AUSTRALIAN ZERO CARBON HOUSING CHALLENGE

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Architects progressing the Architecture Industry Decarbonisation Plan 2025-2050

Prepared by
The Australian Zero Carbon Housing Challenge in partnership with the Australian Institute of Architects and Cerclos, Oct 2026.



We acknowledge the First Nations Peoples as the traditional custodians of the lands, waters and skies of the continent now called Australia.

We express our gratitude to their elders and knowledge holders whose wisdom, actions, and knowledge have kept Culture alive.

We recognise First Nations Peoples as the first architects and builders. We appreciate their continuing work on Country from pre-invasion times to contemporary First Nations architects and respect their rights to continue to Care for Country.

Cover: North Wright Sustainable Precinct by Trella Architecture + Interiors of low- to net-zero townhouses. Architecture Award-winner: Multiple Residential, Missing Middle and Sustainability, ACT 2026. Photography: Tim Shaw and Suburban Land Agency.

The **Australian Zero Carbon Housing Challenge** is a flagship Architecture Industry 2025-2050 Decarbonisation Plan initiative. It is an award-winning, evidence-building, volunteer program researching and demonstrating how low- to net-zero carbon homes can be delivered at scale.

The **Australian Institute of Architects** mission is to develop and promote a strong architectural profession. To be the public voice for architecture, advocating for its value in shaping communities and the built environment.

Cerclos is an Australian sustainability tech company focused on helping the built environment transition to net-zero. Its mission is to empower organisations to decarbonise buildings and infrastructure through robust Life Cycle Assessment (LCA) tools and expert services and to enable science-based net-zero outcomes by providing actionable insights across the asset lifecycle.

RESIDENTIAL DECARBONISATION: OUR RESPONSIBILITY, OUR OPPORTUNITY

The National Imperative

Australia's built environment produces one-third of national emissions, and residential buildings are a major driver[1]. Architects are already cutting carbon — yet the sheer volume of new and existing homes means Australia must accelerate decarbonisation now to stay on track for net-zero.

The Australian Institute of Architects' *Architecture Industry Decarbonisation Plan 2025-2050* sets a clear national pathway, calling for stronger regulation, government leadership in green procurement, and investment in the skills and tools needed to deliver low- to net-zero carbon homes at scale[2].

The Architecture Industry's Response

The **Australian Zero Carbon Housing Challenge** is a Decarbonisation Plan flagship initiative. It is an award-winning, evidence-building program showcasing how architects are delivering low- to net-zero carbon homes.

≈85,000 TONNES CARBON SAVED, EQUALS PLANTING
>HALF A MILLION TREES

ACROSS AUSTRALIA, ARCHITECTS DESIGNED
+330 LOW- TO NET-ZERO HOMES

CARBON CHALLENGE CURRICULUM
+600 ATTENDEES

Across three rounds since 2021, the Carbon Challenge has provided architects with curriculum support and ISO-aligned Life Cycle Assessment (LCA) tools to reduce residential carbon emissions relative to the Australian Residential Benchmark. It is generating data-driven insights to support design-led residential decarbonisation.

Design-Led Carbon Savings

Participating architects have collectively saved around 85,000 tonnes of LCA-modelled whole-of-life carbon across more than 330 low- to net-zero homes, compared with the Australian Residential Benchmark. Early design decisions shape most of a home's lifetime carbon impact and architects are reducing carbon through:

— **Upfront carbon cuts:** alterations and additions, retrofits and restorations that reduce materials use.
— **Compact and Missing Middle homes:** halving their carbon footprint while expanding housing choice.
— **Density Done Well:** low-carbon multiple homes supporting gentle density and liveable neighbourhoods.
— **Modern Methods of Construction:** scalable modularity, prefabrication and biogenic materials.

These outcomes show design-led residential decarbonisation can help deliver much-needed carbon reductions.

Scaling Whole-of-Life Net-Zero Homes Nationwide

This publication presents carbon-modelled case studies demonstrating practical pathways to scale residential decarbonisation across Australia. It showcases action already underway and the low- to net-zero carbon outcomes being achieved. However, significant work remains[2,3]. These results reinforce the need for a national residential decarbonisation program, supported by the regulatory settings, tools and resources required to deliver the next generation of low- to net-zero Australian homes. Congratulations to the participating architects, volunteers and partners who made this initiative possible (Authorship and Contributions, page 6).



The multi-award-winning North Wright Sustainable Precinct of low to net-zero carbon townhouses by Trella Architecture + Interiors. Photography: Tim Shaw and Suburban Land Agency.

Authorship and Contributions

About the Australian Zero Carbon Housing Challenge

The Australian Zero Carbon Housing Challenge is a national volunteer initiative under the Decarbonisation Plan, supporting architects to assess and reduce residential emissions through ISO 14040/14044-aligned whole-of-life and upfront carbon modelling using RapidLCA by Cerclos. It provides education, benchmarking and collaboration to accelerate low- to net-zero carbon housing across Australia.

https://www.lowcarbonhousing.com.au/ email: RegistrarAZCHC@gmail.com https://www.instagram.com/low_carbon_housing/?hl=en

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Our Partners: An initiative powered by volunteer architects and researchers with support from our partners:

Cerclos · Australian Institute of Architects · RapidLCA · ACT Government Suburban Land Agency · Ginninderry · Australian Institute of Architects EmAGN



Anne Street Garden Villas by Anna O'Gorman Architect. Winner 2022 National Architecture Award for Residential Architecture – Multiple Housing. Photography: Christopher Frederick Jones.

Contents

Part 1 – Advocacy

Explores the case for residential decarbonisation and the architecture profession's role in achieving it. It outlines the scale of the emissions challenge, progress towards industry targets, and emerging insights from low- to net-zero carbon homes. Drawing on **Australian Zero Carbon Housing Challenge outcomes**, it identifies the opportunities, benefits and pathways for architects to accelerate design-led residential decarbonisation and contribute to the goals of the Architecture Industry Decarbonisation Plan 2025-2050.

Part 2 – Playbook

Highlights how participating architects are future-proofing the profession and unlocking business opportunities by embedding **design-led sustainability and decarbonisation across +330 homes to date**.

It shares design and carbon performance insights from architect-designed low- to net-zero carbon homes. Data analysis — for whole-of-life and upfront carbon reductions relative to the Australian Residential Benchmark — is presented across **alterations and additions, new single homes and multiple home categories.**

Part 3 – Architecture Industry Action

Provides examples of scalable residential carbon reductions through **architect-led case study demonstration**.

3.1 Upfront carbon-saving alterations and additions, retrofits and restoration case studies

— Net-zero retrofits for colder climate temperature extremes
— Townhouse retrofits for low-carbon Adelaide CBD living
— A low-carbon late-nineteenth century 'Queenslander'
— Built by hand in the 1990s, adapted for a low-carbon future

3.2 Compact new single homes and Missing Middle housing choice case studies

— A compact net-zero home for the family lifecycle
— Award-winning Missing Middle homes in the Nation's Capital
— A high-performance home in a restored woodland
— A net-zero micro-lot precinct of compact Missing Middle homes
— Precinct-scale affordable homes with half the carbon

3.3 Density Done Well: case studies in liveable, low-carbon multiple home neighbourhoods

— Reimagining our neighbourhoods for inclusive low-carbon living
— Solutions for Queensland low-carbon public and social housing
— 'Light-footed' Density Done Well solutions with half the carbon
— Retrofitting our neighbourhoods for 'ageing-in-place'

3.4 Modern Methods of Construction case studies for efficient, scalable residential delivery

— A net-zero ready-to-build off-the-plan project home
— Structural laminated bamboo paired with reclaimed materials
— A net-zero compact home with biogenic wall panels
— Modular prefab achieves lowest upfront carbon in multiple homes

Conclusion, and Future Participation and Research

Catalogue and Architecture Awards — Australian Zero Carbon Housing Challenge

Notes and References



The award-winning low-carbon Little Loft House by Light House Architecture and Science. Benjamin King Photography.

Part 1 - Advocacy

Residential Decarbonisation: Our Opportunity, Our Progress

"As Australia responds to growing residential demand, the *Australian Zero Carbon Housing Challenge* demonstrates the collective impact architects can achieve through their design and delivery of more than 330 low- to net-zero carbon homes nationwide.Together, these projects show how design-led residential decarbonisation can be delivered at scale."
Dr Melinda Dodson, Australian Institute of Architects, Past National President.

What this publication provides

This publication presents carbon performance findings from low- to net-zero carbon homes designed by architects across Australia. Together with a national travelling exhibition of exemplar projects, it spans the categories of alterations and additions, new single homes and multiple homes.

The findings explore carbon reduction outcomes and emerging design trends and form part of a residential dataset established in 2021 using transparent research methods, ISO-aligned LCA software and data-quality review processes. Whole-of-life and upfront carbon modelling undertaken by architects uses standardised national parameters.

Emerging national impact

The Carbon Challenge demonstrates architects' critical role in residential decarbonisation. With three-quarters of participating homes already built and occupied, more than 330 homes nationwide have achieved around 85,000 tonnes of LCA-modelled carbon savings against the Australian Residential Benchmark. That equates to over half a million trees planted (right)[3].

This progress demonstrates the considerable emissions reductions already achievable through residential design decisions. With the delivery of one million new homes under the National Housing Accord[4], the opportunity to scale these outcomes is substantial. By way of illustration, achieving similar whole-of-life carbon reductions across the National Housing Accord pipeline would deliver considerable lifecycle carbon savings. The scale of the opportunity is explored further overleaf.

Around 85,000 tonnes of carbon saved

AGGREGATE WHOLE-OF-LIFE CARBON TONNES COMPARED TO AUSTRALIAN RESIDENTIAL BENCHMARK



EQUATES TO +HALF A MILLION TREES PLANTED



OR REMOVING +3 BILLION BALLOONS OF CARBON FROM THE ATMOSPHERE



OR REMOVING +17,000 CARS FROM THE ROAD

Why low- to net-zero carbon residential?



A GROWING POPULATION



OCCUPANT COMFORT



REDUCE CARBON IMPACT



OPERATING AFFORDABILITY

Which residential types and where?







LOW- TO MEDIUM-DENSITY RESIDENTIAL UP TO 3 STOREYS (EXCL. APARTMENTS)





AUSTRALIA-WIDE

What are the carbon targets?

	ROUND 1(2021), ROUND 2 (2023)	ROUND 3 (2025-26)
WHOLE-OF-LIFE	>33% TO **>100%**	>50% TO **>100%**
UPFRONT	NOT MEASURED	>15% MIN, TARGET **>40%**

ARCHITECTS DESIGNED FOR REDUCED WHOLE-OF-LIFE AND UPFRONT CARBON (SEE PART 2 PLAYBOOK).

Deep Cuts to Residential Carbon Are Urgently Needed

"The Australian Institute of Architects has set a clear pathway with its *Decarbonisation Plan*. The *Carbon Challenge* demonstrates that architects are already delivering meaningful design-led emissions reductions in the residential sector. With more than 330 homes participating nationwide, it provides compelling evidence that residential decarbonisation is achievable today, while also reminding us of the distance still to travel. Achieving net-zero will require these outcomes to move from exemplars to the norm across Australia's entire residential pipeline." Ross Donaldson, National President Elect.

Decarbonisation progress and outcomes

Australia's Paris-aligned commitments imply a net-zero economy by 2050. The Decarbonisation Plan seeks all-electric, highly efficient, grid-interactive homes with reduced upfront carbon.

Australia's residential sector must rapidly reduce carbon emissions to align with national net-zero trajectories[5]. The Decarbonisation Plan identifies residential as a priority pathway, while the GBCA *Our Homes Weigh a Tonne* report highlights the significant upfront carbon embedded in 'typical' homes[6]. Federal and State targets reinforce the scale and urgency of the challenge (right).

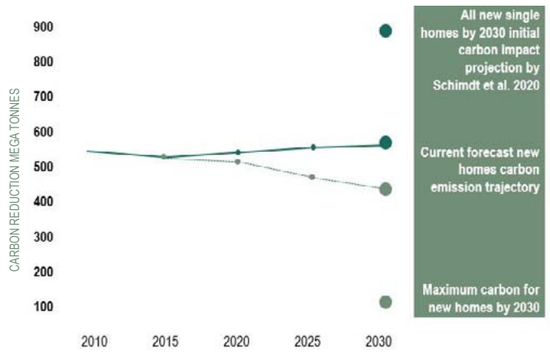
	Baseline	Interim Targets	Net-Zero Target
TAS	1990 (historical)	Already net-zero	Achieved
VIC	2005	75–80% by 2035	2045
ACT	Mixed (sector-specific; historically 1990)	Sectoral targets vary	
NSW	2005	70% by 2035	2050
QLD		75% by 2035	
SA	Historically 1990; now aligned with 2005	50% by 2030	
NT	None specified	None	
WA	2005	None	
AUSTRALIA		43% by 2030	

TABLE BY DODSON, DERIVED FROM THE AUSTRALIAN ENERGY MARKET COMMISSION (AEMC) TARGETS PROGRESS TRACKER (2026) AND THE GREEN BUILDING COUNCIL OF AUSTRALIA (GBCA) CARBON POSITIVE ROADMAP FOR THE BUILT ENVIRONMENT (2018).

Carbon contribution of residential

Residential construction represents a significant share of Australia's building activity, and new detached homes remain the sector furthest off national decarbonisation targets according to Schmidt et al. (2020)[7]. They modelled whole-of-life carbon emissions for all new detached homes and found that projected 2030 emissions would exceed committed targets by a factor of nine (figure, right, bottom)[7].

This gap underscores the need for deep cuts in residential emissions and highlights the importance of early design decisions in shaping whole-of-life carbon outcomes. The next section explores how architectural practice is evolving to reduce emissions and align residential with Australia's decarbonisation commitments.



SCHMIDT ET AL. (2020, P7) COMPARED THEIR PROJECTIONS TO 2030 FOR NEW SINGLE HOMES (DETACHED) CARBON EMISSIONS (MEGA TONNES) WITH CURRENT FORECASTS AND TARGETS. GRAPHICS BY DODSON

The Role of Architects Designing Low- to Net-zero Residential

Leadership role in industry-wide residential decarbonisation

Often serving as lead consultants, architects are uniquely positioned to shape sustainability outcomes[8]. Their influence across clients, consultants and the supply chain makes them critical to delivering low- to net-zero carbon outcomes across the residential categories and to accelerating industry-wide decarbonisation.

