Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF STANDALONE PHOTOVOLTAIC SYSTEM FOR EDUCATIONAL PURPOSES

NURSYAFIZAN BIN MOHD ZAMANI

Bachelor of Electrical Engineering Technology with Honours

2023

STANDALONE PHOTOVOLTAIC SYSTEM FOR EDUCATIONAL PURPOSES

NURSYAFIZAN BIN MOHD ZAMANI

A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electronics Engineering Technology with Honours

Faculty of Electrical and Electronic Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI TEKNOLOGI KEJUTERAAN ELEKTRIK DAN ELEKTRONIK

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : **STANDALONE PHOTOVOLTAIC SYSTEM FOR EDUCATIONAL**

Sesi Pengajian : **1 – 2022 / 2023**

Saya **NURSYAFIZAN BIN MOHD ZAMANI** mengaku membenarkan laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓):

☐ **SULIT*** (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

☐ **TERHAD*** (Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

☐ **TIDAK TERHAD**

Disahkan oleh:

Syafizan

(TANDATANGAN PENULIS)

(COP DAN TANDATANGAN PENYELIA)

Alamat Tetap:

AZHAN BIN AB. RAHMAN
Pensyarah
Jabatan Teknologi Kejuruteraan Elektrik
Fakulti Teknologi Kejuruteraan Elektrik & Elektronik
Universiti Teknikal Malaysia Melaka (UTeM)

Tarikh: 23 JANUARI 2023

Tarikh: 27/1/2023

*CATATAN: Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I declare that this project report entitled "**STANDALONE PHOTOVOLTAIC SYSTEM FOR EDUCATIONAL PURPOSES**" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	Syafizan
Student Name	:	NURSYAFIZAN BIN MOHD ZAMANI
Date	:	23 JANUARI 2023

APPROVAL

I approve that this Bachelor Degree Project 2 (PSM2) report entitled "Development of Standalone Photovoltaic System for Educational Purposes" is sufficient for submission.

Signature :

Supervisor Name : Dr. Azhan bin Ab. Rahman

Date : 27/1/2023

DEDICATION

To my cherished parents, Manomi Deka and Mohd Zamani Nayan, who have continuosly provided me with encouragement and motivation throughout my entire childhood and throughout my journey as a student at UteM.

My beloved companion Syahirah Badri, I want to thankyou for all the inspiration you have given me as I face my last year of college as well as the time you spent with me while I was stressed out studying and doing my assignments.

I would especially like to thank my siblings for their constant advice, suggestions and problem solving assistance. In addition, they serve as an inspiration by demonstrating their stedfast commitment to persuing education and a succesful profession.

ABSTRACT

The Energy Efficiency laboratory at the Faculty of Electrical and Electronic Engineering Technology (FTKEE) placed several Grid-connected Photovoltaic (GCPV) System units for education purposes. However, the laboratory does not have the Stand-alone PV (SAPV) System type for the student reference. Hence, this project aimed to convert one of the existing unused 300-Watt GCPV systems into a SAPV system. A standalone typed 300-Watt PV inverter, an intelligent typed charge controller based on a DC-DC converter, a 12 V battery system, and PV balance of systems such as cables, protective devices and structures. An artificial lighting imitates the sunlight was done using 12 pieces of incandescent light bulb rating 100 watts each. This paper will explain details regarding the results and finding which is present in a SAPV system. It is also hoped that this conversion project will benefit the teaching and learning of the FTKEE students in the future.

ABSTRAK

Makmal Kecekapan Tenaga yang terletak di Fakulti Teknologi Kejuruteraan Elektrik dan Elektronik menempatkan beberapa buah unit Sistem Fotovoltaik Bersambung Grid (GCPV) yang diguna pakai untuk tujuan pembelajaran dan pengajaran. Walau bagaimanapun, Sistem Fotovoltaik Berdiri Sendiri (SAPV) atau dikenali sebagai Sistem Off-Grid tidak terdapat pada makmal tersebut untuk dijadikan rujukan buat para pelajar. Tujuan projek ini dilaksanakan adalah untuk mengubah salah satu panel 300 Watt bersambung grid yang sedia ada dan tidak digunakan kepada Sistem Fotovoltaik Berdiri Sendiri. Penyongsang fotovoltaik 300 Watt jenis berdiri sendiri,pengawal cas pintar yang berasaskan penukaran DC-DC, sistem bateri 12 V dan keseimbangan sistem fotovoltaik seperti kabel DC, peranti pelindung dan struktur. Pencahayaan tiruan yang meniru cahaya matahari dibuat dengan menggunakan 12 biji mentol pijar yang berkadar 100 watt setiap satu. Kertas kerja ini akan menerangkan butiran mengenai keputusan dan penemuan yang terdapat dalam sistem SAPV. Projek penukaran ini juga diharapkan dapat memberi manfaat kepada pengajaran dan pembelajaran buat pelajar FTKEE pada masa hadapan.

