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Title: Cost benefit pathways to zero emission housing: Implications for household cash-flows in Melbourne.

Theme: Beyond Today's Infrastructure

Sustainability literature highlights the potential of the residential sector to contribute to significant greenhouse gas emissions reductions. In this context, recent housing policies, not only in Australia but internationally, have addressed the implementation of minimum energy efficient housing standards. Recent UK, European and USA policy articulates a goal of zero emission housing by 2020. In Australia, while research has indicated that the introduction of the '5 stars' mandatory building envelope performance standard has resulted in a 20% increase in energy efficiency over pre 5 star homes, housing energy efficiency remains a contested policy area. The costs and benefits of more energy efficient housing are frequently argued in terms of a trade off between sustainability and affordability, and debate is focused particularly on upfront capital costs. There is a lack of clear cost benefit information on the impact of higher energy efficiency standards, and similarly on the impacts of integrating renewable energy strategies with energy efficiency strategies. Furthermore, actual impacts at the household cash-flow level have not been studied. This research therefore investigates the lifetime economic and environmental costs and benefits of improved sustainable housing options, including renewable energy options. Analysis focuses on four scenarios of improved housing performance for current and typical housing types in Melbourne, Australia. Research outputs seek to inform current debates surrounding low-emissions housing options by providing a case-book of evidence on household budget level impacts, in terms of monthly cash flows, of improved housing performance options.

Key words: housing policy, emissions, lifecycle, affordable, renewable energy.

Introduction

The debate regarding climate change has seen significant focus on the requirement to increase energy efficiency and seek alternative sources of energy generation as part of the solution to reducing greenhouse gas (GHG) emissions (Garnaut, 2008; Stern, 2007). In this context, recent housing policies, not only in Australia but internationally, have addressed the implementation of minimum energy efficient housing standards. These policies are in recognition of the significant potential for households to reduce environmental impacts.

However, the policy debate on energy efficiency in Australia has centred on a perceived trade off between sustainability and affordability, with affordability more frequently given priority. The cost of housing has risen faster than incomes in Australia in recent years (Yates, 2008) and any additional upfront costs for improved sustainability (which can have long payback periods) is of concern for policy makers and home owners. Most at risk from increasing upfront housing costs are low income earners and first home owners. This paper, as part of a wider RMIT University study titled Lifetime Affordable Housing, carries out some exploratory analysis on the cross-over between sustainability and affordability, using a multi-disciplinary approach, focused in particular on costs.

Firstly, an overview of energy costs and Australian and International sustainable housing policy development is provided. A cost benefit analysis/life cycle costing methodology is then applied to evaluate the economic feasibility of a number of energy efficiency and renewable energy scenarios for low emission housing in Melbourne. Key results are presented as life-time accumulated costs, Net Present Value of investment (NPVs) and analysis of cash flows in terms of mortgage repayments. Analysis is discussed in terms of implications for monthly household budgets, and likely implications for future policy debates in this sphere. Through these methods, the relationship between sustainability and affordability is empirically assessed. Necessarily, the paper is informed by literature from sustainability, energy efficiency and housing policy fields.

The energy efficiency debate – Sustainability Vs Affordability

Recent international housing policy (e.g. UK, European and USA policy) articulates a goal of zero emission housing (ZEH) before the end of the decade for new housing (DCLG, 2007a; EU, 2009). To achieve ZEH, policy is focused not only on improved building envelopes, but importantly the inclusion of renewable energy generation.

