**26TH ANNUAL PACIFIC RIM REAL ESTATE SOCIETY CONFERENCE**

**CANBERRA, AUSTRALIA 19TH – 22ND JANUARY 2020**

# AGE PENSIONERS' HOMES: CURRENT STATE AND ADAPTATION FOR CLIMATE CHANGE

**Caroline Valente, Sara Wilkinson and Alan Morris**

**University of Technology Sydney**

## ABSTRACT

*Older Australians prefer to age in their family home. Age Pensioners mostly live in free-standing houses built prior to the introduction of national housing minimum energy efficiency requirements in 2003. Living in poor indoor environmental conditions increases the possibility of physical and mental health problems, especially for this age group, who are also particularly vulnerable to the effects of global warming. Higher temperatures and an increase in the intensity of extreme weather events have serious implications: increased energy consumption and a risk of extreme cold in winter or over-heating in summer. Adapting the existing housing stock to accommodate these issues is crucial.*

*This paper addresses the following questions; what is the current state of Age Pensioners' homes and how can they be adapted to counter the impacts of climate change. A mixed-methods approach to secondary data sources is employed to investigate these questions.*

**Keywords:** ageing population, adaptation, climate change, energy efficiency, pensioners.

## INTRODUCTION

'Ageing in place', a preference among older people to live independently in their own homes for as long as possible, has emerged as a key strategy to reduce the government's aged care costs (Demirbilek and Demirkan, 2004; Judd *et al.*, 2010, 2014). However, it means people will age in ageing homes, that niether reflect current standards in building codes for energy efficiency, but also suffer from physical decline unless well-maintained. Poor maintenance and the resultant decline further impacts on the energy efficiency of the home. This is significant, as poor energy efficient homes potentially affect the health of older people (Dear and McMichael, 2011; Howden-Chapman *et al.*, 2012; Anagnostopoulos *et al.*, 2016).

Living in poor indoor environmental conditions is a risk to health and can increase cardiovascular and respiratory problems, especially for older people (Howden-Chapman, Signal and Crane, 1999; Wright, 2004; Chard and Walker, 2016). Physical fragility increases with advancing age, as does reduced mobility, incidence of falls and illnesses, which then reduces people's ability to keep their bodies cool and maintain their health during extreme heat events (Steffen, Hughes and Perkins, 2014).

Climate change has accentuated the importance of adequate housing (Berry and Marker, 2015; Rajagopalan, Andamon and Moore, 2018). Climate change prediction models are unanimous; Australia will experience moderate to strong heat stress during summer months far more frequently (Lewis, King and Mitchell, 2017; ClimateCHIP, 2019). Increased temperatures will. in all probability, exacerbate health concerns related to ageing populations, and failure to address this challenge could mean poorer mental and physical health, and greater pressure on government budgets (City of Sydney, 2016). Heatwaves have been shown to increase patient presentations, hospitalisations, and emergency call-outs dramatically (Climate Council, 2016; Campbell *et al.*, 2018; Patel *et al.*, 2019). Studies in several countries, including Australia, Russia, Japan and France, have highlighted the increase in mortality and morbidity, especially among the older generation, during heatwaves (Ogg, 2005; Robine *et al.*, 2008; ABC News, 2010; The Lancet, 2018).

Consequently, as Australia's population ages, the proportion and absolute number of people at risk from heatwaves will continue to rise, increasing the pressure on emergency and health services (City of Sydney, 2016; Cheng *et al.*, 2018; Patel *et al.*, 2019). According to the Australian Bureau of Statistics (ABS) (2018), by 2066, people aged 65 and over will constitute more than 20% of the population. At present, 15.7% of Australia's population is aged 65 and over (ABS, 2018).

Accepting the need for longer term thinking of housing adaptation is imperative (Schneider and Till, 2005). When thinking of energy efficiency adaptation at the present time, it is essential to address the climate change impacts in the coming decades and how the energy use patterns may change, particularly in terms of heating and cooling requirements. In the near future, poor energy efficient houses will experience more absolute changes in energy requirements than highly rated dwellings (Wang, Chen and Ren, 2010). Existing buildings, therefore, represent the greatest opportunity for efficiency improvements, particularly if focusing on energy conservation and demand reduction (Xing, Hewitt and Griffiths, 2011). Low energy homes, besides improving comfort and living affordability, can also deliver least-cost emissions reductions and reduce the stress on the electricity network (Dear and McMichael, 2011; Marmot Review Team, 2011; Fletcher and Lin, 2013).

The impact on the health of older Australians of homes that are not energy efficient is an under-researched area. It is important to understand the intersections between home energy efficiency, energy consumption and expenditure and their impacts on the health of older Australians (Cooper *et al.*, 2016). If nothing is done to rectify the inefficient housing stock, the increasing impacts of climate change and aged people health issues will contribute to more hospital admissions and a greater mortality rate (City of Sydney, 2018). Developing adaptable actions for the existing building stock to accommodate these issues can play a critical role as additions to the total building stock is low; in 2008 Kelly (2008) estimated 87% of the buildings we will have in 2050, are already built (RAENG 2010).

The paper addresses the following questions:

1) *What is the current state of Age Pensioners' homes in Australia?*

2) *How can they be adapted to counter the impacts of climate change?*

## LITERATURE REVIEW

### Minimum residential energy efficiency requirements in Australia

In the Australian context, minimum energy efficiency requirements for new housing were first introduced into the Building Code of Australia (BCA) in 2003 Housing Provisions (ABCB, 2013). Australia has been a very slow adopter of energy efficiency requirements, and the current minimum standards still fail to reflect international benchmarking regulatory practices (Horne *et al.*, 2005; Berry and Marker, 2015). At present many OECD (Organisation for Economic Cooperation and Development) members are proposing to increase standards towards a net zero energy or net zero carbon performance level (Kapsalaki and Leal, 2011). Australia, however, has not changed its minimum building energy efficiency requirements since 2010, currently requiring new developments and major renovations to meet a minimum 6-star rating of NatHERS (Nationwide House Energy Rating Scheme) standard. Table 1 illustrates the necessary artificial thermal energy load (per star rating) for some locations in Australia and the associated electricity costs.

