Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF GREEN STOVE PORTABLE BIOMASS POWER SOLUTION BASED ON IOT

MUHAMMAD RIDZWAN BIN AB RAOF

Bachelor of Electronics Engineering Technology with Honours

2022

DEVELOPMENT OF GREEN STOVE PORTABLE BIOMASS POWER SOLUTION BASED ON IOT

MUHAMMAD RIDZWAN BIN AB RAOF

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

2022

DECLARATION

I declare that this project report entitled “Development of Green Stove Portable Biomass Power Solution Based on IoT” 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	:	
Student Name	:	MUHAMMAD RIDZWAN BIN AB RAOF
Date	:	6 JANUARY 2023

APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology with Honours.

Signature :

Supervisor Name : KAMILAH BINTI JAFFAR

Date : 27/1/2023

Signature :

Co-Supervisor Name (if any) :

Date :

DEDICATION

I committed my endeavour and all my hard work to studies in order to reach my ideal goal of achieving the Dean's List every semester. Not only that, but I dedicated everything to my parents, who have always supported me, as well as to all my family members for being the backbone of my journey to finish my degree with a First-Class result, and to all my lecturers for guiding me and endlessly providing me with the knowledge that I required to complete my project. I would not have been able to complete this with flying colours without the help of everyone. Thank you.

ABSTRACT

Biomass is a renewable organic material that can be produced from organic sources such as animals and plants. Biomass is an essential fuel source in many countries especially for heating purposes such as cooking in underdeveloped countries. As a method of minimising carbon dioxide emissions, there has been a shift from the use of fossil fuels to the use of biomass fuels in many industrialized countries . Biomass stores chemical energy derived from the sun. Photosynthesis produces biomass in plants. Various technologies may convert biomass into sustainable liquid and gaseous fuels, or biomass can be burnt directly for heat. The main purpose of this research is to implement the use of biomass energy into a portable power banks which can be used by everyone and to measure the output power produced by different types of biomass fuels.Various methods have been taken in conducting the research by referring to previous articles and research to further deepen the knowledge about this project. The results for this project are achieved when the green stove prototype can successfully charge electronic devices and can be monitored and controlled through electronic devices such as mobile phones. Different output power should be successfully produced and measured depending on the type of biomass fuels used during the testing. In conclusion, this research project can be learned and used in various industries or daily life as biomass has a lot of uses and benefits.

ABSTRAK

Biojisim ialah bahan organik yang boleh diperbaharui dan diperoleh daripada tumbuh-tumbuhan dan haiwan. Biojisim ialah sumber bahan api penting di banyak negara, terutamanya untuk memasak dan memanaskan di negara yang kurang membangun. Sebagai kaedah meminimumkan pelepasan karbon dioksida daripada penggunaan bahan api fosil, penggunaan bahan api biojisim untuk pengangkutan dan pengeluaran tenaga semakin berkembang di banyak negara perindustrian. Biojisim menyimpan tenaga kimia yang diperoleh daripada matahari. Fotosintesis menghasilkan biojisim dalam tumbuhan. Pelbagai teknologi boleh menukar biojisim kepada bahan api cecair dan gas yang mampan, atau biojisim boleh dibakar terus untuk haba. Tujuan utama penyelidikan ini adalah untuk melaksanakan penggunaan tenaga biojisim ke dalam bank kuasa mudah alih yang boleh digunakan oleh semua orang dan untuk mengukur kuasa keluaran yang dihasilkan oleh pelbagai jenis bahan api biojisim. Pelbagai kaedah telah diambil dalam menjalankan penyelidikan dengan merujuk kepada artikel dan kajian terdahulu untuk mendalami lagi pengetahuan tentang projek ini. Keputusan untuk projek ini dicapai apabila prototaip dapur hijau berjaya mengecas peranti elektronik dan boleh dipantau dan dikawal melalui peranti elektronik seperti telefon bimbit. Kuasa keluaran yang berbeza harus berjaya dihasilkan dan diukur bergantung pada jenis bahan api biojisim yang digunakan semasa ujian. Kesimpulannya, projek penyelidikan ini boleh dipelajari dan digunakan dalam pelbagai industri atau kehidupan seharian memandangkan biojisim mempunyai banyak kegunaan dan faedah.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my supervisor, Madam Kamilah, and co-supervisor, Madam Amalia, for their invaluable assistance, wise words, and patience during this project.

I am also grateful to Universiti Teknologi Malaysia Melaka (UTeM) and my parents for their unending support, which has enabled me to complete the project. Not to mention my colleagues and dearest buddies for their openness to share their opinions and ideas about the project.

My heartfelt gratitude goes to my parents and family members for their love and prayers throughout my studies. My brother, Luqman, deserves special recognition for providing me with all the drive and in-depth information about excellent thesis writing.

Finally, I'd want to express gratitude to everyone who has helped me out, from the professors I've had from the beginning of the semester to my colleagues, friends, and instructors. I couldn't have completed this task without the help of everyone involved. So, again, I appreciate it.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Renewable energy is a natural-type source of energy that can be used for many times without worrying about it depleting as it can be replenished. For example, various types of energy such as wind and solar have been used for a long time to generate electricity for a lot of purposes.

Malaysia also has renewable energies that can be used such as wind, solar and hydro. Solar energy is one of the biggest technologies that is being developed and used in the renewable energy industry in Malaysia. However, other renewable energy such as biomass can also be used as Malaysia is a country that is rich with plants and organisms.

Biomass energy is one of the renewable energies that is not finite and can be replenished. The energy is produced by living or dead organisms such as plants and animals. The process of producing biomass energy started from the energy provided by the Sun for plants through a process called photosynthesis which will be converted to carbon dioxide and water. After that, the energy from these organisms can be burned to produce electrical energy for various uses.

1.2 Problem Statement

Nowadays, power banks are one of the most important products that are needed by a lot of people because of their portability and their functionality to charge electronic and electrical devices. A lot of people love doing outdoor activities such as hiking and camping for days in jungle or mountain areas. They would bring their own power bank to charge their electronic devices so that they can use them everyday without worrying about the battery running out of power.

However, most power banks cannot last for a long time which can be troublesome for outdoor uses especially for hikers or campers. It is very hard to find a power source to charge the power bank when hikers or campers are in the middle of the jungle. This would also cause many problems especially during an emergency.

Therefore, developing a power bank that can use natural sources such as biomass energy to recharge the battery will definitely help especially for hikers and campers that are having trouble finding a power source.

In order to cope with this problem, this project proposes to create a power bank that can use biomass energy to recharge the power bank with IoT and a newly installed automatic night light sensor that can be used as a flashlight during the night.

1.3 Project Objective

The main goal of this project is to come up with a systematic and effective way to make a power bank that can be used for hiking and camping. Specifically, the goals are as follows:

a. To develop an environment-friendly power bank using biomass.

b. To monitor the power bank using Blynk App.

c. To analyse the performance of each source that can help generate more power and electricity

1.4 Scope of Project

To eliminate any confusion about this project as a result of specific limits and constraints, the project's scope is stated as follows:

a) To develop a smart power bank that can sustain without power source .

b) This project is specifically for the long term outdoor uses such as hiking and camping in the jungle.

c) This power bank has a sensor that can detect if it's nighttime or daytime to light up the lamp automatically.

d) The power bank can be monitored through the Blynk app.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In today's contemporary civilization, renewable energy is the key to sustain many types of uses in urban, sub-urban and rural areas because of its massive and unlimited resources. To give an example, biomass is a very adaptable fuel source that may be converted to electrical, gaseous, and liquid fuels. This topic is significant because biomass energy is important for some countries and the usage of biomass is also increasing. For example, Pakistan typically relies on fossil fuels and a little amount of biomass to meet their energy requirements. To meet its current energy demands, Pakistan desperately need advanced conversion technologies such as combustion, gasification, and pyrolysis. These technologies have been successfully implemented in a variety of nations worldwide [1]. Therefore, this project proposes using biomass energy to be converted into electrical energy to supply power for the power bank.

This chapter is focusing on doing more research related to this project from articles, journals and books. The related and relevant theories, models and results based on previous research will be applied to support the effectiveness of this project.

2.2 Biomass energy production

Biomass comes from a variety of sources, including municipal solid waste (MSW), agricultural crops, crop leftovers, and forest residues. The distinct features of biomass in both proximal and final analyses enable the production of dependable energy supplies. Biomass is a versatile fuel source that provides biofuel, which may also be used in transportation, and bioenergy, which can be used to create cleaner, more economical power worldwide [2].

A biomass power plant, which may offer heat and electricity energy, is the most common approach to generate electrical energy from biomass. The typical technique of producing electricity has an efficiency of 30-55 percent, whereas the Combined Heat and Power (CHP) approach has an efficiency of 80-90 percent. The second rule of thermodynamics governs the operation of a CHP power plant.

Figure 2.1 Biomass cycle

First, high-energy heat is converted into electricity and thermal energy is converted into heat at a lower temperature. Biomass power plants use a comparable Basic Parallel Process (BPP) in which the efficiency of the steam turbine generators is about 25%, and fuel conveyance frameworks and the standard BPP is around 20 MW in an estimate, with a couple of dedicated wood-let go plants in the 40– 50 MW estimate range.

First, the flowing cold water feeds the exchanger tubes in the combustion chamber housing the heat exchanger. Burning biomass produces hot combustion gases, which are used to raise the pressure in the feed water. The produced steam is collected in the high-pressure boiler in the next step, with the ultimate objective of feeding the steam turbine to flow the steam pressure at a correct pressure point. Following that, the high-pressure steam is directed onto the steam turbine's blades, which spin the turbine shaft. Power may be generated by connecting an electric power generator at the end of the compressor shaft. The generated electricity is equivalent to 30 million kWh, which may be used for a variety of applications. The combined steam must be returned to the heat trade. However, before delivering the cooled off water to the heat exchanger, the continuing heat might be linked to local warming. Every year, around 50 million KWh of electricity may be saved by taking this option, as a consequence of expelling this heat into the environment via smokestacks, which helps to minimize energy waste. As a result, deploying a Combined Heat and Power (CHP) plant results in energy cost reserve funds to decrease heat waste and CO2 emissions. [3].

2.2.1 Electricity generation from a biomass cookstove

It takes around 4 hours to generate and provide roughly 10 Wh, which is enough to charge electronic devices. In order to satisfy its daily energy requirements of 5 Wh, this will be sufficient. In many cases, 2.5 W is the amount of electricity needed to charge a device. It was found to be adequate for field testing when it came to DC charging of low-powered electronics [4].

2.2.2 Coal and biomass for environment-friendly electricity generation

Gasification is the first step in the CBECCS process, which transforms the solid coal and biomass feedstocks into syngas, a gaseous fuel mostly consisting of H_2, CO, and CO_2. It is our goal to develop a high temperature (1,300–1,500 °C) entrained-flow gasifier (EF) that can gasify the whole coal and biomass feedstock (more than 99.5 percent). It is more tolerant of feedstock variability because of the gasification process's ability to reduce tar. In addition, gasification reduces air pollution significantly compared to direct combustion of these fuels. While the process partially oxidises the solid-fuel feedstock, it also serves to make up for the energy lost during the gasifier's endothermic operations [5].

2.2.3 Types of Biomass Fuels

Biomass may be derived from natural and organic sources such as animals and plants. It may also be generated by industrial operations, municipal waste, or land clearing activities. Heat, electricity, and fuel may all be produced as end products. The terms "pellets," "wood chips," and "cellulosic ethanol" all refer to forms of biomass energy that are rather widespread [6].

2.2.3.1 Non-woody biomass

Because non-woody biomass contains less lignin than woody biomass, it is often classified as trash. This biomass may be obtained via a wide range of agricultural practises, as well as the waste products of animals and herbaceous plants. Examples of non-woody biomass originating from agricultural processing industries include cotton gin trash (also known as CGT), palm oil waste, animal waste, and sugarcane bagasse. Paddy husks, straw, grass, crop stubble, and rubbish are all common agricultural field wastes. A typical hectare of cotton in Australia generates 1.6 tonnes of lint and 2.5 tonnes of seed each year, making non-woody agricultural waste abundant, accessible, and affordable. Approximately 2 tonnes of straw and 0.4 tonnes of cotton gin waste will be created simultaneously. In addition to the 25 million metric tonnes of wheat and 8 million metric tonnes of barley produced each year, Australia also generates large amounts of non-woody biomass in the form of straw and chaff. Wheat and barley have typical straw to grain ratios of 1:1 and 0.7:1. Solid fuels have a larger carbon content, which results in a higher energy content. Non-woody biomass with higher moisture and ash content, on the other hand, would have lower energy content. However, gasification is not only influenced by carbon. During the gasification process, moisture and oxidants that are rich in hydrogen and oxygen often react to generate hydrogen, methane, and carbon monoxide gas components. Additionally, non-woody biomasses often have low densities, especially those derived from grasses or herbaceous plants. This might create issues during gasification, especially when it comes to controlling the fuel flow rate [7].

2.2.3.2 Thermochemical conversion

For woody biomass conversion, there are a variety of methods available, most of which may be divided into thermochemical and biochemical processes. Thermochemical processes include combustion, pyrolysis, gasification, and thermal liquefaction, whereas biochemical processes include digestion and fermentation. This study will highlight current research and development developments in thermochemical conversion systems for the generation of energy, fuels, and chemicals from woody biomass. The combustion process generates heat from the biomass through oxidation combustion reactions. Aside from pyrolysis and gasification (which have been commercialised), this research will focus on thermal liquefaction and liquefied natural gas (LNG). Most biomass comes from plant stems, and their shapes and contents are rather predictable. Structurally supporting the plant, the stems also serve as conduits for nutrients (sugars and derivatives) needed for stem development and water and minerals from the ground to the leaves for photosynthesis, as well as for stem growth. Throughout millions of years of evolution, plant stems have perfected their physical shapes and chemical compositions to do both of these roles [8].

2.2.3.2.1 Biomass Fast Pyrolysis

As a consequence of the thermochemical breakdown process of biomass pyrolysis, which happens in the absence of oxygen, liquid, solid, and gas are all formed. Depending on the kind of biomass utilised, as well as operating temperature, heating rate, and residence time, the percentages of these products will change. Temperatures between 400°C to 650°C are required for the liquid target product, which necessitates swift heating and rapid cooling. Biomass pyrolysis has been the subject of several reviews; this one will focus on the end product of bio-oil and new developments to raise the quality of bio-oil [9].

2.2.3.2.2 Catalytic pyrolysis

The potential for catalytic pyrolysis to increase the quality of bio-oil has also attracted great interest. It is possible to improve pyrolysis vapours in-situ or ex-situ using catalytic pyrolysis, which eliminates the need for hydrogen [10].

2.2.3.2.3 Thermal Liquefaction

Rapid pyrolysis and liquidification of biomass both aim to produce liquid as a byproduct of the process. But in most cases, biomass liquefaction happens in a liquid medium and at high pressures. Liquidification and pyrolysis are two different processes that can process biomass with high moisture content, but only pyrolysis can produce bio-oil that has less than 10% water. It is possible to liquefy biomass via hydrothermal liquefaction, solvent-based liquefaction, or a combination of both. The liquefied liquid product has a lower oxygen and water content, making it easier to process. Because it requires high pressures and the use of solvents and catalysts, liquefaction is a more complex process [11].

2.2.3.2.4 Hydrothermal liquefaction

Between 200 and 400 degrees Celsius, the hydrothermal liquefaction (HTL) process takes place, with pressures ranging from 5 to 25 megapascals (MPa) [12]. In the HTL process, water is often used as a working medium to enhance heat transfer and biomass degradation. The HTL process may be carried out at either a subcritical (250 degrees Celsius and 5 MPa) or a supercritical temperature and pressure since water has a critical temperature and pressure of 373 degrees Celsius and 22.1 MPa, respectively (400 degrees Celsius and 25 MPa).

2.2.3.2.5 Gasification For Woody Biomass

It is also possible to make producer gas or product gas via the thermochemical conversion of biomass, which primarily yields CO, H2, CO2, and CH4 as well as other hydrocarbon species. Temperatures in the 700-1200 degree Celsius range are required for gasification. Gasification agents such as O2, air, steam, and CO2 or their mixtures are used in the biomass gasification process. It is possible to generate heat for later endothermic processes by using oxygen or air as a gasifier. It's necessary to supply heat to the gasification reactor when steam is used as the gasification agent. In addition to fixed bed gasifiers (updraft and downdraft), there are fluidized bed gasifiers (bubbling and circulation) and entrained flow gasifiers. There have been recent developments in biomass gasification that aim to reduce the quantity of tar in the producer gas, boost its hydrogen content, and enhance its energy efficiency [13].

