Sudan University of Science & Technolgy

College of engineering

Electrical engineering

Design and Fabricate of Solar Thermal Tracker Using Fresnel Lens

تصميم وتصنيع متتبع للطاقة الشمسية الحرارية باستخدام عدسة فرينسيل

A Project Submitted in Partial Fulfillment for the Requirements of the Degree of B.Sc. (Honor) In Electrical Engineering

Prepared By:

1-Abubakr Mohamed Ahmed HamdElnil

2-Amna AbdAlbagi Mohamed Ahmed

3-Mohamed Shaaeldeen Ibrahim FdlAllaa

4-Rofida Ibrahim Babeker Alhadi

Supervised By:

Dr.A.A.A.AbuElnuor

October 2017

بِسْمِ اللهِ الرَّحْمنِ الرَّحِيمِ

الآيـــــة

قال تعالي :

{ وَالشَّمْسُ تَجْرِي لِمُسْتَقَرٍّ لَّهَا ذَلِكَ تَقْدِيرُ الْعَزِيزِ الْعَلِيمِ}

صدق الله العظيم

سوره يس الايه 38

DEDICATION:

"Success or failure is own decisions"

Every challenging work needs self-efforts as well as guidance of elders especially those who were very close to our heart.

We dedicate our humble effort to our "Family and Friends" whose affection, love, encouragement and pray all day and night make us able to get such success and honor.

Along with all hard working and respected Teacher.

ACKNOWLEDGE:

Much of this work would have been impossible without the support and help of Allah, then our families and Teachers.

We would first like to single out our supervisor Dr. A.A.A. AbuElnuor for his excellent cooperation and for all of the support and opportunities we were given in Energy field and to conduct our research and further our thesis.

Particularly we would like to thank our teachers of school of Electrical Engineering (SUST) for their wonderful Collaboration. They supported us greatly and always willing to help us, we are privileged to know them.

In addition, we would like to thank Eng. Mohamed Ali AbuElnour and Eng. Ahmed Farah

ABSTRACT:

The sun is the source of life of the earth if otherwise it did not find life in its present form on the surface of our planet, has realized since ancient times the importance of the sun in his life and spare no effort to study the movement, which has recently led to the promotion of research movements in the fields of solar energy and take advantage of the sections of photovoltaic and thermal In this research, the emphasis was on the design of solar energy and the utilization of solar thermal energy in the conversion of water to vapor by collecting the rays in the lens and focus in the water tank.

المستخلص:

الشمس هى مصدر حياه الارض اذا لولاها لما وجدت الحياه بشكلها الحالى على سطح كوكبنا وقد ادرك الانسان منذ القدم اهميه الشمس فى حياته ولم يدخر وسعا فى ان يدرس حركتها الامر الذى ادى موخرا الى تعزيز حركات بحثيه في مجالات تتبع الطاقه الشمسيه والاستفاده منها بقسميها الضوئيه والحراريه.فى هذا البحث تم التركيز على تصميم متبع للطاقه الشمسيه والاستفاده من الطاقه الشمسيه الحراريه فى تحويل الماء الى بخار عن طريق تجميع الاشعه فى عدسه وتركيزها في خزان الماء.

TABLE OF CONTAINTS

LIST OF FIGURES

LIST O F ABBREVIATIONS

GHGs	Green house gases
CO2	Carbon dioxide gas
KWh	Kilowatt hours
MW	Megawatt
MSW	Municipal solid waste
Nm	Nanometer
UV	Radiation above violet
PV	Photovoltaic
CSP	Concentrated solar power
DC	Direct current
VCC	Collector supply voltage
SRAM	*Static random-access memory*
EEPROM	Electrical Erasable Programmable Read Only Memory
PWM	Pulse Width Modulation
LDR	Light Depended Resistor

CHAPTER ONE
INTRODUCION

1.1 Overview

Fossil resources such as coal, natural gas, and oil are dating the backbone of the globalized world providing energy for mobility, manufacturing, agriculture, transportation, communication, and living. Today, most of the investigations all over the world focus on increasing combustion performance by conserving energy.

The amount of solar energy reaching the surface of the planet is so vast that in one year it is about twice as much as ever be obtained from all of the Earth's nonrenewable resources of coal, oil, natural gas, and mined uranium combined [1].

The sun is one of the principal sources of renewable energy. Solar energy is basically the direct conversion of sun's energy into electrical power with the use of solar panels and collectors[2].

Solar energy is heavily reliant on power known as nuclear fusion that is generated from the sun's core. The energy obtained from the sun is gathered and the conversion into electricity can be done in diverse ways such as the use of solar collectors to heat water and the use of solar attic fans to cool the attic for domestic purposes [2].

Solar systems use concentrated lenses or mirrors to focus a large part of the sunlight or solar thermal on a small area and then turn the center light to heat to evaporate the water to operate a steam turbine to operate a generator to produce electricity[3].

1.2 Problem Statement

Current research and development in the field of energy wasfocused toimprovements in energyefficiency and reduction of emissions. Today the Renewable and alternative energies has been highlighted by the researcher and industrial societies. There are many energies of renewable are suitable in Sudan such as solar, due to the location in the areas in tropical and sub-tropical regions. These areas receive a high remount of solar radiations throughout the whole year. For this reason these regions have a significant potential to harness solar energy for their electricity requirements. These studies showed generate electricity from solar energy using lab scale.

1.3 Project Objectives

The main objectives of this study are:

- To design and fabricate solar tracing system.
- To experimentally investigate the convert the water to steam to generate the electricity using solar energy.
- To solve the problem of energy crisis.

1.4 Methodology

To achieve research project the following methodology is used: Designed and gathered, after that they were fabricated and tested, then the experiment of solar thermal was done to produce steam turbine by concentrated solar system and boiler.

1.5 Project Layout

This project is presented in five chapters. The scope of each chapter is explained as follows: Chapter one gives an introduction including general concepts, problem statement, objectives and methodology .Chapter two presents renewableenergy, types of renewable energy, solar energy, type of solar energy, solar thermal energy and type of collector thermal. Chapter three introduces the solar tracking system and control system its benefits. Chapter four includes final model design of solar tracking system. Chapter five contains the conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The study also showed that renewable energy, despite the diversity of its sources and its spread in various regions of the world, has not yet been exploited on a large scale, contributing only about 10%[4].

Thus, solving the problem can be done in the following points:

- Rationalize the consumption of fossil fuel resources and reduce the use of nuclear energy because of its very dangerous environmental returns.
- Direct energy investments towards the development of renewable and clean alternatives to form the basis of the high energy structure of the 21st century to solve the growing problem of undesirable non-renewable energy sources on the one hand and eliminate the pollution risks of expanding the use of this energy through polluted renewable[5].

2.2 Energy

Energy is the basis of everything in this life, it is the basis of movement, and movement from place to place, and used in the construction of the human body and development, even the processes of energy production in need of energy, and the energy in the globe, the forms are many and their uses multiple, With the naked eye, including what can be felt, including what is hidden, Glory to God of creation[6].

2.2.1Conventional energy

A non-renewable resource (also called a finite resource) is a resource that does not renew itself at a sufficient rate for sustainable economic extraction in meaningful human time-frames. An example is carbon-based, organically-derived fuel. The original organic material, with the aid of heat and pressure, becomes a fuel such as oil or gas. Earthminerals and metalores, fossil fuels (coal, petroleum, natural gas) and groundwater in certain aquifers are all considered non-renewable resources, though individual elements are almost always conserved[7,8].

2.2.1.1Oilandgas

Black gold is made up of organic matter that is caused by a combination of carbon and hydrogen under temperature And can produce a lot of energy sources of oil such as gasoline, kerosene and diesel, which is characterized by high flammability, which produces high thermal energy, and uses oil derivatives in the manufacture of industrial plastics and clothing as well[9].

2.2.1.2 Coal

Black blocks made up mainly of the carbon element, found in the lower layers of the earth. It is flammable and has been used to transport trains in the middle Ages, but is polluted to the environment by the gases emitted by the combustion process. Natural gas: consists of the decomposition of organic waste, and can be produced from leaving food and natural waste and animal faces in the room closed for a long time, is composed of flammable methane, and cooking gas used in homes after the passage of methane gas several processes of purification and separation[10].

2.2.2Alternative energy

Nuclear energy is the energy generated by controlling the reactions of fission or fusion of the atom. This power is used in nuclear power plants, where water is heated to produce water vapor, which is then used to move turbines to produce electricity. In 2009, the proportion of electricity produced from nuclear power accounted for 13-14% of the total electricity produced worldwide. More than 150 nuclear-powered submarines are now operating[11].

Scientists see nuclear power as an inexhaustible source of energy. What is controversial about the future of nuclear power is the high costs of building reactors, public safety concerns, and the difficulty of safe disposal of high-radiation waste[11].

2.2.3 Renewable energy

Renewable energy can be defined initially as any energy source that is derived directly or indirectly from solar energy. In the broadest sense, however, almost all of the energy we use today, including fossil fuels, can be considered a form of solar energy. The most familiar forms of energy, such as wood, oil, gas, and coal, are embodied forms of solar energy gathered, stored, and transformed by natural processes.

Climate change due to emissions of GHGs, particularly CO2, becomes an issue when stored solar energy is converted to useable forms of energy (heat, electricity, fuels, chemicals) at a rate far exceeding the rate of formation. For coal, oil, and natural gas, the ratio of time between formation and use is on the order of 1 million to one: that is, the world uses in one year what took natural processes one million years to create. Only biomass among these stored forms has a time ratio that is within a human time frame of years or decades. Renewable energy can now be defined as forms of solar energy that are available and replenished in time scales no longer than human lifetimes. It is the energy that is not implemented over time, and is characterized by its abundance and non-pollution of the environment, and can be exploited in several forms, including[12]:

2.2.3.1 Wind energy

Wind technologies convert the energy of moving air masses at the earth's surface to rotating shaft power that can be directly used for mechanical energy needs especial used in milling or water pumping, also converted to electric power in a generator. Two major types of turbines exist and are defined based on the axis of blade rotation: horizontal-axis (which currently dominate commercial markets) and vertical-axis turbines.

Wind energy has proven the most cost-competitive renewable electricity technology for the bulk power market to date. however, its use is also very appropriate to remote and distributed applications[13].

2.2.3.2Hydro power

The kinetic energy generated by the movement of water from one place to another, such as rivers, dams and sea waves. Special turbines generate kinetic energy to produce electricity, or use kinetic energy caused by water to move from place to place using ships and sailboats.

