RACE for 2030

RELIABLE
AFFORDABLE
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ENERGY

Enhancing home thermal efficiency

APY Lands retrofit pilot

Year 1 Impact Report

September 2025

Australian Government
Department of Industry, Science and Resources

Cooperative Research Centres Program

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APY Lands Energy Efficiency Retrofit Pilot

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Citations

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Acknowledgement of Country

The authors of this report would like to respectfully acknowledge the Traditional Owners of the ancestral lands throughout Australia and their connection to land, sea and community. We recognise their continuing connection to the land, waters, and culture and pay our respects to them, their cultures and to their Elders past, present, and emerging. We acknowledge that everything we do in this project impacts on Aboriginal country and Aboriginal people. We are ready to walk, learn and work together.

What is RACE for 2030?

Reliable, Affordable Clean Energy for 2030 (RACE for 2030) is an innovative cooperative research centre for energy and carbon transition. We were funded with $68.5 million of Commonwealth funds and commitments of $280 million of cash and in-kind contributions from our partners. Our aim is to deliver $3.8 billion of cumulative energy productivity benefits and 20 megatons of cumulative carbon emission savings by 2030. racefor2030.com.au

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Project Partners

Contents

Executive Summary

The harsh desert conditions of the remote Aṉangu Pitjantjatjara Yankunytjatjara (APY) Lands present unique challenges for thermal comfort and energy efficiency in housing. With climate projections indicating hotter summers and more extreme weather by mid-century, the ability of Aboriginal people to continue living well on Country is a growing concern. This pilot project is exploring and testing upgrades to houses within one APY community, with the aim of providing a model for roll-out throughout the region, and inform the development of comparable programs across Australia.

Within our first year, we have assessed the thermal and energy performance of homes in the community, engaged with residents and stakeholders, evaluated numerous building envelope upgrades, and completed retrofits in six pilot houses.

We measured the baseline performance of houses within the community and learned how residents feel in their homes and how they keep warm in winter and cool in summer. Monitoring equipment installed in each pilot and reference house is providing pre and post-retrofit data on thermal comfort and energy use. While householders were relatively satisfied using existing evaporative cooling systems in summer, winter discomfort and high heating costs remained key issues. The building assessments highlighted uncontrolled air leakage and thermal bridging of insulation layers (heat conduction through steel framing) as key contributors to poor thermal performance in every home.

Working with our industry partners, we evaluated a range of insulation and airtightness solutions to these problems. Energy modelling software allowed us to predict the relative impact of each solution under current conditions, and to assess climate change resilience using future weather projections. In parallel, we trialled the installation of the proposed solutions in two test rooms in Adelaide, to assess feasibility and resolve problems before attempting the work in the remote pilot location. From these evaluations, we devised three levels of retrofit, cumulatively addressing (1) airtightness, (2) ceiling insulation and thermal bridging, and (3) thermal bridging in walls.

All major building envelope retrofits are now complete, using materials supplied by our industry partners. Throughout the installation process, we worked closely with the local maintenance contractor, whose staff took a keen interest in the rationale and results of the upgrades. Using materials developed for our trade skills training program, we provided on-site training at each stage of the upgrade work. Informal testing and interviews of householders indicated measurable improvements in airtightness and a feeling that homes with insulation upgrades were staying cooler for longer in hot weather. Ongoing monitoring and re-testing in 2025 will provide a rigorous evaluation of retrofit performance.

Active engagement has been instrumental in our achievements to date. The on-site presence of the project team during installation supported workers in problem-solving and helped verify the correct application of methods. The level of interest shown by the contractors was reflected in the high quality of their work. Engaging local energy education workers allowed us to interview residents in their own language and recruit interested households. Our industry partners have demonstrated a high level of commitment and enthusiasm throughout the project. Perhaps most importantly, the interest in the upgrades and the underlying science among the participating households gives a positive indication of the potential for lasting benefits.

1 Project Background

While Aboriginal people have lived in Australia's Western Desert for tens of thousands of years, temperature extremes and associated severe thermal stresses have become more pronounced over the past century and are compounded by complex social and logistical challenges. With broader climate extremes and overall hotter summers predicted for the future, how people are living and maintaining healthy communities on Country is of growing concern. This project is investigating and providing solutions to challenges for energy performance and thermal comfort faced by Aboriginal people living in remote housing, specifically in the extremely harsh and variable climate conditions of the Aṉangu Pitjantjatjara Yankunytjatjara (APY) Lands.

> *'Healthy and efficient housing is a universal need, but the challenges of the APY environment are unique and add several layers of complexity. Seeing some of these challenges first-hand through testing and surveys was eye-opening.'*
>
> **Sean Maxwell**, Air Tightness Testing and Measurement Association

We are conducting a retrofitting pilot to test the effectiveness and financial viability of various energy efficiency solutions for houses of different ages and constructions, with the goal of replicating successful measures throughout the region. Data and experience captured in the pilot can also inform future upgrades in other remote locations with similar challenges, and in existing homes across Australia.

Figure 1. A recently built house on the APY Lands, with similar construction to those in the study

Figure 2. Map showing location of the APY Lands (outlined in Red) in central Australia.

Map created using Digital Atlas of Australia (digital.atlas.gov.au).

2 Year 1 Highlights

YEAR 1 HIGHLIGHTS

15
PROJECT PARTNERS

15
INDUSTRY REFERENCE GROUP MEMBER ORGANISATIONS INVOLVED

20
HOUSEHOLD INTERVIEWS & RAPID THERMAL PERFORMANCE ASSESSMENTS

12
HOUSES FITTED WITH ELECTRICITY AND THERMAL COMFORT MONITORING

128
RETROFIT SCENARIOS MODELLED

13
THERMAL BRIDGING MITIGATION UPGRADES EVALUATED

2
TEST ROOMS CONSTRUCTED

6
HOUSES RETROFITTED

3
INDUSTRY REFERENCE GROUP/ STAKEHOLDER WORKSHOPS

3 Stakeholder engagements

Engagement with the community in which we are conducting the pilot is a key component of our work. Initial conversations with households allowed us to introduce residents to the pilot and gauge interest in participation. Continuing to consult with stakeholders in the community has helped to maintain the local buy-in critical to making a lasting impact. Households participating in the pilot have shown interest in the principles being applied in their homes, which helps in our goal of building awareness around energy efficiency. The Community Council have expressed ongoing enthusiasm for the project, and feedback from prominent community members continues to inform it's development. In particular, Industry Reference Group members with connection to First Nations communities, and Aṉangu[1] Energy Education Workers (employed through MoneyMob Talkabout), have contributed to the development of our household education strategy.

Early engagements with partners, Healthabitat and Nganampa Health Council, helped us to understand the experience of others working to improve remote Aboriginal housing and health in other jurisdictions. Through their shared experience in household energy use and thermal comfort, we were able to refine our scope and methods, and familiarise our industry partners with the complexities and challenges particular to the region. They also contributed to the initial analyses of housing performance.

'I have been impressed with the professional application to the context and demands of the project, noting the well delivered cross cultural interactions required on each trip and the demonstration of respect to all the participating householders.'

Stephan Rainow,
Nganampa Health Council

Our industry partners have maintained a strong commitment to the project, and a keen interest in the work and its outcomes. Technical Working Group members from the building insulation and airtightness sectors were highly engaged with both developing solutions to the priority issues and evaluating their suitability against our specific criteria. Training materials developed by our partners have already been used for preparing crews for installation work, and will contribute to ongoing work in community education. The project benefits substantially from the willingness of partners to work collaboratively across problem-solving, materials selection, logistics, and training.

