UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN OPTIMIZATION OF SOLAR PUMPING WATER FILTER FOR SUSTAINABLE AND WATER QUALITY IMPROVEMENT

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

by

NURFARAHIN BTE NASIR
B071210591
900327-14-5062

FACULTY OF ENGINEERING TECHNOLOGY
2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Design Optimization of Solar Pumping Water Filter for Sustainable and Water Quality Improvement**

SESI PENGAJIAN: **2014/15 Semester 2**

Saya **NURFARAHIN BTE NASIR**

Mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐	SULIT	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐	TERHAD	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)
☐	TIDAK TERHAD	

Disahkan oleh:

(TANDATANGAN PENULIS)

(TANDATANGAN PENYELIA)

AlamatTetap:

E-16-1, PPR Intan Baiduri

Jalan Taman Intan Baiduri,

52100 Kuala Lumpur

Cop Rasmi:

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FAKULTI TEKNOLOGI KEJURUTERAAN

Tel : +606 234 6623 | Faks : +606 23406526

Rujukan Kami (Our Ref) :
Rujukan Tuan (Your Ref) :

16 Dis 2015

Pustakawan
Perpustakaan UTeM
Universiti Teknikal Malaysia Melaka
Hang Tuah Jaya,
76100 Durian Tunggal,
Melaka.

Tuan/Puan,

PENGKELASAN LAPORAN PSM SEBAGAI SULIT/TERHAD LAPORAN PROJEK SARJANA MUDA TEKNOLOGI KEJURUTERAAN ELEKTRIK (KUASA INDUSTRI): NURFARAHIN BTE NASIR

Sukacita dimaklumkan bahawa Laporan PSM yang tersebut di atas bertajuk***"Design Optimization of Solar Pumping Water Filter for Sustainable and Water Quality Improvement"*** mohon dikelaskan sebagai *SULIT / TERHAD untuk tempoh LIMA(5) tahun dari tarikh surat ini.

2. Hal ini adalah kerana IANYA MERUPAKAN PROJEK YANG DITAJA OLEH SYARIKAT LUAR DAN HASIL KAJIANNYA ADALAH SULIT.

Sekian dimaklumkan.Terima kasih.

Yang benar,

_____
Tandatangan dan Cop Penyelia

* Potong yang tidak berkenaan

NOTA: BORANG INI HANYA DIISI JIKA DIKLASIFIKASIKAN SEBAGAI SULIT DAN TERHAD. JIKA LAPORAN DIKELASKAN SEBAGAI **TIDAK TERHAD**, MAKA BORANG INI **TIDAK PERLU DISERTAKAN** DALAM LAPORAN PSM.

DECLARATION

I hereby, declared this report entitled “Design Optimization of Solar Pumping Water Filter for Sustainable and Water Quality Improvement” is the results of my own research except as cited in references.

Signature **:……**

Name **: NURFARAHIN BTE NASIR**

Date **: ……**

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 Electrical Engineering Technology (Industrial Power) (Hons.). The member of the supervisory is as follow:

…….

(Emy Zairah Binti Ahmad)

ABSTRACT

The photovoltaic (PV) solar system is an alternative way of generating electricity. This project presents the design and development of a portable solar pumping water filter with low cost and easy to maintain over time. It would be great to have clean water and electricity supplied sustainable without needing any outside help. The water is being pump through a pipe and will filter the water for purification. Solar module is used to power the pump for pumping instead of using conventional electricity to on the pump. Battery is needed to be a backup and use at night. The portable solar pump will remove sand and any particles inside the water. The system will generate 200W/day from 50W mono-crystalline type of solar panel with 12V DC pump of 13.3Ah batteries capacity. System sizing is being done using PVGIS system and manually calculated so as achieve optimize design. The sizing of both elements is important to make sure that the panel and battery is protected from power leakage.

ABSTRAK

Sistem solar photovoltaic (PV) adalah antara salah satu cara untuk menjana elektrik. Projek ini menggunakan aplikasi pum untuk menyedut dan membawa air ke dalam penapis untuk ditapis supaya menjadi lebih bersih dan sihat untuk digunakan dengan menggunakan kos yang rendah dan menjimatkan masa. Bekalan elektrik akan dibekalkan secara mampan tanpa perlu apa-apa bantuan luar. Jenis panel Photovoltaic (PV) yang akan digunakan adalah jenis 50Wp mono-kristal dimana ia akan menjana 200W/hari daripada beban yang digunakan dengan penggunaan pam 12V DC 13.3Ah kapasiti bateri. Reka bentuk dan saiz projek dilakukan menggunakan sistem PVGIS dan juga dikira mengunakan kaedah manual untuk mendapatkan hasil yang terbaik. Pengiraan saiz untuk kedua-dua elemen ini amatlah penting untuk memastikan bahawa panel dan bateri dilindungi daripada kebocoran kuasa. Konsep sistem adalah air dipam melalui paip pada hari yang cerah dan penapis akan menapis air untuk pembersihan. Solar digunakan sebagai alternatf lain untuk memberi kuasa kepada pam untuk proses pengepaman. Penggunaan bateri amatlah penting terutama sekali pada waktu malam dimana tenaga solar tidak dapat beroperasi pada waktu tersebut. Pam akan menarik air melalui penapis yang mempunyai kualiti yang baik untuk membuang pasir dan mana-mana zarah di dalam air supaya menjadi bersih dan boleh digunakan.

