UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF BUILDING INTEGRATED PHOTOVOLTAIC (BIPV) HOME AUTOMATION 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 (Industrial Power) with Honours.

by

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ABSTRAK

Akhir-akhir ini, elektrik selalu menjadi masalah besar iaitu kekurangan biayai dan permintaan yang tinggi terutama di kawasan perindustrian berat dan perumahan. Permintaan elektrik yang tinggi akan membawa kita ke pemanasan global dan terkeluar dari sumber-sumber pada masa akan datang. Oleh itu, cara alternatif adalah dengan menggunakan tenaga boleh diperbaharui terutamanya tenaga solar. Di Malaysia, tenaga suria menjadi penyelesaian terbaik dalam untuk mendapatkan kuasa elektrik sebagai gantian atau bekalan sandaran terutamanya di kawasan kediaman. Oleh itu, kertas kerja ini akan membincangkan dan meneroka panel solar yang berpotensi dalam pembangunan seperti bangunan fotovoltaik bersepadu menggunakan Arduino dengan model kawalan pintar dan sistem pengawasan. Bahan fotovoltaik biasanya digunakan kerana boleh menghasilkan voltan keluaran yang tinggi dengan bahan berkualiti tinggi dan kos yang lebih rendah dari segi pemasangan. Jadi Arduino dalam sistem ini digunakan untuk mengawal sistem dalam bangunan atau rumah seperti lampu atau kipas. Oleh kerana tenaga yang digunakan, sistem pengawasan akan bertindak balas melalui modul Internet of Things (IOT) jika pengguna menggunakan banyak tenaga yang telah ditetapkan dari sistem. Bertindak sebagai mekanisme tindak balas pantas yang akan memberitahu pengguna jumlah tenaga yang digunakan dan pengguna akan bertindak balas terhadap mesej dan mengawal penggunaannya. Jadi, Penanam App MIT adalah aplikasi inovasi dalam telefon pintar yang akan menerima maklumat daripada IOT dan memantau semua elemen voltan dan arus yang digunakan oleh sistem.

ABSTRACT

Lately, electricity always becomes a big issue lack high cost and demand especially in heavy industry and residential area. The high demand of electricity will lead us to global warming and out of resources in future. So, one of the alternative ways is by using renewable energy especially solar energy. In Malaysia, solar energy becomes the best solution in replacement of power electricity or backup supply especially in residential area. This project discussed and explores the potential solar panel in development of building integrated photovoltaic (BIPV) using Arduino with smart control model and monitoring system. Photovoltaic materials are normally used because they can produce high output voltage with high quality material and lower cost for installation. So the Arduino in this system used to control system in building or house such as lamp or fan. As the energy being used, the monitoring system will react through Internet of Things (IOT) module if the consumer used a lot of energy that have been set from the system. IOT act as a fast response mechanism that will inform the users on the total amount of energy used and the user will respond to the message and control the usage. So, MIT App Inventor is the innovation application in smart phone that will receive information from IOT and monitor all the element such voltage and current used by the system.

DECLARATION

To my beloved parents Mr Mazlan Bin Mohd Salleh and Mrs Rezni Bt Majid for their support and pray. A full appreciation to my supervisor Mr Maslan Bin Zainon for advising and helping through this project.

Signature : …….

Author‟s Name : Muhammad Amirul Mukmin Bin Mazlan

Date : …….

APPROVAL

This report submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirement for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follow:

……

(Mr Maslan Bin Zainon)

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter will explain about the introduction, objective, problem statement and scope of the project.

1.1 Background

Lately, electricity always becomes a big issue lack high cost and demand especially in weight industrial and residential area. Hence, the high demand of electricity will lead us to global warming and out of resources in future. So , there are many alternative way in resolving this problem and one of them is by introducing renewable energy .There are many type of renewable energy that had been introduces to global such as solar, wind, biomass, rain and many others. So that solar become a famous and well-known as of the alternative sources of energy that have been looking with the recent increase in energy costs. There are several types of renewable energy that have been designed to gain electricity without fully utilizing electricity. Renewable energy generally provides energy in some important area such as electricity generation, air and water heating/cooling and rural (off grid) energy services.

