UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FACULTY OF ELECTRICAL ENGINEERING

LAPORAN PROJEK

SARJANA MUDA

COMPARISON BETWEEN CONCENTRATING SOLAR POWER AND PHOTOVOLTAIC FOR HIGH POWER SOLAR ENERGY HARVESTING

Mohd Aizat Bin Ibrahim
(B010810329)

Bachelor of Electrical Engineering
(Control, Instrumentation and Automation)
JUNE 2012

© Universiti Teknikal Malaysia Melaka

COMPARISON BETWEEN CONCENTRATING SOLAR POWER AND PHOTOVOLTAIC FOR HIGH POWER SOLAR ENERGY HARVESTING

MOHD AIZAT BIN IBRAHIM

A Report Submitted in Partial Fulfillment of Requirement for the Degree of Bachelor in Electrical Engineering (Control, Instrumentation and Automation)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

JUNE 2012

© Universiti Teknikal Malaysia Melaka

"I hereby declare that I have read through this report entitle "*Comparison Between Concentrating Solar Power and Photovoltaic for High Power Solar Energy Harvesting*" and found that is has comply the partial fulfillment for awarding the Degree of Electrical is Engineering (Control, Instrument and Automation)"

Signature	:	……
Supervisor Name	:	**En.Norhafiz Bin Salim**
Date	:	25th JUNE 2012

© Universiti Teknikal Malaysia Melaka

"I hereby declare that this report entitle "*Comparison Between Concentrating Solar Power and Photovoltaic for High Power Solar Energy Harvesting*" is the result of my own work except as cited in the references. The report has not been accepted for any degree and it not concurrently submitted in the candidature of any other degree.

Signature	: ……
Name	: Mohd Aizat Bin Ibrahim
Date	: 25 JUNE 2012

© Universiti Teknikal Malaysia Melaka

DEDICATION

To my beloved parent, brother, sister for their supports and encouragement

© Universiti Teknikal Malaysia Melaka

ACKNOWLEDGEMENTS

In The Name of Allah the Most Merciful and Most Compassionate.

Alhamdulillah, praise be to Allah for the blessings and giving me the strength and ability to complete this final year project (FYP). I would like to express very grateful thanks to my supervisor of this project, Mr. Norhafiz Bin Salim for the valuable guidance and advices. He inspired me greatly by works in the project and without his guidance and advice I would face many problems to figure out this project. Due to his constructive ideas and unrelenting less support, I had been able to complete this project with a certain degree of quality.

Thank you very much to my mother, my family, my lectures and also my friends because their support, encouragement and knowledge give me strength in completing this final report. Besides, I would like to authority of Universiti Teknikal Malaysia Melaka for providing proper facilities to complete this project. Without the help of the particular that mentioned above, I would face many difficulties while doing this final year's project.

© Universiti Teknikal Malaysia Melaka

ABSTRACT

Nowadays, by increasing prices of oil and gas, global warming effect, can damage the environment and ecosystem. The promising incentives to develop alternative energy resources with high efficiency and low emission are very important. Although many types of large scale energy harvesters have been introduced over the years, but researches show that solar energy harvesting is one of the closest options to meet these considerations. Solar harvesting can be done using various methods in present. Comparison and brief explanation of these various types of high power solar energy harvesters has been presented through this research. Much emphasis has been put on high solar power energy harvesting from 1 MW and above. The technology discussed in this report is based on current progress on researches and available technologies around the world at present. Comparison between concentrating Solar Power with photovoltaic plants has been compared and evaluated. The comparison of concentrating solar power between parabolic trough and power tower also takes a part in this report. The analysis has been done by gathering the related information and data from previous studies, journals from related sites and authorities. The comparisons carried out through this research will help in term of to determine the effectiveness and appropriate use of particular solar energy harvesters incorporate with the given facts to produce optimal output for clean energy generation using solar energy harvesting.

