

## **Questionnaire Survey on Behavior for Natural Ventilation and Electricity Consumption in Terraced Houses: A case study of Johor Bahru City**

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### **Abstract**

This paper presents the findings of a questionnaire survey on behavior for natural ventilation and electricity consumption among selected households in Johor Bahru City. The main purpose of this survey was to examine effects of natural ventilation on energy saving among households. The survey revealed that the reduction of both numbers and use of air-conditioners were the most effective means for electricity saving among households. Although approximately 80% of respondents opened their windows during the daytime, only around 10% did so during the nighttime. It is very important to encourage occupants to open windows especially during the nighttime for achieving energy saving objectives.

Keywords: Natural ventilation, Energy saving, Energy consumption, Thermal comfort, Adaptive behavior

### **1. Introduction**

The Kyoto Protocol on climate change has come into effect on February 2005. This requires the signatories to reduce emissions of greenhouse gases below 1990's level by the year 2012 in order to contribute toward a more sustainable global environment. The reductions of greenhouse gases are required only for the developed countries so far. However, it can be predicted that developing countries including Malaysia will be demanded to consent to the Protocol in the near future. Thus, it is important and effective to consider the energy saving means in developing countries in the course of its economic development.

The last three decades has seen tremendous growth of urban population in Malaysia. Its percentage has increased from 27% in 1970 to 62% in 2000. This indicates that the current energy consumption in urban areas has become considerable high percentage and expected to further rise in the near future. The present final energy demand is almost five times larger than that of 1980's (Malaysia, 2002a). Hence, it is essential to attain the energy saving objectives in urban areas in every way.

The emission cut from the use of air-conditioners in residential areas could be effectively carried out through energy saving efforts by maximizing the use of natural ventilation. Therefore, the importance of natural ventilation has been increasingly reevaluated partly due to the recent needs of energy saving. A number of studies related to natural ventilation in buildings can be seen over the last few decades. For example, Backer and Standeven (1996) summarized results of the comfort monitoring surveys in order to develop comfort criteria appropriate to natural ventilated buildings. A field survey of thermal comfort in natural ventilated buildings was carried out in the UK by Raja and Humphreys et al. (2001), in Singapore by Wong et al. (2002) and in Indonesia by Karyono (2000).

Besides, there are several similar surveys on energy consumption among households especially at the national level, but it was suggested that attitudes and behavior with respect to energy use have received less attention (Mansouri et al., 1996). Mansouri et al. also argued that although ownership and energy consumption data of appliances easily can be seen in the literatures, usage patterns of

appliances are still under research and uncertain. In Malaysia for example, household energy consumption data was gathered at the national level (Malaysia, 2001) and some surveys on energy consumption of appliances have been carried out (e.g. Ho Chin Siong et al., 2003). However, there are relatively few researches that dealt with the usage patterns of these appliances.

This paper presents the findings of a questionnaire survey on behavior for natural ventilation including usage of cooling appliances and electricity consumption among selected households in Johor Bahru City, Malaysia. To what extent is natural ventilation considered in the planning of mass housing in urbanized Malaysia? Does natural ventilation efficiently contribute towards reductions of domestic or household energy consumption? The main purpose of this survey is to examine effects of natural ventilation on energy saving among households in urban Malaysia.

## 2. Methods

### 2.1. Outline of case study areas

Johor Bahru Metropolitan City is located in the southernmost part of Peninsular Malaysia. It is the second largest city after Kuala Lumpur and its population size including the conurbations is approximately one million in 2000. According to the property market report (Malaysia, 2002b), terraced houses accounted for around 57% of the total existing housing stock of Malaysia in 2002, followed by apartment houses (25%) and detached houses (11%). Thus, a large majority of housing types in Malaysia is considered as terraced houses. For this reason, this study has been focusing especially on terraced houses (Fig.1). Three typical neighborhood areas in Johor Bahru City (case study area I to III), which are mainly composed of terraced houses, were chosen for this survey.

### 2.2. Data collection

A questionnaire survey was designed to extract information from occupants mainly under the following categories.

- (1) Frequency and duration of open windows: the frequency and time periods when the occupants open windows per day. The main reason why they do not open windows.
- (2) Frequency and duration of operating air-conditioners: the ownership of air-conditioners. The frequency and time periods when the occupants use air-conditioners.
- (3) Frequency and duration of operating ceiling fans: the ownership of ceiling fans. The frequency and time periods when the occupants use ceiling fans.
- (4) Electricity consumption: the mean monthly electricity fee and its consumption. Significant factors to influence the household electricity consumption.
- (5) General satisfaction and free comments concerning living environment.



