Solar power generation by CSP (Concentrating Solar Power) Technology: A review - 2018

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Abstract : The necessity for solar energy has decreased in recent years due to technological improvement, but as the effects of climate change have become more apparent, solar energy has returned as a financially feasible choice for our economic infrastructure. The sector has a global impact by promoting not only environmental stewardship but also increased employment and investment. This paper provides a review of advanced power cycles under consideration for Concentrating Solar Power Technology.

Keywords : Solar Energy, Literature Review, Concentrating Solar Power Technology

1. Introduction

The need for energy is growing every day, and nonrenewable energy sources are being depleted at an alarming rate. Therefore, finding a sustainable energy source as an alternative is essential. These are readily available and environmentally friendly **(Prakash, Kumar and Sharaf, 2016).** The photoelectric effect is the fundamental idea that powers electricity production. When sunlight hits solar panels, it charges the free electrons that are present in their solar cells. Direct current (DC) is produced in this way, and an inverter connected to the solar panels transforms it into alternating current (AC). Our electrical equipment are then powered by the AC, or electricity, as we know it. The main advantages of solar energy include: **a) Clean Source:** Unlike other energy sources, solar energy does not harm or contaminate the environment. In actuality, the installation of a modest 1 kW solar power system reduces the release of an astounding 1.5 tonnes of carbon annually. **b) Reduces Electricity Costs:** You may generate your own electricity and cut your utility costs with a solar power system. **c) Increases Your Property's Value:** Installing a solar power system at your property is similar to making any other home renovation. If your home has a solar power system and you intend to sell it, you may confidently offer a higher price. **Fig 1** illustrates the CSP's operational procedure for producing power. Beams of solar radiation are directed toward the

optical concentrator's plate where they combine to form concentrated solar radiation before travelling to the receiver.

The term "global solar radiation" refers to the total amount of direct, diffused, and reflected sunlight **(Mghouchi, Bouardi, Choulli, Ajzoul, 2014)**. Short wave radiation from the sun that has travelled through air and space reaches the planet **(Zhang, Li, Dai, Wang, 2016)**. The world's 80% energy is supplied by the fossil fuels, and their maximum uses will be serious issue in near future. Developing countries also have international pressure to limit the carbon emission along with continue their nation development programs **(Izquierdo et. al., 2010)**.

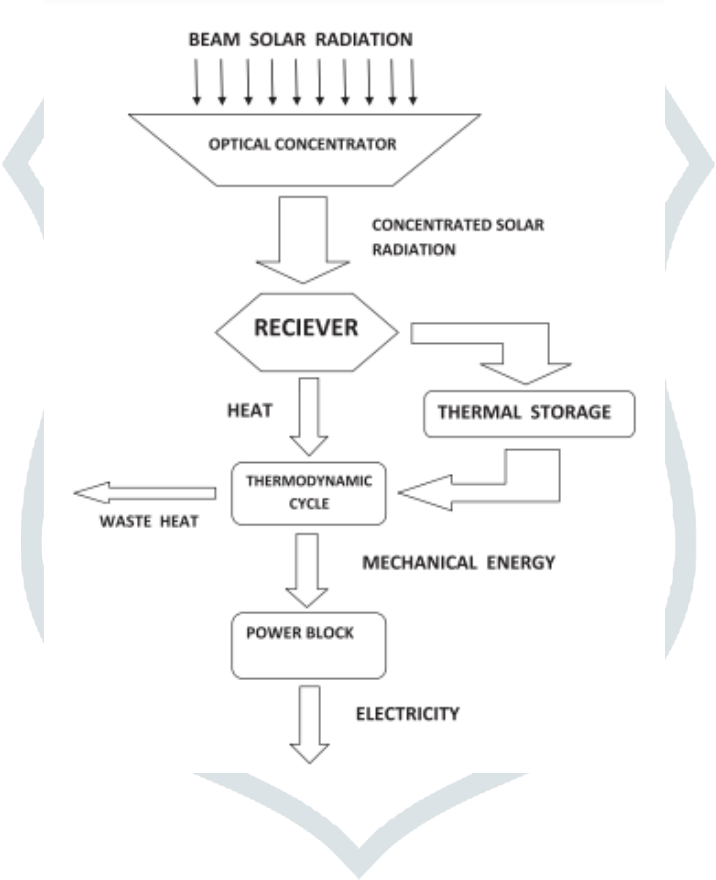

Fig 1 : Schematic diagram of CSP for parabolic trough Collector **(Brenna, Foiadelli, Roscia, Zaninelli, 2008)**