© Universiti Teknikal Malaysia Melaka

ABSTRAK

Pada masa kini, dengan kenaikan harga pasaran minyak dan gas dunia serta kesan pemanasan global yang merosakkan alam sekitar dan ekosistem, inisiatif yang berterusan untuk membangunkan sumber tenaga alternatif dengan kecekapan yang tinggi dan pelepasan gas emisen yang rendah sangat diberi perhatian. Walaupun terdapat pelbagai tenaga alternatif pada masa kini , namun kajian menunjukkan bahawa tenaga solar merupakan salah satu pilihan yang baik untuk memenuhi pertimbangan ini. Penuaian solar boleh dilakukan dengan menggunakan pelbagai kaedah yang terdapat pada masa kini. Perbandingan dan penjelasan mengenai beberapa cara serta kaedah untuk penuai tenaga solar kuasa tinggi telah dibentangkan melalui penyelidikan ini. Penekanan lebih dilakukan terhadap solar berkuasa tinggi dari kapasiti 1 MW dan ke atas. Teknologi yang dibincangkan dalam laporan ini berdasarkan perkembangan semasa melalui penyelidikan dan teknologi yang terdapat di seluruh dunia. Didalam laporan ini, perbandingan diantara kuasa solar tumpuan dengan fotovoltaik telah dibandingkan dan dinilai. Perbandingan kuasa solar tumpuan antara parabola dan menara kuasa juga turut dijalankan dalam laporan ini. Analisis telah dilakukan dengan mengumpul maklumat berkaitan dan data daripada kajian sebelumnya, jurnal, dan pihak yang berkaitan. Melalui perbandingan serta fakta-fakta yang dijalankan melalui penyelidikan ini diharap dapat membantu untuk menentukan keberkesanan dan teknologi solar yang sesuai bagi menuai tenaga solar untuk menghasilkan kuasa yang optimum.

© Universiti Teknikal Malaysia Melaka

TABLE CONTENTS

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

LIST OF TABLES

© Universiti Teknikal Malaysia Melaka

LIST OF FIGURES

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

LIST OF ABBREVIATIONS/SYMBOLS

AC	alternating current
CSP	concentrating solar power
DC	direct current
DNI	direct normal irradiation
DOE	U.S. Department of Energy
EIA	U.S.DOE's Energy Information Administration
EPIA	European Photovoltaic Industry Association
FIT	feed-in tariff
GHI	global horizontal irriadation
GW	gigawatt
GWh	gigawatt-hour
HTF	heat-tranfer fluid
ISCC	integrated colar combined cycle
Kw	kilowatt
kWh	kilowatt-hour
MPPT	maximum power point tracking
MW	megawatt
MWe	megawatt electric
MWh	megawatt-hour
MWp	megawatt peak
NREL	National Renewable Energy Laboratory
PV	photovoltaic
SEGS	Solar Electricity Generating Station
SEIA	Solar Energy Industries Association
TES	thermal energy storage

© Universiti Teknikal Malaysia Melaka

LIST OF APPENDICES

© Universiti Teknikal Malaysia Melaka

CHAPTER 1

INTRODUCTION

1.1 Introduction

Solar energy is the energy coming from the sun. Solar energy becomes more popular now days as a renewable energy to fulfill the demand of power usage due to their environmentally friendly. It produces no greenhouse gases or waste that could cause harm to the environment. In order to expand this renewable energy many countries over the world are doing the research to develop the solar technologies in their countries. There are several types of solar energy depend on the technologies. The most famous solar energy is photovoltaic, solar thermal and concentrating solar power. Photovoltaic is the conversion of light directly into electricity using photovoltaic effect by using a semiconductor. Concentrating Solar Power (CSP) systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Concentrating solar power comes to be a leading method of choice for large capacity, utility-scale electricity generation in the near term.

The aim of this research is to compare concentrating solar power with photovoltaic for high power solar energy harvesting. The comparison focus on the high power solar generation which is the bigger power is produced by the solar during harvesting. This project reveals the history, current status, technologies, performances, area and water consumption of both technologies. Comparison on concentrating solar power between parabolic trough and power tower also takes a part in this research. Detail explanation about the operation, main component, case scenario as well as performance of both technologies has been compared in this report.

© Universiti Teknikal Malaysia Melaka

1.2 Problem Statement

Energy crisis and greenhouse effect are the most common issue we can hear right now. As the result, the temperature is higher than it would be and the ozone layer thinner. The thinner of ozone will effected to the global warming and also affected to the human health. From this issue this research tries to promote and develop renewable sources of energy to encounter the problems to make sure our world is safe. Lack of research and information about high power solar in terms of technology as well as methods is one factor that made it less popular in Malaysia. People do not know and notice of the development of solar harvesting especially concentrating solar power in real life even though it can offer and contributes to encounter energy crisis and greenhouse effect. Therefore more research and project should be done to enable it to grow more rapidly.

1.3 Objectives

There are several objectives of doing this research. The main purpose of this research is to study the comparison between concentrating solar power and photovoltaic for high power solar energy harvesting. The main objectives are:

i. To study and investigate the component involve in solar energy harvesting.
ii. To compare the concentrating solar power with photovoltaic technologies for high power solar energy harvesting.
iii. To analyze the performance on both of the technologies involved in getting energy from solar power

1.4 Scope

The scope of this research only focuses on renewable energy which is solar energy. There are many technologies for harvesting solar energy but this research mainly focuses on photovoltaic, and concentrating solar power in term of high power. This research describes the comparison of history, current status; technologies, an area used, and water consumption of both of the technologies. For

© Universiti Teknikal Malaysia Melaka

comparison on concentrating solar power between parabolic trough and power tower this research describes the comparison of current status, operation, main component, case scenario as well as performance. Finally this project will analyze the performance on both technologies in harvesting solar energy.

