Tan, T. H. (2013), "Assessing Green Home Performance: Case Study of Iskandar, Malaysia", Proceeding for Asia Pacific Network for Housing Research (APNHR) Conference 2013, Global Housing Dilemmas: The Ways Forward, Jointly organized by University of Malaya and University of Hong Kong.

# Assessing Green Home Performance: The Case Study from a Developing Country

Tan, Teck Hong[1]
Sunway University Business School, Sunway University, Malaysia

**Abstract:** This paper reviews data from a survey to determine the satisfaction level of homeowners towards their residence in terms of green features in Iskandar Malaysia. In this survey, 295 copies of questionnaire forms were being distributed to green home owners and 116 forms were returned. Results show that homeowners are most satisfied with the green features of high ceiling, north-south orientation, double-glazed panel glass doors and windows, solar panel system and landscaped parks with facilities. Rain water harvesting system and low-flow water fixtures, on the other hand, are the least satisfied green features among homeowners. Greater knowledge of green home attributes that influence housing satisfaction could lead to better understanding and prediction of decision making in determining homeowners' needs.

**Key words:** Green Home, Performance, Housing Satisfaction, The Aspiration Gap Approach, Iskandar Malaysia.

## 1. INTRODUCTION

Green homes generally take full advantage of the sun, wind and rainfall to help supply the energy and water needs of residents. With the government's latest move to encourage the adoption of energy-saving measures for residential properties, many green homes are built in the country (Green Building Index, 2013). In order to assess the performance of green homes, housing satisfaction has become the most commonly used in evaluating housing conditions and situations (Lu, 1999; Adriaanse, 2007; Erdogan et al., 2007). There have been several studies on housing satisfaction in Malaysia, and these studies are focused primarily on conventional homes. However, to date, less empirical studies has been conducted to appraise the performance of the quality of green homes in the country. Therefore, this paper is to determine homeowners' preferences for green home attributes by examining the relationship between these attributes and homeowners' behaviors in terms of housing satisfaction.

## 2. THE STATE OF KNOWLEDGE

### *2.1 The Evolution of House Types in Malaysia*

Households' preferences are continuously transforming and this is well demonstrated by the evolution of houses styles in Malaysia, which will display households' preferences on house styles in Malaysia from past till present. House types such as terrace house, detached house, apartment and condominium are the evidence of continuing advancement to meet households' preferences. House types take account of the house form, roof form, decorative aspect, entire house component, design, building method and materiality (Ariffin and Talib, 2005).

The evolution of house types in Malaysia began with Malaysia's vernacular house, particularly the 'suckling elephant house'. This is a type of conventional Malay house and it is also commonly known as a regional style of village house (Bahauddin and Adullah, 2008). The structure of this house is known by the shape of its roof whereby the formation of the main house is higher than the roof of the veranda. Thus, the structure is viewed alike to a calf (baby elephant) being fed by its mother. In fact, traditional Malay houses are environmental-friendly and sustainable because these houses are in fundamental nature with post and beam constructions elevated on stilts, with gabled roof, penetrable walls and flooring. Furthermore, this type of house is generally constructed by the inhabitants of the community to fit with their socioeconomic, cultural and environmental needs (Jayapalasingam, 2009).

In the 1600s, the Spice Trade between the East and West encouraged more immigrants and traders from India, Arab, China, Persia, Indonesia and others to Malaya Peninsular. These people had brought in their culture and house-building techniques, for instance, immigrants and traders from Minangkabau, Sumatra bought in the shallow 'U' shaped curved roof or the 'Ruman Gadang' (Chen, 1998). During the Dutch occupation in the 1700s, townhouses or row houses were constructed in Melacca. Then, in the 1800s, during British involvement in the Malaya Peninsular, the Malayan bungalow, which was a combination of European and local elements, emerged such as the 'Bok House'. In the 1900s, when British set up the Straits Settlements of Penang, Melacca and Singapore in 1826, new tin mines were opened in states like Perak and Selangor, which led to the development of small towns. Those laborers in the tin mines, mostly Chinese immigrants brought in their conventional house style and as a result, the two-storey shop houses were built (Chen, 1998).

