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PRIORITIZING OCCUPANTS UNDERSTANDING LEVEL ON RESIDENTIAL BUILDING ENERGY CONSUMPTION

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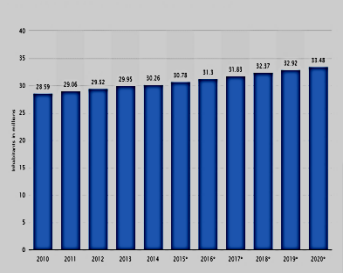
Graphical abstract



Abstract

The building sector is widely known for its greenhouse gas and carbon emission which is very significant to the global warming as observed in recent years. Many research works highlighted that buildings has a negative impact on the society as it consumes up to 80% of the total energy used during operation stage. In Malaysia, electricity energy consumption in buildings is 63,354GWh out of the total 116,353GWh of total energy consumed in the country in the year 2012. This paper consider the understanding level of the residential owners in their building energy usage at their various residential buildings. Energy use by household varies widely, this is due to the living standard of a country, type of buildings and climate condition of the region. The study is based on the tips and guides to energy efficiency at home of the Sustainable Energy Development Authority (SEDA) Malaysia. Data was collected through a questionnaire survey form and was analyzed using regression analysis, the results indicates that the occupants have little or no proper understanding of Air-condition, Home appliance and Lighting appliances.

Keywords: Awareness, building occupants, building energy, energy consumption

1.0 INTRODUCTION

The construction sector is the major contributor of energy consumption. This is due to the growing population of the world, which lead to increasing demand of buildings globally. As a result of this problem, the amount of carbon and related greenhouse gas emission is on the increase worldwide. Electricity energy consumption in the residential dwellings is increasingly becoming higher and multi-dimensional [1, 2]; this makes it very difficult to conclude on the number of factors that attributed to building energy consumption. Many researchers view it from different directions. Some authors look at the socioeconomic/demographic as a factor in electrical energy consumption [3, 5]. Some scholars look at dwelling attributes as a factor [6-8]. Another group considers climate as contributing factor. Wood and Newborough [9], Milani *et al.* [10] reported that, in order to tackle the consumption of electrical energy in residential dwellings, three important points need to be considered. i. Replacement of the existing housing stock identified with low-energy buildings designed primarily to minimize cooling loads and heating ii. Developing and achieving replication for low-energy consuming domestic equipment (e.g. lighting and IT appliances,) and iii. Promoting "energy-conscious" and achieving behavior among end user.

2.0 LITERATURE REVIEW

The electrical energy consumption in the world is 19,710 billion kilowatts. The US consumption of electricity is 3,832 billion kilowatts. China consumes 4,468 billion of electricity and electrical energy consumption in Malaysia stand at 118.55 billion kilowatt all in the year 2012 [11]. Energy Commission [12] indicates that 116,353GWh of electricity was consumed in Malaysia. Electricity energy consumption in Malaysia has increased by 9.2% annually in the last 28 years [13]. Buildings in Malaysia consume a total of 54% of electricity in the country, this is equal to 63,354GWh. Out of the electricity generated, commercial buildings consume 33% this equals to 38,645GWh and the residential buildings consume 21%, which is equal to 24,709 GWh respectively. In 2010 the population of Malaysia is 28.59 million people, by the year 2020 (Figure 1), the population will reach 33.48 million [14, 15] and almost 75% of the population will live in urban areas [11] which implies that more energy will be consumed and more (i.e. CO_2) and GHG will be produced.