Alterations and additions



ALTERATIONS AND ADDITIONS: MERRI CREEK HOUSE BREATHE (PHOTOGRAPHY: TOM ROSS)

New single homes



NEW SINGLE HOME: OCHRE HOUSE, AN OFF-GRID EXAMPLE, BY MYMYMY ARCHITECTURE (PHOTOGRAPHY: ANNE STROUD)

Multiple homes



MULTIPLE HOMES: SIX MARGARET RIVER TOWNHOUSES MDC ARCHITECTS (PHOTOGRAPHY: SHAINA BOSTIN)

Industry upskilling in whole-of-life and upfront carbon analysis

Early design decisions have the greatest influence on whole-of-life and upfront carbon outcomes, often at the lowest cost. However, capability across the construction sector remains uneven, and the adoption of whole-of-life and upfront carbon analysis in residential practice continues to vary[9].

Historically, the complexity and cost of residential carbon modelling limited its application largely to research and specialist consulting[10]. The Carbon Challenge has helped address this barrier by providing architects with access to proprietary LCA tools (RapidLCA), reliable carbon impact datasets and education resources.

The resulting projects demonstrate scalable carbon-saving solutions across three residential categories (above), with designs for compact, landscape-oriented solar passive homes, efficient and renewable energy use, recycled and low-carbon materials, dematerialisation, and other strategies explored in the next section.



Narrabundahaus by Envelope Architecture. Winner of four awards, including the 2023 ACT Architecture Awards for Sustainable Architecture, Residential Architecture – Houses (New), and the COLORBOND® Award for Steel Architecture, as well as the 2021 Carbon Challenge Net-Zero New Single Home Prize. Benjamin King Photography.

Part 2 - Playbook

Carbon Analysis: Method, Data Quality and Benchmarking

Understanding the data: Life Cycle Assessment (LCA) and benchmarking

Architects participating in the Carbon Challenge modelled whole-of-life and upfront carbon impacts for residential projects[11]. LCAs were undertaken using ISO-aligned RapidLCA by Cerclos, powered by the eTool engine, and supported by recognised Australian and international lifecycle inventory databases[12]. Together, eTool and RapidLCA have supported +70,000 LCA strategies and +4,500 LCA peer reviews in Australia and internationally.

LCA is not a sustainability rating or certification system. Instead, it is a decision-support tool that estimates emissions associated with materials, construction, operation, maintenance and end-of-life impacts. Carbon Challenge findings reflect the overall mix of participating homes and the inputs, design decisions and project scopes represented in the LCA modelling (page 81). By testing design options against a consistent method and benchmark, LCA can help inform carbon-saving design decisions.

Broadly, what is the Australian Residential Benchmark?



To provide a national basis for comparison, projects were assessed against the Australian Residential Benchmark (benchmark), reflecting an average or 'business-as-usual' residential mix (above)[13]. Developed using Australian industry average lifecycle data sources such as AusLCI (ecoinvent), the benchmark incorporates residential typologies, floor areas, occupancy, energy use and construction practices. Regional factors — including climate, construction methods and electricity grid emissions — are incorporated into individual assessments to ensure results remain nationally comparable while reflecting local conditions.

Four key messages emerge from the use of LCA in the Carbon Challenge

A national benchmark gives results meaning
It provides a consistent basis for comparison across residential categories. Carbon analysis by architects relative to the benchmark draws on inputs from the National Construction Code, NatHERS, CSIRO, the Australian Bureau of Statistics, the Clean Energy Regulator, GBCA, and AusLCI (ecoinvent).

Context matters
Identical designs can deliver different carbon outcomes in different Australian regions.

Designing for carbon savings is iterative
It involves trade-offs between embodied and operating emissions, with LCA helping identify high-impact design and scope interventions by participating architects.

LCA and the benchmark represent a point in time
The 2026 benchmark reflects national data updates since 2021. For example, as Australia's electricity grid decarbonises and operational emissions continue to fall, the relative importance of 'cradle-to-gate' upfront carbon is increasing. The Carbon Challenge analysis considers both upfront carbon (materials, transport and construction) and whole-of-life emissions (discussed next).

Carbon Analysis: Definitions and Targets

Whole-of-life carbon

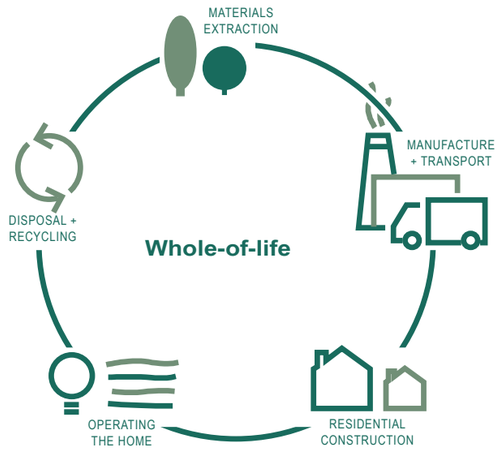
The total carbon emissions over the entire lifecycle (A1-D) of a residence, spanning from **'cradle to grave'.** It includes the upfront (right), operational, maintenance, refurbishment, and end-of-life phases of a home (figure below).

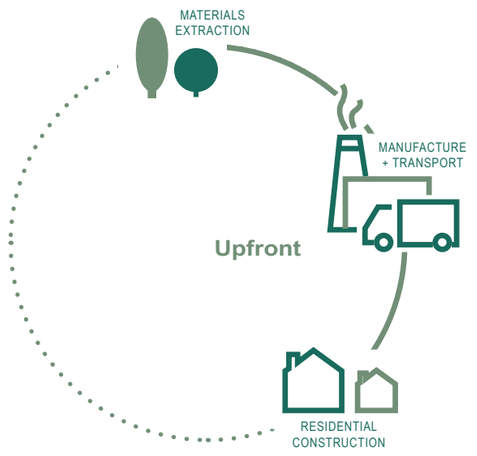
Why it matters
Provides a complete carbon impact picture, crucial to regenerative, circular, and decarbonised design[14,16].

Upfront carbon

Upfront carbon (A1-A5) is locked into the completed home.It is the **'cradle-to-gate'** carbon emissions that are released before a home is used — primarily during its design, material production, transport, and construction phases (figure below).

Why it matters
Can account for half or more of a home's total carbon, especially in high efficiency, low-energy homes[15,16].





Carbon Challenge whole-of-life targets:

% GWP improved on the benchmark home	Alterations and additions	New single homes	Multiple homes
≥ 100% (net-zero)	✓	✓	✓
≥ 50% minimum	✓	✓	✓

Carbon Challenge upfront targets:

% GWP improved on the benchmark home	Alterations and additions	New single homes	Multiple homes
Target ≥40% (15% min)	✓	✓	✓

Broadly, what is a whole-of-life net-zero home in Carbon Challenge?
A net-zero home uses design strategies to minimise materials and operating energy carbon emissions across its lifecycle. Any remaining emissions are effectively balanced through renewables, such as rooftop solar, enabling net-zero whole-of-life carbon performance.

Architecture Industry Action on Residential Carbon Reductions

≈85,000 tonnes of carbon saved by architects

In the Carbon Challenge to date (whole-of-life LCA relative to the Australian Residential Benchmark).

>half a million

trees planted equivalent

Carbon Challenge and RapidLCA access

Upskilling through the Carbon Challenge curriculum and design for carbon savings using robust datasets.

+600

attended Carbon Challenge events

Participating architect-designed homes

Three-quarters of participating homes are already built and occupied, the balance are in progress.

+330

low- to net-zero homes nationwide

Average upfront carbon saved in Round 3

Round 3 homes on average exceeded the Decarbonisation Plan target of +40% upfront carbon.

+40%

improved GWP upfront carbon

Why this progress matters

Early design decisions by architects drive carbon outcomes
The strongest carbon reductions are being achieved through early decisions on home size, form, materials, solar, and electrification. Over half the participating homes were delivered to market as affordable (definition page 81).

Architects are delivering LCA-modelled decarbonisation outcomes
The Carbon Challenge shows considerable carbon savings across the residential transect. Rounds 1-3 whole-of-life category averages are shown below (further results overleaf).



48 ALTERATIONS AND ADDITIONS AVERAGED >90% CARBON SAVED



30 NEW SINGLE HOMES AVERAGED >100% CARBON SAVED

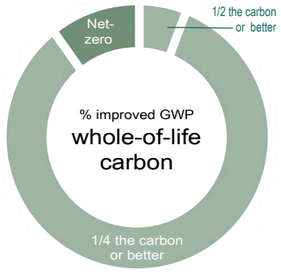


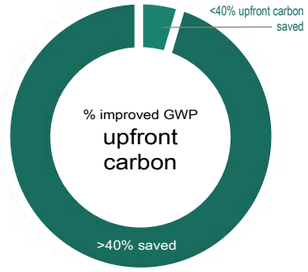
260 MULTIPLE HOMES AVERAGED >60% CARBON SAVED

Multiple home precincts and Modern Methods of Construction deliver scalable carbon savings
Importantly, 260 participating multiple homes more than halved their whole-of-life carbon footprint compared to the benchmark — providing scalable residential solutions essential for meeting national emissions targets.

Carbon Performance Insights by Quantity and Types of Homes

Alterations and additions - overall 48 homes in Rounds 1 - 3 and 30 homes in Round 3

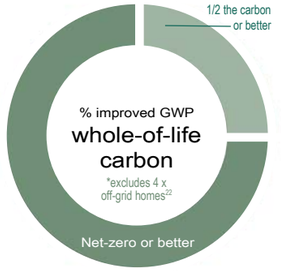


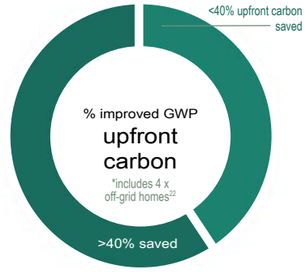


The pie charts (left) compare Round 3 whole-of-life and upfront performance.

Most alterations and additions reduced their whole-of-life carbon to one-quarter of the benchmark or better (far left). They also led all categories on upfront carbon, with most exceeding the Decarbonisation Plan's 40% target through reuse, retention and smaller homes. These projects demonstrate how architects can reduce carbon both upfront and throughout the life of existing homes.

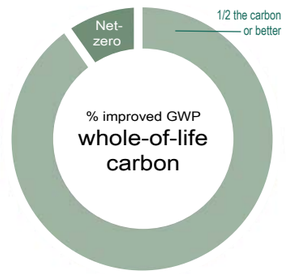
New single homes - overall 30 homes in Rounds 1 - 3 and 12 homes in Round 3

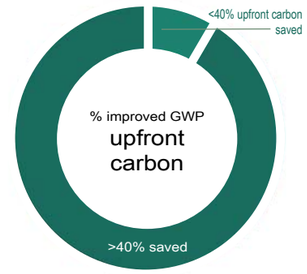




New single homes typically had a higher star rating and rooftop solar capacity than other categories, supporting its higher proportion of net-zero whole-of-life homes (far left). This category however, with its larger homes, had both lower performing bed density efficiency and upfront carbon compared to other categories (left). Bed density is a measure of the compactness of a home relative to its occupancy potential and is discussed further overleaf.

Multiple homes - overall 260 homes in Rounds 1 - 3 and 253 homes in Round 3





The multiple homes category showed strong, consistent carbon performance across a large sample and all data themes. Most homes reduced their whole-of-life carbon by around half or better (far left), and exceeded the 40% upfront carbon target (left). The result is scalable medium-density decarbonisation through efficient materials and operating energy use, Modern Methods of Construction and Density Done Well precinct strategies.

Rationale for Carbon Challenge Data Analysis Themes

% improved GWP whole-of-life and upfront

Global Warming Potential is the carbon dioxide equivalent emissions[17] divided by the expected number of occupants (ABS[18]). For whole-of-life it is annualised over a 55-year reference period. The reported reduction is the percentage difference between the design and the benchmark.

Why it matters
It allows for consistent comparison across residential categories while helping to identify design strategies that deliver the greatest whole-of-life and upfront carbon emissions reductions.

Kilowatts of solar installed at the home

Rooftop solar generation installed on the home.

Why it matters
Reduces reliance on grid-supplied energy and supports net-zero or net-positive outcomes. As Australia's energy grid decarbonises, operational emissions continue to fall[19]. This increases the relative importance of the design, material production, transport, and construction phases of a project, a shift highlighted by the Round 3 inclusion of upfront carbon analysis — a key recommendation in the Decarbonisation Plan.

Bed density (GFA and bedroom quantity)

A home's compactness and occupancy potential, measured as Gross Floor Area (GFA) per bedroom.

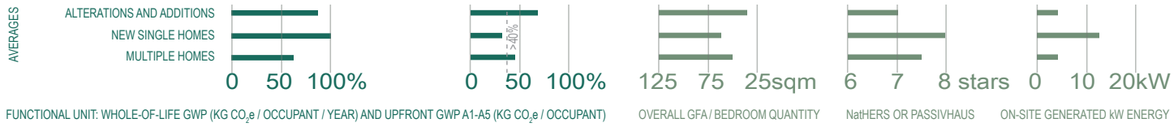
Why it matters
Reflects more compact, material-efficient homes that can reduce upfront and whole-of-life emissions while enabling consistent comparison across projects.

Thermal performance (NatHERS or equal)

The performance of a home's thermal envelope and systems, typically reflected in NatHERS star ratings[20].

Why it matters
Reduces heating and cooling demand, lowering operating energy use and improving comfort, a key driver of whole-of-life carbon reduction.