2.2.3.2.6 Municipal Solid Waste (MSW)

Garbage to fuel facilities produce fuels from the energy-dense elements present in home and industrial waste. It's a word used to describe a collection of municipal and industrial wastes that are produced mostly from suburban, commercial, and industrial sources. Solid waste, food waste, shrubs and paper products, plastics, latex, textiles and firewood are all part of the rubbish collection. The proportion of such components will vary across sites and within a single location. There are many factors that contribute to the development of the waste stream, such as changes in lifestyles and laws, periodic causes, preparation and reprocessing activities, and rubbish composition varies by district in various areas of the world. In impoverished countries, leftovers often include a greater proportion of decomposable material than plastics. However, countries such as Germany have well-developed plans for reprocessing and repurposing trash that are constituted of non-biodegradable compounds and have a more consistent and reliable categorization. There are several ways for managing solid waste in a helpful and environmentally sustainable manner, including hydrothermal liquefaction, pyrolysis, and gasification. Over the last two decades, reusing has been the dominant strategy for recovering resources and minimising garbage, although further study is required in this area. The primary objective is to directly generate heat and power via a range of biological or thermal progressions. Fuel created from waste may have a lower carbon impact than fossil fuels [14].

2.3 Power Banks

Electronics are used to control the amount of electricity going and coming out of a power bank. To charge battery-powered devices like mobile phones and other gadgets, these devices may be recharged using a USB charger.

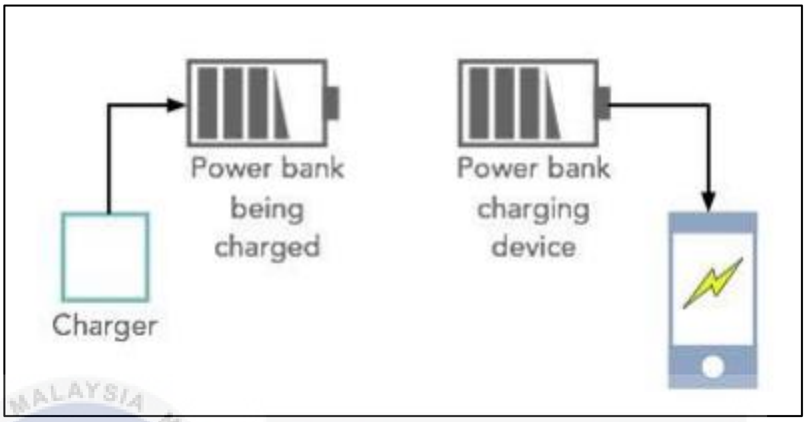


Figure 2.2 Power Bank Operation

"Power bank" is a word used to describe a financial institution that allows customers to deposit, store, and take money as needed. Even while these devices may power things like mobile phones without the need for a mains connection, they still need charging, which is normally done via a mains charger.

2.3.1 Batteries

One or more cells make up a battery, and their chemical reactions generate an electric current in a circuit. When it comes to batteries, there are three main components: the electrolyte, a cathode (the '+' side), and an anode (the '-' side) (a substance that chemically reacts with the anode and cathode).

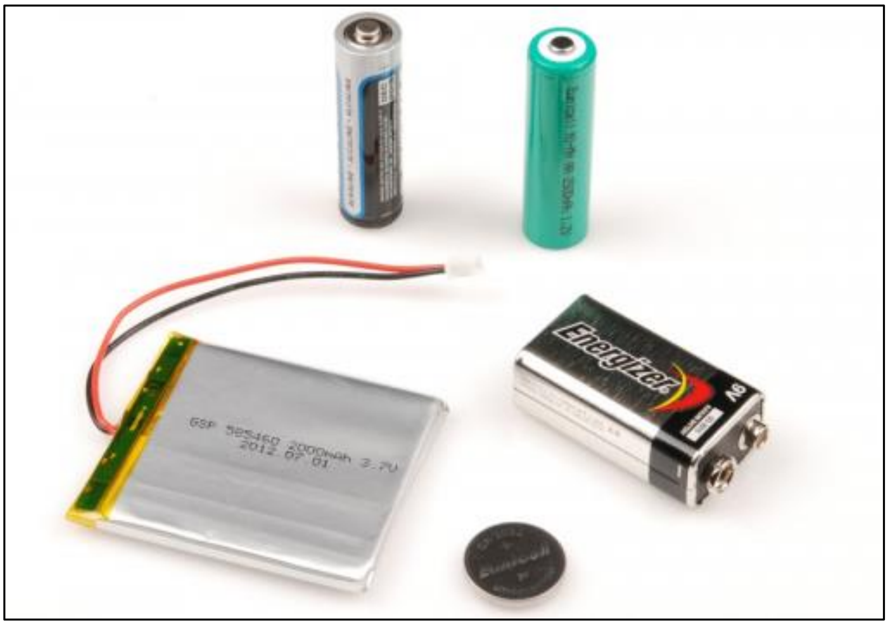


Figure 2.3 Different types and shapes of batteries

Anode and electrolyte reactions occur when a battery's anode and cathode are connected in series. The movement of electrons through the circuit and back into the cathode is the outcome of this chemical process, which causes another chemical reaction. It is no longer possible for a battery to produce electricity if the cathode or anode material has been depleted or is no longer functional. The battery is deemed "dead" at this point.

2.3.2 Types of batteries

When a primary battery is used, it may be thrown away. Batteries that may be recharged several times are known as secondary batteries.

2.3.2.1 Primary batteries

It is not possible to replenish primary batteries. Most people use the dry cell as their primary battery. Zinc and carbon make up the dry cell, a lithium-ion battery. Zinc may be used as both a container and a negative electrode in the same device. An ammonium chloride, manganese(IV) oxide, zinc chloride, carbon powder, and a minuscule amount of water make up the paste that coats the positive electrode.

2.3.2.2 Secondary batteries

Secondary batteries are supplies that may be recharged. In smartphones and electronic tablets, these batteries are often found. One of the three electrodes in a NiCd battery is potassium hydroxide; the other two electrodes are nickel-plated cathodes. The positive and negative plates are rolled together and put in the case, with the separator preventing shorting. "Jelly roll" arrangement allows the NiCd cell to deliver significantly more current than an alkaline battery of the same capacity.

2.3.2.3 Difference between primary and secondary batteries

Primary cells cannot be used multiple times, but secondary cells must be replenished when the charge runs out. Both forms of batteries are widely employed in a variety of gadgets, and these cells vary in size and material composition.

Table 2.1 Difference between primary and secondary batteries

Primary cell	Secondary cell
They have a high density of energy.	They have a reduced energy density.
They are referred as dry cells because the cells contain no fluid.	Molten salt cells, flooded cells, and liquid cells are all varieties of wet cells (liquid cells with different composition)
Its internal resistance is rather substantial.	It has a low coefficient of internal resistance.
It is a chemical compound that undergoes an irreversible chemical reaction.	It undergoes a chemical process that is reversible.

Its design is more compact and lightweight.	Its design is more intricate and substantial.
It has small initial cost.	Its initial investment is substantial.

2.3.2.4 Lithium-Ion

Sony commercialised the Li-ion battery in the early 1990s. Li-ions are added and removed from the negative and positive electrodes, respectively, during charging. Additionally, when charging, Li + is deintercalated from the cathode oxide complex and incorporated into the anode's lattice. Cathodes have a high potential but a low Li state, while anodes have a low potential but a high Li state. During discharge, the procedure is reversed. In comparison to other kinds of batteries, Li-ion batteries have a high energy density (due to the high output voltage), great efficiency, a long cycle life, and are environmentally friendly. These desirable characteristics have resulted in Li-ion batteries being prevalent in portable gadgets such as smartphones and power banks [15].

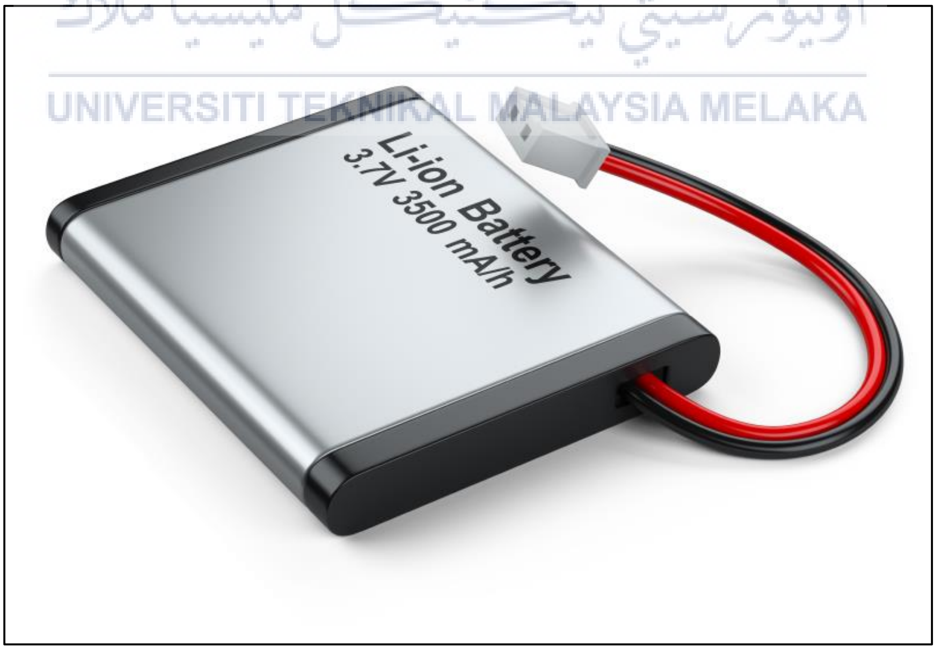


Figure 2.4 Example of a lithium-ion battery

2.3.2.5 Lithium-Ion Polymer

Lithium-ion polymer batteries do not use a liquid electrolyte, but rather a semisolid polymer electrolyte with excellent conductivity (gel). The electrode materials' chemical composition determines the battery cell's voltage. Lithium–metal–oxide (LiCoO2) cells have a completely discharged voltage of 2.5–2.8 V and a fully charged voltage of 4.2 V, while lithium–iron–phosphate (LiFePO4) cells have a fully drained voltage of 1.8–2.0 V and a fully charged voltage of 3.6–3.8 V. Lithium polymer batteries have a greater specific energy than lithium-ion batteries. The polymer electrolyte provides a more stable performance for the lithium polymer battery when subjected to vibration. These two characteristics have aided in the development of lithium polymer batteries for use in electric vehicle applications [16].

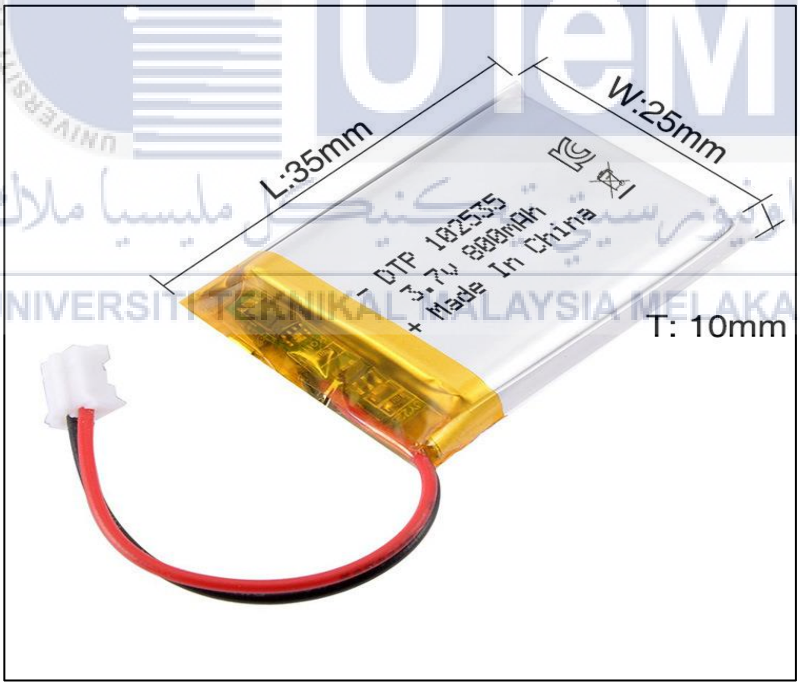


Figure 2.5 Lithium-Ion Polymer

2.3.2.6 Nickel-Cadmium

The nickel–cadmium battery was invented in Sweden in 1899 by Waldemar Jungner. Neumann invented the first sealed version in 1947, paving the way for current nickel–cadmium batteries. High cycle life, increased energy density, low internal resistance, high power density, outstanding performance at low temperatures, extended shelf life, and quick recharging are all advantages of nickel–cadmium batteries. In contrast, the energy density of nickel–cadmium batteries is lower than that of nickel–metal hydride batteries and lithium–ion batteries. Known as the "memory effect," nickel–cadmium batteries need repeated full discharges because of this. Because of the toxicity of cadmium, nickel–cadmium batteries are seen as both environmentally harmful and problematic. The use of nickel–cadmium batteries has so been restricted in EU member states lately. Aside from its high self-discharge rate, nickel–cadmium batteries have a poor performance at high temperatures, and a difficult charging procedure [17].

Figure 2.6 Nickel-Cadmium Battery

2.4 Thermoelectric Generator (TEG)

Increasing attention has been paid to thermoelectric generator (TEG) systems in the waste heat recovery industry because of their unmatched advantages: TEGs enable the generation of electricity from heat energy without the use of moving parts such as turbines, which eliminates additional maintenance and replacement expenses. TEGs have no economy-of-scale impact and may be utilized to produce microwatts in confined spaces or kilowatts. TEGs' quiet functioning makes them environmentally favorable as well. However, the energy conversion efficiency of TEGs is subpar, and they need a constant heat source. TEGs may be used for a variety of purposes, including the recovery of waste heat and the creation of solar energy. Kraemer et al. describe experimental observations of solar thermoelectric generators with a peak efficiency of 9.6% and a system efficiency of 7.4% [18].

2.4.1 How thermoelectric generator works

TEGs are based on the idea of seamless conversion of electric potential and heat. According to the Seebeck effect, if two junctions are made of dissimilar metals, an electric potential may be created between them. An electric potential is applied between two distinct metals in order to alter the temperature between their junctions, and this is known as the Peltier effect, which is the inverse of the Seebeck effect. In power generating mode, TEGs use the Seebeck effect, whereas in thermal management mode, they utilize the Peltier effect. TEGs' flexibility to be tailored for specific purposes, such as temperature control, makes them a popular choice. In a TEG, there are several thermocouples constructed of n- and p-type semiconductor materials that are electrically and thermally linked in series and in parallel. There are normally heat sinks on both sides of a thermoelectric module (TEM), as well as an interface and insulating layers to prevent heat transmission from the hot side of the module to the cool one [19].

