Faculty of Electrical and Electronic Engineering Technology

THE DEVELOPMENT OF PUMPED STORAGE HYDROPOWER USING SMALL SCALE PROTOTYPE

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THE DEVELOPMENT OF PUMPED STORAGE HYDROPOWER USING SMALL SCALE PROTOTYPE

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in partial fulfillment of the requirements for the degree of
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I declare that this project report entitled "The Development Of Pumped Storage Hydropower By Using Small Scale Prototype" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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DEDICATION

I appreciate, respect, and sincerely thank my parents for their love, support, encouragement, and sacrifice throughout my life. I would not have been able to get here without sacrifice and support. The greatest thanks goes out to my siblings as well, who have always helped me out and given me advice in all I do in life. They have also served as my source of motivation and have always given me their moral, spiritual, emotional, and financial support. I would like to extend my sincere gratitude to all of the lecturers, especially my supervisor Dr. Mohd Badril Bin Nor Shah, my academic advisor, and the advisor of the fe^{3}tsa club who have helped me learn and improve throughout my research findings and ensured that this Bachelor's Final Project has been completed successfully. I would like to thank all my colleagues who have always been with me throughout this challenging semester and helped me during this project. I hope all their support and encouragement will help me make this project a success.

ABSTRACT

Pumped hydroelectric energy storage is a form of hydroelectric energy storage that is used for load balancing in electric power plants. Water pumped from a lower elevation reservoir to a higher elevation is used to store energy in the form of gravitational potential energy. Using pumped-storage hydroelectricity, energy from instantaneous sources (such as solar and wind) and other renewables energy, as well as excess power from continuous base-load sources (such as nuclear or coal), may be stored for periods of higher demand. When compared to usual hydroelectric dams of comparable power output, pumped storage reservoirs are quite small, and production times are frequently shorter than half a day. In this project, a small scale of pumped storage hydropower will be developed by using two small water tanks, and a solar panel will be used as a renewable energy source that will power an electrical pump to deliver water from lower elevation tank to the higher elevation tank. The water inside higher elevation tank will flow back to lower elevation tank and the same time will move the water turbine generator to produce electrical energy. It is found that the developed small scaled pumped storage hydropower prototype is not efficient to battery-based solar charging system in term of output power and consistency.

ABSTRAK

Penyimpan tenaga hidroelektrik yang dipam adalah satu bentuk simpanan tenaga hidroelektrik yang digunakan untuk mengimbangi beban dalam loji kuasa elektrik. Air yang dipam dari takungan ketinggian yang lebih rendah ke tempat yang lebih tinggi digunakan untuk menyimpan tenaga dalam bentuk tenaga keupayaan graviti. Menggunakan pam simpanan hidroelektrik, tenaga daripada sumber terputus-putus (seperti suria dan angin) dan tenaga boleh diperbaharui lain, serta lebihan kuasa daripada sumber beban asas berterusan (seperti nuklear atau arang batu), boleh disimpan untuk tempoh permintaan yang lebih tinggi. Jika dibandingkan dengan empangan hidroelektrik biasa dengan keluaran kuasa yang setanding, takungan simpanan yang dipam adalah agak kecil, dan masa pengeluaran selalunya lebih pendek daripada setengah hari. Dalam projek ini, skala kecil kuasa hidro penyimpanan yang dipam akan dibangunkan dengan menggunakan dua tangki air kecil, dan panel solar akan digunakan sebagai sumber tenaga boleh diperbaharui yang akan menguasai pam elektrik untuk menyampaikan air dari tangki ketinggian yang lebih rendah ke ketinggian yang lebih tinggi tangki. Air di dalam tangki ketinggian yang lebih tinggi akan mengalir kembali ke tangki ketinggian yang lebih rendah dan masa yang sama akan menggerakkan penjana turbin air untuk menghasilkan tenaga elektrik. Adalah didapati penyimpanan tenaga hidroelektrik yang dipam berskala kecil yang dibangunkan adalah tidak cekap berbanding dengan sistem pengecasan solar berasaskan bateri dari segi kuasa keluaran dan ketekalannya.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