Graphs: % improved GWP Whole-of-life | Upfront carbon | Bed density | Thermal performance | kW solar



Why these data themes matter

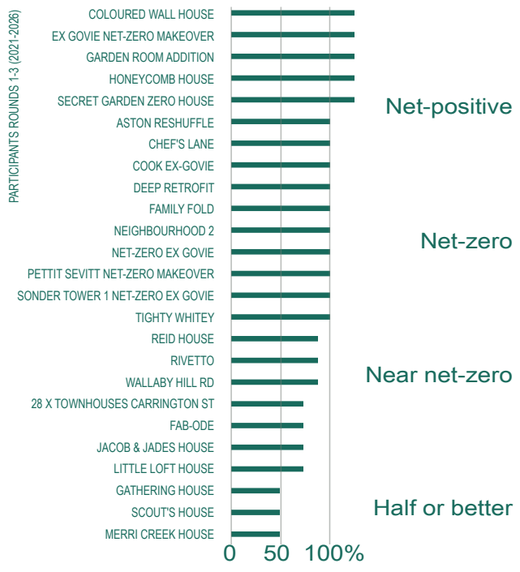
The above data themes combine to offer residential category-level design and carbon performance insights[21]:

- **Alterations and additions**, for example, exhibit the highest upfront carbon (shown above) and the highest bed density efficiency, with the results reinforcing the carbon benefits of compact living and adaptive reuse.
- **New single homes**, with the best whole-of-life carbon, also have the highest solar capacity and star rating.
- **Multiple homes**, including those delivered through affordability programs, demonstrate consistent performance across the data themes, showing that meaningful scalable carbon reductions are achievable.

Design, performance and carbon savings are explored further overleaf for each residential category.

Residential Architecture Category Alterations and Additions

Graph: % improved GWP whole-of-life carbon



"I've learned lots of handy little tips like smart monitoring, how water plays a role in LCA and the context in which materials and services are the 'big hitters' on carbon footprint". CARBON CHALLENGE PARTICIPANT

How have architects reduced carbon?



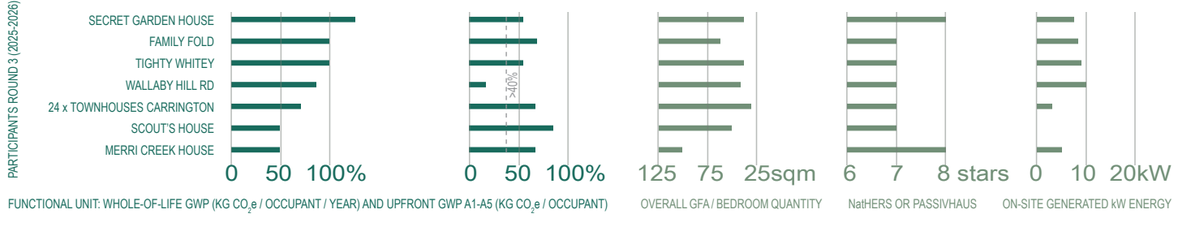
Alterations and additions to existing homes — whole-of-life and upfront carbon

Across 48 alterations and additions (left), whole-of-life carbon performance averaged over 90% improved relative to the benchmark. Round 3 also introduced upfront carbon analysis. Across a sample of 30 homes, participating projects achieved an average upfront carbon reduction exceeding 60% (below).

The graphs below show why. Retaining existing structures, reusing materials, targeted interventions and retrofits, and compact homes all helped reduce upfront carbon. For example, the average bed density for the category (number of bedrooms relative to GFA, below) is around half that of participating new single homes. Together with thermal performance upgrades that improve comfort and reduce energy demand, these strategies delivered upfront and whole-of-life carbon savings.

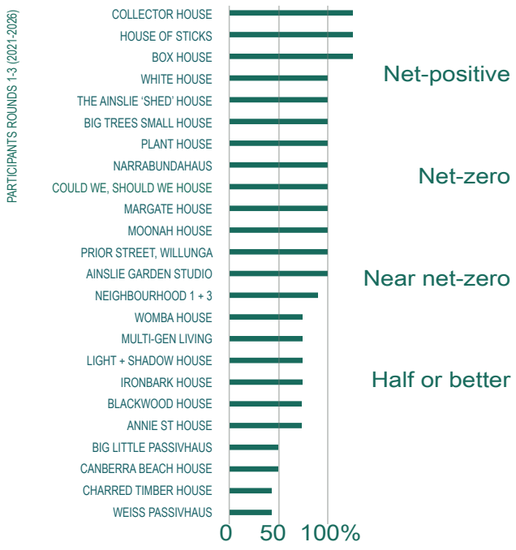
Alterations and additions in the Carbon Challenge reinforce that leveraging what already exists offers a highly effective pathway to reduce carbon — directly aligned with the Decarbonisation Plan's priority to reduce material-related emissions.

Graphs: % improved GWP Whole-of-life | Upfront carbon | Bed density | Thermal performance | kW solar



Residential Architecture Category
New Single Homes

Graph: % improved GWP whole-of-life carbon



How have architects reduced new single homes' whole-of-life and upfront carbon?

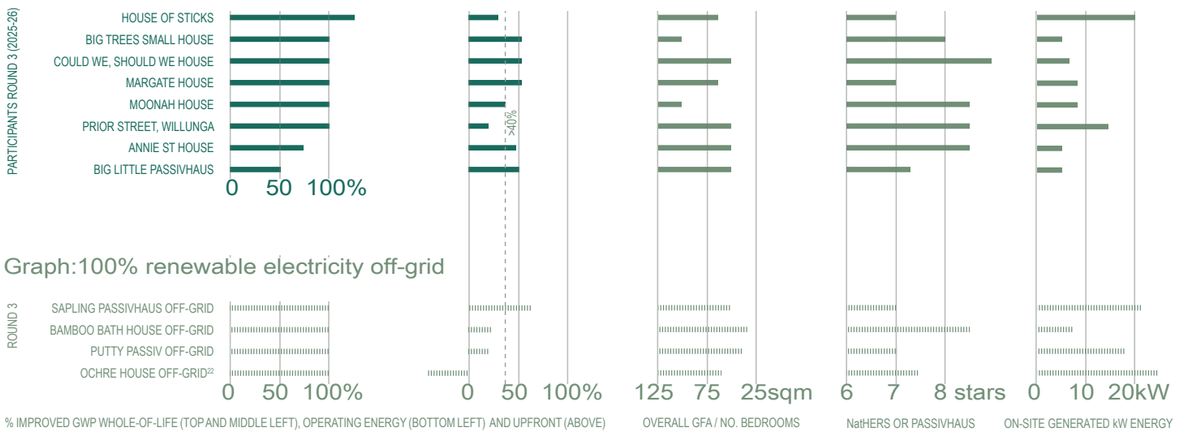
On average, 30 new single homes achieved a net-zero whole-of-life carbon performance against the benchmark (left). In Round 3, where upfront carbon analysis was also undertaken, homes achieved an average ≈37% reduction (below).



The graphs below show how architects reduced upfront and whole-of-life carbon. Most participating new single homes are smaller than the benchmark home, although larger than the other residential categories. They also have the highest average thermal performance and rooftop solar capacity.

Off-grid homes are shown separately (bottom, with a definition at page 81) to distinguish their 100% renewable electricity off-grid performance. Across these projects, higher upfront carbon performance is associated with predominant timber and biogenic material use, while lower performance reflects greater off-grid infrastructure and concrete use.

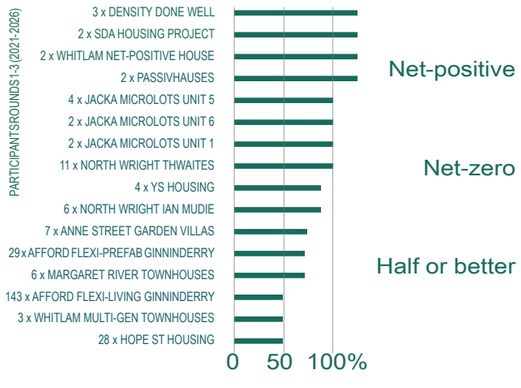
Graphs: % improved GWP Whole-of-life | Upfront carbon | Bed density | Thermal performance | kW solar



% IMPROVED GWP WHOLE-OF-LIFE (TOP AND MIDDLE LEFT), OPERATING ENERGY (BOTTOM LEFT) AND UPFRONT (ABOVE) | OVERALL GFA / NO. BEDROOMS | NatHERS OR PASSIVHAUS | ON-SITE GENERATED kW ENERGY

Residential Architecture Category
Multiple Homes

Graph: % improved GWP whole-of-life carbon



How have architects reduced carbon?

The multiple home category shows how smaller, more affordable and more material-efficient typologies can deliver strong carbon reductions at scale (left). The graphs below highlight the impact of Density Done Well, Missing Middle and prefabrication strategies, all of which reduced material demand, improved bed density and supported efficient building envelopes.

When combined with thermal performance, energy efficiency and renewables, these medium-density typologies achieved considerable whole-of-life and upfront carbon reductions (below), demonstrating the important role of scalable, affordable homes in achieving the aims of the Decarbonisation Plan.



+170 affordable homes averaged half the whole-of-life and upfront carbon.

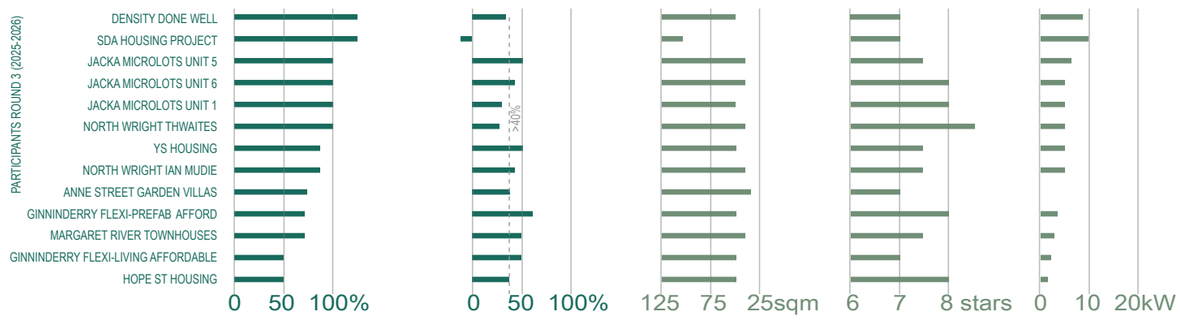


Missing Middle and **Density Done Well** homes averaged >40% upfront carbon



Multiple homes halved their whole-of-life carbon or better

Graphs: % improved GWP Whole-of-life | Upfront carbon | Bed density | Thermal performance | kW solar



FUNCTIONAL UNIT: WHOLE-OF-LIFE GWP (KG CO_2e / OCCUPANT / YEAR) AND UPFRONT GWP A1-A5 (KG CO_2e / OCCUPANT) | OVERALL GFA / NO. BEDROOMS | NatHERS OR PASSIVHAUS | ON-SITE GENERATED kW ENERGY

These graphs provide a residential category-level overview of carbon performance relative to the benchmark. The case studies that follow offer project-level insight into the design decisions shaping these outcomes.



Big Little Passivhaus by BKK Architects retrofits our neighbourhoods with ‘age-in-place’ homes, to support the occupants while reducing environmental impact. Refer Part 3.3 Image BKK.

Part 3 - Architecture Industry Action



Bamboo Bath House, NSW, by Cave Urban combines structural laminated bamboo paired with reclaimed materials and timber. Refer Part 3.4. Photography: Marnie Hawson.

3.1 Upfront Carbon-Saving Alterations and Additions, Retrofits and Restoration Case Studies

Net-zero Retrofits for Colder Climate Temperature Extremes



Secret Garden House, ACT, CCJ Architects

Canberra's monocrete homes of the 1960s were built with thin concrete wall panels and minimal insulation.

In a colder climate where outdoor winter temperatures regularly fall below zero, the large temperature difference between warm indoor air and cold external concrete surfaces creates condensation or moisture forming on the inside of the wall face.

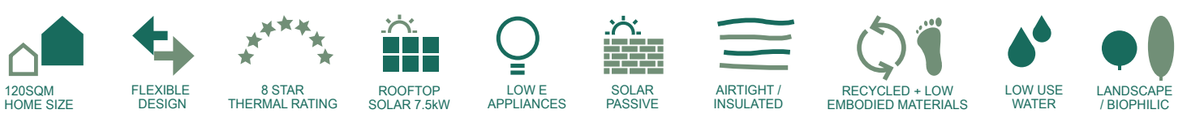
For the Secret Garden House — a refurbished 120 square metre, three-bedroom home for an academic couple — a key design challenge was to make this colder climate home more liveable and resolve underlying condensation issues. Adding an insulating outer layer to the monocrete improved thermal comfort and stabilised internal temperatures.

Another aim was to improve storage, upgrade all internal rooms and connect the internal spaces to the external environment through discrete views via a large screen to the street side of the home. The screen is an interpretation of one of the owner's paintings and provides privacy and shading to the western side of the home. Eventually it will form part of the garden as a vertical screen of plants.

The upgrades sit within a broader suite of architect-led improvements which include:

– seven kilowatts of rooftop solar
– recycled materials
– insulation and air-tightness upgrades
– in-floor displacement heating and cooling
– efficient water and energy systems.

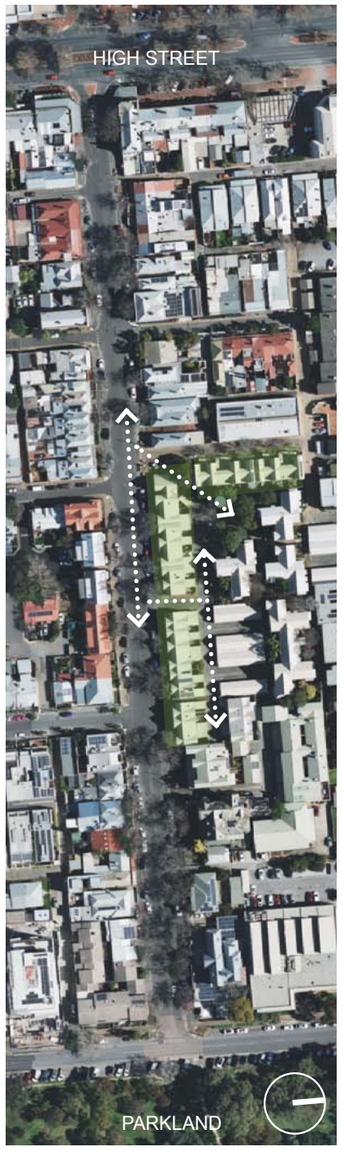
Through reuse, high-performing building envelope upgrades, energy efficiency and solar, Secret Garden House achieves a whole-of-life net-positive footprint while more than halving its upfront carbon.





The Secret Garden Zero House won the 2022 ACT Architecture Awards: Gene Willsford Residential (Alterations and Additions) and Pamille Berg Award Art in Architecture.