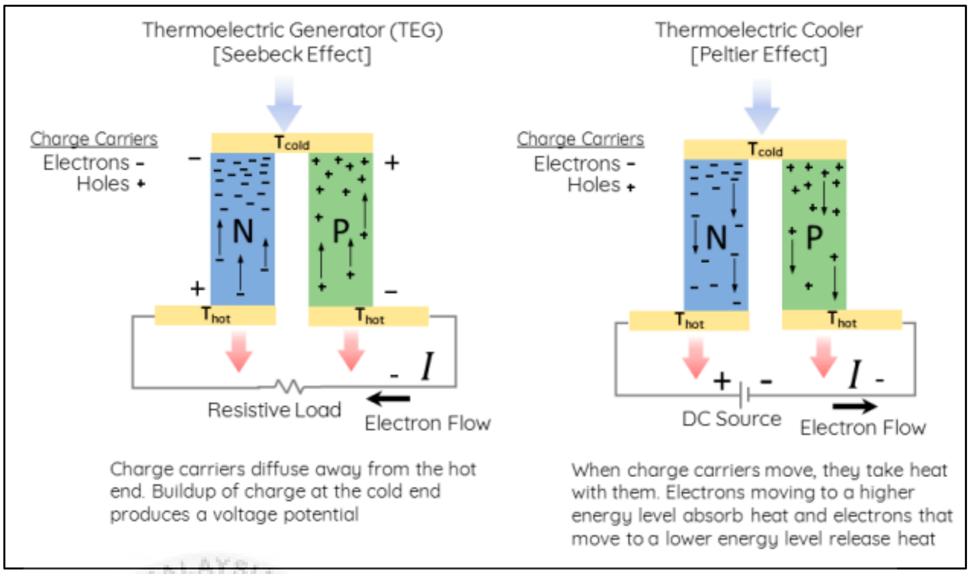


Figure 2.7 Working principle of TEG and TEC

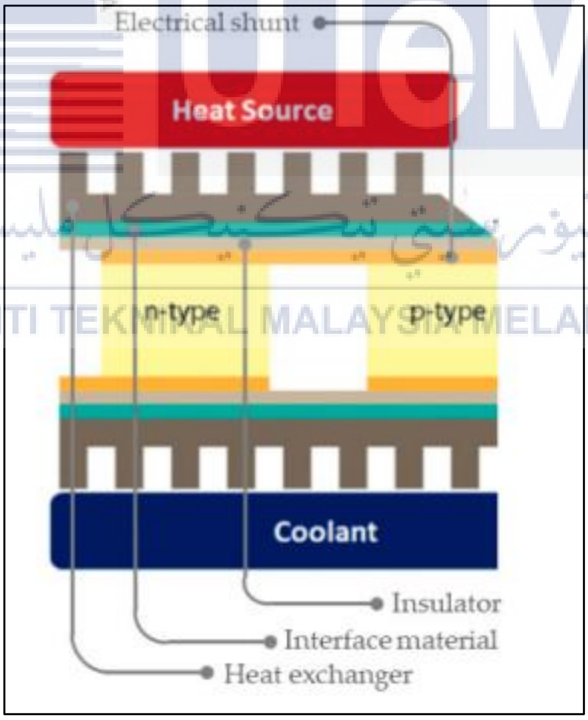


Figure 2.8 Components of thermoelectric generator

2.5 Charge controller

Charge controllers are essential in BIPV systems because they manage the current flow from and to the batteries, protecting the batteries from overcharging and over discharging. In BIPV systems, they may also protect the appliances that are connected to the batteries. Using controllers in BIPV systems may improve the battery's life greatly due to the inability of most batteries to recover from overcharging or over discharging.

2.5.1 Types of charge controllers

In terms of setup, charge controllers may be divided into three types: Shunt, Single-Stage, and Multi-Stage.

2.5.1.1 Shunt controllers

Shunt controllers monitor the maximum point of battery charge. Once the batteries are completely charged, they are separated from the PV arrays by the shunt controller, and the extra power is transformed into heat, and then the heat is dissipated via the heat sinks of the shunt controllers. Through these laws, the overcharging may be avoided for batteries. For shunt controllers, enough ventilation is important for heat dissipation.

2.5.1.2 Single-stage controllers

Once the batteries are completely charged in BIPV systems controlled by single-stage controllers, the charging circle is turned off to preserve the batteries. The charge termination point in the control strategy is decided to be the battery's full state of charge, whereas the charge beginning point is predetermined to be the battery's minimal state of charge. When the battery is completely discharged, the single-stage controller reconnects the charging circle to permit charging. In BIPV systems managed by this sort of controller, minimal power is converted to heat, which eliminates the need for ventilation.

2.5.1.3 Multistage controllers

When the batteries are in a low power condition, current flow for battery charging is allowed in BIPV systems with multistage controllers. When batteries near full charge, excess electricity generated by photovoltaic panels may be dissipated. Similar to shunt controllers, multistage controllers may also extend the life of batteries. Additionally, this control system needs enough ventilation since heat is generated during power dissipation.

2.5.1.4 Pulse-width Modulation (PWM)

Charge controllers that operate in the on/off mode directly use the charge current generated by the energy source. Several experiments are being conducted, again on lead–acid batteries, on various methods for modulating the current by modifying its period. This technique, dubbed pulse-width modulation (PWM), seems to reduce gas and water usage while increasing charging efficiency. Studies are being conducted to optimize the settings of this technology and to better understand the physicochemical processes that result in an increase in battery life when PWM management is used.

2.5.1.5 Maximum Power Point Tracking (MPPT)

MPPT controllers have been critical in tracing the PPP and increasing the efficiency of photovoltaic installations. In 1968, the first photovoltaic system incorporating MPPT was developed for use in a space system. Following then, MPPT controllers improved significantly in terms of reliability, precision, tracking speed, efficiency, and simplicity. The ideal MPPT algorithm is often quick, has little oscillation around the PPP, and can keep up with rapid changes in output power. There are several MPPT control strategies that have been implemented to date. These controllers are used to monitor the maximum power point under uniform irradiation for a single MPP or to track a photovoltaic system with numerous maximum power points (MMPP). The environment has a considerable effect on the output of the photovoltaic system. As a result, the production yield varies dynamically. Solar panels cannot provide their full power output without the usage of an MPPT controller. Nowadays, every photovoltaic system installed has an MPPT controller. The primary objective of MPP trackers is to ensure that the MPP is located quickly, with little convergence time, minimal oscillation, and high precision, in order to improve energy production [20].

Figure 2.9 Example of an MPPT

2.6 Internet of Things (IoT)

Because of the rapid spread of smart devices and high-speed networks in recent years, the Internet of Things (IoT) has become widely acknowledged and popular as the leading standard for low-power lossy networks (LLNs) with limited resources. Networks in which "things" or embedded devices with sensors are connected to each other through private or public networks are examples of this kind of network. It is possible to remotely control Internet of Things (IoT) devices in order to get the desired outcome. The information exchange among the devices is then accomplished via the network, which makes use of the industry-standard communication protocols to do this. The smart linked gadgets, often known as "things," vary from modest wearable items to massive equipment, and each is equipped with sensor chips to communicate with one another. Lenovo's smart shoes, for example, have chips that enable for real-time data collecting and processing. Additionally, appliances like washing machines and refrigerators may be remotely controlled through the Internet of Things. The internet allows anybody in the world to see the surveillance cameras that have been set up to keep an eye on a certain location [21].

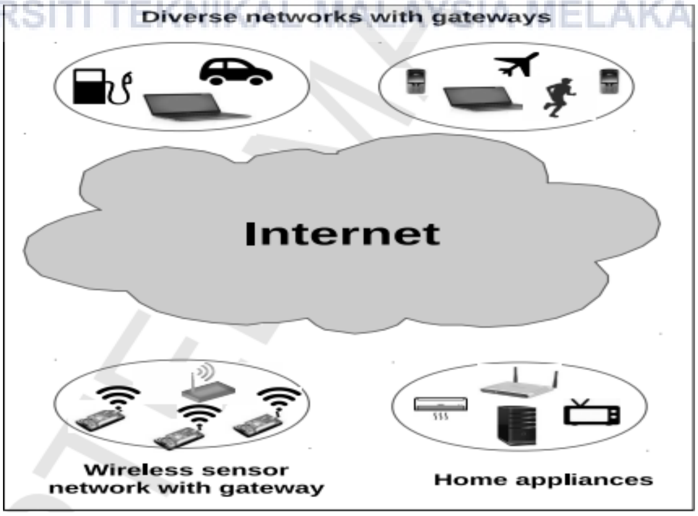


Figure 2.10 Diagram of IoT elements

2.6.1 Blynk Application

Blynk is a platform for the internet of things that enables remote control of electrical equipment through its iOS and Android mobile applications. It has a dashboard via which the user may design a graphical user interface by using various widgets. Additionally, Blynk is capable of storing and visualising sensor data. Blynk includes libraries for the majority of popular hardware platforms, including Arduino, ESP8266, Raspberry Pi, and SparkFun, among others. The three most critical components of Blynk are the App, the Server, and the Libraries. Apps may assist in the interface design process. The server is in charge of all communication between the app and the hardwires. Additionally, libraries allow hardware to communicate with the server through commands [22].

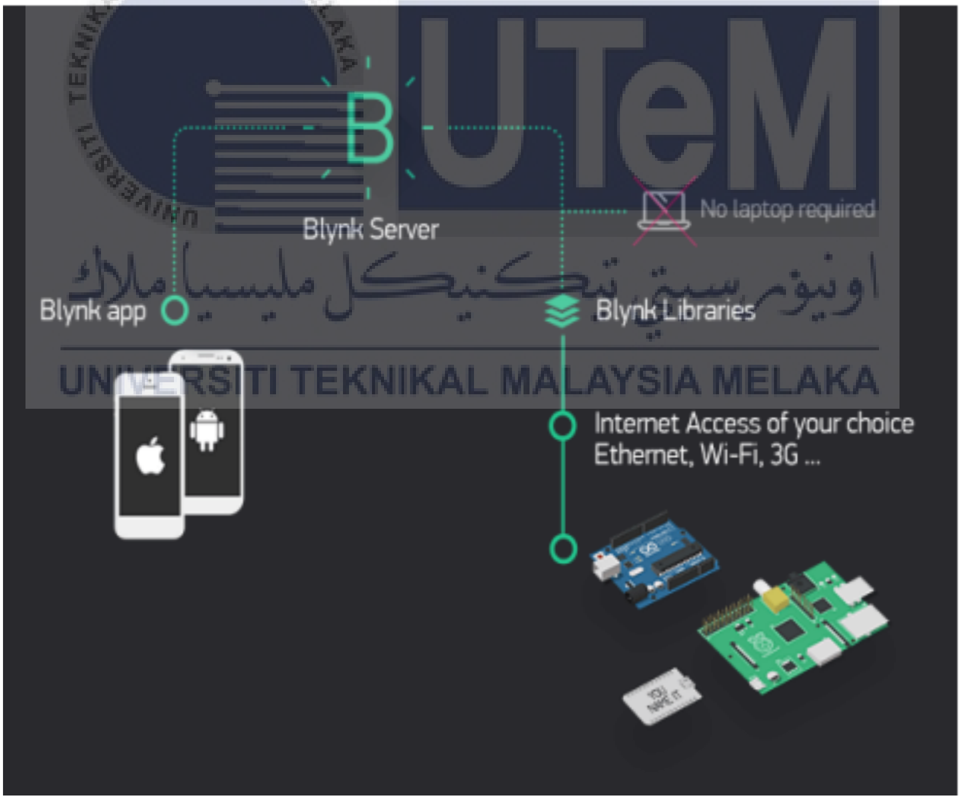


Figure 2.11 Blynk App working diagram

2.6.1.1 Smart Automated Home Application using IoT with Blynk App

The Node MCU ESP8266 controller chip is used to link the relay module system to the home appliances to be controlled and to each other through Wi-Fi. The Blynk app for iOS was customised with a new layout and buttons to make it easier to monitor and manage many paired devices.

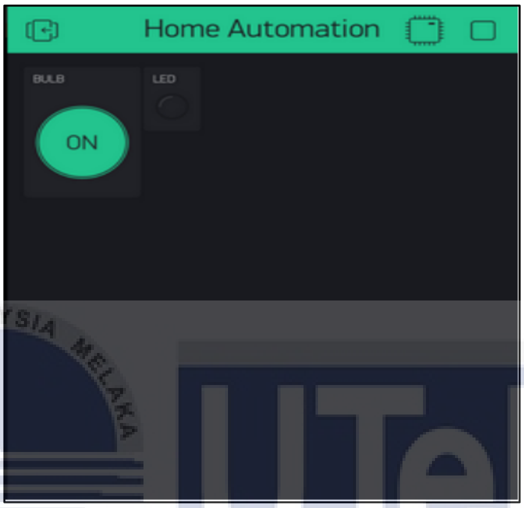


Figure 2.12 Appliance switch on Blynk App

The smart phone may be used to control the home appliances from afar. A big advantage of this programme is that it may be used by all members of a single household. All members of a shared app may see when an appliance is turned on or off by a single user. Aside from GPS location and distance measurements, the app may also be used to gather real-time and historical data on variables such as temperature, relative humidity, and GPS position. As an added bonus, this system may be used in a wide range of settings, including financial institutions, health care facilities, research facilities, traffic control stations, dwellings for people to live in, public roadways, poultry farms, and even greenhouses. To sum it up, this technique may be used to a wide range of industries and areas in order to improve efficiency [23].

2.6.2 Thingspeak

By sharing data, an IoT system enables the simple yet powerful capacity of working with a variety of devices and applications. IoT services are in charge of disseminating messages to the platform's customers. ThingSpeak is an Internet of Things (IoT) platform for collecting and storing sensor data in the cloud, as well as developing IoT applications. The ThingSpeak IoT platform includes programmes that enable you to analyse and display data in MATLAB and then take action on it. Sensor data may be transferred to ThingSpeak through the ESP8266 Wi-Fi module on the NodeMCU [24].

2.6.3 Arduino Uno

The ATMega 328 microcontroller powers Arduino Uno, a single-board computer. All of this microcontroller's digital I/O (six of which may be used for PWM output), six analogue inputs, a crystal oscillator, a USB connection, a power connector, an ICSP header, and a reset button are included in one single board. Using a USB-to-serial adapter, this microcontroller is able to communicate with a computer through the USB port [25].

Figure 2.13 Arduino Uno

2.6.4 Arduino Mega

Modular hardware and software combine to build Arduino's open-source electronics prototyping platform. It's intended towards designers, artists, hobbyists, and anybody else interested in creating interactive objects or environments. Atmel's ATmega2560 SMD chip powers the Arduino Mega 2560 R3, a successor to the original Arduino Mega. SDA and SCL pins are also included on the Mega 2560 R3, which are located adjacent to the AREF pin. Near the RESET pin, two more pins have been added. In particular, the IOREF allows shields to adapt to the voltage provided by the motherboard. An irrelevant item has been put away for future reference. All existing shields can be used with Mega 2560 R3, however new shields that need more pins may be accommodated [26].

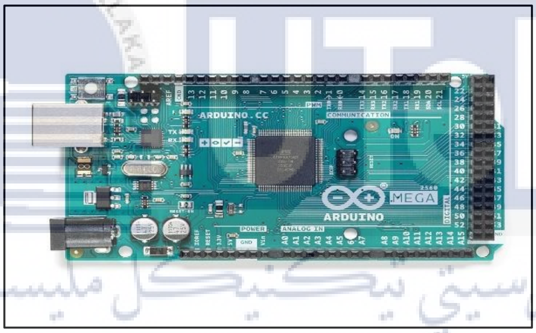


Figure 2.14 Arduino Mega

2.6.5 Raspberry Pi

Credit card sized single board computer (SBC), the Raspberry Pi is both powerful and inexpensive. At about USD35, the Raspberry Pi 3B + includes a quad-core processor that runs at 1.4 GHz (CPU). With the availability of additional SBCs, they are emerging as a disruptive technology with increasing relevance for a variety of applications, particularly in the Internet of Things. SBCs can be programmed using free, open-source software, and the 40-pin GPIO interface can be used to interact with other devices. The small, flexible, low-cost, and mobile nature of SBC-based systems makes them ideal for use in point-of-care and point-of-need applications. A Raspberry Pi-based instrument was used to electrochemically quantify C-reactive protein with a limit of detection (LOD) of 58%, while the same instrument was used by Lin et al. to detect Salmonella with a LOD of 14 CFU/mL 1 using colorimetric analysis with a microfluidic biosensor and a Raspberry Pi [27].

2.6.6 Light sensor

Using a basic electrical circuit, such as a light sensor, you may automate the control of many types of electrical load appliances. By using this light sensor circuit, we can prevent the need to manually switch the loads, as the quantity of sunlight can be regulated automatically. Thus, it may be regarded as an automatic light detector.

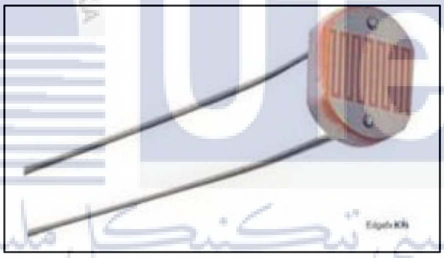


Figure 2.15 Example of a light sensor

2.6.6.1 Design of Automatic Intensity Varying Smart Street Lighting System

A Light Sensor (LDR) was used to control the streetlight's automated ON and OFF. Its resistance varies according on the strength of the light striking it. The light dimmer has been programmed for the LDR ranges. As night falls, the LDR values begin to fall within the range, and the streetlight turns ON based on the intensity of the light shining on the LDR. Current is measured using the current sensor. The LDR transmits the appropriate value to the microcontroller when the sun sets. The microprocessor delivers it to the dimmer, which changes the intensity of the LED based on the signal received. The luminaire utilised is 100

W and has a lumens per watt efficiency of 100. When the luminary is completely black and glowing at its maximum intensity, its effectiveness is 100 lumens per watt. At dawn, the efficiency drops to 80 lumens per watt. The automated intensity changing streetlight prototype has been successfully developed. Different levels offer varying degrees of illumination to the streetlight, so conserving energy. The data acquired from the current sensor enables us to determine the energy saved as a result of the light's fluctuating intensity. This also minimises the need for human involvement [28].

