Jurnal
Teknologi

Full Paper

DWELLING FACTORS EFFECT ON RESIDENTIAL BUILDING ENERGY CONSUMPTION

Jibrin Hassan Suleiman[a*], Saeed Balubaid[b], Nasiru Mohammed Zakari[c], Egba Ernest Ituma[d]

[a]Federal College of Education (Technical) PMB 060 Gombe, Gombe State Nigeria
[b]Kano University of Science and Technology Wudil PMB 3411 Wudil, Kano State Nigeria
[c]Hadhramout University of Science & Technology, Mukalla, Yemen
[d]Ebonyi State University, Abakaliki PMB 53 Ebonyi State Nigeria

Article history
Received
15 April 2015
Received in revised form
29 September 2015
Accepted
12 November 2015

*Corresponding author
hassansuleimanj@gmail.com

Abstract

Most of the developing countries experience rapid urbanization and population growth, Malaysia is among these countries as the population and the energy consumption in the country tremendously increased over the last few decades. A major challenge is the rate of energy consumption in the country is tremendous going higher which is a threat as the country was listed 26th out of the 30 top greenhouse emitters in the world. A survey was conducted on the ways occupants' consumes energy in their residential buildings in relation to dwelling factors in the State of Johor Malaysia. Energy consumption of the residential owners was assessed using drop and pick self-administered questionnaire. The questionnaires were answered by each household heads. Air conditioning system, refrigeration system, kitchen appliances, bathroom and laundry appliances, lighting appliances as well as other home appliances was considered in the survey. Correlation analysis was used using Statistical Package for Social Sciences (SPSS) to analyze the results. The finding shows a positive relationship between dwelling factors. $r \geq 0.3$ and above between dwelling factors and residential building energy consumption.

Keywords: Energy, dwelling factors, Malaysia, home appliances

1.0 INTRODUCTION

Buildings account for approximately 40% of the total energy used in the United States [1]. This is similar to the energy consumed in Europe as well. Research has been on for many years on how to minimize energy consumption of buildings by providing energy efficient structures or retrofitting the existing energy inefficient to improve their energy efficiency. Rozana [2] highlighted that greenhouse gas emission in the Malaysian existing buildings and its communities had contributes to over 40% carbon gases to the environment. Faiza [3] added that, buildings contribute immensely towards global warming and the defection of natural ecosystems. The building sector in the European Union is considered as the largest consumer of energy using up to 40% of the world's energy consumption, 25% of forest timber and 16% of the world's fresh water [4]. The United States building energy data book estimates that 39% of the electricity usage and 40% of the CO2 emissions in the US come from buildings in 2010 [5].

This paper tries to look at the effects of dwelling factors in electricity energy consumption in residential buildings. Dwelling factors are defined as the characteristic of the dwelling [6]. Dwelling factors refers to Building type, building size, number of rooms in the building, size of rooms, total floor area of the building, building orientation, building age (number of years), number of floors in a building, design features (e.g. Wall cavity, double glazing etc), location of the building and Building insulation [6].

Most of the developing countries experience rapid urbanization and population growth, Malaysia is among these countries as the population and the energy consumption in the country tremendously increased over the last few decades. According to the 2000 national census report, the country's final energy demand has increased five times over the last two decades, and the population has doubled in the past 30 years from 10.4 million in 1970 to 22.2 million in 2000. By the year 2020 the population is expected to be around 32 million people [7]. Occupants of buildings similarly manipulate and interact with their environment and structures to obtain the maximum satisfaction they require. Comfort provision on buildings by occupants has a major contribution on energy consumption and carbon dioxide emissions. Several research proofs that buildings consume up to 40% of global energy and emit up to 1/3 of global greenhouse gas emission (GHG)[8].

Malaysia, being one of the equatorial climate countries, has a uniform temperature throughout the year, the temperature range from (32°C) during the day to (22°C) during the night [9]. In some areas, the daily temperature is between 24oC and 36oC. There was little or no variation in temperature throughout the country. In most of the Malaysian towns, the monthly mean air temperature and humidity are almost constant. The annual mean air temperature is around 26 0C in the state of the study area (Johor Bahru) Malaysia [10]. Cooling of residential houses using air condition by the residential occupants became a paramount issue. This is because of two reasons; the first one, there is enough electricity generated by the government and the second reason is the boost in the country's economy. The occupants' interactions are equally related to the assignment or task willingly to achieved by the individuals, example, different electrical appliances can be used in the residential building which may increase the consumption of electricity [11].

