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Concentrating Solar Power

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Abstract - *The ever increasing energy needs and the shortage of conventional energy resources is gradually creating an energy crisis which pressurises us to look at other energy resources and renewable energy sources are the best viable alternative to consider. One such renewable source of energy is solar energy which is very abundant . This paper reviews the technology of Concentrating solar power which converts solar power to electrical energy and its development in various countries.*

***Key Words*: CSP, Parabolic trough, Linear Fresnel Reflector System, Enclosed trough, DNI, Solar Energy.**

1.INTRODUCTION

The energy crisis is the most familiar and disquieting problem nowadays. Suitable and reliable power sources are the first-class solution to this crisis. There are two kinds of energy resources: conventional power and renewable strength. The acquainted traditional electricity sources are coal, herbal gasoline, oil, crude oil, and so forth. The use of traditional strength resources has multi-faceted environmental and fitness hazards. The burning of fossil gas like coal and oil produces photochemical pollution from nitrous oxides and acid rain from Sulphur dioxide. It additionally produces greenhouse gases that reasons the phenomenon of Global Warming. Their assets are also diminishing at an alarming rate.

The constrained supply of fossil hydrocarbon assets and the negative impact of co2 emissions on the worldwide surroundings dictate the increasing utilization of renewable electricity assets. Concentrated solar electricity CSP) is the most likely candidate for presenting most of the people of this renewable energy, because it's far amongst the most cost-effective renewable electricity technologies and due to the fact its supply is not confined if the energy generated is

Transported from the sector's sunbelt to the populace centers. Three important technology have been identified at some stage in the beyond decades for generating strength in

MW range:

While these technologies have reached certain adulthood, as has been demonstrated in pilot initiatives in Israel, Spain, and the USA, sizeable upgrades within the thermo-hydraulic overall performance are still required if such installations are to gain the reliability and effectiveness, and profitability of conventional power plants.

1.1 An Overview:

Concentrated solar energy (CSP, also known as solar energy concentration, solar-focused systems) produces solar energy through mirrors or lenses to focus on a large area of sunlight on the receiver. Electricity is generated when the focused(concentrated) sunlight is converted into heat (hot solar energy), which drives a heat engine (usually a steam turbine) connected to an electric generator or activates thermochemical reactions. Solar Power (CSP) technology uses mirrors to focus (concentrate) on the solar energy and convert it into heat to create steam to drive a turbine that generates electricity.

Plants have two components: one that converts solar energy into heat, and the other that converts heat energy into electricity.

2. Current technologies:

CSP is used to generate electricity (occasionally referred to as solar thermoelectricity, that's usually produced by means of steam). Sun-primarily based technology structures use mirrors or lenses with tracking structures to cognisance on a huge location of daylight over a small vicinity. Concentrated mild after which used as heat or as a warmness supply for a traditional solar electricity gadget (solar thermoelectricity). Sun concentrators used in CSP systems can regularly be used to offer an industrial method for heating or cooling, along with sun panels.

Concentrating technologies broadly exist in four optical categorization, namely parabolic trough, dish, concentrating linear Fresnel reflector, and solar power tower. Parabolic trough and concentrating linear Fresnel reflectors (CLFRs) are categorised as linear focus collector types, while dish and solar tower are point focus types.

Linear focus collectors reach medium concentration factors (50 suns and over), and point focus collectors are able to reach high concentration factors (over 500 suns). Despite the fact that the idea is simple and easy, these solar panels are a ways from the highest theoretical concentration. As an instance, the parabolic-trough concentration offer about gives about 1/3 of the theoretical maximum for the design acceptance angle, that is, for the identical overall tolerances for the system. The nearness of higher efficiency can be done with the aid of the usage of greater concentrators based on non imaging optics.

Specific forms of concentrators produce respective high temperatures and equilibrium thermodynamic performance, due to variations within the manner they track the sun and focus light. Innovation in CSP technology is gradually leading to this technology being affordable and cost effective.

2.1 Parabolic trough:

A parabolic trough is a type of solar thermal collector that is straight in one dimension and bent as a parabola in the other two, lined with a polished , shiny metal mirror. The sunlight which is incident to the mirror parallel to its plane of symmetry is focused along the focal line, where objects are situated that are expected to be receiving the solar energy. In a solar cooker, for instance, food is placed at the focal line of a trough, which is cooked when the trough points in a direction so that the Sun is in its plane of symmetry.