2.7 Summary

In summary, this chapter demonstrates an in-depth comprehension of the variables involved in the current study. The concept of biomass as a renewable energy source and how it can be integrated into this project has been elaborated based on the articles and the previous research that has been made. The previous journals, articles and research were also presented in this chapter in the expectation that it will provide sufficient information regarding this project.

CHAPTER 3

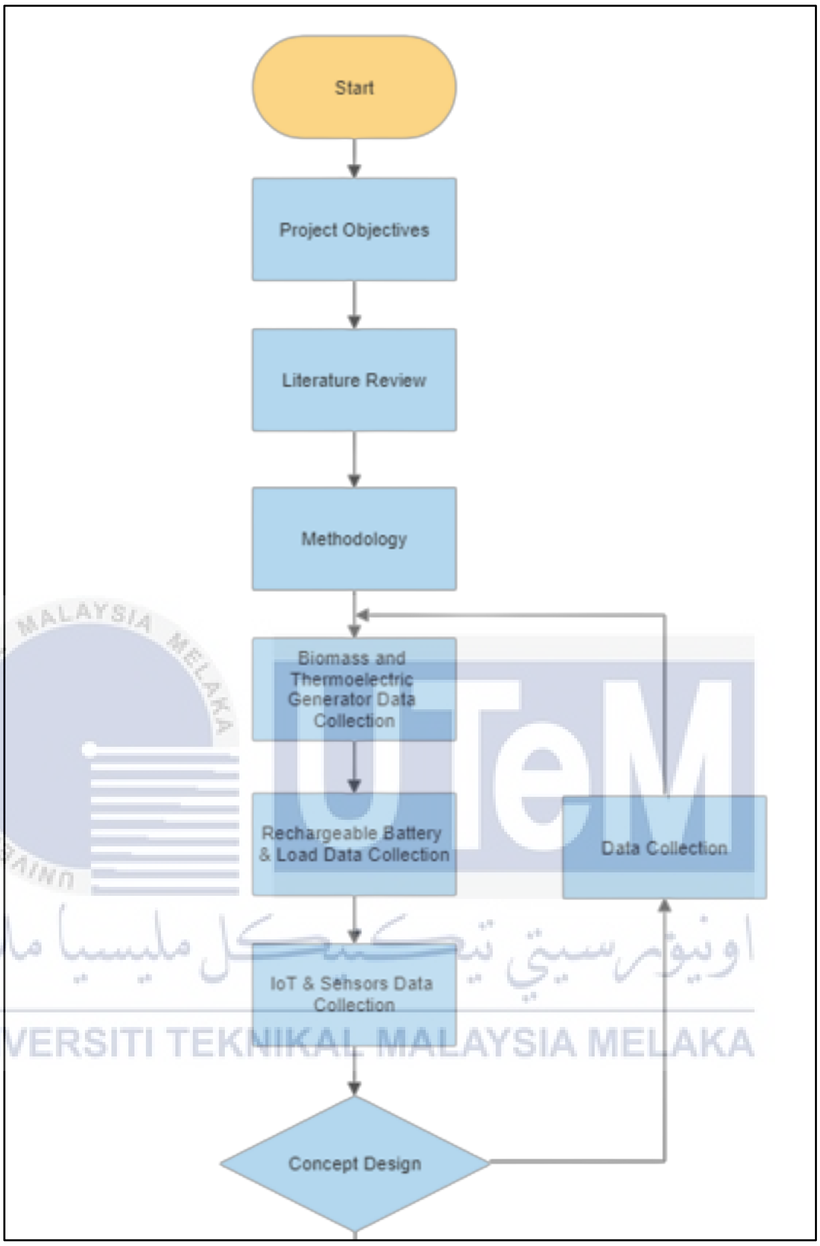
METHODOLOGY

3.1 Introduction

This chapter is important since it details the flow of work on this project. The methodology will serve as a guideline, outlining each stage and flow according to the flow chart planning, including data analysis, in order to support the project's goals while attaining the anticipated outcomes and certifying that the project is effectively and realistically completed.

This endeavour is broken down into four phases. The first stage is preparatory work, during which technical examination is undertaken with direction from a variety of sources, including journals, project papers, and earlier research. Stage two is the execution of stage one, which included data analysis and idea design. Stage three is the operationalization of stage two. This is the location for hardware design and assembly. Stage four will focus on the interface of each component of the project, as well as troubleshooting any current difficulties.

3.2 Methodology



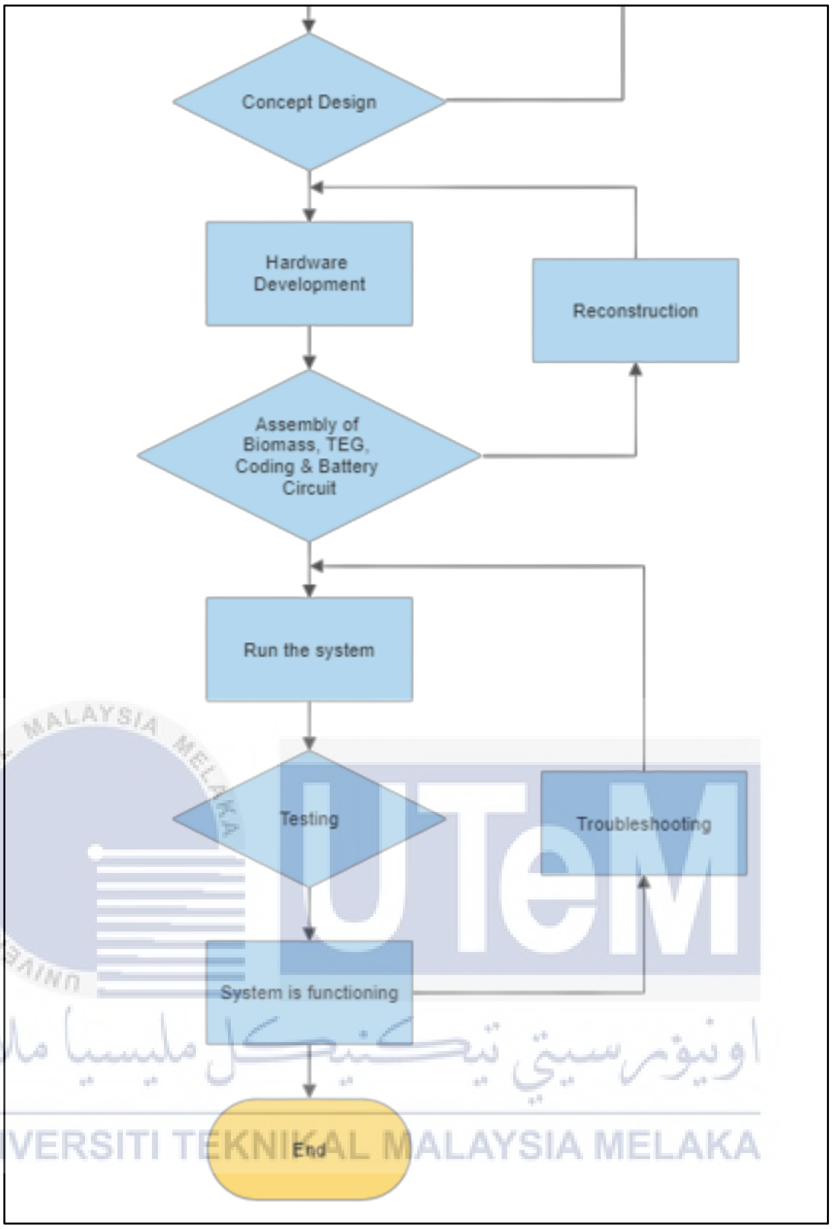


Figure 3.1 Complete flowchart of this project

The flowchart above was constructed using a web-based flowchart maker. The flowchart also shows the overall steps and procedures in developing the prototype of the "Green Stove Portable Biomass Power Solution Based on IoT".

This project's initial stage is to do thorough research into relevant sources such as prior publications, journals, and previous studies. After then, the project's issue statement is nailed down.

The next phase is to gather all the data from the key components, which include biomass, thermoelectric generator, rechargeable battery, sensors, and load. To power the rechargeable battery, a thermoelectric generator module and biomass are both used. To accomplish this step, the two conceptual designs must be compatible with one other.

After the system is completed, the next stage is to create and construct the hardware. To complete the project, the body of the project must be created and implemented. If necessary, a number of examinations and reconstructions should be carried out in order to reach the desired outcome.

Lastly, the system must be tested multiple times to make sure it is functioning properly. Troubleshooting is also required if the system encounters any problem and does not give the desired result.

3.3 System Structure

The goal of this project is to build a thermoelectric generator-powered biomass cook burner that may be used when camping or hiking in the woods, for example. The biomass combustion chamber, the thermoelectric module, the Internet of Things, and the rechargeable battery make up this system's four major components. The biomass chamber in this system burns wood to provide the electricity needed by the system. All electronic devices will be charged using the electricity.

Concurrently, the excess energy will be stored in the battery. The presence of this battery will make this system trustworthy since users will no longer need firewood whenever their electronic gadgets need charging. This technology will make it possible for electrical gadgets to be used everywhere and at any time without worrying about running out of power.

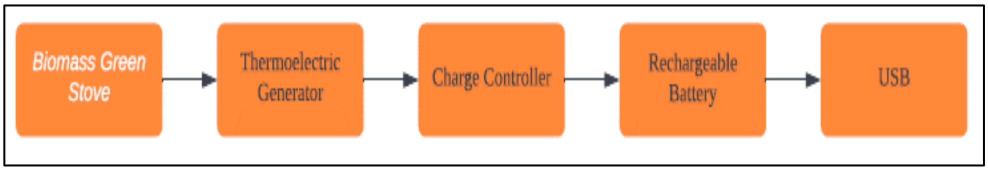


Figure 3.2 The process of Biomass Green Stove

The graphic above depicts the project's system block diagram. The system will be fueled by a variety of biomass fuels. The difference between the sources will be the primary controller of this system since it will determine the output voltage. The output power will be sent to a rechargeable battery to assist in its recharging. Then, two Universal Serial Bus (USB) connections will be made to the battery, allowing electrical devices to be charged.

3.4 Equipment and Materials

Biomass fuels, a thermoelectric generator module, a charge controller, a rechargeable battery, a light sensor, an Arduino Uno, and a USB port will be used in this project.

3.4.1 Biomass

According to recent reports, biomass is the most common modern renewable energy source. Many different forms of energy may be generated from organic material derived from animals and plants. This project will make use of combustion as the method. Due to the project's intended audience of hikers and campers, this approach was chosen. Fire may be regarded as matter since it comprises of space and mass. The mass of fire is related to the mixing of gases in it. Therefore, the heat and light created by the flame is energy.

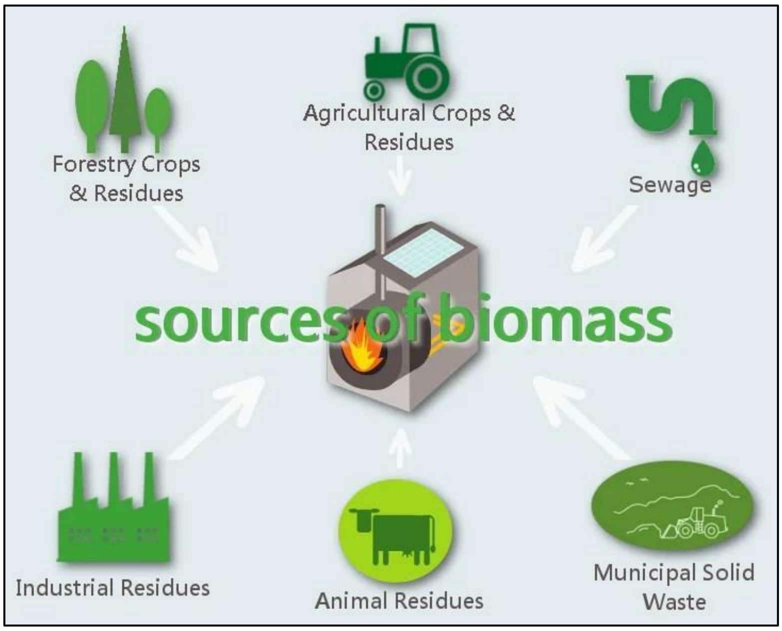


Figure 3.3 Example for sources of biomass

3.4.2 Thermoelectric Generator Module

Regarding this project, a 40mm x 40mm TEG was used. This little component is very dependable and requires no maintenance. Again, based on the constraints of the project, a modest TEG is used. This is done so that users can easily carry the stove in their luggage, and it is very lightweight.

Figure 3.4 Thermoelectric Generator Module

Biomass will be burned on the generator's hot side, and heat will be discharged via a heat sink on the cold side. Heat sink will be 40mm x 40mm and cover all ceramic surfaces of generator, therefore it'll be a perfect fit. So, more heat may be released to generate higher temperature differences.

3.4.3 Charge Controller

The charge controller in this project is a two-stage design that uses transistors to set the upper and lower output limits. Due of this circuit's simple calibration and components, it was chosen.

3.4.3.1 Relay

In this project, the application is switched between two circuits using a high-power relay. It has five terminals, two coils, a generally open terminal, a normally closed terminal, and a common terminal. Depending on which terminal the voltage is supplied, only one may be triggered at once.

Figure 3.5 Relay SLA-05VDC-SL-A

3.4.3.2 Seven-Segment Display

Decimal numbers may be shown using a seven-segment indication. Electrical devices and digital clocks often use this component. Segment displays often make use of LCDs and LEDs as their primary display technologies.

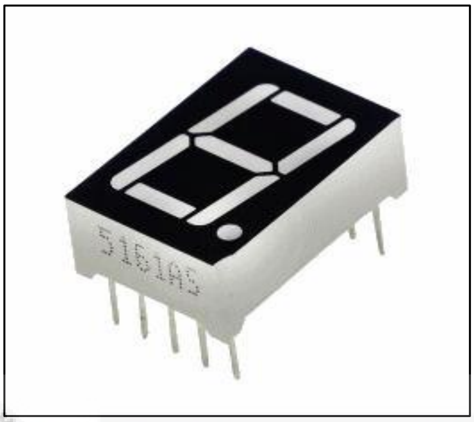


Figure 3.6 Example of a 7-Segment Display

3.4.3.3 Capacitors

A capacitor is the name given to this kind of two-terminal passive component. It's used to store electrical energy in a magnetic field for later use. In electrical terms, the effect of this component is known as its capacitance. The Farad is the standard unit of measurement (F).

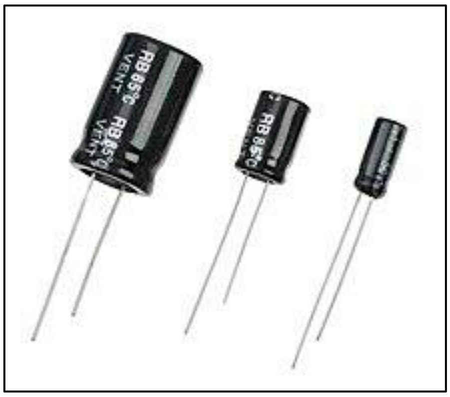


Figure 3.7 Example of capacitors

3.4.4 Lithium-Ion Battery

Due to the project's emphasis on travel, size, form, and capacity play a significant influence in determining the sort of battery to be used. Above all other requirements, a lithium-ion secondary battery is used in this project (Li-ion). Lithium-ion batteries are more dependable than previous battery types such as nickel-cadmium (NiCad). In addition, lithium-ion batteries are not influenced by the so-called "memory effect," in which they must be entirely depleted before being charged again. The size and form of lithium-ion batteries is also a major factor in their selection over other kinds of batteries. The lithium-ion battery has a lower size and more capacity than previous batteries due to its packing.

Figure 3.8 Lithium-Ion Battery

3.4.5 Universal Serial Bus (USB)

Because it is the most commonly used and recognized USB connector, the USB type A connector was chosen for this project. All USB generations, including USB 3.0, USB 2.0, and USB 1.1, are compatible with this connection. On top of that, it's a great fit for this project since it's widely compatible with most electrical devices. In addition, the cable needed for this kind of connection is widely accessible.

Figure 3.9 Example of USB 3.0 Type A

3.4.6 Light Sensor

A Light Sensor creates an output signal representing the intensity of light by measuring the radiant energy that occurs in a very restricted band of frequencies termed "light," which runs from "Infra-red" to "Visible" to "Ultraviolet" light spectrum. The light sensor is a passive device that converts visible or infra-red "light energy" into an electrical signal. Light sensors are more generally referred to as "Photoelectric Devices" or "Photo Sensors" due to the fact that they transform light energy (photons) into electricity (electrons).

