FEASIBILITY STUDY OF MICRO HYDRO ENERGY HARVESTED FROM WATER PIPELINE

by

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15394

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons.)
(Electrical and Electronic)

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CERTIFICATION OF APPROVAL

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Approved by:

……………………...

(Dr. Taib b Ibrahim)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
September 2014

CERTIFICATION OF ORIGINALITY

This is t o certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

NOR SHUHADAH BT MD ZIM

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ABSTRACT

Throughout the whole day, water is being consumed by Universiti Teknologi PETRONAS residents in all domestic activities. As an average of 7.120 million liters of water has been used by UTP each year and has not being fully utilized by the institution to produce energy efficiently. High electricity demand for all economic purposes and increasing population, have forced UTP to find more electrical energy source. There is the way to utilize the kinetic energy in the water flowing in pipeline which is produce the electrical energy whenever water is being consumed. Hence, we can take the advantage from this situation. Moreover, the aim of this project is to conduct feasibility study on the potential electrical will be harvested from UTP water pipeline.. There are three criteria such as velocity of water; rotational turbine and power generated were calculated by using the measurement values of water flow rate. Besides, the velocity of water is calculated based on the water flow rate measurement obtain from UTP pipeline. Simulation for power produced is calculated using MATLAB Simulink computer program and show the ability of the UTP water pipeline to produce electrical energy for institution consumption. Basically, the specification of turbine used depending on the flow rate and net head. From the study, it showed that construction of micro hydropower project was feasible in the project sites.

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CHAPTER 1
INTRODUCTION

1.0 Introduction

The word of *hydro* is comes from Greek word for water. Traditionally, hydropower represents the energy generated by damming a river and using turbine systems to rotate the generator, after that will generate the electrical power. However, there are several ways to generate energy using the power of water such as impoundment hydropower, pumped storage hydropower and diversion hydropower. More than half of renewable energy generated in Malaysia comes from hydroelectric dams. This is because it has the least expensive source of electrical power and is much cleaner compared to fossil fuels. This chapter will explain more about hydropower plant.

1.1 Background study

Hydropower is an electrical power that is produced from the force of water movement. It is one of the clean resources that have a huge potential to be further developed. Normally, the size of hydropower station is very large scale and very expensive to build. However, there also hydropower station in a smaller size called micro hydropower. They are usually installed in small rivers or waterfalls [1].

By the late 19th century, due to the consistent energy source that will produces clean electricity generation, hydropower became one of the sources for generating electricity. In 1879, the first hydropower plant was built at Niagara Falls [1]. Simple concept of power production is used in hydropower systems where the energy of flowing water may be used to generate electrical power. For example, rain is usually originating in hills will create rivers that finally run to the sea.

Currently, hydroelectric installations range in capacity from a hundred watts and up to more than 10 000 Megawatt. It is a reliable type of energy source in Malaysia which Malaysian receives rainfall ranging from 100mm to 300mm. There a few variations of hydroelectric which influence the power output. These variations are can be influence by type of turbine, location of the dam, type of dam and the water capacity. Basically there are three ways to generating hydroelectricity which are pumped storage, diversion hydropower and impoundment [2].

1.1.1 Impoundment hydropower

This is the common type of hydropower plant also known as conventional hydropower. This type of hydropower plant normally use for large hydropower system which used river water as main source. It is consists of dam, penstock, generator, powerhouse and turbine. Water from river will be stored in dam or reservoir and may be released either to maintain constant water level in dam or to meet changing electricity needs.

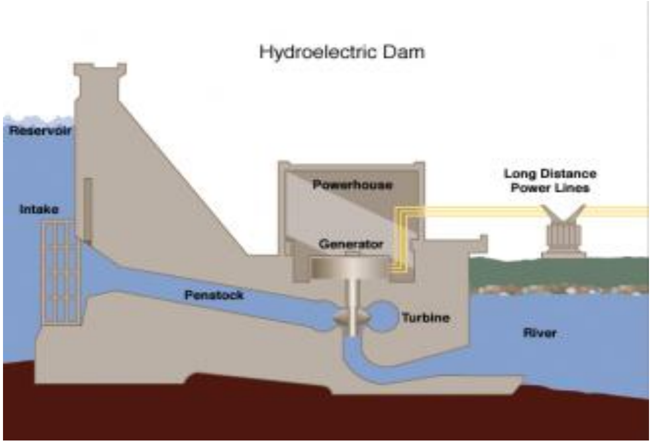


Figure 1: Impoundment hydropower plant

1.1.2 Pumped storage hydropower

Operate by pumping lower reservoir to upper reservoir when demand for electricity is low to stores energy. When there is a high demand of electricity, the water from upper reservoir will be release to lower reservoir to generate electricity.

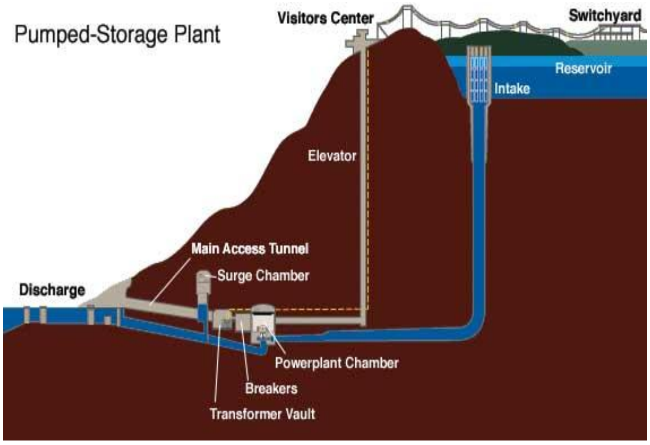


Figure 2: Pumped storage hydropower plant

1.1.3 Diversion hydropower

This is the only method did not have reservoir or need few amount of water to generate electricity. It's called Run-of-River which channel water through canal or penstock to generate electricity.

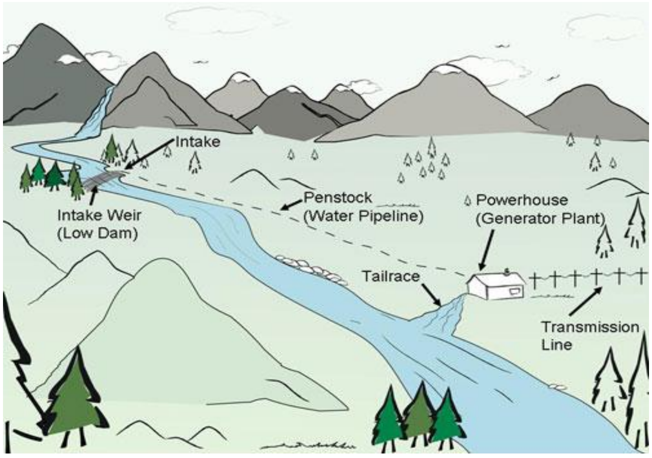


Figure 3: Diversion hydropower plant

1.2 Micro hydropower plant

Basically, the hydropower plants can be classified according to the power output. Table 1 shows the categories for hydropower plants [3]:

Table 1: Scale of hydropower plants

Scale	Description
Large	More than 100MW
Medium	Between 15MW to 100MW
Small	Between 1MW to 15MW
Mini	Above 100kW but below 1MW
Micro	Between 5kW up to 100kW
Pico	Less than 5kW

For the purpose of this project, a micro hydro class of power plant is chosen. This type of hydropower plant will produce power up to 100kW which is enough to power up appliance in one house building.

By looking at the prospective of the hydropower, it can guarantee us with many advantages. Besides, it provides a constant electricity rate and can always be regulate according to the power demand. From this, it will help to prevent the excessive power loss if extra power is generate when the demand is low.

1.3 Problem statement

UTP has been utilizing high water consumption for the washing, cooking and research purposes at research centers. High water consumption required UTP to pay large amount of water bill. In this case, water usage could be utilized for energy harvesting. Once a good physician said that *"energy cannot be created nor destroyed, its can only be changed from one form to another form"*. That physician was Dr Albert Einstein. Basically we can harvest one potential source of energy which is grey water and convert it to a new source of energy that can be used to for UTP community.