© Universiti Teknikal Malaysia Melaka

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter introduces the literature review from the previous study. In this section, the project and research carried out previously will be studied and evaluate by the certain condition of the concepts to gain the ideas and theories as well as to understand the research requirement. The related information consists in this section will be helps for the future research and can be the referring to easy the future task. This chapter covers the literature of component and methods for the harvesting high solar energy besides covering the technology that is used for harvesting low solar power.

2.2 Renewable Energy

Renewable energy is the energy from natural sources and minerals like sun, wind, and tides nuclear and hydroelectric power. Development of various sources of renewable energy is influenced by the effects of environmental, economic, social, political and technical factors. To integrate this new form of generation into the power system network, a new methods and tools of generation technologies have led to the development of a board array. Nowadays by environmentally friendly cause produce no or very small pollution and there is abundant renewable energy available make the renewable energy becomes popular. Besides that, it produces no greenhouse gases or waste that could cause harm to the ecosystem and environment. Renewable energy offers the opportunity to encounter the environmental problem and the many uses to support small as well as large applications.

Electricity and heat are produced by renewable energy from wind, sun and geothermal can use for industrial and home utility appliance. Investing in renewable energy technologies has increased progressively over the decade ago and the analysis

© Universiti Teknikal Malaysia Melaka

estimates that from 2002 until the end of 2009 more than USD 650 billion have been allocated to the green energy market [1]. According to the current rising trend of the fuel prices, especially crude oil in the world market, the Malaysia Government comprehended the potential of renewable energy as a another option to ensure the sustainability of energy resources [2].

Solar renewable energy is the radiant light and heat produces by the sun and converting it into electrical energy, has been used since ancient times using a range of ever-evolving technologies. Solar energy is most constant and predictable of renewable sources as well as drives the global ecosystem [2]. Currently there are 2 different technologies are proposed for capturing solar energy which is photovoltaic and solar concentrating solar power. Environmental impact such as the surrounding air temperature and dust contamination surface of the cell govern the efficiency of PV modules. Meanwhile, the efficiency of concentrating solar power governs by the concentration ratio of the collector as higher temperature give higher conversion efficiency.

2.3 Photovoltaic

Photovoltaic is the one of method for generating electric power by conversion of light directly into electricity using photovoltaic effect and contains a semiconductor element. The solar cell is the vital component of a PV system. The number of cells in a module is governed by the voltage of the module and normally manufacturers make a module which can works with 12 Vdc. In allowing for some over-voltage to charge the battery and to compensate for lower output under standard test conditions (STC), modules usually have 33-36 solar cells in series to produce reliable power.

The series strings of solar cell are connected in parallel to increase the module's output current. The power a module produces at a given moment is proportional the perpendicular sunlight intensity on the module surface. PV arrays can be built ranging from a few mill watts up to several megawatts. Existing arrays can always be expanded to achieve electricity demand. Furthermore, PV modules reduce transmission losses and improve service reliability beside produce electricity at the point of consumption. The

© Universiti Teknikal Malaysia Melaka

modules are connected in series or parallel depending on the desire PV system whether to increase voltage and current.

2.3.1 Photovoltaic Modules

Photovoltaic modules or solar modules produce direct current electrical output power and there are no moving parts as well as no pollutants emitted. PV module normally comes out as a finished product have been electrically connected as well as laminated in the highly durable water proof frame and compiled by several solar cells. The ability of semiconductor to convert electromagnetic radiation directly into electrical energy was called the photovoltaic effect offers an advantage for solar modules. Figure 2.1 shows the photovoltaic modules, there are the basic end use product of the solar industry and construct on different sizes and shape rely on the application. Crystalline silicon is the best material for commercial photovoltaic cell. Silicon is very popular due to it is one of the most material in the Earth's crust and it is nontoxic material. It can be recognized for its familiarity, proven reliability as well as material availability. Silicon-base solar cell technology has gained much from the advances of the microelectronics industry.

There are several types of PV silicon modules but there are three types of commercially available in the market produces by manufacture. Monocrystalline silicon normally bluish black in color is the thin wafer cut from a large single cut crystal of silicon to form the individual cell. This type of cell has good efficiency among the PV modules in the given module area and well-made modules have a proven long life. The efficiency of these cells is around 15-20 % [3] and the surface need to get 1KW in STC is about 7 m^2.

