Conceptual Shift from Green Homes to Sustainable Homes: Case Studies from Malaysia

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As part of the climate change mitigation strategy, the creation of green homes has created awareness over the plight of the environment and the need to alter our lifestyles. Although this is a great step in the right direction, green homes are conceptually inadequate in addressing the overarching principles of sustainability. In order to achieve sustainability, houses should be made to perform a role along the lines of Cole’s ‘Sustainable Building Criteria’. This set of considerations is the backdrop to the four case studies from Malaysia, namely CETDEM’s Demonstration Cool and Energy Efficient House in Petaling Jaya that represents retrofitting existing houses, a private bungalow in Semenyih that was built using the Smart and Cool Home technology, a private bungalow in Melaka that uses the Cooltek system and the traditional Malay house that typifies the cultural response to living in the hot and humid climate and the unique Malay society. Each case study is reviewed against Cole’s sustainable building criteria and the findings are reported in this paper. The findings are used to judge whether the case studies are indeed green buildings that can support sustainable ways of life or Cole’s sustainable building criteria should be more pragmatic according to the context.

Conference theme: Sustainability
Keywords: Green homes, sustainable homes, Malaysia

INTRODUCTION

Until now, there are many home design responses to the environmental dilemma that we are facing. Many of which are labelled ‘green’ homes mainly because they boast ‘green’ features or technologies that could be beneficial to the environment. Unfortunately, these homes should only be classified as ‘pseudo-green’ homes because they are in fact conventional in architectural, structural and ethical terms. Green features and technologies applied to these homes are like after thoughts or a camouflage to the conventional envelope of these houses. Yeang (2006) stressed that ecological architecture is not characterised by having many different green features or ‘eco-gadgets’. Hence, only a select few modern houses in Malaysia (which the houses in this paper belong to) are truly green for they are designed with regard not only to the environment, but also to the satisfaction and comfort of the occupants and their wallets while being able to support a sustainable way of life.

A certain leeway should be given to existing houses however, because green features would definitely be fitted during the occupancy stage. In this case, the retrofitted green features should be judged as a package to effectively push the existing house to become resource efficient to support sustainable ways of life.

1. SUSTAINABLE BUILDING CRITERIA

In order to shift from ‘green’ to ‘sustainable’ Cole (2007) underlined a few design considerations which he calls the ‘Sustainable Building Criteria’ (SBC) that should be satisfied.

1. Buildings will have to adapt to the new environment and restore damaged ecology while mitigating resource use.
2. Buildings need to have a wider positive influence on the surrounding area and buildings rather than serving itself.
3. Building features should be contextually suitable and sensitive to local cultural conditions.
4. Buildings should be valued in terms of its significance to the society and environment, beyond its financial worth.
5. Buildings should also continually perform for a very long time rather than only achieve short-term benefits.

Cole (2007) suggested these criteria because it is insufficient to simply depend on continual improvements in the environmental performance of buildings and collective reduction in resource use and ecological loadings by the building industry to adequately address the environmental sustainability agenda. These design considerations are very much applicable to homes as well.

1.1. Study methodology

The features of each case study presented below are judged against Cole’s ‘Sustainable Building Criteria’ above to find out whether the case studies are indeed sustainable or just green homes. The judgements are subjective in nature and are purely based on findings from literature and interviews with the home owners.
2. CASE STUDIES

2.1. CETDEM’s Demonstration, Cool and Energy Efficient House, Petaling Jaya (PJ house)

CETDEM is the acronym for Centre of Environment, Technology and Development, Malaysia and was founded in 1985 as “an independent non-profit, training, research, consultancy, referral and development organisation” (CETDEM, 2010). This organisation pledged to improve the quality of the environment by using suitable technology and sustainable development (CETDEM, 2010). In doing so, they have modified the late 1970’s home of its founder in bustling SS2 urban centre in Petaling Jaya which is very close to all kinds of public amenities and public transport options, into a demonstration house for public awareness. This was achieved with funds from the Danish International Development Assistance (DANIDA). Construction work took 60 days to complete at a cost of RM 100,000 (CETDEM, 2005). The renovation involved retrofiting the existing roof with reflective aluminium foil to reflect heat from the sun and ‘Rockwool’ insulation. New counter-battens are laid beneath the reused clay tiles to allow hot air trapped underneath to move freely out of the roof. New aluminium louvers are also fitted to shield all windows from morning and afternoon sun. Combined with night ventilation, the house is a thermally comfortable home at a minimum of 27˚C or an average of 3˚C lower than outside temperature (CETDEM, 2005). Even though the average yearly relative humidity (RH) remains high at 80% internally due to unsealed doors and windows (Abdul Rahman, 1999; Department of Statistics Malaysia, 2007), the occupants are well adapted to this condition, thus air-conditioning is not needed. Due to the deep and obstructed internal planning of the house and the layout of the surrounding area, cross ventilation is not possible. Moreover, depending on location in Malaysia, the wind speed is less than 0.3 m/s or calm for 30% to 50% of the year which is insufficient for this purpose (Abdul Rahman, 1999). A grid-connected 0.9 kWp photovoltaic (PV) system was also installed during the renovation to offset the 270 kWh average monthly electricity consumption of the occupants by about 1/5.

