Climate Change Adaption and Affordability – costs, benefits and regulation of improved environmental performance in housing

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Abstract

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Climate change regulatory and construction industry response has lead to a number of recent studies that examine the cost and benefits of mandating improved housing design and specification. Research addressed in the paper seeks an understanding of the financial impacts of 'sustainability' and 'energy efficiency' in housing generally, biased to an Australian temperate climate regional perspective (Victoria and South Australia).

This paper presents the current research literature and examines the question of 'trade-offs' in improved residential building environmental performance. Analyses of data on housing costs, both initial capital and operational, are a primary focus of the paper which draws some conclusions from the studies and housing cost information examined.

Improved housing design and specification, impact of regulation through building codes and climate awareness responses leading to housing industry and consumer change, are key underlying factors in the cost effectiveness questions that the research seeks to address.

1. Introduction

Housing in Australia consumes huge resources and contributes significantly to greenhouse gas emissions. In more base financial terms, housing accounts for a significant contribution to national gross domestic consumption as it does to employment and quality of life factors. There are however major anomalies surrounding the question of environmental performance, cost and affordability in modern housing in Australia:

- *The effectiveness of initiatives aimed at reducing the environmental impacts of housing, yet reducing the capital and longer term costs are not fully understood.*
- *Cost effective design and procurement of housing currently is difficult to achieve without a more rapid response and adaption to newer climate change realities.*
- *Housing economic life span prediction is problematic, as maintenance issues, technological developments and adaption or suitability to future occupancy must account for evolving climate change scenarios.*

The problem of evaluating housing costs for adaption to new climate change realities is part of a wider 'lifetime affordable housing' approach in research undertaken by Morrissey, Horne and O'Leary (2008) at RMIT, Melbourne. One key question is articulated thus: ***what are the through-life costs and benefits of improved environmental performance of predominant housing forms?*** Initial investigation and examination around this theme forms a background to what follows in this paper.

2. Housing Sustainability and Location – Climate variation and Design principles

Concepts of 'sustainable' or more energy efficient housing are greatly influenced by situational and regional climate factors. Consequently, government regulatory responses to improve residential environmental performance are to a degree regional in nature. The emphases and politics of climate change responses can differ across nations and regions. The European experience being more 'carbon reduction' orientated, for example UK government led approaches towards 'code 6' or 'carbon neutral' homes. Houses in the UK and North America are arguably more reliant on heavy heating loads during prolonged and more severe winters and 'cold spells' so 'building tightness' and energy consumption in generating and maintaining heating to living spaces is more of a concern.

