



**Faculty of Technology Management and Technopreneurship**

**ENERGY EFFICIENCY THROUGH PHOTOVOLTAIC  
SYSTEM IN THE ADMINISTRATION BUILDING OF  
JOHOR MATRICULATION COLLEGE**

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## **DEDICATION**

I lovingly dedicate this thesis to my beloved parents, wife,  
and children who supported me along the way.

## ABSTRACT

The extensive fossil fuel exploitation to fulfill almost all human activities for energy consumption has led to some unwanted atmospheric and environmental pollution. Photovoltaic system (PVS) or “solar electricity” converts sunlight (light energy) into electricity is produced with minimal pollution, minimal maintenance and with the good intention to tap the most powerful renewable natural resources in the galaxy-Sun. The objectives of this study are (1) to investigate the factors which needs to be considered, (2) to evaluate these factors throughly, and (3) to propose to the top management for PVS adoption onto the administration building of Johor Matriculation College (ABJMC), after some innovative suggestions have been made to overcome the negative factors for the ease of this technology adoption. Although ABJMC is a non-profit organisation, it is still pressurred by monthly high electricity bill that burdens the ABJMC’s operations (particularly on the administration building that consumes energy the most). Consequently, an alternative way of attain energy efficiency has to be considered which lead to the crystalisation of the researcher's idea for PVS adoption. As PVS has never been implemented in ABJMC, this research is an exploratory case study. The qualitative method through in-depth interview with twenty two significant respondents was conducted, which took in the management of ABJMC, the technicians and also the vendors of PVS. With the concrete evidence generated from this research, the research outcomes are supporting the worthiness of the PVS adoption in ABJMC. This technology will enhance the energy efficiency, as well as saving monthly electricity bill for ABJMC. As a conclusion, with the national renewable energy policy, incentives provided, the natural structure of the administration building, our climate advantage and the commitment of the management from ABJMC, the PVS adoption in ABJMC is viable and exciting to be looking forward.

## ABSTRAK

*Pengeksploitasian bahan api fosil secara meluas untuk memenuhi hampir semua aktiviti manusia bagi penggunaan tenaga telah membawa kepada beberapa pencemaran atmosfera dan alam sekitar yang tidak diingini. Sistem photovoltaic (PVS) atau "elektrik solar" menukarkan cahaya matahari (tenaga cahaya) ke elektrik yang dihasilkan dengan pencemaran dan penyelenggaraan yang minimum serta dengan tujuan untuk meneroka sumber yang paling berkuasa dalam alam semula jadi ini yang boleh diperbaharui dalam galaksi ini iaitu Matahari. Objektif kajian ini ialah: (1) untuk menyiasat faktor-faktor yang perlu dipertimbangkan, (2) untuk menilai faktor-faktor ini dengan sempurna, dan (3) untuk dicadangkan kepada pihak pengurusan atasan supaya menggunakan PVS di bangunan pentadbiran Kolej Matrikulasi Johor (ABJMC), setelah beberapa cadangan inovatif yang telah dibuat untuk mengatasi faktor-faktor negatif bagi memudahkan penggunaan teknologi ini. Walaupun ABJMC sebuah organisasi tanpa keuntungan, namun ia dibebani oleh bil elektrik bulanan yang tinggi dalam operasi harian ABJMC (terutamanya pada bangunan pentadbiran yang menggunakan tenaga yang paling tinggi). Oleh itu, satu cara alternatif untuk mencapai kecekapan tenaga perlu dipertimbangkan yang membawa kepada pencetusan ilham penyelidik untuk menggunakan PVS. Oleh kerana PVS tidak pernah dilaksanakan dalam ABJMC, kajian ini merupakan kajian kes eksploratori. Kaedah kualitatif ini dijalankan melalui temu bual secara mendalam dengan dua puluh dua orang responden yang berkaitan telah dijalankan, yang terdiri daripada pihak pengurusan tertinggi ABJMC, juruteknik dan juga perunding atau pembekal PVS. Dengan bukti konkrit yang dihasilkan daripada penyelidikan ini, hasil penyelidikan menyokong ke arah penggunaan PVS dalam ABJMC. Teknologi ini akan meningkatkan kecekapan tenaga, serta menjimatkan bil elektrik bulanan bagi ABJMC. Sebagai kesimpulan, dengan dasar tenaga boleh diperbaharui negara, insentif yang disediakan, struktur semulajadi bangunan pentadbiran, kelebihan iklim kita dan komitmen pihak pengurusan tertinggi dari ABJMC, penggunaan PVS dalam ABJMC merupakan sesuatu yang menarik dan berpotensi untuk dimajukan.*