%	-	Percent
±	-	Plus minus
Ω	-	Ohms
≥	-	Greater than or equal to
℃	-	Degree Celsius
ℓ	-	Litre

LIST OF ABBREVIATIONS

PHES	-	Pump hydroelectric energy storage
TSO	-	Transmission system operator
V	-	Voltage
PSH	-	Pumped storage hydropower
DC	-	Direct current
AC	-	Alternating current
TF	-	Thin film
CdTe	-	Cadmium telluride
a-Si	-	Amorphous silicon
CIGS	-	Copper indium gallium
R&D	-	Research and development
PV	-	Photovoltaics
Wh	-	Watt-hour
Ah	-	Ampere hours
LCD	-	Liquid crystal display
Wi-Fi	-	Wireless Fidelity
MPPT	-	Maximum power point tracking
PWM	-	Pulse Width Modulation
Hz	-	Hertz
I/O	-	Input/Output
USB	-	Universal serial bus
g	-	Grams
mpa	-	Mili Pascal
W	-	Watt
EVD	-	Electronic visual display
IoT	-	Internet of things
LED	-	Light-emitting diode

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Pumped hydropower storage is a form of hydropower storage in use in hydroelectricity for load balancing. Gravitational potential energy is stored in water pushed from a lower elevation reservoir to a higher elevation reservoir. Energy via renewable sources (such as wind and solar) and other renewables, and also excess power from continuous base-load sources (including such coal or nuclear), may be preserved for periods when demand is higher using pumped-storage hydroelectricity. Pumped storage reservoirs is small in comparison to ordinary hydro power of equivalent power generation, and producing periods are usually less than half a day.

Next, due to the power system's instantaneous nature, constant monitoring and changes are necessary to ensure that power generation matches power consumption, which may be catered by including power storage into the load. Energy storage is especially important for the renewable energy sector since it decreases output voltage and frequency fluctuations, therefore enhancing the quality of power generation. It also prevents the wastage of a tiny quantity of unneeded electrical energy. Furthermore, battery is the most common kind of energy storage for mini-grid solar energy storage systems, but it is expensive, harmful to the environment, and requires frequent maintenance.

This project compares the feasibility and efficacy of a small-scale pump storage hydropower prototype to a battery-based solar charging system that uses a sealed lead acid battery to monitor the voltage and current drawn by the load, taking into consideration the limitations of lead-acid battery systems and the success of pumped storage in large facilities.

1.2 Problem Statement

The most widely used of the existing techniques for storing energy on a large scale is pumped hydroelectric energy storage (PHES). Because of the large amount of potential energy that can be stored in pumped storage reservoirs, the energy conversion efficiency of the full cycle, the cost per power unit, and the ability of these plants to the Transmission System Operator (TSO) in short-term operation, PHES is the most appealing option for large-scale energy storage. Hydropower made for the greatest percentage of the world total. Because of the instantaneous nature of the electrical system, continuous monitoring and modifications are required to ensure that power output and demand are balanced, which may be catered by incorporating energy storage into the grid. since it decreases output voltage and frequency fluctuations, improving the quality of power generation. PHES also avoids the remaining balance of the electrical energy created from going to waste.

1.3 Project Objective

This project's major purpose is to develop an efficient and structured mechanism for determining with tolerable accuracy, the effectiveness of the developed pumped storage hydropower prototype will be compared to a battery-based solar charging system. Specifically, the objectives are as follows:

a) To develop Arduino based circuit that measure load current and load voltage.

b) To design a small scale prototype pumped storage hydropower using solar-powered system.

c) To compare the efficacy of pumped storage hydropower prototype with battery-based solar system.