Sharing the basics of the science behind the issues identified, the rationale for each solution, and updates on implementation and testing, has resulted in a high level of engagement from households, industry partners, and the installation contractors, Furnell Plumbing. The outstanding level of interest from Furnell contributed to the high quality of the retrofit installation work. They worked closely with the project team, who provided on-site training prior to each stage of installation.

[1] Aṉangu, meaning "people", is used when referring to Aboriginal peoples of the Western Desert region.

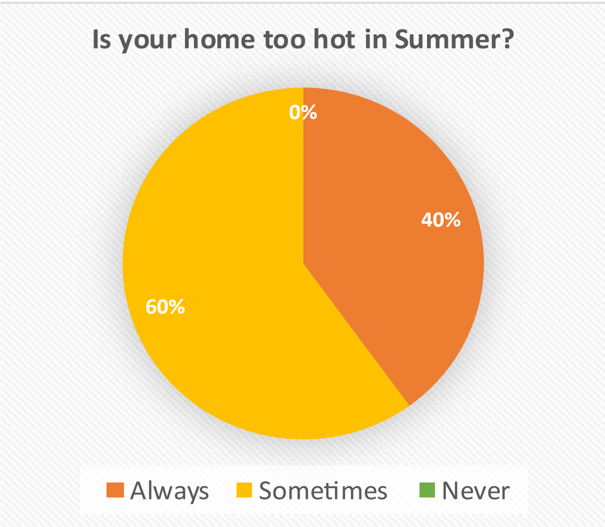
4 Baseline house assessments

Baseline assessments of houses in the APY communities defined clear target issues to address in developing our retrofit strategy, and highlighted challenges specific to the region. Key results are outlined below.

4.1 Household interviews

Like many households throughout Australia, APY residents reported that their houses were hot in summer and cold in winter (Figure 3). In interviews with 20 households in October 2023, more than half the respondents said their house was always too cold in winter. Comments about cold air entering the house in winter were common. Although combustion heaters are installed as standard, access to fuel is limited. All households use electric radiant heaters and around half also use ovens to stay warm. Interviews suggested that people were conscious of energy costs for heaters and attempted to limit the use of ovens for heating, following a Department for Energy and Mining education program in the community from 2021 to 2023.

Nonetheless, over half of the households interviewed used heaters in winter at all times when home, or all day and night. These responses are consistent with the high winter consumption in the electricity supply records. While 40% of households reported their home was always too hot in summer, we clarified that heat discomfort generally related to problems with the evaporative cooling systems. Over summer, about two thirds used evaporative cooling all day and night, or at least when home. Because fresh air is valued, windows are frequently opened in winter as well as summer. Maintaining comfortable conditions is even more challenging in large households, which are common in the APY Lands.



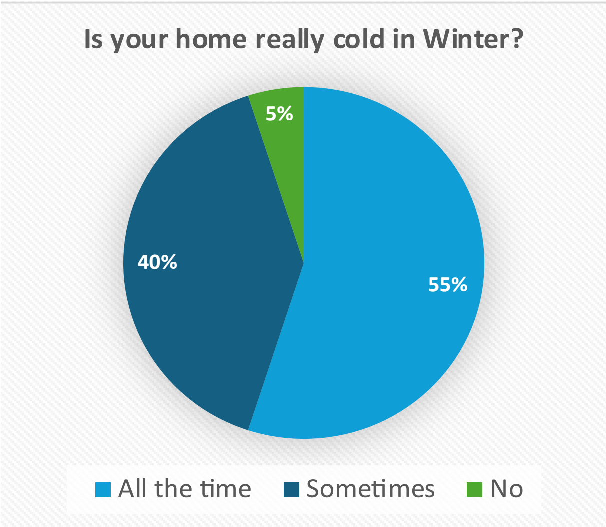


Figure 3. Households reported that their homes were too hot in summer and too cold in winter, at least some of the time. Over half told us their houses were always cold in winter.

As Pitjantjatjara/Yankunytjatjara are first languages in the APY Lands, conducting interviews in English would present a barrier to understanding each other. Cultural differences must also be considered in preparing interview questions. The questions were reviewed by the Iwiri Aboriginal Corporation, to ensure they were culturally appropriate and could be readily understood. Local Aṉangu Energy Education Workers, employed through MoneyMob Talkabout, accompanied project team members during the interviews, to interpret questions and responses between English and Pitjantjatjara. They also clarified with further questions when necessary, allowing a more nuanced understanding than purely delivering questions to a formula.

4.2 Building assessments

Measuring the thermal performance of 20 houses in the APY Lands in August 2023, highlighted thermal bridging and uncontrolled air leakage as prominent issues. Additionally, some sections of bulk insulation were missing, disturbed, or compacted, with instances of damage by rodents.

Thermal bridging occurs when a heat-conducting material spans an insulating layer, and was apparent in all houses. In the walls and ceilings, the insulation batts are interrupted by steel framing (Figure 4). The high thermal conductivity of steel allows a large portion of heat flows to bypass the insulation between the interior and exterior cladding. Infrared imaging indicated a lack of effective thermal breaks between the frame and steel cladding.

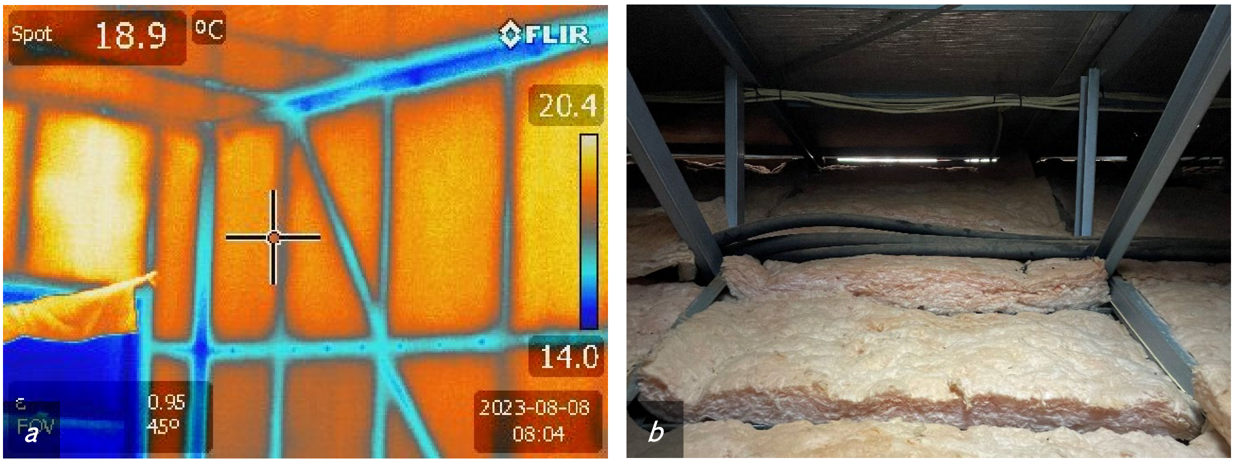


Figure 4. Thermal bridging across the steel framing in the APY houses. (a) The temperature differences shown by infrared imaging highlight the impact of thermal bridging via wall framing. (b) The roof trusses introduce gaps that allow heat to bypass the ceiling insulation; this photograph also shows age-related compaction of the insulating batts.

