Concentrating Solar Thermal Power (CSTP) and Its Advantages

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Abstract -- Concentrating Solar Thermal Power (CSTP) is a free and naturally available energy that has the potential to become the main source of electricity in the upcoming years. No other fuel is required to run the plant only sun energy is sufficient; hence no emission of greenhouse gases. With the total annual 2000kWh/m2 Direct Normal Irradiance (DNI) is present; the area required for production of 100MWe of electricity is around 2km2. India receives an average annual DNI of about 1950kWh/m2 which is higher as compared to other countries and is suitable to run the CSP plant. In 2015 the investment cost of CSP plant is about $3705/kWe. As the CSTP does not required any fossil fuel it can overcome the power crisis of India. In this paper the advantages of CSTP has been focused.

I. INTRODUCTION

The tremendous amount of fossil fuel is used in the last century which caused the disturbance in the climate behavior because of greenhouse gases produced by the industries, coal power plants, vehicles etc. The use of conventional fuel needs to be reduced in order to minimize the CO2 emission and also to promote the 'green energy' to make world a better place. By green energy we refer to the environmentally friendly and non-polluting sources of energy like tidal, wind, solar power etc. The most abundant source of energy is solar; the solar energy can be harnessed by the two ways: Concentrating Solar Thermal Power (CSTP) and Photovoltaic (PV). Since 1990s, the CSTP is gaining popularity in recent years. California has the largest solar power plant of capacity 579Mw in Rosermund, USA. It will produce around 33% of total energy by 2020[1].

In India, solar energy is mainly harnessed by Solar PV technology. Indian Government now also leading stresses on CSTP and deploy a 1Mw plant in small village in Abu road, Rajasthan.

II. TECHNOLOGICAL OVERVIEW

In concentrating solar thermal power (CSTP) technology sun's rays are concentrated to produce heat to acquire temperature range of 500°C to 1000°C[2]. This heat energy is used to convert water into high pressure steam with the help of boiler to run the blade of the turbine connected to generator to produce electricity. The process of receiving and collecting the solar radiation, the CSTP can be categorized into four ways

A. *Central Receiver or Solar Tower:*

In this the main difference is the way of accumulation of heat from the sun. In the central receiver technology, the radial arrangement of the heliostats which consist of many individual personal computer controlled sun chase giant mirrors (named as heliostats) are basically units needed to concentrate the alternative energy on the top of the central tower. Usually nitrate salt is present in the top of central tower and it gets heated up to approximately 600°C. The molten salt is passed to the boiler which contains the cold water. By using the heat energy of the molten salt the boiler converts the water into high pressure steam to run the turbine coupled with the generator to produce electricity. The steam is condensed with the help of condenser to be used again. In this way it forming a closed loop and require less amount of fresh water.

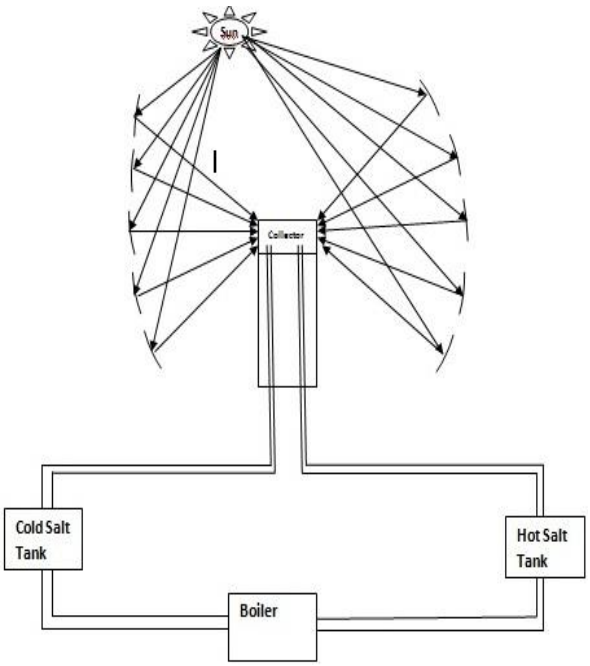

Fig.1.Solar Tower or Central Receiver

B. *Parabolic Trough*

In this parabolic trough shaped mirror are used to concentrate the solar rays on a receiver tube placed at the focal line of the tough. The parabolic trough collector station consists of: a) Solar Collector fields, b) Conventional generating plant and c) Storage.

