UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BASIC DESIGN AND PERFORMANCE ANALYSIS OF MICRO-HYBRID GENERATOR

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology
(Industrial Power) with Honours.

by

ABDUL HAFEEZ BIN ABDUL MALIK
B071210132
930328-10-5211

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Industrial Power) (BETI) (Honours). The member of the supervisory is as follow:

…….

(Mdm. Halyani Binti Mohd Yassim)

ABSTRACT

Micro-hybrid generator is a stand-alone power system (SPS). It is a green technology that produces electricity from the combination of solar and hydro system. This paper focuses on the basic design and concept of micro-hydro generator as it is a backup supply for the solar system. The principle of solar system will not be discussed in detail in this research. The purpose of this paper is to design a micro-hydro generator with power output from 5 kW to 100 kW. Analysis is carried out using the fundamental theory for micro-hydro system. This research is divided into several parts. The first part is searching the potential site for micro-hybrid generator installation in Malaysia. Second part is applying the fundamental theory for micro-hydro generator system. In this part, the suitable design for micro-hydro system was analysed. The overhead tank, turbine to be used and pump power was calculated during the analysis. This type of green technology is still classified as a new technology in Malaysia. So, it is recommended to see the status of implementation in Malaysia. This research will help to reduce our dependence on using the non-renewable sources for generation of electricity. It also raises standard living of residents in remote areas because this system is suitable to be develop at the off grid area.

ABSTRAK

Penjana mikro hibrid merupakan sistem tenaga yang berdiri dengan sendiri (SPS). Sistem ini merupakan teknologi hijau yang menghasilkan tenaga elektrik daripada gabungan sistem solar dan hidro. Kajian ini menumpukan kepada reka bentuk asas dan konsep penjana mikro hidro sebagai bekalan sandaran untuk sistem solar. Di dalam kajian ini, prinsip sistem solar tidak dibincangkan secara terperinci. Tujuan kajian ini adalah untuk mereka bentuk penjana mikro hidro dengan keluaran kuasa dari 5 kW hingga 100 kW. Analisis dijalankan menggunakan teori asas bagi sistem mikro hidro. Kajian ini telah dibahagikan kepada beberapa bahagian. Bahagian pertama adalah mencari tapak yang berpotensi untuk pemasangan penjana mikro hibrid di Malaysia. Bahagian kedua adalah mengaplikasikan teori asas bagi mikro hidro sistem. Dalam bahagian ini, reka bentuk yang sesuai untuk sistem mikro hidro telah dianalisis serta dibincangkan. Saiz tangki, jenis turbin dan kuasa pam telah dikira pada bahagian ini. Teknologi hijau seperti penjana mikro hibrid masih diklasifikasikan sebagai teknologi baru di Malaysia. Jadi, ia adalah disyorkan untuk melihat status pelaksanaannya di Malaysia. Kajian ini akan membantu untuk mengurangkan kebergantunganterhadap penggunaan sumber-sumber yang tidak boleh diperbaharui untuk penjanaan tenaga elektrik. Ia juga dapat meningkatkan taraf hidup penduduk di kawasan pedalaman kerana sistem ini sesuai untuk dibangunkan di kawasan luar bandar.

DEDICATIONS

This research is dedicated to Almighty God for providing me peace, strength and makes it easier for me to complete it.

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All praise for Allah, with blessings and His grace that has made it easier journey along this learning.

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Only God is able to reward you. Thank you.

Table of Contents

LIST OF FIGURES

LIST OF TABLE

LIST OF SYMBOLS AND ABBREVIATIONS

AC:	Alternating Current
DC:	Direct Current
PLC	Programmable Logic Controller
SPS	Stand-alone Power System
PSP	Private Sector Participation
RES	Renewable Energy System
HE	Hydro Energy
Q	Flow rate l/s
ρ	Density of water [1000 kgm^{-3}]
g	Gravitational force [9.81 ms^{-2}]
H	Net head (m)
D_{pipe}	Pipe diameter (m)
D_{tank}	Tank diameter (m)
$Vol._{tank}$	Volume tank (l)
r	radius tank (m)
v	Velocity (ms^{-1})
A	Area (m^2)
KE	Kinetic Energy (Joule
PE	Potential Energy (Joule)
M	Mass (kg)

N	Rotational speed of turbine (rpm)
T	Torque of shaft (kNm)
D	Runner throat turbine diameter (m)
ω	Angular velocity of turbine (rad/sec)
P	Power input to the turbine (kW)
μ	Efficiency
f	Fraction factor

CHAPTER 1
INTRODUCTION

1.0 Introduction

This chapter introduce about renewable energy and its benefits.

