

Case study: Daramu House

Tony Lam



Cover image. Daramu House announces the northern entry point into the commercial core of Barangaroo along Hickson Rd (Image: Ben Guthrie – The Guthrie Project).

Project summary

Daramu House is a 7-storey mass timber commercial building located at Barangaroo, a 7.5 ha waterfront urban renewal project located at the western edge of the Sydney CBD (Cover image). Daramu House has achieved a 6 Star Green Star Design & As Built certified rating, exceeds the 5 Star NABERS rating by 30% and is targeting WELL Building Standard version 2 (WELL v2) building certification.

An important objective was to set a new sustainability benchmark for commercial buildings of this scale, by proving that the adoption of low carbon alternatives to incumbent building practices can be both commercially viable and beautiful. At the core of the design for Daramu House is a commitment to minimising the embodied and operational carbon of the building, while also minimising water use, waste generation and encouraging biodiversity.

Embodied carbon is reduced through a number of measures including structural material selection, structural efficiency, recycled material use, material minimisation and prefabrication. Operational carbon is minimised through measures including a passive cooling strategy, implementation of passive design principles to manage heat load and a high-performance curtain wall. The energy load is also partially offset by on-site renewable energy generation.

Project details	
Project name	Daramu House
Project type	7-storey commercial building
Procurement type	Design & Construct
Year of design completion	2017
Year of project completion	2019
Location	
• Land + nation • Climate zone • Bioregion	• Gadigal Land, Eora Nation • Climate Zone 5 • Sydney Basin
Site area	2074 sqm
Gross floor area m ²	11,703 sqm
Net lettable area m ²	10,865 sqm
Number of levels	7
Number of residents, occupants, visitors	Retail staff: 54 Retail visitors: 504 Commercial occupants: 1094
Sustainability benchmarks and ratings achieved	6 Star Green Star (Design & As Built v1.2 2020) certified rating WELL Health-Safety Rating (2020) WELL v2 Core Certification (targeted) 5 Star NABERS Energy rating (exceeded by 30%)

Project team	
Architect	Tzannes
Consultants	Lendlease DesignMake, Hyder, WSP, Warrington Fire, Inhabit, Jungleyf
Builder	Lendlease Building

Integration

At its heart, Daramu House, along with the neighbouring International House (also designed by Tzannes), is about defining a new form of beauty expressed through efficiency in built form as well as celebrating the natural aesthetic qualities of timber through a highly transparent facade (Figure 1), and internally through the omission of wall and ceiling linings. Made up only of essential elements, the building exhibits material simplicity (see [Resources](#)). A responsiveness to human scale in the lower two floors is achieved through an exploration of detail,

texture and spatial considerations, to create a unique place within the urban fabric (see [Community](#)).

A core driver of design decisions on Daramu House was the potential to demonstrate sustainable design in practice, in areas including greater resource efficiency in design, a broader adoption of mass timber technology, a circular material economy through material reuse, a broader adoption of integrated green roofs and urban landscaping to tackle urban heat island effect, the primacy of human scale and the creation of beautiful urban environments to support a sustainable form of urban density.

