MODELLING OF MICRO HYDROELECTRIC SYSTEM DESIGN

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This project report presented in partial fulfilment of the requirements

for the degree of

Master of Electrical Engineering

Faculty of Electrical and Electronic Engineering

University Tun Hussein Onn Malaysia

JULY 2012

ABSTRAK

Hydropower adalah penyumbang kepada keperluan tenaga dunia. Ia adalah bersih dan mempunyai kelebihan seperti tiada masalah pencemaran alam sekitar. *Stand Alone Power System (SPS)* atau dikenali *Remote Area Power Supply Power System (RAPS)* adalah sistem kuasa yang tidak bersambungan pada jaringan. Pada masa kini, banyak kawasan pedalaman masih lagi tidak mempunyai kuasa jaringan yang disebabkan oleh jarak dan faktor bentuk muka bumi. *SPS* kecil dari sumber tenaga yang boleh diperbaharui adalah sasaran pada kawasan ini kerana ia lebih ekonomi dan mesra alam daripada penjanaan elektrik dengan menggunakan penjana diesel. Projek ini adalah untuk mereka bentuk model *Stand Alone Micro hydropower system* dengan menggunakan perisian MATLAB SIMULINK.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AC	Alternate current
At	Proportionality factor
AWS	Average Wind Speed
CHP	Combined heat power
CO_2	Carbon dioxide
Ce	Resistance torque
Cp	Snubbers capacitance
Ct	turbine torque (pu)
DC	Direct current
DG	Turbine damping
EPS	Existing power system
Eq	Internal voltage
GUI	Graphical user interface
g	Gravity constant
H	Head
HPS	Hybrid power system
He	Effective high
Htn	Nominal fall
hr	Rated turbine head
ht	Effective fall in pu

I_L	Current line to line
I_a	Phase a line current
I_b	Phase b line current
I_c	Phase c line current
I_d	Direct stator current
I_q	Quadrate stator current
JΔ	Combines moment of inertia of the generator and turbine
Kp	Proportional gain
Ki	Integral gain
Kd	Derivative gain
kW	Kilo watt
L	Internal inductance
MG	Micro grid
MHPS	Micro hydropower system
MHPP	Micro hydropower plant
MW	Mega watt
MWPT	Micro wind power turbine
m	report of V_1 and V_2 the water speed at the axis of the buckets
nm	Speed (rpm)
nt	Turbine speed (pu)
P	Active power
PID	Proportional integral derivative
Pm	Input power of synchronous generator
Pmec	Mechanical power
Pt	Turbine power (W)
Ptn	Nominal turbine power (W)

Pu	Per unit
PV	Photovoltaic
Q	Water flow
Qc	Capacitive reactive
QL	Inductive reactive
Qt	Water flow of turbine (m^3/s)
Qtn	Nominal speed of the turbine (m^3/s)
qnl	No load flow
qr	Rated turbine flow
qt	Turbine flow (pu)
R	Internal resistance
RAPS	Remote area power supply system
Rp	Snubbers resistance
Rt	Ray of the turbine
S	Complex power
SPS	Stand- alone power system
SRG	Synchronous reluctance generators
s	Second
V	Voltage
VA	Volts amperes
V_L	Voltage line to line
Va	Terminal voltage
V base	Base voltage
Vf	Field Voltage
Vfd	Exciter voltage
Vt	Drive speed of turbine

V_1	Water speed in the contact of the jet with buckets
V1	Jet speed (pu)
V1n	Nominal speed of the jet (m/s)
Wh	Watt hour
X	Reactance
Xd	Direct reactance
Xq	Quadrate reactance
$\Delta\omega$	Deviation speed
θe	Electrical angle of the rotor
θ	The power factor angle
Ψ	The angle of Eq
δ	The torque angle
ρ	Water density (1000 kg/m^3)
β	Angle between V_1 and V_2
Ωtn	Nominal speed of turbine (rd/s)
τapp	Input torque
ωm	Speed (rad/s)

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

Micro Grid (MG) is a small network of power generators to transform the electricity network in the way that the net changed distributed communication. The Micro Grid formed from the renewable energy resources. The efficiency of a standalone Micro Grid in reliability and economy as well as environment was assessed. The environment efficiency was evaluated considering the amount of CO_2 discharge that was reduced by using installed MG power system renewable energy [1].

The potential economic benefits of micro grid operation are summarized as:

i. Reduced network congestion and line losses
ii. Reduced transmission and distribution cost
iii. Potentially higher energy efficiency
iv. Promoting small individual investment, thus reducing the Huge Capital Expenditure
v. The low capital cost enables low cost access into a viable market

The technologies that play a major role in micro grid operation are:

a) Renewable energy resources
   i. Solar photovoltaic arrays
   ii. Wind energy park
   iii. Small capacity hydro units

iv. Ocean energy

v. Biogas plants

b) Non-renewable energy resources

i. Micro turbine

ii. Fuel cell

iii. Combined heat power (CHP) turbine

iv. Internal combustion engines

Renewable energy includes resources that are constantly present, which never run out. There are various types of renewable energy available in Malaysia as shown in Figure 1.1. However, among these sources, biomass, hydro and solar becomes the most potential renewable energy in Malaysia. Malaysia has tremendous biomass resources available such as oil palm wastes from oil palm mills and plantations, agricultural crops, agricultural crop residues, woods and woods residues, rice husks from rice mills, molasses and bagasse from sugarcane refineries and municipal wastes from landfill and from household. For example, in Sarawak, palm oil industry and agricultural industry emerged to be the largest biomass sector, which both for direct production of energy fuels and use of wastes for biomass generated electricity for sale or own industry usage.

