Solar energy technologies for long-term power generation : A literature review

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Abstract : Solar power is a broad term that refers to a multitude of devices that capture different types of solar energy. Heat, light, radiation, and motion are all examples of ways to exploit the sun's energy. Solar cells may turn the sun's light (radiant energy) into electricity in a similar fashion to how a solar oven uses radiation. Solar energy is an environmentally friendly alternative to damaging fossil fuels. In this study, we will examine the literatures of two widely used technologies in the industry: concentrated solar power (CSP) and photovoltaics (PV).

Keywords : Solar energy, Concentrated Solar Power (CSP), Photovoltaics (PV)

1. Introduction

In a single hour, more energy from the sun strikes the earth than humans consume in an entire year. Solar energy, in fact, outnumbers all other renewable and fossil-based energy sources combined. We require energy, whether electrical or thermal, but it is not always available. Electricity generated from fossil fuels has always been a serious cost competitor for electrical power generation. Solar energy must be absorbed, stored, and utilised in a cost-effective manner to provide a long-term and broad primary energy source. **(Zhang, Baeyens, Degrève & Cacères, 2013)**

Solar energy fluctuates during the day (day–night, clouds) and throughout the year (winter–summer). Solar energy capture and storage is necessary if solar energy is to meet a significant fraction of the total energy demand. The world solar energy map is seen in **Figure 1**. Most countries, with the exception of those above or below latitude 451N or 451S, experience annual average irradiation fluxes in excess of 1.6 MW h/m2, with solar energy peaks recorded in some "hot" spots around the world, such as the Mojave Desert in the United States, the Sahara and Kalahari Deserts in

Africa, the Middle East, Chile's Atacama Desert, and North-western Australia

(Romero, Buck and Pacheco, 2016). The creation of an affordable, limitless, and clean solar power technical breakthrough offers enormous long-term benefits since it improves countries' power security by providing an import-independent source, resulting in enhanced durability, decreased environmental risks, and lower costs **(Devabhaktuni et al., 2016).** Solar energy's potential makes it advantageous in a variety of ways, including:

* Tropical and sub-tropical climates receive more solar radiation throughout the year, thus these countries have a considerable potential to use solar energy to meet their electrical needs.

* The majority of fossil fuels and energy resources contribute to climate change and, as a result, socioeconomic degradation. As a result, solar energy is a more sustainable source of clean energy than fossil fuels. Solar energy is environmentally beneficial, and its social acceptance has grown as a result of its dependability and efficiency.

* Solar power systems are reasonably inexpensive and suitable for use in both urban and rural settings.