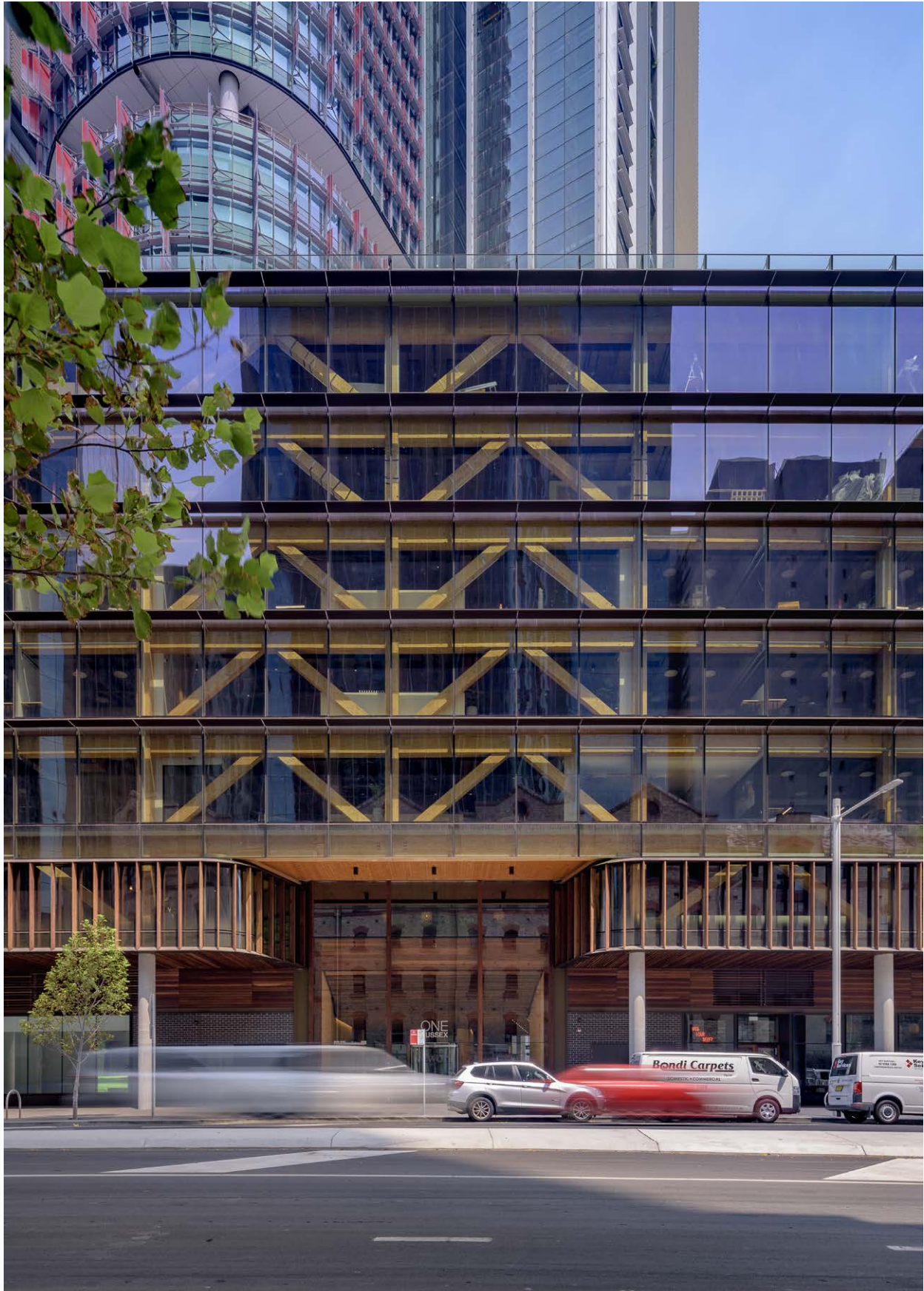


Figure 1. The natural aesthetic qualities of timber are expressed externally through a highly transparent facade (Image: Ben Guthrie – The Guthrie Project).

Community

At an urban scale, Daramu House provides a model for considered density in the public domain that also considers amenity for its users. For example, the curved corners of the building enable pedestrians to experience improved solar access, decreased negative wind effects and safer mobility. The building's geometry more broadly reflects the urban layout of the adjacent streets and lanes – enhancing the urban legibility of the precinct (Figure 2). The exception is the deeply recessed double curved facade on the northern elevation, designed to enhance views from within away from the building opposite as well as increase privacy for the occupants (Figure 3). Above the podium, a transparent glass facade reveals the inherent warmth of the internal timber structure to the city. The commercial lobby and address on Sussex Street to the east provides a generous publicly accessible space with revolving doors at both ends facilitating through-site pedestrian access during business hours.

A sculptural artwork lining the northern wall of the lobby, a collaborative effort between Lendlease and Tzannes led by artist Nicole Larkin, depicts the First Nations, colonial and post-colonial history of the Barangaroo headland, by an intricate mapping of the evolving coastline. Carved out of a cross-laminated timber (CLT) panel using specifically tailored software and Lendlease DesignMake's CNC fabrication facility, the artwork highlights the beauty of this material as used throughout the architecture. The artwork's lobby location gives it prominence and exposure (Figure 4).

It is Tzannes' hope that the evidence-based research study conducted on the integrated green roof (see [Water; Energy](#)) will provide an empirical basis for a broader adoption of landscaping within urban environments and communities around the world to counter the worsening impacts and risks posed by the urban heat island effect.

Daramu House is located in an inner-city location with a Walk Score of 98 in accordance with [Walkscore](#).

