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Influence of Energy Efficient Elements on Energy Saving in Residential Buildings: Case Study of Three Apartments in Penang

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Abstract. This paper examined the energy consumption of energy efficient buildings, and ascertained the extent to which these buildings are efficient when compared to normal buildings. For this purpose, the early literature regarding energy efficient buildings and the related elements have been reviewed, then three energy efficient buildings have been chosen and data collected from their occupants through a questionnaire. The data was then analysed by computing the average yearly electricity consumption per square feet, for both energy efficient buildings and normal buildings. A comparison of the results showed that the energy consumption in energy efficient buildings was almost half that of the normal buildings. Finally a few suggestions are proposed for promoting these types of energy efficient buildings which will eventually lead to economic growth and environment protection.

1 Introduction

According to the Rio Earth Summit, United Nations Conference on Environment and Development (UNCED) in June 1992, ozone layer deterioration, global warming, greenhouse gas emission and the lack of resources due to overuse, has become familiar for most nations. In the matter of environmental conservation and sustainability, the building industry plays an important role because buildings and their construction processes are responsible for at least 30 percent of the world's greenhouse gas emissions, and approximately 40 percent of the consumption of row materials and energy based on the Royal Institute of Chartered Surveyors (RICS) in 2005 [1].

Buildings consume about 40 percent of all primary energy [2], so an effective way to reduce the harmful effects of global warming is to reduce the energy consumption of buildings [3]. By realizing the fact that buildings have a significant negative contribution to greenhouse gas emissions, and energy and resource consumption, the need for the re-designing of buildings which are more efficient has begun. In fact, in achieving considerable energy conservation and reduction in greenhouse gas emissions, communities can benefit from the great opportunities which lie in creating a sustainable approach for designing, constructing and developing buildings to protect the natural environment and at the same time, enhancing it [4].

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The building evaluation was introduced for the first time in United Kingdom in 1990 by the Building Research Establishment Environmental Assessment Method (BREEAM), and after that in the United States of America with the Leadership in Energy and Environmental Design (LEED), in Singapore with the BCA Green Mark, in Australia with the Green Star, in Hong Kong with the Building Environmental Assessment Method (BEAM) and in Malaysia with the Green Building Index (GBI). The Green Building Index (GBI) has been developed by PAM (Pertubuhan Arkitek Malaysia/Malaysian Institute of Architects) and ACEM (the Association of Consulting Engineers Malaysia) in 2009, specifically for the Malaysian tropical climate. The assessment criteria of the GBI in Malaysia are energy efficiency, indoor environmental quality, sustainable site & management, material & resources, water efficiency and innovation [5].

Malaysia has put in much effort towards the reduction of environment damage and keeping the earth safe. On other hand, Malaysia has had significant economic growth, but it can be observed that an enormous amount of energy is wasted in residential buildings due to the lack of energy efficient elements in construction. Buildings have a significant negative impact on the environment due to the overconsumption of resources; energy, materials and water are needed for the creation and operation of the buildings. Residential buildings in Malaysia consume 19% of total energy used in 2007 [6].

The purpose of the study is to develop energy efficiency practices, energy conservation, and the tracking of energy savings in residential buildings in Malaysia and to help reduce greenhouse emissions over time. The first objective of the study is to investigate the energy efficient approaches which can be applied to the residential buildings. The second objective is to examine the extent to which energy efficient elements can have an effect on the energy consumption in residential buildings. The last objective is to survey the area of improvement and propose solutions to enhance residential buildings in Malaysia.

According to Asia-Pacific Economic Cooperation (APEC), the government of Malaysia brought energy efficiency as one of the important elements in its energy policy framework. The Malaysian government recognizes that energy efficiency potentials can alleviate the growing energy demand in the economy. The Ministry of Energy, Green Technology and Water (MEGTW) or KeTTHA is the main energy efficiency policymaker in Malaysia although its control on energy matters is limited to electricity and gas. This Ministry is in the process of finalizing a National Energy Efficiency Master Plan (NEEMP) from 2011 to 2020. The major aim of the NEEMP is to stabilize energy consumption against the economic growth in three sectors i.e. the industrial, the commercial and the residential sector. The Malaysian Government has been using influential approaches to promote energy efficiency development in these sectors. The Government is also supplying financial incentives like tax exemptions to promote a decrease of energy usage amongst energy users by utilising energy efficient technologies and management [7].