Additionally, 64% of all occupied dwellings in Australia are more than 20 years old, and just under half are more than 30 years old, which means they were built before any minimum energy efficiency requirements were introduced (ABS, 2012). Studies have indicated that much of the older stock has a star rating of 2 or less (Noble and Martinelli, 2009; Sustainability Victoria, 2014; Willand, Maller and Ridley, 2019), which means those older houses in Sydney, for example, require between 148 and 286 $MJ/m^2$.annum[i] (Table 1).

**Table 1 – Artificial Energy Loads and Costs per Star Rating and Location.**

| Location | Climate Zone | 0.5 ⭐ | | | 2 ⭐ | | | 6 ⭐ | | | 10 ⭐ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *MJ/m2. annum* | *KWh/m2. annum* | *Eletricity costs in AU$ per m2.annum* | *MJ/m2. annum* | *KWh/m2. annum* | *Eletricity costs in AU$ per m2.annum* | *MJ/m2. annum* | *KWh/m2. annum* | *Eletricity costs in AU$ per m2.annum* | *MJ/m2. annum* | *KWh/m2. annum* | *Eletricity costs in AU$ per m2.annum* |
| Adelaide | 16 | 584 | 162.22 | $ 61.03 | 325 | 90.28 | $ 33.96 | 96 | 26.67 | $ 10.03 | 3 | 0.83 | $ 0.31 |
| Brisbane | 10 | 245 | 68.06 | $ 16.02 | 139 | 38.61 | $ 9.09 | 43 | 11.94 | $ 2.81 | 10 | 2.78 | $ 0.65 |
| Canberra | 24 | 957 | 265.83 | $ 73.26 | 547 | 151.94 | $ 41.88 | 165 | 45.83 | $ 12.63 | 2 | 0.56 | $ 0.15 |
| Melbourne | 21 | 676 | 187.78 | $ 43.70 | 384 | 106.67 | $ 24.82 | 114 | 31.67 | $ 7.37 | 2 | 0.56 | $ 0.13 |
| Sydney | 17 | 286 | 79.44 | $ 21.89 | 148 | 41.11 | $ 11.33 | 39 | 10.83 | $ 2.99 | 6 | 1.67 | $ 0.46 |

**Source: Adapted from (NaTHERS National Administrator, 2012; Canstar Blue, 2019).**

Current renovation rates are still slow and comprise only 7.6% of the total value of building works done in the Australian residential sector (ABS, 2019). Therefore, it is crucial to focus on the existing building stock and promote renovation and adaptation, as the old, low energy efficient and deteriorating building stock will certainly require greater energy consumption and expenditure in coming decades of higher temperatures.

## Energy consumption patterns in the Australian residential sector

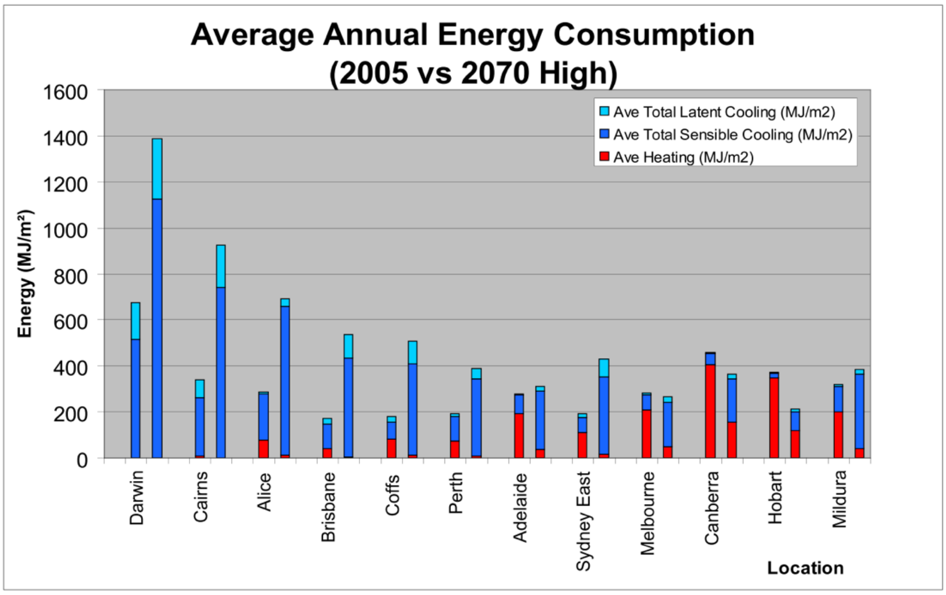
Understanding energy use patterns in residential buildings is fundamental for establishing energy efficiency programs and climate change policies (Allouhi *et al.*, 2015). Household energy use is highly dependent on building characteristics, climate, appliances and system characteristics, tenure type, and occupant behaviour, which can be related to social and economic conditions (Ren, Paevere and McNamara, 2012). However, in the typical Australian home, energy consumption according to end-use source is approximately as follows (DEWHA, 2008; Allouhi *et al.*, 2015; DIS, 2015):

- Heating and cooling (40% - 42%)
- Water heating (23% - 24%)
- Other appliances, such as laundry or entertainment appliances (14% - 16%)
- Fridges and freezers (8%)
- Lighting (6% - 7%)
- Cooking (4% - 5%)
- Standby power (3%)

When thinking of energy efficiency improvements at the present time, it is essential to address the climate change impacts in the coming decades and how the energy use patterns may change. Climate projections for Australia point to higher temperatures, rising sea levels and an increase in the frequency and intensity of extreme events (IPCC, 2012; Saman *et al.*, 2013; Horne, 2018). This will have significant implications for Australian buildings (BRANZ, 2007) including increased energy consumption for cooling, risk of over-heating, and increased risk of damage from more intense tropical cyclones, storms and stronger winds.

As seen in the following graph (Figure 1), the energy modelling conducted by BRANZ (2007) shows an increase in cooling load for all Australian major cities, whilst a decrease in heating load for locations in cooler climate zones.

