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Sustainable Indigenous housing in regional and remote Australia

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Contents

List of tables

List of figures

Acronyms and abbreviations used in this report

ABS	Australian Bureau of Statistics
ACHP	Aboriginal Community Housing Providers
AHO	Aboriginal Housing Office (New South Wales)
AHURI	Australian Housing and Urban Research Institute Limited
AIHW	Australian Institute of Health and Welfare
ANAO	Australian National Audit Office
APO NT	Aboriginal Peak Organisations Northern Territory
APY Lands	Anangu Pitjantjatjara Yankunytjatjara Lands
ARIA	Accessibility Remoteness Index of Australia
BOM	Bureau of Meteorology
CDP	Community Development Program
COFFR	Council on Federal Financial Relations
COVID-19	Coronavirus Disease 2019
CTG	Closing the Gap
DES	Department of Environment and Science (Queensland)
DIT	Department of Infrastructure and Transport (South Australia)
DPTI	Department of Planning, Transport and Infrastructure (South Australia)
EHO	environmental health officer
GGAC	Gunida Gunyah Aboriginal Corporation
HI	heat index
HMO	home maintenance officer
HLPs	Healthy Living Practices
Housing SA	South Australian Housing Authority
HVAC	heating, ventilation and air conditioning
IPCC	Intergovernmental Panel on Climate Change
LCC	life-cycle costing
MSO	municipal services officers
NatHERS	Nationwide House Energy Rating Scheme
NATSISS	National Aboriginal and Torres Strait Islander Social Survey
NCC	National Construction Code
NHC	Nganampa Health Council
NHHA	National Housing and Homelessness Agreement
NOAA	National Oceanic and Atmospheric Administration
NPARIH	National Partnership Agreement on Remote Indigenous Housing
NPRHNT	National Partnership for Remote Housing Northern Territory
NT	Northern Territory
NSW	New South Wales

PMC	Department of the Prime Minister and Cabinet
QA	quality assurance
QLD	Queensland
R&M	repairs and maintenance
RASAC	Regional Anangu Services Aboriginal Corporation
UPK	Uwankara Palyanyku Kanyintjaku environmental health program
SA	South Australia

Executive summary

Key points

- **For Indigenous housing to be sustainable, it should be safe and humane. It should support householders to enact healthy living practices and secure their wellbeing and be provided in the places Indigenous people prefer to live to meet different needs and purposes.**
- **This requires a life-cycle approach to housing management, with appropriate levels of funding for planned and responsive repair and maintenance systems that attend to the functionality, quality and serviceability of a building, ensure safety, comply with statutory obligations, prioritise health hardware function, and protect householders from climate risks.**
- **Repair and maintenance activities are an inevitable cost in the life cycle of a dwelling. Construction defects, wear and tear, ageing and environmental factors impact on building components. Planned maintenance programs are important for sustaining higher levels of house function across time.**
- **Indigenous regional and remote communities will experience the negative impacts of climate change earlier and disproportionately, compared with most urban Australian settings. Funding for housing supply, design and maintenance must reflect this distribution of risk and higher cost.**
- **Modelled in terms of various climate, occupancy, ventilation and other scenarios, the thermal performance of existing and improved Indigenous housing currently fails to ensure the health, safety and comfort of householders.**
- **Addressing climate change in Indigenous housing and health policy is an urgent priority.**

Key findings

This research explores what is required for sustainable Indigenous housing in regional and remote Australia. It argues that sustainability should be understood in terms of the capacity of housing to confer positive health and wellbeing outcomes for householders, where housing stock is consistently maintained at high levels over time and is designed with current and future climate change challenges in mind. The priority of quality design and rigorous property maintenance should be to ensure householders can better exercise healthy living practices (Figure 1).

Current regional and remote Indigenous housing stock is unable to provide consistently healthy and comfortable indoor environments. There seems to be an unstated assumption that what is practically sustainable for governments and housing providers is the undersupply of substandard housing serviced by inconsistent repairs and maintenance (R&M). Operating and maintenance costs are three times greater for remote housing than in capital cities, so developing strategies to reduce these costs is a key goal. The adoption of life-cycle costing (LCC) frameworks offer potential to reduce expensive responsive repair work while guaranteeing amenity to householders. An LCC framework requires thinking of the lifespan and benefits of a structure within which savings might be derived by strategic investments. An LCC approach enables maintenance to be understood as:

- a central consideration in the design phase
- an investment to protect the value of a public asset
- a means of reducing significant costs later in the life cycle
- an essential requirement for improving the health and wellbeing of tenants.

Our research on housing management in the Anangu Pitjantjatjara Yankunytjatjara Lands (APY Lands) identifies features of effective property maintenance within current national policy constraints. Programs are required that prioritise maintaining housing health hardware through both responsive works driven by tenant notification and planned works. A planned multi-trade program significantly reduces travel expenditure by bundling work. This ensures houses are tended to (irrespective of tenant reporting) and it is more likely to maintain better-functioning housing than a responsive program. Where possible, parts and components are also standardised. Housing SA spends 52 to 57 per cent of their remote housing budget on planned maintenance, with only 20 to 26 per cent expenditure on responsive fix work. This distribution conforms to target benchmarks for planned maintenance in urban social housing, but it is rarely achieved in regional and remote housing.

Planned maintenance approaches also offer potential for local employment, including apprenticeships. Local employment is beneficial not only for community capacity but to improve the efficacy of maintenance programs. Such dividends require assured funding, contracts of appropriate length, an adequate volume of work, planning to distribute that work across a scheduled period and investment in trade training and administrative labour. For additional health and wellbeing gains, environmental health programs that operate inside and outside the fence line are also needed to complement property maintenance programs.

This report finds attention to climate change is not yet a feature of Indigenous housing and infrastructure agreements, with inadequate funding and attention paid to climate preparedness in new builds, refurbishments and retrofit programs. This is despite the impact of extreme temperature on both householder wellbeing and health hardware. Current consideration largely extends to the potential provision of split system air conditioning units for existing stock, meeting the minimal requirements of state/territory environmental design measures for new houses and residential tenancy acts for existing houses. Quantitative analysis of the resilience of existing housing stock (unimproved or improved to current construction recommendations) to the pressures of representative climate regions (tropical, arid and hot/mild) and for different heating and cooling scenarios (ventilation, occupancy, mechanical cooling, temperature) reveals the inadequacy of existing policy responses for current and anticipatable climate challenges.

When modelled for their performance under variable conditions of crowding and cooling systems, current Indigenous housing models are unable to provide resilience to different usage patterns and fail to provide comfortable and healthy indoor environments. This situation will worsen. Our simulation of the stressors experienced by housing registers the worst absolute conditions in tropical climate zones. However, it is within the hot/mild climate zone, representing a typical Australian hinterland area, where we calculate that the highest change in likely future energy consumption related to heat management will occur. Since regional and remote areas currently configured as hot/mild will experience comparable conditions with those now found only in tropical climates, this greatly exacerbates the health risks of vulnerable populations, if housing is not more comprehensively upgraded.

Temperature increase is already having significant effects in regional and remote areas, with predictions of higher frequency and intensity of extreme weather events, including heatwaves. Across Australia, a warmer climate will generally increase the energy consumed for cooling, while decreasing heating needs. Buildings must therefore provide better cooling performance, while minimising energy consumption by enhancing passive cooling opportunities. This requires design and refurbishment strategies including insulation, double glazing, energy generation technologies, mechanical and passive cooling and water management technologies. However, modelling of thermal loads shows that while retrofitting existing housing will assist habitability in the immediate to short term, such measures will be insufficient in the medium to longer term. That is, small-scale energy retrofits or reliance on mechanical cooling are necessary but inadequate interventions.

In urging attention to climate issues in relation to housing, it is important to recognise the place-based knowledge and practices of Indigenous people in adapting to Australia's diverse environmental demands and changing environmental conditions. Alongside Indigenous people's capacities to endure rapid and unsettling social, political and economic change, Indigenous histories feature resilience and self-reliance in adjusting to extreme or adverse weather events. However, resilience is not a rationale for the provision of substandard housing.

Policy development options

The clearest area requiring policy development identified by this research is clarifying the intent of sustainability and the associated funding requirements for Indigenous housing under climate change. Addressing the inadequacy of funding to the sector would first ensure the expansion of housing supply, which is no longer guaranteed in many areas, despite demographic increases and continued crowding. Our modelling clearly implies that *occupancy* remains a major driver in determining the cooling needs of Indigenous housing. Adequate funding must:

- enable planned and responsive repair and maintenance systems that increase the lifespan of housing stock and facilitate householders to exercise daily healthy living practices
- reduce current levels of crowding since occupancy levels are a major factor in determining housing performance
- provide people with more accommodation options across various locations
- develop new construction techniques and design strategies to ensure healthy indoor environments for the coming decades.

To this end, policy for sustainable housing must interrogate what is being sustained and specify commitments to standards that cannot be compromised on behalf of 'balancing' competing economic, social and environmental priorities. In many Australian jurisdictions, inadequate Indigenous housing stock of substandard quality is what is being 'sustained'. Sustainable houses are built with structural integrity and robust materials, given climate and household compositional requirements, and are maintained in good working order through effective planned and responsive property maintenance systems. Such systems prioritise health hardware function, not just asset management.

Property maintenance programs are inconsistent across the social housing sector and regional and remote Indigenous housing poses additional challenges to maintaining housing at high levels. There is significant potential for the expansion of planned maintenance programs underpinned by both life-cycle costing and an understanding of housing as a health amenity. Multi-trade planned maintenance programs that are effectively managed promise reduced repair costs over the medium to long term whilst maintaining houses at higher function, compared to what responsive programs can achieve. In turn, planned maintenance programs are likely to improve health outcomes for householders, to support local employment more effectively and to reduce government expenditure in other sectors, especially where property maintenance is augmented by environmental health programs. It is likely that the more comprehensive redesigns and attendant maintenance required for housing to remain health-conferring under more extreme climate conditions will cost far more than is currently allocated to even standard issue housing. Using modified LCC frameworks, further policy-related research is needed to model these cost factors.

Planned maintenance programs should be further examined for their capacity to support local Indigenous employment. This report outlines factors that should be addressed for maintenance programs to provide such employment, which could be incorporated into proposals for remote employment reform, such as the Aboriginal Peak Organisations Northern Territory (APO NT) proposal to abolish the Community Development Program (CDP) to be replaced by a federally-funded Remote Development and Employment Scheme (APO NT 2020).

Current state and territory and federal housing policies and related bilateral agreements do not mention climate change nor adaptive measures for extreme weather events, and national schemes to improve dwelling thermal performance have no legal enforceability. These regulatory inadequacies will become more apparent with climate change and will be exacerbated by the scant detail on issues of housing quality and maintenance under current Closing the Gap commitments. The mandate to hold Indigenous housing construction, refurbishment and maintenance to high standards and key health considerations needs to be annexed to policy and funding. Intergovernmental discussions should take place to clarify funding strategies, ensure health hardware provision, establish standards for manufacturing and maintenance approaches, and plan for climate appropriate housing. Techniques such as better-designed window shadings, improved glazing systems, higher insulation standards, improved thermal mass and augmented natural ventilation must be placed at the core of Indigenous building design practice.

There is a vacuum of cross-jurisdictional engagement within the Indigenous housing sector. This means good practice in housing management and design is not broadcast, inappropriate housing continues to be built, and programs are not funded for best practice. There are gains to be made in the exchange of knowledge regarding the design of specific hardware items and economies of scale to be realised in the manufacture and distribution of new technologies.

Any improvement in Indigenous housing outcomes requires greater and sustained investment from the Australian Government. Improved engagement between state and territory housing authorities offers the potential to develop coherent strategies to compel federal commitments to sustainable funding, rather than intermittent or 'walk away' money. Governments might consider engaging AHURI as an appropriate body to support this policy dialogue.

The gap between present practices and the goals of instituting robust design and effective repairs and maintenance systems will become harder, not easier, in the coming decades. Tacit decisions are already being made not to 'over-invest' in climate-proofing legacy housing stock in outer regional and remote communities. At the least, these conversations should be made more explicit, to enable residents to have greater agency in deciding future options and for Indigenous organisations to determine appropriate responses. Covert policy withdrawal is an unacceptable resolution. Our preliminary analyses of methods for modelling the efficiencies that could be gained from more climate-ready designs and targeted interventions for intermediate gains suggest the benefits of acting early. Further research is also urgently needed to understand current housing performance, how R&M programs can support adaptation to climate change, develop design solutions and identify policy frameworks that Indigenous and other decision makers might consider, going forward.

The study

This report has sought to clarify what sustainable Indigenous housing requires now and into the future. We have targeted two regions—the A<u>n</u>angu Pitjantjatjara Yankunytjatjara (APY) Lands in South Australia and north-western regional New South Wales (NSW)—to assess R&M requirements and the on-the-ground challenges of asset management in the context of climate change. In these contexts, Indigenous property and tenancy management practices are well developed and operating within relatively stable and highly principled organisational systems. We additionally simulated housing performance drawing on data from Borroloola (NT), Alice Springs (NT) and Moree (NSW) to represent the three climate zones (tropical, arid and hot/mild) where most Indigenous people in remote and regional Australia reside.

The research was conducted in partnership with Healthabitat, Nganampa Health Council, the Aboriginal and Remote Housing section of Housing SA and the Gunida Gunyah Aboriginal Corporation. Support for coding Housing SA data was provided by Dr Zoei Sutton, University of Adelaide. Support for virtual modelling for Indigenous housing was provided by Dr Aysu Kuru, University of New South Wales and Haniya Javed, University of Sydney. Additional pro bono support for climate data collation, analysis and visualisation was provided by the Sydney Informatics Hub Project Scheme, a Core Research Facility of the University of Sydney, and specifically by Dr Chao Sun and Dr Sabastine Ugbaje. Support for map design was provided by Isabella Sanasi. We employed a mixed-methods approach, comprising:

1. An evidence and policy review of literature on sustainable property maintenance models and climate change preparedness plans in Indigenous and other forms of social housing. The review also canvassed typical funding and policy settings at state, territory and federal levels and interrogated existing uses and definitions of the ubiquitous term 'sustainability', as it pertains to remote and regional Indigenous housing contexts. Emphasis was paid to material relevant to the case study regions of SA, NSW and the NT.
2. A program of empirical work conducted from July 2020 to February 2021. This involved 20 open-ended formal interviews conducted from July through November 2020 and fieldtrips to Alice Springs, the APY Lands and northwest NSW. Data analysis continued through to February 2021, using R&M log data from Housing SA, Nganampa Health Council and Gunida Gunyah Aboriginal Corporation; and Australian Bureau of Statistics (ABS) records of housing, demography and employment. Housing simulations were computed using transient thermal whole building simulation software, using field records taken in situ and architectural plans for characteristic housing types. Climate data was retrieved from the Queensland Department of Environment and Science and Bureau of Meteorology's partnership SILO data, the ABS, the Intergovernmental Panel on Climate Change and the American National Oceanic and Atmospheric Administration. Life cycle modelling used field data from this project and previous research.

1. Introduction

- **This report understands sustainable housing as housing that is appropriately designed for householder needs and environmental conditions, adequately maintained to facilitate householder safety, comfort and health outcomes, and designed and maintained for present and anticipatable climate change impacts.**
- **Sustainable housing requires both a life-cycle costing approach that promotes upfront and ongoing investment and a conception of housing as health conferring through the provision of functional 'health hardware'.**
- **Indigenous building stock is already unable to provide consistently healthy and comfortable indoor environments and, considering current under-investment in refurbishment for climate-proofing, is unlikely to perform better in the future.**
- **Contemporary state and territory government policy sets some standards for Indigenous employment in relation to Indigenous housing construction and maintenance but is mostly silent on sustainability measures and the need to incorporate climate change impacts into planning, design and maintenance programs. National policy on climate change and Indigenous housing does not yet exist.**
- **This research describes property maintenance programs that attend to regional and remote Indigenous housing and models the performance of housing against current and anticipatable climate impacts. It shows that greater investment is needed for house design and maintenance regimes that will confer health benefits, rather than harms, for householders.**

1.1 Sustainable housing

This report explores the question of sustainability in regional and remote Indigenous housing. The Australian Building Sustainability Board (2021) defines building sustainability as:

> living in harmony with the natural environment, considering the social, environmental and economic aspects of decisions and reducing our footprint through a less energy, water and material intensive lifestyle.

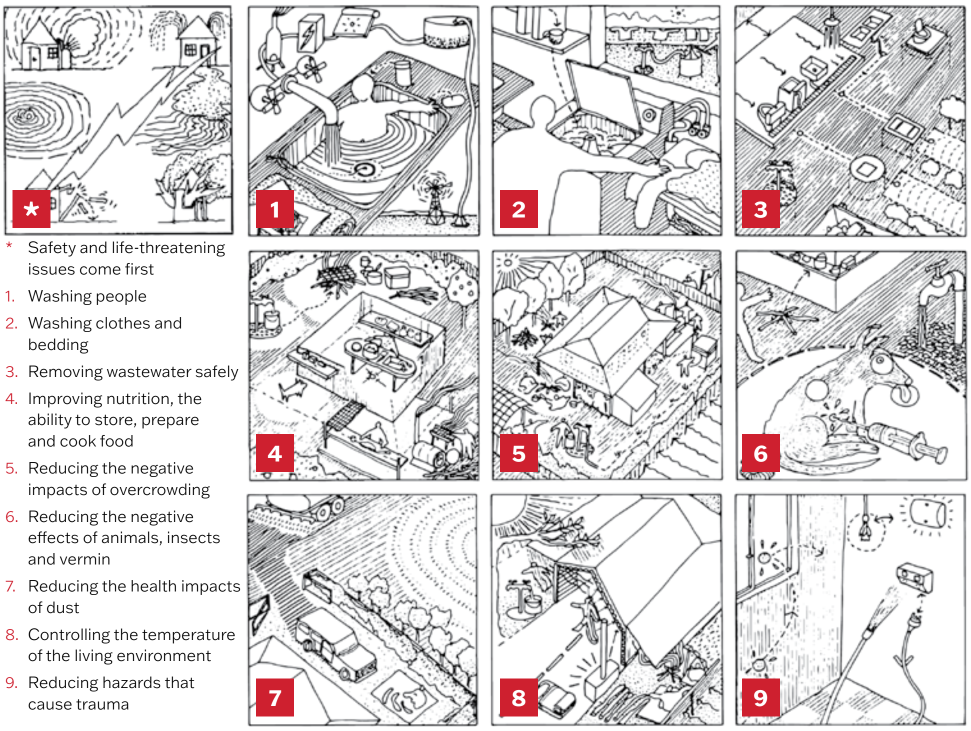
Such definitions of sustainability can seem irrefutable but remain unactionable, at best generating lists of principles or standards which do not clarify where and how contradictions between the pursuit of one aspect of sustainability (say, harmony with the natural environment) might undermine another (economic cost). Nor do such appeals clarify what it is that is being sustained, where and for how long. The provision of substandard Indigenous housing is sustained in many contexts, but it is not desirable if health and wellbeing are foregrounded.

Our research adopts a different framing which prioritises housing's capacity to enable the health and wellbeing of householders. We consider sustainable houses as those that have been built with structural integrity and robust materials, given climate and household compositional requirements and which are maintained in good working order through effective property maintenance systems. The sustainable R&M programs necessary for quality housing are those that are reliably resourced and regularly implemented, are responsive to householder concerns and that provide maximal opportunities for community engagement and local employment. In the context of climate change, sustainable housing attends to specific geographical and climate factors through resilient design, construction and thermal performance considerations. Finally, sustainable housing depends on adequate funding, enabled through an LCC approach. This builds on the conclusions reached by Fien, Charlesworth et al. (2008: 2), who likewise recommend that LCC features in the design approach to Indigenous housing, so that it

> *reflects the principle of 'best value' rather than 'best price' and the subsequent use of whole-of-life costing for housing, which integrates the cost of construction with the planned and budgeted lifespan of a house and associated repair and maintenance schedules.*

Put differently, attention to environmentally contextualised health hardware functionality, the capacity to flexibly accommodate shifting household numbers and ensuring thermal performance and energy efficiency, can be more economically invested in and maintained via an LCC approach. This report also raises questions about the resilience of existing housing in the face of current and future climate changes and recommends that a life-cycle approach to sustainable housing incorporates health and wellbeing goals, including urgent climate concerns.

Figure 1: Safety and the nine healthy living practices (HLPs)



* Safety and life-threatening issues come first
1. Washing people
2. Washing clothes and bedding
3. Removing wastewater safely
4. Improving nutrition, the ability to store, prepare and cook food
5. Reducing the negative impacts of overcrowding
6. Reducing the negative effects of animals, insects and vermin
7. Reducing the health impacts of dust
8. Controlling the temperature of the living environment
9. Reducing hazards that cause trauma

Source: Healthabitat 2021d.

In stating what sustainable housing and maintenance goals should be, this report does not ignore what is needed here and now, for both existing and new housing stock, to support people to secure appropriate and affordable homes in the different places they choose to live, aligned with shifting priorities and needs. It details the actions needed to keep Indigenous properties in regional and remote areas in good repair, both to extend housing lifespan and to ensure householders can rely on functioning 'health hardware', a key concept which was introduced by Healthabitat. Health hardware describes the materials and infrastructures necessary to practice healthy living practices (Figure 1): taps which flow with safe water, toilets which flush away human waste, safe food preparation areas and the like (Torzillo, Pholeros et al. 2008). Functioning health hardware in one house likely serves several crowded houses in a community (Hall, Memmott et al. 2020; Memmott, Long et al. 2006) and relieves the health impact of crowding.

Even so, our simulation of the various pressures on individual health and wellbeing via housing shows that more far-reaching measures are required. Taking as our baseline a three-bedroom house, featuring standard and improved design characteristics (as modelled from fieldwork, construction guidelines and professional data), and comparing three representative climate zones (tropical, arid and hot/mild), we modelled the resilience of housing stock given assorted variables: occupancy, ventilation, mechanical cooling systems, temperature and so on. Our results suggest that retrofitting houses for air conditioning and renewable energy as per existing programs will have positive short-term effects but are insufficient measures to prepare houses for anticipatable climate impacts. We find Indigenous building stock is already unable to provide healthy and comfortable indoor environments and, considering current under-investment in refurbishment for climate-proofing, is unlikely to perform better in the future. This includes new buildings designed and erected (that is, 'improved') following current construction standards.

1.2 Why the research was conducted

Concern is growing about the viability of Indigenous communities in many parts of Australia, given the difficulty of ensuring housing, education and infrastructural supports and of guaranteeing health and safety (Department of the Environment and Energy 2017; Australian Law Reform Commission 2017; Productivity Commission 2016). The 2014–15 National Aboriginal and Torres Strait Islander Social Survey (NATSISS) showed that more than one-third (38%) of remote Indigenous people over 15 years lived in crowded conditions, compared to 13 per cent elsewhere (AIHW 2017). Alleviating the health impact of crowding through design and property maintenance regimes which attend to health hardware remains critical.

Historically, the financial and logistical difficulties of effective asset management have resulted in substandard housing stock. Insufficient or subsidised rental revenue to meet operating expenses creates a vicious cycle where inadequate housing supply results in crowding which in turn exaggerates wear and tear. As the R&M backlog grows, dwellings deteriorate, increasing the costs of repair and the difficulty to maintain, let alone improve, housing stock (Grealy and Lea 2021). Health considerations can take a back seat to tenancy and administrative priorities. In Australia today, there is significant inconsistency between property maintenance approaches within and across state and territory jurisdictions (Nous Group 2017). However, it is typical that programs are predominantly responsive, rather than planned, and that householders are required to live with broken things for extended periods (Grealy 2021; Habibis, Phillips et al. 2019).

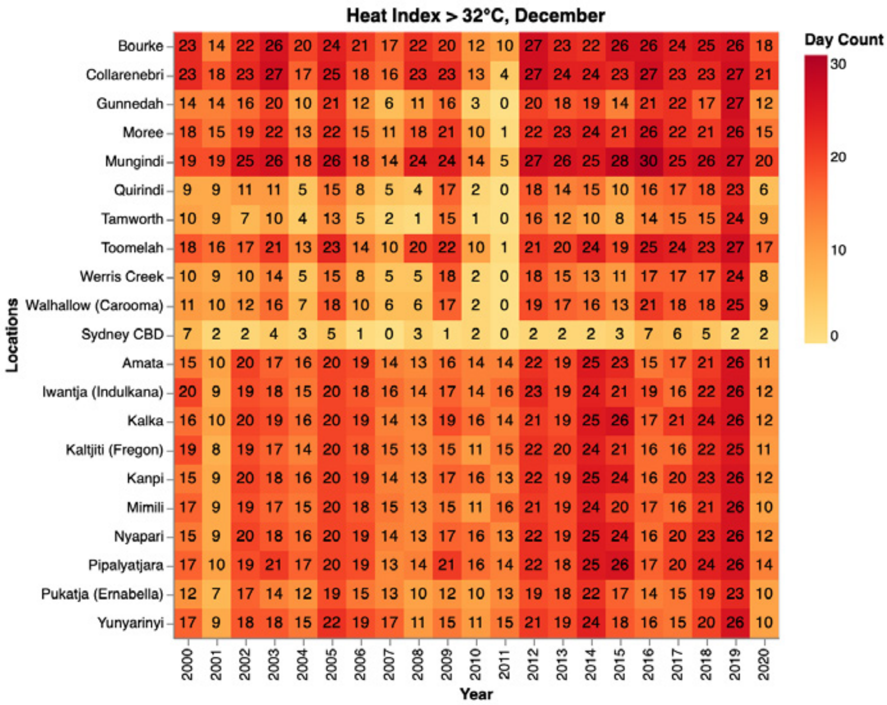
An extensive literature exists on Australia's oscillating climate change policies, particularly regarding changes in government, greenhouse gas emissions reduction strategies, emissions accounting methods, cuts to research funding and the tension between extractive and renewable industries (Climate Council 2016; 2019; Department of the Environment 2015; National Climate Change Adaptation Research Facility 2020). An emerging concern is the potential for increased population movement from locations most severely affected to areas better able to deal with heat stress, land or water loss (Carson, Bird et al. 2014). Such population volatility (Carson, Bird et al. 2014) can involve unpredictable departures of residents with corresponding impacts on services, settlement populations and associated funding. We had originally intended to map such population mobility trends, arguing that consideration of housing using a remote/not-remote binary ignores lived relationships. We hypothesised that regional-remote connections will be deployed more keenly as people manage housing affordability and climate extremes.

However, this emphasis was displaced by the first order need to establish what attention is being paid to sustainable Indigenous housing in the context of climate change. In Alice Springs in central Australia, for instance, there were 55 days above 40°C in the year to July 2019, which included the hottest summer on record and the driest in 27 years (Allam and Evershed 2019). In the APY Lands, the frequency of groundwater recharge-generating rainfall events is projected to decrease by 22–38 per cent between 2030 and 2070 (RDA Far North SA 2016).

Figure 2 lists communities drawn from the two larger regions in which this project examined property maintenance (APY Lands) and property management and climate responses (northwest NSW), for the early summer period of December 2000–2020. We prepared heat index ratings which measure the outdoor 'felt air temperature' by factoring relative humidity into measures of actual temperatures in shaded locations (that is, not under full sun). Ratings at or above 32°C increase the likelihood of heat disorders with prolonged exposure or strenuous activity.

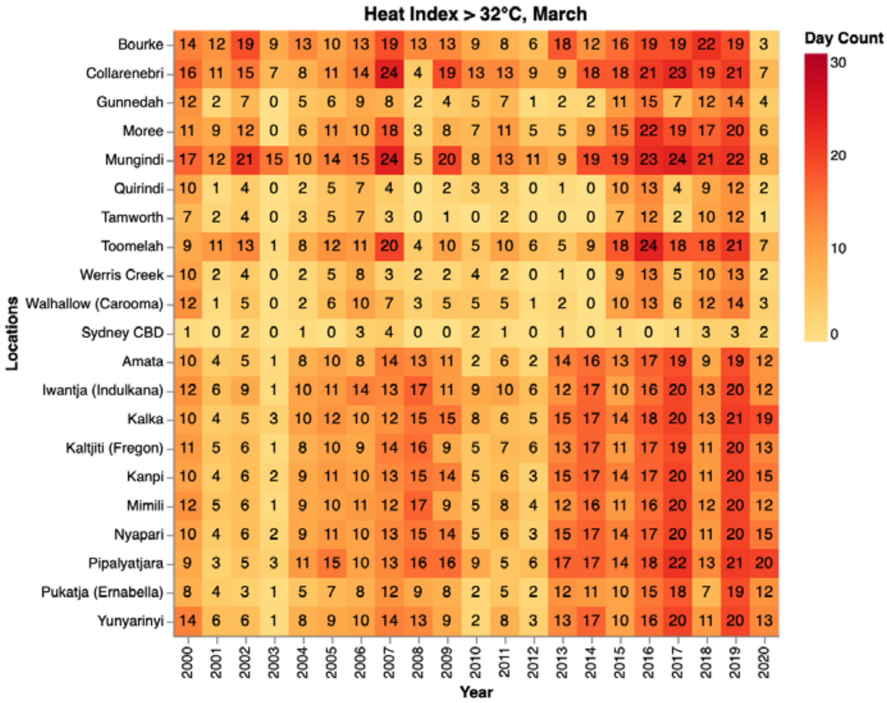
Figure 3 describes the same measures for the month of March. Together, these indicate that high caution heat periods are commencing earlier in summer and continuing for longer (see also Appendix 1).

Figure 2: Heat index, days above 32°C, December, 2000–2020



Source: Author analysis using Queensland Department of Environment and Science (DES), Australian Bureau of Statistics (ABS) and National Oceanic and Atmospheric Administration (NOAA) data.

Figure 3: Heat index, days above 32°C, March 2000–2020



Source: Author analysis using DES, ABS and NOAA data.

Meeting the health risks of these new environmental conditions is a major challenge for governments, which have had mixed success in sustaining existing housing stock (whatever its design qualities) in good repair for healthy living or of meeting current housing demand, let alone investing in future needs. Climate change will exacerbate the cost of liveable housing and support services, and will increase the price of fuel, electricity, food, medicine and the capacity to move people by road and air. It will also make labour supply and logistics more difficult. This further emphasises the logic of encouraging greater levels of paid local employment to extend the lifespan and liveability of housing. Further, it is likely that the more comprehensive redesigns and attendant maintenance required for housing to remain health-conferring under more extreme climate conditions will cost far more than is currently allocated to even standard issue housing. We found no accounts of the cost implications or investment options for sustaining Indigenous housing given these new realities in existing research.

Given all this, our research asks:

> How can fit-for-purpose housing design and associated repair and maintenance systems support the economic, social and environmental sustainability of remote and regional Indigenous communities, given climate change challenges?

Our specific research questions were:

1. What are the key features of effective, health-oriented Indigenous housing asset management and repair and maintenance programs? Do current programs include climate preparedness?
2. How might community-led R&M programs help create sustainable employment, health and wellbeing outcomes in remote Indigenous communities and their regional contexts?
3. What models recognise and accommodate life-cycle costs and climate-related issues for sustainable housing and management?

Taken as a whole, this report provides snapshots of some key areas—R&M, employment, design, thermal performance and LCC models—that must be addressed to make the concept of sustainable Indigenous housing a material reality.

1.3 Policy context

Indigenous housing and housing-related employment policy

Funding for Indigenous housing has reached something of a political stalemate between the Australian and state and territory governments, while moves to 'mainstream' Indigenous tenancy management have increased, with subsequent dispersion of sub-contracting responsibilities (Patterson 2017; Wensing 2015). However, the Australian Government remains a significant funder and under recent Partnership Agreements both tiers of government are responsible for improving Indigenous living standards and wellbeing.

Under the *National Partnership Agreement on Remote Indigenous Housing* (NPARIH), all governments committed to a ten-year program (2008–18) to improve remote housing conditions via mainstream tenancy management and a $5.5b build and refurbish program (Council of Australian Governments 2008). NPARIH made some progress, with ABS Census data showing a reduction in crowding in remote communities from 52.1 per cent in 2008 to 41.3 per cent in 2014–15 (ABS 2016c). However, ensuring cyclical maintenance to prolong the housing lifespan and replace failed building components remains a challenge (Senate Finance and Public Administration Committee 2017; Foster and Hall 2019; Habibis, Phillips et al. 2016). NPARIH also included a procurement requirement of 20 per cent local employment for new housing construction. This target was met, albeit with limited attempts to build ongoing, sustainable employment beyond short-term outcomes (Habibis, Phillips et al. 2019).

Published in July 2020, the *National Agreement on Closing the Gap* is an agreement between the Coalition of Aboriginal and Torres Strait Islander Peak Organisations and all Australian governments (Department of the Prime Minister and Cabinet [PMC] 2020b). Housing is specified as one of five policy priority areas around which a 'joined up approach' will be developed by 2022 (2020b: 7–8). Outcome 9 (of 16) aims that 'Aboriginal and Torres Strait Islander people secure appropriate, affordable housing that is aligned with their priorities and need' (2020b: 25), with a target of increasing the proportion of Indigenous people living in appropriately sized (not overcrowded) housing to 88 per cent by 2031. It remains to be seen whether the 'joined up approach' will identify issues related to housing quality, targets for health hardware or maintenance or any plans related to climate change.

Different management models for Indigenous housing exist in the jurisdictions from which this report's case studies are drawn. In South Australia, community-owned properties on the APY Lands are property and tenancy managed by the Aboriginal and Remote Housing section of Housing SA, jointly funded by the Australian and SA governments. In New South Wales (NSW), properties owned by Aboriginal land councils, the NSW Aboriginal Housing Office (AHO) and others are leased and sub-leased by the AHO to Aboriginal Community Housing Providers (ACHPs) to deliver property and tenancy management services. In the Northern Territory (NT), Australian and NT government funding for new and refurbished houses is contingent on the existence of leases which in most contexts require the government to deliver property and tenancy services directly or to subcontract to Aboriginal and other organisations.

Since NPARIH's expiry, the Commonwealth's investment in Indigenous housing outcomes has been delivered through the *National Housing and Homelessness Agreement* (NHHA) and the *National Agreement on Closing the Gap*. The NHHA mainstreams a previously targeted national policy approach to remote Indigenous housing, providing $4.6 billion to state and territory governments over three years, with matched funding obligations established through eight bilateral agreements (Council on Federal Financial Relations [COFFR] 2018a; 2019). The *National Partnership for Remote Housing Northern Territory* (NPRHNT) is the NT's bilateral agreement under the NHHA. It commits the NT and Australian Government to each invest $550 million. In total, the NT has committed $1.1 billion over ten years to its 'Our Community. Our Future. Our Homes' program, which has allocated funding to new construction, refurbishments, repairs and maintenance and government employee housing (Department of Territory Families, Housing and Communities 2019).