Townhouse Retrofits for Low-carbon Adelaide CBD Living





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‘Recipe’ and Rebates for Carrington Townhouse Retrofit

1. An existing 100sqm home on a 100sqm block close to amenities.
2. Architect-designed townhouse and landscape retrofit.
3. Add rooftop solar, battery and energy monitoring.
4. Upgrade building envelope (double glaze, insulate and gap seal).
5. Upgrade to efficient and all-electric major appliances.
6. Maximise reuse of existing materials, structure and wet areas.
7. Design to prioritise private and flexible indoor-outdoor space use.

Sustainability Incentives Scheme, City of Adelaide Carrington Townhouses, South Australia MDa Architecture and Research

Adelaide has a long history of low-carbon urban living. From the 1970s, the City of Adelaide actively incentivised a return to inner-city living. Compact homes on compact separately titled blocks in walkable neighbourhoods resulted — a legacy visible today across its CBD townhouse precincts.

The City of Adelaide *Sustainability Incentives Scheme* continues this legacy by offering rebate bundles for design-stage decisions and delivered whole-home upgrades to improve thermal-performance and reduce energy and materials use — helping residents reduce carbon and increase their property value.

For example, a full incentives bundle applied to this 1980s Carrington Street townhouse (right) reduces its whole-of-life carbon footprint to about one-quarter of the benchmark.

The Carbon Challenge is revealing case studies that are replicable and nationally relevant. This example shows how historic urban logic and contemporary sustainability incentives combine to form a coherent decarbonisation model for:

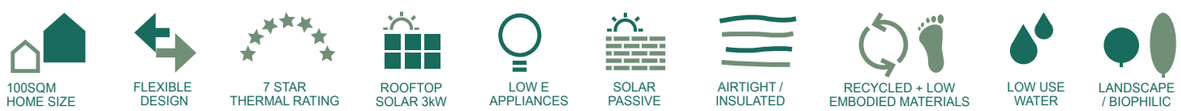
– existing compact homes reducing upfront carbon
– low transport impact walkable neighbourhoods
– architect-led energy efficiency and liveability upgrades
– targeted rebates to accelerate adoption and scale.



Photography courtesy MDa



A 1980s Carrington Street townhouse shows what happens when good urbanism meets good retrofit: whole-of-life carbon reduced to one-quarter of the benchmark, with retained structure and fabric underpinning a more than 70% improved upfront carbon footprint.



A Low-carbon Late-nineteenth Century ‘Queenslander’

Alterations and additions to a 140 year old cottage by Maytree Studio, Queensland

The project achieves low-carbon outcomes through re-use of the 140 year old cottage, a compact footprint, and passive design that minimises operational energy.

Liveability is enhanced through generous natural light, natural ventilation and spatial layering, enabling flexible and comfortable living within a small envelope.







Photography: Toby Scott.



Climate-responsive building openings and shaded thresholds are tuned to the Brisbane climate, reducing mechanical reliance.

Circularity is embedded through material restraint and by prioritising durable, low-toxicity finishes that can be maintained, repaired and allowed to evolve over time, with cost and carbon savings realised by retaining the existing structure and building less.

The retrofit of a 140 year old cottage and its compact addition have halved upfront carbon. Combined with passive design strategies, energy efficiency and rooftop solar, the project achieves a whole-of-life footprint of less than one-quarter of the benchmark.

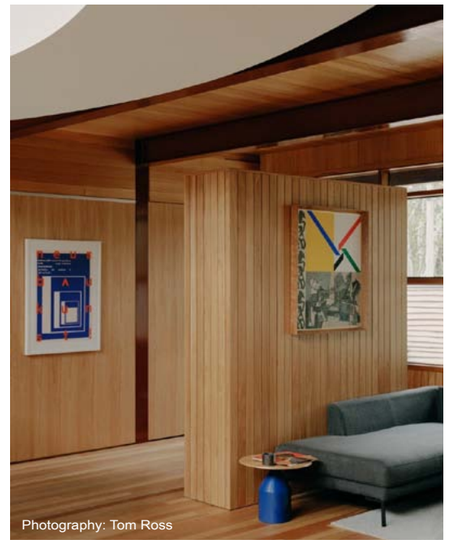
Built by Hand in the 1990s, Adapted for a Low-Carbon Future

Merri Creek House, Victoria, Breathe Architecture

Tucked into the bushland edge of Merri Creek in Northcote, this home was originally designed in 1990 by Goad Fink and later extended by Fink & McMahon. The home was handcrafted by its original owner, Ian Ezard, who pioneered a tongue-and-groove timber floor from a nearby warehouse workshop. The steel frame? He built it himself, using a forklift.

Fast forward to today, and the architect’s role was to gently retrofit this much-loved home—no new floor area, just a more comfortable, efficient, and artful version of itself. Working closely with a family of four who share a deep appreciation for modernist architecture, the design response was an exercise in restraint. Repurposing and retaining as much of the existing building fabric as possible, working within the existing envelope, and stitching in improved performance.

The retention-first approach achieved a +70% reduction in upfront carbon relative to the benchmark while also halving the whole-of-life carbon impacts, showing the value of adapting existing homes rather than rebuilding them. Building less, giving more.



Photography: Tom Ross

How was the whole-of-life carbon impact halved and upfront carbon +70% improved?

1. Retain the existing footprint and structure
2. Refurbish and reuse existing materials
3. Upgrade insulation, airtightness and glazing
4. Electrify heating, cooling, hot water and cooking
5. Generate renewable energy on-site
6. Design for longevity, flexibility and adaptability









Lathlain, WA by Silva & Mustard Architects halved its carbon footprint compared with the benchmark (Photography: Nicholas Putrasia, Taje Singh).

3.2 Compact New Homes and Missing Middle Housing Choice Case Studies

A compact net-zero home for the family lifecycle

‘Could We, Should We House’, Stanhope Gardens Cooee Architecture and Powerhaus Engineering, NSW

“Could We? Should We? Only when the evidence says so,” explains Sarah Lebner, of the Cooee Architecture and Powerhaus Engineering’s award-winning vision for a family home of the future—achievable today!

Rather than chasing complexity, the team set out to test how far evidence-led design could reduce both upfront carbon and whole-of-life emissions while delivering comfort, resilience and flexibility using standard construction methods.

The result is a compact, two-storey home that halves its upfront carbon compared to the benchmark and effectively eliminates whole-of-life carbon impacts through a combination of low-carbon materials, ≈9-star NatHERS thermal performance, electrification and ≈7kW of rooftop solar.



Images: Cooee Architecture





Could we? The evidence said we should:

1. Keep the home footprint compact and flexible over time
2. Design for solar passive performance and climate resilience
3. Build tight (≈3ACH), ventilate right and insulate well
4. Design for ‘no build’ adaptability across the family life stages
5. Electrify heating, cooling and hot water
6. Add on-site rooftop solar generation, but not too much
7. Select attainable recycled-content and biogenic materials
8. Favour low-carbon concrete and less of it
9. Deliver performance using standard construction techniques



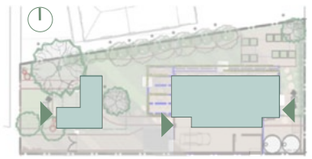
01 Flexible family home

3 BEDROOMS PLUS 2 LIVING AREAS, OR UP TO 5 BEDROOMS



02 Multi-generational

BED-SIT FOR EXTENDED FAMILY, INDEPENDENT LIVING OR RENTAL INCOME



03 Future masterplanning

SITE PLANNING FOR A FUTURE 3RD HOME FOR LONG-TERM ADAPTABILITY

163SQM HOME + CARPORT

FLEXIBLE DESIGN

9 STAR THERMAL RATING

ROOFTOP SOLAR >7kW

LOW E APPLIANCES

SOLAR PASSIVE

AIRTIGHT / INSULATED

RECYCLED + LOW EMBODIED MATERIALS

LOW USE WATER

LANDSCAPE / BIOPHILIC

Award-winning Missing Middle Homes in the Nation’s Capital

North Wright Sustainable Precinct, ACT, by the ACT Government I Suburban Land Agency Trella Architecture & Interiors

The Carbon Challenge highlights residential projects materially advancing the Decarbonisation Plan. Trella Architecture & Interiors demonstrate design-led carbon reduction in practice with their design for a Missing Middle precinct of 23 ‘Room to Grow’ homes responding to the needs of a diversifying demographic.

The whole-of-life carbon footprint of each home ranges from one-quarter of the benchmark to net-zero performance, demonstrating that meaningful decarbonisation is achievable without compromising amenity, durability or cost.

Liveability
Generous raking ceilings lift internal volumes, northern high-level windows draw natural light deep into homes, and direct access to landscape courtyards provides connection to nature.

Climate-wise
The homes utilise double airtight wraps with heat recovery ventilation (HRV), an ‘eco-concrete’ slab with recycled-plastic void formers to lower upfront carbon, and landscaped native, water-wise gardens.

Circularity
Recycled materials have been prioritised throughout, including recycled brick, stepping stones and seating, alongside metal cladding designed for easy disassembly, repair and future upcycling.

Cost savings
The homes are compact, and utilise replicable construction methods, which combine to offer upfront build and purchase price savings. Solar passive design, low energy use appliances and rooftop solar help reduce ongoing operating costs.



Photography: Tim Shaw and Suburban Land Agency.



This multi-award-winning Missing Middle precinct of 23 homes range between a whole-of-life carbon footprint of less than one-quarter of the benchmark through to net-zero carbon performance.

113SQM HOME SIZE

FLEXIBLE DESIGN

8 STAR AVERAGE THERMAL RATING

ROOFTOP SOLAR >5kW

LOW E APPLIANCES

SOLAR PASSIVE

AIRTIGHT / INSULATED

RECYCLED + LOW EMBODIED MATERIALS

LOW USE WATER

LANDSCAPE / BIOPHILIC

A High-performance Home in a Restored Woodland



Photography: Paul Baker, Sarah Drofenik and Anita Beaney

Net-zero Moonah House, Victoria
Baker Drofenik Architects

Moonah House, Connewarre, is the three-bedroom home and coastal studio of Baker Drofenik Architects, conceived as an ongoing project of research, experimentation and learning within a regenerating indigenous woodland landscape.

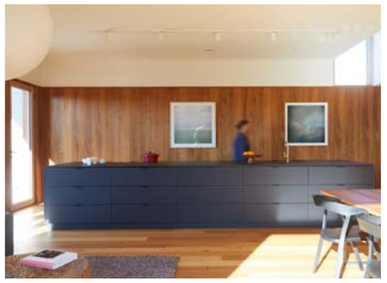
Delivered within a disciplined budget, the project achieves a net-zero whole-of-life carbon footprint relative to the benchmark and exceeds the Decarbonisation Plan's 40% upfront carbon reduction target. Its highly insulated, airtight envelope delivers an energy rating of more than eight stars.

Low-waste construction and low-carbon materials are expressed through a remilled timber flooring, an 'eco-concrete' studio slab, lightweight footings, and an open carport.

Built-in joinery was minimised to reduce material use and support long-term adaptability. The kitchen, conceived as a simple island of low-carbon materials, can be readily relocated, reconfigured or repurposed over time.

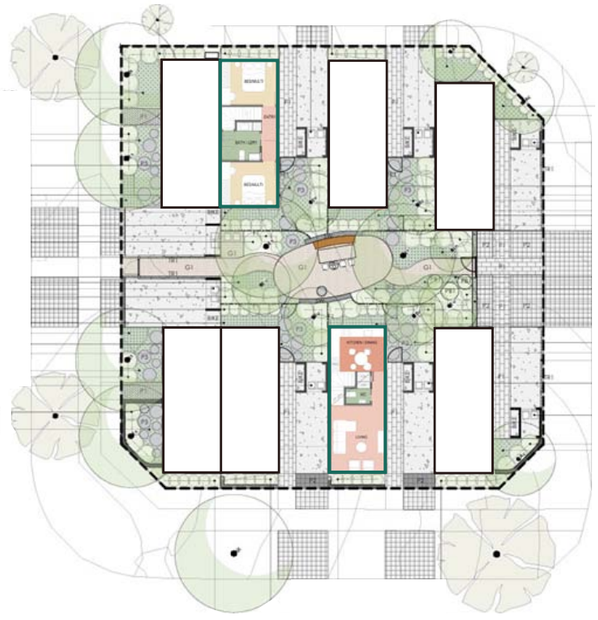
Moonah House saved +40% in upfront carbon.

334SQM HOME + OFFICE
FLEXIBLE DESIGN
>8 STAR THERMAL RATING
ROOFTOP SOLAR 8.3kW
LOW E APPLIANCES
SOLAR PASSIVE
AIRTIGHT / INSULATED
RECYCLED + LOW EMBODIED MATERIALS
LOW USE WATER
LANDSCAPE / BIOPHILIC




A Net-zero Micro-lot Precinct of Compact Missing Middle Homes





Images courtesy DNA Architects.



The Jacka micro-lot homes achieve net-zero whole-of-life and reduce upfront carbon by an average of 40% through their small footprints.

Jacka Small Footprint Housing, ACT Government, Suburban Land Agency, DNA Architects

The Jacka Small Footprint Housing showcases a new model for low-carbon, high-quality urban living. Eight separately titled, smaller footprint homes are built on compact 90sqm blocks and are designed to bridge the Missing Middle gap in the market between single detached homes and high-density apartments.

They reduce upfront carbon through their reduced size and use of low-carbon and recycled materials, combined with lower operational energy demand, and renewable energy use. They demonstrate that compact, more affordable, carbon-conscious homes can set a replicable standard for Australia's growing communities.