As you know, solar power energy is major and most important renewable energy with the huge potential to meet many of the challenges facing the world. This power source also majority used that because got high efficient also give benefit to people and environment. It also an advantage in our country which is Malaysia sunlight received by earth in one hour is good enough to meet the annual energy needs of all people worldwide according to National Renewable Energy Laboratory. Solar energy was the

fastest growing energy sector with a 33% rise since 2015. In early 2016, the percent increasing in solar installation was 43% per annually. Worldwide renewable energy capacity rise around 10–60% annually from the end of 2004.

The main fundamental in solar power system is Photovoltaic (PV) panel are the common model of solar energy used. Photovoltaic also one of the method to generating electric and absorb the sunlight and will convert energy from the sun by using the solar cells.

So for this paper had been finalized to design and develop building integrated photovoltaic home automation model using WeMos D1 R2 with smart control and monitoring system. After had a some research from previous, photovoltaic panel is a suitable material in achieving outcome voltage with high generating efficiency, high quality material and lower cost for installation. The load can be control by using WeMos D1 R2 and will monitoring the system in the house.

1.2 Problem statement

Building Integrated Photovoltaic (BIPV) is a photovoltaic material used to replace conventional building materials or houses in the buildings cover areas such as roofs, facade and walls. Photo voltaic (PV) is a very elegant way of generating electricity on site directly from the sun. Between a utility Interactive PV System and a Stand-alone PV System. The vast majority of BIPV systems will be tied to a utility grid, using the grid as storage and backup. Nowadays, the usage of electricity has been used too much, in order to save the usage of electricity, the BIPV has been used as an alternative source of energy to produce electricity in the buildings without harming environment. Other than that, consumers are often overlooked and did not alert with the amount of the electricity consumption. By using the BIPV as part of the building automatically being a source of electricity energy, consumers do not have to worry and get source of unlimited energy.

1.3 Project objectives

The main objectives in this project:

1. To develop a microcontroller-based prototype of a building integrated photovoltaic (BIPV) home automation system.
2. To develop a smart control and monitoring system using IoT (Internet of Things) that can be controlled and monitored via a smartphone.
3. To analyses the amount of electrical power that is generated by the BIPV home automation system prototype.

1.4 Scope of project.

The scope of this project is to broaden and design the system that could display the electrical appliances status and control it by using smart phone with WeMos D1 R2 and Arduino IDE. The BIPV react as component that absorb the energy taking from solar and the energy absorbed will be stored for electricity appliances such as fan and light. As the energy being used, the monitoring system will react through IOT module if the consumer used a lot of energy that have been set from the system. IoT act as a fast response mechanism that will tell the user the total amount of energy used and the user will respond to the message and control the usage.

This project is implemented in domestic area such as home and small buildings. This project will reduce the cost the usage of electricity for consumer and it is a long term investment for future convenience.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter will be discusses about the main idea of research from variety of source. This part will clarify in detail all the data identified with the study based on dependable sources.

2.1 Building Integrated Photovoltaic.

Photovoltaic is the material of Building Integrated Photovoltaic that is used to supplant common building materials in parts of the building envelope for instance, the housetop, sky, confronting windows or facade. They are progressively being melded into the advancement of new structures or working as a key or assistant wellspring of electrical power, albeit existing structures or structures may be retrofitted with comparable innovation. The benefit of fused photovoltaic over more run of the mill non-coordinated framework is that underlying expense can be balance by lessening the total spent on building materials and work that would frequently be used to build up the piece of the building that the BIPV modules supplant. These points of interest make BIPV one of the snappiest creating pieces of the photovoltaic industry (Kylili and Fokaides, 2014).

Installations of solar photovoltaic (PV) is the technologies on building housetops are regularly in a few parts of the world. Most by far of this system are made out of modules that are mounted off the surfaces of rooftops utilizing distinctive kinds of racking hardware. This system is designed most impacted by PV performance considerations, and feel are regularly optional. In any case, developing PV technologies industry rivalry to reduce installation costs are animating the improvement of multi-functional PV products that are integrated with building materials.

In principle, solar energy was used by individuals as in front of calendar as seventh century B.C., exactly when history advises to us that individuals used sunshine to light flames with intensifying glass materials. A while later, in third century B.C., the Greeks and Romans were known to outfit sun powered power with mirrors to light lights for religious capacities. These mirrors transformed into a standardized gadget alluded to as "consuming mirrors." Another early use for sunlight based vitality that is up 'til now predominant today was the possibility of sunrooms in structures. These sunrooms used monstrous windows to coordinate daylight into one concentrated domain (Temby *et al.*, 2014)

The change of solar panel technology was an iterative one that took different duties from various researchers. Ordinarily, there is some reasonable exchange around when precisely they were made and who ought to be credited for the development. A few of individuals credit the advancement of the sun powered cell to French scientist Edmond Becquerel, who chose light could expand power age when two metal anodes were set into a main course of action. This leap forward, described as the "photovoltaic effect" was enticing in later PV progression with the segment selenium.

