Up to standard
Passive House in Australia

Designing and building your house to the Passive House Standard in Australia is now a viable option. Architect Fergal White visits a certified Passive House home in Canberra to see the house in action and hear its story from owner and designer Harley Truong.

↑ Harley's Passive House, front (north-facing) elevation. Harley built two almost-identical three-bedroom homes on the 1020 m² site, each optimised for passive solar gains.

Passive House Standard

The Passive House Standard (also known as Passivhaus) is an international energy-use standard that requires a house annually use no more than 46 kWh/m² of electrical energy in total, and have no more than 15 kWh/m² of heating and cooling energy demand, while maintaining a constant temperature of 20 °C in each room. The building must be airtight and have minimal thermal bridges. The energy and performance requirements are the same regardless of climate, but the method to achieve them will differ depending on climate.

I APPROACHED Harley Truong's Passive House in Canberra knowing that this freezing cloudy July day would be a real test of the house's certification. Stepping inside, the building was beautifully warm, with no heating system in use. Truly impressive!

The Passive House Standard dictates (low) maximum energy usage per square metre, both overall and for heating and cooling (see box). It does this by specifying a well-insulated envelope and airtightness that is perhaps unprecedented in Australia, where the building code doesn't stipulate any level at all.

There are now six certified Passive Houses in Australia, with many more under construction. But that wasn't the case in 2013 when Harley Truong embarked on his own build, so he made remarkable use of the internet to find his way to successful certification.

Renovation attempt

His family's journey to find a better way of living began with an attempt to renovate their 40-year-old home in Canberra. The house was draughty with cold floors, constant use of ducted gas heating and mould growing on the windows from condensation, all issues that were affecting the family's health and bills. Winter bills were often as high as $600 per month.

Harley attempted to thermally improve the house but to little effect. Replacing steel-framed single glazing with double-glazed windows (non thermally broken aluminium) and adding curtains made the condensation worse. Locating a whirlybird on the roof pulled heated internal air through the 30 ceiling downlight holes into the attic. Harley says, "I slowly realised that the home was almost the perfect inverse to what a passive solar designed house should be. It had the main glazed living areas facing south, minimal insulation, high air leakage and no thermal mass."

So when a large corner site (1020 m²) with no overshadowing came up for sale just down the road, Harley bought it almost instantly. The decision was also quickly made to knock down the poorly sited house on the block, and build two homes, one to live in, and one as an investment property.

Coming around to Passive House

Harley came around slowly to building to a Passive House design. Initially, as perhaps many people feel, he dismissed it as a European-specific standard, not suitable to Australia's milder climate. However, the targets of low energy use, particularly for heating and cooling, were exactly what he wanted after his family's experience in their previous home.

He became aware that the Passive House standard uses site-specific climate data and so

↑ Avoiding thermal bridges in the roofing panels—roofer pictured inserting sawcut gap between internal ceiling and external soffit to obstruct passage for heat conductance.

↑ Blower door testing ascertains envelope airtightness by sucking internal air out through the door and testing for any air infiltration into the building through gaps.

can work in any location. He also found what he calls a "treasure trove" of freely available information online. "I realised that with all the designs and information available, I could design and build the houses myself," he says.

After coming up with a basic house design, Harley worked with a local architecture firm in Canberra to develop the design for council submission. The two 140 m², three-bedroom houses are mirror images of each other and are deliberately compact to minimise external wall area for heat loss and gain, and reduce material use and waste. Entry is from the north into an open-plan living/dining/kitchen, with an east-west corridor separating north-facing bedrooms from south-facing utility rooms. The majority of glazing is to the north where the higher sun angle is easier to shade. Small windows to the south provide daylight to utility rooms and cross-ventilation for summer cooling. There's just one small window on the east and west sides as the low sun angles are difficult to shade. A mechanical ventilation system pulls in air from the north and exhausts it to the south.

A crash course in construction drawing

Once council permission had been granted, Harley, an electrical/mechanical engineer by training, decided to take over the detailed design himself, including preparing the construction drawings. Harley believed that a clear set of construction drawings that detailed every building junction, especially the non-standard ones, would be key to the project's success. "I found the information to do this on the internet," says Harley, "but it was certainly interesting with no training!"

