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Technology Analysis of Concentrated Solar Thermal Power

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Abstract
The current society much more taking interest in green energy and their energy system which are liable to being modified to achieve more efficiency and to sharply decrease CO2 emissions (5%below 1990 level). INDIA is a fast growing country for utilizing solar energy. Form this paper we got to know about basic CSP technologies and their implementation preferable in India by using of SAM(System Advisor Model) . It includes some basic facts and assessment methodology and market challenging on basis of rebellion in energy sector ,prospect to be an alternative huge power generation an assessment of old conventional power plant .Here also specify about theoretically electrical output which help to choose the technology . There small uses in thermal power plant which is also taken a lot of importance as increases in efficiency and cost reduction in term of generation and GHG's emission with reducing of mass of coal.
Keyword: CSP technology and their types, system advisor model (SAM), appropriate CSP technology for India, Application in thermal power plant**.**

1. Introduction

In India, there is a huge source of solar energy .To estimate the solar power in INDIA it would comes more than 5000 trillion kWh of solar energy per year. This much of energy is very high compared to the overall energy requirement and consumption in the country. So we have a lots of technologies which utilize such energy into electricity(directly or indirectly) ,some of that technologies are photovoltaic (Direct conversion of sunlight to electricity using solar cells),thin film technology , concentrating solar power(use mirrors or lenses to focus sunlight),solar water heating. The Jawaharlal Lal Nehru National Solar Mission(JNNSM)of the recently announced National Action Plan on Climate Change (NAPCC) by the Government of India aims to promote the development and use of solar energy for power generation and other uses with the ultimate objective of making solar competitive with fossil. The plan includes specific goals to(a)create an enabling policy framework for the deployment of 20,000MW of solar power by 2022;(b)create favourable conditions for solar manufacturing capability, particularly solar thermal for indigenous production and market leadership;(c) promote programs for off grid applications, reaching 1000MW by 2017 and 2000 MW by 2022,(d)achieve 15 million m^2 solar thermal collector area by2017 and 20 million by 2022,and(e) deploy 20 million solar lighting systems for rural areas by 2022.(2,3)

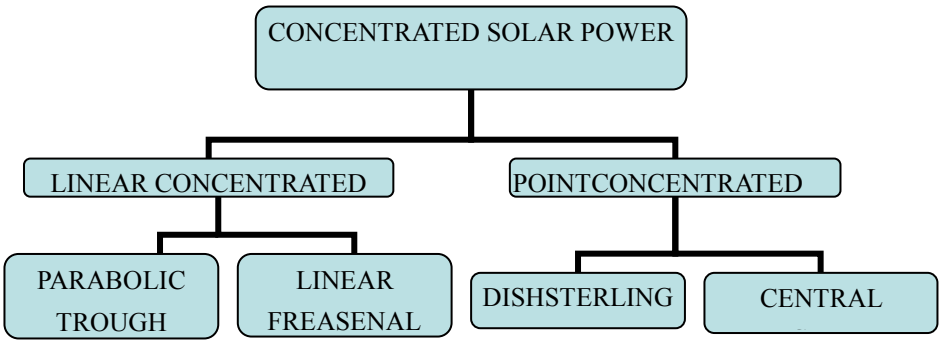
Basically there are two type of energy we use in power generation

1. Conventional
2. Non conventional (renewable energy)

Here you see such a process by which we save the consumption of energy in thermal power generation by using of solar energy .There is only three technology comes under consideration in solar power

1. Photo voltaic cell
2. Thin film technology
3. Concentrated solar power

Fig.1. Classification of CSP technology



2. CSP technologies for power generation- Optical theory predicts that light rays travelling analogous to the axis of a spherical mirror will reflect off the mirror and cross the focus of the mirror positioned a distance R/2 from the mirror where R is the radius of the mirror. So energy of all incident light rays combine at this point, successfully concentrating the light energy. This concentration result heat, hence the name:-concentrated solar power
(CSP). So, in short, CSP systems use different mirror/reflector configurations to transform the sun's energy into high temperature heat. This heat can then be used directly or indirectly transform into electricity(4). The main component of a CSP system are-