110SQM HOME SIZE
FLEXIBLE DESIGN
7.5 - 8 STAR THERMAL RATING
ROOFTOP SOLAR 6kW
LOW E APPLIANCES
SOLAR PASSIVE
AIRTIGHT / INSULATED
RECYCLED + LOW EMBODIED MATERIALS
LOW USE WATER
LANDSCAPE / BIOPHILIC

Precinct-scale Affordable Homes with Half the Carbon

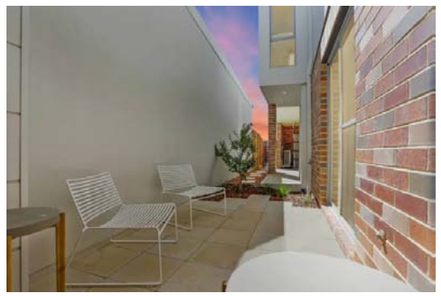
Ginninderry Flexi-living Affordable Townhouse Series, Ginninderry Joint Venture (PPP) Tait Network, MDa Architecture and Research, Oztal, DesignIS and AMC Architecture

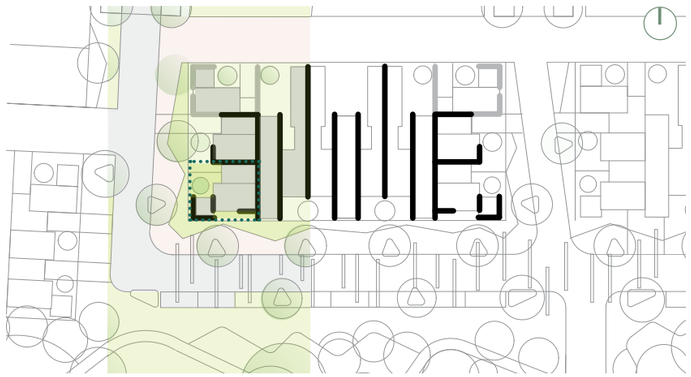
Ginninderry is a Public Private Partnership (PPP) between the Suburban Land Agency (ACT Government) and Riverview Developments (ACT) Pty Ltd. Across the Flexi-living series, LCA analysis shows the homes halved their whole-of-life and upfront carbon compared to the benchmark. When aggregated across near-150 homes, the series has saved more than ≈28,000 tonnes of carbon overall — equal to planting over 170,000 trees[23].

This matters because it demonstrates that attainable, compact homes designed by architects can help deliver the large-scale carbon savings needed nationally. Addressing the Missing Middle, the separately titled Flexi-living homes provide an alternative to both detached homes and apartments. The model expands attainable housing choice while reducing land, infrastructure and carbon intensity per household. It offers a scalable blueprint for more affordable, low-carbon suburban living[24].

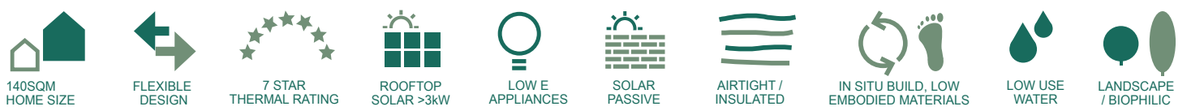


Flexi-living by Tait Network. Photography courtesy Ginninderry.





Ginninderry's Flexi-living affordable series of nearly 150 homes achieved considerable whole-of-life and upfront carbon reductions while creating an attainable pathway to home ownership for first-home buyers. Overall, the series achieved carbon savings equivalent to more than 170,000 trees planted.





The low-carbon Ginninderry Affordable Flexi-living Townhouse Series Stage 1, by MDa Architecture and Research. Photography courtesy Ginninderry.

3.3 Density Done Well: Case Studies in Liveable, Low-Carbon Multiple Home Neighbourhoods



A model for inclusive neighbourhood renewal, Studio Bright's award-winning homes unite dignified, enabling living environments with net-positive whole-of-life carbon performance.

SDA Housing, Victoria, by Studio Bright

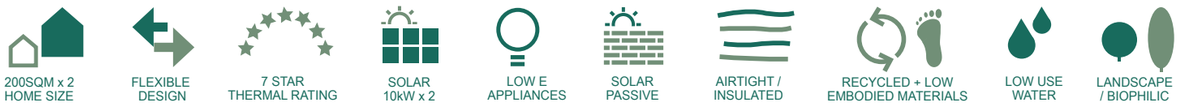
Studio Bright demonstrates significant carbon reductions through its award-winning Specialist Disability Accommodation (SDA) project, designed for residents with sensory needs and their carers.

Developed as a pilot for the Victorian Department of Families, Fairness and Housing and Disability Homes Victoria, the project combines high-performance glazing and shading, airtightness, HRV, rooftop solar and durable materials to achieve a net-positive whole-of-life carbon performance relative to the benchmark.

The project demonstrates how net-positive design can support both emissions reduction and social outcomes, delivering comfortable, resilient and dignified homes that enhance independence, wellbeing and quality of life.



Photography by Gavin Green.



Solutions for Queensland Low-Carbon Public and Social Housing

Anne Street Garden Villas, Queensland Government Department of Housing and Public Works, Anna O'Gorman Architecture

Delivered under the Queensland Government's Density and Diversity Done Well program, Anne Street Garden Villas is a people-centred demonstration precinct of compact, high-amenity, 'light-footed' homes arranged around a deep-soil communal garden.

Open space is concentrated into a central shared landscape with large shade trees, while pedestrian-oriented planning keeps cars to the site perimeter.

One- and two-storey compact villas use lightweight, replicable construction, halving their upfront carbon compared to the benchmark. This matters because a tonne of carbon avoided today is generally more valuable to the climate than a tonne avoided decades into the future.

Climate-responsive design prioritises cross-ventilation, daylight and screened openings to reduce cooling demand, while communal 'garden rooms' and neighbourly sightlines reinforce comfort and connection. Water systems are integrated into the landscape: a 25,000-litre rainwater tank, bio-retention basin and dry creek line slow, filter and reuse stormwater, reducing mains-water demand and managing runoff on site.

Together, these strategies offer a replicable, landscape-centred social housing model where low-carbon construction, shared green space and solar passive design deliver environmental performance, liveability and community connection.



National Award-winning homes with one-quarter the whole-of-life carbon of the benchmark

70SQM HOME SIZE
FLEXIBLE DESIGN
>7.5 STAR THERMAL RATING
ROOFTOP SOLAR (NIL)
LOW E APPLIANCES
SOLAR PASSIVE
AIRTIGHT / INSULATED
RECYCLED + LOW EMBODIED MATERIALS
LOW USE WATER
LANDSCAPE / BIOPHILIC





Photography by Christopher Frederick Jones.



‘Light-footed’ Density Done Well Solutions with Half the Carbon

Hope Street Housing, Western Australia
Officer Woods and MDC Architects

Hope Street explores Density Done Well through 28 diverse compact terrace/walk-up apartments organised around shared and private landscape.

Two rows of well-lit, well-ventilated north-facing homes have generous setbacks enabling deep soil and high permeability gardens.

Judicious thermal mass ensures stable internal temperatures. All terraces are naturally ventilated and have ample natural light. Homes range from eight to nine stars thermal performance. Each home is all-electric and has two kilowatts of rooftop solar, a hot water heat pump system and LED lighting.

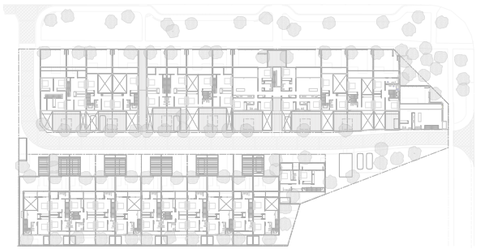
Instances of higher upfront carbon materials are ‘hard-working’, improving the thermal efficiency of homes and left exposed where possible to limit applied finishes and reduce ongoing maintenance.



Photography: Acorn / Robert Frith.

The award-winning Hope Street delivers excellent neighbourhood outcomes with landscape-oriented medium-density and half the whole-of-life carbon.





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Multi-award-winner 2024: Urban Design Award and Commendations for Multiple Housing and Sustainable Architecture, WA, and National Commendation Urban Design in the Walter Burley Griffin Award category.





Retrofitting Our Neighbourhoods for ‘Ageing-in-place’

Big Little Passivhaus, Victoria, BKK Architects

This home demonstrates how ‘ageing-in-place’ principles can be integrated with Passivhaus standards to create a residence that supports occupants throughout life stages while minimising environmental impact.

The design features a secure entry sequence, transitioning through spaces that ‘compress and release’, culminating in a light-filled living area with generous raking ceilings.

The home prioritises comfort through careful consideration of spatial volumes, orientation, natural light, and acoustics.

Predominantly timber interiors bring low-carbon benefit and create warmth, while strategic connections to the low-maintenance garden support mental wellbeing.

Thoughtful details like built-in grab rails and arthritis-friendly cabinetry demonstrate how accessibility can be integrated seamlessly rather than retrofitted.





Photography: BKK.



Big Little Passivhaus is a carefully considered secondary dwelling ‘inserted’ alongside an existing suburban home. As a model for gentle density and ‘age-in-place’ neighbourhood renewal, it demonstrates how additional residential can be sensitively integrated into established suburbs while delivering around half the upfront and whole-of-life carbon of the Australian Residential Benchmark.

148SQM HOME SIZE · FLEXIBLE DESIGN · PASSIVHAUS + >7 STAR NatHERS · ROOFTOP SOLAR 5kW · LOW E APPLIANCES · SOLAR PASSIVE · AIRTIGHT / INSULATED · RECYCLED + LOW EMBODIED MATERIALS · LOW USE WATER · LANDSCAPE / BIOPHILIC



Off-grid low-carbon compact new home: Ochre House by MYMYMY Architecture (Photography: Anne Stroud).

3.4 Modern Methods of Construction Case Studies for Efficient, Scalable Residential Delivery

A Net-zero Ready-to-build Off-the-plan Project Home

Net-zero Pocket House 4, SA by Goodhouse

The Pocket House series of compact, high-performance residential are designed to make energy efficient, resilient homes more accessible to a wider market.

Pocket House 04 is a three-bedroom Project Home in Willunga, SA, organised around an established tree. It has a strong garden connection and good solar access despite a narrow site with limited northern aspect.

A compact footprint limits material use and ongoing energy demand, while durable materials and integrated landscape elements strengthen long-term resilience.

Heating and cooling demand is reduced by its solar passive design, high-performance building envelope, considered glazing and shading, and natural ventilation. The all-electric specification supports lower operating energy use.

Pocket House is a repeatable system, translating Goodhouse's custom-home expertise into a refined set of pre-designed, flexible homes. It demonstrates how thoughtful, systemised design can deliver more affordable, net-zero carbon homes suitable for replication across Australia.



Photography courtesy Goodhouse

147SQM HOME SIZE

FLEXIBLE DESIGN

8.5 STAR THERMAL RATING

ROOFTOP SOLAR >15kW

LOW E APPLIANCES

SOLAR PASSIVE

AIRTIGHT / INSULATED

RECYCLED + LOW EMBODIED MATERIALS

LOW USE WATER

LANDSCAPE / BIOPHILIC

Structural Laminated Bamboo Paired with Reclaimed Materials

Bamboo Bath House, NSW, Cave Urban

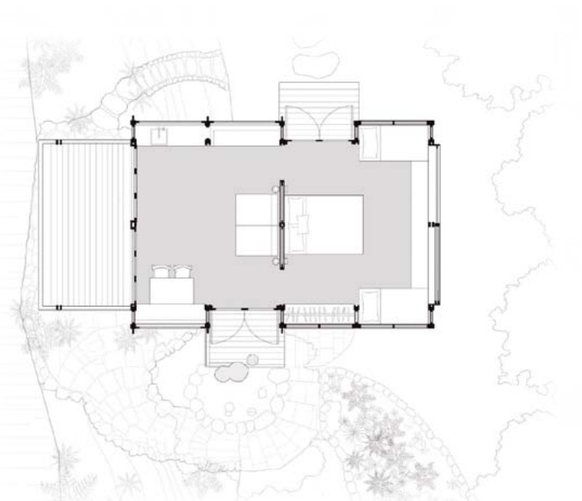
Bamboo Bath House is a compact 36sqm off-grid retreat nestled in the Blue Mountains which combines bamboo, locally sourced hardwood, and reclaimed materials.

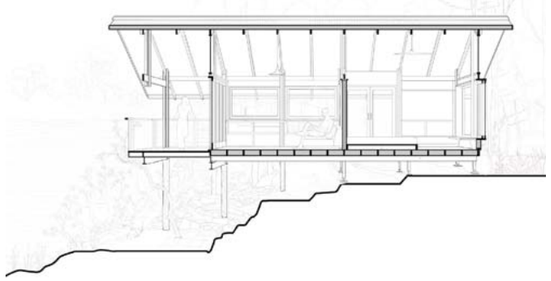
The project pilots the use of structural laminated bamboo in Australia, exploring how engineered biogenic materials could support future low-carbon construction systems.

Its siting and orientation maximize solar gain and natural ventilation, enabling self-sufficiency through on-site solar energy, battery storage and rainwater harvesting.

Open to the surrounding landscape, this compact architecture offers an immersive experience where nature, innovation, and simplicity come together.







36SQM HOME SIZE

FLEXIBLE DESIGN

8.5 STAR THERMAL RATING

ROOFTOP SOLAR 6.6kW

LOW E APPLIANCES

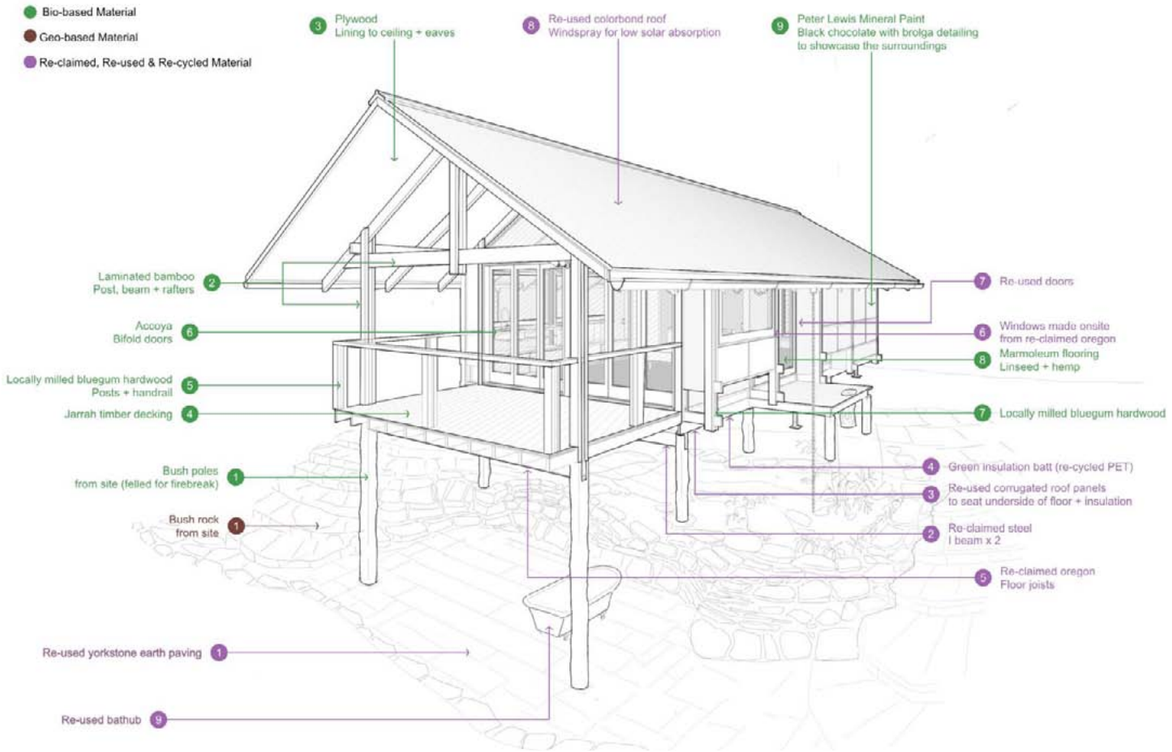
SOLAR PASSIVE

AIRTIGHT / INSULATED

RECYCLED + LOW EMBODIED MATERIALS

LOW USE WATER

LANDSCAPE / BIOPHILIC



Photography: Marnie Hawson.