Hydropower facilities exploit the kinetic energy in flowing or falling water to generate electricity. Conventional hydropower facilities use water from a river, stream, canal, or reservoir to continually produce electrical energy, and water releases from single-purpose reservoirs (dedicated to power production) can be quickly adjusted to match electricity loads Multipurpose reservoirs are not capable of following load Pumped storage plants operate similarly, but instead of tapping free flowing water, the facility uses recycled water. During off-peak hours, water is pumped to an upper reservoir using low-cost resources, where it can be re-used to provide peak power on demand. Pumped hydropower facilities are net energy consumers (typically 1.25-1.40 kWh is required to pump the water to the upper reservoir for each kWh generated); however, they provide significant economic and operational benefits to utilities because of their ability to meet transient peak power demands.

Finally, mini-hydro facilities (30 MW or less in size) offer opportunities for distributed or remote power generation with minor environmental impacts, low operating costs, and high reliability. Installation of these systems is usually quite rapid and can use local labor[13].

2.2.3.3Geothermal energy

Geothermal energy systems tap the heat originating from the earth's molten interior and the decay of radioactive materials in the crust. The potential size of the resource is very large although conversion technologies for fully accessing the estimated 100 million quads of available worldwide resource are yet to be proven. Geothermal energy is currently being used in various locations around the world to produce electricity at costs competitive with conventional sources and provide energy directly for space heating, food and industrial processing, refrigeration, and aquaculture[13].

2.2.3.4 Biomass energy

Biomass energy is a term that includes all energy materials derived from biological sources, including wood wastes, agricultural residues, food industry wastes, sewage, municipal solid waste (MSW), and dedicated herbaceous or woody energy crops. The potential size of the biomass resource is quite large on a global scale, and the ability to utilize existing residue streams that may provide low-cost feed stocks offers attractive near-term opportunities for biomass use. In the longer term, the development of sustainable, dedicated biomass energy plantations may further expand the resource base and help reduce the costs of energy produced from biomass[13,30].

2.2.3.5 Solar energy

People are always looking for new sources of energy to cover their growing needs in the applications of the advanced life we live in and the damage of many sources of energy depletion and high cost of exploitation and the negative impact of its use on the area has been alerted in modern times to the possibility of taking advantage of the heat of the sun, which is classified as renewable energy and permanent In the interior of the sun, there are nuclear fusion reactions in which hydrogen nuclei merge into helium.

Solar technologies use the sun's energy directly to generate energy for industrial processes, buildings, and transportation as well as electricity for general consumption in all three of these end-use sectors. Given the large size of the solar resource, these technologies are not constrained by feedstock requirements but rather by costs and "institutional" obstacles such as performance (e.g. intermittent operation), perceived risks[13].

❖ Solar Spectrum:

Sunlight, solar radiation, or sunlight is a sum of electromagnetic waves. Person can see a part of it called a visible light and its rest is not visible to the naked eye. The visible rays of the sun's spectrum are made up of colored rays from red to violet, which are rainbow colors. Red waves have a wavelength of 700 nm and short-wavelength violet waves and a wavelength of 400 nm. Two parts of the spectrum of the sun are not visible to the naked eye: as in the figure the part has a wave longer than 700 nm (up to about 2700 nm) This is the infrared range, the other part has wavelengths less than 400 nm (left in the spectrum graph) , Which is called ultraviolet range[15].

Solar radiation carries energy and its energy varies depending on the length of its wavelength. Greater the wave of light, the lower its energy. This means that ultraviolet radiation is relatively high, and therefore harmful to human skin if exposed to it long[16].

The sun shines on the ground after passing through the earth's atmosphere. The Earth's atmosphere absorbs some of them and does not reach us. The figure shows the parts of the spectrum that reach the surface of the Earth (brown in shape). Different gases in the atmosphere, such as nitrogen, oxygen, carbon dioxide, water vapor, etc., have different capacities to absorb sunlight[16].

Direct sunlight may be efficiently illuminated by 93 lumens radiant per watt of flow, which includes infrared, visible light, and ultraviolet radiation. The average solar power per square meter of the Earth's surface this is called the solar constant[17].

❖ Solar Constant:

The solar constant defines the amount of energy falling in the unit of time On a unit of space perpendicular to the solar beam and located on the surface of the casing The atmosphere around the globe. The solar constant is particularly important in solar applications So it does not actually get the amount of energy from the sun higher than The value of the solar constant 'and for the amount of energy that reaches the earth Less than the solar constant value due to the reflection of a section of solar radiation or Absorbs while passing through the atmosphere[18, 19].

2.3Types of Radiation

Scientists distinguish three types of radiation that make up solar radiation, including:

Thermal radiation: or infrared radiation is not visible and is estimated to be about 50% of the total solar radiation. Its wavelength ranges from 0.75 to 4.0 microns (1/1000 millimeters) and plays an important role in the whole activity.

Visible light: the sun's rays and called visible light, for example, penetrate the cosmic space without seeing it, but illuminate the transparent physical medium, which is scattered like our atmosphere, or reflected like the surface of the moon, dispersion or scattering is the secret in lighting the atmosphere in daylight, Analysis of the light with a glass sheet to its basic components and estimate the proportion of rays (37.3% of the total solar radiation). Its wavelength ranges from 0.40 to 0.74 microns and the intensity of the light rays on the surface of the earth increases in the afternoon during the day in the summer.

UV rays are (13%) of the total solar radiation and its wavelength varies[17].

2.4 Types of Solar Energy

Many techniques are used to gain the desired solar energy. The photovoltaic cells and solar thermal electricity.

2.4.1 Photovoltaic (PV) cells

A photovoltaic solar cell is generally a device used in the direct conversion of light energy into electricity with the aid of semi-conductors of electricity that unveil a photoelectric impact. Characteristic system of a photovoltaic utilizes solar panels, each made up of various solar cells that generate electricity.

The installations of photovoltaic cells can be mounted on the rooftop, ground or the wall of buildings. The mounting can be done through fixation or simply through the employment of a solar tracker that follows the direction of the sun. No form of pollution is produced into the environment with the use of solar photovoltaic cells as there are no moving parts[20].

2.4.2 Solar thermal electricity

Solar thermal power system collects and concentrates sun energy to generate high temperature heat that is necessary to create electrical power. The system contains two main devices reflectors and receivers [21].

Reflector is basically utilized in capturing and focusing the sunlight into a given receiver. There is also a heat transfer fluid which is put under heat and then distributed in the receiver for the purpose of producing steam. The steam is later transformed into mechanical energy with the aid of turbines that power generators to create electricity as it is shown in Figure 3.13. It is important to note that there exists a tracking system that basically focuses the sun energy onto the receiver during the day, keeping in mind the changes in the position of the sun. A storage system known as thermal energy can also be utilized to store excess energy during hot days so as to be used during the night or cloudy days[22].

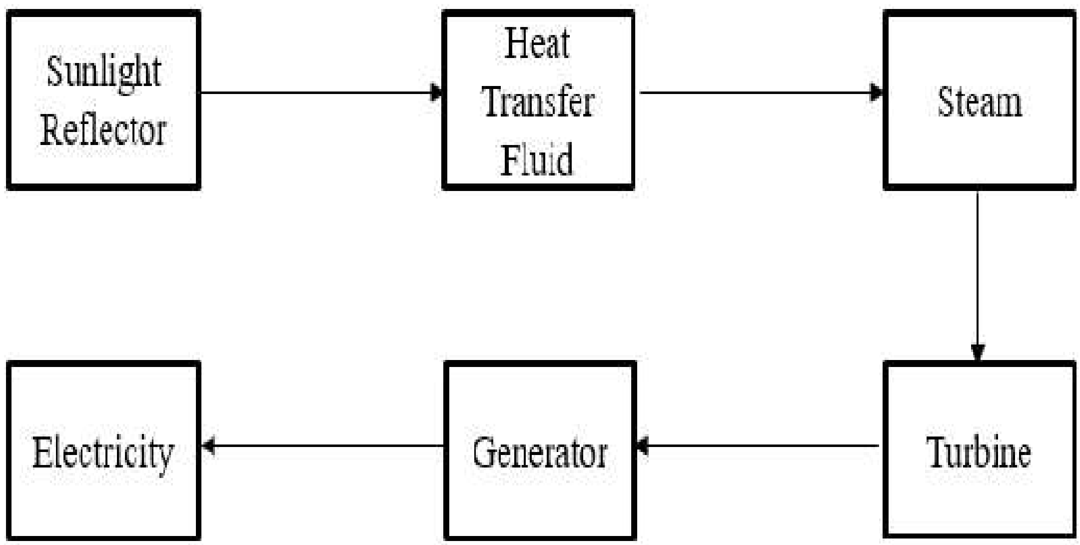


Figure 2.1: Solar thermal electricity system[22]

2.5 Types of Solar Thermal Energy

2.5.1Linear concentrating system

This type of system collects the sun energy with the aid of U-shaped, curved, rectangular and long mirrors. Inside the mirror there is a long tube/receiver that covers the entire length of the mirror and onto which the sunlight is focused. The concentrated sun energy heats a fluid that is freely flowing inside the tubes.

The fluid is later transported to a designed heat exchanger for purposes of boiling water in a modern-day steam-turbine generator. The end result of all this is the production of electricity [21].

The shape of the system allows the mirrors to follow the movement of the sun in all directions through the entire day and concentrate the sun energy continuously onto the tubes. Its large field of collectors positioned in parallel rows allows for the maximization of the energy collected from the sun.

The linear concentrating system can either be a parabolic trough or a linear Fresnel reflector.

The former is characterized by the positioning of the tubes along the focal line of each and every parabolic mirror.

On the other hand, the latter has one tube located above a number of mirrors to create room for the mirrors to easily move in tracking the movements of the sun throughout the day[25].

2.5.2Parabolic trough

A parabolic trough is composed of a huge parabolic-shaped tube whose main purpose is to focus the rays of the sun onto a given receiver pipe that is strategically positioned at the parabola’s focus [21]. To ensure that the sun is continuous being focused, the trough tilts its angle with the change in direction of the sun. Figure 2.2 shows a parabolic trough. Its configuration allows to focus the rays of the sun 30 times above its normal levels of intensity.

Hence, its temperatures of operation are estimated to be 750°F or higher. All this occurs inside the receiver tube that is stationed along the trough’s focal line.

This type of system is the largest in the world and is utilized in California's Solar Energy Generating System that was constructed in 1984.

The system is also in use in three other large thermal power systems as follows: California Mojave solar project, Arizona Solana generating station, and California genesis solar energy project[21, 23].

