The influence of culture on energy consumption in Aboriginal housing in arid regions of Australia

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ABSTRACT
This paper examines both the technical and sociocultural aspects of Aboriginal housing in hot dry climates, posing the question: can domestic living patterns and preferences be harnessed to reduce domestic energy consumption? The colonial history of housing Aboriginal people in Australia is rife with precedents that are unsuccessful on multiple levels. Research has highlighted the frequent mismatch between modern housing types and the sociocultural traditions of Aboriginal households. In arid and semi-arid regions, the majority of Aboriginal housing is poorly designed for the climate, yet this aspect of shelter has received limited scholarly attention. The design of bioclimatic houses that support cultural patterns is still an architectural challenge, complicated by diverse historical and economic conditions. Additionally, the increasing cost of energy causes economic stresses for public housing occupants. Current climate change models for Australian arid regions predict increasing temperatures and less predictable rainfall patterns, which provide further challenges for low-energy housing design. Using recent survey data on Aboriginal housing in Northwest Queensland, this paper examines the design implications of using both sociocultural and technical factors to improve living environments and reduce energy consumption. The integrated design of buildings in landscaped yards can both mitigate overheating and support socio-cultural practices that affect overall residential energy consumption. Despite a general consensus on the significance of external living environments in the literature, there is lack of evidence from research that measures culturally derived adaptive strategies to reduce residential energy consumption in Aboriginal housing.

INTRODUCTION
In the arid and semi-arid regions of Australia, a large proportion of the Aboriginal population face problems associated with socio-economic disadvantage, the high cost of domestic electricity supply, high energy demand, and predicted changes to the climate. These problems are compounded by housing and yards that are poorly designed for the current climatic conditions. In the remote regions, within the last century, the transition to sedentary Western style housing has disrupted and transformed social and cultural practices related to Aboriginal domestic living patterns. Since the 1970s, when housing Aboriginal people became a political concern for Australian governments, researchers have documented the dilemmas and difficulties of designing culturally appropriate housing (Heppell 1979; Memmott 2004; Reser 1979; Ross 1987). This area, and Aboriginal housing generally, remains under-researched (Long, Memmott & Selig 2007), partly due to the diversity of Aboriginal groups, demographic change
and significant socio-cultural changes influenced by multiple factors.

Only recently has research attended to questions of thermal performance of Aboriginal housing and energy use, partly as a result to climate change studies (Duel et al. 2006; Martel et al. 2012; Horne et al. 2013). There is a need for further studies that pursue an integrated approach to research that attempts to measure housing quality and performance, and record and analyze behaviours that affect energy use. This aligns in one of the gaps in data identified by the IPCC (2014:67), which recognized the need for “Improved and more comprehensive databases on real, measured building energy use, and capturing behaviour and lifestyles are necessary to develop exemplary practices from niches to standard.”

Figure 1. Map of the upper Georgina River Region showing settlements Dajarra, Urandangi, Camooweal and Wunara examined in the research on climate change.

Using data from different sources, this paper examines the potential for synergies between low-energy housing design and Aboriginal cultural practices. It also identifies behaviours and external factors that challenge sustainable domestic architecture in remote semi-arid and arid regions. This raises the primary question: once identified, can socio-cultural patterns and preferences be used in design strategies for low-energy domestic living environments? This question is particularly pressing given the added challenge of climate change in the arid regions of Australia, where new approaches to housing design are necessary for mitigation strategies in both Aboriginal and mainstream housing (Wang et al. 2011).

METHODS

This paper draws on research that examined climate change Aboriginal people and in the Georgina River Basin, a semi-arid region in northwestern Queensland, extending across the Northern Territory boarder (Figure 1.). In 2011 and 2012, an interdisciplinary study of Aboriginal adaptation to climate change was conducted in four towns in the region (Memmott et al. 2013). Surveys were used to ask 32 questions (quantitative and qualitative) about the informant’s experience and use of the built environment and utilities. This included housing, domestic behaviour patterns and preferences, water supply and electricity, with some questions related to climate. These data and observations of Aboriginal
houses and yards are compared with the literature on Aboriginal housing design, complemented by evidence from architectural practitioners working in the field. Data on the planning, construction and performance of Aboriginal housing in remote areas draws on post-occupancy evaluations, housing assessments and the collective observations and records of an interdisciplinary research centre with four decades of experience in the field. A number of researchers have conducted research in the upper Georgina River Region for over a decade with a particular focus on the built environment and the delivery of services (Long & Memmott 2007; O’Rourke 2011). In the small town of Dajarra, Long (2005) documented socio-cultural practices in an extended ethnographic study of Aboriginal people’s living environments in the settlement.