Air leakage (Figure 5) increases the amount of heating and cooling needed to maintain comfortable conditions. The houses tested in the APY Lands averaged a leakage of 28 air changes per hour (ACH) at 50 Pa of pressurisation (standard test conditions). In comparison, the 2022 National Construction Code (NCC) specifies a maximum leakage corresponding to 10 ACH for newly constructed houses.[2]

Nonetheless, 90% of the APY home results were within the range reported in a 2015 CSIRO assessment of existing homes in Australian capitals (most no more than three years old).[3] The best airtightness in our testing was 10.3 ACH at 50 Pa, suggesting that dramatic improvements are possible without substantial design changes.

While air leakage was widespread, the evaporative cooling system contributed around **one third** of all leakage measured. Other leakage paths included junctions between internal wall and ceiling surfaces, architraves, door

[2] H6V3 – Verification of building envelope sealing, NCC 2022 Volume Two – Building Code of Australia Class 1 and 10 buildings. https://ncc.abcb.gov.au/editions/ncc-2022/adopted/volume-two/h-class-1-and-10-buildings/part-h6-energy-efficiency

[3] Ambrose MD and Syme M (2015). House Energy Efficiency Inspections Project – Final Report. CSIRO, Australia. https://research.csiro.au/energyrating/wp-content/uploads/sites/74/2016/05/House-Energy-Efficiency-Inspect-Proj.pdf

seals, combustion heater flues, and kitchen and bathroom exhaust fans. Airtightness problems showed no correlation with building age but did show some relation to the overall condition of the homes.

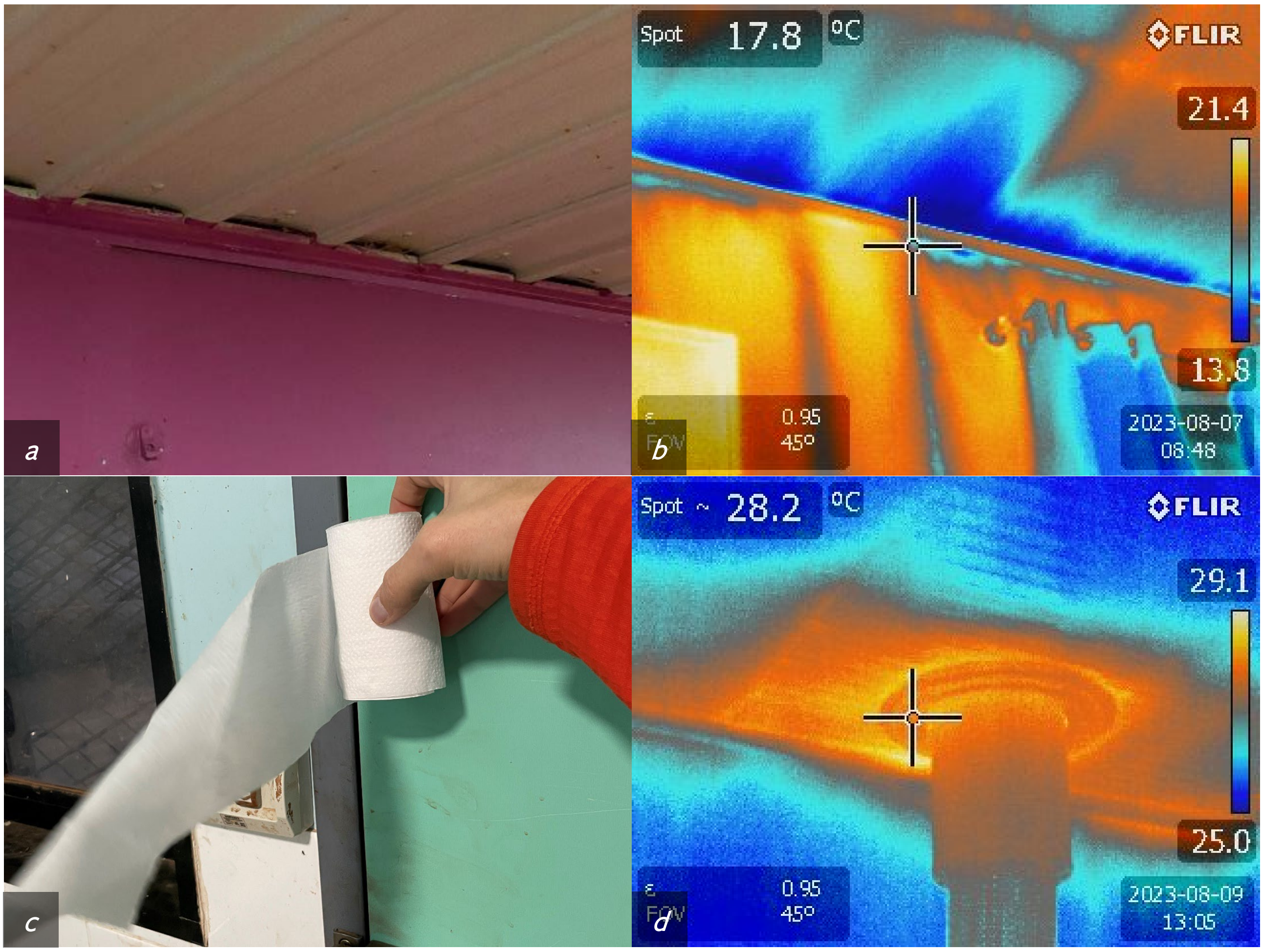


Figure 5. Examples of air leakage routes in the APY houses: (*a*) gaps at cornices; (*b*) infiltration via the cornice junction is highlighted as a cold surface in an infrared image; (*c*) blower door testing reveals air leakage via an unsealed door; (*d*) thermography shows infiltration at the flange of a combustion heater flue (heater not in use), and the effect of missing insulation.

There was considerable variability between the houses tested, both in construction and condition. Although the variability presents challenges in measurement, analysis, and retrofitting, it is a factor that must be addressed in designing and implementing any large-scale rollout of upgrades. By probing specific air leakage paths and thermal imaging, we could identify key issues common to all houses, including hidden defects in insulation.

Buy-in from households was essential to testing, as it required full access to the homes—in some cases including opening the building fabric. Household visits with Energy Education Workers were again invaluable. Testing was conducted by industry partner, the Air Tightness Testing and Measurement Association, assisted by LBS Consulting.

4.3 In-home electricity and thermal comfort monitoring

We installed monitoring equipment from Powertech Energy—a key partner in our Pilot project—in six baseline and six retrofit houses, to track air temperature, humidity, and electricity consumption. Energy use is individually measured for ovens, electric boost for solar hot water systems, evaporative coolers, and refrigerators, with real-time and historical data accessible via a cloud-based dashboard. In addition to providing the monitoring equipment and the data dashboard, Powertech Energy continues to support troubleshooting and processing the complex and highly variable data.

The baseline data from in-home monitoring confirmed heavy reliance on evaporative cooling during summer and indicated that these systems are able to maintain comfortable indoor conditions with outside temperatures up to 45°C. Monitoring bar heaters in selected houses during winter also revealed instances of extremely high electricity consumption, which is again consistent with DEM's historical demand data. Figure 6 shows the relative contributions of the monitored appliances to daily electricity consumption over the cooler months of 2024.