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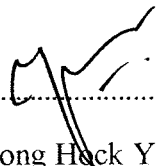
My fellow postgraduate students should also to be recognised for their support. My sincere appreciation also extends to the top management and technicians of Johor Matriculation College (JMC), all my colleagues, TNB Ledang branch manager, Mechanical Training Solution Sdn. Bhd., Solar Sentinel and others who have provided assistance at various occasions. Their views and tips are useful indeed.

Special thanks to Michelle Ooi and Robert Yeo for the proof reading of my thesis. I would like to thank the librarians at Universiti Teknikal Malaysia Melaka for their friendly and helpful information.

Finally, *sincere thanks to my wife, parents, daughter, sons and numerous friends who endured this long process with me, always offering support and love.*

## DECLARATION

I declare that this thesis entitle “Energy Efficiency through Photovoltaic System in the Administration Building of Johor Matriculation College” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :  .....

Name : Chong Heek Yean

Date : 26 February 2013

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## LIST OF SYMBOLS

MW	-	Megawatt
GW	-	Gigawatt
Wp	-	Peak Watt
kWp	-	Kilowatt peak
kWh	-	Kilowatt hour
CO <sub>2</sub> -eq	-	CO <sub>2</sub> -equivalent emissions

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Introduction

The effects from the political, economic, social, technological, environmental and legal factors have shown the way to the fast exploitation of various sources of renewable energy generation. Extensive fossil fuel exploitation in almost all human activities has led to some unwanted atmospheric and environmental pollution that causes undesirable phenomena which has not been experienced in human history. These unwanted phenomena vary and include global warming, the greenhouse effect, climate change, ozone layer depletion, and acid rain. Through scientific research and experiments, it has been clearly understood that these phenomena are closely related to fossil fuel uses as they emit greenhouse gases such as carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>) which hinder the long-wave terrestrial (Sen, 2008).

#### 1.2 Problem Definition

According to Seveda et al. (n.d.), there is continuously increasing demand for energy due to rapid industrialization development and growth in population. Conventional

major energy sources such as coal, oil, natural gas, etc. form two major problems, which every country is facing:

1. These conventional energy sources are on the edge of becoming wiped out. By 2050, the world's oil reserve is predicted to be exhausted.
2. These conventional fuels cause pollutions during energy extraction which include: increasing acid rain cause by sulfur dioxide (SO<sub>2</sub>) emission during fossil fuels burning and global climate warming cause by increasing emission of greenhouse gases (CO<sub>2</sub>). Some extreme natural calamities, such as excessive rainfall and consequent floods, droughts and local imbalances are expected if this trend continues.

According to Tan, et al. (2011), the implementation of energy efficiency (EE) in Malaysia is very slow even though it has been studied extensively. Some of the main barriers to Malaysia's energy efficiency efforts are: i) Government's policy on giving subsidies on energy prices for the power and non-power sectors; ii) Lack of EE knowledge or awareness in terms of techniques and economic benefits; iii) Lack of benchmarks and information access for EE technologies; iv) Perceived EE as 'high-cost/high-risk' business deal and reluctance to acquire; v) Industries prefer to invest on production rather than on EE; vi) Financier is not keen to finance EE projects; vii) Insufficient regulation on EE implementation and standards; viii) Industry or government has very few EE technology demonstration projects; ix) Lack of trained financial and industry personnel in management of energy; x) EE design is seen in the production facilities among the multinational corporations but not with the medium and small companies. These are the reasons why EE in Malaysia is still at an infant stage and more work need to be done about it. However, the response on EE activities was not encouraging due to relatively cheap



energy price in Malaysia because of government intervention on the energy price. Only when the government decides to reduce or eliminate the subsidy and allow energy price to follow the real market price, then Malaysia will be able to create energy prudent and smart society in the long run even if such act may receive resistance at the beginning.

