



REDUCING HOUSEHOLD ELECTRICAL ENERGY  
CONSUMPTION BY IMPROVING OCCUPANTS  
BEHAVIOUR BY FEEDBACK METHOD

BY

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requirement for the degree of Master of Science  
(Building Services Engineering)

Kulliyyah of Architecture and Environmental Design  
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## **ABSTRACT**

The consumption of energy economically and efficiently is one of the crucial matters today. The utilization of earth natural resources for mass energy production not only stresses the depletion of ozone layer or enhances climate changes but also the increases energy prices and the financial plan of people. This study investigates the effect of behavioural change towards utilizing electrical appliances in households through indirect feedback method hoping to change their overall energy consumption in a way that it can be reduced. This study focused on 16 occupants from five different apartment units in a high-rise apartment building in Kuala Lumpur (KL), Malaysia. Changing behavior towards utilizing electrical appliances efficiently is important in the long term; the most effective way is to ensure that people are familiar about the sensible ways in which they utilize their electrical appliances and ways in which it can affect the overall consumption. Moreover, to date no systematic investigation has been considered for household in Malaysia on this matter. (Three research questions motivate this research; what are the most common household electrical appliances that are available and used by the homes, in which manner and how frequently are the electrical appliances being utilized and how awareness can affect the behaviour of occupants to reduce their energy consumption). A quantitative method was used to conduct the study with two sets of survey questionnaire as a research instrument, distributed before and after the fieldwork. The findings from the research suggest that three units (unit 2, unit 3 and unit 5) decreased their overall electricity energy consumption level when two months of usage were compared. The electricity bill shows that unit 1 and unit 4 had an increment of 1.2% and 2% respectively, whereas unit 2, unit 3 and unit 5 reduced 0.3%, 2.3% and 0.6% respectively. It was concluded that positive behavioural changes were seen when the overall electrical energy consumption had been reduced in two units. Also, there were a few occupants whom though they are aware of how to utilize the electrical appliances efficiently; they did not show any behavioural changes in utilizing them. 1% of energy reduction was fully observed following changes in behaviour.

## ملخص البحث

بعد الاستهلاك والترشيد الاقتصادي للطاقة اليوم واحد من الهموم المحروبة، كما هو الحال في أن إنتاج الطاقة واستهلاكها لا يتأثران فقط بتغير طبقة الأوزون، والتغير المناخي الناتج عن ذلك، بل يتأثران بمؤثرات أخرى تؤثر، في الزيادة المستمرة لأسعار الطاقة كسلوك الأفراد والدول في طرق استخدام الطاقة، وأثر ذلك في ميزانيات الأسر والدولة، مما يدعو إلى البحث عن سبيل لترشيد وتقليل استهلاك الطاقة، و هو موضوع هذه الدراسة. وفي هذه الدراسة اختار الباحث عينة من 16 منزلاً من 5 وحدات سكنية في مناطق مختلفة بكوالالمبور بماليزيا لدراسة مدى إمكانية تغيير سلوك الأفراد في استهلاك الطاقة وأثر ذلك في نسبة الاستهلاك الكلي للطاقة في ماليزيا ولاحظت هذه الدراسة أنه لا يوجد حتى اليوم نظام أو لوائح لترشيد الطاقة لدى الأفراد أو المجتمع لخفض الاستهلاك العام. ولذلك تثير هذه الدراسة ثلاثة أسئلة. وهي: ما النظم واللوائح المستخدمة لخفض استهلاك الطاقة في المنازل وفي الدولة ككل؟ ما كيفية تطبيق النظام خفض استهلاك الطاقة في البيوت؟ ومما مدى فاعلية واستمرارية ذلك؟ وكيف يمكن أن يؤثر نظام ترشيد استهلاك الطاقة في السلوك الترشيدي لاستهلاك الطاقة لدى الأفراد، و أثر ذلك في خفض نسبة استهلاك الطاقة العام. واتخذت الدراسة مرحلتين لجمع المعلومات بتوزيع استبيانات قبلية وأخرى بعدية لدراسة الحالة الحالية و أثر التوعية والنظام المقترح في خفض نسبة استهلاك الطاقة. ونتج عن تحليل المعلومات أن ثلاث وحدات سكنية (الوحدات 2 3 5) قام سكانها بخفض استهلاكهم للكهرباء بعد شهرين من بداية تطبيقهم لما اقترحه الدراسة، وأن كشف استهلاك الكهرباء شهريا أشارت إلى أن الوحدات السكنية (1،4) سجلنا انخفاصاً في الاستهلاك بلغ (1/2%) و (2%) في حين أن الوحدتين (2،3،5) سجلنا انخفاصاً بلغ (3%) و (2/3%) و (6%). وأخيراً توصلت الدراسة إلى النتائج الآتية: أن عدم وجود نظام لترشيد استخدام الطاقة أدى إلى وجود سلوك سلبي في ترشيد استخدام الطاقة عند الأفراد والمجتمعات. التغييرات الإيجابية التي لوحظت في سلوك الأفراد في توجيههم لترشيد استهلاكهم للطاقة قد نجح في خفض نسبة الاستهلاك وخفض الميزانية الأسرة و المجتمع بنسبة 1% مع إمكانية زيادة هذه النسبة لاحقاً.

