exist on your site.
- Eliminate: Choose raw finishes, such as polished concrete, instead of layers of materials, or offer 'cold shell' fitouts, rather than 'warm shells' that tenants may demolish and discard in landfill.

**Build smart**

- Prefabricate: Build offsite to reduce the amount of material needed and the amount of waste generated.
- Specify: Drive demand for lower carbon material alternatives (A1-3 emissions), such as lower carbon concrete mixes and carbon neutral certified materials. Procure innovative materials, like cross-laminated timber instead of reinforced concrete for structures.
- Verify: Look for materials that have third-party verified Environmental Product Declarations.
- Recycle: Use circular economy, closed loop principles to reuse, recover and recondition materials.
- Repurpose: Maximise future flexibility by designing for disassembly, so products and materials can be reused as the asset evolves.

**Build together**

- Collaborate: Work with others across the industry to champion the issue of embodied water. Developers, owners and tenants can leverage their purchasing power to advance the sustainability of supply chains by prioritising low embodied water and carbon materials.
- Share: Improve access to data to inform material choices, design strategies and changes to building regulations and government policies.

## How Slattery can help

The enormous challenge of climate change has sharpened the world's focus on carbon emissions. Measuring carbon has challenged the property and construction industry to look for the hidden costs – and hidden value – throughout the entire building lifecycle.

With deep expertise in construction quantities and a vast resource of benchmarking data at our disposal, Slattery's team is well placed to measure embodied water to guide design, specification and construction decision-making.

slattery

## References


Australian Bureau of Statistics (2020-21). Water Account, Australia. ABS website, accessed 20 February 2023.

Crawford, R. (December 2022). Embodied water in construction. Acumen Practice Notes, Australian Institute of Architects, accessed 20 February 2023.

Green Building Council of Australia (2019). Green Star in focus: The business case. GBCA website, accessed 20 February 2023.

Heincke, S, et al (February 2023), Decarbonizing cement and concrete value chains: Takeaways from Davos. McKinsey & Company, accessed 20 February 2023.

McCormack, M., Treloar, G.J., Palmowski, L. and Crawford, R. (2007), Modelling direct and indirect water requirements of construction, Building Research & Information, 35(2), pp.156–162. doi: 10.1080/09613210601125383.

Miller, S.A., Horvath, A. & Monteiro, P.J.M. (2018). Impacts of booming concrete production on water resources worldwide. Nat Sustain 1, 69–76.

NABERS (October 2021), NABERS Embodied emissions initiative. NABERS website, accessed 20 February 2023.

NABERS (2022), Annual report 2021-2022, Program Statistics Office – Water. NABERS website, accessed 20 February 2023.

Our World in Data (July 2018), Water Use and Stress. Our World in Data website, accessed 20 February 2023.

Overbey, D. (2021). LCA Stages Matter When Tracking Embodied Carbon. Building Enclosure, accessed 20 February 2023.

Stephan, A. and Crawford, R.H. (2014). A comprehensive life cycle water analysis framework for residential buildings. Building Research & Information, 42(6), pp.685–695. doi: https://doi.org/10.1080/09613218.2014.921764

U.S. Geological Survey (June 2018). Where is Earth's Water? USGS.gov, accessed 20 February 2023.

Vickers, J et al (December 2022). Embodied Emissions Technical Report. Thinkstep ANZ, accessed 20 February 2023.


## Citation


O'Connor, J., Dean, T. and Mortensen, J., (2022), Embodied water: An untapped source of emissions reductions, Slattery.


## Slattery carbon contacts

If you have any questions arising from this thought leadership paper, please reach out to our Slattery carbon leads for more information.


**Tom Dean**
Carbon Planning
Director
+61 423 444 965

**James Mortensen**
Carbon Planning
Associate
+61 403 614 661

**Malcolm Wren**
Carbon Planning
Quantity Surveyor
+61 417 330 287

**Jacinda O'Connor**
Carbon Planning
Quantity Surveyor
+61 405 593 422

**Lahiru Wijesinghe**
Carbon Planning
Quantity Surveyor
+61 9602 1313




**Image:**
*Family Camping, Illari Spring* (2019)
by Betty Nungarrayi Conway
Slattery Warrang (Sydney) Collection

## About Slattery and Kaizen

Slattery is a property and construction advisory firm specialising in quantity surveying, cost management and early phase project advisory, with an outstanding history spanning more than 40 years.

We work hand-in-hand with governments, institutions and organisations as well as planners, developers, architects and design teams on a broad range of property and construction projects.

A commitment to excellence and innovation, and an ability to become an integral part of the project team has earned Slattery the trust and respect of clients and project teams alike. Slattery adds value by taking control and ownership of the cost management process from the outset.

Slattery's Kaizen Papers focus on sharing knowledge, ideas and pertinent cost information related to our industry. Kaizen is the Japanese word for improvement, and a business philosophy that strives for continuous improvement in process. We produce papers across the sectors we work with, which are shared with our clients and made available on our website for all to view.

We invite you to explore our knowledge sharing further at www.slattery.com.au/thought-leadership

## Slattery Carbon Planning

Slattery is proud to be the first quantity surveying firm in Australia to launch a carbon planning service.

Our service is available in conjunction with cost planning to assist our clients in achieving their net zero and sustainability targets. The focus of the carbon plan will address and educate clients on the embodied carbon of their current and future developments.

Read more about Slattery's carbon planning offering at www.slattery.com.au/carbon-planning

Our team is pleased to hold memberships to the following industry groups:

AIQS Australian Institute of Quantity Surveyors · MECLA · Green Building Council Australia

slattery

**Slattery Australia Pty Ltd**
www.slattery.com.au

**Melbourne**
**Naarm**

Queen & Collins Tower,
Level 10, 376 – 390 Collins Street,
Melbourne, VIC, 3000

Phone +61 3 9602 1313
Email melbourne@slattery.com.au

**Sydney**
**Warrang**

Level 10, 14 Martin Place,
Sydney, NSW 2000

Phone +61 2 9423 8850
Email sydney@slattery.com.au

**Brisbane**
**Meeanjin**

Level 18, 239 George Street
Brisbane, QLD 4000

Phone +61 7 3041 7373
Email brisbane@slattery.com.au

**Perth**
**Boorloo**

Level 32, 152 St Georges Terrace
Perth, WA 6000

Phone+61 8 9221 4444
Email perth@slattery.com.au