- Solar collector field
- Solar receiver
- Energy conversion system

And now a day's one added component which comes into account is Thermal storage system. Concentrated solar power has developed technology in two variants, linear concentrator and point concentrator. Here in this paper we analysis performance of concentrated solar power (CSP) by using SAM(System Advisor Model)Software (https://sam.nrel.gov). Here ,we take the input as weather file (EPW format) of BHOPAL(MADHYA PRADESH), assume gross plant power is 111MWe. The CSP (Concentrated solar power) is a technology which comes into forced as renewable energy now days. From 1980s there are many reliable projects proved CSP to be a set of clean and economical solution as compared to many other conventional and non-conventional technologies(2,1).

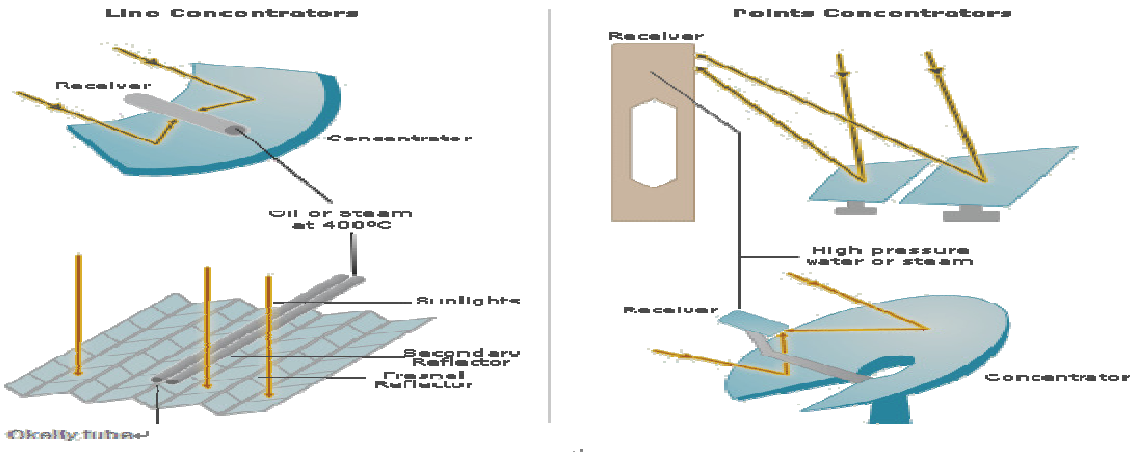


Fig. 2 CLASSIFICATION OF CSP POWER PLANT

A. Parabolic Trough

In parabolic trough power plants long trough shaped parabolic mirrors, usually coated silver or polished aluminum, concentrate Direct Normal Irradiation (DNI) to heat a medium in a pipe with thermal fluid running in to heat a medium in a pipe with thermal fluid running in the line of focus where the absorber is located. The trough is usually aligned on a north-south axis, and rotated to track the sun as it moves across the sky each day. The heat transfer fluid is then used to heat steam in a standard turbine generator. Here simulation occurred based on System advisor model in fig. 3(a) {1}shows the comparison data basis of design gross output which is 111MWe and fig. 3(b){1} shows net monthly energy output.