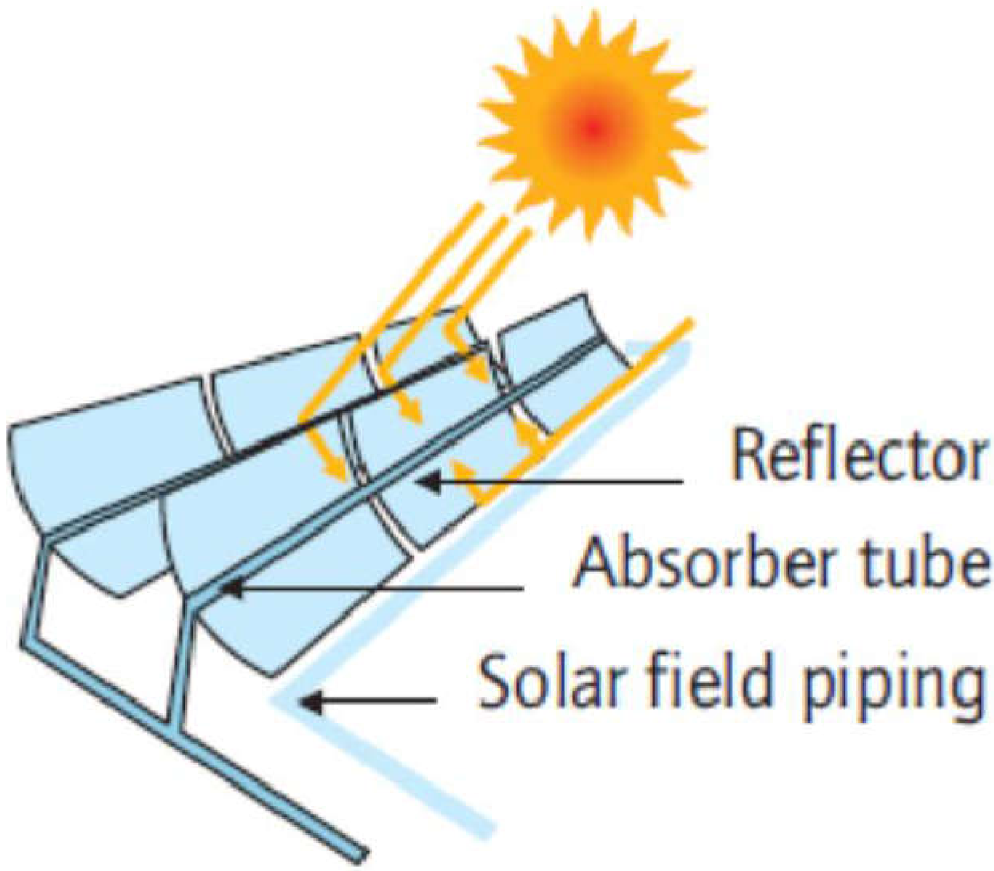


Figure 2.2: Parabolic trough [21]

2.5.3Linear Fresnel reflector system

A linear Fresnel reflector system is more or less similar to the parabolic trough system. It has reflectors that focus the rays of the sun onto a certain receiver that is positioned on top of the reflectors as shown in Figure 2.3. The reflectors utilize the Fresnel lens impact. Such an effect allows for a focused reflector containing a huge aperture and diminutive focal length. The system has the capacity to concentrate the rays of the sun at least up to 30 times their normal power. The numerous receivers contained in the system make it possible to alter the inclination of the mirror in order to reduce their possibility of blocking access to sun rays by the neighboring reflectors. As a result, it enhances the efficiency of the system and decreases both the costs and requirements of the materials that are used[24].

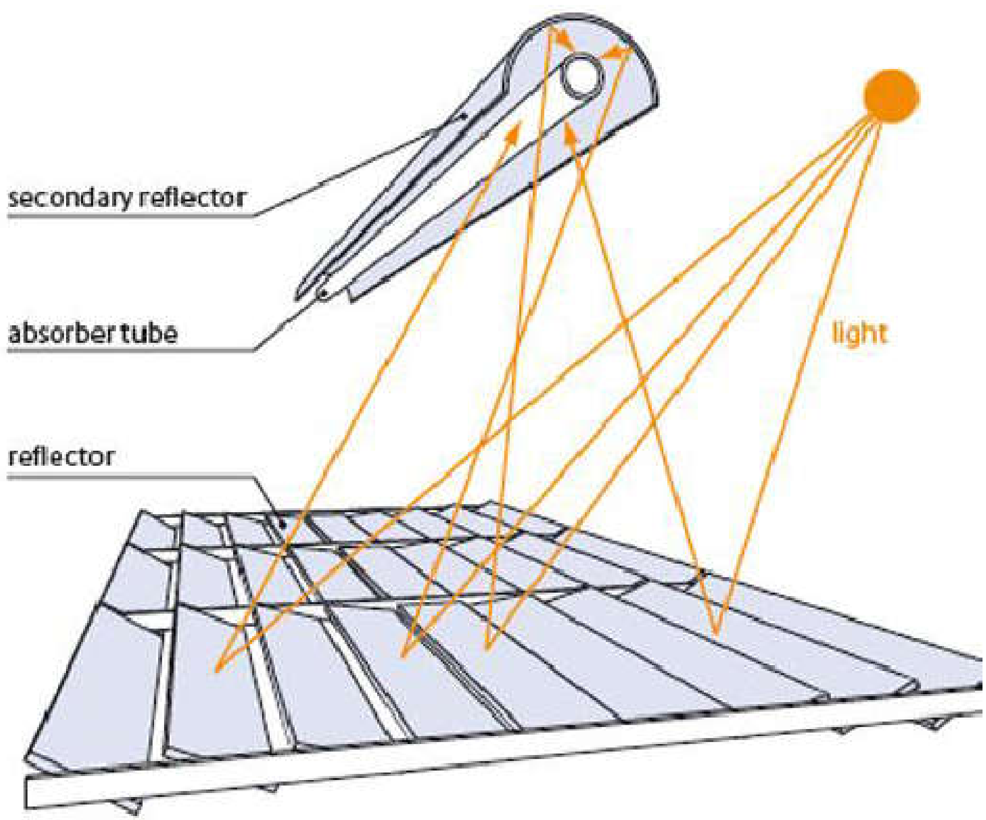


Figure 2.3: Linear Fresnel reflector [24]

2.5.4Solar power tower

The solar power tower has a huge field composed of flat mirrors that track the sun and are known as heliostats. Reflection and concentration of the sunrays onto the receiver is done by the mirrors on the tower's apex. The solar power tower is shown in Figure 2.3. Water is the main element that is used in the heat-transfer fluid. However, molten nitrate salt can be also used due to its superior modes of transferring the energy and its large capacity to store the energy generated.

In the United States, the following solar power towers are currently in use: Ivanpah solar, Power facility, Crescent Dunes solar energy project, and Sierra sun tower [21, 24].

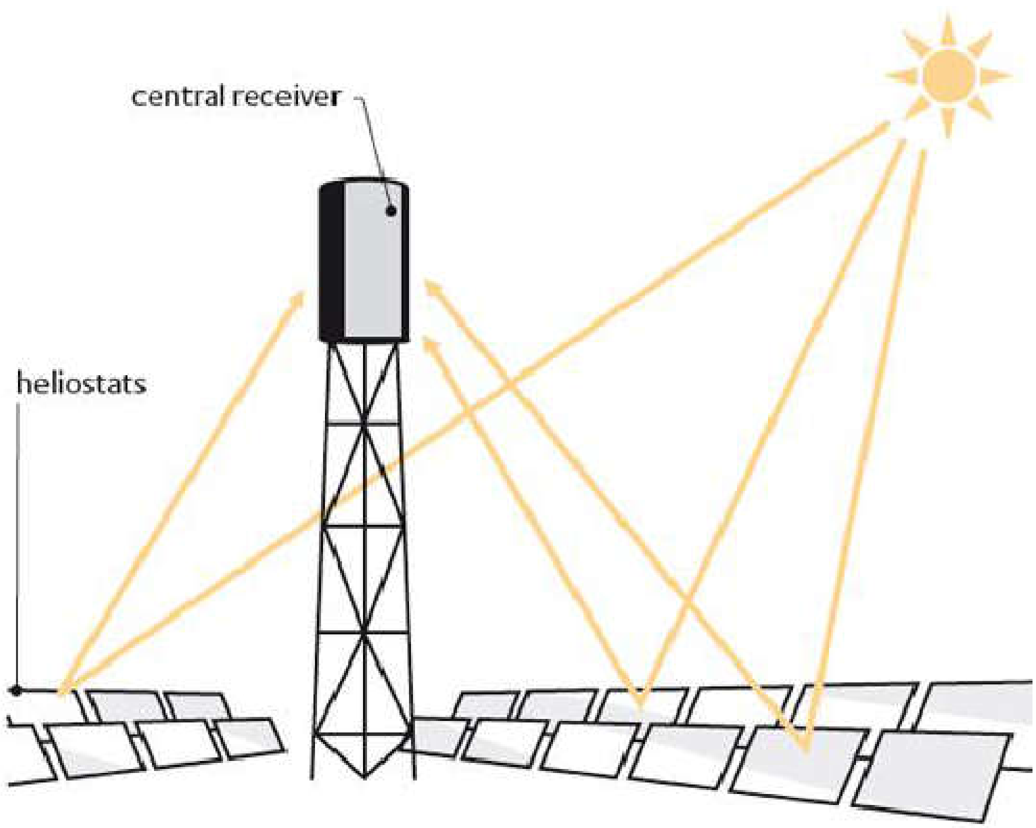


Figure2.4: Solar power tower [24]

2.5.5Solar dish system

The solar dish system resembles a huge satellite dish. It is composed of a number of minute flat mirrors that are shaped into a dish in order to decrease the costs that are incurred [23]. The surface of the dish directs and focuses the sunrays onto a receiver that absorbs and accumulates the heat as shown in Figure 2.4. It later transports the heat into an engine generator.

The fluid inside the receiver is heated to allow for the movement of the pistons and hence, generate mechanical power. The power is used in running a generator and ultimately generating electricity.

A solar dish system is endowed with the capacity of pointing directly to the sun. The solar energy is then concentrated at the central point of the dish. It is estimated that its fluid temperature is approximately 1,380°F. It has a concentration ratio that is much higher as compared to concentrating systems that are made in a linear manner[25].