Figure 3.10 Light Sensor

3.4.7 Arduino Uno

The ATmega328P microprocessor is used in Arduino Uno, an open-source microcontroller board. Various expansion boards (shields) and circuitry may be connected to the board's digital and analogue input/output (I/O) ports. Arduino IDE is used to program the board, which has 14 digital I/O pins (six of which may be used for PWM output), six analogue I/O pins, and a USB connection (Integrated Development Environment). It can be plugged into a USB port or an external 9-volt battery, although it can accept voltages between 7 and 20 volts. Comparable to the Arduino Nano and Leonardo. The Arduino UNO microcontroller board may be used in a variety of electrical applications since it is low-cost, versatile, and user-friendly.

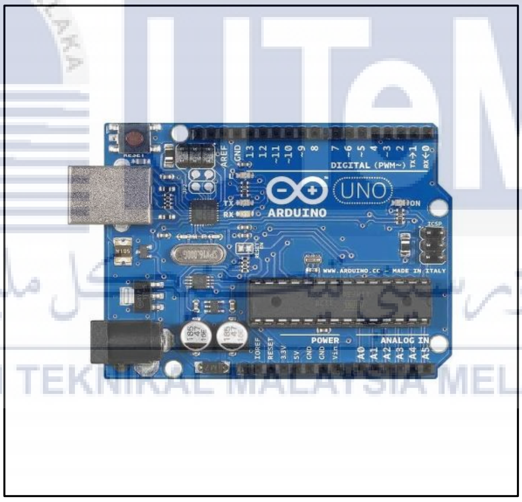


Figure 3.11 Arduino Uno

3.5 Software

The software that will be used in developing this project is Blynk for monitoring and controlling purposes and AUTOCAD to demonstrate the model of the green stove prototype.

3.5.1 Blynk

Because of its ability to compile and provide the right widget address, Blynk App was selected to be utilized in the creation of this project's graphical user interface (GUI). It can remotely control gear, display sensor data, preserve data, and present it in a user-friendly format. Blynk can be used in several platforms such as IOS and Android which is suitable for this project as users can remotely control and monitor the prototype from their mobile phones.

Figure 3.12 Blynk App

3.5.2 SketchUp

The design for this project will be made by using SketchUp. The scale, size and actual shape of the design might not be the same as the actual prototype.

Figure 3.13 SketchUp

3.5.2.1 Model Design

The figure below shows the example of model design for green stove portable biomass power solution.

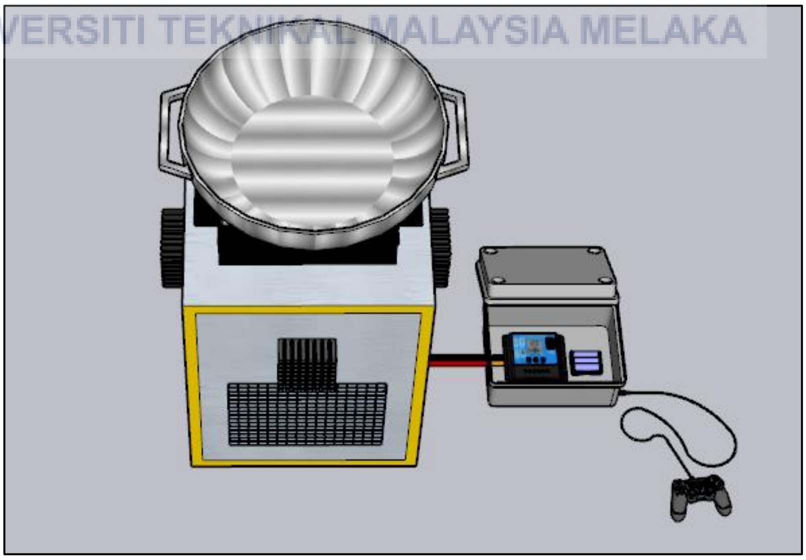


Figure 3.14 Design for Green Stove Portable Biomass Power Solution

3.6 Limitations

There are several limitations and constraints in developing this project. The result for this project cannot be guaranteed to be completely perfect based on the objectives and the scope project as this project is more focused on the real prototype and hands-on work rather than doing simulations. So, the result cannot be guaranteed to be perfect. Not only that, but the total cost for the whole project is also expected to be quite high. It is also lengthy and time-consuming to complete this project.

3.7 Summary

As a summary of the whole chapter, the process of generating this project's design and the materials used have been outlined. Due to the appropriateness of the circuits, the values of certain components may vary. Changes will be done in the future or during the project's development in order to enhance its performance.

CHAPTER 4

RESULTS

4.1 Introduction

This chapter will examine the voltage generated by each biomass source collected from this portable biomass cookstove in order to have a better knowledge of biomass. Results and general hardware performance will be explored in depth.

4.2 System Overview

Biomass is a well-known renewable energy resource since it has an infinite supply and is constantly accessible. However, an excessive amount of biomass residue might pollute the environment. Many initiatives were done to reduce pollution. Burning has long been a popular way of reusing garbage since the heat generated may be utilised for interior uses such as cooking, heating, and so on.

In that regard, this cook stove has been built to benefit the environment by reducing biomass residue via burning technique while supporting the primary objective, which is to enable campers and travellers to produce electric power in the woods. The thermoelectric generator's (hot side) supply will be wood combustion, while the cold side will be chilled water in a metal tray. The temperature differences will determine the value of the TEG's output. The temperature variations will be proportionate to the voltage generated.

The TEG output will be stored in the lithium-ion battery. The system will be regarded reliable if a battery is present. The system will generate enough electrical energy to charge electronic equipment such as mobile phones, cameras, and so on for people who will be camping or trekking in the forest.

4.3 Hardware Analysis

From this point on, the hardware analysis and data outcomes will be discussed. To ascertain the output value, five TEG modules were tested. The voltage and current values were measured using a multimeter.

4.3.1 Hardware Design

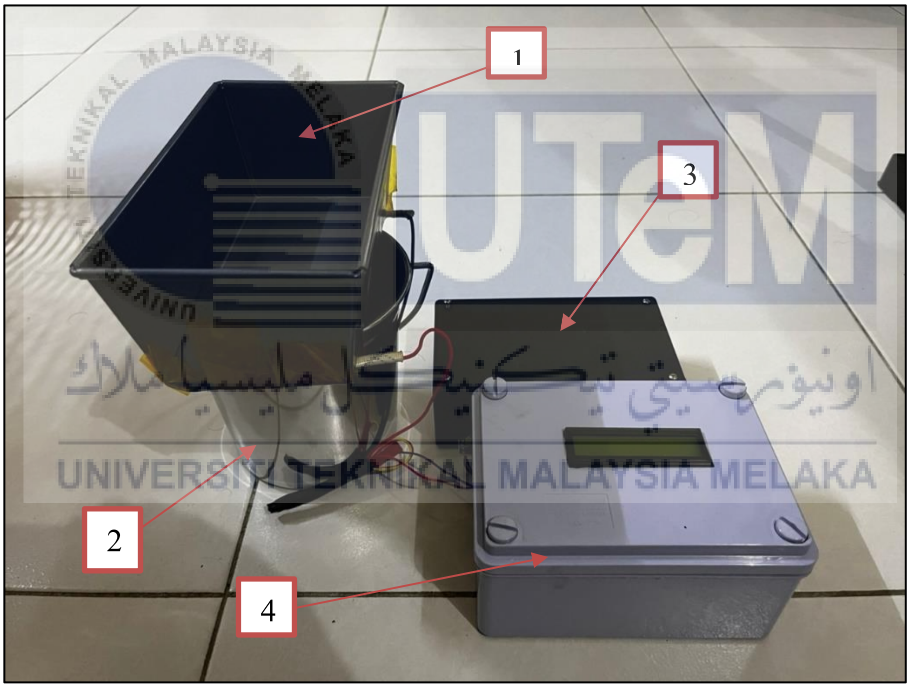


Figure 4.1 Green Stove Portable Biomass Power Solution Based on IoT Design

The illustration above depicts the project's finished design. The total system comprises of four components, including a metal tray (1) with five Peltier modules adhered underneath it, which will be filled with cool water as a cooling solution for the Peltier modules.

The metal basket (2) will thereafter be utilised as a chamber for burning the fuels. The aluminium material was used for this project to guarantee that the heat generated by the fuels lasts longer and does not burn the basket.

The black junction box (3) then has three components: a charge controller module for charging devices and lithium-ion batteries, a battery holder for three lithium-ion batteries, and a USB port for connecting devices.

Lastly, the blue junction box (4) is used to hold IoT system components such as LCD display, Arduino UNO, LDR sensor, voltage sensor and a 9V battery.

4.3.2 IoT System

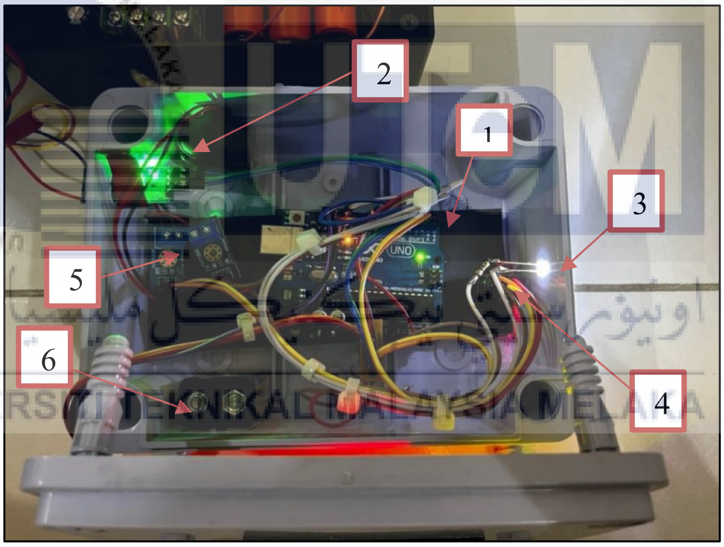


Figure 4.2 Inside of the IoT system junction box

Arduino UNO (1) is used with ESP8266 (4) to connect with Blynk App in the smartphone to monitor the voltage produced by battery, Peltier modules and also battery percentage of the system. The LDR sensor (2) is used with LED (3) which functions as a torchlight for campers and hikers during nighttime. LDR sensor will detect if there is light exposed to it such as sunlight. If there is no light, the LDR will detect it and send signal to the LED which will make the LED light up automatically. The voltage sensor (5) is used to detect both battery and Peltier voltage produced. Then, voltage sensor will send the signal to Arduino UNO which then can be monitored through LCD display or Blynk App. Lastly, a 9V battery (6) is used to supply power to Arduino UNO to run the whole system.

4.3.3 Blynk App monitoring system

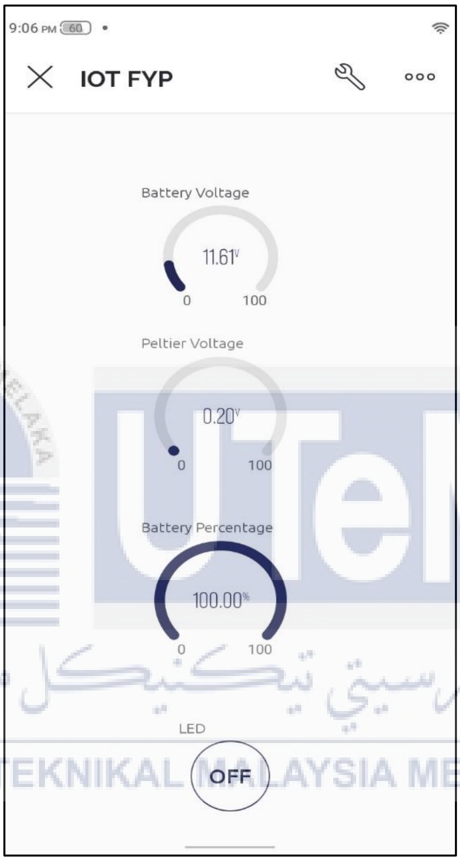


Figure 4.3 Blynk App monitoring system

The Blynk App is used to monitor both battery and Peltier voltage produced from the fuels. The ON/OFF button is also used to control the LED light so that it will not light up for the whole night straight.

4.3.4 Thermoelectric Generator

The thermoelectric generator is divided into two parts: the hot side and the cold side. As a result, the first step is to establish which side is hot and which side is cool. The cold side has the TEG's code in numbers and letters, whereas the hot side is blank.

4.3.4.1 The Hot Side and Cold side

A multimeter may be used to identify the hot side. The surface of a hot and cold side may also be assessed using a simple test.

To begin, connect the red and black wires from the TEG to the multimeter. The red wire is a positive wire, whereas the black wire is a negative wire. Next, apply heat to both surfaces and check the multimeter reading. When heat is applied to the heated surface, it produces a greater reading.

4.4 Results

The project has been tested with five TEG modules stuck under the metal tray. The output of the TEGs is measured using a multimeter and Blynk App based on the time the TEG is exposed to heat. An open fire may achieve temperatures of up to 1100 degrees Celsius. However, since aluminium is utilized in this project, the project can withstand temperatures of up to 660 degrees Celsius before melting. The cold side of the TEGs will be cooled using cool water in a metal tray, which may assist provide a larger temperature differential and hence a higher output value. The output of the TEG modules will be measured using three sources: woody waste, municipal trash, and food crops since these sources are obtainable during camping and hiking.

4.4.1 Wood (Multimeter)

One of the sources that may be found everywhere in the forest is wood. The test is divided into two conditions: dry and wet. A multimeter is used to measure the findings.

In general, the output from wood is not excessive since the heat generated by burning the wood is not excessive when compared to leaves and municipal garbage. Although the output from wood is not very great, the voltage and current rose consistently because the fire took a long time to extinguish from the wood.

4.4.1.1 Dry wood

Table 4.1 TEG output produced using dry wood

Duration of fuel burning (seconds)	Voltage produced (V)	Current produced (A)	Power (P)
20	1.85	0.11	0.20
40	2.11	0.13	0.27
60	2.21	0.16	0.35
80	2.30	0.19	0.44
100	2.41	0.21	0.51

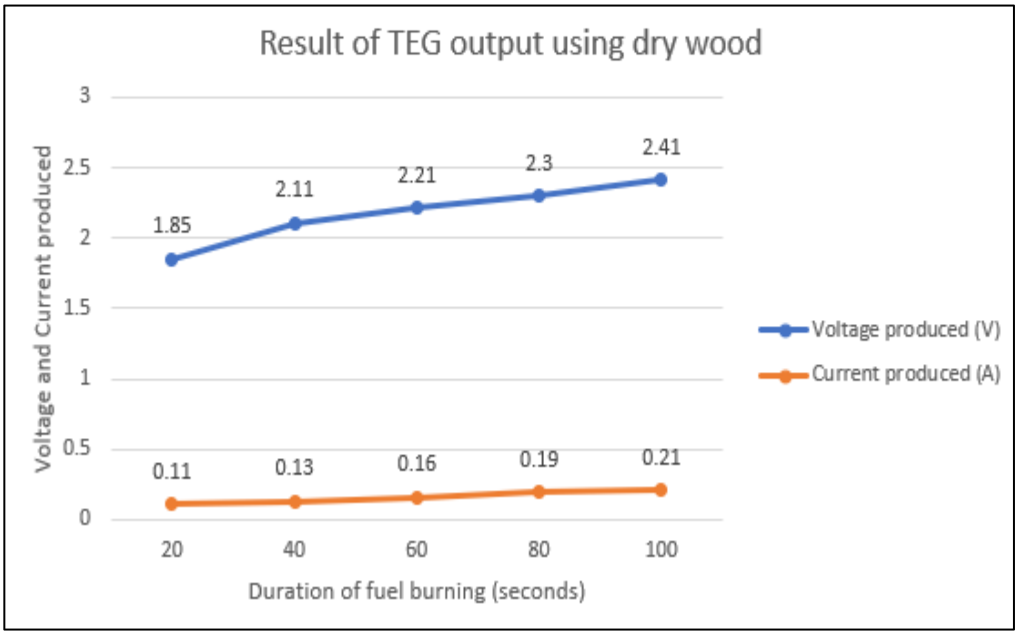


Figure 4.4 Graph for TEG output using dry wood

4.4.1.2 Wet Wood

Table 4.2 TEG output produced using wet wood

Duration of fuel burning (seconds)	Voltage produced (V)	Current produced (A)	Power (P)
20	1.73	0.10	0.17
40	1.94	0.11	0.21
60	2.12	0.13	0.28
80	2.22	0.17	0.38
100	2.29	0.19	0.44

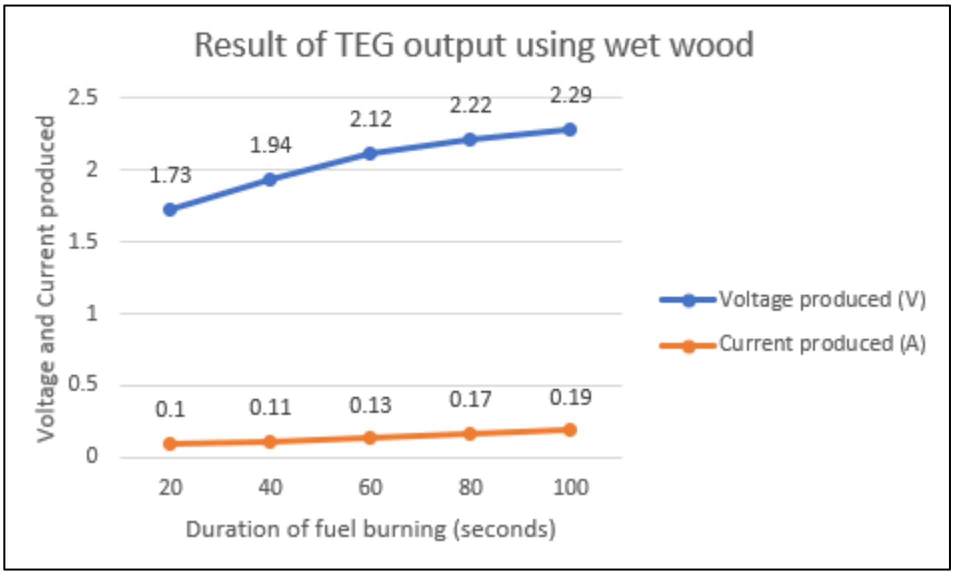


Figure 4.5 Graph for TEG output using wet wood

4.4.2 Leaves (Multimeter)

Since leaves can be found almost everywhere, they may be regarded as a common biomass resource. In addition, the test is divided into dry and wet circumstances. Using a multimeter, the parameters are assessed.