CLIMATE AND HOUSE CONSTRUCTION

The upper Georgina River Region is characterized by a hot dry climate with mild winters, although toward the north of region the summers are more humid. The rainfall varies across the region, with a general decrease in precipitation moving south away from the influence of the northern summer monsoon: from wet summer/dry winter (mean annual rainfall of 401 mm in Cammoweal) to an arid climate (264 mm/annum in Bouila). Landscapes are predominantly grasslands in the north with deserts in the south. In Cammoweal, the annual mean maximum temperature is 32°C and in mean minimum is 17.6°C.

Climate change models for the region predict temperatures to increase in arid regions with a greater frequency of extreme heat events (CSIRO 2007). A recent review of the Australian climate data (CSIRO 2014) describes a significant warming trend across the arid and semi-arid regions of the continent. This includes increases in the duration, frequency and intensity of heatwaves since 1950. Seven of the ten warmest years on record have occurred since 1998. In 2013, the region experienced its warmest spring on record. Overheating is the main challenge with housing in the region, with mean maximum temperatures averaging around 38°C across the four summer months. Winter temperatures require heating for thermal comfort, and Aboriginal people in the arid regions are sometimes more concerned about cold conditions that hot weather (Thorne et al. 2013).

![Figure 2. Climate profile for Cammoweal. (Source Memmott et al. 2013)](image)

In his analysis of the regional climate and housing design, Szokolay (1990) advised that cross-ventilation cannot be relied on for cooling; insulated thermal mass walls are able to exploit the relatively high diurnal variation with nocturnal ventilation, and benefits from either passive or mechanical evaporative cooling. He also recommended slab-on-ground construction with full shading of walls all-year-round. Deep verandahs are generally recommended for cultural reasons, although fixed shading can
limit the use of thermal mass for heating in the regions with colder winters (Duel et al. 2006:45). Recent studies (Wang et al. 2010, 2011) of heating and cooling energy requirements for residential buildings across different Australian climatic zones predict that, under current models, climate change will significantly increase the cooling loads in arid zone housing.

In our survey of housing in four settlements in the Georgina River region, 72% of the participants (N=68) agreed that their house was too hot in summer and similar numbers agreed that their houses were too cold in winter. Over 70% used air conditioning to ‘get through summer’, although the preference to live in an air-conditioned house was less than 50%. In Dajarra, about one third of the houses had evaporative air conditioners and one third had refrigerated air-conditioners—all were retrofitted to the housing. The state-wide use of residential refrigerated and evaporative air conditioners has increased significantly in the past 20 years, with only one third of Queensland households not using air conditioners in 2009 (ABS 2010).

ENERGY PRICE AND POVERTY

Electrical energy is the primary source of domestic energy in the study region with all but a few houses connected to a distribution network. Between 2003 and 2013 in Australia, household electricity costs increased on average by 72% in real terms (Swobada 2014). The increase in the study region was 73%, with additional price increases of 20.4% in 2013-2014 and 13.6% announced in May 2014 (AER 2013:131). This increasing cost in electricity supply has placed considerable financial burden on Aboriginal households in the remote regions where low rates of employment limit disposable income. In a 2008 survey, expenditure on electricity in Dajarra ranged from AUS $2,400 to $6,000 per annum for Aboriginal households of varying size in one settlement (O’Rourke 2011). For many Aboriginal people occupying remote public housing, price rises in electricity increase vulnerability to climatic extremes, and particularly during heatwaves (PWC 2012).

In remote settlements, Aboriginal people have increased dependency on electrical energy although surveys of housing show that refrigerators, air-conditioners and electric heaters are at the lower end of energy efficiency. In our survey, 55% worried about paying bills and the same number of participants had changed the way they used household appliances to reduce electricity usage. A significant number (37%) had changed the way they lived in their house and yard due to extreme weather events.

HOUSING BACKGROUND

The change from mobile hunter-gather patterns of dwelling to more sedentary living conditions in remote regions of Australia varied with the history and circumstances of the colonial frontier. Aboriginal dwelling practices follow three historical phases that were often overlapping and uneven across the last 150 years: 1. In traditional or pre-colonial campsites a repertoire of shelters largely related to seasons were structured around spatial practices: windbreak and shade structures were used for most of year, with thatched domical dwellings used during cold and wet weather; 2. Adaptation of building traditions to more sedentary settlements often on the margins of colonial towns, pastoral properties, and government or missionary reserves; and, 3. The first substantive investment in state-supplied Aboriginal housing began in the late 1960s.