Fig.1. Terraced houses in case study area

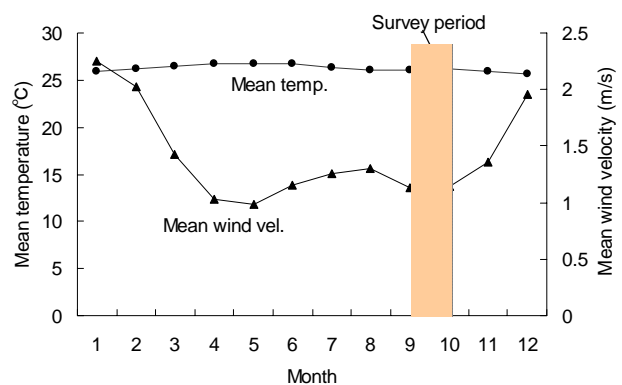


Fig.2. Mean monthly temperature and wind velocity in Johor Bahru City

Source: Monthly abstract of metrological observations (1988-1999)

The questionnaire consisted of 26 questions and requirements. The letters of asking for cooperation to the survey were distributed to approximately 820 households in three selected neighborhood areas at random. After three or four days, the surveyors visited the above households and interviews were made using the questionnaire sheet. There were available supports for the survey from 366 respondents who were mainly housewives. Thus, the respondent rate was approximately 45%.

Fig.2 shows the yearly change of mean monthly temperature and wind velocity in Johor Bahru City over the past 12 years. Most cities in Malaysia experience high temperature and humidity throughout the year without much variation. However, there is a seasonal climatic change, which is mainly dominated by the monsoons. This survey was carried out on every Saturday from 4 September to 9 October 2004. This survey period was in the inter monsoon season, which records relatively low wind velocities (Fig.2).

Electricity consumption data was gathered by investigating respondents' electricity bills through the interview. Although monthly electricity consumption data over the past two years were required, not all respondents had kept their electricity bills. In this case, the surveyors questioned the respondents on the mean monthly electricity fee based on their remembrance. Then, the mean monthly electricity consumption was predicted by the above reported electricity fee using the electricity tariff.

### 3. Results and discussion

#### 3.1. Profile of respondents

A brief characteristic of respondents in the survey is summarized in Fig.3-6. Malaysians mainly consists of three ethnic groups, i.e. Malay, Chinese and Indian. The proportion of these ethnic groups in this survey was similar with national approximate average; 64% of respondents were Malays, 28% were Chinese and 7% were Indians, respectively. The average household size of respondents were 5.4 (Fig.3). They had an average of 2.1 workers and 2.4 children in household (Fig.4, 5). Fig.6 indicates the mean monthly household income. Nearly 26% of respondents earn less than RM 2,000 (US\$530), 29% earn RM 2,000-4,000 (US\$530-1,060), 25% earn RM 4,000-

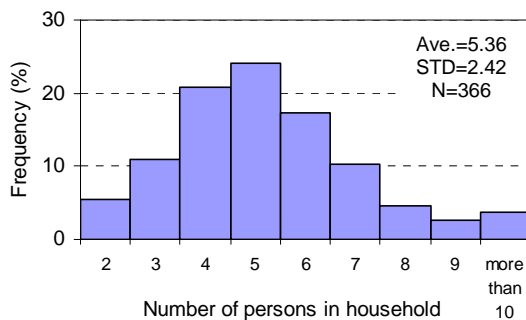


Fig.3. Household size

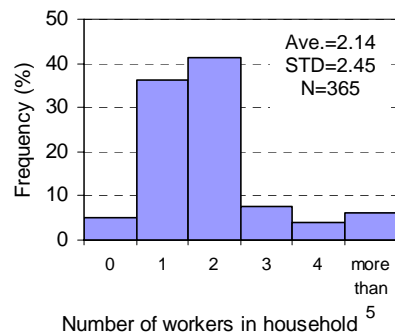


Fig.4. Number of workers in household

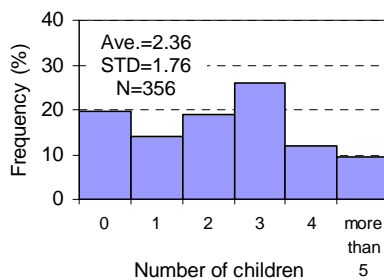


Fig.5. Number of children in household

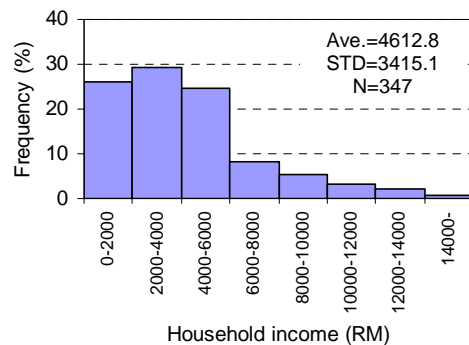


Fig.6. Mean monthly household income

6,000 (US\$1,060-2,120) and 20% earn more than RM 6,000 (US\$2,120) monthly.

House ownership among the respondents was quite high. An approximately 78% of respondents owned their houses, while 22% rented their houses. Majority of housing type was terraced house (88%), followed by semi-detached house (9%) and bungalow (3%). The house buildings consisted with 40% of single and 60% of two story heights and had an average of 3.5 bedrooms. The average site area per dwelling was 198m<sup>2</sup> and total floor area was 143m<sup>2</sup>.