The NPRHNT partnership includes an emphasis on Indigenous-led developments through ensuring a role for Aboriginal Land Councils in the governance of the agreement and by ensuring that works are delivered by local Indigenous people and businesses (COFFR 2019). Following years of campaigning, Aboriginal Housing NT has recently been established as a peak housing organisation, with its constituents consistently promoting the importance of health-oriented housing design (APO NT 2015). The NPRHNT explicitly requires that both capital works and property and tenancy management are delivered by local Indigenous people and businesses to the maximum extent possible. Its employment and procurement framework mandates an annual minimum full-time equivalent Aboriginal employment rate of 40 per cent in 2019–2020, increasing by 2 per cent each financial year for the duration of the agreement. If met, this target represents a strong commitment to both short-term capital works employment and longer term employment through service delivery and support for Indigenous businesses.

The New South Wales NHHA Bilateral Agreement (COFFR 2018c: 15) lists the following joint reform commitments:

- employment participation incentives for social housing tenants, which commits both governments to exploring initiatives to remove barriers to employment
- improving outcomes for Aboriginal social housing tenants, which undertakes to improve understandings of Aboriginal housing demand to inform future programs
- strengthening the Aboriginal Community Housing Provider sector (ACHPs), which includes investing in the growth and capacity-building of providers in the delivery of housing services.

The NSW AHO's *Strong Family, Strong Communities* strategy (2018b) commits to building the capacity of ACHPs in NSW through sector investment and transfer of stock and asset management, with the aim to increase employment and culturally appropriate service provision. Featured in this report, Gunida Gunyah Aboriginal Corporation is one such ACHP.

In South Australia, the Australian Government has matched a state government contribution of $37.5 million to fund remote Indigenous housing for five years from 2019. This funding has fewer administrative, reporting and employment conditions than were attached to funding under NPARIH, but expenditure is limited to replacement and refurbishment of existing housing. The state's NHHA strategy, *Our Housing Future 2020–2030* (Housing SA 2019), commits to delivering up to 1,000 employment and training outcomes for social housing tenants through procurement and targeted employment programs (2019: 17) and addressing Indigenous disadvantage through a separate Aboriginal Housing Strategy. The strategy is administered through a discrete unit in Housing SA, the Aboriginal and Remote Housing section, a key partner to this research. The section contracts providers to build and maintain Indigenous housing uniquely from other state-owned properties.

Queensland's *Aboriginal and Torres Strait Islander Housing Action Plan* (Queensland Department of Housing and Public Works 2019) presents an interesting approach to employment related to property maintenance in Indigenous communities. In addition to a housing construction local jobs program, the plan involves new community tool-lending libraries in three remote communities, to allow homeowners and tenants to undertake R&M, supported by maintenance demonstrations. Although it cites growth of local skills and capacity as benefits, the plan does not refer to any payment for this work or clearly detail the property maintenance program that exists exclusive of work undertaken by tenants. This could be a missed opportunity to generate local employment through routine property maintenance. It also highlights the sometimes-conflicting priorities of property maintenance and employment programs, where insufficient support is provided to participants to maintain housing at high levels.

In summary, government efforts to provide new housing, reliable maintenance, or to increase employment have been inconsistent, lacking clear targets to increase participation and counter the path dependencies of external, non-Indigenous businesses dominating housing work in Indigenous communities. The potential for R&M to provide reliable employment for Indigenous residents of regional and remote communities remains under-realised while the employment potential from readying housing and streetscapes for climate changes is not identified at all.

Life-cycle costing

In their *Assessment Framework*, Infrastructure Australia (2018) highlights the importance of incorporating life-cycle costs into all business cases for infrastructure projects. A similar approach is adopted by most state infrastructure agencies. Australian housing agencies have intermittently encouraged the use of the life-cycle approach in the planning of Australian building projects (see Australian National Audit Office [ANAO] 2011). The Queensland Department of Housing and Public Works (2017: 1) developed a set of guidelines called 'Life-Cycle Planning' which states that:

> Best practice asset management is achieved by adopting a life-cycle approach which uses transparent, informed decision-making processes … that takes into account the whole-of-life implications of acquiring, operating, maintaining and disposing of a building asset. It should be used when making decisions at both strategic and operational levels of capital works investment and building management.

Bilateral agreements for Indigenous housing invoke related terms such as 'long-term', 'future' and in one instance, 'life-cycle approach to asset planning, investment and management' (COFFR 2018b: 5). However, if these terms do not further articulate with funding appropriations, they may be more rhetorical than real.

Sustainability and Indigenous housing policy

The United Nations' (UN) 2015 Sustainable Development Goals put equity and ethical considerations as the focal point of sustainability, recognising that both the consequences of global warming and mitigation strategies are likely to disproportionally impact already disadvantaged populations (IPCC 2018). Given this, housing that accommodates current and projected climate challenges assumes even greater prominence for such groups, including Indigenous Australians. Although Australian Government housing objectives claim that sustainability is at their centre, sustainability is not defined and nor does it appear in the 14 national performance indicators designed to measure progress against the NHHA's objectives and outcomes (COFFR 2018a: 8–9). From these indicators, we can infer that sustainability, alongside safety and affordability, is conceived in terms of:

- access to houses, including social housing
- affordable rent and reduced rental stress
- social housing that rates favourably against occupants' needs and satisfaction
- prioritisation of occupants with greatest need in new social housing allocations
- reduced homelessness and increased support to those at risk
- greater number of houses permitted by zoning in urban areas
- reduced time for development decision-making
- increased Indigenous home ownership.

These indicators largely measure the extent to which Indigenous peoples' right to adequate housing has been realised (UN 2005), with the last three indicating additional aspirations for urban zoning reform, reduced 'red-tape' and increased Indigenous home ownership. The prioritisation of occupants with greatest need in social housing allocation implies that the rationing of inadequate stock is not only acceptable but constitutes what can be reasonably 'sustained' by governments. While these indicators might be appropriate for minimum legislated standards of housing amenity, they do not account for the long view of sustainable housing advocated in this report.

Climate change and housing policy

In the recent *Climate Change Performance Index Results,* which evaluate 57 countries and the European Union (comprising countries which together generate over 90% of global greenhouse gas emissions), Australia ranked 54th (Climate Change Performance Index 2021). The current Australian Government has focussed on technology-led mitigation while prioritising extractive industry-led economic growth, with no discernible policy response to the impacts of climate change on remote and regional communities. Reflecting this, attention to climate change is not yet a key feature of Indigenous housing and infrastructure agreements, nor is adequate funding for climate-appropriate housing a concern in other important national agreements, such as *Closing the Gap*.

Of current state and territory government plans, the SA government's approach warrants mention as an exception in specifically addressing remote Indigenous communities and the infrastructural supports for sustainable community housing. Based on an integrated vulnerability assessment, *The Far North and Outback SA Climate Change Adaptation Plan* identifies essential services, transport and infrastructure and community health, safety and wellbeing as three of eight key sectors to prioritise for adaptation planning (RDA Far North SA 2016). It proposes that initial attention be paid to enhancing current initiatives and retrofitting existing buildings, with a five to ten-year focus on increasing the resilience of the built environment, including by constructing community facilities to serve as heat refuges and promoting climate-sensitive building designs to support preventative health. Key outcomes include:

- embedding climate considerations (intense rainfall, bushfire, sea level rise and extreme heat) in relevant design standards, asset management plans and essential services infrastructure with long lifespans
- reviewing policy to support essential service delivery
- upgrading airstrips to ensure continued access in remote communities
- solar PV and battery storage to support air conditioning, alongside support for people on low incomes
- increased rainwater harvesting to supplement bore supply
- planning for seasonal movements into cooler regional areas
- establishing a regional governance model and forum for engaging Aboriginal communities
- building the capacity of staff across sectors and residents in the region to adapt.

1.4 Existing research

Existing research on the relationship between Indigenous housing and health clearly establishes the importance of quality fittings and consistent repair and maintenance for facilitating health and wellbeing outcomes (Bailie and Wayte 2006; Foster and Hall 2019; NSW Health 2010; Phibbs and Thompson 2011; Torzillo 2008). Research also shows the challenges of building and maintaining Indigenous housing to high standards. Appropriately sized dwellings can be in short supply and residents' preferences poorly matched to the tenancy requirements of mainstream housing providers (Habibis, Memmott et al. 2013). Climatic conditions often require particular construction provisions, materials and skillsets, with floods, cyclones, extreme temperature variations and local geological challenges (hard water and shale soils) variously common in desert and coastal contexts (Browett, Pearce et al. 2012). Qualified tradespeople are generally in short supply in remote areas, external labour and transport are expensive, communities are often located a considerable distance from service centres and unsealed roads can increase the difficulty of accessing materials, logistics and travel (Fien and Charlesworth 2012; Habibis, Phillips et al. 2019). These factors underpin occupational, health and safety and related staffing requirements, increase travel time and maintenance budgets, and make it difficult to train and supervise community-based staff.

These features also challenge the accurate scoping of jobs, monitoring and regulation of contractors and add a considerable margin to construction and maintenance costs. Industry cost-guides estimate remote housing construction costs are likely to be at least double those of non-remote locations (Rawlinsons 2011). In some jurisdictions, the budget for R&M is also limited due to the low rent base. Consequently, major weather events, expensive contractor services and travel times can rapidly overdraw property maintenance budgets or reduce repairs and maintenance to emergency works only (Habibis, Phillips et al. 2016; Pholeros and Phibbs 2012).

Previous AHURI research (Kenley, Chiazor et al. 2010) has described how budget pressures have reduced preventive maintenance in many social housing contexts (Shen 1997; Yusof, Abidin et al. 2013). The challenge is mirrored in private sector tenancies where managers often resist planned maintenance for short-term cost savings (Lee and Scott 2009). In a systematic review of building maintenance literature Rocha and Calejo Rodrigues (2017: 443) note that '[o]ne reason maintenance has not been considered a priority intervention is the fact that it is considered an expense and not an investment'. In this context, while the life-cycle funding approach has considerable benefit in reorienting policy makers toward an investment model, there is little research that explores the application of LCC in the context of climate change or on sustainable maintenance regimes for remote and regional Indigenous communities (Fien, Charlesworth et al. 2008). Existing studies, which model the major costs of Indigenous housing over time (construction, operations and disposal), show that effective and timely asset management reduces depreciation costs and is vital for the extended lifetime and serviceability of housing (De Marco and Thaheem 2013; Wiesel, Davison et al. 2012). Where life-cycle costing is adopted in housing policy, there is potential for a reduction in downtime for major repairs, for rental revenue to increase and for reduced waste and environmental impact (Ferguson 2006).

The concepts of sustainability and resilience are prominent in the field of social housing research but are often undefined and uninterrogated, partly because of their positioning as irrefutably virtuous. At its most succinct, sustainability names an aspiration to live within our limits and reduce the impact of humanity so that things do not get worse. There is an implicit notion of temporality in which the present or the recent past provides a baseline to assess the anticipated impact or reproducibility of an ongoing or proposed activity. Regarding housing and infrastructure, the concept typically focuses on how new buildings will be assembled or regions redesigned. Within the housing industry, sustainability often infers a relatively low environmental impact through reduced energy use and waste production and reduced maintenance requirements (Department of the Environment, Transport and the Regions London 2000: 20). For instance, the Green Building Council of Australia's *Green Star—Communities National Framework* (2016) offers a rating tool to assess the sustainability of community-level projects that are undertaken at precinct, region, neighbourhood or other geographic scales. This valuable framework is only partially applicable to Indigenous housing in regional and remote areas, where the opportunity to redesign entire precincts is rare.

More familiar definitions of sustainability are adopted by affordable housing research, which deploy the 'triple bottom line' model, with three interconnected pillars of the economy, society and the environment (Wiesel, Davison et al. 2012; Yates, Kendig et al. 2008). In the triple bottom line model, housing for sustainable communities must satisfy these goals by meeting key metrics such as optimising rental yields while minimising costs, ensuring ongoing affordability for tenants and efficient consumption of energy and water (Wiesel, Davison et al. 2012). Sustainability in terms of health and wellbeing is not a feature. Maldonado, Meza et al. (2020) bring us closer to a more appropriate definition of sustainability for regional and remote Indigenous housing. They highlight the term's dual meaning of *sostenible* and *sustenable*, 'the former connoting a capacity to be maintained over time, the latter a sense of being reasonable' (2020: 465). However, what is reasonable seems to have low benchmarks in the Australian setting. One of the few Australian studies of the impact of climate change on Indigenous community sustainability, for instance, reveals that plans for shading, shelter and climate responsive design were not in place for any case study areas (Bird, Govan et al. 2013: 83–9). We were not able to find sustainability or other studies which modelled the performance of existing Indigenous housing types and their capacity to withstand increased heat (or cold) under different configurations, as is offered in this report.

There is an extensive literature on climate change in regional and remote Australia predicting significant impacts, including:

- rising sea levels
- saltwater intrusion
- increased storm surge and coastline degradation
- increases in temperature
- decreases in water supply and potable water
- increasing frequency of extreme weather events such as cyclones and bush fires
- decreasing overall rainfall
- rising energy costs and associated energy poverty
- the destruction of ecosystems central to Indigenous cultural life and subsistence activities, including through water theft, fires, feral species invasion and the world's worst mammalian extinction rates (Climate Council 2016; Crabtree, Bird et al. 2019; Green, Jackson et al. 2009: Woinarski, Burbidge et al. 2015).

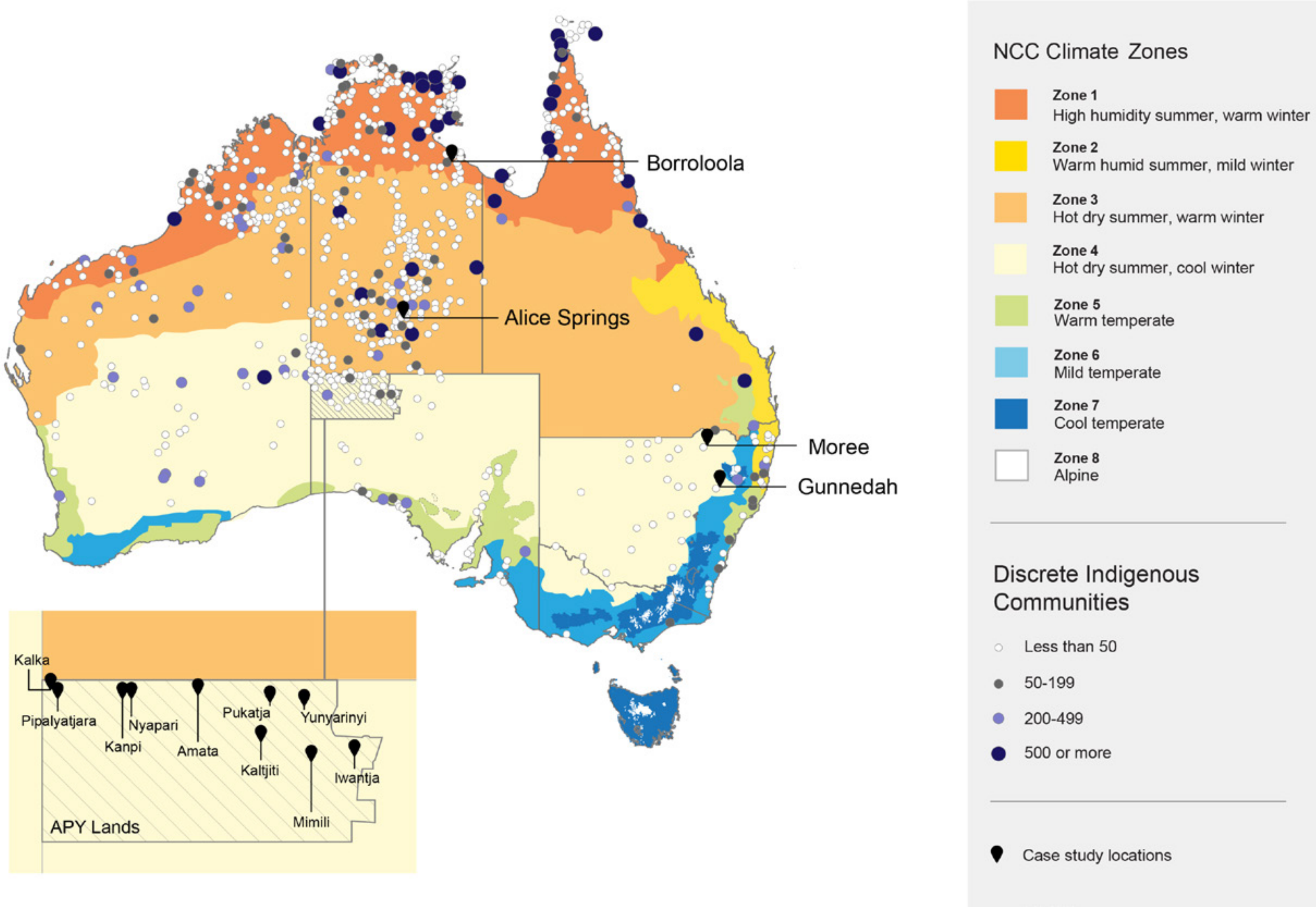
However, while housing and infrastructure play key roles in exacerbating or mitigating these impacts, to date there has been limited analysis of what this might look like in Indigenous contexts (Bardsley and Wiseman 2012). Existing research is mostly silent on how property maintenance can support adaptation to climate change or aid sustainability objectives. Given there is so much at stake, communities are increasingly concerned, as Dr Josie Douglas of the Central Land Council observed:

> Without action to stop climate change, people will be forced to leave their country and leave behind much of what makes them Aboriginal. Climate change is a clear and present threat to the survival of our people and their culture. (Cited in Allam and Evershed 2019)

1.5 Research methods

This research targeted two regions—the APY Lands in SA and north-western regional NSW—to assess maintenance requirements and challenges. It additionally simulated housing performance drawing on data from three climate zones where most Indigenous people in remote and regional Australia reside (Figure 4). The use of the terms 'remote' and 'regional' draws on the Accessibility Remoteness Index of Australia (ARIA), a geographic accessibility index used to reflect the relative difficulty for people in non-metropolitan Australia to access services. Our report uses data from locations that would be characterised as very remote, remote, outer regional and inner regional on the ARIA accessibility-remoteness continuum. We have opted for the terms 'regional and remote' to correspond with policy discourse, with further detail about proximity and amenity provided as relevant to case study descriptions.

Figure 4: Project case studies by National Construction Code (NCC) climate zones



Source: Author synthesis based on NCC climate zones (ABCB 2019) and Productivity Commission's (2017: 26) map of discrete Indigenous communities

This research was conducted in partnership with:

- Healthabitat, which developed the Housing for Health methodology (Healthabitat 2021c). This survey-fix approach tests whether the health hardware in a house functions properly, based on HLPs which prioritise infant and child health, prevention of infectious disease and managing environmental conditions that exacerbate chronic disease or impede health and wellbeing (Healthabitat 2021d).
- Nganampa Health Council (NHC), an Aboriginal-owned and community-controlled health organisation on the APY Lands, which runs the Uwankara Palyanyku Kanyintjaku (UPK) environmental health program—the basis of Healthabitat's Housing for Health framework.
- The Aboriginal and Remote Housing section of Housing SA, the government department responsible for delivering social housing in SA.
- Gunida Gunyah Aboriginal Corporation (GGAC), an ACHP registered with the NSW AHO to manage residential properties in NSW, which includes provision of property maintenance, tenancy support, transitional housing and other social services.

Ethics approval for the project was granted by the University of Sydney Human Research Ethics Committee on 1 July 2020 (Project No. 2020/440) and research agreements were established with the partners above.

The project used a mixed method research design comprising:

- An evidence and policy review of literature on sustainable property maintenance models and climate change preparedness in Indigenous and other forms of social housing. The review also canvassed typical funding and policy settings and interrogated uses of the ubiquitous term 'sustainability', as it pertains to remote and regional Indigenous housing contexts.
- Development of an LCC analysis by taking an existing cost analysis for Australian housing and using comparative maintenance costs developed in previous AHURI research and other studies.
- Ethnographic case studies of Indigenous-run housing management in regional NSW and of property maintenance and environmental health programs on the APY Lands. Field trips to the APY Lands were undertaken in August 2020 and February 2021. A field trip to Gunnedah, Moree and regional NSW was undertaken in September–October 2020.
- A total of 20 formal interviews were conducted from July through November 2020.[1] Interviews mostly occurred via a virtual platform, were recorded digitally, transcribed verbatim by a professional transcription service and entered into NVivo. A thematic framework was agreed upon by the research team and transcripts were coded accordingly. Analysis was conducted using the Framework Approach (Ritchie and Spencer 1994).
- Interview and housing R&M data provided by Housing SA and Nganampa Health Council was parsed to understand local employment opportunities from external trade requirements and the resources involved in planned property maintenance. Housing SA datasets included raw maintenance job data for the whole of the APY Lands from June 2017 until June 2020. This data was imported into the software SPSS Statistics and transformed to allow for basic statistical analysis. The analysis of this data focused on the types of R&M work undertaken by Housing SA on the APY Lands including job type (coded to trade level), cost, location and duration to completion. Data sets related to Nganampa Health Council's environmental health program were coded in relation to Healthabitat's HLPs.

1 Throughout this report, interviewees have been anonymised and interview material is referenced in relation to the participant number (for example, Participant 1).

- A comparison of housing performance in tropical, arid and hot/mild climate zones, represented through data profiles of housing in Borroloola and Alice Springs in the NT and Moree in NSW. The data profiles were created from fieldwork information (interview data, photographs and journal notes), consultations with architects and housing managers in Tangentyere Council Aboriginal Corporation, the Fulcrum Agency and Healthabitat, procurement documents for housing supply in the NT and NSW, plus construction guidelines and house plans discovered through desktop research. These were used to create a simple typology of a standard and an improved three-bedroom house, as the base models to then compute housing performance using transient thermal whole building simulation software. A total of 366 simulations were conducted, testing the performance of standard and improved housing using different variables: temperature, humidity, ventilation, crowding, mechanical cooling and heating. All settings were then additionally modelled with climate change scenarios suggested by the Intergovernmental Panel on Climate Change, taking (optimistic) scenarios where global warming is held at 1.5–2.0°C.
- To explore climate change measures within the regions where fieldwork was conducted, the ABS Aboriginal and Torres Strait Islander Peoples GeoPackage was adopted to determine the geo-boundaries of selected sites (ABS 2016a). Daily climate data was extracted from the Queensland Government's Department of Environment and Science (DES). DES creates gridded climate products from weather station observations from Bureau of Meteorology (BOM) and other data sources, covering 1889 to the present, called SILO (DES 2021). SILO provides daily meteorological datasets for a range of climate variables in formats suitable for biophysical modelling, research and climate applications. For this report, total rain fall (mm), maximum and minimum temperatures (°C) and corresponding relative humidity at maximum and minimum temperatures were calculated as the average value within the geo-boundary of each site daily for the period 2000 to 2020. The daily maximum heat index (HI) was calculated from the maximum temperature and corresponding relative humidity, using the equation provided by the National Oceanic and Atmospheric Administration (NOAA 2014; 2020). Because of the greater number of global data points it draws upon, NOAA datasets expand BOM network information. Indicative results are provided in Appendix 1.

2. Life-cycle costing: a primer

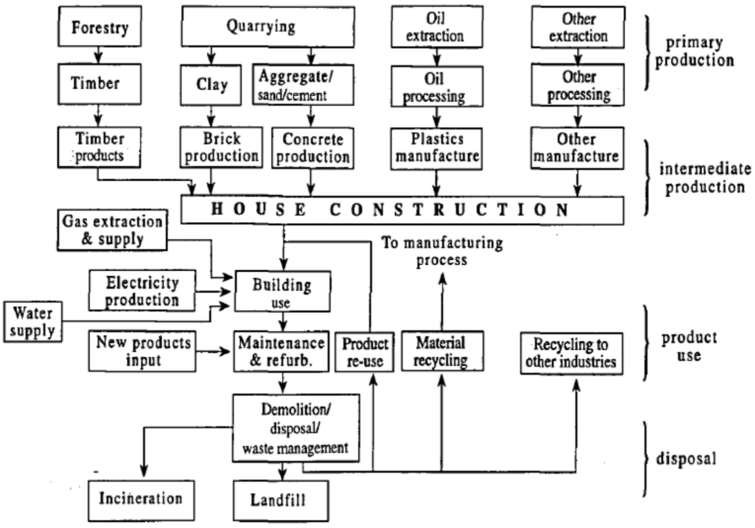
- **This report reveals how policy definitions of sustainability consistently fail to define the criteria by which practices or materials are sustainable or resilient and against which housing sustainability policies and programs can be judged.**
- **To avoid the repetition of an often-unstated assumption—that what is practically sustainable for governments and housing providers is the under-supply of substandard housing serviced by inconsistent repairs and maintenance—sustainability claims should specify the outcomes sought by a particular intervention and clarify the trade-offs on which it depends.**
- **These include trade-offs between upfront and ongoing costs, between profitability for developers, government subsidisation and tenant rent obligations, and between housing hardware that reduces tenant utility costs but requires ongoing maintenance by housing providers.**
- **One way of achieving this is through the adoption of life-cycle costing (LCC) frameworks. Considering housing in terms of sustainability requires thinking of the lifespan and benefits of a structure, within which savings might be derived by strategic investments.**

For the purposes of this report, the life-cycle approach provides a conceptual framing for analysing the requirements of regional and remote Indigenous housing across the lifespan of the house. It counters the tendency of policy makers, builders and property managers to implement 'quick fix' approaches without attention being paid to the economic, health and social consequences of their decisions. We start with this model to indicate the kinds of analyses that should drive government policy and funding for Indigenous housing, to ensure that the sector does not continue to suffer the unpredictability of service largesse and parsimony within otherwise underfunded property maintenance regimes.

In order to recognise the social impacts of building construction and operations, the life-cycle approach modelled here has been modified through the development of *Guidelines for Social Life-cycle Assessment* (Dong and Ng 2015; Benoit and Mazijn 2009). Building on the evidence of the high costs for emergency maintenance (Chapter 3), we argue for the potential of both planned maintenance programs and climate-appropriate technologies and designs to extend housing lifespans and to improve housing resilience against the impacts of climate change. Recognising these are cost arguments too, this report recommends the adoption of a life-cycle funding approach within Indigenous housing portfolios. However, in our review of the literature, we found casual mention of this approach without detail of how it might operate. This chapter offers a remedy to this absence, while recognising that more research and policy analysis is needed to embed such approaches into existing funding appropriation systems for Indigenous housing.

The life-cycle approach involves estimating the financial outlay of original materials against the likely ongoing costs of maintaining, repairing and replacing those materials (Smith, Whitelegg et al. 1997). Its value lies in its capacity to evaluate present actions through predictions of future costs. It encourages housing managers to make decisions for the longer term, based on policy and material decisions that aim to improve entire systems rather than single components. Elements of the housing life cycle can extend to the production and extraction of raw materials, processing, manufacturing, transport, construction, use, demolition or recycling (Figure 5).

Figure 5: Life cycle of a dwelling



Note: Pollutants are generated at all stages. Energy and transport are necessary at all stages.

Source: Smith, Whitelegg et al. (1997: 217).

Life-cycle costs can be represented by the following formula:

$$LCC = I + CM - Res + E + W + OM\&R$$

where:

LCC	is the total LCC in present-value (PV) dollars of a given alternative
I	is the total construction costs of a dwelling
CM	is the present value of capital maintenance costs
Res	is the present value of the residual value (resale value, salvage value) less disposal costs
E	is the present value of energy costs over the life cycle
W	is the present value of water costs over the life cycle
OM&R	is the present value of non-fuel operating, maintenance and repair costs.

Note: the present value converts a stream of future costs into one value in the present day. This approach facilitates the comparison of costs experienced in different time periods.

The three major life-cycle cost elements of a housing program are construction, operations and disposal. The central aim of an efficient Indigenous housing capital works program is to minimise the life-cycle costs for dwellings without compromising on the quality of those dwellings. Effective design, high quality construction and the installation of appropriate technologies can reduce the proportion of life-cycle costs committed to operating and maintenance expenditure. Ikpo (2009) refers to developing maintainability indexes of buildings as a way of measuring their likely performance. This requires the specification of materials for particular climate requirements and anticipated maintenance and replacement needs.

For a property management regime, the aim of a life-cycle approach is to minimise the total operating costs of the house, while meeting maintenance obligations. Life-cycle costs can be reduced by achieving an effective balance between planned and responsive maintenance. A system focused predominantly on responsive maintenance is unlikely to underpin sustainable housing, because a significant proportion of maintenance will be urgent and require additional subcontracting and travel expenditure. The cost penalties of emergency repairs are significant:

> Analysis of works packaging indicates that the median cost of emergency maintenance and repair activities is 75 per cent higher than planned activities, while responsive activities which are non-emergency are 50 per cent more costly than planned.
>
> At the extremes, some maintenance and repair activities are up to 20 times higher in an emergency situation than in a planned maintenance package. (Nous Group 2017: 25)

The Nous Group (2017: 16) indicates that travel costs can account for up to 96 per cent of per-unit costs for emergency repairs in Indigenous housing, compared with 11 to 37 per cent for planned maintenance activities. Investing in planned maintenance is thus likely to reduce life-cycle costs.

A life-cycle cost approach can also be used to frame a specific program within a larger property maintenance regime. For example, regular plumbing and building fabric inspections are likely to identify chipped grout or broken tiles in wet areas and any related water ingress into walls, reducing the likelihood of significant costs associated with major refurbishments. Similarly, an air conditioner's air filter requires regular changing so that it does not become clogged with dust, blocking airflow through the evaporator coil. When this happens, the evaporator coil can freeze due to the reduced airflow and may no longer provide cooling (Cruzan 2009). A life-cycle approach would prioritise the planned replacement of air filters to reduce the likelihood that a specialist technician is later required to repair a frozen coil. One way to explore the benefits of a life-cycle approach is to compare the estimated maintenance costs over five years for a specific hardware type, such as air conditioning.

Table 1 is provided for illustrative purposes only. It shows the relative cost penalty for not undertaking planned maintenance on an air conditioner. Without planned maintenance, an evaporator coil is estimated to fail four times over five years. With planned maintenance it is replaced—prior to failure—twice over the same period, with air filters replaced annually. Table 1 also shows the estimated cost difference between a planned and responsive maintenance program for a metropolitan centre, a regional area and a remote community. The metropolitan costs for responsive maintenance costs are almost twice those of a planned maintenance program, but this increases by seven times in a remote community. If the impacts on the health and wellbeing of householders waiting for emergency repairs is also factored in, the cost would be higher again.

Table 1: Comparing planned and responsive maintenance program costs by regions

Year	1	2	3	4	5	Total ($)	Ratio R/P
Cost of planned maintenance (P) in $							
Routine maintenance	25	25	25	25	25	125	
Replacement		500		500		1,000	
Total	25	525	25	525	25	1,125	
Cost of responsive maintenance (R) in $							
Metropolitan		500	500	500	500	2,000	1.8
Regional		1,000	1,000	1,000	1,000	4,000	3.6
Remote		2,000	2,000	2,000	2,000	8,000	7.1

Source: Author estimates.

Life-cycle cost modelling

Islam, Jollands et al. (2015) provide an excellent review of life-cycle costs for residential buildings in Australia and elsewhere and generate a life-cycle cost for a modest Brisbane dwelling using a cost base of 2011 and occupied by four residents. They estimate that construction costs represent 62 per cent of total life-cycle costs, with operation and maintenance comprising 35 per cent and disposal comprising 3 per cent of total life-cycle costs. The following table takes these figures as the base and calls on the assumptions used to generate the Indigenous housing cost estimates from Habibis, Phillips et al. (2016), the Nous Group (2017) and Cuéllar-Franca and Azapagic (2015). These include:

- Operating and maintenance costs increase by 10 per cent for every two additional people added to a household (Cuéllar-Franca and Azapagic 2015).
- Remote housing construction is 1.7 times greater than capital city costs.
- Very remote housing construction is two times greater than capital city costs.
- Remote housing operating and maintenance costs are three times greater than capital cities.
- Very remote housing operating and maintenance costs are three times greater than remote regions.

Table 2 provides estimates of the relative weighting of the major cost components for remote and very remote Indigenous housing in Australia. The chief focus is the proportional component of total costs. Absolute costs are indicative only and the base case analysis uses a 2011 cost base, which is significantly smaller than current costs. Table 2 further shows that in both remote and very remote regions operating and maintenance costs are significantly higher components of the total life-cycle costs compared to the base case. In very remote regions 75 per cent of the life-cycle costs of a dwelling is related to operating and maintenance costs. Construction is a relatively minor component of the total life-cycle costs of remote and very remote Indigenous housing compared to operations and maintenance over time. These relative costs can inform potential strategies for Indigenous housing policy.

Table 2: Life-cycle cost components for remote and very remote Indigenous housing (2011 cost base)

	Base case#		6-person occupancy		Remote		Very remote	
Construction	129,000	62%	129,000	58%	219,300	44%	258,000	24%
O and M*	74,000	35%	88,800	40%	266,400	54%	799,200	75%
Disposal	5,600	3%	5,600	2%	11,200	2%	11,200	1%
Total	**208,600**	**100%**	**223,400**	**100%**	**496,900**	**100%**	**1,068,400**	**100%**

*Note: *Operation and Maintenance. #Based on Table 7 (Islam, Jollands et al. 2015).*

Source: Author calculations based on assumptions in text.

From an LCC perspective, it is clearly highly desirable to reduce operational and maintenance costs for Indigenous housing. For reasons to be elaborated in the following chapter (concerning the availability of contractors and materials, distance and travel costs, climatic conditions and so on), operations and maintenance is relatively expensive for much regional, remote and very remote housing, yet savings can be found given assured funding and thus planned maintenance programs. However, the life-cycle approach also encourages the exploration of design solutions that offer potential to reduce the need for responsive repair work, while guaranteeing amenity to tenants. Such design innovations illustrate what Indigenous housing policies need to be incentivising to meet the growing challenges of healthy housing provision. Using such an approach, maintenance must be understood as:

- a central consideration in the design phase
- an investment to protect the value of a public asset
- a means of reducing significant costs later in the life cycle
- an essential requirement for improving the health and wellbeing of tenants.

3. Repairs and maintenance on the APY Lands

- **The APY Lands is a region that has long seen the benefits of combining maintenance priorities with health considerations.**
- **Today, the property and tenancy management services managed by Housing SA are complemented by Nganampa Health Council's environmental health program, in a combined housing maintenance approach.**
- **Key factors underpinning the efficacy of the Housing SA maintenance program include the planned approach, bundling contracts to increase the scope of works, flexibility in procedures for reporting hardware failures, the quality of contract relationships, an innovative 'feedback loop', flexibility in the delivery of planned works and the longevity of relational experience in the region.**
- **Despite operating in very remote contexts, Housing SA spends most of its maintenance budget on planned works, with responsive works approximately one-quarter of the budget and travel-related expenses under 11 per cent.**
- **Nganampa Health Council's environmental health program complements the Housing SA program, by taking a holistic view of householder health and wellbeing that attends to maintenance work outside the house and beyond the fence line.**
- **Housing SA and Nganampa Health Council demonstrate the thorough work required for sustainable housing in remote and very remote communities, in the face of climate challenges that threaten residents' abilities to remain on country in housing that supports safety and health outcomes.**

This chapter considers the housing repair and maintenance (R&M) work undertaken by both the South Australian Housing Authority (Housing SA), through its Aboriginal and Remote Housing section, and Nganampa Health Council (NHC), under its environmental health program. Each organisation works to maintain houses and their surrounding areas on the A<u>n</u>angu Pitjantjatjara Yankunytjatjara (APY) Lands, a region that has long seen the benefits of combining maintenance priorities with health considerations.

