

Faculty of Electrical and Electronic Engineering Technology



Bachelor of Electrical Engineering Technology with Honours

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DEVELOPMENT OF RAINWATER SOURCED PICO-HYDRO GENERATOR POWERED WATER FILTER

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



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I declare that this project report entitled "Development of Rainwater Sourced Pico-Hydro Generator Powered Water Filter" 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.



I approve that this bachelor's degree Project 1 (PSM1) report entitled "Development of

Rainwater Sourced Pico-Hydro Generator Powered Water Filter" is sufficient for

submission.

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 **Development of Rainwater Sourced Pico-HydroGenerator Powered Water Filter.**

Signature : Supervisor Name : Dr. Azhan bin Ab. Rahman Date • 27/1/2023 TEKNIKAL MALAYSIA MELAKA UNIVERSITI

ABSTRACT

Malaysia is a country, which receives a lot of rains and up to an extent that it is one the cause of flash flood. At the same time, the increase of electricity bill is also a main concern. To make use of both issues, rainwater sourced pico-hydro generator powered water filter is proposed in this project. This project utilized the rainwater to move a pico-hydro generator, which produces electricity to power a water filter. Proteus software is used to simulate the process and development of the hardware part, which mainly consists of recycled material, is carried out. Hardware testing results showed that the pico-hydro generator was able to generate more than 5 V of voltage to supply electricity to the water filtered water pump. The functionality of the project is justified by the positive results from three types of analysis, namely, optimum head distance, optimum water level and optimum flow rate determination. The three different analysis produced three distinct equations that can be used to make an estimation of ideal settings that to design a more efficient pico-hydro generator system. It is expected that this design can be applied in any domestic household especially in the rural area

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ABSTRAK

Malaysia adalah sebuah negara, yang menerima hujan yang lebat dan sehingga satu tahap yang menjadi salah satu punca banjir kilat. Pada masa yang sama, kenaikan bil elektrik juga menjadi kebimbangan utama. Untuk memanfaatkan kedua-dua isu, penapis air berkuasa penjana pico-hidro air hujan dicadangkan dalam projek ini. Projek ini menggunakan air hujan untuk menggerakkan penjana pico-hydro, yang menghasilkan tenaga elektrik untuk menggerakkan penapis air. Perisian Proteus digunakan untuk mensimulasikan proses dan pembangunan bahagian perkakasan, yang kebanyakannya terdiri daripada bahan kitar semula, dijalankan. Keputusan ujian perkakasan menunjukkan penjana pico-hydro mampu menjana lebih daripada 5 V voltan untuk membekalkan elektrik kepada pam air ditapis air. Kefungsian projek ini dibenarkan oleh keputusan positif daripada tiga jenis analisis, iaitu jarak kepala optimum, paras air optimum dan penentuan kadar aliran optimum. Tiga analisis berbeza menghasilkan tiga persamaan berbeza yang boleh digunakan untuk membuat anggaran tetapan ideal untuk mereka bentuk sistem penjana pico-hidro yang lebih cekap. Reka bentuk ini diharapkan dapat diaplikasikan dalam mana-mana isi rumah domestik terutamanya di kawasan luar bandar

اونيۈم سيتي تيڪنيڪل مليسيا ملاك UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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LIST OF SYMBOLS

- Density ρ m Meter -Ampere А -Mega М -Pascal Pa _
- W Watt _
- Voltage V _
- % _
- Percentage Horsepower HP _



LIST OF ABBREVIATIONS

V	-	Voltage
HP	-	Hydro Power
PHP	-	Pico-Hydro Power
IT	-	Impulse Turbine
PT	-	Pelton Turbine
RT	-	Reaction Turbine
DC	-	Direct Current
AC	-	Alternating Current
CFL	-	Compact Fluorecent Lamp



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CHAPTER 1

INTRODUCTION

1.1 Background

According to the World Economic Forum, based on the official data, which is from the June report by the Indian government, India is facing the worst water crisis in its history [1]. This crisis has affected most of the nation's areas. In 2021, this crisis also happened in Selangor, Malaysia for three days. During the difficult days, the community needed to ask for help because of the lack of clean water used for drinking and daily household chores. Also, the rural areas, especially in Sarawak and Sabah, which are in Malaysia, are mostly exposed tohuge scale water sources but it is difficult to get electrical sources compared with peninsular Malaysia [2]. The issue of energy poverty is centered in rural areas, where 1.6 billion of the people lack access to electricity and 0.2 million of people in Malaysia do not have electricity [2]. Figure 1.1 shows the cooking style in the rural area without facilities.



Figure 1.1 Cooking Style in the rural area [2]

Then, based on the figure 1.2, due to the climate in Malacca, Malaysia, for the last 5 years, there has been the lowest rainfall distribution from 2015 until 2019 at the Malacca Dam, which is in 2019. At the lowest year of rainfall distribution, Malacca state needs to restrict water use due to the lack of a water source for 3 days. For the next 3 days, society will need to depend on its own tank storage. They need to minimize water use for the three days. Then also, there are a limited number of household chores that use water, for example, washing clothes, doing dishes, and drinking water. Otherwise, they need to buy drinking water at the store due to the restricted water use.



With the advancement and sophistication of technology that exists today, researchers, engineers, and others who are related are attempting to find a solution to the crisis. One of the ideas is a hydropower system. Hydropower converts the water's energy to generate electricity through the natural water-moving concept. Hydropower is also one of the most important systems that can generate electricity using renewable resources. This project isfocusing on pico-hydro power.

1.2 Problem Statement

Nowadays, all the latest news and information are mostly based on electronic media communication, which is done through television, gadgets, and smart phones. All these devices need electricity to keep functioning all the time. Then, for the rural areas, there is a lack of electricity sources to keep getting the latest and most important information, especially on the pandemic COVID-19 and heavy flood information .

Then, in the rural areas, there are huge sources of water, for example, from the river and lake, but they are still getting less clean water for humans and animals due to the lack of awater management system. As of today, the total population is increasing, and they need the proper water management system, especially for the youth growing phase. They are entitled to get a clean lifestyle and proper utility services like in the town.

These days, having a proper management system for electricity is like having air for breathing; it is essential for everyone. For example, people need data for searching for a job, for online business, and most importantly, for educational purposes, especially in pandemics.

By developing a rainwater-sourced pico-hydro generator powered water filter, rural areas will get clean water and electrical supply. This will produce huge significance for society.

1.3 Project Objective

The main aim of this project is to propose a systematic and effective system to developrainwater sourced pico-hydro generator powered water filter.

- a) To perform analysis in terms of varying the head and penstock length.
- b) To perform analysis in term of water level
- c) To perform analysis in term of water flowrate.
- a) To determine the design combination that produces the best optimum output.

1.2 Scope of Project

- a) The project's rainwater-sourced pico-hydro generator-powered water filter is a system that generates electrical power for home low-power-usage appliances.
- b) A pico-hydro generator is a small turbine that converts the energy from water flow into electrical energy for less than 5 KW output power, which is called pico-hydro.
- c) The water filter is used to produce clean water and can be indirectly used as drinking water but needs to boil the water first to make it more secure.
- d) The storage of rainwater needs to be higher from the ground to maintain pressure for water flowing, because when the pressure is high, the speed of the wheel of the turbine will increase and produce a higher current.

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- e) The analysis for heads distance are 2 cm, 4 cm, 6 cm, 8 cm, and 10 cm.
- f) The analysis for water level is 2 L, 4 L, 6 L, 8 L and 10 L.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A literature review is part of a report that focuses on the journal, article, and book that the previous works of research reference, which are the main ideas that the author focused on. All the data is simplified based on the title, abstract, introduction, conclusion, and full text. All the information that is focused on the same or different objective can be used as a comparison, which can make the outcome project better. Examples of the research that can be used as a reference for this project are Pico hydropower (PHP) development in Malaysia, Pico-Hydro Electric Power in the Nepal Himalayas, Investigation on the Performance of Pico-Hydro Generation System Using Consuming Water Distributed to Houses, etc. All the quests are limited to English-version papers.

2.2 Background of Pico-Hydropower

2.2.1 History of Hydropower

The main idea of hydropower is the process's flow from kinetic energy from the water's flowing process to electrical power. In the hydropower system, there are two types of process water cycle which are natural cycles and the second is the cycle that occurs within the hydropower station. The purpose of hydropower generation is to create electricity from renewable sources. It is a highly precious and sought-after resource. The world is currently concerned about the depletion of fossil fuels. at the same time, faces the detrimental impact of rising and concerned about oil prices. As a result, numerous countries, including Malaysia, are attempting to integrate renewable energy.

sources such as mini, micro, and pico-hydro [4]. Figure 2.1 shows that the classification of the hydropower.



Figure 2.1 Classification of hydropower

2.2.2 Concept of Pico-Hydro Power System

ALAYSI

According to the Cambridge Dictionary, a generator is a machine that can assemble electrical power, and pico-hydro is a renewable energy that requires a minimal input of electrical power which is less than 5KW to generate electricity. Thus, a pico-hydro generator is a machine that generates electrical power from renewable sources and outputs electricity. This system is converted from kinetic power to electrical power. Pico-hydro power is also known as a subset of small hydropower system. Pico-hydro is gaining popularity for off-grid applications in low-income locations. Pico-hydro systems are often low-cost due to the lack of major construction required to install them. These systems also have less environmental implications because they are consumer-managed and do not interrupt animal habitats or produce pollutants. The main objective of this system is focusing on the small communities [4].