**Figure 1 - Simulated average energy consumption for cooling and heating in several Australian cities.**




**Source: (BRANZ, 2007)**

## Residential energy efficiency improvements

As Howden-Chapman et al. (2007, p. 1) concluded, "the efficiency of domestic energy is linked with health because money spent on energy cannot be spent on other necessities …". Therefore, homes that are more energy efficient have the potential to reduce householders' vulnerability to the climate change effects, while also improving overall quality of life (Johnson, Sullivan and Totty, 2013).

Based on the work of Willand et al. (2012) and Xing, Hewitt and Griffiths (2011), energy efficiency improvements can be addressed through the following aspects (in order or prioritisation):

1. Energy efficient building envelope (i.e. window exchange, wall and ceiling insulation, draught proofing, etc.);
2. Installation of energy efficient operational appliances (i.e. heating and cooling systems, in particular);

3. Installation of on-site low carbon and renewable energy systems (solar PV cells and solar hot water system) with smart grid connections and control.

Cooper et al. (2016) summarised (Table 2) the most common energy efficiency improvements, from retrofits in the building envelope to minor items, such as installation of LED light bulbs.

Having good insulation properties is essential to allow the building to retain the heat that is generated within the house by activities (either by cooking, appliances, people's body heat, etc.) and also via direct solar gain (Xing, Hewitt and Griffiths, 2011). Insulation only retrofits are associated with increases in temperatures in living and bedroom spaces during winter (from 0.5ºC to 2ºC), decreased relative humidity (-2.3%) and up to 19% reduction in energy consumption (Howden-Chapman *et al.*, 2007; Cooper *et al.*, 2016; Willand, Maller and Ridley, 2019).

**Table 2 - Summary of common residential energy efficiency improvements.**

| CATEGORY | SPECIFIC RETROFIT |
|---|---|
| *THERMAL ENVELOPE* | Wall insulation (external, internal or cavity)<br>Ceiling/Loft insulation<br>Sub-floor insulation<br>Draught sealing<br>Sealing large gaps/holes |
| *WINDOW TREATMENTS* | Internal cellular blinds<br>External shading<br>Curtains<br>Window film<br>Double glazing<br>Insect/security screens |
| *HARD-WIRED HEATING AND COOLING SYSTEMS* | Solar hot water<br>Heat pump hot water systems<br>Reverse cycle air conditioning |
| *ELECTRICAL* | In-home energy display<br>Ceiling fans<br>Light replacements<br>AC standby power isolation switch |
| *APPLIANCES* | Refrigerators and freezers<br>Heat pump clothes dryers<br>Pedestal fans |
| *MINOR ITEMS* | Hot water pipe lagging<br>Low flow hot water fittings<br>Replacement LED light blubs<br>Ceiling space downlight covers |
| *OTHER* | Solar PV systems |

**Source: Adapted from (Cooper *et al.*, 2016)**

## Impacts of residential energy efficiency improvements

Household energy efficiency improvement programs have conventionally been assessed by verifying the reduction in energy usage, and consequently, a reduction in energy costs and greenhouse gas emissions (IEA, 2014; Willand, Ridley and Maller, 2015; Acil Allen Consulting, 2017). However, recent studies indicate a broader range of impacts related to increased home comfort and improved health and wellbeing, are potentially of greater value than the energy savings delivered by the interventions (Thomson *et al.*, 2013; Maidment *et al.*, 2014; Maidment, 2016). Residential energy efficiency programs can also lead to tangible benefits along the entire energy supply chain, including: improved system reliability, enhanced capacity adequacy and better ability to manage peak demand (Acil Allen Consulting, 2017).

Although most programs focus on improving comfort during winter, Willand, Ridley and Maller (2015) argue that recent residential energy efficiency improvements should also consider summer thermal comfort and the cost of cooling to cope with the impacts of climate change.

# METHODOLOGY

This is a mixed methods desk top study using secondary sources. A quantitative analysis was undertaken of three existing and recent databases: the Australian Bureau of Statistics (ABS) Census Data (2016), the ABS

Household Energy Consumption Survey (ABS 2012) and the most recent Melbourne Institute's Household, Income and Labour Dynamics in Australia (HILDA) survey (Waves1 to 17). The data analysis is focused on the group of older Australians (65 years and over) dependent on the Age Pension.

The databases were examined to identify the current state of Age Pensioners' homes and some other demographic and socioeconomic characteristics of this group. In respect of the housing characteristics, the analysis aims to identify tenure type, age, size and type of dwelling, housing quality parameters, type of energy used and existing energy efficiency measures. The quantitative analysis of the household surveys and census data involved mainly: selection and categorisation of appropriate data, and analysis of descriptive statistics already provided by the organisations, in order to link the findings to the research questions (Denscombe, 2010).

The second phase of this research involved a descriptive case study approach (Runeson and Höst, 2009; Robson and McCartan, 2016) to expose analytically the situation of adequate energy efficient retrofits to selected housing typologies. A literature search and document analysis of common energy efficient interventions were combined into a preliminary cost-benefit analysis, highlighting which possible energy efficiency adaptations to the typical housing circumstances of Age Pensioners can provide the best results in terms of countering climate change impacts, while also recognising the limited budgets of those in low-incomes.

A limitation of the case study technique is that the researcher does not sample widely enough, though Yin (2008) stated that case study is concerned with analytical and, not, statistical generalisation. Care was taken to ensure conclusions drawn are noted as analytically general rather than statistically representative.

# FINDINGS

## Older Australians Economic Profile and Energy Expenditure

According to Wilkins et al. (2019), over 90% of men and women receiving the Age Pension are not in the labour force, and home ownership usually provides security and independence in retirement (see Morris, 2016). Whereas the reliance on welfare has decreased over time, by 2017, 28% of those aged 65 years and over still relied on the Age Pension for more than 90% of their income (Wilkins *et al.*, 2019). The reliance on the government support can result, in many cases, in problems of income poverty. This is especially so in the case of older Australians who are dependent on the private rental sector for their accommodation (Morris, 2016).

According to the last summary report of the HILDA survey (Wilkins *et al.*, 2019), poverty rates are higher among elderly people, especially single elderly women, than any other family type. The mean gross household weekly income for Age Pensioners is $605.00, while for all households this is $1,872.00 (ABS, 2012). For the mean equivalised disposable household income, this is $458.00 for age pensioners and $929.00 for all households. Their low income would almost certainly shape the way they consume energy.