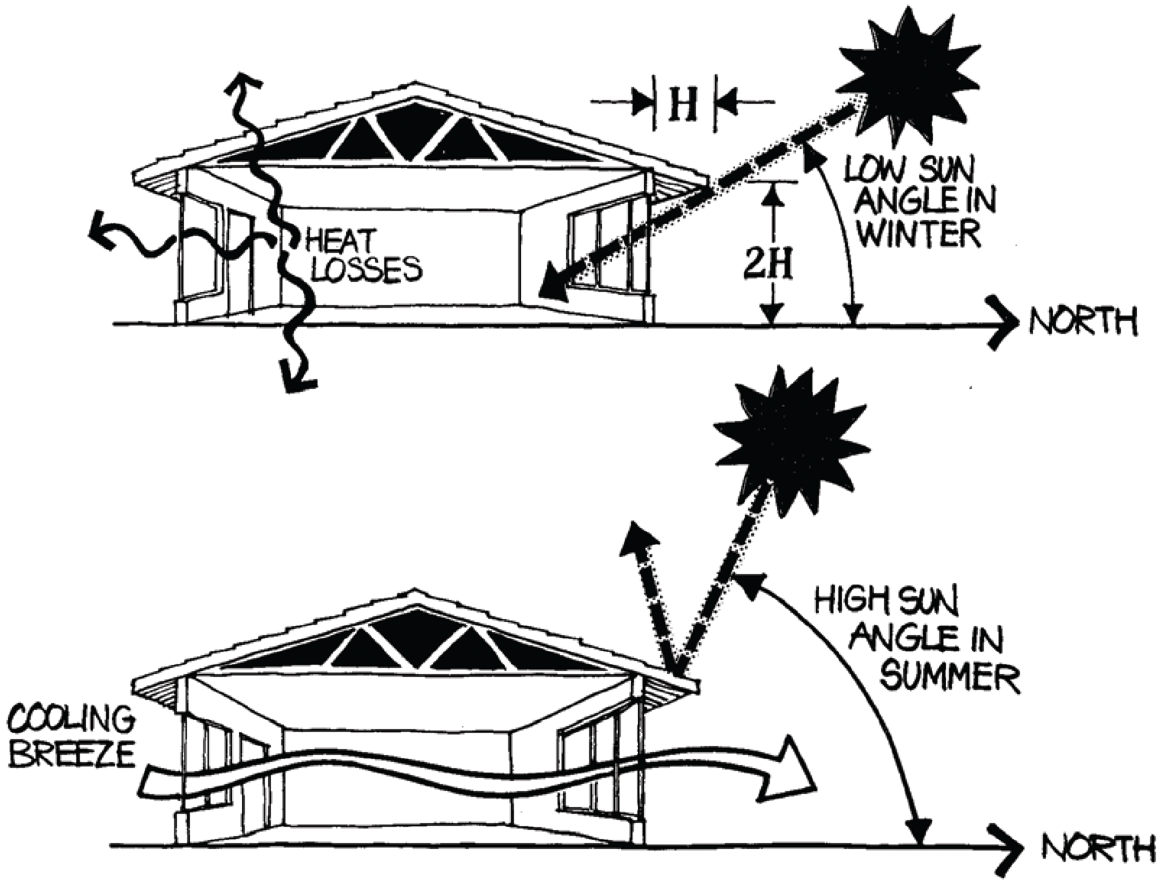

Figure 1: Solar Orientation Principles for Energy Efficient Housing *Source: DTEI, SA Gov.*

In Australia a greater awareness is evident in the literature in design and orientation of houses that need to be site specific, taking as much of the advantages of solar heating and cool breezes as possible (figure 1). Window area and window orientation have been found to be critical to building performance with guidelines for design of windows fairly ubiquitous. According to Department of Transport Energy & Infrastructure, DTEI (2007) recommended maximum area of widows by elevation vary from 60% north and 30% south to 15% east and 7% west. High performance or double glazing is recommended, together with increased insulation and appropriate shading devices. Outside of the volume built 'brick veneer' market i.e. architecturally designed 'one of a kind' or non standard homes the use of thermal mass is promoted in order to retain warmth in winter or provide a barrier to excessive internal solar heat ingress in summer.

Although for South Australia and Victoria, the term 'temperate' is used in climate description, the locations clearly necessitate housing of sufficient thermal mass and internal division to isolate occupants from hot summer temperatures and colder winter temperatures. Ballinger, Prasad & Rudder (1997) explain the impact of climate on design of housing that strives to be energy efficient. House design in Australia must account for climate variation, broadly defined in eight major zones under the Building Code of Australia (BCA).

3. Housing Capital Costs – Affordability, Land and Building Costs

Powall & Withers (2004) studied the rising contribution of the land component to new housing prices for the main capital cities in Australia between 1976 and 2002. The research shows land cost as a significant cost and having over some two decades 'jumped' in value to almost equate to the cost of 'bricks and mortar' or in NSW to exceed the construction cost.

	1976-77		1992		2002	
	New House Price $	Land %	New House Price $	Land %	New House Price $	Land %
Sydney	49,010	32	189,800	44	338,150	60
Melbourne	**63,200**	**24**	**169,000**	**24**	**276,200**	**37**
Brisbane	46,280	21	164,690	39	234,300	49
Adelaide	53,970	16	125,970	26	177,430	32
Perth	57,640	22	115,730	32	163,340	42

Table 1: Land and House Price, Australian state comparison *Source: Powall & Withers 2004*

Comparable research in a same year report, by the Urban Development Institute of Australia (UDIA 2004) provides a breakdown for two typical scenarios of housing in suburbs of Perth. A ‘modest’ 125m2 gross floor area house where land cost is 47% and house cost is 53% of total house and land package and a second example of a larger 236m2 , four bed, 2 bathroom home with double garage, where land cost is 42% and house cost is 58%.