In Malaysia, the utilization of pico- hydro systems is still in its early stages. The current state of technology can be described as both the beginning and the end. The majorityare imported from other countries. Nonetheless, the government was aware of the impact and significance of pico-hydro to the environment nation, particularly in inland areas. As result in 2010, The Ministry is developing a new renewable energy policy, energy, green technologies,

and water, is designed to make better use of local resources and to contribute Security of national electrical supply and long-term viability. The government has established a vision, with 2020 as the target year. The contribution of small hydro (mini, micro, and pico-hydro) will be up to 500MW to the global power supply [4]. Figure 2.2 shows the basic of pico-hydropower system [5].



The flow of the process based on Figure 2.2 is from A to H. This figure explains that the flows begin from the water supply that has been stored in the place that is called a reservoir. The water flows down through the penstock and the water flows to the generator and converts energy from kinetic energy to electrical energy. The energy that has been produced will be used to power the electrical loads such as lightbulbs, batteries, etc.

2.2.3 Component of Pico-Hydropower

There are four main components that make the pico-hydro power successfully operate, which are the reservoir, head, penstock, and turbine. All the components will be explained in detail.

2.2.4 Reservoir

The main idea for this project is renewable energy which is focused on rainwater. Water drops, the other term used for rainwater, are an important part of the water cycle since it is responsible for depositing most of the freshwater resources. Rainwater does not fall every day. That is why rainwater must be collected and stored in a storage unit until it needed. Figure 2.3 showed an example of a tank that is one of the reservoirs that used for stored rainwater.



Figure 2.3 Water tank

Water rushes downward out of the storage tank through the piping system. This down direction distance is known as the "head," and it refers to the ability of the water to accelerate for the primary moving system [6]. As a result, the turbine will turn the alternator to generate electricity. All the parts in the system need to be calculated and considered based on all parameters because the facility needs to be safe and efficient for the community.

To begin, the basic formula is based on what is defined from the input to the output as in formula 2.1, where Pin stands for Hydro Input Power, Pout stands for Generator Output Power, then H stands for Head, which is calculated in meters, Q stands for rate of water flowing, g stands for gravity, which is fixed at 9.81 meters per second, and for the system's efficiency [5].

$$Pin = H x Q x g \tag{2.1}$$

$$Pout = H x Q x g x \eta \tag{2.2}$$

2.2.5 The Measurement of the Head

The vertical distance between the top of the penstock and the level at which the water enters the turbine is measured as a head. Net head is calculated by subtracting the force or head losses caused by friction and turbulence in the penstock from the head. The amount of head loss is determined by the parameters, for example the type of the penstock, dimension, and length of the distance of the penstock pipe, as well as the number of bends or elbows. The main point of the net head is the losses due to the friction and turbulence in the penstock [6].

There are numerous methods for measuring the size of the head [6]. However, because thesuggested Pico-hydro system consumes water distributed to residences by the Water Utility Company, and the utility's water tank may be located a long distance from the residences, the straightforward and most recommended method for head measurement is a water-filled tube and a calibrated pressure gauge. Using the following pressure to head conversion equation, the pressure gauge value in psi can be converted to head in meters [6]. H stands for Head in meters and P is stand for Pressure in psi were The Figure 2.4 showed the head in the Pico-Hydro System.



2.2.1.1 Penstock

To transport the water from the head to the turbine is using the piping systems called penstock. This is frequently called penstock, and it consists of a pipe running from the storage tank to the turbine and a valve or gate that regulates the water flow rate. The planned picohydro system will get its water from drinking water, which will be provided to dwellings. As a result, the system must be built to provide high water pressure to operate the turbine at the highest possible speed while also recycling and reusing the water for other normal tasks such as watering plant, taking shower, and washing dishes [6]. Thefigure shown that.



Figure 2.5 Example of penstock for huge power output

2.2.1.2 Turbine

After the head and the penstock are calculated and selected, the turbine needs to be selected because different lengths will give different pressures of the water. Also, different types of turbines will give different efficiency and performance. The turbine is connected to the penstock, and when the water flows from the penstock to the turbine, the blade will rotate. This kinetic energy will be converted to electrical energy. The speed of the shaft will give a different amount of energy. The speed of the water depends on the penstock and the head [7].



Figure 2.6 Turbine

2.2.6 Different types of pico-hydro

The types of pico-hydropower are determined based on the turbine used. Water turbines for Hydropower (HP) and Pico-hydro power (PHP) are divided into four categories which are impulses, reactions, and feelings. The Francis Turbine is the most widely utilised turbine for HP and PHP plants. Turgo, Pelton, and crossflow turbines are all examples of impulse turbines (IT).

It is indeed worth noting that ITs are designed in a simple and low-cost manner. ITs for general use have been created in recent years. There are high and medium water heads available. IT has been set up. As they proved, they are often used for lower heads and microsites. ITs are now a potential alternative all around the world due to their high effectiveness. A Pelton turbine (PT) is equipped with one or many jets. Because of their excellent efficiency, they are extensively employed in the PHP system. A PT, on average, has a high-performance rate of 70 to 90%. PT can be beneficial [7].

It is easily capable of generating power and runs at a modest water flow rate. PT, on the other hand, cannot be done in a free-flowing atmosphere with boundless resources. Water must be propelled by a nozzle to produce a high-speed jet in the PTs. While using reaction turbines (RTs), the flow of water is used to generate an upward hydrodynamic force that turns the runner's blades. As compared to ITs, the RTs performed admirably in minimumand maximum conditions. The performance of RTs is higher than that of ITs at sluggish working speeds. The widely commonly used type of turbine is the Francis reaction turbine [7].



Figure 2.7 Specification of turbine

2.3 Overview of Existing Project System

2.3.1 Empirical analysis of turbine and generator efficiency of a pico-hydro system

There are 1.5 billion people who are not entitled to power supply. Because of the limitations of the transmission system, especially rural and hilly areas are affected. As a result, there is a significant focus on alternative power sources such as solar, wind, and hydro, which are both reliable and clean. Hydroelectricity can be a practical solution in terms of both the environmentand the economy, especially when executed on a modest scale [8].

This research focused on the performance of the turbine and generator for pico-hydro system efficiency. Yadav and Chauhan introduced the pico-hydro system, which was centred on producing energy using a domestic water tank. The inverter and 6 V lead-acid battery were employed, with the inverter suitable of turning 6 V DC to 175 V AC. The system produced 8.408 Watts of electricity. This was used to power 5Watt compact fluorescent lamps (CFL). Maximum voltage, current, and revolutions per minute (rpm) were specified as 5.646 V, 6.87 mA, and 1500 revolutions per minute, respectively. An experimentwas carried out with various inner diameters of pipe, and it was discovered that such factors were inversely connected to it, whereas it had a direct connection with head. Ridzuan etal. studied a generation system based on the stream of energy through household pipes [8].

Equipment	Specification	Manufacturer
Permanent magnet alternator	Max rpm =2700 Max 3-phase Ac voltage = 170V	Wind Blue Power
Pelton turbine	Material= Bras, PCD = 100mm	ABS Alaskan
Centrifugal pump	Power = 2HP	MP Pumps
Flow rate sensor	0-50 gpm	Omega Engineering
Rectifier	Max current $= 150A$	Wind Blue
Inverter	Power=300W Input voltage=12V Current= (>0.6A)	SNAN
Load	2 bulb (60 W each)	
Pressure transducer	0.50pstg	Omega Engineering
Battery (dry lead acid)	voltage= 12V Current= 9Ah	
Laser tachometer	voltage= 12V 2.5-99,999rpm	Neiko
Hanging scale	0-50kg	Mango Electronic Spot LCD

Table 2.1 The detail of equipment used.

The shaft power is calculated using equations to compute turbine efficiency. The ratio optimization of mechanical energy and flow power is critical for turbine efficiency. The same formula used by Cobb is used to determine jet power. Because turbine efficiency is highly influenced by flow velocity, the impact is evaluated at various flow rates to determine the system's maximum efficiency [8]. The Figure 2.8 shows the schematic of the pico-hydro system based on this research.



Figure 2.8 Schematic diagram for pico-hydro system.

2.3.2 Roof rainwater harvesting systems for household water supply in Jordan

The purpose of this research is divided into two essential points, which are to investigate the ability of the rainwater to make it as a water storage in Jordan and to prepare some issues **UNVERSITITEKNIKAL MALAYSIA MELAKA** and ideas based on the quality and quantity that rainwater has been saved. A variety of data needs to be collected to achieve the objectives. For examples the data of rainfall, the numberof population and the area involved. All the data needs to be accurate and calculated [9].

Based on Table 2.2, the data of roof rainfall that have been collected have been stated that based on thePopulation and Housing Census (2004) around 33k in the Jordanian county, rainwater reservoirs with an estimated volume of $20m^3$ have been constructed and used as an essential source of fresh water for drinking. The public network serves as the primary supply of drinkingwater for the greater part of residential properties in the area, with 82.4 percent [9].

Source of drinking water	No of housing units	% Of housing units
Public network	774,917	82.43
Tanker	34,359	3.65
Roof rainwater harvesting	33,229	3.53
Bottled water	93,996	10.00
Artesian well	1708	0.18
Spring	1756	0.19
Other	182	0.02
Total	940,147	100.00

Table 2.2 Housing unit distribution based on primary freshwater (DOS, 2004).