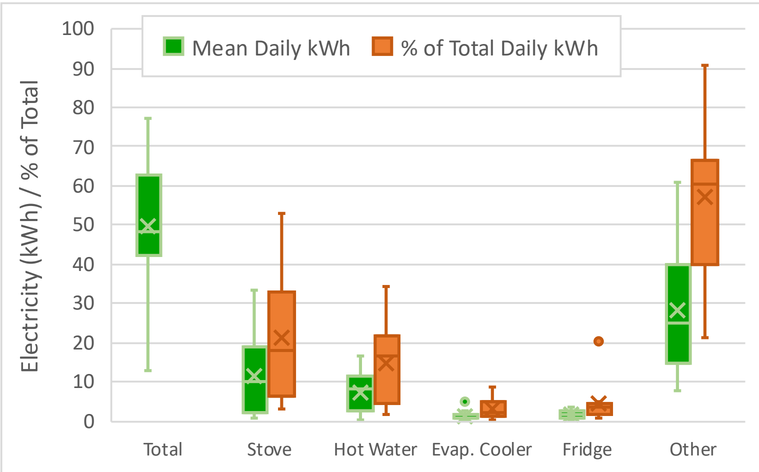


Figure 6. Breakdown of electricity consumption by appliance/circuit, for the 12 study houses, May to September 2024. The high stove usage and its wide variability are consistent with its use for heating in some homes. The hot water figures indicate electric boost usage. Because the time period is heating dominated, "Other" includes bar heaters in many, if not all, homes, and evaporative coolers were infrequently used. In the plot, the boxes indicate the 25th to 75th percentile ranges, the horizontal lines within each box indicate the medians, crosses indicate means, and circles are outliers.

4.4 Modelling baseline performance and energy demand

The most recent APY houses in our study were rated above eight stars (out of a maximum 10) in the Nationwide House Energy Rating Scheme (NatHERS)—a rating verified by our colleagues at CSIRO Energy. At the time of construction, the National Construction Code required six stars for energy efficiency compliance. The high rating likely reflects features designed to exclude heat, including the deep, wrap-around verandas, the low window-to-wall ratio, and high insulation specifications. The measured thermal performance and reported comfort of residents seems inconsistent with this high rating.

This discrepancy in energy efficiency and thermal comfort, between what is expected from the energy rating *as designed* and experienced in the house *as built*, appears common throughout Australia. The Construction Code does not provide for verification that a completed house meets the specifications by which its energy rating was achieved. A key component in our energy modelling and simulation was therefore to represent, as accurately as possible, the thermal performance impacts of the air leakage, thermal bridging, and insulation defects identified during the building assessments. These issues are likely present in all APY houses.

4.5 Thermal performance and energy demand modelling

To evaluate thermal comfort and energy usage in the houses as-built, and to predict the efficacy of each upgrade considered, we developed models of three- and four-bedroom APY houses using the DesignBuilder software (Figure 7). We characterised thermal comfort in terms of the annual hours outside an extended "comfort" range of 15–30°C, excluding the use of heating and cooling appliances to focus on the building envelope. By introducing measured air leakage rates, and thermal bridging calculated according to construction details,[4] we could simulate the "real world" performance of the houses. According to the calculations, which we consider a best-case scenario, thermal bridging through the steel framing reduced the thermal resistance of the bulk insulation by more than half. We are continuing to investigate the impacts of thermal bridging and how best to mitigate them.

In line with household interviews, our initial simulations showed 3.5 times as many hours below 15°C as above 30°C, over a full year, for the baseline three-bedroom house without any air conditioning (Figure 8). This was also reflected in our estimates of heating and cooling demand, which were consistent with the high winter electricity use recorded. By improving the airtightness from 29 ACH at 50 Pa (median for 3BR houses) to 10 ACH (best result from testing), the annual hours outside the comfort range were reduced by 16%. The modelling also showed that complete degradation of the bulk insulation had a more pronounced impact during hot weather, leading to a 120% increase in the number of hours above 30°C. By 2050, under a 'business as usual' greenhouse gas emissions scenario, this figure is projected to rise by 150%.

The disparity between hot- and cold-weather performance – and corresponding energy demands – highlight key challenges for energy efficiency upgrades. The houses' deep verandas help keep houses cool in summer, but also prevent winter sunlight from providing passive heating. Additionally, all APY households rely on radiant heaters for warmth, which lack the efficiency advantage of the evaporative systems used for cooling. Aṉangu are also far more tolerant of heat than cold.

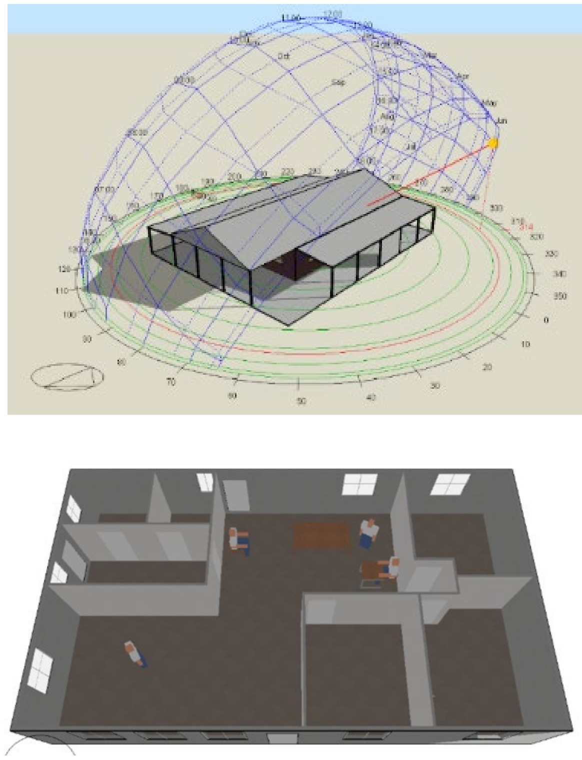


Figure 7. 3D DesignBuilder model of a typical 3-bedroom APY house design. The top diagram indicates the building orientation and the solar illumination paths over a full year.

[4] Using NZS 4214: 2006 – *Methods of Determining the Total Thermal Resistance of Parts of Buildings*, as referenced in the 2022 National Construction Code.

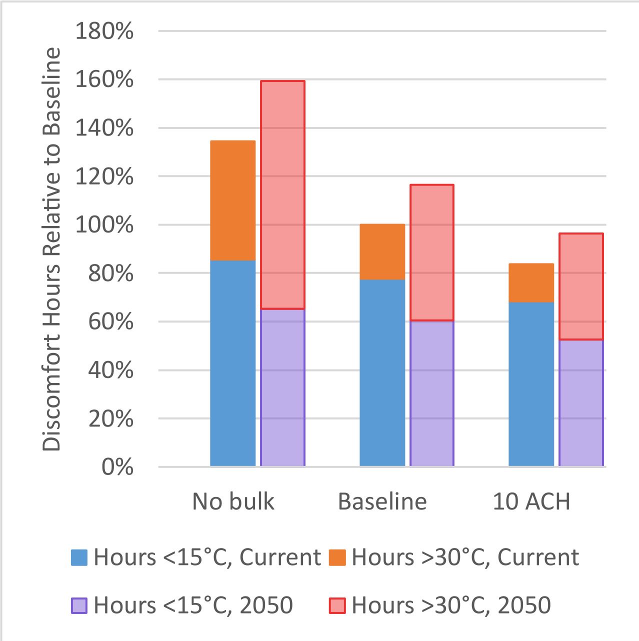


Figure 8. Effect of insulation condition, airtightness, and climate change on annual hours outside a comfort range of 15–30°C, without heating or cooling. Simulation results are expressed relative to the baseline model under current climate conditions. "No bulk" has all bulk insulation removed, representing an extreme case of degradation. "Baseline" assumes an air leakage of 29 ACH under 50 Pa test conditions, while the "10 ACH" models meet the 2022 National Construction Code's airtightness specification. The 2050 simulations assume a high emissions, "business as usual" climate change scenario.

