AWARENESS OF ENERGY-EFFICIENCY AMONG OFFICE BUILDINGS USERS: STUDY CASE OF PUTRAJAYA CORPORATION COMPLEX

BY

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ABSTRACT

This research is motivated by the need to reduce energy consumption in buildings, which will subsequently cut Greenhouse Gas (GHG) emissions. At least one-third of global worldwide energy is used in buildings, which generate about 15 percent of global GHG emissions. In cities, up to 80 percent of CO2 emissions are due to energy consumed by buildings. Consequently, the built environment is a critical part of the climate change problem and conversely, a solution. The improving of energy-efficiency (EE) within buildings is essential to reduce GHG emissions, lowering energy costs and ensuring energy security. Malaysia is currently making efforts to improve its EE status. In order to meet future demands, an effective EE strategy is likely to be a cost-effective alternative to developing new power sources. This study is in line with Malaysia's need for long-term solutions towards attaining sufficiency and sustainability in the energy sector. This study seeks to investigate the level of awareness among office building users towards EE. For the purpose of this study, the Putrajaya Corporation office building is selected for the case study since it features some of the energy-efficient elements and practices and the fact that the Putrajaya Corporation acts as a local authority with a mission to plan, manage and develop the federal administrative capital in an effective and efficient manner. This research aims to evaluate the current level of awareness towards EE among the building users; identify the main factors that are in correlation with the users' level of awareness and to what extent they are capable of changing the users' behaviour. The researcher manages to cover two groups within the building designated as technical staff and non-technical staff, and have been compared through the different analyses done by the researcher. This research is designed with the assumption that people from the technical group are more aware on EE as compared to the non-technical group. Questionnaires and interviews with representatives of the Putrajaya Corporation have been conducted for the purpose of data collection. The findings show that 92.3 percent of the respondents are aware of EE, where those from the technical group are more aware compared to those from the non-technical group. It has been found that the factors 'occupational post' and 'group affiliation' do influence the respondents' level of awareness. A significant association has been identified between the users' level of awareness and the behavioural pattern; the more the level of awareness, the more they use the building components efficiently. Furthermore, analyses done have revealed a significant association between the users' level of awareness and their willingness to participate to the building's EE; the higher the users' level of awareness, the higher they contribute to the building's EE. Based on these findings and issues that have been identified, recommendations and suggestions are given in order to enhance the EE level of awareness among the Putrajaya Corporation staff.

ملخص البحث

كان الدافع من وراء إجراء هذا البحث الحاجة للحدّ من استهلاك الطاقة في المباني، والتي ستخفض في وقت لاحق من انبعاثات الغازات الدفيئة. يستخدم ثلث الطاقة العالمية على الأقل في المباني، والتي تولد نحو 15 في المئة من الانبعاثات العالمية للغازات الدفيئة. في المدن، تمثل الطاقة التي تستهلكها المباني ما يصل إلى 80 في المئة من اجمالي انبعاثات غاز ثاني أكسيد الكربون. وبالتالي، فإن البيئة المبنية تشكل جزءًا مهمًا من مشكلة تغير المناخ، وبالعكس، تمثل الحل. إن التحسين في الفعالية الطاقوية في المباني ضروري للحد من انبعاثات الغازات الدفيئة، وخفض تكاليف الطاقة، وضمان الأمن الطاقوي. تبذل ماليزيا حاليا جهودًا مكثفة لتحسين وضع الفعالية الطاقوية وذلك من أجل تلبية الطلب في المستقبل، حيث أنه من المرجح أن تكون إستراتيجية فعالة من حيث التكلفة لتطوير مصادر جديدة للطاقة. هذه الدراسة تتماشى مع حاجة ماليزيا لإيجاد حلول طويلة الأجل من أجل تحقيق الاكتفاء والاستدامة في قطاع الطاقة. تسعى هذه الدراسة إلى التعرف على مستوى الوعي بين مستخدمي المباني الإدارية فيما يخص الفعالية الطاقوية. كغرض لهذه الدراسة، تم اختيار المبنى الإداري لشركة بوتراجايا كحالة للدراسة نظرا لاحتوائه على بعض العناصر والممارسات الموفرة للطاقة، وحقيقة أن شركة بوتراجايا تؤدي دور السلطة المحلية التي تهدف إلى تخطيط وإدارة وكذا تطوير العاصمة الإدارية الفدرالية بطريقة فعالة وكفؤة. يهدف هذا البحث إلى تقييم مستوى الوعي الحالي تجاه الفعالية الطاقوية بين مستخدمي المبنى، وكذا تحديد العوامل الرئيسة التي تؤثر على مستوى الوعي لدى مستخدمي المبنى وإلى أي مدى هي قادرة على تغيير سلوكهم. تمكّن الباحث من تغطية مجموعتين داخل المبنى والتي تم تحديدهما كموظفين تقنيين وموظفين غير تقنيين، حيث تمت مقارنتهما خلال مختلف التحاليل التي قام بها الباحث. وقد تم تصميم هذا البحث مع افتراض أن الأشخاص الذين ينتمون إلى مجموعة التقنيين هم أكثر وعيا تجاه الفعالية الطاقوية بالمقارنة مع أولئك المنتمين إلى مجموعة غير التقنيين. وقد جرى توزيع الاستبيان وكذا مقابلات مع المسؤولين في شركة بوتراجايا لغرض جمع البيانات. وأظهرت النتائج أن 92.3 في المئة من المشاركين كانوا على علم بالفعالية الطاقوية، حيث أن أولئك من مجموعة التقنيين كانوا أكثر وعيا مقارنة مع أولئك من مجموعة غير التقنيين. وقد وجد أن عامليّ "المركز الوظيفي" و "الانتماء الجماعي" تؤثر على مستوى وعي المشاركين. وتمّ التعرف على ارتباط معتبر بين مستوى وعي مستخدمي المبنى ونمط السلوك؛ حيث أنه كلما زاد مستوى الوعي، زاد استخدام مكونات المبنى بفعالية. علاوة على ذلك، كشفت التحليلات عن وجود علاقة ذات دلالة إحصائية بين مستوى وعي مستخدمي المبنى واستعدادهم للمشاركة في الفعالية الطاقوية للمبنى. حيث أنه كلما ارتفع مستوى وعي مستخدمي المبنى، ارتفعت مساهمتهم في الفعالية الطاقوية للمبنى. وبناء على هذه النتائج وعلى المشاكل التي تم تحديدها، تم تقديم توصيات ومقترحات من أجل تعزيز مستوى الوعي تجاه الفعالية الطاقوية بين موظفي شركة بوتراجايا.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Urban and Regional Planning.

