

The Importance of House Size in the Pursuit of Low Carbon Housing.

Dr Trivess Moore¹, Dr Stephen Clune² and Dr John Morrissey³

¹Research Fellow, Centre for Urban Research, RMIT University, Melbourne, Australia. Email: trivess.moore@rmit.edu.au

²Senior Lecturer, ImaginationLancaster, Lancaster Institute for Contemporary Arts, Lancaster University, Lancaster, United Kingdom. Email: s.clune@lancaster.ac.uk

³Research Fellow, Cleaner Production Promotion Unit, G.02A Civil and Environmental Engineering, School of Engineering, University College Cork, Cork, Ireland. Email: jemorrissey@ucc.ie

Abstract

This paper investigated the relationship between house size, star ratings and renewable energy systems to identify a range of affordable low carbon housing scenarios for the Australian market, specifically focusing on Zero (net) Energy Housing (ZEH) for Melbourne, Victoria. Research is increasingly emerging around the world identifying the technical and financial feasibility of low carbon housing, and policy development is beginning to reflect this. However debate still surrounds the additional upfront costs to achieve low carbon housing, particularly in terms of the costs to include renewable energy technologies. This paper therefore estimated the upfront costs of constructing 15 ZEH's from a variety of house sizes and star ratings scenario. Analysis of the results indicated that: an 8 star ZEH could be constructed for a similar amount to a 9 star house connected only to traditional utilities; a small reductions in floor area can offset most, if not all, of the additional upfront costs associated with achieving a ZEH, as house size is a key determinant of energy consumption. The findings provide valuable insights for architects, planners and policy developers interested in progressing ZEH led development in a carbon-constrained future in Australia.

1. Introduction

The built environment accounts for roughly 40% of the total annual energy consumption in most advanced economies (Kyrö, Heinonen, & Junnila, 2012) and around one third of greenhouse gas (GHG) emissions. In Australia, the residential sector is responsible for 12% of total final energy consumption and 13% of greenhouse gas emissions (Schultz & Petchey, 2011; Wang, Chen, & Ren, 2010). The scientific consensus is that a reduction in global greenhouse gas emissions of up to 90% of 1990 levels by 2050 is required to limit climate change impacts (Garnaut, 2008).

As the world moves towards a carbon constrained future, the importance of the built environment in mitigating GHG emissions has been identified by a number of authors, for example Newton and Tucker (2011). The reduction of energy consumption and associated GHG emissions from the built environment sector has been identified as having one of the highest benefit-cost ratios for mitigation across different sectors (Ren, Chen, & Wang, 2011). This highlights the significant potential for cost and GHG emissions savings in the residential sector.

Once built, residential buildings are important as ongoing concentration points of energy use, and given that buildings may last several decades (Wang, *et al*, 2010), these elements of the built environment also represent a structural driver of GHG emissions. It is therefore essential to incorporate potential impacts of climate change into building design strategies and urban planning regimes at the earliest possible opportunity to mitigate recurring future negative impacts (Jentsch, Bahaj, & James, 2008).

The current system of housing energy provision in Australia, and globally, is arguably unsustainable in the context of the requirements to mitigate climate change impacts (Horne & Hayles, 2008). The benefits of low carbon or zero energy housing (ZEH) have been known for some time (Moore, 2012). While the technical elements to achieve a ZEH have been available for many years, housing which applies the full range of this technology to achieve such a standard remains firmly in the minority of new residential construction, both in Australia and globally.

A lack of consumer and building industry knowledge and higher upfront cost requirements have been identified as part of the reason ZEH has not emerged as the mainstream housing performance standard (Moore, 2012). In recent years a number of jurisdictions such as the UK and California have developed policy which will result in ZEH becoming mandatory for all new dwellings by the end of this

decade (CPUC, 2011; DCLG, 2006). In Australia ZEH remains off the immediate or near term policy agenda. This must be rectified if a transition to a ZEH future in Australia is to be achieved. Australia faces three key challenges in moving towards a ZEH led housing regime: (1.) relatively poor building standards, (2.) the world's largest average new house size, and (3.) a predominately coal fired electricity grid.

Australia's current energy efficiency building standards are less stringent than comparable countries (Horne & Hayles, 2008), although there has been incremental increases in standards towards a more energy efficient building stock across the past decade. Demand side energy reductions via thermal performance and energy efficiency in the residential sector have a high scope for improvement in Australia (Pears, 2007). Demand side energy consumption in Australia has declined gradually in the past four years, with a suggested link to this improved building performance (Pears, 2011). The GHG reductions per new dwelling are positive (Wilkenfeld & Associates, 2007), but fall well short of the significant emission reductions required to mitigate impacts from climate change, as suggested by Garnaut (2008).