Additionally, the same report states that the income poverty situation tends to be more persistent over the long term among older people. Thus, the lack of disposable income for home improvements, particularly related to energy efficiency, needs to be addressed by other means, including subsidised and government programs.

Energy expenditure as proportion of gross income reached an average of 4.6% for the Age Pensioners group, although it represented up to 6% (lone persons household completely dependent of Age Pension). It was only worse for those on unemployment/student payments (4.7%) or family support payments (4.9%). For all households the proportion decreases to about 2% (ABS 2012).

In fact, 12% of Age Pensioners experienced at least one energy related financial stress indicator. This survey was conducted around 2012. Since then, energy prices have almost tripled in most Australian states (AEMO, 2019), which means the situation will in all likelihood be far worse now.

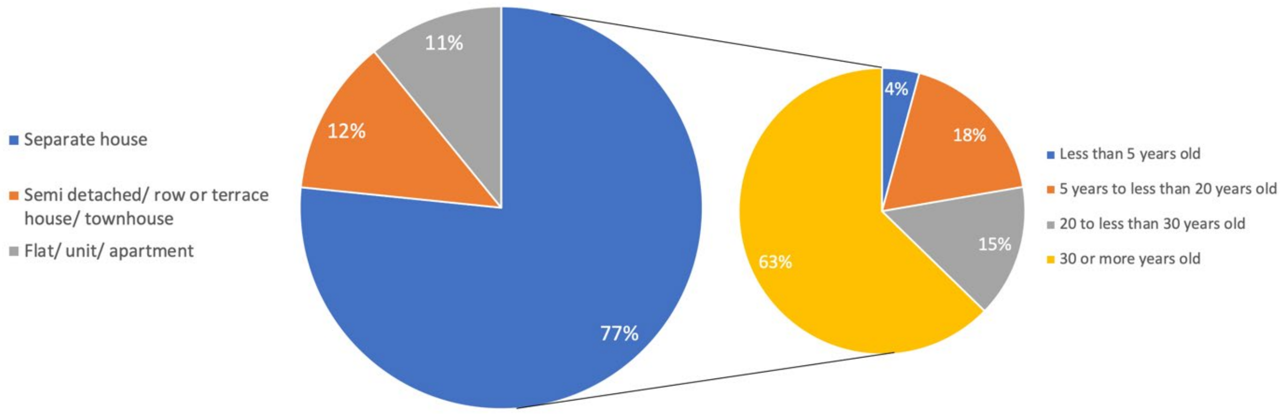
## The current state of Age Pensioners' homes

In Australia, dwelling structures are segmented mainly in three categories: detached houses; semi-detached/row or terrace house/townhouse; and flat/unit/apartment (ABS, 2016a). It is known that detached houses, because they are usually bigger and have a greater area of exposure with the external environment, require more energy than the other types. Despite the trend of smaller homes with the increase in apartments construction, Australia still has the second biggest homes of any country (behind the United States): the average detached house in Australia was 230.8 $m^2$ in 2017-18 (The Sydney Morning Herald, 2018).

According to the ABS (2012), detached houses require 68% more energy than flat units and 44.8% more energy than semi-detached houses. If considering the electricity consumption only, the average household in a detached house spends $31.00 weekly, which is 41% more than what households in semi-detached houses and apartments spend in average (ABS, 2016b).

According to the Household Energy Consumption Survey (HECS 2012), for those whose main source of income is the government Age Pension, the separate house represents about 77% of all housing types (Figure 2). Although this is about the average for all Australian households (78%), Age Pensioners tend to live in older houses. About 63% of these separate houses are older than 30 years and 15% are between 20 and 30 years (ABS, 2012). It means that about 78% of these houses are more than 20 years old (built prior to 1992).

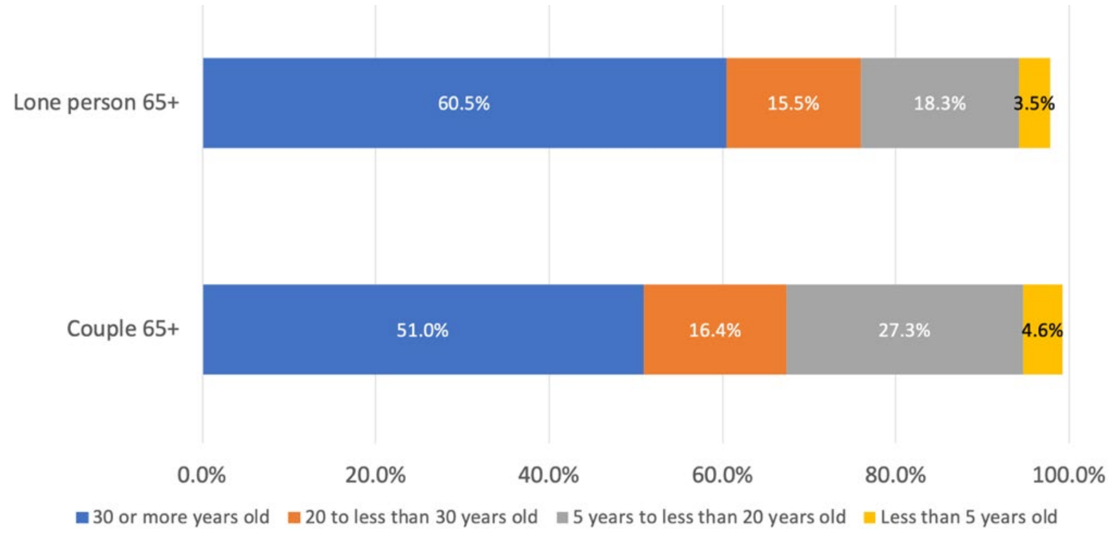
**Figure 2 - Dwelling structure for older Australians whose main source of income is the Age Pension (ABS, 2012)**




If subdividing older people households by couples only and lone persons (Figure 2), 51% of the couples live in homes older than 30 years old (ABS, 2016b) and 94.8% of these are detached houses. For lone persons households, the proportions are quite different: 60.5% live in homes older than 30 years old and 75.3% of these are detached houses. Relocation to another dwelling structure and downsizing is more common among lone person households (Judd *et al.*, 2014).