A Net-zero Compact Home with Biogenic Wall Panels



Photography courtesy WAS.

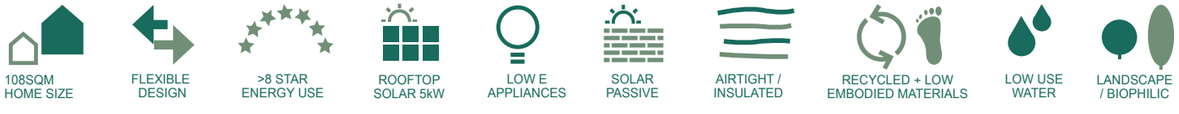
Big Trees, Small House, Western Australia, by WAS (Western Architecture Studio)

Anchored by mature gum trees and native gardens, this compact net-zero home demonstrates how innovative low-carbon material systems can support more efficient residential construction. It halves its upfront carbon through lightweight steel foundations, timber framing and judicious materials selection.

Low-carbon, low-toxic and highly recyclable materials are used throughout, including Weathertex, recycled cladding and EPD-certified Durra Panels manufactured from compressed wheat and rice straw by-products. Together with the lightweight structural system, these materials reduce upfront carbon and demonstrate how agricultural waste streams can become durable biogenic building products in a circular construction economy.

Cross-stack ventilation, natural shading, an eight-star energy rating and rooftop solar achieve net-zero whole-of-life carbon relative to the benchmark. Greywater irrigates the garden, a cartridge-free water system supports healthy water use, and integrated joinery maximises space and storage. An external boardwalk links the living and sleeping areas, strengthening the connection between indoors and outdoors.







Modular Prefab Achieves Lowest Upfront Carbon in Multiple Homes

Ginninderry Flexi-living Prefabricated Affordable Townhouse Series, ACT, AMC and TBS Ginninderry Joint Venture (PPP)

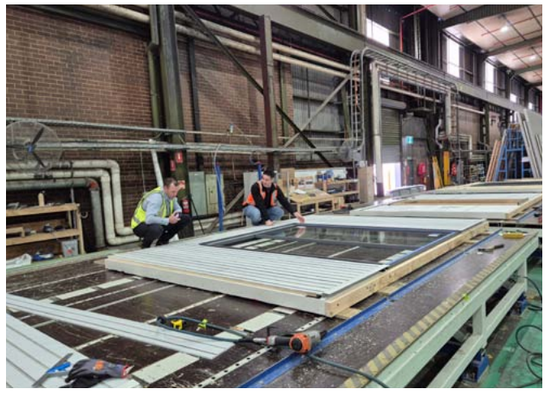
The PPP between the Suburban Land Agency and Riverview (page 40) is developing the Ginninderry Affordable Flexi-living prefabricated series.

The homes comprise factory-assembled lightweight panels supplemented by site enabling construction works. The higher-performing external building fabric of the panels helps improve occupant thermal comfort and lower operating energy, while reducing waste, construction time and neighbourhood disruption.

With its whole-of-life footprint improved by ≈+70% and upfront carbon of ≈57%[23], for Ginninderry, this is an important strategic 'test-bed': demonstrating that repeatable, low-carbon construction systems can be deployed across affordable townhouses at scale[24].



Photography / images: AMC, Johnathan Drury and Ginninderry.





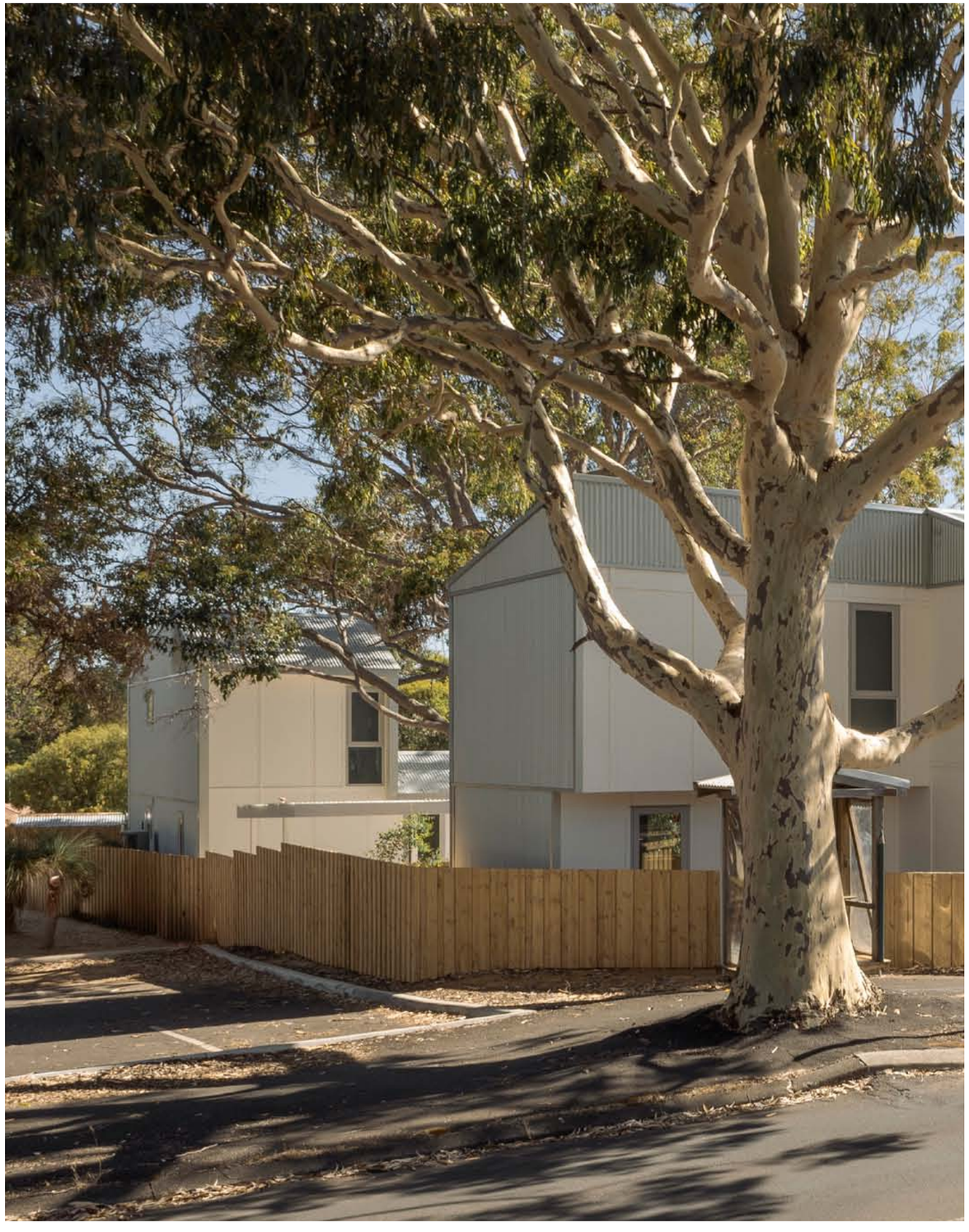
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Flexi-living prefabricated homes — with their precision manufactured lightweight panel assembly — save the most upfront carbon nationally in the 260-multiple home category.



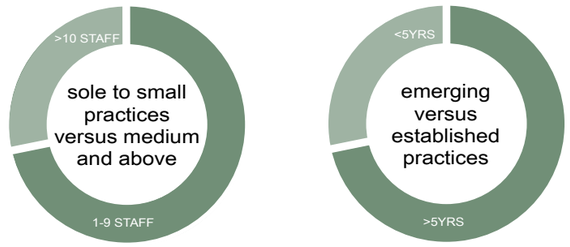
Six prefabricated lightweight townhouses in Margaret River by MDC Architects (Photography Shaina Bostin)

Conclusion and Future Participation and Research

Residential Decarbonisation Reach and Participation

Architect Reach and Engagement

Across three rounds since 2021, the Australian Zero Carbon Housing Challenge has demonstrated growing national reach and engagement. The initiative has attracted +80 architectural entries and +330 participating homes, creating an architect-generated national dataset of residential whole-of-life and upfront carbon performance.



Participation reflects the breadth of the profession undertaking residential architecture (pie charts above). Sole and small practices accounted for approximately three-quarters of participating practices, with medium-sized practices and above comprising the balance.

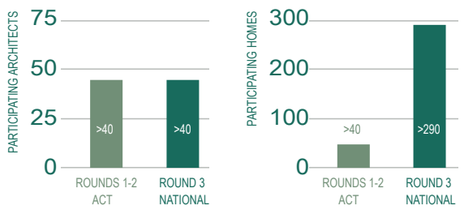
Emerging architects represented over one-quarter of participants, demonstrating strong interest in carbon literacy and Life Cycle Assessment (LCA) capability-building by the next generation of practitioners.

Round 1 began as a ‘grassroots’ ACT-based initiative that encouraged participation through a design competition and cash prizes. Round 2, known as *Studio Share,* invited practices to share their residential portfolios of carbon-savings. Round 3 expanded nationally through integration with the Australian Institute of *Architects National Residential Architecture Awards Program* and the *National Architecture Conference.*

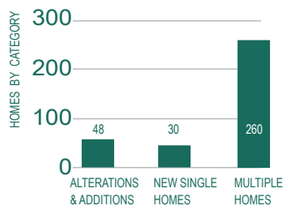
The largest participation growth occurred in Round 3 through partnerships with precinct-scale developers including +40 government demonstration homes and +170 affordable homes delivered through a public private partnership (PPP) precinct developer (below). These Round 3 collaborations accounted for the majority of participating homes and reveal a potentially scalable model combining development delivery, design-led residential carbon reduction, industry LCA upskilling and evidence generation.

Together, Carbon Challenge architects, volunteers and partners have established a valuable national evidence base of in-progress and delivered low- to net-zero carbon homes. The +35 architecture and sustainability awards and commendations across participating projects reflect the design quality, innovation and industry relevance of the dataset (page 74). As it grows, this evidence base is helping inform and support the progress of the Architecture Industry Decarbonisation Plan 2025–2050.

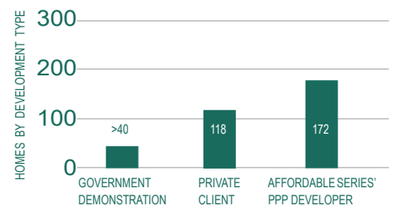
Graphs: Participating Architects and Homes



Residential Categories



Residential Development Type



Australian Zero Carbon Housing Challenge Conclusion and Future Research

Conclusion

The Australian Zero Carbon Housing Challenge offers a pathway to scalable low- to net-zero carbon residential. Across more than 330 homes nationally, participating architects have achieved considerable whole-of-life and upfront carbon savings through practical, design-led solutions.

CARBON SAVED ≈85,000 TONNES, EQUALS PLANTING
>HALF A MILLION TREES

ACROSS AUSTRALIA, ARCHITECTS DESIGNED
+330 LOW- TO NET-ZERO HOMES

CARBON CHALLENGE CURRICULUM
+600 ATTENDEES

The progress and findings reinforce a central message of the Decarbonisation Plan: architects have a critical role in Australia's transition to a low- to net-zero carbon built environment. Across diverse climates, residential categories and project scales, participating homes achieved material whole-of-life carbon reductions through early design decisions, material efficiency, electrification, renewable energy integration, adaptive reuse and smaller homes. Rounds 1-3 whole-of-life category averages are shown below.

