THE ADVANTAGE ELEMENTS AND COST BENEFIT ANALYSIS OF CAR PARK SOLAR PHOTOVOLTAIC SYSTEM IN UTM KUALA LUMPUR

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DEDICATION

I dedicate this dissertation to my supportive and inspiring supervisor Assoc. Prof. Dr. Rozana Zakaria, who always there giving guidance, motivation and inspired me to become a better person and of course, to my lovely mother Mrs. Nor Asiah Mohd Said and siblings Wan Sharefance, Wan Syarehan, Wan Syafirah, Wan Mohd Mustapha Kamel, Wan Muhamad Hanis and Wan Farhana Aishah that always stay by me, giving support, lending shoulder, and making me always smile to endure this Master journey. Then, not to forget, to all my colleagues, who always praying for my success. A word of thanks is not enough to express my gratitude to each of the person that contribute to make who I am today. May Allah give bless and rewards for all your kindness.

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ABSTRACT

The world is facing a global energy crisis due to the overuse of earth's non-renewable sources of energy such as fossil energy and this is relative with the increase of world population whereby the human activities effected to pollution. Generation of electricity in Malaysia is largely dependent on the produced fossil fuels, which mainly from natural gas and coal. This has led to the increase of energy consumption that forces for alternative energy such renewable energy namely solar. The photovoltaic (PV) cells desire to have a high amount of irradiance to produce maximum output power. The Government of Malaysia introduced Building Integrated Photovoltaic Technology Application (MBIPV) plan to encourage the application of renewable energy source in Malaysia. Installing solar systems above the surface and multi-storey car parks is oblivious in Malaysia. The solar carports can enhance the car-parking experience in several ways, as well as improving the economic and environmental performance of the asset. This study aims to investigate the advantage elements of solar photovoltaic system on the solar car park including the cost benefit analysis. The study was conducted through questionnaire survey and semi-structured interview to gain the primary data. The data obtained were analysed using frequency distribution and average index method, which then presented in the form of charts, graphs, and tables for easy understanding. 30 elements were found as the advantage of solar photovoltaic system implementation for car park. Then, there were four major criteria influenced the characteristic of car park solar system which are technical, technology, design criteria and components. The cost benefit analysis found that there is higher ROI and lesser payback period when invested for large power solar harvesting. Hence, it found that the outcome of cost benefit analysis is suitable to be considered in the implementation of PV system for the car park. The findings of this study are significant for the investor, developer, and property owner to decide in implementing solar car park system and encourage the deployments of this technology which will increase the utilisation of renewable in Malaysia.

ABSTRAK

Dunia kini sedang berhadapan dengan krisis tenaga secara global dimana penggunaan berlebihan sumber tenaga yang tidak boleh diperbaharui seperti tenaga fosil dan ini berkaitan dengan peningkatan populasi aktiviti manusia yang memberi kesan kepada pencemaran. Penjanaan tenaga elektrik di Malaysia banyak bergantung kepada penghasilan bahan bakar seperti fosil terutama dari jenis gas asli dan arang batu. Ini menjurus kepada peningkatan penggunaan tenaga yang memberi kesan terhadap penggunaan tenaga alternatif seperti tenaga yang boleh diperbaharui iaitu solar. Solar fotovoltaik (PV) perlu mendapat jumlah sinaran yang tinggi untuk menghasilkan pengeluaran kuasa yang maksimum. Kerajaan Malaysia memperkenalkan rancangan Aplikasi Teknologi Fotovoltaik Bersepadu Bangunan (MBIPV) untuk mendorong penggunaan sumber tenaga yang boleh diperbaharui. Pendekatan pemasangan sistem solar di permukaan dasar dan pakir kereta bertingkat di Malaysia masih kurang. Parkir kereta bersolar dapat menambahbaik keperluan penggunaan parkir kereta dengan beberapa cara seperti meningkatkan prestasi ekonomi dan aset persekitaran. Tujuan kajian ini adalah mengenalpasti elemen kelebihan solar fotovoltaik bagi parkir kereta termasuk menganalisis kos faedah. Kajian ini dilaksanakan melalui soal selidik dan temu bual berstruktur bagi mendapatkan data primer. Data yang diperolehi dianalisis menggunakan taburan frekuensi dan kaedah indeks purata, yang kemudiannya diolah dalam bentuk carta, graf dan jadual bagi mudah difahami. Kajian mendapati bahawa, 30 jenis elemen telah dikenalpasti sebagai kelebihan pelaksanaan sistem solar fotovoltaik bagi parkir kereta. Terdapat empat kriteria utama yang mempengaruhi ciri-ciri sistem parkir kereta bersolar iaitu teknikal, teknologi, kiteria rekabentuk, dan komponen. Analisis kos faedah yang dilaksanakan mendapati apabila melaksanakan projek tenaga solar yang besar akan memberikan pulangan atas pelaburan yang tinggi dan tempoh bayaran balik yang singkat. Jesteru, didapati hasil analisis kos faedah yang dilaksanakan dapat memberi manfaat yang sesuai dalam mempertimbangkan pelaksanaan sistem ini. Hasil kajian ini menjadi satu signifikan kepada pelabur, pemaju, dan pemilik harta tanah dalam pemilihan perlaksanakan sistem ini dan mendorong peningkatan penggunaan teknologi ini di Malaysia.

