Jurnal Teknologi

Full paper

A Preliminary Assessment of Energy Consumption Behaviour Pattern and Factors Influence Among Malaysian Higher Education Institutions Students

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Article history

Received :1 November 2014
Received in revised form :
31 March 2015
Accepted :30 April 2015

Abstract

Towards sustainable campus of higher education institutions (HEIs), energy consumption behaviour is one of the several matters that require attention by the facilities manager. Information on energy consumption behaviour helps on developing a good strategy for energy management. The purpose of this study is to assess energy consumption behaviour among Malaysian HEIs student. This study has an objective to determine energy consumption patterns and analyse the factors that influence the pattern. The 'energy culture' framework consolidated with 'centrographic' approach and econometric analysis used to strengthen the findings. A self-administrated survey carried out involving 158 respondents in Universiti Teknologi Malaysia, Johor. There are three types of energy use among students in HEIs namely, 'high', 'low', and 'conserve'. The 'device', 'activities' and 'building regulation' are the influence factors on the pattern of energy use.

Keywords: Energy consumption behavior; pattern; higher education institutions

Abstrak

Ke arah institusi pengajian tinggi yang mampan (IPT), tingkah laku penggunaan tenaga adalah salah satu daripada beberapa isu yang memerlukan perhatian oleh pengurus fasiliti. Maklumat mengenai tingkah laku penggunaan tenaga membantu membangunkan satu strategi yang baik untuk pengurusan tenaga. Tujuan kajian ini adalah untuk menilai penggunaan tenaga model tingkah laku di kalangan pelajar IPT Malaysia. Kajian ini mempunyai objektif untuk menentukan corak penggunaan tenaga dan menganalisis faktor-faktor yang mempengaruhi corak.Rangka kerja 'budaya tenaga' digabungkan dengan pendekatan 'centrographic' dan analisis ekonometrik untuk mengukuhkan dapatan kajian. Tinjauan tadbir sendiri dijalankan membabitkan 158 responden di Universiti Teknologi Malaysia, Johor. Terdapat tiga jenis penggunaan tenaga di kalangan pelajar di IPT iaitu 'tinggi', 'rendah' dan 'memulihara'. 'Alatan', 'aktiviti' dan 'peraturan bangunan' adalah faktor-faktor mempengaruhi corak penggunaan tenaga.

Kata kunci: Tingkah laku penggunaan tenaga; corak; institusi pengajian tinggi

1.0 INTRODUCTION

Energy consumption behaviour is widely discussed in energy and psychology research; however, there is a lack of studies focusing on HEIs accommodation. This is not surprising, as information on individual behaviour-related energy use is lacking in organisations and offices, which conformed little attention has been given to the large organisational scope (Bansal & Gao, 2006; Lo, *et al.* 2012).

Research mainly focuses on household and industrial environments (Sheinbaum & Dutt, 1996; Lo, *et al.* 2012). Although great attention has been paid to these areas, there are several features that still require further exploration; for example, individual energy consumption behavioural patterns and their characteristics (Ek & Söderholm, 2010; Gatersleben, *et al*. 2002). Exploration of the individual energy consumption behaviour has great potential, especially for the large organization. Through the analysis, HEIs management not only can understand patterns and characteristic aspect, but with further analysis, it's informative when planning university energy policy and programs. Thus, examining energy consumption behaviour at individual levels should be the first step.

The objective of this study is to determine energy consumption patterns and analyse the factors that influence the pattern. Through the objective, the current energy consumption

patterns are reviled. Moreover, it leads to further analysis on the factors that influence the patterns. "Standard Deviation Ellipse" (SDE) calculation from "Centrographic" approach were used to assess the patterns. The patterns were analysed using multiple-regression analysis for determining significant factors.

2.0 LITERATURE REVIEW

In Literature, billing or index data were mainly used by researcher on assessing the energy consumption patterns. For example, researcher present a method that can be used to build an energy audit (Botsaris & Prebezanos, 2004). The method uses energy indices such as the Index of Thermal Charge or Index of Energy Disposition to simulate the heat losses of a building. Other researchers focus on the benchmarking of energy management in an office building in Singapore (Haji-Sapar & Lee, 2005). They use 24 months of electricity consumptions bills to evaluate consumption patterns and specific energy saving measures. Another example, studies focus on the electricity consumption pattern in a secondary school (Stuart, *et al*. 2007). Their research uses billing data which were monitored to identify any changes in patterns.

The efficiency of electricity usage and potential electricity reduction at Malaysian HEIs also has been studied (Jamaludin, *et al*. 2013). Using data regarding annual energy consumption and the building floor area, they develop baseline data for current electricity usage and potential energy conservation in residential building. The problem with this method of exploring billing and index data is that it only presents a general view of patterns without considering the individual behavioural aspect itself. This is supported by earlier studies where the end-user data was found to be lacking and a barrier to the analysis of individual energy use (Sheinbaum & Dutt, 1996).

Literature has proposed an integrated method which is a combination of an engineering and social/psychology approach for assessing individual energy consumption behaviour (Hitchcock, 1993). Cramer *et al*. (1985) proofed that the integrated method is effective in explaining energy usage with individual behaviour. Cramer *et al*. (1985) cited that social/psychology variables do not directly consume electricity, but they are indirectly related to electricity use due to their links with engineering variables.

Lutzenhiser (1992; 1993) suggests that energy consumption is embedded with cultural process. The theory was agreed, that in order to assess the lifestyle aspect and its relation to energy consumption, the culture aspect must become its mainframe Giovannini (1995). Lutzenhiser (1992; 1993) introduced of the "energy culture" model. The core concept of the model is the "material", "cognitive-norm" and "practice".

Energy culture suggests that consumer energy behaviour can be understood at the fundamental level by examining the interaction between cognitive norm (belief and understanding); material culture (technology and building form) and energy practice (activities, process) (Lutzenhiser, 1992; Stephenson *et al*. 2010). Based on the Figure 1, cognitive norm is strongly influenced people's choice of technologies and the practices that they undertake. The material culture has strong effects on cognitive norm and the influence of the people's energy practice. Finally, the energy practice, determine how technologies are used and partly shape people's beliefs and understandings.

Stephenson *et al*. (2010) has expanded the "energy culture" model by designing a new framework of energy culture. In this paper, the framework designed by Stephenson *et al*. (2010) is used as a basis to assess energy consumption behaviour among Malaysian HEI students. Previous research only focuses on demographics from a cognitive-norm aspect, device setting in material aspect and household activity in energy practice.

This paper expands the "energy culture" framework towards its practicality and covers all three main core aspects, namely the material, cognitive norm and practice. The variables include upbringing, demographics and education for the "Cognitive Norm"; device and setting and building regulations for "Material", and activity and social marketing for "Practice". From cognitive norm aspect, upbringing referred to the respondent level of environmental concern, demographic referred to a level of comfort, and education is the understanding level of energy issues. Material aspect refers to the device types and wastage used, and building regulation is the acceptability of energy law in the building. Finally, the practice referred to the activities (in-room energy usage) and social marketing (level of acceptability from the surrounding energy marketing). These variables are selected through its suitableness with the HEIs environment (See Figure 1).