48 x ALTERATIONS AND ADDITIONS AVERAGED A
CARBON SAVING OF >90%

30 x NEW SINGLE HOMES AVERAGED A
CARBON SAVING OF >100%

260 x MULTIPLE HOMES AVERAGED A
CARBON SAVING OF >60%

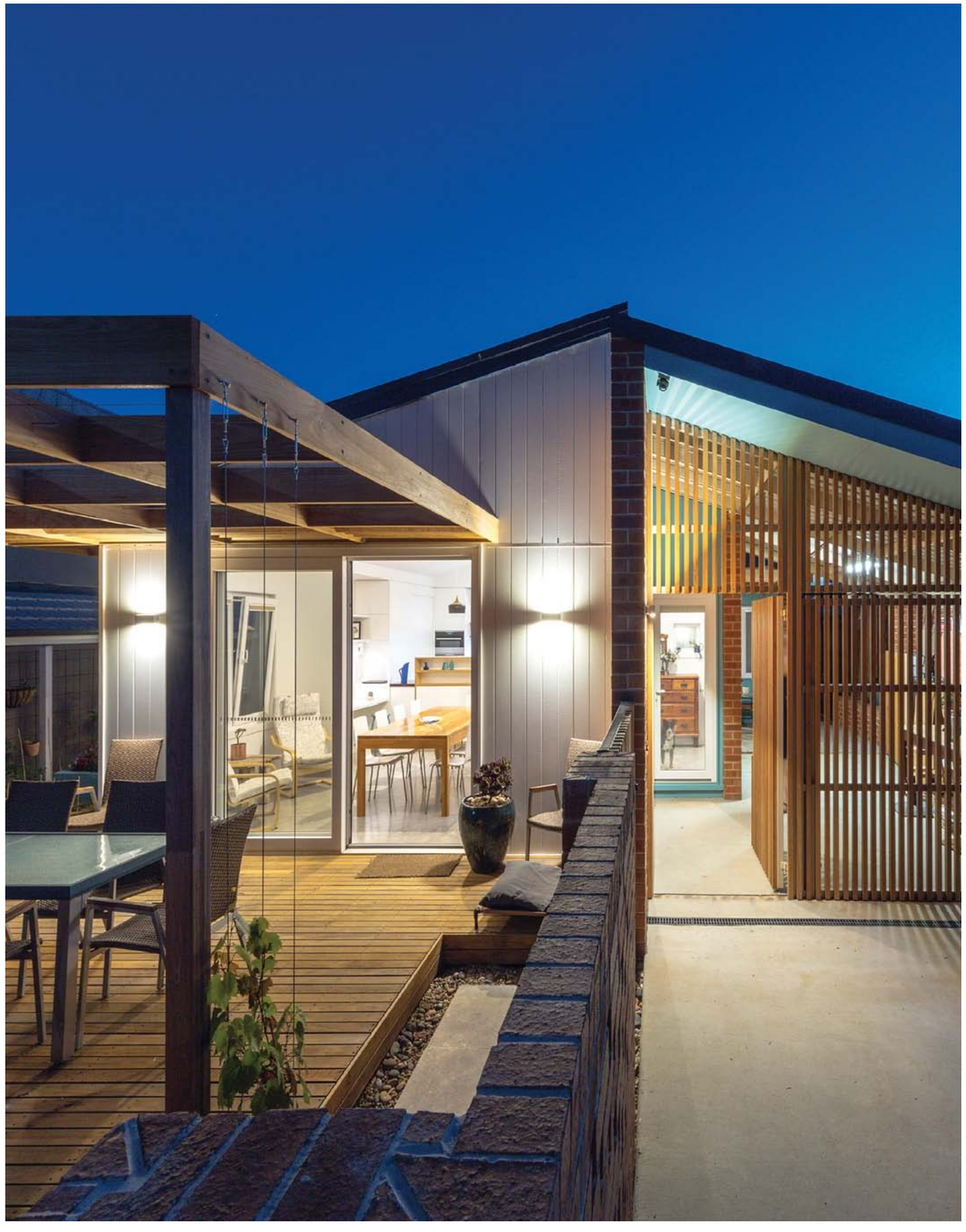
The results are encouraging, but Australia's climate commitments, population growth and demand for more homes will require decarbonisation at a much greater scale and speed. Achieving this transition will depend on continued capability uplift and design for carbon savings, supportive policy and regulatory reform, and broader integration of whole-of-life and upfront carbon LCA into everyday practice.

The evidence presented through the Carbon Challenge shows that substantial residential carbon reductions can be achieved through design-led solutions. The challenge now is to scale these approaches across the millions of homes that will be designed, renovated and built across Australia in the decades ahead.

Future Research and Architect Participation

Future Carbon Challenge research would expand the residential dataset and accelerate architect engagement, industry capability, LCA adoption and low- to net-zero carbon design practice. Its methodology is progressing the Decarbonisation Plan and has potential application beyond the residential sector. With robust datasets, ISO-aligned LCA parameters and a consistent national benchmark, the Carbon Challenge has established a valuable evidence base for assessing and demonstrating the carbon performance of architect-designed homes. In doing so, it is helping to accelerate design-led residential decarbonisation across Australia.

"Designing out carbon upfront, dematerialising and maintaining the value of good design is emerging as the critical skillset of architectural practice." Jane Cassidy, Australian Institute of Architects, Past National President.



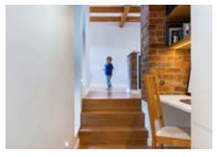
New single home: Canberra Beach House which halved its carbon footprint. Carbon Challenge commendation, ACT 2021, Light House Architecture and Science. Benjamin King Photography.

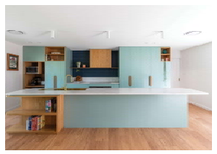
Catalogue and Architecture Awards — Australian Zero Carbon Housing Challenge

Australian Zero Carbon Housing Challenge 2021-2026 Catalogue

	Architect	Project	Whole-of-life
	Allan Spira Architects	Iron Bark House, ACT	75% or better
	Allan Spira Architects	Chef's Lane, ACT	Net-zero
	AMC Architecture + TBS	Flexi-living, current, ACT	50% or better
	Andrew Verri Architect	Reid House, ACT	75% or better
	Archer Design Studio	Scout's House, ACT	50% or better
	Andrew Waite Architecture	House Made of Sticks, NSW	Net-positive

	Architect	Project	Whole-of-life
	Anderson Architecture	Sapling, NSW	100% renewable electricity off-grid
	Anderson Architecture	Putty Passiv, NSW	100% renewable electricity off-grid
	Anna O'Gorman Architecture	7 Anne Street Garden Villas, Qld	75% or better
	Baker Drofenik Architects	Moonah House, Victoria	Net-zero
	BKK Architects	Big Little House, Victoria	50% or better
	Breathe Architecture	Merri Creek House, Victoria	50% or better

	Architect	Project	Whole-of-life
	Cave Urban	Bamboo Bath House, NSW	100% renewable electricity off-grid
	CCJ Architects	Secret Garden Zero House, ACT	Net-positive
	Collins Pennington Architects	Weiss Passivhaus, ACT	Near-50%
	Cooee Architecture	Could We, Should We House, NSW	Net-zero
	Cooee Architecture	Jacob and Jade's House, ACT	50% or better
	DNA Architects	Jacka Small Footprint Housing, ACT	Net-zero

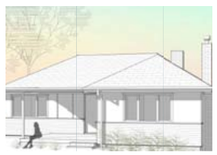
	Architect	Project	Whole-of-life
	Enfold Architecture	Family Fold, ACT	Net-zero
	Envelope Architecture	Narrabundahaus, ACT	Net-zero
	Goodhouse Architecture	Pocket House 4, SA	Net-zero
	Heyward Lance Architects	Whitlam Net-Positive House, ACT	Net-positive
	Heyward Lance Architects	Whitlam ‘Multi-gen’ House, ACT	50% or better
	Hugh Gordon Architect	Charred Timber House, ACT	Near-50%

	Architect	Project	Whole-of-life
	Hugh Gordon Architect	Net-zero Ainslie Studio	Net-zero
	LightHouse Architecture + Science	Net-zero ‘Ex-govie’ Makeover, ACT	Net-zero
	LightHouse Architecture + Science	Pettit + Sevitt Net-zero Makeover, ACT	Net-zero
	LightHouse Architecture + Science	Aston Reshuffle, ACT	Net-zero
	LightHouse Architecture + Science	White House, ACT	Net-zero
	LightHouse Architecture + Science	Little Loft House, ACT	75% or better

	Architect	Project	Whole-of-life
	LightHouse Architecture + Science	Canberra Beach House, ACT	50% or better
	LightHouse Architecture + Science	Cook ‘Ex-govie’, ACT	Net-zero
	LightHouse Architecture + Science	Fab-ode, ACT	75% or better
	LightHouse Architecture + Science	Aston Reshuffle, ACT	75% or better
	LightHouse Architecture + Science	‘Multi-gen’ Living House, ACT	75% or better
	LightHouse Architecture + Science	Wonga House House, ACT	75% or better

	Architect	Project	Whole-of-life
	Mather Architecture	Blackwood House, ACT	90% or better
	MDC Architects	Annie Street, WA	75% or better
	Mustard & Silva	Lathlain, WA	50% or better
	Maytree Studios	White Street, ACT	75% or better
	MDa Architecture and Research	Net-zero ‘Ex-govie’, ACT	Net-zero
	MDa Architecture and Research	Carrington Townhouse Retrofit, SA	75% or better

	Architect	Project	Whole-of-life
	MDa Architecture and Research	Flexi-living Stage 1, ACT	50% or better
	MYMYMY Architecture	Ochre House, NSW	100% renewable electricity off-grid
	Nathan Judd (Judd Stuio)	Ainslie Shed, ACT	Net-zero
	Net Zero Design	Margate House, Qld	Net-zero
	Neighbourhood Architecture	Neighbourhood House 1, ACT	90% or better
	Neighbourhood Architecture	Plant House, ACT	Net-zero

	Architect	Project	Whole-of-life
	Neighbourhood Architecture	Neighbourhood House 2, ACT	Net-zero
	Neighbourhood Architecture	Neighbourhood House 3, ACT	90% or better
	Officer Woods + MDC Architects	28 Terraces, Hope Street, WA	50% or better
	Open Principle Architecture	Collector House, NSW	Net-positive
	Sonder Architects	Net-zero ‘Ex-Govie’ Sonder Tower 1	Net-zero
	Sonder Architects	Rivetto, ACT	Net-zero

	Architect	Project	Whole-of-life
	Sonder Architects	Gathering House, ACT	Near-75%
	Studio Bright	SDA Housing Project, Victoria	Net-zero
	Studio Heim	Box House, NSW	Net-positive
	Studio Heim	Honeycomb House, ACT	Net-positive
	Studio Heim	Coloured Panel House, ACT	Net-positive
	Studio Heim	Garden Room Addition, ACT	Net-positive

	Architect	Project	Whole-of-life
	Studio Orsi	Wallaby Hills House, NSW	75% or better
	Trella Architecture + Interiors	North Wright Sustainable Precinct	75% to net-zero
	Trevor Bunning Architect	New Detached Passivhaus x 2, ACT	Net-positive
	Western Architecture Studio	Big Trees, Small House	Net-zero
	Yellow Architecture	Deep Retrofit, ACT	Net-zero
	Ys Housing	Ys Housing, Victoria	90% or better

AWARD-WINNING LOW- TO NET-ZERO RESIDENTIAL ARCHITECTURE

Australian Zero Carbon Housing Challenge (formerly the Canberra Low Carbon Housing Challenge). Winner, Australian Institute of Architects, 2022, ACT: Clem Cummings Prize (Dr Melinda Dodson, Rob Henry and David Clarke) and ACT President's Prize (Dr Melinda Dodson).

Anna O'Gorman Architect, Anne Street Garden Villas. Winner, Australian Institute of Architects, 2022, Multiple Housing awards: Job & Froud (Qld) and National Architecture Award for Residential Architecture.

CCJ Architects, Secret Garden Zero House, Winner, Australian Institute of Architects, ACT, 2022: Gene Willsford Residential (Alterations and Additions) and Pamille Berg Award Art in Architecture.

Enfold and Allan Spira Architects, Ironbark House, ACT, 2021 Carbon Challenge – Low-carbon New House Commendation.

Light House Architecture & Science, Little Loft House. Winner, Australian Institute of Architects, ACT, 2021: Derek Wrigley Award for Sustainable Architecture, Gene Willsford Award, Alterations and Additions and 2021 Carbon Challenge – Second prize for a Low-carbon House.

Pettit+ Sevitt Makeover, ACT, 2021 Carbon Challenge – First Prize Net-zero Alterations and Additions.

Canberra 'Beach' House, ACT 2021 Carbon Challenge – Low-carbon New House Commendation.

White House, ACT 2021 Carbon Challenge – Net-zero New House Commendation.

Envelope Architecture, Michael Tolhurst, Narrabundahaus. Winner, Australian Institute of Architects, ACT, 2023: Malcolm Moir and Heather Sutherland Award, Residential Architecture (New), Derek Wrigley Award for Sustainable Architecture, COLORBOND® Award for Steel Architecture and 2021 Carbon Challenge – First Prize Net-zero New House.

Heyward Lance Architecture, 2021 Carbon Challenge – Second Prize Low-carbon Whitlam Townhouses.

Maytree Studio, Tighty Whitey, Qld, 2026 Residential Architecture Commendation: Alterations and Additions

MYMYMY, Ochre House. Winner 2025 Institute, Residential Award for Houses (New), Colorbond Award for Steel In Architecture, Commendation for Sustainability.

Officer Woods and MDC Architects, Hope Street Housing, Winner Australian Institute of Architects, WA, 2024: Award for Urban Design. Commendations for Residential Architecture – Multiple Housing and Sustainable Architecture. National Architecture Awards, National Commendation for Urban Design.

Open Principle Architects, Winner 2024 Institute ACT Architecture Awards – Award for Residential Architecture – Houses (New), Derek Wrigley Award for Sustainable Architecture and 2021 Carbon Challenge Commendation for a net-positive new house: Collector House.

Trella Architecture + Interiors (Mather Architecture), North Wright Sustainable Precinct. Winner Australian Institute of Architects, ACT, 2026 – Award for Residential Architecture – Multiple Housing, Derek Wrigley Award for Sustainable Architecture and the Inaugural Missing Middle Prize.

2021 Carbon Challenge – Second Prize Low-carbon New House Blackwood House.

Silva & Mustard, Lathlain House, Winner Australian Institute of Architects, WA, 2026: EmAGN Project Award, Residential Architecture – Houses (New) and Sustainable Architecture.

Studio Bright, SDA Housing Project. Winner, Australian Institute of Architects, Victoria, 2026 – Architecture Award for Residential Architecture – Multiple Housing. Commendation, ArchitectureAu Award for Social Impact, 2026.

Studio Heim (Rob Henry Architects) Net-positive Box House (overleaf). Winner, Australian Institute of Architects, ACT 2015, Malcolm Moir and Heather Sutherland Award, Residential Architecture – Houses (New).

Ys Housing, COLORBOND® Award for Steel Architecture, Victorian Architecture Awards 2026



Net-positive Box House by Studio Heim. ACT winner, 2015, Malcolm Moir and Heather Sutherland Award, Residential Architecture – Houses (New). Photography: Light Studies.

Notes and References

Australian Zero Carbon Housing Challenge Notes and References

1. INFRASTRUCTURE AUSTRALIA (2024). Embodied Carbon Projections for Australian Infrastructure and Buildings, Infrastructure Australia. Infrastructure Australia

   ASBEC & CLIMATEWORKS CENTRE (2025). Embodied Carbon Policy in the Australian Building Sector, Australian Sustainable Built Environment Council. ASBEC & ClimateWorks

   GREEN BUILDING COUNCIL OF AUSTRALIA - GBCA (2023). Carbon Positive Roadmap: Buildings and the Built Environment, Green Building Council of Australia. GBCA

   DCCEEW (2023). Australia's National Greenhouse Gas Inventory: Quarterly Update, Australian Government Department of Climate Change, Energy, the Environment and Water.