Jordan's climate can be classified as arid to semi-arid. Summer peak temperatures in the highlands reach 32oC. Winter low temperatures range from 14 and 17 degrees Celsius in the hills and desert regions, and 21 degrees Celsius in the Jordan Valley. Winter low temperatures in the hills and deserts range from 1 to 4 degrees Celsius, with snowfall on occasion in the highlands. Jordan's rainy season lasts from October to April, with the most precipitation falling between January and February. Under normal climate circumstances, the amount of rainfall is 300 mm (about 11.81 in) annually [9].

In most situations, the storage area is the top of a home which is under the roof or structure. The practical roof area and the substance used to construct it impact the efficiency of collection and water quality. Smoother, cleaner, and more impermeable roofing materials are preferred because they contribute to the improvement of water quality and quantity. Tiled rooftops or roofs sheeted by corrugated mild steel, for example, are preferred because they are the simplest to maintain and provide the purest water [9]. Figure 2.9 shows an example of roof water harvesting system

The most popular types of rooftops in Jordan are cement and tiled roofs. These varieties of roofs are long-lasting, inexpensive, and offer high-quality water. Because of the roof material, many designers expect a 20percent reduction in annual rainfall. These losses are caused by the texture of the roofing material, evaporation, losses in gutters and storage tanks, and inefficiencies in the collection procedure [9].



Figure 2.9 Example of roof water harvesting system.

2.3.3 A survey of innovative technologies increasing the viability of micro- hydropower as a cost-effective rural electrification option in South Africa

Almost 75 percent of the South Africa community are not exposed to the electricity especially in the rural area. Based on the research, South Africa has a huge of opportunity to build while using sustainable energy for examples as wind, solar, or small-scale hydropower to power tiny rural and isolated populations with minimal energy demands. In terms of cost of energy produced, micro-hydro is the future supply choice compared to other renewable resources in places where appropriate water resources are available [10]. Other benefits of using micro-hydropower include.



South Africa has a huge energy potential that can be utilized for local to large-scale electrical power generation. According to DME research, there has been no significant development in the local hydropower business for 30 years. Cumulative hydroelectricity generating appears to account for only about 5 percent of overall installed energy generation capacity [10].

~	_	Installed	Estimated
Size	Туре	Capacity	potential
		MW	MW
			36,4
			00
	i)Imported	1450	10.4
	") Demonstrations of fam	1150	10,4
Micro	1) Pumped storage for	1580	00
hydropower	iii) Diversion fed		520
(larger than 10	iv) Dam storage	- 662	0
IVI W)	regulated head		152
	v) Run of river	-	0
	v) Run of fiver		U
			270
	As above (iv) and (v)	29.4	113
Small			_
hydropower	Water transfer	0.6	38
(from a few kW	Refurbishment of	8.0	16
to 10 MW	existing plants		
KI	Gravity water carrier	0.3	80
F			

Table 2.4 South Africa Hydroelectric potential

Based on the Table 2.4, he use of widely viable micro-hydro turbines is conditioned by water head, flow, pressure, and the necessity for penstock adaptation, which can make them unsuitable for use in a variety of prospective settings. As a result, identifying and proposing a range of viable micro-hydro turbines for generating energy in rural South Africa is critical [10].

Based on the Table 2.5, depending on the specific requirements of each given site, the hydraulic turbine is one of the most important and expensive components of micro-hydro power facilities. The present micro-hydro conversion system is comprised of impulse and reaction turbines. Their main disadvantage is the low efficiency for usually about 30 to 60 percent are obtained when employed in micro-hydropower schemes [10].
Pump-As-Turbine (PAT)	Propeller hydro turbine system
Low cost then the traditional turbing	Used to increase the efficiency of the
Low cost than the traditional turbine	turbine
Durability and simplicity of construction	Low of cost and easy for mounting
Simple because no specific design	Can provide energy from 200W-20kW
Easy maintenance due the simple part	

Table 2.5 Characteristic of micro-hydro turbine

2.3.4 Shaving electric bills with renewables? A multi-period pinch-basedmethodology for energy planning

The fossil-based forms of energy as the primary source of energy have directly contributed to the depletion of fossil fuels. As a result, replacing fossil-based energy sources with alternative power sources is the most suitable option for lowering global carbon emissions. However, the use of clean energy sources in the power generating area drops significantly, representing for only 14 percent of the overall sources of energy in 2017, while reliance on fossil-based energies remains significant. The International Energy Agency (IEA)forecasted the demand rate of various sources of energy in 2040. Renewable energy sources are expected to boost their contribution from 14 to 31 percent during the next 23 years [11].

Acknowledging that urgent action will be required to cut carbon emissions, the Malaysian government has set a goal of 50% sustainable power in generating electricity by 2050. Given that Malaysia's renewables contribution was only 2 percent until 2019, this can be regarded an ambitious effort. Given that fossil-based fuels will continue to be the primary source of energy generation in Malaysia, carbon emissions are expected to rise in the future [11].

As a result, the Malaysian government has been aggressively pursuing solutions to the identified problem. One of them is to encourage the use of renewable energy. As a result, sustainable energy management in the power generation sector is the primary focus for lowering carbon emissions. Figure 2.10, 2.11,2.12 below representing energy profiles under various conditions. The price is displayed in Malaysian Ringgit (MYR). The yellow boxes display theoverall cost of cumulative electricity costs and Maximum Demand (MD) charges for each scenario and the distinct types of renewable energy including hydropower energy gives changesto the cost of the bill [11].



Figure 2.10 Graph illustration without using renewable energy



Figure 2.11 Illustration graph using renewable energy



Figure 2.12 Illustration graph using renewable energy



Scenario 1 depicts the initial energy profile with zero renewable energy (base case), whereas Scenarios 2 and 3 depict the resulting outcomes with and without proper renewable energy scheduling, respectively. The proper energy schedule will aid in the reduction of bill costs. The purple line chart in the figures depicts the total electricity cost throughout the five-time intervals, excluding MD charges. The overall cost (shown in the yellow box) is the sum of the cumulative electricity cost and the MD charges. Scenario 3 has the lowest total cost since it has the lowest MD charges when compared to the other two scenarios.

This is because of the optimal deployment of renewables, which achieved a reduction in the consumption of fossil-based energy in that time span, resulting in a lower total MD value. Scenario 2's overall costs are reduced only marginally when compared to Scenario 1, as the Most of the reduction is attributable to the use of renewables, which are quite inexpensive.In fact, the same MD charges are obtained without adequate scheduling (since the same maximum demand value of 100 kW is achieved). This demonstrates that proper renewable energy scheduling can drastically reduce MD charges, resulting in much reduced electricity costs.

2.3.5 A review on turbines in power production using wind and hydro energy

This study discusses the environmentally friendly helical turbines used to extract electricity from wind and hydro sources. Furthermore, it compares current helical turbines to other conventional turbines in power output in both metropolitan and designated sites. The horizontal turbine, which might be an economical electrical generation turbine that will be used in metropolitan areas with a straightforward generator for energy production, is a cost-effective turbine due to its eco-friendly design and could be deployed in a variety of suitable sites [12].

In power generation, the Gorlov helical turbine, which was evolved from the Darrieus turbine, has proven to be a more economical turbine than the opposing water turbine. The Lucid spherical turbine is a type of helical turbine established from the Gorlov helical turbine of collecting electricity from water network pipelines where mechanical energy is easily dissipated. They are useful to energy production for electric grids and power source for aquatic systems placed for inspection and management in sophisticated infrastructure networks for cities [12]. Based on the Figure 2.14, an example of demonstration turbine blade for water turbines.

24



Figure 2.14 Example of demonstration turbine blade

2.3.6 A New Design of Banki's Water Turbine Model for Pico Hydro in Tabanan Bali

Pico hydro was constructed by water turbine and a generator. The turbine is built for Pagi, Tabanan, Bali. While commercially available generators are employed, pico-hydro development is done in workshops and laboratories. Pico hydro was created in this study utilising a cross flow turbine with an inner diameter of 40 cm, a thickness of 30 cm, and 16 number of blades. The turbine blade was designed with a 15° of curvature. Figure 2.15 depicts the design of the Pico-hydroturbine.



Figure 2.15 Design of turbine of Pico-hydro turbine.

The angle of the shaft significantly impacts the performance of a Pico- hydro turbine. The wheel is spinning because the blade is in touch with the water. A 150-blade curvature has been seen to yield higher efficiency values; the turbine has also been demonstrated to create higher energy output and a high revolutions per minute (rpm), with a peak of 232 RPM. The power produced by the water turbine at an angle of 15° was found to be greater than at an angle of 16°. These data were acquired from a known as micro that used a fixed load installed on a water turbine; the output current and voltage were monitored. The output energy of each design can be computed [13].

2.3.7 In-pipe Waterpower Generation from Spherical Turbine

This generation requires an environmentally friendly electrical power generation system. This project is about an innovative technique to generate electricity by using the flow of pipe liquid as the energy source for operating turbines, which in turn drive electrical power sources. The goal is to build a self-sustaining system that generates power using the kinetic and pressure energy of flowing of water, which drives the turbine assemblies, which include spherical turbines attached to generators that are progressively situated in the following flow of water [14].

This project will investigate the necessary system parameters, technical specifications, operating parameters, cost of installation, and power production capacity of a spherical turbine in-pipe waterpower generator for 10 families on a street in this research activity [14]. Figure 2.16 shows an example of turbine model.



Figure 2.16 An example of turbine model

As a result, to generate 0.00125 kilowatts of output power, a turbine with a rateof flow of 306 cubic meters per hour and a rotational speed of 1440 revolutions per minute must be used. The fluid operating pressure will make 2.5 kg per square meters [14].