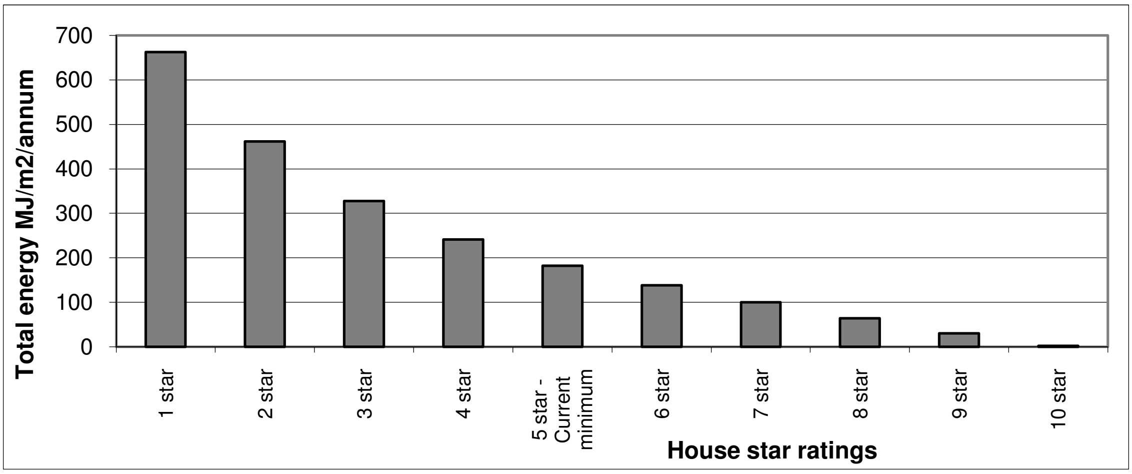

Figure 1: House rating standards for new housing in Melbourne, Australia.

In Australia, new housing is rated on an energy efficiency scale of 1 (worst) to 10 (best) ‘stars’ (based primarily on heating and cooling energy requirements), with ‘5 stars’ being the current minimum standard in many states. In Melbourne this equates to a heating and cooling energy load of 182 MJ/m^2/annum (Figure 1). The ‘5 star’ minimum standard was introduced in Victoria in 2005 with the next revision, ‘6 stars’, to be implemented in mid 2011. The introduction of the ‘5 stars’ mandatory building envelope performance standard has resulted in a 20% increase in energy efficiency over pre 5 star homes in Australia (Wilkenfeld & Associates, 2007). There was discussion from some of the industry about the benefits of moving to '7 stars' over '6 stars' (ABSA, 2009), but this failed to gain traction due to concerns of the impact to housing affordability.

Housing affordability is a significant issue in many countries including Australia (Beer, et al., 2007). It is commonly defined when a household spends more than 30% of income on housing, based upon upfront costs. Based upon this definition, up to 10% of Australian households are struggling with housing affordability (Yates, 2008). However this definition fails to capture the affordability of through life costs of living in the house. These costs include things such as energy, water and maintenance costs.

The environmental necessity of limiting impacts from energy consumption may also have significant social consequence, particularly for lower income groups. The cost of traditional energy is predicted to increase significantly in future years (Garnaut, 2008). If household energy consumption remains steady (or increases), there is the likelihood that increasing numbers of households will struggle to afford their energy. Energy poverty is already a considerable issue in Australia and many other developed countries (Jenkins, 2010).

Energy poverty occurs when a household spends 10% or more of total income on energy requirements, or when the household is unable to consume energy required to meet basic living requirements due to financial constraints (Roberts, 2008). It is estimated that in NSW, Australia, that up to 25,000 households each year are disconnected from their utilities due to financial constraints (ACF, et al., 2008). Future energy cost increases, especially as a pathway for targeting GHG emissions reduction, will have a disproportionate impact on lower-income households. Many of which are likely to be in energy poverty, or close to it, already (Roberts, 2008).

Methodology and Approach - Cost benefit analysis

Changes to minimum housing performance standards have been informed by evidence including cost benefit analysis (CBA). CBA is a process for analysing the need for and effectiveness of alternative strategies and can incorporate valuation of environmental externalities (Pickin, 2008). The method is one of the most commonly applied tools of economic evaluation in the public decision-making process (Simpson & Walker, 1987), despite shortcomings such as those discussed by Sáez & Requena (2007). The cost benefit work underpinning the UK's transition to ZEH (DCLG, 2008b) represents international best practice in terms of research into the costs and benefits of achieving zero emission housing.

Housing policy regulations in Australia are also informed through CBA. The Allen Consulting Group (2002) undertook initial analysis investigating the costs and benefits of implementing a 5 star minimum building standard in Australia. They found that implementation of minimum dwelling performance standards achieved economic, social and environmental benefits and that these benefits are 'significantly greater' for 5 star housing when compared with 4 star housing.