2. AUSTRALIAN INSTITUTE OF ARCHITECTS (2025). Architecture Industry Decarbonisation Plan 2025–2050, Australian Institute of Architects. Among the recommendations, the Plan calls for a national residential decarbonisation program with the regulatory settings, tools and support.

3. SCHMIDT, M., CRAWFORD, R. & WARREN MYERS, G. (2020). Quantifying Australia's lifecycle carbon emissions for new homes. Energy & Buildings. This study provides a widely referenced estimate of whole of life carbon for new detached homes.

   The tree offset equivalence draws on Cerclos' use of Carbon Neutral Australia's estimate that around six trees are required to sequester one tonne of carbon.

   These figures are separate from the *Our Homes Weigh a Tonne* research, which quantifies material mass rather than carbon, adding much-needed context and detail to future upfront carbon targets.

4. AUSTRALIAN GOVERNMENT (2022). National Housing Accord. Commonwealth of Australia.

5. DODSON (2026), Derived From AEMC Targets Progress Tracker (2026) and GBCA Carbon Positive Roadmap for the Built Environment (2018).

6. GREEN BUILDING COUNCIL OF AUSTRALIA (2023), Our Homes Weigh A Tonne. GBCA, Sydney.

7-8. IBID 3. IBID 2.

9. ZUO, J., PULLEN, S., RAMEEZDEEN, R., BENNETTS, H., WANG, Y., MAO, G., ZHOU, Z., DU, H., & DUAN, H. (2017). Green building evaluation from a life-cycle perspective in Australia: A critical review. Renewable and Sustainable Energy Reviews 70 (2017) 358–368

10. IBID 9.

11. PILOT AND STAKEHOLDER CONSULTATION FOR ACT AND NATIONAL ROUNDS

    Pilot phase and stakeholder consultation with architects
    More than 600 architects participated in Carbon Challenge curriculum activities and events delivered through the Australian Institute of Architects (Institute), its Climate & Sustainability Committee (CS) and EmAGN. The Carbon Challenge framework was developed through ACT and national pilot rounds involving architects, industry stakeholders and LCA specialists. Peer-to-peer learning sessions tested RapidLCA modelling, validated assessment parameters and informed final program design.

11. PILOT AND STAKEHOLDER CONSULTATION FOR ACT AND NATIONAL ROUNDS (continued):
Consultation undertaken through Round 3 reaffirmed the adopted 2025-26 carbon targets. Engagement was supported through Institute communications, Architecture Australia, social media, a Sustainable House Day exhibition of selected projects, and targeted outreach to State and Territory Chapter Presidents and their Councils. This consultation and outreach process helped validate program settings, build industry support and prepare the Carbon Challenge for national delivery (table below).

For questions architects asked about carbon during the Carbon Challenge Rounds 1-3, refer:
https://www.lowcarbonhousing.com.au/_files/ugd/1b1e82_7fc08ab4e3514622b8c441252b12264e.pdf

For participant feedback from the late-2025 Round 3 pilot, refer below (green reflects positive sentiment):

Residential type modelled	— As built	**Alterations and additions** — Early concept	— In progress	**New single and multiple homes** — Early concept
How LCA informs design	"Informative… minimal embodied carbon… operational carbon can be significantly improved"	"Test material options… achieve lowest carbon outcome"	"Paired EER with LCA… balance point… big hitters"	"Find balance between conceptual policy and feasible option"
Most valuable aspect	"Helps shift away from knocking down homes… existing stock can be greatly improved"	"Track carbon early… valuable insight"	"Prompt to refresh and polish our use"	"Engagement and ongoing education"
Confusing aspects	"Heating/cooling systems confusing… ACT grid understanding challenged" — Mixed	"Took a few attempts… tutorials helped… alterations more complex" — Mixed	"Useful to learn heating/ cooling loads outside Canberra"	"Extent of detail… where concept finishes and assemblies begin" — Mixed
Prevented finishing	"No"	"No"	"No"	— (no response)
Resources used	Videos, Checklist, FAQs, RapidLCA Results/Analysis	Videos, Checklist, FAQs	FAQs, RapidLCA Results/ Analysis	Videos, FAQs, RapidLCA Support, Results/Analysis, Reports/Share
Comments on resources	"Dashboard speed improving… more joinery options needed" — Mixed	"Videos… excellent"	— (no response)	— (no response)
Architect participation	"Ensure LCA gets exposure across Institute platforms"	"Align with national conference to showcase modelling"	"Free-access, short videos… visual data great content"	"Chapter-based advocacy… peer pressure to beat best practice"
Want to know more	"Always keen to learn!"	— (no response)	— (no response)	— (no response)
Other comments	"Thanks for all your work"	— (no response)	— (no response)	— (no response)

11. PILOT AND STAKEHOLDER CONSULTATION FOR ACT AND NATIONAL ROUNDS (continued):

Alignment with Australian Institute of Architects priorities, program Integration and delivery
The Carbon Challenge is delivered collaboratively by the Canberra volunteer architect and research team, the Institute and Cerclos, enabling architects to design and measure low-carbon and net-zero residential projects using RapidLCA. The program supports implementation of the Institute's Decarbonisation Plan advocacy with industry benchmarking and professional capability development. The design and delivery of the 2025-2026 Carbon Challenge has been aligned to the:

- Architecture Industry Decarbonisation Plan 2025-2050 and Carbon Curriculum CPD
- Residential Architecture Awards (participants could append their LCA report to their awards entry)
- National Architecture Conference 2026 (panel session, exhibition and publication to promote industry participation and knowledge sharing), and
- EmAGN (engagement activities such as *Sustainability Snack* events, with the cohort).

The September 2025 national pilot informed final program refinement, the November 2025 launch commenced national delivery, and Round 3 analysis was completed in 2026 in consultation with LCA specialist reviewers for presentation at the October 2026 National Architecture Conference.

12. BACKGROUND AND USE OF RAPIDLCA (ETOOL) AS THE CARBON CHALLENGE LCA PLATFORM
LCA quantifies a building's environmental impact across its full life, including the manufacture and transport of materials, construction, operational energy and water, maintenance and replacement, and end of life. The greatest carbon reduction opportunities are often found in trade-offs across these life-cycle stages.

Research and consultation in 2020 informed the selection of RapidLCA by Cerclos as the Carbon Challenge LCA platform. Since 2021, Cerclos has supported participating architects by waiving subscription fees and providing technical assistance, including material template requests and curriculum support.

Cerclos is an established Australian company with a global presence. Together with software users, it has supported the modelling of more than 70,000 LCA strategies and saved over 22 million kg CO_2e of carbon, while undertaking more than 4,500 LCA peer reviews across Australia and internationally.

RapidLCA uses eTool, which is designed to produce assessments consistent with ISO 14040, ISO 14044, EN 15978 and PAS 2080. Working to a defined system boundary enables results to be compared consistently between projects. All Carbon Challenge models use eTool's default dataset, drawing on AusLCI (the Australian National Life Cycle Inventory Database) and ecoinvent, the world's most widely used peer-reviewed life-cycle inventory database. For further information on eTool:

- Conformance with international standards for LCA — ISO14040, ISO14044, EN15978 and PAS 2080
- Cerclos' data security, privacy and compliance practices https://cerclos.com/company/trust-centre/
- eTool has also been accredited and/or used in conformance with sustainability rating schemes including the Living Building Challenge, Green Star, BREEAM, ISC and LEED.
- RapidLCA has been used for the two previous Carbon Challenges in the ACT, the SA Zero Carbon Challenge House competition and the WA 10 House Living Labs project.
- Research papers featuring eTool:
  - https://www.tandfonline.com/doi/full/10.1080/09613218.2026.2719725
  - https://www.researchgate.net/publication/273704589_Measuring_Carbon_for_ Urban_Development_Planning/
  - https://www.researchgate.net/publication/264638215_Residential_Building_Sustainability_Rating_Tools_in_Australia/
  - https://researchrepository.murdoch.edu.au/id/eprint/35823/

13. CARBON CHALLENGE BENCHMARK, DATA SOURCES, LCA PARAMETERS AND CURRICULUM: All participating projects are compared to the Australian Residential Benchmark (links and table below):

CARBON CHALLENGE RESEARCH: - https://www.lowcarbonhousing.com.au/research
START MODELLING: - https://www.lowcarbonhousing.com.au/resources
ABOUT LCA MODELLING AND THE RULES: - https://www.lowcarbonhousing.com.au/_files/ugd/1b1e82_bb47299986b54136b33d3e0d5ee5450a.pdf

Average Home Attributes	Previous Canberra Challenge	National Carbon Challenge	Australian Residential Benchmark - Data Sources and Rationale
Number of homes	1	1 (10)	Expanded to a 10-home benchmark portfolio to improve its representativeness of Australia's major residential density types, per ABS FY24–25, national residential approvals by density type: 60.6% detached, 11.8% semi-detached and 27.5% apartments (low and high-rise mix).
Home size (GFA)	250sqm	196sqm (1,960sqm)	NCC-compliant national residential average mix, being 274.82sqm GFA or FECA (Gross Floor Area or Fully Enclosed Covered Area), including a ≈28% unenclosed covered area
No. storeys	1	2	Blended average across the four density types
Design life	55years	55years	Held constant for direct lifecycle comparison
No. bedrooms	4	3.1 (31)	ABS Housing Occupancy & Costs, 2019–20
No. of occupants	2.6	2.6 (26)	ABS Census 2021 average household size
NatHERs star rating: • Cooling thermal demand • Heating thermal demand	6 22 MJ/m2 143 MJ/m2	6.4 26.16 MJ/m2 73.19 MJ/m2	CSIRO Australian Housing Data Dashboard, national average
Kilowatts of solar	0kW	1.9 kW (19.2 kW)	6.6 kW system on 40% of detached/semi-detached homes (Clean Energy Regulator, 2024)

NOTE: CARBON IMPROVEMENT IS RELATIVE TO THE BENCHMARK. SOME ALTERATIONS AND ADDITIONS PARTICIPANTS LCA-MODELLED BOTH THE 'BEFORE' AND 'AFTER' PROJECT TO GAIN A FULLER DECARBONISATION PICTURE.

14. GREEN BUILDING COUNCIL OF AUSTRALIA (GBCA). (n.d.). Carbon and climate definitions. Retrieved from chrome-extension:// efaidnbmnnnibpcajpcglclefindmkaj/https://gbca-web.s3.amazonaws.com/media/documents/carbon-and-climatedefinitions.pdf

15. IBID 13

16. Diagrams from DODSON M, ELATTAR S, SANDFORD D, (2022). Canberra Housing Decarbonisation: Insights from Local Low Carbon Housing, Canberra Low Carbon Housing Challenge

17. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC). (2023). Sixth Assessment Report (AR6): Climate Change 2023. Provides the internationally accepted definition and use of CO_2e as the standard unit for expressing greenhouse gas emissions.

18. AUSTRALIAN BUREAU OF STATISTICS (ABS). (2021). Census of Population and Housing: Household and Family Characteristics. Source of Australian average household size used for normalising GWP / occupant.

19. AUSTRALIAN ENERGY MARKET OPERATOR (AEMO). (2024). Integrated System Plan (ISP). Provides projections of the national energy grid decarbonisation relevant to operational carbon trends.

20. AUSTRALIAN GOVERNMENT. (2024). Nationwide House Energy Rating Scheme (NatHERS). Defines the national thermal performance rating framework used to assess residential energy efficiency.

21. PERFORMANCE INSIGHTS ACROSS RESIDENTIAL CATEGORIES: Each Carbon Challenge round includes a different mix of homes and variables, and category findings will continue to evolve as more residential typologies, climates, materials and design strategies are LCA-modelled.

Findings reflect participating projects only. The authoring architect is responsible for the home's design decisions and scope represented in each LCA. RapidLCA is a decision-support tool. Environmental impact coefficients are generic and may not correspond to specific products or manufacturers. The LCA studies do not seek to meet the ISO 14044 critical review requirements. Instead, Cerclos and researchers undertook spot checks of potential discrepancies and outlier results to support methodological consistency.

22. OFF-GRID HOME DEFINITION IN THE CARBON CHALLENGE**:** An off-grid home is not connected to an electricity grid and meets its operational energy needs through on-site generation and storage. To maintain supply during periods of low solar generation, off-grid homes typically require larger solar capacity and battery systems than grid-connected homes. Surplus generation cannot be exported and is curtailed. As a result, off-grid homes generally have higher upfront carbon and additional embodied carbon from battery and inverter replacements. Depending on local grid emissions intensity, this can result in higher whole-of-life carbon than an equivalent grid-connected home.

An off-grid home may be considered 100% renewable electricity if all electricity is supplied by on-site renewable generation without fossil-fuel backup. This does not mean the home is net-zero whole-of-life carbon, which also includes the embodied carbon of its construction, materials and energy systems.

23. MULTIPLE HOME LCA METHOD IN THE CARBON CHALLENGE (2025-2026): For multiple home projects, representative residential types were LCA-modelled and weighted according to the quantity of each home type to estimate aggregate carbon savings. For example, ten representative Flexi-living types were modelled, averaged and extrapolated across the development.

24. AFFORDABILITY: Lower purchase priced individually titled homes, purchase eligibility restrictions, lower ongoing operating costs and eligible access to first-home buyer assistance and low-deposit schemes.

"Use the Life Cycle Assessment software to find the best possible balance between a conceptual proposal...and the most feasible option for uptake". CARBON CHALLENGE PARTICIPANT





Above are the off-grid new single homes in NSW by Anderson Architecture: Putty Passiv (Photography Lachlan Kain) and Sapling (Photography Tom Ferguson). Rear Cover is Hope Street Housing in WA by Officer Woods and MDC Architects which halved its whole-of-life carbon footprint (Photography Acorn / Robert Frith).

AUSTRALIAN ZERO CARBON HOUSING CHALLENGE

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Architects progressing the Architecture Industry Decarbonisation Plan 2025-2050

Prepared by
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