

ENHANCEMENT OF THE EXTRACTED MAIMUM POWER OF PV ARRAY
DURING PARTIAL SHADING

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DEDICATION

*To my lovely wife and sons, beloved parents, siblings,
mighty lecturers and friends*

Al- Fatihah

*To my beloved father, although not with us, your belief in me has made this success
possible*

ACKNOWLEDGEMENT

In the name of ALLAH the Most Gracious and the Most Merciful, it is with the deepest gratitude that ALLAH gives me strength and ability to complete this project.

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My special thanks go to my beloved family, especially to my mother and my wife who are the dearest person in my life and the greatest source of inspiration and moral support.

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ABSTRACT

In recent days, penetration of Renewable Energy in energy market is significantly increasing. The most popular renewable energy technology implemented is PV solar. This is due to low installation and investment cost, simple scheme connection, incentive given from authority and also technology development. However, PV solar facing an issues of extracting maximum power from solar panel especially during partial shading. It became an important issue in order to maintain the output power from PV that injected to the grid system. Normal connection of PV array is with a dimension of (m x n). During partial shading, this configuration of PV system unable to extract maximum power due to PV characteristic has multiple peak. The PV system algorithm may fail to track the maximum power. Therefore, it is suggested an approach of switched PV. With this approach, the system is reconfigured to form array with dimension of (m/2 x 2n). This approach is expected to improve the extracting maximum power. Besides that, this method is more simple and cost effective. In this project a 4kW on grid PV system is simulated using MATLAB software in order to analysis the impact of partial shading. For this system it have 2 configuration of PV for switching which is 4x4 configuration and 2x8 configuration. This 2 configuration give different output of power for different of percentage of partial shading. Therefore it can be conclude that the switching PV can improve of extracting maximum power from solar panel during partial shading

ABSTRAK

Penggunaan tenaga boleh baharu ke dalam pasaran tenaga menunjukkan peningkatan yang begitu ketara. PV solar merupakan teknologi tenaga boleh diperbaharui yang paling popular dilaksanakan. Hal ini kerana kos pemasangan dan pelaburan yang rendah, skim sambungan yang mudah, insentif istimewa yang diperkenalkan oleh kerajaan dan juga perkembangan teknologi. Walau bagaimanapun, PV solar menghadapi isu berkaitan mengekstrekan kuasa maksimum daripada panel terutama ketika berlakunya separa terlindung terhadap PV module. Ianya menjadi satu isu penting dalam usaha untuk mengekalkan output kuasa dari PV system yang akan disuntik kedalam system grid. Kebiasaanya PV array mempunyai sambungan berdimensi ($m \times n$). Ketika keadaan separa terlindung, konfigurasi system PV ini tidak dapat mengekalkan kuasa maksimum kerana pada situasi ini ciri PV mempunyai beberapa puncak. Algorithm bagi system PV ini mungkin gagal untuk mengesan kuasa maksimum. Oleh yang demikian satu pendekatan dicadangkan. Pendekatan berkenaan dikenali sebagai penyuisan PV. Bagi pendekatan ini, system diatur semula untuk membentuk dimensi ($m/2 \times 2n$). Pendekatan ini dijangka meningkatkan kuasa maksimum. Pendekatan ini juga lebih mudah dan kos efektif. Bagi projek ini satu 4kW PV sistem yang tersambung dengan grid telah di simulasikan dengan menggunakan perisian MATLAB dalam usaha untuk mengkaji kesan terhadap separa terlindung terhadap PV module. Sistem yang dibangunkan ini mempunyai 2 PV konfigurasi bagi penyuisan di mana konfigurasinya adalah 4x4 dan 2x8. Kedua-dua konfigurasi ini memberi kuasa maksimum yang berbeza bagi peratusan separa terlindung yang berbeza. Oleh yang demikian dapat di simpulkan disini bahwa kaedah penyuisan PV akan menambah baik lagi kuasa maksimum yang diperolehi daripada solar panel ketika berlakunya separa terlindung

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LIST OF ABBREVIATIONS

FIT	-	Feed-in Tariff
MPP	-	Maximum Power Point
MPPT	-	Maximum Power Point Tracking
NEM	-	Net Energy Metering
PV	-	Photovoltaic
RE	-	Renewable Energy
ROI	-	Return on Investment
V	-	Volt
W	-	W

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CHAPTER 1

INTRODUCTION

1.1. Background of study

Discoveries of dynamos and motors by Michael Faraday and incandescent lamp by Thomas Edison gave significant rise to the demand of electrical energy in the world [1]. Due to rapid technology development, positive industrial growth, and rising population density our global energy demand is increasing [2]. Nowadays, dependencies on electricity supplies are yet still increasing [3]. In Malaysia, statistics from Energy Commission shows that our domestic electricity consumption was significantly increased [4].

