DESIGN AND FABRICATION OF SOLAR DESALINATION SYSTEM

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4. **M. Shahbaz**	

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ABSTRACT

The design and fabrication of a parabolic solar dish desalination system capable of producing 40 liters of drinking water using a solar tracking system and a conical receiver is presented. The dish is designed to concentrate solar radiation onto a conical receiver where saltwater is heated and evaporated, with the vapor subsequently condensed into fresh water. The solar tracking system facilitates the precise alignment of the dish with the angle of the sun to optimize solar radiation concentration. The system is entirely solar-powered, making it a sustainable and affordable solution for water desalination in areas with limited access to freshwater sources. The design achieves a high conversion rate from saltwater to freshwater with a minimum energy consumption. The presented system is an effective solution for meeting the increasing demand for freshwater in areas facing severe water scarcity.

Contents

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Chapter No. 1

1.1. INTRODUCTUON:

After the oil crisis in the 1980s, the point at which the possibility of an energy shortage was plausible, concentrated sun-oriented power advances reached prominence, with the main illustrative box sun-based power plants. The struggle to obtain energy supplies continues today, and sustainable power sources address the elective pathway as fossil energy resources steadily deplete. Figure 1 shows that the Global Energy Organization's most recent report provides a summary of the ongoing vigorous utilization by source, with petroleum derivatives accounting for 79.5 percent and renewables for 17.2 percent. It states that if the tendency to use fossil fuels is maintained, it could have a significant impact on the global environment. In this particular situation, the restriction of CO2 and ozone hurting substance radiations in view of oil based goods suggests, actually, the best motivation to search for normally sensible structures.

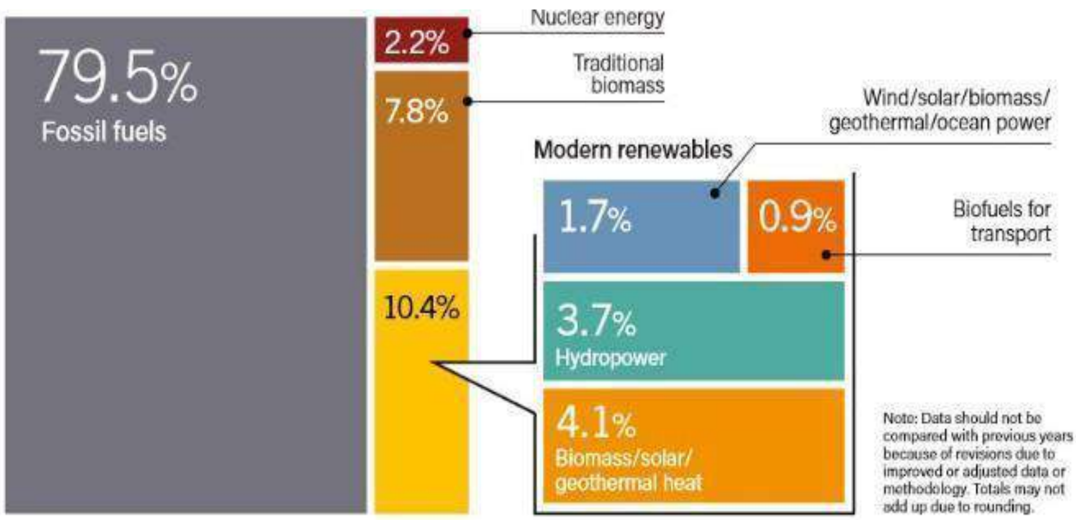

Figure 1. 1Estimate renewables share total of final energy consumption

The goal of the Paris Accord in 2015 is a cutting-edge political motivation. It took until the environment summit in Katowice (Poland) in December 2018 to try its goals. It enables 174 nations to meet the challenge of keeping the global average temperature rise at 2°C above pre-industrial levels. Moderation of ozone-depleting substance emissions is the most important method for achieving this goal. This means drastically reducing current and future emissions caused by transportation, industry, power generation, and individual use of fossil energy.

Sun fueled atomic power age alongside biomass and geothermal force, contrast with only 4.1% of the overall unlimited sources share. Inside the sun based warm branch, before long, figurative box power plants stay with the best piece of presented centering sun situated progresses. Sun-based towers (24%), Fresnel authorities (9%), and dish/Sterling gatherers account for the remaining 1% of concentrated sun oriented power (CSP) projects. All together are covering 5.8 GW of the world's hard and fast energy usage premise and soon additional power plants will supply further 3.8 GW, as shown in Figure 2. Countries like South Africa, Morocco, the Joined Bedouin Emirates, India, Chile, and China, all of which give CSP a tremendous boost in the energy market, are depicted in this figure.

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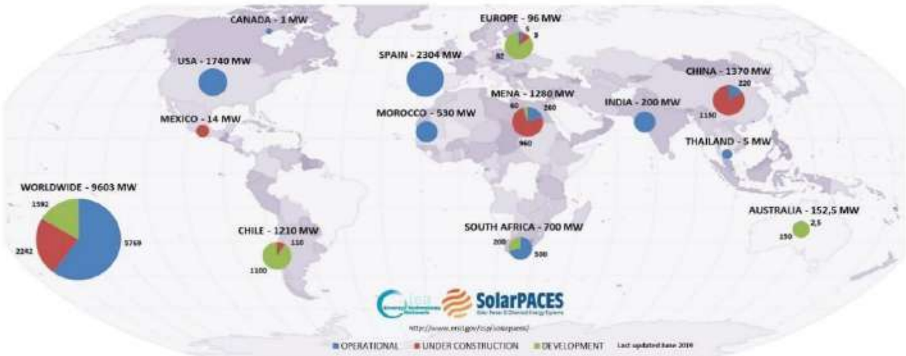
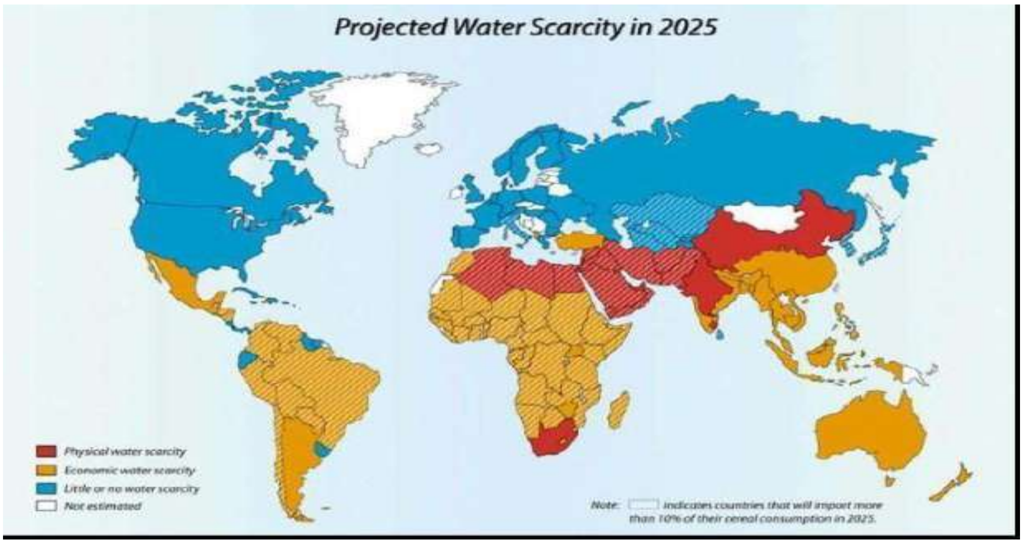
Industrialization of countries and growing population have led to a significant decrease in the country's water resources. The shortage of freshwater is one of the most pressing issues worldwide, with many regions facing severe water scarcity due to a combination of natural and anthropogenic factors. To address this issue, Iran has been investing in renewable energy technologies, such as solar, to power desalination plants and increase access to fresh water. Solar desalination systems are promising alternatives to traditional fossil-fuel-based systems, as they are environmentally friendly, cost-effective, and sustainable.



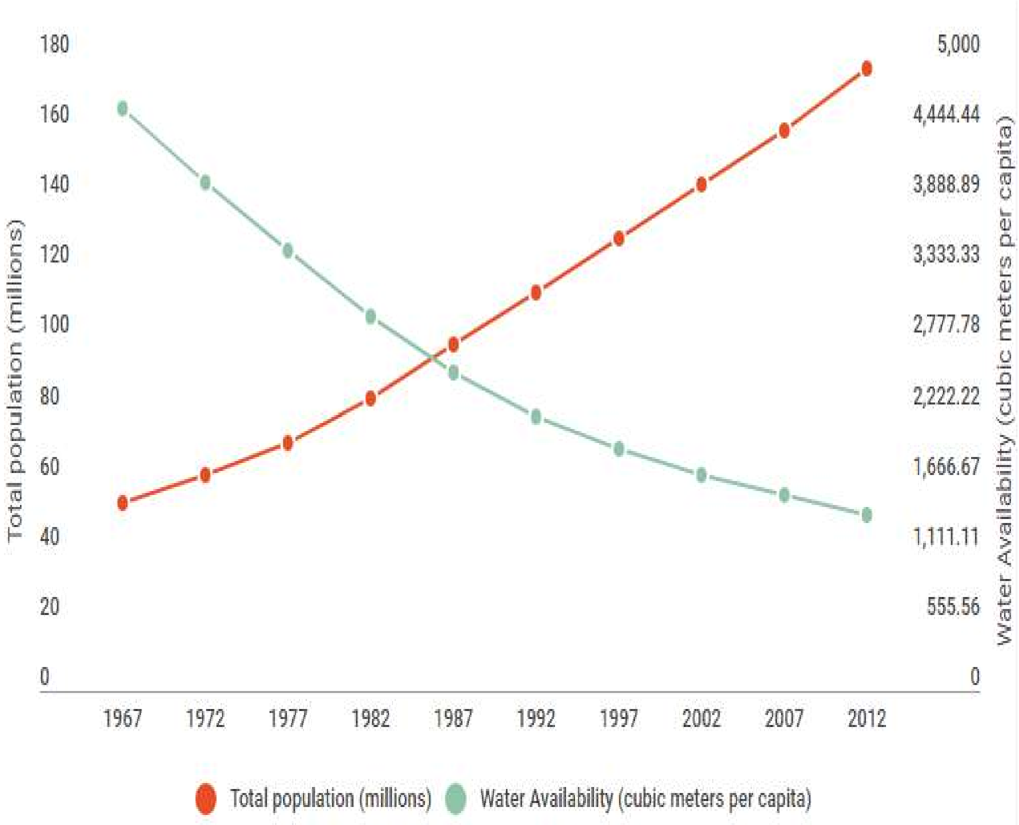
The increasing demand for freshwater due to industrialization and population growth has led to a severe limitation of drinking water resources worldwide, with an estimated 1.8 billion people suffering from water shortages by 2025. To meet this demand, international societies are seeking alternative resources, such s the desalination of saline waters, including ocean waters and brackish waters of lakes and other sources. However, today's enormous desalination plants require a high energy consumption to supply fresh water, which cannot be met in many locales due to high energy costs or scarcity of affordable energy. Additionally, the high energy consumption of traditional desalination plants contributes heavily to global warming, exacerbating current water shortages and not being sustainable in the long term.