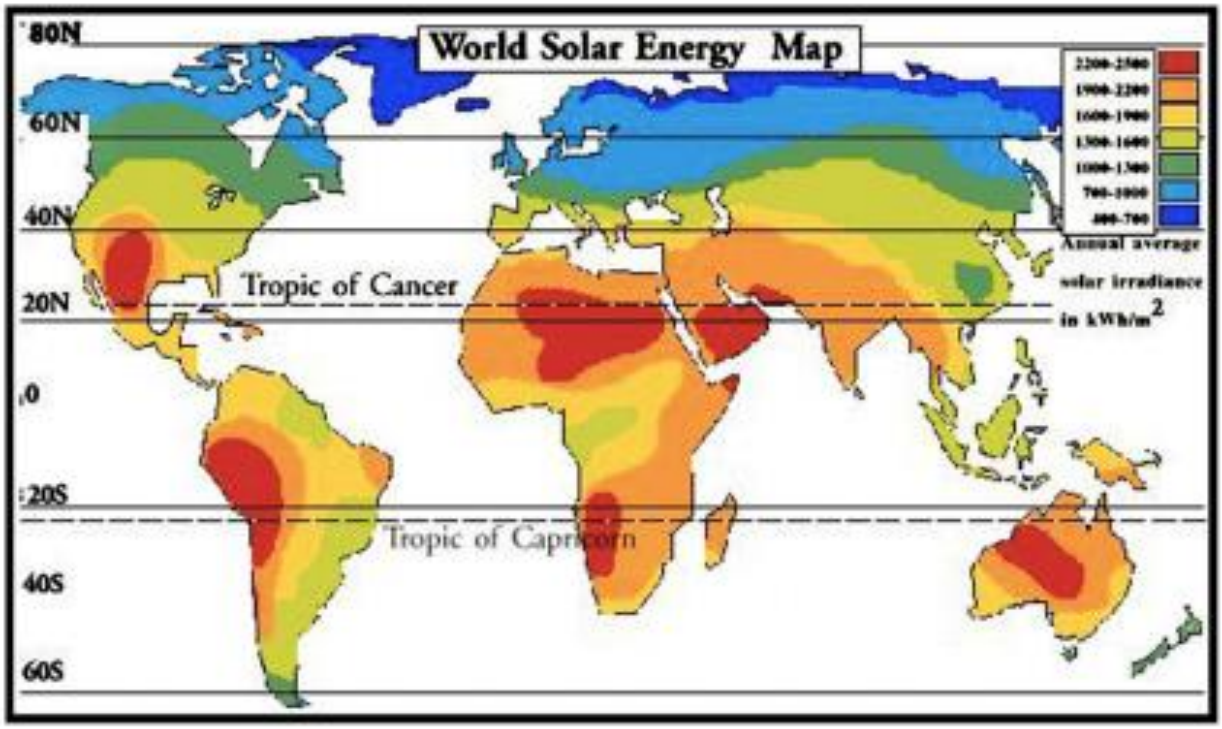

Fig 1 : Solar power distribution throughout the world

2. Methodology

To review the solar power technologies for sustainable power generation, a rigorous literature search has been per- formed to identify existing relevant studies. A review of both types of solar power technologies i.e., PV and CSP has been conducted and different types of their concentration technologies have also been addressed.

2.1. Literature Search

A thorough literature search was conducted to discover existing relevant studies on solar power technology for sustainable power generation. A review of both forms of solar power technologies, namely PV and CSP, was undertaken, as well as many sorts of their concentration methods.

3. Literature Review

The human demand for electricity will rise in the next years as the world's population grows, industrial activity advance, and living standards improve. **(Pazheri and Othman, 2013)** Carbon dioxide emissions and

global warming are caused by traditional fossil fuels such as oil and coal. **(Princiotta and Loughlin,2012)**

Kabir et al in 2018 researched solar technologies and analysed current and future potential and challenges. In 2018, Islam et al. assessed the present state of solar thermal technology and research trends, concluding that direct steam generation using solar energy in solar concentrated schemes is the most promising technique.

Every solar power technology has its own set of benefits and drawbacks, and the best way to use it is largely determined by the circumstances. Solar energy, which is a relatively constant and continuously available source of clean energy, has also been recognised to have tremendous potential to meet ever-increasing global electricity demands.

It is vital to consider social approval when developing a system. Several studies have highlighted the importance of social acceptance of solar power systems.**(Clausing et al., 1981; Bannister et al., 1991)** According to the findings of the researched publications, social approval plays an important influence in the development of various technologies.

There are two types of technology. In the solar industry, there are two types of solar power: concentrated solar power (CSP) and photovoltaic (PV). Researchers, power companies, and state policymakers have been interested in concentrating solar power (CSP) because of its bulk electricity generation capability, which overcomes the intermittency of solar resources. Photovoltaics, on the other hand, are easier to install, especially with the variety of thin film and multi-junction solar cells available.

3.1 Concentrating Solar Power (CSP)

Concentrated Solar Power (CSP) systems transform the sun's energy into high-temperature heat using a variety of mirror designs to generate electricity. The sun's energy is concentrated using various reflectors, and this focused energy is then used to power a heat engine and an electric

generator. The plants that use this technique are divided into two sections: one receives solar energy and transforms it to heat, while the other turns the heat energy to electricity.