For some purposes, a tube containing a fluid runs along the length of the trough at its focal line. Sunlight is concentrated in a tube and the liquid heats up at high temperatures with solar energy. This warm liquid can be used to drive a heat engine, , which uses the heat energy obtained from the solar energy to drive machinery or to run the turbine which in turn leads to generation of electricity with an economical thermal efficiency which observes its low at 60% and a high upto 85%. Much to our surprise, it is astonishing to note that the overall efficiency of the whole assembly or system is only about 15-20 %, which is similar to Photovoltaic cells but substantially smaller than dish sterling concentrators. Solar-powered thermal strength plants require an energy storage method, consisting of a thermocline tank, which makes use of a aggregate of silica sand and quartzite rock to displace a considerable portion of the volume present in the tank. It is only after this procedure, that the heat transfer liquid is filled into it which is typically a molten nitrate salt.

According to the records updated till 2014, the largest solar thermal power systems using the above mentioned parabolic trough technology are:

- The 354 MW SEGS plants in California,
- The 280 MW Solana Generating Station with molten salt heat storage,
- The 250 MW Genesis Solar Energy Project,
- The Spanish 200 MW Solaben Solar Power Station,
- The Andasol 1 solar power station.

2.2 Enclosed trough:

The design of this optical categorisation incorporates a thermal solar system inside a glasshouse which is quite similar to greenhouses. The glasshouse creates a defensive surrounding so as to hold out against elements which could adversely affect the reliability and performance of the solar thermal system. Delicate and lightweight curved solar-reflecting mirrors are suspended within the glasshouse. A single-axis tracking system tracks the position of sun adjusts the mirrors in such a way such that focused light is incident onto a network of stationary steel pipes, also suspended from the glasshouse structure which in turn substantially increases the efficiency of the system. Oil field -quality water flows along the length of the stationary steel pipes.The heat energy so obtained is used to heat up the water. This steam is distributed accordingly to generate electricity by various means. Solar Thermal Power stations using this technology are:

- Miraah solar facility in Oman
- South Belridge Oil Field, near Bakersfield, California.

2.3 Solar power tower:

Power plants with the technology of this optical categorisation are also termed as also known as 'central tower' power plants or 'heliostat' power plants or power towers.It is an innovative variant of solar furnace using the central to receive all the focussed sunlight which is directed towards it with the help of the heliostats. These heliostats are basically an assembly of flat, movable, adjustable mirrors . Similar to the enclosed troughs , the solar energy obtained is used for heating up the water which in turn converts into steam which can be used to power a turbine or in any other way to generate electricity. A complication with this type of arrangement is that we can not store the energy which is obtained , we immediately have to boil up the water and convert it to steam. An innovative solution for this complication is the

use of liquid sodium and molten salts(40% potassium nitrate, 60% sodium nitrate) as the working fluids.These working fluids have high heat capacity, which can be used to store the energy before using it to boil water to drive turbines. This innovative approach also allow power to be generated when the sun is not shining.

2.4 Linear Fresnel Reflector System :

Linear fresnel reflectors use lengthy, skinny segments of mirrors to attention sunlight onto a hard and fast absorber located at a not unusual focal point of the reflectors. This concentrated electricity is transferred thru the absorber into a few thermal fluid (that is generally oil able to maintaining liquid kingdom at very high temperatures). The fluid then goes through a heat exchanger to power a steam generator. As adverse to standard LFR's, the CLFR utilises more than one absorbers within the place of the mirrors.

A compact linear fresnel reflector (CLFR) – also called a concentrating linear fresnel reflector – is a specific type of linear fresnel reflector (LFR) era. They're named for his or her similarity to a fresnel lens, wherein many small, skinny lens fragments are blended to simulate a miles thicker easy lens. These mirrors are able to concentrating the sun's power to about 30 times its everyday intensity.

Fresnel reflectors are made of a number of tiny, replicate-like strips to focus sunlight at the tubes that preserve the lively fluid. Flat mirrors allow for extra viewable space inside the space scale than a normal indicator, as a result absorbing a good deal of the sunlight to be had, and lots less expensive than a standard display. Fresnel indicators may be used in a selection of CSP sizes.

Fresnel signals are now and again considered technically more dangerous than other strategies. The price-effectiveness of this version is what makes a few use this instead of others with better output fees. Some new fresnel reflectors fashions with ray tracing capability have already been tested and initially confirmed higher productiveness than the same old version.

