UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF SOLAR-WIND HYBRID POWER SYSTEM MODEL USING ARDUINO WITH SMART CONTROL AND MONITORING SYSTEM

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Power Industry) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Power Industry) with Honours. The member of the supervisory is as follow:

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ABSTRACT

The solar-wind hybrid power system model is an existing senior project that will be upgraded the system based on the user's option. This project's concept aims for a secondary school student to make them understand the theory of renewable energy working fundamentals. The main target of this project is to develop a microcontroller-based prototype for a small scale solar-wind hybrid power system. The Arduino program is the main controller that control the solar photovoltaic (PV) and the wind system energy that can generate electricity to replace non-renewable energy. Additionally, this project also has an improvement which is to develop a monitoring system for electrical power, solar panel luminance and turbine blades rotation speed using MIT App Inventor that can control the output and can be monitored via smartphone. Futhermore, this project will also analyse the amount of electrical power that is generated by the solar-wind hybrid system prototype by taking into account its solar panel luminance and turbine blades rotation speed. This project consist of two part, software and hardware. The software part will be the main part for this project. At the end of this project, the hybrid solar photovoltaic (PV) and wind energy system that serve as an educational training tool are working properly with Arduino as a controller and MIT app inventor as the human machine interface (HMI). Hence, the students will be able to understand the concept of wind energy and solar phovoltaic (PV) energy as a renewable energy source.

ABSTRAK

Model Sistem Kuasa Hibrid Suria adalah projek "senior" yang sedia ada dimana akan dinaik taraf sistemnya berdasarkan pilihan pengguna. Konsep projek ini bertujuan untuk pelajar sekolah menengah memahami teori asas kerja tenaga yang boleh diperbaharui. Sasaran utama projek ini adalah untuk membangun prototaip berasaskan mikrokontroler untuk sistem kuasa 'wind hybrid'. Program Arduino adalah pengawal utama yang mengawal solar photovoltaic (PV) dan "hybrid power system" yang dapat menjana tenaga elektrik untuk menggantikan tenaga yang tidak boleh diperbaharui. Di samping itu, projek ini juga mempunyai peningkatan yang bertujuan untuk membangunkan sistem pemantauan untuk kuasa putaran elektrik, pencahayaan panel solar dan kelajuan putaran turbin dengan menggunakan MIT App Inventor yang boleh mengawal output dan boleh dipantau menerusi telefon pintar. Tambahan lagi, projek ini juga akan menganalisis jumlah kuasa elektrik yang dihasilkan oleh prototaip sistem hibrid suria dengan mengambil kira kelajuan putaran panel turbin.. Projek ini terdiri daripada dua bahagian, perisian dan perkakasan. Bahagian perisian akan menjadi bahagian utama bagi projek ini. Pada akhir projek ini, sistem tenaga solar photovoltaic (PV) dan tenaga angin yang berfungsi sebagai alat latihan pendidikan berfungsi dengan baik dengan Arduino sebagai pengawal dan pencipta aplikasi MIT sebagai "Human Machine Interface" (HMI). Oleh itu, para pelajar akan dapat memahami konsep tenaga angin dan solar photovoltaic (PV) sebagai sumber tenaga yang boleh diperbaharui.

DEDICATION

Every challenging work needs self-efforts as well as guidance of elders especially those who very close to our heart.
My humble effort I dedicate to my sweet and loving

Parents, Lecturer and Friends,

Whose affection, love, encouragement and prays of day and night make me able to get such success and honour,

Along with all hard working and respected
Lecturer

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter will describe the project's background, the objectives, the problem statements and scope of the project. The full overview of this project will be explained.

1.2 Project Background

This is existing project that will be upgraded the system based on the user's option. MIT App Inventor software will be used in this project to provide user with monitoring system that can be access via smartphone. The rotation speed of the blades from the turbine and the lux intensity from the solar panel can also be controlled using the MIT App Inventor software.

The primary objective of this project is to develop a microcontroller-based prototype for a small scale solar-wind hybrid power system. With the use of the microprocessor Arduino as a main system controller that control the wind energy system and solar photovoltaic (PV), the learning process will be much easier. Most of the students lack the knowledge about renewable energy. They are not aware that oil, coal and natural gas that is currently been used as the energy sources can lead to the bad effect to the environment. This project will use the renewable energy which is wind energy and solar photovoltaic (PV) that can produce electricity.

Besides that, this project will yield students with the knowledge about some renewable energy such as wind and light. At the end of this project, Arduino and an MIT

app inventor as a human machine interface (HMI) will be used to control a hybrid solar photovoltaic (PV) and wind energy system that will be used as an educational training tool. Thus, the concept of solar photovoltaic (PV) and wind energy as a source of energy will be fully understand by students.