Figures 1, 2 & 3: Front and back elevation of PJ house showing the added sun shading devices and workers installing insulation and counter timber battens into the roof

2.2. Private bungalow, Semenyih (Semenyih house)

This two storey bungalow is situated in the rural township of Beranang in the state of Selangor, Malaysia. It is built on a bungalow lot with no immediate neighbours and far away from any public amenities and public transportation systems. However, this house was built using the Smart and Cool Home technology (SCH) whereby old car tyres are reused as foundation material to replace the majority of concrete that otherwise would be needed to build conventional raft foundation (Lee, 2007). Part of the SCH system is the use of arched corrugated steel sheets for suspended floor slab reinforcement to reduce the use of concrete. All walls including internal and external infill panels are made of autoclaved aerated concrete (AAC) blocks which have a very small U-value of 1.091 W/m²K as investigated by Sh. Ahmad et al. (2007) and small carbon footprint compared to clay bricks which are the building material of choice in Malaysia. As a result of the construction technique, the overall thermal transfer value (OTTV) of the building envelope is only 16.05 W/m² (Ismail, Prasad, Tan, & Lee, 2010) which is significantly lower than the baseline standard of 50 W/m² as stipulated by the Green Building Index Malaysia or GBI (PAM & ACEM, 2009). Rather than being a massive heat sink that stores irradiated heat from the blazing sun and conducted heat from the ground, the foundation, external water tank, driveway and fence absorb heat from other parts of the house and occupants and dissipate it quickly. In order to complement the construction system, night ventilation is also practiced at this house. No air-conditioning units are installed at the house. The interior of the Semenyih house has been recorded to be at least 7˚C lower than outside temperatures (Sh. Ahmad, et al., 2007) which needed only the ceiling fans to increase air speed within the house to achieve thermal comfort.

As with PJ house, this house is also susceptible to warm and humid air leaking through the gaps in the door and window frames which are not properly sealed. An additional advantage to the SCH system is that it requires less workers and time to construct the house because the recycled tyre cassettes are modularised and the AAC blocks are significantly lighter to carry than clay bricks and can be easily cut to suit edges and angles, increasing construction accuracy and reducing building material wastage. The ground floor slab also does not require any toxic chemical treatment to prevent termite infestations, hence, better for the environment and health of occupants (Lee, 2007). With funds from the national photovoltaic project called the SURIA 1000 project which is run by the Energy Commission, this house is fitted with a 5.25 kWp photovoltaic system that could generate at an average of 340 kWh of electricity per month (PVMC, 2009) that could offset about 92% of the average monthly usage of up to 370kWh.
2.3. Private bungalow, Melaka (Melaka house)

Similar to Semenyih house, this private bungalow is built away from any neighbours at the edge of a golf and country club in Melaka and surrounded by heavily wooded area. It is also quite a distance away from any public amenities and public transport. However, this suited the owners and occupants of the house who are European retirees looking for a peaceful location to reside. This house is called the Cooltek house for its unique cooling system that helps to significantly reduce energy demand for cooling. Reimann et al. (2007) highlighted that it takes only 8 kWh per day to run the air-conditioning to cool the 200 m² house for 24 hours. This is all attributable to the orientation of the house, building materials, construction technique and a tight overall seal around the house. Unlike the previous two case studies, the Melaka house is actually air-conditioned but set to a bare minimum because the well-insulated envelope of the house alone keeps the heat out while rubber seals around window and door edges keep the air-conditioned coolness from escaping (ASEAN Energy Award, 2008; Reimann, 2008; Reimann, et al., 2007). The house is designed to have an internal temperature of 18°C to 24°C with a relative humidity of 40% to 70%. The air-conditioning is also intended to keep the humidity down to that level to achieve thermal comfort (Boswell & Bacon, 2009).