Compounding the impact of less stringent efficiency standards is the trend in Australia of increasing residential floor areas for newly built homes. For instance, the average new house size in Australia increased from 162.4 m² of floor space in 1984 to 248.0 m² of floor space in 2009 (ABS, 2010). Research has found building size (specifically of conditioned floor area) contributes significantly to overall levels of emissions from the residential sector in Australia (Clune, Morrissey, & Moore, 2012). Carlson, Scott Matthews *et al.* (2011) also report a clear correlation between smaller homes and total electricity loads, which are comprised of fewer appliances¹. Therefore having the world's largest new houses (on average) adds challenges to significantly reducing emissions. In Australia, this influence of size has been neglected from serious policy discussions to date on means to address and reduce energy use and GHG emissions.

Australia's electricity grid presents the third key challenge for ZEH. The grid is predominately coal dependent (Schultz & Petchey, 2011). A rapid transformation of the grid to renewable energy on a scale to significantly reduce CO₂e emissions is not currently on the agenda of any major federal political party, and therefore unlikely in the short to medium term. However theoretical research has shown how a transition to 100% renewable energy in Australia could potentially occur by 2020 (BZE, 2010). Given current conditions, a shift toward ZEH therefore would most likely materialize through on-site energy production, most probably in the form of rooftop solar photovoltaics.

Historically, when proposals are made for increased stringency to the nationwide energy efficiency building regulations in Australia, they receive strong resistance, particularly from the building industry who argue that any changes which increase sustainability performance will negatively impact on affordability (HIA, 2009; MBAV, 2008). To date there has been a dearth of research into the impact of changing house size and thermal performance of housing on affordability. This paper therefore explores the relationship between housing costs (including the cost of construction and of purchasing and installing renewable energy systems), house size and star ratings to identify a range of low carbon housing scenarios for Australia. New housing in Victoria has been identified as being the most significant contributor to GHG emissions across the Australian new housing sector into the future (Clune, *et al.*, 2012). The paper therefore specifically focuses on a range of ZEH options for new housing in Melbourne, Victoria.

2. Aim

The aim of this paper is to investigate the role in which a reduction in house size can play in a transition to an affordable ZEH future. In particular it asks:

What is the relationship between house size and star ratings in providing affordable Zero (net) Energy Housing?

3. Method

This paper estimated the construction costs for 15 ZEH models from a range of house size and star ratings scenarios. This was completed by: (1.) estimating construction costs from over 100 house plans from the Lifetime Affordable Housing (LAH) database (Moore, 2012; Morrissey, Moore, & Horne, 2011), (2.) estimating energy consumption for each scenario via AccuRate energy modelling

¹ When no. of appliances are compared across an 80% of total load threshold.

(Morrissey, *et al*, 2011), and (3.) empirical costing of PV systems to be energy neutral over a 12 month period for each scenario. The following section outlines the approach used in each step in more detail.

The 15 house and star ratings scenarios were generated by selecting three different house sizes, and five different star rating scenarios (Table 1). The sizes were selected by drawing upon ABS data, where the average Australian new house sizes of 250m² was determined as the business-as-usual scenario (ABS, 2010). Two smaller house sizes were then selected based on average international and historic house sizes (Clune, *et al*, 2012).

Table 1: House size and star rating scenarios utilised.

House size	250m ²	220m ²	160m ²
Star rating scenario	6 star	6 star	6 star
	7 star	7 star	7 star
	8 star	8 star	8 star
	9 star	9 star	9 star
	10 star	10 star	10 star

Estimating Construction costs

To identify construction costs for the 15 scenarios, the LAH database was utilised. The LAH database systematically modelled upgrades of building envelope thermal performance from 5 star to 10 star in 1 star increments for the 100 house plans. The LAH modelling involved changes to the material elements of the building only, with no design changes implemented to ensure that a ‘worst-case’ cost outcome was achieved. Changes to achieve higher ratings included measures such as increasing the R-value of ceiling, wall and floor insulation, and upgrading windows from single to double glazed with low-e coating. The database captured the material upgrades to achieve each 1 star increment. To calculate costs of additional materials, a triangulation approach was used, based on a process of consultation with industry expertise and costing resources such as *Rawlingsons* (Rawlinsons, 2009). All costs in the LAH database were peer reviewed by a building industry costing expert. For a detailed overview of the LAH database see Moore (2012, pp 82-140).

LAH data were then averaged across the 15 scenarios house plans used in this paper. The initial upfront costs for the now superseded 5 star rated house models were adjusted to reflect the current 6 star minimum. Houses within 5m² of the size scenario applied in this analysis were averaged to provide an indicative upfront cost for each size range analysed. In practice, architectural design changes may result in improved thermal performance for lower costs when compared with the material addition approach applied in this paper.