Maintenance programs can be characterised as either planned or responsive, with planned programs sometimes additionally distinguished as preventive, predictive or cyclical. A planned program operates according to a schedule of works while a responsive program reacts to tenant or other requests regarding hardware failure. Maintenance programs often also include capital works such as housing upgrades.

The cost penalties of reactive or emergency R&M are significant:

Analysis of works packaging indicates that the median cost of emergency maintenance and repair activities is 75 per cent higher than planned activities, while responsive activities which are non-emergency are 50 per cent more costly than planned.

> At the extremes, some maintenance and repair activities are up to 20 times higher in an emergency situation than in a planned maintenance package. (Nous Group 2017: 25)

The Nous Group (2017: 16) indicates that travel costs can account for up to 96 per cent of per-unit costs for emergency repairs in Indigenous housing, compared with 11 to 37 per cent for planned maintenance activities. Hence the importance of understanding the detail of what sustaining planned maintenance involves, to generate benefits for householders and to reduce life-cycle costs.

3.1 Housing in APY Lands communities

On the APY Lands in South Australia, housing maintenance is the responsibility of the South Australian Housing Authority (hereafter Housing SA) and specifically the Aboriginal and Remote Housing section, according to a 50-year lease agreement. Houses remain community owned, while the lease grants Housing SA the right and responsibility to maintain housing and collect rents (Participants 1 and 2).

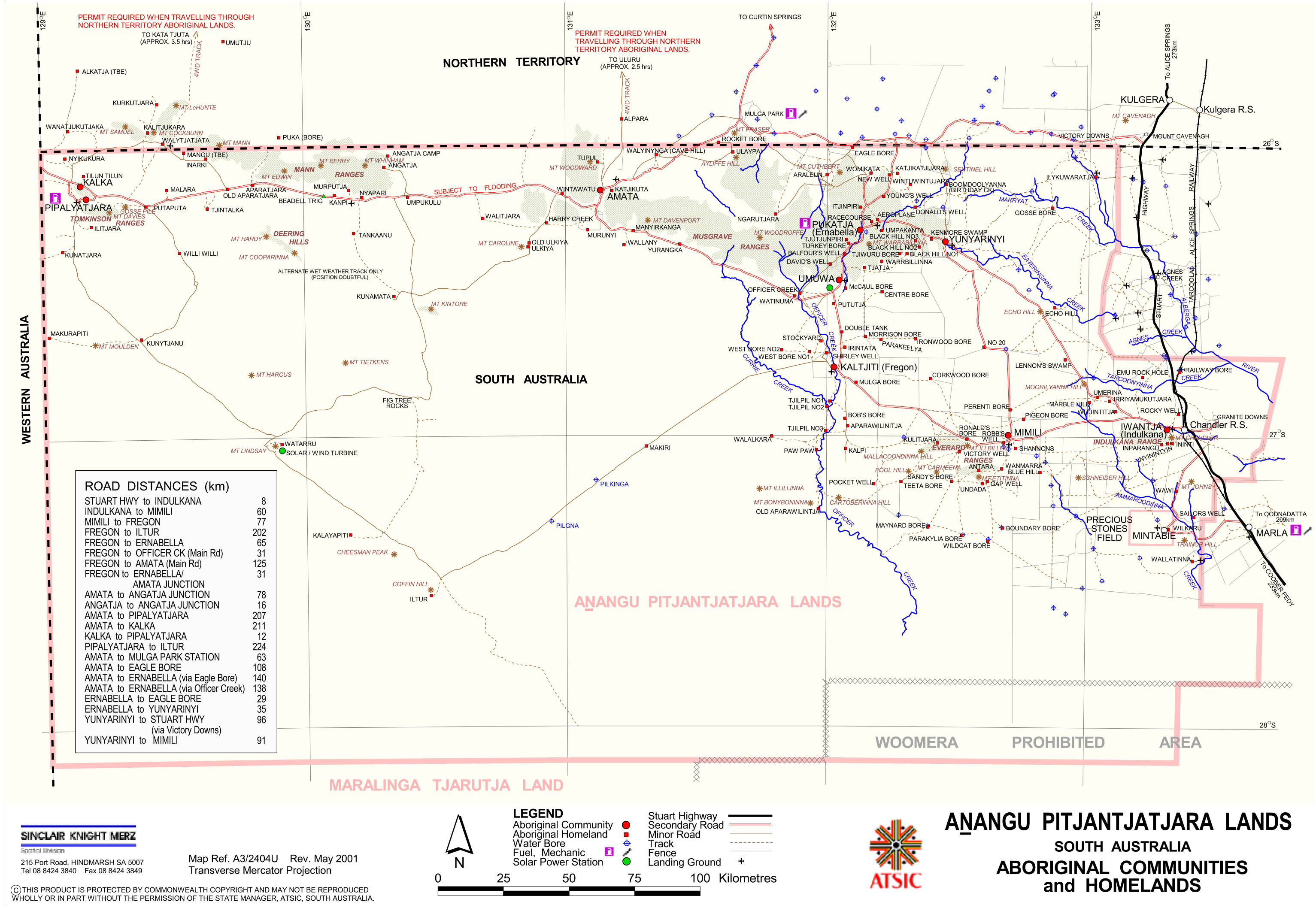
Figure 6 represents the APY Lands communities included in the maintenance programs considered in this chapter. The most northwest of these communities, Kalka, is a 468-kilometre drive along unsealed road to Iwantja, the most eastern of the APY Lands communities, which is located just west of the Stuart Highway. The administrative hub on the APY Lands is located at Umuwa—*'the Canberra of the APY Lands'* (Participant 3)—with section managers located in Adelaide.

Numerous homelands are also located across the APY Lands, typically on the peripheries of the communities listed above. The Housing SA planned maintenance program does not apply to outstation and homelands properties, however there is a budget allocation of approximately $200,000 per annum for maintenance and repairs on these properties.

Housing SA is responsible for the maintenance of about 371 houses across 10 remote and very remote communities on the Lands (see Appendix 2), servicing a total population of approximately 2,276 people (ABS 2016b). Population figures for individual communities and the APY Lands as a whole are subject to significant variation due to intra-regional and remote-to-urban mobility, but the figures demonstrate the high average occupancy rates of houses. Large numbers of Aṉangu people leave the APY Lands for Alice Springs and coastal South Australian cities, such as Port Augusta and Adelaide, during the summer months, when temperatures average over 37°C. In addition, the APY Lands experience large numbers of visitors each year. These transient residents drawn from the same community or regional population are not necessarily represented in population figures (Martin, Morphy et al. 2002).

Housing SA executes its lease obligation through its property maintenance program. However, residential property repair and maintenance on the APY Lands is also undertaken by Nganampa Health Council, through its environmental health program and to a lesser extent by Regional Aṉangu Services Aboriginal Corporation (RASAC). Nganampa Health Council is an Aboriginal community-controlled health organisation that operates on the APY Lands, with administrative offices at Umuwa and Alice Springs (NT). To understand what it takes to maintain housing in this context, it is necessary to consider the interactions between Housing SA and Nganampa Health Council in particular (see Appendix 3).

Figure 6: AP Lands map



Source: Aboriginal and Torres Strait Islander Commission (2001).

3.2 Housing management and funding arrangements

The Aboriginal and Remote Housing section is a discrete unit in Housing SA and its work is distinct from the general maintenance and general construction program applied to Housing SA properties across the state (Participants 1 and 2). Indigenous housing and maintenance have historically occupied a discrete area within South Australian governments, whether as the current Aboriginal and Remote Housing section of Housing SA or the former Aboriginal Housing Authority or Aboriginal Housing Directorate. Respondents described a reluctance to subsume Indigenous housing into the mainstream model for fear of losing the existing planned maintenance approach and the capacity to recognise Indigenous cultural obligations and differences. This specificity is hard-won:

> Over the years, we've had to argue to maintain that Aboriginal housing is different because government loves to say, 'Let's just make it mainstream. Whatever we're doing in the city, we'll do out there' … It's an argument you have to have every couple of years not to go down that path, especially when they look at the budgets and they go, 'Oh wow. You're spending $60,000 on a house. Can't we just build that house somewhere else because it'll be cheaper?' No. It's a continual fight we have and it's an exhausting fight actually. Telling the same story, arguing for the position that you do need a different approach to what you're doing. It can't be a mainstream approach. (Participants 1 and 2)

Funding for housing maintenance is drawn from both the SA and Australian governments. The current allocation of funding is for a period of five years beginning 2018, while the previous cycle was 10 years, under the *National Partnership Agreement on Remote Indigenous Housing* (NPARIH) period 2008–2018 (COFFR 2008). The current 50-50 funding arrangement between the Commonwealth and SA governments allows the Aboriginal and Remote Housing section to roll-over unspent funds from one financial year to the next in the five-year cycle. This enables greater flexibility than if the state were the sole funder, in which case unallocated funds would return to state treasury within a financial year.

The total budget for the APY Lands maintenance program in the 2019–20 financial year was $3,726,237. The average spend per property is approximately $10,000 per annum. Vacancy maintenance is a recent additional component to the program. $500,000 is allocated from the total budget for vacancy maintenance, which aims to refurbish properties between tenancies (kitchen replacement, wet area upgrades, painting, new vinyl flooring and so on). The budget allocation to vacancy upgrades is unlikely to be expended in full due to the difficulty of completing such works, which relates to crowding and the reality that houses rarely stay vacant for long enough to be boarded up to begin this upgrade process. For these reasons, as well as minor fluctuations in spending on planned and responsive maintenance, respondents considered it important that the allocation of funds across budget categories is flexible.

The Aboriginal and Remote Housing section is responsible for both housing maintenance and capital works. This combined portfolio is possible because it is a relatively small capital works program, as compared to construction programs in other Australian jurisdictions. The division of maintenance and capital works undertaken has varied due to changes to the funding allocation. Under the previous ten-year NPARIH funding agreement, works were dominated by new constructions as well as upgrades to existing stock. However, under the current five-year funding agreement repairs and maintenance are prioritised, alongside some house replacements and upgrades. The proximity of these maintenance and capital works areas under the remit of the Aboriginal and Remote Housing section has generated important lessons about effective housing design and material function over time.

> When we were just doing construction, you'd finish, you'd walk away. We'd go back at the end of the 12-month defect liability period, we'd look in the house, we'd talk about how the house has performed. We tick. We go away … Whereas now, we're constantly going back into housing, seeing how they perform, seeing how they're used, seeing what's breaking and failing constantly. (Participants 1 and 2)

This is repeatedly identified by the section as an important ‘feedback loop’ and it is a key aspect of the APY housing maintenance program.

> The feedback making a loop back into housing design, we’ve constantly got that. So, new designs can incorporate things that we’re doing in the R&D maintenance space… that’s where the benefit is. Previously, I would go to the maintenance guys and say, ‘Oh, you got any broad ideas?’ ‘No.’ … But being involved in both [construction and maintenance] heavily, then that’s where you can learn a lot. (Participants 1 and 2)

This feedback loop is also facilitated through aspects of the governance arrangements. Knowledge drawn from the Housing SA capital works and maintenance coordinators informs a flexible approach to materials, drawn from their on-the-ground experience of housing successes and failures. For example, a common failure point is shower rails pulled from bathroom ceilings. The integration of the capital works and maintenance teams means housing upgrades now ensure that wall studs are appropriately located such that shower rails can be attached more effectively.

The roles played by the capital works and maintenance coordinators and the arrangement with the head contractor (described below) mean that significant resources are dedicated to ‘chasing maintenance’ on the APY Lands. The Aboriginal Remote Housing section believes that planned maintenance is beneficial and reduces costs over time.

> We see the value in maintaining the housing stock at a level that’s maintainable, rather than it declining so much that the investment when a house becomes vacant, to bring it back to standards, is so high that is has a significant budget impact. (Participants 1 and 2)

This proactive approach to maintaining the quality of housing is also pursued by Nganampa Health Council’s environmental health program. Nganampa delivers comprehensive primary health care from seven clinics across the APY Lands and runs several health-related programs, including its UPK (Uwankara Palyanyku Kanyintjaku) environmental health program. Based on an original survey in 1986 that formed the basis of the widely respected Housing for Health methodology, the UPK program is focused on health promotion, disease prevention and wellbeing issues, undertaking work designed to increase the environmental quality of the living environment (NHC 1987).

From the mid-2000s until recently, Nganampa Health Council’s UPK environmental health program, comprising two environmental health supervisors (one Anangu) and four Anangu environmental health officers (EHOs), was underpinned by two funding streams: Commonwealth Closing the Gap (CTG) and SA Department of Premier and Cabinet funding, distributed to Health SA. While this is health (not housing) money, an NHC respondent emphasised: *‘We’ve always said that housing and health need to get married’* (Participant 8). Subsequent loss of CTG funding ($180,000) has reduced capacity to employ EHOs. Today’s UPK program involves environmental health worker teams who engage collaboratively with Housing SA, RASAC and visiting specialists, such as the NHC vet. Environmental health workers ‘provide services at houses, schools, clinics, art centres, cemeteries and stores. Yard maintenance, hazard reduction, rubbish removal and tree lopping have been major work activities of these teams’ (NHC 2018: 24).

The key point is that houses on the APY Lands and their broader living environments receive attention from both Housing SA’s property maintenance program and NHC’s environmental health program.

3.3 Hardware failures and reporting maintenance

Respondents described the common hardware failures occurring on the APY Lands. These include electrical failures, air conditioner malfunction or breakdown, damaged and broken doors and door handles, missing screen doors and windows, blocked toilets, septic tank corrosion and appliance failure, especially stoves. Hardware failures were attributed to myriad factors such as the hardness of water and the dusty, arid landscape and the presence of insects, rodents and other animals (domesticated and feral).

Some hardware failure could also be attributed to the inattention to minor issues under previous R&M programs. This can lead to major hardware failures occurring, as one respondent described of a full wet area refurbishment:

> now we're probably up to $50,000/$60,000 worth of repair work which probably originally started off as a $2,000 job. Now it's a $50,000 job. So, it's just that going in and looking and addressing little issues … That's the key for the remote stuff because when it becomes big it is big. (Participants 1 and 2)

Crowding was also identified as another cause of accelerated wear and tear, including crowding related to population mobility and intermittent increases in resident numbers.

> So, if we've got overcrowding at 49 per cent, it doesn't matter what [we] design in a house, we're always going to have high failure points. The septics are always going to be under extreme pressure. When you've got 15 people in a house that's really designed for six or seven, your solar hot water service is always going to be running cold very quickly … Everything in the house is going to be stressed to the maximum capacity. (Participants 1 and 2)

> Lately we've had a lot of visitors, so we've been smashed by the toilets and the washing machines, and everything being overloaded. I've just been trying to keep up with it all, trying to keep the poo flowing and the washing machines working. (Participant 7)

Tenants' requests for fix work are nominally lodged via a phone service located at Umuwa, staffed between 9am and 5pm on weekdays. However, it was noted that faults that are likely to be reported in private residential and urban public housing tenancies are less likely to be reported on the APY Lands. Respondents suggested that this can come from an unwillingness to 'bother' Housing SA, as well as the difficulty of reporting maintenance issues in English.

> People up here are very traditional people and sometimes they'll say, 'Let's not bother them. The toilet's still flushing. Okay, it's going to the top each time it flushes but let's not bother them just yet.' … Sometimes, especially with the elderly people, their English is their second language, so [the challenge is] explaining, number one on the phone and number two, trying to get the message across in English. (Participant 3)

In part, the reluctance of some Anangu residents to report hardware failures via mainstream processes, such as the telephone, has informed the design and delivery of the current maintenance model operating on the APY Lands. Respondents noted that the highest reporting avenue for fix work is via Housing SA tenancy practitioners[2] attending houses, rather than via tenants initiating requests themselves.

Reports for required fix work also come to Housing SA via other organisations such as Nganampa Health Council and disability services (SA Department of Health Services). If EHOs come across an issue that they are not licensed to fix or lack the time to address, they can put in a maintenance request to Housing SA. In relation to emergency fix work or where it is perceived there will be a delay, an NHC environmental health officer might step in.

> Often, it's just easier to fix it myself, rather than wait for Housing to come out. If you've got an issue which is a real health problem, you can't wait. (Participant 7)

In turn, Housing SA tenancy practitioners will raise issues with NHC, where these relate to cleanliness outside the house but within the fence line.

2 Tenancy practitioners are now known as housing officers but are typically referred to by their older name.

In addition, the Housing SA maintenance coordinator is often in communities for quality assurance (QA) inspections, auditing the work of the licensed tradespeople employed by the head contractor. Tenants will make requests directly via this avenue. Finally, fix work is also reported by contracted tradespeople when undertaking planned maintenance work. The head contractor model allows many jobs to be discovered and completed on the spot, but failures in larger household appliances may require reporting to Housing SA.

In sum, while mainstream lines for requesting housing repairs are in place, such reporting occurs on the APY Lands by a range of less formal means, including visits by tenancy practitioners, inter-agency communication, the presence of the Housing SA maintenance coordinator in communities and licensed tradespeople undertaking planned maintenance.

3.4 The Housing SA maintenance contract

The contract for housing maintenance on the APY Lands is a head contract held by Furnell Plumbing Pty Ltd (referred to hereafter as the head contractor) which provides multi-trade services through a combination of employees and sub-contractors. This contract commenced in June 2017 for a period of seven years. The head contractor model is typical of Housing SA maintenance for various regions across the state. However, the *planned* maintenance approach is distinct to the APY Lands. As one respondent noted, '*we're trying to go through more programs because it's just cheaper to deliver*' (Participants 1 and 2).

The head contractor held the previous four-year contract and the company had been undertaking plumbing works on the APY Lands for a longer period. The current contract is held jointly with the Department of Planning, Transport and Infrastructure (DPTI, now the Department of Infrastructure and Transport [DIT]) and Housing SA, each of which invoice the head contractor separately. The contract includes maintenance obligations for Indigenous housing and other government-owned building assets. Respondents estimated an approximate 60/40 split in work undertaken on housing as compared to other government assets.

> [The head contractor] will do all the maintenance on the staff housing, all the police station, schools, everything is all combined into a single contract, whereas previously [the head contractor mainly] did [Housing SA] contract work. He did a little bit of DPTI work, but DPTI would bring in other contractors to do work. So quite often in the community, you would walk into a DPTI electrician coming in and a [Housing SA] electrician coming in, doing electrical work, which is the same. And you're paying all that mobilisation cost for two people. (Participants 1 and 2)

Establishing this cross-departmental contract was a major achievement, as it allowed for increased efficiencies related to mobilising labour in remote areas. Respondents noted that the previous model allowed for multiple tradespeople with similar expertise but employed by different organisations to undertake work in the same community simultaneously. As well as underpinning travel inefficiencies, the former model diluted responsibility for hardware failures. For example, under the former arrangement a contractor might be able to avoid responsibility for unsatisfactory work: '*"Oh no. That was the other electrician. That's his fault".' Whereas, now there's just one [contractor]. If there's anything wrong, [Housing SA] just come to us'* (Participant 5).

Both Housing SA and the head contractor spoke positively of their relationship, including the proactive approach the head contractor has assumed in relation to housing failure. In addition to the form and longevity of the head contract, its efficacy apparently depends on the attitude and experience of the head contractor.

> We've got a really good relationship with our contractor … he works with us. It's a partnership. Whereas a lot of other maintenance contracts, it's an 'us and them' approach. We see him as the doing arm. If he's not successful, then we're not successful as well. He's open, he comes back to us with issues, his team identifies things when they're in houses and communicates back with us. So, there's really good communication on both sides of the fence. (Participants 1 and 2)

This positive framing of the relationship between Housing SA and the head contractor was grounded in the latter's role in the feedback loop that underpins the APY housing maintenance model. The head contractor will raise repeated hardware failure types with Housing SA. For example, the head contractor identified a high failure rate for window and door security screens. In turn, Housing SA has worked with a manufacturer in Adelaide to fabricate new window security screens and is working on a stronger screen door (Figure 12).

From the head contractor's point of view, the positive relationship with Housing SA was dependent on the latter's understanding of what is required to deliver remote area R&M. This understanding has been demonstrated by involving the head contractor in forward planning of required works. It has also been demonstrated by affording the head contractor flexibility to undertake the work as needed and as soon as possible, given various challenges discussed below.

3.5 The Housing SA maintenance program

Housing SA distinguishes between 'planned' and 'responsive' property maintenance. A significant majority of work is completed as planned maintenance, including additional jobs that were unknown to a tradesperson on arrival at a property but were nonetheless completed on a planned visit. 'A stitch in time saves nine' describes the program.

> [The head contractor] uses this stitch-in-time approach and it's sort of an aphorism we're using. Where if we're continually going into a house and fixing up those things that are failing, then we're hoping that we can lower our responsive callouts. They're our most costly callouts, responsive maintenance. But a planned maintenance [approach], because you're in that community and your trades are going through every house and going around … we also can achieve more at the same time. (Participants 1 and 2)

Tradespeople working for the head contractor have significant discretion to complete additional jobs, with only larger jobs valued at over $5,000 requiring separate approval by Housing SA. The discretion granted to tradespeople employed by the head contractor is not typical of property management regimes elsewhere, including the Northern Territory, where work orders of much lower values require additional approvals, with associated impacts on travel times, job completion time, contractor and tenant dissatisfaction (Legislative Assembly of the Northern Territory 2016). It helps to identify needed repairs and to fix them before major repairs or replacements are required. The approach also reduces the travel cost component of the maintenance program.

The discretion granted to tradespeople reflects the trust and respect between Housing SA and the head contractor. The length of time the head contractor had held the contract with Housing SA and the length of time his tradespeople had been employed by him were understood as crucial in fostering both tenant relationships and corporate knowledge of APY Lands housing.

> [The tradespeople have] been around for years … There're some guys out there that have been doing this work for, eight, nine years now … They do build up a relationship. So they get to know tenants, which is always a benefit … And these are benefits because of that model that [the head contractor] got. Whereas, if it's that subcontractor model, then you've got fresh people constantly going in. (Participants 1 and 2)

Across a financial year, each community typically receives ten planned visits, with each house serviced according to a programmed schedule of trade works. These programmed maintenance services are in addition to inspections and tenancy support visits conducted by the tenancy management team. The programmed maintenance schedule is established through consultation between Housing SA and the head contractor. The head contractor identified the flexibility afforded him and his team to determine and undertake the planned maintenance schedule as being central to the efficiency gains obtained.

> Allowing us to schedule these things. We know what we've been provided with, what needs to happen, but allowing us to schedule it so you know you get rid of your highs and lows in volumes of work so we can schedule that to make it just run smoothly. And putting certain activities at the right times of year so people stay safe and get the best outcomes. (Participant 6)

Visits to geographically adjacent communities are grouped together. For example, tradespeople will visit the western communities of Pipalyatjara, Kalka, Nyapari and Kanpi on the same scheduled run and Pukatja and Yinyarinyi together (see Figure 6). The annual programmed schedule of works includes two air conditioning services, four pest inspections, an electrical safety assessment, a plumbing maintenance visit, a hot water system check and a building fabric check.

The programmed schedule staggers planned visits to communities to distribute trade work through the year. Air conditioning maintenance services, for example, are scheduled twice a year and according to seasonal variation, first in July and August, prior to tenants turning air conditioning units on and second in October and November, once those units are being used and prior to the most severe summer temperatures. Air conditioning services include maintenance of the electrical components of the evaporative units but also the pads, which due to the hardness of the water in the region require regular replacement or high-pressure flushing. The regular pest control visits are chiefly aimed at breaking cockroach breeding cycles in the houses. The programmed schedule also specifies the time of year in which fence maintenance and concreting work will be completed. In communities with smaller populations where houses use septic tanks, these are scheduled to be de-sludged every two years, grouped together as 15 to 20 work orders.

To repeat, this planned maintenance program managed by Housing SA is atypical of Indigenous housing property management. Elsewhere, property maintenance programs are predominantly responsive and employ sub-contractors in relatively adhoc ways. Jurisdictions that do have a head contractor model operating in regional areas do not typically have the same emphasis on planned maintenance as Housing SA nor do they give the head contractor equivalent flexibility in scheduling and completing fix work while on-site. The APY Lands model also contrasts with the general approach to maintenance taken elsewhere in South Australia.

The high number of planned visits by licensed tradespeople represented in the programmed schedule of works is a distinctive feature of the APY Lands program. However, it was recognised that the high frequency of visits may be burdensome and intrusive for tenants:

> We've got ten visits by contractors going into a house throughout the year and they're our eyes and ears. If we're not capturing failures and lifting the housing stock, lord help us all. And then we've got our tenancy practitioners. Anangu people must just be fed up with the number of people coming to the house … Then [the maintenance coordinator is] coming around as well. So, it's not for want of trying that we don't have a presence inside a house. We shouldn't have big issues not being identified for us. (Participants 1 and 2)

The hope is that any negative impact on tenants caused by this sustained attention is offset by more functional housing. The aim and the understanding are that the program reduces costs over time. Via the feedback loop, the planned maintenance schedule also aims to identify hardware failures that may be outside the current maintenance remit, but which require prioritisation.

> For instance, [the head contractor] will identify things for us that we can park as issues, as ongoing issues. So, whether that's X number of houses need painting or X number of screens need replacing on houses. So, as part of the delivery of program works as well, we've asked him, 'Can you capture what's missing on a house?' (Participants 1 and 2)

3.5.1 Housing SA repair and maintenance data

This section considers Housing SA property maintenance data. This analysis provides further understanding of the types of work undertaken within the Housing SA program on the APY Lands and how this work occurs.

A chief aim of our data analysis has been to parse those housing faults requiring tradespeople from those which unlicensed local workers might be able to attend to, in order to estimate the proportion of work available to local employment. However, because of how maintenance works are undertaken on the APY Lands, Housing SA data does not allow us to distinguish work undertaken by licensed and unlicensed workers in practice. We have therefore supplemented the quantitative data with qualitative evidence about the contractor's resourcing model by trade (certified, apprentice, non-trade) and the job types undertaken by various workers. From this we have extrapolated the types of work that can be undertaken by unlicensed local workers, indicating the potential for greater local employment through funded maintenance regimes.

Table 3 documents the number of housing maintenance jobs undertaken by each trade type over the period 2017–2020 within the Housing SA maintenance program on the APY Lands. Eleven different trade types are reported in the data.

Plumbing works accounted for the highest average number of jobs over the four-year period and constituted more than 20 per cent of all housing maintenance jobs in any year. In 2020 it constituted nearly half of all jobs undertaken.[3] This work category includes internal work (related to sinks, bath, showers and laundries, taps, toilets and sewer drains) and external work (related to guttering, stormwater, hot water systems and rainwater tanks).

General works constituted the second highest average number of jobs over the four-year period, accounting for around 18 per cent of all jobs undertaken on APY Lands housing. General works includes R&M related to doors and windows, screens, locks, fixing and flushing, internal walls and ceilings, insulation, fencing, gates and roofing and tile repairs.

Electrical works accounted for the third highest average number of jobs, constituting around 15 per cent of all R&M work. Electrical works includes repairs to appliances, lighting, circuit boards and wiring and smoke alarms. Air conditioning R&M constituted around 12 per cent of the total work.[4]

All maintenance jobs incur some travel costs, given the remote locations of homes. The data shows that, on average, approximately ten maintenance work orders were completed for each travel work order. This demonstrates the relative efficiency of the planned approach.

Fire safety, painting, cleaning, waste management and building works accounted for a small proportion of the total work in the program over the period 2017–2020.

Figure 7 uses data for 2019 and plots the proportion of maintenance jobs undertaken in each community by trade. It shows a high proportion of total R&M work is undertaken in the Amata, Iwantja (Indulkana), Mimili and Kaltjiti (Fregon) communities. This holds for most of the different types of trade works and reflects the relatively larger populations of these communities.

3 Note that the 2020 data provided by Housing SA was incomplete. In addition, COVID-19 impacted the maintenance work being undertaken on the APY Lands and likely skews the data for this year.

4 Air conditioning works were much lower in 2020, reflecting the restriction placed on maintenance work due to COVID-19, which restricted travel to remote communities.

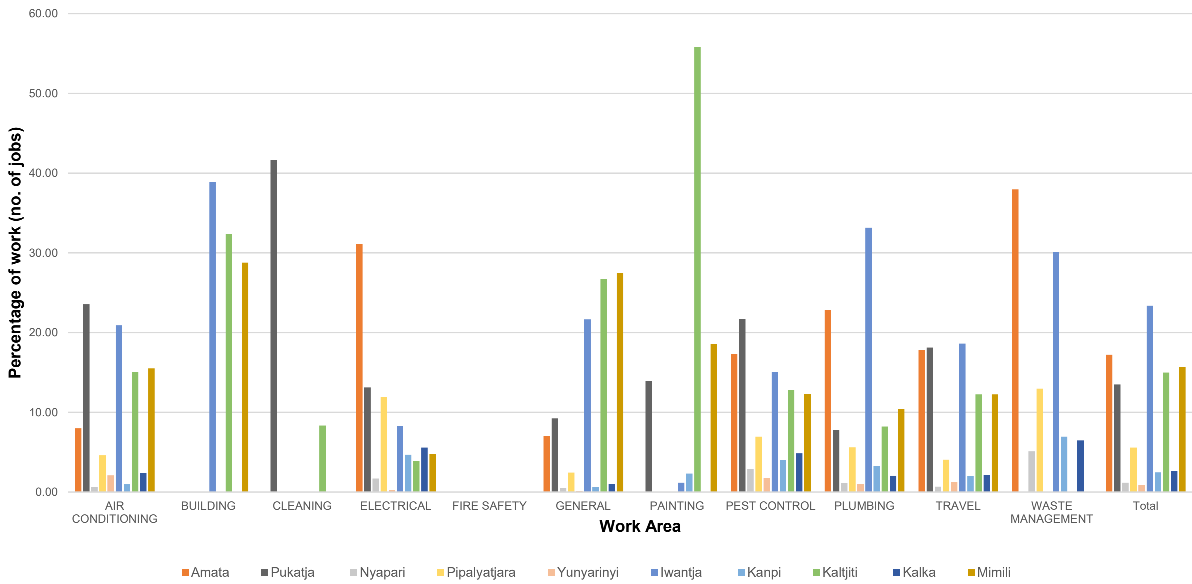
A high proportion of air conditioning work is undertaken at Pukatja (Ernabella) and Iwantja. Building work is largely confined to Iwantja, Kaltjiti and Mimili. A significant proportion of cleaning and pest control work is undertaken at Pukatja, while a significant proportion of all electrical work is undertaken at Amata. General maintenance work is largely undertaken at Iwantja, Kaltjiti and Mimili. Over half of all painting works were undertaken in Kaltjiti. Approximately half of all plumbing work and a higher proportion of waste management work was undertaken at Amata and Iwantja.

Table 3: Number of jobs by trade over the period 2017–2020

	Jobs per year										
	2017		2018		2019		2020		Total		
Trade	No.	%	No.	%	No.	%	No.	%	No.	%	Yearly average
Plumbing	1,411	21.6	2,785	23.7	2,685	25.3	4,483	46.6	11,364	29.5	2,835.8
General	1,234	18.9	1,401	11.9	2,667	25.1	1,702	17.7	7,004	18.2	1,622.5
Electrical	1,038	15.9	2,620	22.3	1,364	12.8	908	9.4	5,930	15.4	1,481.8
Travel	686	10.5	1,625	13.9	1,208	11.4	1,382	14.4	4,901	12.7	1,225.3
Air conditioning	895	13.7	1,750	14.9	1,626	15.3	449	4.7	4,720	12.3	1,179.5
Pest control	1,066	16.3	1,085	9.3	618	5.8	374	3.9	3,143	8.2	785.8
Waste management	2	0.0	287	2.4	216	2.0	185	1.9	690	1.8	172.5
Building	186	2.9	163	1.4	139	1.3	87	0.9	575	1.5	143.8
Painting	0	0.0	1	0.0	86	0.8	40	0.4	127	0.3	31.8
Cleaning	3	0.0	11	0.1	12	0.1	8	0.1	34	0.1	8.5
Fire safety	0	0.0	1	0.0	3	0.0	0	0.0	4	0.0	1.0
Total	**6,521**	**100**	**11,729**	**100**	**10,624**	**100**	**9,618**	**100**	**38,492**	**100**	

Source: Author analysis based on Housing SA data.

Figure 7: Breakdown of R&M work by community (2019)



Source: Author analysis based on Housing SA data.

Table 4 shows the total cost of works undertaken on the APY Lands for each trade in 2019, the latest year for which full financial data was available. While not undertaken as frequently as plumbing works, general maintenance work is the costliest category, accounting for a third of the cost of all R&M work. Plumbing is the second most costly work type and accounts for a quarter of the total spend. Almost 11 per cent of the total cost of maintenance was spent on travel. However, the ratio of maintenance work orders to travel work orders suggests that this approach is more efficient than a predominantly responsive maintenance program where travel costs are incurred on almost all work orders. Travel costs can account for up to 96 per cent of per-unit costs for emergency repairs in Indigenous housing, compared with 11 to 37 per cent for planned maintenance activities (Nous Group 2017: 16). By comparison, the repairs and maintenance approach in APY lands is very cost efficient.

Table 4: Total cost of works undertaken on the APY Lands by trade for 2019

	2019	
Trade	2019 Costs	Per cent yearly cost
Air conditioning	$472,493.02	12.78
Building	$24,479.04	0.66
Cleaning	$33,165.92	0.90
Electrical	$391,745.36	10.59
General	$1,204,342.01	32.56
Painting	$69,857.03	1.89
Pest control	$86,625.88	2.34
Plumbing	$935,766.57	25.30
Travel	$393,180.78	10.63
Waste management	$87,730.98	2.37
Total yearly cost	**$3,699,386.59**	**100.00**

Note: 2019 is the only year in which full costs were available. The total costs are different to those cited above as the data is derived from calendar year costs rather than financial year costs. Per cent yearly cost figures have been rounded to two decimal places

Source: Author analysis based on Housing SA data.

Table 5 provides a breakdown of the Housing SA remote housing maintenance budget for the 2019–2020 financial year and the projected expenditure budget for the year 2020–2021. Note that this budget applies to all remote housing repair and maintenance undertaken by Housing SA. This includes remote communities outside of the APY Lands. It indicates that Housing SA are expending 52 per cent and 57 per cent of their budget on planned maintenance, whereas only 26 per cent and 20 per cent of the budget is expended on responsive fix work. This is in line with target benchmarks of other jurisdictions for planned maintenance in general social housing, where most housing is in urban areas (Community Housing Industry Association NSW 2018).

Travel is approximately 10 per cent of the budget. Given the cost pressures on remote R&M outlined above, it is likely that this proportion would be significantly higher if not for the planned delivery of works.