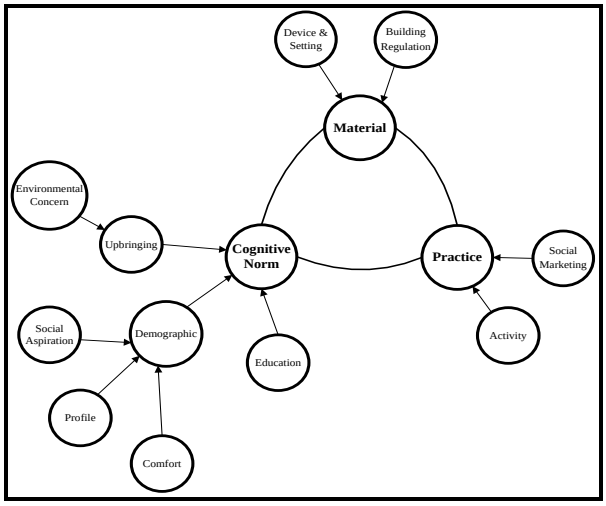

Figure 1 Energy culture framework. *Source*: Stephenson *et al*. (2010)

2.1 Energy Consumption Behaviour Pattern

There are two types of pattern that frequently discussed in literature. First is the "High" energy user and the second is the "Low" energy user. The differences can be explained from the factors selected in energy culture. Overall differences of the energy consumption behaviour pattern explained in Figure 2.

Building regulation factor explains that "High" energy users were less supporting the law compliance within a society (Martinsson, *et al*. 2011). From the environmental concern factor, the "High" energy user were lack of energy awareness and less environmental friendly (Paço & Varejão, 2010; Santin, 2011), compared to "Low" energy user, they were highly motivated with environmental concern and energy issues.

Social aspiration factors shows that the "High" energy user shown no interest practising energy saving behaviour (Masoso & Grobler, 2010), more significance to personal wealth (Martinsson, *et al*. 2011). On the other hand, "Low" energy user, has a positive attitude on energy usage (Kaiser & Shimoda, 1999; Peattie, 2001; Gatersleben, *et al*. 2002; Haron, *et al*. 2005; Ek & Söderholm, 2010; Manan, *et al*. 2010). They have a positive attitude on energy usage (Kaiser & Shimoda, 1999; Peattie, 2001; Gatersleben, *et al*. 2002; Haron, *et al*. 2005; Ek & Söderholm, 2010; Manan, *et al*. 2010). This type of users has the ability to conserve energy (Neuman, 1986; Abrahamse, *et al*. 2007) and

basically has the positive internal form of values, beliefs and norms (Stern, 2000). In general, individual sense of obligation or duty to take measures against environmental deterioration (Fransson & Garling, 1999; Wenshun, *et al*. 2011). The positive belief was translated into behaviour display such as energy saving practice (Chirarattananon & Taweekun, 2003).

"High" and "Low" energy user also can be differentiated from the comfort factors. "High" energy user seeks high levels of comfort in the comfort hierarchy pyramid such described by (Wilk, 2002; Van Raaij & Verhallen, 1983). Compared to "Low" energy user, they have the ability to sacrifice comfort level and only fulfil the basic needs (Ma, *et al*. 2011).

There is no detail explanation about sacrificing comfort level, however, from the energy conservation studies fulfilling basic needs can be interpreted as more use of natural environment energy such as daylight, window opening, etc in daily life. The studies explained that, without operating installed light, or air-conditioning, the environment already comfort their daily activities (Brian A., 1997; Poortinga, *et al*. 2003; Rijal, *et al*. 2007; Kotchen & Grant, 2008; Aries & Newsham, 2008; Rosenberg & Wood, 2010).

Education level differences also differentiate the "High" and "Low" energy user. "High" was referred has a low education level in term of environmental issues. They lack clear information and knowledge of the energy saving (Ma, *et al*. 2011). Different from "Low" energy users, they are well educated people with high level of energy saving preference and high knowledge of the environment issues (Poortinga, *et al*. 2003; Tudor, *et al*. 2008).

Social Marketing has never been specifically interpreted in the literature. However, it can be explained through the level of acceptance of the energy marketing. For example, "High" energy user was explained as the "no-cares" patterns who has no environmental issues intention and have an attitude of using non energy efficiency devices and vice versa to "Low" energy user (Paço & Varejão, 2010). It's highly discussed in buying prospect scope where's researchers explained energy efficiency buying process which has a strong correlation with high environmental concern within consumer (Follows & Jobber, 2000; Ma, *et al*. 2011; Sütterlin, *et al*. 2011; Gadenne, *et al*. 2011).

Device and activities have a direct relationship with energy consumption and most discussed factor in literature. Van Raaij & Verhallen (1983) determined that "High" energy user is the one who use more of electronic, more hours of heating and ventilation. The same character also tested by Santin (2011) and the result was found the same. In terms of device factor, "High" energy users using less energy efficient device other than long duration and frequency usage (Santin & Itard, 2010; Santin, 2011). For the "Low" energy user, they use low duration and frequency of energy (Santin & Itard, 2010; Santin, 2011).

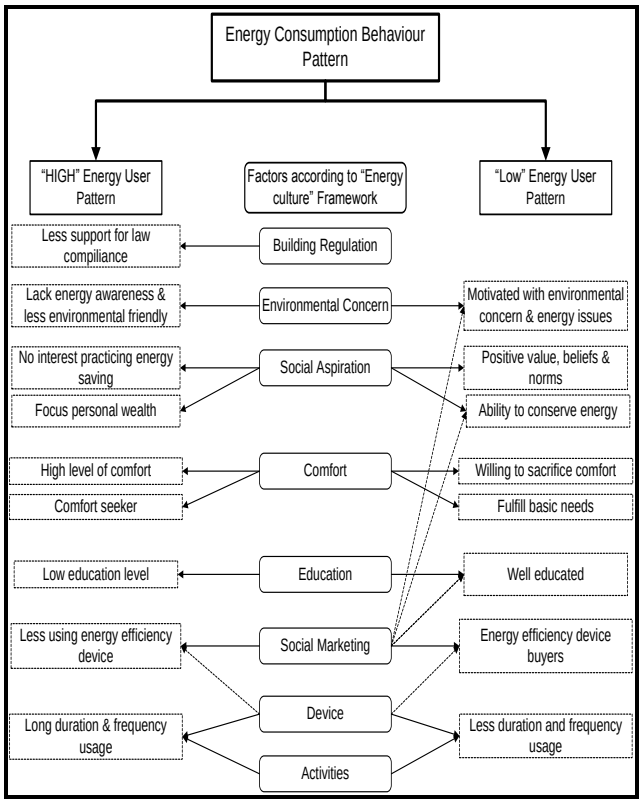

Figure 2 Characteristic of "High" and "Low" energy users

3.0 METHODOLOGIES

Two main stages of methodology are highlighted in this paper. The first stage is data collection, which involves individual energy usage the behaviour aspect and the second stage focus in determining the energy consumption pattern and its significant factors. Overall step of the methodology explained in Figure 3 and Figure 4.

3.1 Stage One–Data Collection

The data were collected through a survey involved 158 students of Universiti Teknologi Malaysia (UTM). Questionnaires were used to elicit the information regarding their energy consumption behaviour in the university accommodation. The questionnaire was designed in three sections. In the first part, data are collected about demographic characteristic of respondents. The second part examines the internal behaviour (building regulation, environmental concern, social aspiration, comfort, education and social marketing). Thirty different questions were created according to their energy consumption factors. The final parts of the questionnaire were intended to collect respondent's daily energy consumption (device and activities) (See Appendix).