2.3.8 Feasibility of harvesting rainwater for power generation

This research looks at the possibilities of using rainwater storage to generate power for high-rise residential structures. Rainfall could be collected and directed to power a mini-DC generator. RK Hostel, the highest building on campus, was chosen for this investigation. It stands 20 metres tall and has a rooftop catchment area of 905 square metres, which can hold 15 thousand gallons (about 56781.15 L) of rainwater [15].

The total energy power (P) is dictated by the water pressure (H) and rate of flow of the vertical outflow pipe (Q). The model's design is created in MatLab software or Simulink software, and then the simulation of the design is run to determine the amount of electricity that can be generated. According to the modelling results, a 17-metre vertical conduit pipe with a consistent flow rate of 7.8 litres per second may generate around 600 watts of power [15].



Figure 2.17 Output power vs rate of water flow

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Based on the result from the Figure 2.17, the output power is directly proportional to the rate of water flow. The flow rate of the water flowing will give the different value of power output since it differs depending on the length of penstock, the height of the head, the speed of the turbine, etc.

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2.3.9 Viability of Hydro-kinetic Turbine as an Alternative for Renewable Energy Harvesting in Nigeria

The purpose for this research is to generate a zero-head system utilising a standard hydrokinetic water turbine as a model to investigate and establish its performance in an open channel environment for power generation in Nigeria. The flow of water determines the power, which is important for turning the turbine blades. The study involves the flow of water around a pool operated by a pump at 0.4 metre per second and 0.6 metre per second water speed. The turbine is designed to float at this free water flow rating. An ability of this investigation of its viability was conducted in Kano state, Nigeria, and a demand flow and output were calculated during the dry season [16].



Figure 2.18 The performance of turbine

The graphs in Figure 2.18 showed that it can be noted that the rotating velocity at 0.6 meter per second flow rate is greater, with an overall rotation speed of 38 revolutions per minute between the 0.4 meter per second rate of flowing water with an average rotation speed

of 28 revolutions per minute, indicating a higher performance at higher flowing rate. The rotational velocity is determined by the flow rate and the consistency of the flowing water.

2.3.10 Development of a standalone pico-hydropower system in monitoring the gully environment applications in Pingtung Ur-Pho Gully

The research aims to identify an efficient and environmentally friendly picohydropower system (PHS) for monitoring the Ur-Pho Gully water source. Taiwan has an abundance of freshwater, and the low-head PHS can be powered by uninterrupted running water energy from any water source. The self-powered monitoring platform provides a wealth of valuable information, such as hydroelectricity, eco-friendly energy, battery bank, and gully scenarios such as rate of water flow, rate of water level, and the quality of the water for longterm environmental studies in Ur-Pho Gully, as well as alternative eco-friendly energy for managing the water valves and lighting lamps in the rural area. A cutting-edge PHS is made up of a piping system, a reaction turbine with twin blades, an AC generator, and a control system

[17]. UNIVERSITI TEKNIKAL MALAYSIA MELAKA



Figure 2.19 Dc power vs the rotating speed of the turbine

Based on the graph from Figure 2.19, the results reveal that the main pipeline can generate approximately292 Watts of hydroelectricity at a rate of flow of 0.025 cubic meters per second and a capacity of 1.4 meters The reaction turbine models with internal diameter, which is 15 centimeters, 25 number of stator blades, and 21 number of rotor blades may give shaft torque of 1.7-2 N-m at a rotational speed of 769 rpm. The turbine is applied to the 200-Watt permanent magnet generator, which provides power to the control system [17].

2.4 Comparison of literature review

Table 2.6 shows that the differences in hydropower will lead to different types of applications. There are 12 comparisons with different authors.

No	Authors	Title	Application	Remark
1	Abdulla, Fayez	Roof rainwater	construction of	The total roof area,
	A, Al-Shareef, A	harvesting systems for	rainwater	average annual
	W Abdulla, F	household water	harvesting	rainfall, and run off
	An Al, A W	supply in Jordan	cisterns has	coefficient are used
	N. MA	LAYSIA 44	been extensively	to estimate the
	Kuller	Lakka -	implemented to	possible rainwater
	T		deal with the	harvesting volume.
	COU SAIN		serious situation	-The potential
	alle	Lundo Kai	of water scarcity.	saving percentage is
		0 .		derived by dividing
	UNIVE	RSITI TEKNIKAL	MALAYSIA MI	the potential volume
				of gathered rainfall
				by the annual
				household demand.

Table 2.6 The characteristic of the project from different authors

2	Kanzumba	A survey of	Used micro-	Generator
	Kusakana	innovative	hydro turbine is	-A squirrel cage is a
		technologies	one of the key	self-excited
		increasing the	and costly	generator induction
		viability of micro-	elements of	motor.
		hydropower as a cost	micro-hydro	
		effective rural	power plants.	



		electrification option		- less expensive than
		in South Africa		synchronous
				generators
				-keep the input
				power constant
				Micro-hydro power
				-pump as Turbine
				(PAT)
				-Propeller hydro
	a A	LAYSIA		turbine system
3	Karen Gah Hie	Saving electric bills	-reduce electrical	create a carbon-
	Konga, Bing	with renewables? A	bill by using	constrained energy
	Shen Howa, *,	multi-period pinch-	renewable	planning model with
	Juin Yau Limb,	based methodology	source as a	the goal of
	Wei Dong	for energy planning	power source.	minimising overall
	Leongc,Sin	RSITI TEKNIKAL	-modelling	electricity bills while
	Yong Tengd,		through Mixed	meeting emissions
	Wendy Pei Qin		Integer Linear	targets - energy
	Nge, Irene		Programming	demand with an
	Moserf, Jaka		(MILP)	optimal share of
	Sunarso			renewable energy
				This can be
				accomplished using
				the proposed
				technique, which

				consists of three
				primary processes,
				such as tar-getting,
				scheduling, and
				optimization.
4	Chidambaram P	A review on turbines	A turbine is a	-The three-blade
	Thamilarasan K	in power production	rotary moving	horizontal axis
	Barath Kumar J	using wind and hydro	part that use the	turbine (HAWT) is
	Auxcilia Mary L	energy	energy from a	the most connected
		LAYSIA	fluid flow &	with alternative
	ser he	A ARE	converts need	energy
	TEKN	KA	work	Conventional
	1116		JEI	hydroelectric power
	NIN EN	n		is benign because it
	ملاك	ننيكل مليسيا	_ى سىتى تيك	provides a reliable,
	UNIVE	RSITI TEKNIKAL	MALAYSIA MI	clean energy supply
				and is significantly
				less variable than
				wind turbines, which
				have shifting wind
				speeds.
				Type of turbine
				-Urban Venturi
				turbine

				-Gorlov helical
				turbine
				- Lift-based
				spherical turbine
				-Lucid-spherical
				turbine
5	Lie Jasa	A New Design of	pico hydro,	The curvature
		Banki's Water	turbine,	angle of the blade
		Turbine Model for	hydropower	affects the output
		Pico Hydro in		power, speed, and
	white he	Tabanan Bali		efficiency of water
	LEK.M	KA		turbines because
	1118		JE	the energy of the
	S'ann	n		flowing water is
	ملاك	ننيكل مليسيا	ىسىتى تىك	absorbed by the
	UNIVE	RSITI TEKNIKAL		turbine blade.
				-
				Pico hydro is made
				up of a water
				generator
6	Vasu Dixit,	In-pipe Waterpower	generate	Water has a lot of
	Nirav Patel,	Generation from	electricity with	energy in the form of
	Rhishabh Jadhav	Spherical Turbine	the help of the	kinetic and pressure
			kinetic and	energy moving
			pressure energy	vertically through



			residential	hydropower capacity
			buildings	is governed by the
				descending height
				and discharge
				velocity of the water.
8	Ibrahim	Viability of Hydro-	zero-head	- The flow of water
	Abubakar	kinetic Turbine as an	floating system	in the stream
	Masud,	Alternative for	using a	determines the
	Yoshihide Suwa	Renewable Energy	conventional	power, which is
	15	Harvesting in Nigeria	hydrokinetic	responsible for
	stat he	A MEL	water wheel as	rotating the blades.
	TEKN	KA	a model to	-the flow of water
	LIG		examine and	around a pool
	AUN	n	determine its	operated by a pump
	ملاك	ننيكل مليسيا	performance in	at 0.4[m/s] and
	UNIVE	RSITI TEKNIKAL	an open channel	0.6[m/s] water
			condition for	velocities.
			energy	-The turbine is
			harvesting in	designed to float at
			Nigeria.	this free stream
				velocity.
9	Zong-Hsin Liu,	Development of a	determine the	- Constructing this
	Hsuah-Cheng	standalone pico-	eco-friendly	green technology of
	Liu, Wen-Chieh	hydropower system in	pico-hydropower	PHS is very
	Wu,Wei-Hung	monitoring the gully	system (PHS)	encouraging - This