The output from leaves is high because the leaves are easily combusted, causing the temperature to rise rapidly. Although the output is considerable, the voltage and current decreased dramatically due to the ease with which the fire was doused by the leaves.

4.4.2.1 Dry leaves

Table 4.3 TEG output produced using dry leaves

Duration of fuel burning (seconds)	Voltage produced (V)	Current produced (A)	Power (P)
20	4.92	0.17	0.84
40	6.80	0.19	1.29
60	7.73	0.22	1.70
80	6.71	0.18	1.21
100	5.54	0.16	0.89

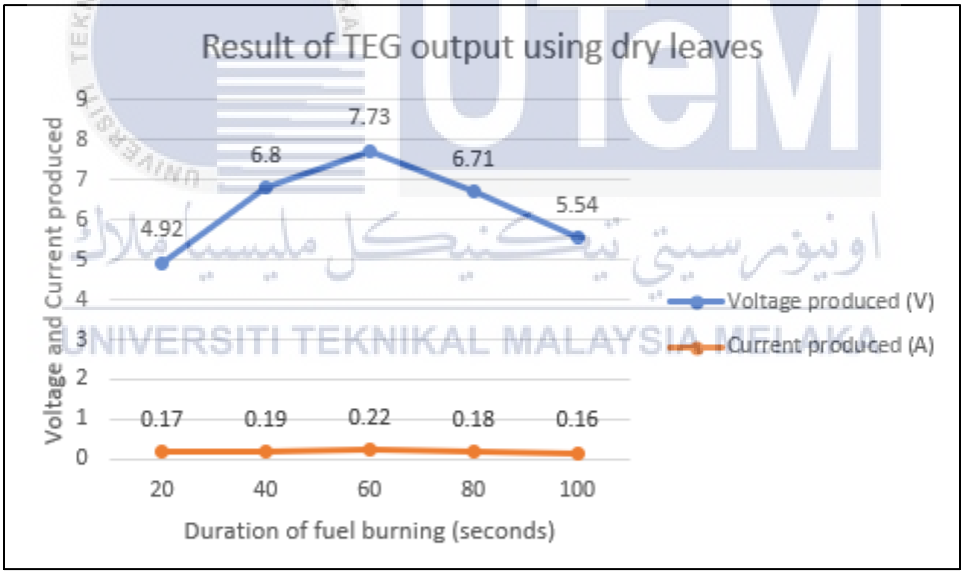


Figure 4.6 Graph for TEG output using dry leaves

4.4.2.2 Wet leaves

Table 4.4 TEG output produced using wet leaves

Duration of fuel burning (seconds)	Voltage produced (V)	Current produced (A)	Power (P)
20	4.23	0.14	0.59
40	5.98	0.18	1.08
60	7.12	0.19	1.35
80	5.71	0.17	0.97
100	4.88	0.15	0.73

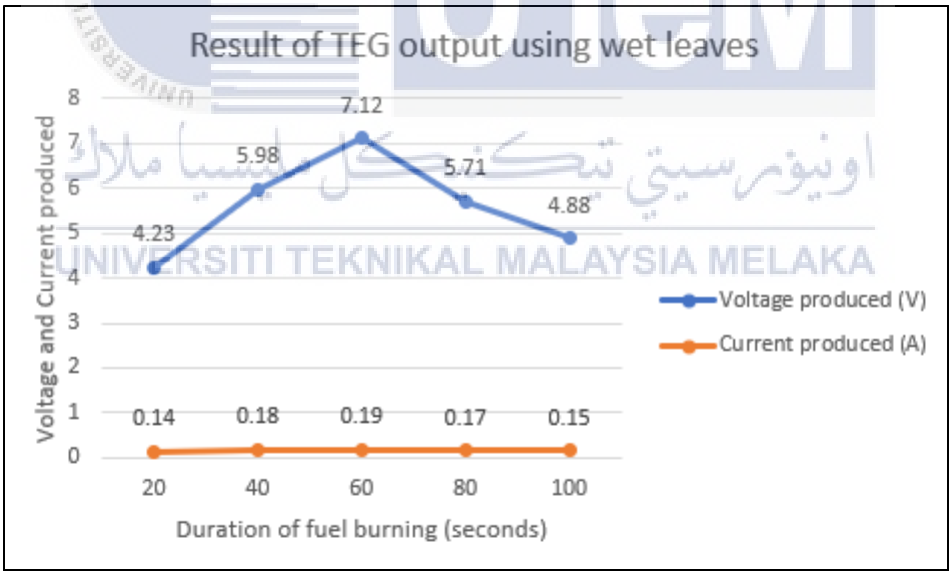


Figure 4.7 Graph for TEG output using wet leaves

4.4.3 Municipal waste (Multimeter)

Municipal garbage is frequently referred to as trash or rubbish and is typically collected from residences. The test is also separated into two conditions: dry and wet.

The testing materials included old plastics, boxes, and food trash. The output is almost identical to that generated by leaves, where the voltage and current are high for the first minute and then gradually drop as the heat decreased slowly.

4.4.3.1 Dry municipal waste

Table 4.5 TEG output produced using dry municipal waste

Duration of fuel burning (seconds)	Voltage produced (V)	Current produced (A)	Power (P)
20	5.85	0.18	1.05
40	7.91	0.24	1.90
60	8.22	0.25	2.06
80	7.65	0.19	1.45
100	6.20	0.16	0.99

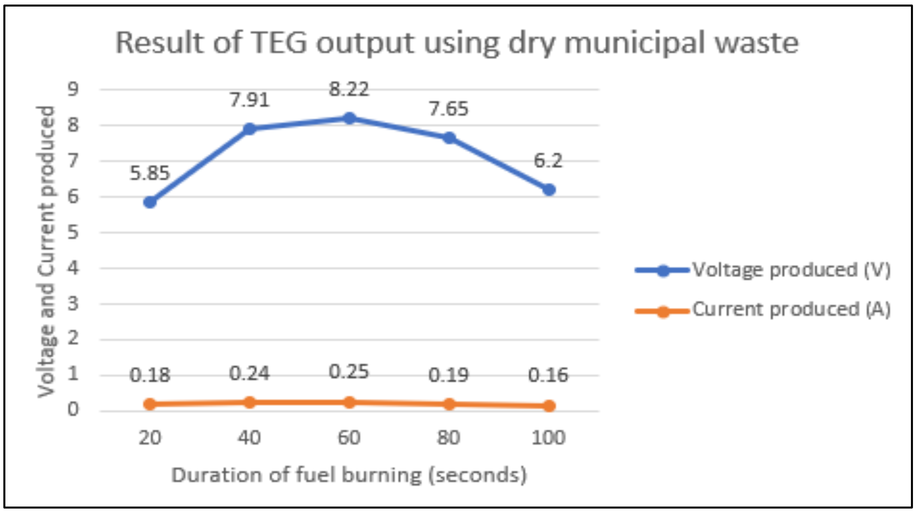


Figure 4.8 Graph for TEG output using dry municipal waste

4.4.3.2 Wet municipal waste

Table 4.6 TEG output produced using wet municipal waste

Duration of fuel burning (seconds)	Voltage produced (V)	Current produced (A)	Power (P)
20	5.32	0.16	0.85
40	7.18	0.21	1.51
60	7.99	0.23	1.84
80	7.21	0.20	1.44
100	6.13	0.17	1.04

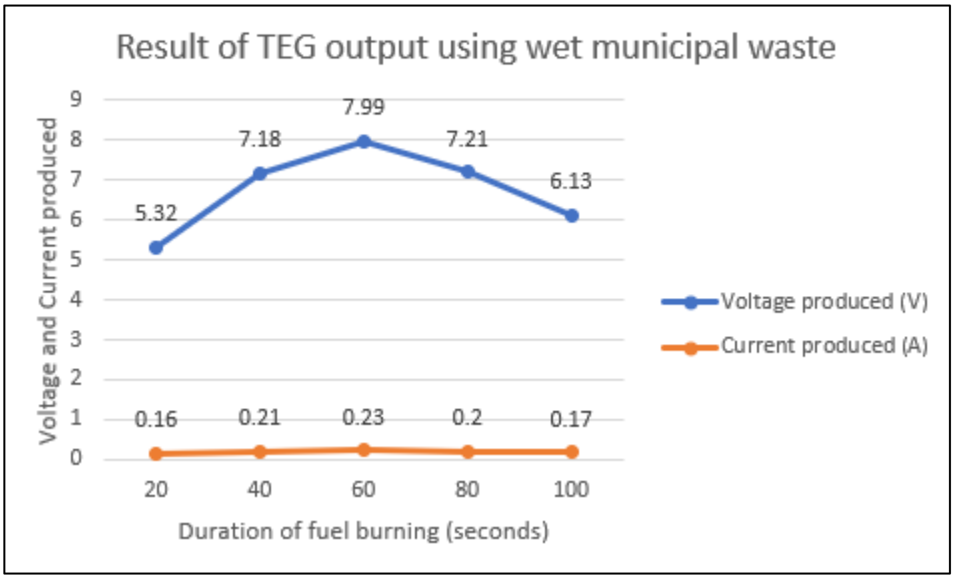


Figure 4.9 Graph for TEG output produced using wet municipal waste

4.4.4 Wood (Blynk)

The test was repeated to check whether there was a change if the output was routed via the Blynk system, which was established for monitoring reasons. The test was likewise separated into two conditions: dry and wet. The result is then compared to the multimeter reading.

4.4.4.1 Dry wood

Table 4.7 Comparison between Blynk and multimeter for dry wood

Duration of fuel burning (seconds)	Voltage produced from Blynk (V)	Voltage produced multimeter (V)
20	1.81	1.85
40	2.09	2.11
60	2.20	2.21
80	2.33	2.30
100	2.40	2.41

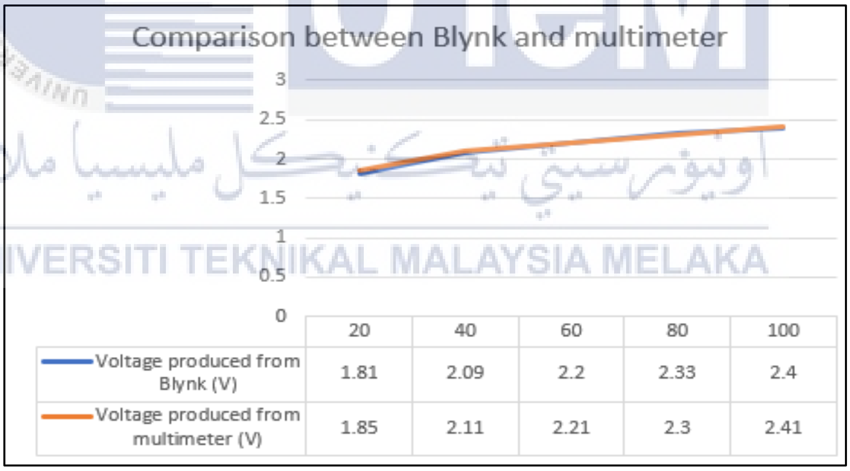


Figure 4.10 Graph comparison between Blynk and multimeter for dry wood

4.4.4.2 Wet Wood

Table 4.8 Comparison between Blynk and multimeter for wet wood

Duration of fuel burning (seconds)	Voltage produced from Blynk (V)	Voltage produced multimeter (V)
20	1.65	1.73
40	1.82	1.94
60	1.96	2.12
80	2.11	2.22
100	2.25	2.29

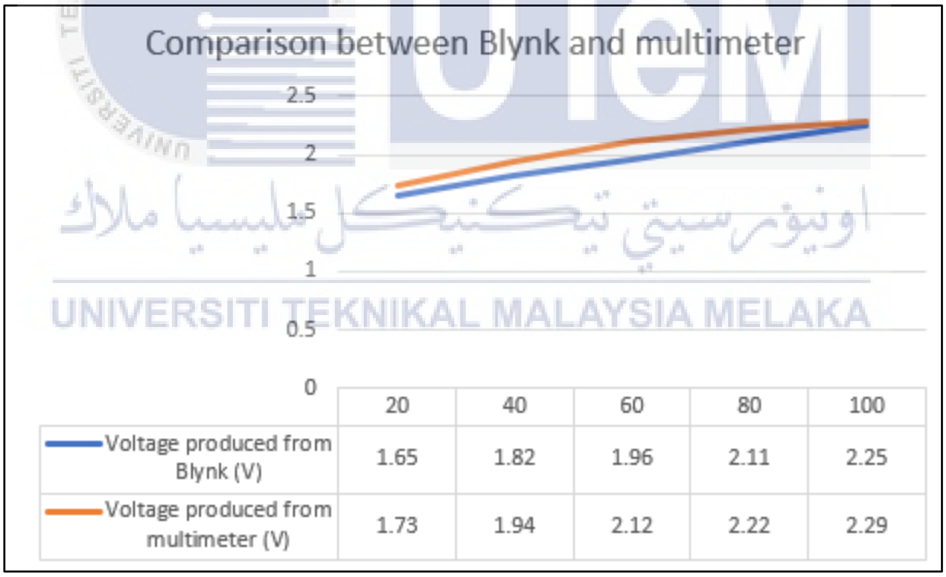


Figure 4.11 Graph comparison between Blynk and multimeter for wet wood

4.4.5 Leaves (Blynk)

The test was performed to see if there was a difference when the output was routed via the Blynk monitoring system. Similarly, the test was divided into two conditions: dry and wet. The result is then compared to the reading from the multimeter.

4.4.5.1 Dry leaves

Table 4.9 Comparison between Blynk and multimeter for dry leaves

Duration of fuel burning (seconds)	Voltage produced from multimeter (V)	Voltage produced from Blynk (V)
20	4.92	4.60
40	6.80	6.21
60	7.73	7.65
80	6.71	6.00
100	5.54	5.32

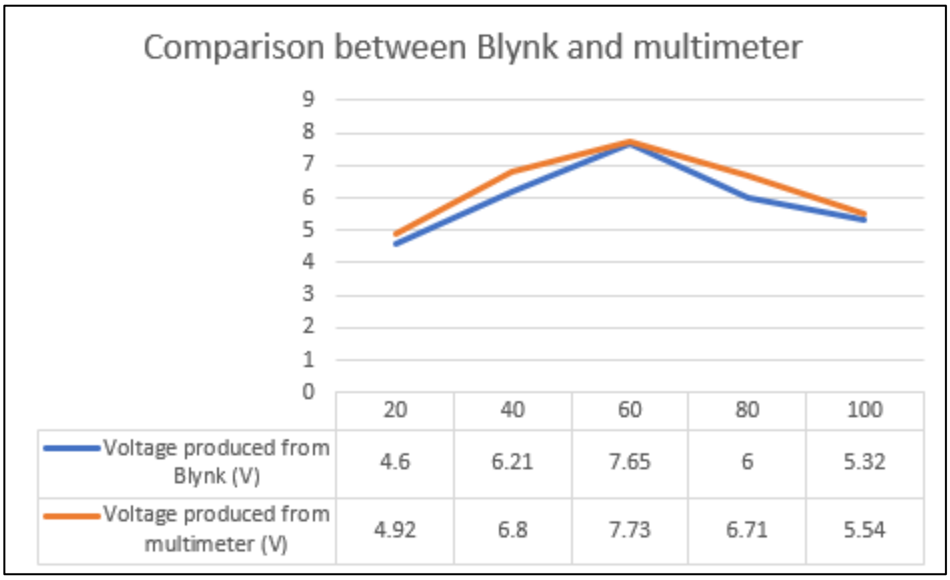


Figure 4.12 Graph comparison between Blynk and multimeter for dry leaves

4.4.5.2 Wet leaves

Table 4.10 Comparison between Blynk and multimeter for wet leaves

Duration of fuel burning (seconds)	Voltage produced from multimeter (V)	Voltage produced from Blynk (V)
20	4.23	4.25
40	5.98	5.92
60	7.12	7.01
80	5.71	5.80
100	4.88	4.91

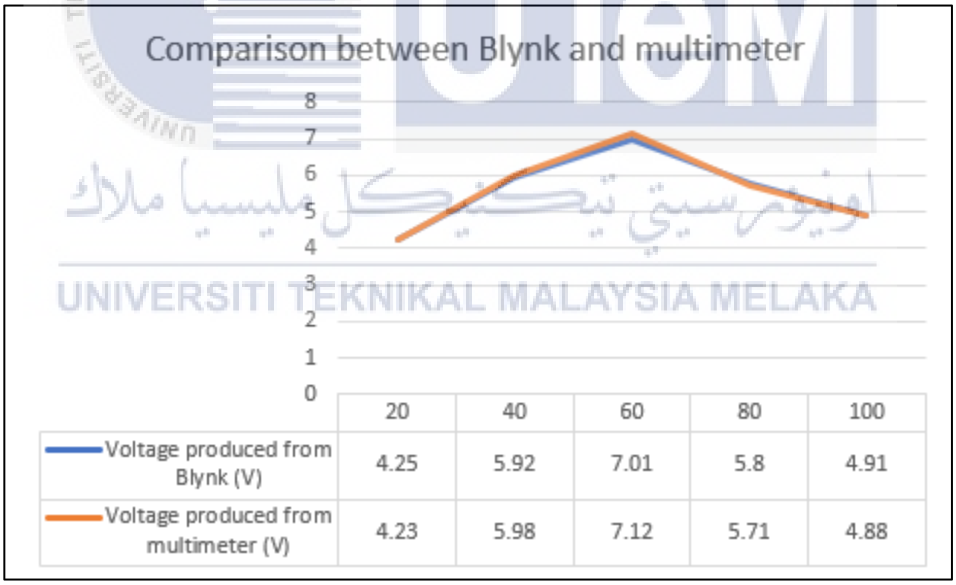


Figure 4.13 Graph comparison between Blynk and multimeter for wet leaves

4.4.6 Municipal waste (Blynk)

The output was submitted using the Blynk monitoring system and compared against its production through a different method. The evaluation was also broken down into a "dry" and "wet" section. Then, the reading on the multimeter is compared to the value obtained.

4.4.6.1 Dry municipal waste

Table 4.11 Comparison between Blynk and multimeter for dry municipal waste

Duration of fuel burning (seconds)	Voltage produced by multimeter (V)	Voltage produced by Blynk (V)
20	5.85	5.34
40	7.91	7.11
60	8.22	7.93
80	7.65	7.31
100	6.20	6.65

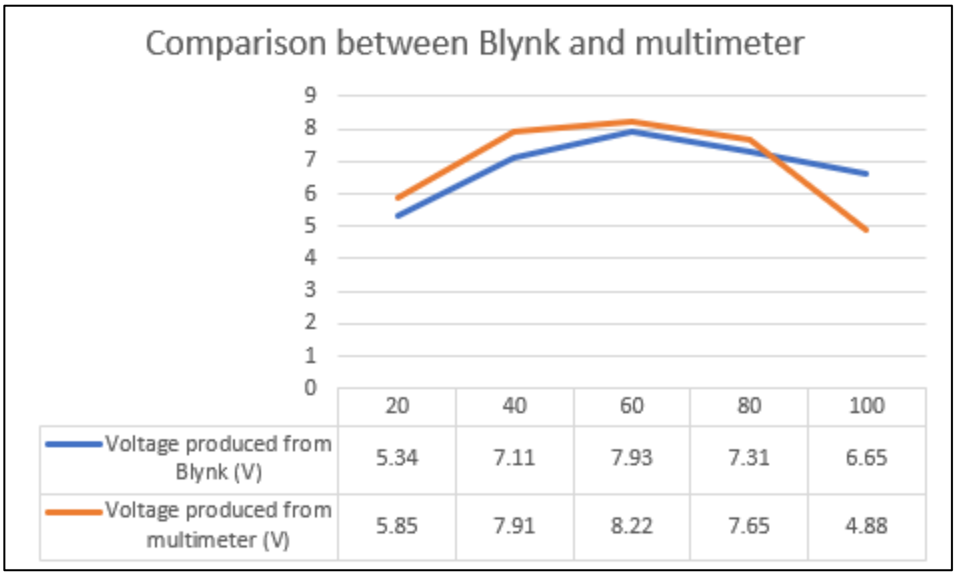


Figure 4.14 Graph comparison between Blynk and multimeter for dry municipal waste

4.4.6.2 Wet municipal waste

Table 4.12 Comparison between Blynk and multimeter for wet municipal waste

Duration of fuel burning (seconds)	Voltage produced by multimeter (V)	Voltage produced by Blynk (V)
20	5.32	5.28
40	7.18	6.84
60	7.99	7.77
80	7.21	7.14
100	6.13	6.02

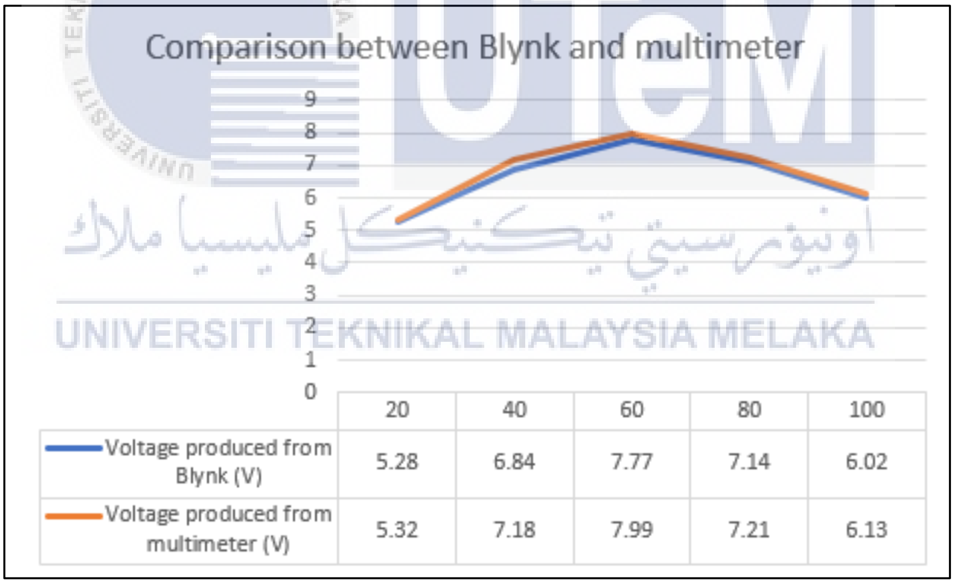


Figure 4.15 Graph comparison between Blynk and multimeter for wet municipal waste

4.4.7 Battery charging test using different sources

The biomass system's functionality is to help charge the lithium-ion batteries. A test was carried out to measure the efficiency of each source in charging the batteries to conclude which source is better in terms of charging. The test was conducted with intervals of five minutes. The battery percentage was set at 70% for the first point.

4.4.7.1 Wood

Table 4.13 Battery percentage charged for wood

Time applied (min)	Voltage produced (V)	Battery percentage (%)
5	4.33	71
10	6.89	72
15	8.24	72
20	8.90	73
25	8.97	75

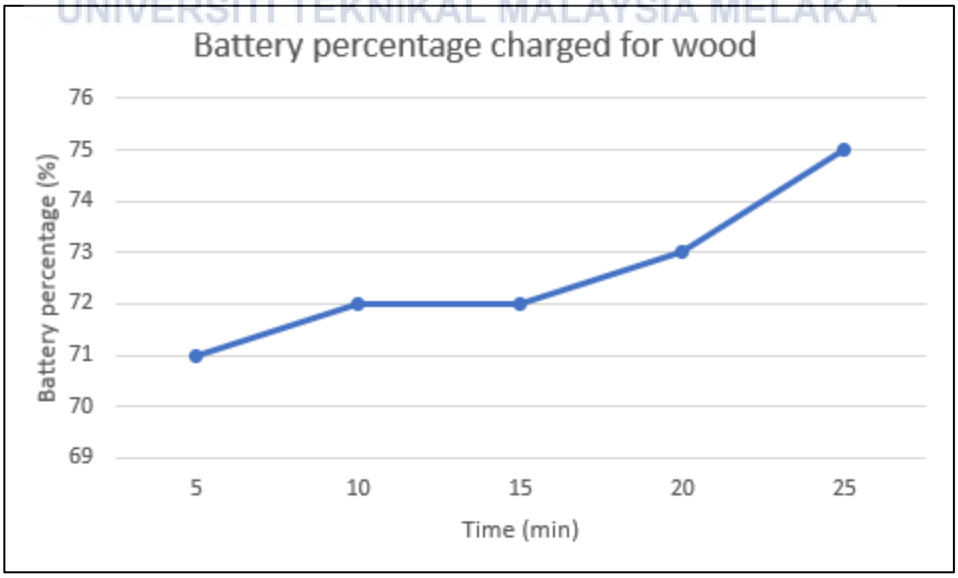


Figure 4.16 Graph for battery percentage charged for wood

4.4.7.2 Leaves

Table 4.14 Battery percentage charged for leaves

Time applied (min)	Voltage produced (V)	Battery percentage (%)
5	7.88	72
10	9.21	74
15	9.45	74
20	7.91	73
25	5.41	71

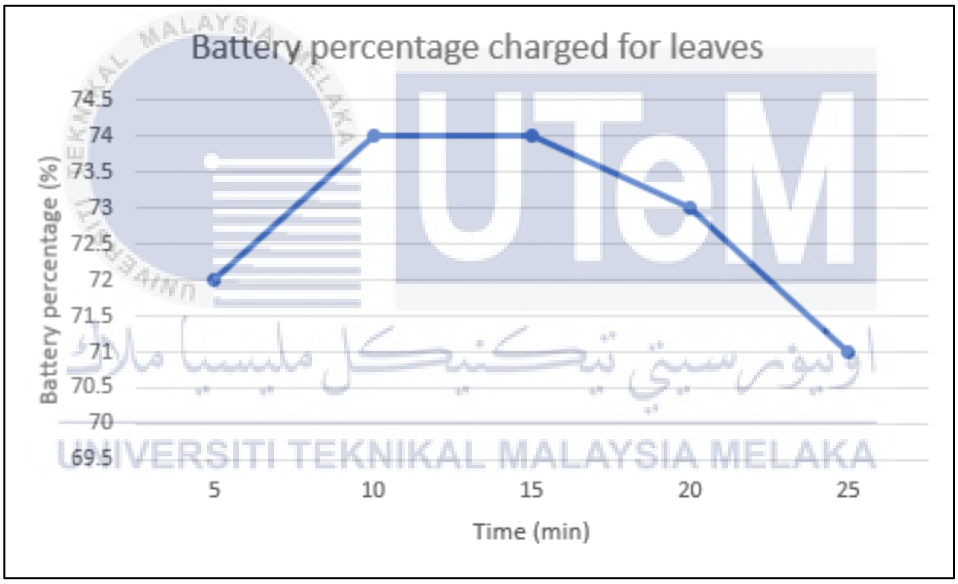


Figure 4.17 Graph for battery percentage charged for leaves

4.4.7.3 Municipal waste

Table 4.15 Battery percentage charged for municipal waste

Time applied (min)	Voltage produced (V)	Battery percentage (%)
5	8.11	73
10	9.67	75
15	9.33	75
20	7.31	74
25	5.06	72

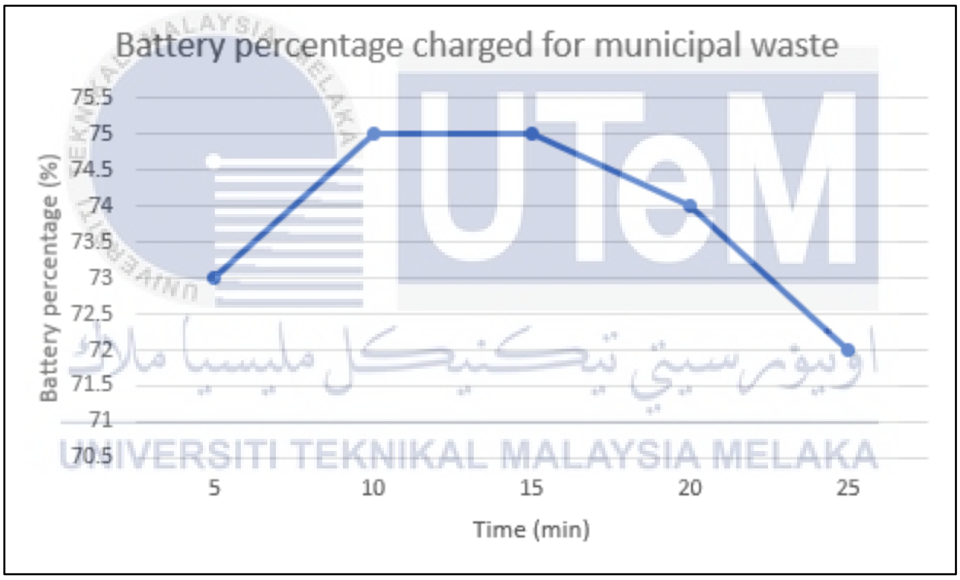


Figure 4.18 Graph for battery percentage charged for municipal waste

CHAPTER 5

CONCLUSION

5.1 Introduction

This chapter highlights the goal, methods, and conclusions acquired from the data while discussing the Seebeck effect of the portable biomass power bank employing various biomass energy sources. To further enhance the development of this system, this would be helpful for future initiatives.

5.2 Summary of the project

This portable biomass power bank is designed for campers and hikers who will spend the day in the forest camping or trekking. They may now charge their phones and other technological gadgets while cooking on the stove. They will no longer be cut off from the rest of the world.

5.3 Summary of the research objectives

The purpose of this project is to create a portable biomass power bank capable of charging electrical gadgets when campers and tourists are in the woods. The Seebeck effect is included into the thermoelectric generator (TEG) plates of this system. Then, the Blynk program will monitor the voltage generated by the battery and Peltier modules, as well as evaluate the voltage provided by each biomass energy source. Ultimately, this biomass portable power bank is able to charge the users' electronic gadgets, showing the existence of current and voltage as the prototype functions correctly.

5.4 Summary of the methodology

This concept is designed to charge electrical items such as cell phones when campers and hikers are away from power sources while camping. The power bank was created using a metal tray that would contain water to aid in its cooling mechanism. Then, five Peltier modules are adhered underneath the metal tray, which is kept in place by thermal grease that has been placed across the Peltier modules. The Peltier modules are then covered with aluminum foil to absorb additional heat from the heat source. Using this method, the cold and hot sides of the Peltier modules will experience a large temperature differential, which will subsequently generate electricity. The design is simple and lightweight which can be carried around easily without worrying of it taking space. The thermoelectric generators (TEG) will generate up to 4V per plate and serve as the power supply for this project. In this situation, there are five plates utilized. The output of the plates will be sent to the charger controller, which will charge a 6000mAh battery, which is comparable to two completely charged phones and a third that is half full. This is an estimate for smartphones having battery capacities of 2200mAh.

5.5 Summary of the results obtained

The findings of the study were recorded and compared for both wet and dry circumstances for each source. The production of wet fuels is lower than the output of dry fuels. The burning length of wood is also greater than that of leaves and municipal garbage, but for the purposes of testing, the duration was restricted to 100 seconds maximum to quantify the output generated during that time. Furthermore, the voltage and current generated by leaves and municipal trash are larger than those produced by woods, but the burning time for both fuels is shorter, making them less efficient. Not only that, leaves and municipal wastes are less efficient to charge the batteries compared to woods because both fuels burned out faster compared to woods. In other words, wood is the ideal fuel since it burns slowly and longer, increasing the production progressively.

5.6 Future works

This concept employs a small metal tray that can only hold five to ten TEG modules, limiting the system's output power. It is strongly advised that the present metal tray be replaced with a larger metal tray or any metal item in order to fit more TEG modules and hence provide higher output power. Aside from that, it is also recommended to utilize cold water instead of warm water to enhance temperature differences, which may aid generate greater output power. Not only that, but battery storage should be improved so that campers or hikers may charge their gadgets more regularly.

REFERENCES

[1] Saeed MA, Irshad A, H. Sattar, A. G. E, Phylaktou H N, and & Gibbs, "Agricultural Waste Biomass Energy Potential in Pakistan," Int. Bioenergy Exhib. Asian Bioenergy Conf., no. February 2020, pp. 21–23, 2015, doi: 10.5071/IBSCE2015-1CO.1.2.

[2] Saeed MA, Irshad A, H. Sattar, A. G. E, Phylaktou H N, and & Gibbs, "Agricultural Waste Biomass Energy Potential in Pakistan," Int. Bioenergy Exhib. Asian Bioenergy Conf., no. February 2020, pp. 21–23, 2015, doi: 10.5071/IBSCE2015-1CO.1.2.

[3] M. Ariful Islam, S. Haydar, M. Abdul Baten, and M. Tauhidul Islam, "The Prospect of Biomass Energy Resources in Bangladesh: A Study to Achieve the National Power Demand," Electr. Electron. Eng., vol. 2021, no. 1, pp. 1–6, doi: 10.5923/j.eee.20211101.01.

[4] M. J. Deasy, S. M. O'Shaughnessy, L. Archer, and A. J. Robinson, "Electricity generation from a biomass cookstove with MPPT power management and passive liquid cooling," Energy Sustain. Dev., vol. 43, pp. 162–172, Apr. 2018, doi: 10.1016/j.esd.2018.01.004.

[5] X. Lu et al., "Gasification of coal and biomass as a net carbon-negative power source for environment-friendly electricity generation in China," Proc. Natl. Acad. Sci. U. S. A., vol. 116, no. 17, pp. 8206–8213, 2019, doi: 10.1073/pnas.1812239116.

[6] L. J. R. Nunes, T. P. Causer, and D. Ciolkosz, "Biomass for energy: A review on supply chain management models," Renewable and Sustainable Energy Reviews, vol. 120. Elsevier Ltd, Mar. 01, 2020. doi: 10.1016/j.rser.2019.109658.

[7] E. R. Widjaya, G. Chen, L. Bowtell, and C. Hills, "Gasification of non-woody biomass: A literature review," Renewable and Sustainable Energy Reviews, vol. 89. Elsevier Ltd, pp. 184–193, Jun. 01, 2018. doi: 10.1016/j.rser.2018.03.023.

[8] S. Pang, "Advances in thermochemical conversion of woody biomass to energy, fuels and chemicals," Biotechnology Advances, vol. 37, no. 4. Elsevier Inc., pp. 589–597, Jul. 01, 2019. doi: 10.1016/j.biotechadv.2018.11.004.

[9] G. SriBala, H. H. Carstensen, K. M. Van Geem, and G. B. Marin, Measuring biomass fast pyrolysis kinetics: State of the art, vol. 8, no. 2. 2019. doi: 10.1002/wene.326.

[10] G. SriBala, H. H. Carstensen, K. M. Van Geem, and G. B. Marin, Measuring biomass fast pyrolysis kinetics: State of the art, vol. 8, no. 2. 2019. doi: 10.1002/wene.326.

[11] D. C. Elliott, P. Biller, A. B. Ross, A. J. Schmidt, and S. B. Jones, "Hydrothermal liquefaction of biomass: Developments from batch to continuous process," Bioresour. Technol., vol. 178, pp. 147–156, 2015, doi: 10.1016/j.biortech.2014.09.132.

[12] A. R. K. Gollakota, N. Kishore, and S. Gu, "A review on hydrothermal liquefaction of biomass," Renew. Sustain. Energy Rev., vol. 81, no. May 2017, pp. 1378–1392, 2018, doi: 10.1016/j.rser.2017.05.178.

[13] E. Shayan, V. Zare, and I. Mirzaee, "Hydrogen production from biomass gasification; a theoretical comparison of using different gasification agents," Energy Convers. Manag., vol. 159, no. December 2017, pp. 30–41, 2018, doi: 10.1016/j.enconman.2017.12.096.

[14] Z. Hameed et al., "Gasification of municipal solid waste blends with biomass for energy production and resources recovery: Current status, hybrid technologies and innovative prospects," Renew. Sustain. Energy Rev., vol. 136, Feb. 2021, doi: 10.1016/j.rser.2020.110375.

[15] X. Hu, C. Zou, C. Zhang, and Y. Li, "Technological Developments in Batteries: A Survey of Principal Roles, Types, and Management Needs," IEEE Power and Energy

Magazine, vol. 15, no. 5. Institute of Electrical and Electronics Engineers Inc., pp. 20–31, Sep. 01, 2017. doi: 10.1109/MPE.2017.2708812.

[16] Y. Liu, Y. Gene Liao, and M. C. Lai, “Lithium-ion polymer battery for 12-voltage applications: Experiment, modelling, and validation,” Energies, vol. 13, no. 3, 2020, doi: 10.3390/en13030638.

[17] S. Petrovic, “Battery Technology Crash Course.”

[18] H. Jouhara et al., “Thermoelectric generator (TEG) technologies and applications,” International Journal of Thermofluids, vol. 9. Elsevier B.V., Feb. 01, 2021. doi: 10.1016/j.ijft.2021.100063.

[19] P. M. Kumar et al., “The design of a thermoelectric generator and its medical applications,” Designs, vol. 3, no. 2. MDPI AG, pp. 1–26, Jun. 01, 2019. doi: 10.3390/designs3020022.

[20] A. O. Baba, G. Liu, and X. Chen, “Classification and Evaluation Review of Maximum Power Point Tracking Methods,” Sustainable Futures, vol. 2. Elsevier Ltd, Jan. 01, 2020. doi: 10.1016/j.sftr.2020.100020.

[21] M. A. Khan and K. Salah, “IoT security: Review, blockchain solutions, and open challenges,” Futur. Gener. Comput. Syst., vol. 82, pp. 395–411, May 2018, doi: 10.1016/j.future.2017.11.022.

[22] P. Kumar, A. Agarwal, G. Purohit, and K. S. Raju, “Intelligent Home with Air Quality Monitoring,” SSRN Electron. J., no. January, 2019, doi: 10.2139/ssrn.3356383.

[23] H. Durani, M. Sheth, M. Vaghasia, and S. Kotech, “Smart Automated Home Application using IoT with Blynk App,” Proc. Int. Conf. Inven. Commun. Comput. Technol. ICICCT 2018, no. Icicct, pp. 393–397, 2018, doi: 10.1109/ICICCT.2018.8473224.

[24] 2019 International Conference on Intelligent Computing and Control Systems (ICCS). IEEE.

[25] F. Hidayanti, A. Ahmed, A. S. Must, F. Rahmah, and A. Wiryawan, “Design of Motorcycle Security System with Fingerprint Sensor using Arduino Uno Microcontroller Cite this paper Mult imodal Biomet ric Syst em Iris and Fingerprint Recognit ion Based on Fusion Technique Design of Motorcycle Security System with Fingerprint Sensor using Arduino Uno Microcontroller,” Int. J. Adv. Sci. Technol., vol. 29, no. 5, pp. 4374–4391, 2020.

[26] G. S. Sharath, N. Hiremath, and G. Manjunatha, “Design and analysis of gantry robot for pick and place mechanism with Arduino Mega 2560 microcontroller and processed using pythons,” in Materials Today: Proceedings, 2020, vol. 45, pp. 377–384. doi: 10.1016/j.matpr.2020.11.965.

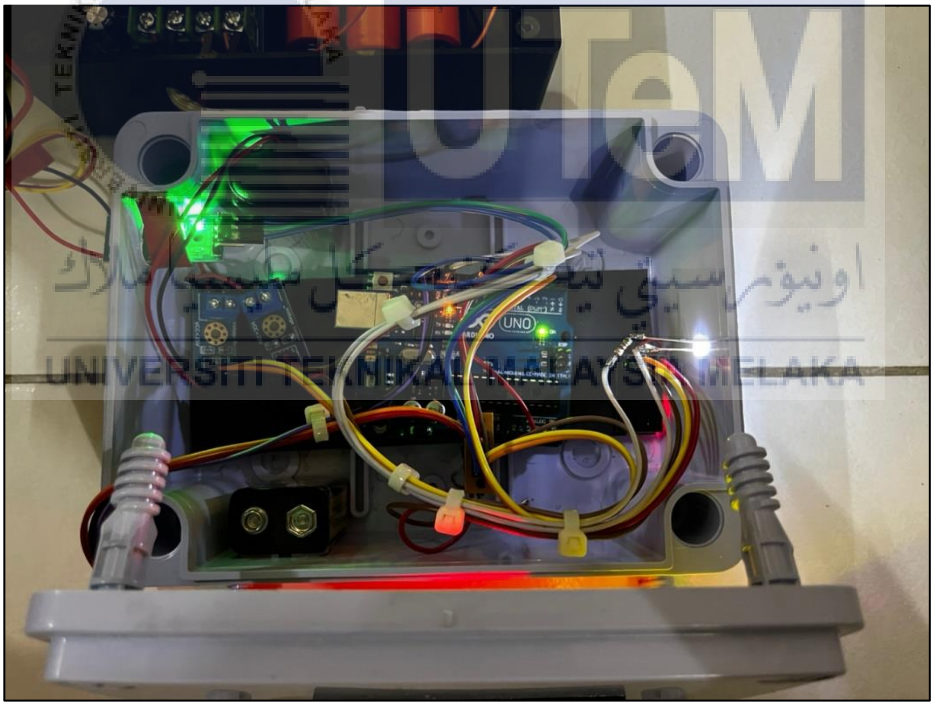
[27] L. D’Alton et al., “A simple, low-cost instrument for electrochemiluminescence immunoassays based on a Raspberry Pi and screen-printed electrodes,” Bioelectrochemistry, vol. 146, p. 108107, Aug. 2022, doi: 10.1016/j.bioelechem.2022.108107.

[28] A. Gupta and S. Gupta, “Design of Automatic Intensity Varying Smart Street Lighting System,” IOP Conf. Ser. Mater. Sci. Eng., vol. 225, p. 012126, Aug. 2017, doi: 10.1088/1757-899x/225/1/012126.

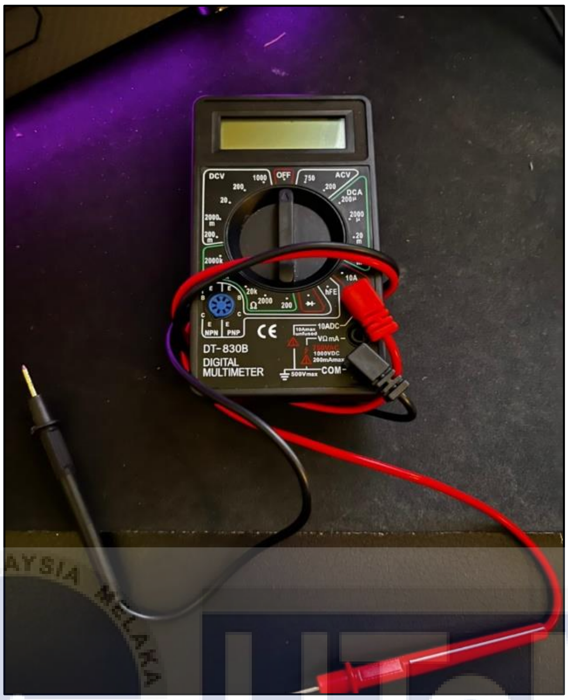
APPENDICES

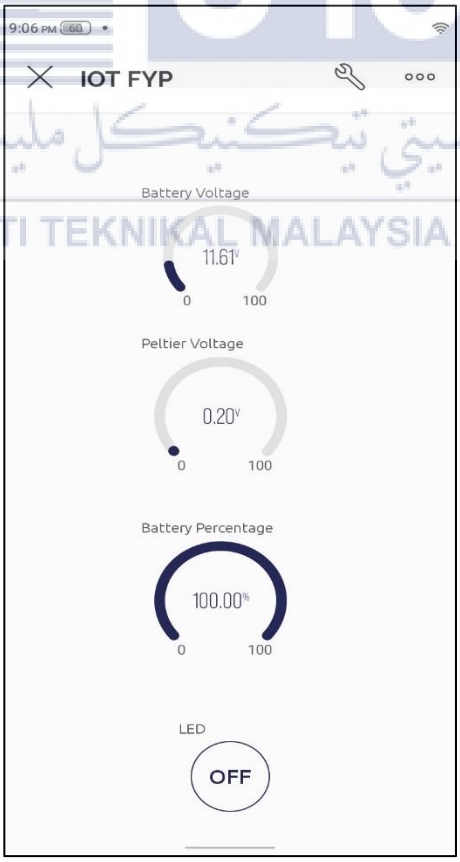
Appendix A Biomass portable power bank prototype


B3 (%)= 106.85
PLT(v)= 0.20



Appendix B Measuring equipment





Appendix C Coding for IoT System

```
#define BLYNK_TEMPLATE_ID "TMPLcZArH274"
#define BLYNK_DEVICE_NAME "IOT FYP"
#define BLYNK_AUTH_TOKEN "vLML8NGYce-UVlDxQn8aLvEkoYPRojfj"

#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27,16,2);

int ldr =6;
int Pin8 =8;
int Pin9 =9;
int LED =10;
int offset1 =20;
int offset2 =20;

#define BLYNK_PRINT Serial


#include <ESP8266_Lib.h>
#include <BlynkSimpleShieldEsp8266.h>

char auth[] = BLYNK_AUTH_TOKEN;
char ssid[] = "anaksoleh@2.4";
char pass[] = "7143ytjt";


#include <SoftwareSerial.h>
SoftwareSerial EspSerial(2, 3); // RX, TX

#define ESP8266_BAUD 9600
ESP8266 wifi(&EspSerial);

void setup()
{

  Serial.begin(9600);
  EspSerial.begin(ESP8266_BAUD);
  delay(10);

  lcd.init(); //initialize the lcd
  lcd.begin(16,2);    // iInit the LCD for 16
  lcd.backlight();

  pinMode(ldr,INPUT);
  pinMode(Pin8,INPUT_PULLUP);
  pinMode(LED,OUTPUT);
  pinMode(Pin9,OUTPUT);
```

```
  Blynk.begin(auth, wifi, ssid, pass, "blynk.cloud", 80);

}

void loop()
{
  int volt1 = analogRead(A0);
  double percentage = map(volt1,205,455, 0, 2500) ;
  percentage/=24.8;

  double voltage1 = map(volt1,0,1023, 0, 2500)+ offset1 ;
  voltage1/=100;

  lcd.setCursor(0, 0);
  lcd.print("B3 (%)= ");
  lcd.print(percentage);
  lcd.print(" ");
  Serial.println(percentage);
  Serial.print("%");
  delay(10);
  Blynk.virtualWrite(V2,percentage);

  int volt2 = analogRead(A1);
  double voltage2 = map(volt2,0,1023, 0, 2500) + offset2;
  voltage2 /=100;
  Blynk.virtualWrite(V0,voltage1);

  lcd.setCursor(0, 1);
  lcd.print("PLT(v)= ");
  lcd.print(voltage2);
//Serial.println(voltage2);
//delay(500);
  Blynk.virtualWrite(V1,voltage2);

  if ((digitalRead(Pin8)==1)||(digitalRead(ldr)==1)){
  digitalWrite(LED,HIGH);
}

else{
  digitalWrite(LED,LOW);
  Blynk.run();

}

}
```

Appendix D Gantt Chart