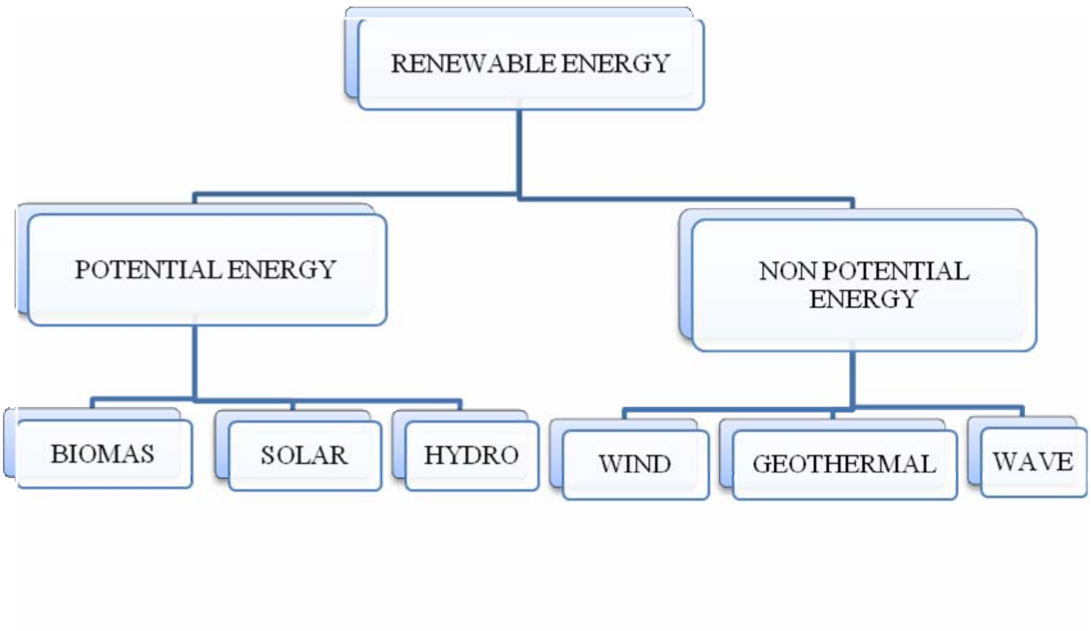

Figure 1.1: General renewable energy sources in Malaysia

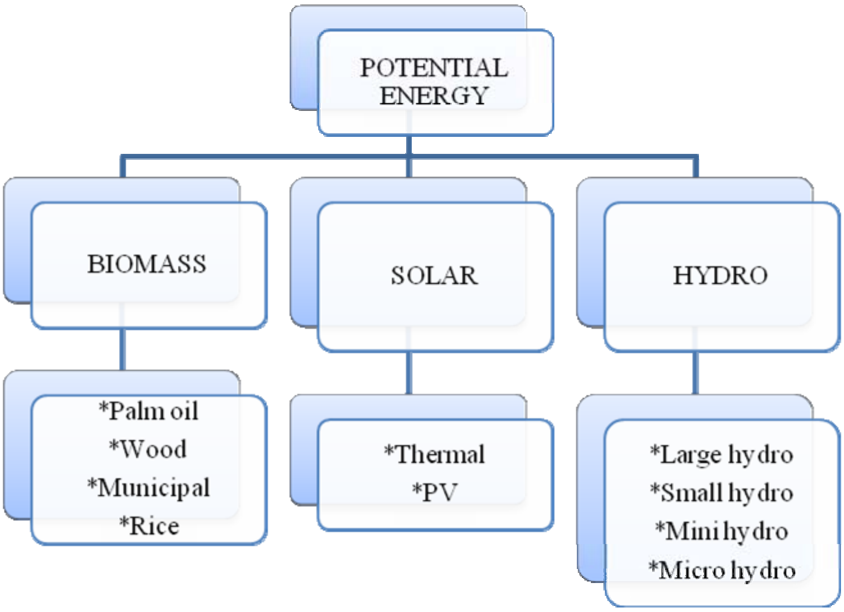

Figure 1.2: Potential energy in Malaysia

Hydropower is currently the world largest source of electricity, accounting for 6% of the world's energy supply or about 15% of the electricity generated. Hydropower is attractive because it is a renewable energy source that can never be exhausted. However, depending on seasonal changes and silt accumulation in large dams, the large reservoirs tend to function less effectively. Unlike large scale hydro, micro hydro or small-scale hydro does not interfere significantly with river flow and is therefore one of the most unobtrusive energy conversion methods available.