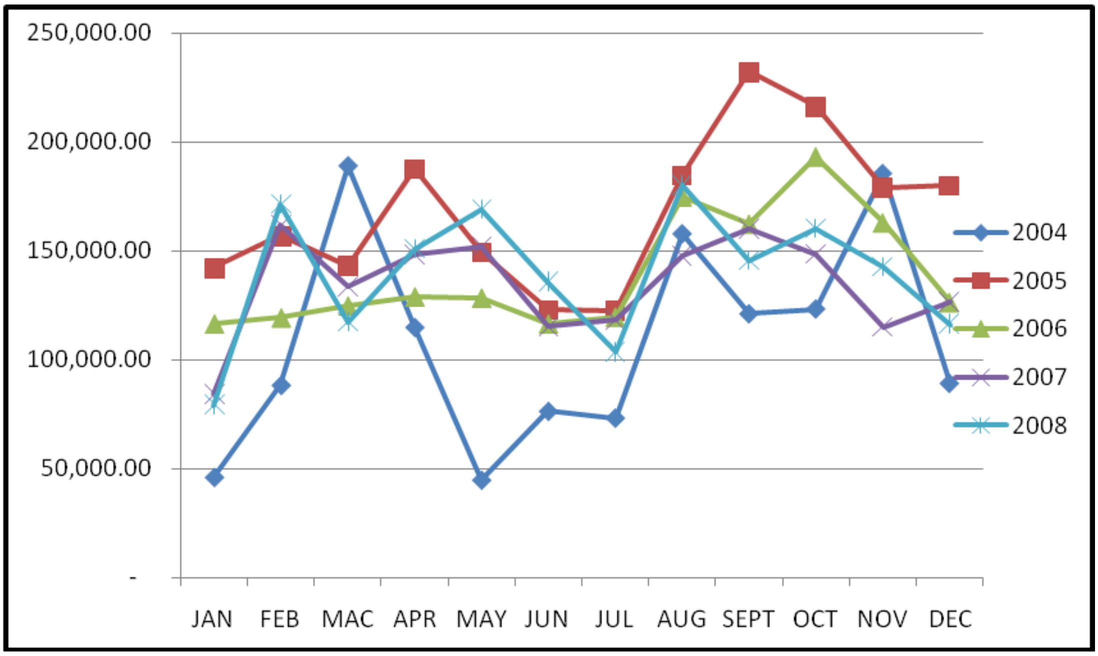


Figure 4: UTP water bill

UTP residential used about 1 132 490.32 gallons of water each year and have to pay an average of RM170000 every months for water consumption. Figure 4 shows details about UTP water bills for five consecutive years [2].

1.4 Objectives

The objectives for the project title of "Design and Development of Micro hydropower System" are as following:

1. To analyze the potential development of micro hydropower in UTP.
2. To model and design a micro hydropower system in UTP water pipeline.

1.5 Scope of study

The scopes of study for the project title of "Feasibility Study of Micro Hydro Energy Harvested from Water Pipeline" are as below:

1. Collect data on water flow rate from dedicated UTP water pipeline using Portable Doppler Flow Meter
2. Estimate power generated from UTP water pipeline using MATLAB SIMULINK.

In the other hand, the scopes of study by each chapter are as follow:

Chapter 1: Introduction of project including background of study, micro hydro energy, problem statement, objectives and scope of study.

Chapter 2: Research and study based on previous research as well as existing technology of micro hydro energy.

Chapter 3: Procedures involved in the whole project including flow chart, project timeline, project key-milestone, location to measure water flow, software and hardware required.

Chapter 4: Result obtained from data measurement and calculation using MATLAB Simulink. Include in this chapter, equation used such as velocity, turbine speed, power produced and torque.

Chapter 5: Conclusion for this project as well as recommendation to improve this project in future.

1.6 Conclusion

By using concept of pumped storage hydropower, author concentrates on analyzing, model and designs a micro hydro system in UTP water pipeline with minimum cost. UTP used extremely large amount of water every month from Jabatan Air Perak, i.e. more than 10000m^3. The water which flows to pipeline can be utilized to produce electricity by implementing an appropriate micro generator. The output power estimated from this system is less than 100kW and it is suitable to complement at UTP power supply. Feasibility study has been carried out to determine the potential development of micro hydropower based on literature review in the next chapter.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

Each and every research will refer back on the previous researches to study by the author. In this chapter author discussed the equation used to design micro hydro energy system based on research paper. Basically, equations for micro hydro energy system are based on Bernoulli concept that will form the equations for potential energy, kinetic energy and mechanical energy. After that, power produced by turbine will be calculated to estimate power produce by the system. In the other hand, author will show the existing technologies using micro hydro energy to produce electrical energy.

2.1 Background

From the early age, water plays the important roles in daily life where it is used for energy source and also as a source of life. Besides, it have the simplest concept where flowing or falling water will rotate the turbine, the turbine spins the generator hence produced the electricity. Hydropower is also a renewable and environmentally source of energy. Moreover, it is one of the reliable energy sources that can produced clean electricity generation because it will generate up to 90% of power efficiency and more than 50% high electricity capacity factor [1].

2.2 Micro hydropower plant

Basically, micro hydropower system is developed from the concept used in hydropower system in dam. Typically, a hydropower system consists of electrical power substation, a powerhouse, dam, penstock, and reservoir [2]. Water will store in dam while the water from the reservoir will carry by penstock to the turbine inside the powerhouse. Generator will produce electricity when the turbines rotated by the water at the powerhouse [2].

There is a combination will effects power generation from the pipeline which is head and flow. These combinations will produce electricity. By referring to the water consumed by the consumer it will give water consumption consume every day while water flow rate depends on the head pressure from the reservoir. In the other hands, pressure head depends to the height between turbine and water intake [2].

A micro-hydro scale of hydropower plant is chosen for the purposed of this project. This scale of hydropower plant usually provided power up to 100kW for a small community or rural industry in remote areas away from the grid.

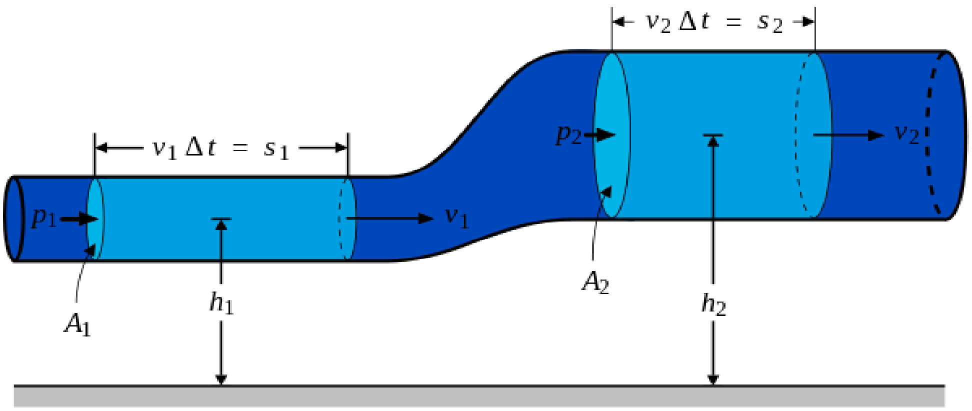


Figure 5: Bernoulli's principle

The equation is obtained by using Bernoulli's principle below:

$$z_1 + H_1 + \frac{v_1{}^2}{2g} = z_2 + H_2 + \frac{v_2{}^2}{2g} + H_f \qquad (1)$$

Refer to the equation (1), variable $z_1$and z_2 are the height points where 1 is the highest point and 2 is the lowest point. These two points are the point before it hits the turbine blade while v is velocity. In his case, water is flowing in vertically so that the value of H_f, frictional factor will consider as negligible [1]. From equation (1), q is water flow rate, v is velocity of water, A is cross sectional area of the pipeline, g is gravitational acceleration, h is head of water pipeline and d is diameter of water pipeline.

2.2.1 Power produced

$$P = gnQH \tag{2}$$

Where g is 9.81m/s^2 of gravitational acceleration, n is turbo generator efficiency for $0 < n < 1$, Q is quantity of water flowing measured by portable Doppler flow meter in m^3/sec and H is effective head which is height for the water pipeline measured in m. Equation (2) can be manipulated to find out the power produced at the turbine shaft [2].

2.2.2 Potential energy

$$U = mgh \tag{3}$$

Head is a height between turbines to the water intake measured in vertical. By increasing the height of head, it wills produce higher potential energy where it is the energy from the object placed at the higher placed [2]. Refer to equation (3), U is potential energy in joules by multiply the value of mass of water, m in kg, 9.81 m/s^2 gravitational force, g and height measured in meter.