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CHAPTER 1

INTRODUCTION

1.1 Problem Background

The rapid intensification of the infrastructure project in Malaysia has been rising faster than anticipated in recent years, although population growth has led to a greater impact on Malaysian energy demands. The world is facing a global energy crisis due to the excessive use of non-renewable energy sources such as fossil energy. Besides, since the industrial age, the scarcity and use of these resources have led to a significant increase in the atmospheric greenhouse effect. Combined with other man-made pollution, it is obvious that global warming and global climate change are the result of the blind and unrestrained use of fossil energy from the earth. (Ahmad et.al, 2012).

Hence, according to Oh et al. (2010) and Ali et al. (2012) the growths of energy consumption nowadays have a great concern of many people from various organizations and agencies. Using energy without controlled will lead the shortage of energy and depleting natural resources such as oil, coal, and natural gas. The main problem of using fossil-based energy is foremost it is non-renewable, which means that after a certain time it will finish, and then global warming reached an alarming level, which showed the real danger of all kinds of life on earth, including humans.

According to The United Nations Development Programmed Global Environment Facility (2008) stresses that renewable energy is energy obtained from renewable resources such as wind, sunshine, rain, waves, and geothermal energy. The strategy for the introduction of renewable energy has paved the way for achieving the priorities of sustainable growth, especially in terms of achieving a low-carbon economy. Malaysia has been installing photovoltaic (PV) solar panels in residential,

industrial, and commercial buildings since 2001. This is attributable to the Eighth Malaysia Plan (2001-2005), in which the Malaysian Building Integrated Photovoltaic Technology Application Program (MBIPV) was launched by the government to facilitate the use of Malaysian renewable energy. These programs are targeted at reducing reliance on fossil fuels and seeking to mitigate the effects of climate change.

1.2 Problem Statement

Solar energy is cheap, readily available and one of the main sources of non-polluting clean energy for the environment. Photovoltaic technology is a technology focused on semiconductors that turns sunlight into direct current. The electrons in the semiconductor will change and form a direct current as sunlight reaches the semiconductor in the PV cell. PV cells consist of different types of semiconductor materials, such as monocrystalline silicon, amorphous silicon, copper indium gallium selenide (CdTe) and copper indium gallium selenide (ClGS). A single-crystal silicon-based photovoltaic cell, which converts solar energy into electricity with an efficiency of 15 percent to 20 percent, is the most efficient among these products, while the remainder is converted into heat. Heat loss is inversely proportional to the solar cell's production (Sainthiya & Beniwal, 2017).

Solar energy absorbs heat from the earth through the atmosphere and absorbs harmful radiation (such as UV-C). It is an excellent renewable resource because it constantly comes from the sun. Wind energy comes from the non-uniform and variable temperature rise (high- and low-pressure difference) of the earth's surface from the sun. Water energy is the energy released by water in motion, and again, solar energy makes water circulation possible. Biomass energy is nothing but solar energy, which is stored in the green (plant) tissues of plants due to photosynthesis. Therefore, most renewable energy and earth-friendly energy are related to solar energy. However, solar technology generally means any type of tool that can directly convert solar energy into a form of energy useful to humans: heating, electricity, and combustible. Solar panels are a well-known solar technology that can directly convert solar radiation into electrical energy, so-called photovoltaic solar panels, or convert sunlight into thermal

energy to generate hot water and indirect electricity, in this case, it is called Thermal solar panels (S. Ashok, 2020).