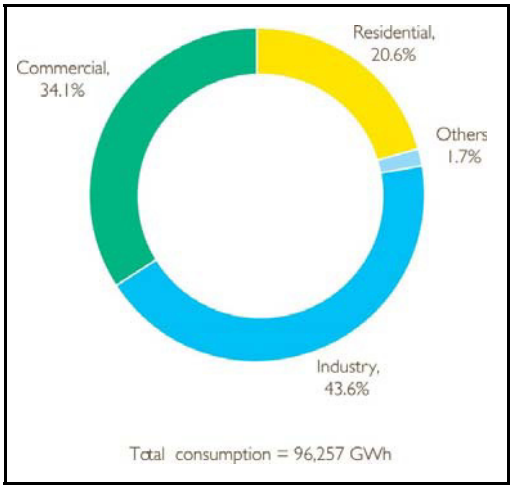

Figure 1: Sectoral percentage contribution for year 2012

As stated by the Ministry of Energy, the Malaysian government spent RM61.95 billion in subsidies in the electric sector between 2000 and 2008 [8]. In early June 2008, the Government declared the reorganization of fuel subsides amidst the continuing intensification in oil prices globally. As the local power sector is currently one of the country's most subsidized industries, the Malaysian government claimed that they could not support the country in the fuel increase due to the global market increment. Consequently, the prices of gas supplied by Petronas in Peninsular Malaysia were also increased on 1st July 2008 [9].

According to the Malaysian Energy Commission, the Malaysian Gross Domestic Product (GDP) has risen steadily at an average of 5.8% per year from 1990 to 2011. The reliable and sufficient electricity supply was a vital catalyst for the economic growth in the country. In terms of energy generated, its gross generation for 2012 was 108,443.1 GWh (from 1st January to 31st December 2012), an increase of 2.6% percent from the previous year. As Figure 1 shows below, the residential sector was responsible for 20.6% of the electricity consumed in Peninsular Malaysia in 2012 [10].

2 Methodology

The main concentration of this study is to examine the effect of energy saving elements on energy saving in residential buildings in Penang, Malaysia. For this reason, both primary and secondary data will be used. The primary data has been provided by the questionnaire distributed and also by conducting direct observations from the current energy efficient buildings which have been chosen for the purpose of this study. The secondary data is prepared from articles, journals, magazines, reliable websites and related books in order to find out what has already been done as a foundation for the evaluation of the data that is collected by the researchers. For conducting a research, first of all the method applied, either quantitative or qualitative should be chosen. Based on the aim of this research, the quantitative method was applied to the project. The raw data was examined with many interpretations to find out the linkage between the research objectives and the outcomes [11]. In order to achieve the research objectives, the data obtained was hypothetically tested. In this study, the elements of energy efficiency that the GBI set out for Malaysia has been determined and then the researcher chose at least three buildings to evaluate the energy consumption by comparing the bills to determine the energy efficient elements which have been used in the buildings. For comparing the energy consumption Microsoft Office Excel was used.

3 Data Analysis

First, three cases with GBI certification was chosen to evaluate the energy consumption. After that, an investigation of those buildings was made to determine the elements of energy saving. Then, the questionnaire was distributed among the occupants of the buildings to define the energy consumption. These data were collected for comparison with the normal building, and find out how much energy can be saved.

3.1 Certified Buildings

The buildings were chosen from the list of GBI certified buildings which are residential and located in Penang. These buildings achieved GBI certification by applying energy saving elements in their construction. The buildings are *The Light Point, The Light Linear and The Light Collection (I)*. The green features of these buildings are listed below:

- Promoting home office with fibre-to-the-home architecture; this reduces waste and avoids unnecessary commuting to the work place.
- Using composite timber and pre-cast green concrete pavement made of recycled aggregates to reduce waste.
- Using low volatile organic compound paint to provide better IEQ.

- The building's façade and orientation is carefully designed to reduce heat in the building.
- There is an energy saving inverter A/C in every unit.
- There is an energy saving hybrid water heater in every bathroom (DC-storage water heater).
- Using dual flush toilet in every unit.
- Using clean renewable energy (wind turbine & solar panel) for the compound, landscape area and the club house.
- Equipped with centralized vacuum system to reduce the amount of airborne particles.
- Rainwater harvesting for irrigation of landscape areas.
- Encouraging occupants with a garbage recycling program.

3.2 Energy Consumption of Selected Buildings

Malaysia has a hot and humid climate in most of the cities. Air-conditioners are the biggest contributors to electricity consumption, and the next biggest contributors are ceiling fans and refrigerators respectively, with almost half of the consumption of air-conditioners.