Solar energy is widely considered as one of the most competitive alternatives among all renewables due to its properties of being green, low-cost, and renewable **(Sun J, Liu Q and Hong H)**. Concentrated solar power (CSP) or solar thermal electricity (STE) is a technology capable of producing utility-scale electricity, giving firm capacity and dispatchable power on demand by incorporating thermal energy storage or in hybrid operation using the energy source**(SolarPACES, 2016).**

CSP systems have a significant advantage over other solar power technologies in that they can generate electricity even when the sun isn't shining. The following are the key characteristics of solar power plants that use CSP technology **(Desideri, 2013)**:

* Mirrors are naturally less expensive than doped silicon wafers, though this advantage is diluted by the weather protection that must be added to both types of systems.

* Scale is the most significant advantage. A large solar plant can generate a lot of money. Maintenance costs are reduced as a result of having all of the key equipment in one location.

The parabolic trough technology, the solar tower technology, the dish Stirling system, and the linear Fresnel system are all used in CSP systems. Many academics have looked into the capabilities and applications of CSP technology in many areas throughout the world. The top three countries in the world using CSP technology are Spain, the United States, and India **(Buck et al.,2018)**. According to geographic information technology, CSP technology as a parabolic trough collector has a lot of promise in South Africa. It has the capacity to generate 547.6 GW of power. According to the study's findings, the CSP system has financial support for the country's northwestern region and produces roughly 1800kWh/m2, which is ideal for CSP technology **(Devabhaktuni et al., 2016)**.

Electricity production from conventional energy sources has various drawbacks, including the risk of a sudden decline in supply quantity, the release of significant greenhouse gases such as CO2, and a threat to overall environmental sustainability. Renewable energy sources, on the other hand, provide abundant, clean, and sustainable energy that will undoubtedly be at the forefront in terms of supplying an endless supply of energy. CSP is capable of generating large amounts of electricity, and several developed countries are investing extensively in the technology. The parabolic trough collector (PTC) and the solar power tower (SPT) are two of the four types of CSP technologies that are currently implemented in various countries, including Spain, the United States, China, and India.

3.2 Photovoltaic (PV)

Solar panels that use photovoltaic (PV) technology, on the other hand, are not the same as CSP. PV solar panels, unlike CSP, make use of the sun's light rather than its energy. To put it another way, photovoltaics is the conversion of light directly into electricity. This works because the solar PV cells absorb light, which causes electrons to be released. After the unbound electrons have flowed for a while, a current is formed, which is then collected and transported into wires, resulting in a direct electric current (DC). After the direct electric current is created, it is transformed to alternating current (AC) using inverters before being distributed on the power grid. PV's have a number of advantages, including:

* The cost per kilowatt-hour has reduced considerably, to the point where solar PV installations in residences may now be supported by a consumer infrastructure. In many regions of the world, the initial capital expenditure is modest enough that funding an installation can result in an immediate reduction in electricity expenses.

* PV’s can generate electricity even on cloudy days and can employ diffuse light to do so. They function best when the incident light is parallel to the surface, but this is not necessary.

* They may easily be installed in situations that would otherwise be useless, such as rooftops. When installed atop huge, flat industrial buildings, there is little risk of damaging the aesthetics or wasting land, and they can immediately begin lowering the building's electricity expenses.

4. Suggestions & Conclusions

Several solar energy research are evaluated, and their findings are provided. Environmental implications must be considered while looking into the long-term viability of power producing technologies. The assembly and decommissioning of solar power plants are the two most significant environmental concerns. After the commissioning of solar power plants, as well as throughout their operation, there is almost no negative impact.

As we are entering the twenty-first century, it must confront the challenges of global climate change and rising crude oil consumption rates. Photovoltaic semiconductors and production technologies are likely to improve, making the PV system competitive with other renewable technologies. As a result, solar energy will become increasingly important in addressing energy shortages, addressing environmental issues such as global warming, and ensuring a future based on clean and sustainable energy.

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