1.4 Scope of Project

The scope of the project is defined as follows:

a) Circuit Design

- The system is made up of solar-powered pumped storage hydropower and a battery-based solar charging system that can display output readings for each load for small scale prototype.

b) Program Development

- To use the Arduino IDE software to write a program for an Arduino UNO microcontroller to perform measurement of load current and voltage.

c) Software Development

- To construct and the circuit connections using PROTEUS software, which can display the output for this design circuit.

d) Hardware

- Solar charging requires a sealed lead acid battery and solar charge controller then use adapter 5V to power up to the Arduino board, and pumped storage hydropower requires two tanks, a pump motor, and a 12V generator. To monitor the output differential of each load, both are connected to a voltage sensor and a current sensor.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The literature review is a past study from a collection of academic references, such as journal articles and theses, related to a particular research subject or challenge. The researcher will utilize the literature reviews to learn about other people's practices in order to use them as guides for this project. It will allow the researcher to have a better understanding of the topic and to create or innovate new ways.

2.2 Pumped storage hydropower

Hydropower with reservoirs is a well-developed and widely used method of renewable energy storage today[1]. Potential energy is stored in water in a reservoir behind a hydroelectric power plant for a variety of time periods, from hours to years. Hydropower reservoirs are frequently multi-purpose reservoirs that also provide home and industrial water supply, agricultural irrigation, flood control, fish farming, and recreational use. By referring figure 2.1 shows a method of hydro power storage is pumped storage hydropower (PSH). It's a system that uses two storage tanks at different elevations to generate electricity as water flows from one to the other (distribution) and via a turbine. Pumping water back into top reservoir requires power as well (recharge). PSH functions similarly to a big battery in that it can store and release energy as needed. PSH is classified as either open-loop or closed-loop. A continuous hydrologic link to a body of water exists in an open-loop PSH. Reservoirs in closed-loop PSH are also not connected to the external body of water [2].

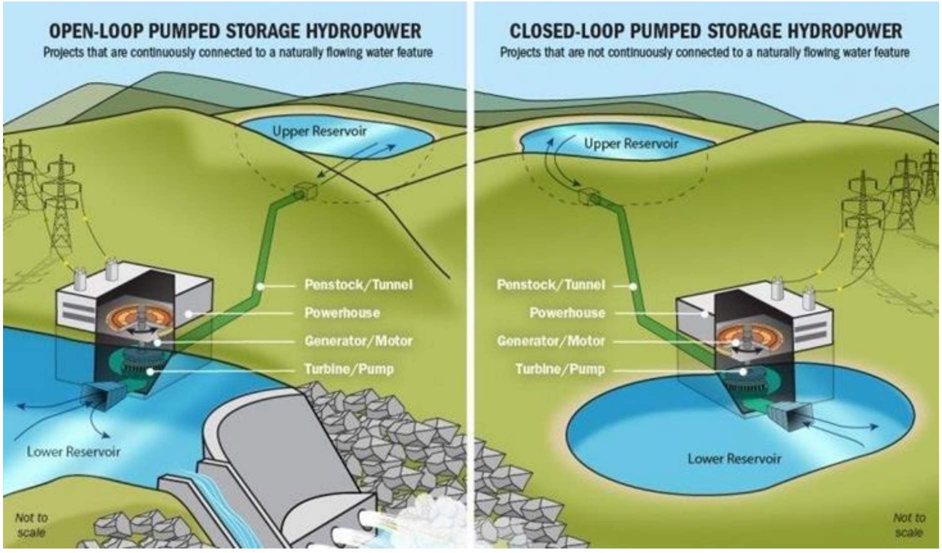

Figure 2.1 Design of pumped storage hydropower [2]

2.3 Solar power as a source of energy

Solar energy systems are already a well-established technology that is innately safer than certain potentially hazardous electricity-generating methods [3]. In addition, solar can also save costs as it is a natural and readily available source of energy. In Malaysia, there have four types of solar system that actually work such as hybrid solar, direct current solar systems, grid-connected system and off-grid residential solar system [4]. The figure 2.2 shows the differences between solar system.