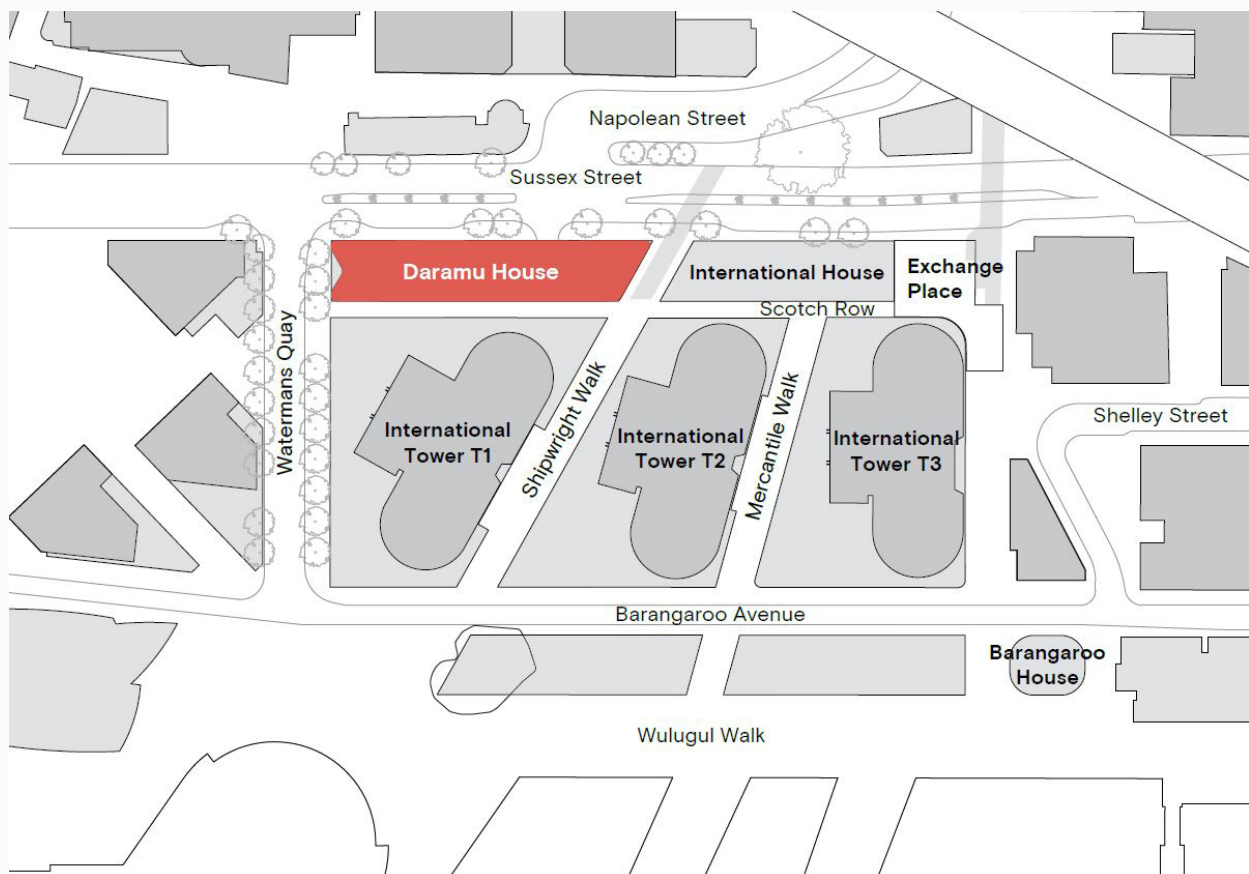


Figure 2. Site plan of precinct with Daramu House shaded (Image: Tzannes)