DEDICATIONS

Specially dedicate to my beloved parents, family and friends.

Also to my supervisor, Puan Emy Zairah Binti Ahmad and not to forget my panels, Puan NurBahirah Binti Norddin and Dr. Zikri Abadi Bin Baharudin

ACKNOWLEDGMENTS

Alhamdulillah. I am greatly indebted to Allah on His mercy and blessing of making this project successful.

First of all, I am grateful and I would like to thanks to my supervisor Puan Emy Zairah Binti Ahmad for her invaluable guidance, a very constant and continues encouragement throughout my project. Her major studies in solar power system have guide me very well and give me the best experience to develop and understanding about this project thoroughly. It would be a lot tougher without her advice and assistance.

I would like to thanks to all my friends who have contribute in giving opinion and who helped me in many ways to finished up this project. Their excellent co-operation and supports is unforgettable and very helpful and also to Universiti Teknikal Malaysia Melaka (UTeM) for a great supports.

I acknowledge my gratitude and sincere to my parents for their great support and constant encouragement during my studies. I am really thankful for their prayers, sacrifice, understanding and patience in all way to make my dreams come true and to my entire period of my studies. Thank you very much.

TABLE OF CONTENTS

DECLARATION iv

APPROVAL v

ABSTRACT vi

ABSTRAK vii

DEDICATIONS viii

ACKNOWLEDGMENTS ix

TABLE OF CONTENTS x

LIST OF FIGURES xiv

LIST OF TABLE xv

LIST OF SYMBOLS AND ABBREVIATIONS xvi

CHAPTER 1 ..... **Error! Bookmark not defined.**

1.0 Introduction ..... **Error! Bookmark not defined.**

1.1 Background ..... **Error! Bookmark not defined.**

1.2 Problem Statement ..... **Error! Bookmark not defined.**

1.3 Objective 3

1.4 Scope 4

CHAPTER 2 5

2.0 Introduction 5

2.1 Renewable Energy 5

2.1.1 Solar Energy ..... **Error! Bookmark not defined.**

2.1.2 Wind Energy 6
2.1.3 Biomass Energy 6
2.1.4 Ocean Energy 7
2.2 Solar Power 7
2.2.1 On-grid Solar Systems 8
2.2.2 Off-gris Solar Systems 9
2.3 Photovoltaic (PV) Panel 11
2.3.1 Mono-Crystalline 12
2.3.2 Poly-Crystalline 13
2.3.3 Thin Film.....14
2.4 Water Pumping Systems 15
2.4.1 AC Motors Pump 16
2.4.2 DC Motors Pump 16
2.4.3 Pressure 17
2.5 Water Filter.....17
2.5.1 Carbon and Silver Impregnated Carbon.....18
2.5.2 Silver Bio Balls 18
2.5.3 Minerals Balls 18
2.5.4 Sand.....18
2.6 PH Value 19
2.7 Energy Storage 19
2.7.1 Battery.....19

2.7.2 Charge Controller 20
2.7.2.1 Pulse Width Modulation (PWM) 21
2.7.2.2 Maximum Power Point Tracking (MPPT) 21
2.8 Photovoltaic Geographical Information System (PVGIS) 21
2.9 Factor Effecting Output 22
2.9.1 Temperature 23
2.9.2 Shading 23
CHAPTER 3 24
3.0 Introduction 24
3.1 Project Flow 24
3.2 Flow Chart 25
3.3 Design Calculation 26
3.3.1 Solar Panel Sizing 26
3.3.2 Battery Sizing 27
3.4 DC Pump 28
3.5 Design Sketch 29
3.6 PVGIS System 29
3.7 Day of Storage (DOS) 32
3.8 Flow Chart of Project Completion 32
CHAPTER 4 33
4.0 Introduction 33
4.1 Main Structure 33
4.1.1 Battery with Charge Controller 34