3.1 Stage Two–Data Analysis

Stage two focuses on determining the energy consumption pattern and its analysing the factors among Malaysian HEIs students. Based on the data collected at first stage, the first step is to calculate the energy consumption behaviour among the respondent. Calculated consumption of the respondent was plotted according to the total duration and kWh (*Hours vs kWh*). Using the same technique of plotting a map or (x, y) coordinates, this

paper proposes to draw a latitude and longitude basis of energy consumption (for example: x = duration (hourly), y = kWh) in order to visualize the consumption. The next steps use the standard deviation ellipse (SDE) analysis to determine the centre point of the energy. From the SDE analysis, segregation can be achieved to differentiate the energy consumption patterns. The central point determined from SDE analysis creates the boundaries of each pattern in energy consumption. The determined patterns were analysed using multiple regression analysis. An energy consumption behaviour regression general form is illustrated in Equation (1) below:

$$TC\ (kWh) = \beta_0 + \beta_1\ Bul_{Reg_1} + \beta_2\ Soc_{Asp_2} + \beta_3\ E_{Con_3} + \beta_4\ \ Comf_4 + \beta_5\ Edu_5 + \beta_6\ Soc_{Mar_6} + \beta_7\ Dev_7 + \beta_8\ Act_8 \quad (1)$$

Where; TC (kWh) = total consumption in kilowatt; Bul_Reg = building regulation; Soc_Asp = social aspiration; E_Con = environmental concern; Comf = comfort; Edu = education; Soc_Mar = social marketing, Dev = device and Act = activities. Through the multi-regression analysis, the significant factors of each energy consumption behaviour pattern can be interpreted.

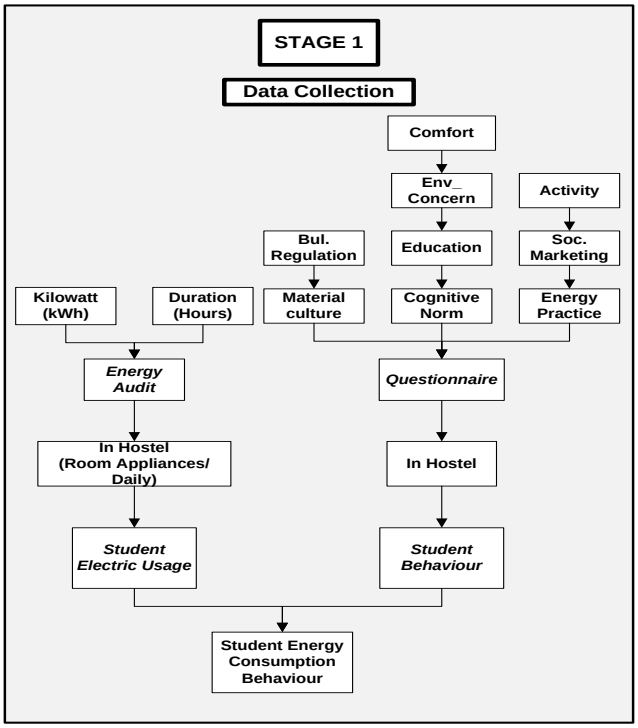

Figure 3 Stage 1 - Methodology

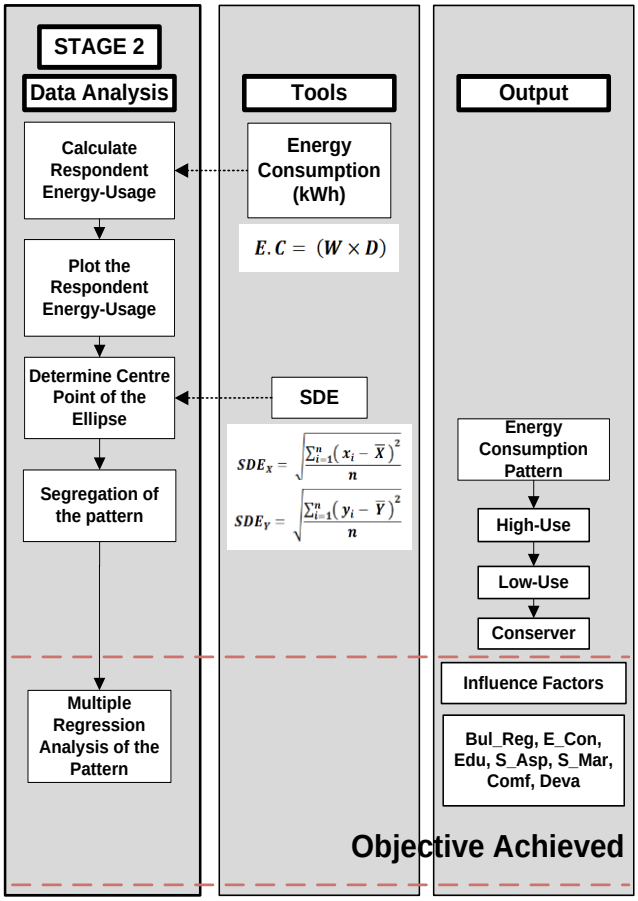

Figure 4 Stage 2 - Methodology

4.0 FINDINGS

Undergraduates consist of 80 female and 78 male students' response were involved in producing this paper. Their energy consumption data were plotted in a graph as in Figure 3. It was based on individual energy consumption calculation using equation (1). The graph was plotted according to total kilowatts (kWh) vs. length of time (Hours). To understand the current pattern that exists among the students' energy consumption, SDE analysis was used as described in equation (2). Through the calculation, the centre point of the ellipses can be recognized and, at the same time, the graph can be segregated into four sections. These sections are the energy consumption pattern namely 'high', 'medium', 'low' and 'conserve' energy user (see Table 1, Figure 5 and Figure 6). Based on the patterns, 35% of the respondent can be categorized as high energy user, 2% as medium energy users, 18% as low energy user, and 45% was conserve energy users (see Figure 5).

$$E.C = (W \times D) \quad (1)$$

Where ***E.C***= Energy Consumption; ***W***= Wattage; and ***D***=Duration

$$SDE_X = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{X})^2}{n}} \qquad SDE_Y = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{Y})^2}{n}} \qquad (2)$$

Where x_i and y_i are the coordinates for feature I, the **X** and **Y** bar present the mean center for the features and n is equal to the total number of features.

Table 1 SDE_x and SDE_y calculation based on Equation (2)

Res	X (Hour)	Y (kWh)
158	0.72	0.00
SUM	8622.67	875.77
Mean	70.95	4.79
SDEx	1007.81	31.75
SDEy	26.01	5.1