Table 5: Planned versus responsive maintenance

	2019–2020		2020–2021	
	$	%	$	%
Responsive	1,300,000	25.7	1,300,000	20.8
Planned	2,600,000	51.3	3,700,000	59.2
Homelands	200,000	4.0	200,000	3.2
Vacancies	500,000	9.9	505,000	8.0
Travel	460,000	9.1	550,000	8.8
Total	**5,060,000**	**100**	**6,255,000**	**100**

Source: Author analysis based on Housing SA data.

3.5.2 Planned maintenance in practice

Housing SA managers typically make monthly trips to APY Lands communities to assess housing stock, scope required capital upgrades, attend council meetings, consult with tenants, contractors and the Housing SA capital works and maintenance coordinators who work on the APY Lands. The maintenance coordinator rarely undertakes fix work himself and is central to the distribution of work orders to the head contractor and his tradespeople.

In addition to assessing photographic records and invoices of completed work, the maintenance coordinator plays an auditing role by conducting QA checks of work completed by the head contractor's team. In a typical two-week work cycle, the maintenance coordinator is likely to check a selection of at least 20 invoiced work orders and would usually prioritise the audit of work valued over $1,000. Both for the ability to see the work undertaken by the head contractor's team and to provide tenants with direct access to Housing SA, the presence of Housing SA staff on the APY Lands was considered by many respondents as fundamentally important to the success of the property maintenance program.

> Somebody has to be here. You can't do a job like this from a desk and the beauty of being up here is interacting with people ... People see me in the community and they just go, 'Housing! Housing! Hey, how are you today?' … It's that rapport that you build with people and then the confidence that people have to report things to you. (Participant 3)

The head contractor described his team as 'on the ground 24/7', with individual crews working for 14-day blocks. The main base for Housing SA and the head contractor is at Marla, a small service centre on the Stuart Highway to the east of the APY Lands. The head contractor has accommodation, equipment and materials bases throughout APY Lands communities, at Umuwa, Amata and Pipalyatjara. Tradespeople will stock-up on materials at Marla and then continue working across the APY Lands on a two-week rotation. Every job is GPS tracked and the tradespeople use tablets to make photographic records of the condition of housing hardware and completed jobs. During a planned maintenance visit, a tradesperson will work according to a tech data sheet relevant to their area.

> They might have a plumbing check and the tech data sheet might say, 'You need to check all drains are clear. You need to check if there is lint under the vents. Check that all taps are functional. Check the hot water pressure relief valve' and stuff like that. (Participant 5)

At the completion of the tech data sheet and any work it has prompted, along with specific responsive work orders, the tradesperson submits a report to the maintenance coordinator, who then has a record of work and an invoice. In addition, if a tradesperson notices a job in another trade area that requires completion, they can report this, and the maintenance coordinator will generate a work order for the relevant tradesperson.

3.5.3 Responsive maintenance

Even a planned maintenance program as extensive as that designed by Housing SA for APY Lands housing requires responsive maintenance works. Housing hardware breaks down, malfunctions, and disappears without warning and between planned maintenance checks. Common housing hardware failures on the APY Lands that are attended to as responsive repairs include broken door handles, dysfunctional air conditioning units, failing stoves and damaged screen doors.

Housing SA uses a spectrum of 1–5 to prioritise responsive work orders. If a work order is prioritised 5, the contractor should attend to the job within 30 days. This may happen sooner, depending on the schedule of planned maintenance visits. A prioritisation of 1 requires that the job is completed on that day, if it is reported earlier than 1pm, or the following day, if reported after that time. Priority 1 work orders relate to major health and safety issues, in particular electrical safety and water availability—*'For example, if there was no water at a school that would be a P-1 because they've got to shut the school if there's no water'* (Participant 5).

Most work orders are raised as a P-2 or P-5. However, in practice, based on the two-week work-cycle of a tradesperson on the APY Lands, most maintenance work is addressed within two weeks, well within the P-5 period. This practice has substantially reduced travel costs under the contract arrangement and created efficiencies in work practice.

3.5.4 Maintenance and environmental health

Housing SA's planned maintenance program is extensive but it is not fully comprehensive. Prioritisation is given to works that impact most directly on safety and health inside the home, including electrical, plumbing, air conditioning and pest control works. At the present time, there is no operational painting or cleaning program. Housing SA respondents noted these budget-induced gaps.

Housing SA's program does not typically involve deep cleaning of wet areas, which is a service popular with tenants and one sometimes provided by Nganampa Health Council. Housing SA supplies stoves, evaporative air conditioning units and water tanks but not whitegoods, including fridges and washing machines. To fill this gap, a Nganampa Health Council UPK supervisor sources washing machines for residents from discarded units at the international tourist destination of Yulara (NT). These are not always fully functional but can be stripped for parts to repair broken machines in people's houses. This supervisor has a running list of washing machines in APY Lands' houses that require repairs or replacement, because they've stopped working, are leaking, or are too noisy (see Figure 8). Housing SA also deems yard work (for example, slashing grass and rubbish removal) to be the responsibility of the tenant during a tenancy. A tenant can request a trailer through RASAC, which provides council services beyond the edge of housing lots and has multiple offices throughout the APY Lands. For example, if Housing SA removed a vehicle from a tenant's yard, RASAC should nominally dispose of it, but will not if it remains within the lot.

Figure 8: Washing machines used for replacement parts on the APY Lands

Source: Liam Grealy.

Nganampa Health Council respondents emphasised the relationship between the house and the yard as central to the UPK program. Buffel grass, an introduced species, is rife across the APY Lands and its removal from in and around yards is an important hazard reduction activity, relating to the fire safety components of Healthabitat's (2021b) *Housing for Health: The Guide.* Such work also reduces crowding.

> Because you're making the yard more liveable. When we looked at overcrowding, you could have 15 people in the house and functional crowding was three groups of five people … If the yard was well furnished, and yard furniture was well kept, you had five groups of three people because two groups were outside. (Participant 8)

At the request of residents, NHC environmental health workers will also leave a trailer in residents' yards, which can be filled with rubbish for delivery to the tip. The program also dispenses parasitic control drugs to dogs between vet visits, provides firewood to sorry camps, slashes grass, and undertakes various public health work as required, such as testing wastewater and distributing personal health hardware products.

NHC environmental health workers undertake preventive and responsive work that does not typically require licensed tradespeople*, 'such as unblocking drains, fitting mirrors in bathrooms, maintaining yards, repairing washing machines, washing houses and removing rubbish'* (Participant 8). The focus on environmental health emphasises an ecological understanding of what is required to effect healthy living practices (Pholeros, Torzillo et al. 2000).

> We always said you've got to take a broad frontal approach … to ensure that when people were at home, they could wash their kid. That relies on the bore working, it relies on the delivery, the pipes. It relies on the taps not falling off, their capacity to buy a towel in the store and the soap and the shampoo … the house has got to be designed, constructed, supervised; there's got to be money for maintenance; there's got to be a store that can supply the essentials. (Participant 8)

Work conducted by the NHC environmental health team operating in the west of the APY Lands (Pipalyatjara, Kalka, Nyapari, Kanpi) can be coded according to Healthabitat's HLPs (Figure 1). During the financial year 2019–2020, the team in the west undertook 317 discrete jobs coded to the HLPs. The fourth quarter of this year was significantly impacted by COVID-19, during which Housing SA operated an emergency maintenance program only. In addition to normal activities, the environmental health teams supported the distribution of public health communications, including fact sheets, posters, video and radio spots and, with RASAC, erected community hand washing stations. Environmental health workers distributed household cleaning products to 250 households, funded by Housing SA. A summary of work for this financial year is included in Table 6.

Table 6: Nganampa Health Council environmental health work distribution by HLPs

HLP	Jobs completed (2019–2020)
Safety	13
1. Washing people	27
2. Washing clothes and bedding	73
3. Removing wastewater safely	49
4. Improving nutrition	22
5. Reducing the impacts of overcrowding	55
6. Reducing the negative effects of insects, animals and vermin	24
7. Reducing the health impacts of dust	0
8. Controlling the temperature of the living environment	36
9. Reducing hazards that cause trauma	18
Total	**317**

Source: Author analysis using Nganampa Health Council data.

Because the work of the environmental health program extends beyond the fence into the community, a range of other work types were undertaken. Across the 2019–2020 period, work undertaken by the team operating in the west of the APY Lands included jobs coded as follows in Table 7.

Table 7: Nganampa Health Council community-based environmental health work (west team)

Job type	Jobs completed (2019–2020)
Cemetery (prepare sites and dig graves)	10
Community infrastructure	10
Cockroach treatment	5
Pressure clean building areas	11
Window repairs	1
Door and door lock repairs	11
Firewood collection and distribution	27
Stock trough maintenance	15
Rubbish trailer delivery and removal	17
Sampling main supplies for SA Water	4
Total	**111**

Source: Author analysis using Nganampa Health Council data.

Rather than completing a list of pre-ordained jobs, the UPK program aims to complete the tasks necessary to maximise the potential for residents to enact healthy living practices. This means that the day-to-day activity of UPK environmental health workers is a matter of responsive needs and available resources.

> Ideally, we do a lot of house-to-house, knocking on doors and saying, 'We're here, what's broken?' … But what happens with me is, when I'm being reactive, I'm driving around and people are flagging me down, 'we've got a problem, our toilet's broken' or 'our washing machine doesn't work'. (Participant 7)

The role of flexible and effective administrative support is key to an effective environmental health program. Like at Housing SA, consistent communication exists at Nganampa Health Council between the work on the ground and in the back office, while flexibility is granted to environmental health workers.

> They know broadly the areas of work. I don't say 'well today you're doing this and tomorrow you're doing that' … My job is to support the guys because that's where the pedal hits the metal, you know. So, I will be the gopher, I will do the government stuff, I will keep government off their backs, I'll sort the timesheets. (Participant 8)

Taken together, houses on the APY Lands are thus subject to Housing SA's property maintenance program, implemented by the head contractor and NHC's UPK environmental health program. While smaller in scale, the latter program fills some important gaps of the extensive works undertaken by Housing SA and provides an additional line of communication for required works. It also emphasises the health conferring function of housing, which similarly underpins Housing SA's approach. On the ground, the maintenance coordinator and, to a lesser extent, the head contractor's tradespeople, will also alert local RASAC municipal services officers (MSOs) to work beyond the scope of the Housing SA maintenance program. This often concerns yard work and issues related to animals. For example, a tenant might call the maintenance coordinator and say:

> 'The camel got in last night and it bent the front tap over and we've got a waterfall now in our front yard. Water's just coming straight out of it.' So, I ring the MSO, give him the name and address of the property and community and he goes and isolates the water. (Participant 3)

Thus, even where a property maintenance program includes extensive detail on the work areas involved and is well-resourced to complete them, there are limits to what is undertaken and some cross-over in the practical involvement of various parties. On the APY Lands, this is an advantage, generating additional lines of communication, expanding relationships with local communities, and attending to work related to a broad conception of the living environment. Such outcomes are not simply an effect of the remote context and there is significant potential for planned and responsive approaches to complement one another elsewhere. After all, remoteness often requires that the nearest person attend to a problem until the relevant tradesperson can get to the scene.

3.6 Impact of COVID-19 on the maintenance program

In 2020, from March to July the COVID-19 pandemic led APY Lands communities to restrict visits from non-residents under the *Biosecurity Act 2015* (Federal Register of Legislation). While there are typically 9 to 12 tradespeople on the ground at any one time, only 3 were available in this period to conduct emergency maintenance work under a priority one program.

With a restricted team allowed on the APY Lands during this period, a narrow range of emergency work was attended to, with attention to less acute hardware failures delayed to minimise the risks of physical contact.

> A lady might ring in and say, 'my tap is leaking, I've got a hole in my wall and my front door lock is broken'. So [under the COVID-19 restrictions] we won't do the hole in the wall, but we'll do the door lock and the leaky tap. (Participants 1 and 2)

During this period of restricted access to APY Lands communities, Housing SA staff were also not present on the APY Lands and experienced a minor reduction in tenant reporting. There was also a reduction in program expenditure as planned works were delayed. This confirmed Housing SA's sense that planned rather than responsive maintenance should be prioritised.

> When COVID was on, we were all working from home, nobody was up here and maintenance pretty much all dried up. We were relying on … the tenants to ring in and we were getting probably less than half of the maintenance when the tenancy practitioners are here. (Participant 3)

With reduced community presence, the role of Nganampa Health Council environmental health workers based on the APY Lands was especially crucial.

> *We've had a couple of blocked soakage trenches over the COVID period, which, if I wasn't here, they just wouldn't have been fixed and there would have been septics backed up in at least two houses with big families, a lot of people staying there. That really points out how you need someone on the ground.* (Participant 7)

3.7 Challenges to property maintenance

There is little new supply of government housing planned for construction on the APY Lands over the next five years: 26 existing houses will be replaced alongside additional upgrades (Participants 1 and 2). There is no funding to expand existing stock and in several larger communities, expanding house numbers will require new serviced lots. This can be compared, in recent times, to the delivery of new housing under the *National Partnership Agreement on Remote Indigenous Housing (2008–2018)*, during which the APY Lands received 109 additional houses, 60 replacement houses and 199 house refurbishments. As of 2017, there was an estimated 160 new houses required on the APY Lands.

Given the current housing shortage and the likelihood of even greater housing under-supply, the property maintenance program assumes additional importance. The under-supply of housing increases crowding, which places pressure on both housing hardware and familial relationships.

> If your family member comes and says, 'I've got nowhere to live', you can't say, 'Well, that's your problem, not mine'. It's your problem, because they're family … When COVID was on, everybody left and now everybody's coming back and people are coming back that hadn't lived here for a while, as well. (Participant 3)

Over the years, there has also been a reduction in funded professional expertise and capacity within communities.

> We don't have municipal services officers in each community or essential services guys. The technical capacity in the communities has been pretty much withdrawn. Every community used to have an ESO [Essential Services Officer]. (Participant 8)

The turnover of staff and the loss of skills is a major challenge to effective housing maintenance and environmental health work in remote contexts. As shown above, the continuity of the relationship between Housing SA and the head contractor has been a major advantage. Reduced health services funding places this at risk. A Nganampa Health Council respondent notes, '*We've been whittled down, you know. I'm sort of one of the only guys left with a lot of corporate memory and knowledge about all this sort of stuff*' (Participant 8).

With the challenge of generational change and corporate transition comes the risk of unsustained initiatives. This is a risk for all of Housing SA, Nganampa Health Council and the head contractor, which have had an unusual level of stability of key maintenance staff working on the APY Lands. Retirements of key people present the potential of opening a void to be occupied by less experienced and diligent operators. In such remote contexts, even clearly well-designed systems require key people to hold houses and their maintenance programs together.

3.7.1 Climate change

Across the APY Lands and within government departments with responsibility for managing services, there are serious concerns over climate change and its impact on communities. The ecological crisis plays out in the provision of appropriate hardware inside houses, such as the selection and maintenance of air conditioning units to increase thermal comfort. Respondents described that while air conditioning units across APY Lands houses had previously varied in make and model, now

> all the air conditioners on the Aboriginal houses are exactly the same unit. They've got the same belt, the same pulley, the same motor. Everything is identical. Whereas seven years ago, there were about ten different models, so we had to stock different belts, different pulleys. We had about 30 different size belts in stock, whereas [now] we've just got that one. (Participant 5)

This issue of standardisation is important for cost-saving and time efficiency for maintenance and repairs. Indeed, Housing SA was commended that it has

> done a good job in standardising their houses and the products they use in them, which makes it easier for the contractor and, at the end of the day, saves them money. (Participant 5)

This outcome can be attributed to Housing SA's Aboriginal and Remote Housing section assuming responsibility for both construction and maintenance and the related feedback loop the section has fostered. Of course, air conditioning is not an uncomplicated solution to managing the impact of climate change for tenants, even if standardisation of the current evaporative air conditioning model has allowed more units to function properly more often.

> Air conditioning is a huge issue. We're using evaporative air conditioners and they're unsustainable to grow the communities … We'll have to look at ducted systems, which power-wise puts too much strain on the grid but at least you can grow power capacity. Whereas water is finite. We've done a bit of research on going to a ducted reverse cycle air conditioner. We did previously trial split systems and they all failed within months because of the dust. And the baby cockroaches getting on the circuit boards. We have to look at a completely isolated unit that can be completely sealed and we're talking about reverse cycle air conditioning. (Participants 1 and 2)

While it is necessary to expand the housing stock to meet crowding needs, the good sense of doing so depends on the capacity and willingness to expand intersecting infrastructures.

> You build more houses, then it puts more pressure on the natural resources, as well. It puts more pressure, then, on the store that has to get food in, the clinics that have to look after people and the police that have to police even more people now. And so, as long as those infrastructures and the services coincide with expanding housing, it's going to work, but it won't work if everything else doesn't expand with the housing population. (Participant 5)

On the APY Lands, there are significant issues related to remote municipal services infrastructure, for water, sewerage and power. In Amata, for example, there is no available land ready for expansion of existing houses. This absence of serviced lots is not uncommon. Even if a new subdivision was developed, many APY Lands communities are at capacity in terms of power generation and available water supply. Numerous respondents identified the challenge of water provision for existing houses and competition over the limited supply in the area.

3.8 Policy implications

The dedicated housing maintenance work undertaken by Housing SA's Aboriginal and Remote Housing section and Nganampa Health Council's environmental health program indicates the diligence required to sustain housing in favour of residents' health and wellbeing. The approach reflects that described in Chapter 2, striving to minimise costs across the housing life cycle while working to maximise health benefits. The key features of the APY Lands property maintenance arrangement that might be applied in other contexts are summarised below.

The combined property maintenance contract

The combined Housing SA and DIT multi-trade contract has increased efficiencies related to mobilising labour and increased transparency for the responsibility and quality of R&M work. Contract bundling should be undertaken with care in other contexts, lest services be monopolised by an unsatisfactory provider. On the APY Lands, the relationship between Housing SA and the head contractor has been critical to success.

The combination of maintenance and capital works

The 'feedback loop' between property maintenance and capital works in the Housing SA program improves effective housing design and material function. Dependent on good relationships and communication inside the section and between agencies, such feedback has contributed to increased efficiencies and innovative solutions to systemic maintenance issues.

Chasing maintenance

Housing SA's planned maintenance approach aims to identify required repairs and to maintain housing hardware to prevent major repairs or replacements. The planned maintenance schedule has allowed Housing SA to maintain relatively low spending on travel costs, especially for one-off visits to address responsive work orders.

Reporting maintenance

Housing SA's property maintenance program overlaps effectively with tenancy services and is flexible in providing multiple avenues through which fix work can be requested. The proactive approach to sourcing requests for R&M provides a more complete picture of required work and reduces the likelihood of major repairs or replacement of failed hardware.

Environmental health as housing maintenance

APY Lands housing benefits from simultaneous attention from Housing SA and Nganampa Health Council. The environmental health program is significant for promoting the health impacts of inadequately maintained houses and yards. The presence of staff in communities and inter-agency cooperation increases the timeliness and quality of R&M.

Undersupply of housing and crowding

There is little new Indigenous housing planned for the APY Lands. Contemporary crowding levels will place acute pressure on maintenance programs in the coming years.

Remote environment and climate change

The environmental conditions on the APY Lands are extreme and impact the selection of appropriate hardware inside houses. There are significant issues related to remote water, sewerage and power infrastructures, with some communities at capacity in their serviced lot availability, power generation and water supply. Integration of environmental designs with housing design and maintenance programs are vital.

4. Employment in repairs and maintenance

- **The potential for Indigenous housing to support sustainable employment remains under-realised. Housing construction projects generate jobs but can be sporadic and short-term. Repairs and maintenance (R&M), as ongoing requirements, could provide a more reliable source of sustainable local employment, an issue which will become more pressing with climate change related impediments to external labour and logistics.**
- **The property maintenance and environmental health programs we analyse from SA and NSW provide significant employment for Indigenous staff.**
- **Successful employment outcomes for local Indigenous people from property maintenance programs depends on a clear determination to prioritise Indigenous employment with targets and measures, the longevity of funding and contracts, the volume of work, planned maintenance, government funding for training and support, skilled supervision, training and mentorship and cultural competence.**

In 2018, the Indigenous employment rate was around 49 per cent overall and just 35 per cent in very remote areas, compared with 75 per cent nationally for the non-Indigenous population (PMC 2020a: 65–66). Housing represents a major investment in almost every regional and remote Indigenous community, providing substantial opportunities for local employment and training for workforce development and more resilient local economies. Accordingly, housing construction is often proposed to simultaneously increase stock and local employment. However, construction programs are typically conducted within tight schedules and scaled for profits, not sustained employment.

This chapter considers the alternative potential of repairs and maintenance to generate sustainable Indigenous employment. It draws on analysis of Housing SA's property maintenance program and Nganampa Health Council's environmental health program on the APY Lands and on Gunida Gunyah Aboriginal Corporation's operations in regional NSW. It argues that property maintenance, being more consistent and predictable than construction, not only increases the durability of existing housing but, if resourced, offers local employment options. Planned maintenance programs may increase operating costs but can secure other social and wellbeing dividends.

4.1 APY maintenance employment

The following sections detail how employment through R&M programs has been approached on the APY Lands. We pay particular attention to identifying unlicensed work as the swiftest pathway to local employment, while also considering the requirements to develop trades in remote contexts. Our aim is to describe the potential of R&M programs to generate local employment and what is required to do this sustainably. Having examined the existing Housing SA planned maintenance program data, we note that it is difficult to determine which specific work orders are undertaken by licensed tradespeople versus unlicensed workers. This is because licensed tradespeople will travel with at least one other unlicensed labourer or apprentice, to supervise their work and for occupational health and safety reasons. In practice, tradespeople might complete jobs that do not require a trade qualification to demonstrate the method for an apprentice, to support an unlicensed worker, or simply because that task requires completion on that visit. In addition, while some work such as painting and cleaning is commonly undertaken by unlicensed labourers, quality assurance compliance requirements mean that these tasks must be signed off by a tradesperson. This means that it is difficult to parse work orders as completed by a particular category of worker. This caveat aside, our case studies show the potential for R&M to generate consistent work remains significant.

In 2017, former NT senator Nigel Scullion called for the Community Development Program (CDP) to focus on housing maintenance. Nganampa Health Council was concerned about the plan to use CDP labour to meet housing maintenance needs (Jordan 2016) but, in consultation with Housing SA and Regional Anangu Services Aboriginal Corporation (RASAC), compiled a list of works that could be completed by people registered for CDP. Appendix 4 extracts from this list to represent many of the tasks undertaken by Nganampa Health Council's environmental health program that do not require licensed workers, and which are both preventive and responsive in nature.

This project indicates the range of R&M work that can be undertaken in and around houses by unlicensed workers. There is potential to connect such lists to proposals for alternatives to the CDP, which has been widely critiqued for discriminatory conditions attached to remote Indigenous participation (compared to the Job Active program operative elsewhere) and the punitive impacts of non-participation (Fowkes 2016; Campbell, Browne et al. 2018). Aboriginal Peak Organisations Northern Territory (APO NT) proposes to abolish the CDP, to be replaced by a federally-funded Remote Development and Employment Scheme (APO NT 2020). Nganampa Health Council's UPK program offers one model of remote employment that could be funded by such a scheme. It also indicates that implementing a responsive maintenance program to a high standard requires significant additional human and material resources, including technical supervision, vehicles, tools, personal protective equipment and cleaning materials.

4.1.1 Existing staff

The Housing SA Aboriginal and Remote Housing section has a staff of about five employees, including a section manager, a project coordinator and designer, an administrative officer and two field officers (a maintenance coordinator and a capital works coordinator). Respondents noted, however, that R&M work on the APY Lands requires flexible job descriptions and the ability to work across roles to ensure the successful delivery of services. The property maintenance team interacts in a variety of ways with the tenancy team, which includes a manager of remote tenancies, four tenancy practitioners and two customer services officers. The tenancy team services Coober Pedy and Dunjiba (Oodnadatta) in addition to the APY Lands communities and the customer services officers are located at Coober Pedy.

Nganampa Health Council's UPK environmental health program employs two environmental health supervisors who cover different areas of the APY Lands. One supervisor is based at Fregon and works in communities all the way to Iwantja (Indulkana); the other, at Kalka, works in the western APY Lands. At the present time, one Anangu environmental health supervisor works with a team of two Anangu environmental health officers while a second supervisor operates alone. This is atypical and across the life of the program each supervisor has usually had at least one offsider. However, previously noted funding reductions mean this is not currently the case. The environmental health officers are primarily trained on the job, supplemented by short courses on health and safety, small engines, chainsaws and so on.

At Housing SA, the maintenance coordinator works according to a four-week cycle. This includes two and a half weeks travelling through communities on the APY Lands in a west to east direction, a few days personal time and one week in the office in Adelaide. While on the APY Lands, the maintenance coordinator is typically located at Umuwa, though he may stay elsewhere depending on travel time and work orders. The locations visited during a particular cycle will vary, based on tenant calls that require in-person follow-up to clarify specific hardware problems, quality assurance audits, and to maintain a presence across the APY Lands by visiting each community at least once every two cycles. The maintenance coordinator is a builder and licensed tradesperson, also qualified in land management and was employed in Housing SA's construction program during the NPARIH period.

Licensed and unlicensed work

The obligations of the head contractor require a team of specialist tradespeople, subcontractors and unlicensed workers. The head contractor directly employs about 30 individuals, including licensed tradespeople, apprentices and labourers. There is no straightforward distinction that can be drawn between so-called 'skilled' and 'unskilled' workers employed under this contract. Most of the tradespeople are qualified in a single trade, some are dual-qualified, while other employees have additional certificates, such as an electrician with a refrigeration certificate. The non-trade labourers include individuals with a range of certifications, such as truck and excavator licenses, and others with no formal qualifications. Local workers also have a range of informal and formal knowledge and skills that contribute to their efficacy on the job. As such, we apply the distinction between licensed and unlicensed workers, as the latter are both skilled and trained but do not have a formal trade qualification. Most of the licensed tradespeople are employed directly by the head contractor, while that company has also entered subcontracting arrangements with businesses for particular works. For example, pest control is undertaken by a specialist subcontractor and there is also a subcontracted fire technician.

In the main, the head contractor handpicks the licensed tradespeople. This ensures their experience and understanding of working in regions where environmental conditions are extreme, that tradespeople are culturally competent and that commitments to local employment targets are supported.

> [It's] got to be someone that's suitable for that region because they travel from location to location sleeping in a swag and their food's coming out of a fridge in their vehicle. As much as our accommodations are neat, tidy and good, they're not five star so you've got to be able to cope in that environment. It's hot, there's flies, the roads are rough as heck, you do whatever hours of the day you want, but the days are long… Also, part of our program we have this Aboriginal employment target ... so you need to be happy with that ... You need people that have a bit of a passion for Aboriginal employment and are willing to mentor and train basically. (Participant 6)

4.1.2 Apprenticeships

The head contractor currently employs two Anangu apprentices, training as a plumber and electrician respectively, as well as three non-Indigenous apprentices. In addition, the head contractor has facilitated another individual's training certification in pest control. That individual works with the specialist subcontractor during the planned pest control visits and is otherwise employed by the head contractor as an unlicensed worker.

The capacity of the head contractor to offer apprenticeships was understood by respondents to be a key success of the housing maintenance program on the APY Lands, something that had not been achieved in the past: '*For the first time in SA, he's started developing [Anangu] apprentices. We'd never had an apprentice on the Lands before*' (Participants 1 and 2).

The length of the multi-trade contract underpinned the head contractor's ability to recruit and train apprentices. If an apprenticeship nominally takes four years to complete, those on the APY Lands are likely to minimally take five years. The head contractor also identified the combined contract between Housing SA and the Department of Infrastructure and Transport (DIT) as providing the volume of work necessary to facilitate sustainable employment for both licensed and unlicensed workers, including the development of apprentices.

In remote contexts, maintenance work, in contrast to major construction, supports the continuity of employment required to facilitate apprenticeships. It allows for works to occur over a sustained period rather than a specific construction phase, after which there is no demand.

> The program is able to support long-term apprenticeship outcomes where previously under the construction program, we had this flood or famine approach. We build, build, build and then there's nothing for 12 months. Which means that any apprenticeship you start developing over your construction [program] falls over because there's nothing to flow into. (Participants 1 and 2)

While the head contractor does not hold the construction contract for new builds on the APY Lands, an informal partnership has developed whereby the Indigenous business enterprise constructing replacement houses uses the head contractor's apprentices for their works. This has allowed apprentices to sustain their training in the maintenance program, while also gaining experience and skills in major construction when such projects are underway.

The ideal of developing Indigenous apprentices is often advocated but there are numerous challenges. Among the many issues on the APY Lands, 'successful trade-based enterprises and other forms of skilled employment (including mining operations) still require literacy, numeracy, and code-switching competencies to at least Year 10 academic benchmark levels, (Lea, Tootell et al. 2008: 17). As illustration, prior to their commencement, the head contractor completed the paperwork to access scholarships for the two Anangu apprentices he now employs. Even though the scholarships target remote and Indigenous people, the application process required literacy skills that exceeded those individuals' abilities.

Alongside those two apprentices, the head contractor employs other apprentices who act as mentors in relation to trade school requirements.

> We have two Aboriginal apprentices and then we've got some white apprentices as well ... When they're at trade school, they're mentoring them. So they go to trade school at the same time, so that they can help each other out. (Participant 5)

These non-Indigenous apprentices act as support persons in the navigation of a formal education setting in Adelaide. Supporting the progress of the apprenticeships requires significant logistical organisation undertaken by the head contractor. This includes organising transport to and from trade school, accommodation, and voluntary financial management support to ensure the apprentices have money and somewhere to stay while in Adelaide.

> Number one we have to contact them—'you're going to trade school'. We've got to organise for someone to pick them up, get them to the bus, a bus ticket, get them to Adelaide, organise their accommodation and we organise for them to be able to get to trade school either by a taxi or sometimes the other staff pick them up. We do all sorts of things like when their trade school money comes in, like $400 or $800, we make sure that is held and paid into their account two days before they attend the trade school because usually when they get paid from their shift what happens is that disappears within a couple of days, sharing with family members ... You can't come to Adelaide and have no money. (Participant 6)

Respondents highlighted that the amount of support the head contractor provided their apprentices far outweighed the government funding received for undertaking this labour, demonstrating commitment to fostering education and employment opportunities of local Anangu workers. For remote apprenticeship outcomes to improve, greater government support is required, in the form of additional funding, but also by clarifying practical supports and streamlining reporting procedures to reduce the administrative burdens placed on employers.

4.2 Sustaining local employment

Maintenance programs in remote contexts promise significant potential for the employment of local people that do not have extensive formal training. In a typical month on the APY Lands, the head contractor employs 8 to 12 local Anangu people as unlicensed workers within Housing SA's maintenance program. These individuals are employed from a larger labour pool on the head contractor's books, depending on the location of work and individuals' availability. The head contractor may also contract from the broader pool of unlicensed individuals for additional projects that require larger teams, such as painting and cleaning within vacancy upgrades and refurbishment works. Informal training is provided to workers on the job via a 'train the trainer' approach.

> I'll grab my core group of Anangu workers and we'll go do a reno and … we'll pressure clean out the house, I'll get the builders in to hang the doors et cetera. I'll be training two [local Anangu workers] to paint, they'll paint the whole house and I've taught lots of young people to paint because I've got the skills as a teacher. 'So, right, this is broken down into more components, this is how you've got your pot, this is what you do … Watch him and then he's got to train the next person and the next person's got to watch him.' (Participant 6)

Respondents highlighted the importance of employing local people in delivering the Housing SA maintenance program. This is true not only for the income or training that employees receive, but for the program's efficacy. Local employment can help to identify systemic maintenance issues and facilitate better solutions. It also assists with the language barrier involved in servicing Anangu tenants, and Anangu employees are often able to convey the relevant social dynamics surrounding work orders which are unknown to external tradespeople.

> It does help with the language barrier. There could be a fight. Well, there could be something happening in the street, a potential fight but it's just talk. They'll say, 'Oh, there's nothing wrong'. Or you go to a house and they know what's going on. They'll say, 'Oh, we can't go in that one'. (Participant 5)

Beyond that, local employment is important for the community's perception of Housing SA and the head contractor: the community '*can see that we are doing the right thing. You get that respect*' (Participant 5).

4.2.1 Supervision

A recurring theme from respondents in relation to the potential for housing R&M work to provide employment for local people was the need for adequate supervision of labour. The importance of supervision, as both facilitation and training, is underacknowledged in recommendations for increased local work in housing maintenance. A Nganampa Health Council respondent highlighted that the potential capacity for local work depends on funded supervision.

> If I had more time, I'd get in and do some landscaping in the yards, I'd be pressure cleaning the houses … You could be making furniture, making beds, you'd never run out of work … But it's got to be supervised. The equipment, you can't just hand out the equipment. That doesn't happen anywhere else. If you're working for a council, you don't just have a bunch of blokes turning up and council throws them the keys and says, 'Off you go, go and do something'. It's got to be supervised. (Participant 7)

Skilled supervision is especially important where unlicensed and possibly inexperienced workers are completing tasks in and around housing.

> When you start digging around the community, there's a lot of buried things, there's power and water, it's not just a matter of jumping on the backhoe to start digging. If you do that, you could get in a lot of trouble and make things a lot worse. (Participant 7)

Effective supervision is not simply a matter of delegating tasks but of creating the conditions in which tasks can be effectively completed. This includes setting safety protocols and managing and servicing equipment. When equipment failures and breakdowns occur, a skilled supervisor will redirect a team to other tasks and organise equipment repair in the background. Effective supervision also requires managing workflows to keep workers interested.

> You've got to try to vary the work. [If you're] cleaning houses, you don't do that all the time, because blokes are just not going to turn up, they'll get sick of doing it … You've got to go on to cutting grass or if it's particularly hot you've got to go inside and do a bit of welding or a bit of maintenance or something like that. (Participant 7)

Finally, supervision, when undertaken by a non-Anangu person, requires sufficient reflexivity and the right temperament to understand one's place in the community.

> You are an uninitiated white fellow, who do you think you're talking to? … There's no excuse for yelling at a man for not turning up to work, he just won't turn up again, you'll lose him. You need to find out why he wasn't at work and usually there's a very good reason. (Participant 7)

4.2.2 Barriers to local employment

Respondents noted that while fostering local employment opportunities via the R&M program is desirable, it can be challenging. The challenges that any employer faces in remote Indigenous communities are myriad, including the remoteness of the labour force, access to vehicles and tools, varying literacy and numeracy skills, licensing and safety regulations, limited formal paperwork, an inability to obtain police clearances and diseconomies of scale of work.

Limited literacy and numeracy skills was commonly identified as posing a barrier for local Anangu in terms of both undertaking the work required, but also in terms of complying with employment practices such as government registrations and completing timesheets. The possession of limited official documentation was also frequently mentioned as posing a logistical barrier to the employment of local people.