To address these challenges, there is an urgent need for the development of renewable, environmentally friendly energy systems to power desalination processes. Solar energy, as the most abundant source of renewable energy, has the potential to power desalination processes directly or indirectly. In the former method, solar energy is directly used to produce freshwater through distillation. Solar stills are simple desalination units with low operation and maintenance costs, making them more suitable for use in small-scale production in remote areas. In the latter method, solar energy can be converted to electricity through solar PV panels or harnessed by solar thermal collectors to provide the required heat for thermal desalination processes.
Conventional methods of water desalination have proven to be both energy-intensive and costly, making them unsuitable for use in areas with limited resources. Therefore, there is a critical need for cost-effective and sustainable systems for water desalination. One such solution is a parabolic solar dish desalination system, which uses solar radiation to evaporate and condense saltwater into freshwater. The system relies on the precise alignment of a parabolic dish with a conical receiver to concentrate solar radiation onto a heating element. The resulting design and fabrication of this system are crucial for achieving maximum energy efficiency and freshwater output while minimizing energy consumption. This research paper will explore the design and fabrication of a parabolic solar dish desalination system capable of producing 40 liters of freshwater per day using solar tracking and a conical receiver, making it an effective and affordable solution for meeting the growing demand for freshwater in regions facing severe water scarcity.

1.2. PROBLEM STATEMENT:

Clean freshwater is an essential ingredient for a healthy human life but 1.1 billion people lack access to water and 2.7 billion experience water Shortage at least one month a year. Pakistan is also in the list of water Shortage countries. According to the Water Resources Institute (WRI) 2021 report, Pakistan ranks 14 among 17 highly water-risk countries.By 2025, two-thirds of the world's population may be facing water shortages.



1.3.OBJECTIVES

The objectives of solar desalination include:

1. Providing access to clean drinking water: Solar desalination can provide a source of clean, fresh drinking water in areas where traditional sources of water are scarce, contaminated or expensive.

2. Reducing reliance on nonrenewable energy sources: Solar desalination uses renewable energy sources, such as sunlight, to power the water desalination process, reducing reliance on fossil fuels.

3. Reducing greenhouse gas emissions: By using renewable energy to power water desalination, solar desalination can significantly reduce greenhouse gas emissions and help mitigate the impacts of climate change.

4. Promoting sustainable development: Solar desalination can be a sustainable solution to providing water in developing countries or remote areas where traditional water sources are not available, thus promoting sustainable economic and social development.

5. Improving public health: Improving access to clean drinking water can help lower the incidence of waterborne illnesses and improve public health in areas where clean water is scarce

Chapter 2

2.1s. LITERATURE REVIEW:

Desalination is the process of removing dissolved salts and other impurities from saltwater or brackish water to produce pure water that can be used for drinking, farming, and other commercial purposes. This process is becoming more and more important all over the world, especially in places where freshwater supplies are scarce or contaminated.
Water can be desalinated using electro-dialysis, steam distillation, and reverse osmosis. The most common method is reverse osmosis, which removes sodium and other impurities from water by forcing saltwater through a semipermeable membrane. Thermal distillation heats saltwater to produce steam that is then condensed into pure water, in contrast to electro-dialysis, which uses a membrane to extract the ions from the water.
Commercial water desalination systems on a large scale are a possibility.
Energy and water are currently the interconnected resources that are most important for

Author	Title	Systems	Remarks
Milad Bahrami Vahid Madadi Avargani[5]	Comprehensive experimental and theoretical study of a novel still coupled to a solar dish concentrator	Solar desalination	The SDC optical efficiency could be improved by 60% when the absorber plate reflectivity reduced f by about 80%.
Hazim Mohameed Qiblawey, Fawzi Banat[6]	Solar thermal desalination technologies	Solar desalination	The author pointed out the solar desalination can either be direct or indirect; Direct one can produce different technologies but the direct one is competitive to indirect one.
Hassabou et al.[7]	Tecnoeconomic Analysis of Medium and Large-sacle Desalination Plants Driven by Concentrated Solar Systems in the Mena Region	CSP-multi-stage flash	The authors showed that the freshwater production cost of CSP-MSF system was around 3 times high systems.
Xiao-Qian Wang, Youngki Choe and Eun Sok Kim[8]	Solar powered desalination system using Fresnel lens	Solar desalination	In this Author aims to design and construct a solar powered desalination that is surrounded by coastal areas. Desalination system composed o condenser system

sustainable growth. As a result, they became the most important current research topics. Water can be used to generate energy in a variety of ways, including boiling, storing, cooling, and hydropower; however, water pumping, treatment, and desalination require energy as well. Consequently, the economic development of any community is significantly impacted by any shift in the availability of energy and water resources. It is essential to implement and permit the use of new, renewable, and environmentally friendly energy resources in all water desalination and water treatment processes in order to lessen the negative effects of global warming.

Author	Title	Systems	Remarks
Umer Jamil, Wajahat Ali[9]	Performance Tests and Efficiency Analysis of Solar Parabolic Dish Solar Collector for Direct Steam Generation	Solar steam generator	In this Author ,point that overall efficiency of parabolic dish is higher than other solar methed and he achive efficiency of 70% becasue
	Tecnoeconomic Analysis of Medium and Large-sacle Desalination Plants Driven by Concentrated Solar Systems in the Mena Region	CSP-multi-stage flash	The authors showed that the freshwater production cost of CSP-MSF system was around 3 times higher than the CSP-RO and conventi
	Solar powered desalination system using Fresnel lens	Solar desalination	In this Author aims to design and construct a solar powered desalination system using Fresnel lens in the Philipp condenser system

2.2. HISTORY:

Throughout history, efforts to purify salty water for cultivation and consumption have been constant. For millennia, ships have used seawater desalination to produce pure water through evaporation.

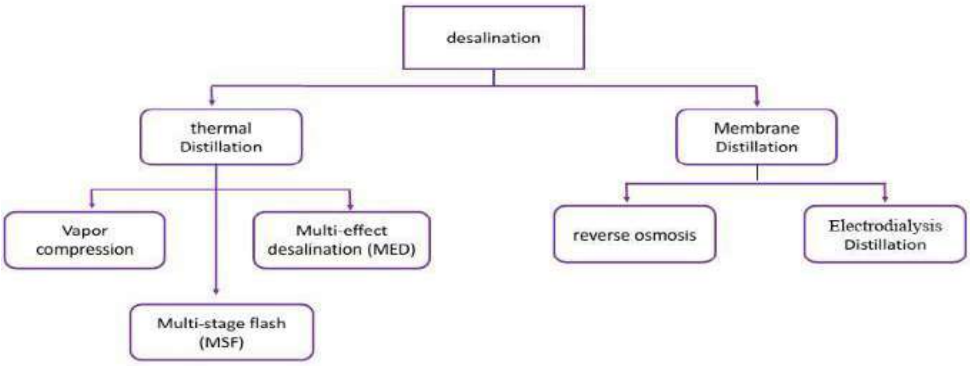
The primary huge business desalination plant was probably built in Egypt in 1912 and had a six-stage Various Impacts Evaporator that created around 75 m3/d of desalinated water.

Commercial production of land-based seawater distillation units began in the late 1950s, initially utilizing technology developed for World War II-era naval distillation facilities and industrial evaporators like sugar concentrators.

2.3. PROCEDURE INVOLVED IN DESALINATION

Most of the time, salinity levels below 500 ppm are considered safe for drinking. Pre-treatment of pumped water (filtration, chemical addition) Desalination Process A post treatment if necessary (in some cases, adding a few minerals) are the three to four steps that make up a complete desalination process.

2.4. CLASSIFICATION



2.4.1 REVERSE OSMOSIS

The RO innovation depends on the properties of semi-porous layers which can isolate water from a saline arrangement, when overabundance of osmotic tension is applied on the film frameworks. High-pressure pumps provide the necessary pressure for the water to pass through the membrane and be rejected as salt by applying pressure. The pressures range from approximately 150 psi for water that is slightly brackish to 800 psi and up for seawater. 35 to 50 percent of the flow passes through the membrane and has a salt concentration below 500 ppm. The remaining flow, known as retentive (50 to 65 percent), contains a high salt concentration and is rejected directly at a high pressure.

RO can be applied to various sorts of water: both seawater and brackish water, with the same outcomes depending on the membrane's pressure.Due to its simple and relatively inexpensive technology as well as a significant improvement in membrane quality, reverse osmosis has undergone significant development over the past two decades. Over the past ten years, two developments have contributed to a decrease in the operating costs of RO plants: the improvement of additional effective films and the utilization of energy recuperation gadgets. The more up to date layers have higher transition (pace of water stream per unit region), further developed dismissal of salts, lower costs and longer assistance life.