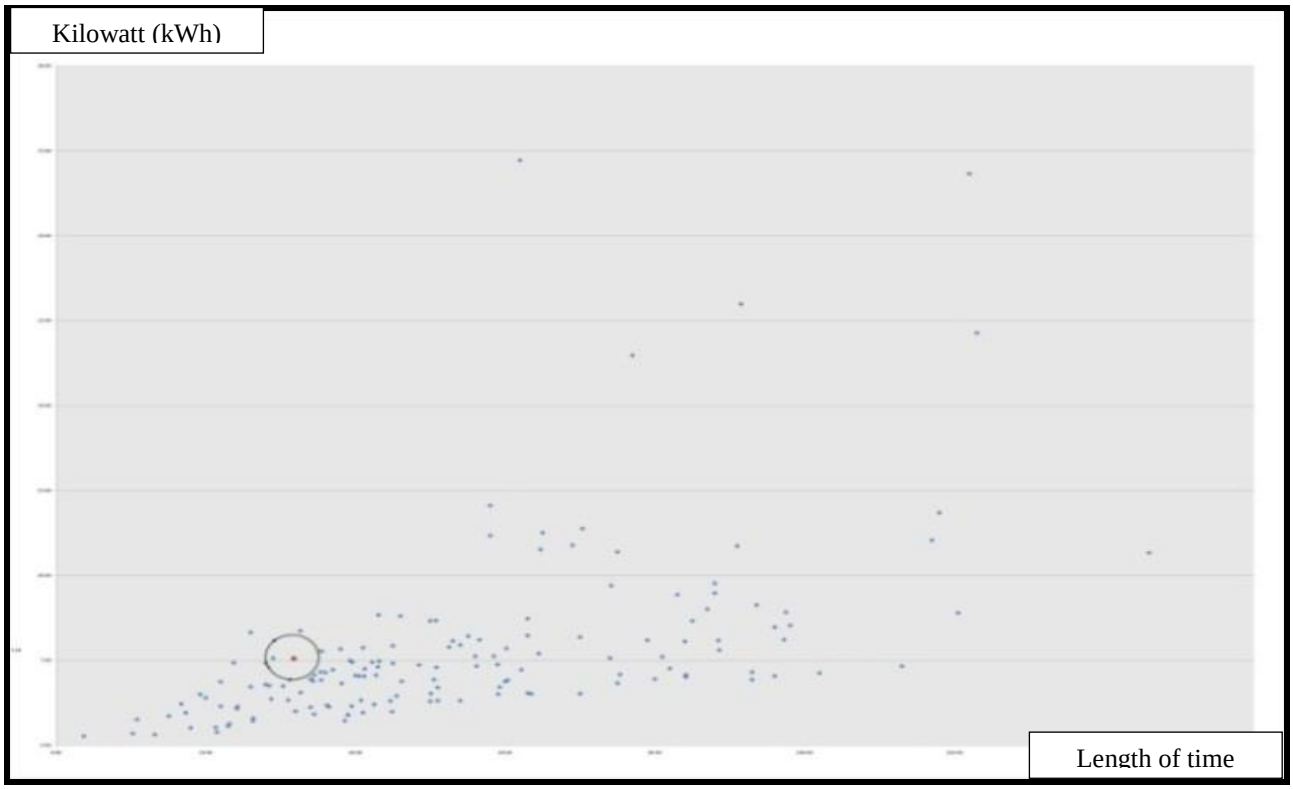

Figure 5 Plotted energy consumption based on calculation using Equation (1)
y=Kilowatt (kWh); x=Length of time and Centre of Energy Consumption Pattern at (*31.75, 5.10*) based on SDE calculation in Equation (2)

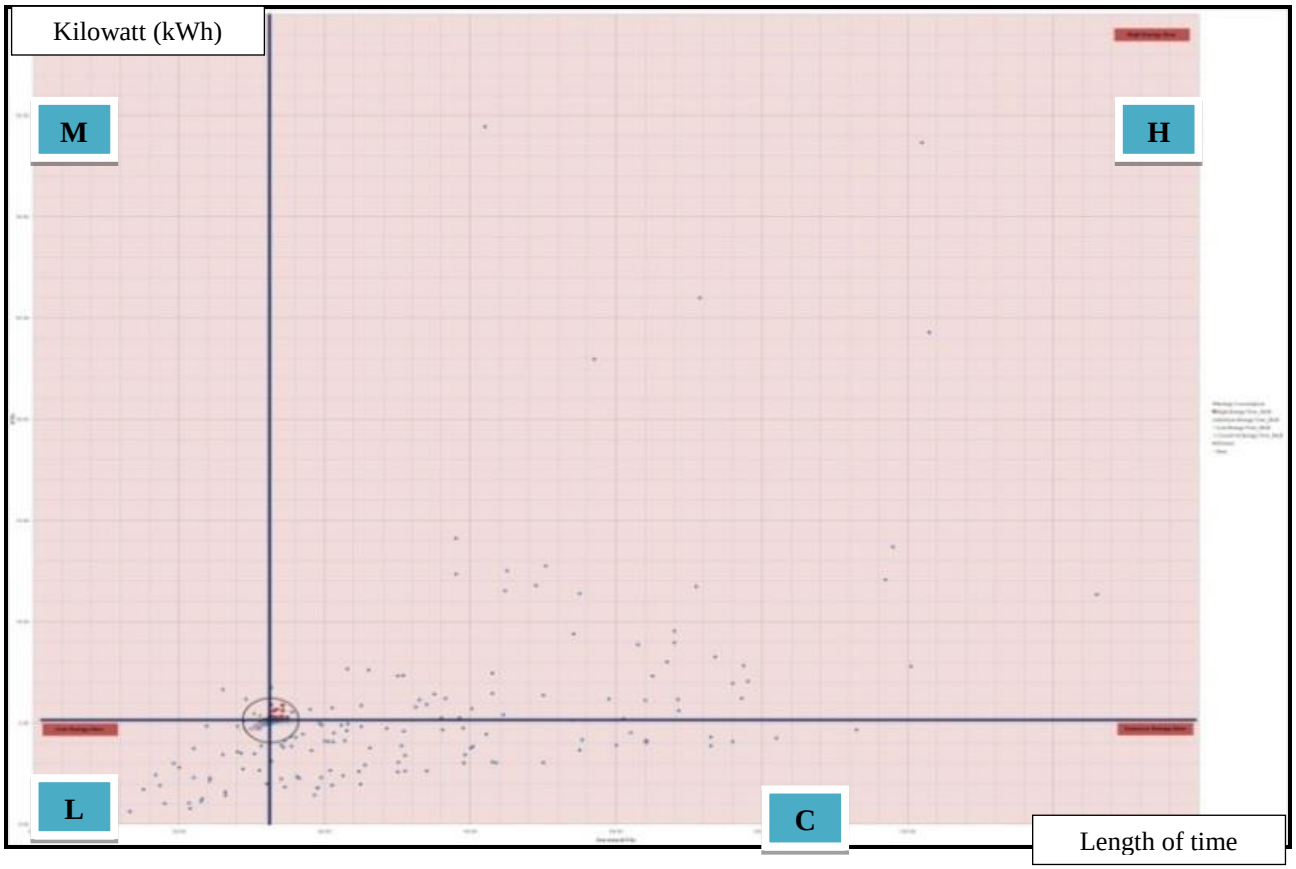

Figure 6 Energy consumption pattern
M=Medium energy user; **H**=High energy user; **L**=Low energy user; and **C**=Conserve energy user

As described early, four types of energy consumption pattern has been determined namely the high, medium, low and conserver energy user. Since, the "Medium" energy user has the less number of observations. It was not considered to be further analyse in this study. Therefore, next analysis only concentrates on the other three patterns.

According to our general regression form in equation (1), the energy consumption behaviour pattern was determined based on the energy culture framework, including material (building regulation and device), cognitive norm (environmental concern, social aspiration, comfort and education), and practice (activity and social marketing). The estimated regression coefficients for this equation are presented in Table 2.

The first equation in Table 2 (Model 1) corresponds to the direct factors on total consumption. Both the device and activities are strongly and significantly related to total consumption as expected. Model 1 explains 96.3% of the variation in total consumption. It is higher than the previous finding with only 51.3% reported Cramer *et al*. (1985).

Model 2 presented the indirect factors of energy consumption. This equation explains 6.5% of the variation in total consumption, so clearly there are indirect factors that affect energy consumption but in a small proportion. The only significant factor is the building regulation perspective with under 0.05 significant levels. Building regulation appears to be an important constraint on energy consumption: highly accepted of building regulation factor consume less electricity. Others indirect factors were found insignificant with energy consumption in Model 2.

Other factors that expected to be significant in Model 2 are social marketing. In literature, social marketing has significant effect on energy consumption Cramer *et al*. (1985). However, the findings has unexpected direction.

