TITLE: A HYBRID SOLAR PHOTOVOLTAIC (PV) SYSTEM DESIGN FOR RURAL AREAS/SCHOOL

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Bachelor of Engineering

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Grade: _____

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TITLE: A HYBRID SOLAR PHOTOVOLTAIC (PV) SYSTEM DESIGN FOR RURAL AREAS/SCHOOL

Title: A Hybrid Solar Photovoltaic (PV) System Design For Rural Areas/School

JULIAN ANAK RABING

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ABSTRACT

The increasing demand in electrical supply has been rising over the years. However, the implementation of solar PV system is not in a steady state as the technology still require a large cost to install. As the location of Malaysia is strategic to farm solar energy, we should utilize the solar PV system in order to improve our socioeconomic and lifestyle. This research discusses on designing a hybrid solar PV system for rural areas or schools. The main objective of this project is to utilize solar energy as the main electrical supply in the rural areas or school. The first chapter is the introduction about where the study is carried out and the background of energy generation is the rural areas in Malaysia. The second chapter discuss on the research done on the application and efficiency of solar PV system including the materials used, technique and design of the solar PV system. The next chapter is the methodology where the design development of hybrid solar PV system will be discussed. The working principle of the hybrid solar PV system will be explained in this chapter. After the methodology, the result of the project will be discussed entirely in the next chapter. The final chapter conclude this paper about the A Hybrid Solar PV System Design for Rural Areas or Schools.

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LIST OF ABBREVIATIONS

Notations

AC- Alternating-Current

BIPV- Building Integrated Photovoltaic

DC- Direct-Current

EU- European Union

FYP- Final Year Project

GCPV- Grid-Connected Photovoltaic

HRESs- Hybrid Renewable Energy Systems

MPPT- Maximum Power Point Tracking

OGPV- Off-Grid Photovoltaic

PV- Photovoltaic

PSH- Peak Sun Hour

SSC- Solar Charge Controller

USA- United States of America

CHAPTER 1

INTRODUCTION

1.1 Background Study

Electricity is the flow of electrical charge or power through a conductor, such as a wire, to power an electrical device. It is a conversion of energy from different types of energy, for example coal, natural gas, nuclear power, renewable energy such as solar power, and wind power. Electrical systems and components must be designed, built, and maintained by electrical engineers. They design effective and secure electrical systems for a range of applications using their electrical expertise.

Electricity in rural areas has always been a crucial component of any country's infrastructure. Malaysia has struggled to provide electricity to its rural communities for as long as it has been a developing nation. Due to the small number of residents, suburban areas cannot be wired into the national power system [1]. The diesel generator's high levels of greenhouse gas emissions are horrible thing for locals. There are several outlying regions in Malaysia that are not connected to the national power system. Most of Malaysia's outlying communities can be found on islands off the coast or in heavily wooded regions. Independent diesel generators are the standard for providing power in Malaysia's outlying settlements.

Energy that can be replenished naturally is widely used and has been the subject of extensive research for decades. The term "renewable energy" is commonly used to describe power that comes from infinitely replenishing resources. The sun provides an unlimited supply of clean, renewable energy. About 10000 TW of solar energy strikes Earth each day. According to The World Counts, it is estimated that annual worldwide energy usage is roughly 580 million terajoules (TJ) [2]. Considering the current rate of

consumption, the projected rate of growth over the next 20 years, and the amount of solar radiation hourly allows us to begin imagining the potential of solar energy.

There are renewable energy resources such as wind, hydro, and solar throughout the world, but the potential of each resource varies on region. However, in terms of environmental issues and as a prospective replacement for the millennium goals in the future, its accessibility looks to be a good development for humanity. These objectives include are not limited to eliminate or reduce the emission of carbon dioxide into the atmosphere as a result of the production of electric power from conventional energy sources as well as the reliance of countries on these fuels for their energy requirements.

Most researchers prefer solar energy to address the rising demand for power in several regions around the world. As common knowledge, solar technology's ability to produce power is highly dependent on sun radiation’s intensity and expected generation may only be according to the accuracy of weather forecast [3].

1.2 Problem Statement

In Malaysia, specifically Sarawak, most of the community in the rural areas still use diesel generator as their main electricity supply. The emission of hazardous gases into the environment, such as nitrogen oxide, carbon dioxide, and particulate matter, is one of the major drawbacks of diesel generators. On the other hand, due to the high cost of diesel and maintenance issues, the restricted hours of generator running restrict any substantial activity for socioeconomic improvement. A socioeconomic of community condition can be improved by making power more readily available.

In addition, having access to reasonably priced electricity is crucial for reducing local poverty. However, grid extension is an expensive alternative due to the minimal residential of isolated suburban areas, and it is not efficient in expenditures for majority of utility companies to develop their grid services to rural areas. [4].