Although the involvement of architects in housing was initially promising in the 1970s (Heppell & Wigley 1981), direct participation in design has been marginal. In remote settlements, the housing stock varies in age and type, ranging from transportable homes, prefabricated housing, to a variety of mainstream housing, often standardized designs. A substantial proportion of Aboriginal housing in remote areas is of poor quality and requires either significant upgrade or replacement (Hall & Berry 2006; Pholeros et al. 1993). Remoteness—defined by distance to a service centre—is a significant factor in the design, delivery and maintenance of housing (Hall & Berry 2006:100). Transportation to remote or settlements limits construction choices and the cost of both labour and building materials escalates with distance from major coastal cities. A correlation between remoteness and continuities of pre-colonial Aboriginal socio-cultural practices adds to complexity of housing design in remote settlements.
Memmott (2003) identified three approaches to Aboriginal housing design that vary in their primary objectives: culturally appropriate factors, design for environmental health, and building procurement and delivery methods. These overlap but design for environmental health has had the largest influence on design standards (FACSIA 2007). There are notable exceptions of housing that provides architecture responsive to socio-cultural practices in remote regions of Australia (Dillon & Savage 2003; Memmott 2001, 2004). But within the literature, low-energy housing, for either socio-economic reasons or concerns about climate change, has received less emphasis than housing for cultural or health factors. There are few empirical studies of the thermal performance or energy use in Aboriginal housing: Duel et al. (2006) modeled thermal comfort of standardized designs in desert communities and Martel and Horne (2013) examined house designs in hot/humid area of northern Australia.

Settlement morphology and conventional housing in arid regions of Australia are not derived from historical or vernacular building traditions suited to hot/dry climates. Residential building types are largely detached suburban housing (variations on the bungalow), which continue to establish patterns and expectations for mainstream residential buildings. Courtyard type housing, for example, has few precedents in arid Australia for either Aboriginal or mainstream housing. Two examples by architects in the 1970s failed for a number of cultural and functional reasons (Heppell 1979; Heppell & Wigley 1981:157). Remote Aboriginal clients are wary of experimental housing design and preferences for conservative, mainstream architecture can conflict with preferred living patterns (Memmott 2003).

Socio-Cultural Factors and Implications for Housing Energy Use.

Research and evaluation of both mainstream and self-constructed Aboriginal housing has identified a range of behaviours and social practices that are relatively consistent across remote settlements in semi-arid regions (Memmott 2003). We need to be cautious about accepting generalizations for diverse groups and changing demographic profiles, but the following factors either directly or indirectly influence residential energy use.

Mobility and the use of houses

High intraregional mobility is a consistent and common practice of people Aboriginal in remote and regional areas across the country and this factor directly affects the occupation of housing with implications for domestic energy use. Research on mobility in three towns in the study region in 2006 found that about one third of Aboriginal households contained visitors, a proportion consistent with other studies (Long & Memmott 2007:3). Cultural and social factors (the maintenance of kinship relationships) and service needs are main reasons for the high mobility.

Across Australia, Aboriginal household numbers are significantly higher than the mainstream household. High household numbers are related to general housing shortage in remote areas, population growth, socioeconomic disadvantage and cultural preferences (Memmott et al. 2012). High mobility also causes household numbers to fluctuate. There is a growing literature on overcrowding Aboriginal households yet there is little direct evidence of the relationship between numbers and energy use. High and fluctuating household numbers present challenges to designers and need to be considered in the assumptions required for thermal modeling of Aboriginal housing.

Unconventional use of housing by Aboriginal people is common in remote and urban settlements. Living rooms are used at night for sleeping (Long2005:223) and bedrooms can be occupied by relatively large numbers (2013). Social and technological change has also increased energy intensive activities such as television and computers, particularly for younger generations, yet the effects on housing use is underexplored. Surveillance of the community and environment was a determinant in the architecture and spatial arrangement of traditional camps yet it is common for windows to be closed and heavily screened. This may relate to privacy but in remote communities the practice may also relate to a fear of the supernatural and sorcery (Dillon & Savage 2003). In areas where this practice is prevalent, the use of windows for either diurnal or nocturnal ventilation needs to be reconsidered—occlusion of windows renders them ineffective for either daylighting or ventilation (per. comm. Finn Pederson 2014).
External living

The literature on Aboriginal housing indicates a strong preference living outdoors during the day, and sleeping outside the house has shown to be been common in remote settlements (Long 2005; Memmott 2003; Musharbash 2008; Pholeros et al. 1993). Both socio-cultural practices and thermal comfort influence these behaviours. In summer, shaded areas outside the house, mostly from trees but also purpose built shade structures, are used in preference to the house interior (Dillon & Savage 2003). External living environments, which include verandahs, also enable social and environmental surveillance, including the monitoring of weather and seasonal indices.