2.2.3 Kinetic energy

$$K = \frac{mv^2}{2} \tag{4}$$

When kinetic energy flows to rotate the turbine, the energy will converted to potential energy where it will be possessed through motion of an object at certain velocity. Refer to the formula below, K is kinetic energy in joules, m is mass in kg and v is speed measured in m/s [2].

2.2.4 Mechanical energy

$$E_{mechanical} = U + K \quad (5)$$

By adding the equation (3) and (4), it will develop the mechanical energy, E $_{mechanical}$. This can be proved by having the potential energy of the water at the elevated height and falls through the penstock, which will turn the potential energy of the water to kinetic energy. Potential energy is decreased when the water goes down through the penstock and increase in kinetic energy.

2.3 Basic components in micro hydropower system

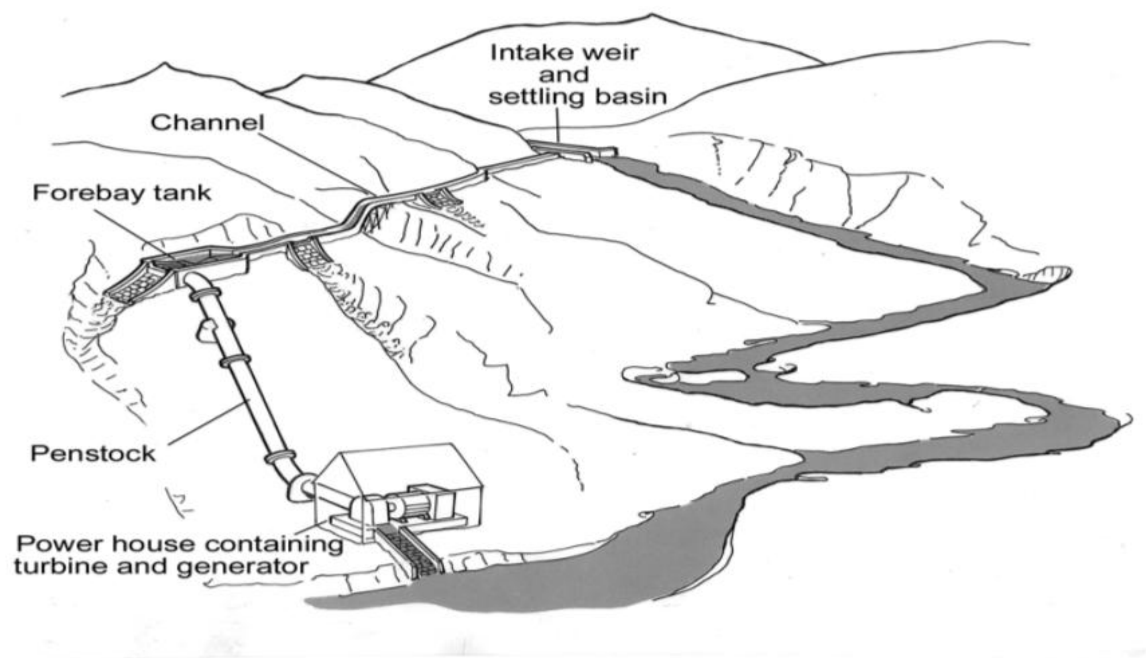


Figure 6: The hydropower system components

Figure 6 shows the basic components of basic hydropower system. Dam, turbine and generator is a set that required in conventional power plant. The basic philosophy of hydropower is conversion of kinetic energy in moving water where will act as a prime mover to rotate the turbine with sufficient speed and volume. Mechanical energy produced from the rotated turbine where it is connected to the power generator. From here, the consumer will received the electricity from power transmission lines where it is connected to the hydropower plant.

2.3.1 Turbine

Turbine can be classified into two types based on their principle of working; reaction turbine or impulse turbine. Reaction turbine is fully immersed in water and is enclosed in a pressure casing. The energy is converted from potential energy to mechanical energy. Example for this type of turbine includes Francis and Kaplan turbine. Meanwhile, impulse turbine operates in air and is driven by jet of water. It is converting kinetic energy into to mechanical energy. Examples for this turbine are cross-flow turbine, Turgo and Pelton turbine.

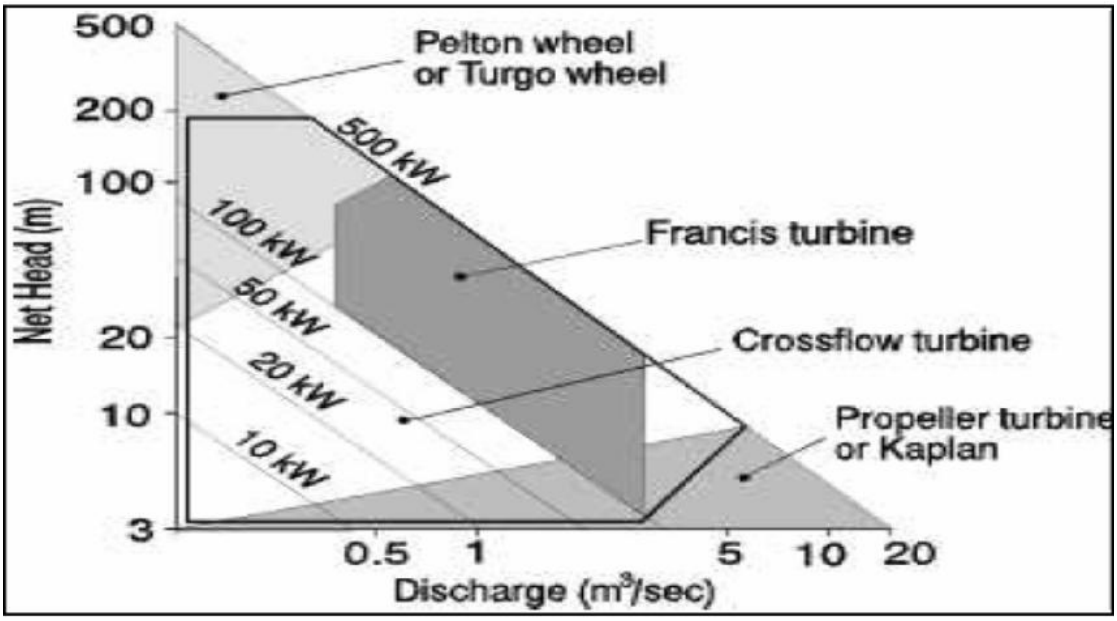


Figure 7: Turbine application chart

2.3.2 Generator

Generator is used to convert the kinetic energy from the rotational of turbine to electrical energy for consumptions. In general, there are two types of generators which are synchronous and induction.

Synchronous generator are can be used in many kinds of ways such as standby power as well as to provide power for the requirement of the facility. This generator is cheaper and is able to produce power during power outages. This type of generator is normally used to start the small motor. In other hand, induction generator is usually used to start the large motors.

2.4 Technology of micro hydro energy

Nowadays, in order to provide clean water to thousand homes and building in every urban city will use gallons of high pressure water. This will cause water flowing inside the water pipeline persistently. Hence, it produces large useable energy, that if not fully utilize is simply lost.

In order to take advantage, New York governments for example, are exploring the possibility of water pipeline hydropower technology. Hence, there are no harmful effects on the environment and no emissions resulting from this conversion process where it is a process that utilizes the natural flow of water. Currently, it is challenges and cost-effectiveness in long tern potential [5].

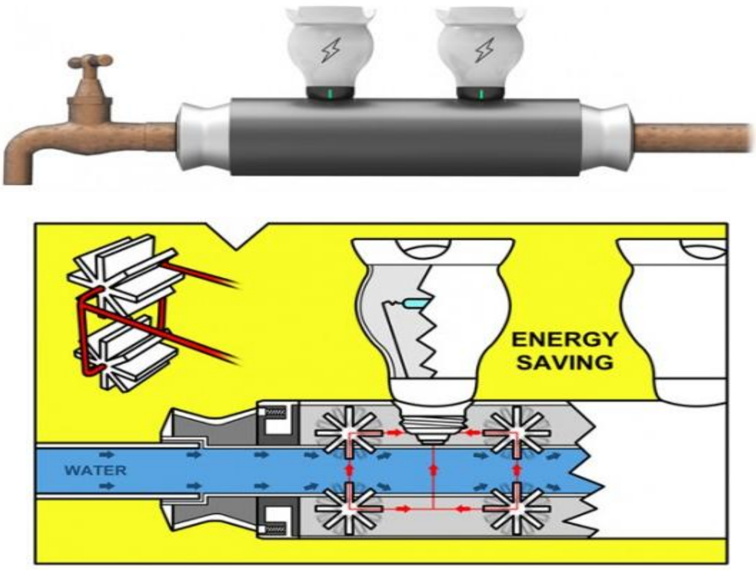


Figure 8: Example of simple system to generate energy

The technology controls high pressured water, which is goes through underground water utility substations. Figure 8 shows the flow and pressure is reduced before enter the smaller pipes of homes and buildings. Then, energy produced will directly sell to the grid. This technology have been implement in public water system on 1985 in Colorado which they installed eight small scale hydroelectric generators. This provided roughly 11% of the city’s electricity [5]. So, it is possible to implement this technology at UTP water pipeline.