The first step was to take four months leave from his job to work full-time on the project. He taught himself to use Google Sketchup for drafting, the Passive House Planning Package software for all building calculations and the Therm software package to ensure that building junctions didn't contain any thermal bridging.

It ended up taking a year to complete the documentation—it was a big challenge—but Harley is pleased with the control it gave him over the design and construction details. A further unorthodox step was that Harley completed the construction drawings prior to appointing a structural engineer. But he was lucky: he found an engineer who was interested in the standard and was 'old school', calculating all necessary details to achieve structural strength from first principles.

Harley used the Passive House Planning Package to determine the required insulation levels for the external building envelope, based on local climate data (Passive House verified). He found the requirements were much lower than the classic European Passive House examples he'd seen online.

The Passive House standard also specifies no thermal bridging. Meeting this requirement involves establishing an insulation layer around the building, including the floor slab, so that the interior of the house is completely isolated from the exterior (not unlike in a Thermos flask). It is because of this sealing that a mechanical ventilation system is required (see *ReNew 127* for more on these systems).

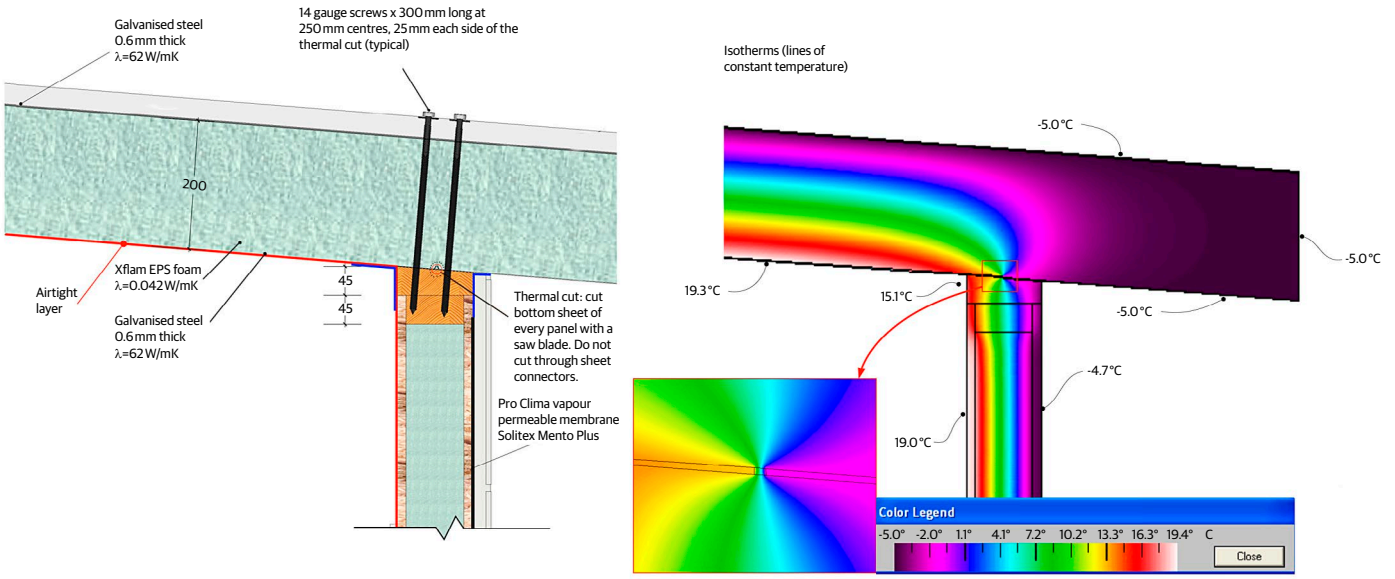
Harley used under-slab insulation, SIPs (structural insulated panels) for his external walls and sandwich roofing panels. As the roof panels have a continuous bottom metal surface that runs from internal (ceiling) to external (soffit), a thermal break, in the form of a continuous sawcut, was required to avoid thermal bridging (a tip Harley picked up from watching roofing videos on YouTube).

Harley made material choices based on thermal values and ease of assembly, with all knowledge gleaned from his research.

