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Energy Efficiency Housing in South Australia – A Gap Analysis between the Expected and Actual Benefits

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Abstract

In Australia, the trend of being energy efficient within modern multi-storey buildings has been more popular in recent years. However, lack of attention has been given to the residential housing in terms of the perceived benefits and actual performance. The purpose of this research is to investigate the gap between the original expectation and the occupants' satisfaction in residential energy efficient dwellings. This research also aims to analyze the relationship between the satisfaction level and both the initial as well as the ongoing cost of energy efficient dwellings in South Australia. Finally, it determines whether the initial cost of residential green building is proportional to the financial savings. The research methodology comprised a literature review and data collection through the use of questionnaires. The literature review provides a background of knowledge that has been studied on green buildings. The findings of this research have indicated that South Australians were satisfied with the perceived benefits of the residential energy efficient buildings since occupation. However, the higher up-front cost has brought the households various concerns including their affordability and actual financial savings. The major benefits that are brought by energy efficient housing including reduced in energy cost and consumption, and improved thermal performance. Through the gap analysis, a positive outcome has been found, indicating that actual performance of energy efficient housing is exceeding the users' expectation. It is suggested that the State Government as a leader of the energy efficient housing promotion needs to provide more financial incentives in order to disseminate the housing option while moving towards a sustainable future. Meanwhile, the local builders need to improve their understandings on energy efficient housing, while providing more energy efficient housing options to the South Australian market.

Keywords: Energy efficient housing, green buildings, South Australia

1. Introduction

The concept of sustainable development has been advocated since late 1980s and the idea of building green in order to respond to the call of achieving sustainable development was first brought up in the "Architects' Chicago Declaration" during the International Union of Architects Congress in 1993 [1]. The Green Building Council Australia (GBCA) was found in the year of 2002 in order to response the need of encouraging and promoting the green building practices across the country as a not-for-profit organisation. There are many research articles which focused on investigating the benefits and barriers of commercial green building design and construction since then [2, 3, 4, 5]. However, less attention has been given to the residential sector. Limited investigations have been conducted to look into the residential housing especially in South Australia regarding to the perceived benefits and actual performance. In fact, both 'residential and commercial buildings in Australia are responsible for 23 per cent of the nation's greenhouse gas emissions' [6]. Hence, there is a need to investigate the current development of green building practices in terms of the perceived benefits and actual performance in the residential sector.

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1.1. Why do we need green building?

Global warming which is mainly caused by the greenhouse gas (GHG) emissions has brought up the public's attention in recent years. Extreme weather condition as a major side effect of global warming has been accounted for huge financial cost in Australia. The Parliament of Australia 2013 has found that total financial estimated cost of extreme weather events in Australia ranging from approximately 900 million dollars to 4 billion dollars annually. Furthermore, 'climate change can significantly impact on the total energy consumption and GHG emissions of residential buildings [7]. In 2005-2006, the residential building sector in Australia contributed around 13 per cent of the total national GHG emissions [8], and the energy demand is anticipated to keep rising due to '... the projected population growth, the trend of smaller family sizes, and the desire for more comfortable indoor environment and larger houses ...' [9]. Hence, there is an urgent need to be green in order to mitigate and adapt the climate changing climate.

1.2. Benefits and barriers

Building green architectures is a way to respond to the climate issues. The most significant advantage that is brought by green building is to reduce the overall energy consumption and cost as well as to enhance the occupants' satisfaction through the incorporation of building design, materials selection and construction delivery [9]. Ries et al. [10] further proved that green building can bring positive impact on the occupants' health and productivity, indoor environmental quality and consumption level of energy resource. However, there are barriers that need to be considered when promoting green buildings. A Swedish paper which focused on investigating the cost of going green has shown that the overall cost can be a concern. Although the difference of total investment cost between residential green building and conventional housing is said to be less than 10 per cent, the cost of design, materials and labour for the green ones tend to be approximately 10 per cent higher than the conventional ones [11]. When there are design variations or market fluctuation, all costs will increase and hence the residential green building will become less affordable. While the saving of operation cost in green building can be up to 20 per cent - 40 per cent, '... achieving the estimated energy efficiency may require more system adjustment than usual' [11], and this has posed a challenge as in balancing the system. Occupants may be frustrated by the above benefit issues. The installation of an appropriate individual metering system for data collection within each household has posted another significant expense to the cost. To sum up, there are uncertainties that lie in the calculation of the total cost.