During the 20th century, flats and condominiums, terrace houses, semi-detached and detached houses were introduced and these houses were inhabited by a great number of urban dwellers. The housing industry will continue evolving to suit the ever-changing households' preferences (Tan, 2008; Tan, 2012a). Recently, there is a growing interest in constructing houses that incorporate sustainable and green features (Green Building Index, 2013). Being a tropical country with abundant sun and rain and the prevailing southwesterly and northeasterly winds, there are many opportunities for developers in Malaysia to construct green homes.

### *2.2 Housing Satisfaction*

Measures of housing satisfaction are often used to assess the actual performance of all types of housing. In this study, it has been used

1 Associate Professor, Sunway University Business School, Sunway University, Malaysia; Email: waltert@sunway.edu.my; waltertanth@gmail.com

as an evaluative measure for judging the success of green housing development constructed by a leading developer in the country.

There have been different approaches to conceptualize housing satisfaction. In the purposive approach, satisfaction is conceptualized as a measure of the degree to which the environment facilitates or inhibits the goal of the user (Canter and Rees, 1982). This approach, which is rooted in a cognitive view, emphasizes goals or associated activities in relation to the attributes of the physical environment. For example, a household may live in a green home with the purpose of improving the quality of life as well as cost savings and if these intentions are met, it is possible that they could gain a high level of housing satisfaction.

However, households are not only goal-oriented but also value affective relations with the housing situation. The aspiration gap approach is the more common conceptual framework of housing satisfaction, describing housing satisfaction as being a comparison between households' actual and desired housing and neighborhood situations (Galster, 1987). Following this approach, a high degree of congruence between actual and desired housing and neighborhood situations is an indication of a high rate of satisfaction because household's needs and aspirations are met by their housing conditions.

Based on previous literatures, there is little doubt that objective and subjective measures of housing attributes are significant factors of housing satisfaction (Lu, 1999; Roper et al., 2009; Amole, 2009; Tan, 2012b). Objective measures refer to the actual measurements, such as the presence, the lack of, or quantities of attributes while subjective measures refer to perception, emotions, attitudes and intentions towards the housing attributes. In this paper, only objective measures of green housing attributes are used to assess the performance of the quality of green homes.

### *2.3 Green Home and Its Advantages*

As explained by most researchers, green homes are constructed with the following green features and characteristics in order to reduce the residential sector's impact on climate change:

- Installation of rainwater harvesting system for irrigating plants
- Use of low carbon-emitting construction materials, such as low volatile organic compound (VOC) paints, recycled content wall and floor tiles
- Use of solar roof shingles to generate renewable energy
- Double-glazed glass panels to reduce heat transmission
- Use of low-flow water features such as water efficient sanitary appliances and tap fittings
- Lush and landscaped greenery with water features (pond)
- Equip with energy efficiency appliances such as LED lights, and air conditioning system

There is a rising attention in the physical structure of environmental-friendly buildings (Eicholtz et al., 2008; Furst and McAllister, 2011). This is because the built environment accounts for an estimated 30% of the total primary energy utilization and greenhouse gas emission worldwide (Bond, 2000). As pointed by Feliciana and Prosperi (2011), a major share of GHG emission from the residential sector could be due to fast and cheap construction practices without making use of energy-efficient measures and renewable energies. There has been a growing focus on energy efficient construction methods in the built environment. In the past, housing developers have relied on conventional processes in constructing houses. However, these processes are unsustainable in the long run. Therefore, sustainable features in constructing homes are an important contributor to achieve sustainable development and practices. Environmentally sustainable homes normally have low carbon footprints, which is particularly important in the construction industry as this industry is a major consumer of raw materials (Lovell, 2004; Feliciano and Prosperi, 2011).