Forecasting energy demand

Energy requirements for the 15 scenarios were calculated by forecasting energy demand for a 12 month period. Data from the Australian Government publication *Energy use in the residential sector 1986-2020* (DEWHA, 2008) were used to generate a Business as Usual (BAU) scenario for all energy consumed within an ‘average’ dwelling, with the exception of heating and cooling requirements. Heating and cooling energy requirements were taken from the AccuRate energy modelling (Morrissey, *et al*, 2011). To model zero (net) energy performance, it was assumed that the houses used a reverse cycle heat pump (air conditioner) for heating and cooling.

Grid connected renewable energy system costs

The above energy requirements were then used to calculate the net renewable energy requirements, including photovoltaic (PV) and solar hot water, of a grid connected ZEH following Moore’s Moore (2012) method. A cost was then attached to each scenario for the renewable energy systems. An average of quotes from a number of local Melbourne renewable energy retailers was applied to estimate the likely final technology costs.

The renewable energy system cost was then added to the construction cost to determine the total upfront cost for each ZEH scenario.

4. Results and analysis

The upfront costs to construct the baseline 6 star house scenarios (excluding renewable energy system) were estimated to be:

- 250m² - \$195,500
- 220m² - \$173,000
- 160m² - \$128,000

The average additional costs to improve the building envelope to achieve improved star ratings (Moore, 2012) are presented in Table 2.

Table 2: Cost per m² of achieving additional stars ratings from 6 stars.

Star rating	Additional cost per m ²
7	\$12
8	\$33
9	\$101
10	\$203

The total energy consumption estimated for the 15 scenarios is presented in Table 3. The larger the house size, the more energy is consumed. As the thermal performance of the house improves, total energy consumption reduces. This is in part through the reduced requirement for heating and cooling, and through lower energy requirements for appliances and technologies within the house (i.e. not as much space within the house for 'stuff') for example see James (2011).

Table 3: Total energy consumption for the different house size scenarios across the different star ratings for Melbourne, Victoria (assume an all-electric house).

Star rating	Victorian house energy consumption (kWh) Total		
	250m ²	220m ²	160m ²
6	7173	6584	5406
7	6771	6230	5149
8	6390	5895	4905
9	6030	5578	4675
10	5734	5318	4486

Table 4 shows the estimated PV size requirement (kW) for each ZEH scenario. Note that as energy requirement decreases, the size of the photovoltaic system required decreases.

Table 4: Photovoltaic system size requirements.

Star rating	PV system size (kW)		
	250m ²	220m ²	160m ²
6	4.9	4.5	3.7
7	4.6	4.3	3.5
8	4.4	4.0	3.4
9	4.1	3.8	3.2
10	3.9	3.6	3.1

The cost analysis finds that as star ratings increase, so does the construction cost of the house, although the renewable energy costs reduce as the PV system size decreases. The cost for the renewable energy technologies are presented in Table 5.

Table 5: Renewable energy costs.

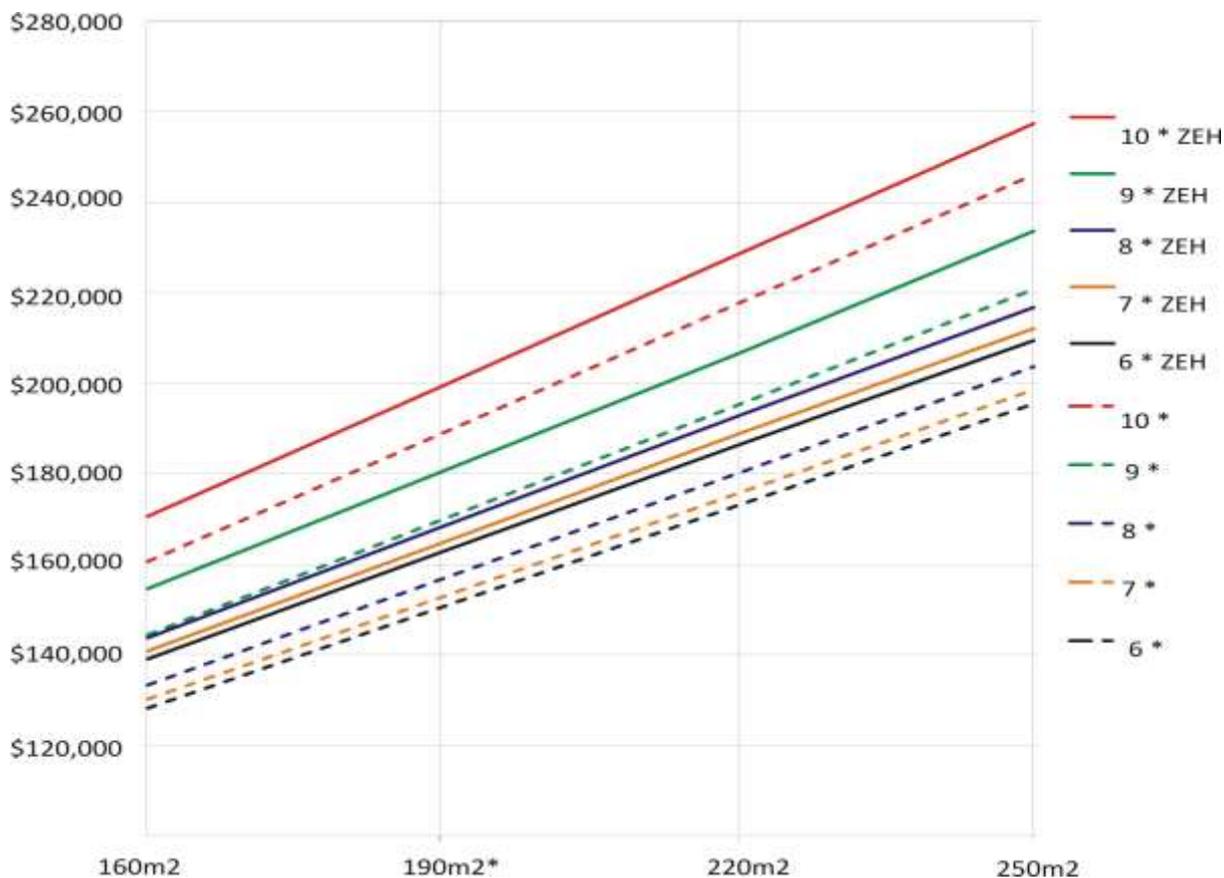
Element	Cost	Size
PV	\$2,100	1kW installed
inverter	\$1,900	2.1-4 kW system
	\$3,000	4.1kW system +
SHW	\$3,200	Average family