Since 2001, photovoltaic panels in residential, industrial and commercial buildings have been implemented in Malaysia. This is attributable to the 8th Malaysia Plan (2001-2005), when the Malaysian Building Integrated Photovoltaic Technology Application Plan (BIPV) was initiated by the government to promote the use of renewable energy in Malaysia. The installation of photovoltaic panels in government buildings in Putrajaya is one of the alternatives developed by the Ministry of Electricity, Green Technology and Water (KeTTHA). In total, photovoltaic panels installed will only meet a limit of 30 percent of a building's energy needs. However, the output of the photovoltaic panel has deteriorated after a few years of service. Since the photovoltaic system's maintenance cost is very high, and because of the lack of awareness to maintain the system (Government of Malaysia United Nations Development Programmed Global Environment Facility, 2008)

According to Kementerian Tenaga Teknologi Hijau dan Air (2008), the performance of photovoltaic systems depends on the technology, sunlight, temperature, architecture and materials used in solar cells. Photovoltaic systems often require more area to mount photovoltaic panels, as the production of energy produced depends on the number of photovoltaic panels. However, solar photovoltaic systems have more benefits, which is why so many people still prefer deploying solar photovoltaic systems at their places. The growth in solar power generation would reduce the amount of carbon dioxide released to the atmosphere. As mentioned above, relative to the generation of fossil fuels, photovoltaic systems do not emit harmful emissions. The amount of carbon dioxide emission depends on the generation or usage of electricity to be supplemented by green energy.

The above statement raises several issues that need to be discussed to trigger discussion on the problem statement, including:

a) What are the potential benefits of implementing a solar photovoltaic car park system?
b) What is the performance impact of solar photovoltaic for cark park systems?
c) What is the cost-effectiveness of the implementation of solar photovoltaic for car park system?

1.3 Aim and Objectives

Among the various renewable energy projects in Malaysia, photovoltaic systems are the car park with solar system technology. This study attempts to investigate the advantage elements and cost benefit analysis of solar photovoltaic system for car park. To achieve this aim, the following objective were identified.

1. To identify the advantage elements of the solar photovoltaic system implementation for the car park.
2. To determine the characteristic influence the car park solar photovoltaic system
3. To analyse the cost benefit of the solar photovoltaic system implementation for the car park.

1.4 Scope of Study

In this study, it wills focuses on the study and analyse about solar photovoltaic systems for roofed outdoor car park in Universiti Teknologi Malaysia Kuala Lumpur, which is the location is in urban area. By considering the electricity demand of developing countries, long-term investment and investment payback period, consumer demand for capacity load, environmental problems caused by the implementation of renewable energy and the benefits that can be achieved through this system.

This research will determine the cost-benefit from the applications solar photovoltaic (PV) system and can produce the outcome from cost benefits in terms of cost development, payback period and ROI.

This study also includes various parties of management team such as from Office of Assets and Development (Pejabat Harta Bina) UTMKL and the selected professional practitioners. The survey will be conducted to get a feedback on the cost benefit analysis of solar photovoltaic system implementation for car park in UTM Kuala Lumpur.

1.5 Significant of Study

In Malaysia, the residential sector consumed the energy is around 19% of the total energy usage of the country. As the process of the urbanization and development of the country from middle income to high income status it is going at an extreme pace in developing country such as Malaysia, this percentage is would expect to upsurge rapidly in the near future. Malaysia has a great potential by using photovoltaic (PV) technology it is because due In Malaysia, energy consumed by the residential sector accounts for approximately 19% of the country's total energy consumption. As the country’s urbanization and development process progress from middle-income to high-income countries, it is at an extreme rate of development in developing countries such as Malaysia, and this proportion is expected to rise rapidly in the near future. Malaysia has great potential through the use of photovoltaic (PV) technology. This is because the average daily solar radiation is 4.5 kWh/m2 due to the country's equatorial and tropical climate patterns, and the period of sunshine is around 10-12 hours. This indicates that the potential energy comes from the photovoltaic solar system (Lim et al., 2009; Johari et al., 2011).

Solar energy is known as the most abundant permanent energy in the world. Compared with fossil fuel as an energy source, solar energy is a clean energy source that requires almost no maintenance and does not pollute the environment. In recent years, active research and development have been carried out in solar energy, including solar cells and modules, solar concentrators, solar thermal energy, photovoltaic (PV) system components, and economic and policy formulation. Photovoltaic-related technologies have a massive influence on the latest release of reliance on fossil fuels due to resource depletion. This is actually mirrored in the world's rising oil prices and rising tariffs on energy.