> I want to employ someone. 'Have you got a tax file number? Or what about a white card?' 'Yeah, I think I got one of them.' 'DIT wants a copy of that white card, but you can't work on that site until that's produced.' So that gives me a barrier straight away. So I've said to all staff if you find anything, even if they've got a license, take a photo of it, send it to the office and I hold it all in a database, so when it's requested, when I have to submit child-related clearances et cetera for the staff, I've got it there ready to go … So, I've got quite a database on documentation for staff. That's where the issue is when I go into community. I've got those three people already set up in my system but when I grab those other people there's nothing on them, I can't employ them, I just don't have the stuff. (Participant 6)

Cultural ceremony and 'sorry business' (grieving and funerary rites) were reported as disrupting the best laid plans for maintenance, by limiting the availability of workers, tenants and restricting road access and thus increasing travel times. '*The thing is that, up here, you can have all the plans in the world, but culture comes first and culture rules everything, yes*' (Participant 3).

An additional barrier to fostering local employment related to the skillset required to undertake required works. There is capacity for some maintenance work, for example air conditioning, to be undertaken by unlicensed labourers and this occurs within the Housing SA maintenance program. However, such work still requires a licensed tradesperson to be present.

> [An unlicensed labourer] could go and clean three air conditioners and they'd get to the third one and there'd be an issue that they couldn't fix where you'd need an electrician to rewire the motor. (Participant 5)

Similar challenges relate to the capacity to employ local people to complete minor housing fix work in a responsive manner. Even basic fix work requires some level of expertise, as well as tools, and it is unrealistic to expect local people to undertake that work without training and support.

> The classic one people often say is why don't we get local people to replace the tap washers? Well, how often do we do that in our own house? Quite often, we call a plumber because you need the right tool to do it. You can take it off and then you realise you need seating and you need a proper tool to seat the tap … Hanging a door. Quite often, the frame's out of place or been damaged, the striker plate needs rejigging and needs welding. So it's nice to talk about it, but the reality is that it involves a lot more and it requires a bit of supervision as well. (Participants 1 and 2)

Even if the R&M could be undertaken by unlicensed workers locally, the volume of the available work provides a challenge to the generation of a sustainable workload. On the APY Lands, this is resolved somewhat through scaling the Housing SA program to multiple communities and through the combined Housing SA and DIT contract.

> [We] have spoken, 'Wouldn't it be good if we could get a local Aboriginal man who lives in the community that has access to washers, he goes and changes it and then this is his job … So, the guy would just do little bits and pieces of maintenance and stuff. Screwing back on door knobs like I did … Now, if this guy on the ground could do that, that would be great. Jobs for local people and it's saving us a bit of money and then skilling up people as well … [But] It wouldn't be a permanent role … Because they may have to sit around their house or the office for four days waiting for something minor in the community to happen. (Participant 3)

The retention of highly skilled and diligent supervisors, who have developed relationships with communities over time, is also a perennial challenge, with flow-on effects for the stability and continuity of local employment. While turnover of staff is inevitable and a central challenge to all sectors in remote contexts, in housing maintenance and environmental health there are particular factors related to diminishing skillsets. In remote contexts like the APY Lands, workers require enthusiasm, diligence and patience. However, where such staff have backgrounds involving work in drilling bores, building windmills, fixing engines and so on, this has proved especially useful. Such skills are less common in the 21st century: '*This is the unfortunate thing, the intelligence of people working out in the scrub now is diminished'* (Participant 8).

The impact of COVID-19 on local employment in the planned maintenance program has also been significant. From March to July 2020, the programmed schedule of works ceased; consequently the employment of local Anangu residents stopped and the ability to offer new apprenticeships was curtailed. Respondents felt that the momentum the program had achieved was undercut.

4.2.3 Facilitators of local employment and apprenticeships

Despite these challenges, respondents noted that the head contractor's practices around local employment easily transcended the government contract mandated requirements for 30 per cent Indigenous employment. The head contractor had extensive construction and maintenance experience on the APY Lands and was committed to developing local apprentices and improving Indigenous housing.

The employment that the head contractor has been able to offer has depended on several factors. The first important factor is holding the dual contract for both Housing SA and DIT works. This has provided the volume of work to support local employment opportunities, including apprenticeships. Importantly, the volume of work has been generated across all major trade categories, which has allowed workers to continue to undertake work orders applicable to skillsets they had developed and felt confident performing. Allowing unlicensed workers to work in a particular area where they develop their expertise also allows for sustained employment.

> We know the skillsets of the people that have been working on such and such a program and then they just slip into the next program. And they're successful. They don't go in feeling anxious about that because they don't know what to do, they feel comfortable with the staff, they know the programs, they know they've already got skills in that area. I'm not throwing them from wiring up the electrics of a house to desludging a septic tank. I'm keeping them within their skillset. (Participant 6)

In addition to the expansion of work related to the dual contract, Housing SA's planned maintenance approach has also benefitted local employment. The programmed maintenance schedule that underpins Housing SA's planned maintenance program allows for the distribution of works throughout the year. Respondents noted that this accommodates the availability of tradespeople employed by the head contractor, as well as the subcontracted tradespeople who have other client bases. It also helps to facilitate more effective employment opportunities for local people. For example, air conditioning checks are scheduled at different periods of the year to the septic tank program, so that local unlicensed workers can participate in both, under the supervision of relevant licensed tradespeople. In this way, the detailed scheduling of planned works across the APY Lands has allowed work to be undertaken in a continuous and sustained manner, flattening the distribution of work and reducing staff attrition during low periods.

> If we can maintain that continuous two weeks on, two weeks off expectation with the continuity of work, that's one of the most significant things that has allowed the Aboriginal employment program to occur and to be successful and without that we wouldn't be successful. That's the underpinning point of not being casual and saying it happens when it happens. But having a definite scheduled approach and letting it unfold to stop the highs and lows in the volumes of work. It's really important. (Participant 6)

The rate of job completion is another critical factor in the planned maintenance approach. It was acknowledged that some works could be undertaken more quickly but would require the employment of a highly skilled workforce. This would have cost implications and would undermine the employment and training of local workers.

> We can rush—if you want us to do 20 renovations in three months, we can make that happen. But that's not going to be unskilled people. We're going to have to bring in people that are skilled, that know how to do that work, that they can do it fast, and do it in your timeframes. (Participant 6)

The mentorship model that the head contractor built into his apprenticeship program has also benefitted local employment. This mentorship model extended to maintenance work on the APY Lands. Apprentices and unlicensed workers are paired with licensed tradespeople to deliver the works and much consideration is given to achieving the right 'fit' between these pairings to ensure sustainable employment.

The practical support provided by the head contractor to support apprenticeships, evidenced above, also extended into the employment of local unlicensed workers, to ensure they start at the same level as licensed workers— *'At Marla I've got a whole section of stuff to support them so that they have entered into the workforce at the same level as our tradespeople'* (Participant 6). This included transport to worksites, the provision of washing and cleaning facilities and of food packs for the two-week work-cycle. It also included the provision of correct tools and personal protective equipment to undertake the required works. The material benefits afforded by employment and the head contractor's practical support were said to be resulting in more people seeking maintenance work.

> *You know we get so many phone calls now we have to say 'I'll put you on the list. You know I've got your details if anything comes up,' but you know we've only got so many spots to employ people.* (Participant 6)

This statement conveys both the efficacy of the current arrangement and a threshold capacity to provide employment for local unlicensed workers in the APY Lands maintenance model.

4.3 Employment at Gunida Gunyah Aboriginal Corporation

As Chapter 5 further elaborates, Gunida Gunyah Aboriginal Corporation is an Aboriginal Community Housing Provider (ACHP) registered with the NSW Aboriginal Housing Office to manage residential properties in NSW, according to the AHO's *Housing Services Policy Framework* (2017c) and its related *Housing Services Guidelines* (AHO 2017b). The latter outlines minimum guidelines in relation to repairs and maintenance. These include obligations to:

- undertake property inspections
- budget for routine R&M
- set aside funds for long-term upgrades
- establish processes for urgent repairs and prioritising R&M
- ensure staff are trained to meet these obligations, among others (AHO 2017b).

Properties must meet standards specified in the NSW *Residential Tenancies Act* and *Regulations* but there is no obligation to manage a planned maintenance program that resembles Housing SA's planned maintenance program. GGAC also has its own 'Maintenance and Upgrading Plan', with relevant priorities including 'Provide timely and quality maintenance services to tenants' and 'Survey, inspect and report thoroughly and systematically to ensure that GGAC staff know and proactively manage their portfolios' (GGAC 2016: 7).

From 2014–15 to 2017–18, GGAC piloted a 'Home Maintenance Officer' (HMO) project with AHO grant funding, which operated in Collarenebri, Pilliga and (initially) Toomelah/Boggabilla. This funding was originally used to purchase a work vehicle and tools and to employ a young tradesperson, but the latter was replaced shortly after commencement by two older men for '*smaller jobs, handyman jobs that they could do. They could pretty much do anything*' (Participants 12, 13 and 14). The purpose of the program was to reduce the costs associated with tradespeople travelling to discrete communities for minor jobs classified by GGAC as 'responsive' maintenance and 'add on (HMO)' jobs, such as changing washers, unblocking toilets and repairing windows and doors.

The two handymen would travel to communities for a week at a time to complete a list of routine maintenance and any other non-trade work required by residents ('add on (HMO)' jobs).

> So, they were out some place for a week and they've got mountains of jobs to get through, small jobs that the tenant can bring up and say, 'Can you change my lock?' or something. We'd bring them way over there, 'Can you go to this place and do this while you're there?' (Participants 12, 13 and 14)

An external evaluation summarised that under the HMO project: two Indigenous staff were employed; tenant wait times were reduced, and

> more repairs and maintenance [was] completed more cost effectively compared to the use of contractors—the average cost of jobs decreased from $1,536 per job in 2014–15 to an average of $830 for 2015–16 [year] to the end of March. (ARTD 2017: 26)

One of the chief reasons this program did not continue related to the ongoing availability of the particular maintenance employees. As on the APY Lands, it is a challenge to both secure the necessary volume of work and to find available staff who are adequately skilled across a range of non-trade housing work that an R&M program must attend to:

> Trying to find the right people that also have enough to do and you know that they can do it … Because we've known too many people go, 'Yeah, yeah, yeah! I can do that.' Then they go, 'Not really.' (Participants 12, 13 and 14)

The expansion of mining in the region surrounding Gunnedah also impacts the availability of licensed tradespeople and unlicensed workers to undertake R&M work for GGAC.

> Well Gunnedah's booming, all the mines around it, so there's massive housing estates out the back that are going up ... My eldest bloke, he did an apprenticeship. He's left, he's gone to the mine. We can't afford to pay what the mines pay. And the same as most of the industries around here with tractors and farmers and that. They can't get drivers anymore because our drivers only get $25, $28 an hour, the mines are paying $70, sitting in a truck and doing nothing. (Participant 17)

4.3.1 Existing staff

Unlike the head contractor on the APY Lands, GGAC does not employ tradespeople or maintenance staff directly. A 'repairs and maintenance' team administers the property maintenance program by subcontracting tradespeople. The R&M team sit alongside a 'housing' (tenancies) team, which also includes a compliance officer. Additional staff are responsible for a transitional housing program and various 'wrap-around' social services.

As an Aboriginal-controlled organisation which favours Indigenous employment within its own ranks, GGAC represents a different approach to the potential for employment from Indigenous housing and property management. Even while subcontracting tradespeople, the expansion of the Aboriginal community housing sector through the expansion of providers like GGAC signals the establishment of sustainable employment for Indigenous people in relation to housing.

Our fieldwork at GGAC witnessed a close team with genuine enthusiasm and warmth between colleagues, evidenced in daily collective lunches at a shared kitchen table.

> We get on really well. We have a little coffee club going on… Everyone's pretty close here. It's not just your work colleagues, it's a little family that little bond that you have going on. Everyone gets along with each other and if anybody needs help, there's always someone there or all of us there that will chuck in and help you out. (Participant 13)

The closeness of colleagues translates into a shared commitment for effective service provision. Regarding R&M, one staff member notes:

> To me, it's a challenge. It's trying to make things better ... And it's trying to figure out things and try to get things across the table. Do you know what I mean? Like I like the rapport that we have with our contractors, I like the rapport that we've got with a majority of our tenants ... I like the accomplishment when we get something done. (Participants 12, 13 and 14)

The GGAC R&M team conducts ingoing ('on') and outgoing ('off') inspections of property condition at the beginning and conclusion of tenancies, which are supplemented by intermittent inspections by tenancy liaison officers. This team is also responsible for maintaining insurance for houses in the portfolio and for managing property files. A significant proportion of the R&M staffs' workload is responding to tenant requests for repairs and raising and managing job orders to be undertaken by external contractors.

GGAC has lists of preferred contractors depending on the location of the housing stock and clauses within sublease agreements. Indigenous contractors are given preference subject to other factors being equal (GGAC 2016). Respondents identified '*trades in the past that, because we are an Aboriginal organisation, take advantage and just whack the price up*' (Participants 12, 13 and 14). Reflecting the importance of contractor relationships also identified on the APY Lands, the importance of developing rapport with external contractors was stressed.

> If you look after your trades, they look after you. Like it's … I scratch your back, you scratch mine. When you get a good trade that is fair in price, does good work, you know he treats the tenants well and the tenants have a good rapport with them, you stick to that man or girl, whoever it is. You stick to them, because it works and you know that they're going to go out of their way for you … And I can speak very highly of most of our trades … It's easier to have that rapport with them and know what the quality of work is going to be. That we're not going to have to be calling somebody back in a week's time. (Participants 12, 13 and 14)

The ability to trust external contractors to not overcharge, to complete work to a high standard and to act respectfully towards tenants is important to an ACHP. However, even where tradespeople have proven themselves to be trustworthy, the remoteness of housing underpins a significant cost for the ACHP. Without the centralised approach coordinated by Housing SA, this can quickly multiply the costs—and illustrates the ongoing potential of locally-funded R&M:

> It's really hard, just to get the repairs and maintenance done is an issue in itself. Because sometimes if you're paying for a contractor to go out there, you're paying more in petrol than you are for the actual job. They could be going out to change a washer, which is 20 dollars, and then they're charging 150 bucks for the travel. (Participant 20)

4.4 Policy implications

Fostering local employment opportunities through property maintenance and environmental health programs is challenging but achievable. Our SA and NSW case study material suggests that reproducing such outcomes requires attention to the following issues.

Government targets and subsidies for local employment

The employment of remote community residents by Housing SA's head contractor and by Nganampa Health Council has taken significant time and resources, adding costs to program delivery. It is appropriate that governments mandate proportionate targets for Indigenous employment in such service contracts and that contractors are resourced and supported to establish meaningful and ongoing employment and training opportunities, including apprenticeships. The GGAC model represents what is possible where an ACHP sub-contracts R&M work. There is potential for cost savings in R&M programs through the direct employment of local unlicensed staff, but this depends on the availability of appropriate people and the capacity of an ACHP to train them. If established as a policy aim and properly resourced, such sub-contracting could include greater numbers of local Indigenous contractors.

Scope and scale of contract

The R&M program on the APY Lands transcends government-mandated requirements for proportional Indigenous employment. The program's capacity to generate continuous local employment has depended on the volume of work generated by the seven-year timeframe of the multi-trade contract, which also allows for apprenticeships, which take a minimum four years to complete. Government contracts must exceed four years to facilitate apprenticeships.

Planned maintenance

The planned maintenance program has facilitated strong local employment outcomes for the head contractor on the APY Lands. The planned schedule allows for the distribution of consistent work across the year. This planned approach is also beneficial for distributing work types on behalf of seasonal requirements and sustaining the interest of employees. While planned maintenance programs offer potential for these outcomes, ACHPs must be adequately resourced if they are to assume the obligation to undertake such work in-house.

Training, support and mentorship

The head contractor has driven Housing SA's property maintenance program's success by offering training to local workers and formal apprenticeships. This has included significant practical support and logistical organisation, such as providing workers with transport to worksites, cleaning facilities and food packs for two-week work cycles. A mentorship model for unlicensed workers and apprentices has also been built into the planned maintenance program. Similarly, at GGAC, mentoring of staff enhances the organisation's capacity to manage the complex tasks associated with managing mixed housing stock.

Contractor relationships

In both the APY Lands and NSW north-west region, relationships with contractors combined with professionalism, dedication and passion are key to Indigenous employment outcomes.

5. Current arrangements for social housing under climate change: NSW case study

- **Sustainable housing will always rely on well managed and diligently implemented property maintenance and tenancy management programs.**
- **However, even where an Aboriginal Community Housing Provider is exceeding its obligations, it is limited in its capacity to plan for and respond to climate-related impacts in regional and remote housing. A wider policy framework orienting the housing sector toward climate issues is required.**
- **Rental revenue and limited government subsidy provide insufficient funding for comprehensive planned maintenance.**
- **We find that the competition for viable housing portfolios and budgetary rationing mean that housing that is the least competent for managing increased temperatures is also least likely to receive additional federal or state funding attention. Such housing is more likely to be in remote Indigenous communities than in regional towns.**
- **Retrofitting existing housing stock to improve thermal and energy performance is overdue and necessary in the short term. However, without major refurbishments that exceed air conditioner and solar panel additions, (and without guaranteeing ongoing maintenance funding of such retrofits), any gains will be short lived.**
- **Current housing stock, funding, and property maintenance regimes are not sufficient to manage the thermal exposure and health risks associated with climate change.**

This chapter expands on the climate change challenges facing Australia, and Indigenous housing in regional and remote areas, overlaid by the larger context of 'mainstreaming' national funding arrangements. It then provides a case study of how Indigenous housing is managed on the ground. In New South Wales, the state with the largest Indigenous population, housing undersupply has seen Aboriginal Community Housing Providers (ACHPs) forced to compete to manage larger portfolios of inherited housing stock. Only a small proportion of this housing is new. As our modelling of housing performance will additionally make clear (Chapter 6), existing housing offers poor thermal performance, while houses built to current standards (representing improved models) are under-prepared for increased cooling demands.

We draw on data gathered in collaboration with Gunida Gunyah Aboriginal Corporation (GGAC) in north-west NSW and information from the NSW Aboriginal Housing Office (AHO), to describe ACHPs and the housing stock that they manage. In focusing on a high functioning organisation and its success in managing different funding rules and assorted housing stock in a context of growing need, we can more clearly delineate whether and how climate change considerations are configured into current Indigenous housing policy and funding arrangements. Within budget constraints, the Aboriginal Housing Office is rolling out programs of air conditioning and solar panel supply, which will provide immediate relief. However, without increasing housing supply and improving overall house designs, such measures will be inadequate to meet the greater health and wellbeing challenges of climate change.

As an Indigenous-controlled housing manager, the importance of housing to other social outcomes is a clear GGAC understanding:

> Well, the home is the base … You can't go to school if you don't have a home. You can't go to work. You need to be grounded, you need to be stable, for you to go out and venture into education or employment … for you to be able to go out and live your life. (Participant 20)

It remains the case that climate change considerations are not sufficiently prominent in current funding and policy regimes, as the next sections elaborate.

5.1 Climate change globally and in Australia

Climate change projection scenarios and their likely impacts on the natural environment are the focus of the Intergovernmental Panel on Climate Change (IPCC), a United Nations (UN) organisation that has collated state-of-knowledge findings since 1988. The latest IPCC report indicates that various regional areas are already experiencing global warming, with temperatures beyond the expected global average. Indeed, up to 40 per cent of the world population has been exposed to a warming of more than 1.5°C above the pre-industrial era in one or more seasons during the period of observation 2006 to 2015 (IPCC 2018). Climate changes have already increased average temperatures and profoundly impacted the global environment and ecosystems, with increased frequency and magnitude of droughts, floods, extreme weather events and biodiversity loss. These effects expose humans to unprecedented vulnerability and risk (IPCC 2014; Mysiak, Surminski et al. 2016).

In recent years, Australian climate trends have aligned with globally observed changes. The mean temperature has increased by 0.1°C per decade, the sea level has risen by 20mm per decade, flood events on the coastal zone and river deltas have intensified, while central and arid regions have experienced drier conditions (Collins, Della-Marta et al. 2000; Plummer, Salinger et al. 1999). Projections indicate warmer temperatures, especially in the interior, and mixed precipitation trends (Smith 2004; Karoly and Braganza 2005; Gallant, Hennessy et al. 2007), with wetter northern zones and drier central and southern regions (Alexander and Arblaster 2008). Longer dry periods are predicted Australia-wide, with peaks in interior areas, which will directly influence Indigenous housing and road access in regional and remote Australia, necessitating greater resilience to extreme events (Alexander and Arblaster 2008; Frich, Alexander et al. 2002).

The average temperature may increase by 0.5°C to almost 2°C, with significant growth in the warm night index, which is likely to increase between 15 per cent and 40 per cent by 2200, consistent with global trends (Tebaldi, Hayhoe et al. 2006). This is coupled with higher extreme temperatures and dramatic heatwave durations (Tryhorn and Risbey 2006), prolonged by 20 days per annum (Alexander and Arblaster 2008).

5.1.1 Indigenous populations and climate vulnerability

Globally, climate vulnerability is intrinsically entwined with inequality in income distribution, access to resources and living conditions (Dryzek 2016; Bäckstrand, Kuyper et al. 2017; Lövbrand, Hjerpe et al. 2017), making equity a pivotal principle in international and climate change law (Bodansky, Brunnée et al. 2017). Australia reflects this disparity, with disproportionate impacts slated for Indigenous communities (Bowles 2015; Ford 2012; Green, Jackson et al. 2009; Nursey-Bray, Palmer et al. 2019; Sweet 2019; UN 2008). The threats of extreme weather events, water insecurity, increasing temperatures and associated health outcomes are exacerbated by distance from health and disaster management services (Carson, Bird et al. 2014) and substandard housing and associated infrastructure (Brackertz and Wilkinson 2017). More frequent and extended heatwaves and increases in humidity may contribute to increases in mortality, gastrointestinal illness, kidney failure and heart attacks (Bailie 2020; Bambrick, Dear et al. 2008; Cornell, Gurran et al. 2020; Koppe, Kovats et al. 2004; Oppermann, Brearley et al. 2017). There will be increased risk of vector-borne diseases such as malaria and dengue and of food- and water-borne diseases such as cholera, dysentery and trachoma. Heat stress, acute respiratory infections, asthma and other respiratory illness represent additional health and wellbeing risks (Green, Jackson et al. 2009).

The challenges are already intense. The New England north-west region, where Gunida Gunyah Aboriginal Corporation is located, is projected to have an additional seven days per year above 35°C by 2030 and 24 more days by 2070 (OEH 2020). Increasing heat stress and water insecurity not only impacts health but strains local infrastructures, generating concerns about the ability of Indigenous individuals and communities to stay on country (Allam and Evershed 2019; Sweet 2019). Appendix 1 provides additional detail on climate change impacts in the APY Lands and north-west NSW for the period 2000 to 2020. The data reports total rain fall (mm), maximum and minimum temperatures (°C), daily heat index and corresponding relative humidity at maximum and minimum temperatures within the geo-boundary of each site. It indicates that already, in these two regions alone, summers are beginning earlier and ending later, offering more days of extreme heat.

5.1.2 Impacts of climate change on buildings

Generally, in Australia, a warmer climate will increase the energy consumed for cooling, while decreasing heating needs. To invert this tendency, under the lens of sustainability, buildings must provide higher cooling performance, while minimising their energy consumption. The basic principle used to reduce energy consumption for cooling is enhancing passive cooling gains through better-designed window shadings, improved glazing systems, higher insulation levels, improved thermal mass and augmented natural ventilation. These techniques are simple yet effective but are currently not placed at the core of building design practice (Moore, Berry et al. 2019), especially for remote Indigenous housing (Duell, De Boer et al. 2006). Despite recent improvements, the National Construction Code's minimum standards are still far from the best practice indicated by other international green building systems (Sangiorgio and Brambilla 2020).

Healthabitat data reveals that of the more than 7,500 Indigenous houses it had surveyed at the time, 59 per cent regularly reached maximum summer temperatures above 40°C, with 36 per cent not having any active cooling system installed (Healthabitat 2021a). A recent review of the correlations between indoor temperature and mortality conducted by the World Health Organization (WHO) indicates that the minimal risk temperature, defined as the threshold beyond which mortality increases with increments in temperature, ranges between 29.4°C and 30°C for warm and tropical climates respectively (WHO 2018). The literature on what thermal comfort and stress means for health is complex (Kingma, Frijns et al. 2012; Vanos, Baldwin et al. 2020). As Tong, Wang et al. (2010) note, 'The magnitude of heatwave-related health effects depends on the intensity and duration of high temperatures, and also population acclimatisation and adaptation.' However, it is clear that once ambient temperatures remain above 30°C and night times offer little relief, the basal metabolic rate increases, which can have negative health consequences for people with weight, illness or age-related vulnerabilities. Hence, it is important to not exceed this value for prolonged periods without the possibility of relief.

Housing in areas projected to receive increased rainfall will require comprehensive updates of existing drainage infrastructure to maintain current performance. The building envelope will be subjected to higher hygrothermal (heat and moisture) loads, resulting in a higher risk of condensation and indoor mould proliferation and associated health impacts (Lohi, Tuomela et al. 2020; Norbäck 2020). Condensation may facilitate structural degradation, especially considering the limitations of commonly used Australian construction technologies such as timber or metal frames (Kempton, Kokogiannakis, et al. 2021; Brambilla and Gasparri 2020; Dewsbury and Law 2017) and policies (Moore, Berry et al. 2019).

In most parts of Australia, higher average nightly temperatures during summer will reduce the capacity of housing to discharge heat through night purging, leading to uncomfortable and increasingly unendurable indoor temperatures that may represent serious health hazards, particularly for infants, the aged and those with pre-existing cardiovascular disease (Kenny, Yardley et al. 2010). Technological adaptations to changing environmental conditions—such as mechanical air conditioning, solar power systems, reverse osmosis, hydropanels and so on—incur costs that often preclude their installation on low-value remote housing stock. Much Indigenous housing lacks mechanical air conditioning and, where this is installed, systems may not operate consistently due to poor product choice, inadequate maintenance, unreliable electricity supply and energy poverty, especially where poor thermal performance of buildings and crowding makes for excessive operational costs (Australian Council of Social Services [ACOSS] 2013; Azpitarte, Johnson et al. 2015).

Such impacts mean that houses can expect to deteriorate faster. It is of concern then, that Indigenous housing policies lack greater emphasis on systematic and planned repair and maintenance regimes to ensure the fitness of health hardware *now*, to ensure householders can access the key amenities for managing infectious diseases and preventing ill health. It is of equal concern that policies on climate change do not have a clear approach to ensuring housing offers greater protection from the prominent threats of climate change.

In the following section, we turn to how housing is being managed in NSW and the impossibility of expecting state agencies or local service providers, Indigenous-run or otherwise, to improve Indigenous housing stock without greater policy mandates and funding resources.

5.2 NSW Aboriginal housing policy context: a snapshot

In NSW, the *Climate Change Policy Framework* and *Climate Change Fund: Draft Strategic Plan* (NSW Office of Environment and Heritage [OEH] 2016a; 2016b) and AdaptNSW website communicate state-wide climate projections and impacts. The Framework and Plan commit the NSW government to manage impacts on government assets and services, but responsibility for adaptation measures is otherwise devolved to local governments, businesses, communities, and individuals. Regional adaptation plans such as the *Western Enabling Regional Adaptation: New England North West Region Report* (OEH 2017) espouse a systems-change approach to transitioning vulnerable systems, however the report falls short of suggesting tangible actions on critical adaptation measures. Cornell, Gurran et al. (2020) also describe the absence of NSW policy that meaningfully connects housing, health and climate change and emphasise the need for integrated approaches across the three tiers of government that situate housing and health adaptation responses within wider frameworks of climate preparedness. This includes the urgent need for improvements in the thermal performance of social housing, fire and storm safety standards, water efficiency and strategies to reduce resident energy requirements.

New South Wales is experiencing an under-supply of social housing. Using forecast estimates derived from 2016 ABS Census data, the AHO indicate that in 2017, 39,494 houses were required to fulfill Aboriginal housing demand, while 28,638 properties were available (AHO 2018a). The supply gap of 10,855 properties is equivalent to 27.5 per cent of total demand. At current rates of acquisition and construction, with attendant demographic shifts, the proportion of unmet demand is expected to increase to 47.1 per cent by 2031, a shortfall of 30,124 properties (AHO 2018a). Gunnedah is located in the west of the Hunter New England region of NSW (the Aboriginal Housing Office's 'Northern Region') and faces a high supply gap, with over 2,000 properties required. Of the top 20 local government areas identified with a shortfall for Aboriginal housing demand in the state, Tamworth Regional is ranked ninth with a shortage of 263 properties and Moree Plains is ranked 13th with an under-supply of 222 properties (AHO c. 2017). The AHO builds between 20 and 50 new houses each year, alongside acquisitions of properties in areas with high demand (Participant 18). As emphasised throughout this report, this makes R&M of existing housing even more vital under contracting conditions that may not favour attention to the most substandard housing stock. The average age of Aboriginal Housing Office properties throughout NSW is about 35 years. The condition and the original design of such properties, or 'hot tin boxes' (Participant 18), underpins their poor thermal performance.

> They're built to make you extremely hot. There was no insulation in a lot of the old houses. It wasn't a big thing back then. Sarking didn't exist I don't think. You got a lot of the floors in these old houses, when you pulled them up, they used to use newspaper under the lino to keep a little bit of warmth in your kitchen. But batts and insulation, sarking the roof? No, not there. (Participant 17)

5.2.1 On-the-ground: the Gunida Gunyah Aboriginal Corporation

Gunida Gunyah Aboriginal Corporation is one of 15 growth providers identified by the Aboriginal Housing Office. Headquartered in Gunnedah, the number of properties managed by GGAC has grown from just 16 in 2010 to over 300, across 11 portfolios, including AHO-owned properties in Gunnedah, Moree, Tamworth, Mungindi, Ashford, Quirindi, Collarenebri and Armidale. It also manages several small portfolios of Aboriginal land council and Aboriginal corporation properties. Under the NSW Government's Build and Grow program, about 275 AHO-managed properties were transferred to GGAC over a two-year period. These were variously owned by GGAC, land councils and the AHO, with rents and subsidies received accordingly. GGAC's R&M budget is dependent on these rental revenues and some limited AHO subsidisation, significantly constraining their capacity to implement planned maintenance and to additionally secure housing against imminent climate change stressors.

While there is significant variation across the communities serviced by GGAC, older fibrous cement sheet ('fibro') houses are common, some brick veneer houses exist, and newer houses use materials like Weathertex and Colorbond roofing. AHO (2020) Construction Requirements specify that ceiling insulation in new builds 'shall meet BASIX [Building Sustainability Index] and Nationwide House Energy Rating Scheme (NatHERS) rating specified requirements' and specific standards for sarking/vapour barriers. These BASIX and NatHERS systems offer a checklist format that allows users to select their preferred environmental credits. As the housing performance simulations conducted for this report further indicate (Chapter 6), such 'improved' design criteria are incapable of guiding design towards what is needed in Australia's changing climate. At any rate, new builds constitute only a small proportion of properties managed by ACHPs, which must otherwise maintain ageing and retrofitted stock.

Most of our respondents identified increasing temperatures in Gunnedah and the surrounding communities as already a challenge for tenants' wellbeing.

> Moree only last year or the year before was the hottest town in Australia. Continuously, day by day. So, we'd get 40 degrees on Monday and we'd still have 40 degrees on Sunday. Again, 41, 42 on Monday all the way through to Sunday. So, it's continuous hot weather that we have and it's necessary that we have air conditioning in our community. (Participant 21)

Many of these assessments were grounded in life-long familiarity with the region.

> I can remember as a kid. It was never this hot. I can't handle it. Collie [Collarenebri] stays in the mid-40s. It affects people's health. People drive to Dubbo to get into the shopping centres. I prefer the summertime to the winter. But that heat—can't cool down … One old duck, she goes to Dubbo to stay with her daughter in summer, she can't handle it. Definitely seeing people moving seasonally. (Participant 15)

As well as being detrimental to tenants, increasingly hot temperatures sustained for longer periods of time impact negatively on tradespeople responsible for construction and property maintenance. Roofing works cannot be completed in summer as one of the many consequences. The age of much of the region's housing makes the structures additionally vulnerable to the effects of sustained heat. This has been evidenced by the impact of decreased rainfall, coinciding with long-term drought, a drying trend that will increase into the future (BOM 2020).

> We've got houses everywhere, doors aren't closing, and things have cracked, and walls are bent. Because we had basically eight, nine years of drought and then … we've had quite a bit of rain and everything's just expanded and houses have moved all over the place … old houses in particular, to the point where piers are falling over and pushing the other side of the house where they've had too much pressure applied to them. (Participant 17)

The age of properties requires targeted programs to improve their thermal performance: 'because we've got such an old portfolio, that's probably our biggest challenge' (Participant 18). Rather than returning to properties for upgrades in a chronological order, the AHO requires that each property it owns is assessed annually on major components and receives a score between one and ten (Participant 19). This process is undertaken by ACHPs and audited independently to determine where capital refurbishments should occur. Life-cycle planning and property condition thus determine upgrades including kitchen and bathroom replacements, flooring, painting, and roofing. Such work occurs under various targeted programs, such as the AHO's roof replacement program and the solar program, delivered under the Strong Family, Strong Communities 2018–2028: Implementation Plan 2019–2022 (2019) which specifies that 65 per cent of AHO houses will have solar power and 35 per cent air conditioning across the same period. The AHO have indicated that every dwelling that has received upgrades or solar installation over the past decade has also had ceiling fans installed.

Under the Climate Resilient Living Program, the AHO is fitting properties with solar systems (including panels, inverters, array mounting and metering), aiming to support tenants with their energy bills. Following an original pilot of 150 houses in Dubbo in 2017 (Fourth&Centre 2018), in the year to September 2020, over 2,000 AHO properties received solar systems, with the corporate goals of 65 per cent of properties by 2022 likely to be exceeded (Participant 18). The AHO has also undertaken a hydropanel program in severely stressed water communities in far western NSW, following a trial at West Wyalong and Nyngan and Menindee in 2019. These panels use solar power to convert water vapour into drinking water (Fourth&Centre 2020). Under this program 797 hydropanels were installed on AHO and community-owned properties.

The perennial nature of upgrading ageing properties to meet contemporary standards can be means a rationing of funds and a deferral of work to future years:

> As a standard policy, every AHO house should have ceiling fans, and ceiling insulation, but the reality is when you get out to it, a lot of these properties, they don't. (Participant 18)

In discussions of changing temperatures, respondents turned repeatedly to the importance of air conditioning: *'If I could wave a magic wand, I'd get air-cons in. Ideally with solar panels'* (Participant 15). ACHPs are required to provide adequate heating in the properties that they manage, but not mechanical cooling: '*We do the best that we can. But there are some houses that don't have air conditioning. So they struggle a lot'* (Participants 12, 13 and 14). Numerous properties in the region surrounding Gunnedah have evaporative air conditioning units but, as in arid and central Australia, increasing temperatures reduce their efficacy.

> We get … phone calls about the air cons not working properly when it's over 40 degrees and you send the contractor out there and they just say, 'It's working, but it's just too hot'. And we do get a lot of those phone calls where you have to turn around and tell the tenants that they're working fine, but it's just too hot. (Participant 12)

One respondent simply noted that '*Evap air-cons are not suitable in this area*' (Participant 15). While that comment referred to the inability of evaporative air conditioning to reduce temperatures above a certain threshold, the dependence of evaporative air conditioning units on a reliable water supply is also a risk factor in an increasing number of sites.