Model 3 presented the indirect and direct factors of energy consumption. This equation explains 96.5% of the variation in total consumption. The findings support the theory of the direct factors would have large coefficient than the indirect factors Cramer *et al*. (1985). The combination of direct and indirect factors increases R^2 from 0.963 to 0.965. Most of the indirect factors have small significant coefficient in Model 3 and most of the exceptions can be plausibly explained.

Four factors have been determined that significant with total consumption namely the building regulation, education, activities and device. As described in Model 1, activities and device are strongly related to energy consumption and again a finding in Model 3 supports this theory. The building regulation was also found has significant level to energy consumption and similar to Model 2. However, it has unexpected direction: the more acceptable of the building regulation the more energy were use. The coefficient of building regulation has the same direction with literature but it is not significant in the findings (Poortinga *et al*. 2003).

Education factor was found significant with energy consumption in Model 3. This was supported by the early findings but in expected direction: the higher energy education, the less energy consumed[36]. On the other studies, the factor is significant but in unexpected direction (Gatersleben, *et al*. 2002; Cramer, *et al*., 1985).

Other indirect factors were found insignificant with energy consumption. Comfort was found insignificant with energy consumption. This is unexpected finding, the comfort factor has significant effect and in expected direction Cramer, *et al*. (1985). Adding in, personal preference regarding indoor temperature definitely affects the electricity consumption.

Environmental concern is another factor that is expected to be significant. In Model 2, environmental concern has been determined that has significant effect on energy consumption but not in Model 3. The factor is not strongly related to energy use; it is related to several other direct factors that contribute to energy use Cramer, *et al*. (1985).

Social aspiration were also reported insignificant in Model 3, although it is part of energy culture framework, previous research reported the same result (Poortinga, *et al*. 2003; Abrahamse, *et al*. 2005). Social marketing was also found insignificant with energy consumption and it was unexpected. People who have more access to information should use less energy Cramer, *et al*. (1985). Education and social marketing has high correlation and it reflect with each other's. This anomalous result cannot be explained but requires further investigation.

The equation in Table 2 has shown the significant factors on energy consumption behaviour. The focus is on the third model where the direct and indirect factors were regress together. Based on factors, four factors were found significant with energy consumption behaviour among UTM students namely building regulation, education, device and their activities.

Table 2 Regression coefficients for three equations from a causal model of energy consumption behaviour among Malaysian HEIs students

Factors	Model 1	Model 2	Model 3
Constant	1.168	7.129	1.184
Building Regulation		-0.051 (-2.479**)	0.009 (2.115**)
Environmental Concern		0.046 (-1.416)	0.003 -0.435
Social Aspiration		-0.14 (-0.377)	0.002 -0.301
Comfort		-0.039 (-1.253)	-0.004 (-0.65)
Education		0.036 -1.052	-0.014 (-2.044**)
Activities	1.756 (11.359*)		1.782 (11.426*)
Device	16.304 (22.659*)		16.409 (22.891*)
Social Marketing		-0.022 (-0.71)	0.004 -0.747
R-square	0.963	0.065	0.965
Vif	3.743	1.716	2.266
Durbin-Watson	1.413	2.062	1.5

*Significant at the 0.01 level, **significant at the 0.05 level, ***significant at 0.10 level.

At the first part of the analysis, there were four energy consumption patterns that have been determined. However, only two patterns that were reported in the paper namely the high and the conserve energy user. The other two patterns medium and low energy user was unable to be reported because of the less number of observations that regression analysis require.

Analysis of high energy user pattern was presented in Table 3. Model 1 presents the equation between the total consumption with the direct factors, Model 2 present an equation between total consumption with the indirect factors and Model 3 present an equation between total consumption and direct and indirect factors that was regress together.

Model 1 shows that the direct factors have high level of significant with 98% of the variation in total consumption. It was expected that: the higher energy usage in activities and device will increase the total consumption. This finding supported the theory of high energy user pattern that use more of electronic and more hours of energy (Van Raaij & Verhallen, 1983; Santin, 2011).

Model 2 presents the indirect factors equation with total consumption. It shows 12.1% of the variation in total consumption with no significant factors to the equation. Model 2 has reject the theory of which group is the high energy user based on literature. For example, high energy user was the one who seek the high level of comfort (Wilk, 2002). In this paper, comfort refers to the use of natural energy in student accommodation: the higher level of comfort seeks by the respondent, the less energy is used. The comfort factor is expected to be significant (Van Raaij & Verhallen, 1983; Santin, 2011).

In theory, all the factors in Model 2 were found significant with total consumption for high energy user pattern. Studies have shown that the factors were important in representing the high energy user pattern. However, it never been proofed in regression analysis and its difficult to be interpreted. For example, in building regulation factors, high energy user has shown less support to law compliances (Masoso & Grobler, 2010). The factors expected to be significant with: lower acceptance level to building regulation will increase the energy use. However, it appears to be insignificant in the equation.

The same situation also happens to environmental concern, education, social aspiration and social marketing. High energy user was lack of energy awareness and less environmental friendly (Santin, 2011; Paço & Varejão, 2010). However, the significant level from the regression analysis was never been reported. The findings did not support the theory, the less environmental concern/education/ social aspiration/ social marketing indexed, the higher energy consumption recorded.

Model 3 presents an equation of direct and indirect factors of energy consumption behaviour on high energy user pattern. The result shows 98% of variation with no changes on the R^2 from Model 1. As expected, direct factors still significant to represent the high energy user compared to the indirect factors that was found insignificant at all. Therefore, the result again proof the theory that high energy user use more of electronic and more hours of energy.

Table 4 presents the regression coefficient of conserve energy user pattern. In literature, its rarely can be found researchers discuss the pattern. However, conserve energy user can be classified as the one who use less energy is similar to low energy user (Van Raaij & Verhallen, 1983)

Model 1 in Table 4 shows the equation of direct factors with total consumption of conserver energy user pattern. The R^2 shows 62% variation of the total consumption. Between the two direct factors, only device was found to be significant with total consumption.

Model 2 presents an equation of the indirect factors. Based on the R^2, its shows 8% of variation with total consumption and no factors that is significant. However, in Model 3 with R^2 is 68.2% variation, there was two factors that has been found significant with total consumption namely the building regulation with 0.05 level of significant and device with 0.01 level of significant.

Device factors were found in unexpected direction: increase of kilowatt of device will increase the energy use. As

mention early, conserve energy user pattern would use less energy compared to high energy user. Although, it is significant in the model, but it requires further exploration to interpret the factor. Similar situation faced with building regulation factor that was found in unexpected direction.

Table 3 Regression coefficients for three equations from a causal model of energy consumption behaviour on high energy user pattern

Factors	Model 1	Model 2	Model 3
Constant	-0.142	11.953	0.123
Building Regulation		-0.078 (-1.55)	0 (-0.026)
Environmental Concern		0.019 -0.244	-0.002 (-0.145)
Social Aspiration		-0.126 (-1.62)	-0.001 (-0.520)
Comfort		0.02 -0.3	-0.006 (-0.581)
Education		0.119 -1.51	-0.003 (-0.244)
Activities	1.554 (8.233*)		1.53 (7.336*)
Device	18.347 (17.486*)		18.474 (16.071*)
Social Marketing		-0.1 (-0.131)	0.007 0.587
R-square	0.98	0.121	0.98
Vif	4.038	1.852	2.539
Durbin-Watson	1.409	2.475	1.415

*Significant at the 0.01 level, **significant at the 0.05 level, ***significant at 0.10 level.