According to world fact book, 118 billion kWh of electricity was produced by Malaysian Government, and on the other hand, the electricity consumption of Malaysian is 112 billion kWh in the year 2012 [12]. CO2 emission in Malaysia has increased by 221% during 1990 to 2004 period which lists the country at 26th among the top 30 greenhouse gas emitters [13]. The energy demand of Malaysia in 2009 is 16,132 MW, compared to 10 years before the demand of electricity is just 9690 MW. The rising in electricity demand from 1999 is about 66.5%. This rapid increase in demand is due to the high economic development rate of Malaysia. [7] [14].

Tenaga [15] indicates that buildings in Malaysia consume a total of 54% of the total electricity consumption in the country. Commercial buildings consume 33% and the residential buildings consume 21%, a sum of 38,645 GWh was consumed by commercial building and residential buildings consume a sum of 24,709 GWh. A total of 63,354GWh out of the 116,353GWh of electricity generated in Malaysia is consumed by buildings. Malaysia experienced a rapid economic and technological growth and subsequently the amount of its energy usage has been increasing. A previous research conducted by (CETDEM) Centre for Environment Technology and Development in Malaysia indicates air condition as the largest consumer of electricity in the buildings followed by lighting [16].

Various researches focus on the lighting utilized in the structure while others on a different aspect, however, the system of lighting is mostly not similar system that exhaust most of the energy, such as Heating, Ventilation and Air Condition (HVAC) systems, but it contributes and gives an opportunity for a very great energy savings. Despite the fact that occupants can directly control lighting, but still need something that have a direct influence on the overall energy demand with little or no idea in mind on energy efficiency like leaving the heating controls on, opening and closing windows etc. Lighting plays a vital role for habitable, productive and comfortable environment. Lighting is considered as one of the electricity consumer, it accounts for approximately 20% to 30% of the electricity consumption worldwide [17].

2.0 AIR CONDITION SYSTEM, REFREGERATION AND OTHER HOME APPLIANCES

Kavousian, Rajagopal [18] observed that weather, the location of the building and the floor area are among the most important factors of residential energy consumption. Furthermore to the above determinants, number of air conditioning, refrigerators and entertainment devices (e.g., television,VCRs) are among the most important determining factors of daily minimum consumption, and on the other hand, number of occupants and high-consumption appliances such as water heaters (electric) are the most significant determinants of daily maximum 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 [19]. A survey conducted in Johor Bahru in 2009 by Kubota [10] indicates 65% of the respondents own air condition in their various residential houses. The average period of their air condition usage is 6 hours on daily basis.

3.0 METHODOLOGY

The scope of this research is focus on the effects of dwelling factors on electric energy consumption of residential buildings. The research data was collected in the state of Johor Bahru 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 variables [20]. The questionnaire respondents are Malay, Chinese, Indian and others (representing internationals other than the one listed) as shown in the table below.

Table 1 Showing House head ethnic frequency and the percentage

Household head ethnicity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Malay	10	27.0	27.0	27.0
	Indians	3	8.1	8.1	35.1
	Others	24	64.9	64.9	100.0
	Total	37	100.0	100.0	

The data were collected using a questionnaire with 106 items which was tested for reliability as shown in the table below.