The dish can be easily used in remote areas due to the ability to mount the power-generating device of dish at the focal point. It is also possible to gather energy from various points so as to convert it into electrical power[23].

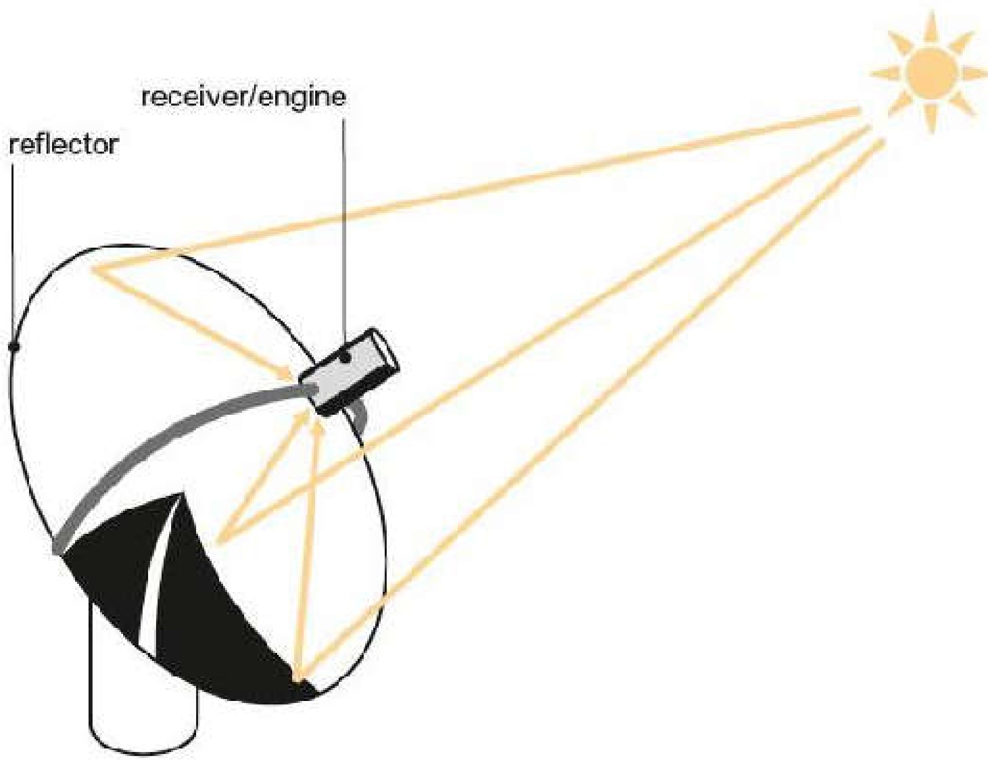


Figure 2.5: Solar dish [23]

2.6 Applications of Solar Energy

There are various applications of solar energy since it is freely available with low damage to environment. Solar energy is now applied for heating of buildings, cooling of buildings, heat generation for industries, food refrigeration, heating of water, distillation, drying, cooking, power generation and other various processes[26].

2.6.1 Roof mounted PV-systems for building integration

Building integrated photovoltaic (BIPVs) are now becoming popular to households in areas where no grid is set for electricity supply.

Arrays of PV panels are mounted on roof or walls of buildings. Solar energy generated at the same premises can also be fed into the system as surplus energy is produced. This is the cheapest and promising technology for better house hold electricity consumption.

2.6.2 Irrigation for agricultural crops

Solar energy is now used in various parts of the world to irrigate field crops cost effectively and in areas where no electrical grid is available. An electrical motor can be driven by microprocessor controlled solar energy system with storage energy to operate either drip or sprinkler irrigation systems for better water utilization efficiencies.

Discharge rate and irrigation interval can be calculated by assessing crop water requirement.

3.6.3 Heating and cooling

Solar water heating and air heating are very popular nowadays for better production. Many researchers are done to improve solar heating and cooling systems. Flat plate and evacuated tube solar heating and cooling systems are now commonly used with an intention of facilitating commercial and residential sectors, water and air heating systems [32].

Many agricultural producers are stored at very low temperature to avoid unwanted damages to produces and thus to increase their shelf life. Reducing temperature of a store using electricity, according to its cooling load, is expensive and complex. However, incorporation of solar photovoltaic technology would improve this system for better capacity. Solar thermal refrigerators are now becoming popular in agricultural sector, which are divided into sorption refrigerators, and solar thermal mechanical refrigerators with specific configurations. Many researches are being undertaken by many researchers in this sector[24].

2.6.4 Solar energy for drying

Moisture content present in the agricultural producers leads to microbial spoilage of such items. It is therefore important to remove free water available in such produces with an intention of avoiding activities of spoilage organisms.

Many drying systems are available for crop drying. However, artificial dryers are not economically feasible. Many people in remote areas therefore use open solar drying long years ago. Hygienic nature of such system is still in question. Introduction of PV technology in this regard is now promising to design solar driven artificial dryers for better operations[26].

2.6.5 Solar energy for green houses

Green house is a structure commonly used in agriculture to grow plants with intensive care for better production. Solar energy is now used prominently to heat green house and therefore such system is labeled as solar green house where solar energy is used for both heating and lighting. The system is well to retain heat during night and cloudy day[26].

2.7 Solar Thermal Electric

Solar thermal technologies collect the sun's radiant energy to create a high-temperature heat source that can be converted into electricity via a number of thermodynamic conversion cycles. Parabolic trough technologies employ a field of parabolic ally shaped solar collectors that focus the sun's energy onto specially-coated metal pipes surrounded by glass tubes containing a heat transfer fluid (such as synthetic oil). Parabolic dish systems use a modular mirror system that approximates a parabola and creates a high-energy flux at the focal point where an external combustion sterling engine converts the heat into electricity [33].

Central receivers use a large field of sun-tracking mirrors (heliostats) that reflect the incident radiation onto a tower-mounted thermal receiver. Finally, solar pond systems collect and store solar energy in a liquid medium (usually a large basin of water with a salt gradient to suppress heat loss), which can then be converted to electricity using a closed ranking cycle engine[13, 27].

2.7.1 Solar thermal station:

Solar thermal plant are stations that exploit the heat generated by solar radiation and fall on the ground ingenerated electricity. Solar thermal power plants are also called concentrated solar power (CSP).

Counter to solar panels known as photovoltaic panels which use the light falling on the ground from the sun to generate electric voltage lead on electrical current solar thermal station are exploiting the heat to evaporate water vapor energy to manage turbines which in turn generate electricity[28].

2.8 Current on Studies in Solar Energy:

Solar energy is the clean energy that will attract the attention of the world soon and quickly, because of the end of the age of oil and the availability of renewable sources of renewable energy that will save a lot of humanity, but if you love the good and development and sustainability of the environment will be interested in this energy from now and how we can develop better use, The solar belt states have begun to plan and build huge photovoltaic or concentrated thermal solar plants. For CSP, they use reflective mirrors to generate the necessary electrical energy, Solar photovoltaic (PV) cells are the most adaptive in the solar belt region; because semiconductor photovoltaic solar cells are up to 12% efficient and less heat-efficient, they cannot dissipate their internal temperatures better. Recently, several types of complexes have emerged, such as DYE-SENSITIZED solar cells and new AUKESTERITE photovoltaic cells, which will threaten the two previous types, because they have many advantages that make them the best in this field [35] .

Ivanpah station in California is produced power by solar towers. The mirrors focus sunlight on the tower, turning the water into vapor that drives the turbine to produce electricity, the plant also operates natural gas to produce energy at night and this plant represents the largest generator of solar power in the world [35].

Figure2.6: the world's largest solar power plant [35]

One of the stations used by the solar collectors is NOOR Station. It is composed of solar panels with a bonus cut (number of mirrors). Each concave mirror passes through a pipeline that contains oil passing through a thermal engine. This oil rises to its temperature until the water turns to steam and then rotates the turbine by evaporation steam Water is produced by electricity and the advantages of this plant have the ability to be stored by salts [35].

Figure2.7: NOOR station [35]

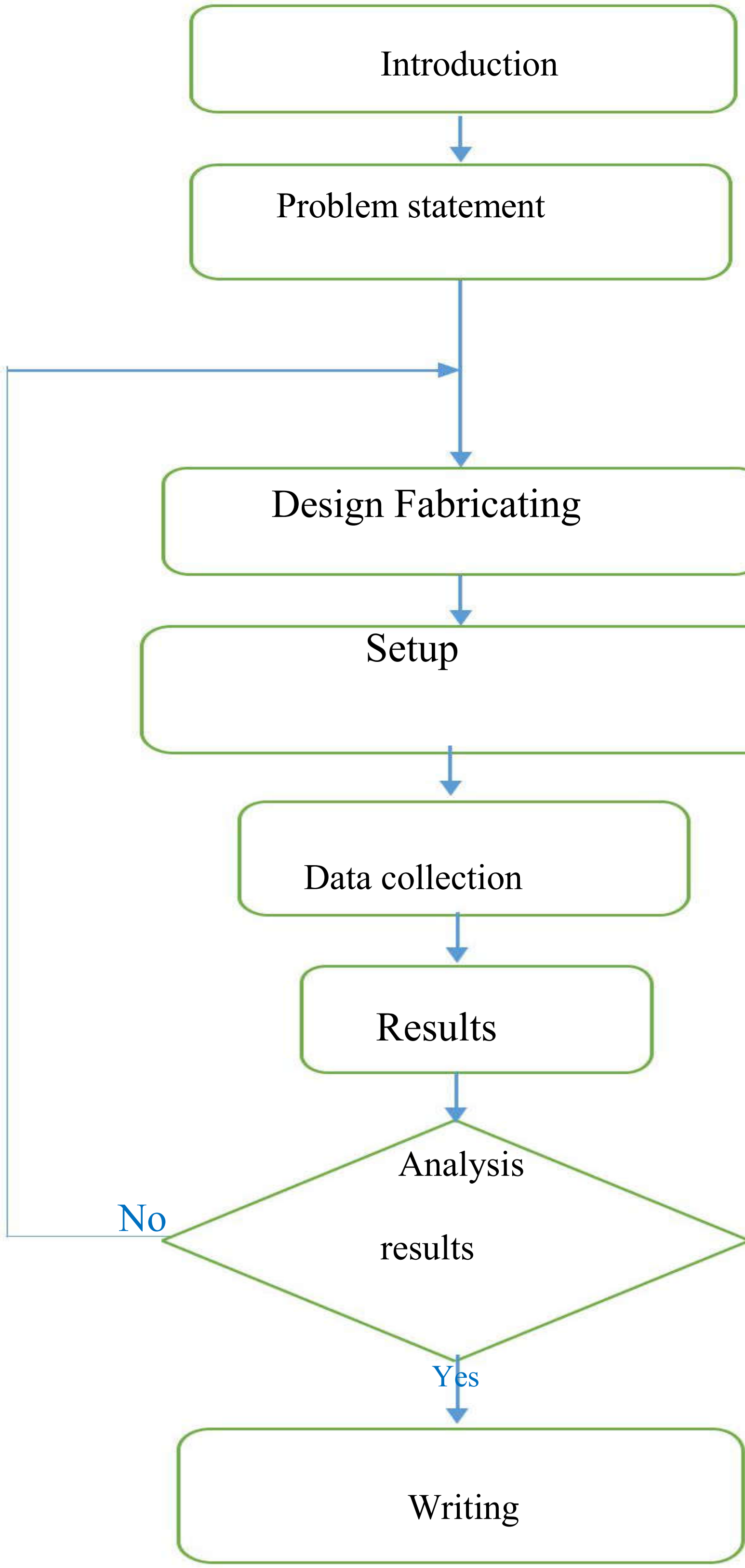
CHAPTER THREE

METHODOLOGY

3.1 Introduction

In this chapter the equipment and tools were modeled, designed and gathered, after that they were fabricated and tested, then the experiment of solar thermal was done to produce steam turbine by concentrated solar system and boiler.