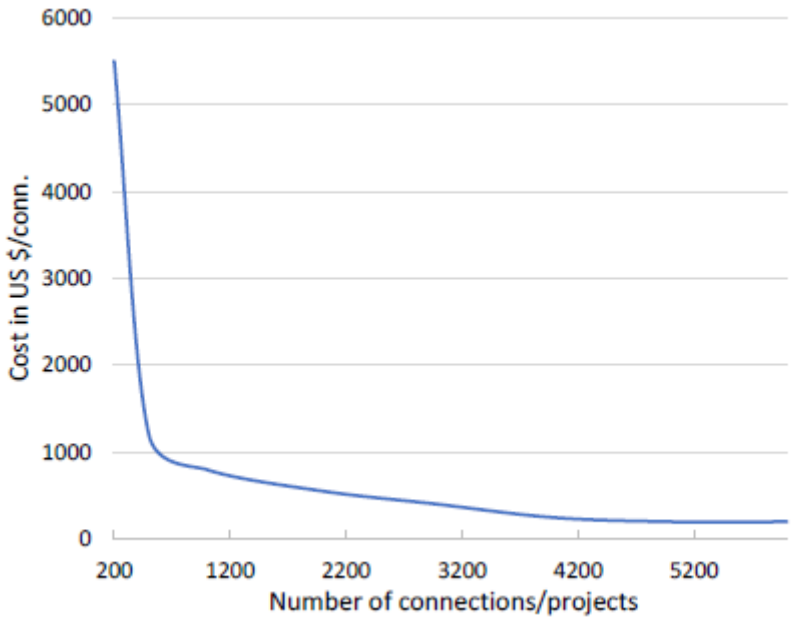

Figure 1.1 The relationship between the number of connections/project and cost in US $/connections [5].

It is not viable to provide electricity to these rural communities by extending the current system due to the huge geographic region and hilly terrain. Sarawak's household power coverage was estimated to be 91% in 2018 [5]. By 2025, the Ministry of Utilities of the Sarawak government aims to fully supply electricity throughout the state by supplying power that is dependable, renewable, and reasonably priced to every home in Sarawak.

Malaysia is one of the countries located along the Equator of the Earth where the solar radiation exposed for a longer time throughout the years compare to the country located in the Artic, Cancer's Tropic, Capricorn's Tropic and circle of Antarctic. Thus, to not develop a renewable energy generation, specifically the solar energy, is implying us not fully utilized the replenishable energy source. A major development of solar energy generation shall be carried out in order to improve the electricity supply throughout the country especially the suburban areas where there is no electricity grid existed.

1.3 Objectives

The main objective of this study is to provide an effective design of solar PV power plants with batteries and the electricity grid as a backup to maintain supply continuity and dependability of the grid. This design will be used to achieve the following objectives:

1. To utilize solar energy as the main electrical supply in the rural areas or school.
2. To implement an efficient solar PV design.
3. To evaluate the need of improvement of the rural areas' socioeconomic.

1.4 Project Scope

1. Develop a solar PV system which consists of storage batteries and grid to provide electricity in SK Ijok, Engkilili.
2. Analyse the intensity of solar irradiance which will power up the solar panels.
3. Comparison between Grid-Connected Photovoltaic (GCPV), Off-Grid Photovoltaic (OGPV) and Hybrid Solar Photovoltaic systems.

Chapter 2

LITERATURE REVIEW

2.1 Overview

This section discusses on the research and current views on the solar PV system globally and in Malaysia. Research on the application and efficiency of the solar PV system has been carried out in the recent years as the popularity of solar PV system has been rising the past decade. Researchers believe that solar energy is the solution to fulfil the global energy demand.

2.2 Global Application of a Solar PV System

In 2021, China has become the main solar PV generating country in the world where they contribute for about 38% in the growth of solar PV generation. Another technology-leading country in the world, the United States of America (USA) contributed 17% of solar PV generation followed by the European Union (EU) with 10% [6]. Numerous of countries in the world has taken a major step to generate power using solar PV as it is a reliable and affordable choice.

The total of solar PV capacity had reached 710 GW globally by the end of 2020. With an additional 125 GW of solar PV capacity in 2020, solar energy experienced the fastest capacity growth of all replenishable energy sources. Installations on the rooftop of 3 to 20 kW to systems with a capacity of several hundred megawatts are all possible with solar photovoltaic (PV) technology. Power generation has moved toward greater democracy.

Solar PV system has been applied in various fields worldwide providing renewable energy solutions and contributing to a sustainable future. Here are some of global applications of solar PV system.

i. Residential.