A limitation we discovered in building energy modelling is in predicting thermal comfort and energy use under extreme conditions. The "typical meteorological year" datasets used for weather inputs, and the future weather projections derived from these, inherently exclude extreme temperatures including heatwaves. Such events are likely to exacerbate the impacts of climate change on thermal comfort and health, and on the peak demands of cooling systems and electricity supply. We have acquired Bureau of Meteorology data for the relevant climate zone and are investigating methods to explore such extreme weather scenarios in our modelling.

5 Retrofit strategy

5.1 Targets

By addressing the three types of thermal envelope issue highlighted by our housing assessments (Figure 9), our retrofit strategy was designed to reduce energy demand and improve comfort, by more effectively keeping heat out in summer and retaining heat in winter.

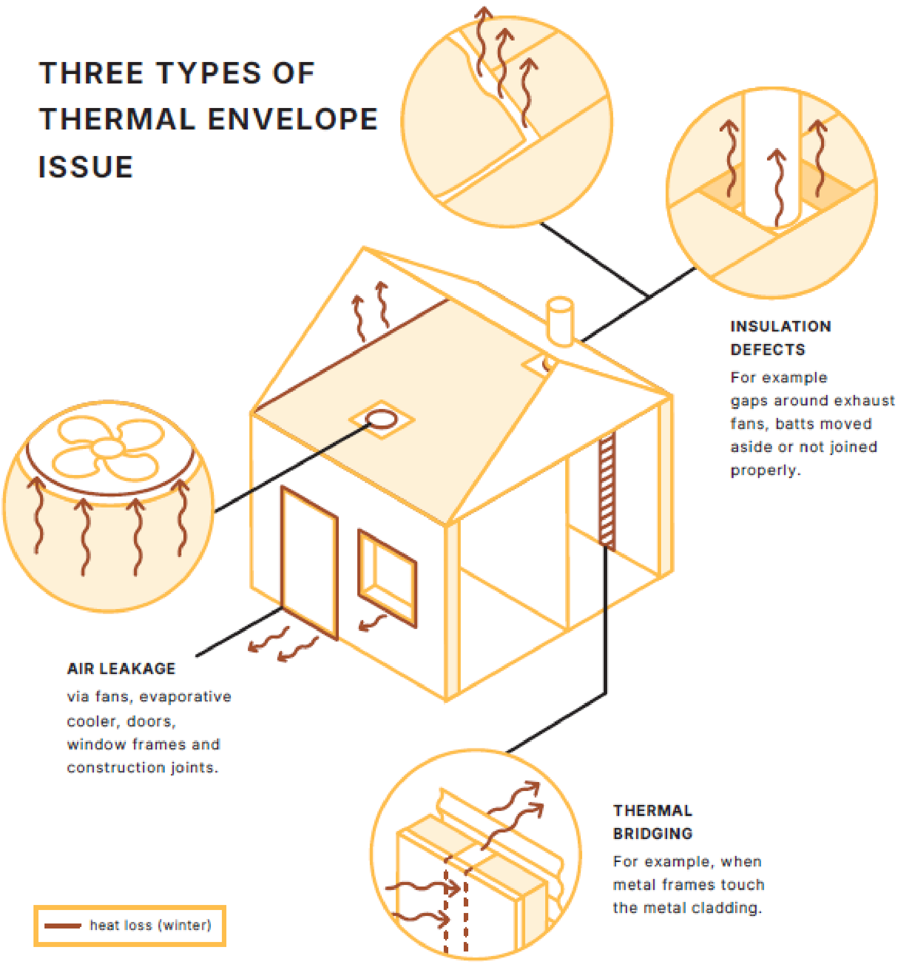


Figure 9. Our retrofit strategy targeted three main issues: air leakage, insulation defects, and thermal bridging.

Working with highly engaged industry partners from ICANZ, Kingspan, Sika Australia, ATTMA, Efficiency Matrix, Fletcher Insulation and CSR Bradford, we identified potential solutions to target problems in airtightness, thermal bridging, and insulation. Multiple thermal bridging solutions for external walls and rooves/ceilings (seven each) were assessed for retrofit suitability and their estimated impact on thermal performance and energy use.

We evaluated potential airtightness measures primarily on their practicality of installation and fitness for purpose, through trials in two purpose-built test rooms and on site. To complement simulation and installation testing, the retrofit suitability of solutions for ceiling and wall thermal bridging were ranked against weighted criteria addressing material costs, installation complexity, durability, maintenance considerations, independence from underlying conditions, and disruption to householders.

5.2 Simulations

We analysed the potential impact of each proposed thermal bridge mitigation and insulation upgrade (102 scenarios in total) on a three-bedroom APY house model using DesignBuilder. To predict the outcomes of airtightness improvements, we assumed that air leakage (at 50 Pa) could be reduced from 29 ACH to 10 ACH and this upgrade would be applied in all retrofits.

As depicted in Figure 10, airtightness improvements had the greatest individual impact on heating and cooling energy demands, and on maintaining comfortable indoor temperatures. Of the options simulated, a continuous, unbridged layer of 50 mm phenolic foam board (highest thermal resistance) was the most effective solution for thermal bridging in both walls and ceiling. This was also the highest-ranked solution in the structured decision-making process.

However, the range of improvements predicted within each class of solutions was narrow for most metrics. Wall improvements generally reduced energy demands more than the ceiling upgrades, particularly with respect to heating and where bulk insulation was degraded. However, we considered wall upgrades to be the most complex of the solutions.

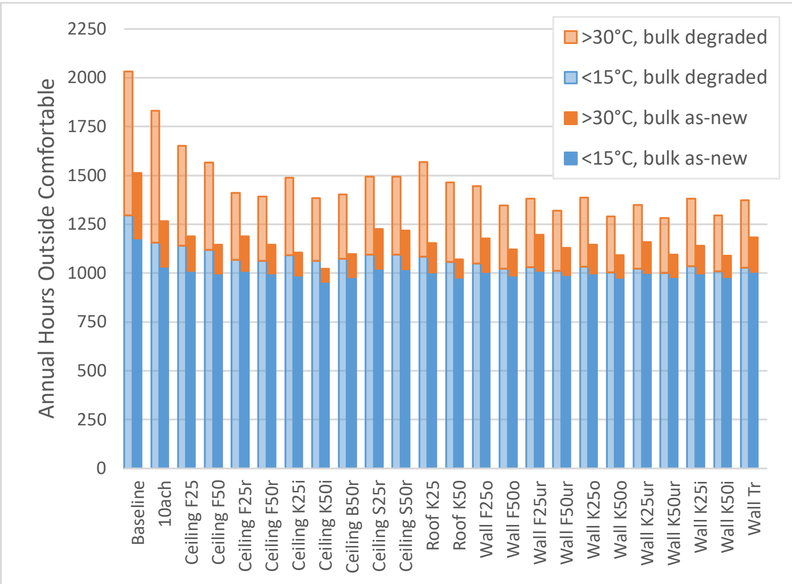


Figure 10. Example of simulation analysis. This shows the predicted impact of a range of individual retrofit solutions on the homes' ability to maintain comfortable temperatures without any heating or cooling. Again, the results are dominated by cold-weather discomfort (blue). The greatest individual impacts were in improving airtightness (10 ACH relative to 29 ACH Baseline) and in replacing degraded/damaged insulation (pale "degraded" vs dark "as-new" bars), with the latter having greater impact in hot weather.