Occupants' behaviour and understandings directly contribute to the level of energy consumption, which is also the actual performance of the green building. Gill et al. [12] commented that 'whilst behavioural change is a major untapped route for energy savings, the varying knowledge, attitudes, and abilities of occupants presented a fundamental barrier to its implementation and optimization'. When occupants' behaviour is not ready to adapt the green practice, it is less likely to achieve the target of reducing the energy consumption.

2. Green Buildings in South Australia

South Australia has promptly responded to the trend of being green in building development. In 2002, Premier Mike Rann announced the launch of Lochiel Park Green Village and stated that the project will become the nation's model [13]. The project is delivered by the Urban Renewal Authority URA (formerly Land Management Corporation), and it is to exemplify the objective of 'Attaining Sustainability' in the South Australia's Strategic Plan (Campbelltown City Council). The project will undergo a 9-year long monitoring program to analyse real time data of all energy consumption in the households throughout the period [13]. There are other upcoming green residential projects including the redevelopment of Tonsley and Bowden which were announced by the Renewal SA in 2013. Both of the projects will be assessed against the Green Star rating scheme which is monitored by the GBCA [6].

2.1. Green affordable housing in South Australia

Cost and affordability is considered as a combined critical factor which influences people whether to build, rent or renovate a dwelling regardless of whether it is an energy efficient or conventional one. In South Australia, providing affordable and energy efficient housing has been listed as one of the seven strategic priorities of the State. The State Government has then further addressed the importance this type of housing through the publication of the South Australia Strategic Plan in 2011. According to the Plan, the State aims to '... lead the nation over the period to 2020 in the proportion of homes sold or built that are affordable by low and moderate income households', while improving '... the energy efficiency of dwellings by 15 per cent by 2020' [14]. Furthermore,

Renewal SA, which is established an official organisation is ‘... responsible for increasing the supply of housing that is affordable so that South Australians have opportunities to live where they want at a price they can afford’ [15].

Nevertheless, it is not easy to identify how to produce affordable housing with energy efficient elements featured within. Boehland [16] outline the considerations that apply to all affordable housing, these including location; the costs of initial, operations and maintenance; health and safety of environment, and; occupant’s satisfaction. Blaess et al. [13] stated that ‘the cost of living sustainability can be high due to the initial lack of volume in the market for some of the new technologies and upfront cost premium’. In terms of initial cost, Tollin [9] stated that the investment premium involved in green building could range from less than two per cent to more than ten per cent when compared to the costs of conventional construction. In 2009, a cost analysis was conducted to study the cost of green for affordable housing in the cities of Seattle and Portland in America. The result of the analysis has shown that there was a 4.6 per cent difference in construction cost in average between the green-rated buildings and standard buildings [17]. Occupants of green housing may not need to face the direct impact of the extra cost if receiving subsidise from the government, however, ‘... higher first cost reduce the number of affordable housing units completed’ [16]. In fact, Australia as one of the leading developed countries is still facing housing affordability problem. In the year of 2008, the Labour Government commented that housing affordability dropped an all-time low [18]. The situation was then improved, and according to the latest “HIA-Commonwealth Bank Affordability Report” which was released in March 2014, the affordability index maintains a positive grow compared with the figure recorded a year ago [19]. However, the Report pointed out that the improvement is ‘... largely due to much more lower interest rates, growth in earnings, and relatively muted home price inflation...’. It should be noted that the influencing factors will not always stay in place since the performance of the economy is unpredictable. Once the favourable factors are ceased, the price of housing may not be affordable. Funding from the government to provide affordable housing to households will become necessary in this case, however, energy efficient features may not be included within due to the extra cost as previously mentioned. The features is no longer to be the priority anymore, in other words, they are not “needs” but “wants”. Hence, it is deduced that green affordable housing is still facing a financial barrier in term of broader promotion.