From these data, we can infer that in the case of these old houses most would not have undergone any process of retrofit or refurbishment, and will probably not meet current energy efficiency standards.

**Figure 3 - Dwelling age for couples only and lone persons 65 plus (ABS, 2016b)**




## Age Pensioners' home energy efficiency characteristics and actions

In regards to the energy source used in the dwelling; Age Pensioners tend to rely more on electricity only than other household compositions. While 32% of all Australian households rely on electricity only at their homes, 38% of Age Pensioners have electricity only as their energy source (ABS, 2012). For electricity and mains gas, which would be the most efficient combination for energy consumption, while those are the energy sources for 46% of all households, this is the case for only 40% of Age Pensioners.

In terms of existing energy efficiency dwelling features, 76% of Age Pensioners responded they had insulation in their houses, while 15.8% did not know if their home had any kind of insulation. Window treatments, such as double glazing or draught exclusion, is also very common: 93% of Age Pensioners responded having some kind of window treatments to their houses, although it is impossible to know exactly which measures are installed. Renewable energy systems were, generally, still an uncommon home improvement: with around15% of Age Pensioners having renewable energy systems; either solar electricity or hot water system, which is around the same average for all households (ABS, 2012).

The reliance on electricity only as an energy source means that in terms of hot water system, Age Pensioners rely more on electric systems, which are either off-peak or, continuous systems (53% of Pensioners' homes). Mains gas hot water systems are found in 33% of Age Pensioners' homes, whereas this is true for 38% of all households and for 41% of households, whose main income is from wages and salaries (ABS, 2012).

When asked which household activity contributed most to household energy costs in the last 12 months (2011), heating the home and water heating were the most common responses, as expected. Surprisingly, cooking accounted for 10% of responses, along with cooling/ air conditioning the home, and running the fridge and freezer (ABS, 2012). As time passes and climate change impacts of higher temperatures increases, we should expect cooling the home to become more common in these responses.

For energy efficient actions, Age Pensioners already save a lot on energy consumption in comparison to all Australian households and, more specifically, to those who rely on salaries and wages for their income. This is in accordance with Cooper et al. (2016) findings, who mentioned the energy frugality practiced by some research participants. See table 2 below comparing the energy efficient actions and the percentage of household groups who responded affirmatively to those actions (ABS, 2012).

**Table 2 – Energy efficiency actions and percentage of affirmative responses per household group.**

| ENERGY EFFICIENT ACTION | AGE PENSIONERS | WAGES AND SALARIES | ALL HOUSEHOLDS |
|---|---|---|---|
| *Drying clothes on a washing line for all or most washes* | 92% | 86% | 87% |
| *Switching appliances off at the wall* | 69% | 58% | 60% |
| *Taking short showers* | 68% | 55% | 58% |
| *Using draft-proofing seals on doors and window* | 37% | 29% | 30% |
| *Using energy efficient light bulbs for the majority of lights* | 81% | 81% | 81% |
| *Using a low-flow shower head* | 63% | 58% | 59% |

**Source: Adapted from (ABS, 2012).**

In terms of intention to improve home energy efficiency, only 2% of Age Pensioners intend to replace their heater or cooler for more efficient models, while 4% of all households intend to do so. Only 5% of Pensioners intend to replace major whitegoods for more efficient models, whereas this is the intention of 7% of all households. The low percentage of these intentions may be linked to the low disposable income and also to payback period issues related to life expectancy.

When comparing two different, yet common, strategies for electric heating and cooling, the reverse cycle air conditioning costs about $34.00 per week, whereas portable electric fans in summer and portable electric heaters in winter account for about $26.00 a week. (ABS, 2012). As the reverse cycle equipment is used for entire rooms and even more than one room (central equipment), the portable equipment appears to be more economic as they can be used for smaller areas – although it is not possible to infer on the thermal comfort of the home.

## Potential for climate change adaptation

As seen previously, there are many ways of retrofitting a home to improve energy performance. Understanding which measures are more suitable and cost effective for age pensioners' homes can enable targeted discussions towards better housing intervention policies for climate change adaptation and healthy ageing in place.

According to the ABS (2006), most Australian houses are built with outer walls constructed of brick or timber (weatherboards), although brick cladding is used more often. In 1999, 71% of dwellings had walls of either brick veneer or double brick walls, compared to 65% in 1994 (BRANZ, 2007).

The brick veneer architectural style was first adopted just before World War II (1930s) and gained more popularity around the 1960s, as an affordable and easy-to-build solution compared to the high costs of double brick homes (Budget Direct Home Insurance, 2015; House of Home, 2017). Although there is no available data, its growing popularity is concurrent with the period when current Age Pensioners were purchasing their family home. Therefore, we could assume many Age Pensioners who are homeowners still live in their brick veneer homes.

According to the House of Home (House of Home, 2017), some key features of brick veneer homes are: they "often feature hipped roofs with simple concrete tiles in bleak or low profile colours, sliding timber framed windows, plain interior with timber flooring, and red, cream or white brick finishes". Other building materials combinations include metal sheeting roofs and concrete floors (BRANZ, 2007). It is still current in new developments and consists of an internal timber structure covered with a single layer of brick on the outside. There is usually some space between the structure and the cladding, and insulation can be inserted there.

In respect to insulation, cavity wall insulation currently offers the largest potential for reduction in energy use and carbon saving per dwelling within a short payback period (DCLG, 2006; Xing, Hewitt and Griffiths, 2011). For the typical Australian home, built with timber frame, timber or brick cladding and concrete floor, this is an effective solution. It can be executed either by pump-in solutions, such as hydrophobic granulated mineral fibre (either rockwool or glass mineral wool), expanded polystyrene beads, or polyurethane or urea-formaldehyde foams, or by installation of blankets, panels and batts insulation (Sustainability Victoria, 2016).

One of the most common and cheapest 'low-hanging fruit' climate change adaptation actions to be adopted among Age Pensioners is to use draft-proofing seals on doors and windows. This energy efficient action is beneficial for both summer and winter seasons, as it helps insulate the home against heat loss and heat gain. Another simple adaptation is to paint the external brick walls with light colours to improve reflectance and avoid heat gain in higher temperatures. Other easy-to-do improvements include using pedestal fans, installing window film or heavy curtains/blinds internally and/or installing outside awnings or shutters to improve energy efficiency (McGee, 2013; Morris *et al.*, 2019). Possibly, those window treatments could be facilitated by existing local council home repair and maintenance programs (IWC, 2019). Other effective energy efficient actions such as using efficient light bulbs and low-flow shower heads are already done by most councils.