### 3.2. Frequency and duration of open windows

Fig.7 shows the frequency of respondents who open their windows at respective hour during the day. Since the purpose of this question was to examine general situations of open windows in the whole dwellings, it did not specify particular rooms, e.g. living room, bedrooms etc. The answers were collected in the case of weekdays, weekends and holidays, respectively. Yet, since there was little difference between these answers, the mean values were calculated by the above values of three different cases (Fig.7). The result shows that nearly 80% of respondents usually open their windows during the daytime from 9am to 6pm. It is argued that the night ventilation is especially

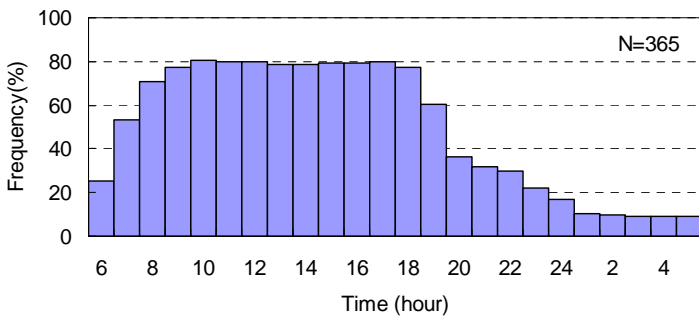


Fig.7. Frequency of open windows during the day (average day)

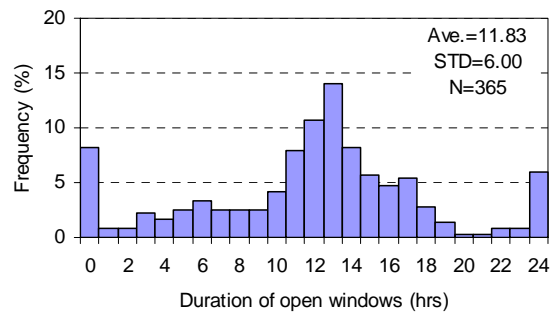


Fig.8. Duration of open windows per day (average day)

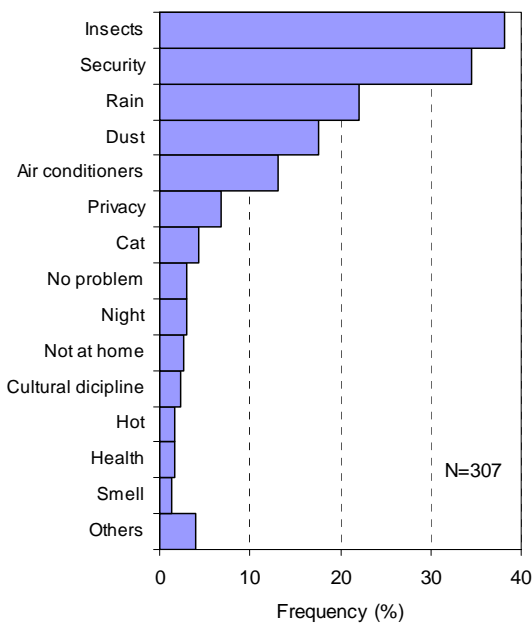


Fig.9. Reasons for not opening windows

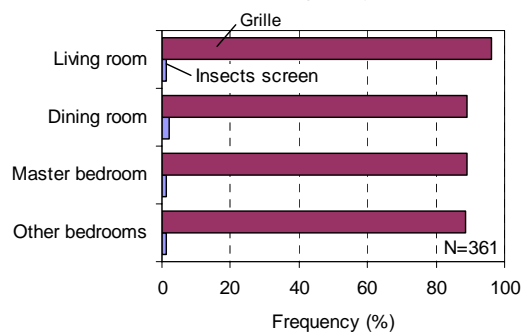
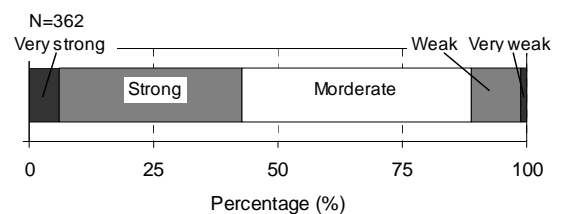
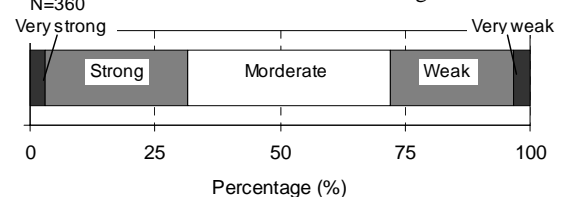


Fig.10. Window devices in each room



a. Wind flow around dwellings



b. Wind flow in dwellings

Fig.11. Consciousness to wind flow

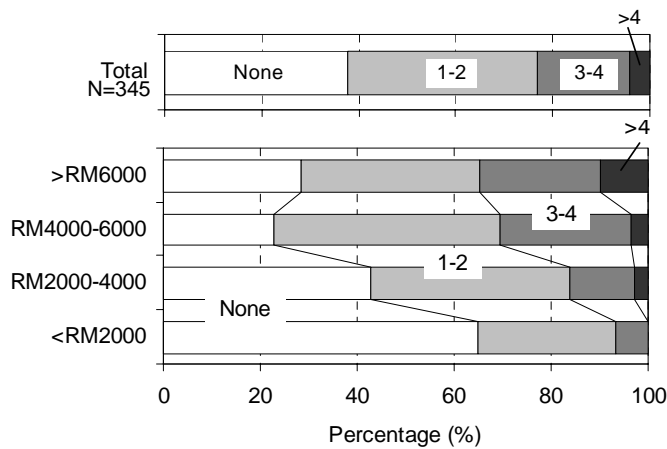
effective to improve thermal conditions in brick houses like these Malaysian terraced houses, which have large heat capacity. However, the frequency of open windows dropped to around 10% during the nighttime as indicated in Fig.7.