1.1 Classification of hydropower plants

Water can be harnessed on a large or a small scale. The categories which are commonly used to define the power output form hydropower are outlined as follows [2,4]:

i. Large-hydro: more than 100 MW and usually feeding into a large grid
ii. Medium-hydro: 15 - 100 MW and usually feeding a grid
iii. Small-hydro: 1 - 15 MW and usually feeding into a grid [3]
iv. Mini-hydro: between 100 kW and 1 MW; either standalone schemes or more often feeding into the grid
v. Micro-hydro: ranging from a few hundred watts for battery charging or food processing applications up to 100 kW, providing power for a small community or rural industry in remote areas away from the grid [1-6].

Micro hydropower system (MHPS) is one of the popular renewable energy sources in the developing countries. Most of the MHPS operate in isolated mode supplying the electricity in the local rural area where the population is very small and sparsely distributed and the extension of grid system is not financially feasible because of high cost investment required for transmission line. Hydroelectric power is the technology of generating electric power from the movement of water through rivers, streams, and tides. Water is fed via a channel to a turbine where it strikes the turbine blades and causes the shaft to rotate. To generate electricity the rotating shaft is connected to a generator which converts the motion of the shaft into electrical energy. Advantage of using water resources is that hydraulic works can be made simple and large constructions, such as dams, are not usually required. Dams, which exploit the kinetic energy of water by raising small quantities of water to heights through the use of regulated pressure valves, can provide water for domestic uses and for agriculture in areas that are moderately higher than adjacent water courses. Generally, in an autonomous micro hydropower system is designed to operate in parallel with local power grids. The main reasons are to obtain economic benefit of no fuel consumption by micro hydro turbines, enhancement of power capacity to

meet the increasing demand, to maintain the continuity of supply in the system, etc. In a micro .hydropower system, frequency deviations are mainly due to real power mismatch between generation and demand.

Today, most of rural area in Malaysia are still not readily accessible of grid power. Regarding to distance and terrain, the cost of connection to the electricity supply grid can be high and the common low load which caused to low payback have escalating the constraint for electric utility to connect power grid into the remote areas. Therefore, generally people in rural area will obtain electricity supply by using diesel generators which operated by using fossil fuel. This seems to be the easiest conducted solution due to the obstacle. However, world's supply of fossil fuels is now becoming scarce and depleting with increasing hazard of global warming. As a result, people in rural area have to afford high cost of electricity generation of diesel generators. Furthermore, the high transportation cost has worsened the situation. Concerning to this situation, an alternative means of energy production should be explored further. Among the available alternative energy sources, interest is focused on clean and environmentally friendly sources that are renewable energy sources such as wind, solar, hydro and so on.

Due to location of rural area, and common low load demand, interest is focused on Stand Alone power systems (SPS) such as micro hydro which is easy been constructed and maintained. SPS formerly known as Remote Area Power Supply systems (RAPS) is the power system that are not connected to the grid. Study has proving that small scale hydro system will only bring very slight side effects on environment compared to large scale hydro power plant. This is because, micro hydroelectric power system can be installed in small rivers or streams while large scale hydroelectric power system requires huge dam or reservoir to store water which will destroying huge area of rainforest thus cause to ecology problems.

The main components of a Micro Hydroelectric Power Plant (MHPP) may be classified into two groups such as the hydraulic system components and the electric system components formed by the synchronous generator and his control system. The water's flow is fixed at the maximal value to guarantee the maximal mechanical power. The upstream hydraulic part of the MHPP consists of water supply from a river, a feeder canal, a regulation basin, a pressure pipeline whose section is accorded

to the flow and the available power. Nozzles direct water jet against a series of spoon shaped buckets mounted around the edge of a turbine. The system ensures the hydraulic energy transformation into mechanical energy. The wheel of the turbine is coupled to a synchronous generator. The general diagram of this system is represented in Figure 1.3. The Pelton turbine is used for the high falls and small flows. It Consists of a set of specially shaped buckets mounted on the periphery of a circular disc. It is turned by jets of water discharged from one or many nozzles which strike the buckets which is shown in Figure 1.4. By a mobile needle inside the nozzle we can adjust the flow. It's moved by an electric servo motor, this servo motor must be relatively slow to minimize the water hammers effect [7].