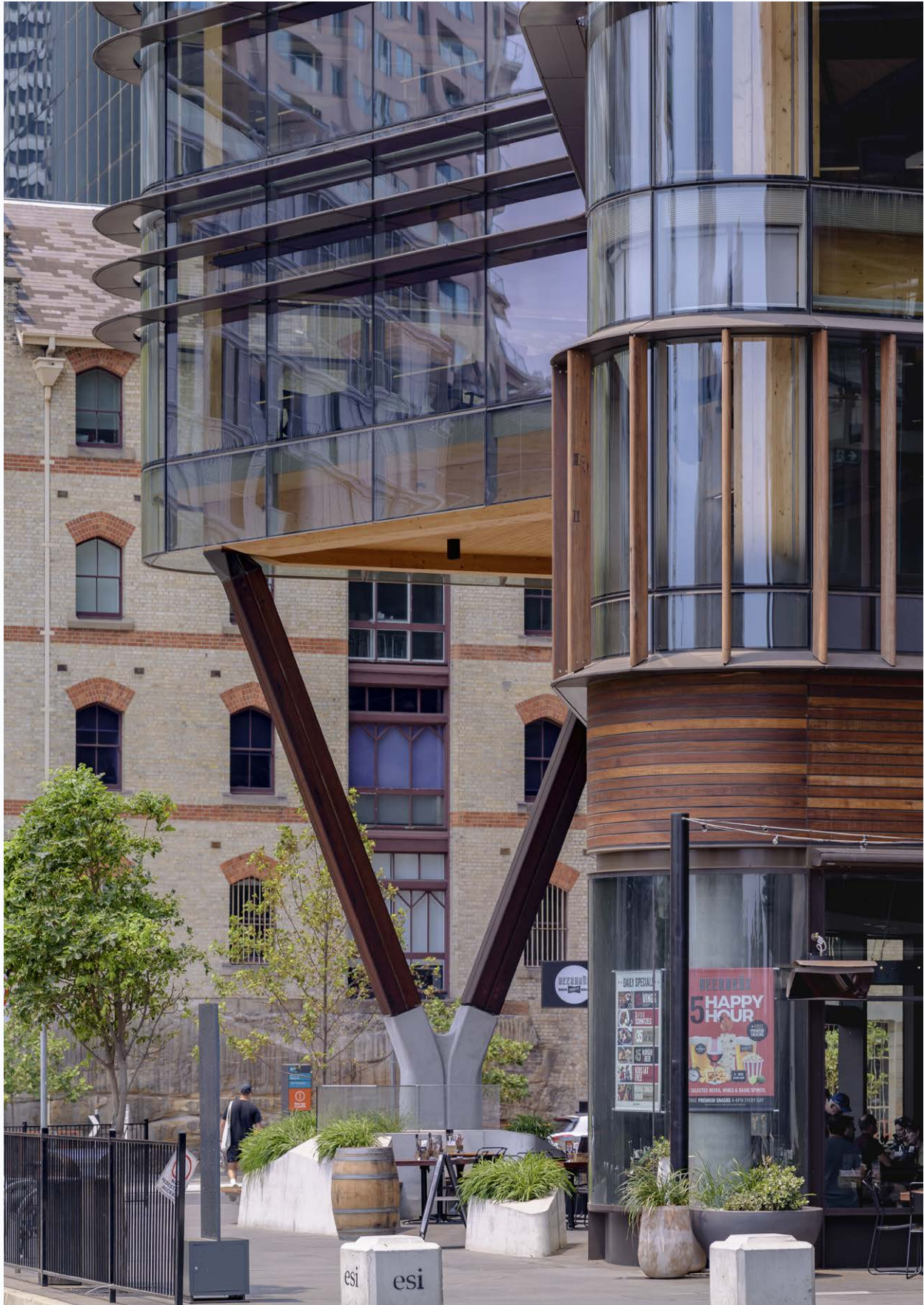


Figure 3. The double curved facade on the north elevation is designed to enhance the views from within away from the building opposite (Image: Ben Guthrie – The Guthrie Project).



Figure 4. A 13 m long artwork carved from CLT panels adorns the entrance lobby and celebrates the evolving history of the Barangaroo shoreline (Image: Brett Boardman).

Country

Daramu House adopts the Dharug word for tree in its name, to signal the primacy and respect for Indigenous culture in contemporary society. A smoking ceremony was held at the topping out ceremony, and proceedings focused on elevating and celebrating the life of Barangaroo as a key female figure within the Indigenous community during early colonisation.

Native Australian hardwoods are used in all external timber elements (see [Resources](#)). They form a key component of the built presence within the public domain and highlight local material use and connection to the land.

An extensive-type green roof (shallow profile, light weight at 156 kg/sqm, comprised of 120 mm proprietary growing medium zone, geotextile fabric and drainage cell layer) occupies the entire roof area and is integrated with a photovoltaic (PV) array. On-site renewable energy generation mitigates the environmental impact on Country (see [Energy](#)). The green roof is populated with a careful selection of native vegetation species mixed with a few flowering exotics to promote biodiversity and pollination within the local environment while minimising the amount of water needed for irrigation (Figure 5).

Consideration was given to what species of vegetation would work with the shaded and unshaded environment provided by the solar panels.



Figure 5. The integrated green roof — a mixture of natives and exotic plants aims to support biodiversity within the urban environment (Image: Brett Boardman).

Viola hederacea was chosen for use immediately under the panels, coupled with *Dichondra repens*, a native groundcover, both known to be resistant and adaptable to fully shaded environments. *Dianella caerulea*, a resilient native species known to be effective in attracting bee activity, occupied the partially shaded spaces between panels. *Aptenia cordifolia*, an exotic ground cover, also occupies the partly shaded areas between panels and is expected to send shoots underneath the panels.

Water

The Barangaroo development, within which Daramu House is located, incorporates a number of precinct-wide water saving measures that on sum allow the precinct to be water positive in operation, exporting more water than the drinking water that is imported. These measures include a centralised wastewater treatment plant which filters and treats black and grey water generated on site with the added ability to draw from the adjacent public sewer system. This processed water is then supplied back to the precinct public domain and buildings for non-potable uses such as irrigation and toilet flushing. Water storage tanks, situated within the precinct basement, capture stormwater from building rooftops and terraces as well as public domain run off to further supplement these uses.

Capitalising on the precinct's proximity to the harbour, a district cooling plant uses pumped harbour water instead of mains water to reject heat from the building cooling systems, thereby removing one of the largest sources of water consumption in contemporary commercial construction (see also [Energy](#)).