Fig.8 indicates the duration of open windows per average day. Although nearly 8% of respondents do not open their windows at all, most of them do so on an average of 12 hours per day. Fig.9 illustrates the main reasons for not opening windows. An approximately 38% of respondents answered 'insects' as the main reason, followed by 'security (35%)', 'rain (22%)', 'dust (18%)' and 'air-conditioners (13%)' etc.

Fig.10 illustrates the frequency of respondents who had installed window devises. Although nearly 90% of respondents had installed window grilles for security purpose, only 1% had installed insects screen on their windows. Yet 'insects' was recorded as the most significant reason for not opening windows (Fig.9). It is important to encourage them to open windows especially during the nighttime by considering proper methods. Hence, it can be suggested that to install the insects screens at the construction phase of the dwellings would be one of the important means to encourage occupants to open windows.

Fig.11 illustrates the results of questions about respondents' consciousness to the wind flow in and around dwellings. Around 43% of respondents answered 'very strong' or 'strong' for the wind flow around their dwellings, while nearly 31% of them selected 'very strong' or 'strong' for the wind flow in dwellings, i.e. ventilation. The authors assumed that when the occupants feel the wind flow around dwellings is higher, they would open windows more frequently. However, the significant relationship cannot be found between 'consciousness to wind flow (Fig.11)' and 'duration of open windows (Fig.8)' in this survey.

### 3.3. Frequency and duration of operating air-conditioners



Note: chi-sq.=44.42 with 9 DF, significant at 1% level

Fig.12. Number of air-conditioners by monthly household income

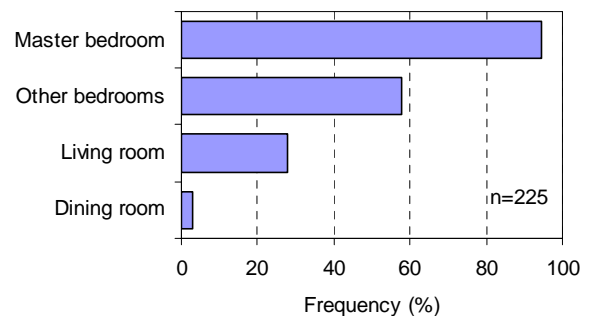


Fig.13. Rooms with air-conditioners

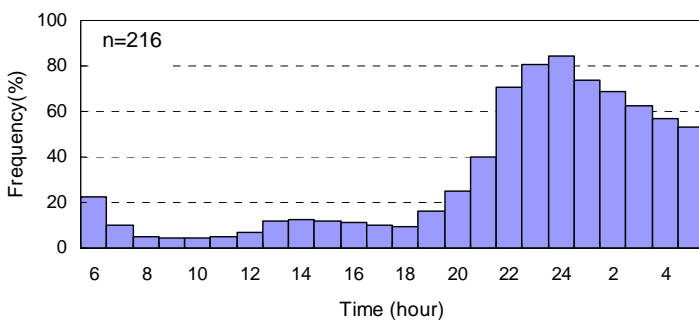


Fig.14. Frequency of operating air-conditioners during the day (average day)

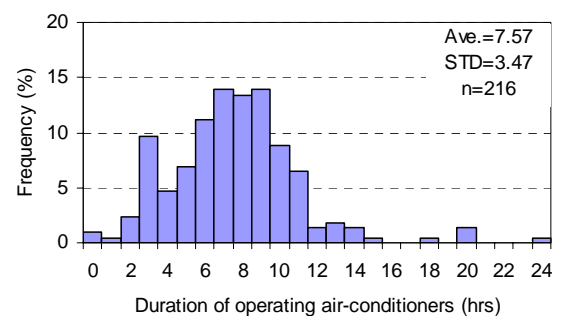


Fig.15. Duration of operating air-conditioners per day (average day)

Nearly 62% of respondents owned at least one air-conditioner in this survey (Fig.12). It is said that the ownership of air-conditioners has been increasing sharply due to continuing rise in household income brought about by recent high economic growth in Malaysia (Mahlia et al., 2004). Fig.12 illustrates the number of air-conditioners classified by monthly household income groups. The result shows that there is a significant relationship between the two items. It indicates that the more monthly income they earn, the more air-conditioners they have. Although only 35% of respondents owned air-conditioners in income group of less than RM2000, its percentage rose to 77% in income group of RM4000-6000. Therefore, it can be implied that the air-conditioner ownership is expected to further rise according to economic growth in the near future, if they do not consider proper energy saving.

The average number of air-conditioners among their owners was 2.3 units per household. They have installed them in the master bedroom (95%), other bedrooms (58%), living room (28%) and dining room (3%) (Fig.13). It can be inferred from this result that since most air-conditioners had been installed in their bedrooms, most respondents use air-conditioners as a cooling appliance for sleeping.