## 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. It is also fully adequate, in scope and quality, as a dissertation for the degree of Master of Science (Building Services Engineering.)

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation. It is also fully adequate, in scope and quality, as a dissertation for the degree of Master of Science (Building Services Engineering.)

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

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*Dedicated to my beloved parents*

*Dad, my mentor*

*Mom, my inspiration*

*And my loving husband and daughter, my eternal gratitude*

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# CHAPTER ONE

## INTRODUCTION

### 1.1 BACKGROUND

The oil shocks that faced during the 1970 have lead for energy efficiency measures (Ponniran *et al.*, 2012). In 1973, the world experienced energy crisis (Alahmad *et al.*, 2012) due to higher demand for energy from several industrial nations such as Germany, Unites States, Canada, etc. So the oil producers were unable to produce or supply to cater the demand while other producers embargo by the peak of oil production. During 1973, Yom Kippur war led the Organization of the Petroleum Exporting Countries (OPEC) limiting oil export embargoes on the European Union (EU)/Western due to their support for Israel causing an energy crisis. Furthermore the Iranian Revolution in 1979 created another major oil crisis. Consequently, the world energy crises in the 1970s had caused in energy efficiency measures (Abrahamse *et al.*, 2005) hence resulted in the study in reducing energy consumption or increasing energy efficiency through different sectors. The figure 1.1 illustrates major incidents that caused energy crises over the last few decades.

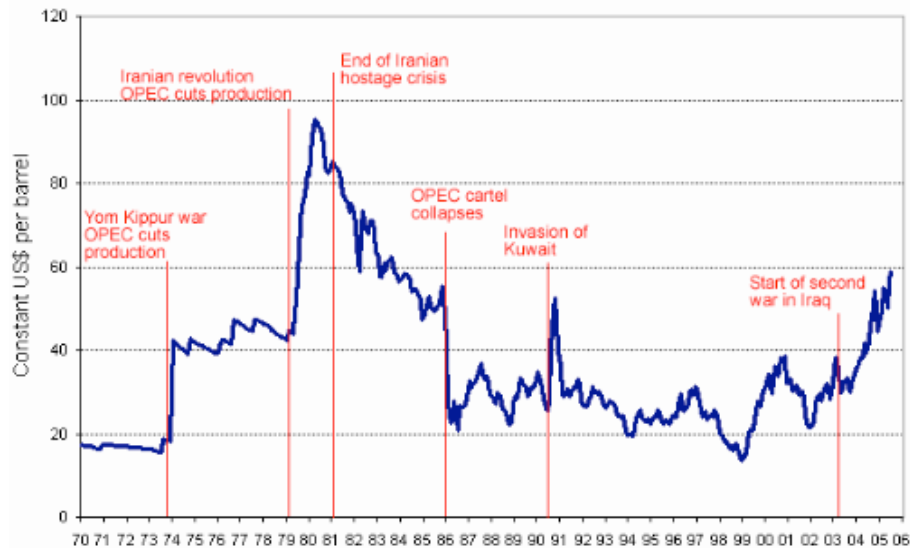


Figure 1.1 Major incidents that caused energy crisis over the last few decades.  
 (Source: Federal Reserve Bank of St. Louis, and Bureau of Labor Statistics as cited in  
 Hidhiir et al., 2007 – online)