2.4. The Malay house

The Malay house is the most well-known indigenous house type in Malaysia. They have been developed for centuries and are still widely built and occupied particularly in the rural areas. The floors of the Malay house are typically raised because the environment in this region is characterised by heavy rain, flash floods and heavy seasonal flooding. This raised floor can keep the occupants clean, dry and comfortable regardless of the conditions on the ground. They are also safe from wild animals depending on the location of the house. Many settlements are close to the seas and rivers or in tidal basins. Malays commonly walk in the house barefooted and wash their feet...
before entering the house usually with rainwater collected in clay pots. No furniture is needed in the house as all household activities are done when sitting on the floor including performing the daily prayers. This meant that rooms are often multi-functional with window sills kept at low level for easy access when sitting and to provide effective ventilation at floor level throughout the house (Mohamad Rasdi, Mohd. Ali, Syed Ariffin, Mohamad, & Mursib, 2005).

In response to the climate, the envelope of the house is lightly built with very low thermal mass. Walls are sometimes made of porous materials such as woven bamboo with tiny holes for ventilation that also allow some daylight through while being waterproof (Mohamad Rasdi, et al., 2005). Alternatively, some houses have timber grilles either in decorated or non-decorated form between the wall plates and floor boards. Similar ventilation grilles are also used between the top of the wall plates and underneath the roof beam level particularly at the gable ends. Grilles are also installed above windows, doors and interior walls to allow free flowing air throughout the house. Grilles are also fitted at the top edge of gable end panels to allow hot air to escape out of the house. In order to shield the house from the harsh heat from the sun, the roof is often made of overlapping panels of woven palm leaves which also act as a thick layer of insulation without the need for a ceiling. The roof is often very steep in inclination with wide eaves to effectively discharge rainwater away from the walls and fenestrations while shading them from the sun (Mohamad Rasdi, et al., 2005; Woods et al., 2008). The interior of the house can have an indoor peak temperature ranging from 34°C to 36°C or 2°C to 4°C higher than the outside temperature. However, due to the light thermal mass, the house cools down quickly to a range of 23°C to 26°C, closer to the night time outdoor temperature (Woods, et al., 2008). Traditionally, a single Malay house would be made of a single tree and other locally available materials such as bamboo, rattan ropes, palm tree trunks and leaves and are communally built. Metal nails are rarely used at all. The walls are often unpainted and decorations blend in well with the overall structure of the house.

3. FINDINGS

3.1. Comparison to Cole’s ‘Sustainable Building Criteria (SBC)’

The features of all case studies are grouped against Cole’s SBC to determine whether or not these houses are indeed sustainable according to Cole’s interpretation of sustainable buildings. Below is a chart showing the summary of categorisation of criteria against Cole’s Sustainable Building Criteria (SBC).

<table>
<thead>
<tr>
<th>Cole's Sustaintable Building Criteria</th>
<th>PJ house</th>
<th>Semenyih house</th>
<th>Melaka house</th>
<th>Malay house</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings will have to adapt to the new environment and restore damaged ecology while mitigating resource use.</td>
<td>14</td>
<td>0</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>1. Environment must adapt to the new environment and restore damaged ecology while mitigating resource use</td>
<td>SBC 1</td>
<td>SBC 2</td>
<td>SBC 3</td>
<td>SBC 4</td>
</tr>
<tr>
<td>PJ house</td>
<td>14</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Semenyih house</td>
<td>21</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Melaka house</td>
<td>22</td>
<td>0</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Malay house</td>
<td>8</td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 1: List of Sustainable Building Criteria One according to each case study
1. Sun shading device to shelter from sun.
2. Aluminium foil to reflect heat in roof.
3. Insulation in roof to restrict heat transfer.
4. Ventilated roof to cool roof cavity.
5. Night ventilation to capture cool air.
6. Ceiling fan to distribute air and increase wind speed.
7. Exhaust fan to assist night ventilation.
8. Well planted and fully grown trees and plants in the garden.
9. Creepers are planted and allowed to grow on to the vertical sun shading device.
10. 0.9kWp PV system installed to offset electricity consumption.
11. Water used for cooking and washing is actively recycled for external usages and gardening.
12. No air-conditioning used.
13. Wall creepers are planted and allowed to grow on to the vertical sun shading device.
15. Large rainwater collection pool and driveway, rainwater foundation of the house, as substitute to concrete in home.
16. Driveway constructed using recycled rubber tyres used to absorb heat from concrete and other thermal mass.
17. Recycled rubber tyres used as substitute to concrete in foundation of the house, driveway, rainwater collection pool and boundary walls.
18. Arched corrugated steel sheets are used to span between concrete beams in first floor suspended slab construction to reduce concrete and steel reinforcements.
19. Highly efficient electrical and electronic devices used at the house.
20. No air-conditioning used.
21. Rainwater from roof run-off is collected for non-potable usages.
22. The house has no timber components to reduce impact on environment and health of occupants.