Research on Australian house build costs also tracks movements in price relative to other goods and services in the economy. REED (2008) reports on construction labour and material prices rising faster than the overall level of price inflation in the economy as measured by consumer price indices for well over a decade. Consistent with this tracking of building costs rising above prevailing inflation is the general problem of ‘affordability’. House prices rise faster than incomes, or at least the ability to borrow against income and in Australia as shown in figure 2 below the problem of affordability is compounded by a supply imbalance over the past 4 years and projected to continue to 2009 and beyond.

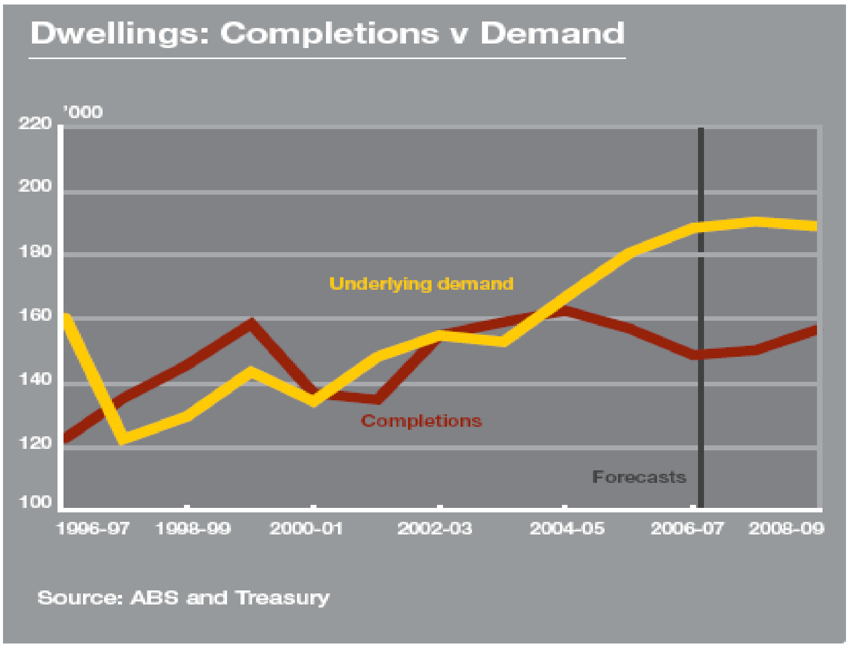

Figure 2: Australian Dwellings – Completions v Demand 1996 – 2009 projected.
(Source: Australian Bureau of Statistics and Treasury, ACT 2008)

Rawlinsons (2007) Construction cost guide provides a range of indicative cost of construction for housing with normal site and locational considerations. Costs , excluding site works and site improvements range from $800 per m2 for normal brick veneer and basic standard fittings rising to as high as $2600m2 for full brick construction to a high standard of finishes, fixtures and fittings. Costs vary by location, with Sydney, Darwin and Melbourne some 15 -20% more expensive to build than Adelaide and Brisbane.

Labour costs as input variables to a house building project will vary across different design and construction methods, however in general terms the literature suggests a range across 30 - 50% of the cost input. Australia has undergone labour market reform coupled with demographic changes and changes to immigration patterns that has impacted on labour supply to many of the building trades used in the construction of housing. A labour 'skills shortage' is evident in daily national newspapers and warning from industry groups such as the Housing Industry Association. In a recent media statement the (HIA 2008) reports labour cost conditions in Melbourne as:

> *"The skills shortage is having a big impact on the price of using a 'Tradie' in Melbourne, with an annual price increase of 8.3 per cent in the 12 months to March 2008. The latest HIA-Austral Bricks Trades Report highlights a further decline in the availability of Trades people in the housing industry, placing upward pressure on prices .We need to urgently increase the supply of affordable housing in Melbourne, but with a shortage of skilled trades people it could take longer and cost more than it needs to."*

4. Housing Costs - Cost of greater energy efficiency and lower environmental impact

Increased Regulation is reported by the Victorian Competition and Efficiency Commission (VCEC 2005) as contributing to progressive cost increases that are passed on from home builders to housing consumers. Davis Langdon (2005) found that mandatory Victorian housing Regulations could impose costs of $15,171, or 5.1% of a typical $300,000 house. Calculating, a worst case scenario, this study also found that case-by-case costs could impose a further $10,410 in costs for a $300,000 house.

