



**ANALYSIS OF GRID-CONNECTED SOLAR PV SYSTEM
INTEGRATED WITH BATTERY ENERGY STORAGE FOR
HOSPITAL PUTRAJAYA**

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MASTER OF ELECTRICAL ENGINEERING

2020



Faculty of Electrical Engineering

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**A thesis submitted
in fulfillment of the requirements for the degree of Master of
Electrical Engineering**

Faculty of Electrical Engineering

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2020

DECLARATION

I declare that this thesis entitles “Analysis of Grid-Connected Solar PV System Integrated with Battery Energy Storage for Hospital Putrajaya” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :.....
Name : Shairam Bin Salleh
Date :.....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Electrical Engineering.

Signature :

Supervisor Name : Assoc. Prof. Ir. Dr. Gan Chin Kim

Date :

DEDICATION

I dedicate my dissertation work to my beloved mother, my beloved wife and my children with thank you from my heart for supporting me to continue my study. May Allah give all of you a healthy life, wellness and longevity. I love all of you so much.

ABSTRACT

The number of solar photovoltaics (PV) system installation is rising globally. This generates increased competition, with new players entering the market. In turn, this necessitates the need to ensure new technology to respect adequate safety, quality and performance requirements. The biggest challenge in the government hospitals is the high building operational cost. This is because hospitals are equipped with equipment and system that are high in kilowatt demand. In this regard, air conditioning system has the highest operation cost. To address this, the solar PV system integrated with battery energy storage (BES) has been proposed in this work. It could shave the system's maximum demand (MD), which could reduce the electricity bill for the hospital. Therefore, the design of solar PV system integrated with battery energy storage has been carried out with technical and economic analysis. The study takes into the consideration of the voltage profile in order to avoid voltage rise problem in the Hospital Putrajaya's distribution system. This project is expected to shave the MD of the hospital and provide the energy and money saving to the Hospital Putrajaya.

ABSTRAK

Jumlah pemasangan sistem solar fotovoltaik (PV) semakin meningkat di seluruh dunia. Ini menjana persaingan yang semakin meningkat, dengan pemain baru memasuki pasaran. Sebaliknya, ini menyebabkan keperluan semakin meningkat untuk memastikan bahawa produk baru menepati tahap keselamatan, kualiti dan prestasi yang mencukupi. Cabaran terbesar di hospital kerajaan adalah kos operasi yang tinggi terutama kos operasi bangunan. Ini kerana pihak hospital dilengkapi dengan peralatan atau sistem yang mempunyai permintaan yang tinggi dalam beban kilowatt. Sehubungan itu, sistem penyaman udara mempunyai kos operasi tertinggi. Untuk menangani masalah ini, sistem solar PV yang disepadukan dengan penyimpanan tenaga bateri (BES) telah dicadangkan. Sistem solar PV yang disepadukan dengan BES boleh mengurangkan permintaan beban maksimum (MD), yang boleh mengurangkan bil elektrik hospital. Oleh itu, reka bentuk sistem PV solar yang disepadukan dengan BES telah dilakukan dengan melaksanakan analisis teknikal dan ekonom ke atas reka bentuk tersebut. Kajian ini mengambil kira profil voltan untuk mengelakkan masalah peningkatan voltan di sistem pengedaran Hospital Putrajaya. Projek ini dijangka dapat mengurangkan MD dan menyediakan tenaga dan penjimatan wang kepada Hospital Putrajaya.

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LIST OF ABBREVIATION

AC	- Alternating Current
AM	- Air Mass
BES	- Battery Energy Storage
DC	- Direct Current
DOD	- Depth of Discharge
FF	- Fill Factor
LCOE	- Levelized Cost of Electricity
MD	- Maximum Demand
MPPT	- Maximum Power Point Tracker
MS	- Malaysia Standard
NOCT	- Normal Operating Cell Temperature
PSHs	- Peak Sun Hours
PV	- Photovoltaic
RE	- Renewable Energy
SDGs	- Sustainable Development Goals
SEDA	- Sustainable Energy Development Authority, Malaysia
SOC	- State of Charge
STC	- Standard Test Conditions
UNDP	- United Nations Development Programme

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Sustainability and sustainable development become more and more popular due to the serious problems faced by human kind such as the risk of depletion of sources and increasing human impact on environment. Sustainability can be described as maintaining welfare over a long-term.

The National Green Technology Policy was launched in 2009 reflects the Malaysian Government's commitment to move towards sustainable construction based on green practices in which will benefit current and future issues related to economic, social and environment and also quality of life. Such policy indicates that government is seriously encouraging the efforts in tackling green issues in the country that complement the global vision on sustainable development (Malaysia Cooperation Production et al. 2012).

Sustainable policy in Malaysia divide into three parts which are renewable energy, energy efficiency and carbon dioxide reduction. Renewable energy systems may be the key for sustainable energy production, but it is important to assess the availability of renewable sources for the specific area, on which a renewable system is planned to be installed. The availability of renewable sources can be challenging to be evaluated, which requires many different factors to consider such as the weather conditions and the potential number of specific sources. Renewable Energy contributed 33% of the global total installed power

generating capacity at the end of 2018 (SEDA et al. 2018). The trend to decarbonize the energy sector is strongly driven by government policies and the corporate sector globally.

Ministry of Health Malaysia is currently implementing the Sustainability Program to all government hospital and healthcare institutes in all over Malaysia to support the government's policy on renewable energy. One of their programs is installing the renewable energy generator. They already installed stand-alone solar PV plant at Malaysia National Cancer Institute and Langkawi Hospital. The installed solar PV systems are currently not integrated with Battery Energy Storage (BES). Based on this situation, there are some ideas had been thrown to the Ministry of Health Malaysia. This analysis proposal will assist the Ministry of Health Malaysia in making decisions on solar PV system's procurement.

1.2 Problem Statement

Government hospital biggest problem is the high operation cost especially the building operation cost because hospital need to operate the high load demand equipment or system. For operation cost, the most higher operation cost is going to air conditioning system. Almost 60% of the hospital's utilities bills are coming from the are conditioning system. Air conditioning systems need to be used 24 hours for critical zone such as operation theatre, intensive care unit, clean room and etc. Without air conditioning system, daily operation of the hospital will be interrupted due to possibility of infection to the critical patient especially during the operation. This condition makes the monthly cost of operation become higher due to high maximum demand.

Implementing the distribution generation could give impact to the voltage profile through the entire distribution network. More distribution generation could let the voltage profile over the statutory limits (Charles Sarimuthu et al. 2017). This matter must be