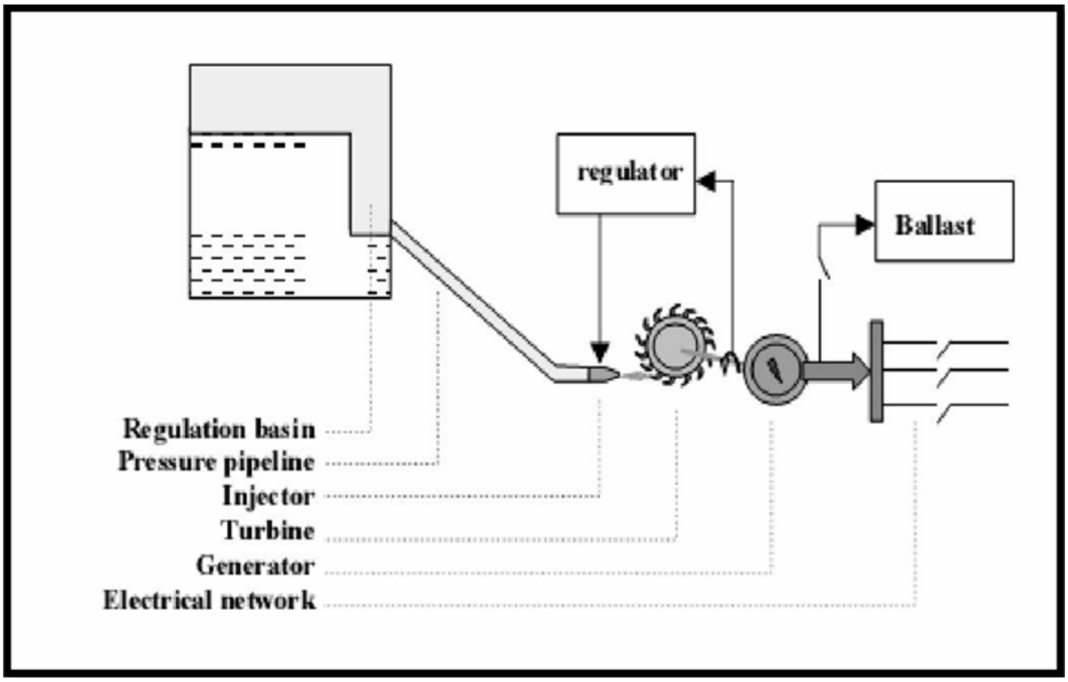

Figure 1.3: Synoptic diagram of a MHPP .

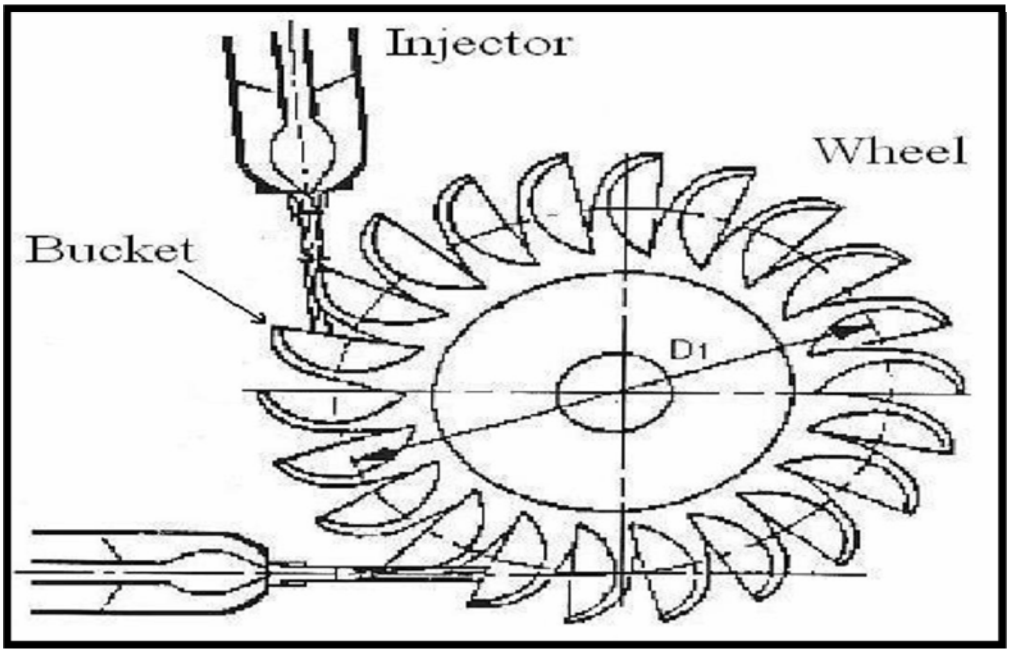

Figure 1.4: The geometrical shape of a Pelton turbine.

1.2 PROJECT BACKGROUND

This research is using the MATLAB SIMULINK software to build the modelling and regulation of the output power of a micro hydroelectric power system. This modelling is built depends on the real parameters which are setting first such as the voltage, frequency and so on to produce the power output is less than 100 kW.

1.3 PROBLEM STATEMENT

In the light of increasing electricity demand, international agreements to reduce greenhouse gases limiting the use of fossil energy and environment problems. As an environmental problem of the global warming, reducing the discharge of greenhouse gas such as carbon dioxides (CO_2) becomes a big objective on the world. It is necessary to introduce more renewable energy for future electric power system. There are many kinds of alternative clean and environment friend resources, such as wind, solar and micro hydro power generation, which are very appropriate for improving our environment conditions. In this project, the micro hydro generation as energy resources usually serve for a local load and not require for high voltage transmission lines crossing through rural and urban landscapes are choosen. By implement this research, the electricity can be supply in the small or local rural area beside that it can be cut cost investment required for transmission line.