Some climate change adaptation measures may be more expensive (longer payback periods) and/or not so easy to install, as they require some disturbance of the home (Sustainability Victoria, 2016). Substituting dark roof tiles for lighter colours have the same effect on reflectance and avoidance of heat gain, but it is expensive and may require specialised professionals. Double glazed windows are known for their insulating features but are also more expensive and may require changes in the window frames. Ceiling fans with reverse mode, for example, are effective solutions for energy efficiency improvement during summer and winter seasons, but their installation may be restricted by ceiling heights in brick veneer homes. Other actions, such as solar hot water system and solar electricity (photovoltaic panels) could take advantage of the hipped roofs but have a substantial upfront cost that may be impossible for age pensioners to afford. In 2012 only 9% of age pensioners had solar electricity connected to grid, which was about the same for all households combined (ABS 2012). The NSW government initiative of installing free solar systems for low-income households could be a way of increasing this percentage while alleviating their financial stress (Energy NSW, 2019).

Finally, not all properties are susceptible to the more cost-effective interventions. There is a hard-to-treat stock, consisting generally of properties that have any of the following features: solid walls, off the mains gas network, and no loft space (DCLG, 2006). As seen previously, more than one third of Age Pensioners have electricity only as their energy source (ABS, 2012), so effective solutions such as replacing electric hot water systems with gas systems are not possible in these homes.

## CONCLUSIONS

Higher temperatures and more extreme weather events have the potential to have an impact on the physical and mental health of our ageing population. Age pensioners with low incomes may be more vulnerable due to their home circumstances and the poor energy efficiency characteristics thereof. This ongoing research sought to investigate the current state of Age Pensioners' homes and explore suitable energy efficiency improvements to cope with the predicted impacts of climate change.

By understanding the economic profile of Age Pensioners, the extent of their reliance on the Age Pension and the lack of disposable income or financial limitations for home improvements, it is argued that the push towards building adaptation and energy efficient actions needs to be partially or heavily subsidised by government.

Low-income households not only have less capacity to sustain a good level of maintenance in the home, but also they do not have the financial resources to improve home energy efficiency (Chester, 2013). Low maintenance of buildings may accelerate the natural process of weathering and wear, which change the energy use pattern of households for heating, cooling and water heating, which represent the biggest proportion of total household energy consumption (Anagnostopoulos *et al.*, 2016).

Additionally, by identifying the typical dwelling structure, architectural style, building materials and energy efficient features of their homes, it is possible to work on framing policies that address the specific gaps in energy efficiency interventions and facilitate the adoption of those avoiding a "one-size-fits-all" approach. Classifying potentially suitable interventions into either "low-hanging fruit" or more expensive ones, has the potential to direct adoption efforts throughout local, state and national governments. Some of those easy-to-do intervention measures could be part of education programs of local councils to motivate DYI measures, or part of their program of home maintenance and repair assistance to local seniors. Other costly measures, such as solar power, for example, should be part of a broader national policy that addresses concerns on energy infrastructure stability and management of peak demands.

## REFERENCES


ABC News (2010) *Russian heatwave killed 11,000 people*.

ABCB (2013) 'How Have Housing Energy Efficiency Requirements Made A Difference', *Codes*, p. 1. Available at: http://www.abcb.gov.au/~/media/Files/Download Documents/Major Initiatives/Energy Efficiency/Residential Housing/FINAL INFOGRAPHIC FOR WEB UPLOAD-v2.pdf.

ABS (2006) *Housing Stock: Trends in housing*. Australian Bureau of Statistics.

ABS (2012) *Household Energy Consumption Survey, Australia: Summary of Results, 2012*, *2014*. Available at: http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by Subject/4670.0~2012~Main Features~Summary of Findings~13 (Accessed: 23 January 2019).

ABS (2016a) *Chapter - Dwelling Structure (STRD)*. Available at: http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/2901.0Chapter29902011 (Accessed: 23 January 2019).

ABS (2016b) *Household Expenditure Survey, Australia: Summary of Results, 2015-16*, *2017*. Available at: http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/6530.0Main+Features12015-16?OpenDocument (Accessed: 23 January 2019).

ABS (2018) *Main Features - Population Ageing*. Australian Bureau of Statistics. Available at: http://www.abs.gov.au/ausstats/abs@.nsf/mf/3222.0 (Accessed: 27 November 2018).

ABS (2019) *Building Activity - Value of Work Done, Australia, Dec 2018*. ABS. Available at: https://www.abs.gov.au/ausstats/abs@.nsf/0/4FB5ACFC0074529ECA2576B00017C434?Opendocument (Accessed: 17 April 2019).

Acil Allen Consulting (2017) *Multiple Impacts of Household Energy Efficiency: An Assessment Framework*. Melbourne.

AEMO (2019) *Data dashboard – Australian Energy Market Operator*. Available at: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Data-dashboard#average-price-table (Accessed: 20 June 2019).

Allouhi, A. *et al.* (2015) 'Energy consumption and efficiency in buildings: current status and future trends', *Journal of Cleaner Production*, 109, pp. 118–130. doi: 10.1016/j.jclepro.2015.05.139.

Anagnostopoulos, F. *et al.* (2016) *Energy Poverty Handbook*. Edited by K. Csiba and A. Gosztonyi. Brussels: The Greens/EFA Group in the European Parliament. doi: 10.2861/094050.

Berry, S. and Marker, T. (2015) 'Residential energy efficiency standards in Australia: where to next?', *Energy*

*Efficiency*, 8(5), pp. 963–974. doi: 10.1007/s12053-015-9336-4.

BRANZ (2007) *An assessment of the need to adapt buildings for the unavoidable consequences of climate change*. Canberra: Australian Greenhouse Office. doi: ISBN 978-1-921297-64-9.

Budget Direct Home Insurance (2015) *How Australian housing has changed over the years*.