There are quite a few reviews available in the open literature on solar energy technologies.

Table 1 : Literature Reviews on CSP Technology

Title	Key Findings	Cite
High-efficiency thermodynamic power cycles for concentrated solar power systems	This article reviews high-efficiency thermodynamic cycles and their suitability for concentrating solar power systems, with a particular emphasis on single and coupled high-efficiency cycles. The literature's novel power generation strategies are also highlighted.	Dunham & Iverson, 2014
A review on progress of concentrated solar power in India	The electricity generated by concentrated solar power (CSP) in every year is being increased with high rate in India. India have enormous solar power potential for solar electricity generation per watt set up because it has solar radiation of 1700–1900 kW h per kilowatt peak with more than 300 clear sky days in year.	Kumar, Prakash & Dube, 2017
Prospect of concentrating solar power in China—the sustainable future	To change the energy-intensive and environment-burdensome economical development way, Chinese government supports the development of this technology strongly. These factors altogether make China a suitable country for utilizing CSP technology. In this paper, the potential of CSP in China was studied and strategies to promote development of this technology were given	Kaygusuz, 2011
Historical development of concentrating solar power technologies to generate clean electricity efficiently – A review	The progressive rise in the earth's average surface temperature (global warming) and the depletion of fossil fuel supplies pose two major challenges to the conventional methods for producing power around the world. Consequently, there is a pressing need to move to renewable energy sources. One renewable technology that can address both current and future electricity issues is concentrated solar power (CSP) technology. In order to demonstrate that CSP technologies are technically and commercially proven and have the potential for hybridization with fossil fuel or integration with storage systems to sustain continuous operation similar to conventional plants, this paper reviewed the historical evolution for the cornerstone plants of CSP technologies to generate clean electricity. It also presented current CSP technology projects around the world.	Baharoon, Rahman, Omar & Fadhl, 2015

2. Concentrating Solar Power Technology

Concentrated photovoltaics is quickly overtaking other solar power generation technologies as the market leader. The 330 kW "OPEL Solar" (Spain) became the first utility-grade CPV power plant to operate in March 2010. For the purpose of concentrating vast amounts of solar energy onto tiny solar cell modules, CPV systems use a variety of light concentration strategies. The high incoming flux is absorbed by very tiny units of expensive, high-efficiency solar cells, which makes the CPV model competitive commercially.

Mirrors are used in CSP technologies to direct and concentrate sunlight onto a receiver. In the receiver, a high-temperature fluid is heated by the concentrated sunlight energy. This heat, sometimes referred to as thermal energy, can drive an engine or spin a turbine to produce electricity. It can also be applied in a wide range of industrial processes, including mineral processing, food processing, chemical production, increased oil recovery, and water desalination.

In ideal circumstances, you can use 90% of the sun's rays and re-direct them to heat various materials in order to produce thermal energy or mechanical energy in order to produce pneumatic or electrical energy, for example. The efficiency of concentrated solar is based on the reflectance of the surface. In contrast to water or silicate, which both have enormous exothermic energy from solid to liquid, phase change energy is created when 90% of the sun's rays are focused on a single place to power a mechanical engine. The efficiency must be excellent if you utilise concentrated solar as direct thermal energy, such as in solar lasers, furnaces, ovens, fabric heaters, etc.

CSP technology makes advantage of concentrated sunlight. By employing mirrors to focus and concentrate the sun's energy into high-temperature heat, CSP plants produce electricity. After that, a typical generator receives the heat. The plants are divided into two sections: one that gathers solar energy and transforms it into heat; the other transforms the heat energy into electricity.