Muhammad-Sukki, et al. (2011) has found from their research that most Malaysians are unaware of the government's incentives and policies towards renewable energies, and are not willing to invest in the Fit-in-Tariff (FiT) scheme.

### **1.3 Research Questions**

Further from here, three research questions are formatted:

- (i) What are the actual factors need to be considered in the implementation of photovoltaic system?

This is aimed to re-examine the factors, albeit some have been addressed by Tan et al. (2011). Besides, the organisation which is under researched is a non-profit organisation. Therefore, it is assumed that the re-examination of factors involved will allow the researcher to discover some of the new factors.

- (ii) How to overcome those negative factors identified while strengthen those positive factors discovered?

In order to materialize the implementation of photovoltaic system, after the identification of actual factors which then subsequently being categorise as negative

factors<sup>1</sup> and positive factors<sup>2</sup>. Some of the strategies have to be identified to overcome those negative factors, while strengthen the positive factors for PVS adoption.

(iii) What are the most innovative ways<sup>3</sup> could be taken to implement the technology at administration building of Johor Matriculation College (ABJMC)?

After the solutions on the negative factors have been identified, while strategies to strengthen the positive factors have been taken, at this stage, the researcher will investigate the most innovative ways to implement the technology at Johor Matriculation College (JMC). A blue print is expected to be produced at the end of the research, and this study will be presented to JMC for suggestion in photovoltaic system adoption.

#### 1.4 Objective

The objective of the study is to investigate the management decision on selecting and adopting the technology of solar powered photovoltaic system into the ABJMC. Besides, the study also investigates how to implement it into the building.

The objective of the study are stated as below,

---

<sup>1</sup> This will hinder the implementation of photovoltaic system.

<sup>2</sup> This will encourage the implementation of photovoltaic system.

<sup>3</sup> Minimize resources use, but to maximize the performance of photovoltaic system.

- i. To examine the factors involved in the implementation of PVS.
- ii. To investigate strategies in order to overcome some of the negative factors identified and to strengthen the positive factors found.
- iii. To suggest the most innovative ways to implement photovoltaic system at the ABJMC.

### **1.5 Scope**

The purpose of this study is to propose energy saving through photovoltaic system to enhance the energy efficiency used in the ABJMC. The study examines factors of using photovoltaic system, and to investigate how to implement it on the ABJMC.

The research is studying on the photovoltaic system in the ABJMC only.

No other reusable energy source such as wind or water, and not any other parts of JMC buildings will be studied.

### **1.6 Limitation**

Two limitations are identified in this study. Firstly, the case study is to examine the factors involved in the implementation of photovoltaic system in the Administration Building of JMC. Therefore, the result and outcome of the study is only applicable for JMC only. Secondly, researcher assumed that all respondents have provided honest and correct answers to the questionnaires given.

## 1.7 Summary

The implementation of photovoltaic system in the ABJMC would enable the college to achieve energy efficiency. Thus, from the money saved for electrical energy usage, the college can channel it for other useful purposes for the benefit of all stakeholders of the college. The case study is focus on the factors involved in the PVS adoption in the ABJMC, and how the implementation could be done.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1. Introduction

This chapter will be discussing about the literature review for this research which the researcher obtained from several sources such as books, journals, and articles. The initial introduction will discuss about the energy efficiency (EE) at 2.2, 2.3 background of the Solar Energy and 2.4 clean environments with Photovoltaic (PV) Technologies. The Diffusion of Innovation Theory will be discussed in section 2.5 and follow by the Factors for Technology Adoption in section 2.6 which will be dealt thoroughly from the TEMIF model (Chew, 2012). Towards the end of this chapter at 2.7, the researcher will discuss about the International Renewable Policies related to Solar Energy. Lastly, the framework of 'Implementation of Photovoltaic System (PVS) in Johor Matriculation College (JMC)' will be drafted in section 2.8.

#### 2.2. Energy Efficiency

According to California Center for Sustainable Energy (CCSE) (2012), EE is simply the process of doing more with less, by using less energy to accomplish the same tasks and functions as before. EE is one of the major concerns in every part of the world.

used for a given service (lighting, heating, etc.). The reduction in the energy consumption is usually associated with technological changes besides better organisation and management or improved economic conditions in the sector.

