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Adapting To Technology: The Case Of Air Conditioning Use In Malaysian Homes.

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Abstract

The use of thicker, comforter type blanket as sleep cover suggests a lower neutral temperature for a subject compared to one that use normal blanket. In hot humid Malaysian climate, this would result in higher cooling load for air conditioners. This study investigates the effect of blanket thickness on occupants' thermal neutrality in air-conditioned bedrooms. A thermal comfort field survey is conducted on the occupants of 36 air conditioned bedrooms in Klang Valley. Thermal neutralities are established using Griffiths method (Griffiths 1990) revised by de Dear and Bragger (de Dear and Brager 2001) . It is found that only 30% of households use comforter type blanket, suggesting the use is by choice rather than necessity. The neutral temperature of households that use comforter type blanket on average is lower by 2.3°C than that of households that use normal blanket. The finding suggests that adaptive behavior does not always result in lower energy consumption when active cooling is employed

Keyword: adaptive behaviour, thermal comfort, air conditioner.

1. Introduction

Air conditioning use in Malaysian home is on the rise. The energy demand created by this appliance constitute up to 50% of energy use in a home, and 20% of energy use in the residential sector. With the rising number of households going to employ this means of cooling, it is foreseeable that the energy use from this appliance will grow in significance. The implications of the behavioural aspects of air conditionings need to be understood in order to determine the actual cooling energy use in the homes. Hours of operation, temperature setting and other operating parameters are the factors that determine the cooling energy demand by the use of air conditioners. As such, other behavioural factors that eventually influence the operating parameters need to be investigated. This study looks into the user behaviour in the use of air-conditioners in Malaysian homes, specifically on the use of sleeping covers.

The use of a comforter covering during sleep in Malaysia is found exclusively in air-conditioned bedrooms. This type of blanket is thicker and normally used in cold and temperate climate. In hot humid Malaysia, the use of this blanket type instead of the normal blanket suggests a lower neutral temperature for a sleeping subject which in turn results in higher cooling load for air conditioning units. The objective of this study is to investigate the effect of blanket thickness on occupants' thermal neutrality in air-conditioned bedrooms in Malaysia. The effect of this adaptive behaviour (opting for thicker sleep covers) on the air conditioning cooling load is also investigated by a simulation exercise.

2. Research Method

A preliminary survey was conducted on 112 households to establish the air conditioning use patterns in Malaysian homes. Another 24 households without air conditioning were also surveyed for comparative analysis. Following this, a level 3 thermal comfort field survey (Nicol 1993) was conducted on 36 households. The thermal comfort survey seeks to establish the thermal conditions found in air conditioned households and the thermal perceptions of occupants. This survey was conducted by monitoring the environmental variables of sample households. The monitoring typically runs from 6 pm in the evening to 8 am in the following day. This period was decided after analysis of preliminary survey revealed that the units are used mostly during the night. Corresponding thermal sensations are recorded on survey form before the subject go to sleep, during mid sleep if they happen to wake up, and the moment they wake up in the morning. The type of blanket used is also noted in the survey forms. Thermal neutrality for the sample population is established using Griffiths Method as revised by de Dear and Brager (de Dear and Brager 2001). Following this a simulation exercise was conducted to assess the implication of the blanket thickness on the cooling load of air conditioned bedrooms.

3. Air conditioning in Malaysian homes and the use of comforter.

The preliminary survey revealed that 90% of air conditioning units are installed in the bedrooms and are predominantly used during sleeping hours (Ja'afar 2009). All of these units are of split unit type where there’s a cooling coil inside the room and a compressor unit located outside the house. Analysis of behavioural adaptation reveals that 54% of occupants sleeping in air conditioned bedrooms used comforter as sleep covers, while none of the occupants in non air-conditioned bedrooms use it (Ja'afar 2009). It can thus be argued that the use of this type of blanket is not a necessity in Malaysian homes. The need for this type of blanket maybe due to the lower indoor temperature afforded by the use of air-conditioners. Even so, only half of the households with air conditioners surveyed use comforters.

Prior to the advent of air-conditioners, people use either normal blanket (single ply blanket) as sleep covers or no blanket at all. With the introduction of air-conditioners, the use of duvet type blankets or comforters becomes a common practice in a warm climate such as Malaysia. Nowadays this type of blanket can be found in major retail stores throughout Malaysia (Figure 1**Error! Reference source not found.**).