Previous studies to standard improvements from the minimum housing performance of 5 stars in Australia are limited (Constructive Concepts & Tony Isaacs Consulting, 2009). There is a lack of clear cost benefit information about further energy efficiency improvements, or on the impacts of integrating renewable energy strategies with energy efficiency strategies (Newton & Tucker, 2009). This paper aims to investigate this gap in knowledge and present through life cost benefit evidence of improved housing options to the policy debate.

Method

This paper investigates the costs and benefits of five housing scenarios, varying in energy efficiency performance. Analysis of upfront and through life costs and benefits of the scenarios establishes empirical data currently lacking. For this paper, zero emission housing is defined as a net balance of zero between renewable energy generation and total energy consumed by the household across a year.

The baseline for analysis was selected to be representative of new housing in Melbourne, Victoria in 2010. This consisted of a 3 bedroom detached 6 star house. The house has a floor space of 246 m^2, consistent with ABS data on average new detached house size (ABS, 2010) (Table 1). Building materials used in the modelling were consistent with building practices in Melbourne in 2010. It was assumed that the baseline house had no renewable energy technology.

Four low-emissions scenarios were then developed with reference to this baseline. The scenarios were based on two specific interventions; a) building envelope efficiency as assessed by star rating, to reduce total energy requirement and then b) renewable energy technology additions, to supplement overall energy requirement.

The low-emission scenarios modelled were: 7 star house, 7 star house with 2kW solar photovoltaics (SPV), 8 star house with 2kW SPV and an 8 star ZEH (3.0kW SPV and solar hot water (SHW) system), see Table 1. The scenarios presented are part of a larger analysis conducted for a PhD thesis by the author (forthcoming). Scenarios presented in this paper were selected on the basis of long term performance and practical feasibility. Further details are available in the working paper (Moore, 2010).

Scenario	NatHERS Star rating	Heating and cooling energy requirement (MJ/m2/annum)	Renewable energy options	Percentage of total energy requirement generated by renewable energy	House size (floor area)	Energy reduction (building envelope) compared to 6 star	Operational energy emissions reduction compared to 6 star
6 star	6 star	138	None	0%	246 sq m	NA	NA
7 star	7 star	100	None	0%	246 sq m	27.50%	5.70%
7 star 2kW	7 star	100	2kW SPV	53%	246 sq m	27.50%	55.50%
8 star 2kW	8 star	64	2kW SPV	56%	246 sq m	53.60%	60.90%
8 star ZEH	8 star	64	3kW SPV, SHW	109%	246 sq m	53.60%	100.00%

Table 1: Details for the different housing options modelled.

Analysis builds upon methods, data and assumptions from previous sustainable housing research from Australia (Constructive Concepts & Tony Isaacs Consulting, 2009; Newton & Tucker, 2009) and internationally (Boardman, et al., 2005; DCLG, 2008a). Life cycle cost (LCC) analysis results can be divided into two critical components; upgrade costs of improved thermal performance of the building envelope and renewable energy options to offset remaining energy use. This enabled comparative cost assessments to be made over a specified period of time (BS ISO, 2008). LCC enables the trade-off between cost elements during the asset life phases to be studied to ensure optimum selection (Woodward, 1997).

Upgrade costs for improved building envelope thermal heating and cooling performances across 80 detached house plans of various sizes for new typical housing in Melbourne were calculated in a previous research phase (Morrissey, et al., 2009). Material upgrades, including improved insulation, improved window glazing, infiltration control and shading, were applied systematically to currently available 5 star house designs (Table 2). Upgrade costs assumed no design changes to the houses.

	Parameters addressed in order of priority →→→					
Star rating	**1. Ceiling**	**2. Infiltration Control**	**3. Shading**	**4. External Wall**	**5. Glazing**	**6. Internal Walls**
6 star						
7 star						
8 star						

Table 2: Guide for systematic upgrades to building envelope.