> At Collarenebri [tenants] weren't allowed to use their air conditioners last year because they had no water. So the Council actually sent out a letter and said that the tenants were under [restrictions], because they [have] the evap air conditioners … And they were actually shipping bottled water into the residents of Collie, because there was no water whatsoever. (Participant 15)

Rather than assuring the relative efficacy of refrigerated air conditioning (which can exacerbate energy security concerns), this dependence on intersecting infrastructures should highlight the corresponding reliance on precarious water supplies and ageing power grids.

5.2.2 Air conditioning and climate

Since 2016 the NSW Aboriginal Housing Office has run a program to install air conditioning units in its properties across the state (AHO 2016). Between December 2016 and June 2019, 834 split-system air conditioners were installed at 634 properties, while other properties received upgrades in relation to ceiling fans, door seals and LED lamps (Fourth&Centre 2019). Prior to this, there were ad hoc cases of tenants purchasing split-system air conditioners and requesting that ACHPs support their installation. When making such a request in 2013, one tenant noted: '*I have had to admit [my husband] to hospital a few times because the heat affects his health and his oxygen life support machine*' (Property file).

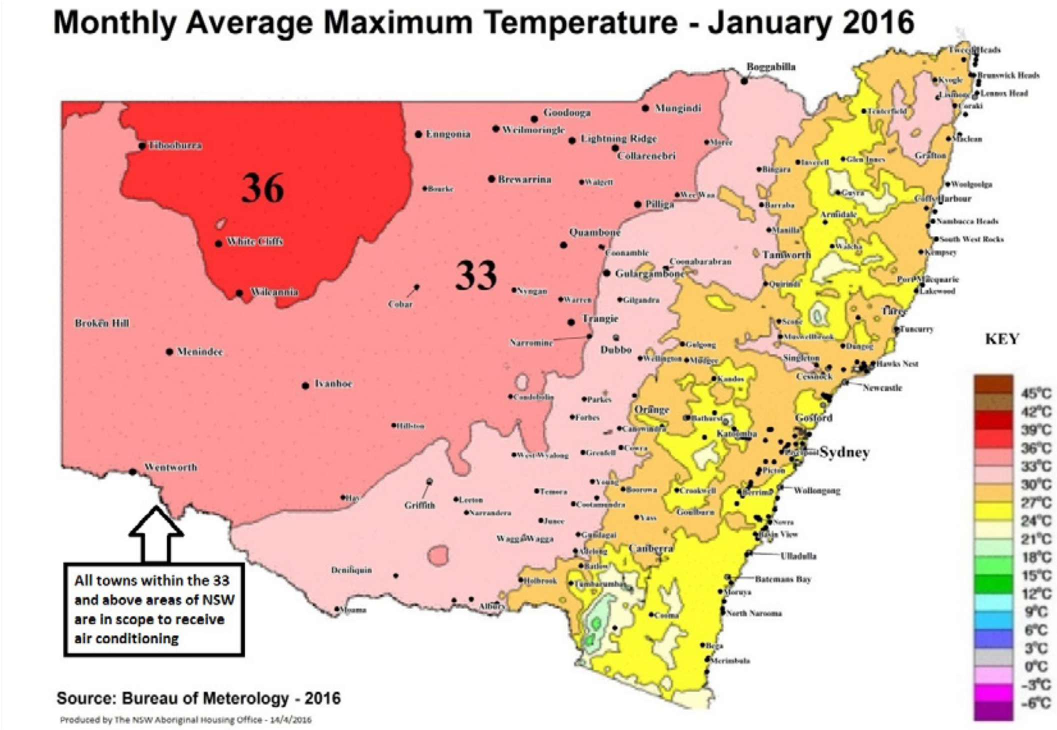
To target the air conditioning program where there is greatest need, the AHO determined eligibility for properties located in places within the Bureau of Meteorology's Isotherm (constant or equal temperature) of 33°C or higher in NSW. This reflects the monthly average maximum January temperature and includes numerous communities serviced by GGAC, including Moree, Mungindi, Collarenebri and Pilliga. Under this program, if a property has an existing ducted evaporative or split-system air conditioner these systems are retained. Where a property had a single-room evaporative system, or 'window-rattlers' (single unit air conditioners with a cooling function only) in living areas, or no mechanical cooling at all, a reverse cycle split-system air conditioning unit was installed in the living area. A consultant was employed by the AHO to assess the relative benefits of evaporative and refrigerated cooling.

> The main driver [for why] we went with split systems, was the water quality for evaps is an issue in a lot of towns, and also the cost of maintenance of evaps is quite significant. The split systems are quite a lot more robust and you don't really need to clean the filters, whereas the evap systems actually need an external contractor to come out twice a year to do maintenance on them, so it's very expensive. (Participant 18)

Split-system air conditioning units were chosen (as opposed to evaporative or ducted refrigerated systems) on the grounds that they provide efficient heating in winter, perform well in warm and humid weather, and are competitive regarding initial capital and whole-of-life maintenance costs (The Energy Project 2016: 12). Units were scoped to room sizes using the Australian Institute of Refrigeration, Air Conditioning and Heating's Fair Air calculator, balancing efficacy against power bills (AHO 2017a). When this program began, there were approximately 1,000 properties located in the Isotherm 33°C region (Figure 9). However, this number has since grown significantly (Figure 10).

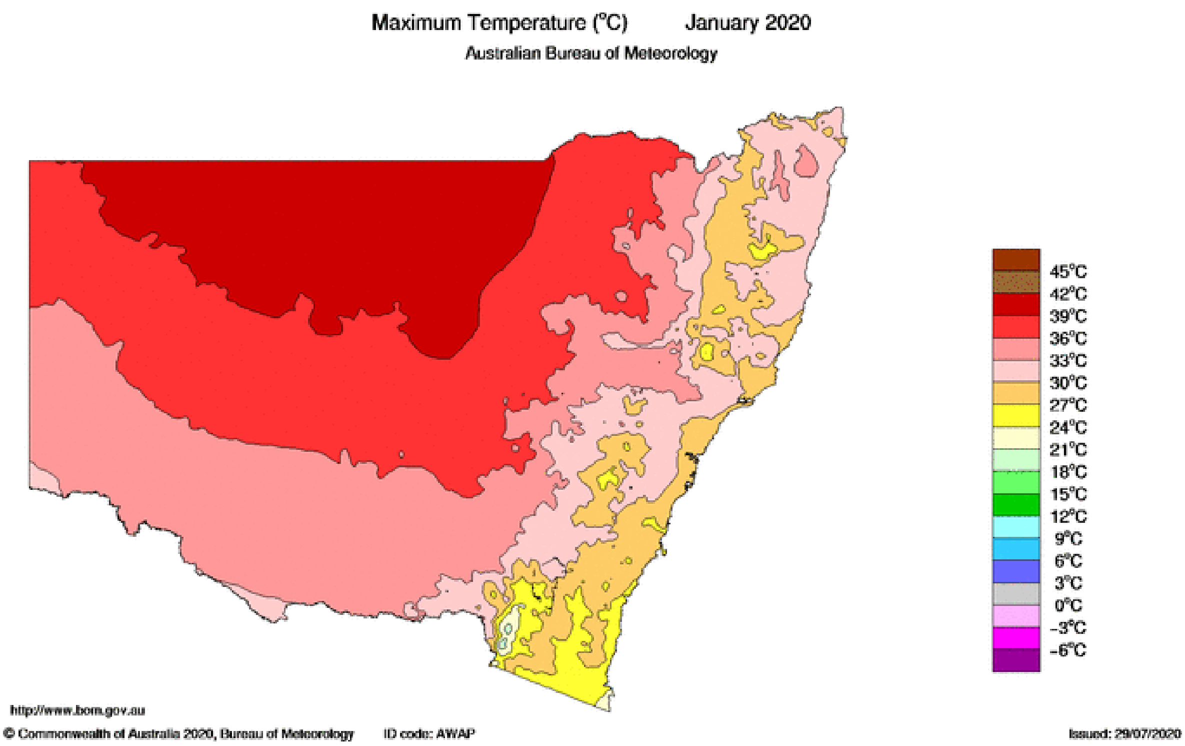
> We created a policy saying any AHO property within Isotherm 33 gets a mechanical cooling system, and surprise, surprise, we've now got about another 1,600 houses that actually fit that criteria, effectively, just because it's getting hotter and hotter. (Participant 18)

Figure 9: Isotherm range 2016



Source: Aboriginal Housing Office (AHO 2017a) using BOM data for 2016.

Figure 10: Isotherm range 2020



Source: Bureau of Meteorology (2020).

5.2.3 Heating to cool

The installation of split-system air conditioning units in properties that previously lacked mechanical cooling provides necessary relief for tenants of housing with poor thermal properties in increasingly hot environments. However, such additions have clear limitations. In the short term, these include the inequities of rationing inadequate funding.

> In an ideal world, if we had funding, we would do a whole portfolio in mechanical cooling but it's just a real competing priority with funds, what we can, and can't do. (Participant 18)

In the longer term, air conditioning alone is insufficient. Even the more efficient air conditioner models are power hungry[5] and as they funnel the heat outside, they also contribute to the very warming the mechanical cooling is responding to. A single unit is unlikely to cater adequately for regular households, let alone those experiencing significant crowding—'*there's so many big families these days, but it's not just the parents and the kids, it's the extended aunts, uncles, cousins, the rest of them*' (Participant 15). The installation of a single split-system unit is also likely to be a contributing factor to crowding, where the living area becomes a shared bedroom. This side-effect further impacts the system: the air conditioner is subjected to higher loads and as it is forced to compensate for the additional heat introduced by the overcrowding, it requires more power to deliver the desired temperature. Often, in these cases, the perceived temperature is not cool enough to meet householders' comfort expectations, with the direct consequence of occupants progressively setting lower temperatures in the pursuit of heat relief. Split-systems are designed according to specific rules, assuming the modality, temperature loads and set-point with which the air conditioner is efficiently operated. Systems that work beyond their capacity are more likely to break, revealing a systematic failure embedded in the current practice:

> In the really, really hot areas, it doesn't cool down that much at night, [and] we still have overcrowding where people are sleeping in the living areas, because that's where the split-system is … Ideally we would have installed three or four split-systems in every property, and cooled the whole house effectively, but that just wasn't practical in terms of delivering on the budget. So, you do see people setting up beds in the living areas. You do see a lot of overcrowding … It is a real problem, and especially in some of these remote communities, where there's a shortage of housing at times, it's a real problem. (Participant 18)

Setting aside the environmental impact, increasing the number of non-ducted split-system air-conditioning units is also hardly an effective solution in social housing, where tenants will face significant electricity bills.

> If they did supply houses with split systems, it'd be nearly every room and then the power bill is going to go way up and then we're going to get phone calls about the electricity. So yeah, I'm not too sure what would happen or what we could do. (Participant 12)

5.2.4 Building for thermal efficiency

The availability of domestic air conditioning units and the fuel-dependent electricity systems which sit behind them, has meant that the construction industry has not had to build for climate considerations. Instead, developers can erect similar styles of building in radically different climate zones (Hawker 2002). Major refurbishments to increase the energy standard of existing stock would require removing and replacing wall cladding, installing insulation, replacing roofs, double-glazed windows, installing wrap-around verandas and shading systems and tree-scaping yards and streets, with air conditioning being a technology of last resort. However, these interventions are not mandated as policy.

5 The International Energy Agency (2018) predicts that the growing use of air conditioners in homes and offices around the world will be one of the top drivers of global electricity demand over the next three decades.

Smaller-scale interventions that generate immediate tenant benefits, such as via the solar program or the installation of air conditioning units, are more typical. Nonetheless, '*insulation in a roof will change a house dramatically*' (Participant 17).

> The older style homes, because they're lacking both those insulation properties [in the ceiling and walls], they can have an evaporative cooler going 24/7, [but] it's still going to be hot. (Participant 17)

Where major refurbishments are undertaken, informal cost-benefit decisions help determine whether these occur in older houses or in remote areas:

> We haven't done these big capital recladding things out west, because … You've got a few factors. When you're managing assets, it's about the person in the house, but there's no property value out there. The houses are worth ten grand and the land is worth four and you're spending 55 grand. So we've done the smaller thermal comfort things, but I wouldn't invest in the whole big recladding in remote. (Participant 19)

5.3 Policy implications

A wider policy framework orienting the housing sector toward climate issues is required. Gunida Gunyah Aboriginal Corporation's systematic navigation of mixed housing stock inheritances within its property management program represents an exemplary version of Indigenous-controlled service provision and tenancy management in NSW. However, the inadequacy of existing housing stock to manage heat stressors, water variability and population migrations is a blind spot in policy discussions and funding allocations targeting Indigenous housing and health. The absence of national policy frameworks is particularly telling. Notwithstanding recent improvements, the National Construction Code's minimum standards are still far from the best practice. The Nationwide House Energy Rating Scheme is a national scheme where dwellings are rated according to their thermal performance for summer and winter. As a model code, NatHERS has no legal enforceability. It is compulsory in New South Wales alone, and then for new builds only. The AHO and organisations like GGAC are thus doing all that is possible within a wider policy landscape that neither acknowledges the challenges nor makes provisions for them. It is essential for governments to be held accountable for managing these issues.

House supply

There is insufficient social housing for current needs and severely inadequate new housing planned to meet future needs in NSW. Greater government investment is required and the construction of new builds should incorporate an LCC approach.

Existing retrofits

Retrofit programs aimed at improving the thermal performance of existing housing should be mainstreamed across Indigenous housing, in anticipation of the growth of existing isotherm ranges. This must be complemented by expanded programs for renewable energy hardware and associated subsidies to mitigate householder energy stress. Such retrofit programs, and the ongoing R&M that new hardware (including solar technologies) require, promise significant potential for sustainable Indigenous employment in regional and remote contexts. Additional strategies could include expanding power subsidies for tenants facing rising power costs.

Refurbishments

The NSW Aboriginal Housing Office's programs related to solar panels, hydro panels and split-system air conditioning systems help mitigate householder energy stress and heat in the short term. These are important interventions, but more comprehensive programs to refurbish housing stock are required. Housing refurbishments should aim to improve window shadings, glazing systems, insulation levels and natural ventilation, while also increasing shading inside the fence and as community infrastructure.

Staying on Country

Under AHO subcontracting arrangements, ACHPs are required to minimise extended vacancies in their property portfolios. This logical measure can inadvertently provide a disincentive for ACHPs to assume management of properties in communities that are experiencing net outward migration due to low amenity. Some participants inferred that tacit decisions are being made about where to invest resources in new or refurbished housing, at the expense of marginal outer regional and remote areas. These trajectories reflect funding pressures on the sector and may run counter to a political program to support Indigenous people to remain on Country in housing that is safe, humane and which provides reasonable comfort.

Regional planning and mobility

The issue of inadequate funding for and attention to climate preparedness in new builds, refurbishments and retrofit programs will apply to many locations across Australia. In remote and outer regional areas, it is likely that increased seasonal and permanent movement of residents in response to climate change will strain services in regional towns and metropolitan areas. While partnership with governments is essential, Indigenous aspirations and strategies need to be at the centre of any strategy. Meaningful consultation and research are essential.

Steps need to be taken to bring key services, agencies, householder representative bodies and Indigenous leaders together to identify workable solutions and to apply coordinated pressure on governments to support action. AHURI might consider partnering with the Indigenous housing, health and land management sectors to facilitate a program of regional consultations involving specialists on climate change, water insecurity and housing design, to assist this urgent dialogue. These issues need to be addressed now to allow deliberative, carefully managed and sustainable plans, rather than via reactive policy.

6. Indigenous housing performance and climate resilience

- **This chapter addresses an absence of quantitative studies of indoor comfort and energy consumption within Indigenous housing. It computes the indoor environment performance of standard (existing) and improved (built to contemporary ideals) designs used for Indigenous housing in representative sites across Australia, under present and future climate scenarios.**
- **Occupancy level is the major factor in determining housing performance in relation to both indoor comfort and non-renewable energy use.**
- **Climate responsive designs configured in contemporary building guidelines (and seen in 'improved' designs) can help make active cooling systems operate with greater efficacy but are insufficient to keep the indoor environment comfortable when no additional air conditioning is provided.**
- **Neither standard nor improved housing designs adequately cater for current and anticipated hygrothermal (heat and moisture) pressures under climate change.**
- **New construction techniques and design strategies are required to future-proof remote and outer regional Indigenous housing and to ensure healthy indoor environments for the coming decades.**
- **The challenge to increase the resilience of housing is therefore greater than refurbishing existing stock to meet contemporary standards. It requires rethinking design and investment priorities more comprehensively.**

A changing climate directly implicates the housing sector: buildings constructed today under current design assumptions and building codes are highly likely to be inhabited in 2050 when the climatic, social and cultural context will be significantly different. These buildings will need to withstand new extremes, retain their functionality and adapt to occupants' changing needs. Given that in 2050 Indigenous housing stock is highly likely to be the same, or very similar, to that which is available now in either standard or improved form, it is of the utmost importance to identify the practical implications of current Indigenous housing system performance. This is the shelter that sits at the heart of sustainability issues.

This chapter considers the sustainability of Indigenous housing in terms of its readiness to withstand current and anticipated climate and other stressors. It does so by modelling the indoor temperature, humidity and energy consumption of a 'standard' three-bedroom house in different representative climate zones (tropical, arid and hot/mild). Performance is simulated according to different scenarios for architectural and construction standards, occupancy and crowding, the presence and type of mechanical cooling and ventilation practices.

Our analysis finds that existing housing models, whether old or newly constructed, offer inadequate indoor environments, resulting in prolonged high indoor temperatures that pose a serious threat to occupants' health and wellbeing. This underperformance will worsen under future climatic conditions, requiring an urgent update of construction and design practices and policies. Given the current under-investment in, and absence of policy attention to, refurbishment for climate-proofing, our simulations suggest that this situation is unlikely to improve, even for new buildings designed and erected according to current best practices.

The following sections offer an indicative assessment of the readiness of existing housing stock for known challenges, by simulating the effects of current building standards, design recommendations, occupancy densities, mechanical cooling systems, window ventilation and climate zones. Simulation inputs and assumptions follow.

6.1 Housing performance modelling inputs and assumptions

Our analysis builds upon existing research and available information on Indigenous housing performance, design and construction to generate a matrix of different architectural, occupancy and technological combinations. Each unique combination of parameters was modelled in a virtual environment, using transient simulation software to assess performance in terms of indoor temperature, humidity and the energy consumption required to keep the environment within acceptable thresholds. This approach allows for predictions of performance on a high-resolution grid, with hourly timesteps, and fair accuracy, according to the assumptions made.

The analysis compares the general responsiveness to weather variations (hourly, daily and seasonally), unveiling the internal resilience that the building should offer to maintain healthy and comfortable indoor spaces (Holling 1973). It should be noted from the outset that although the model parameter values used in the simulations were retrieved from empirical studies, expert inputs and case study data, the exercise did not involve in vivo (human body) experiments and remains indicative only. For instance, we make no distinctions around key householder characteristics such as age, ability or illness profile, nor have we simulated the effects of temperature variation on the function of key health hardware, an issue which greatly affects how well the house performs for residents (Ali, Foster et al. 2018; Torzillo, Pholeros et al. 2008). Such additional research would strengthen the necessity of pulling climate considerations into housing and health-related Indigenous policy.

6.1.1 Reference regions for climatic input

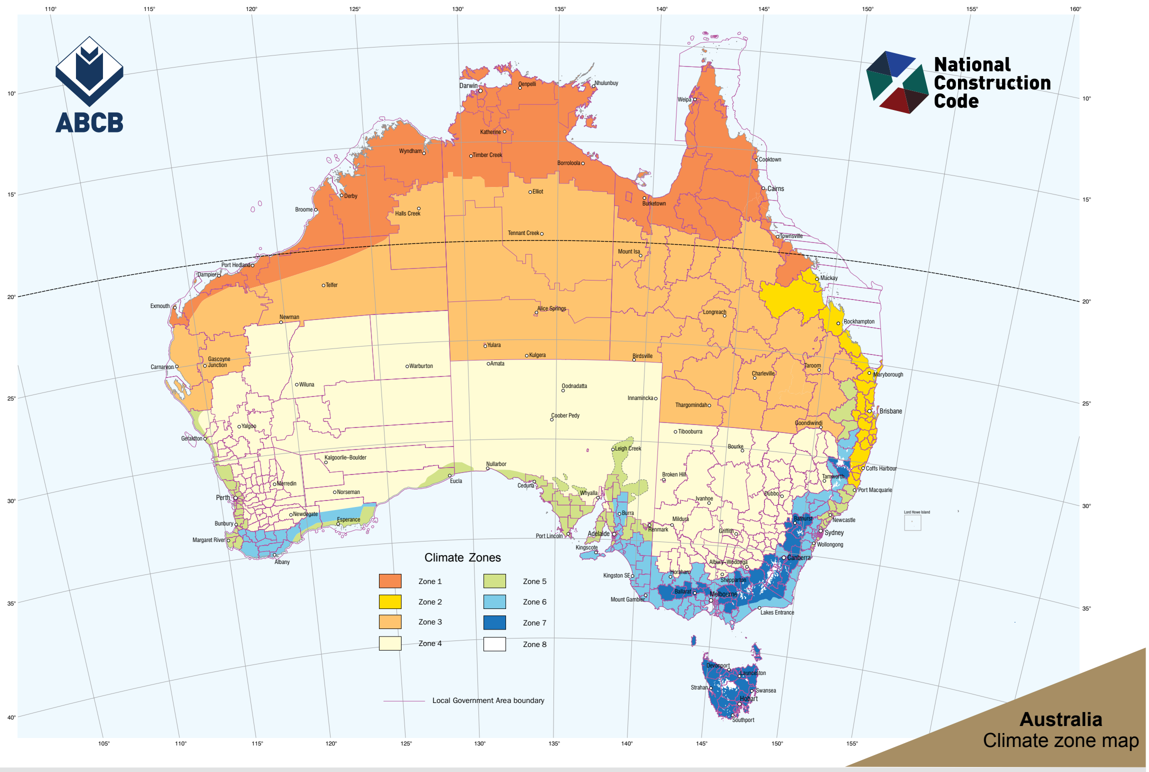
Australia is characterised by a wide variety of climates, resulting in different locations having different heating and cooling requirements. The National Construction Code (NCC) (ABCB 2019) accounts for these differences by dividing the country into eight climate zones (Figure 11).[6]

For this study, the tropical area, corresponding to the NCC climate zone 1, the arid area, corresponding to the NCC climate zone 3, and the hot/mild area, corresponding to the NCC climate zone 4, have been analysed. These are considered the most relevant to represent the variety of climatic conditions that remote and regional Indigenous housing is subject to at:

- Borroloola NT, representing a tropical climate (high humidity summer, warm winter)
- Alice Springs NT, representing an arid climate (hot dry summer, cool dry winter)
- Moree NSW, representing a hot/mild climate (hot dry summer, cool wetter winter).

6 The NCC climate zones are based on both climate data and local government boundaries. This confluence means the zones are construction industry guides rather than accurate renderings of climate change across Australia.

Figure 11: Australia's climate zones



Release Date: Sep 2019
Last amended: Aug 2015
Version: VC00031.3
Developed from a map from the Bureau of Meteorology

Source: Australian Building Codes Board (2019).

These sites were also selected in relation to three major factors: geographical distribution (configured in terms of climate zones and Indigenous population presence), availability of climatic data suitable for the hourly simulation, and availability of housing data. Around 31 per cent of Indigenous Australians live in New South Wales (AIHW 2017: 221). In the Northern Territory, Indigenous Australians constitute almost one-third of the population, compared to other jurisdictions which average between one and four per cent) (AIHW 2017: 221). Given these distributions, NSW and the NT were identified as relevant jurisdictions for our modelling.

The use of a reference community or town as a proxy for a regional area characterised by a similar climate is standard practice in building simulation studies, as it allows for the generalisation of findings to a wider area characterised by similar climatic patterns. With key socio-cultural differences, climate conditions in Alice Springs provide an indicative proxy for the APY Lands, a key case study region in this report.

6.1.2 Architectural design

For each climate, two different architectural design options have been considered, corresponding to a standard and improved design. The standard design represents existing Indigenous housing, while the 'improved' design represents 'best-practice' designs as these might be adopted in new builds. The different architectural design options include geometry, size, architectural composition and construction technologies. The definition of this configuration followed a synthetic approach, based on merging the available data and progressively refining the models. For the standard design, the modelling process started with drawings and photographs of typical three-bedroom houses collected during site visits, which were further refined based on desktop research of additional design data. Previous investigations conducted by Healthabitat were particularly informative (2021e; 2021f). Based on the audit of over 7,500 Indigenous houses across the different climate zones, Healthabitat concluded that standard Indigenous housing performs poorly due to:

- poor orientation, failing to protect from the warm wind in summer and to take advantage of solar radiation during winter
- little to no insulation, with only 26 per cent of the audited houses having wall insulation and 37 per cent roof insulation
- inadequate shading systems, with only half of the audited houses having shaded windows and 44 per cent no verandas to provide buffer zones
- lack of active cooling systems, where only 33 per cent of the audited houses had an installed cooling system, of which 42 per cent were fans.

The model used in this study allowed us to understand the effects of this standard design and to assess the health and energy implications that occupants are asked to cope with.

What we term the 'improved design' draws on discussions with specialised architects involved in projects aimed at modifying and improving the thermal performance of Indigenous housing. Improved design features aim to mitigate, or resolve, issues identified as drivers of poor performance in Indigenous housing. The key points of improvements are reported in Table 8.

Table 8: Key design strategies considered for the improved model

Climate	Design strategies
Tropical	• Awnings to shade windows and prevent solar radiation entering the building • Awnings to shade walls to prevent solar radiation overheating the surface and to increase the heat transmitted indoors through conduction • Additional wall insulation • Verandas or pergolas to create buffer zones and shading • Maximisation of cross ventilation
Arid	• Awnings to shade windows and prevent solar radiation entering the building • Awnings to shade walls to prevent solar radiation overheating the surface and increase the heat transmitted indoors through conduction • Additional roof insulation • Roof vents to increase hot air exhaustion
Hot/mild	• Awnings to shade windows and prevent solar radiation entering the building • Additional wall and roof insulation • Maximisation of cross ventilation

Source: Author analysis.

Importantly, the improved design scenario does not correspond to an *optimal* one, which would offer a higher level of customisation to the specific case, ideally using regenerative design principles (Cole 2012). An optimal design is grounded in the identification of architectural design strategies, passive cooling and heating techniques and construction technologies tailored to occupant lifestyle and preferences while acknowledging site specific constraints and requirements. Further, an optimal design process is highly evidence-based and informed by frequent performance assessment, resulting in a unique combination that offers the best compromise between the above-mentioned parameters for the specific building. This process of negotiation among different requirements is neither cheap nor quick, hence not always feasible. For this reason, a more common approach uses general principles that can be applied to a wider variety of situations and aims at marginally improving the performance of many buildings. In this study, we have used the improved scenarios to represent those cases where this more utilitarian improvement approach has been used for new builds or to refurbish existing housing.

6.1.3 Occupancy density

Occupancy density accounts for the number of residents in a building. This data is essential to determine indoor heat gains, which is the rate of heat generated by the occupants performing daily activities. The higher this number, the higher the indoor temperature and humidity, hence greater cooling function is necessary to maintain comfortable thresholds.

Accounting for indoor crowding is pivotal to a reliable assessment of Indigenous housing performance, as it is a key discriminant between healthy and unhealthy indoor environments. In this study, different scenarios represent the standard occupancy rate as assumed during the design stage and the worst-case scenario of involuntary crowding. Using three-bedroom houses as the architectural models, the following options are not atypical, as described in a recent study of how households cope with crowding, conducted in the NT Barkly region (Hall, Memmott et al. 2020):

- four occupants, representing a small family as this is normatively inscribed in three-bedroom building designs
- seven occupants
- eleven occupants
- sixteen occupants.

The case of highest crowding described in Hall, Memmott et al.'s report indicates 22 people as an upper limit. Because building simulation is performed on a one-year period, assuming constant overcrowding of 22 people would likely represent an exceptional bias in the results, failing to provide a fair comparison between the different scenarios. We propose that the defined worst-case scenario of 16 occupants can be representative of a yearly average, implicitly accounting for periods of extreme overcrowding. That is, the effects of more than 16 occupants in a three-bedroom house would be aggravated versions of this worst-case baseline.

6.1.4 Building services and systems

When no air conditioning is provided, high temperatures and high humidity carry a significant risk of mould growth. This is further aggravated by crowding, inadequate housing design, poorly performing building materials and insufficient R&M, which create fertile grounds for fungal and bacterial infestations. As outlined in Chapter 5, to reduce the negative impacts of heat for residents it is important to not exceed 30°C for long periods. For this reason, our modelling included a series of combinations whereby an active cooling system is installed. The type and extension of this system was then varied across the scenarios.

The setpoint temperature was kept constant at 26°C across all scenarios, based on the NSW Government's guideline for safety and health in workplaces which defines this value as the maximum acceptable upper limit (NSW Department of Customer Service 2020). This value also accounts for potential variations in the operative temperature while not exceeding the minimum risk temperature. We note that the reference is derived from guidelines on offices, as indoor temperature setpoints for residential houses are seldom regulated, leaving residents to choose their comfort temperature if mechanical cooling options are available.

Four different options have been included in the study:

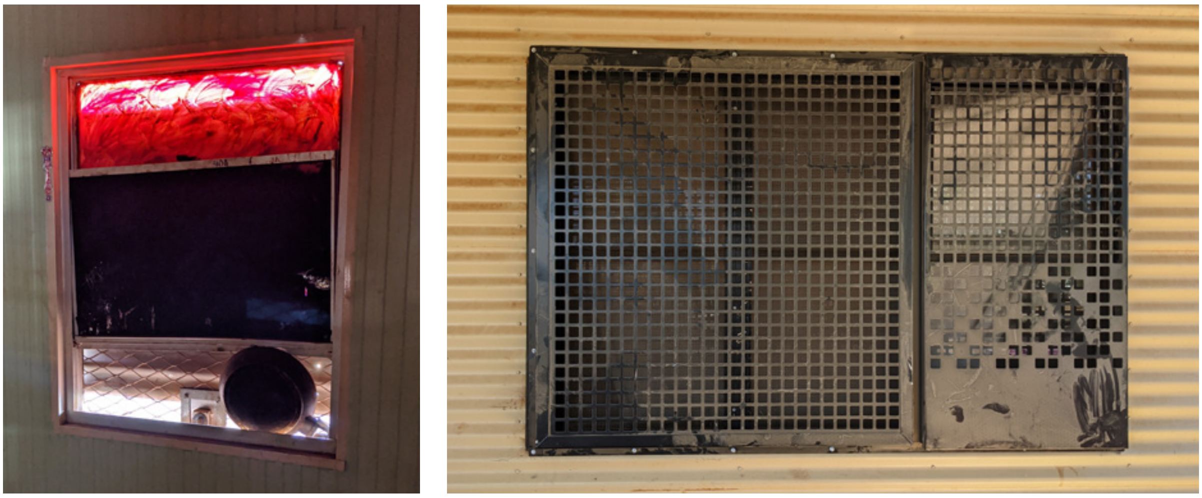
- No active cooling system is installed. This is a worst-case scenario for cooling, where either no mechanical system is provided or major faults prevent its use.
- A non-ducted cooling system is available in the living area and main bedroom. In Healthabitat's review, 31 per cent of houses had some type of refrigerated air conditioning unit, with most (23%) being small window-mounted units, which are cheaper to purchase but less efficient to operate. A reverse cycle refrigerated air non-ducted cooling system was installed in only 8 per cent of Indigenous houses in Healthabitat's review.
- A ducted cooling system. In this scenario, occupants can control the temperature in each room of the house separately.
- Split-system air conditioning plus heating system. Cooling is separately available in all rooms, while heating is centralised and controlled in the living room.

6.1.5 Occupant behaviour

One of the major assumptions needed to close the gap between actual and simulated housing performance results is an accurate prediction of occupant behaviours and their use of active temperature control systems (Delzendeh, Wu et al. 2017). For example, how often and when residents open or close windows, or are able to do so, may have significant impacts on heating and cooling systems and the estimation of any savings from system upgrades (Laurent, Samuelson et al. 2017).

According to Healthabitat informants to this report, windows and window maintenance are critical failure points in Indigenous housing. Indeed, it is often impossible to completely close windows, leaving air constantly flowing through the rooms and influencing infiltration rates or draughts (Figure 12). Cold air infiltrates during winter and hot air during summer, modifying indoor temperatures in a way that is difficult to predict and manage.

Figure 12: Window and window security screen, APY Lands



Source: Liam Grealy.

To anticipate this in our modelling, different variables for window and ventilation operations have been included. These options are defined based on previous work aimed at assessing the sensitivity of the thermal performance in the residential sector (Brunone, Brambilla et al. 2018):

- windows always open
- window always closed
- windows open when the indoor temperature is above 24°C and outdoor temperature is above 16°C (hereafter called 'natural ventilation' for simplicity)
- windows open during the night (also called 'night purging').

The baseline is defined according to NatHERS guidelines (Department of Industry, Science, Energy and Resources 2019), which is the Australian reference document used to assess and rate energy performance for new residential buildings, based on their design. These guidelines provide designers with a complete hourly schedule for key factors that impact indoor hygrothermal (moisture and heat) gains, such as occupancy, heating, ventilation and air conditioning (HVAC) profiles, lighting and occupants' activities. This schedule has then been modified to create a set of options representing different use patterns, especially regarding ventilation systems.

6.1.6 Final matrix

Combining the parameters above, a total of 366 simulations were performed. Table 9 shows the variables that were placed in combination to create these simulation scenarios.

Table 9: Parameters used for generating the final matrix

Climate	Architectural model	Occupancy density	Building services and cooling systems	Occupancy behaviour and ventilation
• Borroloola NT Tropical climate • Alice Springs NT Arid climate • Moree NSW Hot/mild climate	• Standard design as built • Improved design as refurbished	• 4 occupants • 7 occupants • 11 occupants • 16 occupants	• No active system • Non-ducted cooling system in living areas and main bedroom • Ducted cooling system in all rooms • Split system plus heating in living room	• Windows always open • Windows always closed • Natural ventilation • Night purging—windows open during the night

Note: All combinations have been assessed via transient thermal whole building simulation.
Source: Author analysis.

A discrete simulation might look like the following:

1. Borroloola, standard design, 4 occupants, no active system, windows open all day.
2. Borroloola, standard design, 7 occupants, no active system, windows open all day.
3. Borroloola, improved design, 7 occupants, no active system, windows open all day.

Natural ventilation and active cooling systems were not combined linearly but were modelled to reflect usage patterns, such as considering flexible natural ventilation when the cooling system is not in function.