Table 4 Regression coefficients for three equations from a causal model of energy consumption behaviour on conserve energy user pattern

Factors	Model 1	Model 2	Model 3
Constant	1.743	2.775	1.255
Building Regulation		-0.003 (-0.503)	0.007 (1.777**)
Environmental Concern		0 (-0.043)	0.004 0.629
Social Aspiration		0.016 -1.404	0.004 0.524
Comfort		0.011 -1.119	0.006 1.088
Education		0 -0.041	-0.07 -1.163
Activities	-0.28 (-1.033)		-0.23 (-0.845)
Device	11.797 (10.419*)		12.215 (10.789*)
Social Marketing		-0.012 (-1.388)	-0.006 (-1.161)
R-square	0.62	0.08	0.682
Vif	1.061	1.742	1.644
Durbin-Watson	1.352	1.667	1.45

*Significant at the 0.01 level, **significant at the 0.05 level, ***significant at 0.10 level.

5.0 DISCUSSION

Based on the findings, direct and indirect factors play the major role in energy consumption. As expected, direct factors do affect the energy consumption in high variation. As for indirect factors, the result has support the main theory where it only affect the energy consumption in small variation (see Table 2).

In Table 2, from Material aspect of energy culture framework, building regulation and device are the significant factors to energy consumption. In cognitive norm aspect, education found to be highly significant to energy consumption. Finally, from the energy practice aspect, an activity is the significant factors. These results mainly explain that these factors should be the focus of FM on energy management in HEIs. For example, an effective and strict order of building regulation on energy in the HEIs must be applied. The positive side of the regulation is, it will affect the energy use level on the activities and reduce the number of high voltage device. This is supported by the findings on high energy user and conserves energy user patterns (see Figure 7, Figure 8, and Figure 9).

The result shows that high energy user was driven by two main factors which are the device and the activities: the higher energy use on both factors, the higher kilowatt consumption will be produced. In order to reduce the energy usage for this pattern, building regulation on the energy can be used. This is because, to conserve energy user pattern, building regulation has an impact to energy consumption. This means, to change the high energy user pattern toward conserve energy user, building regulation can be one of the effective solutions.

Another factor highlighted here is the education factors. Although it is significant with energy consumption, but it is not significant with the other two patterns determined. Thus, it lead to another question, where, does it significant with the other two patterns that was not determined in this analysis, which is the low and medium energy user pattern? The factors are unable to be explained in specific direction and thus further exploration to justify its significant with the patterns is important.

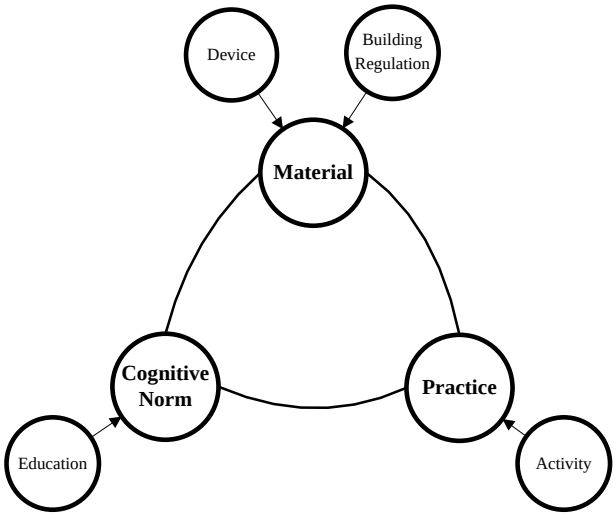

Figure 7 Significant factors on energy consumption behaviour

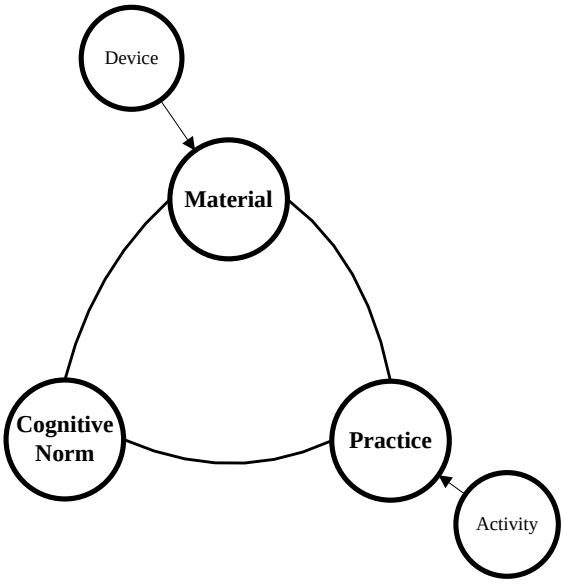

Figure 8 Significant factors of high energy user pattern

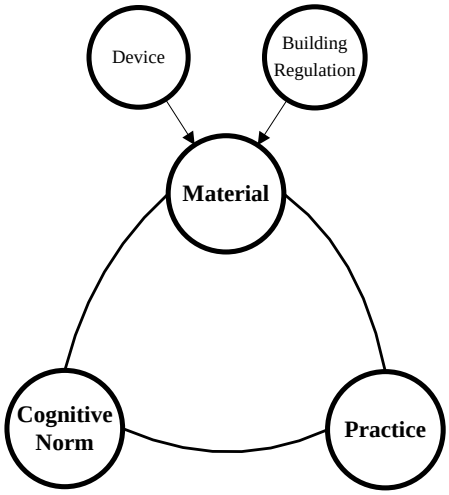

Figure 9 Significant factors of conserve energy user pattern

■6.0 CONCLUSION

This paper has presented the first view of energy consumption behaviour pattern among Malaysian HEIs students. The findings are very important in justifying the current energy consumption pattern and the characteristic that exist among the energy user. It also presents the significant factor that has to be taken into consideration in managing the energy for HEIs FM.

Overall, questions still remain unexplored in this paper such as, is it true, high energy user and conserve energy user can be represent by only two factors: High energy user with device and activities factors; and Conserve energy user with device and building regulation? And is it fair to label these patterns based on these findings. Therefore, further exploration is required to justify the phenomenon.

In this paper, energy consumption pattern was segregated using the centrographic approach which based on the total consumption. The approach has proofed its ability to segregate the pattern in exact figures and present the four types of pattern that currently exist: high energy user, medium energy user, low energy user and conserve energy user. This is the first time, the exact figure of energy consumption pattern was determined in HEIs environments. With further expansion of the approach, it is expected not only the pattern can be categorised, the potential energy saving or the normal energy user characteristic may also be explainable in the future. Therefore, through these findings, several suggestions for future work are recommended:

- This paper only remove considers small observation number in one university. Future work should use large scale of Malaysian HEIs with different level of students to seek different variety of energy consumption behaviour pattern.
- The findings presented the current energy consumption pattern and its characteristic; however, some of the findings were unexpected and unexplainable. Therefore, future work must consider on developing an energy consumption behaviour model that has ability to categorize students into different pattern for better explanation.

Recommended work for the assessment will enhance new knowledge of Malaysian HEI students with regard to their energy use in order to determine an effective strategy that can be used by the university in energy management.

Acknowledgement

This research was funded Malaysian Ministry of High Education through My-Brain scholarship program for Mohd Hafizal Ishak and Universiti Teknologi Malaysia, Skudai, Johor Grant Vote Q.J130000.2527.07H46.