2.2. Post-occupancy evaluation

According to Zimmerman and Martin [20], the earliest definition of post-occupancy evaluation (POE) can be traced back to 1980, and at the time POE was regarded as the assessments of the effectiveness for human users of occupied design environments. Hua [21] and Meir et al. [22] defined POE that it is a process and platform for systematic evaluation and studies of the performance of buildings during the occupation stage of a building. It should be noted that the emphasis of a POE is not to collect technical data and performance of a dwelling; instead, it is more of a user-perspective based assessment tool. The feedback from the occupants will be used for improving the current living environment within the building as well as guiding the future building developments which are of the similar nature. Generally, a POE would include the aspects of thermal comfort (including ventilation, heating, and cooling); illumination and visual comfort; occupants’ satisfaction and behaviour; physiological and psychological comfort; health and safety; aesthetic quality of building; and identification of system defects. The general tools and methods that can be used for conducting a POE including surveys, questionnaires, cohort studies, observations, task performances tests, and document analysis [22].

The GBCA [23] has suggested that a dwelling can be green through a range of initiatives and technologies as cited below:

1. Passive design;
2. On-site generation of energy from renewable sources;
3. Efficient appliances and light fittings;
4. Purchasing green power;
5. Introducing alternative ways to learn; and
6. Optimising, upgrading or removing HVAC systems

In order to investigate the various aspects including the users’ satisfaction in accordance with the occupied buildings’ functions and performance after implementing the above strategies, post-occupancy evaluation (POE) is sometimes carried out for the purpose of further study. Nevertheless, the perceived benefits which are brought by the above implications have not been fully assessed against the users’ satisfaction and the ongoing cost in depth in Australia.

Meir et al. [22] conducted a synoptic overview of POE studies. There were total 58 papers found which involved the use of POE. However, only seven of them were related to the residential sector, indicating that not much

attention has been given to the users' response from the residential sector. The POE studies of those seven papers were conducted in different countries, including the Israel, Japan, Scotland, United Kingdom, and United States.

3. Research methods and analysis

The aim of this study was to carry out a gap analysis between the expected and actual satisfaction of energy efficient housing from the point of view of occupants in South Australia. University Ethics approval to conduct data collection from target audience has been obtained prior to the invitation. The potential respondents were sourced from the occupants who were living in energy efficient dwellings within Lochiel Park [24]. Respondents were invited to complete the questionnaire throughout personal home visits. The total number of energy efficient houses built in Lochiel Park was 72. 45 surveys were completed, representing a total response rate of 62.5 per cent.

The respondents were asked to explain about their decision on purchasing an energy efficient house. According to their replies, the biggest momentum that inspires the respondents to purchase an energy efficient house is "to support environmental sustainability", followed with, "to improve quality of living, occupational health and safety, and productivity", and "to adopt the green philosophy". Financial factors including affordability and future investment value were the least chosen answers from respondents influencing their purchase decision. From the cost perspective, 84.44 per cent of the respondents noticed that there is a significant price difference between energy efficient and conventional housing. It includes the additional cost on the choice of construction materials, architectural designs and the energy efficiency appliances. The total could easily amount to extra of \$100,000 and more.

The following Table 1 illustrates the various levels of satisfaction with respect to each individual question by a likert scale of 1 (very dissatisfied) to 7 (very satisfied).

Table 1. Summary of levels of satisfaction to research questions

very dissatisfied	dissatisfied	slightly dissatisfied	Neutral	slightly satisfied	satisfied	very satisfied
1. Respondents' satisfaction level after occupying in energy efficient housing while considering the overall performance and cost						
0.00%	0.00%	0.00%	2.22%	2.22%	46.67%	48.89%
2. Is energy efficient housing a satisfying (worthwhile) investment in long run considering the overall performance and cost						
0.00%	2.22%	0.00%	4.44%	4.44%	35.56%	53.33%
3. The respondents' original expectation towards energy efficient housing						
0.00%	2.22%	0.00%	13.33%	24.44%	53.33%	6.67%
4. The respondents' satisfaction towards energy efficient housing after occupation						
0.00%	0.00%	2.22%	2.22%	6.67%	55.56%	33.33%

Compared to the conventional houses that the respondents previously lived in, the majority of respondents have noticed that there are tangible differences in energy consumption, between conventional and energy efficient dwellings. Respondents who have noticed the presence of differences were then asked to select the aspects of differences that they have experienced within their energy efficient building. Amongst all the differences, the energy performance of their energy efficient home in terms of cost and consumption are considered to be the most obvious improvements that can be identified. Furthermore, improved thermal performance is also an area that has been addressed by the respondents.