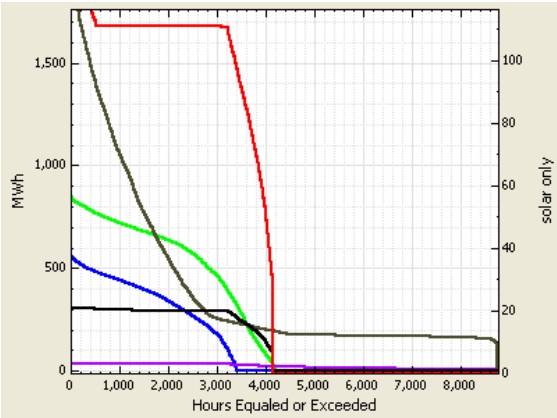


Fig 3(a): comparison between

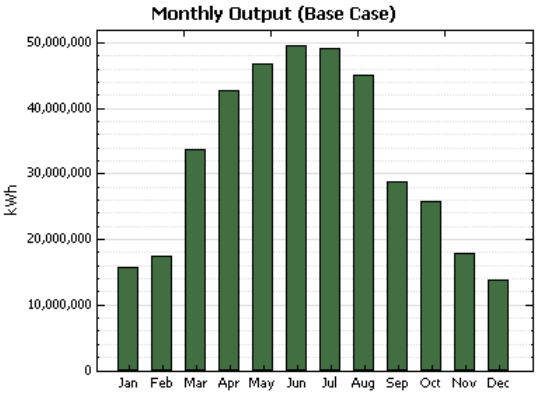


Fig.3(b):Net monthly electrical output

- Incident energy on solar field (MWh)
- Solar field thermal output (MWh)
- Total solar field thermal loss (MWh)
- Energy in thermal storage (MWh)
- Thermal energy to the power cycle (MWh)
- Gross electricity output (Solar output)

Comparison between parabolic trough and Linear Fresnel

Renewable Energy	Parabolic trough	Linear fresnel
Concentration	70-80	25-100
Temperature	~500°C	~500°C
Unit size	1-250MW	1-200MW
Efficiency	10-15%	9-15%

Table 1: **Comparison between parabolic trough and Linear Fresnel**

B. Linear Fresnel

In this technology used flat mirrors which are much cheaper than parabolic mirrors, and that more reflectors can be placed in the same amount of space, allowing more of the available sunlight to be used. Concentrating Linear Fresnel work same as parabolic trough. Fig. 4(a) {1}shows the monthly hourly energy (KWh) data basis of design gross output which is 111MWe and fig. 4(b){1} shows net monthly energy output.

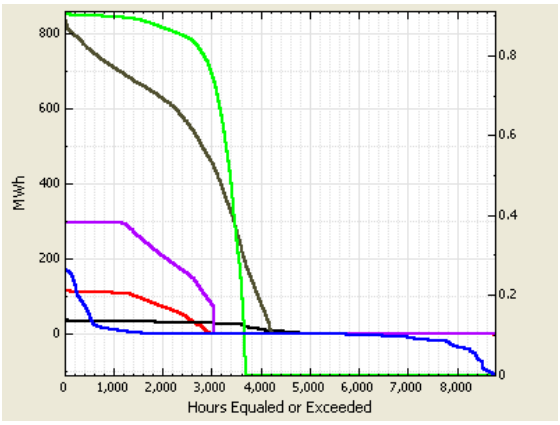


Fig.4(a): comparison between

- Solar field thermal efficiency
- Startup energy consumption (MWh)
- Solar field thermal power (MWh)
- Total power incident on the field (MWh)
- Total solar field thermal loss (MWh)
- Net plant power output (MWh)

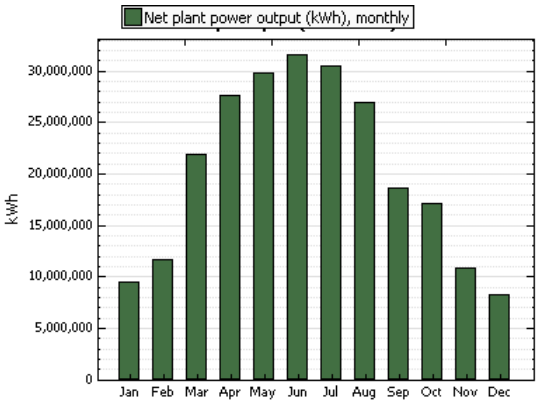


Fig.4(b): Net monthly electrical output

Point concentrators

A:- Dish Sterling: It consist of a single parabolic reflector which concentrates light at the focal point of the reflector, which tracks the sun along two axes. The stirling solar dish combines a parabolic concentrating dish with a Sterling heat engine which drives an electric generator. This technology is ideal for rural area. fig. 5(a) shows the monthly hourly energy (KWh) data basis of design gross output which is 111MWe and fig. 5(b) shows net monthly energy output.

