International Journal of Engineering & Technology, 7 (4.35) (2018) 472-475

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper



Effectiveness of Green Strategies to Reduce Carbon Emission in the Putrajaya Campus Buildings of Universiti Tenaga Nasional

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Abstract

Low Carbon Buildings are regarded as structures with low carbon emission in the construction sector. They are environment-friendly in a sense that they contribute to the reduction in carbon emission through optimization of their energy consumption and passive cooling system. This study concentrated on green strategies that can reduce carbon emission of Putrajaya Campus buildings of Universiti Tenaga Nasional (UNITEN). Survey method in the form of questionnaire was applied to gather sufficient data for the research work. The survey work was performed on UNITEN building occupiers with diverse background inclusive of students, academic and non-academic staffs. The primary result implies that the methods of insulating the wall and utilization of energy saving air conditioners are most effective at reducing carbon emission of the buildings. It was also found that there is a low correlation with *R*-square value of 0.017 between the awareness on the impact of carbon emission from the air conditioning buildings and the awareness on climate change issue. This implies that there is a need for active measures to be taken to educate the respondents on the importance to reduce carbon emission of buildings in order to slow down climate change.

Keywords: *Low Carbon Buildings; Carbon emission; Energy consumption; Passive cooling system; Climate change*

1. Introduction

Carbon emission from buildings is inevitable due to the massive consumption of energy of the buildings. The continuous carbon emission from the buildings can contribute to global warming, climate change and resulting in icebergs to melt away and sea water level to rise because it is a direct result of heat release to the atmosphere. This is particularly harmful to the environment and affect the livability of the society. The problems are aggravated when more buildings are built with little concern on carbon emission from the buildings.

Hu et al. [1] conducted a survey on the energy consumption and energy usage behavior of household and residential buildings in urban China. Four aspects were studied under the survey analysis namely, occupant and building information, device and occupant behavior, energy consumption, and attitude to energy-saving policies. All of these aspects were analyzed for buildings at various climate zones, namely severe cold zone, cold zone, hot summer and cold winter zone, hot summer and warm winter zone, and temperate zone. Based on the research work, Hu et al. [1] justified that improvements in energy efficiency especially of lighting and appliances controlled energy consumption growth effectively although the continual increase in the living standard tend to promote higher energy demand. This is also supported by the trend of existing energy-saving policies that bring significant impact at increasing the awareness among building occupants to develop positive energy saving attitude.

Notably, building sector accounts for a large percentage of the total national energy consumption in most of the countries, thus it is critical to formulate and implement appropriate energy saving policies in the building sector [2]. It also has significant impacts on environment due to large amounts of energy consumption and carbon dioxide (CO_2) emissions, which is the major greenhouse gas responsible for global warming [3]. In fact, reducing energy consumption in buildings and increasing renewable production are two key goals of European policies to achieve a sustainable and competitive low-carbon economy by 2020 and beyond [4].

Raji et al. [5] have conducted a case study on energy-saving solutions for the envelope design of high-rise buildings in temperate climates in the Netherlands. One important aspect of the study is the impact of window-to-wall ratio for various degrees of insulated external wall on the percentage of total energy-saving. It was discovered from the study that insulated external wall tends to have a higher percentage of the total energy-saving with increasing window-to-wall ratio as compared to that of the non-insulated one. However, the percentage of insulation of the external wall had to be reduced to 30% for a high window-to-wall ratio so as to optimize the total energy-saving. This reflects the need to have a feasible design of the high-rise buildings with insulated wall so as to achieve the greatest effect of total energy-saving with respect to insulated wall and window-to-wall ratio. Raji et al. [5] also explored the effect of roof strategies on the percentage of total energy-saving on the buildings and the study proved that roof insulation contributes to a better total energy-saving as compared to that of green roof. This shows that roof insulation can help to improve thermal performance of the buildings, thereby reducing expenses for the building operation.

In another development, Geng et al. [6] established an assessment framework of building energy saving technologies for office buildings in cold areas of China. In all the building categories, it is notable that extra (Wall & roof) insulation and tightness have the

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highest average weighted scores. The study proved that building insulation plays a critical role in the total-energy saving of a building. However, Huang & Mauerhofer [7] found that solar thermal is the low carbon technology that can generate a higher CO_2 emission reduction when compared to that of building insulation. The study focused on low carbon technology assessment and planning for building sector in Chongming, Shanghai.

Shi et al. [8] combined Interpretative Structural Modelling (ISM) and Matrice d'Impacts croises-multipication appliqué a classment (MICMAC) approach to investigate the causal relationships among the varying factors relevant to low carbon buildings. The outcome of the study is a comprehensive visualized tool that can optimize construction of low carbon buildings. It was also revealed from the study that critical success factors for the development of low carbon buildings must be highly interactive. Priority of low carbon buildings' evaluation should be focused on such factors as international cooperation, macro-level management, the development of low-carbon theories and technologies due to their strong driving power to low carbon buildings [8].