Fig.14 shows the hourly frequency of respondents who operate air-conditioners during the day. This was calculated from answers of air conditioner owners (n=216). Only around 10% of their owners operate air-conditioners during the daytime. However, its percentage rapidly rose during the evening from 7pm and it reached 84% at midnight. It is noted that more than 50% of their owners continue to use air-conditioners during the whole nighttime until 5am. The authors inferred that most respondents used air-conditioners as a cooling appliance for sleeping. The above results (Fig.14) support this inference. The mean duration of operating air-conditioners per average day is about 7.6 hours (Fig.15).

The authors assumed that the occupants who frequently open their windows would use less air-conditioners, thus it would contribute to reduce household electricity consumption. However, the significant relationship cannot be seen between ‘duration of open windows’ and ‘duration of operating air-conditioners’ in this survey; correlation coefficient between them was only 0.18. Most respondents opened their windows mainly during the daytime especially from 9am to 6pm as

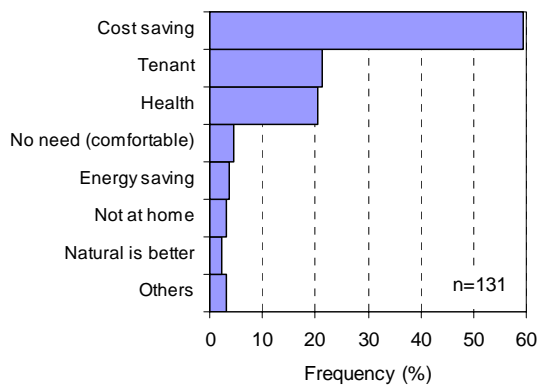


Fig.16. Reasons for not intending to purchase air-conditioners

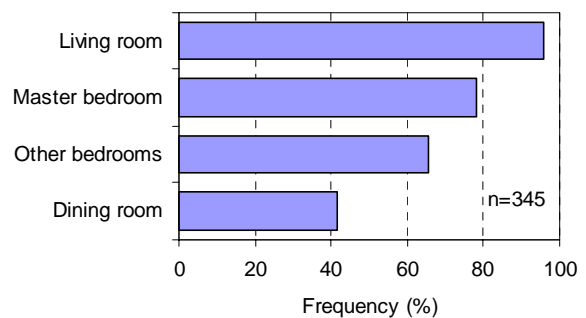


Fig.17. Rooms with ceiling fans

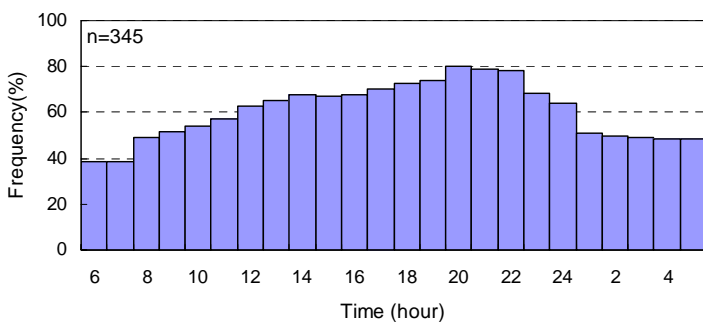


Fig.18. Frequency of operating ceiling fans during the day (average day)

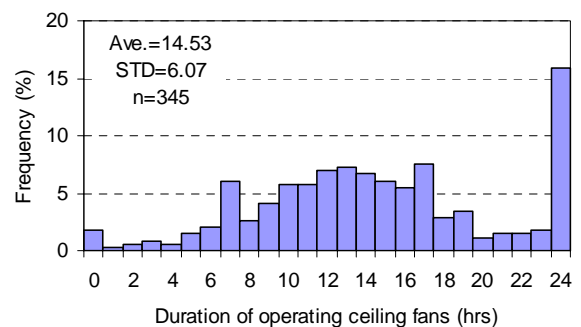


Fig.19. Duration of operating ceiling fans per day (average day)

indicated in Fig.7. By contrast, many air-conditioner owners used them during the nighttime especially from 10pm to 5am as shown in Fig.14. Hence, this indicates that most respondents open their windows during the daytime regardless of the air-conditioner ownership and close windows during the nighttime. In other words, it can be concluded that these usage patterns of windows and air-conditioners do not overlap during the day regardless of the air-conditioner ownership. For the above reasons, it is considered that these adaptive behaviors, i.e. ‘open windows’ and ‘operate air-conditioners’ did not have a significant relationship in this survey.

An approximately 83% of respondents, who did not have any air-conditioners, answered that they do not intend to purchase air-conditioners. Fig.16 illustrates the main reasons that respondents do not intend to purchase it. ‘Cost saving, i.e. financial constraints (60%)’ was the major reason among these respondents, followed by ‘tenant: because of rental house (21%)’ and ‘health (21%)’ etc. Thus, this result also supports the hypothesis that the air-conditioner ownership is expected to further rise according to continuing rise in household income in the near future. By contrast, there were few respondents (3.8%) answered ‘energy saving’ as a main reason for not intending to purchase air-conditioners as shown in Fig.16. Thus, it is found that the awareness of respondents towards energy saving for sustainable global environment is not necessarily high at the moment. Needless to say, it is essential to enhance the public awareness towards global environment in order to achieve energy saving objectives in cities.