The potable water usage of Daramu House is minimised through these precinct-wide measures. In addition, all fixtures within the base build wet areas are 4-star WELS rated.

The green roof of Daramu House incorporates predominantly low water use native species to minimise irrigation demand (See also [Country](#) above). A dedicated irrigation system is coupled with a proprietary soil medium to optimise water use. The green roof has been studied by a team of researchers from the University of Technology Sydney (Irga et al 2021) to determine its impact on the quality of stormwater run-off as well as the flow rate of water. Field observations demonstrated a significant reduction in soluble and insoluble copper entering the stormwater systems as well as a reduction in insoluble zinc and chromium. Stormwater flow rates were also shown to be dramatically reduced by the green roof during storm events when compared to a conventional roof.

Economy

Daramu House has demonstrated that mass timber is a viable commercial alternative to concrete. The costs for the supply of mass timber were slightly higher than concrete, but this cost was offset through other material minimisations (particularly elimination of internal wall and ceiling linings), simplification of construction, minimisation of site wastage, simplification of facade and benefits to the programme enabled through prefabrication and optimised staging (Figure 6).



Figure 6. Daramu House under construction — building without scaffolding exposes the process of construction to the public (Image: Michael Nicholson).



Figure 7. Sunshading mitigates excessive heat load on the north facade (Image: Brett Boardman).

The use of recycled Australian timbers throughout promotes local industry and material sourcing (see [Country; Resources](#)).

The City of Sydney awarded a research grant to Lendlease, Junglery and the University of Technology Sydney to track the effectiveness of the green roof across four key areas: stormwater, renewable energy generation, thermal performance and local biodiversity. The positive results from this study (Irga et al 2021) provide a firm evidence base for the adoption of green roofs and urban landscaping in general but particularly in connection with a photovoltaic system. This could encourage the growth of associated industries within Sydney and other cities around the world that are at risk of rising urban heat, overwhelmed stormwater systems due to increased precipitation, suffer from poor biodiversity as well as those looking to maximise the efficiency of their renewable energy assets.

Energy

The optimisation of energy use across the building's lifecycle was central to every design decision and was guided by a full Life Cycle Assessment (LCA) carried out by Lendlease (see [Resources](#)).

To reduce embodied carbon, recycled Australian hardwoods were utilised in the structure alongside sustainably grown and manufactured CLT from Stora Enso and glued laminated timber (glulam) from Hess

and Wiehag. The facade was optimised with large panel sizes to minimise aluminium framing. The concrete used in the building is Envisia concrete, which achieves a high rate of cement replacement using fly ash and blast furnace slag, resulting in an embodied carbon reduction of 40% when compared to conventional concrete.

To further minimise operational energy use, passive fixed solar shading mitigates peak heat loads to the glass, particularly on the northern and south western ends of the building where the sunshades increase in number from one to three blades (Figure 7). A high-performance double-glazed curtain wall facade achieves a U-value of 2.1 and SHGC of 0.26. In addition, the green roof has been demonstrated as having potential to improve thermal performance to the roof. The internal environment is conditioned using chilled beams which are cooled passively using the nearby harbour water via a precinct-wide heat exchanger in the basement (Figure 8) (see also [Water](#)). Resulting energy use for the building in the operations phase is projected to be approximately 438,702 kWh/year, which is 52% less than the NCC 2016 compliant reference case representing conventional practice in 2017.

Energy loads are further offset through on-site renewable energy generation via a 143 kW rooftop solar PV system.