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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LIST OF ABBREVIATIONS

ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning
BCIS	Building Consumption Input System
BEI	Building Energy Index
BEMS	Building Energy Management System
CETREE	Centre for Education and Training in Renewable Energy
CFL	Compact Fluorescent Lamp
EE	Energy-Efficiency
EEB	Energy-Efficient Building
EUI	Energy Utilisation Index
GFA	Gross Floor Area
GHG	Greenhouse Gas
GWh	Gigawatt Hour
HFC	Hydrofluorocarbon
HVAC	Heating, Ventilating and Air Conditioning
IDP	Integrated Design Process
KWh	Kilowatt Hour
LEO	Low Energy Office
MEWC	Ministry of Energy, Water and Communication
MSC	Multimedia Super Corridor
NGO	Non-Governmental Organisation
PPJ	Perbadanan Putrajaya (Putrajaya Corporation)
PTM	Pusat Teknologi Maklumat (Centre of Infomation Technology)
TNB	Tenaga National Berhad (National Energy Company)

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

This research was motivated by the need to reduce energy consumption in buildings, which would subsequently cut Greenhouse Gas (GHG) emissions. At least one-third of global worldwide energy is used in buildings, which generate about 15 percent of global GHG emissions (Wafula, 2012). In cities, up to 80 percent of CO_2 emissions are due to energy consumed by buildings (Wafula, 2012). Consequently, the built environment is a critical part of the climate change problem and conversely, a solution. Moreover, the majority of existing buildings were not designed to be energy-efficient. The improving of energy efficiency within buildings is essential to reduce GHG emissions, lowering energy costs and guaranteeing energy security.

Reducing the use of energy in buildings is crucial for attaining carbon reduction commitments. The achievement of this goal can be done through the involvement of a different set of stakeholders. Most of the undertaken actions in this area follow a physical, technical and economic model of the built environment (Lutzenhiser, 1993). In this situation, architects, engineers and efficiency promoters are the major players; they can make technical enhancements to existing buildings and designing new ones with higher standards. The use of energy in buildings can be considered as a social problem rather than a technological one (Nader, 1980). How people are motivated to reduce their energy consumption has been occasionally evoked by social scientists for more than a century (Rosa, Machlis, & Keating, 1988). From this angle, it can be argued that the reduction of energy use in buildings involves

modifications in the entire fabric of society, not just changing the shape and nature of the buildings.

1.2 BACKGROUND OF THE STUDY

According to the report of Tenaga Nasional Berhad (TNB) 2008 on electric power generation by energy sources, energy sources from gas and coal have 54.46 percent and 27.96 percent of the generation rate respectively, while the power generation rate for hydropower and other types of energy sources have the generation rate of 17.47 percent and 0.11 percent respectively (Kok, 2009).

In fact; most of the electricity consumed by buildings is generated using fossil energy (Raman, 2009). With such trends, the building sector will soon consume as much as industry and transport sectors combined, which is quite alarming since Malaysia has one of the fastest growing building industry in the world (Zainordin, Abdullah, & Baharum, 2012). While it may be a reason for worry, there are opportunities for the development of sustainable energy technology.

The energy used in Malaysian office buildings is mostly consumed by air conditioners (57 percent), followed by lighting (19 percent), lifts and pumps (18 percent) and other equipment (6 percent) (Saidur, 2009). Because of the increase in living standards, a growth in electricity use has resulted, especially during hot and humid periods where there is an increasing demand for air conditioners capable of providing occupants with thermal comfort. The buildings' energy consumption is in terms of the Building Energy Index (BEI), the Malaysian average BEI is 269 kWh/m²/year (Zainordin et al., 2012).