	Shih, Chao-Wen	environment	for monitoring	effort provides many
	Wang, Cheh-	applications in	Ur-Pho Gully	benefits in terms of
	Shyh Ting	Pingtung Ur-Pho Gull	water	capacity, cost-
			environment	effectiveness, the
				size of the design,
				and installation
				compared to other
				larger hydropower
				systems - to
	15	AYSI		minimise the impact
	Ser. Mr.	A MEL		on aquatic animals
	TEKN	KA		and the natural
	III S		JE	habitat, users do not
	NIN CONTRACT	n		need cranes and civil
	ملاك	ننيكل مليسيا	ىسىتى تيك	works for
	UNIVE	RSITI TEKNIKAL	MALAYSIA M	installation.
10	T. H. Ching, *T.	Renewable Energy	development of	- Thus, the four key
	Ibrahim, F. I. A.	from UTP	micro hydro	points to construct a
	Aziz, N. M. Nor	(UNIVERSITI	generation	necessary micro
		TEKNOLOGI	system which	hydropower system
		PETRONAS)	uses water to	are:
		Water Supply	generate	•Flow (the vertical
			renewable	distance between the
			energy.	intake and the
				turbine) (how much

				water comes down
				the pipelines)
				•Length of the
				pipeline (penstock)
				•Transmission of
				electricity (from
				turbine to battery
				bank)
11	dr hab. inż.	Design and tests of	design,	First generator
	Zbigniew	generators for micro	parameters and	-rotor (steel pipe
	Goryca prof.	hydro plants	selected results	with segment
	PŚk	AKA	of tests	magnet glued)
	LINES		conducted for	Second generator
	AIN	n	two generators	-magnet placed
	ملاك	ننيكل مليسيا	designed to	inside the rotor
	UNIVE	RSITI TEKNIKAL	work with a	(composed of plates)
			small water	
			turbine	
12	M.F. Basar, A.	Introduction to the	basic theory	-pico-hydro as
	Ahmad, N.	Pico Hydro Power	and concept of	subset of small
	Hasim, K.	and the Status of	pico-hydropower	hydro
	Sopian	Implementation in		-head and flow
		Malaysia		-the advantageous of
				pico- hydro

2.5 Summary

In this chapter, all the theories about this project are discussed, such as the related product and theories, the process of product design and development and the critical part or components used for electrical appliances in pico-hydro systems. The project can then proceed after being familiar with all the information and data.



CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes in detail the "Development of Rainwater Sourced Pico-Hydro Generator Powered Water Filter" system that will be implemented. There are two phases to this project which are installing hardware and implementing software. The hardware framework for the system is made up of a variety of components. An outline of how the system building approaches this project will be provided throughout this chapter. This projects development is described and can be seen throughout this chapter

3.2 Methodology

This project presents a pico-hydro system generated by the water filter using turbine. This flow of the whole project is presented by Figure 3.1 flowcharts. Flowcharts are used in designing and documenting simple processes of the system. By identifying the opportunities that have around, the idea came out to create an application of the system. By using a flowchart, it helpsto understand the step in a process and how a process is done. Then, other steps as shown in Figure 3.1 is followed to design and fabricate an efficient product



Figure 3.1 The Project Flowchart

According to the flowchart above, this project methodology begins with a literature review on a topic relevant to the pico-hydro system that generated the water filter. The data wasacquired from a variety of sources. For example, from a journal article, a conference paper, oran online piece. Following that, a Gantt chart and to ensure that the project can be completed, a flowchart of the project process is created perfectly on time and to prevent a frantic schedule.

The circuit will then be tested. If it passes and can run successfully, it will go to the next process, which is result and data analysis. However, if the project fails due to an error, the procedure will return to designing the circuit. When the project is completed, the data will be analysed and collected to continue report writing.

Finally, once the report has been completed and finalised, it will be given to the supervisor and panels for marking. Finally, after the report and presentations are completed, the BDP 1 is completed.

3.3 **Project Architecture**

Based on the Figure 3.2, there is a block diagram that depicts the project's operation. Because of the strength of being delivered to generate the water filter.



Figure 3.2 Block diagram of the project

In this project, renewable energy, which is rainwater, will be turned into electrical energy. The rainwater will be stored in the reservoir on a rainy day. Then the water will flow to the turbine through the penstock. The penstock needs to be measured at around 100m (about 328.08 ft) to 500m (about 1640.42 ft) to maintain the pressure of the water flowing. When the water comes to the turbine as mechanical energy, the turbine will act as a generator to convert the mechanical energy to electrical energy. The water waste from the turbine is transferred into the storage and the generated energy from the turbine powers the water filter.

3.4 Experimental Setup

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3.4.1 Proteus Software

LabCenter Electronics created this circuit design programme. It was used to create various circuits on PCBs (printed circuit boards) and to simulate various circuits. Based on the Figure 3.3, by using Proteus software for electronic circuit project, there will be reduced costs and errors due to schematic design on the Proteus. Also, the software can define circuits with advanced analysis, and they also can turn the schematic circuit into PCB (Printed Circuit Board) prototype effortlessly. Thus, saving time, money and lessen the iteration of the prototype.



Figure 3.3 Proteus Software

3.4.2 Polyvinyl Chloride (PVC) Pipe

Figure 3.4 shows a type of pipe which is PVC pipe. PVC pipe is a type of plastic pipe constructed of thermoplastic polyvinyl chloride (PVC). PVC pipe is widely used in a variety of industrial and commercial applications and available in many varieties. PVC pipe is commonly used in plumbing supply applicationssuch as drainage, water systems, agriculture, chemical processing, ventilation tubing, ducting work, and sewage treatment systems. The regular dimension pipe in the market is typically 1/8 inch up to 24 inches in diameter and there a some of them range sizes are 1.27cm (about 0.5 in), 3.81cm (about 1.5 in), 7.62cm (about 3 in) and 10.16cm (about the length of the long edge of a credit card) PVC pipe. Hence, the size dimension and the thickness of the pipe will affect the efficiency of the generated energy.



Figure 3.4 PVC Pipe

3.4.3 Turbine

From the Figure 3.5, the output voltage of the turbine is 12 volts, and the wire impedance is 10.5 plus minus 0.5 ohms. The insulating resistance is rated at 10 M. (DC100 megger). The maximum load at the outlet opening is 1.2Mpa when the outlet is closed. The beginning pressure of the turbine is 0.05Mpa. Third, there are mechanical qualities and the working environment to consider which are an appearance for examples, clean generator surface, no corrosion, no significant scratches, sturdy structure. Mechanical noise 55dB-axial clearance 0.2-1.0mm (about 0.04 in). The weight of the generator is around 90g and 3000 hours (about 4 months) of generator life.



Figure 3.5 Turbine

3.4.5 Ammeter

Figure 3.6 shows an ammeter. Ammeter is an instrument that measures the magnitude of an electric current, usually in amperes. An ammeter is a measuring tool used to determine the amount of electric current in a circuit. The term comes from the fact that electric currents are measured in amperes.



3.4.6 Water Storage Container

From the Figure 3.7, this water storage is made from rigid plastic and can withstand elevated temperatures. In an urgent situation, the water supply may be unavailable or unsafe to consume. As aresult, people will either require a safe drinking water supply or learn how to purify their rainwater for use in various chores such as consuming, making ice, handwashing, and cleaning.



Table 3.1 shows the components for water filter system which are water hose and water pump.

Name	Remark	Description
1. Water hose	• Connect to the water pump to make the flow	
	of water.	• affordable price
	• The design is	• easy to get
	transparent so that the	• transparent
Imeter / diameter 6mm Fit pam Beli 1meter lebih x potong	water can be seen	
UST MALAYSIA	• flowing.	
2. Water pump	• To make the water	
Fag -	come out from the low	
SAININ	pressure to high	
مليسيا ملاك	سيني نيه=pressure	Light item
Horizontal UNIVER TIT	• They have a built-in	Easy to get
Cable length : 23cm	filter to remove debris	• Build in filter
	that can cause the	
	water to become	
	clogged.	

Table 3.1 Component for water filter system

3.5 Project Design

Figure 3.8 shows that the illustration of the project design. Every project that we work on requires a design process. There is compelling purpose of designing project for example.

- To make specific goal for the project
- To keep the flowing of the project in track
- To minimize the failure of the project



Figure 3.8 Illustration of the project design

3.6 Calculation of Project Design

Each component needs to be calculated in detail for the best performance for this project. All the components are decided based on the calculation, for example turbine, the lengthof the penstock.

3.6.1 Turbine Specification

Each component will have specification to describe or identify something precisely or of stating a precise requirement based on the Table 3.6.1.



Based on the Table 3.2, the selected turbine will generate a 10Watt of power output.

When the power output is defined, we can calculate the current will be received. The formula is from Ohm Law

Table 3.2 The calculation of current outp

Calculation Current Output
P = IR
P = IV
$10W = (I) \ge (12V)$
I = 0.83A

Based on the table 3.3, the maximum and minimum water pressure are calculated from the formula for waterpressure because the range of the head needs to be determined. The table showed the calculation of the minimum and maximum water pressure. The formula is water pressure = (water density)x (gravity) x (height).

$$P = \boldsymbol{\rho} g h \tag{2.5}$$

Minimum water pressure		Maximum water pressure		
$P = \rho g h$		$P = \rho g h$		
N	ALAYSIA		411) Craj	
0.5MPa =	(1 x10 ³) (9.8) x (h)	1MPa =	(1 x10 ³) (9.8) x (h)	
0.5MPa	9800h	1MPa =	9800h	
H 🗧	51.0204m	Н	102.0408m	
**************************************	Nn String of the second	Eriction in the pipe	causes 25% of the head to	
Friction in the pipe causes 25% of the head to		Therefore in the pipe causes 2.5% of the head to		
be lost. The head loss is calculated as 0.25x 52=		be lost. The head loss is calculated as 0.25x		
13m. If 15m are lost, th	e useable head	102= 25.5m. If 26m are lost, the useable		
(Or net head) is reduce	ed to 39meter [5].	head (or net head) is reduced to 76meter [5].		