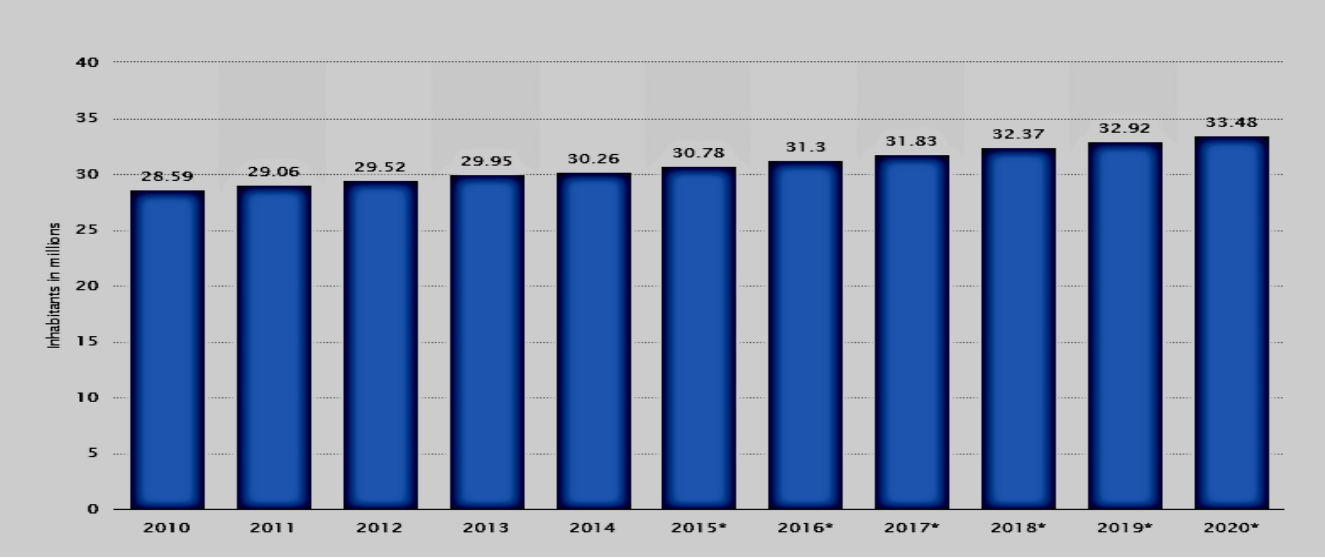


Figure 1 Statistic showing the total population of Malaysia from 2010 to 2014, with projections up until 2020. Source: statista [14]

The buildings are well known for their role in providing shelter, offices etc., however, it contributes negatively towards global warming. Buildings globally are responsible for one-third global GHG emissions [16] [17]. Residential buildings accounted for 6% directly, [18] and 11% indirect global CO_2 emission due to electricity consumption [18]. Despite the campaigns on global energy awareness and mitigation of GHG emissions in the last 40 years, there is more than 100% growth in CO_2 emissions annually. This is more than 32 billion tonnes of CO_2 [19,20]. Global carbon emission is expected to increase to 36 billion CO_2 by projection in 2020 [21]. This projection is expected to double (72 billion CO_2) by 2050 if proper climate change mitigation is not considered [20, 22]. The question here is do the occupants of residential buildings have the full understanding of their contribution to building energy consumption? This is what the paper is trying to look at.

According to Agarwal and Weng [23] there are two major ways to be used in reducing the energy consumption of the building, the first one is by enhancing the energy efficiency design of the devices which will be used in replacing the existing ones, example is by replacing incandescent and fluorescent lights with LEDs (Light Emitted Diode) and the use of more energy efficient HVAC in our buildings. The second way is by improving the existing system's efficiency in reducing the amount of wasted work which includes the switching of lights and equipment after use and keeping the essential lightings powered on in the night [24,25].

Foucquier [26] and Parapari *et al.* [27] express that many parameters have to be considered in order to evaluate the energy performance of a building which include passive solar system, indoor and outdoor condition and ventilation, thermal characteristic of the building and the energy and uses. Brohus [28] and Keyvanfar et al. [29, 30] reported that building energy consumption is strongly influenced by varying energy loads because of the occupants' behavior and weather.

Kavousian et al. [31] observed that the weather, total floor area the location of the building are among the most important factors of building electricity consumption. In an addition to above determinants, entertainment devices (e.g., television) number of air conditioning, the use of refrigerators are among the determining factors and most importantly the number of occupants and high-consumption appliances such like water heaters (electric) are the common significant determinants of daily electricity

consumption. One of the major challenges for achieving the desired goal towards energy efficiency of buildings is the inconsistency of the behaviors of the occupants. Occupants of buildings can influence their buildings through a different means of interaction [32-34]. This study considers electrical energy usage by the residential owners through some tips and guides by SEDA to measure their level of awareness on the efficient usage of electricity in the dwellings. Socio economic is considered as independent factors in measuring understanding level of energy usage of electricity by the households occupants.

2.1 SEDA Malaysia

In its effort towards solving building energy consumption and reducing carbon footprint, Malaysian government establish a body called SEDA (Sustainable Energy Development Authority) with a vision "of promoting the deployment of sustainable energy measures as part of the solutions towards achieving energy security and autonomy.
The body sets its Mission as to:

i. Ensure sustainable energy plays an important role in the nation's economic development and environment conservation;
ii. Ensure existing sustainable energy programmes are managed prudently and efficiently;
iii. Continuously assess new potential sustainable energy solutions in partnership with our domestic and international stakeholders to diversify and complement the existing portfolio of our existing sustainable energy programmes; and
iv. Advocate the public towards accepting responsibility in a paradigm shift towards living sustainably".