Under a warming climate scenario, the simulations indicated that the number of hours above and below a 15–30°C "comfort" range would be approximately equal by 2050, particularly in baseline and degraded insulation scenarios. Although reduced, heating continued to dominate the total heating and cooling energy requirements, due largely to the far greater energy efficiency of cooling with evaporative systems relative to heating with bar heaters.

5.3 Implementation testing

The project team built two test rooms in Department for Energy and Mining facilities in Adelaide (Figure 11). These proved invaluable for exploring practical aspects of implementing the proposed retrofit options, before attempting in the remote pilot location where resources are limited. Their construction mimicked contemporary South Australian Housing Trust houses in the APY Lands. We also used the test rooms to demonstrate the final retrofit installation techniques to trade supervisors and trainers (Figure 19).

Testing allowed us to determine specific requirements for attaching the new insulation layers. It also revealed issues that helped to eliminate some options from consideration, including the excessive compression observed in code-complaint thermal break strips between the steel frames and cladding that would likely compromise their performance.

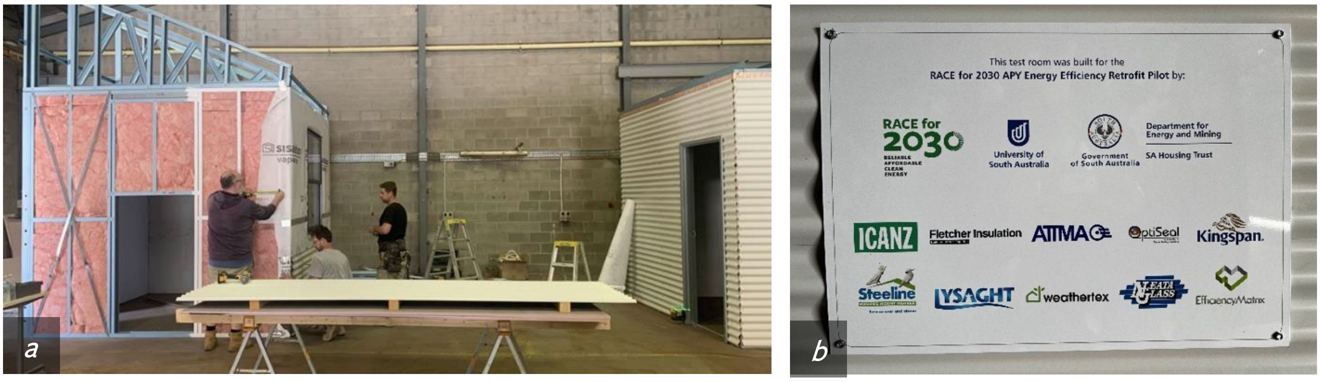


Figure 11. (*a*) Two 3 m × 3 m test rooms were built in Adelaide, mimicking the construction of houses in the APY Lands. (*b*) They were made possible through the support of industry partners and donors of materials: ICANZ, Fletcher Insulation, ATTMA, OptiSeal, Kingspan, Steeline Mt Gambier, Lysaght, Weathertex, Neata Glass, and Efficiency Matrix.

Figure 12. The team tested a wide range of gap-sealing options in the Adelaide test rooms.

We tested a wide range of sealing products and methods in the test rooms (Figure 12), in consultation with industry partners, to develop effective strategies for different air leakage areas in the building envelope. The APY houses posed unusual sealing challenges, which we assessed during the blower-door testing. This complemented earlier on-site tests and highlighted difficulties in sealing narrow, irregular gaps. The most effective solutions combined both design and material considerations.

5.4 Finalisation of strategy

We decided on three levels of retrofit, progressively addressing (1) airtightness, (2) insulation and thermal bridging at the ceiling level, and (3) insulation and thermal bridging in walls, as summarised in the infographic (Figure 13). The three levels correspond to increasing complexity as well as comprehensiveness. The Level 1 retrofit comprised a full suite of airtightness upgrades, including gap sealing, installation of new, self-closing extraction fans and installation of dampers in evaporative coolers. For Level 2 and 3 upgrades, we elected to test both a semi-rigid glasswool blanket and a rigid phenolic foam board as a continuous insulation layer. Bulk ceiling insulation was also replaced in Levels 2 and 3.

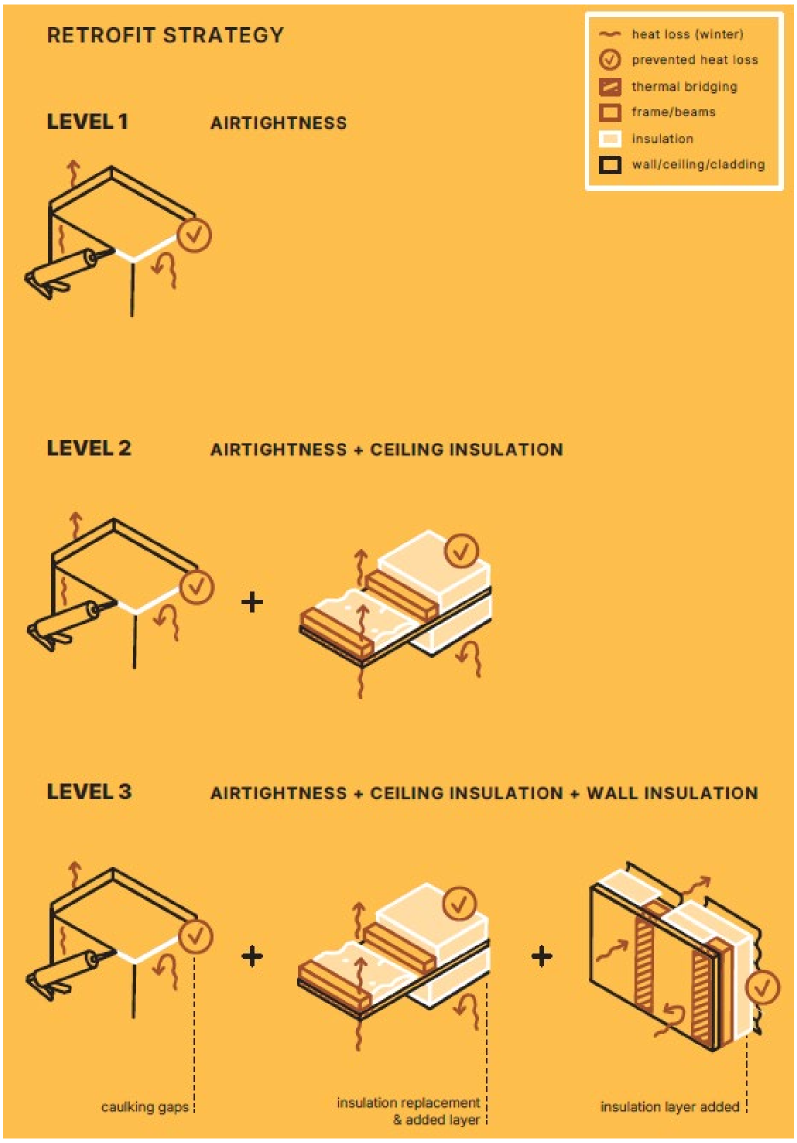


Figure 13. Summary of the retrofit strategy. Three levels of retrofit were developed, with each building on the last.