Furthermore the Victorian Building Commission (2005) commissioned Jettaree Pty to investigate the additional costs of 5 star compliance in a survey of 100 -200 homes, the additional costs were in the order of 2%. In its summary of overall findings it stated that data provided by the builders indicate that the incremental costs to comply with the 5 star standard (i.e. energy rating plus water management elements) averaged:

- *$2840 for single storey houses of 100 to 160m2 – average price $118,000*
- *$3450 for single storey houses of 160 to 250m2 – average price $150,000*
- *$3950 for single storey houses of 250 to 380m2 – average price $209,000*
- *$5910 for double storey houses of 250 to 380m2- average price $311,000*

In a UK study '*A Cost Review of the Code for Sustainable Homes*' for the Housing Corporation and National Regeneration Agency (2007) adopted a different approach in assessing the likely cost difference for several forms of housing in moving to the UK Code 3 level of mandated house design. The figures were a comparative analysis based moving from additional cost of code 3 homes over traditional homes and apartments. Results for a range of 4 scenarios (based on differing options for solar, wind and cogeneration of power) are shown in table below:

	Traditional Detached house	Traditional terraced house	Low rise apartment	High rise apartment
Scenario 1	$9,955(4.8%)	$9,621(5.7%)	$5,674(3.2%)	$10,780(3.8%)
Scenario 2	$6,274(2.9%)	$6,129(3.5%)	$3,296(1.9%)	$5,938(2.0%)
Scenario 3	$6,888(3.2%)	$6,963(4.1%)	$2,081(1.2%)	$1,415(0.4%)
Scenario 4	$11,198(5.4%)	$10,446(6.2%)	Not achievable	$8,672(3.0%)

Table 2: Additional cost for Code 3 homes over traditional (converted at £ = 45cents Aus, 2006 prices)
(Source: Housing Corporation and National Regeneration Agency 2007)

As part of the project a number of suppliers of energy and water efficient technologies were contacted. The technologies reviewed comprised; solar hot water, photovoltaics, biomass boilers, wind turbines, ground source heat pumps, greywater recycling, rainwater recycling and micro combined heat and power(CHP) systems. No response was received from any of the photovoltaics companies contacted, and the responses were highly variable yet one of the key findings of the report points to opportunities arising from potential savings arising from the combined effects of an increase in demand for and much higher levels of global investment in new technologies, growth in the environmentally sustainable buildings market and some bulk purchasing opportunities. Whilst the report noted that the predictions for price falls in newer greener technologies are based largely on anecdotal information it could be said that;

> *"Some new technologies on the verge of becoming widely available may well enable Code standards to be achieved more cost effectively"*

Earlier UK studies by Oliver and Willoughby (1996) and Bell & Lowe (2001) indicated more wide variation and major differences in the methodology of the research into the additional cost of 'going green'. In Olivier and Willoughby's review of ten of the most energy efficient homes in the UK they concluded that the additional build costs for construction varied from 0 to 20 percent. The dwelling with the 20 percent increase in build costs was a one-off custom architectural design with the implication that even in the absence of the extra energy efficiency measures the build costs would be substantially greater than a more standard 'volume' built house of comparable area. Bartlett and Howard (2000) contend that in many instances construction cost consultants undertaking analysis of house building costs may be overestimating the capital costs of sustainable building features and undervaluing potential savings.