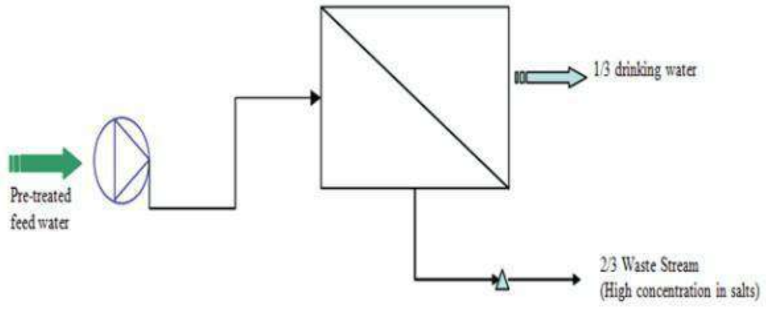


Fig .Reverse osmosis schematic

- **FEATURES OF REVERSE OSMOSIS**

The following are some of the most important aspects of the RO process:
• Low consumption of energy
• Ready-to-Use and Simple: immediate halt and resumption.
• Requires significant pre-treatment: chemical and pre-filtration to prevent membrane fouling.
• A salt concentration of 500 ppm or less in the outlet

2.4.2. MULTI STAGE FLASH DESALINATION

Seawater is heated to 120°C in a vessel known as the brine heater during the MSF process.It then flows into a vessel known as a stage, where the ambient pressure is lower and water boils. After that, steam is condensed in a series of tubes that run through the vessel. Low strain guarantees seawater chilling off to 40°C.
Although the MSF process can also be used with solar power, this well-known technology has been used on large installations (more than 50,000 m3/day) with the coupling of heat generation from a power plant. Unless a lot of stainless steel is used, MSF plants will corrode. MSF plants are also susceptible to erosion and impingement attack in addition to corrosion.
The turbulence of the feed water in the flash chamber when it moves from one stage to another causes erosion.
This cycle produces around 3.4 billion Gallons each day internationally, which is around 50% of the overall desalination limit. About 84% of that capacity is provided by MSF plants. The majority of those facilities were constructed outside of the United States, primarily in the Middle East, where energy resources are abundant and nexpensive.

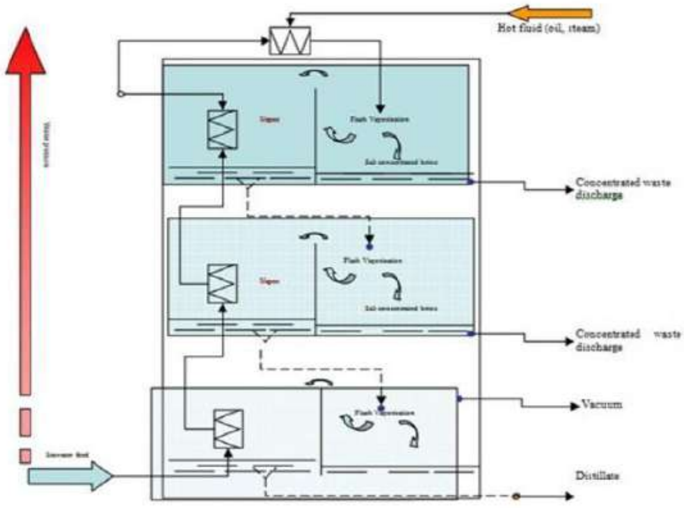


Fig .MSF system

- **<u>FEATURES OF MULTI STAGE FLASH DESALINATION</u>**

Key highlights for MSF are the accompanying:
• Great dependability
•No requirement for convoluted pre-treatment because of extremely restricted scaling: anti-scalant and simple filtration
• A high cost of investment
•Excellent of delivered freshwater (contingent upon the quantity of cells): salts focus under 50 ppm.
• Low running flexibility (low flow rate variation).

2.4.3. MULTI EFFECT DISTILLATION

The Multi Effect Distillation (MED) method provides heat to a second cell by utilizing the latent heat of condensation of the vapor from the first cell. The evaporation takes place in cells where the equilibrium temperature (Te) of the liquid or vapor is between 40 and 68 degrees Celsius. To ensure that the evaporation and condensation take place at a lower temperature, the produced steam from the first cell is injected into the second effect. The process continues in each of the subsequent cells. The performance ratio rises with the number of vessels or effects. MED units can be categorized as horizontal, vertical, or vertically stacked tube bundles depending on the arrangement of the heat exchanger tubing.
Hot water from the solar collector is introduced directly or through a heat exchanger into the bottom tray when the source of heat is the sun. Aluminum brass (AlBr) for the tubes and stainless steel 316L for the casing of MED units with horizontal sprayed tubes are typically used in their construction. A vertical heat exchanger may be utilized at times.

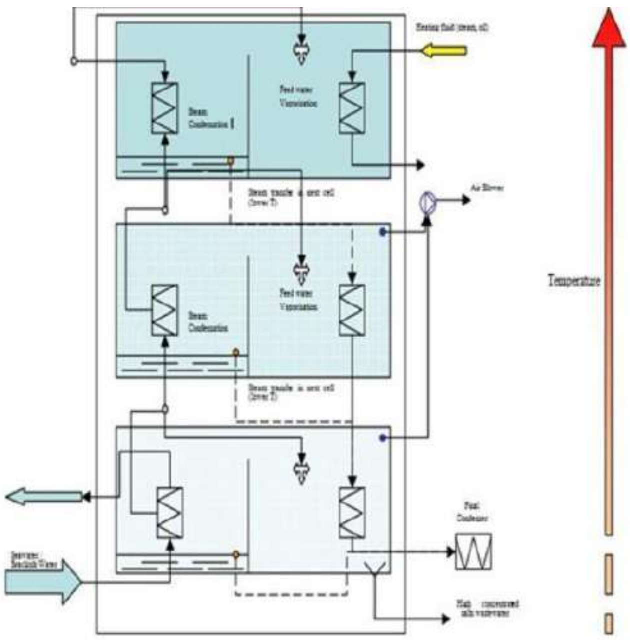


Fig .MED system

- **FEATURES OF MULTI EFFECT DISTILLATION**

Quick and simple system startup (less than an hour) and high reliability

• Produced freshwater of high quality (depending on the number of cells): salts focus under 50 ppm.

• Due to the very limited scaling, there is no need for a complicated pre-treatment: anti-scalant and simple filtration

• Can be utilized on heat that is heated to a low temperature (from 60°C), and it is simple to recover as a byproduct in industrial plants

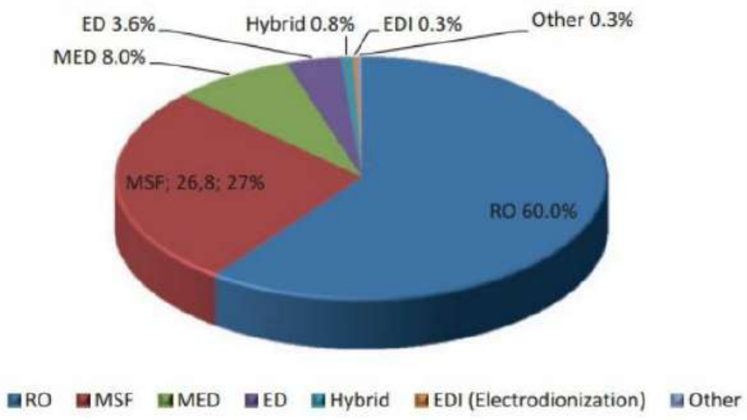
- **COMPARISON OF ENERGY CONSUMPTION OF DESALINATION TECHNOLOGIES**

The energy expected for different desalination processes, as gotten from an overview of makers information is displayed in Table. As can be seen from the table, RO with energy recovery is the process that uses the least amount of energy. However, because the energy-recovery turbine is so expensive, this is only a viable option for extremely large systems. The following most minimal is the RO without energy recuperation and the MEB.

Table. Energy consumption of desalination Technologies

	Multi stage Flash	Multi effect distillation	Reverse Osmosis
Electrical Demand, kWh/m^3	2.5 – 3.5	1.5 – 2.5	3 – 6
Thermal Demand, kWh/m^3	80 – 120	50 – 90	0

Chart Desalination Market:



2.4.4 SOLAR TECHNOLOGIES

The majority of the desalination techniques discussed here make use of thermal energy. It is evidence to use solar power for the operation of the plants that desalination is most needed in dry countries that receive a lot of solar radiation. Through a turbine (CSP), solar technologies can generate heat and, consequently, electricity, or directly electricity (PV and CPV). CSP and PV technologies tend to become increasingly appealing as a result of growing interest and advancements.

Concentrated sun based power frameworks create sun based power by utilizing mirrors or focal points to think a huge area of daylight, or sun powered nuclear power, onto a little region. Power is created when the concentrated light is switched over completely to warm, which drives an intensity motor associated with an electrical power generator.

Concentrator photovoltaic (CPV) is a type of photovoltaic that uses sunlight to generate electricity. It uses lenses and curved mirrors, unlike conventional photovoltaic systems, to direct sunlight toward tiny but highly effective multi-junction (MJ) solar cells. In addition, to further improve their efficiency, CPV systems frequently make use of cooling systems and solar trackers.

There are two distinct categories of solar technologies:

Photovoltaic Concentrating Solar Power Technologies and Concentrating Solar Power Technology include primarily:

• Linear Fresnel reflector systems and a parabolic trough or parabolic dish desalination.

2.4.5. PARABOLIC DISH DESALINATION

A solar parabolic dish desalination system is a type of solar desalination system that uses the concentrated solar energy from a parabolic dish to heat seawater and evaporate it to produce freshwater. The system consists of a parabolic dish reflector that concentrates the sunlight onto a receiver, which heats the seawater and creates steam. The steam is then condensed on a heat exchanger and collected heat saltwater or brackish water and produce fresh drinking water through a process called desalination. The system typically consists of a parabolic dish reflector that concentrates sunlight onto a receiver at the focal point of the dish. The receiver contains a heat-exchanging tube that circulates the saltwater or brackish water and absorbs the solar energy to generate steam. The steam is then condensed and collected as fresh water, leaving behind the salt and other impurities. The solar parabolic dish desalination system is a sustainable and effective solution to provide access to clean drinking water in remote or arid areas where fresh water is scarce.

2.4.6. PARABOLIC TROUGH

CSP illustrative box produce steam and power using an explanatory reflecting surface that concentrates direct typical sun oriented radiation (DNI) onto a getting tube encircled by a glass component.

During the day, the solar collectors follow the sun from east to west, allowing the sun to remain focused on them. The receiving tube is where the thermal fluid is heated to between 350 and 400 °C. After that, the power plant uses it as a heating fluid to produce high-pressure steam. Warm capacity (on reasonable or inert intensity) can be added to the framework to guarantee congruity during low sunlight based radiation period (evening time or overcast days). The most advanced CSP technology, the parabolic trough, is now commercially available for industrial heat production.

Fig. Parabolic trough

2.4.7. LINEAR FRESNEL REFLECTORS SYSTEM

A linear Fresnel reflector system uses thin mirror segments arranged in long parallel lines to reflect sunlight onto a fixed receiver. This allows energy to be transferred through the absorber into a thermal fluid (such as oil or water). The mirrors can focus about 30 times as much light as the sun normally does. Thermal storage can be added to the system for parabolic troughs.