4.1.2 Motor Pump 38

4.2 Testing and Analysis 41

4.2.1 Water Pump Distribution 45

4.3 Cost Analysis.....48

CHAPTER 5 50

5.0 Conclusion.....50

5.1 Future Work 51

APPENDIX A 53

APPENDIX B 54

APPENDIX C 55

APPENDIX D 56

REFERENCES.....56

LIST OF FIGURES

Figure 1.1: A Conveersional Way of Collecting Water....3
Figure 2.1: On-Grid Solar System....8
Figure 2.2: Inverter used in FKE....9
Figure 2.3: Off-Grid Solar Syatem....10
Figure 2.4: Stand-Alone PV System in FKE....10
Figure 2.5: Solar Process....11
Figure 2.6: Mono-Crystalline Solar Panel....**Error! Bookmark not defined.**
Figure 2.7: Poly-Crystalline Solar Panel....**Error! Bookmark not defined.**
Figure 2.8: Thin Film Solar Panel....**Error! Bookmark not defined.**
Figure 2.9: DC Pump....**Error! Bookmark not defined.**
Figure 2.10: Filter Layer Processl....**Error! Bookmark not defined.**
Figure 2.11: Solar Charger Controller PWM Type....21
Figure 2.12: Solar Charger Controller MPPT Type....22
Figure 3.1: Flow Chart of Phase 1....25
Figure 3.2: Solar Pumping Water Filter Process....26
Figure 3.3: Design using AUTOCAD....29
Figure 3.4: Photovoltaic Geographical Information System (PVGIS)....30
Figure 3.5: Probability of Power Production Estimation....31
Figure 3.6: Flow Chart of Phase 2....32
Figure 4.1: Structure of Project Hardware....34
Figure 4.2: Structure with 15 Degree Inclination....35
Figure 4.3: Soldering the Panel Cable....36
Figure 4.4: Sizing of 5W Mono-Crystalline Solar Panel....36
Figure 4.5: Battery of 7.2 Ah Capacity....37
Figure 4.6: Inverter Indicator....38
Figure 4.7: Car Withshield Wiping System....39
Figure 4.8: Measurement of Pump Performance....39
Figure 4.9: Pump Connected to the Structure....40
Figure 4.10: Switch ON OFF Button....41
Figure 4:11: Measurement Procedure....41
Figure 4.12: Characteristic of Solar Panel....42
Figure 4.13: Graf of Voltage (Voc) versus Time....43
Figure 4.14: Graf of Current (Ioc) versus Time....44
Figure 4.15: Piping System....44
Figure 4.16: Filtering Process....45

LIST OF TABLE

Table 2.1: Advantages and Disadvantages of Solar Energy **Error! Bookmark not defined.**
Table 2.2: Measurement of PH Value.....**Error! Bookmark not defined.**
Table 3.1: Estimation of PV Power Information 30
Table 3.2: Probability of Power Production Estimation 31
Table 4.1: Measurement for Open Circuit Voltage (Voc) 42
Table 4.2: Measurement for Short Circuit Current (Ioc) 43
Table 4.3: Tabulated Performance for 5 Days 46
Table 2.2: Measurement of PH Value.....**Error! Bookmark not defined.**
Table 3.1: Estimation of PV Power Information 30
Table 3.2: Probability of Power Production Estimation 31
Table 4.1: Measurement for Open Circuit Voltage (Voc) 42
Table 4.2: Measurement for Short Circuit Current (Ioc) 43
Table 4.3: Part Cost Analysis.....48

LIST OF SYMBOLS AND ABBREVIATIONS

SBM	=	Shape-Based Matching

CHAPTER 1
INTRODUCTION

1.0 Introduction

This chapter is all about the beginning of the project which is the pumping system that had being generated and powered by the solar power and control the flowing of water for filtering processes.

1.1 Background

Water is one of the important elements in human life and essential to the survival of most other organisms. Clean and purity water is the most concern issues in rural communities where by dirty water is the biggest problem of health risk and lack of basic protections that is harmful for humans used and not fit for drinking. Human body required about seven liters of water per day to avoid dehydration. The World Health Organization state that water hygiene and sanitation improvement can reduce 32 percent of diarrheal disease. However, over 40 percent of the world's 6 billion people not accept the fact about sanitation and still using water from unsafe sources (Kindhauser, 2002).