Currently, there are few technologies exist to generate at least two lamps by using water flow in pipeline. By using simple system that is allows consumers to generate energy every time they turn on the tap, simple designed by Korean innovator Ryan Jongwoo Choi, the system is an independent system that contains mini turbines which generate power from flowing water. Every time someone turns on the tap, it creates energy which can then be stored for future use or implemented straight away. Figure 8 shows how the turbine works when water flow through the pipeline.

2.5 Conclusion

There are for elements involved in micro hydro energy which are potential energy, kinetic energy, mechanical energy as well as power produce. In this chapter, author clearly shows the equation for each element based on selected research papers. To show that micro hydro energy can produce electrical energy from water pipeline, some of existing technology has been discussed in this chapter. Other than that, there are few other elements needed to consider such as locations and procedures to measure water flow in water pipeline. Chapter 3 will explain about step takes and location involved in this project.

CHAPTER 3
METHODOLOGY

3.0 Introduction

A main element in this project is the location to measure water flow rate in order to estimate power produced. In this chapter, author will explain about research methodology involved in this project. In the other hand, author shows selected locations. Flow chart, project timeline and project key-milestone are shown as indicator for this project. In order to design the system, there is software required used in this project which is MATLAB Simulink. In the other hand, hardware is used to measure water flow rate inside water pipeline which is Portable Doppler flow meter PF D550.

3.1 Research methodology

The objective of this project is to do research and data collection and feasibility study of the micro hydro energy system. This project divided into two stages which is first and second stage. For the first stage, author need to do data gathering and data analysis work where second stage is an intensive analyzing work. On the other hand, author need to obtained water bill for five consecutive years from maintenance department from the institution.

First stage is the critical part where at this stage all the data collection is properly evaluated for the next stage. The data need to be collected are suitable location, size pipe and water flow rate. As mention before, this project will conducted inside the academic institution which is Universiti Teknologi PETRONAS. Location chosen based on the pipeline scheme which is water flow for particular pipe is from main pipeline.

At the second stage, author will familiarize with SIMULINK MATLAB software. By using data collection obtained in first stage, author will designing simulation program to calculate power produced by water flow rate from water pipeline.

3.2 Location

Figure 9: UTP Map

Author measured water flow rate from the main water pipeline in three locations which are water pipeline near to Gas District Cooling (GDC), opposite of Village 4 and pipe from Village 2 water tank. Figure 9 shows all the locations mentions.

Figure 10: Pipeline near to GDC

Sizing pipe for GDC and V4 water pipeline is 60mm. These two pipelines are the main intake water pipeline which is GDC is the main intake from Jabatan Air Perak while the V4 is main intake from UTP reservoir. Net head measured from pipeline to UTP water tank is 40 meters. Figure 10 and 11 shows the details location for GDC and V4 pipeline.

Figure 11: Pipeline opposite to V4

Based on water flow rate measurement obtained from data collections, author decided to remove this location from possible location that need to measured because the water flow is too small.

Figure 12: Pipeline from V2 water tank

3.2 Flow chart

All of the project steps and stages are illustrated in the flow chart below.

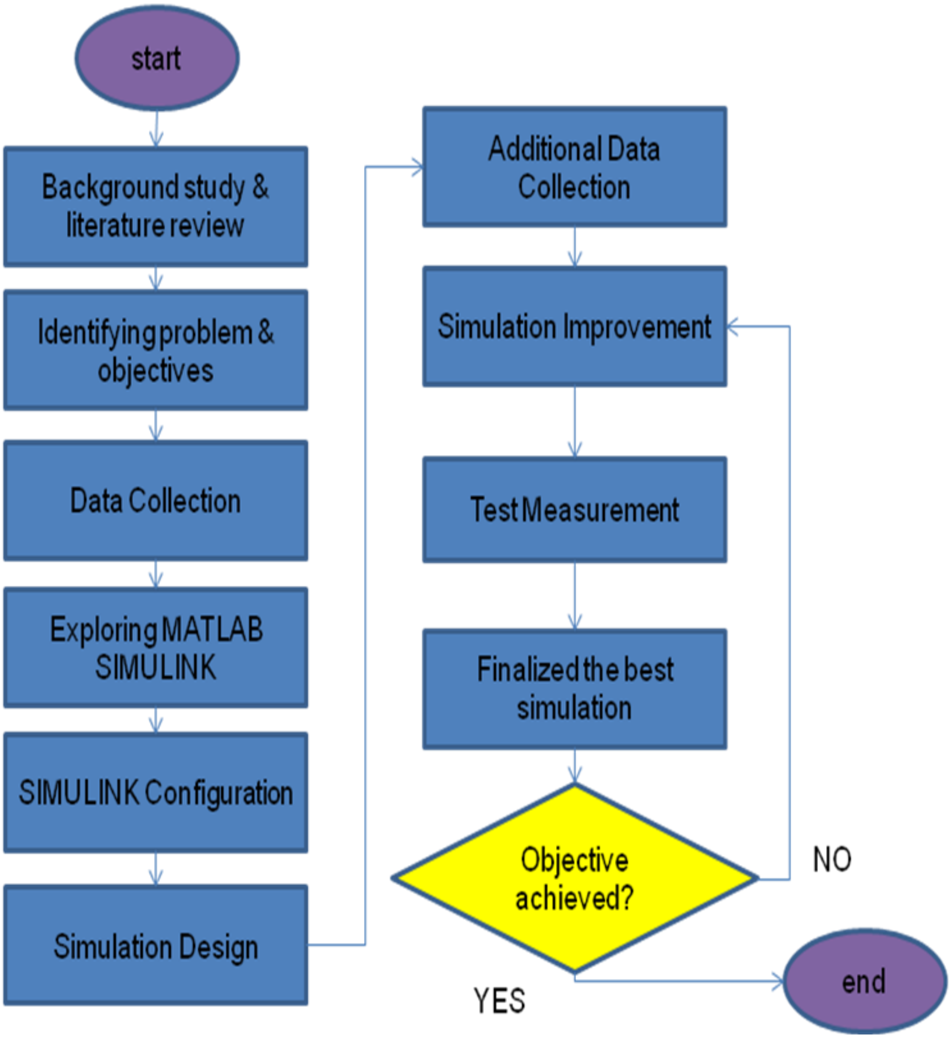


Figure 13: Project flow chart

Starting with study about theoretical of micro hydro energy system author form background study based on literature review from previous researches. Next, by using background study, author found out the problem statements and forms the objectives for this project. After that, author start with data collection at dedicated water pipeline.

In order to start designing system using MATLAB Simulink, author need to explore it first. After that, author has started with designing the system. At the early stage of designing the system, author found that the data was not enough to simulate the system. Additional data is required. Next, simulation improvements have been made. Testing the design of micro hydro energy has been obtained to ensure whether the design is achieved the objective or not.

3.3 Project timeline

Refer to Appendix 1.

3.4 Project key milestone

Other than required report submission and assessment course of the project that will be carry out by the university, this project have three key milestones. There are testing of Portable Doppler Flow Meter (PF D550), Data Collection, SIMULINK configuration, additional data collection and analysis, simulation improvement, test measurement and finalized the best simulation. m^3

3.5 Software and hardware required

This project author needs a few hardware and software to make the project successful. In the side of hardware, author needs a Doppler flow meter whereby in term of software author used SIMULINK software from MATLAB which is to design the power generation simulation.