Although the cost of developing a green building may be more than that of a conventional building, several studies have demonstrated the financial advantages of green buildings both for residential and commercial buildings. The most frequently cited financial benefits of green building are the increase in rental as well as the property value (Furst and McAllister, 2009; Miller et al, 2008; Pitts and Jackson, 2008; Yu and Tu, 2011). Green homes generally use key resources like energy and water more efficiently than traditional homes, which could result in savings in utilities bills (Ling and Gunawansa, 2010). These externalities have contributed to the overall reputation of the property.

## 3. METHODS

While there are a limited number of studies of green home in Malaysia to provide a case study, this paper focuses on 295 green houses developed by one of the leading developers by examining responses to the variation between the expectations and realities of key green home attributes as experienced by homeowners who reside in their green homes for at least 6 months in Iskandar Malaysia. Iskandar Malaysia is suited for the purpose of this study because it is Malaysia's proposed model of a socio economically and environmental sustainable development zone with excellent connectivity, infrastructure services, and environmental sensitivity (Rizzo and Glasson, 2012).

In this survey, only semi-detached and detached houses in these townships were considered for this study. Reason being that the Malaysian government has recently mandated that builders of semi-detached and detached houses to put in place energy efficiency features, such as rainwater harvesting system. Of the questionnaire, 295 sets were hand-delivered, and 116 responses were received with the assumption that the sample was representative of the population. The response rate was 40 percent.

In order to determine the effects of green home attributes on housing satisfaction, regression analysis was performed. The outcome variable in the analysis was housing satisfaction. It has been common, in measuring housing satisfaction to use an index or highly correlated items rather than a single-item variable. Following Tan (2012b) and Tan (2013), the construct of housing satisfaction was measured using an index based on four questions (alpha = 0.892) which were: "I am satisfied with living here in general", "I do not intend to move to another type of housing in the near future", "I will recommend my friends/relatives to move into my neighborhood" and "I intend to buy another property in the same neighborhood". Responses were scored on a five-point scale of 1 (strongly disagreed) to 5 (strongly agreed).

Furthermore, respondents were asked to express the extent to which they are satisfied or dissatisfied with different types of green features using a dichotomous scale (1 = yes; 0 = no). In-depth interviews were also conducted to ascertain the expectations and attainment of respondents and to discuss issues in relation to green home attributes.

The degree of housing satisfaction may tend to vary by life cycle attributes, such as gender, maritial status and education attainment. In this study, these variables are controlled to identify the green home attributes that are significant in influencing green housing satisfaction. Given the preceding discussion, the research question of this paper as follows:

*To what extent do the importance of green home attributes relate significantly to housing satisfaction after controlling for socio-demographic characteristics of green home owners?*

## 4. RESULTS AND DISCUSSION

### *4.1. Satisfaction level of Green Features*

In this analysis, two regression equations were examined. The first equation was to assess the effect of green home attributes on the satisfaction level of green home and the second one was to examine whether green home attributes predict housing satisfaction after controlling for differences in socio-demographic characteristics of respondents, such as gender, marital status and education background. As shown in Table 1, the Adjusted $R^2$ values of the first and second regression equations explained about 73.6% and 75.1% of variation in the level of housing satisfaction, respectively. There was no much difference in the explanatory power of two models, indicating green features influenced more strongly than socio-demographic characteristics. However, only the results in the second model were emphasized and examined in details in the following analysis.

From the study, it seems that respondents are interested in the experiences they can get from consuming the product. The following tables were to show the satisfaction level of the respondents in Iskandar Malaysia based on specific green features of the property (Table 1).