1.4 PROJECT OBJECTIVE

The objectives of this research are to:

a) Investigate the micro hydropower system design problem
b) Develop the modelling of micro hydropower system structure using MATLAB SIMULINK
c) Test the system of modelling micro hydropower system design using MATLAB SIMULINK
d) Generate the electricity using the modelling was build.

1.5 SCOPE PROJECT

This research concerned about the implementation of MATLAB SIMULINK software to build the modelling and regulation output power of a micro hydroelectric power system design. To design this modelling, the actual parameters of micro hydroelectric plant such as the water flows, types of turbine, head and other parameters must be known.

1.6 Thesis Outline

This thesis consists of five chapters. The current chapter mainly presents the background, objective and significance of this research. It also provides the general development of method used in the modelling of micro hydroelectric power system.

Chapter 2 consists of previous studies and research that are relevance in determining the placement of modelling of micro hydroelectric power system. In this chapter also discusses about the important equipment to build the micro hydroelectric power system.

Chapter 3 discussed the methodology that is used for this study. It details the process that has been carried out for the short listing of alternatives and the steps taken in building the micro hydroelectric power system design.

Chapter 4 details the analysis and the result of the study. In this chapter is discuss about the data and calculation to build the modelling of micro hydroelectric power system. The comparison results are also discussed in this chapter.

Chapter 5 discusses and concludes the findings of this thesis, and review the parameter of the future development.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Malaysia has extensive electricity coverage, including rural areas. Micro hydro is often used in autonomous or semiautonomous applications to replace diesel generators or other small scale power plants or to provide electricity to rural populations. Ninety-five percent of the rural population is served through the grid. Even the more isolated areas are serviced through diesel generators, solar, and mini-hydro sources.

The common barrier in the development of micro hydro project is the capital cost which is relatively higher than conventional power plant. Maximising local content by utilizing locally manufactured components and designing correct components selection and sizing with appropriate operation strategy will alternatively reduce the project costs. Financial and technical assistance is relatively important in facilitating the development of micro hydro power in Malaysia

Interest in using renewable energy technologies to provide electricity to rural and remote areas as a cost effective alternative to grid extension is gathering momentum in many developing countries. Governments are recognizing geographic rural areas that are non-viable for grid extension to be equipped with the renewable energy technology. This further supported by the policies interventions and subsidies programs for rural electrification. This is happening worldwide. Examples of Asian countries with explicit mandates for renewable energy for rural electrification include Bangladesh, China, India, Indonesia, Nepal, the Philippines, Sri Lanka, Thailand, and Vietnam.

Indonesia, Thailand, Vietnam and other Asian and African countries have micro hydro projects implemented which in most cases implementing standardized technologies for off grid decentralized village hydro schemes. In some cases the micro hydro systems are used as an alternative to the diesel generators and some of it are applied as hybrid systems with solar power. Although small scale hydro power applies a basic technology but recently it attracts worldwide interest because it contribute power at low annual running cost and less technical complication [8].