Solar PV systems installed on residential rooftops enable homeowners to generate their own electricity. The system consists of solar panels, which convert sunlight into electricity through the photovoltaic effect. This electricity can be used to power appliances, lighting, heating, and cooling systems within the home. By relying on solar energy, homeowners can reduce their dependence on the traditional power grid, leading to lower electricity bills and decreased carbon emissions.

ii. Commercial and Industrial.

Solar PV systems are increasingly adopted by commercial and industrial sectors to meet their energy needs. Businesses and factories often have large roof spaces or open land areas where solar panels can be installed. These systems generate clean electricity, which can be used to power various operations, including lighting, machinery, refrigeration, and air conditioning. By utilizing solar power, commercial and industrial entities can significantly reduce their energy costs, improve their environmental footprint, and showcase their commitment to sustainability.

iii. Agriculture

Solar PV systems have multiple applications in agriculture. They can power irrigation systems, which are essential for maintaining crop health and productivity. Solar-powered pumps can draw water from wells or other sources, reducing the reliance on manual labour or fossil fuel-powered pumps. Solar energy can also be utilized for drying agricultural products, such as grains or fruits, increasing their shelf life and value. Additionally, solar PV systems can power farm equipment, such as electric fences or machinery, reducing operational costs and promoting sustainable farming practices.

iv. Transportation.

Solar energy is increasingly being utilized to power electric vehicles (EVs). Solar charging stations, equipped with solar panels, can be installed in public

areas, parking lots, or highways, enabling EV users to recharge their vehicles with renewable energy. This integration of solar power and EVs promotes sustainable transportation and reduces reliance on fossil fuel-based vehicles. It also helps to decrease air pollution and mitigate the impact of transportation on climate change.

Nowadays, solar panels are affordable and frequently chosen as the reasonable source of electricity due to the major reduction in the solar panel cost of production over the prior decade. From 2010 to 2020, the price of solar modules decreased by as much as 93% [7].

2.2.1 Malaysia

In Malaysia, the government has taken an initiative to develop its own solar farm. The main objective is to eliminate the carbon emission by 11,800 Malaysian household. In addition, Malaysia has set a new goal to be able to generate energy for at least 25% of renewable energy by 2025. One of the approaches taken is by operating a solar farm in Kerian, Perak [9]. This solar farm is expected to supply more than 212GWh of power annually and has a capacity of 100MW. This has been a significant approach by the government as they want to fully utilize the renewable energy and provide a more affordable energy resources for the people. According to nextenergy.my (2019), the solar panel cost in Malaysia is around RM15,000. For the entire installation, the price of installation ranging from RM 40,000 to RM 100,000. Most preferable solar panel in Malaysia are Canadian Solar, Hanwha Q Cells, JA Solar, Jinko and GCL.

Figure 2.1 Kerian Solar Farm located in Perak, Malaysia

2.2.2 Sarawak

In 2022, Premier of Sarawak, has stated the commitment to make Sarawak a powerhouse of Southeast Asia. Sarawak is the main exporter of renewable energy to the neighbouring country, West Kalimantan, Indonesia [10]. Due to the success of being able to supply renewable energy, Sarawak Energy will push for a sustainable energy future and work to enhance the amount of alternative and renewable energy. One of the future major contributors to the renewable energy source is Batang Ai Hydropower plant and Sarawak's first floating solar farm at. In parallel to our country mission, Sarawak determine to reduce the carbon emission by 52kilotonnes annually.

Figure 2.2 Batang Ai Hydropower plant where installing floating solar farm is planned.

The only obstacle that existed in Sarawak to fully utilize the solar energy production is the monsoon season and night-time. During monsoon season, the solar radiation performance deteriorates significantly, and the system will not be able to supply sufficient energy to power up the residents. The implementation of the OGPV does assist in supplying electricity when there is no sun radiation, however, the weather is rainy for days the battery storage will not be able to supply electricity as the depth of discharge of the battery is empty.

2.3 Sarawak Alternative Rural Electrification Scheme (SARES) [20]

SARES represents an innovative partnership model between the government and local communities. This integrated initiative, led by the State Government, aims to address the challenge of providing round-the-clock electricity to remote communities that are not feasible to connect to the State Grid.

The primary objective of the SARES scheme is to mobilize government machinery and agencies in assisting villagers to establish, own, and operate sustainable and affordable electricity generating systems. The scheme specifically focuses on 300 isolated

villages, encompassing 8,700 households, and spans from 2016 to 2020. Micro-hydro and solar systems are utilized as the primary technologies for this community-based initiative.