**Table 1: Regression Analysis**

| | **Model 1** | | **Model 2** | |
|---|---|---|---|---|
| | B | t | B | t |
| Constant | 2.619** (0.103) | 25.392 | 2.259** (0.154) | 14.675 |
| Water features in the neighborhood | 0.233** (0.081) | 2.886 | 0.213** (0.079) | 2.698 |
| North-south orientation | 0.383** (0.071) | 5.360 | 0.389** (0.070) | 5.544 |
| Low-flow water features | 0.037 (0.085) | 0.436 | 0.118 (0.087) | 1.355 |
| Double-glazed panel glass | 0.179** (0.063) | 2.825 | 0.127* (0.066) | 1.923 |
| Energy saving appliances | 0.102 (0.065) | 1.578 | 0.093 (0.069) | 1.358 |
| Rainwater harvesting | 0.082 (0.064) | 1.274 | 0.047 (0.067) | 0.706 |
| Recycled content tiles | 0.013 (0.065) | 0.192 | 0.064 (0.067) | 0.960 |
| High ceiling | 0.477** (0.072) | 6.648 | 0.477** (0.074) | 6.480 |
| Landscaped greenery | 0.290** (0.059) | 4.904 | 0.257** (0.060) | 4.319 |
| Solar panel system | 0.255** (0.069) | 3.688 | 0.271** (0.068) | 3.965 |
| Primary education (ref) | | | | |
| Secondary education | | | 0.302** (0.105) | 2.876 |
| Tertiary education | | | 0.319** (0.112) | 2.858 |
| Males | | | 0.066 (0.060) | 1.093 |
| Married | | | 0.070 (0.089) | 0.784 |
| | | | | |
| $R^2$ | 0.759 | | 0.782 | |
| Adjusted $R^2$ | 0.736 | | 0.751 | |
| Std error of estimate | 0.28056 | | 0.27205 | |
| Durbin-Watson | 1.095 | | 1.083 | |
| | | | | |

*** Significance at the 0.01 level; Significance at the 0.05 level*
*Figures in parenthesis are standard errors.*

The results in Table 1 revealed that all other thing being equal, high ceiling (β = 0.477), north-south house orientation (β = 0.389), lush and landscaped greenery (β = 0.257), solar panel system (β = 0.271), and water features in the neighborhood (β = 0.213) were statistically significant related to housing satisfaction at the 0.01 level. However, double-glazed panel glass door and window (β = 0.127) was only statistically significant at the 0.05 level.

In this survey, respondents generally satisfied with green features to improve indoor air quality such as high ceiling and north-south house orientation. Respondents generally agreed that high ceiling homes allow cross ventilation for a cooling ambience. Also, homes oriented in the north-south position that could reduce heat by minimizing direct sunlight into the house. The results also implied that respondents prefer to live in a home with lush and landscaped greenery as the trees and shrubs surrounding the residential development could serve as the natural shades to cool down the house and reduce the need for cooling systems. There is also evidence that respondents were more likely to use solar panels to capture and store the heat from the sun. Solar power would appear to be a good source of renewable energy for Malaysia as the country is bathed in sunlight. It has been found that a high level of satisfaction was reported for respondents who reside in the green neighborhood with water features. Lastly, respondents generally were satisfied with double-glazed glass door and window due to the fact that the usage of electricity could be reduced as glass door and window are being used to reduce heat transmission and take advantage of daylight.

Rainwater tanks are installed in this housing development to capitalize on nature's offering by collecting rainwater from the sloping rooftop for irrigating plants and vegetation. However, respondents in the survey were not satisfied with the rainwater harvesting system that uses recycled water for watering plants even though this could result in a significant reduction of water consumption. These viewpoints are supported from the in-depth interview with few respondents in describing the practicality of using the rainwater harvesting system. One respondent in the interview explained: "The water collected is so dirty that I cannot use to flush the toilets and irrigate the garden". Echoing these sentiments another respondent said: "It is a good system but its practicality needs some work". He added further: "The storage tank will dry out when there is no rain for a week." Judging from the mixed responses to this system, it seems that much has to be done with regard to increasing the practicality of this system. It appears that there is a need to improve the quality of the rainwater filter collector which could effectively separate the water from leaves and other debris.

According to this survey, it showed that low-flow water fixtures could not function as good as the normal high-flow water fixtures. Low-flow water fixture is a water efficient fitting to reduce water usage by reducing the flow of water such as water-

efficient sanitary appliances, but respondents generally complain about these low flow water features supplied by the developer. As few respondents pointed out: "We need long waiting time to fill up a bottle of water". Also, respondents in the survey were not satisfied with wall and floor tiles that use recycled materials and energy saving appliances. From the above findings, it would seem that marketing a green home is not without its share of challenges. Housing developers are required to carry out continuously long-term engagement programs to promote and raise awareness about environmentally friendly home features.