In any case, solar cells as we most likely mindful they today are made with silicon, not selenium. Therefore, some consider the veritable development of sun powered boards to be appended to Daryl Chapin, Calvin Fuller, and Gerald Pearson's arrangement of the silicon photovoltaic (PV) cell at Chime Labs in 1954. Various battle that this event signifies the certified making of PV development since it was the main case of sun powered innovation that could truly control an electric device for a few of hours of a day. The primary ever silicon sun based cell could change over daylight at four percent productivity, not as much as a fourth of what exhibit day cells are set up to do (Kylili and Fokaides, 2014). Figure 2.1 and figure 2.2 shows the type of BIPV façade and advantages and disadvantages.

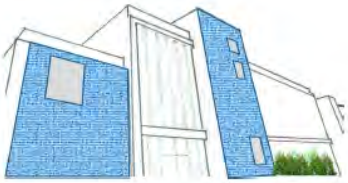
BIPV Façade Type	Design Impact
1. Curtain Wall/Cladding Systems Solar panels integrated as a conventional cladding system for curtain walls and single layer façades [37].  a.	• Advantages - Intelligent way of balancing daylighting and shading [37]. - Iconic importance in the field of architecture [37]. - Different colors and visual effects can be included [61]. - Regulates the internal temperatures of the building by minimizing solar gain in the summer [61]. - Light effects from these panels lead to an ever-changing pattern of shades in the building itself [61]. - Impacts on overall architectural image - Maximizes façade wall for energy generation • Disadvantages - Installation costs can be high [61]. - Potentially less energy than on roof-top [37]. - Requires complex planning and compliance with a great many physical properties [37]. - Properly handling needed to prevent view obstruction by electrical cables
2. Solar Glazing and Windows Applied as semi-transparent/translucent parts of the façade based on solar cell transparency. They can be integrated into windows, glazing panels, for view or daylighting [59].  b.	• Advantages - Allowing for filtered view as well as energy generation [61]. - Potential application as opaque or semi-transparent/translucent glazing [59] - Special PV elements used thermal insulators in combination with standard double or triple glazing elements [59]. - Added functionality as sun shading - The patterns from the shading generate a dynamic experience of spatial variety through the day. • Disadvantages - Potentially lower efficiencies [37] - Increase in cell spacing yields less energy due to fewer cells

Figure 2.1: BIPV façade type and advantages and disadvantages

BIPV Façade Type	Design Impact
3. External Devices/Accessories Sunshades and sunscreens, spandrels, balconies parapets, elements of visual and acoustic shielding [61].  c.	• Advantages - Potential for minimizing both building heat loads and energy consumption [59]. - Vertical or horizontal sun shading provided above windows [61] - Use of building shading structure as mounting to prevent additional load on façade [61]. - Potential as fixed or adjustable devices [59,61] - Allows for PV modules of different shapes [61]. • Disadvantages - Shadows cast from BIPV panels may need filtering to even out light distribution - Obstruction of view if not transparent or translucent
4. Advanced/Innovative Envelope Systems Such as double skin façades, active skins, rotating or moving façade parts, etc. [59]  d.	• Advantages - Integration with advanced aesthetic polymer technologies [59]. - Generation of heat in winter for space heating - Double skin façades assist in cooling of BIPV panels [64]. - Possible integration with other building elements for performance and aesthetics [53,55–57] • Disadvantages - Potentially more expensive than other types - Energy maybe required for extraction of heat in summer via mechanical means or forced ventilation [64].

