THE ENHANCEMENT OF SOLAR POWER SYSTEM IMPLEMENTATION IN BHEUU BUILDING

MOHD ATHIR BIN KAMARUDDIN

UNIVERSITI TEKNOLOGI MALAYSIA

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MOHD ATHIR BIN KAMARUDDIN

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Dedicated to my beloved parents, wife and sons for their patience and support, mighty lecturer and friends

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ABSTRACT

In Malaysia, the installation of PV panels in residential, industrial and commercial buildings has been imposed since 2001. This is due to the 8th Malaysia Plan (2001-2005) when Government introduced Malaysia Building Integrated Photovoltaic Technology Application (MBIPV) plan to encourage the application of renewable energy source in Malaysia. One of the alternatives that have been done by the Ministry of Energy, Green Technology and Water (KeTTHA) was installing PV panels in government buildings in Putrajaya. Mostly, the installed PV panels only cover up to 30% of the energy demand in one level of a building. However, after operating for some years, the performance of the PV panels was degrading. Since the maintenance cost for PV system is quite high, and due to the factor of lack of knowledge on how to maintain the system, the installed PV systems are mostly abandoned now. The project was discontinued after the warranty period and the contract with the contractor end. Therefore, the aim of this study is to re-improvise the abandoned PV system in one of them which is Building of Section of Legal Affairs (BHEUU). Through this study, three new models of the BIPV system were proposed, namely Model 1 (4IWOB), Model 2 (4IWB), Model 3 (1IWOB), and Model 4 (1IWB). In this study, the technical and economic assessment has been performed. From the findings, results show that Model 3 (1IWOB) provides the best choice to replace the existing BIPV system where this model only use 1 unit of inverter and no battery storage is used. Saving can be saved up to 37.5% if Model 3 (1IWOB) is chosen to replace the existing PV system at BHEUU building, where the existing system is represented by Model 1 (4IWOB), which used 4 inverters, and no battery was installed.

ABSTRAK

Pemasangan PV panel di Malaysia yang telah digunapakai pada bangunan-bangunan komersial, kilang dan di rumah persendirian telah diperkenalkan sejak tahun 2001. Ini adalah disebabkan oleh perancangan Malaysia ke-8 (2001-2005) apabila kerajaan memperkenalkan pelan *Malaysia Building Integrated Photovoltaic Technology Application* (MBIPV) untuk menggalakkan permintaan sumber tenaga boleh perbaharui di Malaysia. Salah satu alternatif yang telah dilaksanakan oleh Kementerian Tenaga, Teknologi Hijau dan Air (KeTTHA) adalah dengan pemasangan PV panels pada bangunan-bangunan kerajaan di Putrajaya. Kebanyakan pemasangan PV panel hanya menampung 30% daripada permintaan tenaga pada satu aras sesebuah bangunan. Bagaimanapun, selepas beroperasi beberapa tahun, prestasi PV panel tersebut telah menurun. Kos penyelenggaraan PV sistem yang agak mahal dan disebabkan oleh faktor kekurangan pengetahuan bagaimana untuk menyelenggara sistem tersebut, pemasangan PV sistem tersebut telah terpengkalai. Projek tersebut tidak disambung selepas tempoh tanggungan dan kontrak dengan kontraktor tamat. Oleh itu, sasaran dalam kajian ini adalah untuk menambahbaik semula sistem PV di bangunan Hal Ehwal Undang-Undang (BHEUU). Melalui kajian ini, tiga model baru sistem BIPV diperkenalkan, iaitu Model 1 (4IWOB), Model 2 (4IWB), Model 3 (1IWOB) dan Model 4 (1IWB). Dalam kajian ini, penilaian ekonomi dan teknikal dilaksanakan. Hasil menunjukan bahawa Model 3 (1IWOB) adalah pilihan yang terbaik bagi menggantikan sistem BIV sedia ada dimana model ini hanya menggunakan 1 unit inverter dan tidak menggunakan bateri. Penjimatan boleh melebihi 37.5% jika Model 3 (1IWOB) adalah dipilih untuk menggantikan sistem PV sedia ada di bangunan BHEUU, dimana sistem sedia ada diwakili oleh Model 1 (4IWOB) yang mana menggunakan 4 inverter dan tiada pemasangan bateri.