The total cost for the different house size scenarios across different star ratings to achieve a ZEH standard are presented in Table 6.

Table 6: Total cost for the different house size scenarios across different star ratings to achieve a ZEH standard.

Rating	Victorian ZEH upfront cost (house+PV+inverter+SHW)		
	250m ²	220m ²	160m ²
6	\$209,500	\$186,400	\$139,000
7	\$212,100	\$188,700	\$140,700
8	\$216,900	\$192,800	\$143,700
9	\$233,700	\$206,500	\$154,500
10	\$257,600	\$228,600	\$170,500

Figure 1: Total costs ZEH (solid lines) compared to traditional utility connected housing (dashed lines). Note * 190m² house excluded from empirical modelling.



The results presented in Table 6 and Figure 1 show there is significant difference in costs across the 15 scenarios to achieve a ZEH, from \$139,000 for a 6 stars 160m² ZEH to \$257,600 for a 10 stars 250m² ZEH. Figure 1 also includes as a benchmark houses constructed without renewable energy systems (indicated by a dashed line). The results raise questions of the relationship of house size, star ratings and renewable energy systems. The results illustrate that:

- Different combinations of house size, thermal performance and renewable energy systems produce varying cost optimisation points. For example, the cost optimal renewable energy system is likely to vary, depending on the thermal performance standard of the house in question. The most cost optimal solution may not necessarily equate with the optimal energy performance solution.
- Across all house size scenarios, the modelling predicted that an 8 star ZEH costs less than a 10 star house connected only to traditional utilities.
- For houses of floor size of 160m², an 8 star ZEH costs less than a 9 star house connected only to traditional utilities.
- A reduction in house size for an 8 star rated house in the order of 10-15m² would produce sufficient capital cost savings to enable a 6 star ZEH to be constructed. A decrease in floor space of 15-20m² would produce sufficient savings to construct a 7 star ZEH.
- A reduction of approximately 25m² of floor size for a 6 star house connected only to traditional utilities would produce sufficient capital cost savings to construct a house with a 6 star rated envelope and sufficient renewable energy technologies to reach ZEH performance standard.

In addition there are significant environmental benefits to be achieved. Extrapolating from Clune, *et al* (2012), it is estimated that each ZEH will avoid the emissions of over 9,500 kg CO₂e emissions per dwelling per year from the base case (6 star 250m²). In comparison to a 10 star 160m² house, an estimated 6,000 kg CO₂e emissions per year would be avoided. The avoided emissions compound annually if ZEHs replace traditionally grid-connected houses. Furthermore, the CO₂e emissions decrease as house size decreases and as star ratings increase.

The results raise two areas for further discussion, (1.) from a housing affordability perspective, what is most desirable star rating, size and ZEH combination? And (2.) given that reducing house size is a viable affordability strategy, how may this be achieved.

5. Discussion

A Zero Energy Home or high stars rating house?