In a comparative cost benefit study of energy efficiency measures for Victorian housing, Energy Efficient Strategies (2002), data regarding costs and benefits associated with the achievement of various target performance levels were used to make estimates at the State level. The results produced positive benefit to cost ratios for a range of measures such as improved glazing, weather sealing, insulation etc. for both dollar($) energy savings and CO2 greenhouse gas reductions.

The study also looked at the cost of improvements to meet a 5 star rating by such measures as higher levels of insulation by first comparing a generic unit rate for the element e.g. cost of R3.5 ceiling insulation per m2, with rates derived from selected manufacturers/suppliers and rates from selected volume builders. The results of this analysis provided two separate rate levels; a low rate applicable to volume builders and a high rate applicable to non volume builders. The analysis revealed across a range of building products and various house improvements that volume builders generally enjoyed lower costs (in the order of 10%). The study implication was that this, if transferred the volume built home market could lower somewhat upfront costs for sustainable features incorporated into the mass housing market.

5. Housing Operational Costs

Few, extant studies are found in the Australian literature of a true whole of life cost approach to dwelling purchase, maintenance and occupancy costs. Accurate economic evaluations of housing costs based of life cycle costing (LCC) or life cycle appraisal (LCA) techniques are problematic, particularly for single owner occupied dwellings (*as opposed to multi unit housing association type schemes were maintenance and operating costs are often captured in housing scheme administration).* The difficulties lie in predicating the effective and economic life of the building (house) and its components. Nature plays a part in weather events impacting on maintenance frequency etc. and the quality of construction may be hard to assess at time of building. The lack of systematic data on maintenance and replacement of building fixtures and fittings the requirement for future predictions re interest rates (*the cost of capital*) and also future changes in regulations and taxes which impact on building costs and on going charges all add to the challenge of accurately modelling the life cycle economics of an individual building or house.

Some case study data exists nevertheless. In a study by the EPA (2004) of energy efficiency for a 3.5 star house, '*Brahminy House'*, designed by a local architect in the Queensland council area of Maroochy Shire and built for under $130,000 in 2001, the life cycle costs of both lighting and water heating were modelled, the analysis for water heating is shown in figure 3 below:

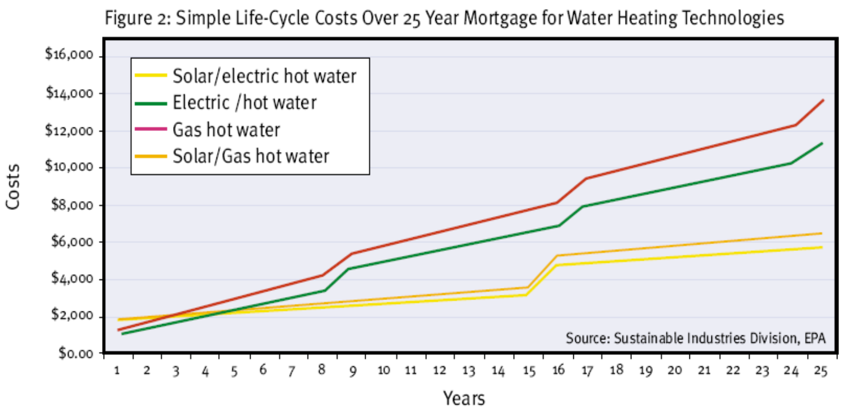

Figure 3: Domestic Water Heating life cycle costs *Source: EPA Queensland*

The data above shows lower overall life costs for heating options which incorporate a solar element. Interestingly or perhaps counter intuitively (as gas is a more calorific efficient heating fuel than electricity) is that the gas/solar example is modelled as more expensive to operate that the electric solar. This in part is explained due to the additional cost of separate gas mains in the analysis, whereas an existing electricity mains and the cost associated therewith has been assumed as a sunken cost in the general electrical systems cost provision to a standard house. In a South Australian analysis, Oliphant (2008) has also alluded to this '*misconception of the universal greenhouse gas benefit of using gas*' in her work on monitoring energy consumption in small households.