Campbell, S. *et al.* (2018) 'Heatwave and health impact research: A global review', *Health and Place*. Elsevier Ltd, 53(September), pp. 210–218. doi: 10.1016/j.healthplace.2018.08.017.

Canstar Blue (2019) *Electricity Costs Per kWh | QLD, SA, VIC, NSW Rates – Canstar Blue*.

Chard, R. and Walker, G. (2016) 'Living with fuel poverty in older age: Coping strategies and their problematic implications', *Energy Research and Social Science*. Elsevier Ltd, 18, pp. 62–70. doi: 10.1016/j.erss.2016.03.004.

Cheng, J. *et al.* (2018) 'Heatwave and elderly mortality: An evaluation of death burden and health costs considering short-term mortality displacement', *Environment International*. Elsevier, 115(April), pp. 334–342. doi: 10.1016/j.envint.2018.03.041.

Chester, L. (2013) 'The Impacts and Consequences for Low-Income Australian Households of Rising Energy Prices', *The University of Sydney*, Department(October). doi: 10.1007/s12134-011-0187-3.

City of Sydney (2016) *Resilient Sydney - City Context Report*. Sydney.

City of Sydney (2018) *Resilient Sydney - A strategy for city resilience 2018*. Sydney. Available at: http://www.cityofsydney.nsw.gov.au/vision/towards-2030/resilient-sydney.

Climate Council (2016) *The silent killer : Climate change and the health impacts of extreme heat Thank you for supporting the*.

ClimateCHIP (2019) *Your Area: Tomorrow | Climate CHIP*.

Cooper, P. *et al.* (2016) *EE3A: Pathways and initiatives for low-income older people to manage energy - Final Report*.

DCLG (2006) *Review of Sustainability of Existing Buidings: The Energy Efficiency of Dwellings – Initial Analysis*. London. Available at: http://webarchive.nationalarchives.gov.uk/20120920070517/http://www.communities.gov.uk/documents/planningandbuilding/pdf/154500.pdf.

Dear, K. B. G. and McMichael, A. J. (2011) 'The health impacts of cold homes and fuel poverty', *Bmj*, 342(7806), pp. 1–2. doi: 10.1136/bmj.d2807.

Demirbilek, O. and Demirkan, H. (2004) 'Universal product design involving elderly users: A participatory design model', *Applied Ergonomics*, 35(4), pp. 361–370. doi: 10.1016/j.apergo.2004.03.003.

Denscombe, M. (2010) *The Good Research Guide for small-scale social research projects*. Fourth Edi. Berkshire: Open University Press.

DEWHA (2008) *Energy Use in the Australian Residential Sector 1986 - 2020*. Available at: http://pandora.nla.gov.au/pan/85431/20080612-1302/www.environment.gov.au/settlements/energyefficiency/buildings/publications/energyuse.html.

DIS (2015) *Residential Energy Baseline Study: Australia*. Canberra. Available at: http://www.energyrating.gov.au/sites/new.energyrating/files/documents/Report_Residential_Baseline_Study_for_Australia_2000_-_2030_0.pdf.

Energy NSW (2019) *Solar for low income households | NSW Government*.

Fletcher, C. and Lin, L. (2013) ‘The Bottom Line’, *Bloomsberg Businessweek*, (March 4-March 10), p. 23. doi: 10.1108/08880451211276566.

Horne, J. (2018) ‘Resilience in major Australian cities: assessing capacity and preparedness to respond to extreme weather events’, *International Journal of Water Resources Development*. Routledge, 34(4), pp. 632–651. doi: 10.1080/07900627.2016.1244049.

Horne, R. E. *et al.* (2005) *International comparison of building energy performance standards*, *Report to Australian* …. Melbourne. Available at: http://www.researchgate.net/profile/Ralph_Horne/publication/265435778_International_comparison_of_building_energy_performance_standards/links/552452f90cf2caf11bfcc64d.pdf.

House of Home (2017) *Australian Home Periods | Housing Eras | Australian House Styles*.

Howden-Chapman, P. *et al.* (2007) ‘Effect of insulating existing houses on health inequality: Cluster randomised study in the community’, *British Medical Journal*, 334(7591), pp. 460–464. doi: 10.1136/bmj.39070.573032.80.

Howden-Chapman, P. *et al.* (2012) ‘Tackling cold housing and fuel poverty in New Zealand: A review of policies, research, and health impacts’, *Energy Policy*. Elsevier, 49, pp. 134–142. doi: 10.1016/j.enpol.2011.09.044.

Howden-Chapman, P., Signal, L. and Crane, J. (1999) ‘Housing and health in older people: ageing in place’, *Social Policy Journal of New Zealand*, pp. 14–30.

IEA, I. E. A. (2014) *Capturing the Multiple Benefits of Energy Efficiency*. Paris.

IPCC (2012) *Managing the risks of extreme events and disasters*. Edited by C. B. Field et al. Cambridge, UK, and New York, NY, USA: Cambridge University Press. doi: 10.1017/CBO9781139177245.

IWC (2019) *Home maintenance and modification service - Inner West Council*.

Johnson, V., Sullivan, D. and Totty, J. (2013) *Improving the energy efficiency of homes in Moreland social research final report*. Fitzroy.

Judd, B. *et al.* (2010) *Dwelling, land and neighbourhood use by older home owners*, *AHURI Final Report*. Melbourne.

Judd, B. *et al.* (2014) *Downsizing amongst older Australians*. Melbourne.

Kapsalaki, M. and Leal, V. (2011) ‘Recent progress on net zero energy buildings’, *Advances in Building Energy Research*, 5(1), pp. 129–162. doi: 10.1080/17512549.2011.582352.

Kelly, M. (2008) ‘Britain’s building stock – a carbon challenge’.

Lewis, S. C., King, A. D. and Mitchell, D. M. (2017) ‘Australia’s Unprecedented Future Temperature Extremes Under Paris Limits to Warming’, *Geophysical Research Letters*, 44(19), pp. 9947–9956. doi: 10.1002/2017GL074612.

Maidment, C. D. *et al.* (2014) ‘The impact of household energy efficiency measures on health: A meta-analysis’, *Energy Policy*, 65, pp. 583–593. doi: 10.1016/j.enpol.2013.10.054.