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LIST OF ABBREVIATIONS

STC	-	Standard Test Condition
Voc	-	Open Circuit Voltage
Vmp	-	Voltage At Maximum Power Condition
PTM	-	Pusat Tenaga Malaysia
LCOE	-	Levelized Cost Electricity
STC	-	Standard Test Conditions
PCS	-	Power Condition System
BHEUU	-	Bahagian Hal Ehwal Undang-Undang
MBIPV	-	Malaysia Building Integrated Photovoltaic Technology
KeTTHA	-	Kementerian Tenaga, Teknologi Hijau Dan Air
PV	-	Photovoltaic
SAM	-	System Advisor Model
GFA	-	Gross Floor Area
ACA	-	Air Conditioned Area
TNB	-	Tenaga Nasional Berhad
SEDA	-	Sustainable Energy Development Authority
FiT	-	Feed-In Tariff
FiAH	-	Feed-In Approval Holders
UPS	-	Uninterrupted Power Supply
IEA	-	International Energy Agency
STC	-	Standard Test Conditions
BOS	-	System of Balance

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CHAPTER 1

INTRODUCTION

1.1 General Background

The renewable energy is the energy was collected from renewable resources such as wind, sunlight, rain, waves, geothermal and etc. The renewable energy implementation initiative has paved the ways to achieve sustainable development goals, especially in the realization of low carbon economies. In Malaysia, the installation of PV panels in residential, industry and commercials buildings has been imposed since 2001. This is due to the 8th Malaysia Plan (2001-2005) in which Government was introduced Malaysia Building Integrated Photovoltaic Technology Application (MBIPV) plan to encourage the application of renewable energy source in Malaysia. The goal of these initiatives is to reduce the dependence on fossil fuels and contribute towards reducing the impact of climate change [1][2]. One the alternatives that have been done by the Ministry of Energy, Green Technology and Water (KeTTHA) was installing PV panels in government buildings in Putrajaya [4]. Therefore, Figure 1.1 shows that the buildings of Section of Legal Affairs (BHEUU) that have been installed the PV panels.

Figure 1.1 Building of Legal Affairs Section (BHEUU)

The BHEUU building that is more than 10 years old and has total gross floor area (GFA) of 56,527.82m², net floor area (NFA) of 30,595.9m² and air-conditioned area (ACA) of 41,360.91m² with capacity 520 person. The building consists of 11 floor including a ground floor and three basements floor for parking. The building is divided into two sections, North and South Wing. Based on electricity bills from Tenaga Nasional Berhad (TNB), annual electricity consumption recorded in year 2014 was 3,878,205.607kWh/year at a cost of RM 1, 415, 545.05/year. While, in year 2015, annual electricity consumption is 4, 054, 963.714 kWh/year at costing of RM 1, 480, 061.76/year [5]. Year by year the electricity energy consumption has been increase due to the addition of staffing and electrical equipment's in the building. Hence, KeTTHA decided to install PV panels at the BHEUU building with the aim to reduce electricity consumption cost and pollution as well as to develop Putrajaya as a pioneer in green technology township as a platform for the development of others township and to ensure the Putrajaya Green City 2025 could be realized in the future [1][4].

The PV panels were installed on 2 Jun 2015 by Pekat Solar Sdn Bhd as a PV Service Provider, KeTTHA acts as the owner and Sustainable Energy Development Authority (SEDA) as the in charged agency. Figure 1.2 depicts the installed PV panels at BHEUU rooftop. The PV panels are installed on the roof top of the building is 186 panels with a capacity of 48.36kWp to cover up only for lighting at level 6 and maintained by Pekat Solar Sdn Bhd from 3 Jun 2015 until 2 Jun 2016 [6]. The PV cells are connected to other cells to produce a larger units are called as modules. While, modules are connected together to form as panels or strings or array. The number of strings will determine the capacity and capabilities of solar energy system. The DC electricity are generated by the PV panels is fed to the inverter to convert the DC to AC electricity to supply the power to the building through PV grid connected system.