Based on the literature findings, it can be summarized that there remains a research gap in the performance of the clean strategies and establishment of a systematic assessment method for office buildings in different countries with different climate exposures. Therefore, it is interesting and justifiable for this study to be carried on the Putrajaya Campus buildings of Universiti Tenaga Nasional (UNITEN) in order to identify the most viable green strategies that can be used to ensure energy-saving and sustainability of the buildings. As an energy specialized University, UNITEN needs to move ahead by having energy efficient buildings with reduced carbon emission. Such initiative must be started with a study to assess the level of acceptance and awareness on the green strategies adopted in the buildings that can help to reduce their carbon emission. Through such comprehensive assessment, criteria to rate and establish low carbon buildings in the University can be developed and standardized.

2. Method of the Survey Research

The research method was designed so that a comprehensive survey could be conducted to evaluate the level of awareness and acceptance among the respondents on the green strategies adopted by UNITEN to reduce carbon emission. The respondents for this study are the selected students and staffs in UNITEN buildings (Putrajaya Campus). It is necessary to explore their understanding and conceptualization of the existing green strategies implemented in the buildings. This study involved a questionnaire survey method that aimed to investigate the awareness and acceptance of green strategies implemented in the buildings, with a target of 100 respondents. The method of sampling of the respondents for the survey research is convenience sampling which is a typical non-probability sampling. The method of convenience sampling is documented in the published work of Chua [9]. Convenience sampling was chosen for the study because it could speed up data collection since respondents were readily available to give feedbacks, thus assuring the survey results to be obtained in timely and cost effective manner. The targets for the survey are respondents from the Facility and Development Management (FDM) staffs whose roles are to monitor and control the daily technical and management activities of UNITEN buildings, as well as other administrative staffs. A thorough analysis was conducted to examine their responses based on the results of the survey.

2.1. Questionnaire Method

The design of questionnaires for the survey is based on the guidelines published by Walliman [10]. The questions were prepared in two modes to suit the various categories of respondent in terms of their readiness. The first mode of questions targeted the work experienced staffs of UNITEN including academics and non-academics staffs. The level of vocabulary and the structure of questions were designed to show the significance of the study that can be comprehended by the respondents. The second one was simplified for the sake of getting the students to understand better the questions and to receive appropriate feedbacks from them. Below are the steps that were carried out in order to do the questionnaire survey for the study.

Step 1: The questions were written in systematic pattern. They are designed to gather certain personal details of the respondents such as information regarding the age group categories, and years of study or work experience. The questions started with gathering information for the purpose of accumulating perceptions on the level of awareness among respondents on low carbon buildings and then assessing the level of knowledge of existing green strategies applied in the buildings of the University. The questions ended by enquiring the respondents regarding their level of acceptance on implementation of green initiatives for the buildings in the University.

Step 2: Instructions were given to the respondent to answer the questions appropriately. The questionnaire was assigned a selection tick for the appropriate answer, with a rating numbered from 1-5 indicating the lowest to the highest approval rate regarding the choice and a choice to agree or disagree type of question.

Step 3: A pilot test survey was performed on a few students to ensure the validity and reliability of the survey questionnaire. Three main questions were considered in devising the questionnaires for the pilot test survey are listed below.

- Is the language suitable for the respondent?
- Are the questions understandable?
- Can the instructions or arrangements be changed?

The survey questionnaire was designed to have ten questions that can be averagely answered in not more than ten minutes by the respondents.

3. Results and Discussion

In order to evaluate the background of the respondents, the results categorize the respondents in terms of age, specialization and the buildings of their presence. Then, the next focus of the results is on the correlation between the impacts of climate change with the usage of air conditioners in the buildings. Furthermore, the distribution of respondent's preferences on various types of green strategies based on their effectiveness are critically discussed in the result.

3.1. Age Variation of the Respondents

Table 1 shows the distribution of the age of the respondents who participated in the questionnaire survey. It is shown in Table 1 that the majority of the respondents are occupying the first age group between 18 to 28-years old with a 52 out of 100 per cent of targeted respondents. This provides an indication that students and non-academic staffs are the major respondents in this group. Meanwhile, 26% of the second age group (29 to 39-years old) is mostly consist of postgraduate students, academic and non-academic staffs. It was found that 18% of the third age group (40 to 50-years old) is mostly formed by academic and non-academic staffs as well as postgraduate students. Also, it is very clear from Table 1 that only 4% of the fourth age group (50 to 60-years old) were in the target and this group is comprised of academic and non-academic staffs. Finally, no respondent under the survey is above the age of 60-years old.