3.2 Flow Chart



3.3 Solar Tower Systems

Solar tracking system sets either a solar panel (photovoltaic) or a concentrating solar reflector towards the Sun while tracking the position of the sun. It gained importance mainly because the source of solar energy is free to provide us electricity and heat. Furthermore, it can improve the energy efficiency of any solar power systems and saves a lot of money in the long run despite the additional setup cost and more complex system.

Several factors affecting a solar tracking system are the natural climatic condition of the place where the system is to be used, the load of the system, the placement of the system, the availability of the solar tracking of the chosen system. Many research works laid the design's foundation based on the factors mentioned before with different total accuracy achievement but with similar drawbacks such as increased cost and complex systems.

Generally, solar tracking systems are still expensive and inaccessible for the common consumers or domestic applications, therefore the cost and complexity of the system must be reduced without compromising the total efficiency. On top of that, a good solar tracking system must be able to produce high power output while setting the solar panel based on the changes of the Sun position and consuming a small fraction of the power output[36, 37].

In solar tower systems numerous large, flat, sun-tracking mirrors, known as heliostats, focus sunlight onto a receiver at the top of a tall tower [38]. Heat-transfer fluid heated in the receiver is used to generate steam and then converted to electrical energy using steam turbine [39].

3.4 Fresnel Lens System

It is a Piece of plastic in order to create annular rings of a flat body. Each ring is slightly thinner than the next and focuses the light toward the center. The Fresnel lens properties were studied in references [40-43]. This solar concentrator expected to acquire a higher thermal efficiency at high temperature level than those non concentrating collectors and can be used for solar thermal power generation or solar cooling [44, 45].

3.4.1 Fresnel lens

Fresnel lens with high efficiency of transparency for solar radiation was used and it must track the sun to get high efficiency and power supply.

Figure 3.1: Fresnel lens

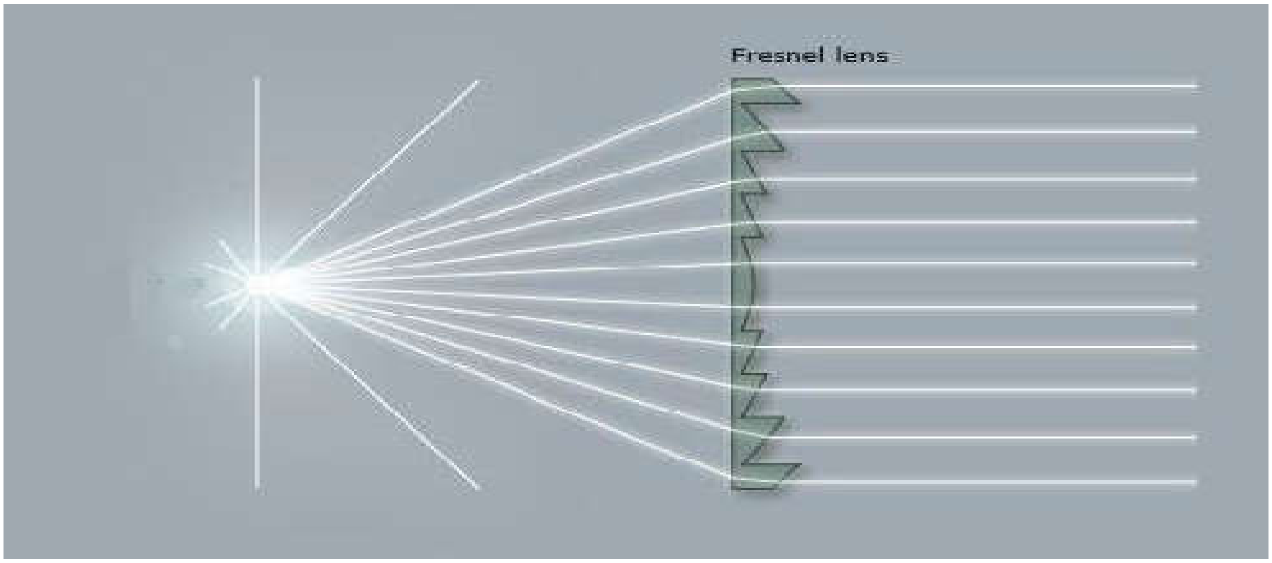


Figure 3.2: The angle of each ring's angled face will be different [46].

3.5 Tracking System

The use of a highly portable, efficient solar energy system with solar tracker can be very useful as a viable source of renewable energy over the past two or three decades to applications of the military, industrial, or residential variety [47]. The output power produced by high-concentration solar thermal and photovoltaic systems is directly related to the amount of solar energy acquired by the system, and it is therefore necessary to track the sun's position with a high degree of accuracy [48].

To adjust the Fresnel lens with sun it must place in two axes. A Dual-Axis Solar Tracker that designed and built by "ECO-WORTHY Company" was used. It uses linear actuator to make the displacement in axes.

3.6 Component of Tracking System

The equipment's were used to control of tracking system:

- Motor actuator.
- Sensor LDR.
- Relayboard.
- Controller device.
- Power supply.

3.6.1Controller device:

The received signals from sensors converted to digital signals in rang of binary numbers from 0 to 1023 and processed by operations depend on code witch written by programmer to get specific according to system needs. All these functions can be done by one control system called ARDUINO UNO microcontroller and here are some definition about ARDUINO UNO:

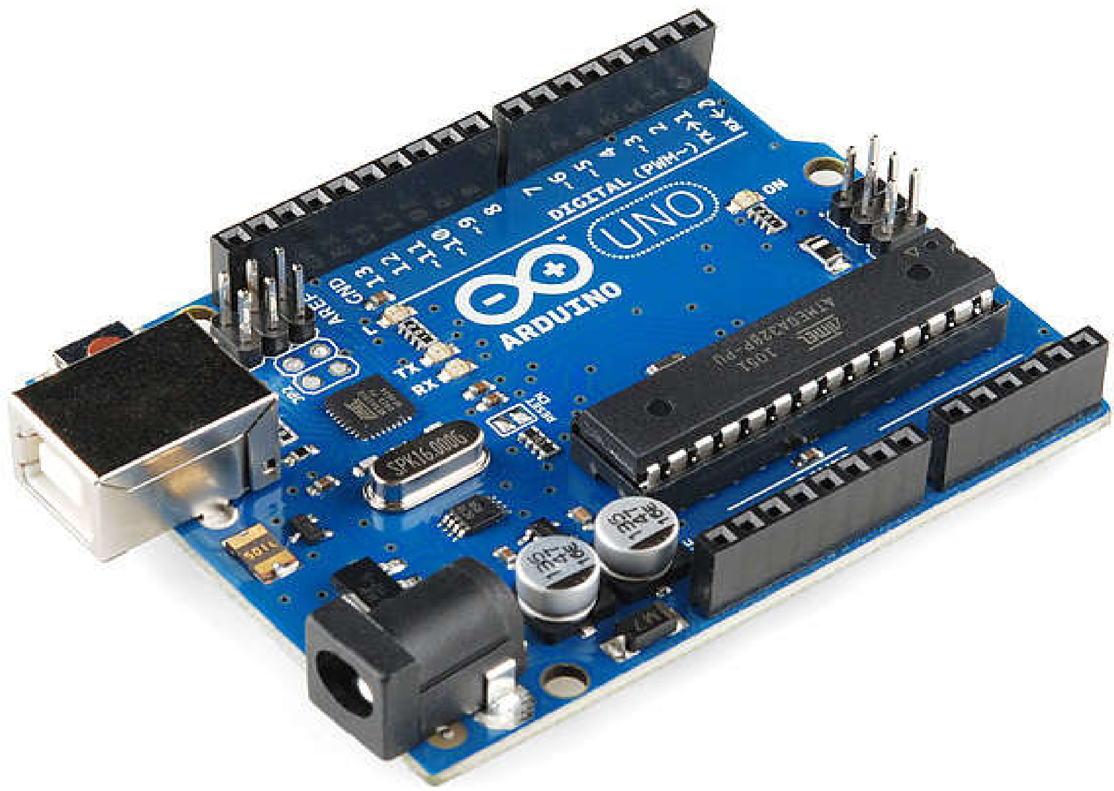


Figure 3.3: ArduinoUNO

Arduino is an open-source computer hardware and software company, project and user community that designs and manufactures microcontroller-based kits for building digital devices and interactive objects that can sense and control the physical world.

Arduino UNO is a microcontroller board based on the ATmega328 It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

Table3 .1: Arduino UNO properties:

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage	7-12V(recommended)
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by boot loader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

3.6.2 Light sensor selection and circuit:

Light detecting sensor that may use to build solar tracker include; phototransistors, photodiodes, LDR and LLS05-A light sensors, a suitable, inexpensive, simple and easy to interface sensor is analog LDR. Depending on particular application and required maximum energy receiving of solar panel, two-axis (two directional) sun tracking system using four light detectors sensors are mounted on the Fresnel lens and placed in an enclosure, the LDRs are screened from each other by opaque surfaces.