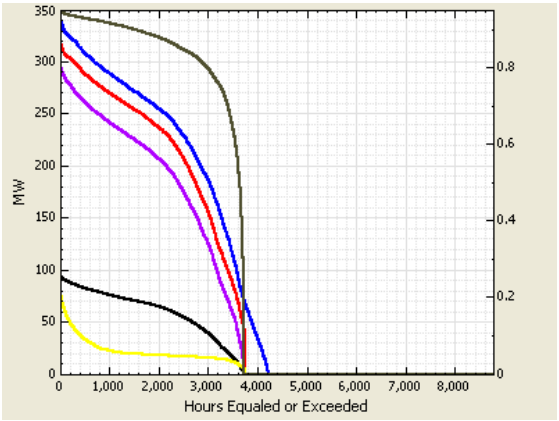


Fig.5(a): comparison between

- Power incident on collector (MW)
- Power from the collector dish (MW)
- Receiver output power (MW)
- Sterling engine gross output (MW)
- Total collector losses (MW)
- Receiver thermal efficiency (hourly)

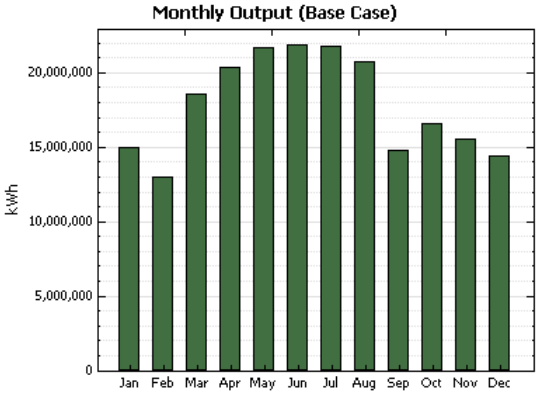


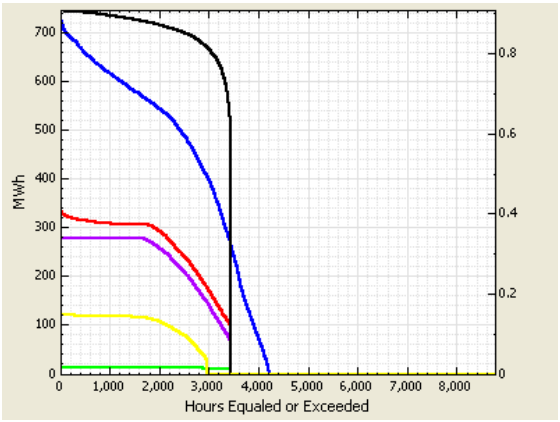
Fig.5 (b):Net monthly energy output

Renewable Energy	Dish Stirling	Central receiver
Concentration	>1000	300-1000
Temperature	~1200 °C	~1200 °C
Unit size	1-250 MW	1-200MW
Efficiency	18-25 %	14-17 %

Table 2: comparison between Dish Sterling and Central receiver

B:- Central receiver

It consist of an array of dual axis tracking reflectors(heliostats)that concentrate light on a central receiver at the top of a tower. The receiver contains a working fluid to absorb the heat, and can be sea water. The working fluid in the receiver is heated to 500-1000°C and then used as a heat source to generate power or to store energy. fig. 6(a) shows the comparison data basis of design gross output which is 111MWe and fig. 6(b) shows net monthly energy output.



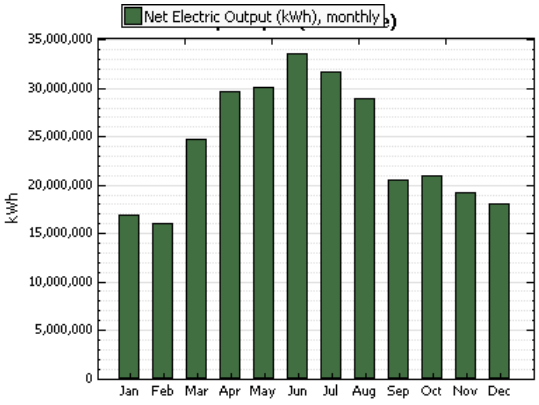


Fig.6(a):comparison between

- Total incident radiation on the field (MWh)
- Total absorbed thermal power (MWh)
- Total radiative losses (MWh)
- Thermal power transfer to steam (MWh)
- Thermal efficiency (hourly)
- Electrical power output (MWh)