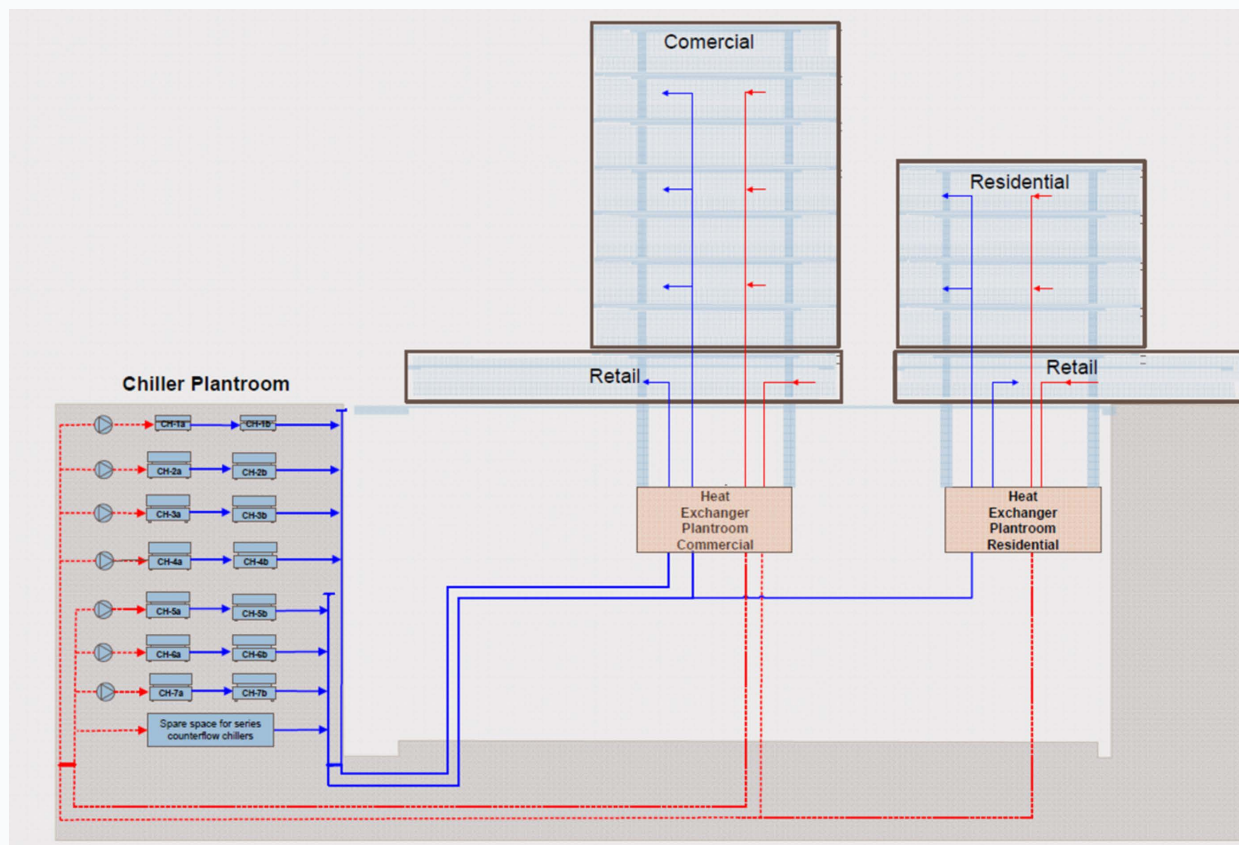


Figure 8. Schematic diagram of Barangaroo district chiller plantroom. Daramu House is conditioned by chilled beams which are cooled passively using the nearby harbour water via a precinct-wide heat exchanger in the basement (Image: Lendlease Corporation).



Figure 9. The integration of PV and green roof moderates the operational temperature of the panels, improving their energy yield throughout the year (Image: Brett Boardman).

A research study (Irga et al 2021) on the integrated green roof demonstrated a 3 to 15% improvement to panel efficiency over the year-long study period. At the time of its design, this was the largest integrated green roof and PV array in the southern hemisphere (Figure 9).

The Barangaroo precinct is carbon neutral in operations, achieved through significant energy efficiency measures applied across the precinct along with carbon offsets.

Well-being

Daramu House is seeking WELL Building Standard version 2 (WELL v2) Core Certification for the base building. 'WELL is an international performance-based system for measuring and certifying building features that impact human health and wellbeing' (Hampton and Clay 2016). The building currently achieves maximum points under the WELL Community category through interventions such as promoting health and wellness education to all occupants, Integrative Design, offering health services and health risk assessments to building management staff, and participation in equity programs. Daramu House has also already implemented strategies in the Mind and Nourishment

categories such as promoting mental health literacy amongst occupants, offering mental health support and training to building management staff, providing healthy food offerings and meal support to building management staff.

In addition to the journey towards a WELL v2 Core Certification, Daramu House was awarded a [WELL Health-Safety Rating](#) in December 2020. Designed for facilities operation and management, this rating focuses on operational policies, maintenance protocols and emergency plans including strategies for air/water quality assessment, cleaning and emergency preparedness practices.

Through incorporation of its green roof, prevalence of softwood and recycled hardwoods throughout, access to views and daylight, Daramu House seeks to create a work environment which supports the wellbeing of its users.

The relatively narrow, 20 m wide, floor plate enables ready access to views and good daylight penetration. Doors to the timber fire stairs were engineered to be glazed to encourage active movement between floors (Figure 10) and reduce dependency on elevators for vertical movement.

Chilled beams not only passively condition the work environment (see [Energy](#) above), they also contribute to thermal comfort through creating convective air movement. This system works alongside a ducted air system which supplies all commercial spaces within the building with fresh air. Air quality sensors monitor

the CO₂ concentration of each floor and enable the fresh air supply system to respond accordingly to moderate air quality. Under a standard commercial occupancy rate of one person per 10 sqm, a 50% improvement on minimum fresh air rates is achieved at 11.25 L/s/person.