Figure 1.1 shows Malaysian electricity consumption from 1990 until 2015. Domestic electricity consumption in year 2015 is higher by 6.7 times compared to 1990, due to changes in our economic policy from agriculture based to industrial based country. To cater the increasing electricity demand, the electrical power generation, transmission network and distribution network need to be expanded. Previously power in Malaysia mostly generated by fossil resources such as coal fired, oil fired and gas fired and then it been transmitted through transmission line and lastly, the power is step down using transformer to reach the consumer. However, these fossil fuels are becoming extinct. Malaysia can no longer rely on fossil fuels to fulfill the customer electricity demand anymore. Therefore, seeking of alternative energy is urgently needed in order to ensure the continuity and reliability of electricity supply in Malaysia.

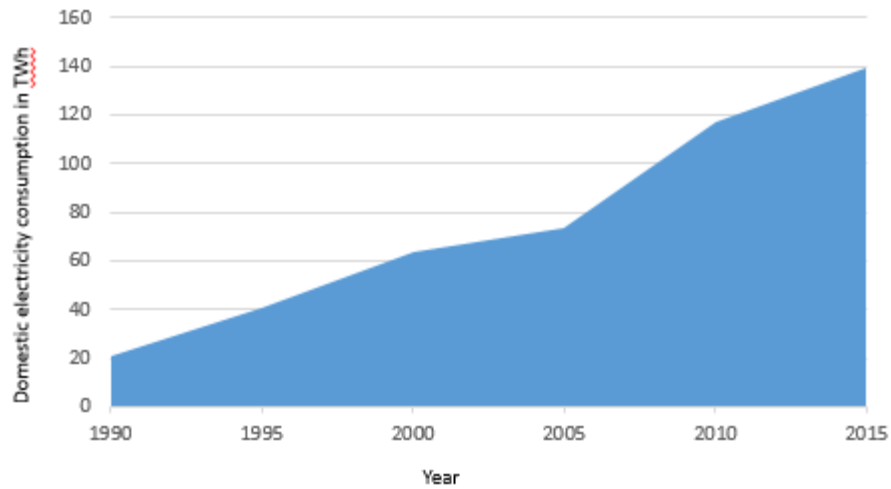


Figure 1.1: Malaysian domestic electricity consumption 1990 to 2015

Besides the issue of shortage of supply, the energy generated by fossil resource have another disadvantage which is the fossil resource will harm the environmental. Fossil resource will release carbon dioxide during burning process to generate electricity. These obviously will add to the greenhouse effect and increase global warming. Out of three fossil resources (coal, oil and gas), coal produce the most carbon dioxide compare to others. This situation directly may contribute to public health.

Therefore, renewable energy has become a hot topic that being discussed in this new era of electrical power generation as an alternative resource to overcome issues that discuss before. Renewable energy can be defined as an energy resource that is continually replenished at the rate it is being consumed, all happening within a relatively short duration [5]. Nowadays, there are several technologies available in renewable energy such as solar, hydro, biogas, and biomass, wind, tidal and geothermal. However, not all country in the world has potential to generate all the renewable resources. It solely depends on the location that made the resource of energy available. Figure 1.2 shows the top country with installed renewable energy by technology in year of 2012.