Fig.6(b):Net monthly energy output

3.Application of CSP in Thermal power plant

Using of CSP in thermal power plant at major section

1. HPH(high pressure heater)
2. LPH(low pressure heater)
3. APRDS(Stem pressure reduction and De-superheating station)

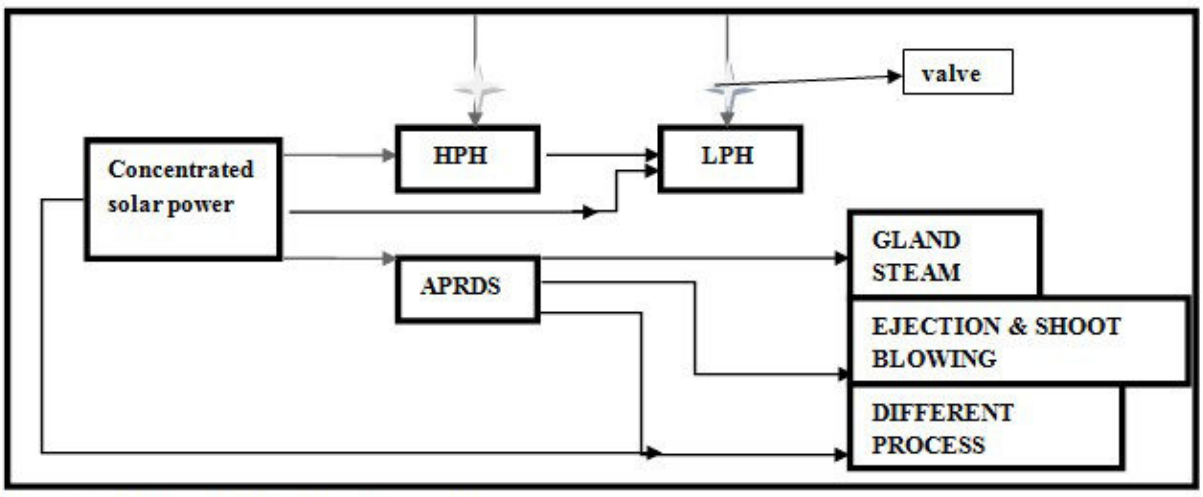


Fig.6- Application of CSP in thermal power plant

Energy consumed in HPH is: if assume that only irradiative energy transfer from one body to another then. Basically temperature of HPH does approximately 170°Celsius and in Kelvin it would be 443.15k

So to know the energy used in HPH for heating up water by module of steam here I am used Stefan's Boltzmann law:

$$J=\sigma T^4$$

where, E (remissibility) one for each stage(suppose for maximum output)
J –Emissive power of the body
σ-Stefan's Boltzmann law
T – Thermodynamics temperature

By using of above formula we get 2.186838 KJ energy in this heater. For similar doing for LPH (110 °C)and APRDS(200°C) we get the energy .6985KJ and 2.841902KJ.SO by using CSP in this section ,getting all the energy which previously getting by burning of coal from boiler .so here by application of CSP it save a lot of Indian coal and GHG emission by producing steam generation from free resource.

4.Conclusion:

India is a high demand of electricity that means a large production of electricity that why we have to improve our technology not only PV cell or CSP but also choose a optimum option. As we take performance analyses by SAM to give input as whether condition (BHOPAL,M.P. INDIA) and assuming gross power plant output 111MWh.By which we find optimum technology which have higher efficiency with maximum utilization (we excluded cost analysis).Here we find parabolic trough seems to be good option with maximum monthly electrical output with reasonable losses, dark side of this technology is low efficiency which is between 10-15%. But at same time when we look at the point concentration solar power we find some good efficiency up to 25% (disk sterling). All these aspects improve the assimilation of CSP plants into the power systems. Nevertheless a deep comparison of the technology will help to analyze the modern powerful CSP technology .One substitute is the central receiver, which has more efficiency, good availability for generating power and least cost KWh produced. If move the direction on application of CSP it get more effective by reducing requirement of coal for producing steam for different work in power plant which is important as glanding cleaning the boiler ,and very much of HPH(high pressure heater),LPH(low pressure heater) by using of valve which is good initiative.

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