The results raise an interesting question in is it worthwhile pursuing the 10 star rating standard when an 8 star ZEH is more affordable? The money budgeted to achieve the higher star rating could offset the cost of a renewable energy system at a lower star rating. The cost of PV has been on a steady decline over the past decade, thereby meaning that renewable components can be included in better performing housing more cost effectively. The pursuit of higher star ratings, beyond possibly 8 star, to achieve a ZEH outcome makes less economic sense as PV costs continue to fall.

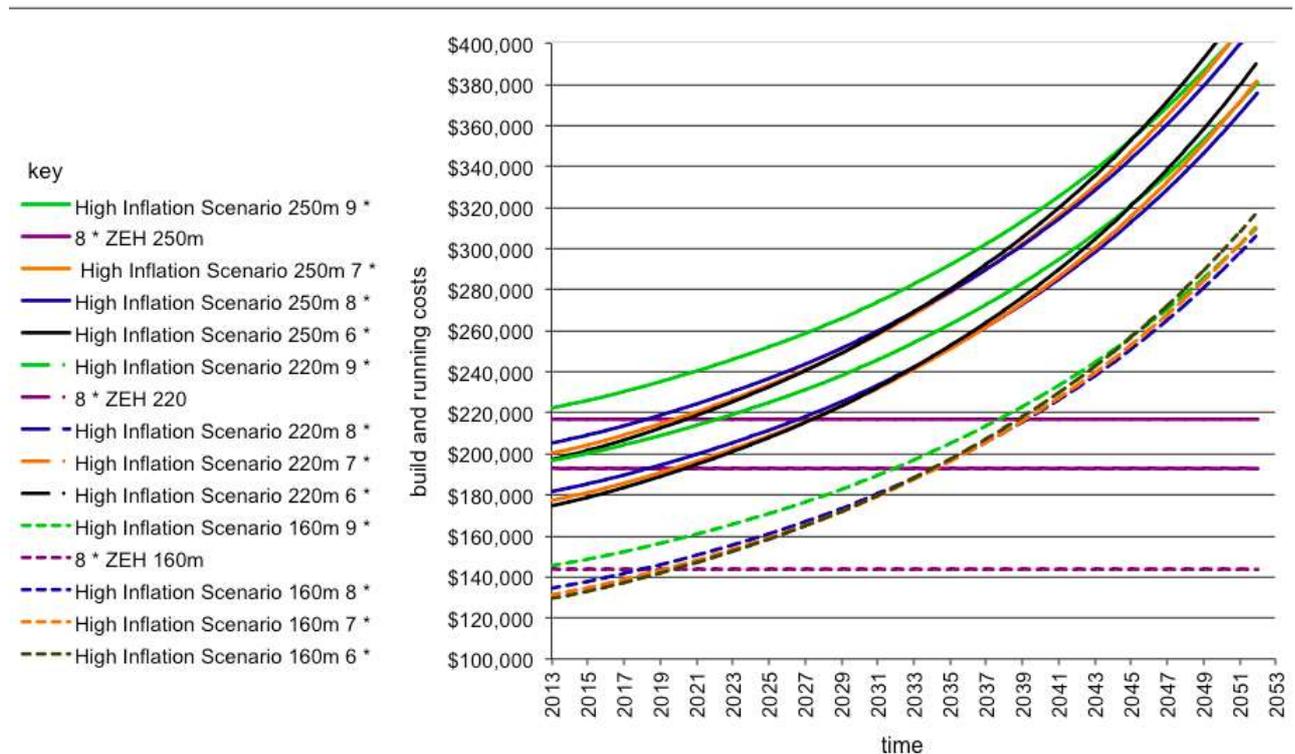
This analysis is based upon altering, through material additions only, standard house designs. Purpose designed 9 or 10 star houses would likely find significant cost efficiencies through changes in design and use of innovative materials and technologies. If this could occur, it might bring the balance back to a more equal focus on higher star ratings.

That is not to say that improving star ratings should be overlooked all together. Thermal performance and comfort is important for many reasons. It reduces the energy requirement for heating and cooling. In this respect it can help reduce discomfort in extreme weather conditions such as in a heat wave in the middle of summer, and is predicted to better protect performance in a changing climate (Wang, *et al*, 2010). Further it can help to improve occupant health through ensuring the indoor temperature remains within the 'healthy' zone (Williamson *et al*, 2009).

Discussion of more complex economic modelling, such as net present values and return on investments has deliberately been avoided in this paper. Reducing the house size can provide an economic saving. The payback of building an 8 star ZEH which is slightly smaller as opposed to a 10 star house connected only to tradition utilities could be zero. The savings due to not paying utilities are immediate and ongoing.