Table 3.3 Calculation for the water pressure

3.7 Project Costing

Based on the Table 3.4, all pricing is determined by the product's quality to provide optimal performance while minimising handling errors. To make the best decision, all costs are determined after conducting a poll and reviewing feedback from prior customers. When assembled, all components should provide the best performance possible.

No	Name	Description	Quantity	Price (Rm)
1	Turbine	1 Unit = Rm20	2	Rm40
2	Pipe Head	1 Unit = Rm28	1	Rm28
3	Water Storage	1 Unit = Rm21		Rm42
4	Pipe	1 Unit = Rm8	2	Rm16
5	Water Filter	1 Unit =	بيو محيي بي AYSIA ¹ MELA	Rm25
6	Water Pump	1 Unit = Rm6	1	Rm6
7	Meter Tube	1 Unit = Rm2	1	Rm2
8	Click Switch	1 Unit = Rm1	1	Rm1
9	Battery	1 Unit = Rm7	1	Rm7
				Total= Rm167

Table 3.4 Project costing

3.8 Project Construction and Testing

In this section, the project construction and testing will be discussed. Project testing is an essential part of quality management. It is the process of ensuring that a project has achieved its specifications and performs as expected. Testing ensures that the project is fit for its intended purpose. All the parts for this project such as head, water level and water flowrate will be tested and calculated. For the data and calculation, it will be discussed in Chapter 4.3.

3.8.1 Head and Penstock

The project's head is measured from the vertical distance between the reservoir pipe and the level at which the water enters the turbine and penstock is the length of pipe. The total length of the head is 13 cm for the pipe, not including the pipe length and the lengths of the penstock, which are 2 cm, 4 cm, 6 cm, 8 cm, and 10 cm, plus the length of the penstock to the turbine which is 3cm. The head length for 2 cm penstock is 18cm, the head length for 4 cm penstock is 20cm, the head length for 6 cm penstock is 22cm, the head length for 8 cm penstock is 24cm, the head length for 10 cm penstock is 24cm.

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Figure 3.9 The different length of the penstock

From the Figure 3.9, the different length of penstock will obtain different output for current, voltage and power. For the length it will be fixed into 2cm, 4cm, 6cm, 8cm and 10cm in this project testing part. In the hydroelectric part the pipe is called a penstock. For this part, the reservoir needs to be placed at a higher elevation from the ground to boost the pressure of the water. The height of the reservoir is fixed until the last analysis to avoid any disturbance.

3.8.2 Water level



Figure 3.10 The different parameter of the water level

Figure 3.10 shows the setup for measuring water with a scale. The scale has a capacity of 10 liters. Following the selection of the penstock, the water level measurement is chosen. The water volume varies after five readings, which are 2L, 4L, 6L, 8L, and 10L. All the parameters are measured, and data will be collected. The different water levels coming out of the reservoir through the penstock will give different readings of current, voltage, and power output.
3.8.3 Water Flowrate



Figure 3.11 The different angle of the pipe opening

The different angle of the pipe opening will result in different outputs for current, voltage, and power. The design of the pico-hydro systems for flowrate measurement is depicted in Figure 3.11. The parameters that have been set for water flowrate are the angle of the pipe opening, which is 18° , 36° , 54° , 72° , and 90° .



Figure 3.12 Flowmeter is used for flowrate measurement.

When water flows out of the reservoir, the water flowrate is measured at the chosen penstock. The flowrate is measured using a flowmeter. The flow rate varies after five readings based on the different angle of the pipe opening. The optimal flow rate has been determined using the data that has been collected

3.9 Gantt Chart

The Gantt Chart showed the flow of the project schedule in terms of date and task, which will keep this project on track. Time management will be more efficient and more conducive when it is planned from the beginning.

	Tasks	1	AA	LA	181	4		PS.	M 1													PS	M 2						
No.	Weeks	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1	Briefing for PSM 1 by JK PSM, FTKEE	r.					$\langle \langle \rangle$																						
2	Project Title Confirmation and Registration							The.																					
3	Briefing with Supervisor							\geq								100	-												
4	Study the Project Background															1													
5	Drafting Chapter 1: Introduction							Concernent of the second																					
6	Task progress evaluation 1																												
7	Drafting Chapter 2: Literature Review	à.,				-						1																	
8	Table of summary literature review	14																											
9	Drafting Chapter 3: Methodology		1.66	n																									
10	Work on the Software/Hardware																												
11	First draft submission to Supervisor	M.									5.1	1		-		- 47													
12	Task progress evaluation 2	10	1000	~~	fighter 1	~~~	1				1000			_	~	16			1	- 2	~	2							
13	Submission report to the panel					100					1.0				1 ⁻¹	1													
14	Presentation of BDP1											_																	
15	Drafting Chapter 4: Analysis Data and Result	IV	F	RS			TE	ŀΚ		K.	$\Delta 1$	N	1.0		$\Delta \gamma$	121	A	M	F	1	ιK	A							
16	Data Analysis and Result																												
17	Record the result																												
18	Drafting Chapter 5: Conclusion and Recommendation																												
19	Compiling Chapter 4 and Chapter 5																												
20	Submit the latest report to Supervisor																												
21	Finalize the report																												
22	Presentation of BDP2																												

3.1 Summary

This chapter presents the proposed process for establishing a new system project. Every improvement in this chapter must be accomplished well to accomplish allthe project's goals. This chapter elaborates all the system's hardware and software stages.Furthermore, the step process is explained by using a flowchart and a block diagram todemonstrate how the project system operates. This chapter covered the hardware and software chosen for this project and the rationale for its use.



CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter will explain the progress of the project, particularly in circuits. This chapter shows product testing and analysis, such as the output outcome and the product's influence using the variance in input distance, and an analysis will be made to see if the final project is capable in a new age. There are manyadvances towards producing the expected product.

4.2 Simulation Results and Analysis

Figure 4.1 shows the simulation in Proteus software for the initial condition for the pico-hydropower system before simulated. Due to the zero of supply power, all the lights will be off.



Figure 4.1 The incoming voltage and output voltage



Figure 4.2 Result when simulate.

Figure 4.2 shows the condition of the circuit after it has been simulated. The incoming voltage of 9V is represented as a voltage input which is generated from the pico-hydro system's power. The component with code U1 is represented as a turbine, where Vi stands for the voltage input and Vo stands for voltage output.

The circuit needs to include a switch for the ON and OFF supply power. The resistor needs to be connected to avoid any over current or over voltage from its resistive to make the component safe. Because of the load requirements of 3V–6V for functionality, the pico-hydro power is predicted to be up to 6V. The output power is 5V, the LED lights up, and the USB can be used, according to the simulation.

4.3 Hardware Analysis

Hardware analysis encompasses both electronic and mechanical design and serves to reduce project risk while increasing confidence in the upcoming hardware build. For the hardware analysis part, there are three parameters analyzed, such as the head length, water volume, and water flow rate. All parameters were recorded, and the results are shown in the table and graph.

4.3.1 Heads and Penstock

The project's head is measured from the vertical distance between the reservoir pipe and the level at which the water enters the turbine and penstock is the length of pipe. The total length of the head is 13 cm for the pipe, not including the pipe length and the lengths of the penstock, which are 2 cm, 4 cm, 6 cm, 8 cm, and 10 cm, plus the length of the penstock to the turbine which is 3cm. The head length for 2 cm penstock is 18cm, the head length for 4 cm penstock is 20cm, the head length for 6 cm penstock is 22cm, the head length for 8 cm penstock is 24cm, the head length for 10 cm penstock is 24cm.

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Figure 4.3 The head design

Figure 4.3 depicts the design of the pico-hydro system's head and penstock. The selection of the head is critical in this section because the next step is to select the volume of water and the flow rate of water. With five readings, the penstock varies. With the data that has been recorded, the optimum result for the penstock will be used to select the other part.

Penstock		Curren	t (mA)	
length (cm)	Reading 1	Reading 2	Reading 3	Average
2	0.7	0.8	1.12	0.87
4 ALAYS	2.1	1.4	1.10	1.53
6	2.5	1.8	1.60	1.97
8	1.7	2.0	1.50	1.73
10	2.4	1.4	2.10	1.97
(A) =				

Table 4.1 The results of current reading were obtained by using various parameters of head.

Table 4.1 displays the analysis results for the current reading of penstock length, such as 2 cm, 4 cm, 6 cm, 8 cm, and 10 cm. All the readings have been taken three times, and all the readings have been averaged. From the table, the graph will be plotted.



Figure 4.4 Average Current Output Vs Penstock length

According to Figure 4.4, on the average of the current output is greatest when the penstock length is between 6 and 8 cm (about 3.15 in), and the current output is lowest when the penstock length is 2 cm (about 0.79 in) because the distance from the reservoir is too close to the penstock. As a result, the water flow will be unstable. According to the graph's equation, as the penstock length increases, so does the current output. This is highly suggested. For example, if the output of current required 10mA and the head distance can be obtained by using the equation 4.1.

The calculated penstock length if the current output is 10mA



From equation 4.1, the calculated head (X) is 75.88 cm (about 2.49 ft) approaching 76 cm (about 2.49 ft) if the output of current (Y) is 10mA. From the average table and graph of **UNIVERSITI TEKNIKAL MALAYSIA MELAKA** the current output, the penstock length 6cm (about 2.36 in) and 8cm (about 3.15 in) have been selected.