2.5 Dish sterling :

The dish sterling or dish engine system consists of a stand-by myself indicator that focuses the light at the receiver mounted on the focal point point of the reflector. The reflector tracks the solar with two axes. The working liquid in the receiver is heated to 250-seven hundred ° c (482-1,292 ° f) and used by the sterling engine to generate strength. [41] parabolic-dish systems offer high efficiency for sun to electricity (among 31% and 32%), and their modular situation provides durability. Sterling electricity structures (ses) vessels, united solar systems (USS) and science packages worldwide employer (SAIC) at unlv, and huge dish of Australia country wide college in Canberra, Australia constitute this generation. The sector document for solar and energy efficiency was set at 31.25% via ses vessels at the national sun thermal test facility (NSTTF) in New Mexico on 31 January 2008, a chilly and vibrant day. [54] in keeping with its founder, ripsaw strength, a Swedish organisation, in 2015 its dish sterling software examined inside the Kalahari desolate tract in South Africa confirmed a 34% efficiency. [55] the set up of the seas in Maricopa, phoenix became the most important sterling dish set up within the world to be bought to united sun structures. Because then, huge parts of the imports had been moved to china as a part of a bigger electricity demand.

2.6 CSP with thermal energy storage :

In a CSP plant that includes garage, solar electricity is first used to heat dissolved salt or synthetic oil saved to provide warmness / heat energy at high temperatures in heated tanks. Later melted warm salt (or oil) is used to provide steam to provide strength to generate energy with a steam turbo generator as needed. Sun power is consequently simplest to be had during the day and is used to generate energy day and night time on call for as a load following the strength plant or solar peaker plant. [warmness garage capability is expressed in hours of strength production at the plate call ability. Not like sun PV or CSP without garage, strength production from thermal electricity flora is exported and impartial inclusive of coal / fuel-fired energy flora, but without pollution. [CSP with thermal energy storage plants can also be used as included flora to supply strength and procedure day and night smoke. As of December 2018, the CSP with the value of manufacturing tropical plants has been among five c € / kWh and seven c € / kWh depending on the quantity of solar radiation received domestically. Unlike sun PV plant life, CSP with thermal power storage vegetation can also be economically used around the clock to provide best a steam system in place of fossil fuels. The CSP plant also can be blended with solar PV for higher interaction.

CSP with thermal storage structures are to be had the use of a bray-ton cycle and air instead of strength to provide power and / or smoke day and night time. Those CSP plant life have a fuel turbine to generate energy. These also are

small in capacity (<zero.4 MW) with set up fluctuations in a few acres. Waste emissions from an energy plant may be used for the steam system and HVAC requirements. Inside the occasion that land availability is not restrained, any variety of those modules can be mounted up to one thoUSAnd MW with rams and value financial savings because the cost in step with MW of those components is less expensive than in big solar thermal stations.

The mid-day and night temperatures are also possible with sun-targeted solar plants.

Technology	World capacity Operational(MW)	World capacity Under construction (MW)	World capacity Planning phase(MW)
Solar tower	627.9	461.4	2330
Dish sterling	2	2.5	72.08
Linear Fresnel Reflector System	37.65	117	10
Parabolic trough	4109	715	530

3. Present scenario of CSP in the world :

After introducing in 1990, CSP is getting popular more and more. In last seven years, Global CSP capacity has more than 5 times increasing to almost 5GW in October 2016 from less than 1GW in 2010. Now a day's size of CSP is increasing due to reduce cost through economics scale.

CSP had a global total installed capacity of 5,500 MW in 2018, up from 354 MW in 2005 half of which belonged to Spain , to be precise 2,300 MW, despite of the fact that no new developments have been made in this field since 2013. It was just 530MW in 2005 which proves to the fact that Spain has actively invested in this technology .United states at the second position with a capacity of 1740 MW. Research has been going on in India, China, North Africa and the middle east as these regions get quite abundant solar energy. 90% of the CSP plants used the parabolic trough technology. Since 2010, interest towards central power tower CSP has risen due to its higher temperature operation — up to 565 °C (1,049 °F) vs. trough's maximum of 400 °C (752 °F) — which promises greater efficiency.

Some large CSP projects are the Ivanpah Solar Power Facility (392 MW) in the United States, which uses solar power tower technology without thermal energy storage, and the Ouarzazate Solar Power Station in Morocco,[10] which combines trough and tower technologies for a total of 510 MW with several hours of energy storage.