1.1 Background

The first power network was created by Thomas Edison in 1882 in the United States. DC generator was used to generate energy and this energy is distributed using underground cables. However, this system has a disadvantage which power can only be spread in small distance from power station. The first AC power network was formed in the United States in 1885. During this year, William Stanley has created a transformer which is intended to rise or decline the amount of voltage. In 1888, Nicola Tesla has become the first person who invented the induction motor. The purpose of the creation of an induction motor is to generate AC power to substitute the existing DC power. Among the advantages of AC generator is that it can produce better power than DC generator. Moreover, the power can be spread in a wide range.

Grid system was designed to connect the utility network with the main electrical grid. The term off-grid means that the system is not being connected with the main electrical grid. Stand-alone power is one of the off-grid systems. It is developed to provide electricity to rural areas.

Distributed energy is stored or produced by several of grid connected devices which is also referred to as distributed energy resources (DER). There are some differences between conventional power station and DER. First, DER system uses renewable sources such as wind, solar, biomass and hydro. The use of resources for the system can reduce the effects of pollution on the environment. Moreover, it is also not bounded by the fluctuation in price of non-renewable energy. On the other side, the conventional power station use natural resources such as gas, coal, and nuclear to generate electricity. The use of non-renewable sources will indirectly contribute to environmental pollution due to emission of carbon dioxide produced from combustion of the sources.

For conventional power station, it is centralized and often requires electricity to be transmitted over long distances. Unlike conventional power system, DER is a system that is flexible and decentralized. It can be managed and coordinated within a smart grid. Renewable energy is energy that always available and never run out of resources. It can be divided into two types which are potential energy and non-potential energy. Figure below shows various type of renewable energy available in Malaysia

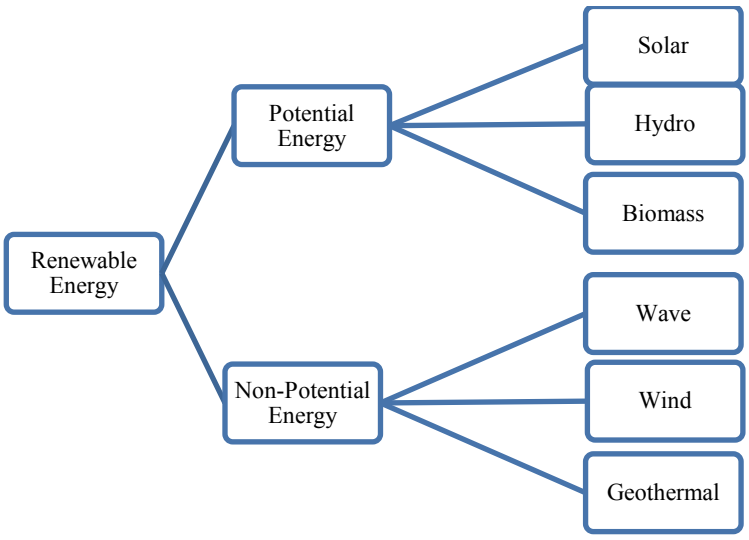

Figure 1.1: Available Renewable Energy Source in Malaysia

In Malaysia, solar and hydro systems have shown a good growth. Both systems use clean and environmental friendly energy resources. Malaysia has an equatorial climate with high temperatures and wet months all over the year. This is an advantage for Malaysia to lead the research of solar system used in industries. Application of this system can be seen in low energy consuming equipment. For example, the system is used to heat water in a hotel and power up street light.

In this era of globalization, the demand for fossil fuels is increasing. Same goes with the price of fuels (Muda and Tey 2012). Because of Malaysia is too dependent on this resource, we should be aware that sooner or later, this resource will be exhausted **(**Malaysia Country Report, Energy Situation in Malaysia: Present and Its Future**)**.

The Malaysian government is aware of this problem. Therefore, the government has introduced a plan to use renewable energy resources instead of fuel source in generation of electricity. The government`s efforts can be seen when the plan is included in 8th Malaysia Plan (2001-2005). According to Amer Aqel (2013), the government is committed to continue this program and it has been included once again in the 9th Malaysia Plan (2006-2010).