1.3 Problem Statement

Nowadays, most of the students lack the knowledge about the renewable energy. There are some non-renewable energy such as oil, coal and natural gas that are widely use in our country. This non-renewable energy will lead to some environmental issue. The greenhouse effect and global warming are the effect caused by an enormous usage of the non-renewable materials that are used to generate electricity. Besides that, the usage of electricity is rising day by day due to the economic issues. To overcome this issue, a renewable energy must be used and it is the best solution for this issue.

1.4 Project Objectives

This project have some objectives which are:

a) To develop a microcontroller-based prototype for a small scale solar-wind hybrid power system.

b) To develop a monitoring system for electrical power, solar panel luminance and turbine blades rotation speed using MIT App Inventor that can be monitored via smartphone.

c) To analyse the amount of electrical power that is generated by the solar-wind hybrid system prototype by taking into account its solar panel luminance and turbine blades rotation speed.

1.5 Project Scope

This project goal is to develop a prototype as an educational purpose. The prototype consist of hybrid solar PV and wind energy system with an Arduino controller that can monitor the system. The scopes in this project are as follows:

a) Monitoring the electrical power produced by a solar photovoltaic (PV) and vertical axis wind turbine (VAWT),

b) Use a vertical axis wind turbine and solar photovoltaic (PV),

c) Use Arduino Mega as a controller with an MIT App Inventor as a human machine interface (HMI).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will describe how the renewable energy source can generate electricity. However, a PV solar and wind turbine are the primary principles of this project with a definite goal to amass a framework for educational purposes.

2.2 Power Plant

An industrial facility for the production of electricity to meet consumers' demand is known as power plant which is also known as a power station. The solar thermal power plant, the wind power plant, the geothermal power plant, the fossil fuel power plant, the nuclear power plant and hydroelectric power plant are some example of power plant ("Electric Power eTool: Illustrated Glossary - Power Generation Plants," n.d.). Although the power plants sounds like a complicated system but the basic operation is just to produce electricity. The turbines that is used to produce electricity is drive by the steam that resulted from the heat produced by the power plant. Furthermore, the wind energy, the potential energy, the solar energy and chemical energy are some example of other sources of energy that can generate electricity.

This energy is known as renewable energy and it consists of two basic components at the power plant system. The first component is the furnace boiler that is created to burn and store the heat energy that was produced. The steam turbine generator is the second components which the function is to convert the heat energy stored into

electrical energy. A main shaft is connected to the rotor inside the turbine and the magnets with a coil inside a generator will be spin. Lastly, the consumers will received the transmitted electrical energy from power plant through the distribution by the electric grid system.

2.3 Solar Photovoltaic

Solar energy is a clean, abundant, inexhaustible and infinite source of energy. In addition, the solar energy is the cleanest compare to other renewable energy. Besides that, it is known as a renewable energy because it can produce electricity. The word photovoltaic is a combination of two words which are the “photo” and “voltaic”. The sunlight is represented by the word “photo” and the electricity is presented by the word “voltaic”. Photovoltaic technology is considered as is the perfect plans that to harness the solar energy. The direct conversion of daylight into electricity with no heat engine to obstruct is the basic operation of Photovoltaic conversion. Photovoltaic devices are rugged and easy to design. It only requires a slight care and their profit is their development as complete systems to give outputs from microwatts to megawatts. The demand for photovoltaic is increasing once a year with such an extensive bunch of applications, (Bhubaneswari, S.Iniyan & Ranco Goic, 2011).

2.3.1 Solar Photovoltaic Working Principle

According to Markvart and Castaner (2012), N-doped and P-doped layer of semiconductor is the two layers that is combine to form solar photovoltaic. The solar cell working principle is shown in Figure 2.2. Some interactions will occur when the two of the semiconductor parts are combined. When the N-type region and P-type region made a contact with each other, some electrons will be pulled to the positive side and a few positive charge of holes will shift towards the N-type area. A new layer will be formed between these two regions due to the travelling of electrons and holes to other side of the layer. This layer is known as depletion layer or depletion region. When the depletion layer is formed, electrons and holes will stay on the side and will not move to the other side. Electrons and holes will be created and the electrons will move towards the connected wire or contacts when the depletion layer area is strike by sunlight or photon energy. Then, the electricity will be generated.

