PERFORMANCE COMPARISON OF GRID CONNECTED PHOTOVOLTAIC SYSTEM WITH ENERGY STORAGE SYSTEM UNDER MALAYSIA RENEWABLE ENERGY PROGRAMS

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DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

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ABSTRACT

The purpose of this study is to analyse the feasible solution of grid-connected PV system with and without battery for a typical residential load under Malaysia renewable energy (RE) programs. To date, net-energy-metering 3.0 (NEM3.0) scheme was launched in 2021 by Malaysia government. After the end of NEM 3.0 program, it will be replaced by self-consumption (SELCO) scheme, which new former NEM 3.0 users have to find a way to address the excess PV energy. The PV project may not economically viable under combination of NEM 3.0 and SELCO scheme. So, in this project, Homer Pro software was used to simulate the study. Due to some limitation of the features in Homer Pro software, the grid-connected PV system under NEM and SELCO was simulated separately. By combining the nominal cash flow data computed by Homer under NEM and SELCO respectively, the economic assessment was performed on the data to determine the feasibility of the solution. There is a total of six types of solution proposed in this study. Unfortunately, the battery that available in 2021 market was uneconomically viable to integrate into grid-connected PV system under combination of NEM and SELCO scheme. By using the forecasted inputs from a professional and international agency, the PV system with battery under NEM and SELCO are able to achieve lower net present cost than grid-only system. Other than that, the study proposed two solutions, which keep the initial sizing without battery or resized the RE system for aiming day time load consumption during SELCO scheme. These two solutions are able to achieve lower NPC than grid-only system and the resized configuration had a slightly lower NPC than initial RE system with battery under SELCO. So, if the forecasted results become realistic in future, grid-connected PV system with battery would be the recommended option. Because it is not only achieved lower NPC than grid-only system, the CO_2 emission by generating the energy was also greatly reduced. And if the forecasted results could not become realistic, resized configuration without battery may be the best option. This study may help to establish a more attractive financial return of RE program in future for promoting RE in residential sector.

ABSTRAK

Kajian ini adalah untuk menganalisis optimum system PV konfigurasi yang bersambung grid untuk sector kediaman di bawah RE program Malaysia. Sehingga kini, skim pemeteran tenaga bersih 3.0 telah dilancarkan pada 2021 oleh kerajaan Malaysia. Tetapi masalahnya selepas penamatan program NEM 3.0, ia akan digantikan dengan skim SELCO, dan bekas pengguna NEM 3.0 perlu mencari penyelesaian untuk lebihan tenaga PV. Projek PV mungkin tidak menguntungkan bagi pengguna PV apabila projek beroperasi bawah kombinasi NEM 3.0 dan SELCO. Perisian Homer Pro telah digunakan untuk mensimulasikan kajian ini. Disebabkan oleh seditik pengehadan fungsi dalam perisian Homer Pro, sistem PV bersambung grid di bawah NEM dan SELCO perlu disimulasikan secara berasingan. Dengan menggabungkan data aliran tunai nominal yang dikira oleh Homer di bawah NEM dan SELCO masing-masing, penilaian ekonomi boleh dilakukan ke atas data untuk menentukan optimum system untuk kajian ini. Keputusan dari Homer menunjukkan bateri baru yang ada di pasaran 2021 tidak sesuai untuk system PV dibawah SELCO selepas NEM 3.0. Kajian ini juga menggunakan bateri yang diramalkan oleh antarabangsa agensi and keputusan telah memastikan penyelesaian itu boleh dilaksanakan oleh pengguna NEM 3.0 kerana boleh mencapai NPC yang rendah. Selain itu, penulis juga telah mencadangkan dua penyelesaian, iaitu mengekalkan saiz awal tanpa bateri atau mengubah saiz sistem PV hanya untuk bekalan tenaga semasa siang hari dibawah skim SELCO. Kedua-dua penyelesaian ini juga mampu mencapai NPC yang rendah. Jadi, jika hasil ramalan menjadi realistik pada masa hadapan, sistem PV bersambung grid dengan bateri akan menjadi pilihan yang disyorkan. Kerana ia bukan sahaja mencapai NPC yang lebih rendah daripada sistem grid sahaja, pelepasan CO_2 semasa menjana tenaga juga telah dikurangkan banyak. Dan jika keputusan yang diramalkan tidak boleh menjadi realistik, pengguan NEM 3.0 boleh guna konfigurasi saiz yang kecil. Kajian ini boleh membantu untuk membina satu RE skim yang lebih menarik kepada bukan pengguna PV pada masa hadapan untuk mempromosikan RE dalam sektor kediaman.

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LIST OF ABBREVIATIONS

AC	-	Alternating Current
BOS	-	Balance of System
DC	-	Direct Current
DOD	-	Depth of Discharge
GCPV	-	Grid Connected Photovoltaic
HOMER	-	Hybrid Optimization of Multiple Energy Resources
IRR	-	Internal Rate of Return
kWh	-	Kilowatt Hour
LCOE	-	Levelized Cost of Energy
NEM	-	Net Energy Metering
NPC	-	Net Present Cost
SOC	-	State of Charge
SPB	-	Simple Payback
PV	-	Photovoltaic
ROI	-	Return of Investment
UTM	-	Universiti Teknologi Malaysia

LIST OF SYMBOLS

λ	-	Temperature Coefficient
$	-	US Dollar
P	-	Pressure
f	-	De-rating Factor
β	-	Optimal tilt angle (deg)
Φ	-	Latitude of the site (deg)
RM	-	Malaysia Ringgit

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Since the first industry revolution began in 18th of century, fossil fuels become the major sources for energy power production and the demand of usage started increase exponentially till now. The conversion of fossil fuels to electric power mainly achieve by combustion process in order to produce steam power to driving the machine. Therefore, power generation activities were largest contribution to the greenhouse gases emission to earth. Other than that, the by-product during power generation such as waste heat, nitrogen oxide (NO_x) and sulphur oxide (SO_x), were bring huge negative impact to environment.