Figure 1.2: Top Country with Installed Renewable Energy by Technology

Solar become the popular renewable energy technology compare to other. This is because that solar system is more simple and the cost for solar is cheaper. The solar energy is harvest through Photovoltaic (PV) technology that convert the sun light to electricity. This electricity then is converted using inverted in order to meet the grid requirement. The brief history of PV was started by discovering of PV effect by Alexandre-Edmond Becquerel in 1839. He observed that certain material would produce electric when exposed to light. [5] Then, in 1905 Albert Einstein has explain the photoelectric effect using quantum theory of physics and was awarded Noble Prize in 1922 [5]. From there, in 1950 there are first application of PV system is used for space application and later in 1970's the PV is used for terrestrial application and it's become commercial public application in the 1980's [5]

Beside the development in the technologies as mention before, the high awareness towards green environmental has attract more researcher to study in the PV technology. Impact of this study has made the cost to install and the efficient of PV system is cheaper and increase respectively compared to the last few decades. This resulting to PV system possible to harvest and to be implemented as alternative sources. However PV technology facing its own issue that need to be handle in order to harvest the energy. The

main issues that facing by PV is that, extracting maximum power. The maximum output power is easily to extract if the sunlight directly hit the PV module. However if there are partial shading occurs at the surface of PV it will give impact to the output power produce by the PV

1.2. Problem Statement

Photovoltaic (PV) cell is one of the component that used in order to convert the solar power into the electricity. In application of PV cell, extracting maximum power become an important issue. With condition of no shading the PV array characteristic only have one power peak. However, during partial shading the PV array characteristic have more than one (multiple) power peak value. This situation will affect the extraction of maximum power.

This study will propose an approach of switched PV system. Normal connection of PV array is with a dimension of $(m \times n)$. With this configuration and existing MPPT algorithm it can extract maximum power easily during condition with no shading. To overcome issue during partial shading, switched PV will reconfigure to form array with dimension of $(m/2 \times 2n)$. With this configuration it expected to improve the extracting maximum power due to the partial shading. This method also simple and more cost effectively. Furthermore, in this study an analysis to a 4kW system grid connected is conducted. This system is set to have 2 configuration of PV which 4x4 and 2x8 in order to analysis the power output during the partial shading that apply to the designated system.

1.3. Objectives

This study focuses in the development of PV system and comparison of extracted maximum output power from the PV system. The objectives to be achieved in this study are,

- 1) Analyzing the effect of partial shading to the PV output performance

- 2) Assessing the effect of switched PV to the output power of PV system.
- 3) Assessing financial impact to the user under Feed-in Tariff (FIT) and Net Energy Metering (NEM) scheme in Malaysia

1.4. Scope of study

This study is focus on observing the output power of PV system under shading and non-shading condition. A 4 kW grid connected PV system was selected and has been design in order to observe the output. The 4 kW grid connected PV system was used since it one of the common system used for residential area in Malaysia. Then, this system was observe under 3 condition (case study) to observe the effect. This 3 case study is created to see the different effect of shading which is during morning, afternoon and evening. Besides that, the study was extend to see the impact in term of financial gain by user in Malaysia that subscribe to Feed-in Tariff (FIT) and Net Energy Metering (NEM). All the system was using MATLAB Software.

1.5 Project Organization

Chapter 1 Focus on project report present introduction, objective, and scope of work and organization of the project report.

Chapter 2 Focus on a literature review on the technique available to extract maximum power under partial shading condition.

Chapter 3 Present the overall methodology and system design to complete this project

Chapter 4 Focus on the simulation result that process using MATLAB. The output power for shading condition were discussed in details

Chapter 5 The conclusion and future development of the project was presented

Base on the simulation that have been carried out show that there are differences in the output power for PV system when the Photovoltaic (PV) is switched form one arrangement to another arrangement.

The Switched PV is another simple method that can be used in order to harvest more output power especially when facing with shading issues. It can be observe from the simulation result of each case study. The simulation result show that a significant different of power output between the different PV arrangement. In this project it show the different of output power become more significant when the percentage of shading is higher.

In term of financial aspect there are significant impact also recorded for both scheme which is Feed-in Tariff (FIT) and Net Energy Metering (NEM). The different for Net Energy Metering (NEM) show more significant impact especially when the consumer import more energy from grid. The more energy imported will give better tariff when the excess energy exported to the grid

5.2. Future Development

For the future development, this method can be explore more in different focus or condition. The area can be explore are:

- 1) Applying switched PV under different scheme such as Large Scale Solar (LSS)
- 2) Applying Switched PV for stand-alone PV System (off grid system)
- 3) Applying switched PV for non-static shading

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**Appendix A Data Sheet of Sunmodule Plus SW 250 Poly/ Version 2.0 and 2.5
Frame**