1.2 Problem Statement

In some rural areas, they have difficulties to access to electricity. This happens because of the difficulties in installing the distribution system in the area. There are several factors that prevent the installation of the system. Among them are the hilly shape of the earth surfaces, region with water flow like rivers and thick forest. In order to get electricity, diesel generator is used. It has been applied for a long time. Unfortunately, the fluctuation of diesel price which keep increasing has become a burden. Main energy resources for electricity in Malaysia are from natural gases (53.2%) and coal (30.4%), which in emission of carbon dioxide (CO2) and the thinning of ozone layer that lead to increase in temperature. Solar system is an alternative to conventional power system. Solar system has grown in Malaysia rapidly. Unfortunately, solar system has several disadvantages. Solar system only operates during daylight and depends on the climate. It can be said that solar system cannot provide a constant access to electricity.

These problems can be overcome by combining the solar with a micro-hydro system. Combination of both systems has improves system reliability. Moreover, the combination of these two systems will not cause pollution to the environment. This research discusses about the new micro hybrid-generator through the combination of solar and micro-hydro system that can produce electricity from both system. This research focuses on the basic design and concept of micro-hydro generator as it is a backup supply for the solar system

1.3 Objectives

There are three objectives of this research:

1. To review and choose the most potential site for micro-hybrid generator system installation in Malaysia.
2. To design micro-hydro system as a backup power for stand-alone solar system.
3. To analyse system efficiency by using Matlab / simulink.

1.4 Scope

Firstly, this research focuses on the basic design and concept of micro-hydro generator as it is a backup supply for the solar system. The principle of solar system was not discussed in detail in this research. The fundamental theory for micro-hybrid generator system is applied. Among the calculations taken referred are calculations of the head tank, turbine and water pump. The output power generated from micro-hybrid generator system is between 5 kW to 100 kW.

CHAPTER 2
THEORETICAL BACKGROUND

2.0 Introduction

In the era of globalization, the demand for fossil fuels is increasing. Same goes for the price. Because of Malaysia too dependent on these resources, Malaysian should be aware that sooner or later, these resources will be finish.

Malaysian government is aware of this problem. The government has introduced a plan to use renewable energy resources as an alternative energy sources in electricity generation. The government`s efforts can be seen when the plan is included in 8th Malaysia Plan (2001-2005). The government is committed to continue this program and it has been included once again in the 9th Malaysia Plan (2006-2010).

Today, hydropower has been a catalyst for economic and social development. The participation of Private sector (PSP) in Rwanda that implement a small hydro projects for rural electrification has been a great impact on society. Among the projects run by PSP is micro-hydro generator. PSP also committed to the implementation of the project for the development of rural areas (Pigaht and van der Plas 2009).

2.1 Hydro Power Plant

2.1.1 History Development of Hydro Power Plant

The first hydroelectric power plant was installed in Cragside, Rothbury, England in 1870. Hydro power has been used in industry since 1880 in Grand Rapids, Michigan, when a dynamo driven by a water turbine was used to provide theatre and storefront lighting. Today, hydropower plants are much more reliable and efficient than the fossil fuel-fired plants (Baird, 2006). This resulted in a proliferation of small- to medium-sized hydropower stations distributed wherever there is an adequate supply of moving water and a need for electricity. As electricity demand grows, the number and size of fossil fuel, nuclear and hydropower plants increases. In parallel, concerns arise around environmental and social impacts (Edenhofer et al., 2011).

2.1.2 Categories of Hydro Power

Water is a clean and environmental friendly source of energy. It is the ideal source for electricity generation. Hydro power plants convert the potential energy of water into electricity Mohibullah et al (2004). The determination of the size of the hydro power plant depends on the desired output power. The figure below shows the hydro category, power range that can be created and the number of homes powered.

Table 2.1: Hydro categories

Hydro Category	Power Range	No. of Homes Powered
Pico	0 kW – 5 kW	0 – 5
Micro	5 kW – 100 kW	5 – 100
Mini	100 kW – 1 MW	100 – 1,000
Small	1 MW – 10 MW	1,000 – 10,000
Medium	10 MW – 100 MW	10,000 – 100,000
Large	100 MW+	100,000+

1. **Pico Hydro Power Plant**

   Hydro power generation under 5 kW is known as pico-hydro. It is very suitable to be applied in area that required small amount of electricity. M.F. Basar (2011) said that pico hydro power plant only need a small stream to generate electricity.

2. **Micro Hydro Power Plant**

   It produces the output power less than 100 kW. Micro-hydro can generate electrical power to small remote communities. Sometimes, the output is connected to the electric power network.

3. **Small Hydro Power Plant**

   Mini and small-hydro are in the same class. It can provide power not more than 10 MW. It can be connected to conventional electrical distribution network as low-cost renewable energy.

4. **Large Hydro Power Plant**

   Large hydro power generation is often referring to facilities that can produce from over a few hundred Megawatts to more than 10 GW power.