Some international researchers such as Gluch and Baumann (2004) argue the value and usefulness of life cycle costing techniques across a range of environmental decision making whilst a more micro focus as specifically applied to renovations to existing high rise flats is evident in Gorgolewski (1995) where using the output from an early version of the BREDEM domestic energy calculation model together with estimated capital improvement costs and component life measures he has modelled the cost effectiveness of various alterations to a domestic high rise dwelling using a Savings-to-Investment ratio approach.

This ratio is simply the Present value of the total lifetime energy saving divided by the Investment cost in present day terms. Though modelling various individual housing improvement measures on a crude ratio, Gorgolewski points to the problems of LCA analysis where investment returns or savings are not constant and can change when other measures are installed in the dwelling or when energy prices fluctuate. Similarly, annual energy use is not a simple function of the variable building parameters, and even less so of the cost of the retrofit measures which affect these parameters.

In one of the few Australian studies to consider the cost effectiveness of improved housing environmental performance, McNicol (2004) modelled a range of energy savings for both building 'shell' and 'heating and cooling elements' of houses (new and existing). In this study on Energy Efficiency Improvements(EEI) measures in the residential sector in Victoria the baseline or 'business as usual'(BAU) refers to existing standard housing specification before improvements are made such as weather stripping or moving to satisfy 5 star compliance building code measures. His work suggests clear and quantifiable benefits, albeit at a macro level for capital improvements that will improve energy efficiency and thereby lower operational costs. Table 3 below shows figures for total annual energy saving amounts for corresponding capital improvements to homes across the state of Victoria, Australia over the study period.

EEI Measure	Energy Savings (PJ pa)	Energy Savings (%)	Energy Savings ($M)	Total Cost ($M)	Payback (Yrs)
Weather stripping & sealing	7.3	3.0%	$81.2	$423	5.2
Increase all States to 5-Star	8.8	3.6%	$173.8	$1,132	6.2
Insulate existing houses	3.0	1.2%	$34.1	$639	18.8
Improve efficiency of or replace gas & solid fuel heaters	20.7	8.5%	$162.4	$483	3.0
Improve efficiency of ducted heating and cooling systems	3.0	1.2%	$41.4	$136	3.3
Improve efficiency of RACs	1.2	0.5%	$41.9	$1,000	23.9
Replace electric heating with RACs	2.6	1.0%	$91.8	$1,171	12.7
Total (all measures < 6.5 years)	**39.9**	**16.4%**	**$458.8**	**$2,175**	**4.7**

Table 3: Housing Energy Efficiency Improvement Measures – Savings and Costs (Source: SEAV 2004)

McNichol (2004) further models appliance related EEI measures i.e. lighting systems, refrigeration and washing which given the contribution to household occupancy costs as shown in figure 4 below are critical to an evaluation of true life costs of housing occupancy.

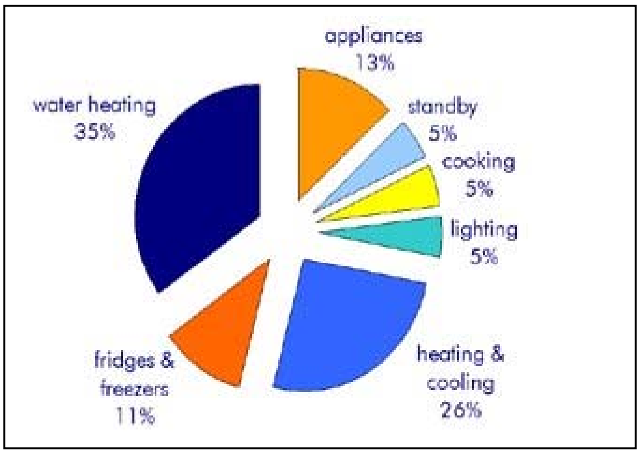

Figure 4: Breakdown of typical Australian (all climates) house energy consumption

6. Housing Sustainability – Building regulatory response and Rating systems

Housing climate change regulatory responses clearly promote the need to reduce energy usage, particularly over the operational life of a house. The Australian Building Codes Board, (ABCB, 2000) produced a comprehensive report for the Australian Greenhouse Office(AGO) 'International Survey of Building Energy Codes' looking at Australia, Canada, New Zealand, Singapore, United States of America and United Kingdom. The intent was to compare Australian practices and regulation with these particular countries. Some regional variations in regulation and practice were discovered, however in end their final report they came to a view that they essentially were looking at overseas practices which were not significantly different to Australia's at that time , as quoted below in section 13.3;