Penstock		Voltag	ge (V)	
length (cm)	Reading 1	Reading 2	Reading 3	Average
2	5.01	4.59	4.72	4.77
4	5.23	5.03	4.91	5.06
6	5.33	5.13	5.06	5.17
8	5.03	5.03	5.06	5.04
10	5.19	4.99	5.13	5.10

Table 4.2 The Reading of Average Voltage with different penstock length

From the Table 4.2, displays the analysis results for the current reading of penstock, such as 2 cm, 4 cm, 6 cm, 8 cm, and 10 cm. All the readings have been taken three times, and all the readings have been averaged. From the table, the graph will be plotted.



Figure 4.5 Average Voltage Output Vs Penstock length

According to Figure 4.5, on the average of the voltage output is greatest when the penstock length is between 6 cm (about 2.36 in) and the output voltage is lowest when the penstock length is 2 cm (about 0.79 in) because the distance from the reservoir is too close to the penstock. As a result, the water flow will be unstable. According to the graph's equation, as the penstock length increases, so does the voltage output. This is highly suggested. For example, if the output of voltage required 10V and the penstock length can be obtained by using the equation 4.2.

The calculated penstock length if the voltage output is 10V

$$Y = 0.032x + 4.836$$

$$10 = 0.032x + 4.836$$

$$10 - 4.836 = 0.032x$$

$$X = 161.375cm$$
(4.2)

From equation 4.2, the calculated penstock length (X) is 161.375 cm (about twice the length of a baseball bat), approaching 161 cm (about 5.28 ft) if rounded to the first decimal place, and the voltage output (Y) is 10 V. From the average, table, and graph of voltage output the penstock length of 6 cm (about 2.36 in) has been selected.

Length (cm)	Average Voltage (V)	Average Current (mA)	Average Power (mW)
2	4.77	0.87	4.15
4	5.06	1.53	7.74
6 MALAYS	5.17	1.97	10.18
8	5.04	1.73	8.72
10 LEK	5.10	1.97	10.04

 Table 4.3 The Reading of Power Output with Different Length of Penstock

Table 4.3, displays the analysis results for the power output reading of penstock length, such as 2 cm, 4 cm, 6 cm, 8 cm, and 10 cm. All the readings have been taken three times, and all the readings have been averaged. From the table, the graph will be plotted.



Figure 4.6 Power Output Vs Penstock length

According to Figure 4.6, the power output is greatest when the penstock length is between 6 cm (about 2.36 in) and the power output is lowest when the penstock length is 2 cm (about 0.79 in) because the distance from the reservoir is too close to the penstock. As a result,

the water flow will be unstable. According to the graph's equation, as the penstock length increases, so does the power output. This is highly suggested. For example, if the output of voltage required 10mW and the penstock length can be obtained by using the Equation 4.3.

The calculated penstock length if the voltage output is 10V

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$$Y = 0.638x + 4.338$$

$$10 = 0.638x + 4.338$$

$$10-4.338 = 0.638x$$

$$X = 8.874 cm$$
(4.3)

From equation 4.3, the calculated penstock length (X) is 8.874 cm, approaching 9 cm if rounded to the first decimal place, and the power output (Y) is 10mW. From the average, table, and graph, for the power output the penstock length of 6 cm has been selected.

A 6 cm (about 2.36 in) penstock length was chosen for the next step measurement based on the overall and average of all the data in the table and graph for the penstock length, which are current output, voltage output, and power output. This gives the best output for current, voltage, and power.

4.3.2 Water Level



Figure 4.7 The Setup of Water Volume Measurement

According to Figure 4.7, the setup for the water measurement with a scale. The limitation of the scale is two liters. The water volume measurement is selected after the penstock selection. With five readings, the water volume varies. With the data recorded, the optimum result for the water volume will be selected to select the other part.

Valuma (L)		Current	t (mA)	
volume (L)	Reading 1	Reading 2	Reading 3	Average
2	1.5	1.7	1.3	1.50
4	1.8	1.5	1.4	1.56
6	1.7	1.0	1.2	1.30
8	1.7	1.0	1.6	1.43
10	1.1	1.6	1.1	1.27

UNIVER Table 4.4 Reading of Current Output (mA)

Table 4.4, displays the analysis results for the water volume, such as 2 L, 4 L, 6 L, 8 L, and 10 L. All the readings have been taken three times, and all the readings have been averaged. From the table, the graph will be plotted.



Figure 4.8 Average Current Output Vs Water Level

According to Figure 4.8, the average of the current output is greatest when the water level is 4 L, and the current output is lowest when the water level is 10L cm because the when the amount of water flow out from the reservoir and flow through the head is decreasing due the pressure of water is decreasing. The pressure of water is directly proportional. According to the graph's equation, as the water level decreases, the current output will decrease. This is highly suggested. For example, if the output of current required 10mA and the water level can be obtained by using the equation 4.4.

The calculated water level if the current output is 10mA

$$Y = -0.03x + 1.594 \qquad (4.4)$$

$$10 = -0.03x + 1.594$$

$$10 - 1.594 = -0.03x$$

$$X = -280.2 L$$

From the equation 4.4, the calculated water level (X) is -280.2 L approaching 280 L. The negative symbol is obtained because of the 2 factors which are the reservoir needs to be improved by increasing the volume of water so that the water level will increase and 10mA will be obtained. For the second factor is the maximum water level for this project is average in 10 L. There higher the water level the less the current output. From the average, table and graph of the current output, the water level 2 L is selected for current output.

Volume (L)		Voltag	ge (V)						
volume (L)	Reading 1	Reading 2	Reading 3	Average					
2	5.11	5.11	5.07	5.09					
4	5.03	5.13	5.10	5.09					
6	4.97	5.07	4.95	5.00					
8	4.83	5.05	4.77	4.88					
10 10	5.02	4.91	4.87	4.93					
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 Table 4.5 Reading of Voltage Output

Table 4.5, displays the analysis results for the water volume, such as 2 L, 4 L, 6 L, 8 L, UNIVERSITI TEKNIKAL MALAYSIA MELAKA

and 10 L. All the readings have been taken three times, and all the readings have been averaged.

From the table, the graph will be plotted.



Figure 4.9 Average Voltage output Vs Flowrate of Water

According to Figure 4.9, the average of the voltage output (Y) is greatest when the water level (X) is 2 L, and the voltage output is lowest when the water level (Y) is 10L cm because the when the amount of water flow out from the reservoir and flow through the head is decreasing due the pressure of water is decreasing. The pressure of water is directly proportional. According to the graph's equation, as the water level decreases, the voltage output will decrease. This is highly suggested. For example, if the output of voltage required 10V and the water level can be obtained by using the equation 4.5.

The calculated water level if the voltage output is 10V.



From the Equation 4.5, the calculated water level (X) is *182.75L* L approaching to 183 L. The negative symbol is obtained because of the 2 factors which are the reservoir needs to be improved by increasing the volume of water so that the water level will increase and 10V of voltage output (Y). will be obtained. For the second factor is the maximum water level for this project is average in 10 L. There higher the water level the less the current output. From the average table and graph of the current output, the water level 2 L is selected for current output due to the optimum voltage output obtained.

Volume(L)	Average Voltage (V)	Average Current (mA)	Average Power (mW)
2	5.09	1.5	7.64
4	5.09	1.57	8.00
6	5.00	1.30	6.50
8	4.88	1.43	6.97
10	4.93	1.27	6.26

Table 4.6 Reading of Power Output (mW)

Table 4.6 displays the analysis results for the water volume, such as 2 L, 4 L, 6 L, 8 L, and 10 L for the average current, voltage, and power output. All the readings have been taken three times, and all the readings have been averaged. From the table, the graph will be plotted.



Figure 4.10 Power Output Vs Water Level

According to Figure 4.10, the power output is greatest when the water level is 4 L, and the voltage output is lowest when the water level is 10L cm because the when the amount of water flow out from the reservoir and flow through the head is decreasing due the pressure of water is decreasing. The pressure of water is directly proportional. According to the graph's equation, as the water level decreases, the power output will decrease. Same as with using formula Power = Current x Voltage. By the formula, if the current and voltage decreases the power will decrease. This is highly suggested. For example, if the output of voltage required 10mW and the water level can be obtained by using the equation 4.6.

The calculated water level if the power output is 10mW.

$$Y = -0.189x + 8.207$$
(4.6)

$$10 = -0.189x + 8.207$$

$$10-8.207 = -0.189x$$

$$X = -9.486L$$

From the Equation 4.6, the calculated water level (X) is -9.486L L approaching -10 L. The negative symbol is obtained because of the 2 factors which are the reservoir needs to be improved by increasing the volume of water so that the water level will increase and 10mW of power output (Y) will be obtained. For the second factor is the maximum water level for this project is average in 10 L. There higher the water level the less the current output. From the average table and graph of the current output, the water level 2 L is selected for current output due to the optimum power output obtained.

A 2 L of water level was chosen for the next step measurement based on the overall and average of all the data in the table and graph for the water level, which are current output, voltage output, and power output. This gives the best output for current, voltage, and power.

4.3.3 Water Flowrate



Figure 4.11 Design of the Pico-hydro Systems for Flowrate Measurement

Figure 4.11 depicts the design of the pico-hydro systems for flowrate measurement. After the selection of the head, the water level for the reservoir and for this section is measuring the flowrate of water when the different angle of pipe opening which are 18° , 36° , 54° , 72° , and 90 ° of water is flowing out from the reservoir. With five readings, the flowrate varies. With the data recorded, the optimum result for the flowrate was obtained.