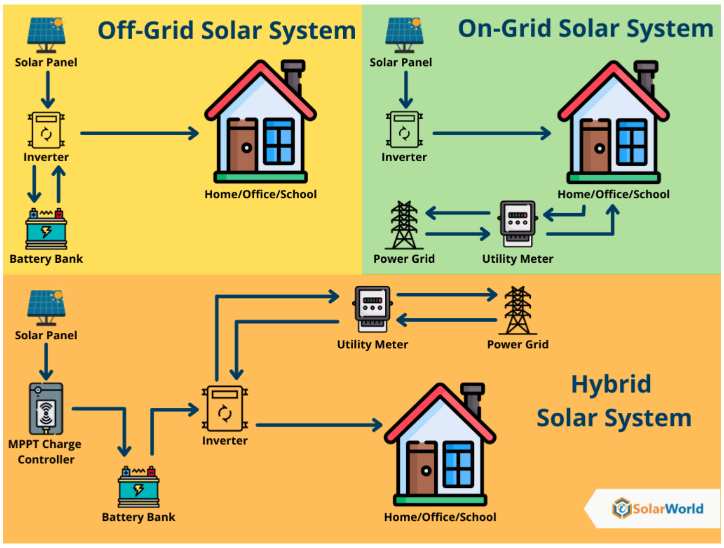

Figure 2.2 Differences between solar system [5]

Hybrid solar, often known as grid-connected solar with energy storage, is the first form of solar system. When compared to off-grid residential solar systems, this solution saves money for consumers. This is because if the battery has energy stored in it, it will use it instead of the grid's electricity. However, one disadvantage of this technology is that it is more expensive. This is due to the fact that you will need to replace the batteries on a regular basis to keep it from being worn out.

Furthermore, the most widely used system is the Grid-Connected System. It connects to the home's electrical system and the local grid. Any excess electricity is sent back to the grid. This method is excellent since it does not need much maintenance. Because it requires less equipment, the operational expenses are quite cheap. It is very efficient for a direct current solar system since it only requires one conversion, which is Direct Current, making it more effective.

Figure 2.3 shows the Off-grid power system with solar power appropriate for pumped storage hydropower prototype with battery-based solar system. In smaller DC coupled systems, a solar charge controller is used to regulate battery charging, after which the DC power is converted to AC and provided to the load through an off-grid inverter.

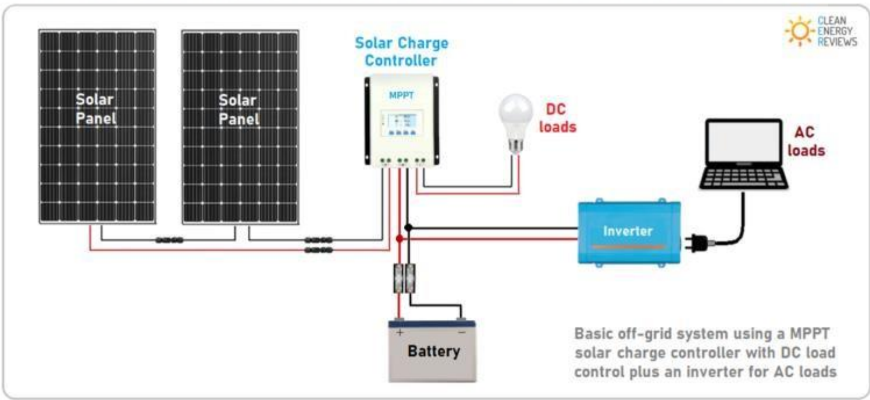

Figure 2.3 Off-grid solar power system [6]

2.4 Type of solar panel

Solar panels are an important consideration in terms of solar panel efficiency and site suitability, as well as possible financial savings and environmental benefits for the user. There have three type of solar panel which monocrystalline, polycrystalline and thin film (TF) [7].

2.4.1 Monocrystalline

Referring figure 2.4, Monocrystalline solar panels are made up of cells cut from a single crystalline silicon. When compared to polycrystalline solar panels, it is slightly more efficient. As a result, monocrystalline panels have a high power output. It's also the smallest and lasts the longest of the other panels.

Figure 2.4 Monocrystalline solar panel [7]

2.4.2 Polycrystalline

Figure 2.5 shows the polycrystalline solar panels use the same material as monocrystalline panels, but polycrystalline are made up of multiple pieces of silicon combined together. It's slightly less efficient, but it's the most sustainable to produce and therefore costs less to the end user.