References

[1] Abrahamse, W., Steg, L., Vlek, C., and Rothengatter, T. 2005. A Review of Intervention Studies Aimed at Household Energy Conservation. *Journal of Environmental Psychology*. 25(3): 273–291.
[2] Abrahamse, W., Steg, L., Vlek, C., and Rothengatter, T. 2007. The Effect of Tailored Information, Goal Setting, and Tailored Feedback on Household Energy Use, Energy-related Behaviors, and Behavioral Antecedents. *Journal of Environmental Psychology*. 27(4): 265–276.
[3] Aries, M. B. C., and Newsham, G. R. 2008. Effect of Daylight Saving Time on Lighting Energy Use: A Literature Review. *Energy Policy*. 36(6): 1858–1866.
[4] Bansal, P. and Gao, J. 2006. Building the Future by Looking to the Past. *Organization and Environment*. 19(4): 458–478.
[5] Botsaris, P. N. and Prebezanos, S. 2004. A Methodology for a Thermal Energy Building Audit. *Building and Environment*. 39(2): 195–199.
[6] Brian, A. R. 1997. Impact of Daylight Saving Time on Residential Energy Consumption and Cost. *Energy and Buildings*. 25(1): 63–68.
[7] Chirarattananon, S., and Taweekun, J. 2003. A Technical Review of Energy Conservation Programs for Commercial and Government Buildings In Thailand. *Energy Conversion and Management*. 44(5): 743–762.
[8] Cramer, J. C., Miller, N., Craig, P., Hackett, B. M., Dietz, T. M., Vine, E. L., Levine, M. D., and Kowalczyk, D. J. 1985. Social and Engineering Determinants and Their Equity Implications in Residential Electricity Use. *Energy*. 10(12): 1283–1291.
[9] Ek, K., and Söderholm, P. 2010. The Devil is in the Details: Household Electricity Saving Behavior and the Role of Information. *Energy Policy*. 38(3): 1578–1587.
[10] Follows, S. B. and Jobber, D. 2000. Environmentally Responsible Purchase Behaviour: A Test of a Consumer Model. *European Journal of Marketing*. 34(5/6): 723–746.
[11] Fransson, N. and Garling, T. 1999. Environmental Concern: Conceptual Definitions, Measurement Methods, and Research Findings. *Journal of Environmental Psychology*. 19(4): 369–382.
[12] Gadenne, D., Sharma, B., Kerr, D., Smith, T. 2011. The Influence of Consumers' Environmental Beliefs and Attitudes on Energy Saving Behaviours. *Energy Policy*. 39(12): 7684–7694.
[13] Gatersleben, B., Steg, L. and Vlek, C. 2002. Measurement and Determinants of Environmentally Significant Consumer Behavior. *Environment and Behavior*. 34(3): 335–362.
[14] Giovannini, B., 1995. Introduction of Cultural and Institutional Factors into Energy Modeling. *Energy for Sustainable Development*. 2(3): 7–9.

[15] Haji-Sapar, M. and Lee, S. E. 2005. Establishment of Energy Management Tools for Facilities Managers in the Tropical Region. *Facilities*. 23(9/10): 416–425.
[16] Haron, S. A., Paim, L. and Yahaya, N. 2005. Towards Sustainable Consumption: An Examination of Environmental Knowledge Among Malaysians. *International Journal of Consumer Studies*. 29(5): 426–436.
[17] Hitchcock, G. 1993. An Integrated Framework for Energy Use and Behaviour in the Domestic Sector. *Energy and Buildings*. 20(2): 151–157.
[18] Jamaludin, A. A, Mahmood, N. Z., Keumala, N., Ariffin, A. R. M., and Hussein, H. 2013. Energy Audit and Prospective Energy Conservation: Studies at Residential College Buildings in a Tropical Region. *Facilities*. 31(3/4): 158–173.
[19] Kaiser, F. G. and Shimoda, T. A. 1999. Responsibility as a Predictor of Ecological Behaviour. *Journal of Environmental Psychology*. 19(3): 243–253.
[20] Kotchen, M. J., and Grant, L. E. 2008. Does Daylight Saving Time Save Energy? Evidence from a Natural Experiment in Indiana. *The Review of Economics and Statistics*. 1–32.
[21] Lo, S. H., Peters, G.-J.Y. and Kok, G. 2012. Energy-related Behaviors in Office Buildings: A Qualitative Study on Individual and Organisational Determinants. *Applied Psychology*. 61(2): 227–249.
[22] Lutzenhiser, L. 1992. A Cultural Model of Household Energy Consumption. *Energy*. 17(1): 47–60.
[23] Lutzenhiser, L. 1993. Social and Behavioral Aspects of Energy use. *Annual Review of Energy and the Environment*. 18(0): 247–289.
[24] Ma, G., Andrews-Speed, P., and Zhang, J. D. 2011. Study on Chinese Consumer Attitudes on Energy-saving Household Appliances and Government Policies: Based on a Questionnaire Survey of Residents in Chongqing, China. *Energy Procedia*. 5(0): 445–451.
[25] Manan, Z. A., Shiun, L. J., Alwi, S. R. W., Hashim, H., Kannan, K. S., Mokhtar, N., and Ismail, A. Z. 2010. Energy Efficiency Award system in Malaysia for Energy Sustainability. *Renewable and Sustainable Energy Reviews*. 14(8): 2279–2289.
[26] Martinsson, J., Lundqvist, L. J., and Sundström, A. 2011. Energy Saving in Swedish Households. The (Relative) Importance of Environmental Attitudes. *Energy Policy*. 39(9): 5182–5191.
[27] Masoso, O. T., Grobler, L. J. 2010. The Dark Side of Occupants' Behaviour on Building Energy Use. *Energy Build*. 42(2): 173–177.
[28] Neuman, K. 1986. Personal Values and Commitment to Energy Conservation. *Environment and Behavior*. 18(1): 53–74.
[29] Paço A. M. F.do., and Varejão, L. 2010. Factors Affecting Energy Saving Behaviour: A Prospective Research. *Journal of Environmental Planning and Management*. 53(8): 963–976.
[30] Peattie, K. 2001. Golden Goose or Wild Goose? The Hunt For The Green Consumer. *Business Strategy and the Environment*. 10(4): 187–199.
[31] Poortinga, W., Steg, L., Vlek, C., and Wiersma, G. 2003. Household Preferences for Energy-saving Measures: A Conjoint Analysis. *Journal of Economic Psychology*. 24(1): 49–64.
[32] Rijal, H. B., Tuohy, P., Humphreys, M. A., Nicol, J. F., A. Samuel, A., and Clarke, J. 2007. Using Results from Field Surveys to Predict the Effect of Open Windows on Thermal Comfort and Energy Use in Buildings. *Energy and Buildings*. 39(7): 823–836.
[33] Rosenberg, M. and Wood, L. 2010. The Power of Policy to Influence Behaviour Change: Daylight Saving and Its Effect on Physical Activity. *Australian and New Zealand Journal of Public Health*. 34(1): 83–88.
[34] Santin, O. G. 2011. Behavioural Patterns and User Profiles Related to Energy Consumption for Heating. *Energy and Buildings*. 43(10): 2662–2672.
[35] Santin, O. G. and Itard, L. 2010. Occupants' Behaviour: Determinants and Effects on Residential Heating Consumption. *Building Research and Information*. 38(3): 318–338.
[36] Sheinbaum, C., and Dutt, G. S. 1996. The structure of residential energy consumption in the Mexico City Metropolitan Area. *Energy for Sustainable Development*. 3(1): 43–48.
[37] Stephenson, J., Barry Barton, B., Carrington, G., Gnoth, D., Lawson, R., and Thorsnes, P. 2010. Energy Cultures: A Framework for Understanding Energy Behaviours. *Energy Policy*. 38(10): 6120–6129.
[38] Stern, P. C. 2000. New Environmental Theories: Toward a Coherent Theory of Environmentally Significant Behavior. *Journal of Social Issues*. 56(3): 407–424.
[39] Sütterlin, B., Brunner, T.A., and Siegrist, M. 2011. Who Puts the Most Energy into Energy Conservation? A Segmentation of Energy Consumers Based on Energy-related Behavioral Characteristics. *Energy Policy*. 39(12): 8137–8152.
[40] Van Raaij, W. F., and Verhallen, T. M. M. 1983. Patterns of Residential Energy Behavior. *Journal of Economic Psychology*. 4(1–2): 85–106.
[41] Wenshun, W., Xiaohua, L., and Hualong, L. 2011. Empirical Research of the Environmental Responsibility Affected on the Urban Residential Housing Energy Saving Investment Behavior. *Energy Procedia*. 5(0): 991–997.
[42] Wilk, R. 2002. Consumption, Human Needs, and Global Environmental Change. *Global Environmental Change*. 12(1): 5–13.