We used new simulations to assess each retrofit variant, considering both as-new and degraded insulation (Figure 14). As expected, greater retrofit levels yielded increased benefits, especially for internal temperatures without air conditioning. Airtightness had the greatest individual impact. Retrofits were most effective when degraded insulation was upgraded in both walls and ceilings (Level 3). Products for levels 2 and 3 performed similarly due to comparable thermal resistance. In the warm 2050 scenario, energy demand shifted from heating to cooling, with higher retrofit levels offering greater heat protection. Only the most comprehensive retrofit maintained current comfort levels without active heating or cooling under the future scenario with high-emissions conditions for 2050.

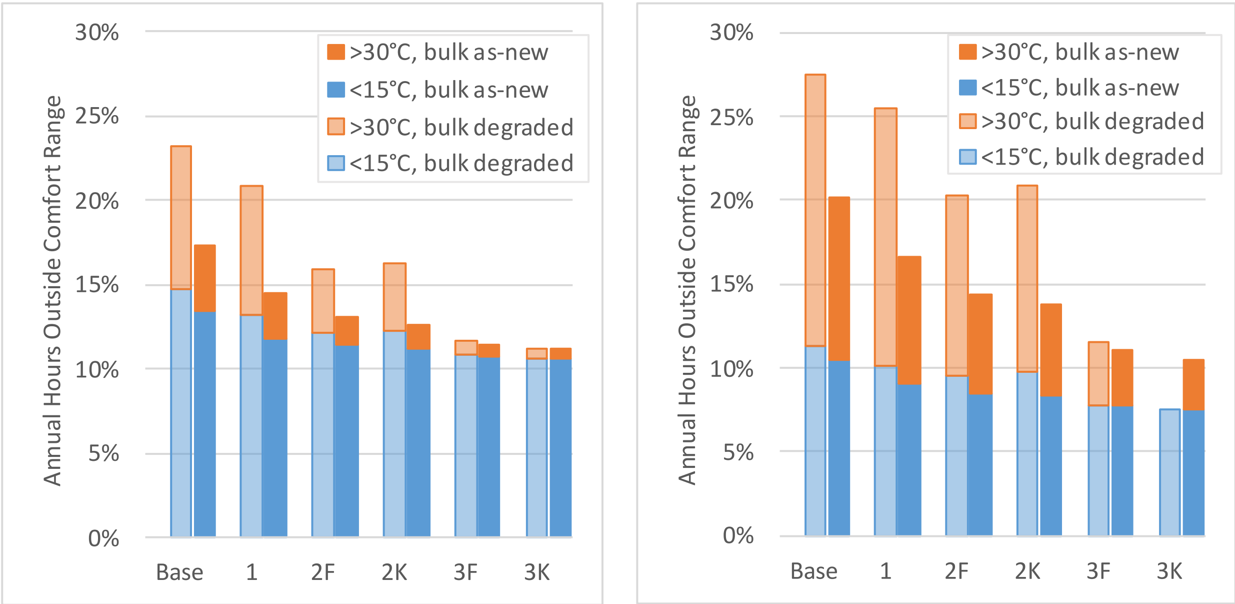


Figure 14. Retrofit impacts on living room temperatures without heating or cooling appliances, according to DesignBuilder simulations for a typical 3-bedroom APY house under (*a*) current climate conditions and (*b*) a high-emissions 2050 climate scenario. Solid and translucent bars represent intact and degraded bulk insulation initial conditions respectively. The codes represent the level (1–3) of retrofit, with F and K indicating variants using different insulation products.

6 Retrofit trial

Building envelope upgrades were installed between September and December 2024 (Figures 14 and 15). Retrofits were organised such that each level would be applied to one older (up to 2002 construction) and one newer house (from 2009 on). The selected households all participated in the initial assessments, with other selection criteria including standard designs, and length of remaining service life. The involvement of local Energy Education Workers was pivotal in recruiting households. An equal number of older and newer houses will serve as unmodified references (six in total). Monitoring is active in all retrofit and reference houses.

Figure 15. Example upgrades to address airtightness issues: (a) damper installed in evaporative cooling system; (b) door seal; (c) new cornice detail, applied to linings with caulking.

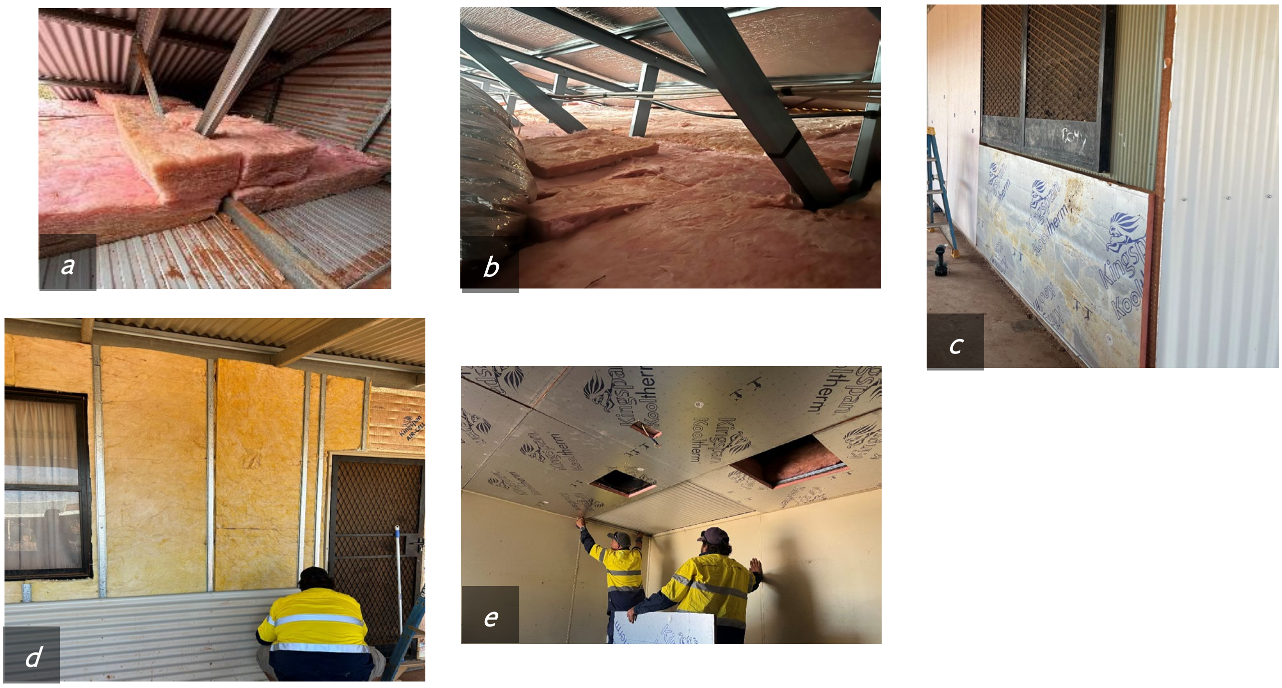


Figure 16. Installation of thermal bridging mitigation measures: (a) glasswool batt segments covering roof truss bottom chord; (b) semi-rigid glasswool rolled through trusses; (c) rigid foam board added to external walls; (d) semi-rigid insulation affixed to external walls with furring system; (e) rigid foam board added to ceiling.