Nowadays, technological age has resulted in high demand for electricity. Hence, the demand of the production has led to global warming and environmental effected. Therefore, renewable energy was created to concern the environment issue and produce more electricity. Solar have the greatest potential of renewable energy that can be commercial in Malaysia regarding the location of Malaysia on the equator give this country an advantage which receive 12 hours of sunlight daily. It generated electricity during the day at peak power usage time when

the cost and value of electricity is at the highest. Photovoltaic (PV) is the main component in solar power system that will convert the light directly into electricity in direct current (DC) form. The term of photovoltaic represents two words; photo refers to the light and voltaic represent the electricity. By using solar panel, we can save eco-system and global warming rather than using fossil fuels as energy power and we can also reduce our energy cost and contribute to a clean environment.

Solar pumping water filter is the low cost of purifying the water and can be implemented rather than rely on firewood that has impact on the environment. It is inexpensive, effective and increasing water safety and decrease dehydration. It can be used in rural area that not connected in grid with utility companies. Solar powered pumps are the best choice when the utility power and piped water is not available. There are many researcher studied about solar pumping system but they are only focusing on modeling and simulation of the system.

1.2 Problem Statement

Nowadays, people at rural or remote area are still beyond the coverage and lack of knowledge about fresh and pure water for their daily usage. As we known, drinking unsafe water will affected their health and it would be great to have clean water and electricity supplied sustainably without needing any outside help since lack of electricity is one of the main problem in rural area. Usually fresh water is not available in many locations that are too far from water supply system which they have to transport from nearby sources at high cost.

Solar pumping water filter is an alternative way to make the water purification, suitable for drinking and usable for household activities. The water supply that has been used for drinking water is usually stored in households in a container which is exposed to dirt and environment that not very clean. Apart from that, the quality of cleanliness of water from other sources; lake or rivers used by villagers are rarely known whether it is clean water or not.

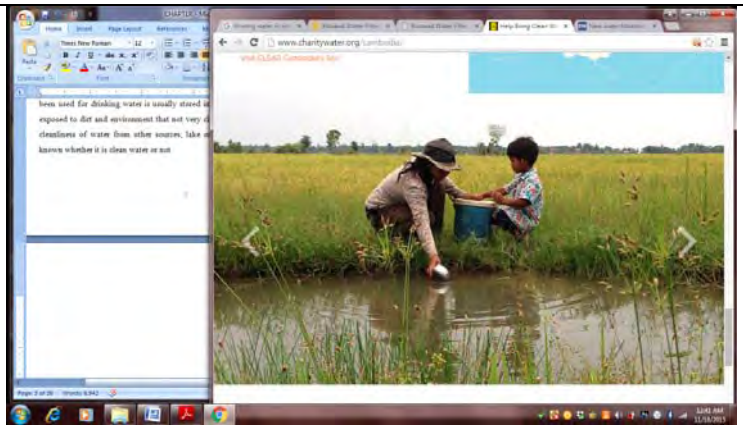

Figure 1.1: A Conversional Way of Collecting Water

An automatic pumping system is developing through this project since it is easy to use technology and simple which is effective to bring the latest technology to a new level of usage and innovation. This filtering of water is basically and manually done by a person where it's require an extra work by collect the water by their self and keep it inside a tank. With this pumping system that attach together with the filter, it will pump water automatically without needing to collect the water from any sources and directly filter the water.

1.3 Objective

The aim of this project is to design a portable solar water filter with low cost and easy to maintain over time. A design for a small-scale PV system will able to supply a rural area with safe portable water. To fulfill this objective, a photovoltaic (PV) panel stand-alone solar was used as a solar power source and stored the power energized in the battery. A basic water filter system is connected to the solar panel to purify the water and produced safe water for drinkable. This green power sources will benefit rural communities where utility companies are too far from their places. Other than that is to study and establish more knowledge about renewable energy especially solar energy.

1.4 Scopes

Project scope is one of the essential ingredients that required guiding and assisting for development of the project. The size of the system intended to be small therefore it can be portable and easy to handle. The project scope includes:

- To design the simple pumping system that will automatically collect water
- To determine the suitable sizing for the battery and solar panel to be used
- To make an analysis about the system performance and to determine if it capable to filtering the unwanted substances

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

To design and develop this project, research about the system such as renewable source, PV panel, battery sizing, water filter and pumping system must be in detailed. The literature review is conducted by doing some research and searching information to the related point subjected to the project through internet and journal from IEE articles and other resources helps a lot.

Generally, water pumping system is the process of moving the fresh sources of water and purified it through the filter to get clean water with the best result of pH value. Fresh water that comes from lake, river or pond is usually unhealthy or poisonous. Thus, this purifies and treatment directly after being pumped will result a clean water and safe for human. A typical stand-alone solar system comprises the following components; solar panels, voltage or charge controller, storage battery and inverter for AC load.