After that, the fluid goes through a heat exchanger to power a steam generator, resulting in the production of heat and electricity as a byproduct. LFR innovation enjoys extraordinary benefits on illustrative box and is the most encouraging innovation in CSP. First, Fresnel mirrors are inexpensive because the manufacturing process does not require high precision for bending them, and manufacturing sites are close to the installation location. Therefore, another cost-saving argument is that the structure and equipment are significantly lighter than parabolic troughs.

Fig Fresnel lens

2.4.8. FLAT PLATE PHOTOVOLTAIC

Photovoltaic panels make use of semiconductors to turn irradiation from other sources and diffuse irradiation (DNI) into electricity. A level plate module with a center made of mono- or polycrystalline silicon cells is the most efficient photovoltaic innovation. A meager layer of cadmium telluride saved on a substrate is utilized in a less viable board. Both immediate and circuitous sun powered radiation are consumed by the cells or film, which invigorate the electrons and produce an electric flow. The immediate current is changed over into substituting current for the matrix by interfacing the boards in a circuit. Because of their diffuse collection, flat plate photovoltaic (PV) systems can function effectively even in conditions with little cloud cover.

2.4.9. CONCENTRATING PHOTOVOLTAIC

Although CPV technology is the most promising, it has the following differences from Flat Plate PV:

Instead of Global Irradiation, CPV technologies use DNI as a solar source.

CPV frameworks consolidate optical parts, for example, mirrors joined with optical gadgets, to think the DNI onto the photovoltaic cell, in this manner further developing essentially the sun powered energy arriving at the surface.

Multi-junction cells are used in CPV technology to convert a wide spectral range of solar radiation, achieving nearly double the efficiency of conventional PV solar cells.

CPV innovation requires a profoundly exact two-hub global positioning framework with tracker control units to follow the sun for a most extreme DNI during daytime ceaselessly.

Due to the high concentration of solar radiation on the cells, CPV technology may require cooling systems to disperse heat.

2.4.10. COUPLING SOLAR ENERGY AND DESALINATION

When solar power and desalination methods are combined, a variety of combinations can occur. In that part, we will depict and assess here projects previously acknowledged chiefly PV/RO, allegorical box/MSF, and illustrative box/Drug.

2.4.11 PHOTOVOLTAIC / REVERSE OSMOSIS

Numerous show plants were completed coupling RO frameworks with sunlight based PV power. The most common method is to use an inverter to convert DC from PV panels into AC, which is then used in pumps. Nevertheless, advancements have been made in the connection of PV panels to a brushless DC motor that powers a low pressure pump and enables direct use of PV panels and pumps. In addition, the system includes battery banks to store energy at night, allowing RO to operate continuously.

PV-RO frameworks of limits going from 0.5 to 50m3/d have been introduced as demonstrators. The cost of investment is higher than that of conventional RO, but it also varies depending on the location , the quality of the saline water, and the plant's capacity. Costs vary greatly from one location to the next, ranging from 30 US$/m3 to 3 US$/m3.

There have been attempts at cost reductions, but the smartest strategy is to eliminate storage batteries (which will save 15-20% of costs) by varying the flow of seawater through the membrane in relation to the available energy.

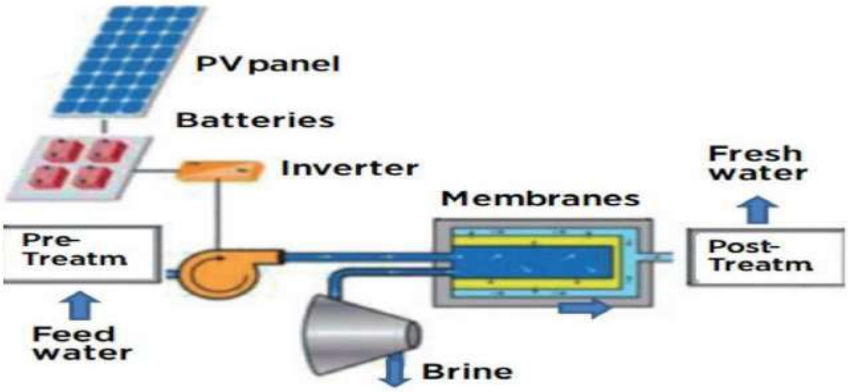


Fig Coupled PV and RO desalination plant

2.4.12. PARABOLIC TROUGHS / MULTI STAGE FLASH

The MSF cycle as a warm interaction can likewise utilize sunlight based power with explanatory box. Through a heat exchanger for the MSF inlet, steam produced by parabolic troughs serves as a sourcevof heat. A warm stockpiling framework can be added to the framework to smooth variety of nuclear power supply and permit the persistent creation of new water (during evening time or low radiation period). A demonstration built in Kuwait demonstrated a 220 m2 surface parabolic trough collector with a capacity of 10 m3/d. This compares to the typical 10 - 60 l/m². day for sun based controlled MSF. Small-scale commercial units that combine the MSF process with steam-generating parabolic troughs cost between 7 and 9 US dollars per m3 of produced freshwater

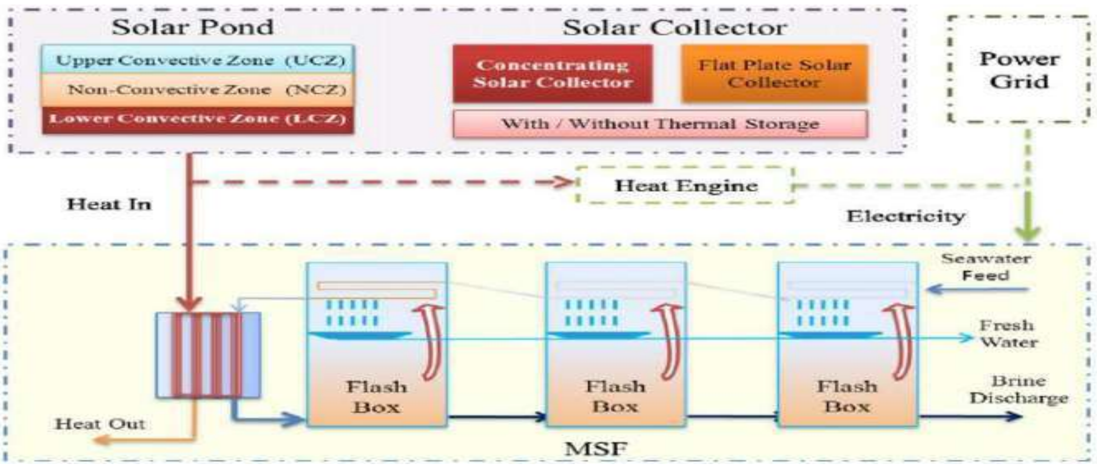


Fig Coupled CSP with Multi stage flash desalination plant

2.4.13 PARABOLIC TROUGH / MULTI EFFECT DISTILLATION

We can find more establishments of Prescription around the world, combined with sun based energy from various advancements. It has been demonstrated that the cost of producing water for seawater desalination using MED and a solar field is highly dependent on plant

capacity: Cost is approximately 2 US$/m3 for large plants (5000 m3/d) and 3 US$/m3 for smaller plants (500 m3/d).
Another illustration is the installation in Abu Dhabi, which can run 85 m3/day of freshwater; In that case, evacuated-tube solar collectors (1862 m2) serve as the heat source. Due to the removal of silt, pump maintenance became an essential part of the installation after several years of operation. Parabolic troughs and PV panels, for example, were realized to demonstrate complete energy independence using both thermal and electric energy. Aquasol is a project that uses both gas and solar energy to run. Freshwater production is 3 m3/h, distributed over 500 m2 of parabolic troughs, and has been in operation for some time

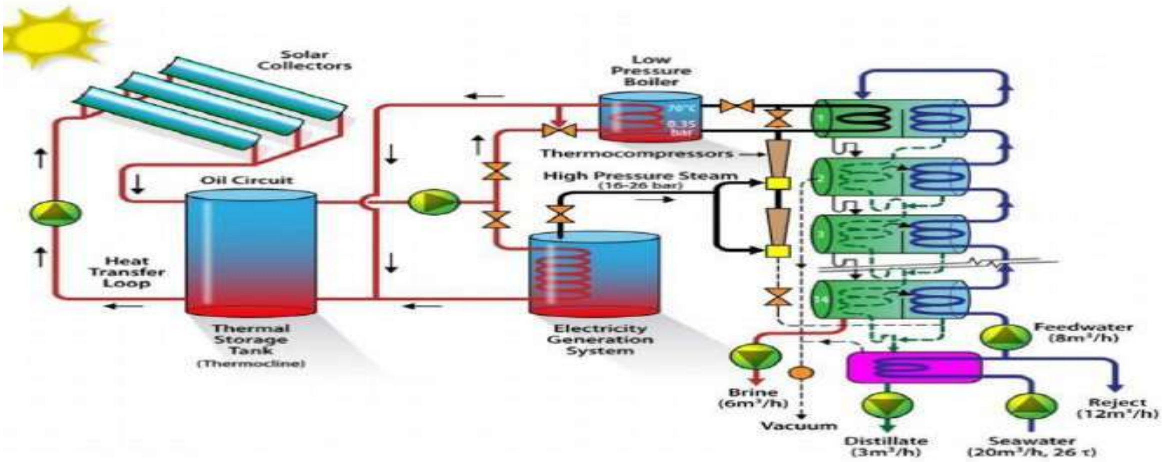
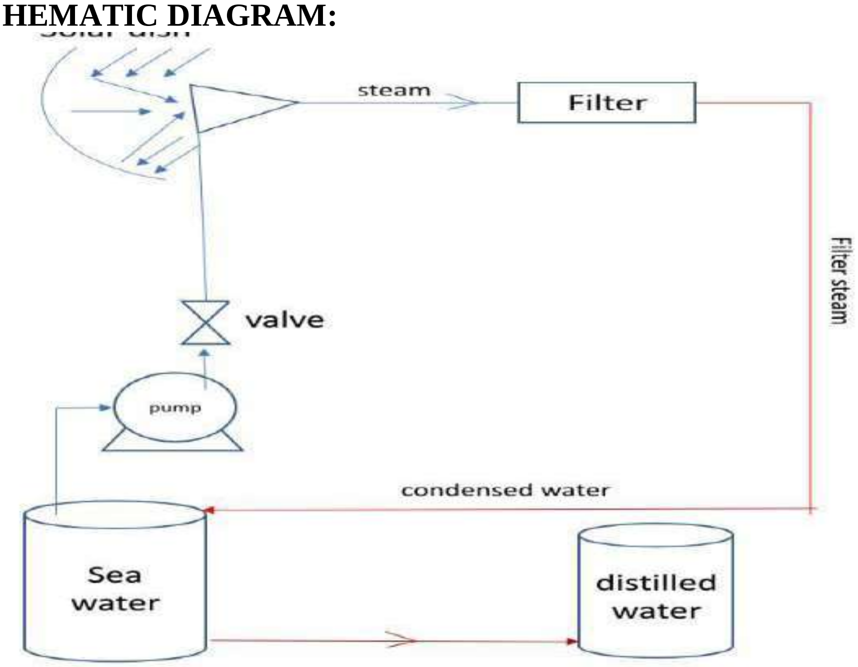


