Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF BIOGAS IOT SMART STOVE USING KITCHEN WASTE

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Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours

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DEVELOPMENT OF BIOGAS IOT SMART STOVE USING KITCHEN WASTE

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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 (Industrial Automation & Robotics) with Honours.

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DECLARATION

I declare that this project report entitled "DEVELOPMENT OF BIOGAS IOT SMART STOVE USING KITCHEN WASTE" 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.

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Date : 11/6/2021

DEDICATION

I wish to express my sincere appreciation to my my supervisor for this project , Pn Siti Nur Suhaila Binti Mirin that guide me through this project by support their keen and endless guidance, encouragement, critics and inspiration till the success and completion of this work. I wish to express here, my sincere appreciation and thanks to all fellow lectures for the advice and fellow friends that had directly and indirectly helped me throughout this research project. I am grateful and acknowledge for both of my parents Alicia Pinsom and Simon Ongi also my sibling for their encouragement and endless support. Finally thanks to god for giving me this opportunity and to guide me and strengthen my mind and body to complete this project.

ABSTRACT

About 16687.5 tonnes of food waste are generated by Malaysian daily which. This food can feed into 12 million individuals about three times a day. This shows a massive food waste that can lead to the emission of the greenhouse effect and pollution to land and the environment as it emits a gas called methane. Instead of releasing methane gas, it is better to use it as cooking gas, which benefits the community more. Therefore, Malaysia also faces fire accidents every year as the incident of fire accidents increases, which will cause a lot of losses and pollution, which affect the habitat and ecosystem. To come up with a solution, a stove comes with the use of IoT for safety precaution and the use of kitchen waste to produce biogas for the cooking gas, which combine that makes Biogas IoT Smart Stove. This project is so eco-friendly food waste does not come to waste as it can be recycled and be used to produce biogas.

Moreover, this project provides a safety feature involved by using IoT, which is the internet. Nowadays, the use of the internet is not something very unusual, so that this IoT bright stove will be equipped with a wireless connection to the internet and the user smartphone. Therefore, this Smart Stove also has an automatic control stove knob. User can check their phone through the Apps called Blynk apps that will be used to control the stove knob wirelessly to turn the fire off the stove if it is ON. Also, there will be three sensors used: fire sensor, gas sensor, and motion sensor, to detect fire, gas, and motion in a specific value. If either these three sensors detect fire, gas or no motion, this will give the user a notification as a warning, and the user can be alert, which will prevent fire accidents from happening.

ABSTRAK

Kira-kira 16687.5 tan sampah makanan dihasilkan oleh rakyat Malaysia setiap hari dan jumlah makanan ini dapat memberi makan kepada 12 juta individu kira-kira tiga kali sehari. Ini menunjukkan pembaziran makanan yang sanga besar . hal ini demikian boleh menyebabkan pelepasan gas methane and menyebabkan kesan rumah hijau. Di samping kesan rumah hijau, pencemaran tanah dan persekitaran juga akan berlaku. Daripada melepaskan gas metana, ianya lebih baik menggunakannya sebagai gas memasak ianya lebih memberi maanfaat kepada community. Selain itu, kejadian kemalangan kebakaran di Malaysia meningkat setiap tahun. Ini menyebabkan banyak kerugian dan pencemaran yang boleh mempengaruhi habitat dan ekosistem. Untuk menyelesaikan masalah ini, biogas IoT dapur masak pintar membolehkan penghasilan gas memasak dan keselamatan di dapur untuk mengelakkan kemalangan. Projek ini sangat mesra alam, sisa makanan tidak sia-sia kerana boleh dikitar semula dan digunakan untuk menghasilkan biogas. Lebih-lebih lagi, projek ini menyediakan ciri keselamatan yang melibatkan dengan menggunakan IoT .Kini penggunaan internet bukanlah sesuatu yang sangat luar biasa, jadi dapur pintar IoT ini akan dilengkapi dengan sambungan tanpa wayar ke internet dan juga telefon pintar pengguna. Oleh itu, dapur pintar ini juga mempunyai tombol kawalan automatik. Pengguna boleh memeriksa telefon mereka melalui aplikasi Blynk dan digunakan untuk mengawal tombol dapur tanpa wayar untuk mematikan api jika hidup. Juga akan ada tiga sensor yang digunakan yaitu sensor api, sensor gas dan sensor gerakan untuk mengesan api, gas dan gerakan . Sekiranya ketiga-tiga sensor ini mengesan kebakaran, gas atau tidak ada gerakan, ini akan memberi pengguna notifikasi sebagai peringatan dan pengguna dapat berjaga-jaga dan ini akan mengelakkan terjadinya kebakaran.

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First and foremost, I would like to express my gratitude to my supervisor, *Pn Siti Nur Suhaila Binti Mirin* for her precious guidance, words of wisdom and patient throughout this project. Without her guidance and encouragement, this project might not complete in time.
Not forgetting my fellow colleague, for the willingness of sharing their thoughts and ideas regarding the project. This gives me more benefit and idea to develop the project.

My highest appreciation goes to my parents especially my mother, Alicia Pinsom for her moral support and financial support throughout this project. Also my family members for their love and prayer during the period of my study along with their support on answering the market research conducted for my presentation. An honourable mention also goes to my grandfather that recently passes away and he will be remembered for all the motivation and wise word for me to not give up and keep pushing. I am forever grateful with all the support given. Finally, I would like to thank all my classmates, the Faculty members, as well as other individuals who are not listed here for being co-operative and helpful.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

FIGURE **TITLE** **PAGE**

LIST OF SYMBOLS

l	-	Length
tv	-	total volume
α	-	crossection area of the tube
lp	-	Liquid phase
rt	-	retention time
v	-	Volume
	-	
	-	

LIST OF ABBREVIATIONS

V	-	Voltage
	-	
	-	
	-	
	-	
	-	
	-	
	-	

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
Appendix A	Mildstones for PSM 1	106
Appendix A	Mildstones for PSM 2	107
Appendix B	Arduino Coding	108

CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays the world is facing many environmental problems which dealing with polution that involve with food waste and fire accident. These problems will cause so much damage to the environment that will cause global warming and climate change. According to the number of food waste ("sisa makanan") statistic provided by SWCorp Malaysia (*Kertas-2.Pdf*, n.d.) it show the highest compare to plastic("plastik"), paper("kertas"), dipper("lampi pakai buang"), glass("kaca"), steel("logam"),dangerous house waste ("sisa isi rumah merbahaya") and others("lain-lain") which is 45%.

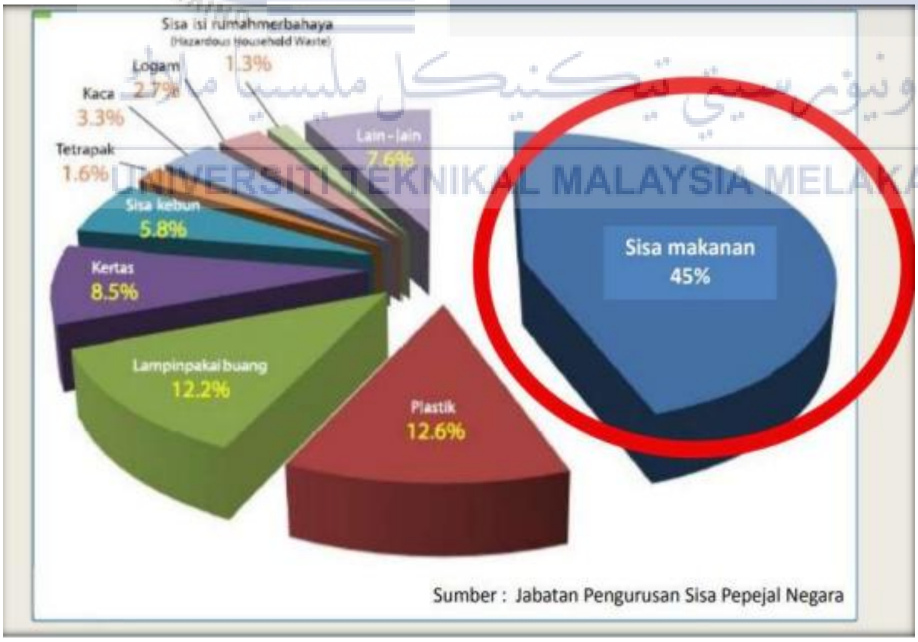

Figure 1.1 A statistic provided by SWCorp Malaysia in showing the number of food waste ("sisa makanan") in Malaysia

Here in Malaysia, according to Star news (Aruna, 2011), the people's living conditions have significantly improved due to the economic boom of the last two decades. As a result, many people have become affluent, and food waste has become a problem for local governments. After regular business events, such as wedding parties, conferences, banquets, households and business outlets such as hotels, restaurants, and resorts, are left with large quantities of food. Malaysians are throwing away up to 930 tonnes of unconsumed food daily, equivalent to throwing away 93000 kg bags of rice per day.

The authority is also growing concerned about managing waste, as much of it is dumped in unsanitary landfills regularly. This will result in greenhouse gas emissions, which will have an effect on future generations as well as the climate in general. The problem could also affect food supplies and the cycle of supply from agriculture, processes, and production in general. There is a massive loss of our food supply at the moment, with a report estimating that 1.3 trillion tonnes of food worth RM4.4 trillion was lost every year due to food management failures around the world (Theses & Abd Razak, 2017).

According to Figure 1.2, Malaysia shows the highest food waste rate compared to other countries such as Hong Kong, Singapore, Taiwan, America State, and South Korea. So using food waste as biogas will be the solution to solve the problem and adding the safety feature using IoT for monitoring system at the kitchen to reduce the fire accident.

BIL.	NEGARA	Kg / orang / hari
1	Malaysia	0.544
2	Hong Kong	0.50
3	Singapura	0.36
4	Taiwan	0.35
5	Amerika Syarikat	0.30
6	Korea Selatan	0.29

Figure 1.2: A statistic by SWCorp Malaysia in showing the comparison of food waste by countries

1.2 Problem Statement

The current situation or problem is that not every house is suitable for installing the biogas, for example, flats, condominiums or apartments, because the biogas digester needs somewhere with open space and the availability of sunlight. Thus, there are problems where that can be highlighted, such as:

i. Most of the households in Malaysia use Liquefied Natural Gas(LNG) as their source of heat for cooking

ii. Not be able to turn the fire off from the stove immediately when away from the kitchen.

iii. Do not have any monitoring system in the kitchen to warn users if there is a fire or gas leakage hazard.

1.3 Project Objective

In order to overcome the problem, the objectives of this project are as follows:

a) To develop a biodigester with filtration system for the production of cooking gas .

b) To develop a prototype of an automatic stove knob to turn the fire off using IoT.

c) To analyze the temperature and pH value of digester that affects the production of biogas

1.4 Scope of Project

The scope of this project are as follows:

a) Only food waste will be used for the biogas production.

b) Node MCU (ESP8266) as the microcontroller to that would act as the wifi module for the project which will control the servo motor and the brain to control all sensors.

c) Flame sensor can detect flames at 60 degree viewing angle of 0.3m to 1m.

d) Passive infrared sensor is adjusted up to 7 meters and the delay between detections can be set between 5 seconds to 5 minutes.

e) Gas sensor detect gas in the range of 500 -900ppm.

f) Provide stove monitoring by sending notification to the user.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

By referring to the previous study, there are element that needs to be determine on choosing the best feature of the biogas digester and IoT smart stove. These aspect can be consider based on the design, materials, functionality and component of hardware and software on destructing the biogas digester with IoT smart stove. Basically this project is to provide cooking gas and fertilizer by using kitchen waste. Besides that it also provide safety feature in the kitchen for installing Iot smart stove where the stove knob can be automatically turning off the fire by using the apps in the smart phone wirelessly. Therefore, there's a lot of method and technique involved in designing the bio digester system and also the IoT smart stove system. In this chapter, this study of project focus on the production of biogas, filtering the raw biogas, storing biogas, designing motored stove knob with sensor hub and observing the system and the comparison of previous study.

2.2 Biogas

The Biogas is one of the most environmentally-friendly and commercially viable that been used as cooking gas, generation of electric power, feeding into natural gas network and fuel for vehicle (زين الدين, 2005). Small – scale biogas production from organic waste and application in mid income countries. The benefits of waste disposal, energy recovery, and nutrient recycling are all combined in the controlled decomposition of organic waste in a biogas facility, making it a promising technology for resolving current waste management and energy recovery issues. So small-scale biogas production units can be easily built and operated even in environments with restricted access to advanced technology equipment and institutional capacity. Biogas production rates and volumes of treated organic waste, generally referred to as "liquid digestate," were determined (Huber, 2019). According to (Cogollos et al., 2003), the bacteria produce biogas through bio-degradation or organic material by the anaerobic condition which contain methane (CH_4), carbon dioxide (CO_2) and small amounts of water vapour (H_20), hydrogen sulphide (H_2S), hydrogen (H), Ammonia(NH_3), Nitrogen(N) and Oxygen(O_2) shown in Table 2.1.

Table 2.1 Composition of biogas

Component	Concentration (by volume)
Methane (CH4)	55-60 %
Carbon dioxide (CO2)	35-40 %
Water (H2O)	2-7 %
Hydrogen sulphide (H2S)	20-20,000 ppm (2%)
Ammonia (NH3)	0-0.05 %
Nitrogen (N)	0-2 %
Oxygen (O2)	0-2 %
Hydrogen (H)	0-1 %

(Cogollos et al., 2003) studied that kitchen waste is obtained which can be utilized for better purposes which it can be used to produce biogas when going through the anaerobic digestion which is a digestion process occurring without (absence) oxygen that generates mixtures of gases. The gas produced, which is mainly methane produces 5200-5800 KJ/m3, which, when burned at average room temperature and presents a viable environmentally friendly energy source to replace fossil fuels (non-renewable). Anaerobic digestion has four processes: hydrolysis; enzymes begin to break down larger polymers and molecules such as proteins, carbohydrates, and fats from the feed into amino acids, sugars, and fatty. Then Acidogenesis, the hydrolysis stage products, is converted to volatile fatty acids and alcohols. Next, in Acetogenesis, bacteria break down these volatile fatty acids into acetic acids. Lastly, Methanogenesis, where acetic acid is converted into the final products of methane and carbon dioxide.

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2.2.1 Factor Affecting Yield and Production of Biogas

(Ray & Mohanty, 2019) studied that biogas undergoes four-phase which is hydrolysis, acidogenesis, acetogenesis and methanogenesis. To undergo this process, it is essential to consider the environmental condition that the bacteria need because bacteria are sensitive to temperature, whereas mesophilic bacteria require a temperature between 25 ˚C and 45 ˚C. For bacteria, the temperature required is 45 ˚C and above, but thermophilic digestion is more difficult to control.

According to the study of (Cogollos et al., 2003), the quantity and nature of organic matter, the temperature, acidity and alkalinity (PH value) of the substrate and the flow and dilution of material need to be considered and based on Figure 2.1 and 2.2 which set 1 contain 200gm cow dung, set 2 contain kitchen waste and set 3 contain 400gm of cow dung but from the result that is obtained set 1 is the lowest and the 2nd goes to set 3rd, and the highest biogas production is set 3 which contain kitchen waste. But for the pH value set, one remains in the range of 6 -7.5 pH value, and for set 2, the pH value is more than seven, but then on day 8, it decreases to 5. Then lastly, for set 3, it stays the same as set 1 with the 6 -7.5 pH value. This shows that kitchen waste may produce more biogas than cow dung, but the pH will decrease over time. As for cow dung, it increases at first, but then it decreases over time, but the pH remains stable.

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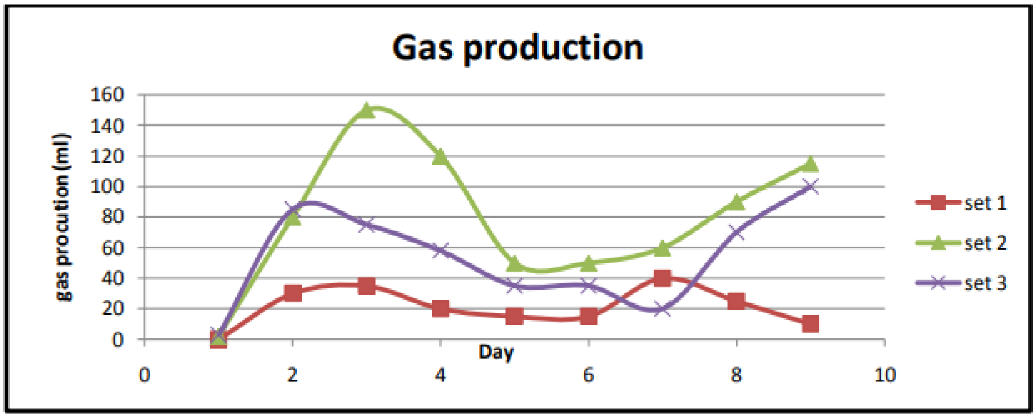


Figure 2.1: Gas production V/s day for three sets

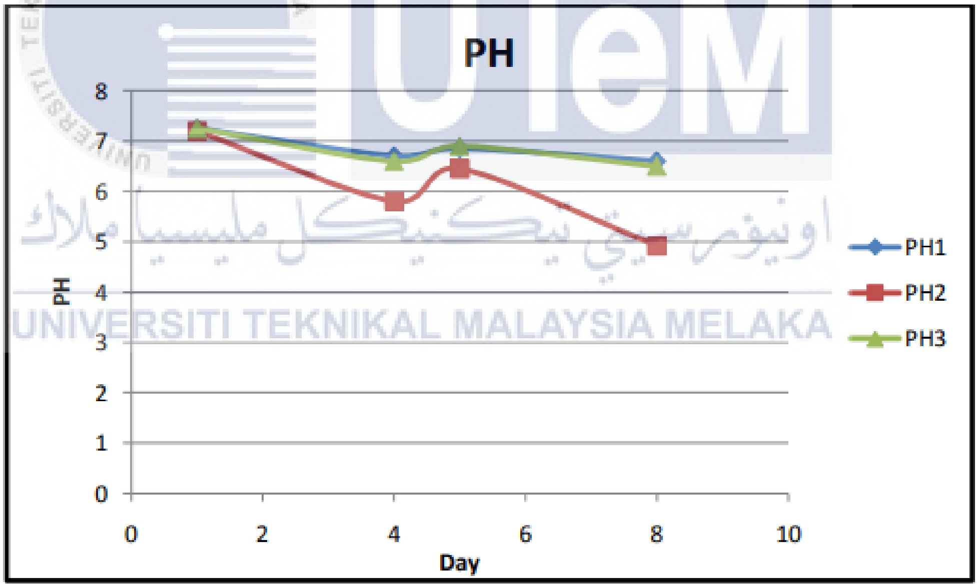


Figure 2.2: pH V/s day

(According to the research paper of (Dhanariya et al., 2015), when 6 kg of food waste is mixed with 7-litre water and 1 kg of cow dung to the biodigester with room temperature 25˚ to 36 ˚ and pH range to 5.5 to 8.5 throughout the experiment. In table 2.2, on day one, the pH starts are from 6.8, and on day five, it decreases to 5.83. But after ten days, it increases to 7.18 until the highest is 7.52 on day 15, then when it comes to day 20, the pH is decreased again until day 25, which is 7.16. Besides that, for temperature start is at 28˚C, and on day five, the temperature drops by three ˚C, then it gets back up again on day ten and increases to 32 ˚C on day 25. Lastly, the volume of biogas produced increases day by day, and the highest reading is 10900ml. So from the result, it can be concluded that when the temperature increases, the amount of biogas is also increases, and the pH value is at optimum for the methanogenesis stage within the narrow range of 6.8 to 8.0 pH value. From figure 2.3, at optimum temperature, pH, and TS%, the biogas production increases, shown in Table. The hydrolysis and acidogenesis stage, which produce bacterial for methanogenesis, is evaluated by the variability in the gas. From the graph, it can be seen that the production of biogas is decreasing in the first week because hydrolysis and acidogenesis reaction is very fast as bacteria utilize the waste. Next from Figure 2.4, pH Graph Analysis - Acid concentration dramatically affects biogas production. From the graph, it can be observed that the gas production is less first up today six but then start increasing. The acid concentration decreases in the digester, and the pH as a slurry of kitchen waste is added to dilute, increasing the pH value. So the gas production starts increasing, but then the Acidogenesis reaction is very fast as bacteria utilize the waste more readily, so gas production decreases.

Table 2.2: Reading of substrate according to the parameter

Parameter	**Days**	**Substrate**
pH	**1**	**6.8**
	5	**5.83**
	10	**7.18**
	15	**7.52**
	20	**7.3**
	25	**7.16**

Temperature

	1	**28°C**
	5	**25°C**
	10	**28°C**
	15	**29°C**
	20	**31°C**
	25	**32°C**
Vol. of biogas produce in ml	**1**	**-**
	5	**400**
	10	**8500**
	15	**8600**
	20	**10650**
	25	**10900**

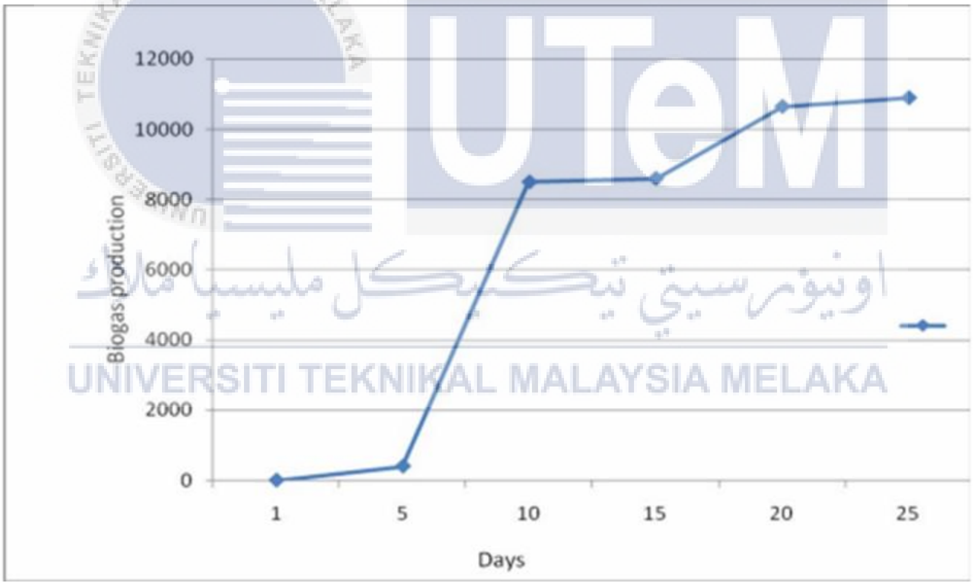


Figure 2.3: Gas production ml vs days

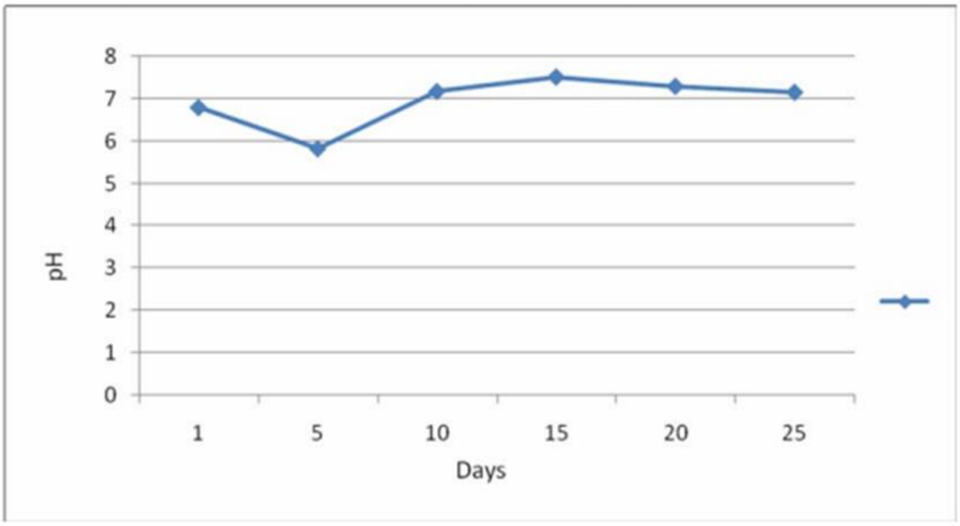


Figure 2.4: Variation in pH vs days

From the study (Ray & Mohanty, 2019), the level for methanogens is 7 to undergo anaerobic digestion. If it is single stage digestion where only one fermenter is used, pH-level is recommended to be maintained. Therefore, there are other factors, such as bacteria need a humid environment with at least 50% of water content for the production of methane building bacteria. Besides that, it also needs a dark environment because this supports the digestion process. After all, the light slows down the process of anaerobic digestion. In addition, nutrients in anaerobic digestion are essential to building up cell material and bacteria. Hence, the retention time is shorter when the substrates are more acceptable, which gives a large surface area, and better digestion process develops for example (Younas et al., 2018) has developed biogas generation using kitchen waste which included a 4-litre shredder that has sharp blades which can be used to chopped and shred the food waste into the smaller piece because this will make the process of anaerobic digestion easier with large surface area and also less time consuming to generate biogas.

Moreover, must create a substrate flow to prevent the bacteria from being overfed. Then, a gas outlet is essential to prevent the gas pressure to become high, and it’s easier for the biogas to escape from the substrate. Besides, avoid other disturbing substances, such as oxygen, antibiotics, or mouldy substrates, because this can affect the digestion process. Therefore, three process parameters describe the digestion process, which is loading on how much is the weight in kilograms of the kitchen wastes per fermenter volume per day are being fed into the digester. Second is the hydraulic retention time, the theoretical duration that the substrate stays in the fermenter.

So when the substrates are easier to break down, the hydraulic retention time will become shorter. Lastly is the degradation percentage. This indicates how much of the total kitchen waste is broken down during the retention period. This is usually about 60% of the time. More is probable, but it would necessitate a considerably more extended retention period.

(Budiyono et al., 2018) studied that organic waste, vegetable waste and fruit waste are the best substrate for biogas. Therefore, adding a buffer to the digester to increase its alkalinity can help the methane genetic develop and improve because the buffer is used in this study to hold the pH constant. It will be in good and neutral condition so that it can be used. Therefore, this research uses Ammonium bicarbonate $NH4HCO3$ and Sodium carbonate $Na2CO3$ which function as a buffer to improve its alkalinity as long as the fermentation process is done. From Table 2.3, it can be seen the notation formula research and compare each Figure 2.5 to 2.8 shows accumulative biogas volume per gram total solid (ml/g total solid) from all various papaya, apples, tomato and orange substrate composition. Biogas production is more at the beginning of fermentation. The acid genesis process causes the non-methanogen microorganism to grow fast. But suppose the pH value is below six and decreases to 5. In that case, it will be no bacteria activity because the pH concentration in the reactor is influenced by the number of ammonia, carbon dioxide, fatty acid volatile(VFA) and its bicarbonate alkalinity, which is produced. After a few days of the fermentation process, the methanogen bacteria start to be more active, and methane gas, carbon dioxide gas, residual gas such as Hydrogen Sulphide and water from Hydrogen gas, carbon dioxide and acetate acid is produced on the genesis stage.

Moreover, Figures 2.9 to 2.11 Acid genic bacteria and methane genic bacteria are the two groups of bacteria that play the most critical roles in biogas reactors. If the anaerobic fermentation is done in an oxygen-free environment, the biogas output would be more optimal. That is why this study uses a buffer to maintain pH to remain neutral and prevent oxygen from entering the digester. From Figure 2.5 – 2.11, it can be seen that adding cow dung into tomato, orange, apple and orange waste can increase biogas production. Hence, adding cow dung on fruits substrate can increase daily biogas cumulative production. Also, the ratio of 1:2 of food waste and water F/W with sodium carbonate as a buffer to control the pH produces a higher reading of biogas than the ratio of 1:1 F/W.

Table 2.3 Reading of substrate according to the parameter

Formula	Symbol	Ratio F/W	Biogas Substrate Production
1	♦	1:1	Fruit substrate+Ruminant+Urea+Cow dung+Na_2CO_3+water
2	▪	1:2	Fruit substrate+Ruminant+Urea+Cow dung+Na_2CO_3+water
3	▲	1:1	Fruit substrate+Ruminant+Urea+ +Na_2CO_3+water
4	X	1:2	Fruit substrate+Ruminant+Urea+ +Na_2CO_3+water
5	*	1:1	Fruit substrate+Ruminant+Urea+ +NH_4HCO_3+water
6	●	1:2	Fruit substrate+Ruminant+Urea+ +NH_4HCO_3+water

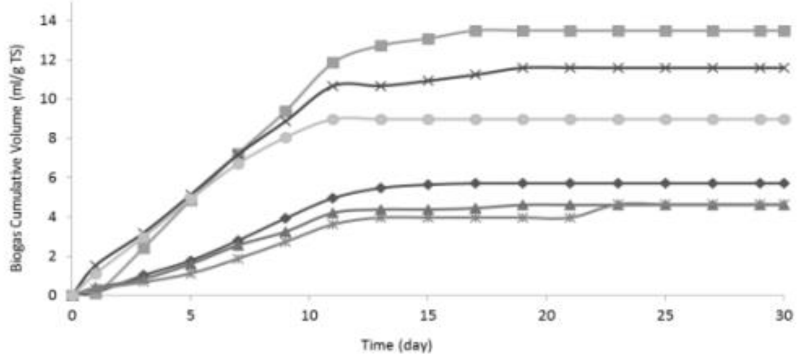


Figure 2.5: All Various Orange Substrate Composition for Biogas Accumulative Volume per Gram Total Solid (ml/g total solid)

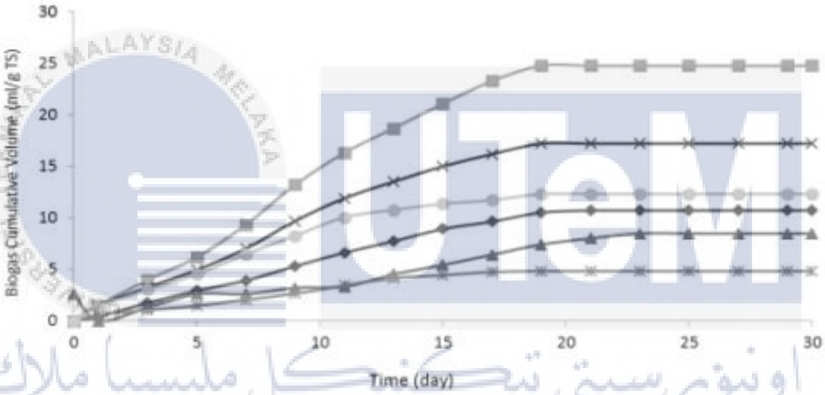


Figure 2.6: All Various Apple Substrate Composition for Biogas Accumulative Volume per Gram Total Solid (ml/g total solid)

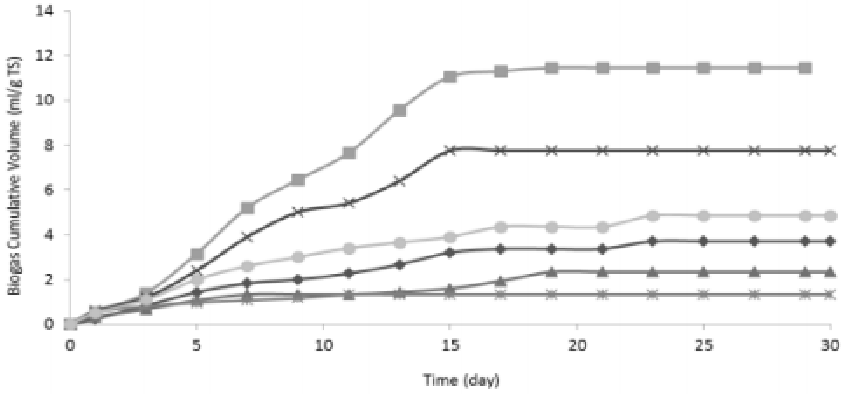


Figure 2.7: All Various Papaya Substrate Composition for Biogas Accumulative Volume per Gram Total Solid (ml/g total solid)

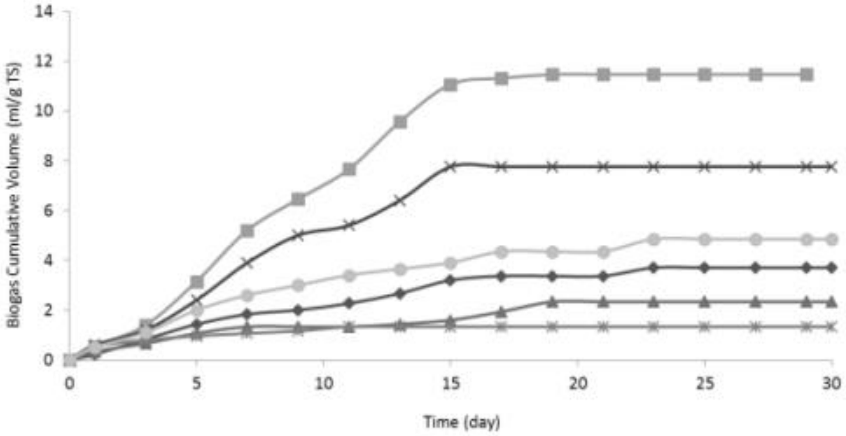


Figure 2.8: All Various Tomato Substrate Composition for Biogas Accumulative Volume per Gram Total Solid (ml/g total solid)

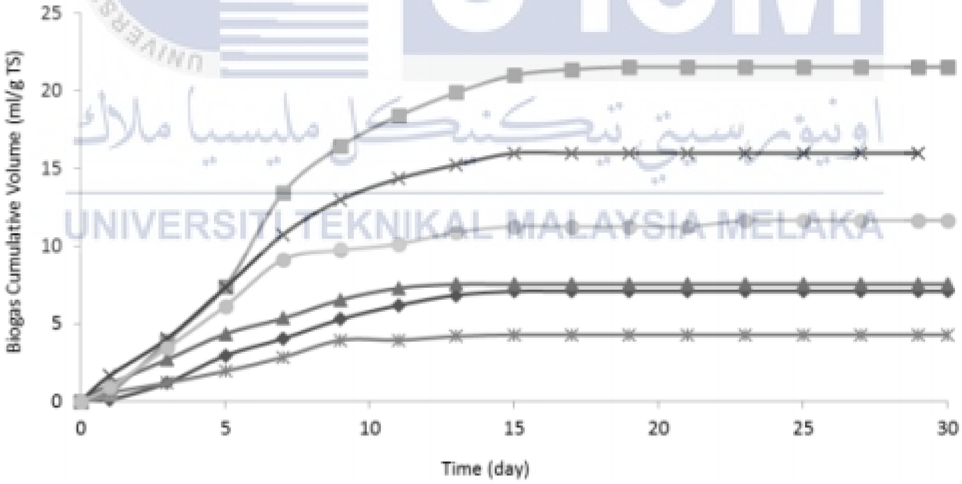


Figure 2.9: All Composition Substrates between Tomato and Orange for Biogas Accumulative Volume per Gram Total Solid (ml/g total solid)

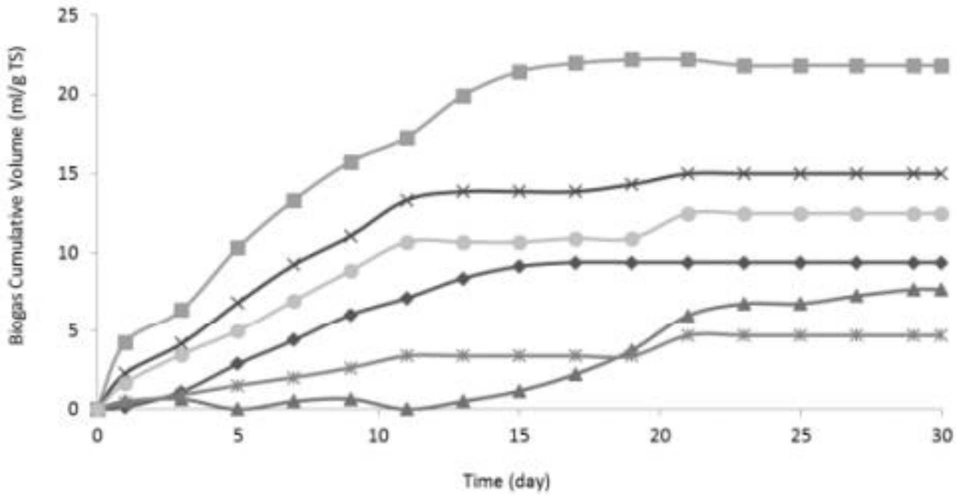


Figure 2.10: All Composition Substrates between Papaya and Tomato for Biogas Accumulative Volume per Gram Total Solid (ml/g total solid)

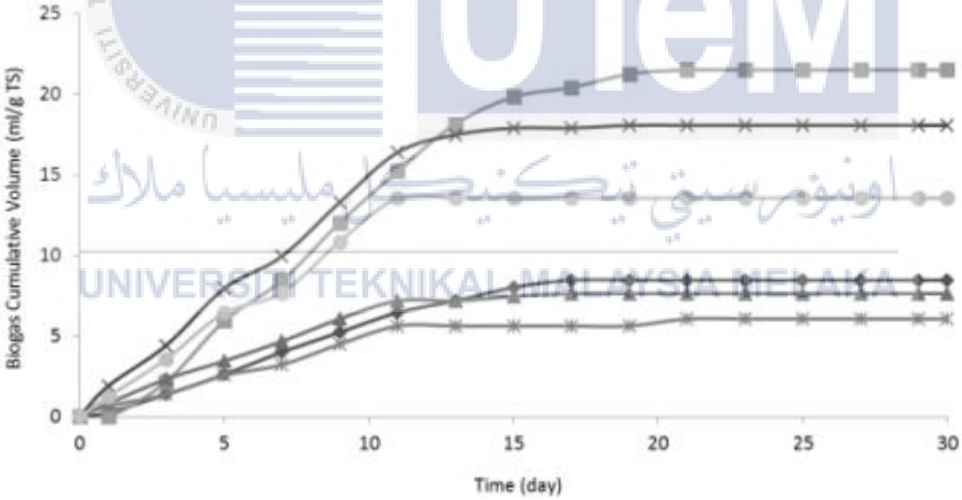


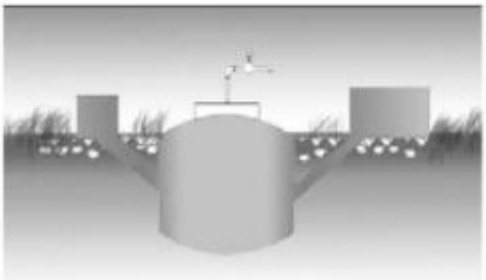
Figure 2.11: All Composition Substrates between Papaya and Apple for Biogas Accumulative Volume per Gram Total Solid (ml/g total solid)

2.3 Type of Biogas Digestion Design

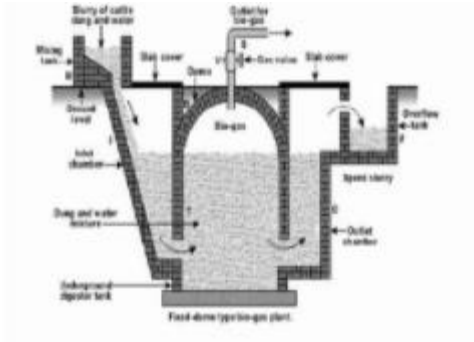
(Bhol et al., 2011) have reviewed the Biogas digester in India. There are three types of digester: fixed dome digester, floating type digester, and bag type digester. This digester needed to meet the criteria, such as durable, compact, and versatile. Besides that, it needs to be operated with a minimum of monitoring and regulating. Also need to maximize the amount of biogas produced per time and have a continuous flow of anaerobic digester. Next, it also should reduce time and money on maintenance. Lastly, the user needs to know how to operate and understand the function of the biodigester.

2.3.1 Dome Biodigester

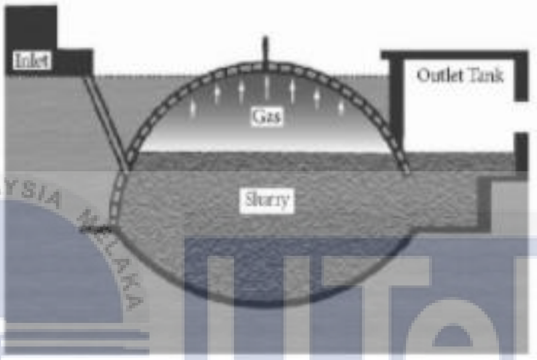
According to the study of (Bhol et al., 2011), a fixed-dome biogas plant has low operating costs. It's easy because there are no moving pieces. There are also no rusting steel pieces, implying that the plant can last a long time (20 years or more). The plant is built underground, protecting it from physical damage and saving space. Although the underground digester is insulated from low temperatures at night and during the winter, it takes longer for the digester to warm up in the summer. The bacteriological processes are not influenced by the digester's day/night temperature variations. Chinese fixed-dome plant is normally constructed using bricks and mortar, but the main disadvantage is that it can only produce gas of variable pressure. Therefore, as a response to the Chinese fixed dome plant, the Janata model was the first fixed-dome concept in India. It is no longer being built. Deenbandhu was more crack-proof and consumed less building material than the Janata plant with a hemisphere digester which all of the fixed dome biogas plants is shown in Figure 2.12.



A: Chinese fixed-dome plant



B: Janata model

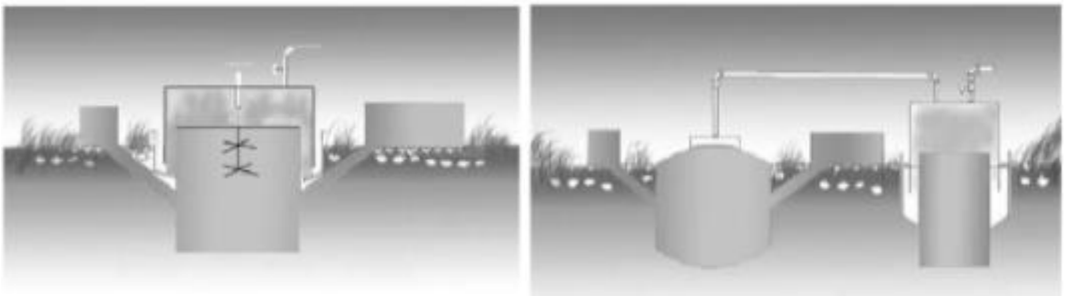


C: Deenbandhu Model

Figure 2.12: Fixed-dome biogas plant

2.3.2 Floating Dome Biodigester

(Singh & Sooch, 2004) studied that the Khadi &Village Industry Commission (KVIC) of India created and popularized this design, known as the KVIC model shown in Figure 2.13. This was standardized in 1962 and is still widely used today. An underground well-shaped digester with inlet and outlet connections through pipes located at the bottom on either side of a partition wall is used in these plants. In the digester, an inverted drum (gas holder) made of mild steel sits on the wedge-shaped support and the guide frame at the level of the partition wall. With the accumulation and disposal of gas, this drum will go up and down along a guide pipe. The drum's weight exerts pressure on the gas, causing it to flow through the pipeline to the point of use.



A: Cylindrical digester B: Dome digester

Figure 2.13: Floating type digester

2.3.3 Tubular Bag Biodigester

A polyethene biodigester device is a tubular structure made of polyethene "plastic" bags shown in Figure 2.14 with an inlet for organic material (manure) and an outlet for decomposing material (effluent). The fermentation unit comprises two parts: a liquid phase and a gas phase. The liquid process is made up of a 4:1 mixture of water and manure(Ortega, 2009)

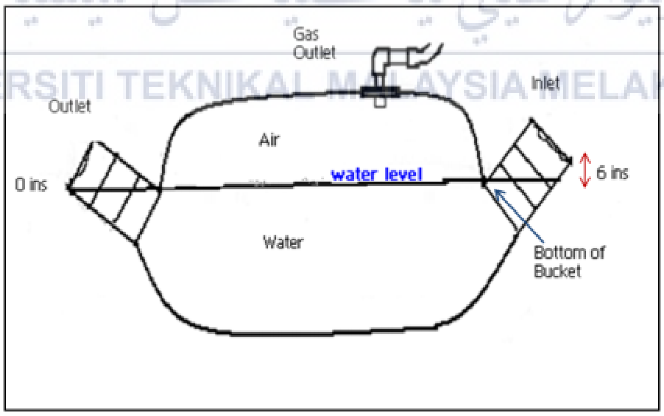


Figure 2.14 Tubular Bag Biodigester

2.4 Biogas Digester Body Material Type

According to (Daniyan et al., 2019) research paper, galvanized steel lagged with fibreglass is used for the fabrication of the digester which to retain the heat absorbed by the digester tank. Besides that, they design with water tightness to prevent seepage and groundwater quality and the resultant threat to the soil. Ensure proper containment to prevent air from entering into digester for biogas yield. In addition, the design also has good tensile strength and ease of rolling by machine. Hence a stirrer with paddle type impeller blade connected to the shaft driven by the spark-less electric motor is installed. Figure 2.15 show the design of the biogas system.

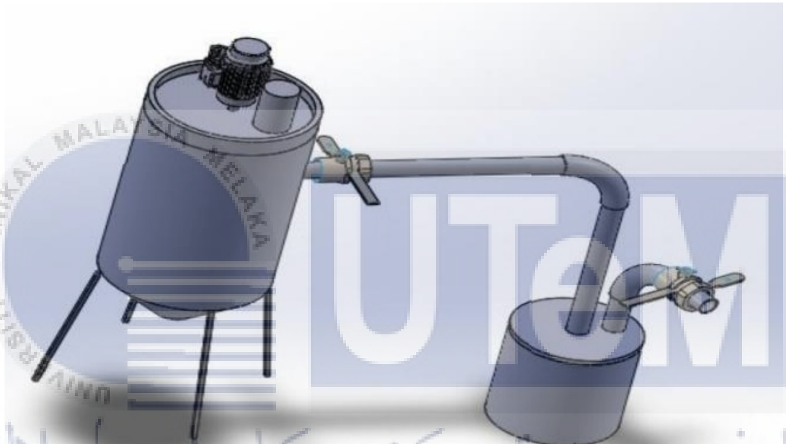


Figure 2.15: Galvanized steel lagged with fiber glass bio digester

(Jekayinfa et al., 2014) have designed and constructed a metallic (stainless steel) biodigester to produce biogas from cow dung that will be mixed with water in ratio 1:2 about five gallons of particular mass. This experiment is carried out under mesophilic temperature and an average retention time of 30 days. The design of the metallic biodigester is shown in Figure 2.16.

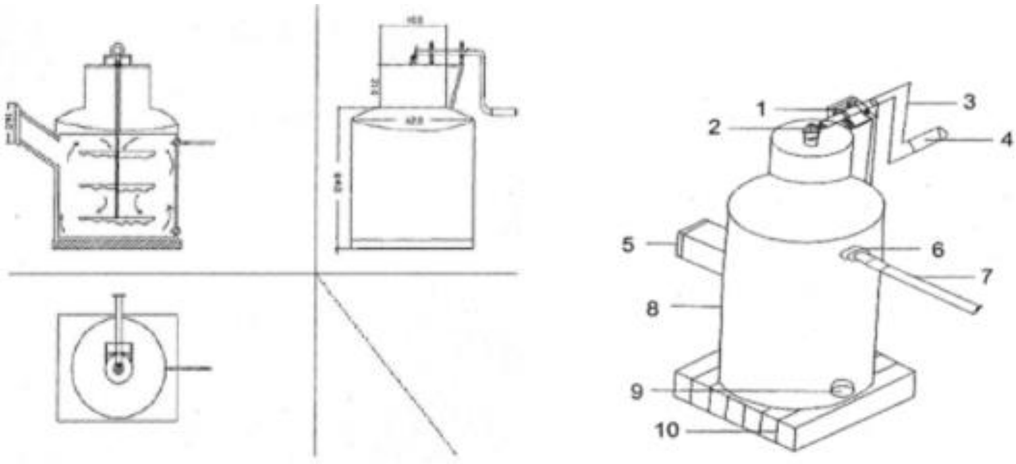


Figure 2.16: Stainless steel digester

According to ((SCI), 2016), stainless steel is corrosion resistant which will be able to resist the corrosive elements in a biodigester without expensive additional coatings are required. Next, stainless steels have an economical design with strength, stiffness, flexibility, toughness to build the biodigester. It also requires low maintenance and repair requirements which will save cost. Lastly, having a quick installation that does not require expensive heavy-duty that involve scaffolding and heavy machinery also needed to be added that it is recyclable. From Table 2.4, the average internal and external temperatures were 32.3 and 38.8 degrees Celsius. The developed metallic bio-digester is appropriate for biogas production from cow dung at mesophilic temperature.

Table 2.4: Average Temperature Readings during Biogas Production

HRT	Temperature (°C)	
Weeks	Internal	External
1	33	38
2	34	39
3	33.5	40

4	32.5	38
Average	32.3	38.8

Based on (Younas et al., 2018), a thick plastic drum as a digester chamber in which kitchen waste is added for the anaerobic digestion process is used. The digester is shown below in Figure 2.17. By using Biogas digesters are generally made of plastic (low-density polyethene (LDPE), high-density polyethene (HDPE) or polyvinyl chloride (PVC), and therefore they are flexible and take the form of containers in which they are installed, most often installed in the ground(Fahriansyah et al., 2019). It is much cheaper, simple to operate, and has good maintenance (Adebayo et al., 2014).

Figure 2.17: Thick plastic Biogas digester

2.5 Biogas Stirrer

According to (Rojas et al., 2010), the stirring and biomass starter influences the anaerobic digestion of different substrates for biogas production. This paper compared the stimulating effect (batch reactor) and (continuous reactor). A total volume of 500ml is shown in Figure 2.18. (A) of the batch, reactors are filled with inoculum (digested biomass from Wittmund). But then, only half of the bottles were stirred with a magnet stirrer. The second is the continuous reactor, where the stirrer is performing in a 7L of digester tank. The second test is conducted without a stirrer, and later, biogas will be measured using a miligascounter and an infrared gas sensor device. Therefore, feed without stirring had the same amount of food frequency to compare biogas production with a stirrer and without stirrer. From the graph above in Figure 2.19 and 2.20, it can be observed that the amount of biogas produced is much higher with stirrer compared to no stirrer as it can be seen on day one the biogas yield at almost the amount of $400m^3/t$ OTS with stirrer and 250 m^3/t OTS without stirrer in batch experiment (A).

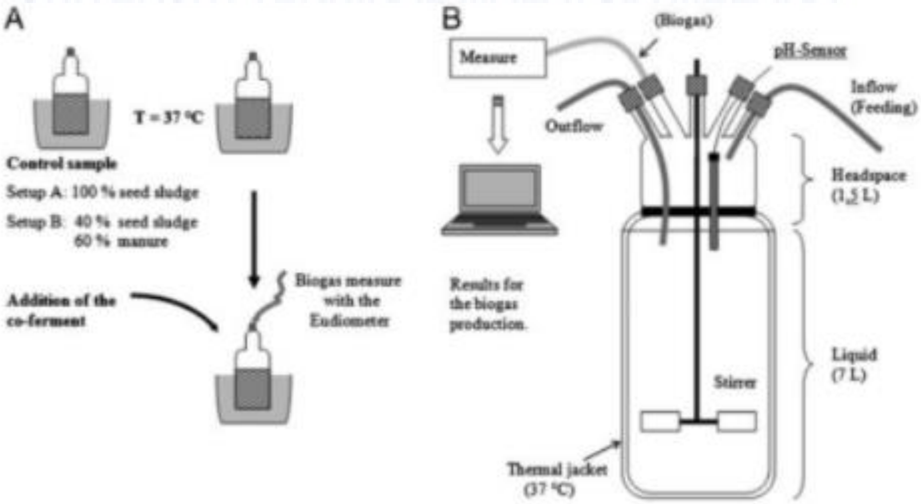


Figure 2.18 Diagram of equipment. (A) Batch experiment and (B) continuous reactor

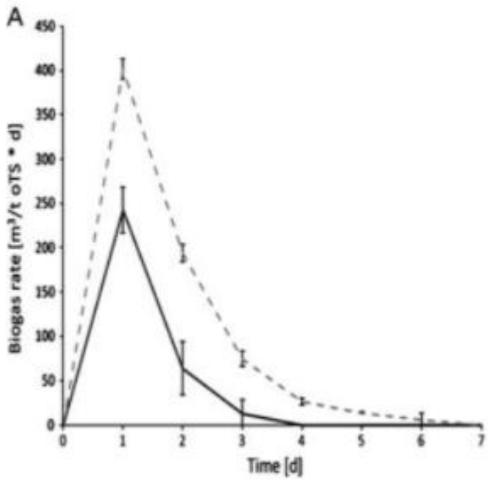


Figure 2.19: Biogas rate vs time

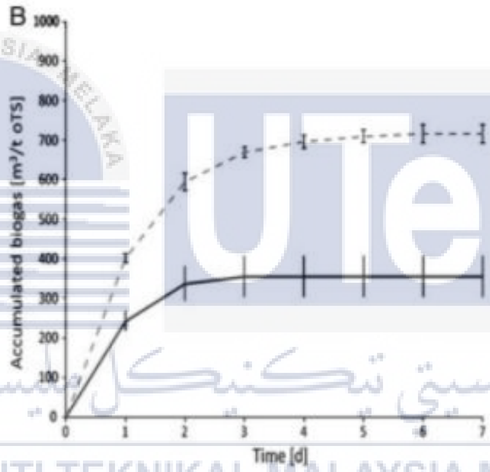


Figure 2.20: Accumulated biogas vs time

Therefore, both begin to decrease the amount of biogas production until day seven there is no more gas production. So when compared to the continuous reactor, it indeed gives a lot better gas production as for with stirrer the amount of biogas production is around 699 m^3/t OTS and without stirrer is between the number of 318 m^3/t OTS compared with the process with stirring: only 45% of the available organic substrate was digested in 7 days digested time. The production of biogas becomes maintained on day four till day seven without decreasing biogas production. The experiments without stirring presented considerable lower biogas yields. That means the biogas production without stirring was reduced to about 60% compared with stirring for this substrate.

Besides stirrer, the starter biomass can also affect biogas production as lipid-rich waste and corn silage using 60% manure slurry as part of the starter shown in Figures 2.21 and 2.22. When manure is aggregated as part of the starter, the results show that the impact of stirring on biogas yield is negligible. The batch experiments without stirring present similar digestion to the experiments with stirring for lipid-rich waste, according to Figure 2.21. Furthermore, the biogas in both cases yields at the same anaerobic digestion around 700 m^3/t OTS. By comparing the result by using lipid-rich waste as fermenting in the stirred batch reactor for seed sludge of the Wittmund biogas plant without and with manure as shown in Figure 2.21 A and Figure 2.22 A shows an increase of value in the reaction time for the maximum rate from the first day to the second day with final accumulated biogas collected in both cases is 700 m^3/t OTS.

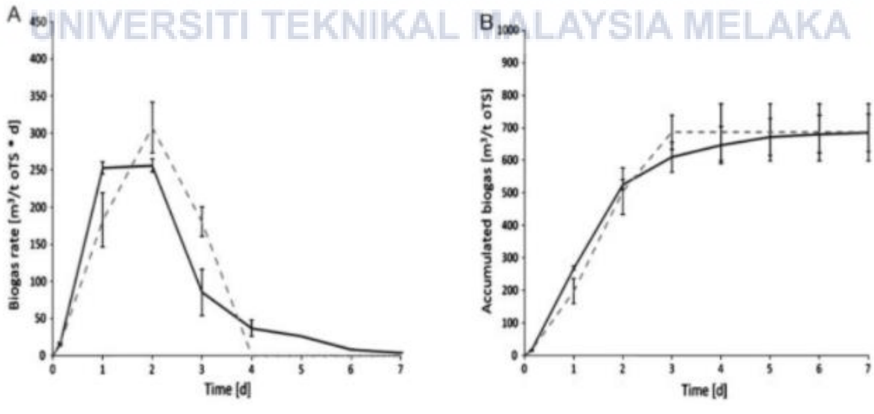


Figure 2.21 Lipid rich waste Biogas rate and accumulated biogas

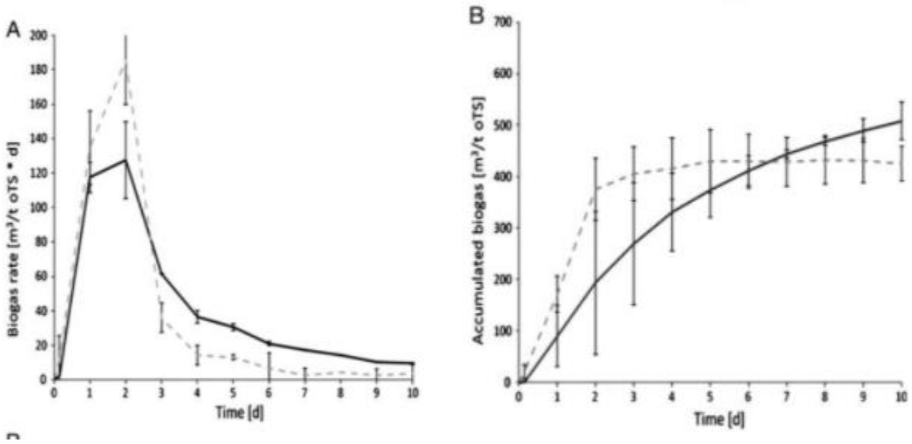


Figure 2.22: Corn silage Biogas rate and accumulated biogas

The effect on reaction time may be due to the substitution of manure for a portion of the seed sludge, resulting in a reduction in bioactive material. The seed sludge contains $5m^3/t$ OTS, while the manure contains 1.38 %, implying that the OTS of fresh manure slurry accounts for around 1% of the particulate, chemical oxygen demand. It's fair to assume that a higher concentration of digested biomass, combined with a higher concentration of bacteria, affects the biogas rate in the beginning. Next, Corn silage as co-ferment shows no significant difference in biogas between stirred and non-stirred batch reactor when manure is added for a starter. The reading of biogas production is higher compared with the lipid waste. The corn silage reaches a maximum biogas rate of approximately 185 m^3/t OTS with a stirrer and 125 m^3/t OTS without stirrer in Figure 2.22 A. In addition, the particle size of corn silage is relatively large and homogeneous, and it appears as accumulations on the surface of the dispersion in the batch reactor. A larger particle of corn silage will make a more significant tendency to float on the liquid. Lastly, the contact between the bacteria and the substrate is reduced with manure, making the stirring effects insignificant for the biogas yield. Both cases of corn silage with and without stirring yield comparable biogas yields, about 450 and 400 m^3/t OTS, respectively. As a result, the biogas yield obtained using a digested biomass–manure mixture as a starter without stirring is equivalent to the biogas yield obtained using a pure digested biomass as a starter with stirring, which is 437.

(Fahriansyah et al., 2019) have studied a design of a conventional mixer for biogas digester, a manual mechanic mixer of biogas digester and is used to mix biogas-producing organic waste in a fixed-dome type digester. Figure 2.23 and 2.24 is the stirrer's design and a manual stirring to stir the organic waste. In figure 2.23, the stirrer is a turning lever attached to a horizontal shaft supported by bearings. The movement of the horizontal shaft is channelled through a straight cone gear to the vertical shaft supported by bearings. Three pairs of drivers are linked to the vertical axis; each driver has one horizontal fin and three vertical fins, and it is installed to a fixed dome type digester. This digester is made of fibreglass, which is much cheaper in construction cost, more efficient to handle, lighter, and stronger.

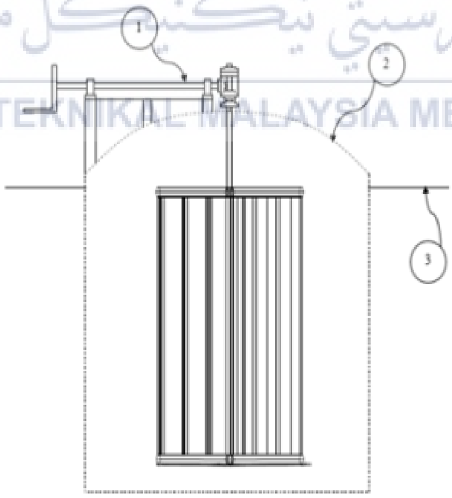


Figure 2.23: Mixer in the digester

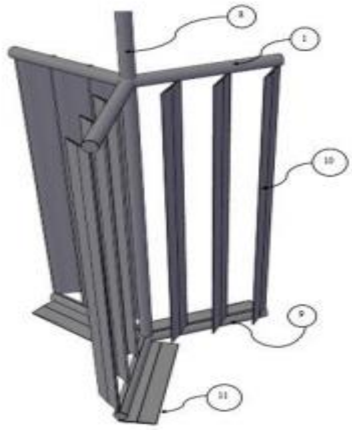
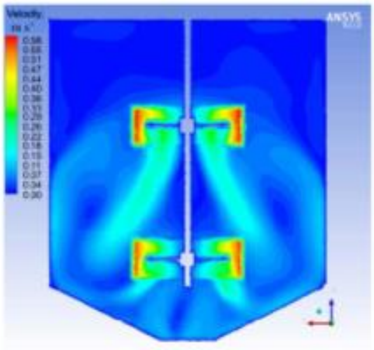
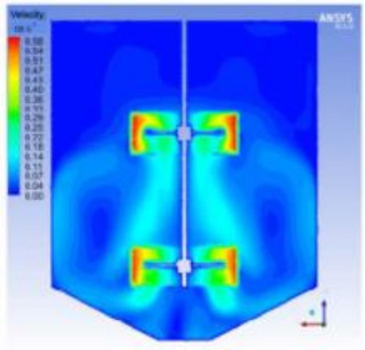


Figure 2.24: Three-dimensional view of the mixer

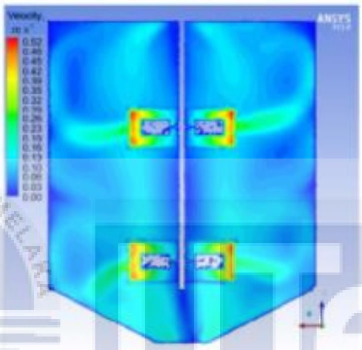
(Mohammadrezaei et al., 2017) researched the performance of mechanical stirring in biogas plants by computational fluid dynamics (CFD) that was used to determine a suitable mechanical stirrer for biogas plants and stimulate the flow pattern of cow manure. There are three types of impeller: six flat blade disc turbines, six-blade turbines, and four-blade turbines are studied to be selected for the optimum design of the impeller. These three design impellers have tested the effectiveness to stir the slurry by using the Fluent 15.0 software package in Figure 2.25. From the simulation of the working of the three types of impellers and as it observed that the six flat blade disc turbine impellers are more efficient than the other two impellers because it provides the maximum mixing zone, but for the other two impellers it only able to mix the bottom part of the substance. So the six flat blade disc turbine impeller is the most effective stirrer to stir the slurry.



A: six blade turbine impeller



B: Four blade turbine impeller



C: six flat blade disc turbine impeller

Figure 2.25: The result of the simulation when each stirrer is working

2.6 Raw Biogas Gas Filtrations

Biogas filtration is crucial to producing top-quality cooking fuel (Industry 2015). Based on the development of (Lohani et al., 2017), the biogas scrubbing system consists of three units, the hydrogen sulphide (H_sS) removing the unit, Carbon dioxide (CO_2) removing unit, and moisture trapping unit. In the experiment, there are three units interconnected with plastic hoses: steel wool shown in Figure 2.26, which is before scrubbing and Figure 2.27 after scrubbing. Next, pure water and an adsorbent material (silica gel) were used in the purification process of biogas. The original colour of silica gets shown in Figure 2.28. the colour of silica changes to pink after moisture is removed, shown in Figure 2.29. So, desulfurized, which contain sponge of steel wool to remove hydrogen sulphide.

Then next is the carbon dioxide scrubber, which contains water to remove carbon dioxide, and moisture remover was added to remove moisture which contains silica gel. After that, when carbon dioxide is dissolved in water, carbonic acid (H_2CO_3) is formed. It is a weak acid. The concentration of carbon dioxide will increase after the liquid leaves the scrubbing unit. The methane concentration will also increase as the gas leaves the scrubbing unit. Therefore, water vapours can be found in the filtered biogas obtained at the top of the scrubber unit; usually, corrosion is often caused by water vapour. In this experiment, silica gel was used to achieve water content as low as purified biogas. Silica gel is a type of material that can absorb moisture. Also, this paper shows that purifying raw biogas reduces the cooking time, which is shown in Table 2.5, which means methane is a flammable gas that adds to the combustion mixed with other mixtures that are useless, harmful, and toxic. So, is a necessary need to be removed from raw biogas to increase the quality of calorific value.

Figure 2.26: Steel wool before scrubbing the raw biogas

Figure 2.27: Steel wool after scrubbing the raw biogas

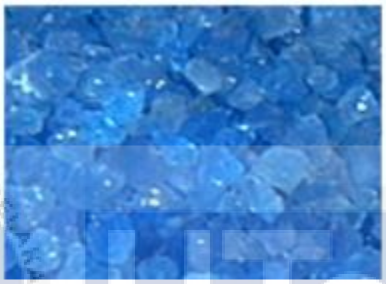


Figure 2.28: Ready to use silica gel for raw biogas

Figure 2.29: Silica gel turns pink once it has soaked up moisture from the filteration of biogas

This can be proven in the research paper of (Jekayinfa et al., 2014) that has been developed a biodigester but with no biogas filtration. From Table 2.6, it can be observed that percentage of before and after digestion of ash content decrease about 1.26% and for volatile acidity, it increases about 0.706%. The dry matter also increases from 86.40 % to 94.10%. As for the pH, it is 13.6 % initially, but when Sodium hydroxide is added, it reduces the acidity to 8.2% after digestion, indicating that the methanogenic bacteria had broken down volatile fatty acids create a neutral slurry. Nitrogen decreases by 1.09%, Phosphorus increases to 0.81% from 0.74%, Potassium slightly increases as much as 0.09%, carbon also increases t0 5.42% from 4.72%, and lastly, for organic matter, it increases 9.60% from 8.17%. Then, the findings of the chemical analysis of fresh cow dung before and after digestion are shown in Table 2.7. A total of biogas was generated. The biogas produced consisted of 59 % methane (CH_4), 40 % carbon dioxide (CO_2), 0.08 % hydrogen sulphide (H_2S),and 0.003% water vapour. The gas has been tested using Kerosene and Domestic Gas from this result. The result is shown from Table 2.8, where biogas takes the longest time boiling the water compared to the two other fuel gases, which are domestic kerosene gas. This shows the presence of 40 % carbon dioxide slows down the heat combustion process to boil water.

Table 2.5: Time for boiling 500 ml of water.

Energy Source	Time (minutes) for boiling 500 ml of water
Raw biogas	5.62 ± 0.02
Purified biogas	4.54 ± 0.03

Table 2.6: Results of Chemical Analysis of Fresh Cow Dung

Component	Analysis before digestion (%)	Analysis after digestion (%)
Ash content	3.40	2.14
Volatile acidity	3.140	3.826
Dry matter	86.40	94.0
Moisture content	13.6	5.12

Ph	7.3	8.2
Nitrogen	3.42	2.33
Phosphorus	0.74	0.81
Potassium	2.38	2.47
Carbon	4.75	5.42
Organic matter	8.17	9.60

Table 2.7: Percentages of the Components of Biogas

Component	%Composition
Methane (CH_4)	59.0
Carbon dioxide (CO_2)	40.0
Hydrogen Sulphide(H_2S)	0.08
Water Vapour	0.003

Table 2.8: Time Variations of Biogas Testing with other Fuels (Kerosene and Domestic Gas)

Fuel	Duration of Boiling
Biogas	15 minutes 21 seconds

2.6.1.1 Scrubber Unit

$\boldsymbol{CO_2}$ Seperating Unit

Carbonic acid (H2CO3) is generated when carbon dioxide is dissolved in water. It's a very weak acid.

$$H_2O + CO_2 = H_2CO_3$$

As a result, the liquid leaving the cleaning unit will have a higher carbon dioxide concentration, whereas the gas leaving the scrubbing unit will have a higher methane concentration. Water vapours can be found in the purified biogas collected at the top of the scrubber unit. The primary cause of corrosion is water vapour. In this experiment, silica gel was employed to achieve water content as low as pure biogas. Silica gel is a porous substance with the ability to absorb moisture.

2.6.1.2 H_2S Seperating Unit

Hydrogen sulphide is eliminated using a catalyst iron oxide, which can be found in the form of oxidised steel wool or iron turning in any workshop. Iron oxide is transformed to elemental Sulphur when biogas comes into touch with this wool.H_2S Seperating Unit.

$$2Fe_2O_3 + 6H_2S = 2Fe_2S_3$$
$$2Fe_2S_3 + 3O_2 = 2Fe_2O_3 + 6S$$

2.6.1.3 Moisture Seperating Unit

Silica gel crystals are used to separate moisture. According to the rate of purification, silica gel crystals should be replaced after a certain amount of time. The scrubbing units' capacities are determined by the size of the biogas plant. The biogas that comes out of the cleaning machine is now 98 percent pure.

2.7 Gas Storage for Biogas

Filtered biogas will be stored in biogas storage, and there are a few types of biogas storage that can be used to store biogas before compressing them into the LPG Cylinder tank. Based on the development of biogas, digester (Younas et al., 2018) have used rubber tube tires to store the filtered gas with a 16-inch diameter which then grew to 23 inches when the biogas is filled inside Figure 2.30. Besides that, (Ray et al., 2016) have developed a biogas production, compression, and storage system suitable for cooking gas in rural households. The digester is a floating drum type digester that produces biogas by anaerobic digester of kitchen waste. The gas is collected in an elastic balloon shown in Figure 2.31.

Figure 2.30: Storage tube

Figure 2.31: Elastic balloon Biogas storage

From the research paper of (Lohani et al., 2017), after collecting the biogas, it needs to be compressed and stored in the LPG tank to be used in the kitchen. A compressor, a pressure gauge and an LPG cylinder are the three units used for the biogas storage system. For the compressor, a hermetic reciprocating type compressor is used in the manufacture of commercial refrigerators with a hydrocarbon refrigerant that will be the compressor to compress the biogas to the LPG cylinder tank then it will be monitored by the pressure gauge shown in Figure 2.32. But from the research paper of (Ray et al., 2016), after the filtration of biogas, a compression mechanism is a design that involves a foot compression pump that delivers 0.015m^3/min and delivers pressure is up to 4bar with the use of two cylinders to support the stand by the frame which is shown in Figure 2.33. Lastly, the compressed biogas is stored in the LPG cylinder.

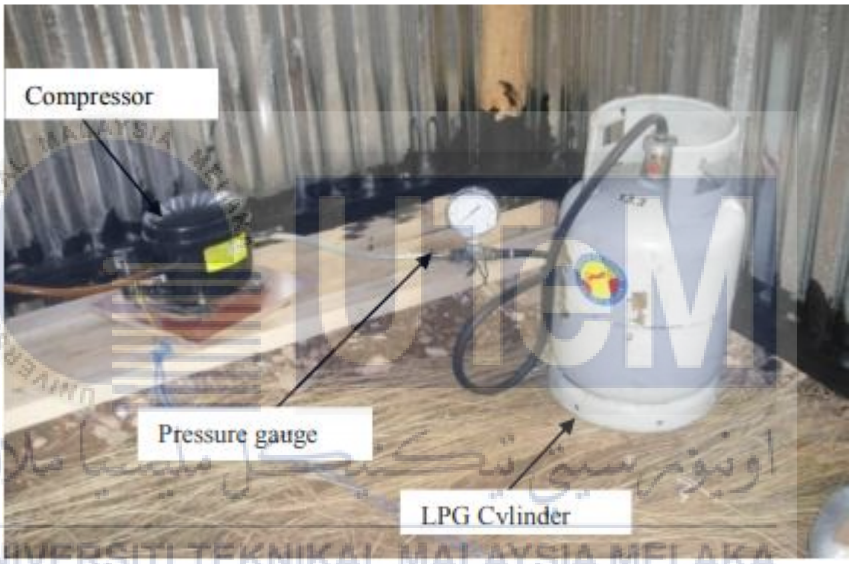


Figure 2.32: Biogas Compression and Bottling System

Figure 2.33: Foot pump compressor

2.8 IoT Smart Stove

According to the analysis of fire losses and characteristics of residential fires based on investigation data in Selangor from 2012 until 2014 (Tan et al., 2012). The data collected regarding residential fires from fire investigation reports prepared by the Selangor Fire and Rescue Department show that residential fires are more likely to occur from 8 am to 6 pm, as shown in Figure 2.34. Besides that, Kitchen is also the cause of the residential fires shown in Figure 2.35. Moreover, Tables 2.9 and 2.10 show cooking appliances, which are ranked second, are another common source of ignition caused by carelessness or negligence while cooking and leaking of gas in the Kitchen that needs to be concerned.

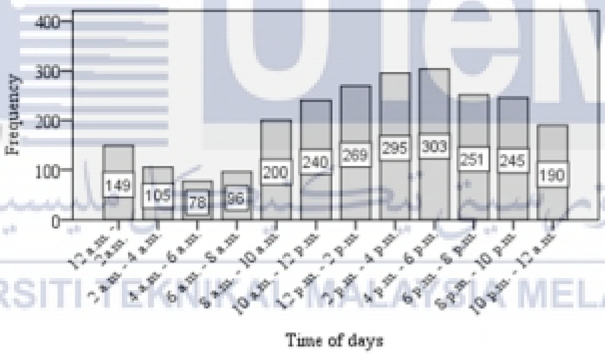


Figure 2.34: Frequency distribution by time of day

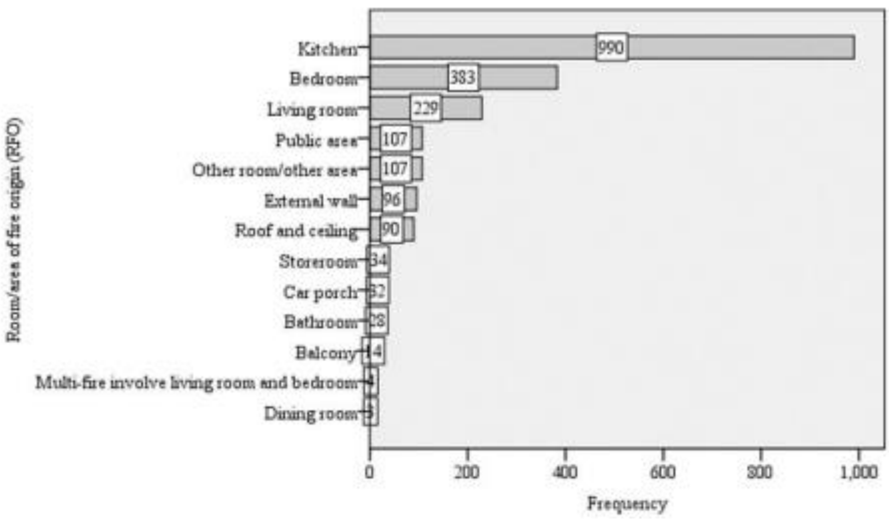


Figure 2.35 Room or area of fire origin

Table 2.9: Frequency table of ignition factors

Ignition Factors	Frequency
Electrical failure	611
Careless or negligence during human activity e.g. cooking	189
Heat source close to combustion materials	167
Incendiary	92
Leaking of gas	92
Lightening strikes, including short circuit after	80
others	76
Abandoned or discarded materials e.g. cigarattes	47
Children playing fire	47
Unknown i.e specified as unknown after investigation	6
Drugs,alcohol impaired and mental illness	3
*Unspecified or missing data	253
Total	2423

Table 2.10: Frequency table of ignition factors

Source of Ignition	Frequency
Electrical	949
Cooking appliances	834
Matches or lighter	194
Glowing fire including cigarette, mosquito coil and joss stick	138

Candle or torch	118
Lightening	80
Others	45
Hot object or surface	15
Fireworks or firecrakers	13
Friction	4
Unknown i.e specified as unknown after investigation	3
*Unspecified or missing data	30
Total	2423

This problem can be solved with the help of IoT, which is easier to use and more efficient. User according to (Stępień 2019). The Internet of things will be more included in everyday life and will impact individuals the society they live in. Until today, IoT kitchen devices may increase the quality of life and increase safety precautions by making the cooking process efficient with monitoring, convenient and time-saving.

2.8.1 What is IoT

Internet of Things development implies that the environments, cities, vehicles, clothing, portable devices and other objects have more and more information associated with them and the ability to sense, communicate, network and produce new information. In addition, the network technologies have to cope with new challenges such as very high data rates, low energy, low latency, dense crowds of users, low cost and a massive number of devices. Wireless connectivity anywhere, anytime, and between everybody and everything, such as smart houses, cities, vehicles, and offices, is gaining momentum, making our daily lives more accessible and efficient. This momentum, rendering our daily lives more accessible and more efficient as it will continue to rise, resulting in the need to enable wireless connection between people, machines, communities, physical things, processes, content and more at any time, reliable and secure ways. However, the emerging trend of connecting everything to the internet brings up the need to go beyond this approach (Vermesan et al., 2015).

According to (Stępień 2019), The Internet of Things (IoT) is one of the most rapidly evolving technologies in the twenty-first century. As with every advancement in information technology, the Internet of Things (IoT) causes social and economic disruption. Innovative technologies cover many topics, including healthcare, education, commerce, and city infrastructure. However, most IoT technologies are used to help people. On the other hand, IoT apps are most commonly used on personal devices like wearable and home appliances. A "smart" home environment can be built by integrating IoT into a household—a location where several devices are interconnected and take actions based on the sensing. This phenomenon has a massive impact on people's lifestyles. IoT products for the home often take on new roles, introduce new modes of interaction, and alter consumer behaviour patterns.

The Internet of Things (IoT) offers solutions that combine information technology (hardware and software used to store, retrieve, and process data) and communications technology (electronic systems used to communicate between individuals or groups). At three levels of technological advancement, the rapid integration of knowledge as communications technology is taking place: the clouds, data and communication networks and devices (World Economic Forum, 2012)

2.8.2 Type of smart stove

The development project of (Hsu et al., 2019) uses the IP Camera attached to a cell phone to check the status of the kitchen's cooking fire. When the user realizes that they haven't switched off the stove, a phone button to connect to the Webduino is used and toggle the relay to turn off the main gas switch. When any of the sensors detect a value greater than the set value, the controllable function at the bottom of the figure can be enabled. The Internet of Things was used in this study to build a smart kitchen fire prevention system. Integrating the control board, sensing components, managed devices, and designing control software were all part of the system architecture. It was also decided to set up Line alerts shown in Figure 2.26, compatible with any type of phone. The proposed system can be used as a model for developing kitchen fire suppression systems.

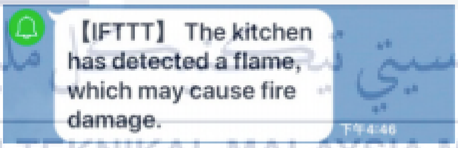


Figure 2.36: Notification message on Line

From Figure 2.37, three control panels were used in this study: Arduino, Webduino, and D1 Mini. Arduino reads the sensor's detection data after it establishes the link. It sends a notification to the D1 Mini and triggers the sound and flash warning features. It is also connected to the electrical appliance to turn it on. Open the gas main switch and close the door. These positions do not necessitate the use of Wi-Fi. Webduino is used in this study to perform similar remote invalidation controls. Webduino can be linked to the network quickly since it already has Wi-Fi networking capabilities. When the stove is turned off, press the phone button to connect to the Webduino and allow the relay to turn off the main gas switch. When any of the sensors detect a value greater than the set value, the controllable mechanism at the bottom of the figure may be used to activate the alarm and open the lock the door, send a Line notification note, and turn on the light.

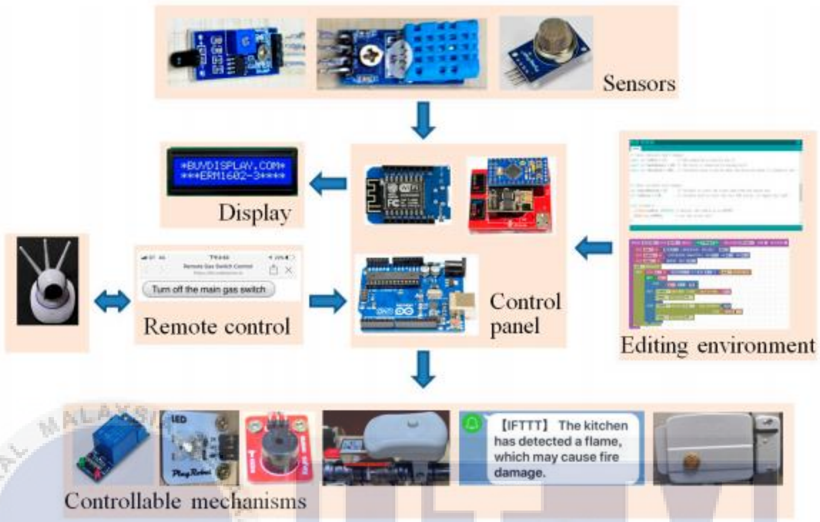


Figure 2.37: Architecture of the smart kitchen fire prevention system.

Another research paper that developed the Smart Kitchen system by (Nugroho & Pantjawati, 2018) in Figure 2.38 show that the Arduino is connected to the power supply. The DHT11 sensor detects temperature changes, the Mq-135 sensor detects LPG gas leaks, the IR flame sensor detects a fire, and the PIR sensor detects human activity in the kitchen. The sensor's data will be directly sent to the Arduino via digital or analogue pins, which controls the relay. In the case of a gas explosion, an uncontrolled fire, or an extreme temperature rise, the relay functions as a fan switch. In these circumstances, Arduino will also trigger the alarm and the led and send data to the computer web server.

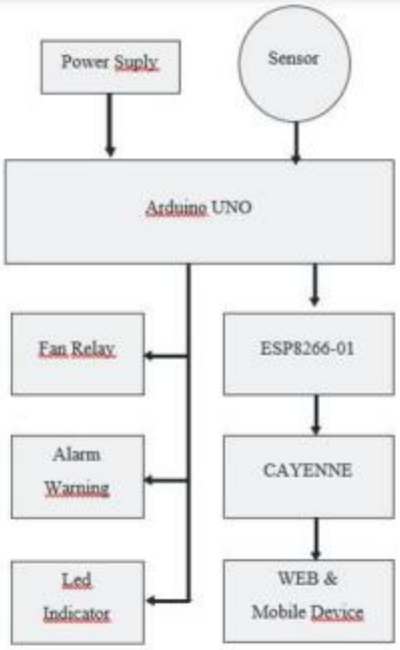


Figure 2.38: Architecture of Smart Kitchen System

In the research paper of (S et al., n.d.), Figure 2.39 proposed device is made up of an atmega328 processor connected to sensors such as the MQ2 sensor, a load cell, and infrared sensors, among others. The Wi-Fi module is connected to these, allowing them to communicate. The proposed method takes an automatic control action when gas is detected. The regulator valve (motor) will be turned off, effectively stopping the gas flow. If there is a gas leak, the electronic sensor, which is a gas sensor that works on the same concept as an LPG sensor, detects any gas. If there is some leakage from the storage, the performance of this sensor goes high. The microcontroller will detect this high signal and determine whether there is a gas leak. If a leak occurs, the user is notified via the internet on his computer, and a signal is sent back to the microcontroller, instructing it to close the valve. A sensor (load cell) is used in this device to monitor the weight of the gas cylinder; if it falls below a critical value, the sensor detects this and alerts the user. The object detection sensor detects the presence of any vessel over the burner. If a vessel is not identified within a certain time, an alarm is triggered, and the user is notified.

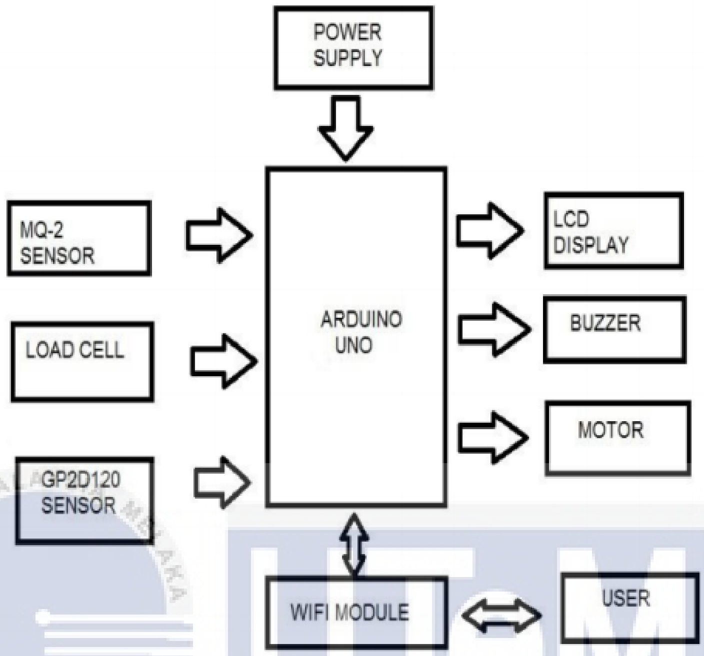


Figure 2.39: Block diagram of the system

(Mahzan et al., 2018) have developed an Arduino-based home fire alarm system with a GSM module based on Figure 2.40 where Arduino Uno and GSM SIM900A is the control panel, and with the temperature sensor, LM35 can switch on the heat if a fire breaks out in the building. When the temperature reaches 40 degrees Celsius, it will signal to the Arduino telling it of the high temperature. As the temperature rises, the Arduino will send a text message to the user via the GSM module, informing them of the situation. An SMS will be sent to the user as soon as possible to inform them of the fire in the building. Simultaneously, the presence of fire will be shown on the LCD panel.

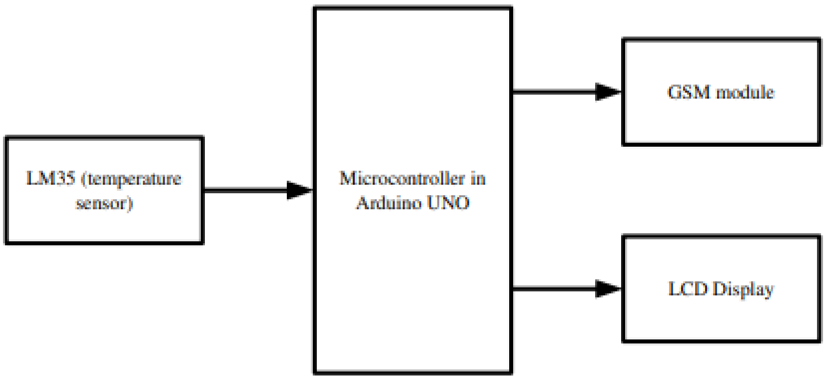


Figure 2.40: Block diagram of the home fire alert system

2.8.3 Type of Microcontroller and Sensor used on smart stove

From the development bright stove of (Hsu et al., 2019), Arduino Uno is used as the microcontroller shown in Figure 2.41, D1 Mini and Webduino (Figure 2.42) developed based on Arduino. Arduino uses C/C++ programming language, whereas Webduino is controlled using HTML and JavaScript and operated through Wi-Fi, Bluetooth, Websocket and serial port. These three components are used as the control panels. Besides that, for the sensor used, the flame detector, temperature detector and gas detector are used for the environment data collection. In Figure 2.43, the flame detector is reactive to normal light and can detect flame and light with a wavelength of 760 to 1100nm and with a maximum distance for flame and light detection is 80 cm. Next, a temperature sensor in Figure 2.44 is low power consumption and has a signal transmission distance of up to 20 meters. Lastly, the gas methane sensor in Figure 2.45 is susceptible to methane and can detect other combustible gases with the detection range of 300 to 10000 ppm. Based on the common value from Occupational Safety and Health Administration (OSHA) organization show(Yan & Rahayu, 2014) in Table 2.11 show the safety value of the LPG (ppm) value, precaution value and also danger value of the sensor of MQ-9 value and this can be referred.

Figure 2.41 Arduino Uno control board

Figure 2.42: D1 Mini

Figure 2.43: Flame detector

Figure 2.44: Flame detector

Figure 2.45 MQ-4 natural gas methane

Table 2.11: OSHA measure value for MQ-9 LPG

Level	Light indicator	LPG(ppm)	Sensor value in MQ-9	Voltage(V)
Safety	Green	<500	<342	<1.67
Precaution	Yellow	>=500 <=1000	>=342 <=512	>=1.67 <2.50
Dangerous	Red	>1000	>512	>2.50

Therefore another development of Automation and Monitoring Smart Kitchen Based on Internet of Things (IoT) from (Nugroho & Pantjawati, 2018) has been using Arduino UNO as a microcontroller and ESP8266-01 shown in Figure 2.46 as a data communication device that uses wireless fidelity (Wi-Fi) network. Besides that, the sensor used is IR flame sensor to detect fire, temperature detector DHT11 sensor (Figure 2.47), which have a measuring limit of only up to 60° C and MQ-135 (Figure 2.48) gas sensor to detect Liquefied Petroleum Gas (LPG) leak and passive infrared (PIR) sensors (Figure 2.49) to detect human activity in the kitchen for the environment data collection.

Figure 2.46: ESP8266-01 WiFi Module

Figure 2.47: DHT11

Figure 2.48: MQ-135

Figure 2.49: Passive Infrared (PIR) sensors

Moreover, in the research paper of (S et al., n.d.) have been using Arduino UNO but with MICROCONTROLLER-ATMEGA328 as the microcontroller to maximize performance and parallelism, the AVR uses Harvard architecture – with separate memories and buses for program and data. As for the sensor: the MQ2 Sensor, Load cell and Infrared sensor are used to measure the heat of an object and detect the motion. Therefore, in the development to design an Arduino-based home fire alarm system with a GSM module from (Mahzan et al., 2018), Arduino microcontroller and GSM SIM900A type are used to carry out the task of communication part. Next, this project used LM 35 to measure the temperature shown in Figure 2.50.

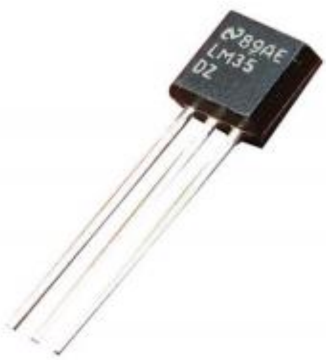


Figure 2.50: LM35 sensor by Texas Instrument

2.8.4 Type of Stove Knob design

The development of the Intelligent Stove Knob Controller by (Naqvi et al., 2020) consists of a stepper drive, a stepper motor and a NodeMCU where a 0.5 amp stepper motor with a 0.8-degree turn angle and 5 volts is used in the design. From Figure 2.52, the NodeMCU framework is a free and open-source IoT platform. It includes software that runs on Espressif Systems' ESP8266 Wi-Fi SoC and hardware based on the ESP-12 board. By design, the name "NodeMCU" applies to the code rather than the event kits. The code was created using the Lua scripting language and the Espressif Non-OS SDK for ESP8266. The Grove - Gas Sensor (MQ5) module was used for gas sensing because it helps detect gas runs (home and industry). It can be used to detect H2, LPG, CH4, CO, Alcohol, Smoke, or power. The signals from the sensor block are received and then processed. The values sent are verified using Firebase.

Figure 2.51: Stove Knob Unit

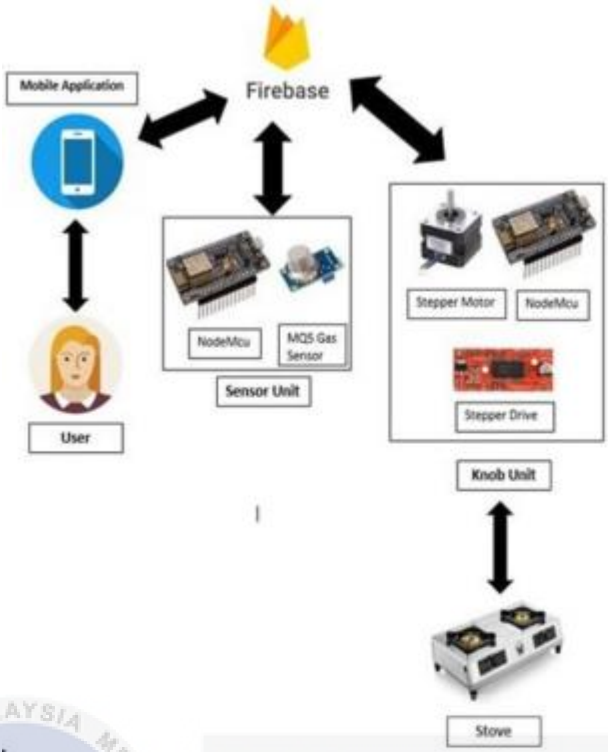


Figure 2.52: System Design

Another IoT Smart Stove Knob was developed by (Garg et al., 2018) using Message Queue Telemetry Transport (MQTT) where it's called a lightweight protocol because all of the messages are small in size. It's a protocol that's free to use. Embedded devices that do not run on TCP/IP networks use certain flavours of the MQTT protocol. MQTT is a machine-to-machine protocol that plays an essential role in the IoT. MQTT enables a computer to transmit messages to a server, often known as an MQTT broker. It then sends the message to those who have already signed up for it. Another module that has been used in this device is the Wi-Fi module (ESP8266) is used in this project for connecting it to any device shown in Figure 2.53. When the user is not at home, he or she needs to connect to the MQTT App to learn about the status of the gas stove. This improves both the simplicity and the safety of the process. Smart knobs are inexpensive and straightforward to manage. From Figure 2.54, the Here we have connected the gas knob with a magnetic sensor to detect the status of the gas knob. This improves the ease and security of the process. Smart Knob is a smart kitchen gadget that is simple to use, inexpensive, and easy to maintain.

Figure 2.53: Flow Chart of Working

Figure 2.54: Flow Chart of Working

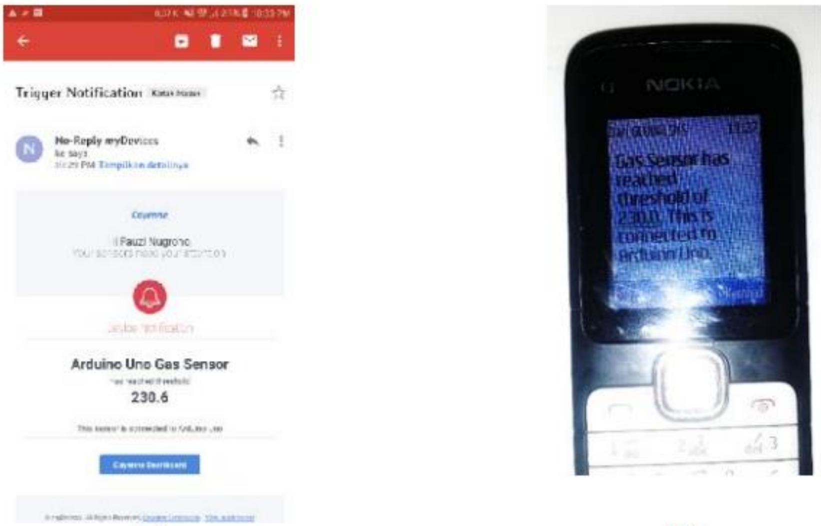
2.8.5 Type of Software used

(Nugroho & Pantjawati, 2018) have used Arduino Integrated Development Environment (IDE) to programme the Arduino Uno and ESP 8266-01 using the serial monitor available on the Arduino IDE. Next, the Cayenne web server is also used as an application and web to create IoT projects as this app has a feature to monitor and control the object's connection. Cayenne used to display all the sensor data shown in

Figure 2.55, controlling relay fan and sending warning notices to the mobile user device via email or SMS is shown in Figure 2.56.

On the other hand, Arduino Integrated Development Environment (IDE) and Proteus Design Suite are Electronic Design Automation (EDA) used to do the programming and construct a schematic circuit with all PCB Design products, including an auto-router and basic mixed-mode SPICE simulation capabilities. This will show the project's simulation before doing the project's hardware shown in Figure 2.57.

Figure 2.55: Cayenne application Display



(a) (b)

Figure 2.56: (a) Email Warning Notification (b) SMS Warning Notification

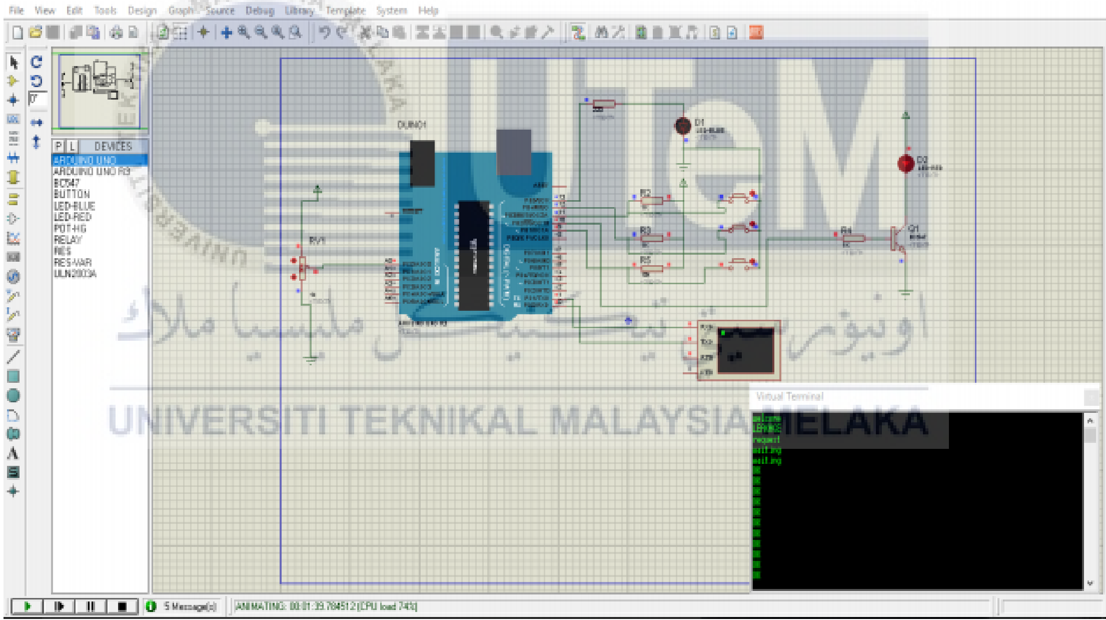


Figure 2.57: Proteus Design Simulation

For the software development, Java and Android Studio 3.0, shown in Figure 2.58, have been used to develop IoT Stove Knob by (Naqvi et al., 2020). The flow chart in Figure 2.59 shows that the NodeMCU programme is initially initialized. Next, the value of the gas sensor is then read and updated in the database. After the database reading has been updated, the appropriate gas values that have already been identified in the database will be verified. If the gas value exceeds the threshold, the buzzer is triggered, and the gas value is then tested regularly. When the buzzer goes off, it means there is more gas in the stove, which can result in a threat such as an uncontrolled fire. If the gas value falls below the threshold, the knob value is examined. If it is adjusted, the knob is shifted to the desired location, and the value of the gas sensor is read once more. If the knob value is not changed, the operation is terminated.

Figure 2.58: Flow Chart of Working

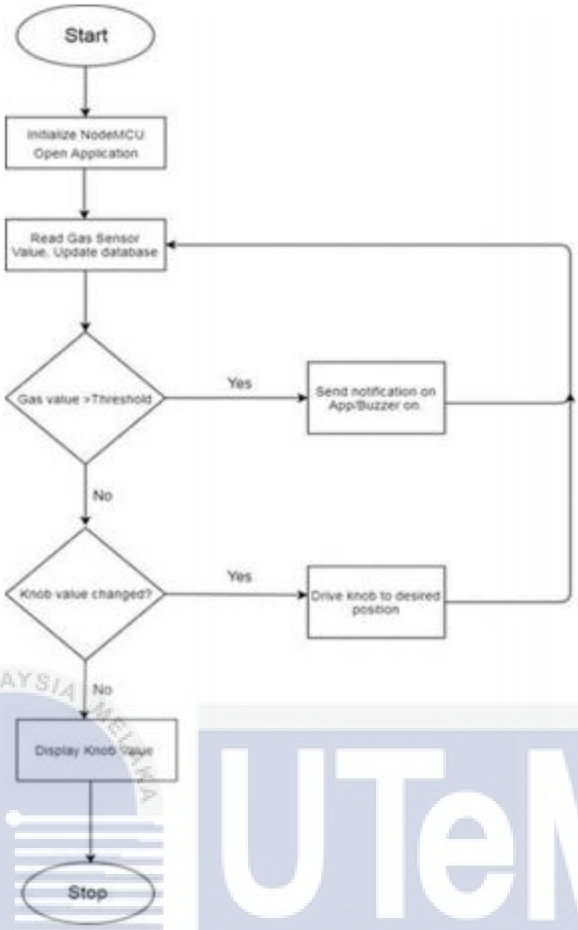


Figure 2.59: Flow Chart of Working

2.9 Sample formulas

Calculating Based on Quantity of Manure Produced (2.1)

Determining the liquid phase of the unit.

$$Length(l) = \frac{total\ volume\ (tv)}{crossection\ area\ of\ the\ tube\ (\alpha)}$$

Determine total volume of liquid phase

$$Liquid\ phase(lp) = volume\ of\ micture(vm) * retention\ time(rt)$$

Manure produce = 3lbs (food waste) x 5 plastic food bag =15 lbs

This will be as the example where 5 plastic bag of food waste produce a total of 15 lbs which will be convert to volume of manure produced. It will be multiply by the conversion factor (0.105)

15 lbs * 0.105 = 1.575 gallons of manure by volume

Determine the total liquid that will be fed to the unit on a daily basis

1 part manure: 4 parts water

1.575 gallons of manure: (4 x 1.575 = 6.3 gallons of water)

Based on this the total daily misture of 7.875 gallons (1.575 gallons of manure and 6.3 gallons of water) to feed the unit.

Determine the volume of mixture

$$Lp = vm * rt$$

= 7.875gl * 50 = 393.75 gallons

This total then calculated by the conversion factor for cubic feet.

525 * 0.134(conversion factor) = 70.35ft^3

Determine the length applying the formula to calculate the volume of cylinder

$$Volume(v) = \pi r^2 * length(l)$$

$$L = \frac{v}{\pi r^2}$$

$$\frac{70.35ft^3}{3.14 * 1ft^2}$$

$$= 22.4ft$$

$$= 23ft$$

2.10 Summary

As a conclusion for this chapter, based on the past studies of this project and the articles and journals related to this project, various techniques can be implemented in developing this biogas IoT smart stove. This is due to the evolution of the method or technique that increases the features that help make this project desired. This study has been discussed in this chapter under biogas production and IoT smart stove. Besides that, the study done in this chapter shows that some research has the advantage over the other and some need to be improved to be better applied.

Lastly, in this chapter, we can conclude that using galvanized steel lagged with fibreglass for the digester fabrication, which retains the heat absorbed by the digester tank with good tensile strength and ease of rolling by machine. Next, a manual stirrer with six flat blade disc turbine impeller to increase biogas production. After that, the gas produced will be undergoing filter proses to get a better quality of cooking gas stored in the LPG cylinder. For the IoT smart stove, Arduino Uno will be used as the microcontroller and wifi module that will be linked to fire, gas and motion sensor, which will be connected to the stove knob with the use of analogue feedback servo motor actuation that turns the knob to different angles by sending PWM signals. The servo motor requires a PWM signal with a period of 20ms with the duty cycle varying from 1ms to 2ms.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In the summarization of the process, the flow for this research was clearly described in this chapter. All the process performed was included in the systematic flow or procedure. This chapter will explain the method and steps towards developing the actual project, which consists of software, and hardware development, the possibilities, and the implication that can occur during the testing phase of this project. This chapter of methodology is the crucial step in ensuring that the objectives of this project are achieved. The component discussed in this chapter includes project implementation, where the choices of biodigester will converse. The project development consists of a flow chart that shows the overview of how the application works and, lastly, the requirements analysis phase that is considered the flow of the project development. Lastly, this chapter mainly comprises all of the stages needed to complete the project implementation, the development until the documentation phase.

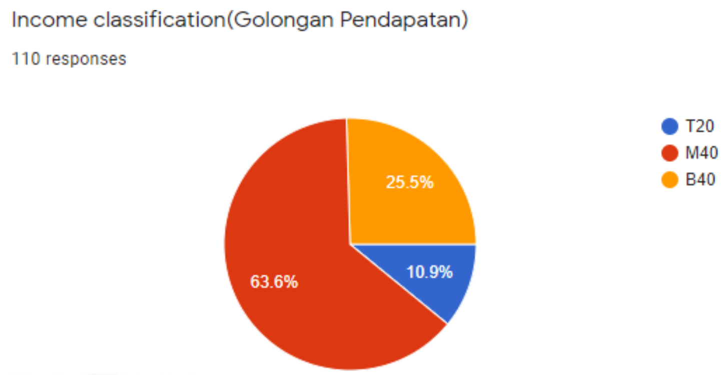
3.2 Market survey

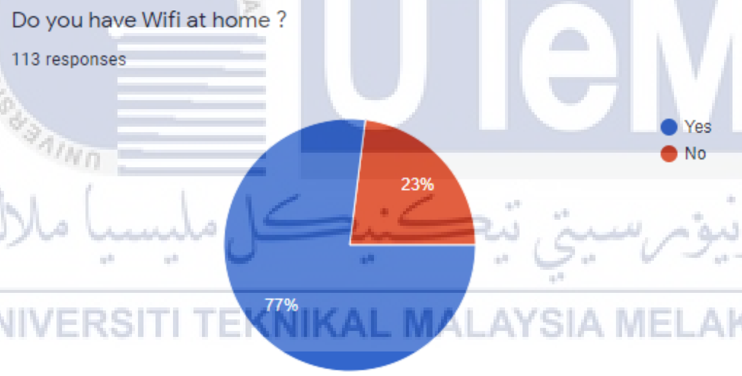
Other than that, 107 respondents agreed that adding safety monitoring systems such as IoT Smart Stoves at their kitchen will increase the safety precaution to avoid fire accidents h. Before doing this project, a market survey had been conducted to get the respondent opinion, and according to the market survey that has been conducted among

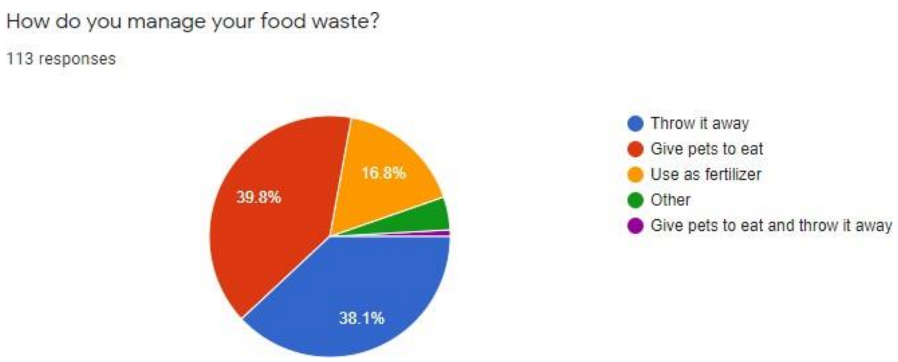
113 respondents, most of the respondents came from M40, about 70 people and the second highest is B40, which is 31 people, and lastly T20 that comes with 20 people. Based on how the respondent managed their waste, 45 of them gave pets to eat their food waste, but there was 43 respondent that threw away their waste, which adds to the food wastage. Therefore, this project needs internet WIFI at home, so based on the survey and about 86 of them own WIFI at home while the other 27 don’t have.

It is still very good because the majority have their WIFI at home, which can be used to connect to the IoT Smart Stove for wireless control stove knob. Besides, from the survey, some of them are careless, forgetting to close the stove sometimes, so as the survey show, about 67 of people agree on being careless. Moreover, their opinion on this project, 80 people agreed that this project would give an advantage to them by using the food waste or collecting food waste from the restaurant to produce Biogas (cooking gas) and organic fertilizer for those who do gardening or a farmer.

Besides, 97 think Biogas as cooking gas can replace natural gas or kerosene gas that is not renewable for substitution. For the safety precaution in the kitchen, about 98 households of the respondent do not have any safety feature in their kitchens such as CCTV or fire detector to monitor the kitchen. About 96 respondents stated that it would be helpful to monitor their stove with their phone that controls and switches off their stove when they are not at home or far away from the kitchen wirelessly. One hundred six respondents responded that this project could reduce their living cost in buying cooking gas and fertilizer where they can have free cooking gas from Biogas and fertilizer for farming or append. Besides producing Biogas and providing safety monitoring features in the kitchen, 109 of the respondents think this project will reduce pollution and increase the quality of life for humans and the environment. In conclusion, the project developing Biogas IoT that, majority of the respondent using the gas stove as their cooking module about 106 people. Smart Stove saves money, increases safety precautions, and saves the environment outstanding sustainability.

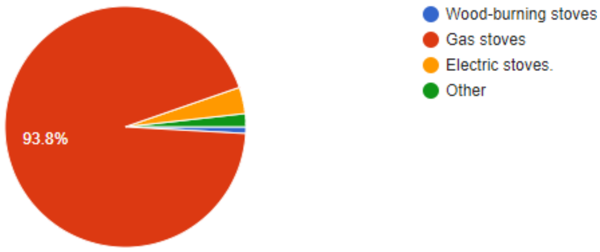






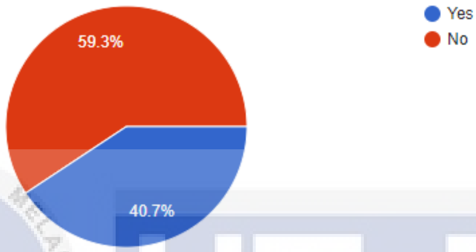
What type of Stove do you have?

113 responses



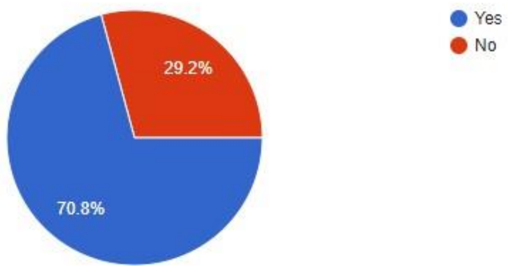
Have you ever leave your stove On while cooking and forget to turn it Off?

113 responses



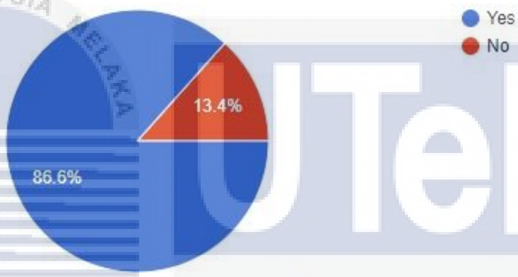
Would it gives advantage to you by using your food waste or collecting food waste from the restaurant to produce Biogas (cooking gas) and also organic fertilizer?

113 responses



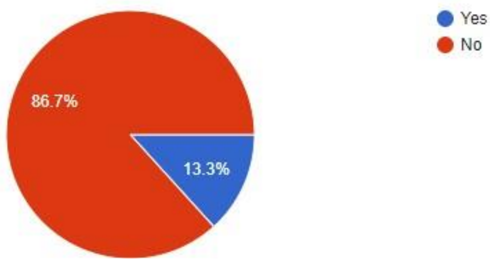
Do you think Biogas as cooking gas can replace natural gas or kerosene gas which is not renewable?

112 responses



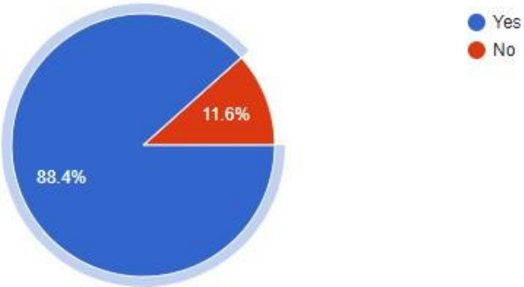
Do you have any safety feature in your Kitchen such as CCTV to monitor or Fire Detector?

113 responses



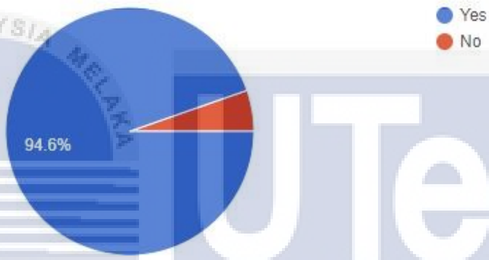
Would it be very helpful for you to control and switch Off your stove when you are not at home or far away from the kitchen wirelessly ?

112 responses



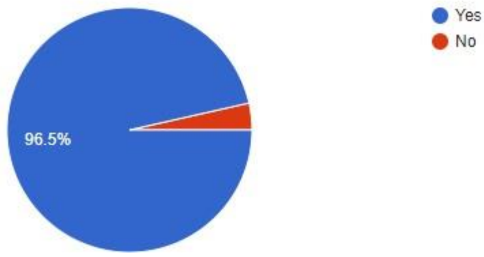
Do you think this project which combine with the production of cooking gas and fertilizer from food waste able to reduce your living cost?

112 responses



Do you think this project will reduce the pollution and increase the quality of life to human and environment?

113 responses



3.3 Project implementation

At this phase of project implementation, the sequence of the method used will be shown in the diagram. The figure below shows the stages of the development of this project. Figure 3.1 shows that the stages involved in this project are the primary investigation, analysis and the phase where the decision was made. Lastly, the stage where the development of software and hardware was decided.

The combination of the flow chart can be the guidance to conduct the project within the due date. Mendeley software helped with the citation, which made the works more accessible. For the methodology flow chart, the organisation is more to develop the project from the start till finish.

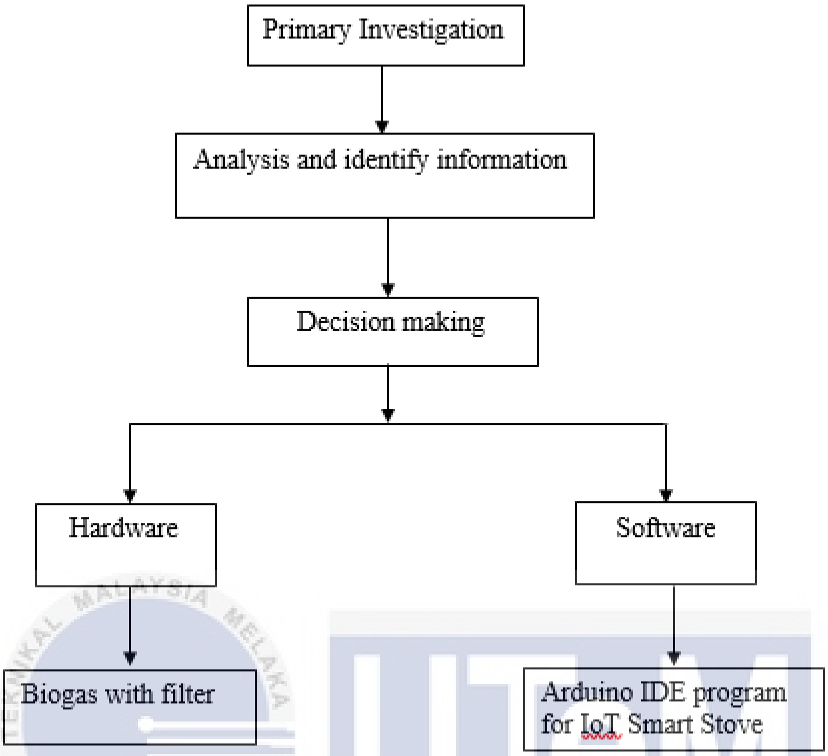


Figure 3.1 Stage of project development

3.3.1 Schematic diagram

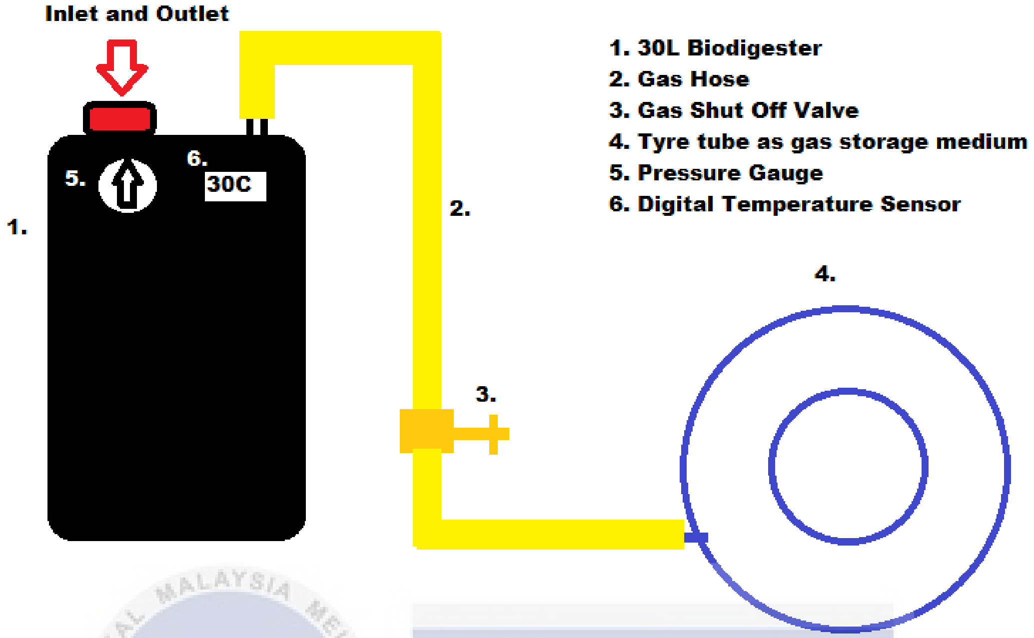


Figure 3.2: Schematic diagram for biogas digester tank

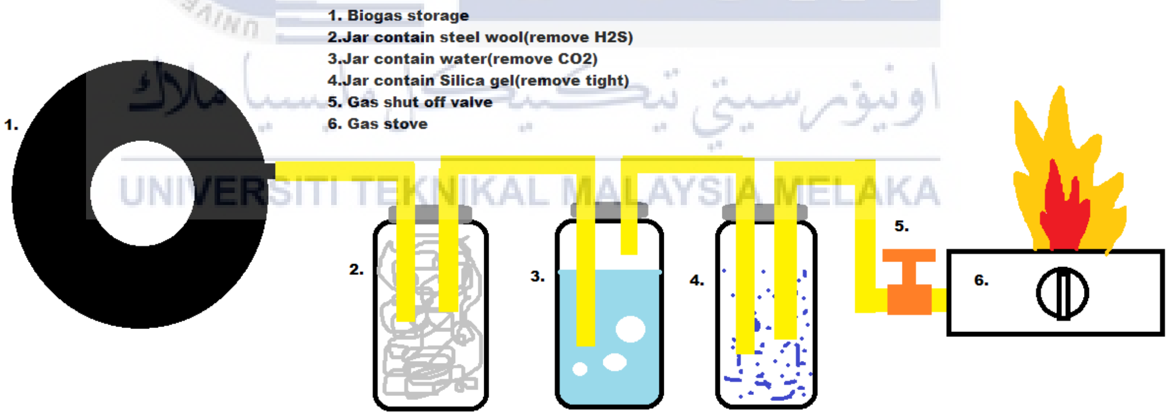


Figure 3.3: Schematic diagram for filtering Biogas to stove

3.3.2 Experimental measuring biogas production setup

Figure 3.1 depicts the methodology flow for this research which involves the preparation and the experimentation works. At the beginning of the flow, the research was started with collecting food waste. After that, a 30 ℓ batch type anaerobic digester is designed in this experiment. A 30 ℓ Jarry can are used, and the opening is drilled and fixed with a valve. To ensure no air is entering the container, each valve is fitted with rubber rings. Another way to detect leakage is by adding soap water on the place, which is fitted, and the opening to insert food waste. Next, connect the hose and blow to it until the gallon is expanded, and if there is bubble form at the fitting and opening, there is leakage. This step is essential to prevent the gas from escaping.

Furthermore, three glass containers will contain steel wool, water, and silica gel. The three containers will be used for a filtering system where the steel wool removes hydrogen sulphide**(H_sS),** water to remove carbon dioxide **(CO_2)** and silica gel to remove moisture. Water is used to lower the amount of carbon dioxide in the purified biogas, steel wool is used to react with hydrogen sulphide, and silica gel minimises the amount of water vapour in the purified biogas.

Then lastly, when the gas passes through the filter unit, the gas will be collected in a tire tube. In table 3.3, the digester will be equipped with a pressure gauge and temperature gauge to monitor the digester and take readings. The collected biogas will be used to test by recording the time to boil water using biogas and can be compared by using kerosene shown in table 3.2. Lastly, in table 3.4, the biogas production will weigh the tire tube day by day for 20 days and subtract the original weight of the tire tube, then will use-measuring cylinder to measure the production of biogas using the diffusion method.

Table 3.1: Measurement of Biogas production

	Substance	Amount
Digester Contain	Food waste + Water	10Kg + 10ɭ

Table 3.2: Measurement of Biogas production

	Substance	Boiling time
Non Filter	Food waste + Water	
Filter	Food waste + Water	

The gas collected for the non-filter and filter will be tested by boiling 500ml of water in a pot, and the timer will be set. The result will be compared to Kerosene gas to see which gas is better for cooking gas.

Table 3.3: Measurement of Biogas production

No of days	Pressure (Bar)	Temperature (°C)
Digester Contain	Food waste + Water	Food waste + Water
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Pressure at the digester and temperature will be monitoring each day for 20 days according to categories.

Table 3.4: Measurement of Biogas production

No of days	Weight of tire by day (Kg) ❖ Original Weight of the tire 1.59kg
Digester Contain	Food waste + Water
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

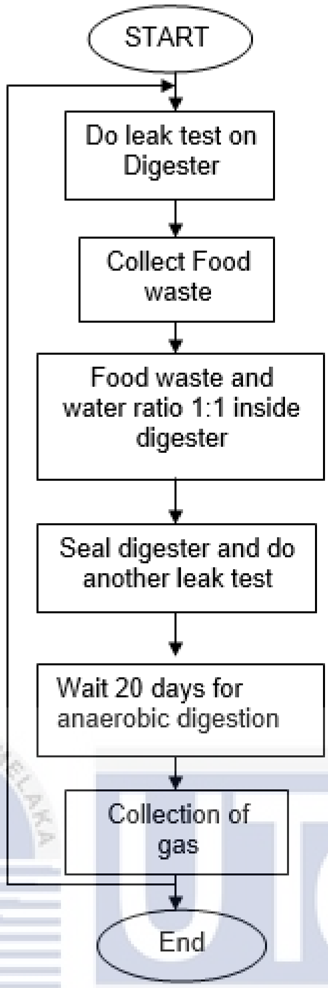


Figure 3.4: Flowchart for experiment on collecting biogas production on different type of food waste

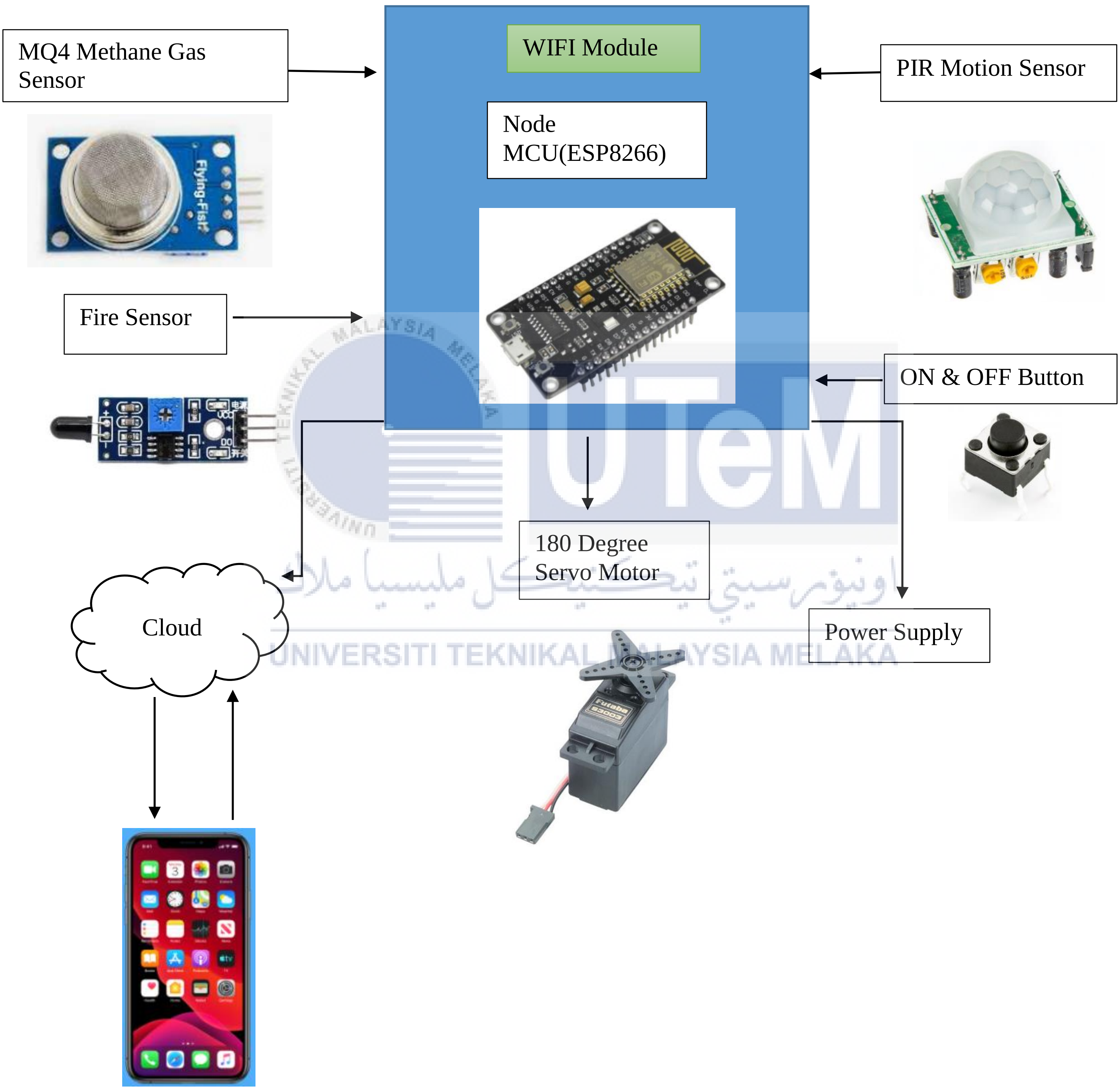
3.4 Electrical Part Development

To ensure the project is done correctly based on the objective stated, a strong understanding of the project needs to be considered the primary need in this study. Hardware and software used in this project were needed to ensure it worked according to plan. The appropriate selection of components is needed to give the project's desired function, which will help the project develop smoothly.

This system can help the user or someone who has a kitchen at home to monitor the stove, especially when they are not around. So using IoT to monitor the kitchen is very convenient and increase safety at home, especially fire accident in the kitchen. So the use of IoT will connect to the Wi-Fi module and use three types of sensor: Fire sensor, Motion sensor, and Gas sensor. This type of sensing element will give users information through their phone for warning and alert them when they are not at home. So just by using their phone, they can wirelessly turn off the stove.

So the process of transmitting and retrieving data from the motion, gas and fire sensor to the main microcontroller, which is connecting through a series of wire connections, resolves whether the sensors sense the fire, gas, or motion are correct or not will be done in the program coding itself in the software to ensure the angle and range of detection that need to fulfil to make compatible for the IoT Smart Stove.

3.4.1 Block diagram ot the model



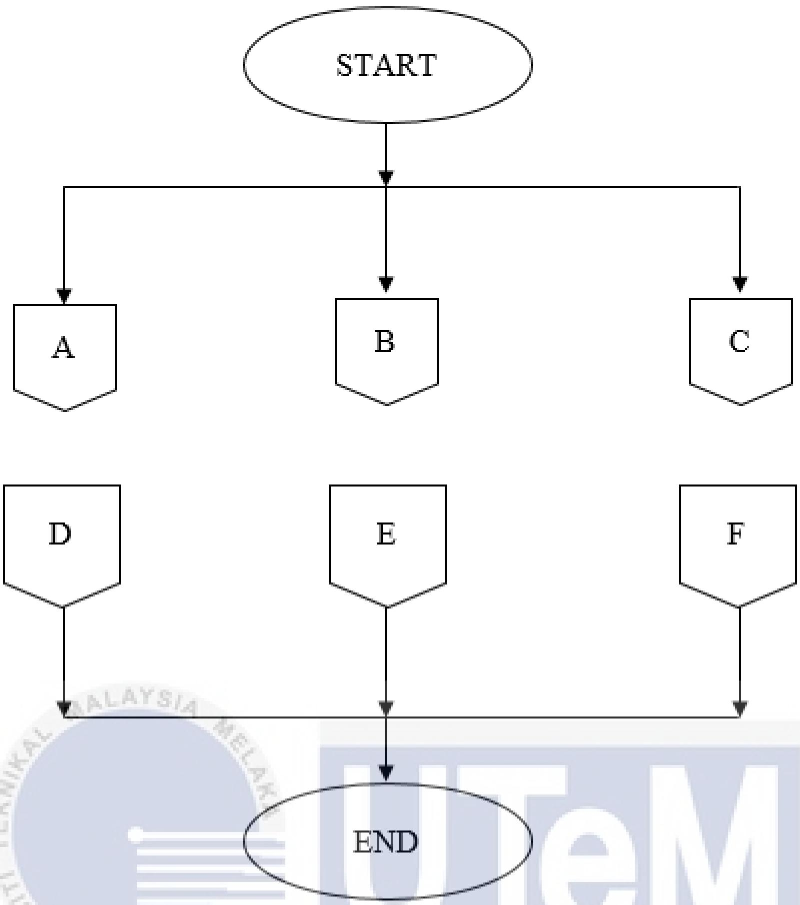


Figure 3.5: Electrical part process flow of project

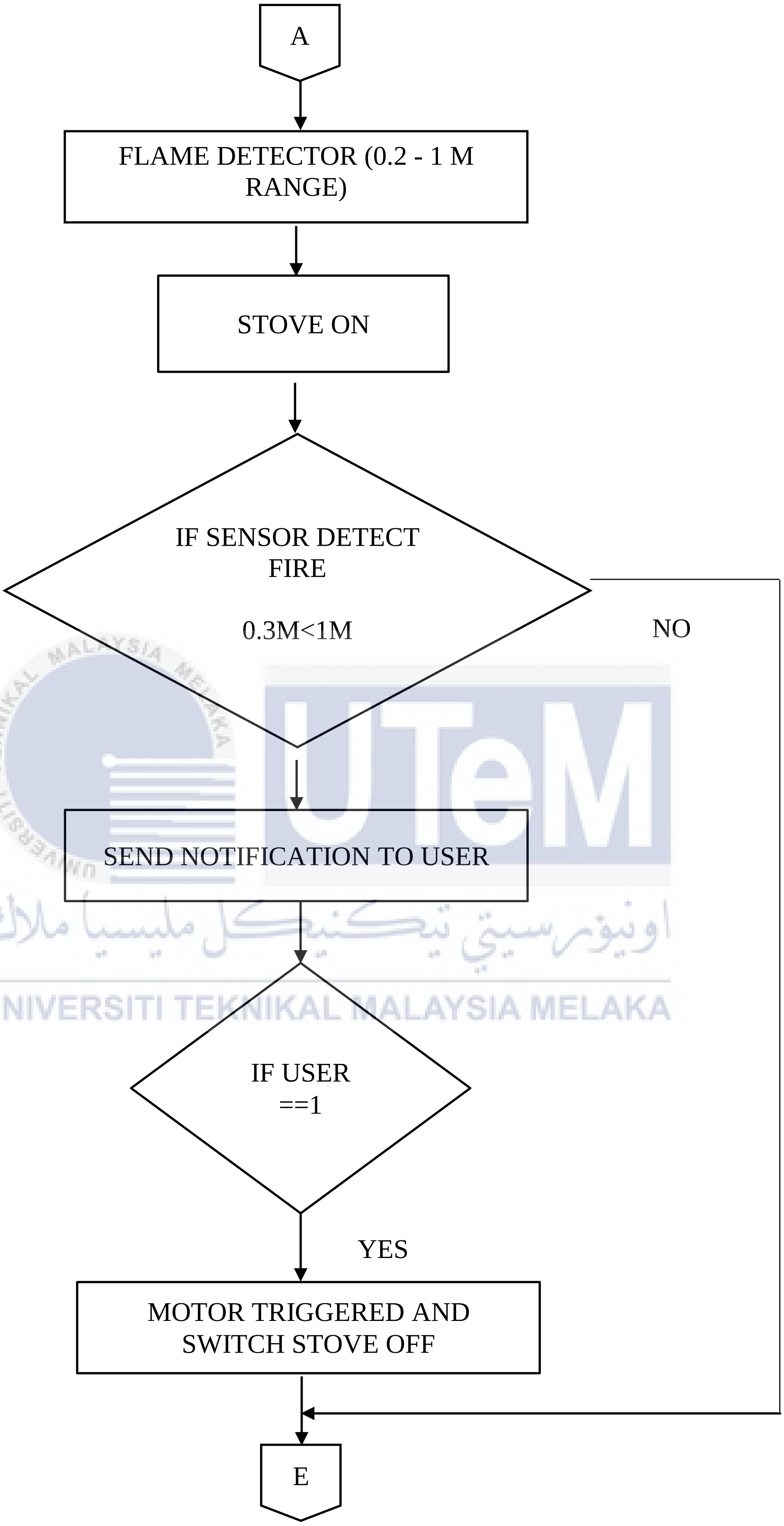


Figure 3.6: Flame sensor flow of project

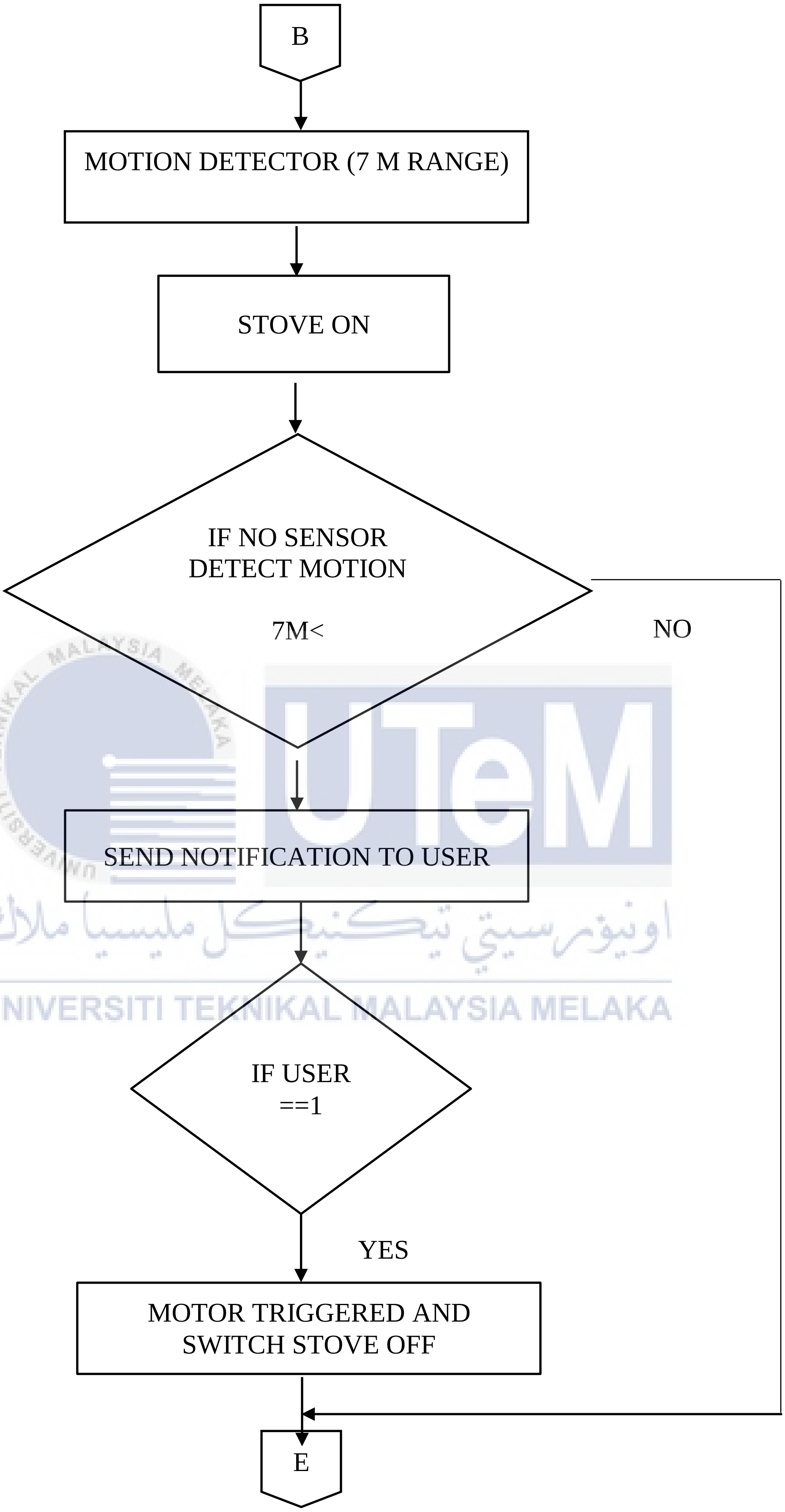


Figure 3.7: Motion sensor flow of project

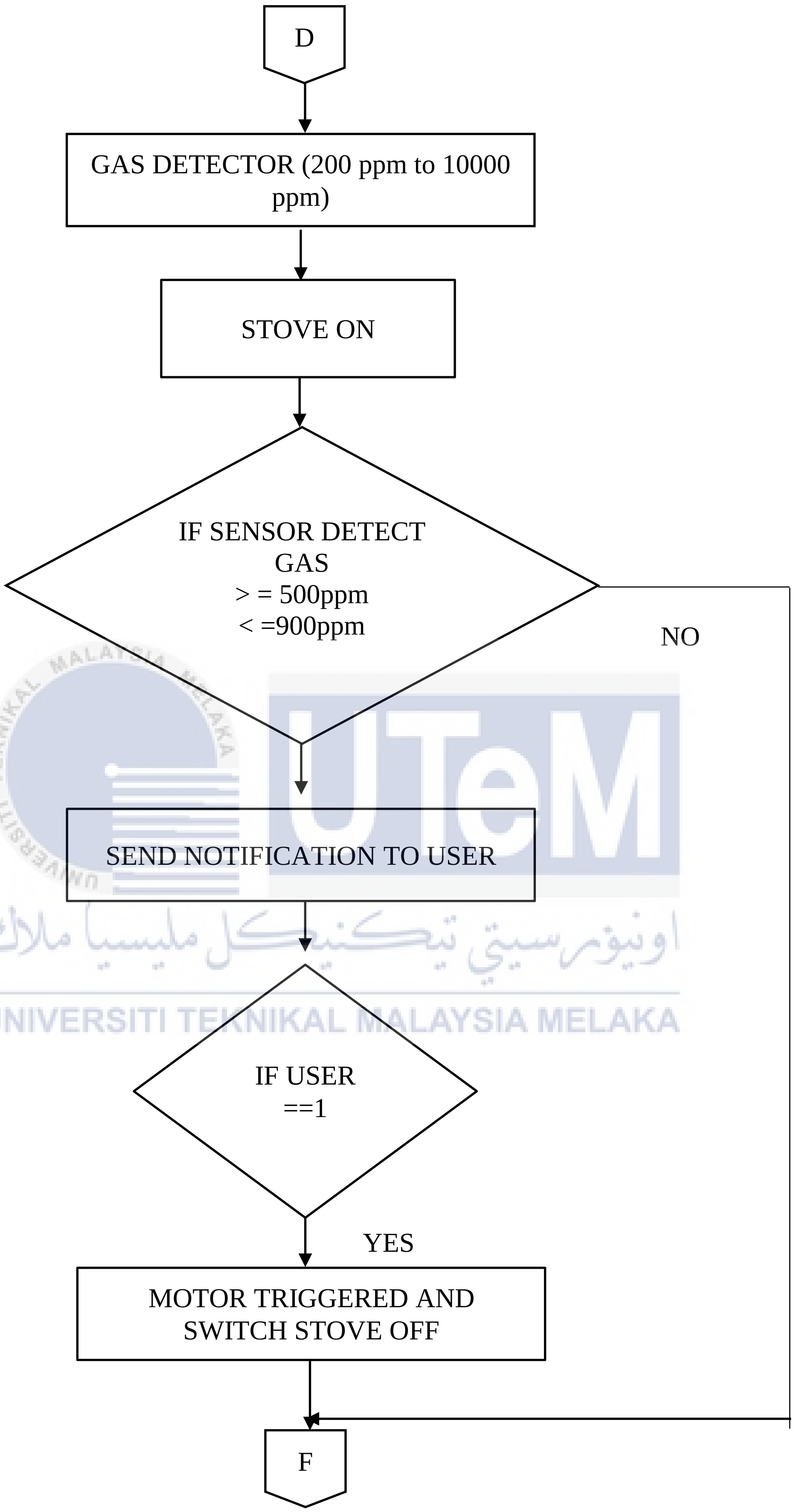


Figure 3.8: Gas sensor flow of project

From the flow chart, the process when the main microcontroller is launched or supplied with input power will initiate the Flame sensor, Motion sensor, and Gas sensor to start detecting. When the Flame sensors detect flame in the range of 0.3m to 1m, it will send a notification to the user phone, and the user can control through their phone to trigger the motor wirelessly to turn and off the stove. Besides that, with no motion is detected but either the flame sensor or gas sensor is detected at danger value which flame sensor will be set 0.4m to 1m and gas sensor which is 500ppm to 900ppm, the user will receive notification to show the warning and user will use their phone to turn off the stove and it will trigger the motor and automatically turn off the stove.

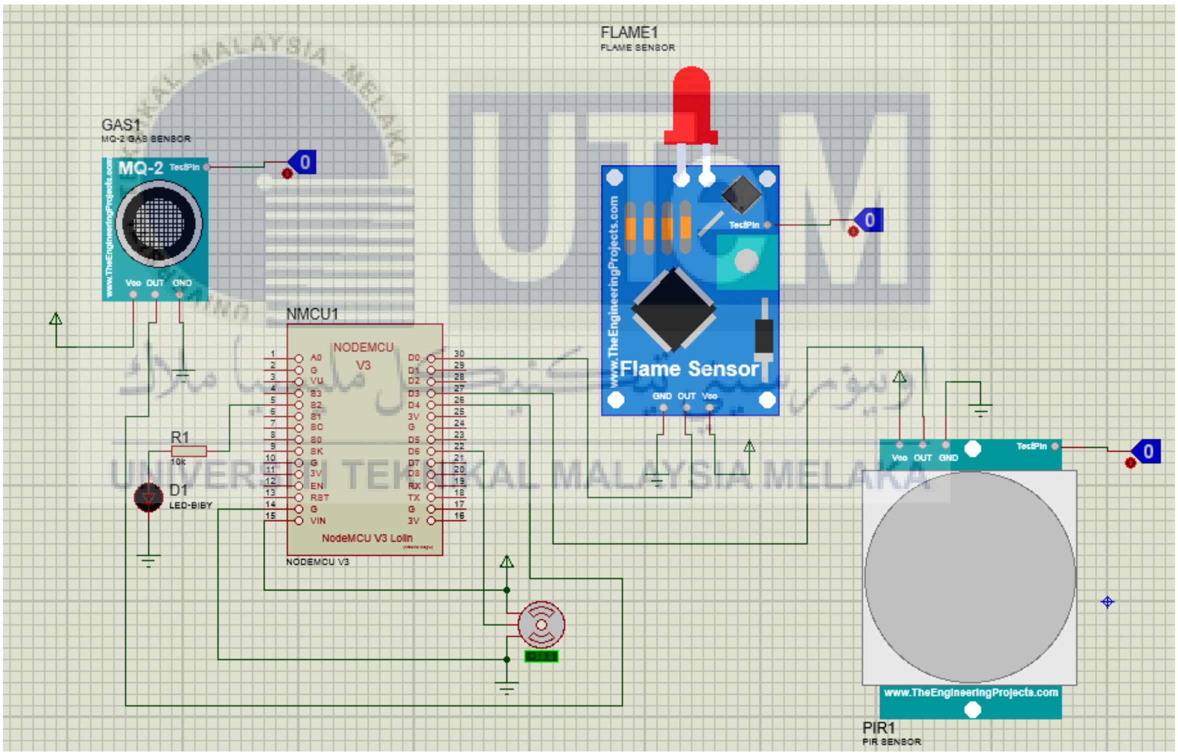


Figure 3.9: Circuit diagram for IoT Smart Stove

3.4.2 Software development

3.4.2.1 Proteus

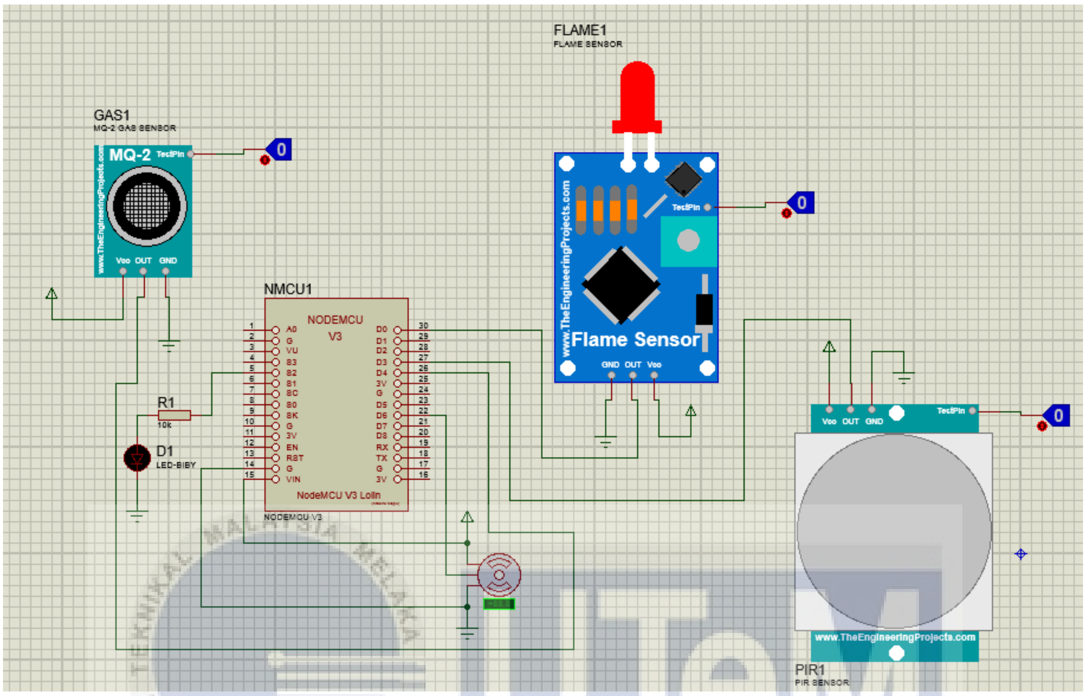


Figure 3.10: Proteus software

For this project, software implementation, a schematic circuit is drafted and designed using Proteus software, and simulation is accomplished by importing and running programmable code using the Arduino IDE software. The schematic circuit and coding are built using the datasheets for each sensor and controller utilized, as each has its preference for connections and coding language established by the manufacturer. This is accomplished by writing and applying the correct command to each of the pins on the sensor and controller to run the code in Arduino.

3.4.2.2 Arduino software IDE

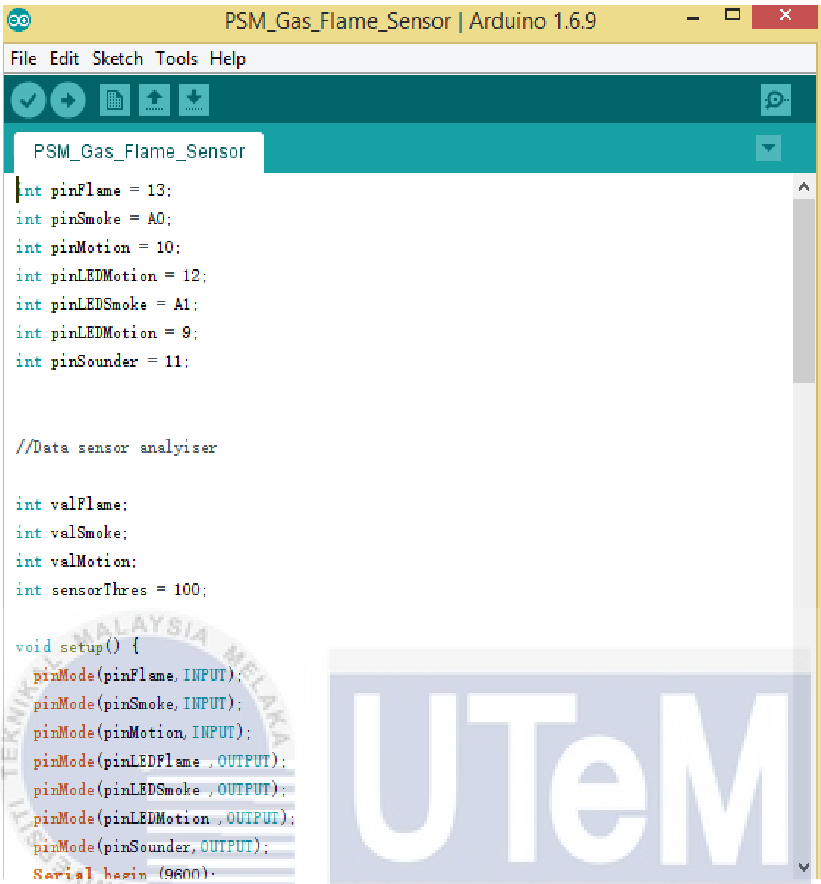


Figure 3.11: Arduino (IDE) software

For the programming on this project, Arduino software is used, and the computer language is C++, which is easy to understand. First of all, before starting to identify the pin of the component connected to the Arduino and list the entire pin connected. Next, identify the role of the component, whether it is input or output. Then declare the pin number used on each component name the integral that is easy to identify.

Figure 3.12: Arduino (IDE) software coding

After declaring all the input and output of the sensor and LED light, the necessary condition is stated of the sensor HIGH means ON and LOW means OFF. The program needs to have a delay for a smooth program running. For this coding, the condition is when the fire sensor, gas sensor or motion sensor have detected the fire, gas or motion, it will light up each of the LED when triggered. This show the sensor is working and able to take a reading.

```
#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include <SimpleTimer.h>
#include <Servo.h>
```

Figure 3.13: Arduino (IDE) software coding Library used

```
char auth[] = "pjNvfQA96LGua2fIeEKlKGdtePt0voel";
char ssid[] = "ALICIA PINSOM@unifi";//Enter your WIFI name
char pass[] = "050425120565";//Enter your WIFI password
```

Figure 3.14: Declare auth, ssid and pass

This coding is for the Wi-Fi module. First, include the library that needed to use. Next, declare the char for the SSD and WIFI password. Then, declare the servo motor's position, fire sensor, PIR sensor, and MQ-4 sensor. Then, declare the number of pins used in the Node MCU (ESP8266) to each sensor and servo motor.

```
int flag=0;
int gas_value;
int gas_avalue;
int variable = 0;

void notifyOnFire() //Flame Sensor Code
{
  int isButtonPressed = digitalRead(D3);
 if (isButtonPressed==0 && flag==0){
    Serial.println("Fire Detected");
    Blynk.notify("Alert : Fire Detected");
    flag=1;
}
  else if (isButtonPressed==1)
  {
    flag=0;
  }
}
```

Figure 3.15: Arduino (IDE) software coding for Node MCU (ESP8266)

Next, figure 3.15 show the function of fire sensor where it will gives a notification if fire is detected.

```
void notifyOnMotion() //Motion Sensor Code
{
  int isButtonPressed = digitalRead(D6);
  if (isButtonPressed==0 && flag==0){
    Serial.println("Alert!!! No MOTION is Detected");
    Blynk.notify("Alert!!!No MOTION is Detected");
    flag=1;
}
  else if (isButtonPressed==1)
  {
    flag=0;
  }
}

void notifyOnSmoke() //SMOKE Sensor Code
{
  int isButtonPressed = digitalRead(D1);
  if (isButtonPressed==1 && flag==0)
  {
    Serial.println("Alert!!! SMOKE is Detected.");
    Blynk.notify("Alert!!! SMOKE is Detected.");
    flag=1;
  }
  else if (isButtonPressed==0)
  {
    flag=0;
  }
}
```

Figure 3.16: Arduino (IDE) software coding for PIR and MQ-4 sensor

Figure 3.16 is the coding function for the motion sensor and MQ-4 sensor that detect methane gas. It declares the number of the pin of each sensor, and when the sensor detects no motion, it will notify the user same goes for when methane gas is detected. It will give notifications to the smartphone.

3.4.2.3 Blynk

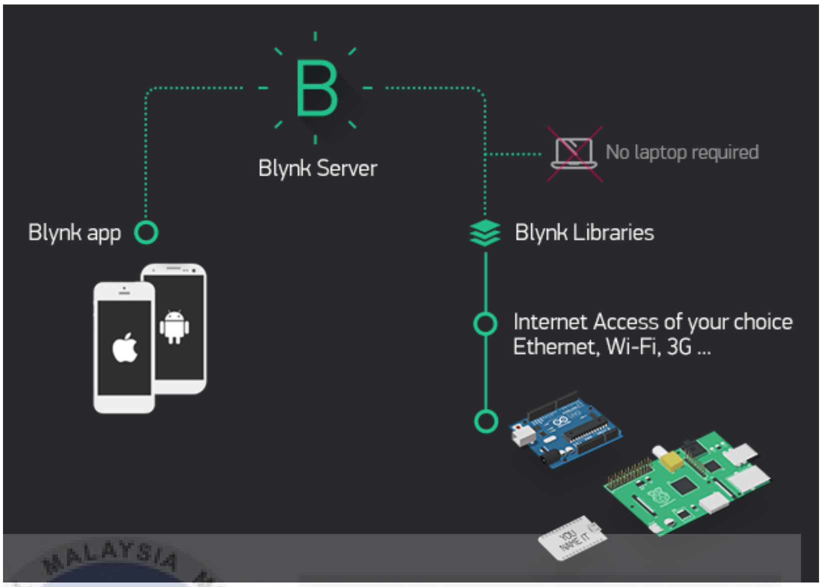


Figure 3.17: Blynk Apps

According to Figure 3.13, the Blynk platform enables users to quickly create interfaces for controlling and monitoring project hardware from IOS and Android devices. Blynk apps can be found in the Google Play Store and the Apple App Store. Blynk can build the project's hardware where Blynk supports platforms such as Arduino, Raspberry Pi, and smaller microcontroller boards. Next, Blynk provides the following connection types, Ethernet, WIFI, and Bluetooth, connecting the microcontroller board (hardware) to the Blynk cloud and Blynk personal server. Besides that, The Blynk software also allows project-specific apps with a selection of widgets. It works on both Android and IOS devices. The Blynk server handles all communication between the mobile devices to run the Blynk app to hardware. It can run a local blynk server or connect to the Blynk Cloud. It is open-source and capable of supporting devices, and it can even run on the ESP8266, Raspberri Pi with WiFi dongle, Particle Photon or SparkFun Blynk Board. Blynk libraries provide server connections and handle all incoming and outgoing commands between the blynk app and the hardware. All of the major hardware platforms are supported by Blynk apps for IoT.

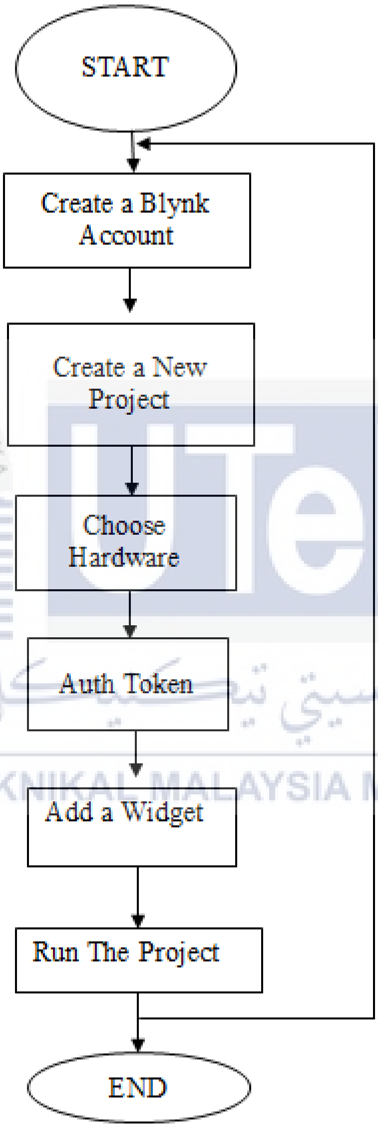


Figure 3.18: Getting Started With The Blynk App

3.4.2.4 Digester calculation

Volume of Biogas Digester

a) Volume of slurry

$$V_s = volume\ of\ cylinder\ to\ contain\ the\ slurry + volume\ of\ base\ cone$$

Where:

$$Volume\ of\ cylinder = \pi r^2 h$$

b) Volume of biogas to be produced

$$C_{16}H_{12}O_6 \rightarrow 3CO_2 + 3CH_4$$

$$V = \frac{mRT}{P}$$

Where:
V= volume of gas to be produced
m= number of moles of gas(6moles)
R = molecular gas constant (517.59KJ/KgK)
T = temperature
P = pressure

c) Volume of the top cylinder, V1

$$Volume = \pi r^2 h$$

Where:
Depth, h = 0.1m
Diameter, D = 0.12m
Radius, r = 0.06m

$$Volume = \pi \times 0.06^2 \times 0.1$$

$$Volume = 1.130973355 \times 10^{-3} m^3$$

d) Volume of the top cylinder, V2

$$Volume = \pi r^2 h$$

Where:
Depth, h = 0.1m
Diameter, D = 0.36m
Radius, r = 0.18m

$$Volume = \pi \times 0.18^2 \times 0.1$$
$$Volume = 0.01017876m^3$$

e) Volume of the top cylinder, V3

$$Volume = \pi r^2 h$$

Where:
Depth, h = 0.1m
Diameter, D = 0.36m
Radius, r = 0.18m

$$Volume = \pi \times 0.18^2 \times 0.1$$
$$Volume = 0.01017876m^3$$

f) Volume of the top cylinder, V4

$$Volume = \pi r^2 h$$

Where:
Depth, h = 0.3m
Diameter, D = 0.36m
Radius, r = 0.18m

$$Volume = \pi \times 0.18^2 \times 0.3$$
$$Volume = 0.03053628m^3$$

g) Total volume of digester

$$Total\ volume = V1 + V2 + V3 + V4$$

$$= 1.130973355 \times 10^{-3}m^3 + 0.01017876m^3 + 0.01017876m^3 + 0.03053628m^3$$

$$\cong 0.052m^3$$

h) Volume of digester tank to carry substrate

$$Volume = V4$$
$$= 0.03053628m^3 \cong 0.03m^3$$

Remember;

$$1m^3 = 1000liters$$

$$\therefore 0.03m^3 = \frac{0.03m^3 \times 1000l}{1m^3} = 30liters\ of\ tank$$

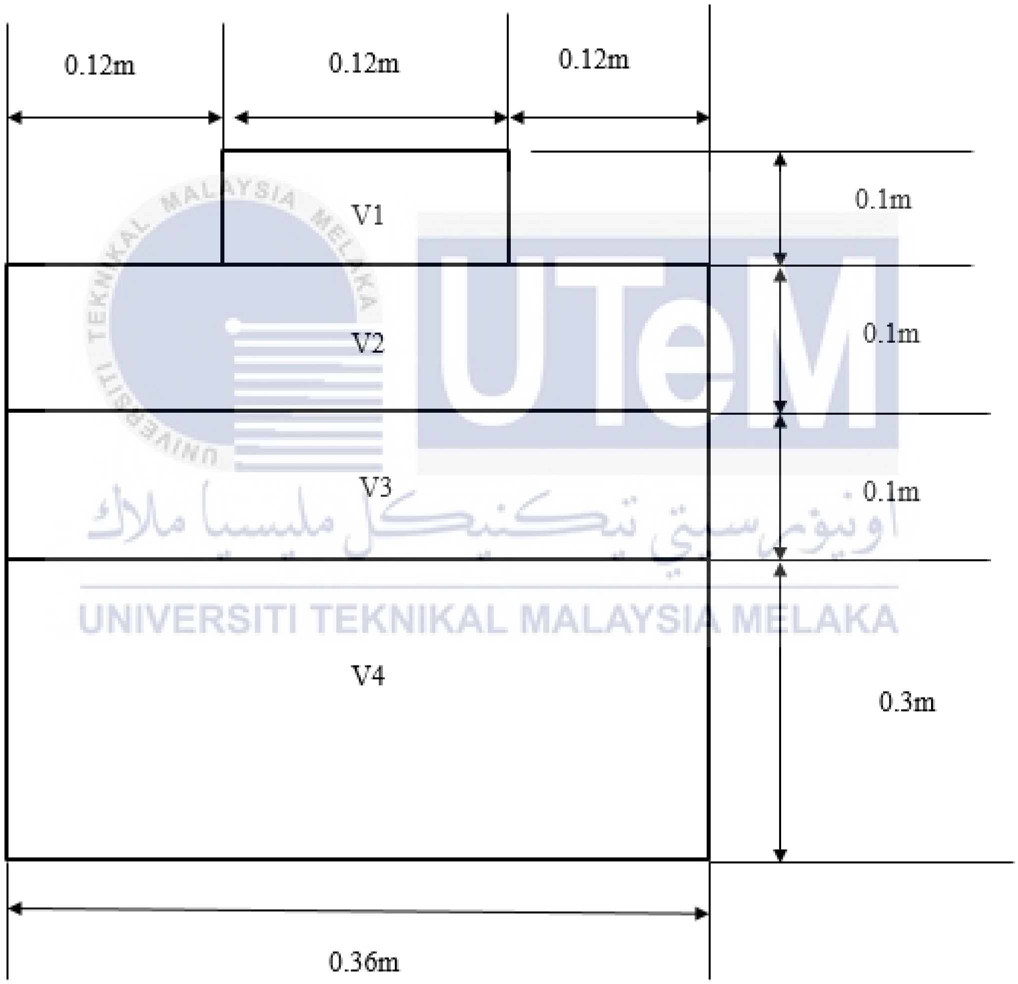


Figure 3.19: Schematics of various sections of the bio-digester

The amount of substrate utilized was as follows:

$Volume\ of\ tank\ to\ carry\ substrate =$

$volume\ of\ substrate$

Hence,

$amount\ of\ substrate\ for\ 30litres\ of\ the\ tank =$

$30litres$

Since the amount of substrate to be used is by weight, we convert the value in liters to kg

$1litre\ of\ substrate\ occupies\ 1kg\ of\ substrate$ (N.A.S., 1977)

i) Value of liter convert to Kg

$$\therefore 30liters = \frac{30litres \times 1kg}{1litre} = 30kg\ of\ substrate$$

Substrate is the mixture of the slurry and water in the ratio 1:1 for food waste.

j) Mass of slurry in the substrate

$$30liter = 30\ kg$$

Only use 20 liter of the gallon and the 10 liter of the gallon is left for the production of biogas

$$= \frac{1}{2} \times 20kg\ of\ substrate = 10kg$$

k) $Mass\ of\ water\ in\ the\ substrate$

$$20kg - 10kg = 10kg$$

3.5 Hardware development for IoT Smart Stove

There are two parts for the whole IoT Smart Stove system to design. First is from the schematic circuit design based in the software, and Multisim software will be used to construct the circuit before proceeding to hardware. The circuit will be transferred onto the breadboard for connection or soldering. Next is the assembling part of the design circuit, which interconnects the fire, gas and motion sensor to the main controller and sets up the sensor 20cm above the stove. Next, the second part is the automated stove knob which will connect to the 90-degree servo motor with the Wi-Fi module to turn the stove knob.

3.6 Component

3.6.1 Node MCU (ESP8266)

For the Wi-Fi module Node MCU ESP8266 is used and this will connect to the 90 degree servo motor and will be used to control and switch off the stove knob. ESP8266 is easy to use with low cost and develops TCP connection by connecting with WIFI. From Figure 3.14, only 2 pin is connected with is the Digital IO pin for Node MCU to the servo motor and another is to the ground.

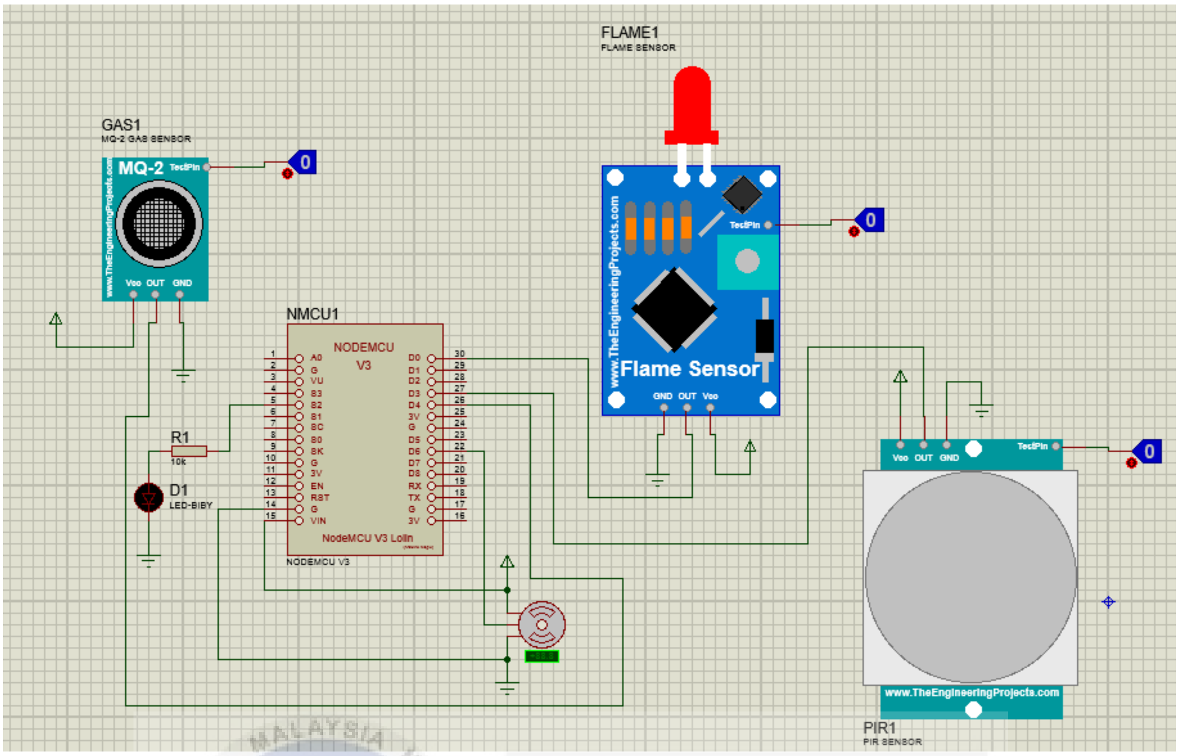


Figure 3.20: Connection circuit for Node MCU (ESP8266)

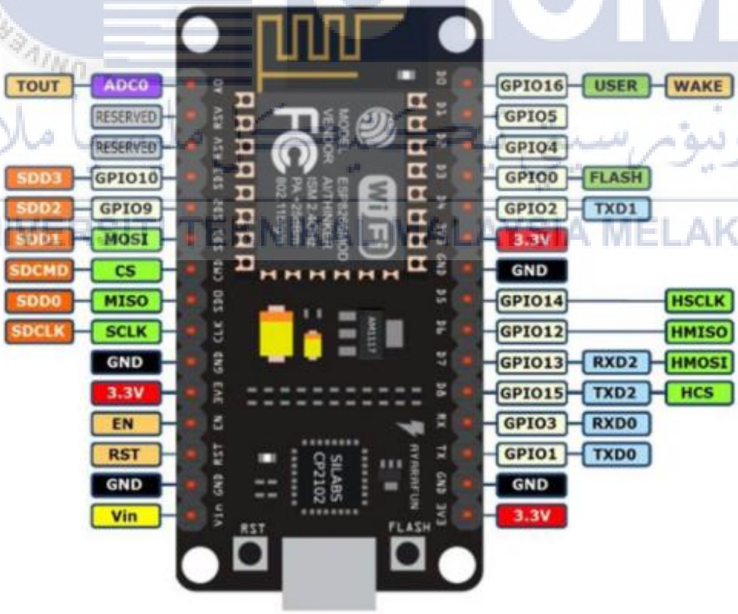


Figure 3.21 NodeMCU ESP8266 Pinout

Table 3.1: Technical specs of NodeMCU ESP8266

No.	Features	Description
1	Microcontroller	Tensilica 32-bit RISC CPU Xtensa LX106
2	Operating voltage	3.3V.
3	Input voltage (recommended)	7-12V.
4	Digital IO pins	16 pins
5	Analog IO pins	1 pin
6	DC current per IO pins	40mA
7	Flash memory	4MB
8	Clock speed	80MHz
9	UARTs	1
10	SPIs	1
11	12Cs	1

3.6.2 Servo Motor

This circuit interfaces a servo motor with the NodeMCU ESP8266 WiFi module. The NodeMCU serves a web page that contains the servo motor controls. The user can visit the web page by connecting to the NodeMCU ESP8266. To open a web page in a browser, the user must type the HTTP address of the web page's server. Ac and dc servo motors are the two types of servo motors. Ac servos are powered by alternating current and need a lot of energy. A lot of power means they can pick heavier loads. Ac servos are used in industrial applications. Ac servos can move their shaft precisely to any angular or linear position. They have a controller with a feedback mechanism used for adjusting the control variables.

Only 180 degrees can be rotated with RC servos. The goal is to offer a precise location in an angle field ranging from 0 to 180 degrees. Tower pro micro servo sg90 is the RC servo motor I'll use in this project. The servo motor Sg90 is powered by 4.8 volts. At 4.8 volts, the small torque produced by the sg90 can displace a weight of 1.8 kg per cm. The frequency and duty cycle of the PWM signal determine the spinning of the sg90 servo motor shaft. Most RC servo motors require a PWM frequency of 50 Hz. On a PWM signal duty cycle of 1 millisecond to 2 milliseconds, they can spin from 0 to 180 degrees.

The servo shaft is moved to a 0-degree angle after a one-millisecond duty cycle at 50 Hz frequency. 1.5 milliseconds equals 90 degrees, and two milliseconds equals 180 degrees. For example for 45 degree shaft rotation the duty cycle will be 45/180= 0.25 so 1(0 degree)+0.25= 1.25 ms. The image and pinout for the Tower pro sg90 servo motor are shown below. There are three pins on the Tower pro servo motor. The power pins are two, while the PWM control pin is three. The red lead can be connected to +5 volts. Create a black background. Connect the yellow lead to the PWM signal on the controller, which is NodeMCU ESP8266, to link on doing the IoT.

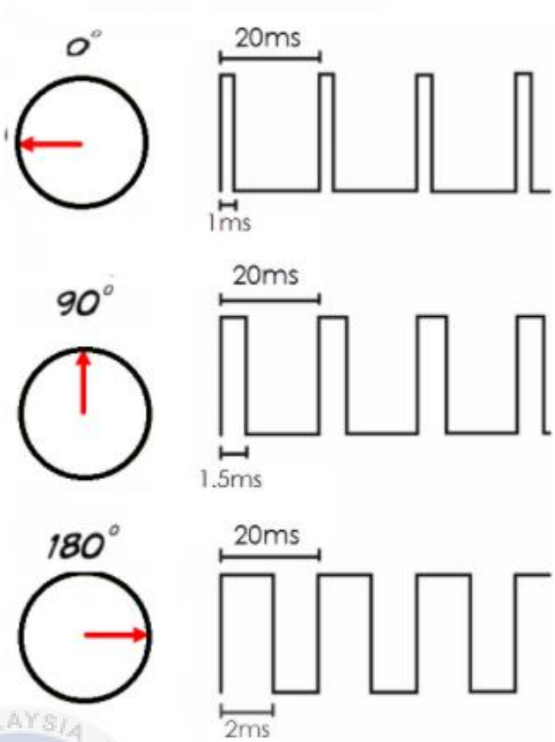


Figure 3.22: Sg90 servo motor pwm signal requirements duty cycle and frequency

Figure 3.23 Sg90 servo motor

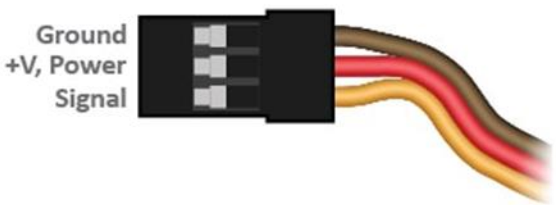


Figure 3.24 Sg90 servo motor wire connection

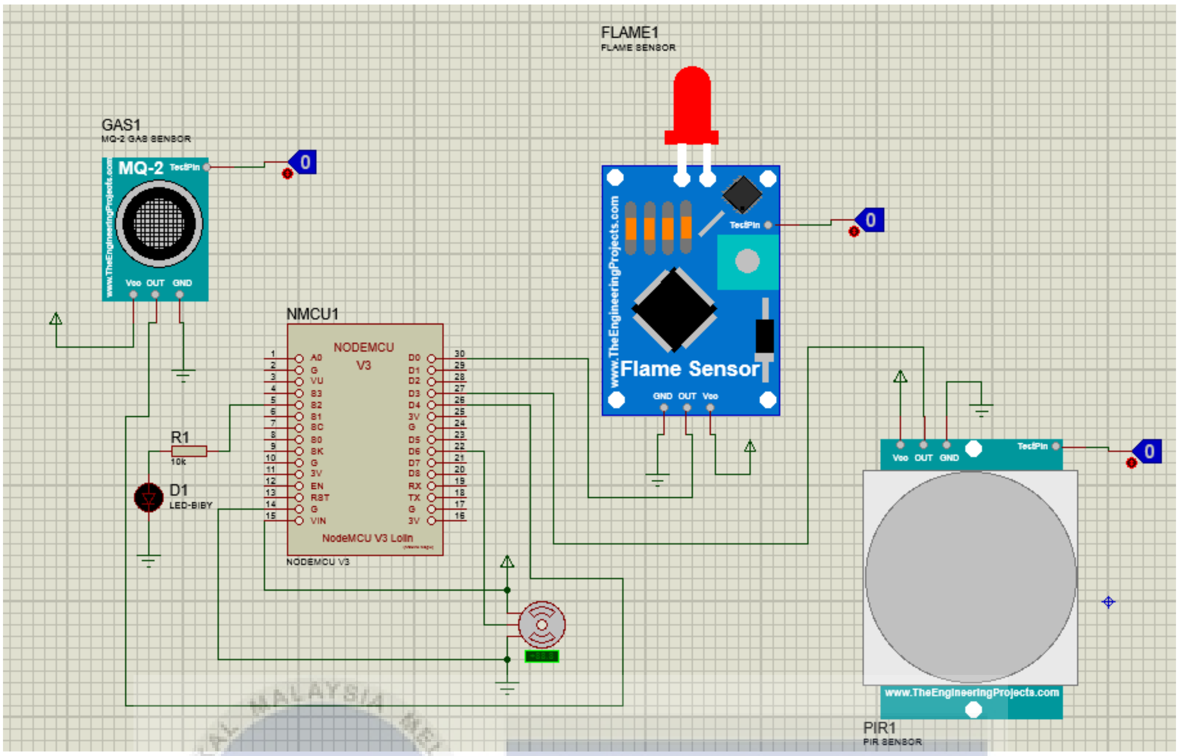


Figure 3.25: Circuit for Servo motor with NodeMCU ESP8266 module

The Node MCU ESP8266 runs on 3.3 volts, while the servo motor runs on 5 volts. As a result, we'll need separate power sources for both peripherals. The Node MCU ESP8266 is powered via the computer's USB connection, while a separate 5-volt adapter powers the servo. The Node MCU ESP8266 12e's GPIO-2 or D4 pin outputs a PWM signal for servo motor spinning. The Node MCU's PWM signal is also in 3.3v TTL format. Before feeding the servo motor, it must also be elevated to 5v TTL. For this project, I used a pair of transistors. The first transistor inverts the PWM signal but elevates it to 5 volts. The output of the first transistor is fed into the input/base of the second transistor. With the TTL level raised to 5 volts, the second transistor inverts the signal once more and returns it to its original shape. The Node MCU's ground and the 5-volt power supply's ground are commonly grounded in the circuit.

3.6.3 Flame Sensor

For the monitoring system on the IoT Smart Stove, a flame sensor is used to detect any hazard to the flame sensor with a height of 0.4 m to 1 m. The flame sensor will be connected to the Arduino, and there are three pins on the flame sensor: the output, GND and VCC (3V-5.5V). So, the output pin will be connected to the Arduino at the Digital IO pin, the Green LED, which indicate the presence of fire to warn the user. GND pins go to the ground and VCC pin to the power.

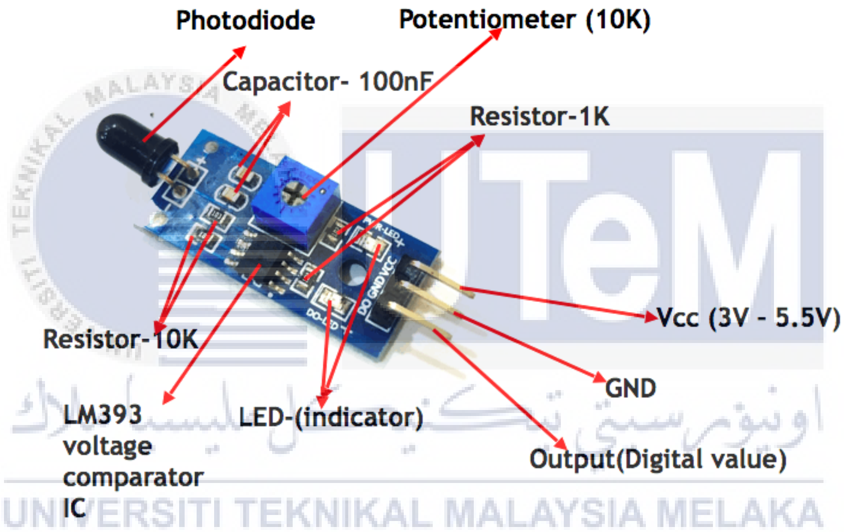


Figure 3.26 Flame Sensor technical part

Table 3.2: General flame sensor specification

Parameter	Description	Unit
Spectra response	185 to 260	nm
Window material	UV	-
Weight	Approx. 1.5	g

Table 3.3: Maximum ratings flame sensor

Parameter	Value	Unit
Supply voltage	400	V
Peak current	30	V
Average discharge current	1	min^{-1}
Operating temperature	-20 to + 60	min^{-1}

Table 3.4: Characteristic of flame sensor (at 25°C)

Parameter		Value	Unit
Discharge starting voltage (with UV radiation) (DC)	Max	280	V
Recommended operating voltage	__	325 +_ 25	V
Background	Max	10	min^{-1}
Sensitivity	Typ	5000	min^{-1}

3.6.4 PIR Motion Sensor

For the monitoring system of the IoT smart Stove sensor, it is needed to detect the presence of human activity in the kitchen. But when no motion is detected when the stove is on. Therefore, either a fire or gas sensor has detected the hazard; this will warn the user that they did not turn OFF the gas stove. So PIR motion sensor is an essential part of the monitoring system. Next, to connect the PIR motion sensor to the Arduino UNO, there are three pins: GNG, OUT, and VCC, so pin OUT will be connected to the Digital IO on the Arduino and RED Led will also be added to indicate the presence of human activity. GND pin will connect to the ground, and the VCC will connect to the power source.

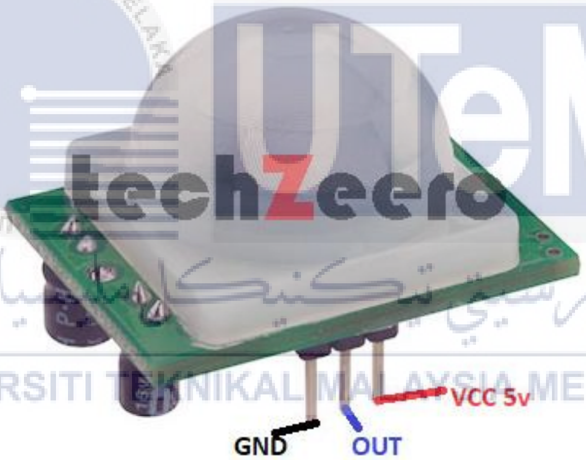


Figure 3.27 PIR sensor

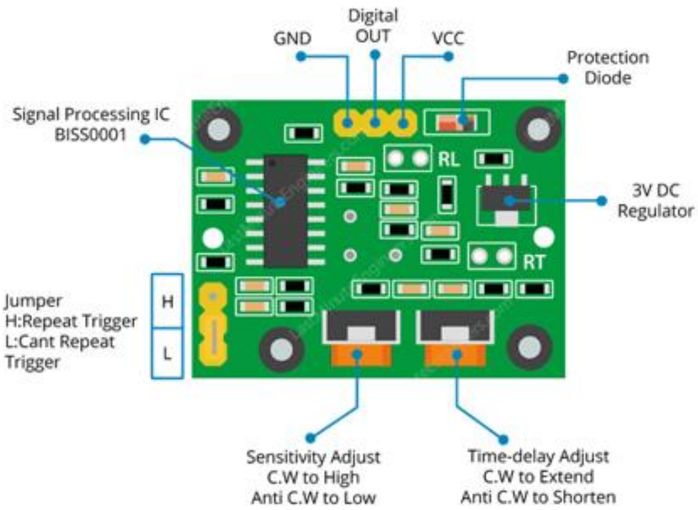


Figure 3.28: PIR sensor technical parts

Table 3.5: Technical Spec for PIR Motion sensor

Feature	Description
Operating voltage range	DC 4.5 – 20V
Quiescent current	50uA
Level output	High 3.3 V / Low 0V
Trigger	'L' position for a single trigger / 'H' position for repeated trigger (Default repeated trigger)
Delay time	5 – 2005(adjustable) the range is (0.xx second to tens of seconds)
Block time	2.55(default) can be made a range (0.xx to tens of seconds)
Board dimension	32mm*24mm
Angle sensor	<100° cone angle
Operating temp	-15 to +70 degrees
Lens size sensor	Diameter 23mm(Default)

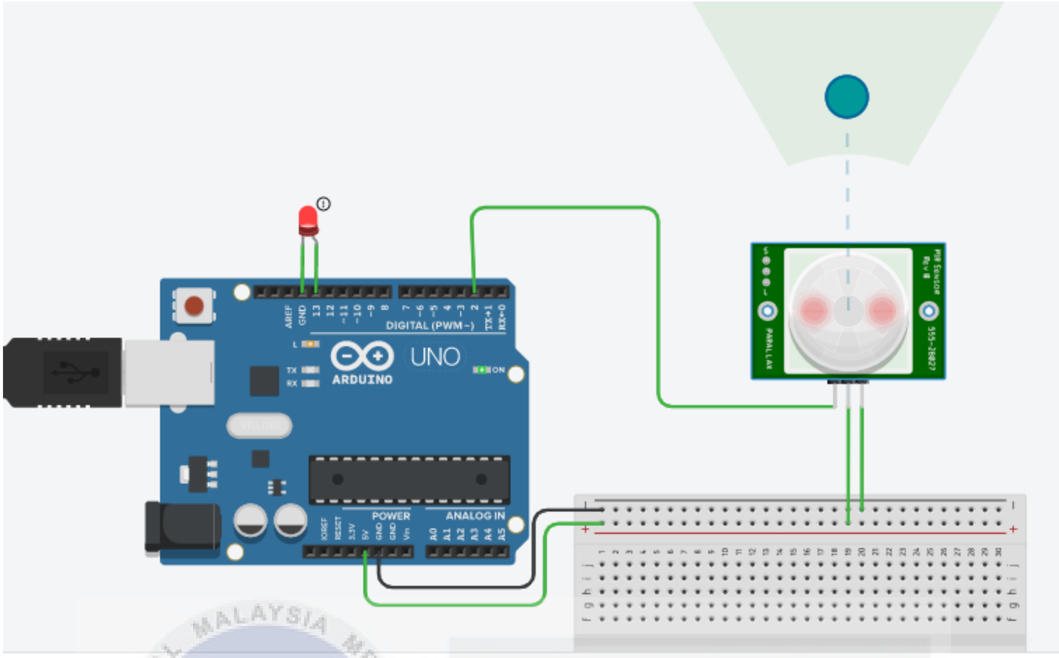


Figure 3.29: PIR Motion Sensor connect to Arduino

3.6.5 MQ4 Methane Gas Sensor

` In this project, MQ 4 Methane gas sensor is used to detect any presence of methane gas leakage. Because methane gas is a dangerous gas that will cause harm to users if they breathe into the methane gas, for the connection, methane gas sensor has four types of pin, but in this project, only three pins are needed to connect, which are D0 pin, GND pin and VCC pin.D0 pin will connect to the Arduino Uno, GND connect to the ground but will be added resistance 330ohm of resistance and yellow LED to indicate the presence of methane gas and lastly the VCC pin will connect to power. The number of pins used for the sensor needs to be declared in the C++ Arduino coding to run the circuit.

Figure 3.30: MQ-4 Methane gas sensor

Table 3.6: Function of each pins MQ-4 Methane gas sensor

Pin Name	Function
VCC	Positive power supply pin
GND	Reference potential pin
AO	Analog output pin. It generates a signal proportional to the intensity of methane.
DO	Digital Output pin. It also produces a digital signal whose limit can be set using a potentiometer.

Table 3.7: Technical spec MQ-4 Methane gas sensor

Feature	Description
Operating voltage range	5V±0.1V
Heating voltage	5V±0.1V
Load Resistance	2 Kohms

Sensing Resistance Range	10 – 60 Kohms
CH4 Sensing Range	300 – 10000 ppm
Sensor Heat Consumption	≤ 950 mW
Output Analog Voltage:	2.5 – 4 Volts (5000 ppm CH4)
Preheating Time	Over 48 Hours
Operating temp	-15 to +70 degrees

3.7 Biodigester development

It is essential to consider the material of the biodigester as it is highly acidic, which may cause corrosion onto the biodigester. Next, after deciding the material, measurement and dimension also need to be considered by using Fusion 360 to design the body of the biodigester. Then, material cutting can be done after all dimensions have been decided. Assemble each material by welding because mild steel will be used for the body of the biodigester. Also include the inlet for the food waste to enter and two outlets for gas and fertiliser to be released. The gas later will flow to the biogas bag, and then it will be compressed to the LPG cylinder and ready to use for cooking gas.

3.8 Summary

This chapter describes and explains the methodology of developing biogas IoT bright stoves using kitchen waste. This mythology will be used as guidance to follow the sequence and help the development of the project step by step. The development step consists of determining, selecting, process and analyzing the parameter of the topic that be guided efficiently to reduce any error while developing this project. From the previous literature review, we were able to know and decide what method to use in the project and improve what is needed to get a much better result, either hardware or software. From the understanding, the biogas formation, into the type of biodigester, type of material used for the biodigester body, type of software used on the IoT Smart stove, choosing on hardware component. The content is described by drawing a flowchart, tables for experiment and block diagram for better understanding. Lastly, the complete project needed to be troubleshot repeatedly until it reached the project's objective, and to ensure the project was done in time, Gantt chart is used to do the list sequences and periodic tasks required to ensure successful plan management.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results and analysis on the development of Biogas IoT Smart Stove and discusses all of the required data to determine the project's performance. The data will be obtained based on the objective and scope, whether it is achieved or not. The analysis will be conducted and observed, discussed in this chapter for the preliminary and final results.

4.2 Results and Analysis

Three-part results and analyses are needed: hardware and mobile application and cloud server. Overall, the hardware of this project is a prototype that will be used to collect data. A temperature sensor and pressure gauge are installed for biogas production to monitor the digester. Besides that, gas production will be collected in a tire tube and then weighed using a digital weighing scale. Data is collected for 20 days. After 20 days, a gas collected in the tire tube is used to test on fire if it is flammable. This will be as an observation. Moreover, sensors have also tested the functionality and range to detect fire, methane gas and motion sensors. Blynk console is used to record the data reading of methane gas detected in ppm (parts per million).

4.2.1 Software implementation

Proteus software is used to simulate the three inputs and three outputs: Flame sensor, PIR Motion Sensor, and MQ-4 Methane gas sensor. As for the output that indicates the presence of the element on each sensor is the 3 LED lights. Figure 4.1 show the circuit simulation, and Arduino Uno is the microcontroller that controls the input and output of the circuit where if the toggle triggers each sensor, it will light up the LED light, and the virtual terminal will show one if it is triggered and show 0 if it is not triggered. The results show in Figure 4.2 until 4.4 for each sensor.

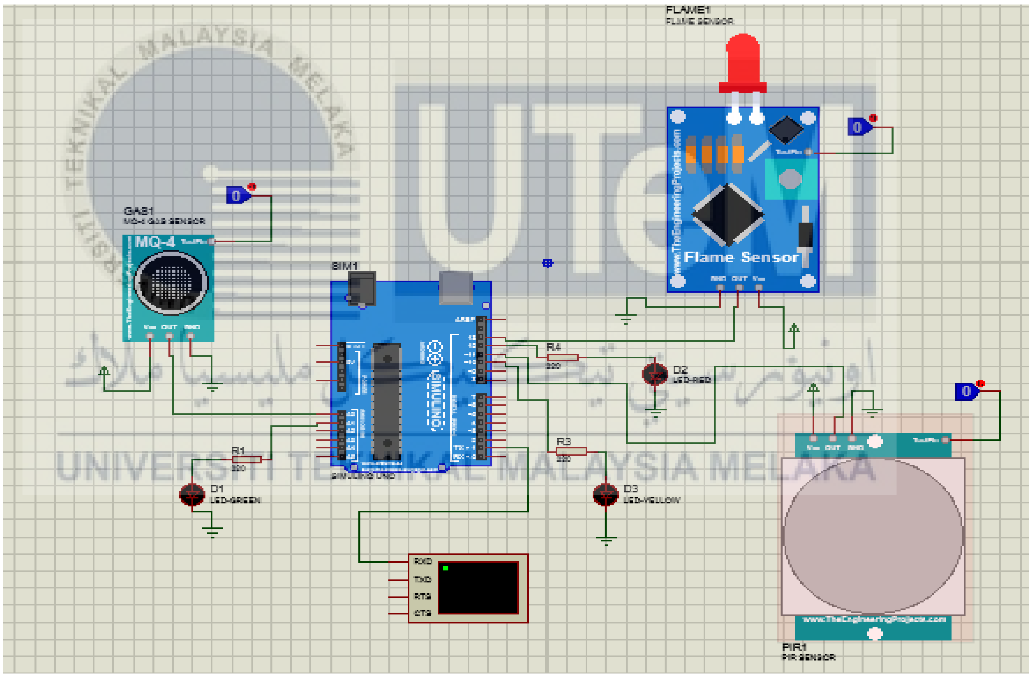


Figure 4.1: Simulation of Circuit

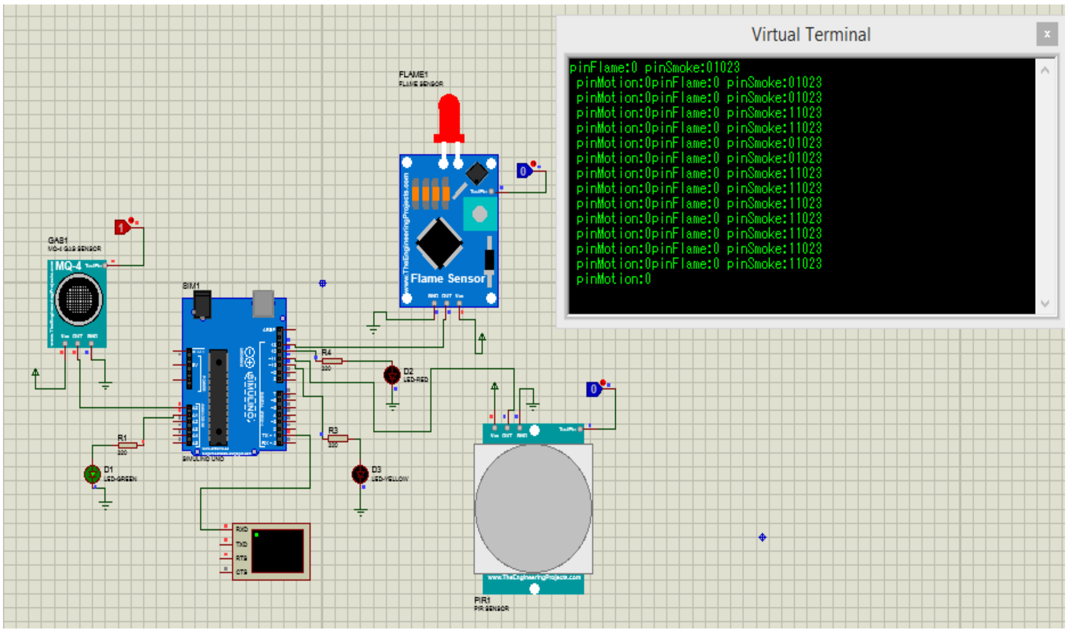


Figure 4.2: Green LED light turn ON when the toggle at sensor MQ-4 is triggred

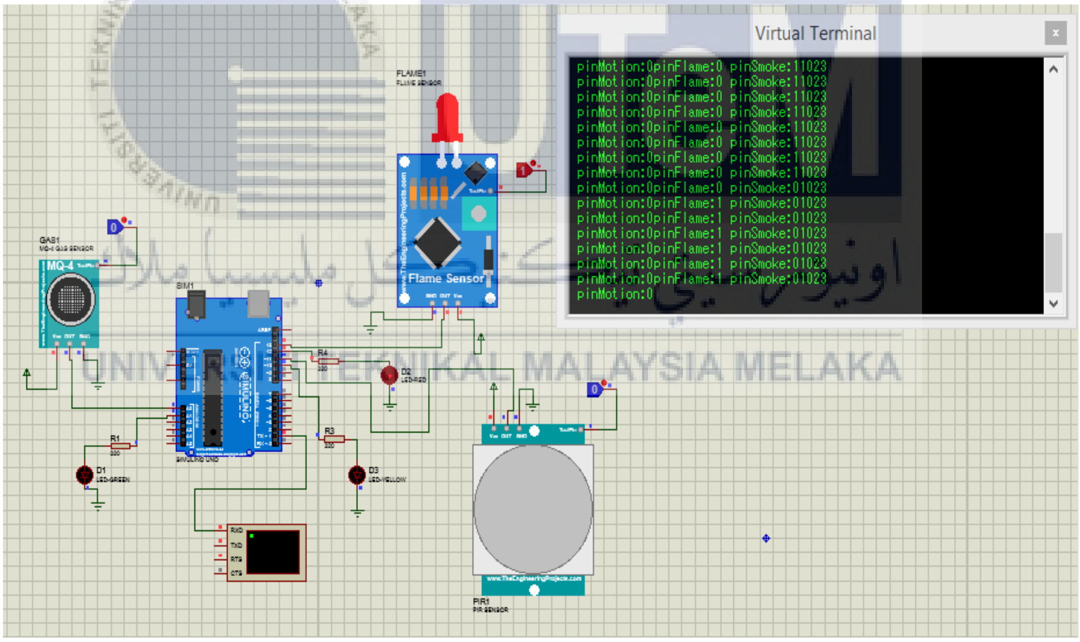


Figure 4.3: RED LED light turn ON when the toggle at Flame sensor is triggred

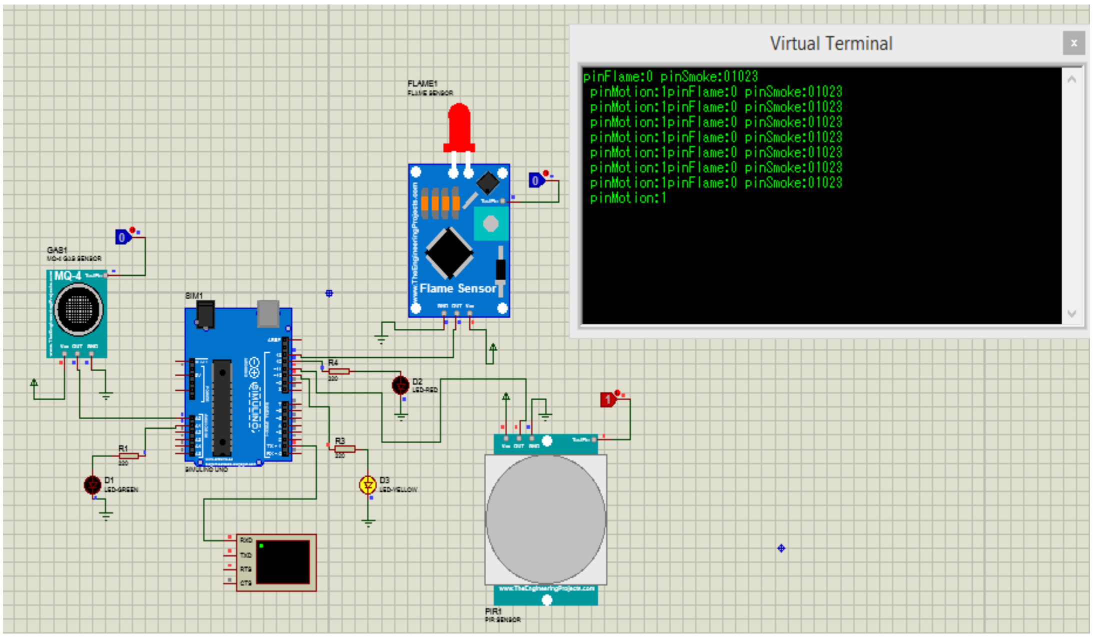


Figure 4.4: Yellow LED light turn ON when the toggle at PIR Motion sensor is triggred

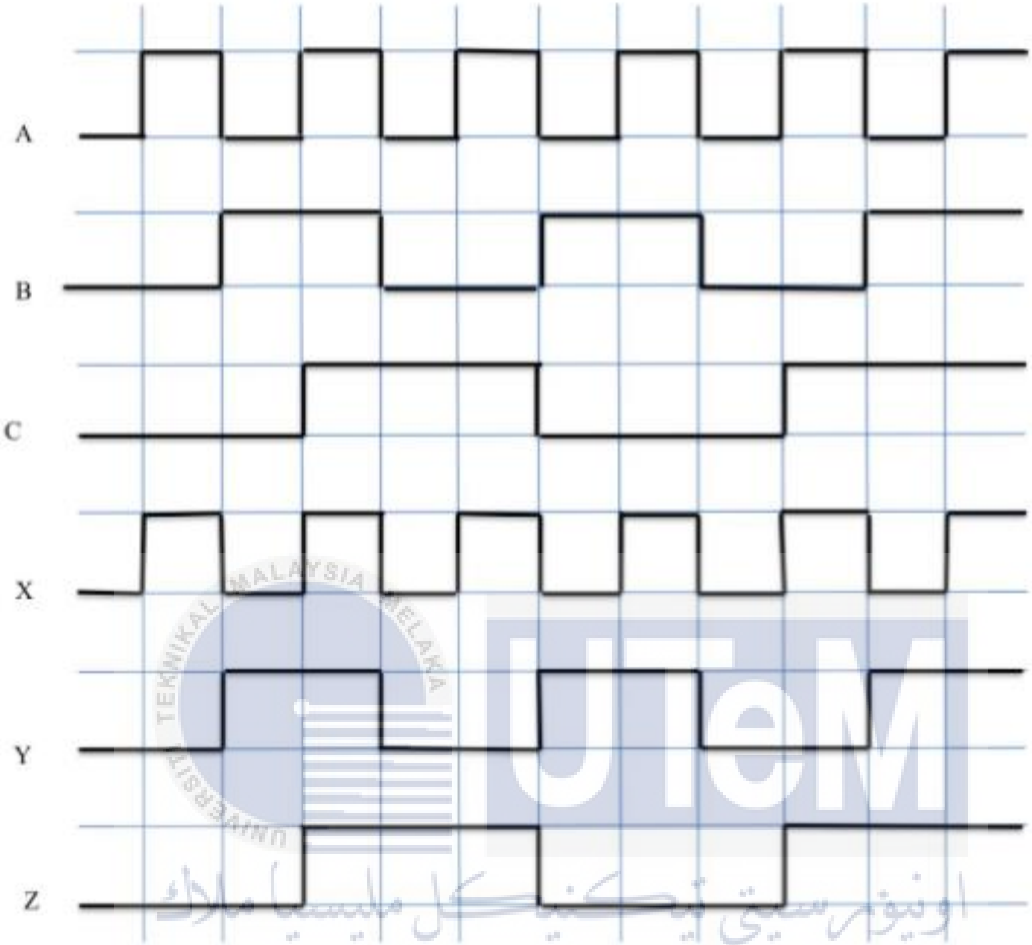
4.2.2 Result Analysis

4.2.2.1 Logic Diagram

Input			Output		
Flame sensor (A)	PIR Motion sensor (B)	MQ-4 Methane gas sensor (C)	LED RED (X)	LED YELLOW (Y)	LED GREEN (Z)
0	0	0	0	0	0
0	0	1	0	0	1
0	1	0	0	1	0
0	1	1	0	1	1
1	0	0	1	0	0
1	0	1	1	0	1
1	1	0	1	1	0
1	1	1	1	1	1

This is the truth table of the circuit at Figure 4.1 showing each sensor when detected . Basically when when any sensor is triggered it do not affect to other sensor because they are specifically function for each of the led light.

4.2.3 Real time results analysis



4.2.3.1 Testing the distance of Flame sensor detection

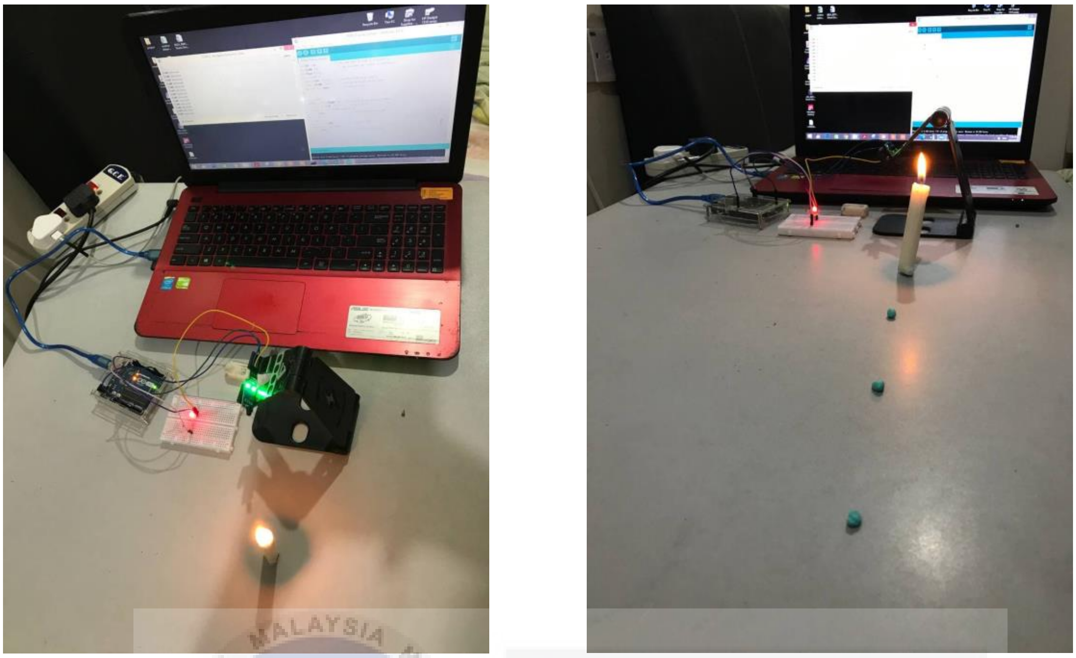


Figure 4.5: Flame sensor distance testing settings

The position of the light of the candle is measured from 0.01 meter to 0.1 meter. To know the flame sensor detect the fire, red LED will light up indicate the sensor can detect the fire.

Figure 4.6: Flame sensor detect fire at 0.02 and 0.04 meter

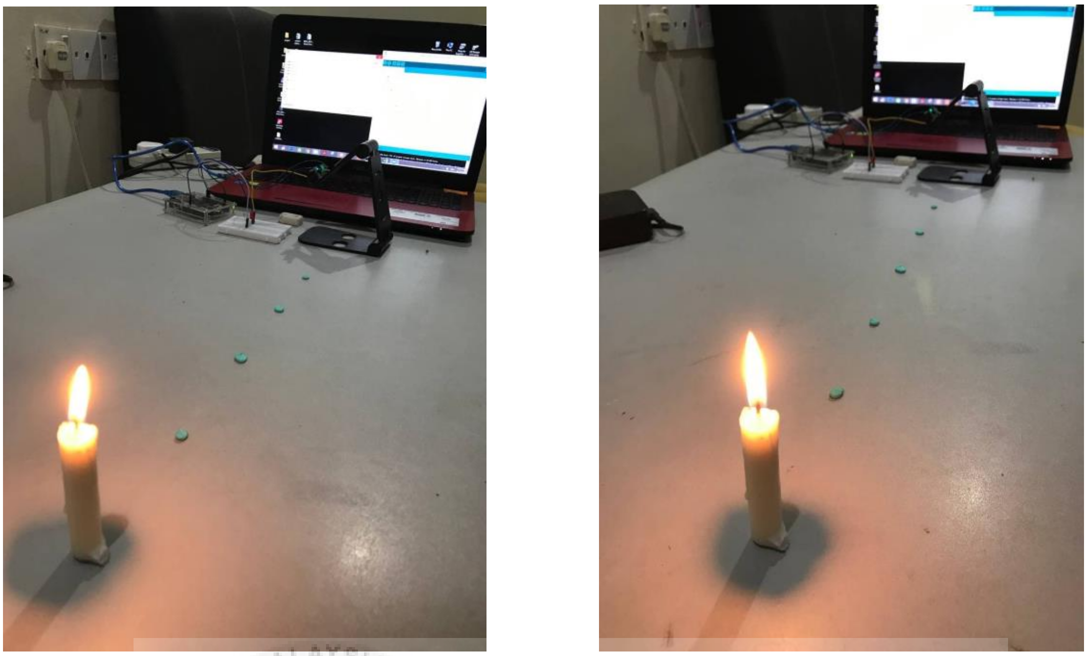


Figure 4.7: Flame sensor did not detect at 0.05 and 0.06 meter

From the real-time analysis result of the flame sensor, the sensor can only detect from 0.01 to 0.04 meters. But when the candle is placed at the distance of 0.05 and 0.06, the red led is not lit up, indicating the flame sensor cannot detect the fire. Therefore, this experiment will be the guide to know the maximum distance of the flame sensor to detect fire and apply it to the assembly of the intelligent stove, which will be placed 0.5meter above the stove. This is to ensure that if the fire from the stove reaches more than 0.1 meters, then this will send a notification for the user if they forgot to close the stove.

4.2.3.2 Testing distance for PIR motion sensor

For PIR motion sensor setting , the distance of movement is from 0.3 meter to 6.6 meter. This reading is taken in Arduino serial monitor .

Condition PIR sensor	Distance detected(m)
Motion detected	0.3
Motion detected	0.6
Motion detected	0.9
Motion detected	1.2
Motion detected	1.5
Motion detected	1.8
Motion detected	2.1
Motion detected	2.4
Motion detected	2.7
Motion detected	3
Motion detected	3.3
Motion detected	3.6
Motion detected	3.9
Motion detected	4.2
Motion detected	4.5
Motion detected	4.8
Motion detected	5.1
Motion detected	5.4
Motion detected	5.7
Motion detected	6
Motion detected	6.3
No Motion detected	6.6

From the table, it can be seen that the maximum detection of the PIR motion sensor is up to 6.3 meters. Therefore, from this experiment result, the maximum distance of the PIR sensor can be detected from the data taken from Arduino serial monitor. This shows how well the sensor detects movement when assembled in the kitchen.

4.2.3.3 Blynk app software analysis

Figure 4.8: Bylnk app to notify user

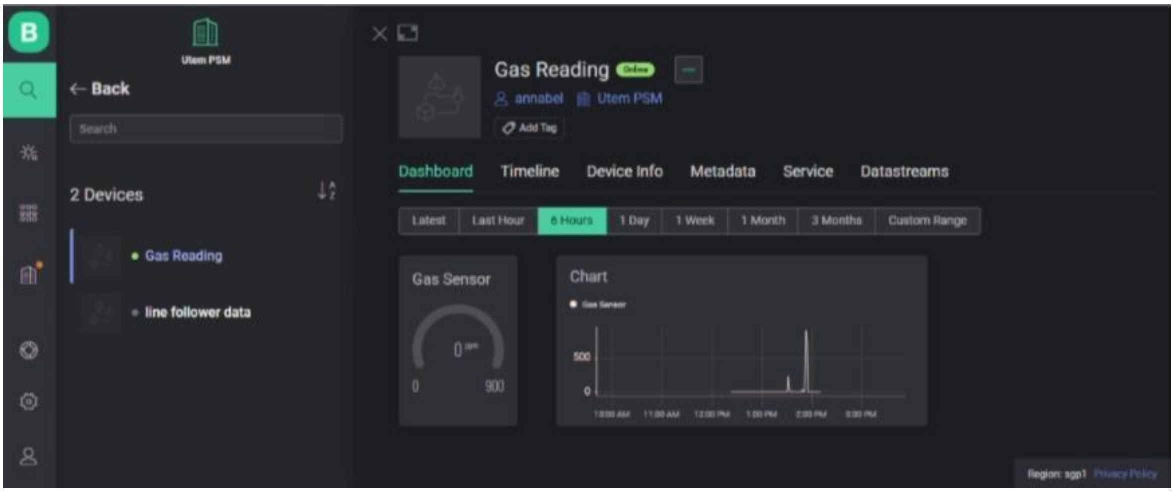


Figure 4.9: Bylnk Console

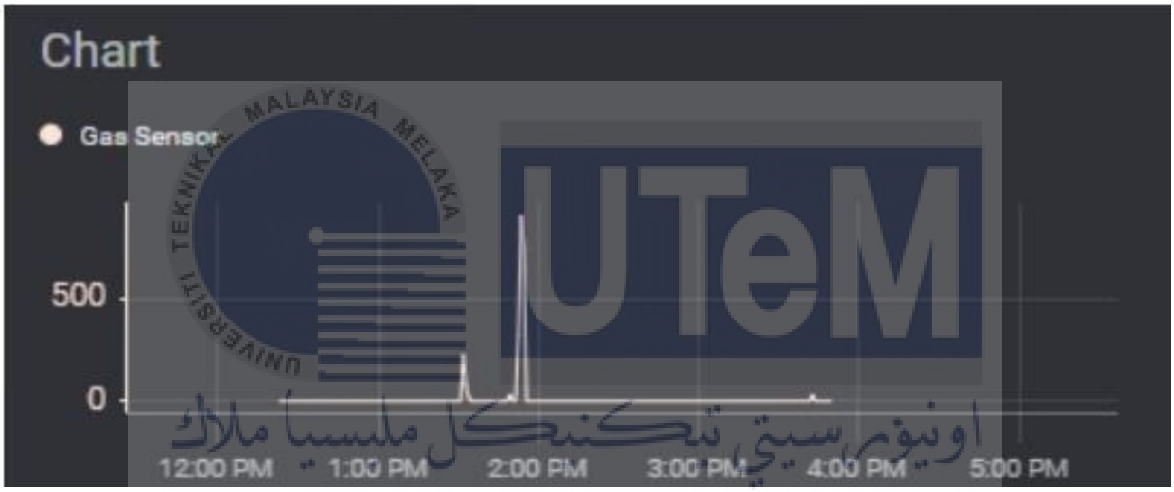


Figure 4.10: Bylnk Console gas sensor analytic reading

4.2.3.4 Biogas hardware setup

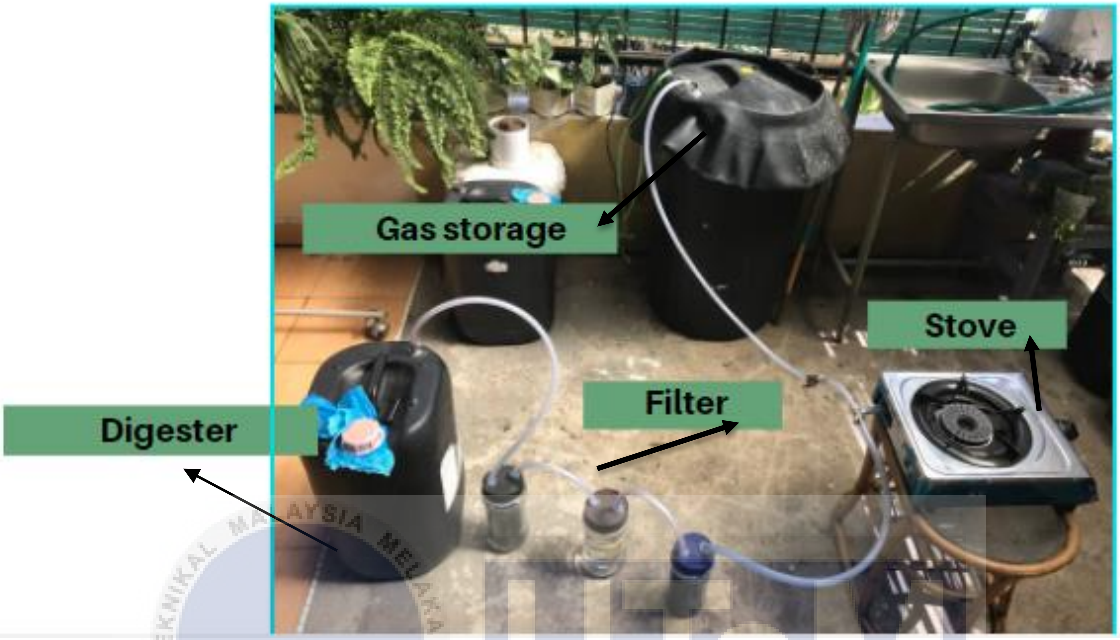


Figure 4.8: Biodigester installation with filter that connect to stove and tire tube

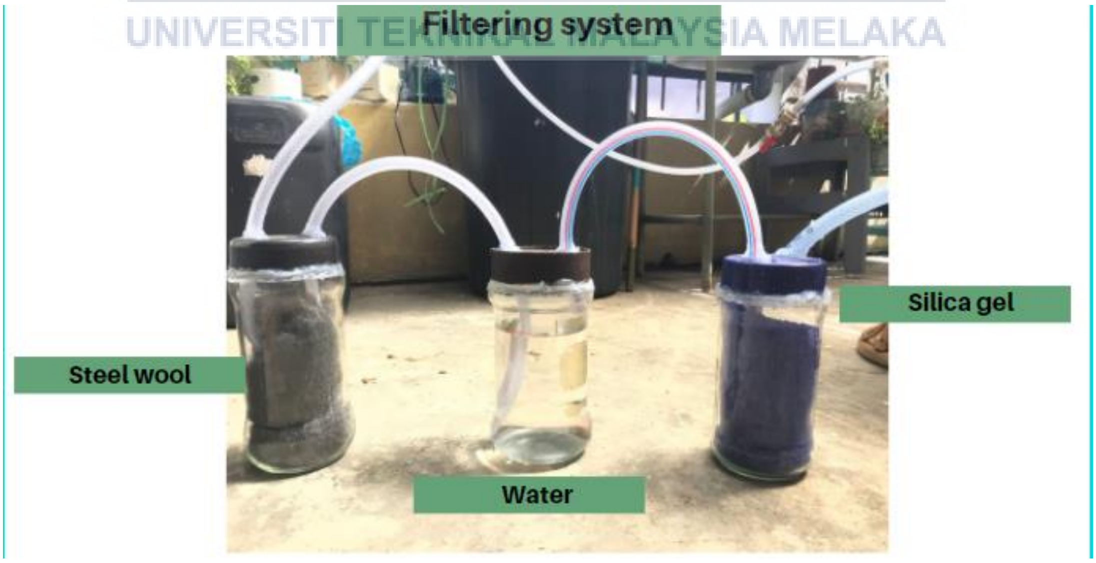


Figure 4.9: Filtering system setup

Figure 4.10: Electrical part hardware setup

Figure 4.11: Gas sensor and Flame sensor is installed under the red container

Figure 4.12: Front view of the Electrical Hardware and PIR sensor installed infront to detect motion

Figure 4.13: Front view of Servo Motor installed to the stove knob

Figure 4.14: Side view of Servo Motor installation on the Stove Knob

Figure 4.15: Foodwaste waste with ratio 1:1

Figure 4.26: Foodwaste pour into digester

4.2.3.5 Biogas result

Table 4.1: Measurement of Biogas Pressure and Temperature in 20 days

No of days	Pressure (Bar)	Temperature (°C)
Digester Contain	Food waste + Water	Food waste + Water
1	0	34.5
2	0	35.6
3	0	36.6
4	0	37.0
5	0	37.3
6	0	36.5
7	0	37.4
8	0	38.3
9	0	36.8
10	0	37.4
11	0	39.0
12	0	38.7
13	0	37.9
14	0	37.8
15	0	35.7
16	0	29.9
17	0	25.6
18	0	25.3
19	0	35.5
20	0	36.4

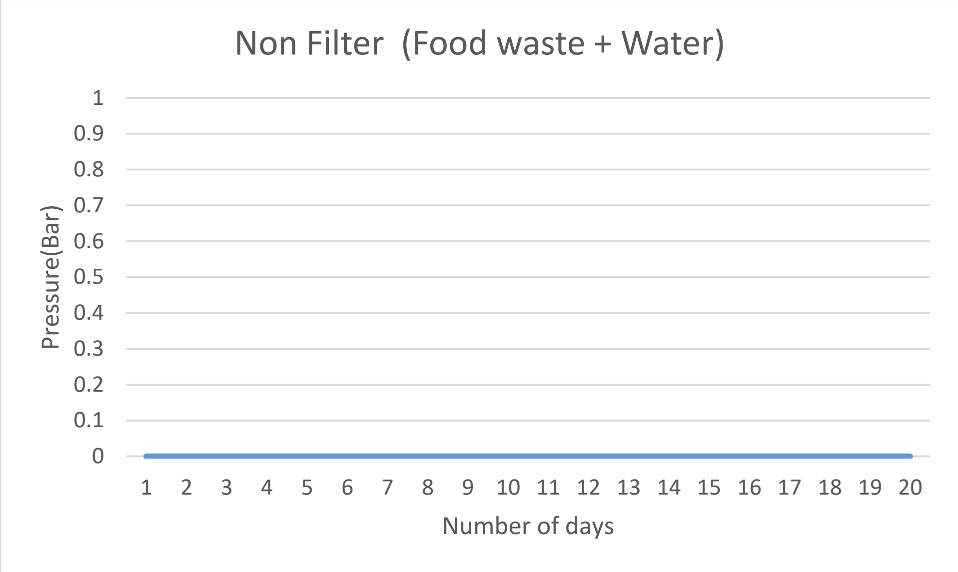


Figure 4.15: The reading of pressure for 20 days

Figure 4.15 shows that the pressure reading from the digester shows all 0 from day 1 to day 20. This is because the pressure in the digester is not enough to detect the pressure gauge. The pressure gauge needs to change into a more sensitive one with a small scale to detect the pressure.

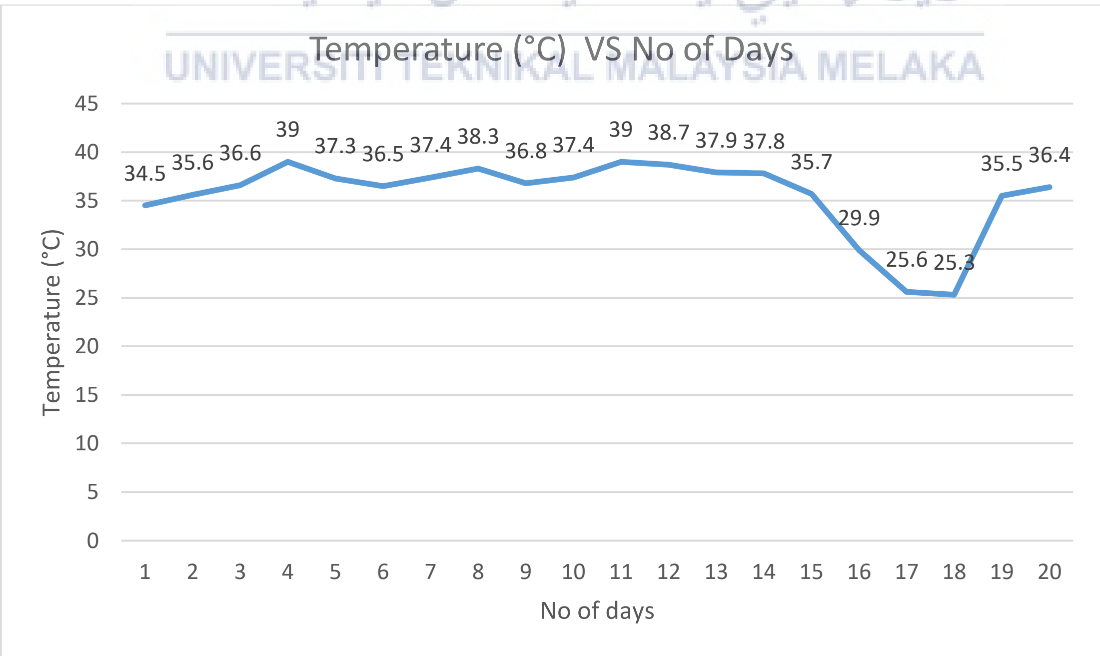


Figure 4.16: The reading of temperature of digester for 20 days

Figure 4.16 shows that the temperature for the first 14 days is consistent, but on days 15 to 18, the temperature drops due to rainy weather. The highest temperature recorded by the digital temperature sensor is 39°C, and the lowest is 25.3°C. This temperature is recorded at 5 pm for 20 days.

Table 4.2: Measurement of Biogas production in 20 days

No of days	Weight of tire by day (Kg) ❖ Original Weight of the tire 1.59kg
Digester Contain	Food waste + Water
1	1.59
2	1.622
3	1.655
4	1.698
5	1.767
6	1.859
7	1.901
8	1.955
9	2.025
10	2.094
11	2.174
12	2.215
13	2.249
14	2.292
15	2.347
16	2.384
17	2.384
18	2.384
19	2.427
20	2.45

Table 4.2 show the production of biogas from day 1 to day 20 with the original weight of the tire tube that is increasing every day till day 20. It can be seen that the highest reading taken can be reached during the 20 days is about 2.45Kg from 1.59Kg. About 0.86Kg of biogas is collected. Besides that, days 16, 17 and 18 show no biogas production because the weight reading is the same for the three days.

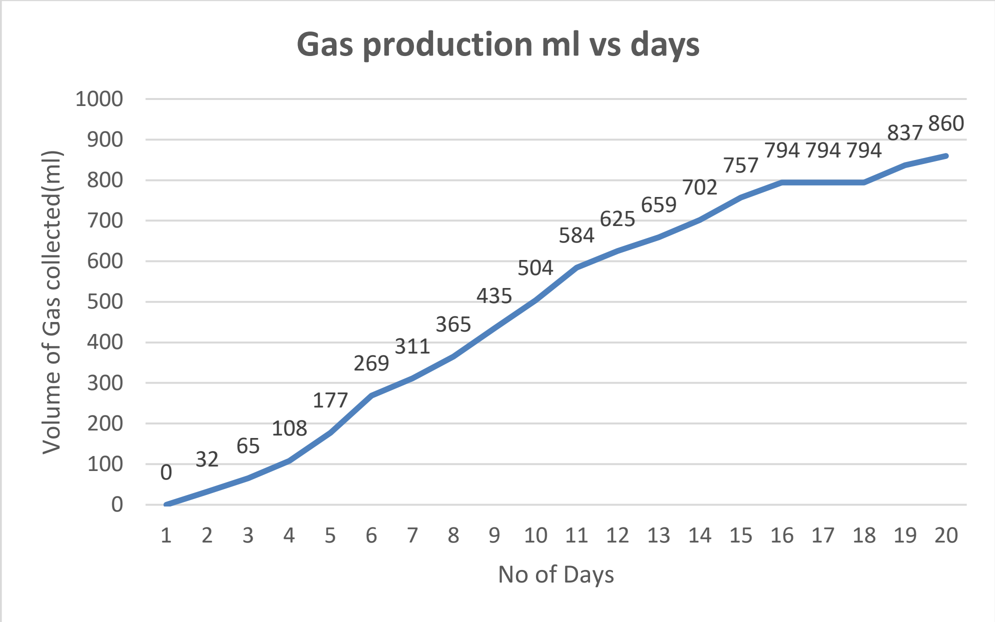


Figure 4.17: Volume of gas in 20 days

From Figure 4.10, the tire's weight from 1.59 Kg increased to 2.45 Kg. For the first two days, the tire's weight is constant, but it starts gradually increasing on day three till day twenty. Therefore when compared to the temperature and the tire's weight, it can be seen that when the temperature is below 30°C, the weight of the tire at day sixteen today eighteen show no production of biogas is produced at that temperature. Showing that 35 °C to 39°C is the optimum temperature to produce biogas from the experiments. The production of gas also depends on the temperature of the digester to do anaerobic digestion.

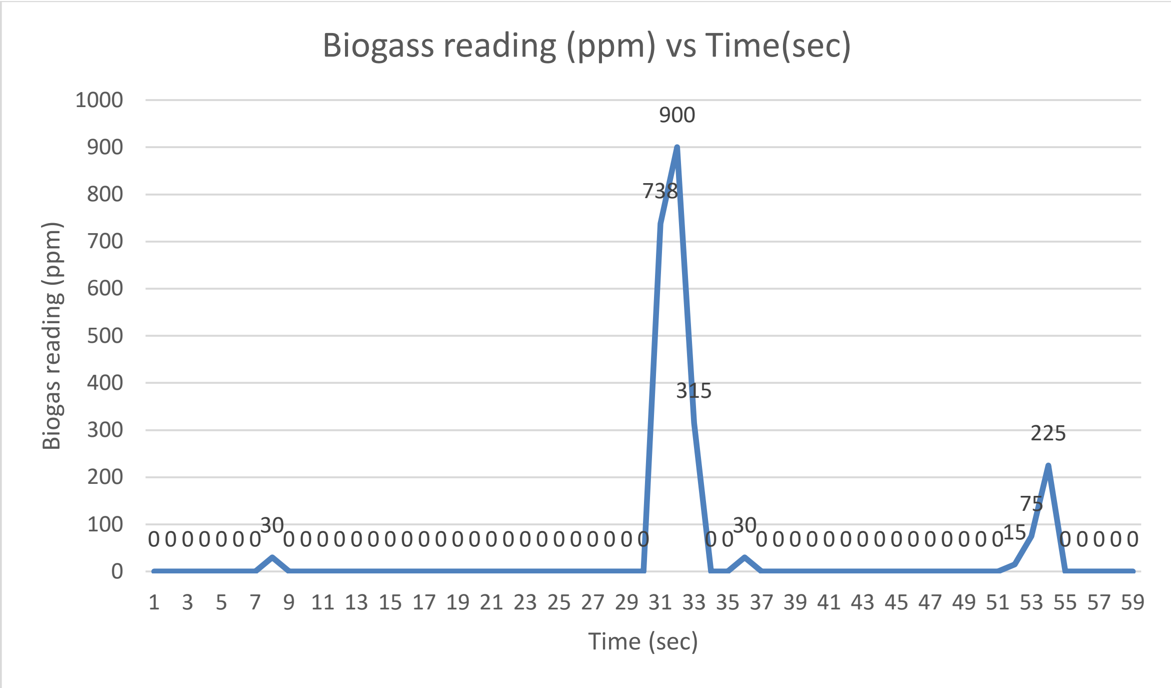


Figure 4.18: Biogass reading (ppm) Vs Time (Sec) line graph

Figure 4.18 shows the graph of Biogass reading taken using blynk apps in detecting the value of biogas in ppm. Showing the highest reading is 900ppm. When more gas is detected, it shows the highest, and when there is no gas, it shows no reading. But this project shows that methane gas is present.

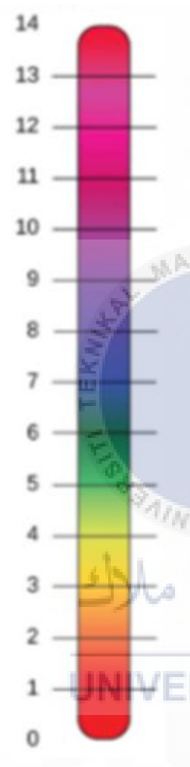
Table 4.3: Measurement of digester in beginning and after 20 days

Digester Contain	Beginning of digester weight (Kg)	After 20 days digester weight (Kg)
(Food waste + water)	20.6	19.7

From the Table 4.3 it is stated that the weight of the digester is lighter by 0.9 Kg after 20 days where the food is disintegrate through anaerobic digestion and produce biogas.

4.2.3.6 Day 1 to Day 20 Result

Table 4.4: pH value day 1 and day 20 comparison

Ph Value parameter	**Day 1**	**Day 20**
		

In table 4.4, day one, blue litmus paper shows the pH is in the range 7 to 8, and at day 20, the blue litmus paper turns red with a pH value between 1 and 2. So for the optimum value of pH 6 – 8 to produce flammable gas and for this project digester, it can only be checked at the beginning of the process before the biodigester is sealed for 20 days, and the litmus paper will be tested again after 20 days. There is a limitation on monitoring pH value for 20 days of the process and adjusting the pH value of the slurry.

Table 5.5: pH value day 1 and day 20 comparison

Tire tube	Day 1	Day 20
		

Table 4.5 show the tire tube on day one and day 20, where the gas is collected from the digester for 20 days and ready to test if it is flammable or not. For collecting the gas, it is essential for the digester or hose not to have any possibility of gas leakage as this prevents biogas from escaping.

Table 6.6: pH value day 1 and day 20 comparison

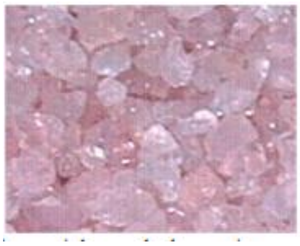
Silica gel after moisture absobtion	Day 1	5 month
		

Table 4.6 shows that the silica gel absorbs water vapour from the gas that comes from the digester, flows through steel wool, and then passes through the water jar. The result can be seen that when compared to the picture from Figure 2.29, it is the same showing that the silica absorbs moisture from the biogas.

Table 7.7: pH value day 1 and day 20 comparison

Steel wool after scrubbing raw biogas	Day 1	Day 20
		

In table 4.7, the observation of steel wool in 5 months show that the steel is rusting because of the presence of Hydrogen Sulphide. Therefore, Figure 2.27 shows the steel turning brown powder after scrubbing but does not mention how long it takes for the steel wool to turn after the scrubbing process.

Table 4.8: Boiling time for non filter and filter biogas

	Substance	Boiling time
Non Filter	Food waste + Water	-
Filter	Food waste + Water	-

The boiling time in Table 4.8 shows no result because the gas is not flammable because of some of the factors such as gas leakage at the digester allow impurities and other gas to enter the digester or methane gas escape from the digester; ph value of slurry must be at least 6 to 8 pH value to get flammable gas and temperature must not be less than 30 °C.

4.3 Summary

For the initial result, simulation for flame sensor, PIR motion sensor and MQ-4 Sensor can run in gaining the output that uses the led. This determines the coding functionality by using Arduino software IDE and Proteus software. Besides that, sensor testing in real-time analysis help to determine the maximum detection of each sensor which will give a good outcome in assembly.

Besides that, biogas production shows that temperature can affect biogas production. The result in Figures 4.17 and 4.18 shows that when the temperature at 35°C to 39°C is the optimum temperature to produce biogas, when the temperature is below 30°C, biogas production is delayed. Moreover, the pressure of the digester shows zero readings because the pressure is not high enough for the pressure gauge to read.

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CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, this paper can conclude that there are factors that need to be considered when developing the biodigester in terms of material use and design of biodigester. The more holes that have been made to the digester, the more the weak point where there will be the possibility of gas leakage. Besides that, the temperature, pH value, the amount of food waste and water need to be considered too because the optimum temperature for anaerobic digestion to work is 30 °C to 40°C, and for pH value, the optimum value to produce flammable biogas is 6 to 8 pH value. Moreover, a leak test needs to be done to detect any leakage.

According to the data analysis of the result, the collected biogases cannot produce flammable gas to cook because the pH value is two, which is acidic to produce flammable gas. But when the sensor is used to test the gas, methane gas is present. Next for filtering system show that biogas needs to be filtered to produce better quality biogas as it removes carbon dioxide, hydrogen sulphide and moisture from the raw biogas.

For IoT bright stove, it is a success, and it can function well with the use of Wi-Fi connected to ESP8266 and the Blynk app to control the stove knob and receive notifications if there are fire or gas hazards. Lastly, this project can fulfil the objective of this project.

5.2 Future Works

For future improvements, a lot needs to be improved in terms of digester design that can be added stirrer, temperature adjuster, and pH monitoring to balance out the pH of the slurry to produce better biogas.

Besides that, stove knob control design and monitoring system also need to be added more functionality, and for the stove, the knob is preferred the build-in automatically wireless stove knob that is easy to use.

Lastly, more experiments need to be conducted to test the best way to produce more quality biogas which is flammable that can produce blue flame, knowing biogas can have a competition on natural gas. Not only producing biogas but also increasing the safety in handling biogas.

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APPENDICES

Appendex A Gantt Chart

Milestone for PSM 1

Project PSM 2	% of task complete	2021												Month 6 - 12	
		March				April				May				Jun to December	
		01/03- 1/04				01/04-1/05				01/05-20/06				01/06-1/12	
		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Milestone 1 (Literature Review)	100														
Chapter 2 (Literaure Review)	100														
Chapter 1(Introduction)	100														
Chapter 3(Methodology)	100														
Milestone 2(Design)	100														
Hardware and Software Review	100														
Design the schematic diagram, develop part by part of the component's connection and the coding for the projects & troubleshooting for IoT Smart Stove	100														
Design portable servo motor stove knob	50														
Milestone 3(Simulation & experimental result)	100														
Fully function simulation on IoT Smart Stove	100														
Sensor testing	100														
Milestone 4 (Assembling and Testing)	50														
Assembling of Biogas digester , filter system and gas storage	30														
Assembling electrical part for IoT Smart Stove	50														
Testing, record the initial result and calculated	0														
Milestone 5 (Report Writing)	50														
Report Writing	50														

Milestone for PSM 2

Project PSM 2	% of task complete	2021												2022	
		October				November				December				January	
		01/10-31/04				01/11-30/11				01/12-31/12				01/01-11/01	
		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Milestone 1 (Literature Review)	100														
Chapter 2 (Literaure Review)	100														
Chapter 1(Introduction)	100														
Chapter 3(Methodology)	100														
Milestone 2(Design)	100														
Hardware and Software Review	100														
Design the schematic diagram, develop part by part of the component's connection and the coding for the projects & troubleshooting for IoT Smart Stove	100														
Design portable servo motor stove knob	100														
Milestone 3(Simulation & experimental result)	100														
Fully function simulation on IoT Smart Stove	100														
Sensor testing	100														
Milestone 4 (Assembling and Testing)	100														
Assembling of Biogas digester , filter system and gas storage	100														
Assembling electrical part for IoT Smart Stove	100														
Testing, record the initial result and calculated	100														
Milestone 5 (Report Writing)	100														
Report Writing	100														

Appendix B Arduino Coding

```
#define BLYNK_PRINT Serial #include <ESP8266WiFi.h> #include
<BlynkSimpleEsp8266.h> #include <SimpleTimer.h> #include <Servo.h>
Servo servo; BlynkTimer timer;
char auth[] = "pjNvfQA96LGua2fIeEKlKGdtePt0voel";    //Authentication code sent
by Blynk
char ssid[] = "ALICIA PINSOM@unifi";//Enter your WIFI name char pass[] =
"050425120565";//Enter your WIFI password

int flag=0;
int gas_value; int gas_avalue; int variable = 0;

void notifyOnFire() //Flame Sensor Code
{
int isButtonPressed = digitalRead(D3); if (isButtonPressed==0 && flag==0){
Serial.println("Fire Detected"); Blynk.notify("Alert : Fire Detected"); flag=1;
}
else if (isButtonPressed==1)
{
flag=0;
}
}

void notifyOnMotion() //Motion Sensor Code
{
int isButtonPressed = digitalRead(D6); if (isButtonPressed==0 && flag==0){
Serial.println("Alert!!! No MOTION is Detected"); Blynk.notify("Alert!!!No MOTION
is Detected"); flag=1;
}
else if (isButtonPressed==1)
{
flag=0;
}
}
```

```
void notifyOnGas() //Gas Sensor Code
{
int isButtonPressed = digitalRead(D1); if (isButtonPressed==1 && flag==0)
{
Serial.println("Alert!!! GAS is Detected."); Blynk.notify("Alert!!! GAS is Detected.");
flag=1;
}
else if (isButtonPressed==0)
{
flag=0;
}
}

BLYNK_WRITE(V3){
servo.write(param.asInt());
}

void setup()

{ Serial.begin(115200); Serial.begin(9600); Blynk.begin(auth, ssid, pass);
servo.attach(D8); pinMode(D3,INPUT_PULLUP); pinMode (D6,INPUT_PULLUP);
pinMode (D1,INPUT_PULLUP);
timer.setInterval(1000L,notifyOnFire); delay(100);
timer.setInterval(1000L,notifyOnMotion); delay(100);
timer.setInterval(1000L,notifyOnGas);

}

void loop()
{
Blynk.run();
timer.run();
}
```