The inherent beauty of the structural timber eliminates the need for additional wall and ceiling linings, minimising both material usage and the potential source of volatile organic compounds (VOCs). The choice of mass timber also benefits occupant well-being through biophilic design. The report, 'Wood: Nature Inspired Design' (Planet Ark 2015), gathered information from numerous scientific studies along with their own survey data which demonstrated the positive relationship that the presence of timber in a work environment can have on lowering occupant heart rate, improving mood, general occupant well-being and reduced absentee rates (Figure 11).

A LCA of Daramu House revealed significant improvements across the following environmental indicators: a 40.5% reduction in human toxicity potential largely resulting from the removal of ceilings and other linings and better management of construction waste, a 68.1% reduction in water stress and a 40% reduction in particulate matter, both primarily resulting from the avoidance of hard coal as an energy source during the operational phase (See [Resources](#) for further LCA results).

Generous end of trip facilities which include showers, lockers and bicycle storage, have been provided to support and encourage occupants to adopt an active form of commuting as well as participation in daytime sports.



Figure 10. Glass doors to the timber fire escapes promote healthy movement between floors (Image: Brett Boardman).



Figure 11. View of a typical commercial interior — exposing the services maximises the presence of the timber structure to improve the biophilic benefit to the workplace (Image: Brett Boardman).

Resources

The design for Daramu House prioritises material minimisation. The structural grid of 9 x 9 m is at the limit of what mass timber is currently capable of, minimising structural columns and maximising flexibility to the tenant.

All external structural timbers are fabricated from recycled Australian hardwoods that have been recovered from several sources along the east coast including decommissioned telegraph poles and dilapidated bridges. Recycled Australian hardwoods were also utilised as cladding throughout the building (Figure 12).

As the mass timber is a form of prefabrication, each structural element can readily be repurposed at the end of the building's life, subject to a wear assessment. Noting that most of the wear on these building elements occurs at the junctions, which are all steel and readily replaceable.

Lendlease, who delivered the building, achieved a 97% rate of diversion from landfill of all on site construction waste.

Prefabrication of the structure, facade and other elements significantly minimised on-site wastage. 95% of all timber (by cost) is either reused, FSC certified or PEFC certified timber.

A LCA carried out by Lendlease, using the 'EN 15978:2011 'Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method' and the GaBi LCA software by Sphera, demonstrated a 48.3% reduction in global warming potential (measured in kg CO2 equivalent) over the entire building life cycle when compared to an equivalent test case in concrete. It also demonstrated a 38.2% reduction in acidification potential, a 62.6% reduction in eutrophication potential, 40.8% reduction in Photochemical Ozone Creation Potential and 42.8% reduction in fossil fuel depletion (Refer also [Well-being](#) for environmental indicators from the LCA report).

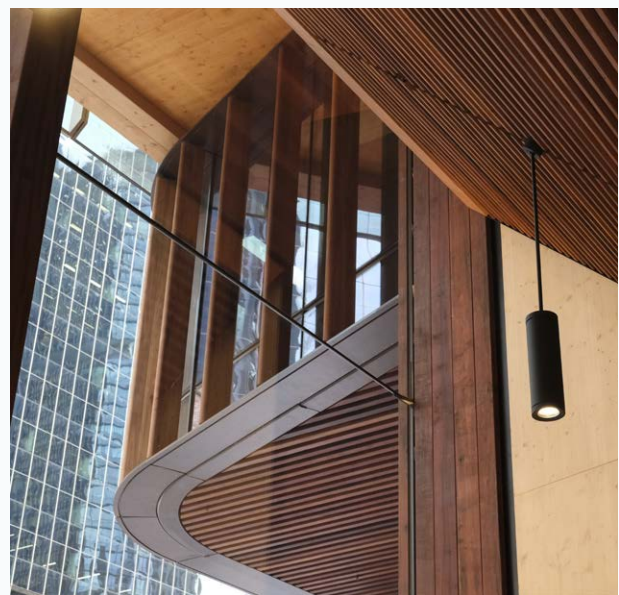


Figure 12. A rich palette of engineered softwoods and recycled Australian hardwoods defines the commercial lobby and lower two storeys (Image: Author).

Change

The roof mounted PV system provides a renewable source of energy in the event of grid failure with provision for off-grid operation and future battery connection. A vegetable oil generator has been provisioned for in the mezzanine as an alternative source of sustainable backup power.

The structural floor is comprised of individual floor modules, three in each 9 x 9 m structural bay, each measuring 3 x 9 m. These can each be readily removed to create stair wells or voids between floors to accommodate future tenant flexibility.