Ongoing savings to the household from an average sized ZEH compared to the BAU scenario can be estimated to be \$1,750 per year (Moore, 2012). Figure 2 illustrate the economic saving over time, which is likely to increase into the future as the cost of energy is forecast to rise. In this way, a ZEH can help to protect the household against future energy price rises and can stabilise living costs of the house. Further, reducing house size will reduce overall energy consumption and costs within a house, resulting in even further economic and energy savings compared to the BAU scenario.

Figure 2: Scenarios showing build cost, plus compounding energy costs over time in a high-energy inflation scenario.



The findings have significant implications for future planning and policy development based on these metrics. If a through-life affordability view is to be taken, there will be a higher premium placed on house size as a means of environmental impact and capital and operating cost reduction and on the overall sustainability of a house (Clune, *et al*, 2012). This may become more important in the Australian context if a mandatory disclosure of dwelling performance at time of sale or rent is introduced, allowing potential occupants to compare housing options.

House Size Matters

The results overwhelming show how a modest reduction in average house size would more than offset the additional costs of constructing a zero (net) energy house. Further the analysis shows significant environmental benefits from ZEH. The immediate question raised from the results is how such a reduction in house size may be possible. Four themes are discussed that have agency to reduce house size in: (1.) sound policy (2.) Australia’s changing demographics, (3.) good architectural design, and (4.) reduced operational costs.

Policy options to contain house size

A range of direct and indirect policy measures are available that may restrain house size and contribute to achieving ZEH performance. Direct policy measures relate to initiatives that may place restrictions on parameters such as building height, floor area ratios, front, side or back yard set back (Chan, Tang, & Wong, 2002; Kono *et al*, 2012; Nasar, Evans-Cowley, & Mantero, 2007). Indirect policy measures are more subtle and could include: mandatory disclosure of performance of the energy and water house; taxation measures that provide a disincentive for owning a large home (particularly investment properties); more stringent land use controls in the protection of urban boundaries that by default force infill; alteration to financing models by banks that consider not just interest repayments but also ongoing through-life operational costs; house size and star rating conditions placed on incentives schemes like the new home owners grant, and support for innovative

housing provision such as dual occupancy development (Clune, *et al*, 2012). NSW's granny flat legislation (DoP, 2011), and the relaxation of development standards for dual occupancy development in Queensland e.g. 'Fonzie flats' (Council of Mayors, 2011) are examples of innovative policy. While this is a start, there are further opportunities for policy development in the Australian context.

Changing demographics

Two key demographics within Australia have the potential to shift the demand towards smaller houses in the ageing population and across Generation Y's (born between 1979 and 1995) housing preferences. Australia's ageing population (65+) is forecast to be 4.0 million by 2022, up from 2.4 million in 2007 (ABS, 2009). Increasing number of smaller households has been linked to an aging population (AHURI, 2004). The increase in an ageing population, and potential desire to downsize from the large family home for convenience and practicality presents a potential market for small ZEH. Investment in such housing types assists to future-proof a risk averse demographic from rising energy prices. If such housing involved higher star ratings, this would likely result in improved health outcomes for this group as well, a group who typically deal with more health issues than younger people.

Anecdotal evidence also suggests that Generation Y's resistance to invest in the housing market comes from a preference for 'smaller homes, well situated to work, transport, cafes and entertainment venues' (James, 2011). The Urban Land Institute in the USA reported similar results suggesting that Generation Y require a diversity of housing options, and may prefer to locate in car free infill development (Krueger, 2013).

Both of these groups have the potential to drive changes in the characteristics of new housing. However it may take some time for consumer preferences to filter through to the building industry and result in smaller, more sustainable housing being constructed for the market. This is especially true as the building industry in general only builds to minimum regulatory standards (Moore, 2012).

Good Architectural Design

Possibly the approach with the greatest agency to make smaller homes attractive is good architectural design. Jigsaw Housing in Canberra provides an interesting case study in affordable smaller housing. Jigsaw Housing held community consultation sessions on affordable housing asking potential clients what they wanted in a house. Specifically they asked what was critical, desirable and not needed. The sessions identified that natural light, warmth and a connection to the outdoors were desirable, while theatre rooms, large bedrooms, double garages, separate laundries, dining rooms, en suites and baths were seen as surplus (Verrie, 2013). By eliminating features of the house seen as surplus they created a set of open source house plans almost half the size of the national average. By engaging with the people who will be using the house and achieving smart and sustainable design, it has resulted in an affordable low carbon (8 star) home. This shows that if the critical elements are right, a household can be happy with reduced space. The authors argue that good architectural design could be applied to reduce the house size, and resulting savings could be used to pay for the renewable energy system.