Figure 2.2: BIPV façade type and advantages and disadvantages

2.2 Photovoltaic (PV) Panel

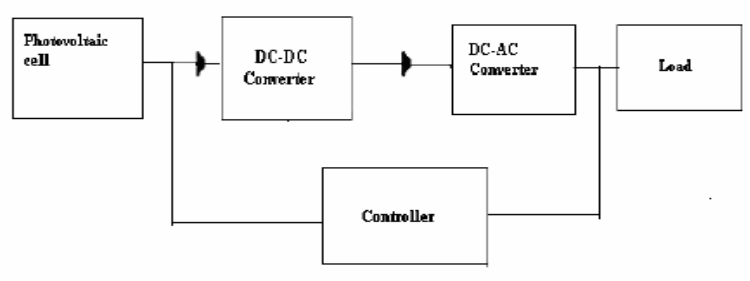


Figure 2.3: Photovoltaic Block Diagram

Photovoltaic is the main part component in renewable solar energy that designed to supply usable solar power by means photovoltaic (PV). It consists of several components such as solar panel, it work to absorb and convert sunlight into electricity. Then, change the electric current from DC to AC used by solar inverter. The advantage of solar photovoltaic (PV), once installed its operation generates no pollution and no gas emissions. The power output is dependent on direct sunlight is the major disadvantage of photovoltaic system. So that, if the tracking system is not use it will be lost about 10-25% because the cell will not be directly facing the sun at all times. Depending on the efficiency on turning the sunlight into the electricity is the performance of solar cell (Biyik *et al.*, 2017).

2.3 On-Grid solar PV system

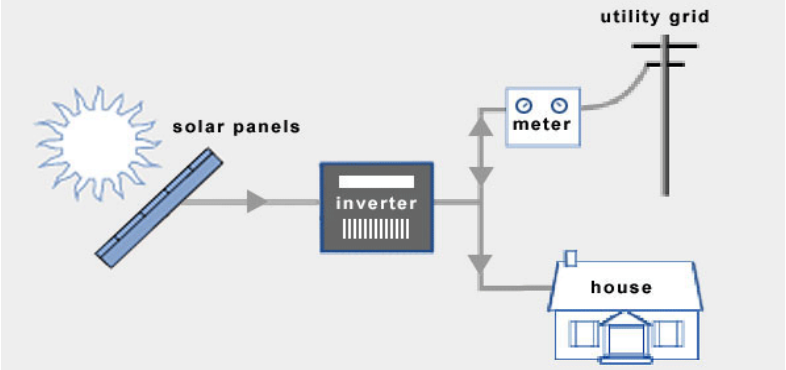


Figure 2.4: Operation of on-grid system

On-grid solar systems are by a long shot the most well-known and broadly utilized by homes and other buildings. These systems are associated with people in public electricity grid and don‟t require battery storage. Some solar power that you create from an on-grid (which isn‟t utilized directly in your house) is traded onto the power electricity grid and generally gets paid a feed-in-tariff (FiT) for the energy that you send out(Kylili and Fokaides, 2014).

2.4 Off-grid solar PV system

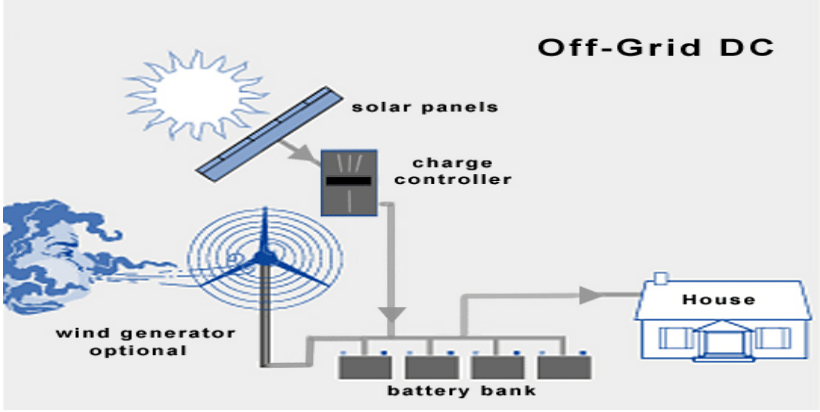


Figure 2.5: Operation of Off-Grid solar PV system

An off-grid system isn‟t associated with the electricity grid and along these lines requires battery storage. An off-grid solar system must be outlined properly with the goal that it will generate enough power consistently and have enough battery ability to meet the home‟s requirements, even in the insights of winter when there is less daylight. The high cost of batteries and inverters implies off-grid system are much more costly than on-grid system as are typically just required in more remote areas that are a long way from any power electricity. Conversely, battery costs are decreasing quickly, so there is currently a developing market for off-grid solar battery systems even in urban areas and towns (Kylili and Fokaides, 2014).