Considering item iv above as an aim of the study, (Advocate the public towards accepting responsibility in a paradigm shift towards living sustainably) occupants understanding on ways of using electrical appliances in their respective homes will serve as gate way in achieving the objective of this research paper.

3.0 METHODOLOGY

The scope of this research is focused on the level of understanding on the residential building occupants on electric energy consumption in their dwelling. The items considered are; Refrigeration Appliances (RA), Kitchen Appliances (KA), Air condition system (AC), Laundry and Bath Appliances (LaA), Lighting Appliances (LA) and lastly Home Appliances (HA). The data items of the questionnaire used are associated with the ways and manner electricity appliances need to be used in the residential buildings based on the tips and guides by SEDA. The research data was collected in Johor Bahru (Skudai), Malaysia. 36 residential buildings were considered based on the rule of thumb which indicates an average of approximately 30 participants for a correlational study that relates the variables [30]. The method of "drop and pick" was employed in the collection of the study data. Drop and pick simply means dropping or leaving the questionnaire with the respondent to be collected after some days (weeks). This method was used because the study targeted residential household heads, in some cases, the person collecting the questionnaire may not be the head of the household rather a member, a good example is a wife not being the head of the household she really needs time to forward the questionnaire to the husband who is the head of the household. The questionnaire respondents are Malay, Indians and others (representing internationals residing in Malaysia) as shown in the Table 1below.

Table 1 House head ethnicity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Malay	10	27.8	27.8	27.8
	Indians	3	8.3	8.3	36.1
	Others	23	63.9	63.9	100.0
	Total	36	100.0	100.0	

4.0 RESULTS AND DISCUSSION

Multiple Regression analysis using SPSS software version 22 was employed to predict and identify the best predictor out of the total variables identified. The 6 different variables which are abbreviated as follows; FRA= Refrigeration system, FKA= Kitchen Appliances, FAC= Air-Condition system, FLaA= Laundry Appliances, FLA= Lighting Appliances and FHA stand for other Home Appliances. The results shows that, the model summary in Table 2, explained the level of understanding of the residential building owners. The value .399 under column R square explained the variance (.399 multiply by 100). This explained 39.9% of their understanding on the use of electrical appliances in their residential buildings. In assessing the significance of the result, statistical ANOVA results shown in Table 3 becomes necessary. The null hypothesis tests represented by multiple R in the population is equals to 0.15. The model in this example reaches statistical significance (Sig = .015, this really means $p<.05$). Table 4 explained the contribution of model to the study. The standardized coefficient under the Beta column. This shows which among the beta

value is the largest (ignoring any negative signs). Considering this case, the largest coefficient beta is .557, which is for FRA. This means that FRA variable makes the strongest exceptional contribution in explaining the dependent variable, followed by FLaA, which is .297, the FKA which is .226, followed by FLA which is .106, then FHA at .062 and lastly FAC at .047.

Table 2 Model Summary

del	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.631[a]	.399	.274	.40926

a. Predictors: (Constant), FHA, FKA, FAC, FLA, FRA, FLaA

Table 3 ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.219	6	.537	3.203	.015[b]
	Residual	4.857	29	.167		
	Total	8.076	35			

a. Dependent Variable: FDF
b. Predictors: (Constant), FHA, FKA, FAC, FLA, FRA, FLaA

Table 4 Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1.532	.882		1.736	.093	-.272	3.336
	FRA	.646	.220	.577	2.935	.006	.196	1.097
	FKA	-.272	.212	-.266	-1.284	.209	-.704	.161
	FAC	.039	.156	.047	.247	.806	-.281	.358
	FLaA	.217	.199	.297	1.088	.285	-.191	.625
	FLA	-.103	.211	-.108	-.491	.627	-.534	.328
	FHA	.063	.181	.062	.347	.731	-.308	.434

a. Dependent Variable: FDF

5.0 CONCLUSION

The study indicates that there is no much understanding of utilizing electrical appliances in the use of Air condition, home appliance and lighting appliances in comparison with kitchen appliances, home appliances and refrigeration system. This indicates that there is need for creating more awareness on this 3 areas. This are Air condition, home appliance and lighting appliances. In addition, building insulation and the use of energy efficient appliances will bring about positive savings in building energy consumption. Overhauling of energy management systems by adopting new regulations will help a lot in energy savings.

6.0 RECOMMENDATION

Electrical energy consumption management should be considered beyond public places only, individual residential dwellings and proper awareness through the media should be emphasized by the government and other agencies. In addition to the above mentioned statement, this study may serve as a channel, a systematic and exhaustive study on the topic is required, which may help the construction industries in proposing a much more and better solution to the problems, and can be used to reduce the rate of energy consumption in the country.

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