23. Large rainwater collection pool and driveway, rainwater foundation of the house, as substitute to concrete in home.
24. Driveway constructed using recycled rubber tyres used to absorb heat from concrete and other thermal mass.
25. Recycled rubber tyres used as substitute to concrete in foundation of the house, driveway, rainwater collection pool and boundary walls.
26. Arched corrugated steel sheets are used to span between concrete beams in first floor suspended slab construction to reduce concrete and steel reinforcements.
27. Highly efficient electrical and electronic devices used at the house.
28. No air-conditioning used.
29. Rainwater from roof run-off is collected for non-potable usages.
With respect to SBC Two, only the Malay house has a single feature which has a wider positive influence on the surrounding area and buildings rather than serving itself. Any produce from fruit trees planted around any Malay house are usually shared among neighbours due to cultural normalities. Neighbours could even enjoy the shade that these trees provide. Due to the limited number of building feature that serve beyond the boundaries of each case study, the sole feature categorised as part of SBC Two represents only 1.09% of all building features from all case studies that amounts to 92. Perhaps building services such as waste water recycling, centralised rainwater collection system, centralised PV panels that serve a group of houses or a neighbourhood suit the definition of SBC Two best. These systems are more financially viable when serving more than one house as they are expensive and difficult to maintain individually by single dwellings.

Table 2: List of Sustainable Building Criteria Two according to each case study

<table>
<thead>
<tr>
<th>Sustainable Building Criteria Two:</th>
<th>PJ house</th>
<th>Semenyih house</th>
<th>Melaka house</th>
<th>Malay house</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings will need to have a wider positive influence on the surrounding area and buildings rather than serving itself.</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>1. Produce from fruit trees are often shared with neighbours.</td>
</tr>
</tbody>
</table>

In terms of having features that are contextually suitable and sensitive to local cultural conditions as outlined by SBC Three, the Malay house is again superior than it's contemporaries by having five features as compared to only one each for all the others. Most notably, the planning wisdom of the house whereby, the Malay house plan is laid out in modularised segments and can be added-to cost-effectively when the need arises such as when the children have grown up and need more space or one of them gets married and need a separate sleeping area from the rest of the family. This flexible planning quality is completely the opposite of the other modern case studies which are either custom-built to suit the current living requirements or cannot be added-to due to site constraints. The overall architectural designs of both PJ and Semenyih houses arguably suit their respective contexts. This is not the case with Melaka house. Although deep overhangs can be classified as a tropical architectural feature, the overall architectural design and aesthetics of Melaka house could be deemed as out of context especially with the glaring white only colour scheme. In all, out of 92 features for all case studies, SBC Three has only eight features or 8.70%.

Table 3: List of Sustainable Building Criteria Three according to each case study

<table>
<thead>
<tr>
<th>Sustainable Building Criteria Three:</th>
<th>PJ house</th>
<th>Semenyih house</th>
<th>Melaka house</th>
<th>Malay house</th>
</tr>
</thead>
</table>
| Building features should be contextually suitable and sensitive to local cultural conditions. | 1. The house fits inner city high density built environment with subtle architectural design features. The majority of people live in similar terrace houses in this area. | 1. The architectural design of the house is contemporary Malaysian. | 1. Only deep overhangs of the house conform to local architectural design and building tradition. | 1. The house design blends seamlessly into the built environment of rural areas. 
2. The house design suits the culture of occupants, for instance, the ‘Serambi’ or porch is used for entertaining, different house sections reserved for different groups of occupants and each section of house is on different levels to signify hierarchy and suit local customs. 
3. Local culture is embedded into the ornaments that adorn the house and spatial organisation of the house. 
4. Indigenous construction technique is preserved. 
5. Indigenous planning wisdom is also preserved. |

As for SBC Four, all case studies have been used in various academic studies and research in order to find the best thermal comfort qualities for houses in Malaysia. Some of the houses are also used to educate the public in sustainable ways of living and green construction. The various cultural aspects of the Malay house have been continually studied for a long time and because of that, the Malay house is now a well-known indigenous dwelling. The Melaka house is also internationally recognised with an ASEAN Energy Award for 2009. The award recognises the efforts of the owners in demonstrating to the public on how to cool their house efficiently with minimum amount of electricity and knowledge of local weather data that they share through their website, collected from their own mini weather station on-site. They, together with the owners of the PJ and Semenyih houses are also active proponents of
green buildings and the environmental movement in Malaysia. With a total of 13 features out of 92, SBC Four amounts to 14.13% of the total.