Over the past few decades, due to the rapid growth of the population, economic development, technological advancement and changes in living styles increased the demand for energy dramatically and hence emitting a significant amount of Carbon dioxide (CO<sub>2</sub>), which has become the primary contributor to global warming and changes in the climate (Abrahamse *et al.*, 2005). Utilizing earth's natural resources has become the most common methods of generating energy thus not only depleting the earth's natural resources but also contributing to climate changes. Bachellerie (2012) stated that with the increase in demand for such expanse of energy not only damages the environment but also over-reliance on oil and gas is not sustainable. However, Hayes and Cone (1977) suggested that either source of energy can shift towards renewable source or consumption of energy needs to be altered to find a solution for energy. So conservation of energy has become a critical subject.

Around 80% of the world has access to electricity (Wilson, 2013 – online). In which 77% of world energy consumption is by burning fossil fuel (coal, petroleum (oil), and natural gas), 2% uses renewable energy sources, and 21% is other sources that are being used for energy generation (The New Internationalist, 2003 – online). It is important to conserve energy by using energy efficiently and shifting energy that generates from renewable sources. According to Marsh *et al.* (2010) due to the rapid growth in the urbanization the studies shows that residential electricity consumption dominates the total primary energy. Moreover, Alahmad *et al.*, (2012), stated that the world energy crisis in the 1970s has been the rationale behind studies conducting in reducing energy efficiency in the household since it is the primary energy dominating sector.

Swan and Ugursal (2009) agree that the residential sector is a substantial consumer of energy in every country. Several authors stated that the residential sector causes the highest energy intake and carbon dioxide emission (Bari *et al.*, 2013, Alahmad *et al.*, 2012, Marsh *et al.*, 2010 and Darby, 2006 – online) in Malaysia as well (Bari *et al.*, 2013). Colourcoil (2011 – online) reported that 53% of the energy is consumed by the residential sector in Malaysia alone and is continuously expanding. Besides, Bari *et al.* (2013) highlighted that in their preliminary assessment of residential energy consumption rate, they found out that there would be a substantial increment in the energy consumption and CO<sub>2</sub> emission from the year 2008 to 2020 (4,397 kilotons of oil equivalent (Ktoe) and 11,689,308 tonne respectively). So reducing electricity consumption rate in the household can bring a vast difference in the electricity consumption rate thus reducing the CO<sub>2</sub> emission rate from the power plants. Furthermore, the Prime Minister of Malaysia, Najib Razak said that through

energy efficiency strategies the Malaysian government is looking forward in reducing Malaysia's carbon emission by 40% by the year 2020 (Mohamad, 2009 – online).

Reducing energy consumption can be achieved by providing various techniques to the consumers. One of the important ways to reduce energy is by using the feedback method. The feedback method delivers information on the amount of energy consumed by the consumer. Although the feedback method on household energy consumption rate provides a noticeable percentage of energy saving and contributes to a reduction in energy consumption rate (Darby, 2006 – online; Petersen *et al.*, 2007; McKerracher and Torriti, 2013) this has not been applied in Malaysia. Therefore, this is a study based on how effective it could be in reducing the energy consumption rate by providing feedback to the households in Malaysia. Moreover, Haley and Mahone (2011) highlighted that “*the use of behaviour based energy efficiency is not widespread*”.