3.5.1 MATLAB Simulink

By taken from Simulation and Link, it used as an interface for project data flow from graphical program and its easy to be used by engineers especially students and lecturers. Beside, this software can calculate any mathematical expressions. Simulink also is a simulator to analyze or compare mathematical models for any types of field. It is develop by MathWorks to develop multi domain dynamic systems using interfacing graphical block diagram.

3.5.2 Portable Doppler flow meter PF D550

Figure 14: Portable Doppler flow meter PF D550

This equipment is used to measure water flow inside pipeline. It is used sensor coupling compound as shown in Figure 14. This set of flow meter supplied with Micronics flow meter or petroleum gel. This equipment is user friendly because it is easy to use; user just need to enter the measurement of pipe diameter and some other input. Other than that, user also can choose the output type whether to used m^3/h or m^3/s. Since the reading of water flow is low, author decided to use measurement in m^3/h.

3.6 Conclusion

There are two locations to measure water flow which are main water pipeline near to GDC and opposite to V4. Portable Doppler flow meter is used in order to measure water flow in dedicated water pipeline. Water flow is measured in m^3/s. Other than hardware, MATLAB Simulink software is used to design the micro hydro energy system. Data measurement of water flow rate and power produced is recorded in graph based on times and locations in Chapter 4.

CHAPTER 4

RESULT AND DISCUSSION

4.0 Introduction

By using flow rate measurement obtained earlier, simulation design has been made to calculate power produce by using Simulink. In the other hands, there are few parameters need to take action which are velocity of the water, turbine rotation and power produce by the turbine. Details explanation will be discuss below.

4.1 Flow rate measurement

Flow rate measurement done to measure how much water flow in the pipeline, so that author can calculate how much power will produce by the waste energy. For measurement, author have used Doppler flow meter apply at the pipeline surface.

During FYP I, author has taken several measurements using on the water pipeline in UTP in three different locations; which are main pipeline at Gas District Cooling (GDC), main pipeline opposite to Village 4 and Village 2 (V2) water tank. After several data collections, author found that water flow at V2 water tank is very small even thought it have the highest head between all locations. As discuss with Supervisor, author only focus on the two locations which are main pipeline at GDC and V4.

In the other hands, there are three different sessions to take the measurement which are at the morning session, afternoon session and night. For every session, author spends at least 30 minutes to take measurements where data has been collected each 5 minutes. Data have been recorded by author in 35 days starting from 22nd September 2014 until 26th October 2014.

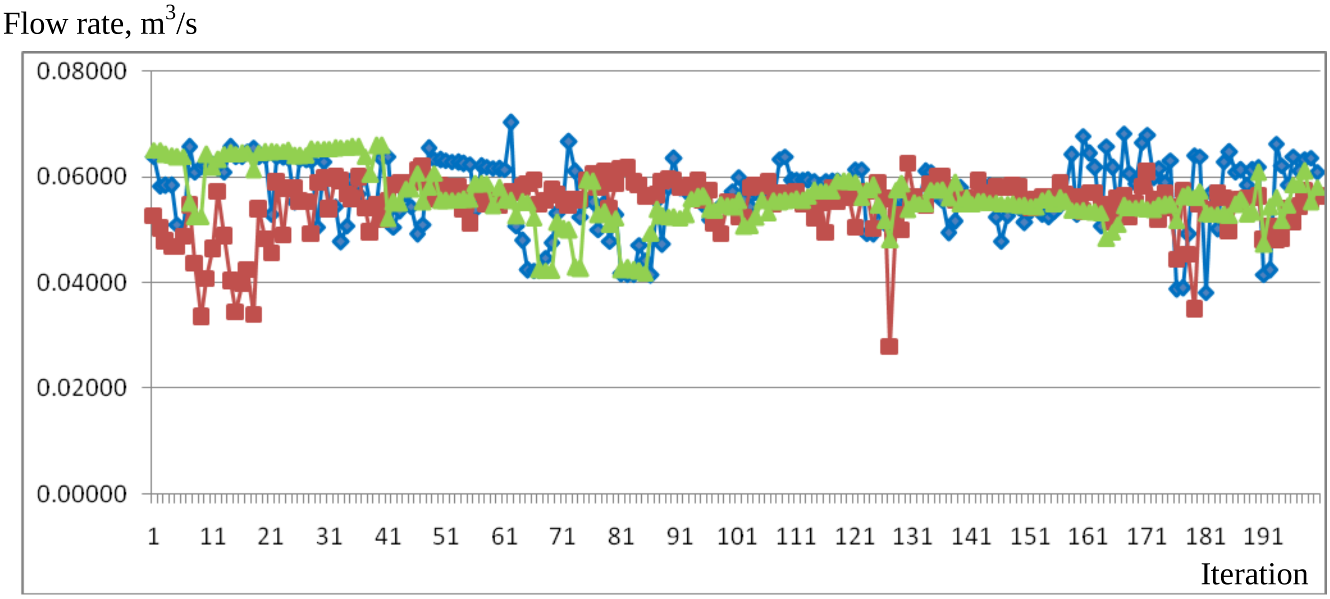


Figure 15: Flow rate at GDC

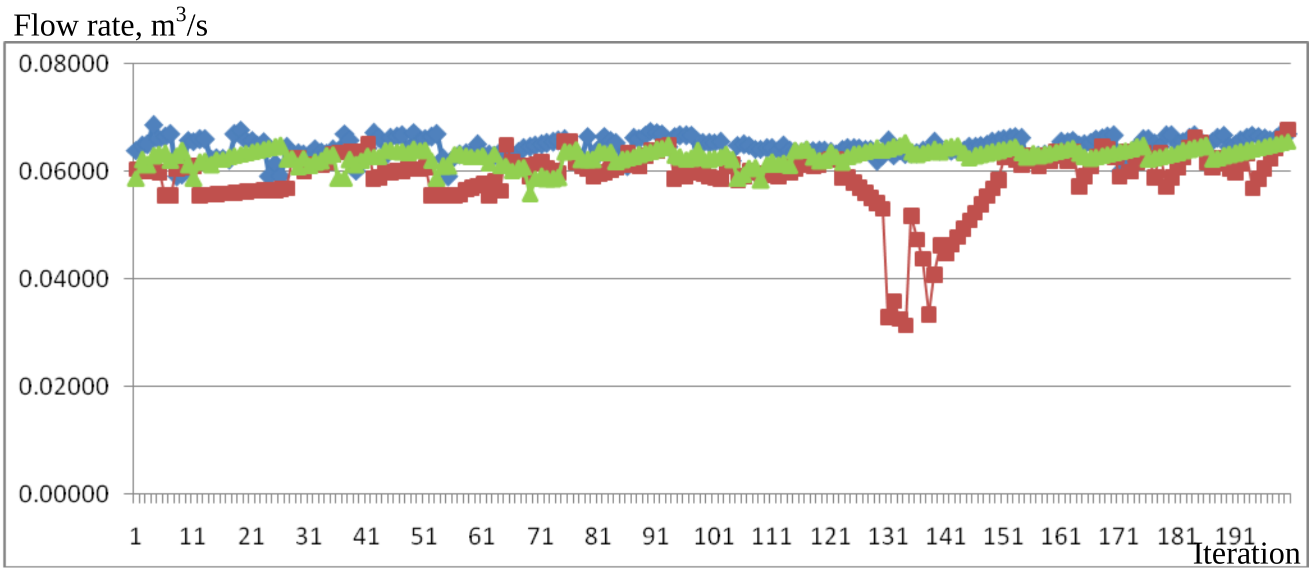


Figure 16: Flow rate at V4

Figure 15 and Figure 16 shows flow rate obtained from data measurement at dedicated water pipeline. It clearly shows that, the highest water consumption is at morning and night at the main pipeline near to GDC and V4 while it is low at afternoon in both locations. This happens because; at the morning residents are preparing their self to the classes. Hence, it resulting the peak value of the water consumption**.** It is because these two locations are near to the load which is students residential. In the other hands, there are few causes that affected the water flow rate during this period which is the prestigious event held October. So that, there are a lot of people comes to UTP and consume more water during this period.

4.2 MATLAB Simulink

By applying hydropower concept, author has made a simulation design using Simulink. The objective of simulation design is to get the power produce by the micro hydropower system. Besides that, there are few simulation design focused by author which is water velocity, rotational turbine, and torque. All the simulation design will discuss below.