Following is the list of all CSP plants over the world :

Name	Country	Location	Electrical capacity (MW)	Technology
Noor / Ouarzazate Solar Power Station	Morocco	Ghassate (Ouarzazate province)	510	Parabolic trough and solar power tower (Phase 3)
Ivanpah Solar Power Facility	US	San Bernardino County, California	392	Solar power tower
Solar Energy Generating Systems (SEGS)	US	Mojave Desert, California	310	Parabolic trough
Mojave Solar Project	US	Barstow, California	280	Parabolic trough
Solana Generating Station	US	Gila Bend, Arizona	280	Parabolic trough
Genesis Solar Energy Project	US	Blythe, California	280	Parabolic trough
Solaben Solar Power Station[27]	Spain	Logrosán	200	Parabolic trough
Solnova Solar Power Station	Spain	Sanlúcar la Mayor	150	Parabolic trough
Andasol solar power station	Spain	Guadix	150	Parabolic trough
Extresol Solar Power Station	Spain	Torre de Miguel Sesmero	150	Parabolic trough
Dhursar	India	Dhursar, Jaisalmer district	125	Fresnel reflector
Ashalim Power Station (Negev Energy)	Israel	Ashalim	121	Parabolic trough

Megalim Power Station (Negev Energy)	Israel	Ashalim	121	Solar power tower
Crescent Dunes Solar Energy Project	US	Nye County, Nevada	110	Solar power tower
Cerro Dominador Solar Thermal Plant (Atacama 1)	Chile	María Elena, Antofagasta	110	Solar power tower
Kathu Solar Park	South Africa	Northern Cape	100	Parabolic trough
KaXu Solar One	South Africa	Pofadder, Northern Cape	100	Parabolic trough
Xina Solar One	South Africa	Pofadder, Northern Cape	100	Parabolic trough
Manchasol Power Station	Spain	Alcázar de San Juan	100	Parabolic trough
Valle Solar Power Station	Spain	San José del Valle	100	Parabolic trough
Helioenergy Solar Power Station	Spain	Écija	100	Parabolic trough
Aste Solar Power Station	Spain	Alcázar de San Juan	100	Parabolic trough
Solacor Solar Power Station	Spain	El Carpio	100	Parabolic trough
Helios Solar Power Station	Spain	Puerto Lápice	100	Parabolic trough
Shams solar power station	UAE	Abu Dhabi Madinat Zayed	100	Parabolic trough
Termosol Solar Power Station	Spain	Navalvillar de Pela	100	Parabolic trough
Palma del Río I & II	Spain	Palma del Río	100	Parabolic trough
Ilanga 1	South Africa	Northern Cape (Upington)	100	Parabolic trough
Shouhang Dunhuang	China	Dunhuang (Gansu Province)	100	Solar power tower
CSNP Royal Tech Urat CSP	China	Urat Middle Banner, Inner Mongolia	100	Parabolic trough
Martin Next Generation Solar Energy Center	US	Indiantown, Florida	75	ISCC with parabolic trough
Nevada Solar One	US	Boulder City, Nevada	75	Parabolic trough
Guzmán	Spain	Palma del Río	50	Parabolic trough
Khi Solar One	South Africa	Upington	50	Solar power tower
Bokpoort	South Africa	Groblershoop	50	Parabolic trough
Puertollano Solar Thermal Power Plant	Spain	Puertollano, Ciudad Real	50	Parabolic trough
Alvarado I	Spain	Badajoz	50	Parabolic trough
La Florida	Spain	Alvarado (Badajoz)	50	Parabolic trough
Arenales PS	Spain	Morón de la Frontera (Seville)	50	Parabolic trough[28][80][81]
Casablanca	Spain	Talarrubias	50	Parabolic trough[28]
Majadas de Tiétar	Spain	Caceres	50	Parabolic trough

La Dehesa	Spain	La Garrovilla (Badajoz)	50	Parabolic trough
Lebrija-1	Spain	Lebrija	50	Parabolic trough
Astexol 2	Spain	Badajoz	50	Parabolic trough
Morón	Spain	Morón de la Frontera	50	Parabolic trough
La Africana	Spain	Posada	50	Parabolic trough
Olivenza 1	Spain	Olivenza	50	Parabolic trough
Orellana	Spain	Orellana la Vieja	50	Parabolic trough
Godawari Green Energy Limited	India	Nokh Village, Rajasthan	50	Parabolic trough
Enerstar Villena Power Plant	Spain	Villena	50	Parabolic trough
Megha Solar Plant	India	Anantapur	50	Parabolic trough
Delingha Solar Plant	China	Delingha	50	Parabolic trough
Supcon Solar Delingha	China	Delingha	50	Solar power tower
Shagaya CSP	Kuwait	Shagaya	50	Parabolic trough
Waad Al Shamal ISCC Plant	Saudi Arabia	Waad Al Shamal	50	ISCC with parabolic trough
Qinghai Gonghe CSP	China	Gonghe, Qinghai Province	50	Solar power tower
Luneng Haixi CSP	China	Haixi Zhou, Qinghai Sheng	50	Solar power tower
Hami CSP	China	Hami, Xinjiang Autonomous Region	50	Solar power tower
Dacheng Dunhuang CSP	China	Dunhuang, Gansu Province	50	Fresnel reflector

3.1 CSP in Malaysia:

Malaysia being in the tropical regions experiences high wind speed, rapid change of clouds, rain, thunder storm and high humidity level which challenge the efficacy of CSP technology. Therefore, research and innovation has to be conducted for it to be efficient and economically viable. The research will be useful not only Malaysia but for other countries in tropical environment. Malaysia and other countries in the tropical regions have abundant solar resources to develop CSP plant and most world regions except Canada, Japan, Russia and South Korea have significant potential areas for CSP.