Further to this, houses which can be divided into discrete areas, such as a duplex, also provide an option for more appropriately sized housing which can increase or decrease as the household's life situation changes. For example, consider a single storey duplex which has two bedrooms, a kitchen, living area, bathroom and small study in one half and in the other another two bedrooms, a living area, small kitchen and bathroom. If there was a door joining the two areas which could be easily sealed off this would allow a young couple to live in one part, while renting out the other. When the time comes that they have children, they can open up the doorway and the children can live in the other part which had been previously rented out. Once the children leave home, the door can be sealed up and the area rented out again. In this way the original couple can remain in the same house (reducing the cost, stress and emotion of having to move) and ensure they are in appropriate sized housing throughout their lives.

Reduced operational costs

The incentive to construct a home with significantly reduced operational costs may be a driver of housing size in the future. With increasing living costs a topical issue in Australia currently, there is increasing pressure to reduce costs where possible. Utility costs (energy and water) have seen significant increases in price in recent years and this is likely to continue in the future. Therefore households are becoming more aware of the cost of these resources. As evidence of this, recent

Australian Government programs such as the insulation scheme and renewable energy rebates have seen a significant increase in houses with these elements (Hearps & McConnell, 2011). A requirement for households to reduce operational costs may result in smaller house sizes and increased demand for renewable energy technologies to be integrated into building design. Furthermore, this approach could be applied by governments for improving the liveability and sustainability of public/low-income housing, where living costs can present a financial issue for the occupants.

6. Further research needs

The above analysis is based upon average assumptions such as current levels of appliance use. However, the cost-benefit and technology balance equation may result in different outcomes if changes to the assumptions are applied. For example future occupant behaviour, including use of an increasing number of appliances, is likely to have a significant impact for the overall performance of the house; if occupants buy more appliances and use them more, this may result in a requirement for a larger PV system to offset additional energy requirements. Future work is needed to clearly articulate the capacity of a self-powering ZEH house to accommodate changes to the assumptions, including increased levels of appliances. However, the question quickly becomes a more normative one at this point, including if the grid is better able to support ever increasing numbers of appliances, should it? Particularly given increasing environmental and resource constraints as we transition towards a low-carbon future. Additionally, the implication of house size and environmental performance on the density of housing supply is another question requiring further research. Such questions are beyond the scope of this particular study, but would represent a useful contribution to the wider debate on energy consumption.

7. Conclusion

The analysis found that a small reduction in house size (5-10%) can help to offset additional upfront costs to achieve a ZEH standard. Based upon current house designs and building practices, decreasing benefits are evident from building above an 8 star standard. Results of this analysis demonstrated that it was more cost effective to increase slightly the size of the PV system, rather than address thermal performance beyond an 8 star standard. This may change in the future as improved design of housing and new building materials and building practices mean it becomes cheaper to build to higher star ratings.

Moving towards smaller (more appropriate) house sizes in Australia is likely to require a multi-pronged approach. Improved policy, changing demographics, improved architectural design and a drive to reduce operational costs have all been explored as methods to coerce people into smaller housing. The requirement now will be to develop a strategy to foster new housing which is more sustainable and more affordable. As this paper has demonstrated, reducing house size will be a critical element in transitioning to a low carbon housing future.

8. References

- ABS. (2009). 4102.0 - Australian Social Trends. Canberra: Australian Bureau of Statistics.
- ABS. (2010). 8731.0—Building Approvals, Australia, February 2010. Canberra: Australian Bureau of Statistics.
- AHURI. (2004). Housing futures in an ageing Australia. *AHURI research and policy brief bulletin, issue 43*. Melbourne: RMIT University.
- BZE. (2010). Zero Carbon Australia: Stationary Energy Plan. Melbourne: Beyond Zero Emissions, Melbourne Energy Institute, University of Melbourne.
- Chan, E. H. W., Tang, B.-s., & Wong, W.-S. (2002). Density control and the quality of living space: a case study of private housing development in Hong Kong. *Habitat International, 26*(2), 159-175. doi: [http://dx.doi.org/10.1016/S0197-3975\(01\)00041-8](http://dx.doi.org/10.1016/S0197-3975(01)00041-8)
- Clune, S., Morrissey, J., & Moore, T. (2012). Size Matters: House size and thermal efficiency as policy strategies to reduce net emissions of new developments. *Energy Policy, 48*, 657-667. doi: 10.1016/j.enpol.2012.05.072
- Council of Mayors. (2011). Next Generation Planning. A handbook for planners, designers and developers in South East Queensland. Brisbane: Council of Mayors.
- CPUC. (2011). California energy efficiency strategic plan. January 2011 update. San Francisco: California Public Utilities Commission.
- DCLG. (2006). *Code for Sustainable Homes: A step-change in sustainable home building practice*. London: Department for Communities and Local Government.
- DEWHA. (2008). *Energy use in the Australian residential sector 1986-2020*. Canberra: Department of the Environment, Water, Heritage and the Arts.
- DoP. (2011). *Supporting Affordable Rental Housing – Granny Flats (Secondary Dwellings)*. Sydney: NSW Government.