Appendix

PART A: RESPONDENT'S BACKGROUND
Please fill in the space provided and tick (√) your information below.

a) Your age: _____ Years

b) Sex: _____ Male

_____ Female

c) What is your student classification?

_____ Undergraduate
Postgraduate. Please specify –
_____ (Msc: Course, Research/ PhD)

d) Semester/Year: _____

e) Religion: _____

f) Nationality: _____

g) Race: _____

h) Family income per month (RM): _____

PART B: QUESTIONNAIRE
Please rank the following statements based on your evaluation regarding energy consumption from 0 to 100 by ticking ANY POINT between the lines that reflects your DEGREE of feeling/perception. ***Example:***

The government should take strong action to reduce emissions and prevent global climate change.

Totally Disagree 0 ---------/---------- 100 **Totally Agree**

1. *Do you feel that electrical appliances registration in the collage can control the amount of electricity use among the students?* **Totally Unacceptable** 0----------100 **Totally Acceptable**
2. *Do you feel that university hostel SHOULD only allow several types of electrical appliances that can be used by the students?* **Totally Unacceptable** 0----------100 **Totally Acceptable**
3. *Do you feel that student has to pay extra charges for use of electrical appliances that are not permitted by the hostel management?* **Totally Unacceptable** 0----------100 **Totally Acceptable**
4. *Do you feel that green landscape and park design on campus will enhance joy for you as a student?* **Totally Unacceptable** 0----------100 **Totally Acceptable**
5. *Do you feel that beauty of nature and culture in the campus has an impact for you as a student?* **Totally Unacceptable** 0----------100 **Totally Acceptable**
6. *Do you feel responsible to maintain a good-quality environment of air, water and soil?* **Totally Unacceptable** 0----------100 **Totally Acceptable**
7. *Do you feel partly responsible for electricity wastage in the university?* **Totally Unacceptable** 0----------100 **Totally Acceptable**
8. *Do you feel bad when energy is consumed unnecessarily in the room (Example: leave lights on in unused)?* **Totally Unacceptable** 0----------100 **Totally Acceptable**
9. *I belief that every student pursuit high level of environmental quality such as clean air, water and soil.* **Totally Unacceptable** 0----------100 **Totally Acceptable**

10. *I belief that student has a high level of understanding and awareness regarding energy saving and wasting in the campus.* **Totally Unacceptable** 0----------100 **Totally Acceptable**
11. *I pay attention to energy consumption because I care for the future of the next generation.* **Totally Unacceptable** 0----------100 **Totally Acceptable**
12. *I feel a personal obligation to avoid unnecessary energy consumption wherever possible.* **Totally Unacceptable** 0----------100 **Totally Acceptable**
13. *I feel a personal obligation to change my electricity wastage behaviour.* **Totally Unacceptable** 0----------100 **Totally Acceptable**
14. *I collected waste selectively (Example: battery, electrical appliances, plastic bottles, glass, papers etc.)* **Passively Perform** 0----------100 **Actively Perform**
15. *I seek information on electrical appliances before doing the purchase (Example: Brand reputation, required voltage to operate, appliances material, Green Energy Logo, etc.).* **Passively Perform** 0----------100 **Actively Perform**
16. *I open the windows frequently to allow natural air coming into the room.* **Passively Perform** 0----------100 **Actively Perform**
17. *I'm allowing natural light inside to the room without using electric light at noon.* **Passively Perform** 0----------100 **Actively Perform**
18. *I change the fan setting frequently according to the room temperature.* **Passively Perform** 0----------100 **Actively Perform**
19. *I clean the fan frequently so it performs at optimum level.* **Passively Perform** 0----------100 **Actively Perform**
20. *I'm using small source of lighting when studying in the room (Example: Table lamp).* **Passively Perform** 0----------100 **Actively Perform**
21. *I do understand the objectives of energy conservation program held in the university.* **Totally Unacceptable** 0----------100 **Totally Acceptable**
22. *I do understand why energy-efficiency appliances and change of energy use behaviour are important to have in the university.* **Totally Unacceptable** 0----------100 **Totally Acceptable**
23. *I regularly watch documentary program regarding energy consumption issue in the television/ internet.* **Totally Unacceptable** 0----------100 **Totally Acceptable**
24. *I read lots of articles regarding energy consumption from the book/ magazine/ newspaper.* **Totally Unacceptable** 0----------100 **Totally Acceptable**
25. *I realized some of the subjects teach in the university has sustainability/environmental input.* **Totally Unacceptable** 0----------100 **Totally Acceptable**
26. *I will give more support to the energy conservation program held in the university.* **Totally Unacceptable** 0----------100 **Totally Acceptable**
27. *I will practice more energy-saving behaviour in the hostel.* **Totally Unacceptable** 0----------100 **Totally Acceptable**
28. *I want to learn more about energy consumption and how it affects the environment.* **Totally Unacceptable** 0----------100 **Totally Acceptable**

29. *I would use/buy more energy efficiency product in the market.* **Totally Unacceptable** 0----------100 **Totally Acceptable**
30. *I would use more natural lighting and ventilation in the hostel room.* **Totally Unacceptable** 0----------100 **Totally Acceptable**

PART C: STUDENT'S ELECTRICAL APPLIANCES AUDIT
Please fill in the space provided and tick (√) the required information.
What type of appliance and daily duration do you use for each in-hostel room activity below?

	Device	**Morning**	**Afternoon**	**Evening**	**Night**
		Hour	Hour	Hour	Hour
In-room lighting & temperature.	Table Lamp				
	Fluorescent Lamp - Ceiling/Wall				
	Ceiling Fan				
Personal Study	Computer with monitor (PC)				
	Fax machine				
	Laser printer				
	Inkjet printer				
	Laptop				
Entertainment	Television (color)				
	Stereo				
	VCR/DVD				
	Radio				
	Computer with monitor (PC)				
	X-box, Game cube, Play station				
	Laptop				
Cooking	Toaster				
	Microwave oven				
	Electric frying pan				
	Coffee maker				
	Kettle				
	Refrigerator				
	Water Heater				
Others	Clothes iron				
	Vacuum cleaner				
	Hair dryer				
	Curling iron (Hair)				
	Electric shaver				
	Electric tooth brush				
	Phone Charger				
Sleeping	Table Lamp				
	Fluorescent Lamp - Ceiling/Wall				
	Ceiling Fan				