Maidment, C. D. (2016) ‘The Health Impacts of Household Energy Efficiency Measures’, (April).

Marmot Review Team (2011) *Marmot Review Team. The Health Impacts of Cold Homes and Fuel Poverty.* London, UK.

McGee, C. (2013) *Your Home: Passive Design - Shading*.

Morris, A. (2016) *The Australian dream: Housing experiences of older Australians*. Csiro Publishing.

Morris, N. B. *et al.* (2019) 'The Effects of Electric Fan Use Under Differing Resting Heat Index Conditions: A Clinical Trial', *Annals of Internal Medicine*. doi: 10.7326/M19-0512.

NaTHERS National Administrator (2012) *NATIONWIDE HOUSE ENERGY RATING SCHEME (NatHERS) - SOFTWARE ACCREDITATION PROTOCOL*.

Noble, K. and Martinelli, A. (2009) *Towards climate safe homes: The case for zero emissions and water saving homes and neighbourhoods*.

Ogg, J. (2005) *HEATWAVE: implications of the 2003 French heat wave for the social care of older people*.

Patel, D. *et al.* (2019) 'Joint effect of heatwaves and air quality on emergency department attendances for vulnerable population in Perth, Western Australia, 2006 to 2015', *Environmental Research*. Elsevier Inc., 174(March), pp. 80–87. doi: 10.1016/j.envres.2019.04.013.

RAENG (2010) *Engineering a low carbon built environment - The discipline of Building Engineering Physics*. London: The Royal Academy of Engineering. Available at: https://www.raeng.org.uk/publications/reports/engineering-a-low-carbon-built-environment.

Rajagopalan, P., Andamon, M. M. and Moore, T. (2018) *Energy Performance in the Australian Built Environment*. Singapore, SINGAPORE: Springer. Available at: http://ebookcentral.proquest.com/lib/uts/detail.action?docID=5451753.

Ren, Z., Paevere, P. and McNamara, C. (2012) 'A local-community-level, physically-based model of end-use energy consumption by Australian housing stock', *Energy Policy*. Elsevier, 49, pp. 586–596. doi: 10.1016/j.enpol.2012.06.065.

Robine, J. M. *et al.* (2008) 'Death toll exceeded 70,000 in Europe during the summer of 2003', *Comptes Rendus - Biologies*, 331(2), pp. 171–178. doi: 10.1016/j.crvi.2007.12.001.

Robson, C. and McCartan, K. (2016) *Real world research*. John Wiley & Sons.

Runeson, P. and Höst, M. (2009) 'Guidelines for conducting and reporting case study research in software engineering', *Empirical Software Engineering*, 14(2), pp. 131–164. doi: 10.1007/s10664-008-9102-8.

Saman, W. *et al.* (2013) *A framework for adaptation of Australian households to heat waves*, *National Climate Change Adaptation Research Facility (NCCARF)*. Available at: http://eprints.qut.edu.au/62001/.

Schneider, T. and Till, J. (2005) 'Flexible housing: opportunities and limits Tatjana', *Theory Arq*, 9(2), pp. 157–166.

Steffen, W., Hughes, L. and Perkins, S. (2014) *Heatwaves: hotter, longer, more often*. Climate Council of Australia. Available at: http://www.climatecouncil.org.au/uploads/9901f6614a2cac7b2b888f55b4dff9cc.pdf.

Sustainability Victoria (2014) *Victorian Households Energy Report*. Melbourne. Available at: http://www.sustainability.vic.gov.au/services-and-advice/households/energy-efficiency/toolbox/reports.

Sustainability Victoria (2016) *Cavity Wall Insulation Retrofit Trial*. Melbourne.

The Lancet (2018) 'Heatwaves and health', *The Lancet*. Elsevier Ltd, 392(10145), p. 359. doi: 10.1016/S0140-6736(18)30434-3.

The Sydney Morning Herald (2018) *New Australian homes are the smallest they've been in 22 years*.

Thomson, H. *et al.* (2013) 'Housing improvements for health and associated socio-economic outcomes', *The Cochrane database of systematic reviews*, 2(2), pp. 61–67.

Wang, X., Chen, D. and Ren, Z. (2010) 'Assessment of climate change impact on residential building heating and cooling energy requirement in Australia', *Building and Environment*. Elsevier Ltd, 45(7), pp. 1663–1682. doi: 10.1016/j.buildenv.2010.01.022.

Wilkins, R. *et al.* (2019) *The Household, Income and Labour Dynamics in Australia Survey: Selected Findings from Waves 1 to 17*.

Willand, N. *et al.* (2012) *Drivers of Demand for Zero and Towards Zero Emissions Residential Retrofits*. Melbourne.

Willand, N., Maller, C. and Ridley, I. (2019) 'Addressing health and equity in residential low carbon transitions – Insights from a pragmatic retrofit evaluation in Australia', *Energy Research and Social Science*. Elsevier, 53(March), pp. 68–84. doi: 10.1016/j.erss.2019.02.017.

Willand, N., Ridley, I. and Maller, C. (2015) 'Towards explaining the health impacts of residential energy efficiency interventions - A realist review. Part 1: Pathways', *Social Science and Medicine*. Elsevier Ltd, 133, pp. 191–201. doi: 10.1016/j.socscimed.2015.02.005.

Wright, F. (2004) 'Old and cold: Older people and policies failing to address fuel poverty', *Social Policy and Administration*, 38(5), pp. 488–503. doi: 10.1111/j.1467-9515.2004.00403.x.

Xing, Y., Hewitt, N. and Griffiths, P. (2011) 'Zero carbon buildings refurbishment - A Hierarchical pathway', *Renewable and Sustainable Energy Reviews*. Elsevier Ltd, 15, pp. 3229–3236. doi: 10.1016/j.rser.2011.04.020.

Yin, R. K. (2008) *Case study research: design and methods*. 4th ed. Thousand Oaks, California. USA.: Sage Publications.

**Email contact: caroline.portovalente@student.uts.edu.au**

---

[i] As an estimate of a home's potential heating and cooling energy use, this calculation is a predicted annual energy load (in MJ – megajoules) for heating and cooling of the conditioned floor area ($m^2$) based on standard occupancy assumptions.