Table 1: Age variation of respondents in the buildings

No. of Respondents	Age Group	Respondents (%)
52	18 - 28	52
26	29 - 39	26
18	40 - 50	18
4	50 - 60	4

0		60 - 70	0	
Total	100		Total	100%

3.2. Qualifications of the Respondents

Table 2 shows the qualifications of respondents who participated in the survey. In total, there are 7 groups of respondents. They are foundation, first year, second year, third year and fourth year bachelor degree students, postgraduate students as well as UNITEN staffs. Based on the variation in the qualifications, it was found that postgraduate students have the highest percentage of 20% out of the total number of 100 respondents. The lowest percentage of the respondents is 8% which comprises of the fourth year Bachelor degree students. Overally, UNITEN staffs consist of 18% of the respondents which is the second largest group under the survey.

Table 2: The varying qualifications of the respondents

Group	No. of respondents
Foundation students	16
First year Bachelor Degree students	12
Second year Bachelor Degree students	12
Third year Bachelor Degree students	14
Fourth year Bachelor Degree students	8
Postgraduate students	20
UNITEN staffs	18
Total	100

3.3. Distribution of Respondents According to Buildings

The result as shown in Table 3 indicates the variation in the number of respondents for all the buildings under survey. It is indicative in Table 3 that 20 respondents were targeted in the administration building (BA) which is considered to be the highest number among all the other buildings. Only 6 other buildings are sharing the lowest number of respondents (BE, BC, BD, BW, CFGS and Security) under the survey.

Table 3: Respondents' distribution according to UNITEN Putrajaya Campus buildings

UNITEN Building	No. of respondents
BA	20
BN	8
BM	12
BL	6
BE	4
BV	6
BC	4
BD	4
BW	4
BJ	8
Library	8
FDM	8
CFGS	4
Security	4

3.4. Respondents' Preference on the Various Types of Green Strategy in the Buildings

Figure 1 indicates the respondents' rating on 4 types of green methods implemented in the buildings of UNITEN. The result shows the level of preference of each respondent based on his or her view, knowledge and experience. As shown in the figure, at the first level of awareness (Rating number 1), which is considered the lowest level of effectiveness of the green strategies, fountain installation was discovered to be the least effective method as 18 respondents choose it when compared to other green methods. At the second level of awareness (Rating number 2), the result shows a similar type of response where fountain installation was still preferred at the same number of 18 respondents and this shows that respondents regarded it as a less effective method when compared to the other green methods to be implemented in UNITEN buildings. At the third level of awareness (Rating number 3), an interesting observation can be seen based on the results among the three green methods (Planting on roof, insulation of wall and fountain) in that the green methods have the highest number of 24 respondent approval rates with respect to their preferences. By comparison, only 18 respondents selected the green method of using energy saving air conditioners at such moderate level of awareness. For the fourth level of awareness (Rating number 4), the respondents had different preference, of which 40% of the respondents agreed that energy saving air conditioner green method is most effective at reducing the indoor temperature of buildings than other methods. Such finding is supported by the recognition that energy use in buildings is a significant source of global greenhouse gas emissions and that abatement by the building sector can provide significant social, economic and environmental benefits [11]. For the fifth level of awareness (Rating number 5), out of the expectations, majority of the respondents viewed that the best green method is to insulate the wall for the buildings as compared to other green methods. It must be noted that this finding is supported by the discovery of Li et al. [12] which justified that wall insulation as an ideal method to reduce carbon emission of residential buildings in Hong Kong. Furthermore, the need for building wall insulation is supported by the fact that reinforced concrete and clay bricks are the major carbon emitting materials contributing to more than 70% of the total embodied carbon [13].

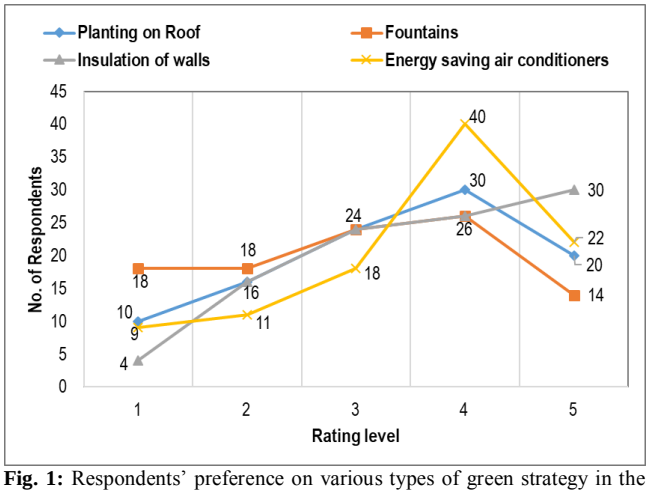


Fig. 1: Respondents' preference on various types of green strategy in the buildings