On the other hands, in the process of converting sunlight into energy through photovoltaic technology components, the system is clean and quiet. The photovoltaic technology is produced by sun rays and thus does not emit any greenhouse gases (GHG) into the atmosphere and the environment since it is produced directly from the sun. In this way, the national economy will increase and improve the environmental quality, because reducing costs includes managing carbon dioxide (CO2) emissions, pollutants in rivers, and the protection and preservation of the country’s natural resources (such as forests and forests). Habitat. The electricity generated by solar or photovoltaic (PV) systems is a renewable energy, which means that it will not be exhausted in terms of energy and can always be used to generate electricity compared to non-renewable energy, such as oil and gas. The scale and quantity of energy are currently being reduced worldwide.

Building Integrated Photovoltaics (BIPV) is an interesting application of PV technology, which integrates PV panels into parts of the exterior of a building, such as roofs, facades or skylights. PV panels can be used to generate electricity for consumption in a particular building or to connect to the grid. The latter has the potential to accelerate the growth and acceptance of photovoltaic power generation through feed-in tariffs and other incentives. This has been widely implemented in many European countries such as Germany, Spain, Italy and Greece, which proves this.

Hence, since the mid-1990s, Universiti Teknologi Malaysia (UTM) has been actively involved in photovoltaic-related research and development through its two engineering schools, the School of Electrical Engineering (FKE), the School of Mechanical Engineering (FKM) and the School of Science (FS). Since UTM participated in the Australian World Solar Car Competition in 1995, FKE and FKM have cooperated in many photovoltaic projects to develop UTM's SuriaKar. Other projects include the development of solar bikes for the 1996 World Solar Bike Competition in Australia and the installation of photovoltaic systems near the UTM Skudai campus, such as FKE venues, religious schools and bus stations. On the other hand, the FS of the Department of Chemistry is more involved in the improvement of solar cell efficiency.

Then, in the past few years, FKE and FKM have participated in the BIPV project through UTM's institutional research fund. This project represents the work done by UTM and has contributed to the development of BIPV technology in terms of new ideas, discoveries, and applications. The contribution made is the photovoltaic inverter research conducted at FKE, which is suitable for off-grid and grid-connected applications. The following is an explanation about the establishment of a 5 kW BIPV and its online monitoring system in Perpustakaan Sultanah Zanariah (PSZ) in UTM Skudai. This has made an important contribution to development of BIPV, because BIPV has played a role in showing to the public and showing them the current PV technology (Naziha et al., 2008).

REFERENCES

1. **A. Johari**, et al. (2011), "Potential use of solar photovoltaic in Peninsular Malaysia," in Clean Energy and Technology (CET), 2011 IEEE First Conference on, 2011, pp. 110-114.
2. **Ahmad**, A. S., Hassan, M. Y., Abdullah, H., Abdul Rahman, H., Majid, M., & Bandi, M. (2012). Energy Efficiency Measurement in a Malaysian Public University. *IEEE International Conference on Power and Energy (PECon).*
3. **Alanne, K.,** & Saari, A. (2006). Distributed energy generation and sustainable development. Renewable and Sustainable Energy Reviews, 10(6), 539-558.
4. **Ali**, R., Daut, I., & Taib, S. (2012). A review on existing and future energy sources for electrical power generation. *Renewable and Sustainable Energy Reviews,* 4047-4055.
5. **Allouhi,** A., El Fouih, Y., Kousksou, T., Jamil, A., Zeraouli, Y., & Mourad, Y. (2015). Energy consumption and efficiency in buildings: current status and future trends. Journal of Cleaner Production, 109, 118-130.
6. **Bilgen**, S. (2014). Structure and environmental impact of global energy consumption. Renewable and Sustainable Energy Reviews, 38, 890-902.
7. **C. Lim**, et al. (2009), "Assessment of Public Perception on Photovoltaic Application in Malaysia Urban Residential Areas Using Trudgill's Framework for Analysis," Eur. J. Soc. Sci, vol. 8, pp. 589-603.
8. **Caforio-Ferilli** (2019), Solar Energy, Corso di fisica sperimentale. http://www.dimec.unisa.it/leonardo_new/ro/solar_energy.php.
9. **Christopher Jackson** (2016). Solar car parks: a guide for owners and developers. BRE National Solar Centre. Renewable Energy Association.
10. **F. Muhammad-Sukki**, et al. (2012), "Solar photovoltaic in Malaysia: The way forward," Renewable and Sustainable Energy Reviews, vol. 16, pp. 52325244.
11. **Faranadia.A.H**, A.M.Omar, Nor Syafiqah Syahirah Mohamed; Prediction of Grid Connected Photovoltaic Power Systems Performance Using Mathematical Approach, IEEE Conf on Control and System Graduate Research Colloquium, August 2014, Pages 11 – 12.