Flourate (m/a)		Curren	t (mA)	
Flowrate (III/S)	Reading 1	Reading 2	Reading 3	Average
18°: (0.00)	0.00	0.00	0.0	0.00
36°:(0.01)	0.00	0.00	0.0	0.00
54°: (0.71)	0.00	0.00	0.0	0.00
72°:(0.80)	0.02	0.07	0.0	0.03
90°: (0.87)	1.50	1.90	1.7	1.70

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Table 4.7 The Re	esults of Current	Reading	Obtained	d for Flow	rate

Table 4.7 displays the analysis results for the angle of pipe opening, such as 18° , 36° , 54° , 72°, and 90°. All the readings have been taken three times, and all the readings have been averaged. From the table, the graph will be plotted.

Current Output Vs Flowrate of Water

Figure 4.12 Current Output Vs Flowrate of Water

According to Figure 4.12, the current output is greatest when the water flowrate is around (0.81–1 m/s) due to the 90-degree angle of the reservoir pipe. The greater the angle at which the pipe is opened, the higher the flow rate obtained. The flow rate increases as the angle increases because the diameter of the pipe through which water can pass expands. The reservoir's water level cannot be higher than 2L per second flowing out of it.

At a water flow rate of 0–0.80 m/s, the reading of the water flow rate is the lowest when the water level is 10 L because the amount of water flowing out of the reservoir and through the head is decreasing as the pressure of the water decreases. The pressure of water is directly proportional. According to the graph's equation, as the flow rate decreases, the current output will decrease. This is explicitly suggested. For example, if the output of the current is 10mA and the water flowrate can be obtained by using the equation 4.7.

The calculated water flowrate if the current output is 10mA

$$Y = 0.9657x - 0.2315 \qquad (4.7)$$
$$10 = 0.9657x - 0.2315$$
$$10 + 0.2315 = 0.9657x$$
$$X = 10.59 \text{ m/s}$$

From the Equation 4.7 the calculated water flowrate (X) is 10.59 m/s, which is close to 11 m/s. If the current output (Y) needs to be increased, the water flowrate (X) must be increased for the first step because it is a directly proportional relationship.

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Table 4.8 The Results of Voltage Reading Obtained for Flowrate Voltage (V) Flowrate (m/s) Reading 1 Reading 2 Reading 3 Average 18° :(0.00) 0.00 0.00 0.00 0.00 36° :(0.01) 0.00 0.00 0.00 0.00 0.24 54°:(0.71) 0.27 0.21 0.24 72° :(0.80) 0.76 4.63 0.18 1.86 5.13 90° :(0.87) 5.03 5.09 5.11

Table 4.8 displays the analysis results for the angle of pipe opening, such as 18°, 36 °, 54 °, 72 °, and 90 °. All the readings have been taken three times, and all the readings have been averaged. From the table, the graph will be plotted.



Voltage Output Vs Flowrate of Water

Figure 4.13 Voltage Output Vs Flowrate of Water

According to Figure 4.13, the voltage output is greatest when the water flowrate is around (0.81-1 m/s) due to the 90-degree angle of the reservoir pipe. The greater the angle at which the pipe is opened, the higher the flow rate obtained. The flow rate increases as the angle increases because the diameter of the pipe through which water can pass expands.

The reservoir's water level cannot be higher than 2L per second flowing out of it. At a water flow rate of 0–0.80 m/s, the reading of the water flow rate is the lowest when the water level is 10 L because the amount of water flowing out of the reservoir and through the head is decreasing as the pressure of the water decreases. The pressure of water is directly proportional. According to the graph's equation, as the flow rate decreases, the voltage output will decrease. This is explicitly suggested. For example, if the output of the voltage is 10V and the water flowrate can be obtained by using the equation 4.8.

The calculated water flowrate if the voltage output is 10V

$$Y = 3.6841x - 0.7651 \qquad (4.8)$$
$$10 = 3.6841x - 0.7651$$
$$10 + 0.7651 = 3.6841x$$
$$X = 2.922 \text{ m/s}$$

The calculated water flowrate (X) from Equation 4.8 is 2.922 m/s, which is close to 3 m/s. If the voltage output (Y) needs to be increased, the water flowrate (X) must be increased for the first step because it is a directly proportional relationship.

Flowrate (ms)	Current (mA)	Angle (°)	Voltage (V)	Power (mW)
0.00	0.00	18	0.00	0.00
0.61	0.00	36	0.00	0.00
0.71	0.00	54	0.24	0.00
0.8	0.03	72	1.86	0.06
0.87	1.70 🍃	90	5.09	8.65

Table 4.9 The Results of Power Reading Obtained for Flowrate

Table 4.9 displays the analysis results for the angle of pipe opening, such as 18°, 36°, 54°, 72°, and 90°. All the readings have been taken three times, and all the readings have been averaged. From the table, the graph will be plotted.

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Power Output Vs Flowrate of Water



Figure 4.14 Power Output Vs Flowrate of Water

According to Figure 4.14, the power output is greatest when the water flowrate is around

(0.81–1 m/s) due to the 90-degree angle of the reservoir pipe. The greater the angle at which the pipe is opened, the higher the flow rate obtained. The flow rate increases as the angle increases because the diameter of the pipe through which water can pass expands. The reservoir's water level cannot be higher than 2 litres per second flowing out of it.

At a water flow rate of 0–0.80 m/s, the reading of the water flow rate is the lowest when the water level is 10 L because the amount of water flowing out of the reservoir and through the head is decreasing as the pressure of the water decreases. The pressure of water is directly proportional. According to the graph's equation, as the flow rate decreases, the power output will decrease.

The power output depends on the current output and voltage output. If the two parameters increase, the power output will also increase. This is explicitly suggested. For example, if the output of the power source is 10 mW and the water flow rate can be obtained by using the equation 4.9.

The calculated water flowrate if the power output is 10mW **UNVERSITIEEXNY** = 4.877x - 1.1738 (4.9) 10 = 4.877x - 1.1738 10+1.1738 = 4.877xX = 2.291 m/s

The calculated water flowrate (X) from Equation 4.9 is 2.29 m/s, which is close to 2.33 m/s. If the power output (Y) needs to be increased, the water flow rate (X) must also be increased for the first step because it is a directly proportional relationship.

For the water flow rate, the angle of 90° has been chosen because of the data that has been obtained from the table regarding current, voltage, and power output. According to the data, the higher the flow rate, the higher the power output.

4.4 Summary

First, a 6 cm penstock length was chosen for the next step measurement based on the overall average of all the data in the table and graph for the head distance, which are current output, voltage output, and power output. This gives the best output for current, voltage, and power.

Next, a level of 2 litres of water was chosen for the next step measurement based on the overall average of all the data in the table and graph for the water level, which are the current output, voltage output, and power output. This gives the best output for current, voltage, and power.

For the water flow rate, an angle of 90° has been chosen because of the data that has been obtained from the table regarding current, voltage, and power output. According to the data, the higher the flow rate, the higher the power output.

Finally, calculating the power output desired by the user is the most crucial step in designing the pico-hydro system. Then, determine the penstock length, followed by the water level, just as you would for the system's water storage or reservoir, and finally, determine the water flow rate, which is dependent on the penstock length and water level.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter will discuss the total completion of the "The Development of Rainwater Sourced Pico-Hydro Generator Powered Water Filter" projects. This chapter would clarify various recommendations and prospective work that might be used to further the project's development.

5.2 Conclusion

In the conclusion, all the theories about this project are discussed, such as the related products and theories, the process of product design and development, and the critical part or components used for electrical appliances in pico-hydro systems. The project can then proceed after being familiarised with all the information and data.

All the theories about this project are discussed, such as the related product and theories, the process of product design and development and the critical part or components used for electrical appliances in pico-hydro systems. The project can then proceed after being familiar with all the information and data.

Then, to proposed process for establishing a new system project. Every improvement in this chapter must be well accomplished to accomplish all the project's goals. This chapter elaborates on all the system's hardware and software stages. Furthermore, the step process is explained by using a flowchart and a block diagram to demonstrate how the project system operates. This chapter thoroughly covered the hardware and software chosen for this project. Besides that, in this chapter, the setup of the overall project is stated, and all the parameters are measured by using tools, for example, a flow metre for measuring the water flow rate. Next is discussing the analysis from the project setup based on examples from Chapter 3. For example, First, a 6 cm penstock length was chosen for the next step measurement based on the overall average of all the data in the table and graph for the penstock length, which are current output, voltage output, and power output. This gives the best output for current, voltage, and power. Next, a level of 2 litres of water was chosen for the next step measurement based on the overall average of all the data in the table and graph for the next step measurement based on the overall average of all the data in the table and graph for the next step measurement based on the overall average of all the data in the table and graph for the water level, which are the current output, voltage output, and power output. This gives the best output for current, voltage, and power.

For the water flow rate, an angle of 90° has been chosen because of the data that has been obtained from the table regarding current, voltage, and power output. According to the data, the higher the flow rate, the higher the power output. Finally, calculating the power output desired by the user is the most crucial step in designing the pico-hydro system. Then, determine the penstock length, followed by the water level, just as you would for the system's water storage or reservoir, and finally, determine the water flow rate, which is dependent on the head and water level.

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5.3 Recommendation

- 1) This project can be improved with:
 - I. Increasing the penstock of the project
 - II. Increasing the volume of water level of reservoir.
 - III. The higher the penstock and water level, the higher of flowrate.
- Based on the project, due to a lack of funds, this project was only used to one generator.
 For another project, it can be used different type of generator with high power output.
- 3) By increasing the height of reservoir from the ground, the pressure of water will increase and will give the better output of the current, voltage, and power.



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APPENDICES A

Figure of Flowmeter

CONTROLS AND TERMINOLOGY



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