Table 2 Showing reliability statistics

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.949	.951	106

Table 3 Correlation between dwelling factors and electrical energy consumption

		Dwelling Factors	Refrigeration System	Kitchen Appliances	Air-condition System	Laundry Appliances	Lightening Appliances	Home appliances
Dwelling Factors	Pearson Correlation	1	.378*	.453**	.354*	.308	.058	.226
	Sig. (2-tailed)		.025	.006	.037	.042	.742	.192
	N	35	35	35	35	35	35	35
Refrigeration System	Pearson Correlation	.378*	1	.509**	.635**	.678**	.496**	.360*
	Sig. (2-tailed)	.025		.002	.000	.000	.002	.034
	N	35	35	35	35	35	35	35
Kitchen Appliances	Pearson Correlation	.453**	.509**	1	.662**	.689**	.385*	.338*
	Sig. (2-tailed)	.006	.002		.000	.000	.022	.047
	N	35	35	35	35	35	35	35
Air-condition System	Pearson Correlation	.354*	.635**	.662**	1	.873**	.743**	.662**
	Sig. (2-tailed)	.037	.000	.000		.000	.000	.000
	N	35	35	35	35	35	35	35
Laundry and bathroom appliances	Pearson Correlation	.308	.678**	.689**	.873**	1	.792**	.563**
	Sig. (2-tailed)	.042	.000	.000	.000		.000	.000
	N	35	35	35	35	35	35	35
Lightening Appliances	Pearson Correlation	.058	.496**	.385*	.743**	.792**	1	.683**
	Sig. (2-tailed)	.742	.002	.022	.000	.000		.000
	N	35	35	35	35	35	35	35
Home Appliances	Pearson Correlation	.226	.360*	.338*	.662**	.563**	.683**	1
	Sig. (2-tailed)	.192	.034	.047	.000	.000	.000	
	N	35	35	35	35	35	35	35

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

4.0 RESULTS AND DISCUSSION

The study indicates that dwelling factors has a positive significance on residential building energy consumption. The analysis shows that dwelling appliances have strong relationship with 4 out of the 6 factors that was used in the study. These factors are as follows, refrigeration system, kitchen appliances, air-condition system and laundry appliances. However the study shows no significance relationship between dwelling factors and lightening and home appliances.

The significance of r is strongly influenced by the size of the sample. In a small sample like in this work (N=36), moderate correlations do not reach statistical significance at the traditional p<.05 level. In large samples (N=100+), however, very small correlations may be statistically significant. Many authors in this area suggest that statistical significance should be reported but ignored, and the focus should be directed at the amount of shared variance [21]. The output is the size of the value of Pearson correlation (r). This can range from –1.00 to 1.00. This value will indicate the strength of the relationship between the two variables. A correlation of 0 indicates no relationship at all, a correlation of 1.0 indicates a perfect positive correlation and a value of -1.0 indicate a perfect negative correlation.

5.0 FINDINGS AND CONCLUSION

Electrical energy consumption seems to have direct influence on the type of dwelling due to varying characteristics. Types of rooms, floor space, exposure to sun and wind and many more characteristics are attributed to the energy consumption in various types of dwelling [6]. Longhi [23] observed that, individuals living in detached houses spend an additional 7- 8% more on electricity than people staying in flats and apartments. In addition, people staying in terraced houses pay an addition of 9-12% more on electricity expenditures in comparison with those living in flats and apartments.

Obviously, a lot more about energy consumption in relation to residential building occupants need to be explored. More data from different part of the country need to be gathered and analyzed in order to draw conclusions about the significance of the topic. In addition, this study may serve as a gateway to detailed and thorough investigation on the topic which may help the construction industries in proposing a desired model that can be used to reduce the rate of energy consumption in the country. Different authors suggest different interpretations; however, Cohen (1988) suggests the following guidelines:

r=.10 to .29 or r=–.10 to –.29 small
r=.30 to .49 or r=–.30 to –.4.9 medium
r=.50 to 1.0 or r=–.50 to –1.0 large [21]

The result shows that kitchen appliances have higher correlation with energy consumption followed by refrigeration system and air condition, this is in line with Sustainable Energy Development Authority (SEDA) which indicates that kitchen appliances consume up to 35% of the total energy consumption in residential buildings [22].

Acknowledgement

The authors gratefully acknowledge the support of this research from the Federal College of Education (Technical) Gombe and Tertiary Education Trust Fund (tetFund) Abuja, Nigeria.