According to Tan et al. (2011), Malaysia government recognizes the advantage and significance of EE in the country. Several measures and action plans have been taken to ensure economic, energy and environmental sustainability. These includes the drafting of National EE Master Plan, dissemination of EE information through the mass media, newspapers, conferences, seminars, workshops and publication, and emphasis on short term goals in the 10th Malaysia Plan (2011-2015) which include the promotion for power producer of EE, establishment of EE standards and targets. Furthermore, the awareness level of the public concerning EE must be enhanced and a culture of energy conservation must be developed. The prime emphasis area to implement and demonstrate the benefits of improved energy productivity should begin with the government offices, universities, hospitals and schools. Chung and Hui (2009) believe that the major improvement in EE is making the energy system more environmentally sustainable, not by less energy usage but increase in saving.

### **2.3. Solar Energy**

Due to the rising cost of energy from conventional sources, the emergence of interest in solar energy utilization has taken place since 1970. Solar radiation is the world most abundant and permanent energy source and for every minute the surface of the earth is receiving enormous amount of solar energy which is greater than the energy consumption by the entire population in one year (Sen, 2008). Research on renewable

energy technologies has been triggered to overcome global warming, ozone depletion and energy shortage in our society. Solar energy has received much attention as it is abundant and clean for the design of energy system for buildings (Zhai et al., 2008).

The design of many technical apparatuses such as cooler, heater, and solar energy electricity generator in the form of photovoltaic cells are result of the scientific and technological studies in the last three decades that tried to convert the continuity of solar energy onto sustainability for the human comfort. Energy policies and strategies have been made to reduce CO<sub>2</sub> emission and decrease building energy consumption that causes climate change (Rosiek and Batlles, 2009).

#### **2.4. Photovoltaic Technologies**

Photovoltaic (PV) comes from the word “photo,” means light and “voltaic” means producing electricity. Therefore, PVS is the system that produces electricity directly from sunlight. PVS uses PV modules to convert sunlight into electricity. PV modules are made up of PV cells which are interconnected together in a sealed, weatherproof package. PV cells consist of at least two layers of semiconductor material with one layer of positive charge and the other negative. Photons from the sunlight are absorbed by the semiconductor atoms when light enters the cell, freeing electrons from the negative layer of the cell to flow through an external circuit and back into the positive layer, thus, producing electric current. Modules are wired in series (current stays constant) and parallel (voltage stays constant) form to achieve the desired voltage and current, which is known as a PV array.

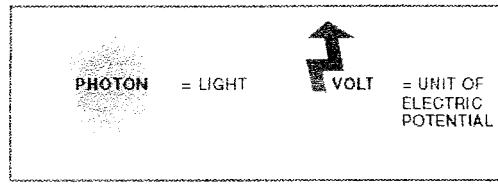


Figure 2.1 The Meaning of the Word “Photovoltaic”

Source: EPIA in EPIA and GI (2011)

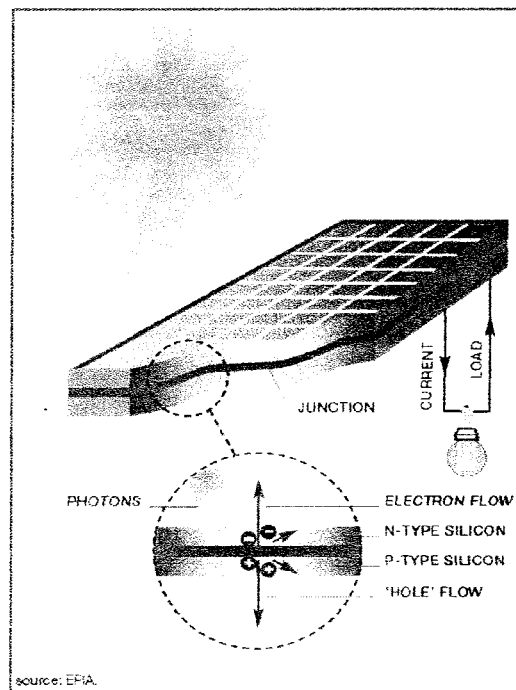


Figure 2.2 Example of the Photovoltaic Effect

Source: EPIA in EPIA and GI (2011)

Solar PVS is clean and reliable which can be applied in residence, industry, agricultural and farm. The electricity generated can be stored or used directly, fed back into