### 3.4. Frequency and duration of operating ceiling fans

Nearly 98% of respondents owned ceiling fans in this survey. The average number of ceiling fans among their owners were 3.9 units per household. They have installed them in the living room (96%), master bedroom (78%), other bedrooms (66%) and dining room (41%) (Fig.17). Although air-conditioners have been installed mainly in bedrooms (Fig.13), ceiling fans have been installed particularly in the living room.

Fig.18 shows the hourly frequency of respondents who operate ceiling fans during the day. This was calculated from answers of ceiling fan owners (n=345). The frequency was relatively high throughout the day. Especially during the evening from 8pm to 10pm, the percentage rose to almost 80% as indicated in Fig.18. Then, its percentage recorded still 40-50% during the nighttime. Fig.19 illustrates the duration of operating ceiling fans per average day. It is found that nearly 16% of their owners used ceiling fans during 24 hours. The average operating hour was about 15; this was much longer than that of air-conditioners (7.6 hours).

### 3.5. Electricity consumption among households

Fig.20 indicates the mean monthly electricity consumption among respondents. The household electricity consumption was investigated by two means. The first method was to gather respondents’ electricity bills over the past two years through the interview. Then, the mean value was calculated using these data (‘calculated’ data: 111 samples). Nevertheless, not all respondents

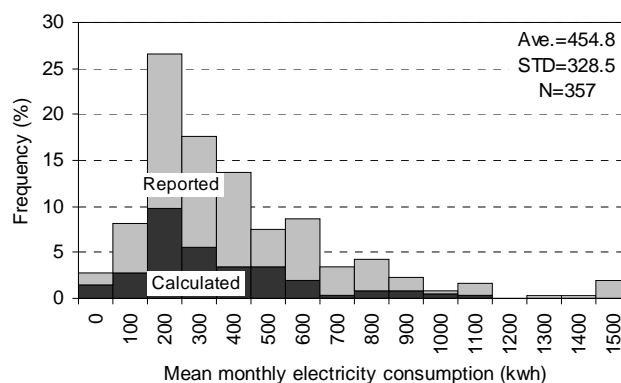


Fig.20. Mean monthly electricity consumption among households

had kept their electricity bills. In this case, the surveyors questioned the respondents on the mean monthly electricity fee based on their remembrance ('reported' data: 246 samples). The mean value of 'calculated' data was 390kwh, while the mean value of 'reported' data was 484kwh. The t-test was conducted to test the difference between mean values of these two groups. The result revealed that there is a significant difference between them at 1% significant level. Therefore, strictly speaking, these monthly electricity consumption data should be analyzed in the above different two groups separately. However, since this survey aims to examine the approximate tendency among households, both these two groups of data are used together for the following analysis.

Table 1. Correlation coefficients between selected variables and mean monthly household electricity consumption

Variables	Correlation coefficient (R)	Significance level of t	Significant (at 1% level)
1 Number of air-conditioners	0.55	0.00	S
2 Duration of operating air-conditioners	0.52	0.00	S
3 Number of water heaters	0.45	0.00	S
4 Household income	0.39	0.00	S
5 Site area	0.37	0.00	S
6 Number of bedrooms	0.30	0.00	S
7 Building area	0.30	0.00	S
8 Total floor area	0.29	0.00	S
9 Number of ceiling fans	0.29	0.00	S
10 Household size	0.24	0.00	S
11 Duration of operating ceiling fans	0.18	0.00	S
12 Duration of staying home	0.11	0.05	NS
13 Duration of open windows	-0.03	0.53	NS

S=significant; NS=not significant

Table 2. Correlation coefficients of variables included in regression equation

	y Electricity consumption	x <sub>1</sub> Number of air-conditioners	x <sub>2</sub> Duration of operating air-conditioners	x <sub>3</sub> Number of water heaters	x <sub>4</sub> Household income	x <sub>5</sub> Site area
y	1.00					
x <sub>1</sub>	0.55	1.00				
x <sub>2</sub>	0.52	0.19	1.00			
x <sub>3</sub>	0.45	0.57	0.21	1.00		
x <sub>4</sub>	0.39	0.36	0.11	0.32	1.00	
x <sub>5</sub>	0.37	0.41	0.11	0.39	0.36	1.00

Table 3. Coefficients of variables included in regression equation

Independent variables	Unstandardized coefficient	Standardized coefficient	Significant
x <sub>1</sub> : Number of air-conditioners	78.01	0.362	S**
x <sub>2</sub> : Duration of operating air-conditioners	39.75	0.419	S**
x <sub>4</sub> : Household income	0.0166	0.173	S**
x <sub>5</sub> : Site area	0.305	0.114	S*

S\*=significant at 5% level; S\*\*=significant at 1% level



Table 1 indicates results of correlation analysis between selected variables and mean monthly household electricity consumption. The highest correlation coefficient by 0.55 was obtained between ‘number of air-conditioners’ and ‘household electricity consumption’ in this survey, followed by ‘duration of operating air-conditioners (0.52)’, ‘number of water heaters (0.45)’, ‘household income (0.39)’, ‘site area (0.37)’ and ‘number of bedrooms (0.30)’ etc. It is found that there is a relationship particularly between the variables concerning air-conditioners and household electricity consumption.