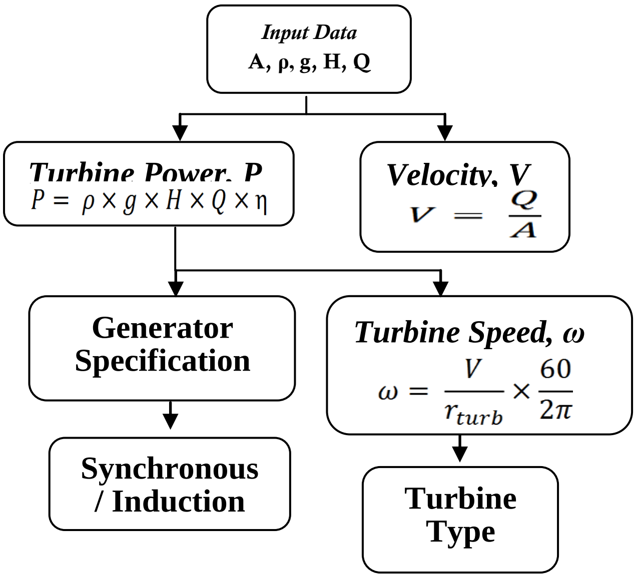


Figure 17: Flow chart of Matlab Simulink program

4.2.1 Calculations for water velocity, v

Author determined to calculate the velocity of water by using water flow rate obtained from data measurement. By using this equation, author produces calculation to calculate the rotational of turbine.

$$v = \frac{Q}{A} \tag{6}$$

$$A = \pi r^2 \tag{7}$$

From the above equations, Q is water flow rate measurement, where v is velocity of water and A is cross sectional area of the pipeline, and r is radius of pipeline [2]. Velocity of water flowing in the pipeline is in the form of kinetic energy which will turn the turbine. In this project, author is using the propeller type of turbine which is Kaplan turbine to produce power.

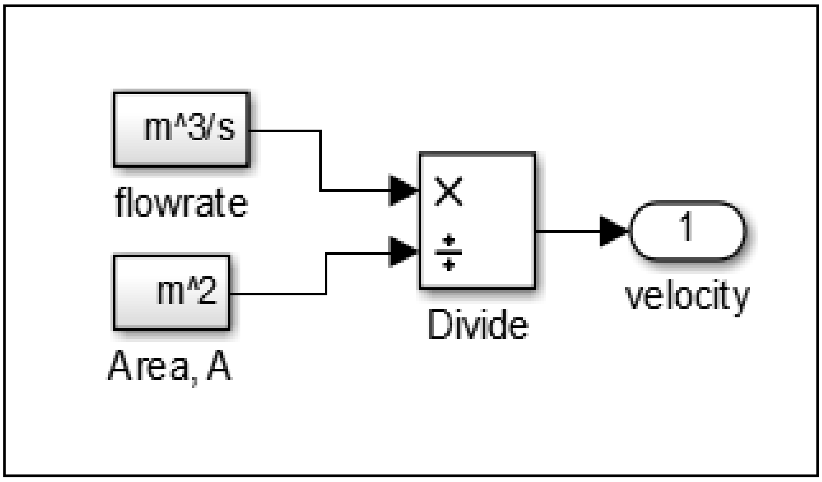


Figure 18: Simulation design for water velocity using Simulink

4.2.2 Calculations for angular speed, ω

$$\omega = \frac{V}{r_{turb}} \times \frac{60}{2\pi} \quad (8)$$

Speed of the turbine can be determined by divided the velocity water in the pipeline obtained in previous calculation, and radius of turbine; in this project author have been decided to use 0.15m from the diameter of pipeline. Equation (9) shows turbine speed for in Radian per Second (RPM).

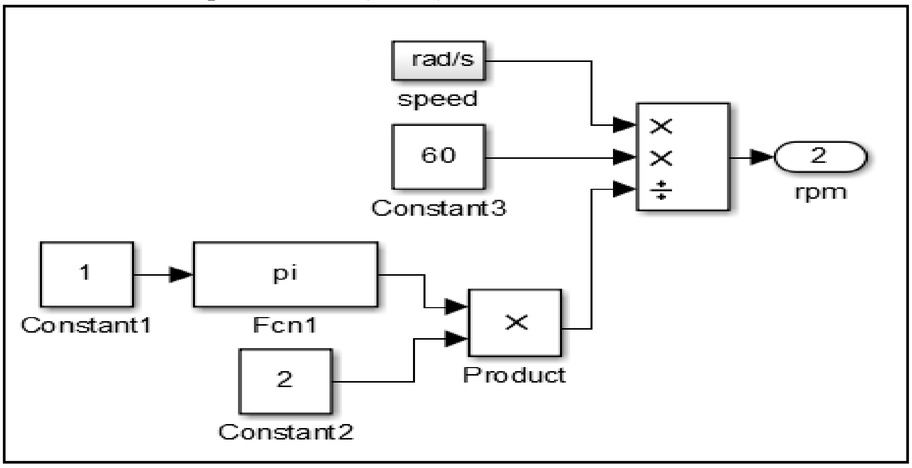


Figure 19: Simulation design for angular speed in rad/s

4.2.3 Calculations for power produced, P

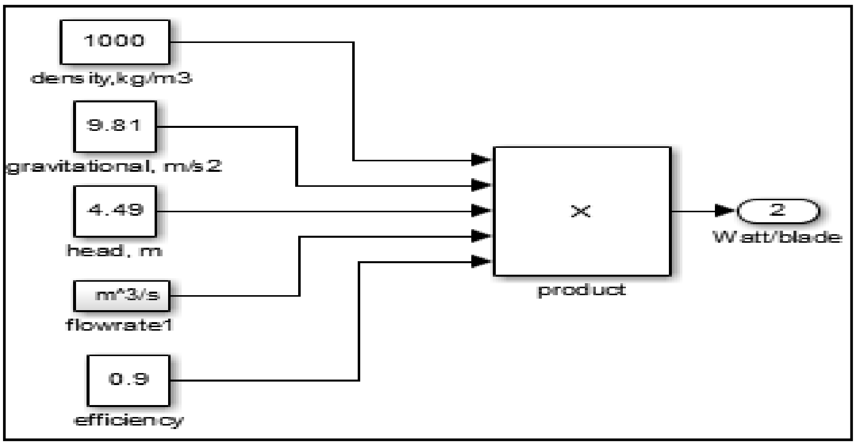


Figure 20: Simulation design for power produced

To produce more rotations of turbine, water flow in pipeline must be directly proportional to the turbine rotation. Besides that, author has decided to use 12 blades of turbine, so that it will produce more rotations and also power. Equation below is for power produced by one blade and torque.

$$P = \rho \times g \times H \times Q \times \eta \qquad (9)$$

Where;

P = power in watt generated in the turbine shaft

ρ = water density (1000kg/m^3)

H = net head (m)

Q = water flow rate (m^3/s)

g = gravitational acceleration constant (9.8 m/s^2)

η = turbine efficiency

4.2.4 Calculations for torque, τ

$$\tau_{N/m} = \frac{P_{total}}{\omega} \qquad (10)$$

After power has been calculated, author can find torque in order to rotate the turbine. In another words, torque is where a force acting in order to rotate the object. Equation (10) shows torque measure in Newton per meter:

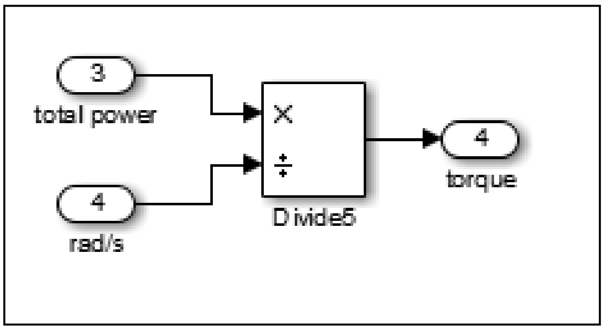


Figure 21: Simulation design for torque

Below is the block diagram illustrated by combining all the above equation:

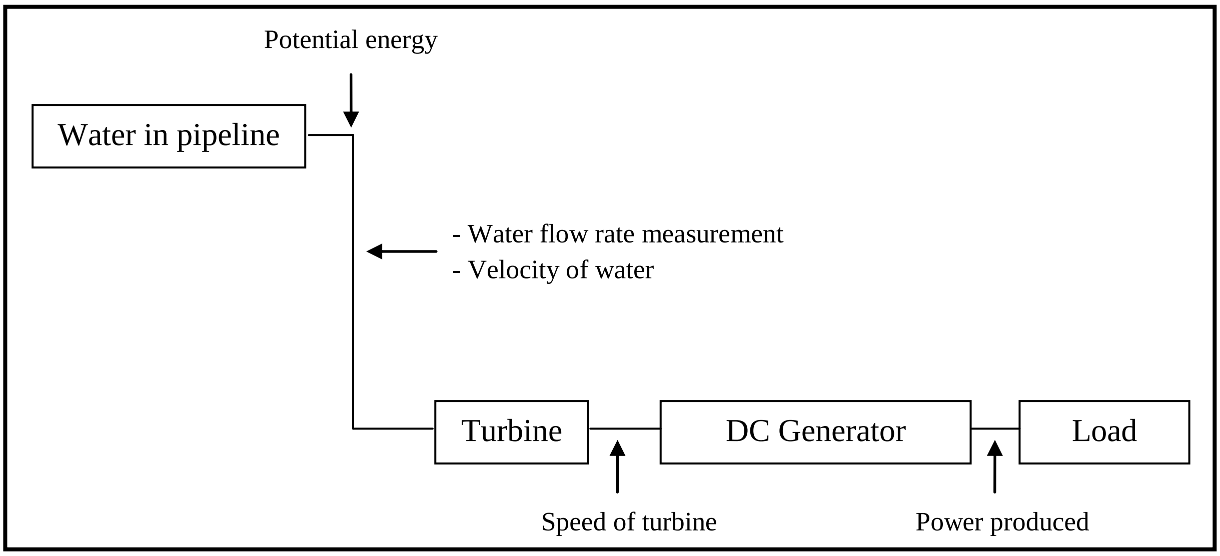


Figure 22: Block diagram for micro hydropower

4.3 Power Produced

Power produce by the turbine obtain from Figure 20 and equation (9). Power produced at GDC and V4 in three different times shown below.

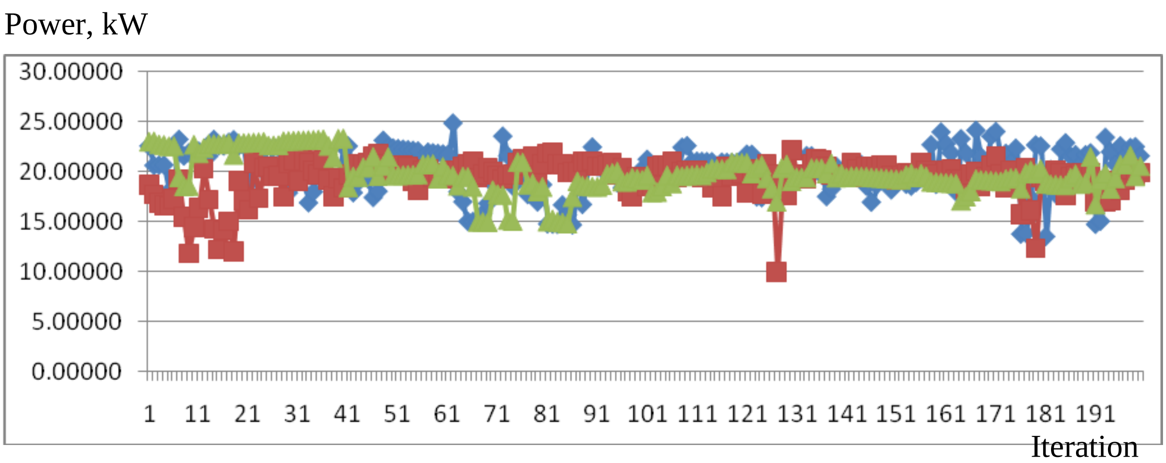


Figure 23: Power produce at GDC in three different times

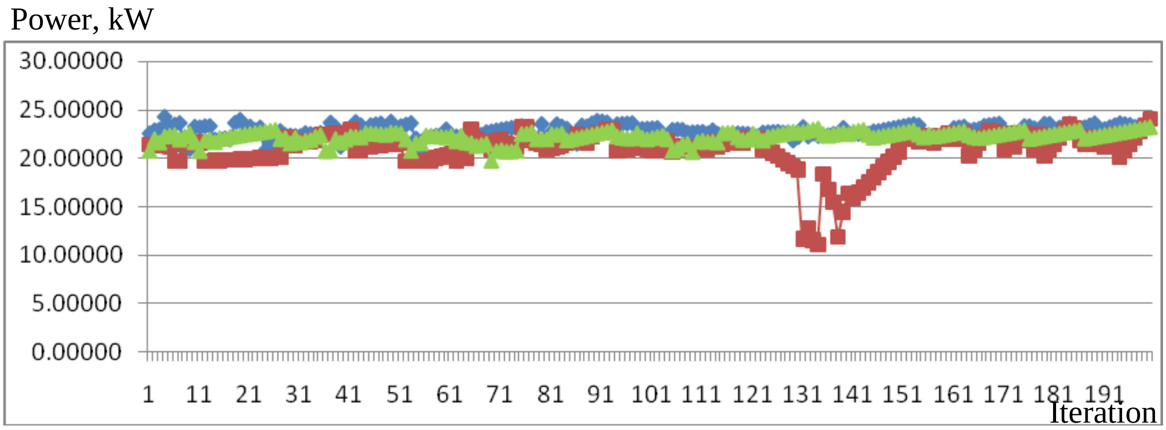


Figure 24: Power produce at V4 in three different times

Figure 23 and 24 shows the power produced by turbine at the main intake pipeline at GDC and sub intake at V4 pipeline in three different times. From the results obtained in Figure 23 and 24, it shows that the powers are more stable during morning and night session. Refer to figure 23 and 24, it shows that the powers are more stable at V4 pipeline at morning and night. This happen because it is the sub pipeline from the main intake and near to the consumer which is student. Besides, at the morning student are preparing their self to the classes. Hence, it resulting the peak value of the water consumption.

4.4 Flow rate vs. power produced

As well aware, power produce is linear to water flow rate. If comparing the measurement of flow rate with power produced obtained, the graph will shows the same indication. The biggest water flow inside water pipelines, the highest power will produced by the turbine. It is proven in Figure 25 and Figure 26.