2.1 Renewable Energy

Renewable energy is an energy that naturally gets from our surrounding and environment resources. There are many types of renewable energy such as solar, wind, geothermal and others that can be use as sources to generating the electricity. Renewable energy is important regarding the benefits that provides by the energy such as environmental benefits. Renewable energy is a clean energy and sources that have a lower environmental impact. It is also an energy that will

not run out. Renewable energy is an alternative way in rural and remote areas rather than using fossil fuels that expensive and difficult to get.

2.1.1 Solar Energy

Sunlight is the sources of heating and lighting when the energy is used directly from sun. It can generate electricity for variety of commercial and industrial uses and will give benefits to homes and other buildings. Solar energy is an environment friendly, requires minimal maintenance and PV cells is last until 30 years. The only disadvantage of solar panel is it cannot operates within the night, without light and it is also requires large area for large scale applications.

2.1.2 Wind Energy

Wind turbines are a process of evaporation of water by using hydroelectric power. The energy from the sun will drives the winds and cause water to evaporate turns into rain or snow into the river or streams. Wind energy is the most widely renewable energy consumed in term of capacity. The advantages of the system are it wills reduces consumption of fossil fuels for electricity production and prevent from pollution. Wind energy is using wind generator that is only available in certain areas and will make a humming sound of noise that can disturb people nearby. It is also need a wide place and the height of the generator can block the viewing of scenery.

2.1.3 Biomass Energy

Biomass is a renewable energy that gets the sources of energy indirect from the sun. Biomass energy is consists of biological material produced by the living organisms. It is often apply for plants and also can apply to animal. It is exists by transferring through the food chain

of animal bodies and their wastes. This system is widely used due to its low cost and amount of energy captured. The good example of biomass energy is wood from tree that will produce energy for heating and cooking and biomass is suitable for off-grid electricity generation.

2.1.4 Ocean Energy

Ocean energy comes from the gravitational pull of the moon and the sun with the earth. The energy that produces the oceans wave drives by the winds. There is much renewable energy that can forms ocean energy to produce electricity (Kishore, 2009). The benefits of using ocean energy are it can prevent from uncontrolled flooding and provide water for irrigation. Regarding the disadvantages, dirt can build up at dams and decreasing their effectiveness. It is also interfaces with natural flow of water through environment and wildlife migration pattern such as salmon.

2.2 Solar Power

The sun is the only star of our solar system located at its center whereby the earth and other planets orbit the sun. Energy from the sun in the form of solar radiation support almost all life on earth via photosynthesis and drives the earth's climate and weather. Soteris (2009) also highlights that solar energy is the greatest advantages compared with other forms of energy are that is clean and can be supplied without environmental pollution.

Solar energy is the most popular renewable energy and it is suited to apply in rural and remote area where the energy is crucial in human development. It is an energy that consistent and steady source throughout the year that convert energy from sun to usable electricity. The main benefit of solar energy is it can be easily to get and very economic.

Table 2.1: The Advantages and Disadvantages of Solar Energy

Advantages	Disadvantages
• Environment friendly • Low noise • Minimal Maintenance requirements • Reduce production of various pollution • Long life, PV cell last until 30 years • Easy to install	• Low output in cloudy weather • High initial cost • Large area needed

2.2.1 On-grid Solar Systems

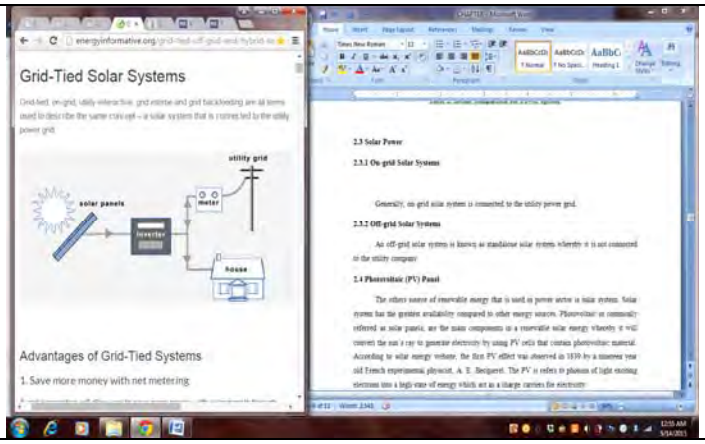

Figure 2.1: On-grid Solar System

Generally, on-grid solar system is connected to the utility power grid. The advantages of this system are it save more money with metering system with solar panel. Usually, household will consume a lot of electrical energy, but with metering, homeowners can excess electricity onto utility grid instead of paying extra bills and storing the energy to the battery. Homeowners can make a benefit by selling the energy and the utility company is committed to buy the