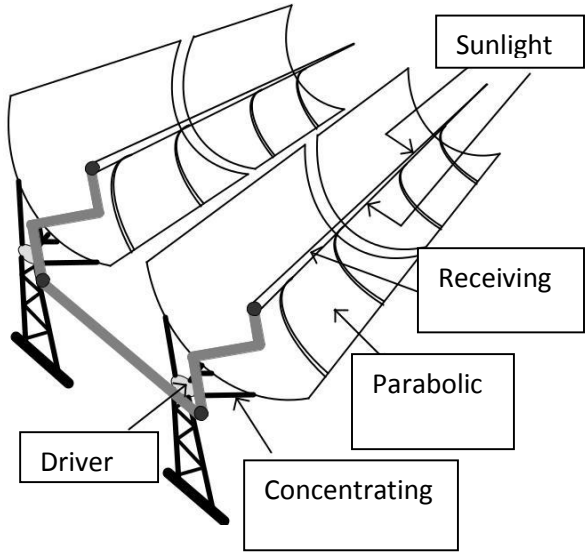

Fig.2. Parabolic Trough assembly

Fig. 2 shows the basic layout of the solar collector assembly (SCA). The reflector used in it is coated with thick silver on the back layer and a glass of high transmittance on top of it, gaining the overall reflectivity of about 93.5%. The heat transfer liquid (HTF), such as synthetic thermal oil is heated up to 400°C by the help of concentrated solar rays. The whole structure is automatically rotates with the help of drive motor to track the sun from sunrise to sunset.

The thermal storage system is also used as a backup for producing the power at night. The thermal storage system consists of the 'Two-tank molten salt storage system' in which one consists of hot tank, a cold tank and a heat exchanger. Cold molten salt is pumped from the cold tank to the heat converter/exchanger. During the peak load in sunny days and in continuously production in cloudy days the solar thermal power plant is used with the fossil fuel fired system.

C. *Parabolic Dish*

The parabolic dish-shaped solar concentrator, concentrates the sunlight on the receiver which is solar heat exchanger placed on the dish. The dish tracks the sun from two axes that are the azimuth and elevation for the tracking system. The heat produced by it is used to run the sterling engine which is attached with the receiver. A parabolic dish of 37 feet diameter produces 25kWe output.

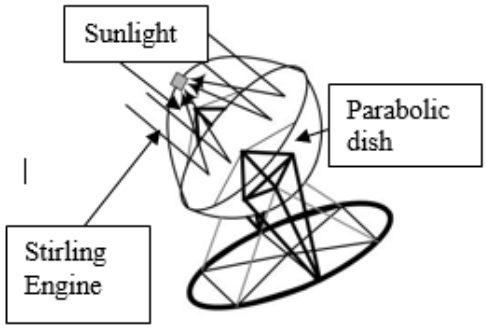

Fig.3.Parabolic Dish

D. Linear Fresnel Reflector

In the Linear Fresnel Technology elevated ground linear receiver is used to concentrate the solar rays

reflected by the number of flat reflector placed on the surface.

III. CSPT TECHNOLOGY

The main advantage of CSPT technology is the centralized power generation technique. The main driving factor for the CSPT is the intensity of the sun radiation. The HTF are used to produce the super-heated steam. This steam is used to convert the electrical energy in a conventional steam turbine or engine. This heat is also stored in form of molten salts to use it at night or during the cloudy days in which solar radiations are not properly received. The fuel expense in this technology is almost zero and it is also pollution free. The research shows that the CSTP require at-least 5.5Whm-2day-1.