Of socio-demographic characteristics, only education was statistically significantly related to housing satisfaction when controlled for all other factors. In line with previous studies, more highly educated households might be more likely to pay for environmentally sensitive products. In terms of marital status and gender, these two demographic descriptors appear to be insignificant factors in explaining housing satisfaction.

## 5. CONCLUSIONS & RECOMMENDATION

In recent years there has been increasing media coverage of issues relating to green homes. A green home focuses on improving the efficiency of resource use, while reducing the building's impact on the environment during the building's lifecycle (Bond, 2010). Housing developers are urged to construct homes that incorporate energy efficient measures because of the impact of the built environment on climate change. However we do not know which green features are preferable by green homeowners. Therefore, this research intends to fill the gap by determining the extent to which homeowners are satisfied with different types of green features and revealing the green features that homeowners are not satisfied with. The aspiration gap approach of housing satisfaction is adopted in this study to understand households' evaluation and their experience of using energy efficiency measures.

Based on the survey, respondents are satisfied with features that lead to energy efficiency, environmental protection and better indoor environmental quality, such as high ceiling, north-south orientation, solar panel system, double-glazed glass panel and lush and landscaped parks with water features. Rainwater harvesting system, low flow water fixtures, some energy saving appliances and recycled ceramic titles, on the other hand, are not the more popular features of green homes.

It appears that homebuyers are conscious of what they are buying and they also insist on the house design that is efficient in energy consumption. The support from homebuyers is a clear indication that the demand for green homes is here to stay. In order to lead the local property industry towards becoming more environment-friendly, there is a need to require a collaborative effort of the different stakeholders that come into play from the designers to the architects, engineers, government and developers to support the green building rating tools that are developed locally for local conditions. One way to demonstrate on-going commitment at government level to the Green Building Index that are developed locally for local conditions is to provide more incentives, such as subsidies to mall developers for the adoption of the GBI. These incentives come in the form of tax exemption for building owners that achieve GBI certification. Subsidies should be given out as going green is not as affordable as it seems. Certain examples of subsidies are solar panel subsidies; water saving subsidies, hybrid car subsidies and so on, these subsidies could be designed for housing developers to develop their eco-friendly credibility as financial incentives are identified as major motivational factor to encourage builder to go beyond the minimum requirement under the rating system (Raisbeck & Wardlaw, 2009). Furthermore, the housing developers should continue to contribute to the green efforts by creating through information and education that put genuine green thoughts into the design such as, rainwater harvesting system and low-flow water fixtures to minimize energy and resource usage.

## ACKNOWLEDGEMERNTS

I would like to thank Mr. Ling Ten Heng for his kind assistance in completing this project.

## References

Adriaanse, C. C. M. (2007). "Measuring Residential Satisfaction: A Residential Environmental Satisfaction Scale (RESS)." *J. of Housing and the Build Environment*, 22, 287 – 304.

Amole, D. (2009). "Residential Satisfaction in Student Housing." *J. of Environmental Psychology*, 29, 76 – 85.

Ariffin, M. and Talib, A. (2008). "Perak Malay (Kutai) Architecture: A Methodological Approach in Extensive Survey and Analysis." 3rd International Qualitative Research Convention, Universiti Teknologi Malaysia and Qualitative Research Association of Malaysia.

Bahauddin, A. and Abdullah A. (2008). "Sustainable Design of the Suckling Elephant House of Malaysia." *Proceeding of Ecocity World Summit 2008*. Universiti Sains Malaysia.

Bond, S. (2010). "Lessons from the Leaders of Green Designed Commercial Building in Australia." *Pacific Rim Property Research Journal*, 16 (3), 314 – 338.

Canter, D. and Rees, K. (1982). "A Multivariate Model of Housing Satisfaction." *International Review of Applied Psychology*, 31, 185-208.

Chen, V. F. (1998). *The Encyclopedia of Malaysia: Architecture*. Singapore, Archipelago Press.