In addition to building envelope data, onsite renewable energy options were considered, consistent with the approach taken by the UK in developing their ZEH policy (DCLG, 2007b). Government rebates and feed-in tariffs for renewable energy generation were included where appropriate based on current government policy measures. The resale value of improved building thermal performance (Laquatra, 1986) and renewable energy technologies (Jackson, et al., 2009) was included in the analysis.

Results

Results were presented focusing on 25 years (mortgage length) and 40 years (life of house used by Australian Government analysis (Centre for International Economics, 2009)). A discount rate of 3.5% for the first 30 years, falling to 3.0% from 30-40 years, was used in the analysis, in line with international best practice (Garnaut, 2008; Rambaud & Torrecillas, 2005) to produce Net Present Values (NPV) for investment scenarios. A rate of inflation of 3.32% (RBA, 2009), interest rate of 7.89% (RBA, 2010), and energy costs based upon Garnaut's (2008) energy predictions were applied.

Scenario	House and land value (total upfront cost)	Extra cost for building envelope upgrade	Extra cost for renewable energy upfront	Total through life energy costs across 25 years	Total through life energy costs across 40 years	Total savings across 25 years (compared to 6 star)	Total savings across 40 years (compared to 6 star)	NPV across 25 years	NPV across 40 years
6 star	$365,688	$0	$0	$76,653	$224,468	$0	$0	$0	$0
7 star	$368,644	$2,956	$0	$75,605	$215,141	$1,048	$9,327	-$1,094	-$194
7 star 2kW	$377,610	$2,956	$8,966	$55,375	$146,288	$21,278	$78,180	$2,244	$8,709
8 star 2kW	$382,819	$8,165	$8,966	$56,791	$139,861	$19,862	$84,607	-$1,201	$6,116
8 star ZEH	$391,325	$8,165	$17,472	$37,985	$81,714	$38,668	$142,754	$3,073	$14,738

Table 3: Summary of results.

Table 3 presents a summary of the key results. The 8 star ZEH had the lowest accumulative costs across both 25 and 40 years. Six star BAU was the least economical across both time periods (Figure 2). The highest average annualised costs were found for the 6 star BAU scenario ($2,918 - 25 years), with the lowest found for the 8 star ZEH ($523 - 40 years) (Figure 3).

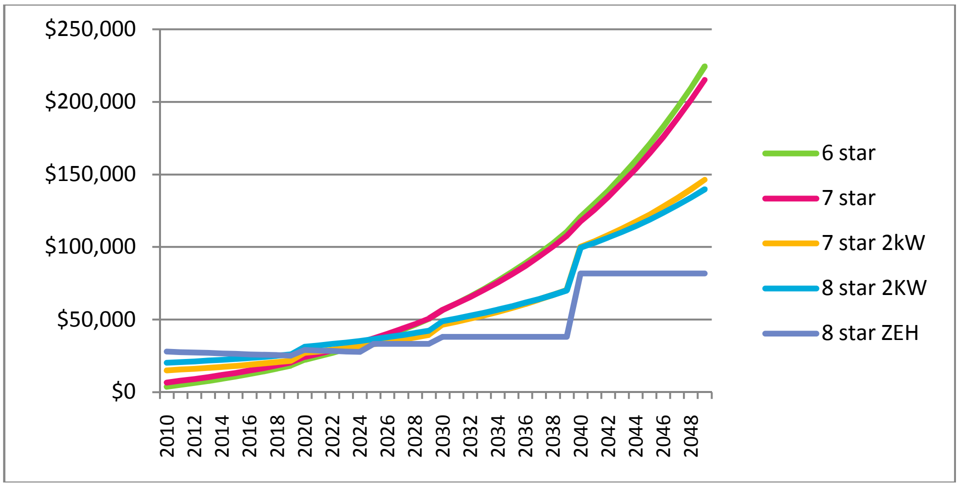

Figure 2: Accumulated through life costs (including upfront costs, yearly energy costs, technology replacement costs and feed-in tariffs) across time.