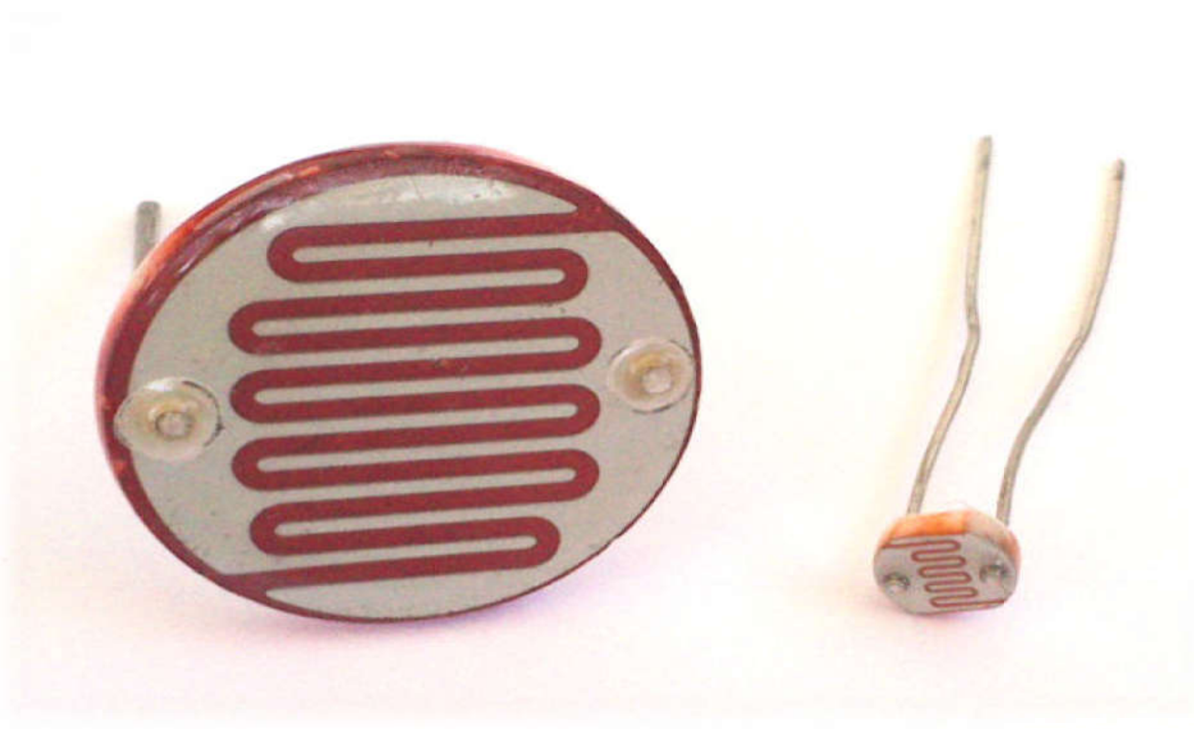


Figure3.4: LDR

Optical resistance LDR:

Photovoltaic resistance is an electronic component whose value of resistance changes with the intensity of the light falling on it. It is low cost and inaccurate and available measurements.

These resistors are usually made of cadmium sulfide, with resistivity ranging from 200K in the case of total darkness to 300 under bright sunlight. Resistance values vary from one resistor to another for the same light intensity, so read values must be calibrated of which.

Of course, we cannot measure the resistance directly using theArduino circuits. Therefore, we build a photovoltaic voltage-resistor and 10K resistivity to convert the optical resistance value to a change in the voltage breaker output. In order to connect the sensor circuit, we make a three-wire link with the SYRDUINO Sensor Shield and a short of 1 cm of optical resistivity. We enter the other end of the connection between the feed and the circuit inlet. Also, Approximately 1.5 cm and enter it at the same end between the ground GND and the circuit entrance.

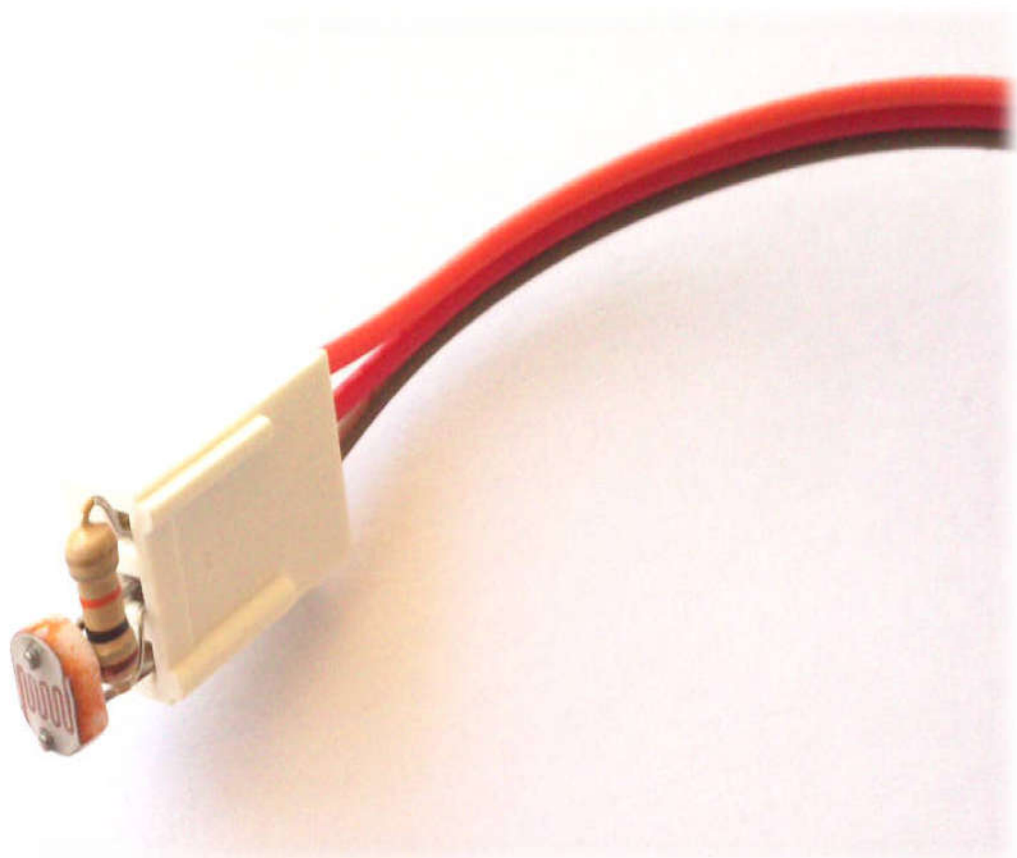


Figure 3.5: Connect LDR with resistance

3.6.3Driver selection

Circuits that operate at high voltages or at high currents cannot be controlled directly by an Arduino. Instead, you use a low-voltage control signal from the Arduino to control a relay, which is capable of handling and switching high voltage or high power circuits. A relay consists of an electromagnet that, when energized, causes a switch to close or open. Relays provide complete electrical isolation between the control circuit and the circuit being controlled. Generally the relay typically has five pins, two of these pins connected to positive and negative terminal, normally open pin is connected to common when the relay activated, normally closed pin is connected to common when the relay is not activated and common is connected to the ground of the source.

The relay board four channels was used to control system with device controller. These board relays are used to connect 2 DC motors or actuators as per following diagram.

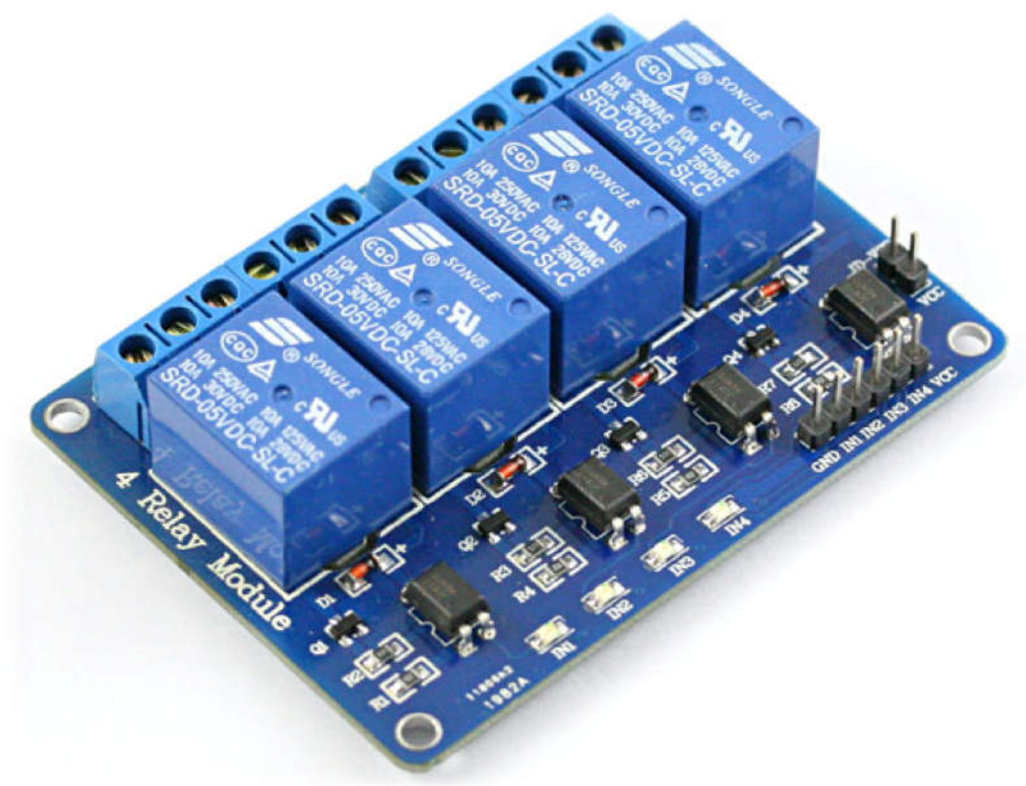


Figure 3.6: Relay board

3.6.4Actuator motor

Linear actuator is an actuatorthat creates motion in a straight line, in contrast to the circular motion of a conventional electric motor. Linear actuators are used in machine tools and industrial machinery, in computer peripherals such as disk drives and printers, in valves and dampers, and in many other places where linear motion is required. Hydraulic or pneumatic cylinders inherently produce linear motion. Many other mechanisms are used to generate linear motion from a rotating motor.