3. Practical Use

For utility-scale projects, concentrating solar-thermal power technologies are typically used. There are various configurations available for these utility-scale CSP systems. Mirrors are arranged around a central tower in power tower systems, which serves as the receiver.

Mirror rows in linear systems focus sunlight onto receivers in parallel tubes that are positioned above them.

Peak power is produced by PV, and base load by CSP. Batteries cost more than 10 times as much as the thermal storage utilised by CSP reactors, which is molten salt. Neither CSP nor PV have a significant efficiency advantage over the other. Since CPV, a subset of both PV and CSP, directly competes with PV, it has been having a tremendously difficult time lately. However, the efficiency of CPV cells are still increasing quickly and are at 46% right now. The key to CSP is the possibility of thermal energy storage, which enables dispatchability, or the ability to deliver power to the grid at will. Currently, PV lacks this capability in CSP's pricing range and with the same level of dependability. If they can lower cost and boost dependability, storage alternatives for PV could include batteries, flywheels, compressed air, and others. CSP will continue to lead the pack of dispatchable renewable energy sources up until that point.

Concentrated solar power systems offer a wide range of uses for solar thermal energy that can be exploited in addition to their primary goal of producing electricity. Just a few of the numerous applications that can be implemented with CSP technology include industrial thermal processing, chemical synthesis, salt-water desalination, heating, and cooling. It is significant to highlight that some applications are CSP technology selective and necessitate integration with a particular CSP design, whilst others can be coupled to several of the regimes.

CSP’s make uses the fact that sunlight on a clear day is highly collimated, in contrast to photovoltaics (PV), which ignore this thermodynamic benefit and treat all incoming photons as though they were coming from any direction. It is simple to focus sunlight to a temperature of exceeding 1000oF due to point 1. Theoretically, a heat engine's greatest efficiency occurs between two temperatures, Tmax and Tmin.

(Tmax - Tmin)/Tmax

So you can truly get efficiencies of more than 70%. Less than 40% of solar energy is converted using even the best solar panels, and by best I mean the extremely expensive ones used in orbiting satellites.

Smaller CSP systems can be installed just where electricity is required. For instance, distributed applications can use single dish/engine systems that can generate 5 to 25 kilowatts of power per dish.

The expansion of the commercial, industrial, and residential sectors contributed to the rise in electricity demand. Fossil fuels are the main fuel source for traditional thermal power plants. Due to the negative effects on the environment and the finite supply of fossil fuels, CSP-based power generation technologies must now take the place of conventional thermal power plants. A promising technology, CSP has the ability to replace the current thermal power plant because of its PCM storage facility and clean life cycle **(Mahfuz et. al., 2013)**.

4. Conclusion

CSP with thermal energy storage is in a great position to offer the grid low cost stability and reliability while variable renewables make rapid commercial progress. To realise this promise, though, it must keep making technological advancements. Increasing efficiency, particularly through enhanced power cycles, is one of the most crucial techniques. Such power cycles must be able to operate at temperatures well within the capabilities of collector technologies while also providing better efficiency without incurring prohibitive additional costs.

Table 2 : SWOT analysis for Concentrating Solar Power Technology

S.No	Strength	Weaknesses	Opportunity	Thtreat
1	Renewable energy technologies	Do not work well on cloudy days, even when when there is plenty of diffuse light from all directions.	They require a big capital investment up front	They require a big capital investment up front
2	Low maintainance cost.	Require more area for the technology.	It is growing industry and requires research.	If it leaks, ammonia is a dangerous pollutant for the environment.
3	Stores energy.	They (usually) require access to water for cooling, and to wash the mirror surfaces.	High reflectors	Cannot provide grid inertia

4	Many regulatory approvals needed so it takes lot of time .	CSP is an also ran tech.	Requires battery backup for widespread use	CSP works with molten salts, it does have a limited amount of energy storage built in already, but it still cannot operate long without the sun.

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