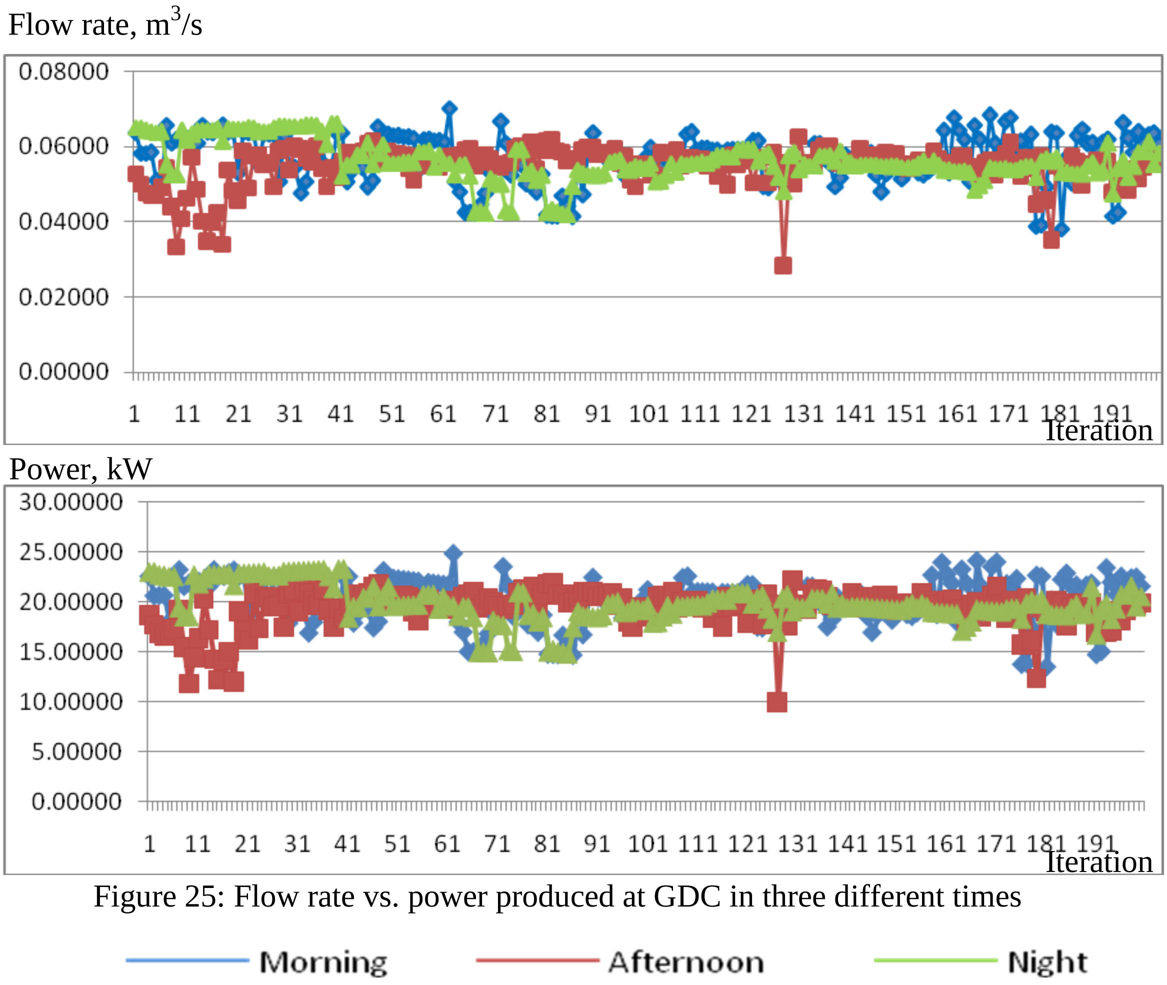
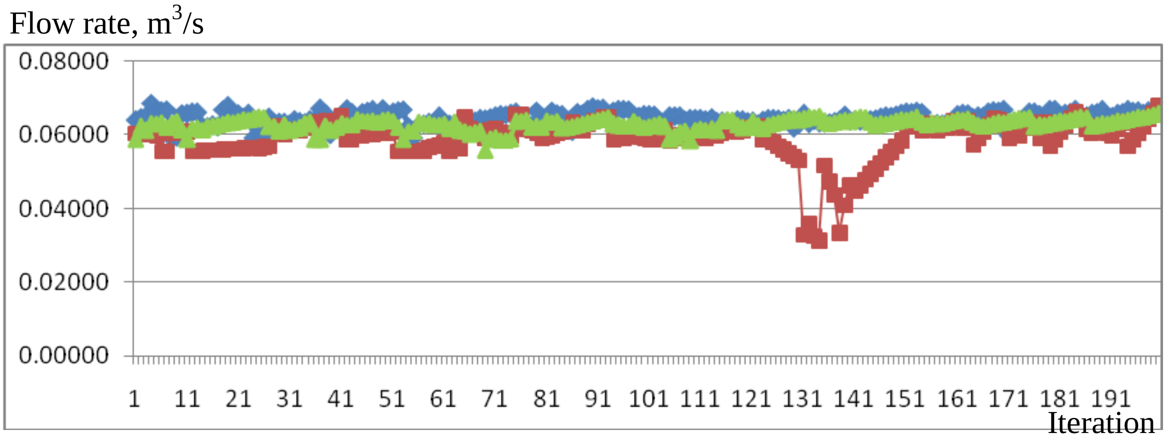


Figure 25: Flow rate vs. power produced at GDC in three different times



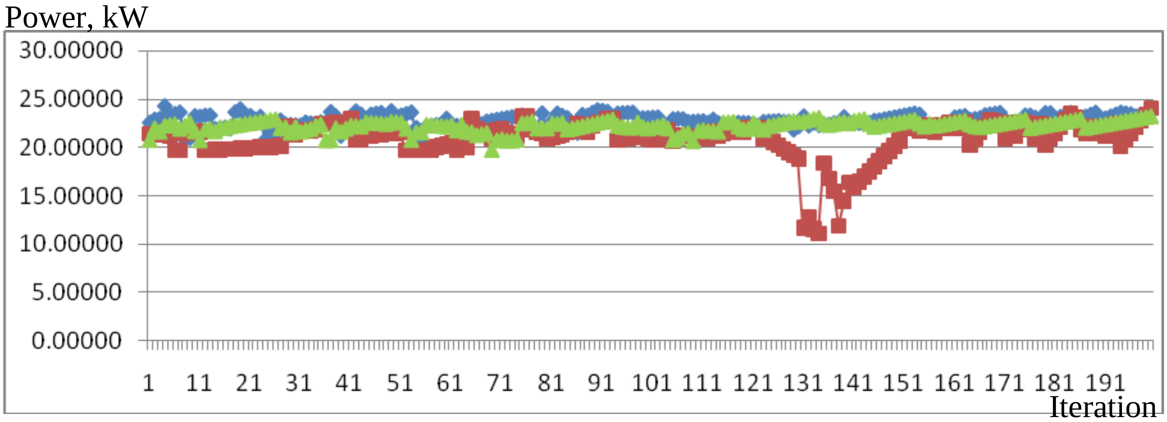


Figure 26: Flow rate vs. power produced at V4 in three different times

Based on the results obtained above, author found the available generator ratings and specifications in the market suitable for micro hydropower. This generator can be purchase for further research in the future. Table 7 shows the details of generator purposed by author based on the power produced using MATLAB Simulink.

Table 2: Generator ratings and specification

Parameters	Details
Type	Excitation generator
Model	Small hydropower generators
Output type	Single phase / three phase
Frequency	50 Hz tor 60 Hz
Output Voltage	3 to 15kV
Excitation system	Brushless

4.5 Conclusion

First and foremost, flow rate measurements obtained in previous chapter are recorded in graphs based on times and locations. Besides, there are calculations involved to design the system which are calculations for water velocity, turbine speed, power produced by turbine and torque. Results are compared between flows rates with power produced to prove that power produced is linear with water flow. If highest water flow the power will produced by turbine is large.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

The objectives of the project are to analyze the potential development of micro hydropower in UTP and to model and design a micro hydropower system in UTP water pipeline. Feasibility studies have been done to calculate the amount of power produced from the micro hydropower using water flow obtained from main pipeline. After several researches, author found that the best way to analyze the power produce calculation is through a simulation in the MATLAB Simulink.

Based on the several general equations, the simulation is designed to produce output results. The results are compiled in tabulation form and graph. Hence, author analyze that this project archived the objectives. In the nutshell, through several calculations, predictions and experiments on water flow rate, it is proven that the faster water velocity will increase the rotation of turbine and will produce more rotations on the shaft coupled with the turbine. More power will be produced for the consumption of household electrical appliances.

Based on the results, power produced by water flow in UTP pipeline is near to student residential. Hence, this is recommended if the power produce will be stored in the battery to use at night to power up at least lamps outside student residential for example Village 4. Thus, UTP can save energy at that time. Continuous power generation can be produce when continuous water flow flowing in the pipeline and it will able to generate electrical appliances for student residential.

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APPENDICES

Appendix 1

Project Timeline:

			Final Year Project I (FYP I)														
No	**Subject**	**Allocation**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1	FYP Title Selection	2 weeks															
2	Project Introduction	13 week															
3	Research - Literature Review	1 weeks															
4	Testing of Portable Doppler Flow Meter	2 weeks															
5	Research – Data Collection	11 weeks															
6	Extended Proposal Submission	27.06.2014						▲									
7	Design of Micro-hydro System – SIMULINK configuration	7 weeks															
8	Proposal Defense Preparation	3 weeks															
9	Proposal Defense Evaluation	14.07.2014									▲						
10	Submission of Interim Draft Report	14.08.2014													▲		
11	Submission of Interim Report	22.08.2014														▲	
			Final Year Project II (FYP II)														
12	Additional Data Collection & Analysis	8 weeks															
13	Data Analysis – Theoretical Calculation	8 weeks															
14	Progress Report Submission	12.11.2014							▲								
15	Design Simulation – Test Measurement	3 weeks															
16	Design Simulation – Finalized the Best Simulation	3 weeks															
17	Data Analysis – Calculating error between result obtained from simulation and theoretical values	1 weeks															
18	Pre-SEDEX	3.12.2014											▲				
19	Preparation of Final Report	4 weeks															
20	Submission of Draft Final Report	15/12/2014													▲		
21	Submission of Dissertation (Soft Bound)	22/12/2014														▲	
22	Submission of Technical Paper	22/12/2014														▲	
23	Viva	29/12/2014															▲
24	Submission of Dissertation (Hard Bound)	26/01/2015															▲