3.2 CSP in Thailand:

Thailand has started their CSP Plant with the capacity of 5MW in 2012 and the country aims to increase the capacity to as high as 150MW in the next upcoming five years.

3.3 CSP in Bangladesh:

Bangladesh is a country with small land area and has a high population.
As per the reports of the United States Energy Association (USA) the energy supply deficiency in Bangladesh is aprroximately 19%. Bangladesh Power Development Board (BPDB) aims to achieve about 24000 MW before 2021 while present installation capacity is 13,000MW (November'2016).

3.4 CSP in India:

The CSP technology is not explored in India but a clean source of stable production. Traditional CSP plant comprise of rows of innumerable mirrors in a massive solar subject that concentrates sunlight on a system of receiver circulating a warmness switch fluid like oil, water and molten salt. This warmness produces steam that powers the turbine for sustainable sun thermal power generation inside the CSP plant.

To lessen energy dependence on conventional sources, a total of 470 MW CSP initiatives were planned in India

under the Jawaharlal Nehru country wide solar project (JNNSM). However, only 228 MW of total planned capacity is observed operational in India as of 2018.

Following is the list of CSP plants in India :

S. No.	Location	Area (acres)	Technology used	Capacity (MW)	Current Status
1	Jaisalmer, Rajasthan	840	Linear Fresnel	125	Operational, since 2014
2	Jaisalmer, Rajasthan	370	Parabolic Trough	50	Operational, since 2013
3	Anantapur, Andhra Pradesh	600	Parabolic Trough	50	Operational, since 2014
4	Bikaner, Rajasthan	12	Solar Tower	2.5	Operational, since 2011
5	Gurugram, Haryana	NA	Parabolic Trough	1	Operational, since 2012
6	Jaisalmer, Rajasthan	NA	Parabolic Trough	100	Under Construction
7	Jaisalmer, Rajasthan	NA	Parabolic Trough	100	Under Construction
8	Jaisalmer, Rajasthan	388	Parabolic Trough	50	Under Construction
9	Kutch, Gujarat	NA	Parabolic Trough	25	Under Construction
10	Dadri, Uttar Pradesh	NA	Linear Fresnel	14	Under Construction

3.4.1Further analysis of India's situation :

Merits :

In India, the coal-fired thermal electricity flora utilise 5-7 cubic meter water for 1 MWh of electricity generation, however, the CSP systems utilises only 2-3 cubic meter water per MWh of energy technology for cooling and washing of reflect surfaces. The CSP vegetation with thermal electricity storage (TES) can store electricity, which may be used day or night, and throughout cloudy weather. The CSP is an economically-green technology to offset the carbon emission via changing the fossil-gasoline based totally thermal strength flora, and may be mixed as a hybrid gadget for strength technology with the present set up capacities in India.

Demerits:

The installation of CSP is a huge mission (5 to 10 acres of land in step with MW of ability). A plant size of 100 MW or greater is particularly green and productive in operation, which makes this venture steeply-priced to construct. Consistent with the IPCC report, approximately 22g carbon dioxide emission in keeping with unit of energy from CSP flora, however, this emission is negligible in evaluation to 800-1000g carbon dioxide emission in step with unit of electricity from coal and lignite based totally strength flowers in India. Strength buyers prefer photovoltaic technology over the CSP flora because of its low techno-economic feasibility. Most of the additives of CSP flowers like mirrors, tubes and absorbers are imported, which increases its manufacturing value. The shortage of skilled man-power to build and function is some other mission in a hit commissioning of CSP plant life in India.

4. Conclusions:

Concentrating solar power is the future of energy but still lacks research and implementation in many countries including India . But soon there will be a time when this will become a viable and efficient alternative.

Various types of single- and dual-purpose plants have been analysed and tested in the field. Moreover , experience has been gained from the first commercial installations in use world-wide since the beginning of the 1980s. Solar thermal power plants will, within the next decade, provide a significant contribution to an efficient, economical and environmentally benign energy supply .

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