Since its inception in December 2016, SARES has successfully electrified 57 villages situated in Ulu Skrang, Sebauh, Katibas, Bukit Mabong, Nanga Medamit, and Ulu Pelagus. In the current year, approximately 32 villages in Tatau, Sg Pila, Katibas, Sg Gaat, Marudi, and Limbang are slated to be illuminated. Furthermore, an additional 27 villages in Marudi, Telang Usan, Sg Oyan, and Julau are expected to receive electricity by July 2018.

The implemented systems cater to the basic electricity needs of rural households, facilitating lighting, fans, television, freezer, and cooker functionality. They are designed to be simple yet effective, prioritizing safety without compromising on essential functionalities. By adopting these sustainable energy solutions, SARES effectively alleviates the financial burden on villagers, eliminating their dependence on costly diesel generators that only provide limited hours of electricity supply.

In conclusion, SARES stands as an innovative government-community partnership model that strives to provide sustainable electricity solutions to remote communities. By harnessing the potential of micro-hydro and solar technologies, the scheme offers reliable and affordable electricity access, enhancing the overall quality of life for rural households. Through its implementation, SARES addresses the challenges associated with remote electrification while promoting economic and social development in these underserved areas.

2.4 Type of solar PV system

There are two types of solar PV system which are available on the current market, Grid-Connected Solar PV (GCPV) and Off-Grid Solar PV (OGPV) system.

2.4.1 Grid-Connected Photovoltaic System (GCPV)

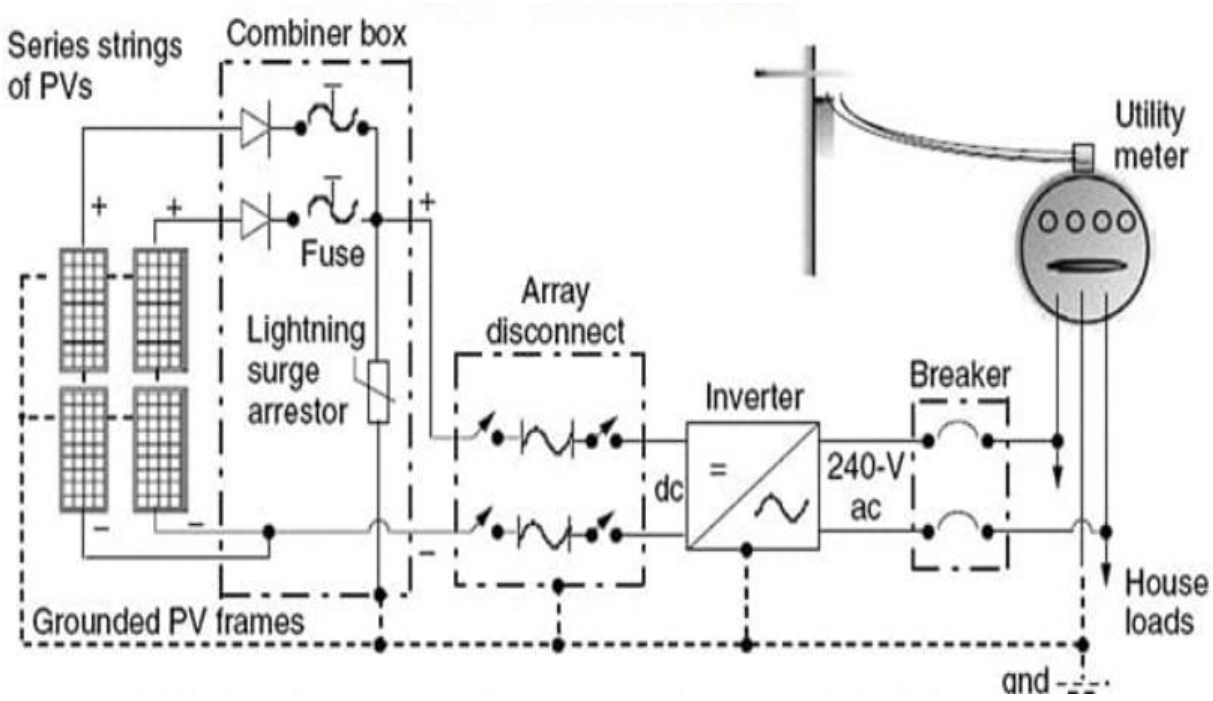

Figure 2.3 An example of GCPV system diagram

The escalating demand for electricity, coupled with the urgency to reduce greenhouse gas emissions, has fuelled the adoption of grid-connected solar photovoltaic (PV) systems. A grid-connected solar PV system, also known as an on-grid or grid-tied system, is designed to generate electricity from solar energy and feed it directly into the utility grid. This integration allows users to offset their electricity consumption from the grid while contributing clean energy to the overall electricity supply.