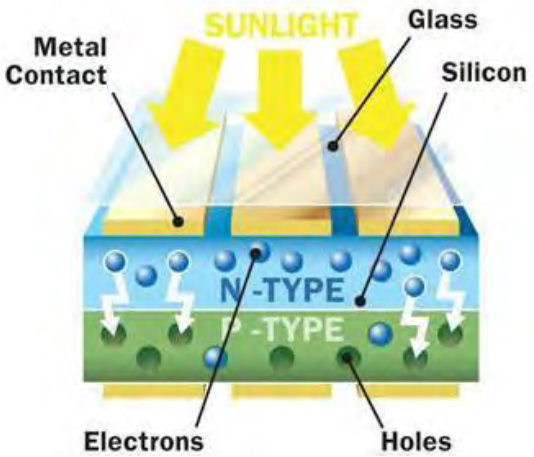

Figure 2.1: The Block Diagram of Solar Cell Working Principle

2.3.2 Type of Solar Cell

There are a lot of companies that are focus on developing solar cell. There are certain types of solar panel with their specific advantages. Until now, there are only three common types of solar panel that is widely used (Energy, 2015),

a) Polycrystalline panel

A multi-crystalline panel is also known as polycrystalline panel. The combination of a deviation of crystals that are connected in a single panel is known as polycrystalline. It is the most popular solar cell with a 48% of production in 2008 (Sharma et al., 2015). The polycrystalline panel is cheaper and has simple manufacturing process compared to the monocrystalline. However, it has less efficiency but with a better performance during hot days (Maehlum, 2015).

b) Monocrystalline panel

The first material that were used in the photovoltaic cell is monocrystalline and it still remain as the most common used (Hersch & Zweibel, 1982). It is the product of Czochralski process that is made up of a single-crystal silicon (Sharma, Jain, & Sharma, 2015).It has an efficiency of 17% to 18% (Sharma et al., 2015). If compared to other types of solar cell, Monocrystalline has a better efficiency than them

c) Thin film panel

A thin film panel can be classified under three types which are Cadmium Telluride Thin Film Solar Cell Amorphous, a Silicon Thin Film, and a Copper Indium

Gallium Di-Selenide Solar Cells. Thin film is a solar cell that is created by planting one or more thin layers of a photovoltaic composite. The thin film solar cell is more flexible compare to other solar cells. It also can be put into a collection of different surfaces, curves and straights (Sharma et al, 2015).

The difference type of solar cell has a different percentage of its efficiency. Figure 2.2 shows The Comparisons of Efficiency of Technologies.

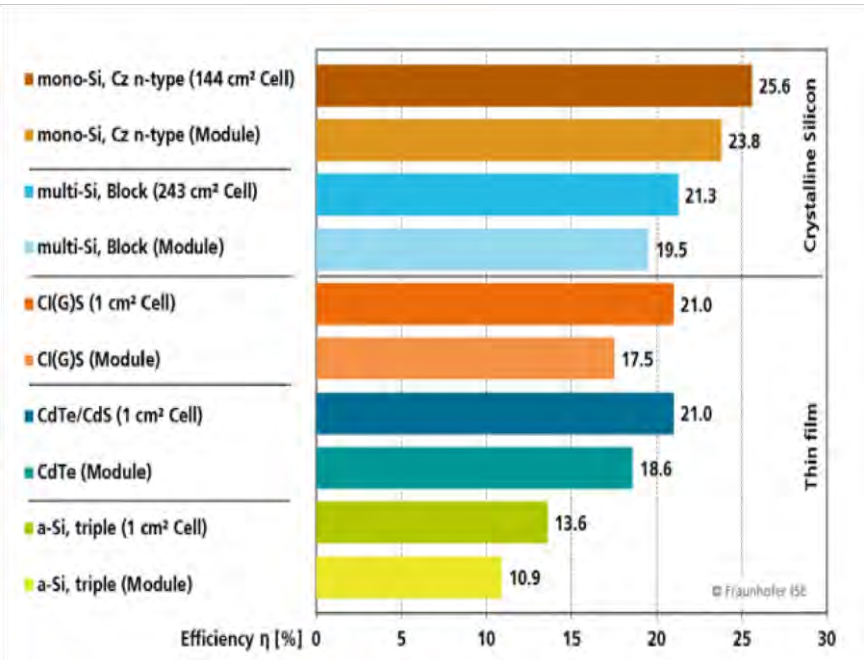

Figure 2.2: The Comparisons of Efficiency (Energy, 2015)

2.4 Hybrid Photovoltaic Power Generation

According to Bhubaneswari, S.Iniyan & Ranco Goic (2011), Hybrid power generation system merge a renewable energy supply (PV during this case) with various types of generation, typically a standard generator that is powered by diesel or other renewable sort of energy such as wind. Barton et al. explained a completely unique