3.5. Correlations between Awareness of Climate Change Issue and Air Conditioners Usage

Figure 2 shows the distribution of respondents' awareness on the need to reduce the consumption of energy by reducing the usage of air conditioners in order to minimize the level of damage to climate change through carbon emission. There is a low correlation between the two variables as the *R*-square value was found to be only 0.017. The result implies that the respondents have low level of awareness on the fact that excessive usage of air conditioners will lead to high energy consumption which in turn contributes to the increase in the amount of carbon emission into the atmosphere. Reluctance in using low carbon dioxide materials and the lack of environmental awareness hinder the carbon dioxide labelling of materials and consequently the development of low-carbon buildings [8]. Therefore, it is not surprising when Kim et al. [14] stated that much effort has been paid to the management of CO_2 emission by many nations to cope with climate change because CO_2 emission has been regarded as a main cause of global environment disasters that occurred in recent years. The survey finding provides an indication that there is a need for a proactive approach to educate the respondents on the need to decrease car-

bon emission from buildings in order to minimize the impact of climate change.

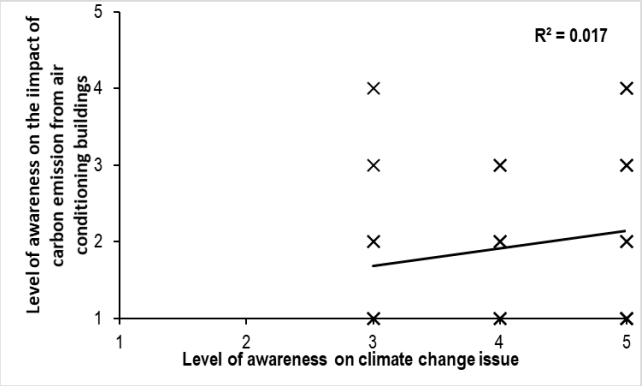


Fig. 2: Level of respondents' awareness towards climate change versus impact of carbon emission from air conditioning buildings

3.6 Framework Design of Green Technologies for implementation in UNITEN Buildings

On the basis of the results of the survey, a framework design that outlines the strategies of low carbon technologies which can help to reduce carbon emission for the buildings in UNITEN is depicted in Figure 3. According to the framework, priority of low carbon measures should be given to the wall insulation followed by in decreasing order, energy saving air conditioners, planting of green roofs and fountains' installation. These measures need to be further intensified within the framework in order to promote low carbon technologies in UNITEN buildings with emphasis on minimizing building carbon emission. As much as the need for the establishment of the framework design, an organization needs Sustainability Policy, Facilities Management and Energy Management as a sub-set of Strategic policy incorporated into its core management policy and operations energy management to achieve low carbon building [15].

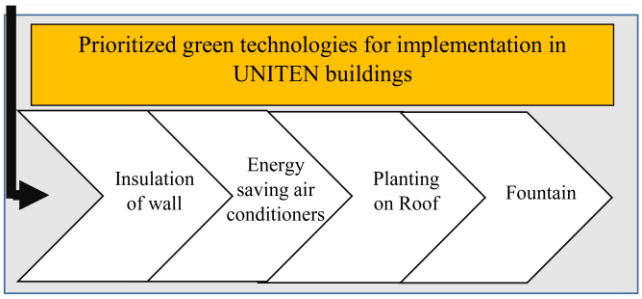


Fig. 3: Framework design of green strategies for implementation in UNITEN buildings

4. Conclusions

The outcomes of the paper serve as a baseline for UNITEN to chart up with more green strategies to reduce carbon emission of the University's buildings. The correlation between the levels of awareness on the impact of carbon emission from air conditioning buildings with that of climate change issue yielded the result *R*-square value of 0.017, which implies the low linear fit regression. The result implies that people still prefer to use air conditioners without paying attention on the negative impacts they can bring to the environment. It is also conclusive that insulation of walls is the most effective method in the existing buildings to reduce carbon emission as such green strategy has the highest rating of 5 in term of effectiveness. Low energy consuming air conditioners are also a perfect rival of green strategy to insulation of walls as it was preferred by 40% of respondents with an effectiveness rating of 4. It is recommended for more feasible green strategies to be implemented in UNITEN buildings so that a comprehensive evaluation on them can be done for the development of a more detailed framework design for regulating carbon emission of the buildings.

Acknowledgement

The authors would like to acknowledge Universiti Tenaga Nasional for financial support to carry out the study through UNITEN BOLD Research Grant 2017 (Project code number: 10289176/B/2017/17).

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