An electric water heater, which is normally used for shower bath in urban Malaysia, also has large electricity consumption. For this reason, it is considered that ‘number of water heaters’ had a relationship with the whole electricity consumption. Meanwhile, the relationship between ‘duration of open windows’ and ‘household electricity consumption’ was found to be very weak in this survey. This is mainly because although there is a significant relationship between ‘duration of operating air-conditioners’ and ‘household electricity consumption’ as indicated in Table 1, the relationship between ‘duration of open windows’ and ‘operate air-conditioners’ was weak as discussed in section 3.3.

In order to illustrate further determinants of mean monthly household electricity consumption, a multiple regression analysis was attempted. The independent variables included in the regression equation were the variables, which were found to be highly correlated and significantly related with household electricity consumption in Table 1. The correlation coefficients of all variables included in the regression analysis are presented in Table 2.

According to the regression equation, the coefficient of determination ( $R^2$ ) was 0.53. Thus, more than 53% of the spatial variation of mean monthly household electricity consumption to the case study areas can be explained by the model. This means that four explanatory variables, i.e. ‘number of air-conditioners’, ‘duration of operating air-conditioners’, ‘household income’ and ‘site area’, fit the model well and they are in fact good predictors of mean monthly household electricity consumption in the case study areas.

Table 3 shows coefficients of respective independent variables in the regression equation. The standardized coefficient was the highest in ‘duration of operating air-conditioners (0.42)’ at 1% significant level, followed by ‘number of air-conditioners (0.36)’, ‘household income (0.17)’ and ‘site area (0.11)’. This indicates that the reduction of both numbers and use of air-conditioners are the most effective means for achieving electricity saving among households.

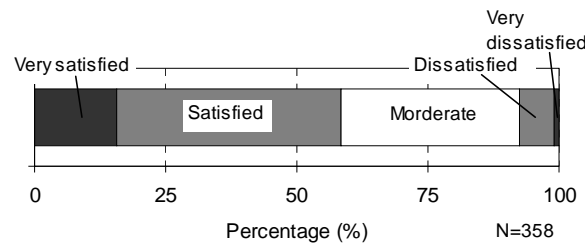


Fig.21. General satisfaction for living environment

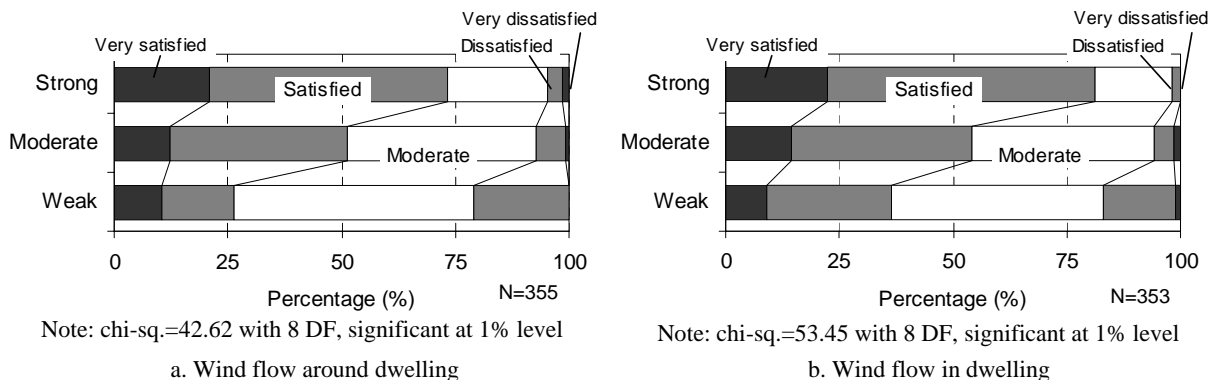


Fig.22. General satisfaction for living environment by consciousness to wind flow

### 3.6. General satisfaction and free comments concerning living environment

The respondents' general satisfaction for their living environment was found to be high in case study areas. An approximately 58% of respondents answered 'very satisfied' or 'satisfied' for their living environment, while merely 8% indicated 'dissatisfied' or 'very dissatisfied' (Fig.21).

As indicated in section 3.3, the significant relationship had not been found between 'consciousness to wind flow' and 'duration of open windows'. Thus, it can be implied that the respondents' behavior for opening windows was not necessarily caused by the increase of wind flow around dwellings. Nevertheless, the significant relationship was found between the wind flow both in and around dwellings and respondents' general satisfaction at 1% significant level (Fig.22). When they felt the wind flow in or around dwellings was higher, respondents had a higher satisfaction with their living environment.

The wind flow in and around dwellings is essential not only to improve thermal conditions but also diffusing humidity and air pollutions. Although respondents' behavior for opening windows was not necessarily influenced by the consciousness to wind flow, its consciousness would have affected respondents' satisfaction for their living environment synthetically.

The free comments concerning living environment were gathered at the end of the interview. Several typical comments were selected and summarized as Fig.23. The Roman numeral in the brackets indicates the place of case study areas. A total of 297 respondents (81%) gave their comments.

An approximately 12% of their comments expressed very brief satisfactions with their living environment such as 'everything is okay' or 'we do not have any problems'. However, other than that, there were several comments that need to be highlighted.