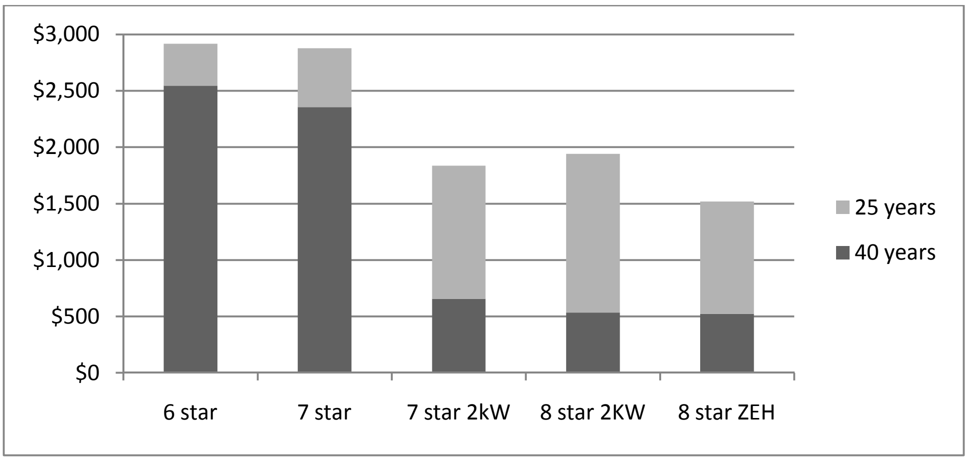

Figure 3: Average annualised costs across 25 and 40 years.

NPV is higher across 40 years than across 25 years for all scenarios. Across 25 years there are two scenarios (7 star and 8 star 2kW) with negative NPVs. The 7 star scenario also has a negative NPV across 40 years. Across both 25 and 40 year time horizons the 8 star ZEH has the highest NPV.

Economic savings increase significantly more with renewable energy generation scenarios and are generally greater across 40 years than 25 years (Figure 4). Economic savings ranged from $60 (7 star) - $967 (8 star ZEH) per annum across 25 years and $62 (7 star) - $880 (8 star ZEH) per annum across 40 years.

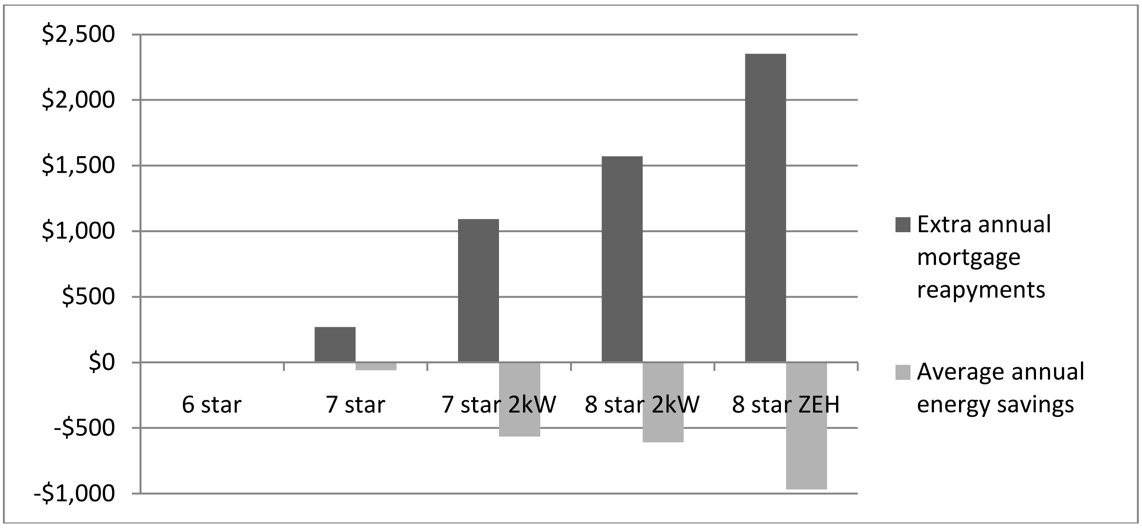

Figure 4: Extra annual mortgage costs compared to annual average energy savings (NPV) across 25 years.