Although test room trials solved many problems in advance, several issues needed to be resolved during installation. The project team and maintenance contractors worked together to modify the ceiling insulation upgrade in one instance, and trials of alternative airtightness solutions for combustion heater flues, door seals and narrow gaps are ongoing.

The presence of the project team on ground during retrofit works was valuable in terms of support, troubleshooting and ensuring correct application, as well as initial training. We note that inadequate compliance checking is a critical problem across the building industry. The team found Furnell's installation workers highly engaged and responsive throughout the retrofit process. Their involvement in preliminary testing sparked ideas for further potential improvements.

Likewise, householders and the broader community have shown interest in the science underpinning thermal comfort and the upgrades. The team is endeavouring to provide information to match and nurture this level of interest.

Installation during the pilot was labour intensive, but the time required for each component decreased with practice. As methods are optimised, the time required for troubleshooting is also expected to decrease. Additional training and/or supervision could further reduce the costs of both labour and materials. Ongoing refinement of our product selection may better accommodate the substantial variability among older houses in particular, in turn reducing the degree of supervision required.

Learnings from the pilot are already informing design and procurement for SAHT projects and industry partners are continuing to show the same goodwill to SAHT outside the project.

6.1 Preliminary assessments

The team conducted informal air leakage testing in five of the six retrofit houses in late November 2024, as an interim assessment of upgrades to that time. All showed clear improvement and, in the first house to receive the majority of the planned airtightness upgrades, the leakage reduced to less than half that measured initially. A full re-assessment will be completed in the winter of 2025.

In addition, we asked the four available retrofit households which, if any, differences they noticed. Three of four felt that the houses were remaining cooler for longer. The other home required substantial additional gap sealing at the time. We will conduct comprehensive follow-up interviews alongside the final building assessments, again with the assistance of local Energy Education Workers.

'(We are) proud to know our insulation materials can be retrofitted into older buildings, bringing them up to a performance that meets today's standards and makes a difference in comfort to people living in areas with extreme weather.'

James Pinyon, Kingspan

7 Trade skills training

As well as trialling upgrades in the APY Lands, the project aims to build capacity for energy efficiency retrofit work, in the region and across Australia. Although this work is ongoing, materials developed by our training partners has already been used in training the retrofit installation crews (Figure 17). These included ICANZ instructional videos and its insulation handbook (accessed via CodeSafe's QIN platform – Figure 18), modules from Pointsbuild, and educational videos from Efficiency Matrix.

Figure 17. Retrofit crews were trained in community, prior to each stage of installation work. Workers responded well to understanding the "why" as well as the "how".

A 'train the trainers' program was held in Adelaide over two days in July 2024 (Figure 19). The first day, delivered by the Australian Passivhaus Association, covered the principles of energy efficiency. The second day directly addressed the issues and solutions in the context of the Pilot, and featured demonstrations of retrofit installation and testing techniques using the purpose-built test rooms, led by Sean Maxwell from the Air Tightness Testing and Measurement Association.

The Pointsbuild Net Zero Energy Builder Scholarship was launched as part of the Adelaide training program, with the first ten scholarships awarded to attendees including members of TAFE SA, SAHT, the Master Builders Association, and Renewal SA.

Figure 18. ICANZ training materials, in the QIN mobile platform, were used in delivering training to the installation crews.

Figure 19. The two-day pre-retrofit training program in Adelaide covered building energy efficiency principles and strategies, the issues addressed in the Pilot, and how the solutions would be installed.

8 Keeping connected

Regular updates on the project's progress have helped maintain the high level of enthusiasm and engagement from our industry partners and Industry Reference Group (IRG). The project's IRG helps to ensure the needs of those with an interest in the housing and wellbeing of Aboriginal people, particularly in remote regions, are considered in our work and its recommendations. Crucially, it helps us to understand issues experienced by APY Lands and other First Nations households, and to maximise the positive impact of our work in Aboriginal communities. IRG discussions have informed our ongoing investigations of efficient heating and cooling solutions, and community education in particular, as well as fuelling interest in thermal bridging and other opportunities for upgrades to housing components. With members across Australia, the IRG also forms a key part of spreading our learnings to inform future projects and programs.

'It has been insightful to be part of the multifaceted approach to the complex issue of thermal performance. Learning these lessons in real time via project updates has provided us critical queries to reflect on our own work.'

Justine Playle, Healthabitat

Table 1. Organisations represented in the Industry Reference Group

Organisations represented in the Industry Reference Group
Aboriginal Housing Northern Territory
Department of Communities, Government of Western Australia
Department of Energy, Mines, Industry Regulation and Safety, Government of Western Australia
First Nations Clean Energy Network
Gething Pty Ltd
Menzies School of Health Research
Mobile Language Team
Moneymob Talkabout
National Indigenous Australians Agency
NSW Department of Climate Change, Energy, the Environment and Water
RACE for 2030
Regional Engagement (APY Lands), University of South Australia
Resilient Building Council (to September 2024)
Sustainability Victoria (to November 2024)
Wilya Janta

9 The road ahead

With building envelope retrofits completed, the priority work for the second year of the pilot is to:

- measure the impacts of the upgrades,
- provide education to the community, so households can get the full benefits of the changes, and
- roll out training to develop local opportunities and capacity in relevant trades and build skills in energy efficiency retrofitting across Australia.

A further component is to evaluate potential upgrades to heating and cooling, with a particular focus on efficient heating.

Outcomes will be detailed in the Pilot's final report, to be completed in December. We will continue to engage with our industry partners and Industry Reference Group, to disseminate and leverage our findings, with a final Workshop to be held in late 2025.

In the meantime, our Pilot and partnerships are already informing SA Housing Trust new-builds and upgrade opportunities.

9.1 Retrofit evaluation

Ongoing monitoring will enable us to compare electricity consumption and thermal comfort between upgraded and reference houses, and to performance before the retrofit. Follow-up building thermal assessments and household interviews are scheduled for June 2025. Combining the results of these evaluations with projected roll-out costings and simulation data will allow us to present a cost–benefit analysis.

9.2 Community education

The way residents use their homes is critical to benefiting from the energy efficiency retrofits we have implemented. We are developing education materials to build awareness of energy efficient behaviours, in consultation with Industry Reference Group and community members, and drawing on the behavioural psychology expertise of our Energy Upgrades for Australian Homes colleagues. Print and video resources in Pitjantjatjara and English will support in-person engagement, and content for local social media will help build momentum.

9.3 Trade skills training

2025 will see the launch of the Pilot's Learning Hub on the Net Zero Energy Builder website, and completion of a comprehensive training video. The video will highlight the key problems identified in our work and how to implement solutions, with a strong focus on the type of construction used across the APY Lands. It will incorporate content from our work in the community and new material from our industry partners.

9.4 Heating and cooling

While upgrades to the building fabric are aimed at reducing energy demands for heating and cooling, appliance upgrades are an opportunity to lower the cost of meeting these demands. We are investigating alternatives to the existing bar heaters, wood stoves, and evaporative coolers. Our focus is equally on reliable technologies suited to the challenging environment and increasing energy efficiency. In this work, we are again drawing on the expertise of our Industry Reference Group and engaging with the Heating, Ventilation and Air Conditioning industry.

10 How to connect with us

To learn more about what's been achieved in this pilot, its latest updates, and what's planned next, please get in touch with us by contacting our project leaders:

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11 Appendix

11.1 Figures

11.2 Tables

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RACE for 2030

Australian Government
Department of Industry, Science and Resources

Cooperative Research Centres Program