Figure 2.1: Photovoltaic module [3]

© Universiti Teknikal Malaysia Melaka

Polycrystalline silicon is a thin wafer cut from a block of multiple crystal silicon. There are easily recognized by looking to surface color usually blue, but there are other color also this is the most common panels available from arrange of manufacturers. These structures are not as ideals as in the monocrystalline cell so the efficiencies lower, around 11-15 % [3]. Therefore, the manufacturing process to build this cell inexpensive compare than monocrystalline modules. The surface needed to obtain 1KW in STC is about 8 m^2.

Amorphous silicon also called thin film silicon modules is made from an uncrystallized form of silicon and it is the non-crystalline form of the silicon. The silicon is deposited in a thin layer or film on a variety of surfaces, such a glass. This type of modules commonly performs in low light conditions and can recognize in a dark mark color. This module is inexpensive compared to other photovoltaic modules because the manufacturing process is quite simple and easy. The advantages of these modules are looking for their efficiency, the efficiency of these modules quite lower around 6-8 % [3]. They have been used since the 1980s in consumer electronic application such as calculators.

2.3.2 Type of Photovoltaic System

This system can be divided into two groups according to their function and functional requirement, component configuration as well as the equipment is connected to other power sources or type of electrical loads. Stand alone and utility grid connection is the most commonly photovoltaic systems available in current progress.

2.3.2.1 Stand Alone Systems

A standalone system does not have a connection to the electricity utility. Inverter used to convert DC voltage sources into AC voltage sources for conventional household electricity in the particular system. The battery is connected directly in parallel with the DC bus in traditional standalone PV system, therefore its charge and discharge current cannot be controlled. Figure 2.2 shows the proposed standalone PV system. Therefore a bi-directional converter (BDC) needs to be implemented between the DC bus and the battery to charging and discharging current for control purpose [4].

© Universiti Teknikal Malaysia Melaka

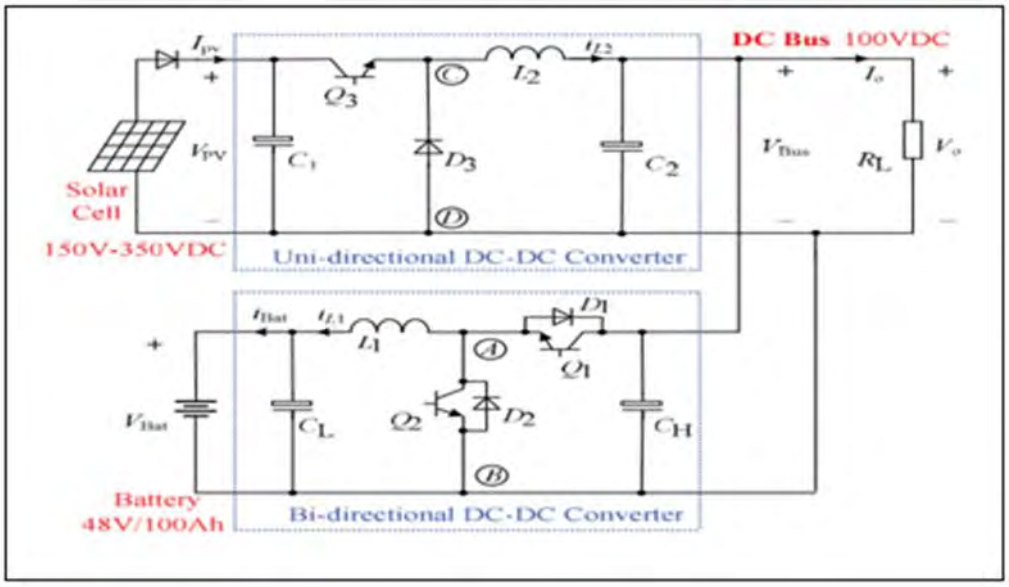

Figure 2.2: Proposed stand-alone PV system [4]

Charging and discharging current of the battery only control by BDC, hence it is the advantages by applying bi-directional and uni-directional DC-DC converter besides the system structure is simple. Power management can be realized by the control of the UDC and BDC, hence the system can work with high efficiency. The working situation of the system commonly divides into 4 operation modes based on the value of the voltage of the solar cell array, the voltage of battery and charging and discharging current of the battery [4].

2.3.2.2 Utility Grid Connection Systems

A grid connected or utility-interactive PV system is design connected to a large independent grid, typically the public electricity grid and feeds power into the grid. In the case of residential or building mounted grid connected PV systems, the electricity demand of the building is met by the PV system. The excessively of the power will be sent back on the grid in the any moment if the PV supplies generated more power than is needed and the potential will span the meter backwards [5]. Figure 2.3 shows the grid connected systems of photovoltaic. Only the excess is fed into the grid when there is an excess. Special grid-controlled solar inverter is required to be fed electricity into the grid by transformation of DC into AC sources. String of PV modules may be tight into inverter in a manner analogous to the individual inverter for large grid connection systems [5].

© Universiti Teknikal Malaysia Melaka