Figure 1 Comforters are now a common item in every major retail outlets in Malaysia (Source: (Ja'afar 2009))

In Malaysia, the word comforter denotes a blanket type consisting of two layers of sheet, filled in between with natural or synthetic insulative material such as polyester wool. A queen size comforter weights between 0.7 to 1.5 kg. The insulating property can be anywhere between 3 to 5 clo. Unlike tog rating available for duvets in the UK, there is no standard rating for the insulating property of comforters in Malaysia.

Without air-conditioning, it is unbearable to sleep under such a blanket in hot humid Malaysian climate. Its use in air conditioned bedrooms indicates a waste of energy as the primary use of a comforter is to keep a person warm, while energy is used by air-conditioning to keep condition cool. The reason for the use of this type of blanket has not been researched. At this juncture, it can be prematurely suggested that comforters are necessary in air-conditioned bedroom due to overcooling.

Psychological and social reasons for adopting this type of covering, however, should not be dismissed. Just as the noise of a fan can psychologically helps deliver the notion of comfort for people, the use of a comforter might add to the feeling of cool comfort in a warm climate. On top of this, browsing through various home design publications in Malaysia nowadays, the sight of a comforter spread on a bed is becoming a common feature and suggests ‘good taste’ in home decoration.

4. Analysis of results and findings

4.1. Thermal Comfort analysis

A total of 136 votes were acquired from occupants of air-conditioned bedrooms in the field survey, each with corresponding thermal sensation of occupants as well as their use of blankets. Out of the 136 votes, 49 votes were excluded from analysis since these were cast when subjects were going to bed, and the metabolic rate could not be determined conclusively. The remaining votes are that of the time when subjects wake up in the morning or if they happen to wake up during mid sleep, and these are assumed to be the metabolic rate of a sleeping person (0.7).

In establishing the neutral temperature, the method adopted by Griffith (Griffiths 1990), and revised by de Dear and Brager (de Dear and Brager 2001) is used to establish the neutral temperature for the sample population. In this method, applying Griffiths method on RP-884 database, de Dear and Brager proposed that the increase in temperature for each scale point on the comfort scale was 2K for each point on a 7-point comfort scale (Nicol 1993). The equation for this relationship is thus:

$$T_n = T_a - (T_{sv})2 \qquad (1)$$

Where Tn is the neutral temperature, Ta is the air temperature when the vote was cast and Tsv is the actual votes cast by subjects.

The neutral temperature for each vote established by using this method is shown. The mean neutral temperature of the votes for the whole sample is calculated, and the result is shown in Table 1**Error! Reference source not found.**. It is found that the neutral air temperature for the sample population is 26.8°C. This is found to be 3.4°C lower than the neutral temperature for non air-conditioned group which is 30.2°C (Ja'afar 2009).

Table 1: Neutral Temperatures of whole sample of air-conditioned population

	N	Minimum (C°)	Maximum (C°)	Mean (C°)	Std. Deviation (C°)
Air temperature	87	18.5	32.0	26.8	3.0

Analysis of the difference between the two blanket groups are then conducted on the dataset. For blanket type analysis, it is necessary to exclude votes cast by subjects when they were not employing any blanket. A cross tabulation analysis reveals that there are five votes that fall within this category. These votes are therefore excluded, leaving only 82 votes for this analysis.

The votes are then segregated between these two groups. The mean neutral air temperatures for the two different blanket groups are obtained from the sample and the difference between them is investigated by conducting an independent sample T-test. The results are shown in **Error! Reference source not found.**.

Table 2: Average neutral air temperatures between different blanket groups

	Blanket type	N	Mean (C°)	Std. Deviation (C°)	Std error	T-test
Air temperature	normal	53	27.5	2.3	0.3	P=0.000* p<0.01
	comforter	29	25.2	3.3	0.6	

*The difference is found significant to 99% level

It is found that the neutral air temperature is 27.5°C for the normal blanket group and 25.2°C for the comforter group. The mean difference between the two groups achieved a 99% significant level.

4.2. Internal condition analysis

The thermal comfort analysis reveals a significant difference in the thermal neutralities between the two blanket groups. Analysis environmental conditions are also conducted to investigate the thermal condition differences between the two groups.

The average air temperature and the use of comforter are investigated. The table below shows the average temperature between households where the occupants used comforter (22.1°C) and those that did not (24.9°C). T-test results shows that the difference is significant (p=0.008) (Table 3).

Table 3 : Blanket type and average air temperature.

P=0.008	Household	N	Mean (°C)	Std. Deviation	Std. Error Mean
Average Air temperature	Comforter	8	22.1	3.0	1.05
	Normal blanket	21	24.9	2.1	.46

P=0.008., p<0.01 the difference seen is significant at the 99% level

The result suggests that comforters are used in conditions where the average internal temperatures are colder. However, since in an air conditioned rooms, the internal condition is regulated by the operation of air-conditioner, it can thus be argued that the use of comforters results in occupants operate their units to colder conditions.