As the consequences of global warming and climate issues, the phenomenon such as glacier collapse, flood, extreme weather condition, sea level rise etc., had been reported frequently in recent years. Apart from that, the fossil fuels resources in earth is limited and someday the fossil fuels would deplete. As human civilization widely depended on the powered machines, which their power to run the operation is generated from fossil fuels, the energy crisis may lead to human civilization regress.

The high increasing rate of energy demand is because of human population and economic growth. As human population increase, the total energy demand to perform their daily activities is increasing. And human needs may drive the expansion of market, which the energy demand for commercial and industrial activity increase. Therefore, a widely implementation on renewable energy use is urgent in order to address the energy crisis issues and avoid the environmental issues be more worst.

1.2 Problem Background

As global warming and climate issues starting gain attention from public, most of countries around the world had signed Paris agreement and committed to achieve net zero carbon emission by 2050. However, to date year 2021, the policies and measures made by those countries to underpin the pledge was considering not enough and yet to be understood. Additional to that, due to covid-19 pandemic, most of countries subjected to high economic losses and recession, which may prohibit the penetration of renewable energy use.

Nevertheless, to widely adopted RE power generation, the intermittency of renewable resources is the biggest issue to counter. When people have a demand in electric power use, the electric power was supply by base load power plant and peak load power plant to meet the peak demand during daytime. Whereas for the renewable energy power plant, such as solar plant, is fully dependent on the solar radiation to the photovoltaic panel, which only allow to operate during daytime. Therefore, if future the countries around the world can achieve net zero carbon emission with high renewable energy usage in energy mix, battery energy storage system become significant important to store excess generated energy during renewable resources are available and supplying load when renewable resources are intermittent.

In term of economic performance of power generation, although the solar resources are costless, but due to intermittency of solar resources, the capital investment to generate electric power is more expansive compared to other conventional power plant. If compare to wind power generation, the amount of energy produced by wind power is much larger than solar power generation under same capital cost. Therefore, including battery storage system may increase the burden to the investor. However, a good sizing of renewable system underpins by renewable energy policies and measures from national government, investor still able to achieve cost effective in renewable energy production. Additional to that, along with the growing of technology and cheaper component cost, people able to bear the cost of renewable energy investment, as the pricing of electricity generated from fossil fuels are increasing every year.

1.3 Problem Statement

Malaysia declares its commitment to achieve net zero carbon emission by year 2050. To date in year 2021, Malaysia is aiming to reach the goal of 31 % renewable energy (RE) capacity by year 2025. Malaysia have enforced RE incentives and policy to promote the penetration of RE in Malaysia. In solar power sector, the available Malaysia RE program for residential sector is net-energy metering (NEM) scheme. Another scheme is called self-consumption (SELCO) scheme for those residential users who do not participate any RE program offer by the government. NEM scheme allow residential consumers to feed the excess electricity that generated from solar PV to the grid and offset the electricity bills when needed electricity supply from the grid due to intermittency of solar power. Whereas SELCO scheme only allow customers to generate PV power for own use and may need to invest extra cost to install battery system to address the excess solar electricity. Both NEM scheme and SELCO scheme can save the electricity bills, but apparently, NEM scheme are more attractive because no need extra investment on battery system. However, there is quota limitation on NEM scheme and customers only eligible to enjoys the benefits from NEM scheme for up to 10 years. Thereafter, automatically replace to SELCO scheme after end of NEM scheme duration. Customers who installed higher PV capacity under NEM scheme, needed a economically solution to address the excess PV energy under SELCO scheme. Therefore, an optimum configuration and its economic performance to a typical residential load under combination of NEM scheme and SELCO scheme must be investigated. Additional to that, as battery energy storage system often not preferable in PV system due to its expensive pricing, thus, a techno-economic study on impact of Malaysia RE program to battery penetration use in renewable energy is needed when former NEM customer need to rely on RE. In this project, HOMER software was used to perform the techno economic study. By taking NEM and SELCO scheme into account, the optimum configuration of PV system for residential sector throughout the two schemes are yet to be determined.

1.4 Research Goal

1.4.1 Research Objectives

The objectives of the research are:

(a) To simulate grid-connected PV system without battery energy storage system for a typical household unit under NEM scheme.

(b) To simulate the grid-connected PV system with and without battery energy storage system for a typical household unit under SELCO scheme.

(c) To perform economic assessment on results and determine the best solution for a typical household under NEM and SELCO schemes.

1.4.2 Research Scopes

The study is carried out by HOMER PRO software on grid-connected PV system with and without battery under Malaysia RE program. The simulated location is on Kampung Langkap, Perak, Malaysia. The project lifetime is 25 years. The studied residential load is a single phase, medium load profile with domestic tariff. The study is under NEM 3.0 (NEM Rakyat Programme), with a maximum allowable capacity of 4 kWac. The overall project lifetime is 25 years.

1.5 Report Organization

This report consists of five chapters, which are:

Chapter 1 is the introduction section to the report, which gives an introduction about the study. Chapter 2 is the literature review section, the show the past research related to this study. Chapter 3 is the methodology section, which explain details of the method of conducting the work. Chapter 4 is the results & discussion section, which present and discuss on the simulation results. Chapter 5 is the conclusion section, which conclude the work of this study.

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