2.5 Types of solar panel

The solar panel has three types, mono-crystalline, polycrystalline and thin film.

2.5.1 Mono-crystalline

Figure 2.6: Mono-crystalline panel

Mono-crystalline silicon also called single-crystal silicon is the most component of solar panel that have been used, it also made from a semiconductor device. This semiconductor functions as a photovoltaic that absorb the energy of solar cells. This panel also most efficient than other panel but most expensive, with an efficiency rate of 15% to 20%.The thickness of the molten silicon is 0.2mm to 0.3mm and this panel very pure silicon. The performance of this panel is affected when it‟s come to shading. The advantage of this panel is longevity which is even several of the early modules installed since 1970 are still producing electricity today. As you know, this panel is able to convert the highest amount of solar energy to electricity. So that, the generate energy is most efficiency (Temby *et al.*, 2014). Figure 2.6 shows the comparison solar panel of Mono-crystalline and Polycrystalline.

Mono vs. Poly solar panels: Comparison table

	Monocrystalline	Polycrystalline
Cost	More expensive	Less expensive
Efficiency	More efficient	Less efficient
Aesthetics	Solar cells are a black hue	Solar cells have a blue-ish hue
Longevity	25+ years	25+ years
Major manufacturers	Canadian Solar SunPower LG Hyundai SolarWorld	Hanwha Kyocera Hyundai SolarWorld Trina

Figure 2.7: Comparison Mono-crystalline and polycrystalline panel

2.5.2 Polycrystalline solar panel

Figure 2.8: Polycrystalline Solar Panel

Principal solar panel of polycrystalline silicon, which in like manner is known as polysilicon (p-Si) and multi-crystalline silicon (mc-Si), were familiar with the market in 1981. Not in any manner like monocrystalline solar panel, polycrystalline needn't bother with the Czochralski procedure. Efficiency of polycrystalline 11% to 15% lower than mono-crystalline panel (Biyik *et al.*, 2017).

2.5.3 Thin film solar panel

Figure 2.9: Thin film panel

A thin film solar panels are made with solar cell by depositing one or more thin layers, or photovoltaic material from thin film on a substrate, such as metal, glass or plastic. Thin film solar cells are widely used in others technologies that including copper indium gallium diselenide (CIGS), cadmium telluride (CdTe), and amorphous thin film silicon (a-Si, TF-Si). Thin-film technology has always been cheaper but less efficient than conventional technology (c-Si). It is used to reduce the price per watt from the high cost from producing crystalline silicon wafer panel.

2.6 Net metering

Net metering permits consumers who create a few or the majority of their own power to utilize that electricity whenever, rather than when it is produced. Net metering also is a charging instrument that credits solar energy system for the power they add to the grid. For instance, if a private client has a PV system on the home‟s housetop, it might create more power than the home uses during sunlight hours. On the off chance that the house is net metered, the power meter will run in reverse to give a credit against what power is devoured during the evening or different periods where the home‟s power utilize surpasses the system‟s output (Coonen, 2016).

2.7 What are Feed-In Tariffs?

Feed-In Tariffs are the power some portion of what a few people call Clean Energy Cash back, a plan that pays individuals for making their own “green electricity”. The second portion of the plan is the Renewable Heat Incentive, a comparable measure for heat. The tariffs have been acquainted by the Government to help increment the level of sustainable power source in the UK toward our legally restricting focus 15% of total energy from renewables by 2020 (Coonen, 2016).

2.8 Renewable Energy

The renewable energy is energy that is gathered from our encompassing and condition assets. Numerous kinds of renewable energy for example, daylight, wind, rain, geothermal and others that can be utilized as sources to gives the power. It also can be used directly for lighting and heating to homes and other buildings to generating the electricity. Renewable energy is important in regards to the advantage that gives by the energy such as environmental benefits. Renewable energy also important for our children because other sources of energy are limit and some day will be depleted (Mardani *et al.*, 2015).

2.8.1 Solar Energy

Solar energy is radiant heating and lighting from the sunlight and turning it into electricity for home and other buildings. Solar energy also can reduced electricity bills because generated own energy at the same time the maintenance is easy and low. Once system installed, it not take too much to make sure solar panel are always working in fully potential. The disadvantage of solar energy is depending on weather, when rainy season so it causes the solar system can‟t absorb heat to generate electricity.