Therefore the main concern of the questionnaire was regarding the average electricity bills, the area of the units and the number of occupants, air-conditioners and finally electrical equipment applied in each unit. The average of the abovementioned data collected from 41 occupants of three energy efficient buildings, along with the average of the data for five units from five different typical buildings (the buildings without any energy efficient features) are demonstrated in Table 1 below:

Table 1: The buildings average data

Items	Ave. of Area(sq. ft)	Ave. No. of occupants	Ave. monthly electricity bill(RM)	Ave. No. of A/C
The Light Point	2118.438	4.625	136.875	5.25
The Light Linear	1505.714	3.786	84.643	4
The Light Collection(I)	2098.182	3.818	129.545	4
Typical Buildings	1179.8	3.4	166	3.6

In this section, the data obtained from aforementioned buildings are analysed. For this purpose, the yearly average energy consumption, which is mainly electricity, will be estimated for each square feet of the building. By this means, the related figures can be compared with the normal buildings. To do this, firstly the yearly average electricity bill is estimated, and then it is divided by average area of units to find out the cost of electricity consumption in a year per square feet. At this stage, it is possible to make a comparison among the buildings. Table 2 shows the amount:

- *Average electricity bill (per sq. ft) in a year:*
  (Ave. Monthly Electricity Bill × 12 Months = Ave. Yearly Electricity Bill) ÷ Ave. of Area

Table 2: The amount of yearly electricity consumption per Sq. Ft

Yearly Average Bill per Sq. Ft	The Light Point	The Light Linear	The Light Collection	Normal Building
	0.775	0.674	0.74	1.68

The figure below shows the yearly energy consumption of the abovementioned buildings per square feet. As it was demonstrated, the normal buildings have the highest electricity consumption, almost double the consumption of the energy efficient buildings.

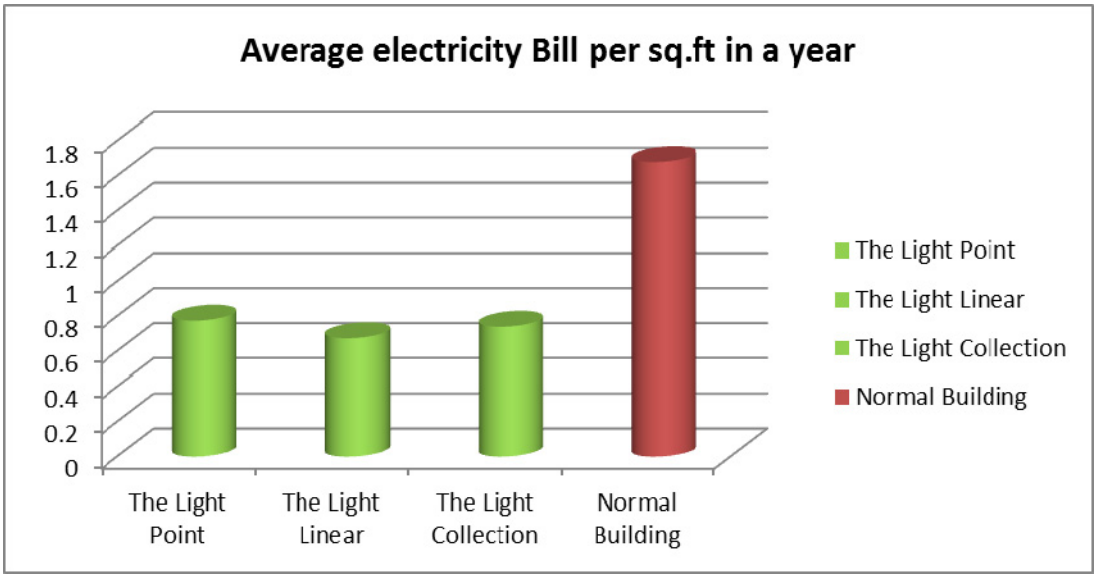

Figure 2: Yearly energy consumption of selected buildings per sq. ft

4 Conclusions

After reviewing the literature, gathering information about the energy efficient buildings and introducing their elements, three energy efficient buildings have been chosen, their specific elements described, and the data from some occupants have been gathered and then analysed. The main elements of the selected buildings which have an effect on the electricity bill of the units are their façade and orientation, the energy saving inverter A/C, the energy saving hybrid water heater and the centralized vacuum system. For the purpose of better understanding of the effect of the energy efficient elements of energy saving, some data was also gathered from a few typical buildings, and the same analysis was done on those buildings to enable a comparison with the energy efficient buildings. It has been shown that the yearly energy consumption per square feet of these energy efficient buildings is almost half of the normal buildings. It means that the occupants of normal buildings pay almost double what the occupants of energy efficient buildings pay for their bills. Therefore, the residents of energy efficient buildings can save a considerable amount of money in a year, and more over a longer term.

On the other hand, the reduction of energy consumption contributes to a decreasing dependency on fossil fuel, which means that the government is less obligated to pay subsidies for the electricity sector. This helps the economic growth of the country and their gross domestic product (GDP). Besides that, using less fossil fuel ultimately means producing less carbon dioxide, hence less greenhouse gas emission, and therefore contributes to environmental protection.

Finally, in the area of improvement, the author believes that the Malaysia government should take some measures to encourage and facilitate the construction of more energy efficient buildings by developers and replace normal buildings with these as much as possible. In addition, the government should contribute towards those who are professionals in improving existing buildings and upgrading them by applying some energy efficient elements.

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