6.2 Modelling the performance of Indigenous housing

The analysis in this chapter allows for a multidimensional assessment of Indigenous housing performance. All scenarios can be investigated under comfort and health perspectives, both in terms of general tendencies and specific resilience to heatwaves. Scenarios where an active or mechanical cooling system are included can also reveal trends in energy consumption. When a scenario does not feature an active cooling system, the predicted energy consumption for cooling or heating is zero. This value is not an indication of overall better performance, as the assessment should integrate both energy consumption and hygrothermal indoor comfort and, further, the different modulating factors associated with human bodies. Simply put for our purposes here, the absence of an active temperature moderation system is associated with higher indoor temperatures, higher humidity levels and unacceptable comfort conditions in warmer months, with inversely undesirable results in cooler months.

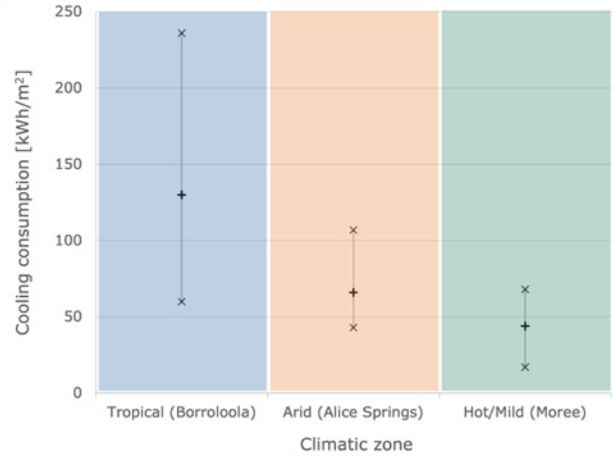
6.2.1 Energy consumption and operational costs

Energy consumption can be used as a proxy to evaluate the efficiency of a house design and its economic impacts. Inefficient designs not only result in low environmental efficiency and discomfort but are consequential for the welfare of householders, making thermal comfort an unaffordable luxury, with sometimes severe health impacts (D'Alessandro and Appolloni 2020).

Our analysis reveals that some heating consumption is necessary to keep indoor spaces comfortable in both arid and hot/mild climates. For standard Indigenous housing, the average energy consumption is comparable in both locations (Alice Springs and Moree), ranging between 14 and 38 kWh/m^2 yearly, depending on the occupancy scenario. Scenarios simulated around improved designs perform slightly better, allowing a reduction of the energy consumed by 8 per cent compared to the standard design model. Australian houses are often not equipped for central heating purposes and, in this case, the analysis indicates that indoor temperature may drop significantly under 18°C when heating is not provided, underlining the importance of having a fully functioning heating system. In Healthabitat's survey of more than 7,500 Indigenous houses, it was found that 51 per cent of the buildings reached a minimum temperature between 0°C and 10°C. Our results validate and extend this finding.

However, cooling is the primary concern for Indigenous housing performance. In Figure 13 (as for Figure 15 and Figure 17), the values for energy consumption are calculated across all scenarios for each climate to provide an immediate measure of comparison. It indicates an average household consumption of 107 kWh/m^{2}y, 66 kWh/m^{2}y and 43 kWh/m^{2}y for tropical, arid and hot/mild climates respectively. The tropical climate results are the most critical of the configurations, with cooling-related energy consumption almost three times higher than the hot/mild climate and twice the arid climate.

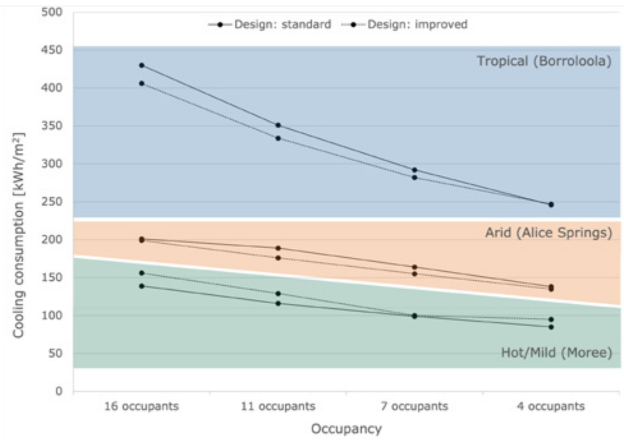
Figure 13: Maximum, minimum and average cooling consumption per climate, expressed in kWh/m^{2}y



Source: Author analysis.

Figure 14 shows a comparison of the predicted energy consumption for cooling of the standard and improved house designs across both the different climates and occupancy scenarios. It demonstrates the higher variability of results obtained for the tropical models. This variability can be expressed as the difference between the maximum and minimum values. The tropical climate has a variability of 3.5 times higher than the hot/mild climate, and 2.75 times higher than the arid one. Both the maximum values predicted for arid and hot/mild climates fall in the lower end of the tropical range, with the hot/mild climate average even lower than the minimum. This indicates that Indigenous housing placed in tropical areas is more likely to be characterised by very poor passive design, heavily reliant on air-conditioning systems.

Figure 14: Comparison of the predicted cooling consumption of various design, climate and occupancy scenarios



Source: Author analysis.

What matters: improved design or crowding levels?

Counter-intuitively, the improved design approach is not equally effective for all scenarios. In tropical areas, improved design consistently improves overall performance, reducing the energy consumed for cooling from between 8 to 11 per cent, depending on the occupancy scenario. Indeed, the higher the overall energy consumption for cooling, the higher the saving potential of improved design compared to the standard design. This result indicates that improved tropical design offers greater returns for increased resilience to accommodate changing system and occupancy patterns, despite the overall performance remaining inadequate.

After the climate zone, the second most significant parameter in predicting energy consumption, and more influential than whether the design is standard or improved, is occupancy. When considering the complete set of simulations by climate, the overall ranking is determined by the occupancy scenarios: the higher the number of occupants, the higher the energy consumed, regardless of the design model, the type of cooling system or ventilation scenario. This means that *occupancy* is a major driver in determining the cooling needs of Indigenous housing. It also reveals that current architectural solutions are not resilient to different use and occupancy densities, necessitating design processes where the users, their lifestyles and social-cultural practices are placed at the centre (Fien, Charlesworth et al. 2008; Memmott and Chambers 2003; Cole 2012).

Economic implications of improved design

Energy consumption can be used as a proxy to understand the economic implications of different design strategies. To express the results in dollar terms, we have taken the average energy market price for the NT and NSW and multiplied this for the energy consumption per square metre over a year for the scenario under consideration (dollar per kWh x kWh/m^{2}y = \$/m^{2}y). In this way, it is possible to assess the efficacy of the improved design and compare different scenarios (of climate, occupancy or system) based on the spend per square metre over a year to keep the house comfortable. It is worth noting that the conversion is based on average market data for 2020, assuming that the price of energy will not change in the future. The data are thus presented as a measure of comparison, rather than a reliable price indication.

When evaluating the effects of the improved design, the economic savings in tropical areas correspond to a maximum of \$7 per square metre per year on a total of \$61/m^2/y when the building accommodates 16 occupants and \$3 per square metre per year on a total of \$38/m^{2}y when the building is occupied by four residents. Hence, the range of savings to be accrued through design improvements and reduced occupancy rates can be established between these two values. Although these numbers are small, when multiplied by the heated surface and when assessed relative to family income, their relevance is much more significant.

Figure 14 shows that improved house design in the arid scenario is less effective for reducing the economic impact of energy consumption, with the saving potential fairly steady in all scenarios and ranging between 7 and 4 per cent. This is indicated by the two lines (continuous and dotted) being almost parallel, in contrast to the lines representing the tropical climate, which diverge clearly, indicating the higher saving potential for improved design. In arid climates, looking at the standard design operational price, the cost ranges from \$28/m^{2}y to \$20/m^{2}y, and the improved design offers additional benefits of approximately \$1/m^{2}y or \$2/m^{2}y. If the strategies included in the improved design scenarios are used to refurbish a building, a more comprehensive analysis of the economic cost-benefit is needed, as the final overall cooling reduction may not be repaid during the operational life of the building. This is not to negate the health benefits from stabilising heating needs in winter, which is increasingly well established in the literature (Fyfe, Telfar et al. 2020).

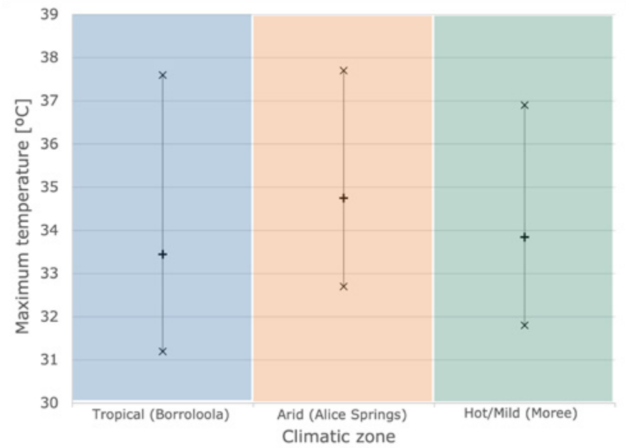
Similar results can be found in the hot/mild climate (Moree), where the savings introduced by the improved design are stable across the different scenarios. In this case, the efficacy of the improved design is more evident for overcrowded situations (16 occupants) indicating that such improvements could offer resiliency for temporary overcrowding. The savings registered are around \$3/m^{2}y. Further, the improved model for this climate is beneficial on a whole-year performance basis, which includes both cooling and heating seasons. Indeed, the higher quality insulation enables more stable temperatures throughout the year, despite the model being not able to prevent overheating during heatwaves, when higher cooling consumption is generated.

6.2.2 Indoor environment quality and health

Scenarios with active cooling systems

Even with active cooling systems, all scenarios show some overheating: the difference lies in both the duration and peak temperatures. In the combinations where an active cooling system of any sort was considered, the average maximum temperatures achieved range around 34°C, with peaks up to almost 38°C. Figure 15 shows values averaged across all the scenarios with an air conditioning system installed in at least one room.

Figure 15: Maximum, minimum and average temperatures per climate



Source: Author analysis.

Occupancy density impacts the frequency of overheating at a factor of almost two for the tropical climate, and 2.5 for arid and hot/mild zones in the case of partial air conditioning (one or two rooms only). However, in comparing scenarios for overheating alongside active cooling systems, the most important parameter is the system used. As would be expected, there is a higher frequency of overheating when the house is not equipped with an active cooling system in all rooms. This underlines the importance of an HVAC system to prevent overheated indoor environments, regardless of the climate region, architectural design or occupancy density, and particularly in the absence of other mitigation efforts. The approach of the NSW Aboriginal Housing Office (Chapter 5) is thus essential, if insufficient, for current climate pressures.

Scenarios without active cooling systems

The results obtained for the scenarios where no air conditioning system is provided differ from the ones obtained with full or partial air conditioning.

Table 10: Maximum temperature achieved in the standard design, reported per climate and ventilation scenario (°C)

Model	Ventilation	Occupancy x4	Occupancy x7	Occupancy x11	Occupancy x16
Tropical	Open	35.4	35.6	35.7	35.9
	Closed	37.7	37.8	34.9	37.9
	Natural ventilation	37.7	37.5	37.6	37.6
	Night purging	35.9	36.0	36.2	36.4
Arid	Open	37.6	37.7	37.8	37.8
	Closed	39.3	39.3	39.3	39.3
	Natural ventilation	36.6	36.6	36.7	36.7
	Night purging	37.9	38.0	38.1	38.2

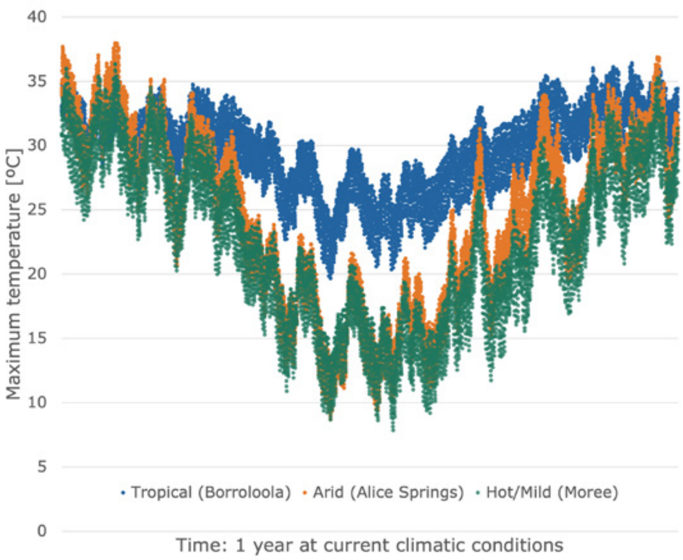
Model	Ventilation	Occupancy x4	Occupancy x7	Occupancy x11	Occupancy x16
Hot/mild	Open	35.8	35.9	36.1	36.3
	Closed	37.8	37.9	38.0	38.1
	Natural ventilation	36.0	36.2	36.3	36.5
	Night purging	36.4	36.5	36.7	36.9

Source: Author analysis.

In Table 10 the maximum temperature achieved is represented for all scenarios using the standard design. All scenarios present the same ranking according to the ventilation strategy: the worst case is represented by closed windows, followed by night purging, then open and, finally, the lowest temperature is registered in the natural ventilation scenario. However, when these results are crossed with the frequency of overheating, the ranking changes. In this case, the arid model presents the clearest trend across the different occupancy scenarios, with the ranking changed to open, natural ventilation, closed and then night purging (worst to best). This is clearly due to a climate characterised by very hot days and cool nights. In arid regions, opening the windows during the day allows hot air to enter the rooms, which, coupled with internal occupancy loads, is then difficult to discharge. Night purging takes advantage of cooler night air to discharge the heat of the day. The tropical and hot/mild models do not show a clear trend visible through all the occupancy scenarios and the same conclusions cannot be made.

Figure 16 shows the critical nature of maintaining the indoor environment at comfortable temperatures in the tropical climate in particular. While the night purging scenario is provided as an example, we observed this trend across scenarios. Figure 16 reveals the temperature peaks found in the arid zone as the main deviation between the arid and hot/mild climates. These fluctuations require more energy consumption to be controlled, resulting in higher overall cooling loads, although the trend observed in these climate scenarios is very similar.

Figure 16: Yearly trends of the indoor temperature, January–December, plotted for the scenario of night purging, 4 occupants



Source: Author analysis.

Implications of 'improved' designs

The improved design has a relatively small influence on the maximum temperature reached across the climate scenarios, with a maximum difference in the hot/mild climate of less than 2°C (the arid and tropical zones offer an even smaller dividend). This value is less than the minimum noticeable temperature difference, defined as that difference in temperature that can be thermally sensed by the human body. In this case, the difference recorded with the improved design is less than this threshold, suggesting that the effectiveness of improved house design strategies are not as significant as other changes in reducing temperature peaks.

However, if the assessment of overheating is not restricted to looking at the maximum temperature reached and is instead concerned with the maximum temperature throughout the year, the analysis indicates the higher resilience that improved design can offer. This is evident in cases where, for instance, the air conditioning system malfunctions or is not provided. This means that improved design can offer additional protection from hardware failure (including from inadequate R&M), but it cannot substitute for the active cooling system either failing completely or not existing. The implication is that a more tailored and climate responsive design could provide more comfortable indoor environments, with overheating events reduced, but current improvement recommendations are insufficient for increased heat with climate change.

The figures in Appendix 5 model the percentage of time that a house will remain within a specific temperature range, according to occupancy, ventilation and active systems scenarios, for each of the climate zones. The results highlight the importance of improving current design practices to take full advantage of passive strategies to prevent overheating, as well as providing an adequate air conditioning system and educating users on optimal ventilation. The scenarios can also be used to indicate the effects of poor maintenance practices: the partial system can represent a failed air conditioning program and the ventilation scenarios include situations where windows cannot be closed or opened anymore. The difference between the design assumptions of housing, intended as a perfectly working system with optimal occupancy density, may lead to significant overheating during a prolonged period, reflected in serious health hazards for occupants.

These implications are already with us. In the following section, we factor in the additional pressures that are associated with climate change.

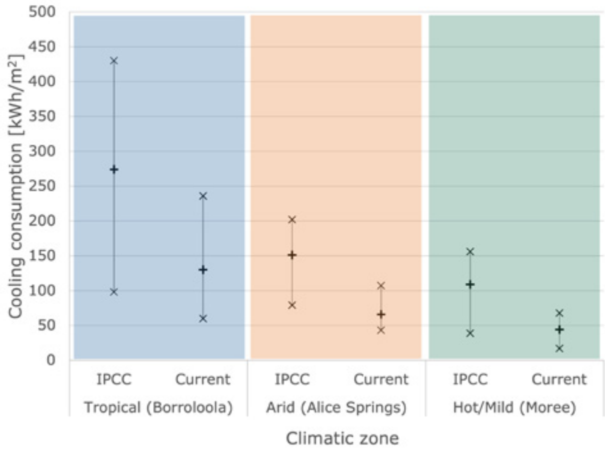
6.3 Likely impacts of projected climate changes on Indigenous housing

This section investigates the potential impacts of climate change on regional and remote Indigenous housing stock to further quantify the potential range of outcomes. The following analysis is based on the assumptions identified and adopted for the models described above, here adding climatic inputs, taken from IPCC projection scenarios. This has been generated with Meteonorm software whereby future climate scenarios can be generated for any location, based on the interpolation of available data and climatic regional models. IPCC gives different future climates, based on the emission scenarios considered. However, we note that mean climate patterns are proportional to the emission scenario: more intense carbon emissions lead to higher climate variability (Harvey 2004). For this study, the mid-range scenario A1B[7] has been considered, accounting for an average variation.

If design and construction practices do not change, our model suggests an intensification of key criticalities.

7 IPCC released future climate projections following a set of emissions scenarios that are consistent with certain socio-economic assumptions about the future. The A1B scenario describes a future world of very rapid economic growth, low population growth, and the rapid introduction of new and more efficient technologies, with a balanced emphasis on all energy sources.

Figure 17: Maximum, minimum and average cooling consumption per climate, expressed in kWh/m²y



Source: Author analysis.

Figure 17 shows that when compared to the results discussed to this point, future energy consumption increases consistently across all climate zones, with a shift of the average toward the upper limits (red cross closer to the upper end compared to the black cross). The tropical model registers the worst absolute conditions, but it is the hot/mild climate, representing a more typical Australian region, which registers the highest increment increases. In such regions, future energy consumption will be comparable with that now found for the tropical climate. The increment factors are:

- **Tropical region:** the average consumption almost doubles, while the maximum and minimum increase at 1.8 and 1.6 times respectively.
- **Arid region:** the average consumption is 2.2 times higher, while both maximum and minimum increase 1.8 times.
- **Hot/mild region:** the average consumption is 2.5 times higher, while both maximum and minimum increase 2.3 times.

Figure 18 shows energy consumption for current and future climates, as well as standard and improved designs, in relation to occupancy density and distinguished by active cooling scenario. As might be expected, the difference is higher for fully air-conditioned scenarios compared to those where the cooling system is installed only in the main living room (as per NSW Aboriginal Housing Office practice). However, it is interesting to note that the scenario where a heating system is provided registers lower increments of energy consumption, due to the warmer climate and lower needs of heating with climate change. All scenarios register a dramatic increase of energy consumption, revealing a need for future implementation in the energy grid, production and provisions. When assessing the potential economic impacts in the worst scenario (fully air conditioned), both tropical and arid designs see an average increment of $21/m²y, while the hot/mild zone registers an average raise of $38/m²y.

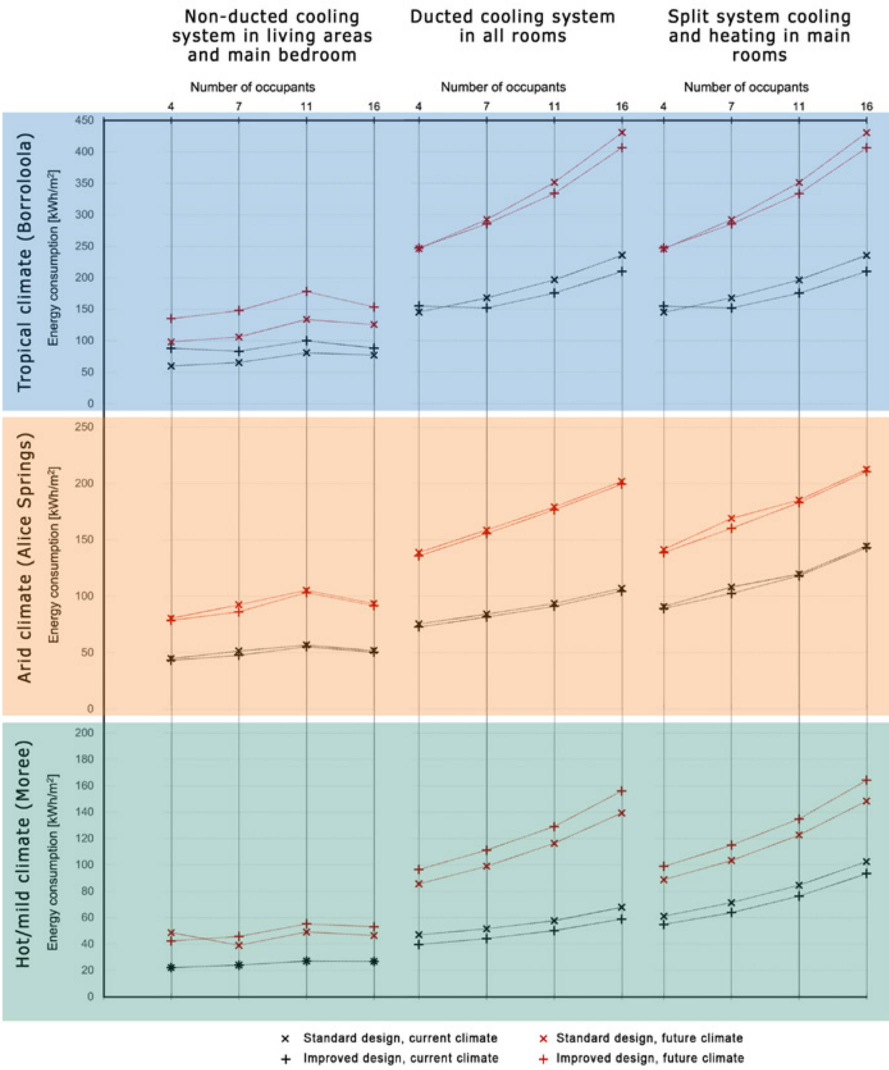
Interestingly, the impacts of improved design, despite variations across climate and multiple scenarios, present the same trend: they are less beneficial, or even detrimental, in the future compared to now.

In the tropical climate, except with the partially air-conditioned scenario, the more densely occupied a building is, the higher the benefits of adopting an improved design. Even so, the savings are less than what can be presently achieved. This may indicate that retrofit or refurbishment interventions should be done as soon as possible to realise maximum benefit before the saving potential is dramatically reduced. On the other hand, the results question the long-term benefits of the retrofit approach following *current* improved design practices in all cases, as the savings in housing occupied by 4 to 7 occupants are rapidly reduced over time.

It is worth noting that the partially air-conditioned scenario seems to be more efficient where 11 people are considered, compared to 16. This is due to our modelling assumptions, where the occupants have been distributed across different rooms. In the case of 11 occupants, the main bedroom accommodates a higher number of people during the night and hence its consumption results are higher.

For the arid climate, improved design is consistently not very effective across all the scenarios, while for the hot/mild climate, it even increases the cooling needs. Despite proving to be a valid strategy under the current climate to reduce overall air conditioning consumption needs (heating plus cooling), its effects in the future result in higher consumption, underlining once more the importance of a tailored intervention that could account for the specificities of each case.

Figure 18: Energy consumption, expressed in kWh/m²y, in relation to occupancy density

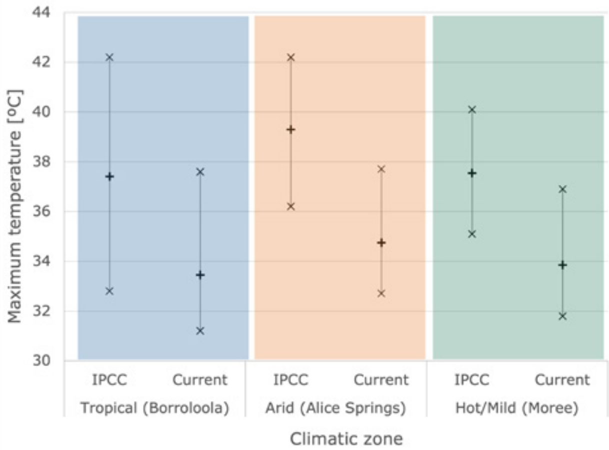


Note: The Y-axis has a different scale in the three climates. The different active cooling scenarios present different types and sizes of systems, hence a direct comparison of the energy consumed is not relevant. Indeed, it is obvious that a system with heating consumes more than one without heating in a temperate climate, or that a system installed only in the living room consumes less than one with an outlet in every room. However, when the scenarios are analysed to compare a second parameter (e.g., climate or type of design) they can provide useful insights on the resilience offered by different cooling strategies.

Source: Author analysis.

In any case, the increment difference between standard and improved design is lower than $2/m²y in all cases. This indicates that, in the future, what currently stands for improved design will have reduced efficacy and be unable to effectively improve housing performance. This trend questions the long-term benefits of current design standards and refurbishment interventions, opening the discussion about the need for more profound changes in the design, construction and policy framework for future-proofing Indigenous housing

Figure 19: Maximum, minimum, and average temperatures per climate, with values averaged across all scenarios



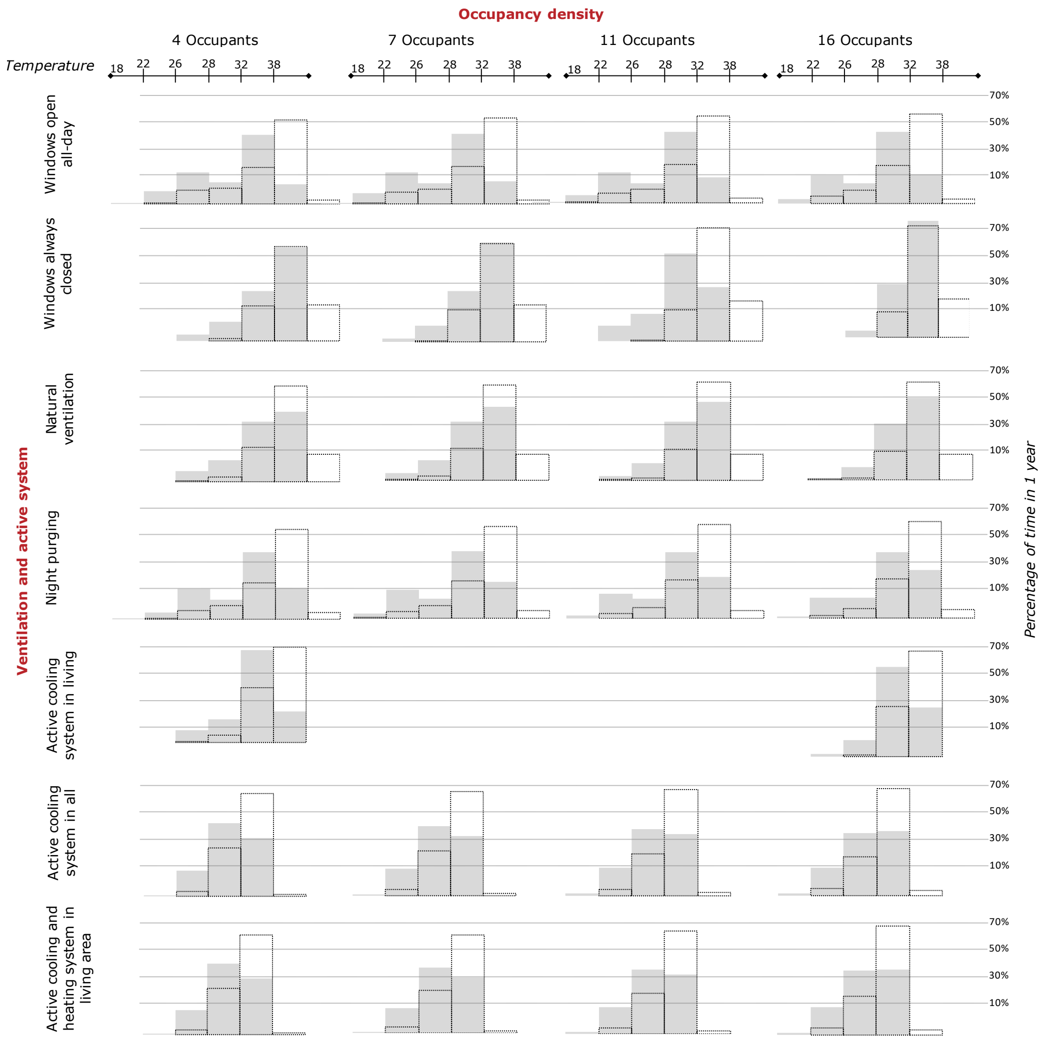
Source: Author analysis.

Future climates will bring higher indoor temperatures and increased risks of overheating, with maximum temperatures consistently higher across all scenarios, up to 7°C (Figure 19). The trends are similar to those found in the current climates, and the general conclusion for energy consumption can be made for temperature as well.

Looking at the duration and frequency of future overheating events, the ranking between the natural ventilation scenarios appears more significant. In the tropical and hot/mild climates, the worst ventilation scenario relates to night purging. The same result is found for the arid standard model, but not for the improved design, where having windows open all day is still the worst case. This is consistent with the prediction of having more warmer nights and less temperature difference during the day. Night purging relies on the gradient of temperature: the higher the ambient temperature, the more efficient this strategy is. Hence in the future, its efficacy will be reduced or even counterproductive.

Figure 20 shows the temperature distribution over the year for the tropical climate. Most of the scenarios report an upsurge of hours with a temperature above 32°C, up to three times more than under current climatic conditions. The alarming trend is also visible from the number of hours above 38°C, with thresholds barely reached before. All scenarios without mechanical ventilation present indoor environments that are unhealthy for the occupants, sometimes with temperatures that never fall below 26°C. This clearly means that, in the future, Indigenous housing must either rely on fully functioning active cooling systems or better and more high performing construction and architectural systems to provide decent living environments.

Figure 20: Percentage of time within a specific temperature range for current and future climate scenarios —tropical climate



Note: The grey shade indicates current climate; the black line indicates future climate.

Source: Author analysis.

6.4 Policy implications

This analysis provides a snapshot of current Indigenous housing performance, considered against standard and improved models (as improvements are currently envisaged) as well as the potential impacts that climate change may bring. The results highlight vulnerability to change in climatic conditions, occupancy regime and operational status, and expose the inadequacy of current design and construction practices to guarantee climate-responsive housing given present conditions and future projections.

Despite being based on predictions limited by data inputs and the assumptions of the modelling process, the results unveil a significant knowledge gap related to suitable strategies to future-proof remote and outer regional Indigenous housing for the climate to come, while assuring sustainable and health-conferring housing. Building on the implications outlined in Chapter 5, policy that addresses such vulnerabilities should take the following issues into consideration.

Occupancy

Crowding is a thermal health and comfort issue. The complete set of simulations highlights the central significance of occupancy to the thermal comfort of residents and to householders' energy consumption. The required expansion of housing supply can be augmented by refurbishment programs that expand the size and amenity of existing houses (for example, through the addition of bedrooms and wet areas). However, consideration should be given at the household level to residents' preferences for sleeping arrangements and to whether existing retrofit programs encourage crowding, such as through the provision of single air conditioning units in living areas.

Design and construction guidelines

The relatively poor results regarding 'improved design' suggest the need for an urgent update of current design and construction guidelines to improve the energy and thermal performance of Indigenous housing, while tailoring the interventions and design strategies around occupier needs. Higher standards for indoor design should be set in tenders and new builds should be subject to periodic inspection of thermal performance to ensure householder health and increase house lifespans. Accounting for householder practices and needs is essential to determine the economic viability of a specific design intervention (as retrofit or refurbishment), as well as its benefits on the lifespan of a building. Indeed, benefits derived from refurbishing a building may be reduced significantly in future climates, especially if futureproofing, resilience, and the specific needs of householders are not properly acknowledged during design and associated R&M processes.

Further research

The model parameter values used in the simulations were drawn from empirical studies, expert inputs, and case study data. However, this chapter did not make distinctions in key householder characteristics such as age, ability, or illness profile, nor did we simulate the impact of temperature variation on key health hardware. Further research along these lines should emphasise the necessity of locating climate change concerns at the centre of Indigenous health and housing policy. Major potential also lies in the possibility for Australia to develop a design approach that looks beyond the house, aiming to restore, renew and revitalise its surroundings.

7. Policy development options

In a context where the Australian Government appears to have stepped away from regional and remote Indigenous housing provision, and state and territory governments have not developed comprehensive and well-funded strategies for stepping in, extending the lifespan of existing housing is essential. Our report has outlined the strategies that SA and NSW program managers and service providers are pursuing. Our additional data and analysis indicate that such exemplary efforts cannot fill the funding and policy gaps that generate housing undersupply and poorly performing housing stock in relation to climate change.

Policy development options include:

- keeping existing housing stock in good repair via well planned, reliably funded and effectively implemented repair and maintenance programs. Consistent R&M additionally offers greater opportunity for sustainable local employment.
- reducing the impact of crowding, by providing new stock, adding space, and ensuring functioning health hardware. The latter relieves the pressure on houses and should be assured by targeting bathroom and laundry facilities, using high quality componentry and design standards. Moderating the impact of crowding counts as much as the consistency of R&M in sustaining Indigenous housing.
- adopting life-cycle costing models to meaningfully account for asset management costs over time. Adopting life-cycle approaches in housing policy can reduce the downtime for major repairs, waste and environmental impact while increasing overall asset value.
- refurbishing and retrofitting existing housing to improve the energy efficiency and environmental cooling of properties to offer immediate living condition improvements, particularly in tropical and hot/mild climate zones.
- sponsoring research and development on economical design solutions for climate-ready housing and related investment requirements.
- designing houses that reflect how they will be used and within what kinds of climate pressures, to ensure they perform adequately now and into the future.
- enshrining rigorous design standards and systematic R&M responsibilities within enforceable legislative and funding frameworks.

7.1 What is sustained now?

For regional and remote Indigenous housing to be sustainable, there is a requirement that it be adequately adapted to its geographical, climatic and social contexts. Sustainable housing must be built with structural integrity and robust materials, given climate and household compositional requirements, and maintained through systems that are reliably resourced, regularly implemented and responsive to householder and community needs, including employment. Maintenance should be understood as:

- a central consideration in the design phase
- an investment to protect the value of a public or community asset

- a means of reducing significant costs across the life cycle
- an essential requirement for improving the health and wellbeing of householders.

Such approaches are not uniformly offered across different Indigenous housing arrangements. Instead of recurrent funding to support people to secure appropriate and affordable homes in the different places they choose to live, householders are subject to the vicissitudes of changing government policies and the rationing decisions that follow inadequate funding to the sector.