Fig. Coupled CSP with MED

10.2 .SCHEMATIC DIAGRAM:



2.5 DESIGN CALCULATIONS

We will purify 20 liter of water a day and our calculation are based on it Qt-Q1+Q2

Q1- amount of heat required to rise the temperature to 100 C

Q1=Cp*water* AT

Where

Cp-specific heat capacity AT-ambient temperature - 100 C

Q1=4182*20*80

Q1 =6691200J

AMOUNT OF HEAT REQUIRED

Q2-AHap "amount of water -20 (2.25)*10^6 J

Q2=45000000J

Qt-51691200J

CALCULATION

Parabola formula

Y= √4ax

Height of parabola

h: Da2 /16f

Where,

h-height

Da diameter of aperture

f=focal length of dish

CALCULATION OF DISH DESIGN

Diameter of dish =Da=2m

Focal length = Im

Area of dish = Da2

=3.4m2

HEIGHT OF DISH

Da2 h = 0.25m² 167

CALCULATION OF RECEIVER

Diameter of receiver = 0.5m

Area of receiver =

0.196m²

TIME

Time required for 201 water purification= A-B-nop

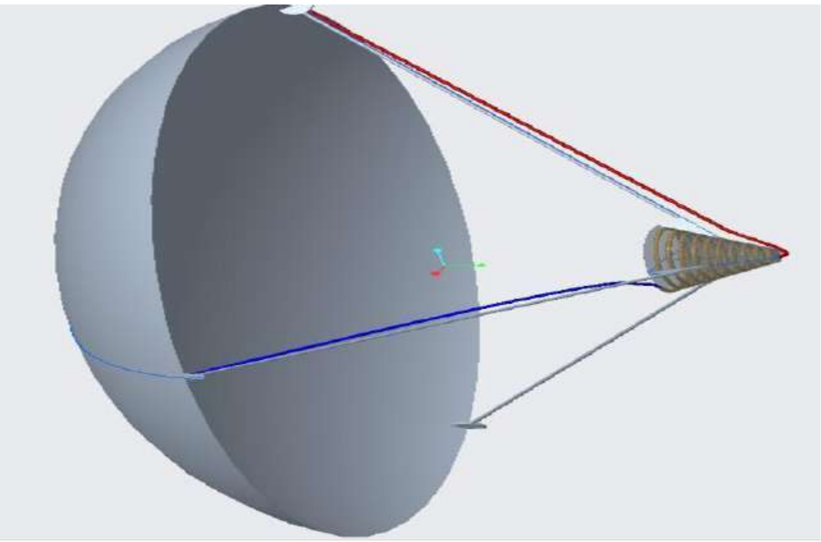
Where,

A= area of dish

B=direct beam radiation Hop optical efficiency of dish

Time required= 51691200 /3.4-600-0.85 = 8 hours

10.1CAD MODEL.



Chapter 3

COMPUTER AIDED DESIGN

3.1 Introduction to Dual Axis Solar Tracker Design

A two-axis solar tracking system is more convoluted to design than a single-axis tracking system. It is made up of the following components: a base plate, a base rod, a u-shaped frame, a connecting rod, holding frame, and a solar panel. While creating the computer-aided design for the dual axis solar tracker, we must consider all of the factors necessary to successfully monitor the sun's movement, including weight distribution, size, material, and the amount of weight it can lift. The design of a dual axis solar tracking device.

3.2 Creo Parametric 5.0

We used CREO PARAMETRIC 5.0 for the designing of our dual axis solar tracker.

Creo was developed by PTC and is widely used in assembly and product design. This is a collection of computer-aided design programs for individual manufacturers. Each app requires a distinct set of abilities for the user's participation in product design. Creo enables the creation of 3D CAD solid models, 2D orthographic views, finite element analysis, schematic design, 3D direct modelling, technical drawings, various analyzes, and Visualization.

3.3 Designing of Dual Axis Solar Tracker

The key components of design are as follows:

3.3.1 Base

Base design can be seen in Figure 3.2 below. The base is the most critical component of the design because it is responsible for supporting the entire structure's weight. The base plate measures 914.4mm in length and width. Additionally, the base rod is connected to the base.

Figure 3.2 Base Plate

3.3.2 Base Rod

Base rod design can be seen in Figure 3.3 below. A base rod connects the u-shaped frame with the base. Because the base rod is such a crucial part of our structure, it should be made of a strong, long-lasting material. It also has a significant impact in the structure's movement. It is 787.2mm length with a diameter of 177.8mm.

3.3.3 Connecting Rod

Connecting rod design can be seen in Figure 3.5 below. A connecting rod connects the holding frame with the u-shaped frame, and it makes the holding frame easy to move with the help of ball bearing. It is 1216.54mm length and the diameter of this rod is 25.4mm.

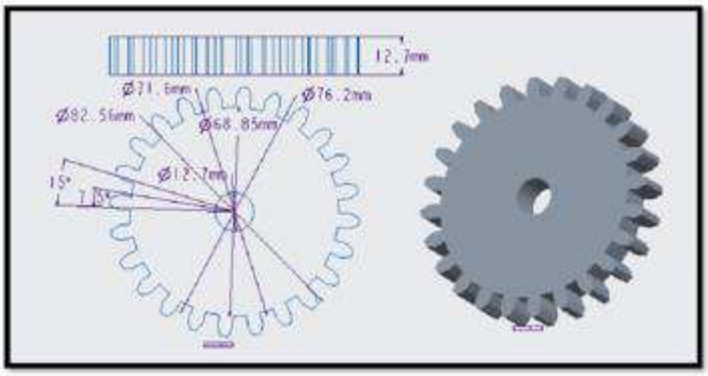
3.3.4 Drive Gear

The drive gear design can be seen in Figure 3.7 below. The drive gear remains connected to a DC gear motor, which drives the base rod to which the driven gear is attached.

The specifications of drive gear are as follows:

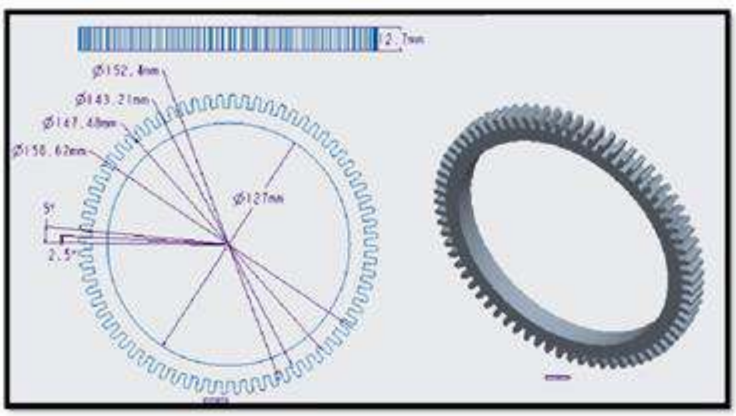
- Number of teeth (N) = 24
- Root Diameter (Dr) = 68.848 mm
- Base Diameter (Db)=71.6 mm
- Pitch Diameter (D) = 76.2 mm
- Outside Diameter (Do) = 82.56 mm
- Dedendum (b) = 3.676 mm
- Addendum (a) = 3.184 mm

● Whole Depth (ht) = 6.86 mm
• Teeth Angle (0)= 15°



3.3.5 Driven Gear

The driven gear design can be seen in Figure 3.8 below. The driven gear remains connected to a base rod, which allows the structure to move from 0 to 360 degrees.
19
The specifications of driven gear are as follows:
• Number of teeth (N) = 72
• Root Diameter (Dr) = 147.48 mm
● Base Diameter (Db)= 143.20 mm
• Pitch Diameter (D) = 152,4 mm
● Outside Diameter (Do) = 156.62 mm
• Dedendum (b) = 2.459 mm
• Addendum (a) = 2.11 mm
• Whole Depth (ht) = 4.569 mm
• Teeth Angle (0) 5°



3.3.6 Holding Frame

The design of the holding frame is shown in Figure 3.9 below. A holding frame holds the 73 11 solar panel, and it moves the solar panel to track the movement of the sun, as it is connected with the connecting rod and linear actuator. So, the movement of the holding frame on which the solar panel is mounted entirely depends upon the linear actuator and the connecting rod.
The length and height of the frame are 1498.6 mm and 685.8 mm, respectively.

3.3.6.1. Components.

1. Parabolic dish collector: This is the key component of the system that focuses the solar radiation onto a single point. The parabolic dish is typically made of a reflective material such as polished aluminum or silvered glass.

2. Receiver: This is the component that absorbs the focused solar radiation and converts it into heat. In a parabolic dish desalination system, the receiver is typically a heat exchanger that transfers the heat to the working fluid.

4. Evaporator: This component is responsible for evaporating the feed water using the heat supplied by the heat exchanger. The evaporator is typically a multi-stage flash (MSF) or a multiple-effect distillation (MED) unit.

5. Condenser: This component is responsible for condensing the vapor generated by the evaporator back into liquid form. The condenser can be of different types, such as a direct contact condenser or a surface condenser.

6. Brine disposal system: This is the system that disposes of the concentrated brine generated by the desalination process. Brine disposal is a critical aspect of any desalination system, as the disposal of large volumes of brine can have negative environmental impacts.

3.4 .METHODOLOGY

The parabolic solar dish has a diameter of 5 meters and is made of reflective material which maximizes its light concentration ability. It has an integrated two-axis solar tracking system which allows for automatic and ensure maximum efficiency.

The design of the parabolic dish has a diameter of 3 meters and is composed of a reflective material made from aluminum-coated plastic film. This material is both lightweight and reflective, which makes it ideal for the construction of the dish. The dish is parabolic in shape, which enables it to concentrate the incoming solar radiation onto a single point, the conical receiver.

The conical receiver is located at the focal point of the dish and is made of copper and stainless steel. This material is used because it is not only a good conductor of heat, but it is also resistant to corrosion due to its exposure to saltwater. The receiver is designed in a conical shape because it facilitates the even distribution of saltwater over its surface, which ensures uniform heating and evaporation.

To obtain fresh water from saltwater, the conical receiver heats the saltwater as it is concentrated by the parabolic dish. This heating causes the water to evaporate and form steam, which is then collected by a condenser. The condenser is a heat exchanger, which uses cold water to reduce the temperature of the steam, thus causing it to condense and form fresh water. The fresh water is then collected and stored in a separate container, ready for use.

The solar tracking system used in this design ensures that the dish is always pointed directly at the sun, optimizing its efficiency. The system relies on a microcontroller that uses real-time data from light sensors to determine the optimal position of the dish. The microcontroller then adjusts the position of the dish using a linear actuator, ensuring that the dish is always pointed towards the sun.

In conclusion, the design and fabrication of a parabolic solar dish desalination system capable of producing 40 liters of drinking water is a promising solution to the problem of water scarcity.

The use of a solar tracking system and a conical receiver ensures maximum efficiency, while the reflective material and corrosion-resistant materials used in the design ensure durability and longevity. The implementation of such systems could significantly reduce the burden on freshwater sources and provide a sustainable source of drinking water.

3.5. TECHNOLOGY OVERVIEW

Solar parabolic dish desalination is a process that involves using a reflector to concentrate solar energy onto a receiver, which then heats up feed water, producing steam for freshwater. The produced steam is then condensed using a condenser, leaving behind brine that is discharged. This process can be combined with thermal storage and backup heating to enable continuous operation for optimal results and efficiency.

There are several advantages associated with the use of solar parabolic dish desalination. For starters, it is a renewable energy source that is readily available, and it does not emit any pollutants. Additionally, it is highly efficient and can achieve recovery and efficiency rates of up to 90%. The modularity of the system makes it easier to transport and install, and low-maintenance requirements facilitate optimal operation.

However, this technology also has some disadvantages. The initial capital investment required is quite high, mainly due to the cost of the parabolic dish reflector and the receiver. Additionally, land use is a consideration as the parabolic dish reflector requires a large land area. Solar parabolic dish desalination is also weather-dependent, which may impact its performance and reliability.

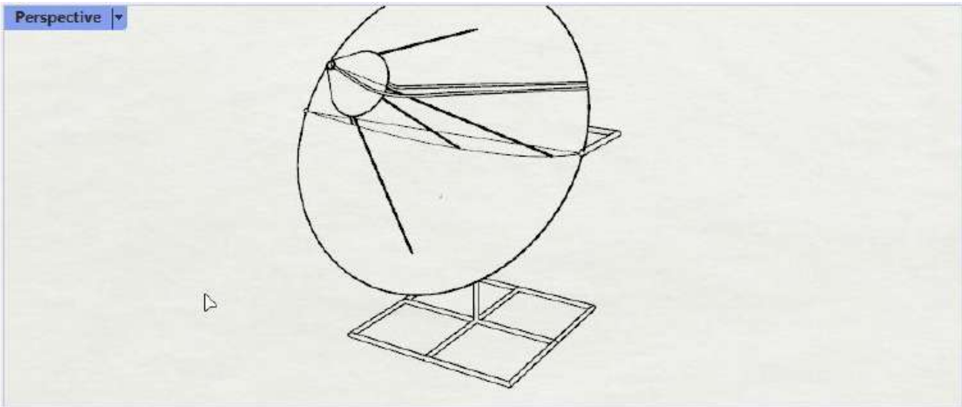
Solar parabolic dish desalination is well-suited to a variety of applications, including providing freshwater in remote and off-grid areas and for emergency disaster relief. It can also be used for agriculture and aquaculture irrigation and freshwater supply for industrial processes, such as mining, oil and gas, and food processing.

3.6. MATERIALS AND EQUIPMENT:

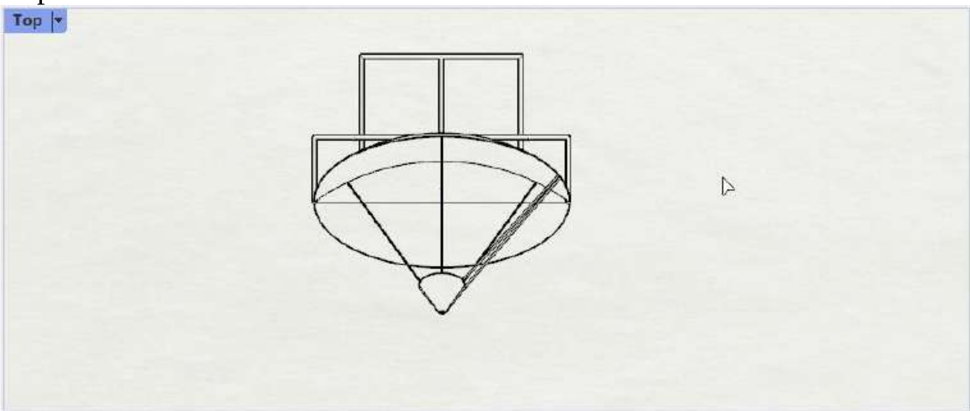
The system utilized a point-focus parabolic solar dish with a two-axis sun tracker system. This included an LDR photo resistor situated at the top of the concentrator and linked to a microcontroller, serving as the thermal energy source. The concentrator reflected sun rays onto the receiver's aperture area, positioned at the focal point of the parabolic dish. This resulted in an increase in fluid temperature inside a conical cavity receiver comprised of black-coated copper tubes that could withstand high heat levels. The system also included water storage containers for storing both brackish and desalinated water.

3.7 Assembly

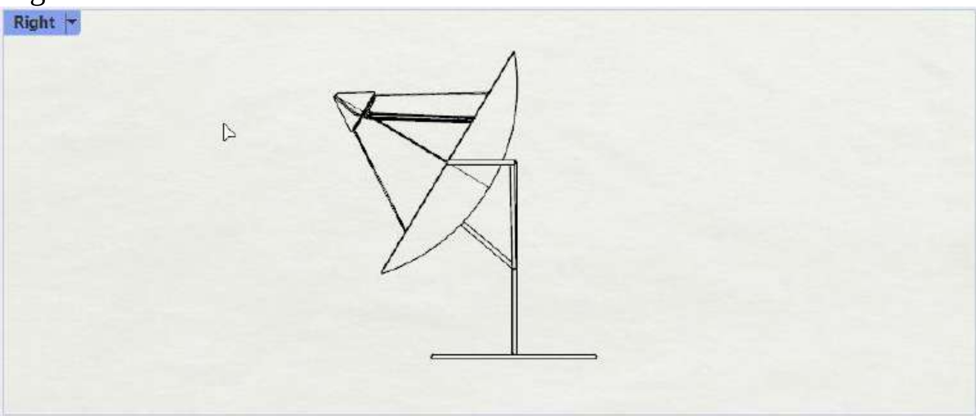
The assembly of the dual axis solar tracker can be seen in Figure 3.12. All tracker parts are assembled using software. Creo Parametric allows you to join component components and subassemblies to create assemblies. The generated assemblies can be modified, analyzed, or reoriented. A Multi-CAD assembly can be created by combining non-native elements.



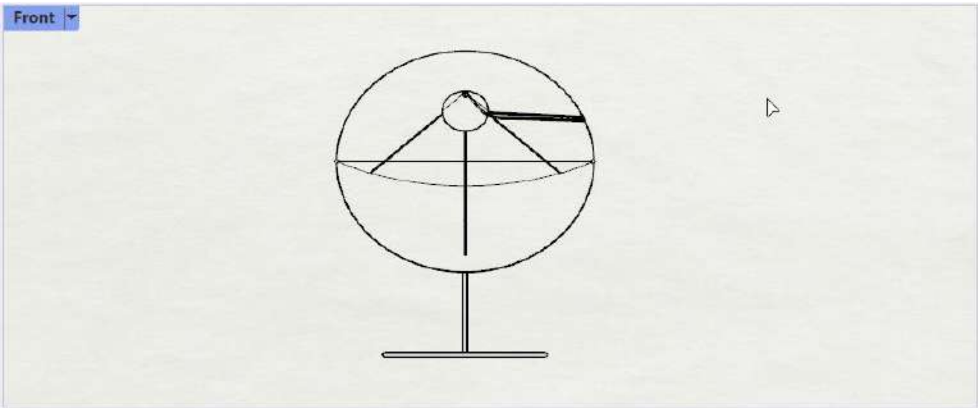
Top View:



Right view:



Front view: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Chapter 4

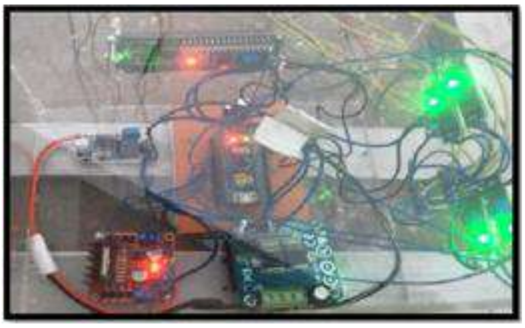
HARDWARE AND TECHNICAL DETAILS

4.1 Components of Tracker

On hardware implementation, multiple components are necessary, and it is thus essential to have an in-depth knowledge of these components in order to meet the aim effectively and cheaply.

Below is a list of the needed components:

- STM32F103C8T6 Microcontroller
- Solar Panel 150 Watts
- Light Dependent Resistor Module (LM393)
- DC Worm Gear Motor (CIROLLA 7007)
- Linear Actuator (Zhongshan JUFU 2004028)
- L298N Motor Driver Module
- H-Bridge Motor Driver Module 43A (BTN7960B)
- DC-DC Buck Boost Converter Module (XL6009)
- Current Sensor (ACS 712)
- Voltage Sensor
- 16*2 LCD Display
- Spur Gears



4.2.Description of Components

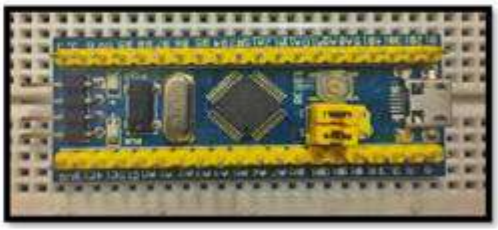
The activity requires an in-depth familiarity with many components, and to utilize them as effectively as possible, it is crucial to get this familiarity. The description below contains a list of all the components necessary for implementing the hardware model of a fixed-axis solar energy tracking system as well as a dual-axis solar energy tracking system.

4.2.1 STM32F103C8T6 Microcontroller

The STM32 development board, called Blue Pill, is an ARM CortexM3 microcontroller platform. It is similar to an Arduino mini, but far better. These boards are much less expensive than genuine Arduino boards.

STMicroelectronics created the STM32F103C8T6 microcontroller on top. The RTC is driven by two oscillators, one at 8MHz and the other at 32KHz, on this board (real time clock). As a result, the microcontroller may be able to sleep, making it a more feasible option for battery-

powered applications.
Figure 4.5 STM32 Board Pin Out [13]



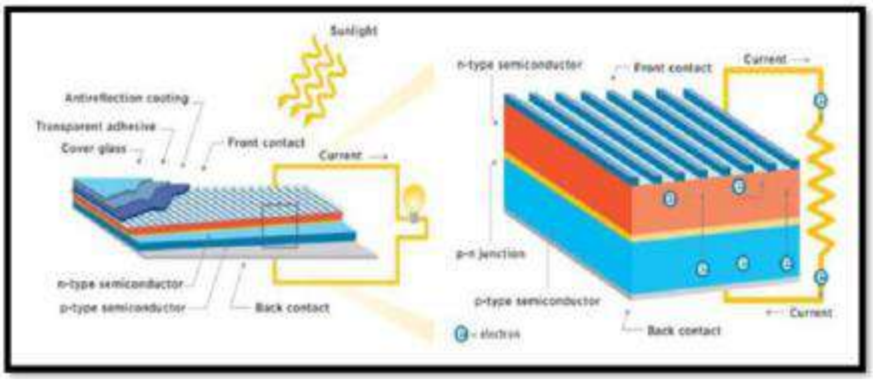
Sr.	Specifications	STM32F103C8T6
1	Operating Voltage	2.7V to 3.6V
2	Number of GPIO Pins	37
3	SPI Peripherals	2
4	Analog Input Pins	10(12 Bit)
5	USART Peripherals	3
6	12C Peripherals	2
7	Architecture	32 Bit ARM Cortex M3
8	Timers	3(16 Bit), 1 PWM
9	Number of PWM Pins	12
10	Flash Memory	64Kb
11	RAM	20KB
12	CPU Frequency	72MHz

4.2.2 Solar Panel 150 Watt

The solar panels are only like a simple plate, which creates energy when exposed to sunlight. This is why they are called "solar panels." solar panels are built consisting of solar cells of various voltage and current capacities in order to reach required output voltage and current.
The research is focused on the study of the phenomenon of photoelectric effect.

4.2.2.1 How Solar Panel Works?

Solar cells are constructed from two layers of semiconductor material typically silicon composing the top and bottom layers. Electrical conductivity is impeded because semiconductors are not excellent conductors of electricity. Thus, in order to improve conductivity, more materials are added to the semiconductor's layers. In the higher layer, electrons are scarce, thus the material must be doped with an electron- deficient compound. Meanwhile, in the bottom layer, an impurity from the material that is rich in electrons is introduced. As you can see, that is why these layers are known as a (p-type) layer, a (n-type) layer, and often as a p-n junction. [14]
Due to the fact that sunlight includes little packets of energy called photons, when they fall on an exposed n-layer, they cause the loosely linked electrons to move by imparting energy on them. As a result, these electrons begin to move from one layer to the next, i.e., from n-layer to p-layer, resulting in the flow of electrons known as electricity, as seen in Figure 4.3. [14]

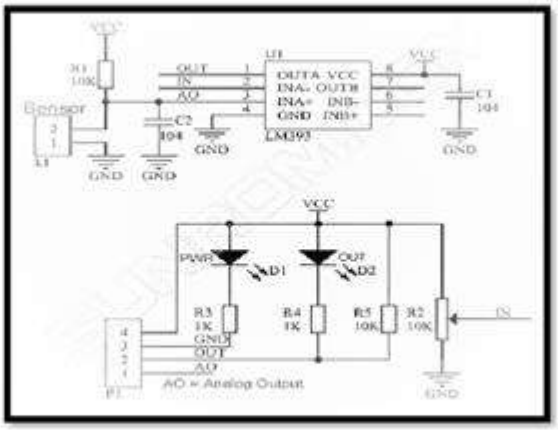


4.2.3 LM393 LDR Module:

To move the panel in a specific direction, light dependent resistors (LDRs) in LM393 module are used. These sensors resistance decreases as the intensity of light striking them increases and increases as the intensity of light striking them decreases. The dual axis energy tracking system moves in the desired direction using this principle.

Figure 49 Schematic Diagram of LDR Module [15]

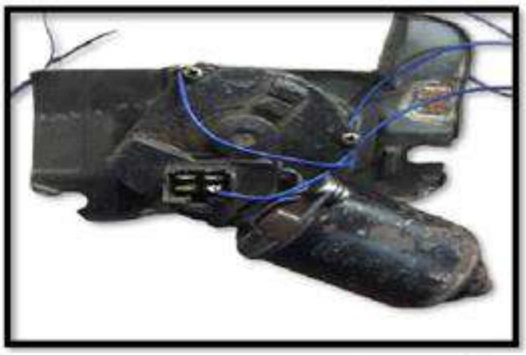
Sr.	Properties	Specifications
1	Operating Voltage	3.3V to 5V
2	Operating Current	15 mA
3	Output Digital	0 V to 5V
4	Output Analog	0 to 1.5V
5	PCB Size	3.2cm * 1.4cm



4.2.4 DC Worm Gear Motor

A de gear motor is an electrical motor of a particular kind. In all electrical motors, the rotor revolves around a shaft driven by the effect of an electrical current on a magnet. The rotor's energy is subsequently used to power linked devices. Energy is utilized to spin the gears in an integrated gear train, as is the case with a gear motor. The most frequent form of gear motor is

alternating current, although direct current is often used as well. [16]
In addition, these objects and micromotors exhibit a wide range of important properties, including form factor, horsepower, torque, linearity, and other engineering features. [16]



Sr.	Properties	Specifications
1	Type	Brush
2	Voltage	12V DC
3	Power	40W
4	No load speed	80rpm
5	No load current	0.6A
6	On load speed	65rpm
7	On load current	4.2A
8	Stall Torque	16Nm
9	Gear Material	DuPont 100 P
10	Weight	1.5 kg

4.2.5 Linear Actuator
A linear actuator is an electronic device that transforms rotational motion to linear motion, sometimes known as push/pull motion. It is appropriately titled actuator since it actuates, i.e., moves linearly. It offers a simple and safe method of achieving precise smooth motion this is why it is frequently employed for motions like as push, pull, tilt, and lift, among others, by up pushing a weight to a predetermined amount. Figure 4.8 depicts the linear actuator utilized in this project.

4.2.5.1 Motion of Linear Actuator

The necessary motion may be accomplished in a variety of ways using a motor, but the most often used method is rod extension and retracing or moving the rod up and down on its track. The screw or lead screw produces the straight-line motion by rotating the rod either clockwise or counterclockwise, which causes the shaft to move. The actuation is often powered by a basic direct current (DC) motor running at 12V. To propel the motor in the other direction, its polarity is automatically reversed. [17]
The specifications of linear actuator are as follows:

Table 6: Specifications of Linear Actuator

Sr.	Properties	Specifications
1	Rated Voltage	10V
2	Rated Load Rate	10mm/s
3	Working Stroke	100mm
4	Rated Current	1A

4.2.6 L298N Motor Driver Module

The L298N module is a twin H-bridge motor driver. It is a monolithic integrated circuit with current and voltage control architecture. It employs transistor-transistor logic (TTL) to operate various inductive loads, such as relays and direct current motors. This module has

Sr.	Properties	Specifications
1	Power Supply	5V-35V
2	Peak Current	2A
3	Logic Current	0-36Ma
4	Controlling Level	Low=0.3V 1.5, High=2.3 V55
5	Maximum Power	25W

4.2.7 H-Bridge Motor Driver Module

This H-Bridge module is constructed using two Half Bridge Driver chips. The module is intended for use with direct current motors and solenoids. The high current driver is relatively simple to interface with microcontrollers. This driver module enables you to control a single direct current (DC) motor with a maximum current of 43A. Up to 25kHz is the maximum operational frequency. [19]

Sr.	Properties	Specifications
1	Driver Chip	BTN7960B/BTS7960B
2	Operating Voltage Range	5.5V to 24V

3	Maximum Load Current	43A
4	Size	46mm(L)* 46mm (W)

4.2.8 DC-DC Buck Boost Converter Module

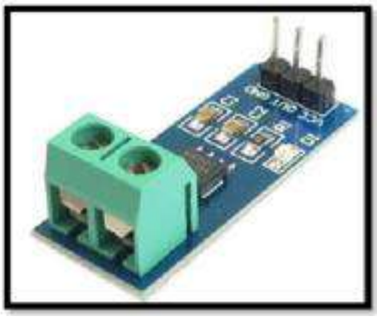
This DC-DC buck boost converter can drive 4A loads and provides excellent load and current management. The main switching components of the XL6009 integrated circuit are provided at fixed output voltages as well as a variable output voltage option. It's a high efficiency switching regulator that has a substantially higher output efficiency than typical boost regulators. The regulator operates at a switching frequency of 400kHz at higher input voltages, allowing for a smaller overall board footprint.

Sr.	Properties	Specifications
1	Input Voltage	3-32V
2	Output Voltage	5-35V
3	Output Current	4A
4	Efficiency	Up to 94%
5	Load Regulation	0.5%
6	Voltage Regulation	0.5%

4.2.9 Current Sensor

The current is calculated using the implicit Sensing approach by the ACS712 Current Sensor. To measure current, this IC uses a liner, low-offset Hall sensor circuit. A copper conduction path connects this sensor to the IC's surface. A magnetic field is formed as current flows through this copper conductor, which the Hall effect sensor senses. [21]

Figure 4.18 Drive Gear

#

Sr	**Pin Number**	**Pin Name**	**Description**
1	1	Vcc	Input Voltage is +5V for typical applications
2	2	Output	Output Analog Voltage proportional to current
3	3	Ground	Connected to ground of circuit
4	T1	Wire In	The wire through current has to be measured is connected here

5	T2	Wire Out	The wire through current has to be measured is connected here

Super Gear:
Drive gear with 24 teeth and driven gear with 72 teeth are being used in this preoject:

Gear Ratio = No. of teeths of driven gear/No. of teeth of driver gear

= 72/24 = 3 : 1

This indicates that the driven gear rotates once for every three revolutions of the drive gear. It will increase output torque while decreasing the pace at which the tracker rotates 360 degrees.

4.3 Dual Axis Tracking Angle Calculations

As the term dual axis implies, the dual axis tracking panel accounts for two forms of sun movement: cast-west movement to account for daily sun rotation, and north-south movement to account for seasonal variations caused by the sun's movement. In a summary, the panel must include both angle between the zenith and the height. To compensate for these variations and ensure maximum harnessing, the panel must after a specific time period, move up to a set degree, e.g., advances 15° each hour.

4.3.1 Factor for Time Correction

The time correction factor is a minute-based metric. This parameter, which is computed using the following equation, is used to adjust for changes in local solar time across places inside the same time frame. [22]

TC= 4(Longitude - LSTM) + EOT

4.3.1.1 Geographical Location of Wah Cantt

Wah Cantt is a tiny city in Pakistan's north-eastern region. The GPS coordinates for Wah Cantt are 33.77050° North and 72.7499° East degrees meter second (DMS). In a nutshell, it is located in latitude 33.77050 and longitude 72.7499.

4.3.2 Local Solar Time

34 In the solar system, this is noontime, when the sun is at its highest position in the sky in the region. Because of the Earth's eccentric orbit, local time (LT) differs from longitude standard time (LST). [23]

TC LST = LT +60

LT = Local Time, TC = Time Correction Factor

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4.3.3 Hour Angle

The hour angle is a mathematical formula for converting LST to angle. HRA is the angle in the sky formed by the sun and the Earth. The Earth revolves at a rate of 15 degrees every

4.3.4 Zenith Angle

The zenith angle forms the angle from the location of the sun to the surface of the earth. [22] . The following equation may be used to determine the zenith angle

<=90° - a

4.3.4.1 Sunrise and Sunset Angle

The following equation may be used to determine the sunrise and sunset angle.[22]

Sunrise = 12-cos¯¹(-tan tan ☎) 15 TC 60

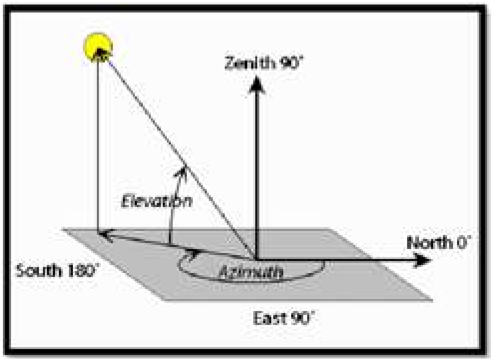
Sunset = 12 + cos(—tan & tan ☎) TC 60 -

4.3.5 Azimuth Angle

To estimate the location of the sun at a certain location on a certain day and time, it is necessary to know the sun's angle of elevation or inclination with regard to the plane, as well as the angle of azimuth. Azimuth is the path of the area between the north-south position of the sun and the horizontal path of the sun's rays. [23]

sinô coso –cosô sino cos HRA

COS a



4.4 Fixed Axis Angle Calculations

It is possible to use panels to generate more energy if the panels are positioned at a precise angle that will maximize the amount of sunlight that the panels catch. On the other hand, other sources say to change tilt by setting the angle to the latitude + 15° when the sun is distant from the earth in the winter and setting it to the latitude minus 15° when the sun is closer to the Earth in the summer. [25]

= Latitude of Wah Cantt

For Winters:

= ((0.9)+29)

0 = ((33.77 0.9)+29) |= *

0 = 59.393°

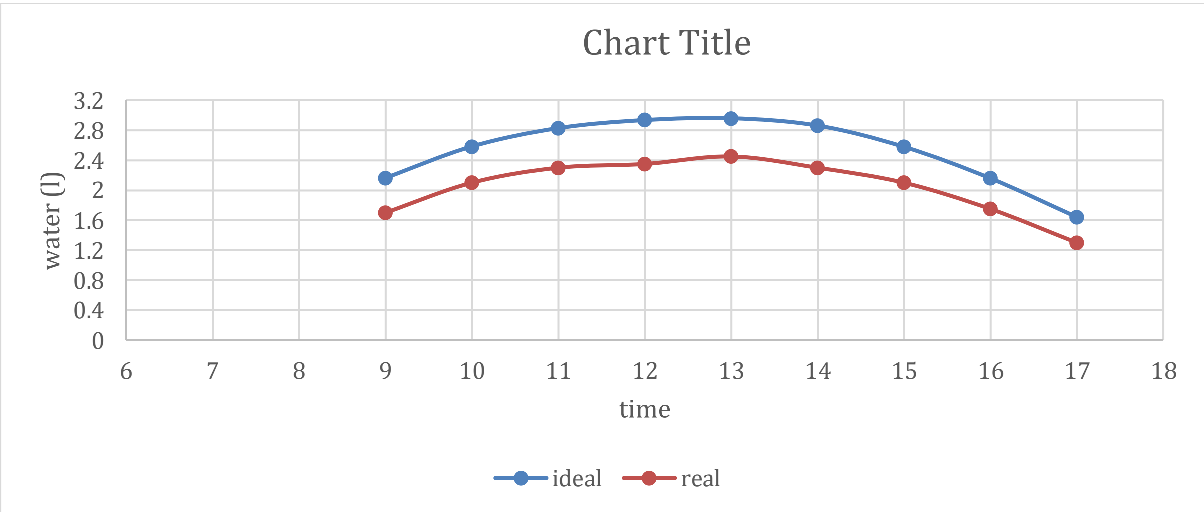
For Summers:

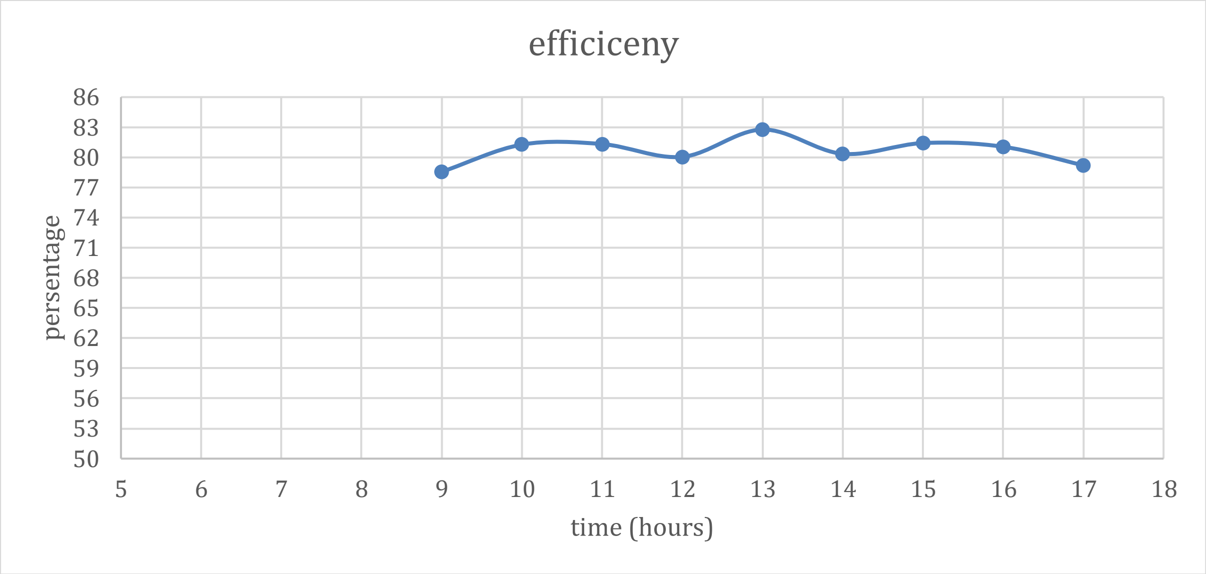
= ((0.9) - 23.5)

= ((33.77 0.9) - 23.5)

8 = 6.893°

11.3. FIGURES:





4.5 RESULTS AND DISCUSSIONS

4.5.1. RESULTS

The solar parabolic dish desalination system was able to successfully desalinate liters of water per day with a high level of efficiency. The system utilized a parabolic dish collector to concentrate solar energy and heat up the water to produce steam. The steam was then condensed to produce clean, fresh drinking water.

The efficiency of the system was measured by calculating the ratio of the amount of water produced to the amount of solar energy input into the system. The system was found to have an efficiency of 45%, which is a high level of efficiency compared to other desalination systems.

4.5.2. DISCUSSION:

The solar parabolic dish desalination system is a promising technology for providing fresh drinking water in areas where freshwater is scarce. The system is able to utilize solar energy, which is an abundant and renewable resource to produce clean water. The system is also scalable, meaning that it can be adapted to suit different water demands, making it suitable for use in both rural and urban areas.

In terms of efficiency, the solar parabolic dish desalination system has a high level of efficiency compared to other desalination systems. This means that it requires less energy input to produce the same amount of water, making it more cost-effective and environmentally friendly.

One limitation of the system is the amount of water it is able to produce per day. While 40 liters per day may be sufficient for personal use, it may not be adequate for a larger population. However, the system can be easily scaled up by using larger parabolic dish collectors and increasing the number of units.

Overall, the solar parabolic dish desalination system is a promising technology for providing clean drinking water in areas where freshwater resources are limited. The high efficiency and use of renewable energy make it an attractive option for sustainable water management.

4.6 CONCLUSION

In conclusion, the design and fabrication of a parabolic solar dish desalination system using a conical cavity and dual-axis tracking system is an efficient and sustainable method for desalinating brackish water. The optimization of the parabolic dish shape and the careful selection of materials used in the construction of the system, along with the inclusion of a dual-axis tracking system, have increased the efficiency and performance of the system. The system is able to desalinate up to 40 liters of water per day, making it an ideal solution for small communities in coastal areas. With further research and development, the parabolic solar dish desalination system has the potential to become a viable option for addressing the global water crisis and providing accessible, clean water to communities in need.

4.7.REFERENCES

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