2.2 Micro Hydro Power System

2.2.1 Brief Description of Micro Hydro Power System

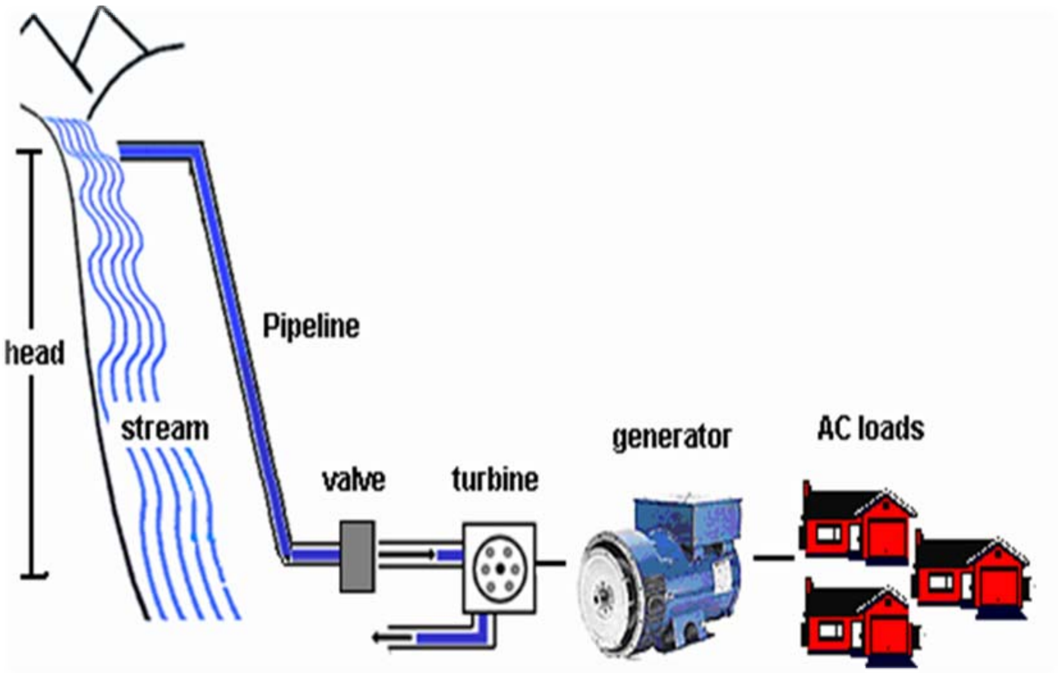

Figure 2.1: Typical micro-hydro systems

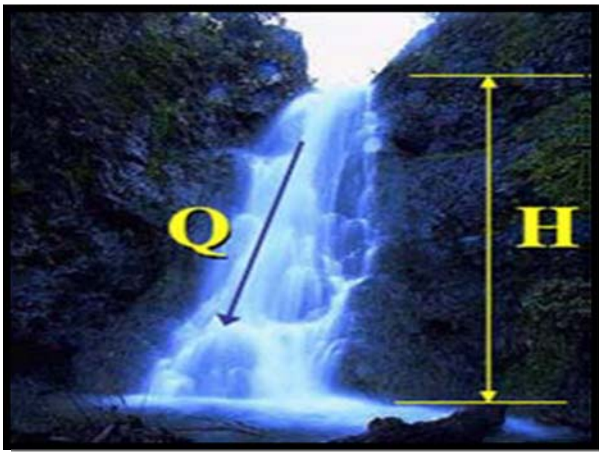

Figure 2.2: Flow rate, Q and Head, H of a stream

Table 2.1: Categories of streams' head

TYPE	HEAD (meters)
High head	≥100
Medium head	30-100
Low head	2-30

Generally, there are two types of micro hydro system, flow of stream and storage type. However, in this research, the system based flow of stream as Figure 2.1 is chosen as the capital cost is lesser compared to storage type and easier been conducted. A micro hydro system converts the potential energy of water into electricity by the use of flowing water. This water flows in water streams with different slopes giving rise to different potential for creating heads, varying from river to river. The capacity of power is depends on the head and flow rate as Figure 2.2.

2.2.1.1 Head

The head, H (in meters) is the vertical height difference between where the water would enter the intake pipeline or penstock and turbine. Hydro sites can be categorized according to the available head as shown in table 2.1. For hydro system, the greatest fall over the shortest distance is preferable when choosing a hydro site. However, more head is usually preferable since power is the product of head and flow. So, less flow is required at a higher head to generate similar amounts of power. With a higher head, the turbine is able to run at a higher speed. If a high head is available, a smaller turbine and generator might be necessary for the same flow and the water conveyance system can also be smaller and thus less costly.

2.2.1.2 Water Flow

The water volume is simply measured as the flow rate, Q (in cubic meters per second) of the water which is usually limited by the size of the stream. The larger the stream the more water is available for a hydro development. However, there is not all the water can be diverted from a river for use in power production, as water must remain in the river for environmental reasons. Nevertheless, other solutions are possible where no water is diverted such as storage type micro hydro system.

2.2.1.3 Power Generation

In micro hydro system, there are two factors determine the power potential of the water flowing in a river or stream flow and the head. The potential power can be determined as:

$$P = \text{Flow rate}(Q) \times \text{Head}(H) \times \text{Gravity}(g) \tag{2.1}$$

Where

P = Power (W)

H = Head (m)

Q = Water flow (m3/sec)

g = gravity constant (9.81 Newton)

This potential energy will turn into kinetic energy when the water falls down over the head through the pipeline. This kinetic energy is kind of pressure which will rotate the shaft of hydraulic turbine. Mechanical energy from turbine then will drive synchronous generator to produce electricity in term of alternating current (AC). The electricity will then be distributed to residences. The AC power supply must be maintained at a constant 50 or 60 cycles/second for the reliable operation of any electrical equipment using the supply. This frequency is determined by the speed of the turbine which must be very accurately governed. The best geographical areas for exploiting micro-hydro power are those where there are steep rivers flowing all year round, for example, the hill areas of countries with high year-round rainfall, or the great mountain ranges and their foothills.

2.3 Basic Components of Micro hydro System

The basic parts of micro hydro systems are [9]

i. Pipeline (penstock) - to deliver the water.

ii. Turbine - to transform the energy of the flowing water into rotational energy.

iii. Alternator or generator - to transform the rotational energy into electricity.

iv. Shut off valve – to immediate shut down the system by cut off water input.

v. Battery bank (optional) - to store the low voltage DC electricity, and usually an inverter which converts the low voltage DC electricity into AC electricity (i.e. 230/400V).

2.3.1 Pipeline

Pipeline used to feed water to the turbine in micro hydro system. The water should pass first through a simple filter to block debris that may clog up or damage the machine. It is important to use a pipeline of sufficiently large diameter to minimize friction losses from the moving water. Pipelines are usually made from PVC or polyethylene although metal or concrete pipes can also be used. Polyethylene pipe may be used for pipe up to 100 PSI, PVC to 160 and 350 PSI and some steel pipe may be specified to 1000 PSI. Water hammering is caused by the rapid loss of momentum of the water in the pipe and this kinetic energy must go somewhere so the pipe contorts, expands and bangs against the interior of the walls to absorb the stress. The same affect will take place in a penstock with long runs with a high rate of flow. Therefore, ensure the pipe and gate valves are able to withstand these forces. When

possible, the pipeline should be buried in order to stabilize the pipe and prevents critters from chewing it.