In 1989, the Malaysian Ministry of Energy, Water and Communication (MEWC) presented guidelines for energy-efficiency in Non-Domestic buildings.

These guidelines were revised as the Malaysian Standard MS1525: 2007. This standard was aimed to boost the use of renewable energy within the existing and the new buildings in order to reduce the dependence on non-renewable energy sources. However, this standard cannot be applied immediately as mandatory by the Malaysian government since it does not ensure that all new buildings will be built as energy-efficient buildings. On the other hand, there is a chance to improve the current situation above the average construction practices. The constant improving of the standard need to be done in order to enhance the energy-efficiency in buildings in Malaysia.

1.3 PROBLEM STATEMENT

Reducing energy use in buildings is a critical component of meeting carbon reduction commitments. This research argues that building users play a critical but poorly understood and often overlooked role in the built environment. Both advanced technologies used and energy use behaviour changed measures can realise energy efficiency in buildings (Yen & Wai, 2010). The behavioural way to energy saving is a simple and easy way, which does not necessitate any capital investment. It simply encourages the change of energy usage in daily life, and energy-savings are remarkable. Meanwhile, the technical energy conservation way will need additional investment, and the energy-saving effects are not effective immediately.

The vitality of behavioural approach in any energy conservation programme whereby energy use is considered as a key success factor in energy management. Compared to the technological approach, the behavioural approach can be effective and can make a significant difference in energy-efficiency. Hence, problem statement could be listed in three points;

i. The Building's technological components have developed to be more energy-efficient but buildings as a whole have not due to unchanged users' behaviour regarding energy wastage.

ii. The key obstacles to improving energy-efficiency in the existing office buildings are the users' behaviour. The lack of awareness is usually the reason for energy inefficiency.

iii. Energy awareness programs not inclusive of significant energy awareness measurement among the office building users.

The investigation of awareness among the energy users within the office buildings is very relevant to this study. Typically, office buildings consume about 21% of a country's total commercial energy use (Chirarattananon & Taweekun, 2003). Based on this assumption, it is estimated that total energy used by Malaysian office buildings is about 6090 GWh (Saidur, 2009). By referring to Statistics of energy uses in Malaysia, it has been found that the commercial sector, the second largest user, accounts for about 32% of the total energy use in Malaysia (Saidur, 2009).

1.4 RESEARCH QUESTIONS

Based on the issues argued in the statement of the problem, three research questions have been identified:

i. What is the existing level of awareness and comprehension of energy-efficiency in office buildings?

ii. What are the factors influencing the users' energy conservation behaviour?

iii. What are the energy-efficiency awareness models probable to improve the building's energy-efficiency?

1.5 RESEARCH OBJECTIVES

This research was aimed to evaluate the users' level of awareness at the Putrajaya Corporation office building and how it is affecting the behavioural pattern towards energy consumption. Therefore, the following research objectives have been formulated:

i. To measure the users' level of awareness towards energy-efficiency in the selected office building.
ii. To detect factors affecting the energy conservation behaviour.
iii. To propose awareness programs, approaches and recommendations likely to increase the building's energy-efficiency.

1.6 SCOPE OF THE STUDY

This study attempts to cover the important aspects regarding energy-efficiency. However, the focus will be mainly on evaluating the level of awareness among the selected office building users and how it is influencing their attitudes towards energy consumption. The fundamental concepts and principles of energy-efficiency will be included in this study in order to examine the users' knowledge regarding the topic. Furthermore, the study will identify the main factors that are in correlation with the users' level of awareness and to what extent they are capable of changing the users' behaviour. The study did not cover the broader environmental or socio-economic issues often associated with energy-efficiency studies. This research only focuses on

evaluating the energy-efficiency level of awareness, and its effectiveness in achieving deep energy savings within the Putarajaya Corporation office building.

1.7 METHODOLOGY OF THE STUDY

This study was conducted following four different stages, namely background and theoretical studies, gatherings of data, analysis of data and findings, lastly conclusions and recommendations. The flowchart illustrated in figure 1.1 demonstrates the four stages of this study.

1.7.1 Stage 1: Background and Theoretical Studies

The first stage of this study commenced with a preliminary study that comprised readings from different references relevant to the topic of interest, which is awareness of energy-efficiency. This phase is very important since it leads to the identification of the issues and problems related to the topic, and subsequently, the formulation of the research problem statement, the objectives of the study, the scope and the contribution of this study. This phase is essential because it allows the researcher to acquire a general comprehension of the topic besides of determining a preliminary theoretical approach to the study. This stage is demonstrated in Chapter 1 and Chapter 2 of the study.

1.7.2 Stage 2: Data Collection

This stage consists of the discussion on the gathering of different types of data from both primary and secondary sources. The primary data was collected through the distribution of questionnaires to the users of the case study building (Putrajaya Corporation) from different categories namely officers, engineers, technicians and