5. Energy implication of blanket type

A simulation study is conducted to evaluate the difference in cooling load between the two blanket groups. Simulation was done using ECOTECT. The model house used in this study is based on the typical double storey terrace house found in the study, with a total floor area of 120.3m2. (See **Error! Reference source not found.**). The simulated zone is the master bedroom situated on the upper floor with a floor area of 22.3m2. The construction of the house is shown in **Error! Reference source not found.**. The master bedroom in the double storey terrace is located on the first floor facing south.

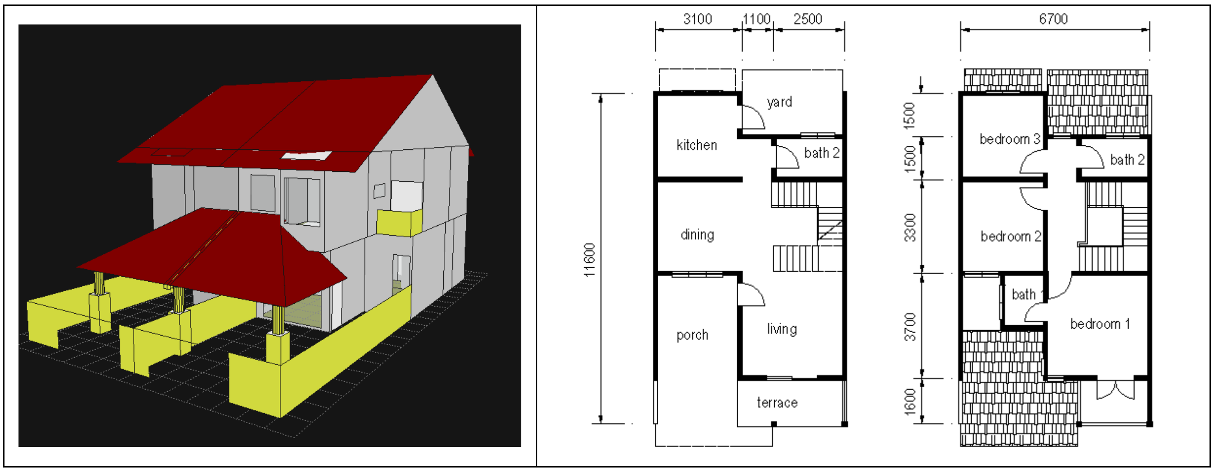

Figure 2 The model house

For internal condition, the maximum temperature settings for both group is set at the average internal condition found in the study between the two blanket groups. From Table 3, the setting for households which all occupants used comforters is 22.1°C and those which occupants did is set at 24.9°C. The lower range is set to 0.0°C for all cases although the internal conditions never get lower than 15°C. The value 0°C is chosen so that heating is not simulated since none of the units have heating capability.

The cooling loads for the bedrooms of the different blanket groups are shown in Table 4. From the table, it can be seen that the difference in the cooling load between the different blanket types is found to be 1,152 kWh. It can be argued that switching from using a comforter blanket to a normal single ply blanket in air conditioned room results in a reduction of 52% in cooling load.

Table 4 Cooling load by different blanket types (values in kWh)

	Household types	
	Comforter	**Normal Blanket**
Maximum temperature settings (°C)	22.1°C	24.9°C
Cooling load (KWh)	2229	1077
Cooling Load difference (kWh)	1152	
Load difference (percentage)	52%	

6. Conclusions

The results presented in this study shows that there are differences in the thermal neutralities between people who used single ply blanket (Tn=27.5°C) and those who used thicker, comforter type blanket (Tn=25.2°C). Rationally, we may suggest that the choice of blanket thickness is a result of the thermal conditions experienced by people. However, it can be proposed here that the phenomenon is reversed in this situation. Since the internal conditions can be controlled by occupants, it is the choice of blanket that dictates the thermal conditions they choose, i.e. they set lower temperature when they use comforters as sleep covers.

It follows that in the case of air conditioning use for sleeping hours, the proper choice of blanket thickness affects the desired temperature selected by occupants, hence may result in lower air conditioning load, and lower energy use and hence operating cost.

The simulation study suggests that the cooling load may be reduced as much as 50% if one were to switch from using a comforter to a single ply blanket.
It may be possible that the choice to use comforter is made based on psychological need and not physiological. A social or psychological study on why people use comforters in air-conditioned bedroom is needed. The information presented herein will be valuable in formulating corrective measures such as educating the public on choosing appropriate coverings in order to save energy.

7. References

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