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

First and foremost, I give Allah (SWT) praise for his favour because it has enabled me to successfully complete my final year project. With this, I would like to sincerely thank everyone who assisted me in completing my Bachelor's project successfully.

I would like to convey my gratitude to my supervisor, Dr. Azhan Bin Ab Rahman, for his invaluable advice, words of wisdom, patience during the completion of this project, and encouragement I received along the way. Without his knowledge and help, I don't think I'll be able to finish my job.

My parents, partner, and other family members have my deepest gratitude for their support and prayers throughout my study period. A special thanks goes out to my buddies for all of their support, cooperation, and memories throughout our time at UTeM, particularly this past year.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

V	- Voltage
A	- Ampere
DC	- Direct Current
AC	- Alternating Current
PV	- Photovoltaic
GCPV	- Grid-connected Photovoltaic
SAPV	- Standalone Photovoltaic
W	- Watts
GSS	- Grid Supply System
IoT	- Internet of Things
TNB	- Tenaga Nasional Berhad
kW	- kiloWatt
BoS	- Balance of System
EFG	- Edge-defined Film-fed Growth
CIGS	- Copper Indium Gallium Selenide
CdTe	- Cadmium Telluride
GaAs	- Gallium Arsenide
HEV	- Hybrid Electric Vehicle
UPS	- Uninterruptible Power Supply
Wh	- Watt-hour
Kg	- Kilogram
Ah	- Amp-hours
SLI	- Starting, Lighting, Ignition
Pb	- Plumbum/Lead
o2	- Dioxide
Ni	- Nickel
LED	- Light Emitting Diode
CFL	- Compact Flourescent Light
LCC	- Life Cycle Cost
BTS	- Base Transceiver Station
IGBT	- Insulated Gate Bipolar Transistor
MOSFET	- Metal-Oxide–Semiconductor Field-Effect Transistor
CVT	- Continuously Variable Transmission
P&O	- Pertubation and Observation
PWM	- Pulse Width Modulation
MPPT	- Maximum Power Point Tracking
PSIM	- PowerSIM
DoD	- Depth of Discharge
LPSP	- Loss of Power Supply Probability
SCC	- Solar Charge Controller

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

The power source is separated into two classes, Renewable Energy and Non-Renewable Energy. Renewable energy is a characteristic asset that can be recharged in a brief timeframe[1]. An asset is continuously replaced or re-established essentially. The case is solar, wind and water. The second one is Non-Renewable Energy. A characteristic asset can't be re-made or re-developed at a scale similar to its consumption. When they are spent, they can't be replaced commonly. The case of non-renewable energy is coal, atomic and gaseous petrol. In Malaysia, the most utilized energy sources are non-renewable energy. Coal is one of Malaysia's essential energy sources, with 21% utilization kept in 2019[2]. The coal process produces dust which dirties the air. Consequently, it isn't eco-accommodating for our environment.

Malaysia likewise involved renewable energy, for instance, hydro power. Hydro power is renewable, which means it will never run out until the flow of water ceases. Consequently, hydropower plants are rock-solid. Occasionally, gear that was reliable 25 years ago is still operating after twice as much time has passed. The generation of hydroelectricity does not contribute to environmental pollution. Clearly, this is the biggest appeal of all renewable energy sources. Hydropower is by a significant measure the most reliable renewable energy source on Earth. In contrast to when the sun sets or the wind dies down, water typically flows continuously every minute of every day.

Indeed, even hydropower enjoys many benefits, yet it never runs from disservice. For example, it gives an impact on fish living space. A running water source must be dammed in order to create a hydroelectric power plant. This hinders fish from reaching their preferred habitat, thereby impacting all organisms that depend on them for sustenance. As the water ceases to flow, the riverbank's natural surroundings begin to fade. This might prevent creatures from gaining access to water. Hydroelectric generating plants need the construction of a dam to stop the flow of water, which is a complex process. Consequently, they are more expensive than comparable non-renewable energy source plants. Lastly, when dams are constructed at higher altitudes, they pose a significant threat to nearby communities. There are risks, despite the fact that these dams are fairly durable. The failure of the Banqiao Dam is the worst dam failure in history. The dam collapsed as a result of the typhoon's excessive precipitation. This resulted in the deaths of 171,000 people[3].