Mortgage repayments due to higher upfront costs for sustainability aspects added an extra $196 per month for the 8 star ZEH, with extra repayments as low as $23 per month for the 7 star house (Figure 4). When the annual energy savings are deducted from the extra mortgage repayments, it results in extra monthly costs to the household of: $18 (7 star), $44 (7 star 2kW), $80 (8 star 2kW) and $115 (8 star ZEH).

Discussion

A major concern with improving housing performance has been the impact on affordability, primarily in the form of upfront costs. The analysis confirms that the major costs for improved sustainable housing arise at the initial capital investment stage. For an extra upfront cost of 7% of total cost, 8 star ZEH could potentially save the household 64% in total accumulated costs across 40 years compared to BAU. Including extra mortgage repayments, the household will save 52% in total accumulated costs across 40 years compared to BAU. The savings are significantly greater when renewable energy is combined with building envelope improvement. Results show after 12 years the 8 star ZEH was the least cost option. The savings for the higher standards of housing increases rapidly across time as the cost of energy increases.

Researchers such as Zhu et al (2009) argue that many sustainability aspects over short term time frames are currently unaffordable. The analysis shows that this is true.

Savings for improved sustainability offset the upfront costs across time and were cost effective. However, looking at the analysis in terms of household cash flow and energy poverty, the energy savings do not offset increased mortgage repayments. For the 8 star ZEH this equates to an extra $115 per month or $3.78 per day. Cash flow for households is heavily dependent on financial aspects such as interest rate, home loan length and upfront costs. For example, an interest rate of 5% across a loan of 30 years would see the extra monthly costs fall to $56. Households have the ability to absorb some changes to monthly mortgage repayments, for example the official Reserve Bank of Australia interest rate has risen by 1% over the past year (RBA, 2010), adding $182 per month to a $330,000 home loan, which is more than the additional amount for the extra upfront costs for increased sustainability. An increase in upfront costs will impact on those in or near energy poverty and of low income earners.

A defining characteristic of the current debate regarding affordability is the limited scope of the definition of affordability, which focuses on upfront costs and does not consider through life costs/benefits and risk. The argument fails to acknowledge the complexity of determining house prices or that cost efficiencies will be determined by the market. House price factors includes; location of house, interest rates, supply and demand, size of house and access to local infrastructure (Berry & Dalton, 2004; Commonwealth of Australia, 2008). To argue that sustainability is unaffordable without including these other complexities of housing affordability provides a limited analysis.

Based upon the evidence, the debate around sustainable housing should move beyond affordability and explore ways in which improving sustainable housing can be incorporated in policy. Of particular importance is the inclusion of renewable energy technology into future housing policy. The inclusion of renewable energy is important as, from an emissions point of view, the type of energy consumed can be as significant as the amount consumed (Entrop, et al., 2010). This is particularly true in Victoria, Australia, where electricity generation is primarily through burning of brown coal (90.6% in 2007-08 (ABARE, 2009)), which is considered the highest greenhouse gas emitting electricity generation processes (ITS, 2002). Integrating renewable energy into building envelope standards would orientate housing performance policy in Australia in line with international best practice, allowing for affordable sustainable housing.

Analysis limitations

There are a number of assumptions in the analysis including; no behaviour change from occupants, no change in house use, no appliance change in use, quantity or efficiency, no improvements in efficiency or costs from renewable energy technologies and no changes in the house design or size between scenarios.

Conclusion

The results showed that there are considerable upfront costs associated with achieving reduced GHG emissions in new housing, especially with the inclusion of renewable energy technologies. However when a through life cost/benefit approach is taken there are not only significant environmental benefits but also significant economic benefits (accumulated costs) to the household across the life of a home loan. The impact to cash flow from an increased home loan amount showed that for the particular interest rate, energy savings are less than the extra mortgage repayments. This added cost may be negated with improved resale value however the impact of added mortgage repayments still requires further study, especially the impact on low income earners and first home owners. The results do show however, that higher environmental performance in new housing can have the capacity to reduce and control increasing energy costs for households. Zero emission housing has been shown to be an achievable goal and should clearly be at the forefront of housing standards across the next decade in Australia.

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