## **1.2 PROBLEM STATEMENT**

Currently, the high-energy consumption rate in the households is one of the major concerns that the society is facing. Continuous population growth along with the lack of awareness and knowledge that the dwellers have in utilizing their electrical appliances is the main reason for high-energy consumption rate (Hoelzl *et al.*, 2014, Wai *et al.*, 2009) in the residential sector. The first step towards implementation of conservation measures is by creating awareness on the importance of energy conservation (Bekhet and Ivy-Yap, 2014). The advancement in technology has led to quality of everything thus energy problems are unavoidable. Although the technology has grown within the years, and it helped in energy efficiency measures (Abrahamse

and Steg, 2011), this is insufficient to reduce the energy consumption. To use energy efficiently, strengthening behavioural intentions are essential (Hayes and Cone, 1977; Abrahamse and Steg, 2011) and frequency in utilizing the electrical appliances and level of consumption electrical equipment are dimensions aimed for behavioural intentions thus the specific problem is some the residents are not aware on ways to use energy efficiently and the frequency that they utilize their electrical appliances.

### **1.3 RESEARCH QUESTIONS**

1. What are the most common household electrical appliances that are available and used by the households?
2. In which manner and how frequently are the electrical appliances being utilized?
3. How can awareness affect the behaviour of occupants to reduce the energy consumption?

### **1.4 RESEARCH AIM**

The primary aim of this study is to see whether the ‘feedback method’ is successful in creating awareness towards behaviour changing.

### **1.5 RESEARCH OBJECTIVES**

1. To determine the household electrical appliances most often found and their energy rate
2. To determine how frequently the electrical appliances are being used

3. To evaluate the effectiveness of feedback survey questionnaire method in creating awareness among the dwellers in electrical energy consumption.

## **1.6 RESEARCH SCOPE AND LIMITATION**

The study was set out to bring behavioural changes to residents the way electrical appliances that are being utilized within the household by creating awareness. So that the changes in electrical energy consumed can be observed. The study was carried out to five units in a condominium located in an urban setting (Cheras) in Malaysia. Though the best of efforts was used to minimise the limitations that might come in course of the research; the research completed within certain constraints.

Some of these constraints faced were the limited duration of time for research and data collection, the size of the selected sample for study (in terms of types of dwellings, occupations and types of households etc.). Only college students were focused to ensure that their age is about the same, as well as their usage of electrical appliances. As students, they would have to use similar electronic devices in a common pattern rather than people with different occupancies. Moreover the effect of thermal comfort would also be uniform as it is the same age group. Due to the time limit as well, question rises as to what degree did the awareness provided in survey questionnaire influenced the participants, since one-month duration is a limited time frame, thus only a minimal behavioural changes can be observed.

Furthermore, limited number of willing participants recorded in the study while some potential survey participants have backed out since the data collection period was throughout their exam period. However the participated surveyors fully cooperated in answering the questionnaire since they have been informed about the phases of the study before they were willing to participate. From the literature review

also (refer table 2.9) it shows that even though the sample size is limited it is sufficient for this type of study since it could be quick to conduct the fieldwork and could help to achieve the research aim in a relatively short space of time.

## **1.7 DISSERTATION STRUCTURE**

The research conducted for this study is presented in five chapters where each chapter discusses a different area required for this research. This part highlights an overview of the dissertation overall. The dissertation begins with chapter one. Chapter one highlights the general background on how the energy conservation matters began and the reason behind in which demand for energy. It also discusses the effects of harmful gases released during energy generation for electricity. In addition to this, the importance of shifting the energy either to renewable energy or taking energy conservative measures is discussed. The chapter further outlines the main aim and objective of the study and ways in which it could be achieved.

The second chapter, literature review discusses the effectiveness of providing energy consumption information to residents as a mean of reducing residential electrical energy. This chapter also discusses the overview of energy, effects of electricity generation, various external and internal factors that influence the electricity intake and the preceding studies that have been done on several feedback approaches and their effect on reduction rate of electricity consumption. This review further covers the discussion among the experts the benefits of reducing consumption rate towards energy efficient improvement.

Chapter three which is explaining the data collection stage comprises detail methodologies followed to achieve the stated aim and objectives. Moreover, Chapter

four comprises of the analysis while chapter five encloses with conclusion and recommendation.