Underpinning these issues is the absence of a national vision for sustainable Indigenous housing. There is a significant gap in understanding how to maintain housing in ways that minimise costs, maintain operational viability, anticipate thermal needs, and maximise energy efficiency in the context of changing climates. This policy gap meets a research gap. There is insufficient attention paid to analysing the thermal needs of existing housing, whether old or newly built. Research is needed into how to cool indoor environments and manage shifting humidity conditions and regarding the benefits and concessions of specific design features. Such research must pay attention to specific locational challenges, including factors such as housing undersupply, occupancy levels and housing condition.

The sustainability issues are multiple and complex. A perfectly sealed and insulated container is the most efficient for mechanical air cooling, but far from ideal for intergenerational living and ignores the need for airflow and ventilation. How will physical and professional labour be managed under longer lasting conditions of high heat, when mainstream trade apprenticeships already fail over the issue of temperature and humidity in the tropical regions of Australia (Zoellner, Brearley et al. 2017)? What are the supply chains, investment regimes and logistical systems for sustainable Indigenous housing and health services in remote and regional areas? There is low to no attention paid to how construction industry standards and expectations need to change or what the regulatory apparatus will need to be, to ensure housing that is safe, health-conferring and thermally comfortable, now and into the future. Future research should attend to such issues to support policy initiatives, in dialogue with Indigenous organisations who are leading discussions on how to live with new climate realities and resource depletions.

7.2 How might planned maintenance improve the status quo?

Many of the principles identified in our accounts of the 'should' and the 'ought' in repair and maintenance are well-established in the Indigenous housing literature. But establishing them in practice through consistent funding and focused implementation programs has remained elusive. The program implementation case studies provided in this report in many respects represent best practice under current constraints. Housing SA's program on the APY Lands is an exemplary case of a planned maintenance program that incorporates Housing for Health principles.

In 2021, Infrastructure Australia (2021) included 'Remote housing overcrowding and quality' on its list of 'High Priority Initiatives'. It highlights a range of required actions to reduce crowding in line with *Closing the Gap* goals, including increasing housing supply, replacing legacy stock and 'addressing maintenance and utility deficiencies for existing and future housing stock' (2021: 85). This report demonstrates that the promotion of planned maintenance programs that incorporate the life-cycle approach and housing for health principles is essential for housing that sustains its function to support householder health and wellbeing over time.

Government subsidy for remote housing maintenance is likely to always be required as rental revenues derived from remote Indigenous properties will not meet the expense of adequate maintenance programs. However, there remains significant potential to reduce the social and health costs of poor housing, particularly if LCC methods are used. Designing with clear planning of the life cycle of a building supports more accurate decision-making processes, especially with regard to renovations (Islam, Jollands et al. 2015; Hossain, Uzzal et al. 2018). Note that initial design and material choices can influence up to 80 per cent of post-construction life-cycle costs (Fantozzi, Gargari et al. 2019).

Although there is some policy recognition of the desirability of place-based solutions and of supporting greater Indigenous employment, our analysis suggests that, overall, progress in making this a reality is chequered. Existing research is mostly silent on how R&M programs can support adaptation to climate change and how labour and supply issues will impede or strengthen the case for local employment options.

There is an urgent need for modelling to support budget determinations on the sustained funding levels required to create desirable jobs in communities through R&M programs, including the possibility for a cross-agency approach in which employees divide time between asset management and health hardware R&M and wider environmental health tasks. Proposed developments should maximise opportunities for local training and employment and support capacity building with employers and within the community more generally. This requires close and careful liaison and negotiation with key stakeholders, an understanding of community dynamics and greater willingness to share power within decision-making.

7.3 How resilient is Indigenous housing under climate change?

Our preliminary simulations clearly suggest that both existing housing stock and new housing built to current environmental guidelines are unable to ensure householders will have access to adequate living conditions throughout the year. Factoring the exacerbations of climate change, this situation worsens. Metrics of thermal comfort are difficult to standardise given locational, temporal, social and biological variables (Halawa and van Hoof 2012; Fanger 1970), but this does not explain the absence of policy urgency. The National Housing and Homelessness Agreement makes no mention of cultural or climate adaptation or local delivery. There is a risk that mainstream housing and homelessness providers will continue to exacerbate historic problems associated with low cultural competency in the provision of housing, contributing to tenancy failure and Indigenous disadvantage while not supporting Indigenous people's choices in where they are located, because the available housing stock aggravates rather than relieves conditions of poor health and thermal discomfort (UN 2005; Go-Sam 2008; Fien and Charlesworth 2012).

Although '[e]xposure to heat has killed more people in Australia than all other natural hazards combined' (Opperman, Brearley et al. 2017), studies of the health impacts of passive heat exposure for Indigenous people from poorly designed housing are scant. Houses built under NPARIH relied heavily on air-conditioning units, despite evidence of high failure rates and slow repair times (Habibis, Phillips et al. 2016). More broadly, our policy analysis revealed a worrying lack of commitment and action to the issue of climate change in regional and remote Indigenous communities. Early studies, investigative reports and community statements clearly situate the need for housing interventions within assessments of climate change vulnerability and highlight this as an urgent area for policy review, to ensure housing offers shelter at liveable temperatures (Allam and Evershed 2019; Cornell, Gurran et al. 2020; NT Council of Social Services, Arid Lands Environment Centre et al. 2020).

The history of failed programs for Indigenous housing clearly indicates that one-size-fits-all approaches will not work—but neither will environmental credit systems in construction programs that offer a 'pick or flick' preferencing format be rigorous enough for climate change adaptation. An analysis of 187,000 Nationwide House Energy Rating Scheme certificates from 2016 to 2018 found 81.7 per cent of housing is designed only to meet minimum standards, and 98.5 per cent falls below the economic and environmental optimum (Moore, Berry et al. 2019: 607–8). The ratings covered in Moore, Berry et al.'s study mostly concern the warm temperate zones of Victoria, Western Australia and South Australia, and the cool temperate zones of Tasmania and the Australian Capital Territory, not the areas where most remote and outer regional Indigenous communities are located. It indicates that while current standards are far from what is required, even these are observed minimally. We were not resourced to undertake an analogous study, but such a fine-grained approach to clarifying regulatory options is required.

7.4 What can be done?

Simply, the Australian situation of what is required to provide sustainable housing in regional and remote Indigenous communities remains under-investigated. Research is needed on how affected populations would prefer to adapt to climate change and what infrastructural and social supports will ensure their needs and aspirations are met. An evidence base on how weather events of heat, flooding, cyclones and water inundation impact on housing and the measures that can be taken to address these in both the short and the long term is urgently required. Likewise, there is little Australian research that investigates the impact of climate change on population mobility from and between remote and regional Indigenous communities. As climate change increases the severity and regularity of extreme weather events and erodes the habitability of certain parts of Australia, researchers must clarify the extent of these phenomena. This report could not research the relationship between population movement, climate, and the inhabitability of Indigenous housing. This is an urgent priority for Indigenous decision-making and for related policy. For policy makers, this requires understanding the relations between remote communities and regional urban centres. Housing stock, the housing market and essential services infrastructures require built-in redundancies, or additional capacity, to accommodate climate-driven population mobility.

There are exceptions to these generalised policy gaps. For instance, the South Australian Government's climate adaptation plan provides a comprehensive framework for building, infrastructure, services, and health adaptation pathways moving forward, with accountability and in-built flexibility to respond to further climate-based contingencies as they arise. There is an opportunity to integrate this approach to strategic climate planning across multiple policy areas—particularly housing, planning, and health—and across all tiers of government.

Our modelling demonstrates the central significance of occupancy density to householders' experience of thermal comfort: the most effective immediate measure to reduce the impact of temperature on tenant health and health hardware is to reduce crowding. Effective early interventions in key failure points in health hardware (the amenities required to enact health-conferring practices) will assist in extending the habitability of even highly degraded housing stock to alleviate the health impact of crowding. Proper redress requires increasing the supply of functional housing, through high quality new builds, refurbishments that target health hardware and planned maintenance approaches that reduce the likelihood of major and prolonged disrepair in existing housing stock. A life-cycle costing approach informed by the health-conferring capacity of housing should be incorporated into housing policy and planning, which itself can justify expenditure on robust designs and technologies and sustained maintenance through medium- and long-term gains. Communities and organisations should be informed about and supported to implement effective adaptation strategies, climate-appropriate housing design and wider street cooling designs to help mitigate the impacts of climate change.

In urging research and policy action, we also stress that Indigenous people have a long history of adaptability and endurance. Efforts to create better housing and heat adaptation strategies, with a view to protecting the health of vulnerable groups within the Indigenous population, should augment existing efforts by Indigenous organisations and stakeholders to reassert control over their housing and property management regimes.

7.5 Sustaining regional and remote Indigenous housing

Indigenous peoples are vocal in their commitment to country and have demonstrated their determination to retain their links whenever these have been threatened. This view is supported by the literature which suggests that although there may be changes in the way people use and relate to remote communities, a sizeable component of the Indigenous population will continue to visit and live on country (Mohamed 2015). It remains an imperative to ensure that regional and remote housing and related infrastructure are made sustainable.

Given static funding levels for increasing supply and improving the quality of housing, extending the lifespan of existing housing stock in remote and affiliated regional areas assumes high importance, alongside finding ways to generate meaningful and properly remunerated work at local levels. Our research has indicated the importance of planned maintenance to increasing the sustainability of existing stock and urged that the emphasis be placed on householder health and wellbeing in determining maintenance priorities. We have also pointed to the importance of ensuring housing and health policy considerations are expanded to include climate considerations in all aspects of planning and program funding. Failure to do so risks defaulting to climate migration (not mitigation) as the de facto policy.

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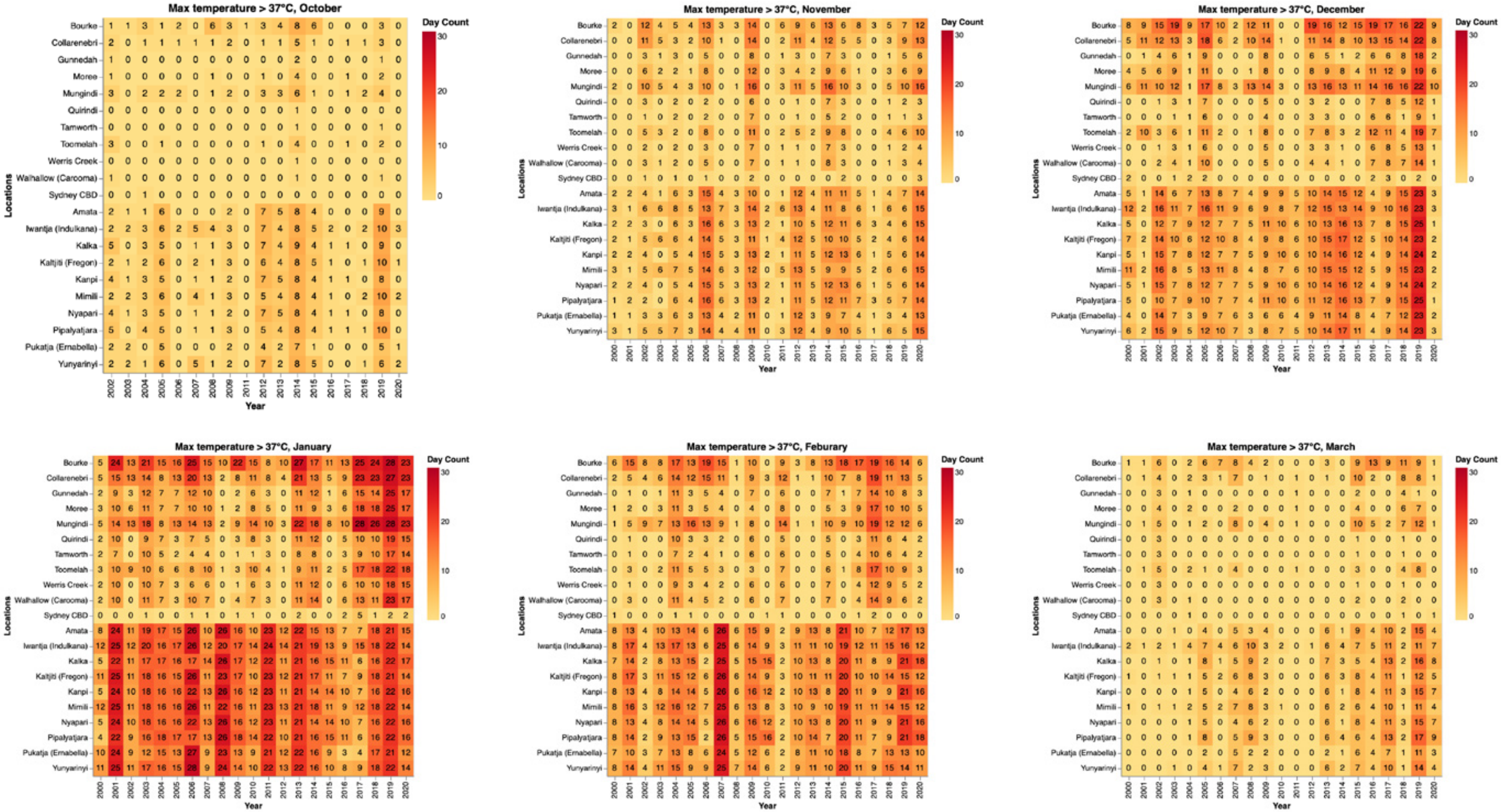
Appendix 1: Climate modelling

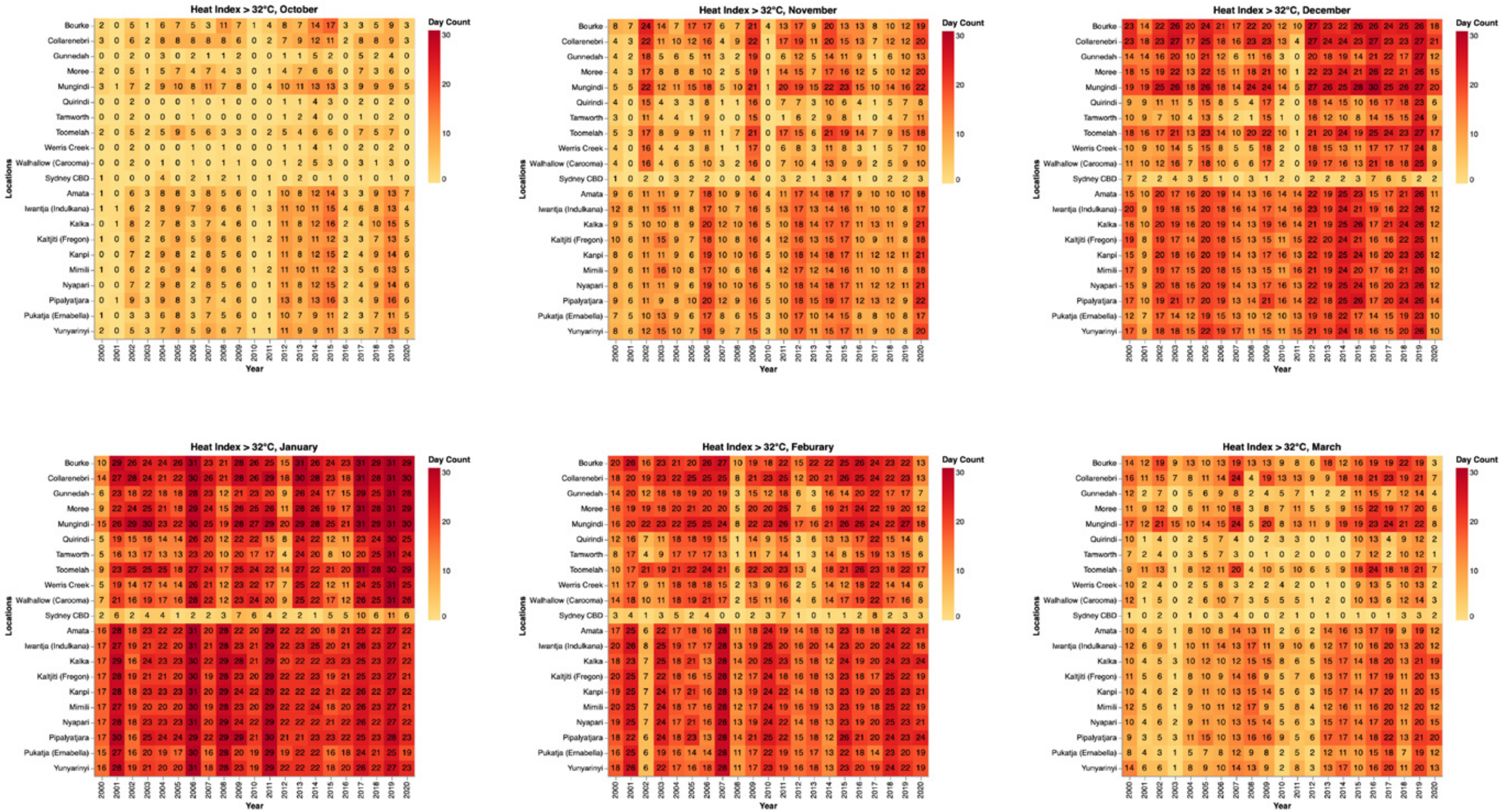
Figure A1: Number of days the maximum temperature exceeded 37°C in October–March, 2000–2020



Note: October shows no result for 2000, 2001 and 2010 because there were no days where the maximum temperature exceeded 37°C.

Source: Author analysis using DES, ABS and NOAA data.

Figure A2: Heat index, days above 32°C, October–March, 2000–2020



Source: Author analysis using DES, ABS and NOAA data.

Appendix 2: Housing in APY Lands communities

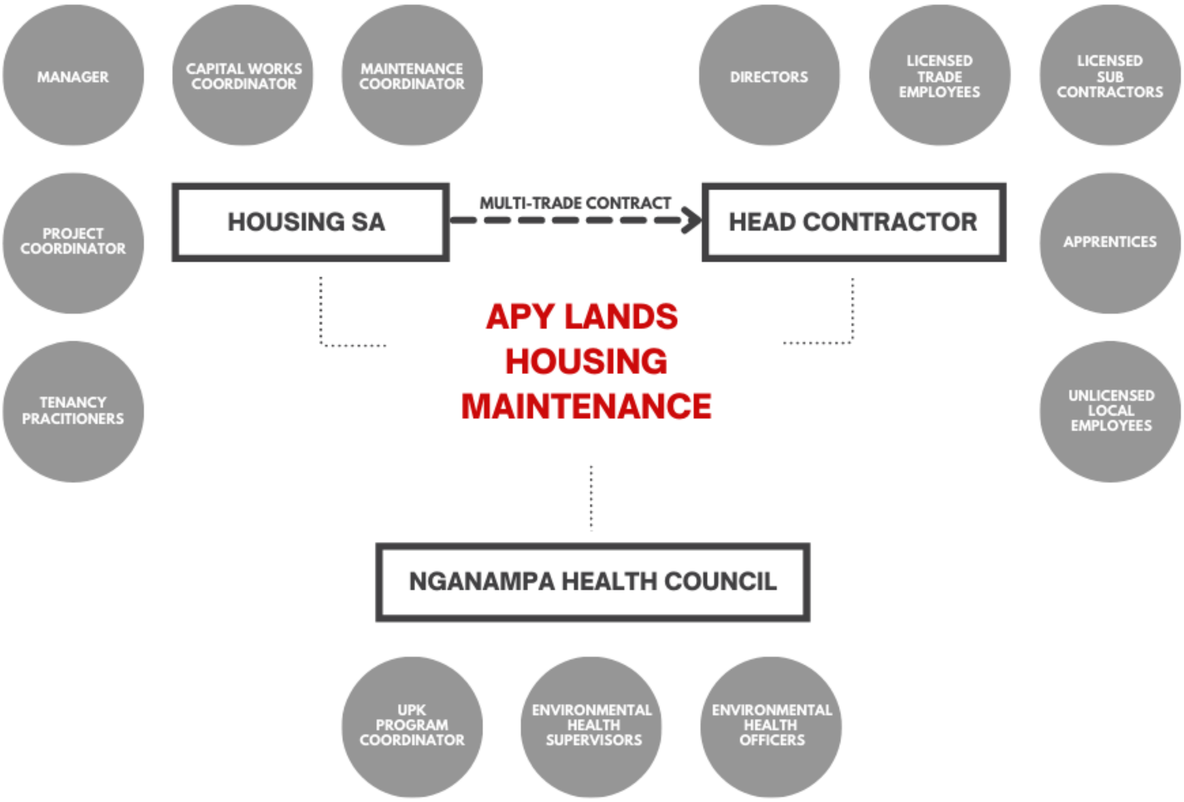
Table A1: Housing in APY Lands communities subject to Housing SA property maintenance

Community	Housing SA abbreviation	Housing SA properties	Population (ABS Census)
Amata	AMA	65	455
Mimili	MIM	53	243
Pukatja (Ernabella)	ERN	76	412
Kaltjiti (Fregon)	KAT	48	220
Iwantja (Indulkana)	IND	56	256
Pipalyatjara	PIP	28	189
Kalka	KLK	15	92
Kanpi	KAN	13	35
Nyapari	NYA	11	72
Yunyarinyi (Kenmore Park)	YUN	6	-

Source: Author analysis based on Housing SA and ABS Census data.

Appendix 3: Property maintenance on the APY Lands

Figure A3: Organisations and their roles in APY Lands housing maintenance



Source: Author analysis based on interviews.

Appendix 4: Nganampa Health Council environmental health work

This list includes many of the tasks undertaken in Nganampa Health Council's environmental health program that do not require licensed workers and which are both preventive and responsive in nature. These include:

- ongoing assessment of the functionality of health hardware
- ongoing reporting of R&M requirements to Housing SA
- slashing
- unblocking of sanitary drainage using plungers
- fitting clothes hooks, towel racks and toilet roll holders in wet areas
- fitting acrylic mirrors in wet areas
- levelling of ground surface to prevent ponding of water (fresh fill)
- removal of hard refuse (including vehicles) from the yard and verge
- cleaning of gutters
- clothesline rewire
- concrete path to clothesline
- house and yard rubbish clean up
- high pressure water clean of external walls, veranda, and wet areas
- fence and gate repair
- cockroach treatment
- firewood collection.

Appendix 5: Modelling house performance by climate

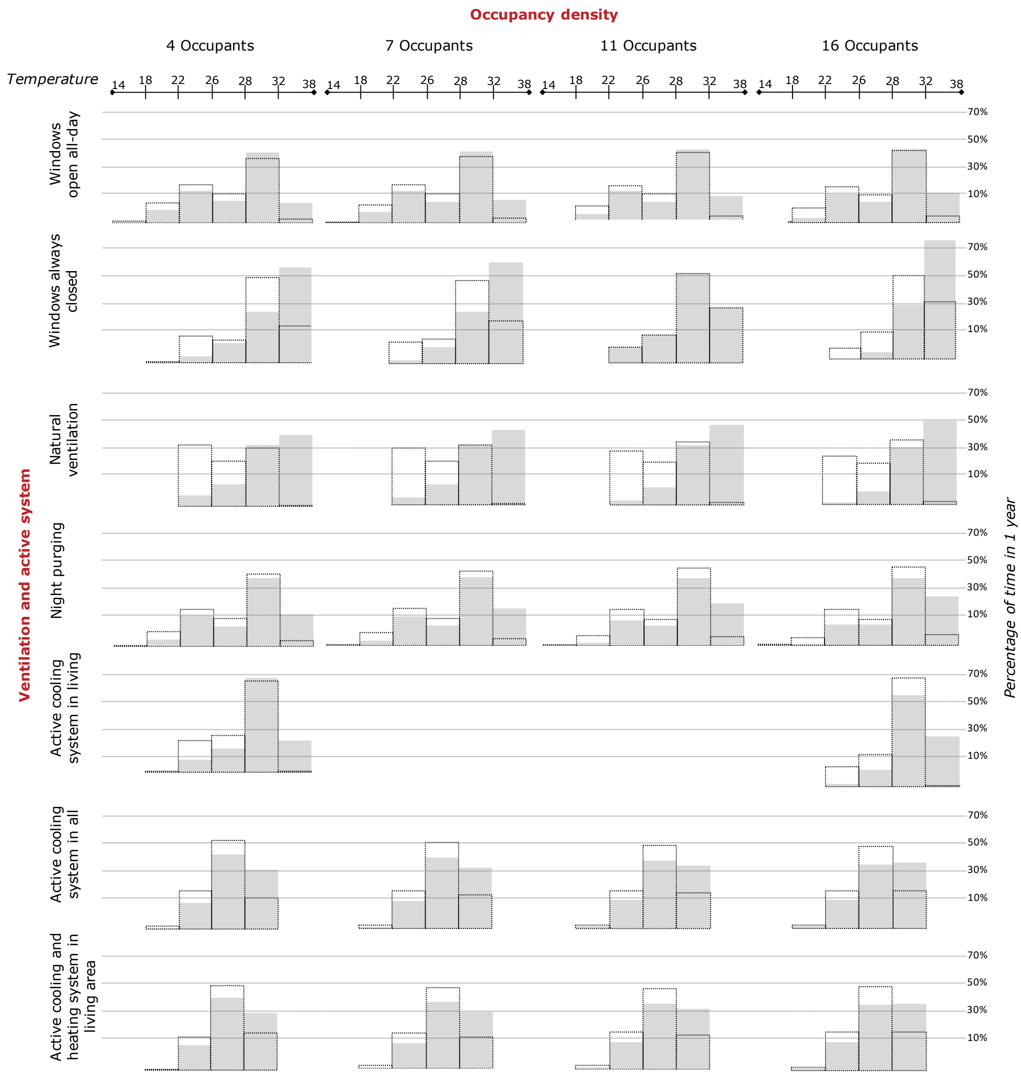
The following figure sequence is drawn from our housing performance simulations.

Figure A4 indicates that improved design has significant potential for temperature mitigation in tropical climates. Improved design coupled with active cooling systems can significantly reduce the frequency and length of indoor overheating, albeit slightly moderated by occupancy levels. In this case, the reduction is relatively greater when the house is not fully air conditioned because the initial temperature, obtained when assessing overheating values for the standard design, is higher for partially air conditioned compared to fully air-conditioned buildings. Improved design and flexible natural ventilation form the best combination for temperature distribution across a year: the percentage of hours where the temperature falls between 32°C and 38°C is reduced by 90 per cent, while it is possible to observe a consistent distribution of hours between 22°C and 28°C, which is usually considered the optimal thresholds for thermal comfort.

Figure A5 displays the same data for the arid climate. Contrary to the tropical climate, the improved design in the arid climate zone is less effective in changing temperature distribution over the year. This confirms findings from our energy analysis: improved scenarios and energy retrofits should be carefully considered, as general design strategies may be ineffective to provide improved thermal indoor environments. It is thus necessary to tailor design strategies to the specific case to ensure benefits from both energy consumption and indoor environment provision perspectives.

Figure A6 shows the results obtained for the hot/mild climate. Like the trends observed in the tropical climate, here the benefits of improved design are more visible when no or partial active cooling is provided. For the same reason, the difference is even higher for scenarios with more occupants. The overall impact of improved design is probably closer to that observed in the arid climate, although some scenarios offer a clearly different temperature distribution compared to the standard design. This difference is not always beneficial. For example, when natural ventilation is used in scenarios with significant crowding (11 or 16 occupants), the percentage of hours above 32°C increases significantly. This is mainly due to the poor resilience offered by the building to a situation where both indoor heat and outdoor temperature increase: the insulated envelope, if not coupled with thermal mass, adequate ventilation rates and optimal shading systems may trap the indoor-generated heat and aggravate the overheating. On the other hand, the good results showed by the night purging strategy offer a potential short-term solution to this issue, if combined with daytime natural ventilation.

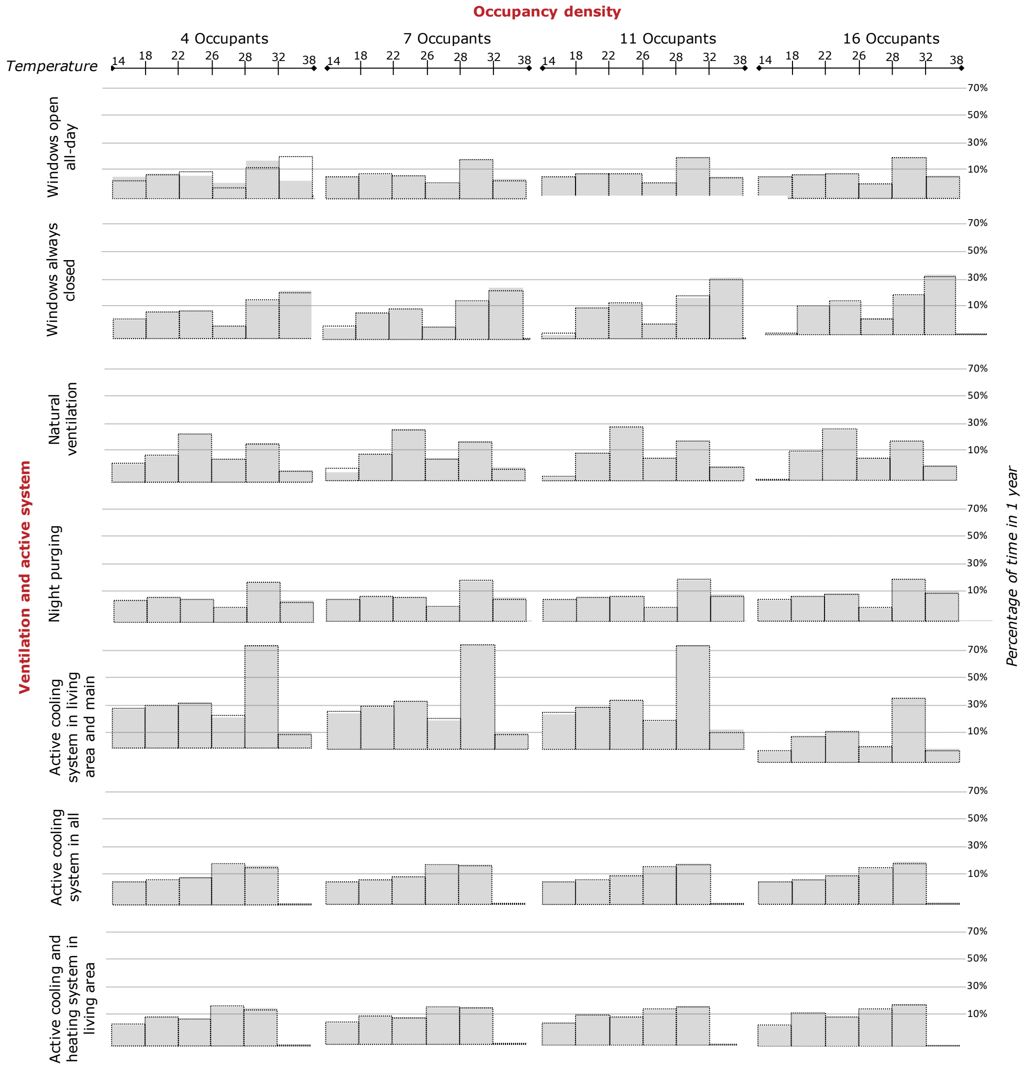
Figure A4: Percentage of time within a specific temperature range for the standard and improved house designs—tropical climate



Note: The grey shade indicates the standard design; the dotted line indicates the improved design.

Source: Author analysis.

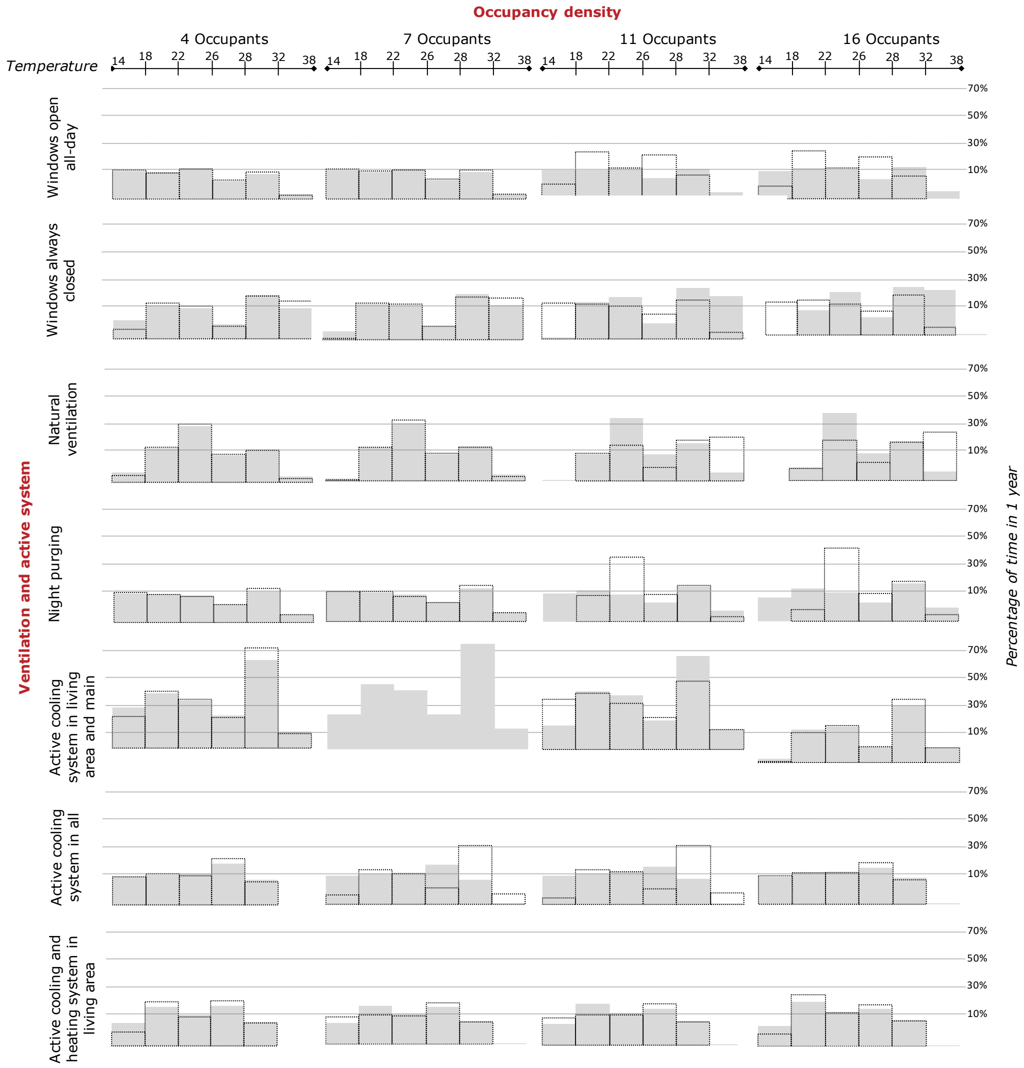
Figure A5: Percentage of time within a specific temperature range for the standard and improved house designs—arid climate



Note: The grey shade indicates the standard design; the dotted line indicates the improved design.

Source: Author analysis.

Figure A6: Percentage of time within a specific temperature range for the standard and improved house designs—hot/mild climate



Note: The grey shade indicates the standard design; the dotted line indicates the improved design.

Source: Author analysis.

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