> *"Most overseas codes have a relatively simple national approach for houses that usually cover the envelope R-value, the envelope seal, a limit on the envelope window to wall ratio and the insulation on SWH piping and ductwork."*

Horne, et al (2005) from RMIT, Melbourne, produced an *International comparison of building energy performance standards* which looked beyond the ABCB data, in comparisons with regions of Canada and the United States of America concluding;

> *"More stringent building codes DTS* requirements are currently practicable in similar lightweight, large house construction regimes to Australia, and these provide significant environmental benefits in reduced energy demand. The current efficiency of Australian homes is well below comparative international standards in terms of energy efficiency and greenhouse gas emissions. The adoption of 5 stars as a minimum standard is clearly a step forward for energy efficiency of Australian homes. However, actual typical house designs in comparison countries use significantly less energy than the proposed 5-star standard. This demonstrates an opportunity for significantly more stringent standards and further reductions in energy demand in the future."*
>
> **DTS (Deemed to Satisfy)*

Recent (ABCB 2007) housing regulation changes such as mandatory adoption of 5-star for both renovation and new housing have strong backing from Government and environmentally aware advocates of energy conservation. In conjunction and tied to compliance and evaluation tool, approved software packages Accurate™, First Rate (ver 5) and BersPro™ for the purposes of complying with ratings based assessment of building compliance to mandated performance. Compliance reports list features of house design and construction that are identified as critical to the achievement of a rating whilst underlying mathematical algorithms model thermal performance based on input values for materials and building components.

The software packages mentioned above are referred to in the literature as 2nd generation as they now regarded as enhanced versions of earlier software models and deemed more accurate and sophisticated in their modelling of building thermal performance. Enhancements include more accurate mathematical modelling of thermal transmittance and air flows, greater scope to pre select composite building elements, a more detailed library of construction types and more detailed climate zone data.

It is beyond the scope of this research paper to examine in detail the technical aspects of house energy rating, however it is noteworthy that some i.e. Williamson, T (2004), Szokolay (2006) and Kordjamski (2005), question the accuracy and validity of house energy rating based tools. In contrast Howard's (2004) work is of an international comparative study on Building Environmental assessment methods in which he concludes;

> *"Considerable progress has been made in recent years in the evolution of environmental assessment methods and promoting their use by the industry. Also, improved performance based metrics, underpinned by better research for a broader range of sustainability measures in existing assessment and certification systems"*

6. Conclusion

Some key questions of future housing sustainability and affordability require careful consideration by society as climate change impacts evolve. A focus for some researchers is on through-life or lifetime evaluation and modelling of house options under various climatic conditions, development of tools for undertaking life cycle costing and potential integration of findings into future policy and regulation.

A central premise of the research and studies presented in this paper is that of a perceived trade-off between residential building (environmental) performance and 'cost' although this appears to be largely examined in studies looking at individual 'case study' houses or bespoke housing modifications promoted as cost effective measures to improve housing environmental performance.

The studies presented in this paper clearly show, that across Australia and for some international cases, the imposition of new energy standards for housing (such as 4 star going to 5 star) have had two major effects i.e. reduction or potential reduction in household energy consumption whilst also increasing capital cost or upfront housing costs. This 'increased cost' is seen as reasonably modest when total housing development costs (land and building) are factored in. Whether these costs remain regarded as such or that future economic drivers will increase technological innovation and change (as well as cost) in housing products for greater sustainability is an important aspect for current and future studies.

Attaching more rigorous research study around costs of housing (capital and operational) is fundamental to examining the problem of 'affordability' attached to increasing the housing stock to cater for increased housing demand. And, where questions of greater levels of housing sustainability or energy efficiency (such as 6/7 star and beyond) need to be framed within and examine rapidly changing climate scenarios and evolving markets for housing energy and utilities costs.

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