Cradduck, L. and Wharton, N. (2011). "The Adoption of Residential Sustainability Programs: Lessons from the Commercial Sector." *Pacific Rim Property Research Journal*, 17 (3), 388 – 403.

Eicholtz, P., Kok, N., and Quigley, J. (2008). "Doing Well by Doing Good? Green Office Buildings." Working Paper, Fisher Centre for Real Estate and Urban Economics, University of California, Berkeley.

Erdogan, N., Akyol, A., Ataman, B., and Dokmeci, V. (2007). "Comparison of Urban Housing Satisfaction in Modern and Traditional Neighborhoods in Edirne, Turkey." *Social Indicators Research*, 81, 127 – 148.

Eves, C. and Kippes, S. (2010). "Public Awareness of 'Green' and 'Energy Efficient' Residential Property: An Empirical Survey Based on Data from New Zealand." *Property Management*, 28 (3), 193 – 208.

Feliciano, M. and Prosperi, D. C. (2011). "Planning for Low Carbon Cities: Reflection on the Case of Broward County, Florida, USA." *Cities*, 28, 505 – 516

Furst, F. and Mc Allister, P. (2009). "An Investigation of the Effect of Eco-Labeling on Office Occupancy Rates." *J. of Sustainable Real Estate,* 1 (1), 49- 64.

Furst, F and McAllister, P. (2011). "Green Noise or Green Value? Measuring the Effects of Environmental Certification on Office Values." *Real Estate Economics*, 39, 45 – 69.

Galster, G. (1987). "Identifying the Correlates of Dwelling Satisfaction: an Empirical Critique." *Environment and Behavior*, 19 (5), 539 – 568.

Green Building Index. (2013). "Residential New Construction (RNC) – Certified Building." <http://www.greenbuildingindex.org/organisation-certified-buildings-NRNC.html> Accessed 19.01.2013.

Jayapalasingam, S. (2009). "Malaysia's Terraced Housing: towards an Environmentally Sustainable Future." Master Thesis. Deakin Univ.

Ling, F. Y. Y. and Gunawansa, A. (2011). "Strategies for Potential Owners in Singapore to Own Environmentally Sustainable Homes. Engineering." *Construction and Architectural Management*, 18 (6), 570 – 594

Lovell, H. (2004). "Framing Sustainable Housing as a Solution to Climate Change." *J. of Environmental Policy and Planning*, 6 (1), 35 - 55.

Lu, M. (1999). "Determinants of Residential Satisfaction: Ordered Logit vs. Regression Models." *Growth and Change*, 30, 264 – 287.

Miller, N., Spivey, J. and Florance, A. (2008). "Does Green Pay Off." *J. of Sustainable Real Estate,* 8 (2), 91 - 103.

Pitts, J. and Jackson, T. O. (2008). "Green Buildings: Valuation Issues and Perspectives." *Appraisal J.*, Spring, 115 –118

Raisebeck, P. & Wardlaw, S. (2009). "Considering Client-Driven Sustainability in Residential Housing." *International Journal of Housing Market and Analysis*, 2 (4), 318 – 333.

Rizzo, A. and Glasson, J. (2012). "Iskandar Malaysia." *Cities*, 29 (6), 417 – 427.

Roper, A., Voler, B., and Flap. H. (2009). "Social Network and Getting a Home: Do Contacts Matter?" *Social Networks*, 31, 40 – 51.

Tan, T. H. (2008). "Determinants of Homeownership in Malaysia." *Habitat International*, 32, 318 – 335.

Tan, T. H. (2012a). "Meeting First-Time Buyers' Housing Needs and Preferences in Greater Kuala Lumpur." *Cities*, 29 (6), 389 -396.

Tan, T. H. (2012b). "Housing Satisfaction in Medium- and High-Cost Housing: the Case of Greater Kuala Lumpur." *Habitat International*, 36 (1), 108 – 116.

Tan, T. H. (2013). "Determinants of Intention to Inhabit Eco-Friendly Homes in Malaysia." *J. of Green Building*, 8 (3) (In Press).