12. **Government of Malaysia United Nations Development Programmed Global Environment Facility** (2008, November). Building Integrated Photovoltaic Project (MBIPV). Retrieved at http://www.undp.org/content/dam/malaysia/docs/EnE/EnEProDocs/Building%20Integrated%20Photovoltaic%20Technology%20Application%20Prodoc.pdf

13. **Holt**, G., & Elliott, D. (2002). Cost benefit analysis: a summary of the methodology. The Bottom Line, 15(4), 154-158.

14. **J. Abdulateef**, et al. (2012), "Economic Analysis of a Stand-Alone PV System to Electrify a Residential Home in Malaysia," in the 10th IASME/WSEAS International Conference on Heat Transfer, Thermal Engineering and Environment (HTE'12). Istanbul, Turkey.

15. **Kementerian Tenaga Teknologi Hijau dan Air**. (2008). *National Renewable Energy Policy & Action Plan*, KeTTHA, Kuala Lumpur. Retrieved at https://www.mestecc.gov.my/web/wp-content/uploads/2019/04/12-National-Renewable-Energy-Policy-and-Action-Plan-2009-english-only.pdf

16. **Kementerian Tenaga**, Teknologi Hijau Dan Air, KETTHA (2011), "Low Carbon Cities Framework & Assessment System" vol. 1.0.

17. **Khoo,** Yong Shen, Andre Nobre, Raghav Malhotra, Dazhi Yang, Ricardo Ruether, Thomas Reindl, and Armin G. Aberle; Optimal Orientation and Tilt Angle for Maximizing In-Plane Solar Irradiation for PV Applications in Singapore, IEEE Journal of Photovoltaics, 4.2 (2014) 647-53

18. **Lee Leonard**, Chief of Energy and Building Research, 2002, "A Solar Design Manual for Alaska," Second Edition September 2002.

19. **Naziha Ahmad Azli**, Pakharuddin Mohd Samin, Awang Jusoh & Zainal Salam. (2008). Building Integrated Photovoltaic (BIPV) Research and Development at Universiti Teknologi Malaysia. *Progress of Solar Energy Research and Development 2008*

20. **Oh**, T. H., Pang, S. Y., & Chua, S. C. (2010). Energy policy and alternative energy in Malaysia: Issues and challenges for sustainable growth. *Renewable and Sustainable Energy Reviews 14*, 1241-1252.

21. **Paul A. Lynn**. Electricity from Sunlight an Introduction to Photovoltaics. Imperial College London. 2010

22. **Putrajaya Corporation** (2013, October). Towards Putrajaya Green City 2025, 1st edition. Retrieved at http://www-iam.nies.go.jp/aim/aim_workshop/aimws_16/presentation/s05_wang_ppt.pdf
23. **Renewables 2011 Global Status Report**, (REN 21), Paris 2011.
24. **S. Ashok**. (2020). Solar Energy. *Encyclopaedia Britannica, Inc*. Retrieved at https://www.britannica.com/science/solar-energy
25. **Sainthiya,** H., & Beniwal, N.S. (2017). Different types of cooling systems used in photovoltaic module solar system: A review. *2017 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET)*, 1500-1506.
26. **Shim**, J.K. and Siegel, J.G. (1989), Encyclopedic Dictionary of Accounting and Finance, Prentice-Hall, Englewood Cliffs, NJ.
27. **T. H. Oh**, et al. (2010), "Energy policy and alternative energy in Malaysia: Issues and challenges for sustainable growth," Renewable and Sustainable Energy Reviews, vol. 14, pp. 1241-1252.
28. **T. J. Alan Goodrich**, and Michael Woodhouse (2012), "Residential, Commercial, and Utility-Scale Photovoltaic (PV) System Prices in the United States: Current Drivers and Cost-Reduction Opportunities," U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy.