**A**

**Seminar Report**

**On**

# "Solar Tower Technology: Harnessing Sunlight for Sustainable Power Generation"

Submitted

In partial fulfilment of the requirements for the degree

Of

Bachelor of Engineering

in

Electrical (Electronics &Power) Engineering

Sant Gadge Baba Amravati University, Amravati


Submitted by

Mr. Amogh Jaronde

Under the esteemed guidance of

Mr. P. R. Dhabe




Department of Electrical Engineering

Shri Sant Gajanan Maharaj College of Engineering, Shegaon,

Dist. - Buldhana – 444 203 (Maharashtra)


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Shri Sant Gajanan Maharaj College of Engineering, Shegaon,
Dist. -Buldana-444203(Maharashtra),
India
(2023-2024)

# Certificate

The seminar report entitled **"Solar Tower Technology: Harnessing Sunlight for Sustainable Power Generation"** is hereby approved as a creditable study carried out and presented by **Mr. Amogh Jaronde** in a manner satisfactory to warrant its acceptance as a prerequisite in a partial fulfilment the requirements for degree of **Bachelor of Engineering Electrical** of Sant Gadge Baba Amravati University, Amravati.

Mr. P. R. Dhabe
Guide

Dr. S. R. Paraskar
Head
Department of Electrical Engineering

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Place: Shegaon

Mr. Amogh Jaronde

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# ABSTRACT

This report contains the design basis for a generic molten-salt solar power tower. A solar power tower uses a field of tracking mirrors (heliostats) that redirect sunlight on to a centrally located receiver mounted on top a tower, which absorbs the concentrated sunlight. Molten nitrate salt, pumped from a tank at ground level, absorbs the sunlight, heating it up to 565°C.

The heated salt flows back to ground level into another tank where it is stored, then pumped through a steam generator to produce steam and make electricity. This report establishes a set of criteria upon which the next generation of solar power towers will be designed.

This tower can generate electricity by using turbine. Tower generate to run 1, 50, 000 homes. This is non-flammable & non-toxic Solar power tower fuelled by sunshine & do not release greenhouse gases. Solar tower can produce air above 1000 degree Celsius or synthesis gas for gas turbine operation.

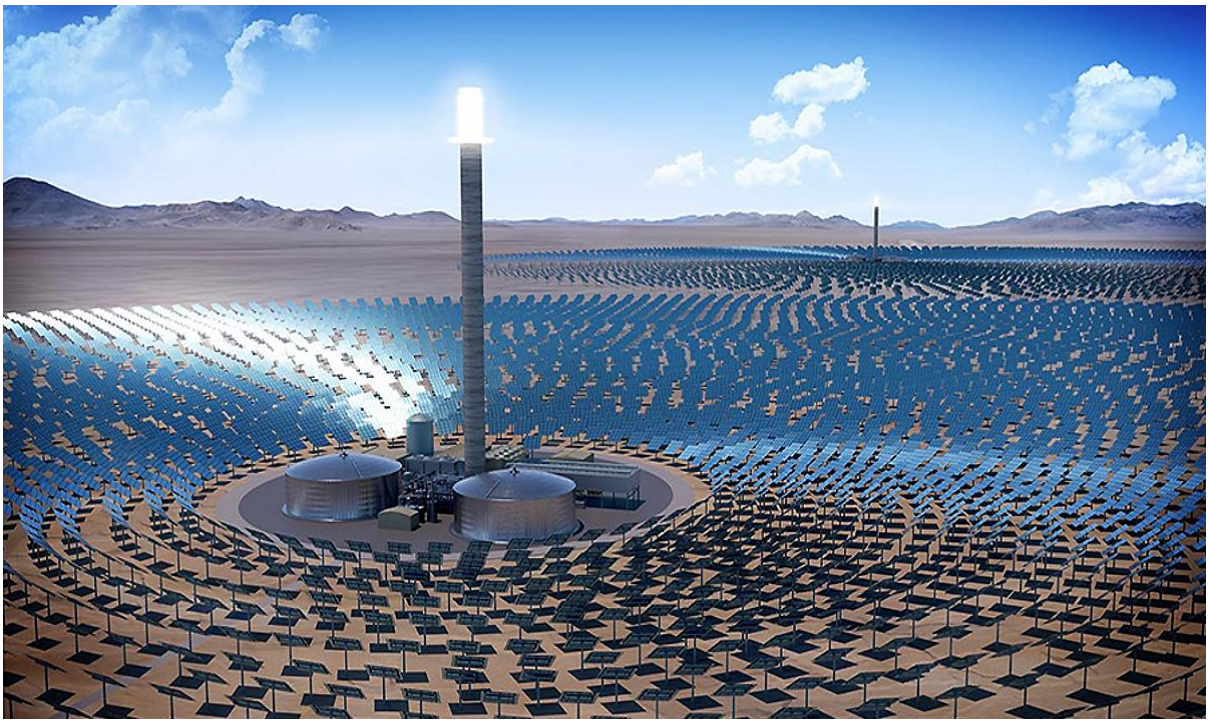
# INTRODUCTION:

Solar power towers generate electric power from sunlight by focusing concentrated solar radiation on a tower-mounted heat exchanger (receiver). It uses an array of flat, moveable mirrors (called heliostats) to focus the sun's rays upon a collector tower (the target).

The high energy at this point of concentrated sunlight is transferred to a substance that can store the heat for later use. The more recent heat transfer material that has been successfully demonstrated is liquid sodium.

Sodium is a metal with a high heat capacity, allowing that energy to be stored and drawn off throughout the evening. The solar power tower, also known as 'central tower ‘, power plants or 'heliostat' power plants or power towers, is a type of solar furnace using a tower to receive the focused sunlight. It uses an array of flat, movable mirrors (called heliostats) to focus the sun's rays upon a collector tower (the target). Concentrated solar thermal is seen as one viable solution for renewable, pollution-free energy.

Early designs used these focused rays to heat water and used the resulting steam to power a turbine. Newer designs using liquid sodium have been demonstrated, and systems using molten salts (40% potassium nitrate, 60% sodium nitrate) as the working fluids are now in operation. These working fluids have high heat capacity, which can be used to store the energy before using it to boil water to drive turbines. These designs also allow power to be generated when the sun is not shining.



# HISTORY:

Solar technology is not new process. Its history spans from the 7thCentury B.C. to today. We started out concentrating the sun's heat with glass and mirrors to light fires. Today, we have everything from solar-powered buildings to solar powered vehicles.

During the operation of Solar One, research began on the more advanced molten-salt power tower design described. This development culminated in the Solar Two project.

Solar Two, which is currently going through its startup phase, will generate (in addition to electric power) information on the design, performance, operation and maintenance of molten-salt power towers. The largest power towers ever built are the 10 MW (Solar One and Solar Two plants). Assuming success of the Solar Two project, the next plants could be scaled-up to between 30 and 100 MW.

As non-polluting energy sources become more favoured, molten-salt power towers will have a high value because the thermal energy storage allows the plant to be dispatch able. The value of power is worth more because a power tower plant can deliver energy during peak load times when it is more valuable.

One possible concern with the technology is the relatively high amount of land and water usage.

# LITERATURE SURVEY:

International Energy Agency (IEA) This report provides a global outlook on concentrating solar power (CSP), including solar power towers. It relies on data collection and analysis from CSP projects worldwide to assess the growth and potential of the technology. The methodology involves compiling information on operational CSP plants, installed capacity, cost trends, and policy support. Weizhong Zhao et al [4] This comprehensive review paper employs a systematic approach to provide an overview of solar power towers. The methodology involves a thorough literature review of existing research on solar power towers, including receiver technology, heliostat field design, and performance modelling. The authors also discuss recent developments and research gaps in the field. Manuel Romero et al [3] This paper focuses on advances in CSP technologies, including solar power towers. The methodology includes a review of recent innovations and developments in CSP technology, with a particular emphasis on solar tower advancements. The authors analyse the technical aspects and performance improvements in CSP systems and discuss the implications for future research and deployment. Aldo Steinfeld et al [3] This review paper delves into the thermodynamics, heat transfer, and optics of solar power towers. The methodology involves a detailed examination of the fundamental principles governing the operation of solar power towers. The authors discuss the theoretical aspects, modelling approaches, and experimental studies related to heat transfer and optics, providing insights into improving system efficiency. Bryan M. Jenkins et al [2] This survey explores technological advancements and innovations in solar power towers. The research methodology involves an in-depth analysis of recent developments, materials, coatings, and system enhancements. It aims to categorize and evaluate the impact of these innovations on overall system and cost-effectiveness, with the goal of providing insights into the future of solar power tower technology.

# SYSTEM DESCRIPTION:

Solar power tower converts sunshine into clean electricity. The technology uses many large, sun-tracking mirrors commonly referred as heliostats to focus sunlight on a receiver at the top of a tower.

The gained thermal energy can be used for heating water or molten salt, which saves the energy for later use. Heated water converts to steam, which is used to move the turbine-generator. This way thermal energy is converted into electricity.

Water is the oldest and simplest way for heat transfer. But the difference is that the method in which molten salt is used, allows storing the heat when the sun is behind clouds or even at night.

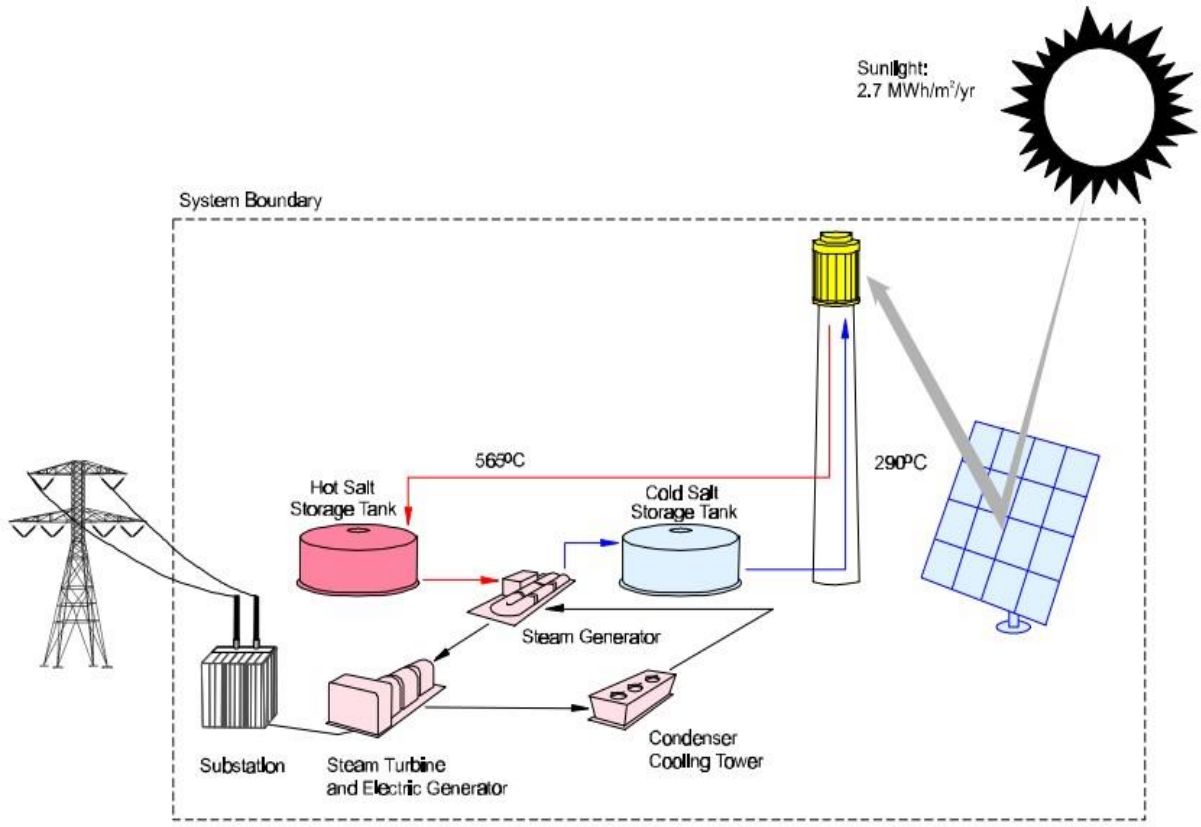



Figure 1. Molten-salt power tower system schematic (Solar Two, baseline configuration).

# DESIGN:

Some Concentrating Solar Power Towers are air-cooled instead of water-cooled, to avoid using limited desert water Flat glass is used instead of the more expensive curved glass.

Thermal storage to store the heat in molten salt containers to continue producing electricity while the sun is not shining Steam is heated to 500 °C to drive turbines that are coupled to generators which produce electricity.

Control systems to supervise and control all the plant activity including the heliostat array positions, alarms, other data acquisition and communication. Generally, installations use from 150 hectares (1,500,000 m2) to 320 hectares (3,200,000 m2).

The Pit Power Tower[12] [13] combines a Solar Power Tower and an Aero-electric Power Tower[14] in a decommissioned open pit mine. Traditional Solar Power Towers are constrained in size by the height of the tower and closer heliostats blocking the line of sight of outer heliostats to the receiver. The use of the pit mine's "stadium seating" helps overcome the blocking constraint.

As Solar Power Towers commonly use steam to drive the turbines, and water tends to be scarce in regions with high solar energy, another advantage of open pits is that they tend to collect water, having been dug below the water table. The Pit Power Tower uses low heat steam to drive the pneumatic tubes in a co-generation system. A third benefit of re-purposing a pit mine for this kind of project is the possibility of reusing mine infrastructure such as roads, buildings and electricity.

TOWER (RECEIVER): The tower is a 1000m tall thin concrete shell of 120m internal diameter. It is based on a slab Foundation. Wall thickness at the top is expected to be around 3 cm. The first 80m Of the tower comprise 32 radial support buttresses (inlets) arranged circumferentially, between each of which is a single turbine exhaust duct. This represents a huge design and construction challenge that has required exacting studies especially with respect to wind loadings. The size and design of the slab foundation and the complex structural base of the tower is not only dependent on the wind loads but on the soil properties of the selected site that has been found to be geotechnically appropriate. However temperature loads and construction imperfections may contribute to induced stress and should all be carefully studied.

HELIOSTAT: Most modern heliostats are controlled by computers. The computer is given the latitude and longitude of the heliostat's position on the earth. From these using astronomical theory, it calculates the direction of the sun as seen from the mirror, e.g., its compass bearing and angle of elevation. Then, given the direction of the target, the computer calculates the direction of the required angle-bisector, and sends control signals to motors, often stepper motors, so they turn the mirror to the correct alignment. This sequence of operations is repeated frequently to keep the mirror properly oriented. Large installations such as solar-

thermal power stations include fields of heliostats comprising many mirrors. Usually, all the mirrors in such a field are controlled by a single computer.

TURBINE GENERATORS: The horizontal axis turbines are arranged radially outside the tower support walls, equally spaced and concentric. This arrangement makes it easier to optimize machine layout with tower base design. 32 shrouded axial turbines are proposed for the 200MWe Solar Tower. The advantages claimed for shrouded turbines are greater power output for a given rotor diameter (up to 8 times with double the on-blade air velocity) and higher efficiency (up to 80% compared with 20% to a maximum of 30% for conventional open wind turbines). Individual turbine peak ratings of 6.25M We would meet the 200MWe plant design output. Wind velocity over the turbine blade cross section will range between approximately 4m/s and 18m/s.

GENERATORS: The generators proposed are 1 IkV synchronous machines with either static or brushless Excitation. Grid connection of the 32 Solar Tower generators will require step u transformers with on load tap changing facilities to meet voltage regulation and reactive power requirements. The control system will be simple and no unusual risks are foreseen.

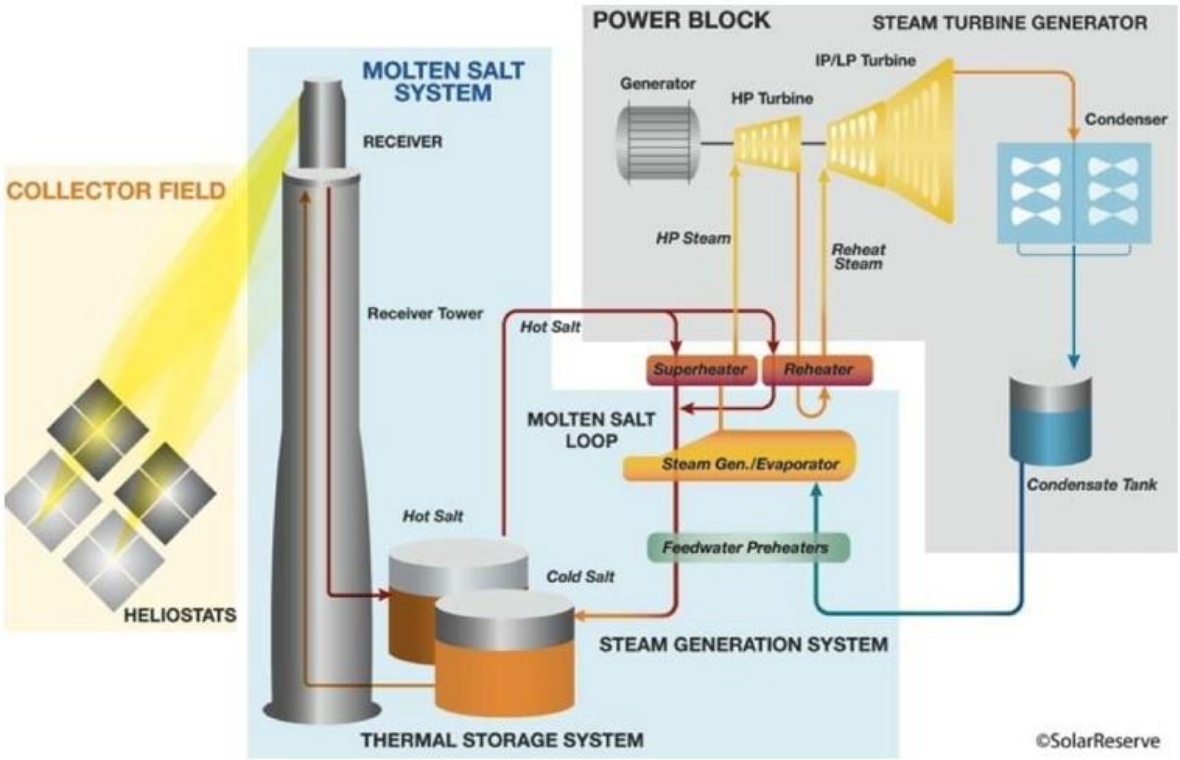



**Fig:**-working of solar power tower

# WORKING:

Solar towers use heliostats (or dual-axis sun-tracking mirrors) to reflect the sun's heat onto a single receiver point. This technology is favor because it can generate more heat than other technologies, has great economies of scale, and can integrate storage. That heat could be used for industrial processes, such as steam production, as well as generating electricity. Generally, the more heat that is created, the more efficient the plant.

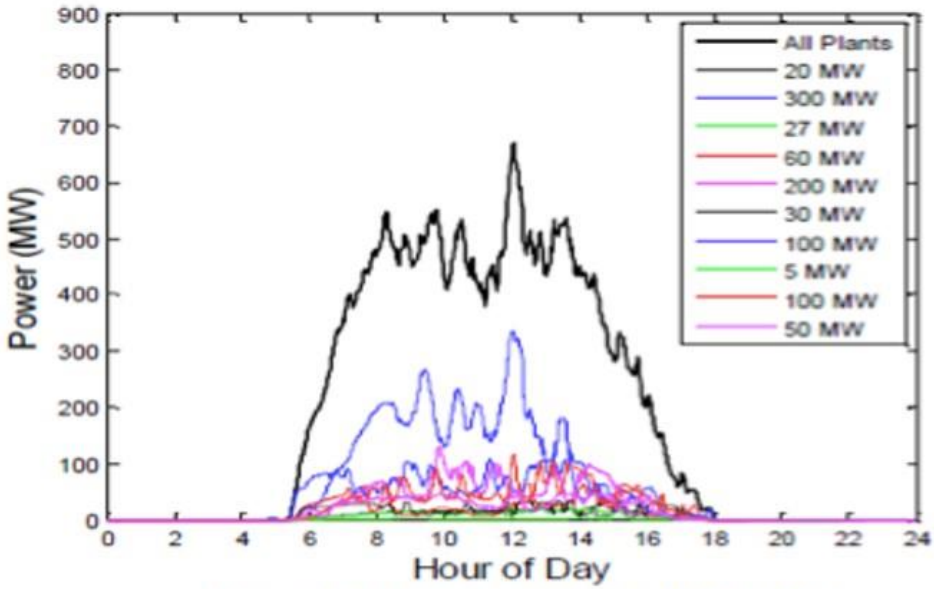
Solar Reserve's technology, typically referred to as Concentrated Solar Power (CSP), uses thousands of mirrors to reflect and concentrate sunlight onto a central point to generate heat, which in turn is used to generate electricity .More than 10 thousand tracking mirrors called heliostats reside in a 1,500 acre field, where they reflect and concentrate sunlight onto a large heat exchanger called a receiver that sits atop a 550-foot tower.

Within the receiver, fluid flows through the piping that forms the external walls; this fluid absorbs the heat from the concentrated sunlight. In Solar Reserve's technology, the fluid utilized is molten salt, which is heated from 500 to over 1,000 degrees Fahrenheit. Molten salt is an ideal heat capture medium, as it maintains its liquid state even above 1,000 degrees Fahrenheit, allowing the system to operate at low pressure for convenient energy capture and storage. After passing through the receiver, the molten salt then flows down the piping inside the tower and into a thermal storage tank, where the energy is stored as high-temperature molten salt until electricity is needed.

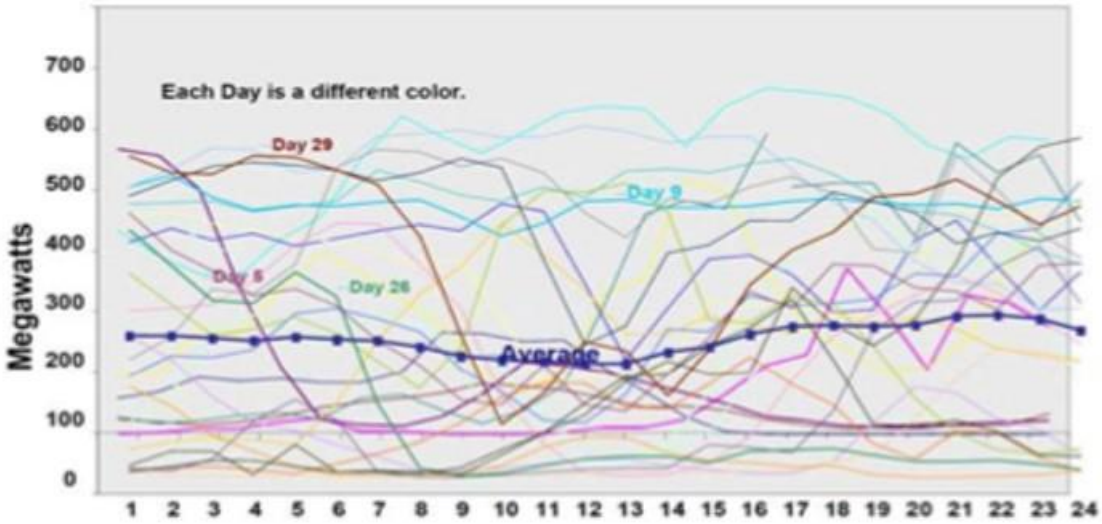
Solar Reserve's technology leverages liquid molten salt as both the energy collection and the storage mechanism, which allows it to separate energy collection from electricity generation. When electricity is required by the utility, day or night, the high-temperature molten salt flows into the steam generator, as water is piped in from the water storage tank, to generate steam. Once the hot salt is used to create steam, the cooled molten salt is then piped back into the cold salt storage tank where it will then flow back up the receiver to be reheated as the process continues.

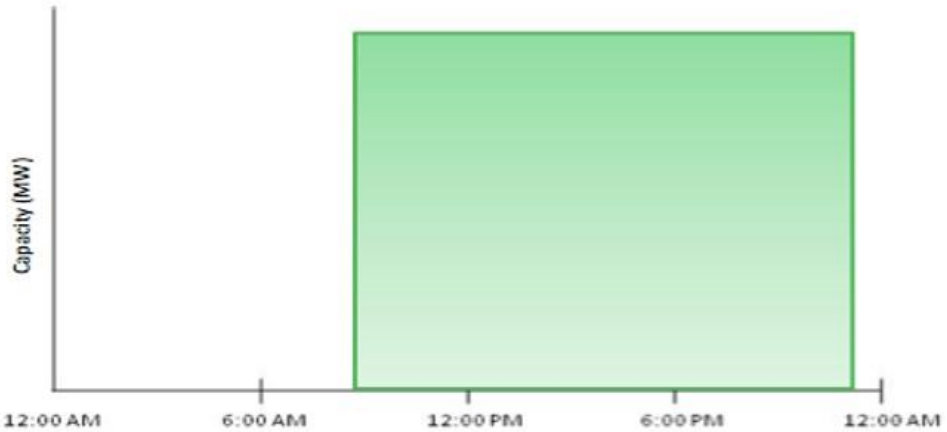
After the steam is used to drive the steam turbine, it is condensed back to water and returned to the water holding tank, where it will flow back into the steam generator when needed. After the molten salt passes though the steam generator, it flows back to the cold tank and is re-used throughout the life of the project. The hot molten salt generates high-quality superheated steam to drive a standard steam turbine at maximum efficiency to generate reliable, non-intermittent electricity during peak demand hours. The steam generation process is identical to the process used in conventional gas, coal or nuclear power plants, except that it is 100 percent renewable with zero harmful emissions or waste. Solar Reserve plants provide on-demand, reliable electricity from a renewable source—the sun—even after dark.

# GRAPH:




*Source: Large-Scale PV Integration Study**



# RANKINE CYCLE:

A Rankine cycle describes a model of the operation of steam heat engines most found in power generation plants. Common heat sources for power plants using the Rankine cycle are liquid salts, natural gas, oil etc.

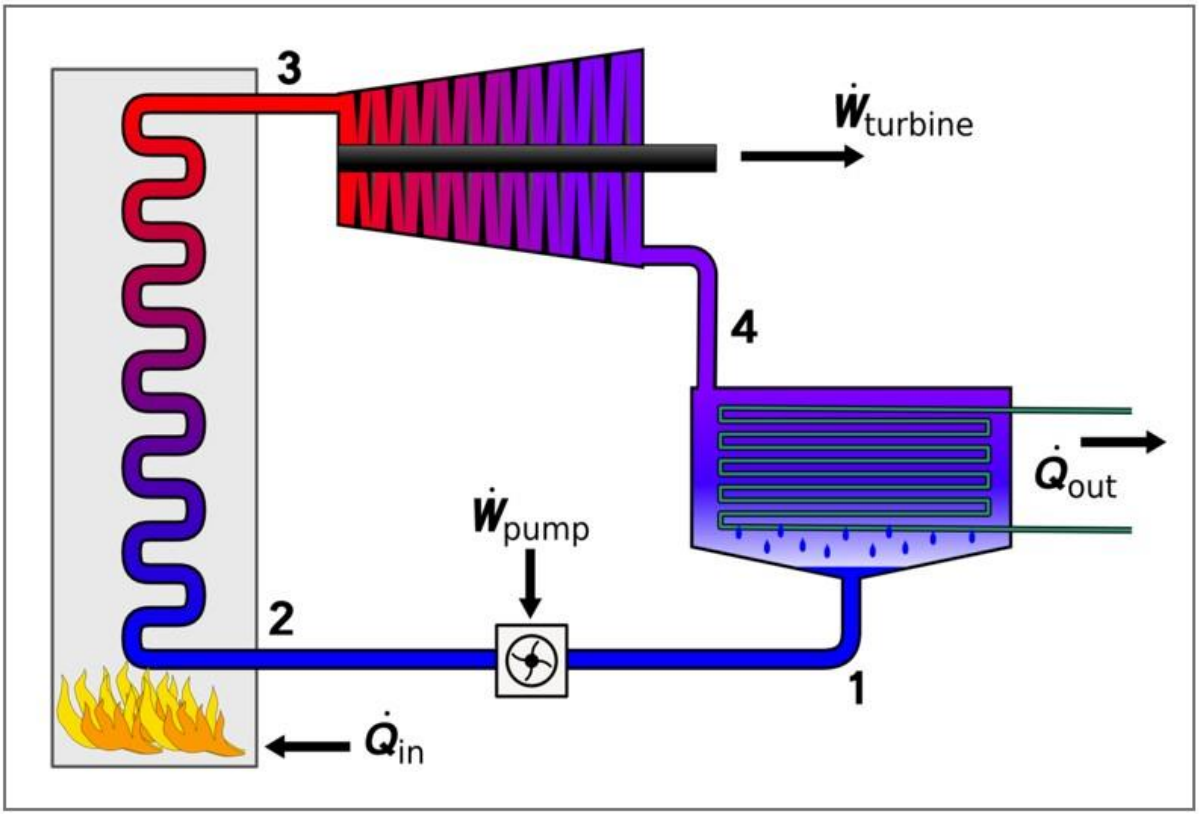



Fig: -Rankine cycle

The working fluid in a Rankine cycle follows a closed loop and is re-used constantly. The Rankine cycle is a thermodynamic cycle which converts heat into work. The heat is supplied externally to a closed loop, which usually uses water as the working fluid. This cycle generates about 80% of all electric power used throughout the world. There are four processes in the Rankine cycle, each changing the state of the working fluid.

The working fluid is pumped from low to high pressure, as the fluid is a liquid at this stage the pump requires little input energy. The high-pressure liquid enters a boiler where fluid is heated at constant pressure by an external heat source to become a dry saturated vapor. The dry saturated vapor expands through a turbine, generating power. This decreases the temperature and pressure of the vapor, and some condensation may occur.

# TECHNICAL SPECIFICATIONS:

The following specifications are purposed for 200 MW Solar.

| | |
|---|---|
| Solar Tower power plant rated capacity | 200MW |
| Tower height | 1000 meters |
| Tower internal diameter (constant over full height) | 120 meters |
| Collector diameter | 7000 meters |
| Number and configuration of turbine generators | 32 units |
| Maximum continuous rating (MCR) of each turbine | 6.25 MW |
| Plant land usage | 3800 hectares |

# SITE SELECTION:

The adequacy of solar radiation and proximity of power transmission infrastructure generally govern Solar Tower location. The following factors should be kept in mind while selecting the site for solar tower.

- Region should be non-cyclonic.
- Region should be non-seismic.
- Ideally with underlying rock strata for economic tower foundation design and adequate bearing
- safety and stability.
- Not subject to excessive precipitation as hail or desert sandstorms.

# ADVANTAGES:

- Solar energy comes directly from the sun it is not only renewable, but also accessible in any part of the world.
- Solar power is also one of the cleanest forms of energy, since it creates no pollution, and produces no greenhouse gases or waste products.
- Solar Power is safer alternative to wind & hydro power.
- Not only solar energy is non-pollutant, in terms of gases, but it also causes zero noise pollution.
- Maintenance costs are low as well – only occasional cleaning and periodic battery replacements are needed.
- Most manufacturers of solar panels provide twenty-year warranties for their equipment, guaranteeing long-life operation.
- No hazardous gaseous or liquid emissions are released during operation of the solar power tower plant.
- Salt can be recycled if necessary.
- If the power tower is hybridized with a conventional fossil plant, emissions will be released from the non-solar portion of the plant.

# DISADVANTAGES:

- The most obvious drawback of solar energy is its sole dependence on the sun. Once the weather becomes cloudy or night-time strikes, energy collection comes to a halt.
- Solar panels can also be expensive, because of the materials that are used to create them.
- Fortunately, there are some people who sell damaged solar cells, which are much cheaper. These damaged solar cells are be used to build solar panels.
- Huge amount of water and land is required.

# APPLICATION:

- Recently, there has been a renewed interest in solar tower power technology, as is evident from the fact that there are several companies involved in planning, designing and building utility size power plants.

- Traditional Solar Power Towers are constrained in size by the height of the tower and closer heliostats blocking the line of sight of outer heliostats to the receiver. The use of the pit mine's "stadium seating" helps overcome the blocking constraint.

- Solar Powered LED lighting system provide bright light charged by sunlight. Suitable for wherever the grid electricity is unreliable or unavailable.

- In order to supply Electricity for streetlights, solar power tower technologies are use.

- Solar Power can be used as Alternative for Wind & Hydro power.

- These plants are best suited for utility-scale applications in the 30 to 400 MW range.

- Provides rough enough Electricity for night use & during Cloudy weather.

# COMPANIES BEHIND THE IMPLEMENTATION:

Siemens Energy is to supply an industrial steam turbine for one of the world's first commercial solar tower power plants. The Spanish company Sener will build the innovative solar thermal power plant. Siemens is market leader for steam turbines for solar thermal power plants and has already secured orders for the supply of more than 40 of these specially adapted turbines. Unlike the Sener solar tower power plant, most of the solar power plants planned to date featured parabolic mirrors in a parallel configuration, which focus the solar radiation on pipin

# CONCLUSION:

- It is very efficiency system can be increased by hybridizing it with the other conventional plants.
- Can be implemented with alternative like WIND and HYDRO power generation.
- Molten salt has the best Heat capacity.
- Non pollutant power technology.
- It will be the power source for developing countries.
- Solar power towers offer large-scale, distributed solutions to our nation's energy needs, particularly for peaking power. Like all solar technologies, they are fuelled by sunshine and do not release greenhouse gases. They are. unique among solar electric technologies in their ability to efficiently store solar energy and dispatch electricity to the grid when needed even at night or during cloudy weather.
- The solar power tower is an emerging technology & economically erected for the production of electricity. Now a days solar thermal technology had been successfully implemented for future perspectives for overall development.

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