To keep away from every one of the disservices expressed over a Photovoltaic (PV) system is a decent decision of power asset which doesn't make air or water pollution. Since solar cells do not employ any other fuel source but sunlight, the energy they generate is clean and silent. PV systems do not release hazardous air or water pollutants into the environment, regularly exhaust assets, or endanger animal or human health. Photovoltaic systems are tranquil and externally unremarkable. Solar plants with a limited scope may use vacant space on the roofs of existing structures. The power distribution system is the final link in the transmission chain, distributing electrical energy to customers from the grid supply system (GSS) or transmission organisation. Due to the increasing development in energy consumption, distribution feeders and transformers are rising in size, traversing vast geographical areas, and are continually expected to be trustworthy, secure, and dependable.

1.2 Problem Statement

Continuity of electrical supply is one of our daily basic needs. During this time, everything related to the Internet of Things (IoT) needed to have a continuous electrical supply to maintain its eco-system. Therefore, to maintain the situation, we have to create a system that can store energy and can be used during a power failure that can happen at any time.

There is an on-grid photovoltaic system in our laboratory that needs to be connected to the grid to power it up. This module inverter needs to synchronize with the supply from TNB so that only the system will work properly. To propose a standalone PV system, it is required to have an inverter that can be on or off at any time for the study purpose. It is more reliable for lecturers to teach on a standalone system than on a grid system.

In addition, this project is looking forward to developing the standalone PV systems incorporating with charge controller and battery as the energy storage bank.

1.3 Project Objective

The goals that must be achieved for the project:

a) To design a standalone PV system using solar panel available in the efficiency laboratory at FTKEE.

b) To construct the actual hardware system that can be used for further study purposes.

c) To validate the function of the system in a real-life situation.

1.4 Scope of Project

To complete this project, it is required to design and create a prototype of a solar system that operates independently. This project is limited to small-power appliances with a wattage below 300 watts for the load. The item listed is stated as below:

a) PV panel rating 300 watt

b) DC to AC power inverter 300 watts (maximum power)

c) The circuit breaker 30A (for protecting equipment)

d) This project will only involve with standalone PV system type

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This section describes the findings and interpretations of prior research on the topic. In other words, it demonstrates to the reader through comprehensive research what is known and why regarding a certain issue. [4]. Likewise, it will make sense of the background of the past study concerning the subjects.

2.2 Background of Studies

A stand-alone photovoltaic (PV) system is not intended to transmit energy to the grid. It does not require a grid-connected inverter, though backup grid power may be employed. From a simple DC load controlled directly by the PV module to systems with battery storage, an ac converter, and a backup power source, independent systems are available in a variety of configurations. Typically, they are utilised for low-power applications in areas where electricity is not readily available, such as certain provincial districts and remote areas where the utility grid is not readily available. Then, the fundamentals of standalone and PV system configuration will make clear.

Solar electric systems that are self-contained do not contribute capacity to the electric utility grid, but they can use as a backup. Solar power systems could be utilised to supplement grid power. Grid input and output connections are absent in non-grid systems. Any system that does not use a grid is considered a standalone system.

Based on the specifications of the load, independent systems might just have a DC or AC output. Independent systems seem adequate for powering equipment which does not require a substantial amount of force, including light or small machines. 12 V or 48 V is the most frequent output voltages for small systems, although 48 V and higher are utilised for larger systems.

As with any electrical system, national electrical rules and general electrical safety criteria must be observed, including the manufacturer's recommendations for cable size, installation, and required environment. Depending on the application and the electrical power requirements of the load, the vast majority of stand-alone PV systems contain a battery to provide power when solar input is minimal. Certain uses, such as a storage room fan or certain liquid applications, may not require a battery backup, hence saving battery costs and maintenance.

In ascending order of system complexity, table 2.1 shows five possibilities for freestanding PV systems. The table below is the sole representative of these systems due to common variances in their configurations. The power output of a compact minicomputer can range from less than 1 W to more than 10kW. Grid-tied systems, which are electrically producing systems that are connected to the electric utility grid, are often more powerful than systems less than 10kW. Solar tracking devices and other system monitoring devices are examples of alternate components that can be added to any system.

System monitoring can offer fundamental performance statistics to the system, such as power, energy, administration, and advanced diagnostics. A bad panel, rodent damage,