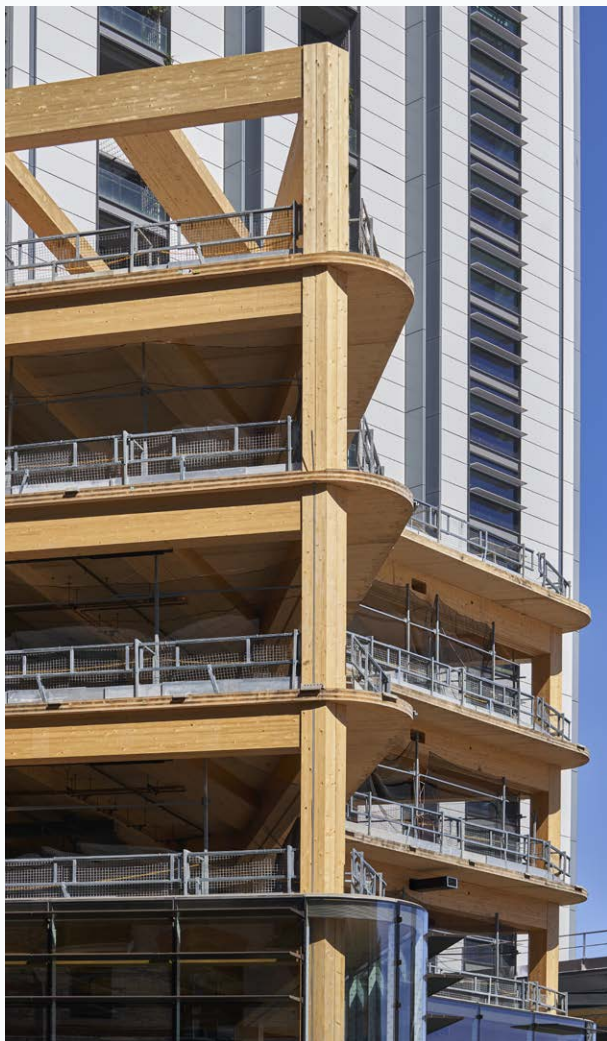


Figure 13. The timber structural elements can be repurposed, subject to wear assessment, at the end of the building's life cycle (Image: Michael Nicholson).

A 100 mm high, modular access floor at each commercial floor (Level 1 to Level 6) creates a void space between the structural floor and the finish floor for reticulation of power and communications infrastructure. The modular units can be lifted with ease, allowing ongoing maintenance and future adjustment where necessary.

The extensive use of timber and incorporation of the green roof work collectively to minimise the local effects of Urban Heat Island effect. The timber naturally retains far less heat than concrete and is therefore a negligible contributor to radiant heat. The green roof insulates the building while also moderating the surface temperature of the roof environment. A recent research study (Irga et al 2021) demonstrated ambient air temperatures near the roof surface as differing by up to 20°C when compared to a conventional roof.

At the end of the building's service life, the timber structural elements can be repurposed into new building uses subject to a wear assessment (see also [Resources](#)) (Figure 13).

Discovery

Daramu House posed a unique and rare opportunity to push the limits of what mass timber could achieve at this scale.

Through a close collaboration with Lendlease and the timber engineers, Lendlease DesignMake, the structural grid was able to be increased from 6 x 9 m to 9 x 9 m, affording greater flexibility in fit-out opportunities. The structural bracing elements required on the western facade were consolidated to form a 5-storey high, 18 m wide truss which enabled the removal of a ground floor column at the entrance lobby to create a grand 2-storey commercial address on Sussex Street (Figure 1). The slabs were engineered to cantilever 1.5 m at the northern and southern ends of the building, enabling expressive architectural form. These elements collectively gave rise to the unique architectural character of Daramu House.

The green roof (see [Economy](#)) and urban landscaping in general – particularly in connection with a photovoltaic system – has a strong role to play in cities by creating a more hospitable environment, resistant to increasing heat, and by contributing natural habitat to improve biodiversity.

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About the Author

Tony Lam

Tony is passionate about sustainability and he believes that as humans, we have a duty to act on anthropogenic climate change in order to preserve the planet for those who will later inherit it. As architects trained to think critically about the world we inhabit, he believes we have enormous capacity and opportunity to influence the 38% of global greenhouse gas emissions which the building industry is responsible for. He strongly acknowledges the inability of incumbent building practices to address the unfolding climate crisis and actively seeks to advocate for a shift towards a more conscious and regenerative form of architectural practice.

As a Senior Associate at Tzannes, Tony leads the Tzannes Regenerative Futures Strategic Group wherein he is guided by his passion for sustainability to improve the internal and external environmental performance of the practice. He is focused on identifying opportunities to minimise the environmental impact of the buildings that he and the practice are involved in.

Tony was the project architect for Daramu House and a lead architect for International House, two mass timber buildings at Barangaroo which seek to demonstrate that the adoption of low carbon alternatives to established building practices can be both commercially viable and beautiful.



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