Table 4: List of Sustainable Building Criteria Four according to each case study

<table>
<thead>
<tr>
<th>Sustainable Building Criteria Four:</th>
<th>PJ house</th>
<th>Semenyih house</th>
<th>Melaka house</th>
<th>Malay house</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building should be valued in terms of its significance to the society and environment, beyond its financial worth.</td>
<td>The house is used to teach the general public on sustainable ways of living.</td>
<td>The house is used to demonstrate greener building method and studied by others.</td>
<td>Weather data from own weather station is collected for local area use.</td>
<td>The house belongs to a hierarchy of house types, sizes and locations in a village.</td>
</tr>
<tr>
<td>1. The house is used to teach the general public on sustainable ways of living.</td>
<td>Data is collected from PV system for research conducted by others.</td>
<td>Data is collected from PV system for research conducted by others.</td>
<td>Data is collected from PV system for research conducted by others.</td>
<td>The interior environment of the house is studied by others for thermal comfort and indoor air quality.</td>
</tr>
<tr>
<td>2. The interior environment of the house is studied by others for thermal comfort and indoor air quality.</td>
<td>The interior environment of the house is studied by others for thermal comfort and indoor air quality.</td>
<td>The house is open to the general public as an educational tool.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The house has been continually studied for architectural and cultural reasons.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

In terms of durability, the building fabric of the modern case studies could survive for a minimum of 30 years before their brush finished mortar on their external walls need to be replaced or repaired even though their main wall materials could last a lot longer (IBEC, 2007). The timber building fabric of the Malay house could have a much shorter lifespan even though countless Malay houses survived for decades and are still habitable. This house type remains popular among rural folk for centuries due to ease of construction, low construction cost and their cultural significance. In all, there are only five features that can describe SBC Five or only 5.43% of the 92 features.

Table 5: List of Sustainable Building Criteria Five according to each case study

<table>
<thead>
<tr>
<th>Sustainable Building Criteria Five:</th>
<th>PJ house</th>
<th>Semenyih house</th>
<th>Melaka house</th>
<th>Malay house</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building should also continually perform for a very long time rather than only achieve short-term benefits.</td>
<td>The building fabric will last 30 years without material replacement.</td>
<td>The building fabric will last 30 years without material replacement.</td>
<td>The building fabric will last 60 years without material replacement.</td>
<td>This house type has been continuously constructed for centuries.</td>
</tr>
<tr>
<td>1. The building fabric will last 30 years without material replacement.</td>
<td></td>
<td></td>
<td>Countless homes are decades old and still liveable.</td>
<td></td>
</tr>
<tr>
<td>2. Countless homes are decades old and still liveable.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chart 2: Building feature percentage for each SBC out of the total of 92 features

- SBC 1: 70.65%
- SBC 2: 14.13%
- SBC 3: 8.70%
- SBC 4: 1.09%
- SBC 5: 5.43%
CONCLUSION

A consensus is needed to determine the importance of each SBC against another, unless Cole intended the SBCs as equal importance and significance. This is important because SBC Two in particular underlines that the houses must have a wider impact on the surrounding buildings and environment which will definitely require community-wide services to be installed, operated and maintained properly. This is only financially viable when developing a large cluster of houses not individual homes. Current standalone green homes similar to the case studies are very individualistic and do not have green features that could benefit others physically. Meanwhile, SBC Four is more applicable to showcase houses. Once sustainable homes are a norm, SBC Four might not be too relevant anymore. Otherwise, the SBC could be used as basis to design and build sustainable homes.

Despite excelling in only SBC One with numerous features to adapt to the climatic conditions, all four case studies still complied with Cole’s ‘Sustainable Building Criteria’ at varying degrees. However, only the Malay house has criteria that suffice all SBCs unlike the modern case studies that do not have any criterion belonging to SBC Two. In conclusion, only the Malay house can be called a sustainable house whereas the other case studies can only be called green homes that could still support sustainable ways of life without having any influence physically on their surroundings and other buildings.

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