Figure 1.2 The PV Panels are installed at BHEUU

The efficiency of the PV system depends on the technology, radiation, temperature, design and the material of the solar cells. The PV system also requires more space to place PV panels because the amount of electricity generated depends on the number of PV panels. However, the advantages of solar PV systems are more, that's why so many people still consider installing solar PV system at their place. The increasing of solar electricity production, there will be reduction in the amount of carbon

dioxide thrown out into the atmosphere. As already explained, the PV system is not produce harmful emission if compare to the fossil fuel power generation. The amount of carbon dioxide reductions to be obtained depends on generation or energy uses that to be replacing into the renewable energy. Refer to the National Renewable Energy Policy; growth of the renewable energy is one of the initiatives in reducing greenhouse gas emission. As shown in Table 1.1, it shows that the renewable energy generation planned outcome from 2011 until 2050 that has been quoted from National Renewable Energy Policy [4].

Table 1.1: Renewable Energy Policy Planned Outcome

Year Ending	Cum. Total RE (MW)	Share of RE Capacity	Annual RE Generation (GWh)	RE Mix	Annual CO_2 Avoidance (Tonnes)
2011	217	1%	1,228	1%	773,325
2015	975	6%	5,374	5%	3,385,406
2020	2,065	10%	11,227	9%	7,073,199
2030	3,484	13%	16,512	10%	10,402,484
2050	11,544	34%	25,579	13%	16,114,871

The National Renewable Energy Policy and Action Plan (2009) has implemented by the KeTTHA. While, SEDA was formed under the Sustainable Energy Development Board Act 2011 to control and manage the implementation of Feed-In Tariff (FiT) mechanism mandated under the Renewable Energy Act 2011 (Act 725). Malaysia FiT systems oblige the distributions license holder such as TNB or WIRAZONE to purchase the electricity from renewable resources that produced by Feed-In Approval Holders (FiAHs). By guaranteed access to the grid and setting favorable price for renewable

energy, the feed-in tariff mechanism would ensure that renewable energy becomes a viable and strong investment at long-term for the companies, industries and also for individuals [3][4].

1.2 Problem Statement

In Malaysia, the installation of PV panels in residential, industrial and commercial buildings has been imposed since 2001. This is due to the 8th Malaysia Plan (2001-2005) when Government introduced Malaysia Building Integrated Photovoltaic Technology Application (BIPV) plan to encourage the application of renewable energy source in Malaysia. One of the alternatives that have been done by the Ministry Of Energy, Green Technology and Water (KeTTHA) was installing PV panels in government buildings in Putrajaya. Mostly, the installed PV panels only cover up to 30% of the energy demand in one level of a building. However, after operating for some years, the performance of the PV panels was degrading. Since the maintenance cost for PV system is quite high, and due to the factor of lack of knowledge on how to maintain the system, the installed PV systems are mostly abandoned now. The project was discontinued after the warranty period and the contract with the contractor end. Hence, the efforts and intentions to make Putrajaya Green City 2025 could be realized in the future. Then, the questioned of how to propose a new and better building integrated PV system need to be investigated in this study.

1.3 Objective of Project

The main objectives in this project are:

1) To design and develop the enhancement models for BHEUU integration PV system at Putrajaya using System Advisor Model (SAM) Software.
2) To analyse the performance of the proposed BIPV system in terms of technical and economic assessments.

1.4 Scope of Study

This study focuses on how to re-improvise the abandoned PV system at BHEUU building. Hence, the load profile of the BHEUU building and the existing PV system have been studied. The conceptual design on how to propose lowest capital, operation and maintenance costs were considered. System Advisor Model (SAM) software has been used to model the existing and the other three proposed models to analyze the system performance of the developed system.

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