Reference

[1] EIA. 2009."Use of Energy in the United States Explained." US Energy Information Administration.
[2] R Zakaria, K. S. F., R. Mohamad Zin, J. Yang and Samaneh Zolfagharian.2012. Potential Retrofitting of Existing Campus Buildings to Green Buildings. *Applied Mechanics and Materials*. 178-181: 42-45.
[3] Faizah M. B, M.H.A., and Jibril D. Jibril. 2014. Green building Components used in Universiti Teknologi Malaysia Design Studio. *Advanced Materials Research*. 935:44-47.
[4] EPBD. 2010. Directive 2010/31/EU of the European Parliament and of the Council. *Official Journal of the European Union*.
[5] Energy, U.S.D.o. 2011.*Building Energy Data Book 2010*.
[6] Elisha R. Frederiks, Karen Stenner, and E.V. Hobman. 2015. The Socio-Demographic and Psychological Predictors of Residential Energy Consumption. A Comprehensive Review. *Energies*. 8(1): 573-609.
[7] Shafie, S. M., et al. 2011. Current Energy Usage And Sustainable Energy in Malaysia: A review. Renewable and Sustainable Energy Reviews. 15(9): 4370-4377.
[8] Shahrul Nizam Mohammad, R.Z., Wahid Omar, Muhd Zaimi Abd Majid, Abd Latif Saleh, Mushairry Mustafar, Rosli Mohammad Zin and Noor Azland Jainuddin. 2014. Potential of Solar Farm Development at UTM Campus for Generating Green Energy. *Applied Mechanics and Materials*. 479-480: 553-558.
[9] Taufiq, B. N. M., H. H. Mahlia, T. M. I. Amalina, M. A. Faizul, M. S. Saidur and R. 2007.Exergy Analysis Of Evaporative Cooling For Reducing Energy Use In A Malaysian Building. *Desalination.* 209(1-3): 238–243.
[10] Kubota, T.G., S. Hooi, D.C.T. Remaz, D. O. 2011.Energy Consumption and Air-Conditioning usage in Residentials Buildings in Malaysia. *Journal of International Development and Cooperation*. 17(3): 61-69.
[11] Virote, J. and R. Neves-Silva. 2012. Stochastic Models For Building Energy Prediction Based On Occupant Behavior Assessment. *Energy and Buildings*. 53(0): 183-193.
[12] Central Intelligence Agency, U.2013. The World Fact Book.Malaysia. East & Southeast Asia 2013. 6/12/2013. [Online].Available at:https://www.cia.gov/library/ publications/the-world-factbook/geos/my.html. [Accessed on 25/12/2013].
[13] Islam, F.S., Muhammad Ahmed, Ashraf U. Alam and Md Mahmudul. 2013. Financial development and energy consumption nexus in Malaysia: A multivariate time series analysis. *Economic Modelling*. 30(0): 435-441.
[14] Jibrin, H.S., et al. 2014. Building Energy Consumption in Malaysia: An Overview. *Jurnal Teknologi*. 70(7): 33-38.
[15] Tenaga, S., National Energy Balance 2012. 2012. SURUHANJAYA TENAGA (ENERGY COMMISSION): No. 12, Jalan Tun Hussein, Precinct 2, 62100 Putrajaya, Malaysia.
[16] Aun., C. A. S. 2009.GREEN BUILDING INDEX – MS1525 Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings.
[17] G. S. B. Ganandran, T.M.I.M., Hwai Chyuan Ong, B. Rismanchi and W. T. Chong. 2014. Cost-Benefit Analysis and Emission Reduction of Energy Efficient Lighting at the Universiti Tenaga Nasional. *The Scientific World Journal*. 1-11.

[18] Kavousian, A., R. Rajagopal, and M. Fischer.2013.Determinants of Residential Electricity Consumption: Using Smart Meter Data to Examine The Effect Of Climate, Building Characteristics, Appliance Stock and Occupants' Behavior. *Energy*. 55(0): 184-194.

[19] Robinson, D. 2006. *Some Trends And Research Needs In Energy And Comfort Prediction.Comfort and Energy Use in Building.* Windsor, United Kingdom.

[20] Creswell, J. W. 2012. Educational research: *Planning, Conducting, and Evaluating Quantitative and Qualitative Research*. ed. 4th. Boston, USA: Pearson Education, Inc.

[21] Pallant, J. 2005.SPSS Survival Manual, A Step By Step Guide To Data Analysis Using Spss For Windows (Version) 12. National Library of Australia.

[22] Sustainable Energy Development Authority Malaysia (SEDA Malaysia) 62100 putrajaya. Malaysia.

[23] Longhi, S. 2015. Residential Energy Expenditures And The Relevance Of Changes In Household Circumstances. *Energy Economics*. 49(0): 440-450.