2.3.2 Turbine

Table 2.2: Turbines with the efficient operating head range

Turbine type	Head range, H (m)
Kaplan and Propeller	$2 < H < 40$
Francis	$10 < H < 350$
Pelton	$50 < H < 1300$
Banki-Michell	$3 < H < 250$
Turgo	$50 < H < 250$

The turbine will extract energy from the flowing water, and turn it into mechanical energy that turns the generator to create electrical energy. System efficiencies range between 65% and 80% depending upon the turbine style and design. Turbines need to be robust machines, and the best use steel (rather than plastic). A turbine selection is largely determined by the head under which it operates. Besides, turbines are also divided by their principle way of operating and can be either impulse or reaction turbines. Impulse turbines convert the kinetic energy of a jet of water to mechanical energy such as Pelton turbine, Turgo turbine, Cross flow turbine and etc. While, reaction turbines convert potential energy in pressurized water to mechanical energy such as Francis turbine, Propeller turbine, Kaplan turbine and etc. Table 2.2 shows the various types of turbines; each operates most effectively in a certain pressure and flow range.

2.3.3 Generator

There are many types of generators such as synchronous generator, inductor generator, and DC generators. Synchronous generator used in almost all standalone applications. While, induction generator used most often with grid tie systems. DC alternator produces rectified alternating current, and it is easy to service. The turbine, generator, and electrical control boxes should all be "housed" in a weather proof building. The building should resist inclement weather, animals, and intruders (children & unwelcome visitors). Regarding to these, a sturdy lock is recommended.

2.3.4 Shut-off Valve

A shut-off valve is necessary, and should be directly in front of the turbine in case an immediate shutdown of the system is required. This valve should be of high quality and very durable. It is recommended that the switch of valve controller should be in normally close condition which mean the valve should be in open position then do not function when most needed.

2.3.5 Battery bank

Normally, lead-acid deep cycle battery will be used in micro-hydro system. Since the energy consumption of users are not consistently, so the battery bank can be charged during less energy consumption time. Battery bank then can compensate when there is overloading condition where energy needed greater than the micro hydro producing. During the dry season the average rainfall is undeniably lower than wet season, however, many streams still able to reach to the minimum requirement of river flow. Hence, an assumption of water source might always within the minimum range throughout the year, so in this research, micro hydro system proposed without storage system. Nevertheless, by adding a battery bank to the micro hydro system can guarantee a never ending supply of energy. Batteries used by a micro hydro system will last longer than those used by other energy systems, as they will not discharge as deeply and as frequently as others do.

2.4 Software used

2.4.1 MATLAB Simulink

Simulink (**Simu**lation and **Link**) is an extension of MATLAB by Mathworks Inc. It works with MATLAB to offer modelling, simulation, and analysis of dynamical systems under a graphical user interface (GUI) environment. The construction of a model is simplified with click and drag mouse operations. Simulink includes a comprehensive block library of toolboxes for both linear and nonlinear analyses. Models are hierarchical, which allow using both top down and bottom up approaches. As Simulink is an integral part of MATLAB, it is easy to switch back and forth during the analysis process and thus, the user may take full advantage of features offered in both environments.

2.5 Technology developments

2.5.1 Modelling and regulation of a micro hydroelectric power plant [7]

The research made by Issam Salhi, Mohammed Chennani, Saïd Doubabi and Nabil Ezziani from faculty of science and technology of Marrakesh, Morocco. This paper presents how to develop a mathematical model for a micro hydroelectric power plant (MHPP). This paper validate the model by analysing a MHPP prototype's performances. The Prototype is installed in the laboratory. This research used downstream regulation which ensures good frequency regulation results. The used controller is the 'PI' one. The practical results obtained are similar for those in simulation.

2.5.2 A self-excited synchronous generator for small hydro applications [10]

The research made by Hilmy awad, Mohamed wadi and Essam hamdi from Chalmers University of Technology, Sweden. This paper describes a class of self-excited synchronous reluctance generators (SRG) and presents preliminary test results obtained from an experimental machine. The concept of SRG described in this paper not only has the advantages of simplicity and ruggedness, but can also have enhanced steady-state characteristics and high efficiency over a wide range of operation. Additionally, its output frequency is determined only by the prime mover speed and this enables integration with power electronic devices to realise control schemes more economically. This proposed design provides a competitive alternative to both induction and conventional brushless synchronous generators used in stand-alone applications.