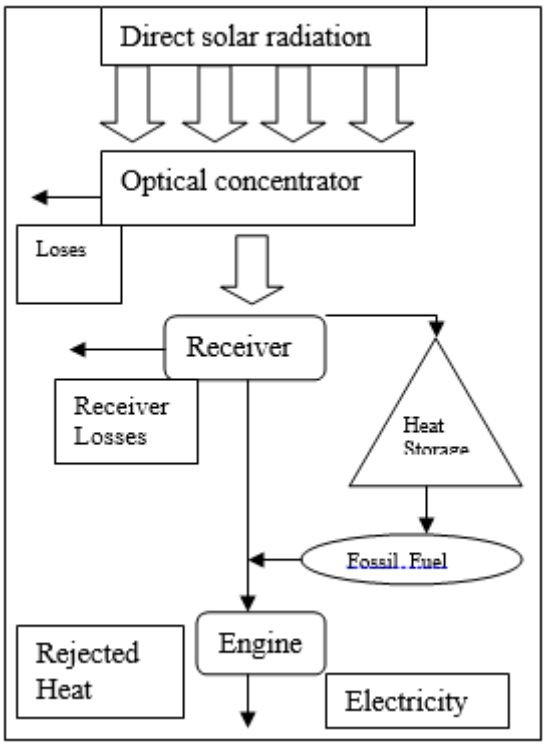

Fig 4. Block diagram of CSTP systems

IV. CSPT EFFICIENCY

The efficiency of CSPT is very high; it can become the ultimate source of power generation in the following years. There are many sources which are available to generate the electricity but do not possess such good efficiency. The biggest concern of this technology is the requirement of the large amount of landfor the reflectors and also for the feasibility of the project. The concentrated sun radiations are proportional to the number of concentrators used; given that they have the same size and also the same material. The formula for the solar efficiency is given as;

Solar Electricity Efficiency (SEE)

$$= \frac{\text{Annual Net Power Generation}}{\text{Annual DNI on apparatus}}$$

Land Requirement Factor (LRF)

$$= \frac{\text{Apparatus Area of Reflectors}}{\text{Total Land Required}}$$

Therefore, Solar Electricity=Efficiency*Land Use Factor

V. COMPARISON OF CSPT

The CSPT technology has the main advantage of generating free electricity with the help of green energy; but the main disadvantage of CSPT is the huge land requirement. In Mojave Desert, California covers 6.5km2 of land area for producing 354MWe. It is to be noted that the land required for the CSTP is less than the coal or hydro power plant, if the lakes and rivers required for the water intake are included.

The CSTP has some advantage as well as some disadvantages the heat energy which is being trapped is only in some proportions which causes efficiency of the plant limit up-to 14%. Although the parabolic dish has the highest efficiency of about 31.25% in hybrid operation is still in R&D phase.

VI. TECHNICAL ISSUES

Solar energy is the ultimate source of energy if harnessed properly. However, there are still some problems which limit the solar power energy.

A. Costing

The cost of building a solar power plant is large, and also it is very labor intensive. Due to the delayed government policies and inter states disputes. The construction and operation of various solar plants is still a dream.

B. Heat Storage System

It is necessary to build a heat storage system in order to run the plant for 24*7. During the night and also in the cloudy days, the heat storage system has the capability to run the plant with full efficiency for next 15 to 24 hours.

C. Tracking Technique

For the optimize working of the solar thermal plant the tracking of the sun is very crucial. The tracking of sun is done by the help of the computer controlled sensors which tracks the sun and control the movement of the collectors by instructing the motor attached to the structure of the collectors.

D. System Structure

The concentrated solar thermal power generation includes: receiver, concentrator and collector. The receiver, receive the sun radiation and concentrate them to the top of the solar collector. The structure of the solar thermal is very cost intensive and required high engineering works.

VII. IMPACTS ON THE ENVIRONMENT

Renewable source of energy provides solution to many problems. Solar energy can contribute to the sustainable development of human activities. One of the main advantages of the use of solar energy is the reduction of the green houses gases emitted by the use of the fossil fuel in the conventional power plants. Due to the increase in the CO2 concentration in the environment. This is the high time to shift from non-conventional sources to conventional sources. The pollution level and the diseases increased by the use of the hazardous sources that we are using for fulfilling our daily needs. The sun is the best source of energy if we capture the sun energy we can get up-to 1000 times the present requirement. The cost of the conventional fuels are also going up and scarcity of the fuels is also there, therefore government and also the private sector needs to invest and take interest on the solar energy.

VIII. CONCLUSION

CSTP has gained a worldwide popularity in the power production and also provide a vision to achieve more from the sun. Most countries are having good DNI which is essential and fruitful to construct and operate the solar thermal plant. The CSTP is indeed a clean technology and surely it can be the main source of energy in the future. With the advancement in the storage system and also improvement in the reflectors the use of the CSTP technology is more often. With tremendous amount of sun energy, the energy crisis of the world facing at the moment can come to an end.

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