After having a basic review on the cost and dwelling performance issues, the survey then combined the considerations of cost, performance and living experience together. The respondents were asked to rate their satisfaction based upon the above considerations. There is a clear stance of the majority respondents that they were very satisfied with their energy efficient homes while considering the overall cost and performance. The options of "very satisfied" and "satisfied" were mostly rated, representing a combined percentage of 95.56 per cent. None of the respondents had any negative views on the current living dwelling as no count was recorded for all negative options including "slightly dissatisfied", "dissatisfied" and "absolutely dissatisfied".

When it comes to the question of whether energy efficient housing a worthwhile investment in long run considering the overall performance and cost, 88.89% of respondents indicated that it is still a worthwhile investment. However, negative comments were also found, including "(the respondent's home) has not performed as well as expected", "not much saving if you consider the (up front) investment (cost)", and "not (worthwhile) as a rental (option)".

In order to further investigate the difference between expectation and level of satisfaction of their energy efficient housing, the respondents were asked about their expectation before and satisfaction after moving into their energy efficient homes. According to the Table 2 below, majority of respondents had high level of expectation towards energy efficient dwelling before occupation, and high satisfaction were recorded after occupation. The

recorded scores of both expectation and satisfaction level were used to produce a mean score for each level. A gap difference of 0.69 is shown, representing a small and positive change in satisfaction level.

Table 2: Gap analysis between the original expectation and satisfaction after occupation

Answer Options (expectation)	No.	Mean	Answer Options (satisfaction)	No.	Mean
Absolutely no expectation	0	0.00	Absolutely dissatisfied	0	0.00
No expectation	0.04		dissatisfied	0	0.00
Slightly no expectation	0	0.00	Slightly dissatisfied	1	0.07
Neutral	6	0.53	Neutral	1	0.09
Slightly high expectation	11	1.22	Slight satisfaction	3	0.33
High expectation	24	3.20	Satisfied	25	3.33
Very high expectation	3	0.47	Very satisfied	15	2.33
	45	5.47		45	6.16

4. Conclusions

The results of questionnaire show that the occupants of Lochiel Park who participated in the questionnaire survey tend to pursue a sustainable and quality living life style. Meanwhile, the financial factors are not considered as the most influential factors affecting the purchase decision of the energy efficient house. There is an obvious cost difference between conventional and energy efficient housing. While the majority of survey respondents believe that the cost difference can be more than a hundred thousand dollars, the selection of construction materials, installation of energy efficient appliances, and architectural design of energy efficient housing are considered to be major factors that increase the investment cost in advance. The respondents realise that there are tangible differences in the aspects of reduced in energy cost and consumption, thermal performance, lighting and general living experience. Considering the overall performance and cost, the majority of respondents have a positive stance that energy efficient housing is a worthwhile investment in long run. There is a shift indicating that those who had a relatively neutral and slightly high expectation to energy efficient housing, move toward a more satisfied attitude after occupation. The gap analysis has reflected that there is a minor positive difference between the expectation and satisfaction level before and after occupying in energy efficient dwelling. Finally, most of the respondents look forward to promoting the energy efficient housing as a future housing option to family and friends. The respondents from the home visits agree that it is important to be energy efficient in order to reduce environmental impact as well as to achieve a sustainable future. The positive phenomenon has provided a solid foundation to support the broader promotion of residential green building in South Australia. However, since the higher up-front cost is considered as the major barrier for the broader promotion, more financial incentives from the State Government are needed in order to attract the low income households as well as those who have a relatively low interest in environmental issues. Otherwise, it will not be affordable. Meanwhile, the government needs to educate the public about energy efficiency with actual facts and numbers gathered from the existing energy efficient dwellings. This can improve the public's interest while providing a momentum for South Australians to move towards a sustainable future. On the other hand, some builders were not able to answer the owners' inquiries regarding the energy efficiency, and many believed that the builders did not fully demonstrate their professionalism due to lack of experience. This has reinforced the importance of additional training and education to the builders.

Whilst South Australians agree that it is important to be energy efficient in order to reduce environmental impact as well as to achieve a sustainable future, this research has found that up-front cost is still the major barrier precluding many South Australians to choose energy efficient housing as a potential housing option. It is necessary to further investigate the factors which cause the cost difference, and hence, to determine suitable strategies to reduce the differences. On the other hand, there are uncertainties regarding the actual financial savings that energy efficient housing can provide to the households in a long run, there is a need to conduct further research on how the uncertainties will impact on the actual financial savings.

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