In remote areas, adapted forms of pre-colonial shelter types continue to be constructed in yards to support socio-cultural practices. Variations on the windbreak are used extensively in yards and often associated with fires for warmth or cooking purposes: firewood piles are common in yards in the study area with the elderly often supplied by family. In the study region, and arid-zone settlements generally, traditional thatching materials are used on shade structures, but certified uses of such materials are limited.

Aboriginal residents use conventional (mainstream) internal kitchens but a range of traditional cooking activities occur outside the house in open fires and wood-fueled stoves (Long 2005). Long has traced the continuity of these traditions in the study area, recording the additions and alterations to rental housing to make external cooking areas. Thermal comfort was an additional reason for external cooking. In survey questions about adapting to increasing energy costs (Memmot et al. 2013), almost of quarter of respondents preferred to cook outside on wood fires.

Design guides (FACSIA 2007) and good architectural practice (Dillon & Savage 2003) recognize the use of external living environments but exemplars of yard design are rare and not recorded in the study region. Our research shows that gardening practices vary and landscaping around housing for shade depends on the householder. In Dajarra, comparisons of aerial photographs show an increase in vegetation cover over the last three decades. Garden irrigation is also used for evaporative cooling effects in summer but garden maintenance results in very high residential water use in settlements with unreliable water supplies (O’Rourke 20110).

With limited empirical data, it is difficult to gauge whether outdoor living activities are diminishing as people adapt more to houses and become accustomed to air-conditioning. In survey questions on adaptation of living environments to increasing hot weather, the most common answer was to use trees and landscaping. A recent post occupancy evaluation of Aboriginal housing in Alice Springs (CAT 2013), suggested that improvements to yards were more desirable for tenants than alterations to the house. Although the potential of landscape elements to improve thermal performance of residential buildings has long been recognized in arid region design in Australia (Aitchison 1962), there is a wide
gap in studies of the actual and potential contribution of microclimates to low-energy housing, particularly in the reduction of cooling loads. Selection, testing and evaluation of xerophytic plants are also necessary given climate change and problems with water supply in arid regions.

With the high cost of construction, landscaping of yards is rarely delivered in remote public housing projects. Cost, household mobility and resources limit ability of the tenants to improve landscapes around remote public housing. Despite these impediments, a range of gardening practices can be identified in the study region. Design improvements to residential landscapes benefit from the participation of household, in both maintenance and involvement in the design process.

CONCLUSION

Studies in the Georgina River Region found that vulnerability to climate change was related to poor quality housing and increasing energy prices. Low-energy housing is required for socio-economic reasons and the viability of remote Aboriginal settlements, in addition to low carbon imperatives. In the semi-arid and arid regions of Australia, modeling software demonstrates that both existing and new residential buildings will need substantial changes to building envelopes to achieve existing levels of thermal comfort without large increases in energy intensity (Wang et al. 2011). Harvey’s review of low-energy buildings (2013:303) suggests that high performance housing requires “significant additional investment costs, with simple payback times of 20–30 years or more.” His survey shows that high levels of skill, from integrated design processes to construction, can produce economical low-energy buildings.

Although integrated design and technologies can inform approaches to Aboriginal housing, the literature emphasizes knowledge of domestic social and cultural behaviours as a prerequisite for cross-cultural design. Limited but relatively consistent evidence presented in this paper suggests that certain socio-cultural practices provide a level of passive thermal comfort. This is particularly the case with the use of external living environments. These practices present opportunities for synergies between behaviour and passive or low-energy design. Landscape design for residential microclimates in the arid region supports current cultural practices and has potential to reduce the energy intensity of housing. In contrast, mainstream housing, reliant on air-conditioning, can work to undermine domestic cultural practices that are inherently sustainable.

It is a challenge for researchers to devise methods to record behaviours and preferred practices that influence the use of housing and yards over different seasons in remote areas. This does require an ethnographic strand to the research. In different settings, social and cultural change affects the currency and relevance of existing data. Data is also deficient in the measurement of energy use and the thermal performance of existing housing and yards as well as data on new approaches to design of both the internal and external living environments in arid regions.

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REFERENCES