Figure 3.7 Shape of actuator dc motor

Table3.2 motors properties

Type	Short secondary	Short primary
Voltage	12v	12v
Load capacity	1500N	1500N
Speed	5.7mm/s	5.7mm/s
Stroke length	6inch	14inch
Minimum installation distance	10.24inch	18.50inch
Duty cycle	25%	25%
Protection class	IP65	IP65

3.7 Operating in General

Operation the solar tracker position is controlled automatically depending on the reading of the four LDR's two of them for north and south axis, the other two for east-west axis. The Arduino receives the signals from LDR's in voltage signal form and after processing decide the suitable action that makes the tracker in vertical position with the sun light as far as possible.

The solar tracker system requires movement in twodirections, solar tracker system motion control is simplified to an electric motor motion control. In solar tracking system design, any light sensitive device can be used as input sensor unit to detect and track the sun position, based on sensors readings, and generated sun tracking error, the control unit generates the voltage used to command the circuit to drive the motor, that outputs the rotational displacement of electric motor, which is the motion of solar tracking system.

The movement of the tracker has been controlled using two control methods: one of this method manual control and other method automatic control

3.7.1 Manual control

The characteristics of the actuator motor movement can be reversed, the motion was reversed by reversing the source electrodes applied to the motor and in case of return to the direction of movement the poles of the source are reversed again.

3.7.2 Automatic control

In this type of control the actuator motor was controlled by an electronic circuit consisting of controller device, board relay and sensor.

The control circuit here is an open loopsystem, where there is no signal reference from the system output (no feedback), because the movement of the motor depends on the reading sensors difference between the axes.

3.7.3 Connection of circuit

In input circuitLDR1 has two conjunctions the first one is connected to +VCC and the other connected to the ground (GND) through a resistor and to pin A0 in Arduino, LDR2, LDR3 and LDR4 same as LDR1 are connected to +VCC and to the ground (GND) through another three resistors but also connected to pinA1, pinA2 and pin A3 respectively in Arduino.

To connect the four relay board to an Arduino is very easy as shown in figure(3,8) and can be used with an wide range of devices, both AC and DC.Relay work on electromagnetism, when the Relay coil is energized it acts like a magnet and changes the position of a switch. The circuit which powers the coil is completely isolated from the part which switches ON/OFF, This provides electrical isolation. At the end 12V circuit was completely by 5V Arduino circuitry.

In output circuit relay board connect to actuator motor, which every two relay in board is controlled in one motor.

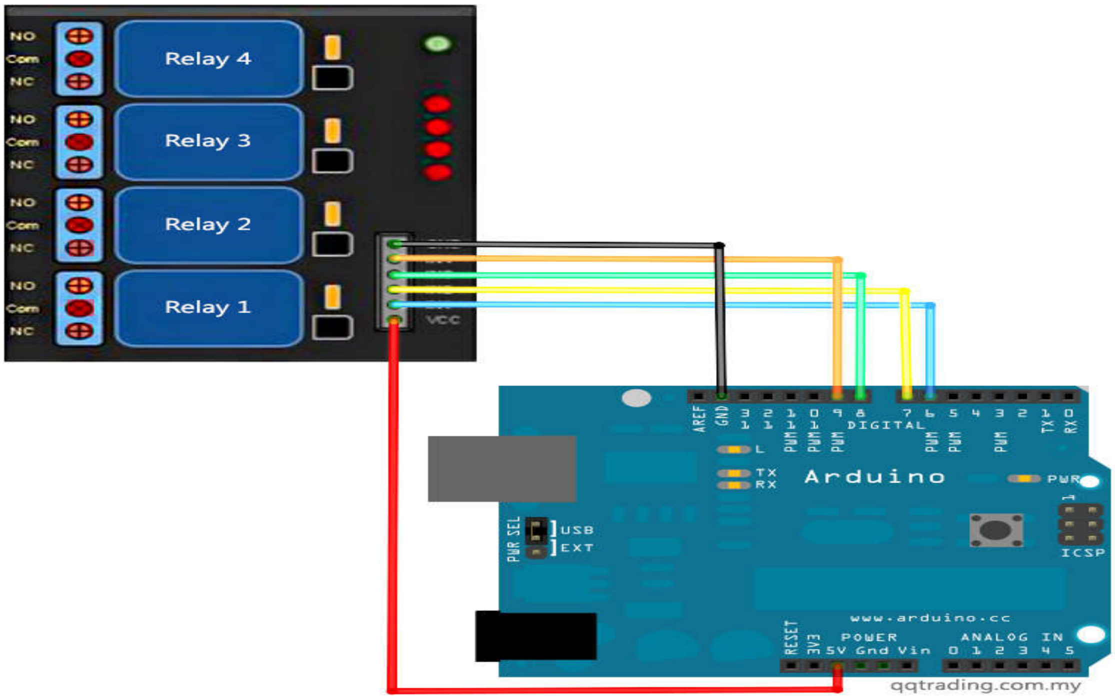


Figure 3.8: Connection Arduino with board relay

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Experimental Result

A mechanical frame has been designed and manufactured to convert the linear displacement into angular movement to track the sun. Then the Solar Tracker at most was tested and guided to actual north and then the top plane of the frame perpendicular to the light source. It was manufactured by Aluminum alloy to minimize the total weight.

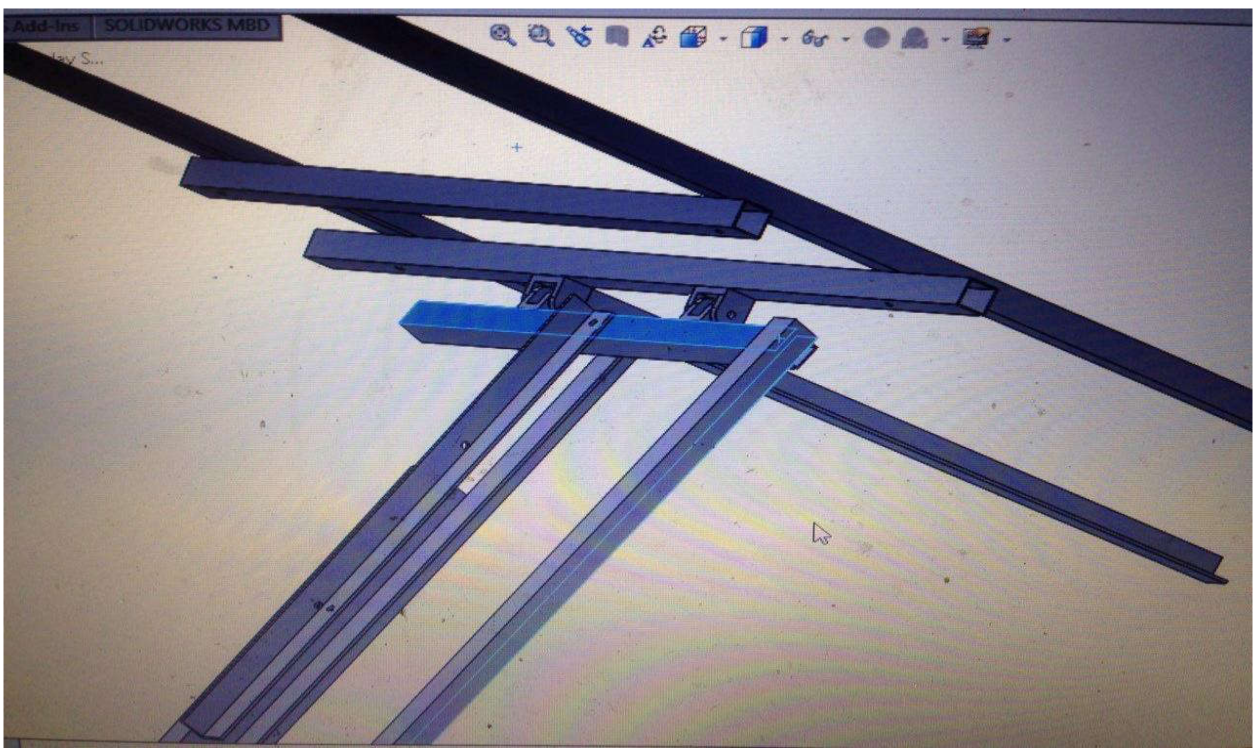


Figure 4.1:3D model of frame created by Solid works 2015

Figure 4.2: The final structure of tracking system

The most suitable and available solar concentrated system is Fresnel lens due to high capability to produce high concentrated ratio. This high concentration of rays requires the reactor to withstand a high temperature.

The body of the boiler was created from steel, because it is high thermal conductivity and can be stand that high temperature focus from Fresnel lens as shown in figure (4.3).

Figure 4.3: Final structure of tracking system with Frensial lens

The quantity of heat energy (Q) is gained explained by this equation:

$$Q = m*C*\Delta T \qquad (4.1)$$

$$\Delta T = (Tf-Ti)$$

$$Q= m \times C \times (Tf-Ti) \qquad (4.2)$$

The experimental runs initially performed with 10 min reduction step at 0.6 kW solar radioactive power inputs under concentrated ratio 8890 suns [49].

$$Q (KW/S) = 0.6/(60*10) = 1(W/S) = 0.001(KW/S)$$

Mass of the water (m):

$$m = (Q/(C*\Delta T))$$

$$m = (0.001*60)/(4.2*(100-35)) = 0.2 (kg)$$

Mass of water 0.2 (kg) is evaporated in 1 second that means 3 (kg) (mass of water is used in tank in the model) is evaporates in15 second.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion:

One of the most important problems facing the world today is Energy problem. Most of energy production is depended on fossil fuel like oil and coal. These mains sources of fossil fuel are expected to end up from the world during the recent century. Therefore, renewable energy replaces the conventional fuels for producing electricity. Renewable energy is energy which comes from natural resources such as sunlight, wind tides and waves Solar energy is one of the most popular renewable sources now a day .

In this research, the focus was on design solar tracker system to increase the amount of power generated and uses that tracker with Fresnel lens to convert water to steam.

5.2 Recommendations:

- Activate the research on the subject of conservation of solar energy to benefit from them during the night or cloudy days.
- Attention to continuous cleaning of dust in a period of not more than a few days because the accumulation of dust on the solar complexes reduces their efficiency.
- The best use of solar energy in the regions of northSudan because of its high temperature and also in the months march, April, May are the summer in Sudan as is shown in APPENDIX B.

- For high efficiency the motion must be added ECO-WORTHY controller to tracker instead of Arduino device.
- Add electrical generation to know the efficiency of the electrical system and the amount of generation that can be produced from evaporated water.