He ended up importing German uPVC double-glazed windows which use a double airtight seal, not unlike a car door. "At the time I couldn't find an Australian-designed window or door that would achieve the airtightness required," Harley says. He notes, however, that there are now local window manufacturers making airtight windows in timber and uPVC at competitive prices.

A smooth build

After a year of preparing the construction documents, Harley approached three builders for a fixed price quotation. The response was varied. The first contractor, a high-end builder, had a look but didn't want to make a bid. The second builder, with green building experience, put in a high bid. In the end,



↑ Sample of construction drawings showing instructions and isotherms. It is critical to make sure that no heat is escaping in winter or infiltrating in summer through the continuous insulation layer around the building.

Harley went with a third builder who didn't give a price immediately, but wanted to talk with Harley about every single aspect of the job, including how the contract would be structured. As with the structural engineer, Harley was impressed with the 'Let's see how we can make this work for you' attitude. This builder had also previously worked on a project where airtightness was a critical factor.

Harley ended up taking on much of the risk of meeting Passive House certification. In the three months prior to starting construction, Harley held weekly meetings with the builder to discuss the building details and interview all the tradespeople.

Harley says the eight-month construction went very smoothly. He worked part time during this time (four hours of labouring/resolving issues on-site and four hours at his workplace), and he attributes the project's success to having all the key decision-makers on-site every day in close communication.

Of all the Passive House requirements, Harley found that airtightness was the one least understood by tradespeople and general contractors. The Australian building code does not require a particular performance level, so not many builders know about it or prioritise it. As this is a mandatory Passive House performance requirement, Harley bought his own 'blower door' testing kit and tested both houses three times: when they were first sealed up, prior to plasterboarding and upon completion. "Failing the air-tightness test was my greatest fear," he says. Consequently he "over-engineered", using over one kilometre of airtight tape. Harley found the quickest way to detect an air leak was to use the back of his hand with his eyes closed!

A certified joy to live in

There were no Australian Passive House certifiers available at the time so Harley arranged certification online with a certifier from Canada. Certification relies on performance tests, software calculations and photographic evidence. Without any preliminary checks during the build, certification took four months, longer than Harley had hoped (several weeks would be a more typical length for certification), but was eventually granted in 2015.

The result is a house that's "a joy to live in". Harley says, "We're not the type of people who tough it out when it gets cold or hot—we like to be comfortable without having to rug up—but we have not needed to use heating or cooling during the first 12 months living here."

The whole family has developed a heightened awareness of passive solar design. "It's wonderful," Harley says, "how the moment the low winter sun shines through the windows it's like a heating system being turned on." The ventilation system is completely silent and the air in the house is very still. Harley describes the warmth of the house as "being everywhere" with all surfaces and areas having the same temperature.

On nice spring and autumn days, the family leave the windows open to enjoy the outdoor temperature. Natural night-time ventilation, by opening windows and doors, is the best way to cool the house down in summer in Canberra, where night temperature are much cooler. This concept is encouraged in the Passive House standard and allowed for in the calculations with windows and doors located strategically to maximise cross ventilation.

A testament to the house is the improved health of the family along with their lower annual energy bills, down to around $1000 (from $3500) thanks to their new energy-efficient home. ✱

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For more details on Passive House, see the Australian Passive House Association at passivehouseaustralia.org.

Lessons learnt

For anyone thinking about building a new Passive House home, these are some pointers from Harley:

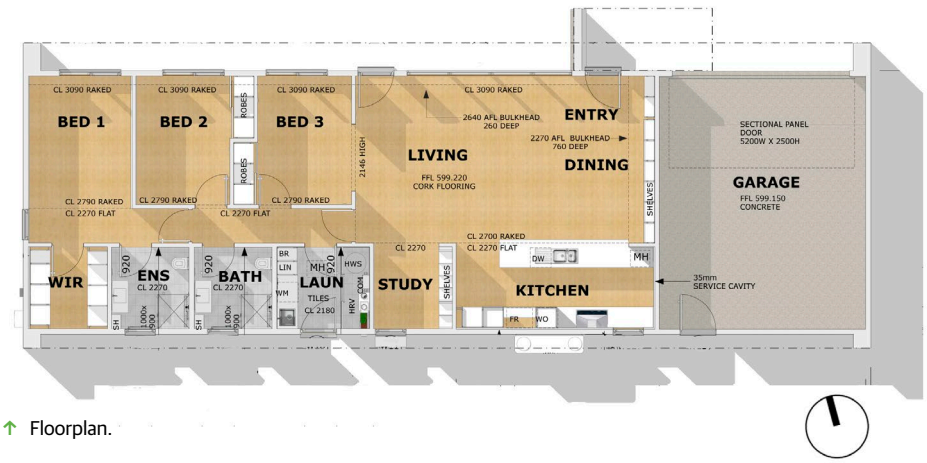
- It is not as expensive as you think: the cost per house was around $460,000, including garages, or $415,000 excluding them, giving around $3000/m² assuming 140 m² size, compared to around $3500–$4500/m² for a standard custom-designed house. This cost doesn't include Harley's labour, but with increasing availability of Passive House products and experienced builders/architects, the cost premium is likely to reduce over time.
- Choose your architect and builder carefully, to ensure they have knowledge of and (preferably) experience with Passive House.
- Appoint a Passive House certifier at the detailed design stage to avoid delays or issues later.
- Use conventional building methods where possible as this will involve less perception of risk for a builder.
- Be mindful of airtightness during construction and perform tests at progressive stages of sealing the house.
- Select materials with independent testing results. The International Passive House Association certifies materials, but most are not available in Australia, so thorough research is needed.
- If you can afford to splash out on just one item, spend your money on high-quality, European-standard windows and doors.
- If the Passive House Planning Package specifies heating/cooling requirements, install inexpensive post-heaters/coolers for the ventilation air; you may not use them but they are a fallback.
- Have fun!

Is Passive House applicable in warmer parts of Australia?

One of the questions that many people ask when considering Passive House is whether it's applicable to the warmer climates in Australia.

Fergal White, the author of this article and a Passive House architect, says the Passive House low-energy standard is achievable in both the warmer and cooler climates of Australia. He says that research has been conducted, based on completed projects, to verify that Passive House buildings can suit a wide range of climates, and that there are many successful Passive Houses in warm climates including Spain, Indonesia and Mexico. Fergal is currently conducting research into what adjustments would be required for Harley's house to meet the standard in Darwin, Alice Springs, Sydney and Melbourne; his preliminary results indicate that the thermal adjustments for the Canberra building envelope are minimal for all locations except the desert climate of Alice Springs which would require higher R-values with this particular design.

Fergal believes a particular strength of the standard is that it is performance-based and covers all operational energy in the house. He says although draught sealing is integral to the standard, the house can still be opened up to allow for cooling breezes. It will be interesting to follow up more on Fergal's research in a later issue.



↑ Floorplan.

House specs

Treated floor area of each house: 127 m² (140 m² using Australian (external) method of measuring).

Passive solar principles: north-facing living areas, south-facing utility rooms with windows/doors positioned for cross-flow ventilation. Tiled on-ground floor slab providing thermal mass.

Passive House data: Airtightness 0.11 ACH @ 50 Pa, annual heating demand 15 kWh/(m²a), heating load 15 W/m².

Insulation: Underslab R 4.7 TYCO extruded polystyrene, wall R 3.4 Ozone SIP panel, roof R 5 Askin sandwich panel with XFlam foam.

Windows and doors: glazing—Saint Gobain Planitherm Climaplus Ultra N 6/16Ar/6LE g-Value 0.61 (similar to SHCG), Ug Value = 1.14 W/(m²K). Frame—Inoutic Elite uPVC.

Mechanical ventilation with heat recovery: Zehnder ComfoAir200.

Hot water system: Sanden Eco heat pump.

Airtightness layer: Pro Clima Intello Plus wrap with Tescon Vana airtightness tape.

Credits

Building designer and Passive House calculations: Harley Truong

Architect: Andrew Verri

Structural engineer: John Skurr Consulting Engineers

Builder: RJ Building ACT Pty Ltd—Richard Philippa and Jorg Staufenbiel

Mechanical ventilation supplier: Air2Energy.

Window supplier: Sustainable Building Resources

Air pressurisation tester: AJP Engineering

Passive House certifier: Peel Passivhaus Consulting, Canada.