- Garnaut, R. (2008). *The Garnaut Climate Change Review*. Melbourne: Cambridge University Press.
- Hearps, P., & McConnell, D. (2011). *Renewable Energy Technology Cost Review*. Melbourne: Melbourne Energy Institute.
- HIA. (2009). Response to the consultation regulation impact statement 2009-03. Proposal to revise the energy efficiency requirements of the BCA for residential buildings. Campbell, ACT: Housing Industry Association.
- Horne, R., & Hayles, C. (2008). Towards global benchmarking for sustainable homes: an international comparison of the energy performance of housing. *Journal of Housing and the Built Environment*, 23(2), 119-130. doi: 10.1007/s10901-008-9105-1
- James, C. (2011). Australian homes are biggest in the world; But signs that home size has peaked. Sydney: CommSec.
- Jentsch, M. F., Bahaj, A. S., & James, P. A. B. (2008). Climate change future proofing of buildings— Generation and assessment of building simulation weather files. *Energy and Buildings*, 40(12), 2148-2168. doi: <http://dx.doi.org/10.1016/j.enbuild.2008.06.005>
- Kono, T., Joshi, K. K., Kato, T., & Yokoi, T. (2012). Optimal regulation on building size and city boundary: An effective second-best remedy for traffic congestion externality. *Regional Science and Urban Economics*, 42(4), 619-630. doi: <http://dx.doi.org/10.1016/j.regsciurbeco.2012.02.004>
- Krueger, R. (2013). Where Americans Want To Live: New ULI Report, America In 2013, Explores Housing, Transportation, Community Preferences Survey Suggests Strong Demand for Compact Development Retrieved 27/06/2013, from <http://www.uli.org/press-release/america2013/>
- Kyrö, R., Heinonen, J., & Junnila, S. (2012). Housing managers key to reducing the greenhouse gas emissions of multi-family housing companies? A mixed method approach. *Building and Environment*, 56(0), 203-210. doi: <http://dx.doi.org/10.1016/j.buildenv.2012.03.008>
- MBAV. (2008). Submission to the Liveability Inquiry. Victorian Competition and Efficiency Commission. February 2008. Melbourne: Master Builders Association of Victoria.
- Moore, T. (2012). *Facilitating a transition to zero emission new housing in Australia: Costs, benefits and direction for policy*. RMIT University, Melbourne.
- Morrissey, J., Moore, T., & Horne, R. (2011). Affordable passive solar design in a temperate climate: An experiment in residential building orientation. *Renewable Energy*, 36(2), 568-577. doi: 10.1016/j.renene.2010.08.013
- Nasar, J. L., Evans-Cowley, J. S., & Mantero, V. (2007). McMansions: The Extent and Regulation of Super-sized Houses. *Journal of Urban Design*, 12(3), 339-358. doi: 10.1080/13574800701602478
- Newton, P., & Tucker, S. (2011). Pathways to decarbonizing the housing sector: a scenario analysis. *Building Research & Information*, 39(1), 34-50. doi: 10.1080/09613218.2010.531085
- Pears, A. (2007). Imagining Australia's energy services futures. *Futures*, 39(2-3), 253-271. doi: DOI: 10.1016/j.futures.2006.01.012
- Pears, A. (2011). Powering down - has Australian electricity consumption hit its peak? , 03/07/2013, from theconversation.com/powering-down-has-australian-electricity-consumption-hit-its-peak-3044
- Rawlinsons. (2009). *Rawlinsons Australian construction handbook*. Perth: Rowlhouse Publishing.
- Ren, Z., Chen, Z., & Wang, X. (2011). Climate change adaptation pathways for Australian residential buildings. *Building and Environment*, 46(11), 2398-2412. doi: 10.1016/j.buildenv.2011.05.022
- Schultz, A., & Petchey, R. (2011). Energy update 2011. (June 2011 ed.). Canberra: Australian Bureau of Agriculture and Resource Economics and Sciences.
- Verrie, A. (2013, 08/03/2013). [Jigsaw Housing 8 star house information].
- Wang, X., Chen, D., & Ren, Z. (2010). Assessment of climate change impact on residential building heating and cooling energy requirement in Australia. *Building and Environment*, 45(7), 1663-1682. doi: 10.1016/j.buildenv.2010.01.022
- Wilkenfeld & Associates. (2007). Options to reduce greenhouse emissions from new homes in Victoria through the building approval process. Melbourne: DSE.
- Williamson, T., Grant, E., Hansen, A., Pisaniello, D., & Adamon, M. (2009). An investigation of potential health benefits from increasing energy efficiency stringency requirements. Building Code of Australia Volumes one and two. Adelaide: The University of Adelaide.