References

1. Armaroli, N. and V. Balzani, The future of energy supply: challenges and opportunities. Angewandte Chemie International Edition, 2007. 46(1-2): p. 52-66.
2. Goetzberger, A., The global significance of solar energy supply. Energy Materials, 2006. 1(1 :(p. 20-21.
3. Kalogirou, S.A., Solar thermal collectors and applications. Progress in energy and combustion science, 2004. 30(3): p. 231-295.
4. Chambers, R., Whose reality counts. Vol. 25. 1997: London: Intermediate technology publications.
5. Reddy, A.K ,.et al., Energy and social issues. World Energy Assessment, 2000: p. 39-60.
6. Krishnamoorthi, M., and S. Kaviyarasu. "SOLAR PUMP WITH SOLAR PANEL TILTING ARRANGEMENT." (2016).
7. Marks, S.R., Multiple roles and role strain: Some notes on human energy, time and commitment. American sociological review, 1977: p. 921-936.
8. Abuelnuor, Ali Abuelnuor Abdeen, et al. "Review of numerical studies on NOx emission in the flameless combustion." Applied Mechanics and Materials. Vol. 388. Trans Tech Publications, 2013.
9. Haile, M., Biofuel Energy: spent coffee grounds biodiesel, bioethanol and solid fuel. 2014: diplom. de.
10. Dincer, I., Renewable energy and sustainable development: a crucial review. Renewable and Sustainable Energy Reviews, 2000. 4(2): p. 157-175.
11. Zinkle, S.J. and G. Was, Materials challenges in nuclear energy. Acta Materialia, 2013. 61(3): p. 735-758.

12.Kalogirou, S.A., Solar energy engineering: processes and systems. 2013: Academic Press.
13.Twidell, J. and T. Weir, Renewable energy resources. 2015: Routledge.
14.Rao, D.P ,.Infrared thermography and its applications in civil engineering. The Indian Concrete Journal, 2008. 82(5): p. 41-50.
15.Michaelson, S.M., Human exposure to nonionizing radiant energy—Potential hazards and safety standards. Proceedings of the IEEE, 1972 . :(4)60p. 389-421.
16.Kirk, J.T., Light and photosynthesis in aquatic ecosystems. 1994: Cambridge university press.
17.Bisi, O., Visible and Invisible. 2015: Springer.
18.Foster, R., M. Ghassemi, and A. Cota, Solar energy: renewable energy and the environment. 2009: CRC Press.
19.Johnson, F.S., The solar constant. Journal of Meteorology, 1954. 11(6): p. 431-439.
20.Aygün Özyüzer, G., Growth of Cu2ZnSnS4 absorber layer on flexible metallic substrates for thin film solar cell applications. 2014, İzmir Institute of Technology.
21.Latunussa, C.E., et al., Life Cycle Assessment of an innovative recycling process for crystalline silicon photovoltaic panels. Solar Energy Materials and Solar Cells, 2016. 156: p. 1.111-01
22.Alalewi, A., Concentrated Solar Power (CSP). 2014, Higher Institute for Applied Science and Technology.
23.Zhang, H., et al., Concentrated solar power plants: Review and design methodology. Renewable and Sustainable Energy Reviews, 2013. 22 :p. 466-481.

24. Alhouli, O., Using solar energy in Kuwait to generate electricity instead of natural gas. 2017.
25. Kumar, N.S. and K. Reddy, Comparison of receivers for solar dish collector system. Energy Conversion and Management, 2008. 49(4): p. 812-8 .
26. Kannan, N. and D. Vakeesan, Solar energy for future world:-A review. Renewable and Sustainable Energy Reviews, 2016. 62: p. 1092-1105.
27. Sathaye, J. and S. Meyers, Renewable Energy Supply, in Greenhouse Gas Mitigation Assessment: A Guidebook. 199 ,5Springer. p. 133-149.
28. Teske, S., et al., Energy [r] evolution-a sustainable world energy outlook. 2012: Greenpeace International, EREC and GWEC.
29. Jaccard, M., Sustainable fossil fuels: the unusual suspect in the quest for clean and enduring energy. 2006: Cambridge University Press.
30. Hosseini, Seyed Ehsan, Mazlan A. Wahid, and Abuelnuor Abdeen Ali Abuelnuor. "Biogas flameless combustion: a review." Applied Mechanics and Materials. Vol. 388. Trans Tech Publications, 2013.
31. Tina, Yuan, and Chang-Ying Zhao. "A review of solar collectors and thermal energy storage in solar thermal applications." Applied energy 104 (2013): 538-553.
32. Duffie, John A., and William A. Beckman. Solar engineering of thermal processes. John Wiley & Sons, 2013.
33. Kaltschmitt, Martin, Wolfgang Streicher, and Andreas Wiese, eds. Renewable energy: technology, economics and environment. Springer Science & Business Media, 2007.
34. Aslani, A. and K.-F.V. Wong, Analysis of renewable energy development to power generation in the United States. Renewable Energy, 2014. 63: p. 153-161.

35.Devanand, P. and C. Chao, Genetic variation within 'Medjool'and 'Deglet Noor'date (Phoenix dactylifera L.) cultivars in California detected by fluorescent-AFLP markers. The Journal of Horticultural Science and Biotechnology, 2003. 78(3): p. 405-409.
36.Tiberius Tudorache1, Liviu Kreindler1, "Design of a Solar Tracker System for PV Power Plants", University Polytechnic of Bucharest, Romania, June-2013.
37. İ. Sefa, M. Demirtas, and İ. Çolak, "Application of one-axis sun tracking system," Energy Conversion and Management, vol. 50, pp. 2709-2718, 2009.
38.Wang, W., et al., Performance Analysis of Tower Solar Thermal Power System. 2015.
39.Riadh, R.R., et al., Design and Prototype Implementation of a Miniature Concentrated Solar Thermal (CST) Power Plant with Single-Axis Tracking System: An Alternative Energy Supply for Bangladesh.
40.Olah, S., Solar energy module and Fresnel lens for use in same. 2002, Google Patents.
41.Morgan, B., et al., Development of a deep silicon phase Fresnel lens using gray-scale lithography and deep reactive ion etching. Journal of microelectromechanical systems, 2004. 13(1): p. 113-120.
42.Sato, S., A. Sugiyama, and R. Sato, Variable-focus liquid-crystal Fresnel lens. Japanese journal of applied physics, 1985. 24(8A): p. L626.
43.Yabe, T., et al., High-efficiency and economical solar-energy-pumped laser with Fresnel lens and chromium cooped laser medium. Applied Physics Letters, 2007. 90(26): p. 261120.

44. Zhai, H., et al., Experimental investigation and analysis on a concentrating solar collector using linear Fresnel lens. Energy Conversion and Management, 2010. 51(1): p. 48-55.
45. O'neill, M.J., InflatableFresnel lens solar concentrator for space power. 2000, ogle Patents.
46. https://www.quora.com/Is-there-a-lens-that-can-make-light-rays-parallel-no-matter-the-position-of-the-light-source seen at 21/9/2017 9:42 PM.
47. Roth, P., A. Georgiev, and H. Boudinov, Cheap two axis sun following device. Energy conversion and management, 2005. 46(7): p. 1179-1192.
48. Lee, C.-Y., et al., Sun tracking systems: a review. Sensors, 2009. 9(5): p. 3875-3890.
49. Ahmed mhamed eltyeb , o.a.e., mohamed ali ,mohmed ahmed alawad, solar thermochemical redox cycle to splitting co2 based oncerium oxide. 2016, sudan university of Science and Technology.

APPENDIXES

APPENDIX A

Arduino Uno code for two axis solar tracker:

```
int LDR1=A0;
int LDR2=A1;
int LDR3=A2;
int LDR4=A3;
int R1=6;
int R2=8;
int R3=9;
int R4=10;
int A=100;
int X,Y,Z,K;
void setup(){
  Serial.begin(9600);
// Initialize the Arduino data pins for input and output
  pinMode(LDR1,INPUT);
  pinMode(LDR2,INPUT);
  pinMode(LDR3,INPUT);
  pinMode(LDR4,INPUT);
  pinMode(R1,OUTPUT);
```

```
  pinMode(R2,OUTPUT);
   pinMode(R3,OUTPUT);
  pinMode(R4,OUTPUT);
}
void loop(){
  while(1){
  X=analogRead(LDR1);
  Y=analogRead(LDR2);
  Z=analogRead(LDR3);
  K=analogRead(LDR4);
  //part of code to control relay 1 and 2
  if(X>Y)
  {
    digitalWrite(R2,HIGH);
    digitalWrite(R1,LOW);
    delay(1000);
  }
  else if(Y>X)
  {
```

```
  digitalWrite(R2,LOW);

  digitalWrite(R1,HIGH);

  delay(1000);

}

else

{

  digitalWrite(R2,LOW);

  digitalWrite(R1,LOW);

  delay(1000);

}

//part of code to control relay 3 and 4

if(Z>K)

{

  digitalWrite(R4,HIGH);

  digitalWrite(R3,LOW);

  delay(1000);

}

else if(K>Z)

{
```

```
  digitalWrite(R4,LOW);
  digitalWrite(R3,HIGH);
  delay(1000);
}
else
{
  digitalWrite(R4,LOW);
  digitalWrite(R3,LOW);
  delay(1000);
}
}
```

APPENDIX B

The experimental work was carried out at Khartoum according to the record from the meteorological administration (Figure (3.1)).

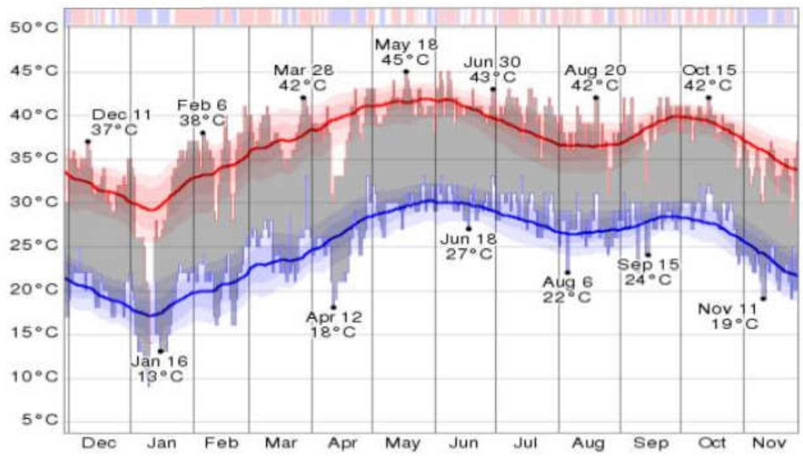


Figure (3.1): The distribution of the temperature on Khartoum in 2015 [89].