Throughout three case study areas, many comments were related to the security issues. According to their comments, for example, it is found that many burglar cases are taking place frequently in these areas (Fig.23(1)). One of respondents said that 'the security level is poor, so we must close windows'. Although most

#### (1) Security

- 'The relationship with neighbors is good. Since we have a residents' committee, the security level is high (I).'
- 'Neighbors are good. But, there are some burglar cases, so we need help from the police. It is good if they would visit our area regularly (II).'
- 'We are facing with some small burglar cases. Around two events happen per week. We need to provide more security guard stations to this area (II).'
- 'The security level is poor, so we must close windows (III).'

#### (2) Safety

- 'Narrow and busy roads are not safety for children to play in outdoors (I).'
- 'There are many stray dogs in our residential area (II).'

#### (3) Community

- 'The neighborhood community is working well. We can join the religious activities etc (I).'
- 'Since each ethnic group has different culture, the relationship with neighbors is not so strong (III).'

#### (4) Noise

- 'We are facing with noise because my house is located just behind the main road (I).'
- 'We are suffering from noise caused by illegal race of motorcycles (III).'

#### (5) Thermal comfort

- 'I think ventilation will be much better if my house has a higher roof (I).'
- 'It is hot in the evening. I think building can avoid the hotness, if more trees would be planted around it (II).'

#### (6) Air pollutions

- 'The problem is air pollutions. Many people are burning rubbish in outdoors. So, I am not satisfied with the air quality (I).'
- 'Everything is OK, but there are strong smells from the factory after the rain (I).'

#### (7) Cleanliness

- 'Since many residents throw away rubbish into the back site, it is becoming terrible environment (I).'
- 'Many houses are seldom occupied because the owners are Singaporeans, thus their houses are dirty (I).'
- 'We need to improve the waste collection system; it is not punctual (III).'

#### (8) Public facilities

- 'Public facilities are well equipped, compared with others places. We have a community meeting room, mosque, etc (I).'
- 'Streetlights should be more effective. It is too dark at nighttime (III).'

Fig.23. Free comments concerning living environment (selected)

residents had installed iron grilles on their windows for the security purpose as shown in Fig.10, 'security' was found to be one of the most significant reasons for not opening windows (Fig.9). Security issue is considered one of crucial problems in these areas. Further improvement of security in residential areas is strongly required in order to make residents feel safe and encourage them to open windows more.

Among the comments concerning safety, several respondents pointed out deterioration of safety in outdoors due to heavy traffic and narrow road (Fig.23(2)). The respondents' satisfaction was divided on their community relationship. Some respondents mentioned that there are gaps between three ethnic groups, thus the community relationship is not strong (Fig.23(3)). Although 'noise' had not been chosen as reasons for not opening windows in this survey (Fig.9), it would become considerable reason to make them close windows if it gets worse (Fig.23(4)).

As for the 'thermal comfort', several respondents identified that the unsuitable housing design and material were one of the main causes for uncomfortable thermal conditions (Fig.23(5)). Meanwhile, many comments related to 'air pollutants' and 'cleanliness' could be seen. Especially under the hot and humid climate like Malaysia, the rubbish easily spoils and smells. The improvement of waste system is another aspect suggested by the respondents (Fig.23(7)).

#### 4. Conclusions

This paper presented the findings of a questionnaire survey on behavior for natural ventilation and electricity consumption among selected households in Johor Bahru City, Malaysia. The summary of the findings (N=366) is indicated below.

The results showed 62% of respondents owned an average of 2.3 air-conditioners in this survey. The significant relationship was found between 'mean monthly household income' and 'number of air-conditioners'. Thus, it could be implied that the air-conditioner ownership is expected to further rise according to continuing rise in household income in the near future.

The multiple regression analysis revealed that four explanatory variables, i.e. 'number of air-conditioners', 'duration of operating air-conditioners', 'household income' and 'site area', were good predictors of mean monthly household electricity consumption in the case study areas. The results showed that the reduction of both numbers and use of air-conditioners were the most effective means for achieving electricity saving among households.

Meanwhile, the duration of open windows per day was not directly related to the duration of operating air-conditioners in this survey. This was mainly because the usage patterns of windows and air-conditioners did not overlap during the day regardless of the air-conditioner ownership. Many air-conditioner owners used them during the nighttime especially from 10pm to 5am. By contrast, although approximately 80% of respondents opened their windows during the daytime regardless of the air-conditioner ownership, only around 10% did so during the nighttime. Therefore, it is very important to encourage both air-conditioner owners and non-owners to open windows especially during the nighttime for achieving energy saving objectives.

'Insects' was chosen by respondents as the most significant reason for not opening windows. However, only 1% of respondents had installed insects screen on their windows. Thus, it was argued that to install the insects screens at the construction phase of the dwellings would be one of the important means to encourage occupants to open windows. Moreover, it was found from respondents' free comments that many burglar cases were taking place frequently in the case study areas. Security issue was considered one of crucial problems in these areas. Further improvement of security in residential areas was also strongly required in order to make residents feel safe and encourage them to open windows more.

Furthermore, the results indicated that the awareness of respondents towards energy saving for sustainable global environment was not necessarily high at the moment. Needless to say, it is essential to enhance the public awareness towards global environment in order to achieve energy saving objectives in cities.

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