2.5.3 Planning of Micro-grid Power Supply Based on the Weak Wind and Hydro Power Generation [11]

This research made by Zulati Litifu, Noel Estoperez, Mostafa Al Mamun, Ken Nagasaka, Yasuyuki Nemoto and Izumi Ushiyama from Department of Electrical and Electronics, Tokyo University of Agriculture and Technology. This paper presents the installation and verification processes of Micro Hydro Power Plant (MHPP) and Micro Wind Power Turbine (MWPT) for Kuromori Mountainous Region of Yamanashi Profecture based on the Planning Project of COE Program. This paper focuses on the technologies to develop and utilize the natural energy in a region where the Average Wind Speed (AWS) and water discharge are relatively weak just like the most other regions in this prefecture. Micro-grid (MG) consisting of MHPP and MWPT sources are to be installed in Existing Power System (EPS). Contribution of MHPP and MWPT are determined by investigated wind and water characteristics on complex shaped mountainous land. Stability and reliability of the new hybrid power system are proved by using the compound controllers. Benefit from MG of MHPP and MWPT is proved by comparing the environmental and financial efficiency before and after installing the MG. This paper, with the important practical significance, indicated that regions with relatively weak natural energy may be developed by applying the MG with possible compensation between micro sources.

2.6 Conclusion

As a conclusion all the findings from the previous method will be accumulatively used to gain more knowledge on the topic and at the same time improving the result by identifying the weaknesses from the previous research. By revisiting the previous research, the quality of this thesis can be improved and give more impact in the development of distribution system.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will be described the methods that has been implement in this research. This research implementation method will be divide into 4 phases in order to make everything more systematic, manageable and easier to troubleshoot. Below is the 4 phases that will be done throughout this research:

i. Phase 1 : Project planning

ii. Phase 2 : Project research

iii. Phase 3 : Project development

iv. Phase 4 : Project verification and analysis

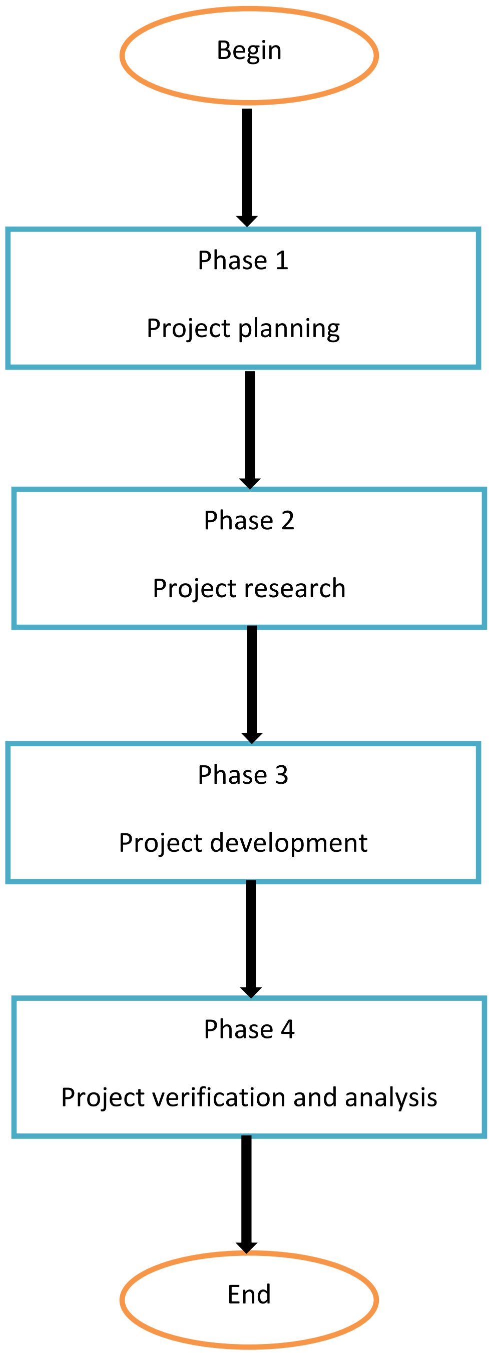
Begin
Phase 1
Project planning
Phase 2
Project research
Phase 3
Project development
Phase 4
Project verification and analysis
End

Figure 3.1 : Flowchart of Overall Project Development

3.1.1 Phase 1 : Project Planning

The project planning is most important to develop the project because it is involving the whole processes from the project title until the end. It also as a guideline for project implementation. At this phase, the title of project is choosing after have a discussion with the supervisor. From the discussion that have done, the problem statement, objective and the scope of limitation have been identified to develop this project.

At this stage, the type of software will be using in this project is identified. The MATLAB Simulink software will be using to design the modelling of the micro hydropower system.

3.1.2 Phase 2 : Project Research

In this phase, the research of the project that will be developing is done and the software that will be used in this project has been studied. By this way, it will make easier to work on this software because the understanding about this software has been studied.

During the research, the books, thesis and journal are also used to get the information for developing this project. A few websites that are related with this project has been surfing in order to get more information to develop this project.

3.1.3 Phase 3 :Project Development

In the system development phase, the parameter that are normally used in micro hydro system are collected. After that, the MATLAB Simulink will be used to design the modelling of the micro hydro system.

3.1.4 Phase 4 :Project Verification and Analysis

The last phase of this research is, the modelling that has been designed will be tested to make sure it operates successfully or not. If the modelling design is not operated the analysis of this project will be occurred to identify the problem to make sure this modelling design work successful.

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