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ANALYSIS OF CONCENTRATING SOLAR POWER PLANT IN RENEWABLE ENERGY SOURCES

Mihir K. Patel[1], Prof. Alpesh M. Patel[2], Prof. Bhupendra K. Patel[3]
[1]P.G. Scholar, MEC, Basna, [2]Asst. Prof. Electrical Engineering Dept GEC, Palanpur
[3]Asst. Prof. Electrical Engineering Dept GEC, Patan
Gujarat, India.

Abstract: ***This paper presents the importance of concentrating solar power plant compare to other renewable energy sources like solar pv cells, wind power generation, ocean thermal energy etc. in this paper we discuss the basic concept an introduction of concentrating solar power plant their working and types of components used for concentrating the solar energy. Day by day the use of solar energy is increased all over world, so it is necessary to study about solar energy. Still to date solar pv cells type solar power plant used in solar energy but due to their lower efficiency (near about 14% - 18%) use of concentrating solar plant is come into picture. In this paper we discuss about its demand and advantages compared to other solar pv cells.***

I. INTRODUCTION

Concentrating Solar Power (CSP) plants use mirrors to concentrate sunlight onto a receiver, which collects and transfers the solar energy to a heat transfer fluid that can be used to supply heat for end-use applications or to generate electricity through conventional steam turbines. Large CSP plants can be equipped with a heat storage system to allow for heat supply or electricity generation at night or when the sky is cloudy. There are four CSP plant variants, namely:

1. Parabolic Trough
2. Fresnel Reflector
3. Solar Tower
4. Solar Dish

Which differ depending on the design, configuration of mirrors and receivers, heat transfer fluid used and whether or not heat storage is involved? The first three types are used mostly for power plants in centralised electricity generation, with the parabolic trough system being the most commercially mature technology. Solar dishes are more suitable for distributed generation.

1. Sunlight consists of direct and indirect (diff used) components. The direct component (i.e. DNI or Direct Normal Irradiance) represents up to 90% of the total sunlight during sunny days but is negligible on cloudy days. Direct sunlight can be concentrated using mirrors or other optical devices (e.g. lenses). CSP plants can provide cost-effective energy in regions with DNIs > 2000 kWh/m2-yr, typically arid and semi-arid regions at latitudes between 15° and 40° North or South of the Equator. Note that equatorial regions are usually too cloudy. High DNIs can also be available at high altitudes where scattering is low. In the best regions (DNIs > 2800 kWh/m2-yr), the CSP generation potential is 100-130 GW he/km2-yr. This is roughly the same electricity generated annually by a 20 MW coal-fi red power plant with a 75% capacity factor.
2. The capacity factor is the number of hours per year that the plant can produce electricity while dispatch ability is the ability of the plant to provide electricity on the operator's demand.
3. The solar multiple is the ratio of the actual size of the solar fi eld to the solar field size needed to feed the turbine at nominal design capacity with maximum solar irradiance (about 1 kW/m2). To cope with thermal losses, plants with no storage have a solar multiple between 1.1-1.5 (up to 2.0 for LFR) while plants with thermal storage may have solar multiples of 3-5.

While CSP plants produce primarily electricity, they also produce high-temperature heat that can be used for industrial processes, space heating (and cooling), as well as heat-based water desalination processes. Desalination is particularly important in the sunny (and often arid) regions where CSP plants are often installed.

Figure 1: CSP Parabolic Trough Solar Collectors

II. CSP TECHNOLOGIES AND PERFORMANCE

The CSP technology includes four variants; namely, Parabolic Trough (PT), Fresnel Reflector (FR), Solar Tower (ST) and Solar

Dish (SD). In PT and FR plants, mirrors concentrate the sun's rays on a focal line, with concentration factors on the order of 60-80 and maximum achievable temperatures of about 550°C. In ST and SD plants, mirrors concentrate the sunlight on a single focal point with higher concentration factors (600-1,000) and operating temperatures (800-1000°C).

A. Parabolic Trough (PT)

PT is the most mature CSP technology, accounting for more than 90% of the currently installed CSP capacity. As illustrated in Figure 2, it is based on parabolic mirrors that concentrate the sun's rays on heat receivers (i.e. steel tubes) placed on the focal line. Receivers have a special coating to maximise energy absorption and minimise infrared re-irradiation and work in an evacuated glass envelope to avoid convection heat losses. The solar heat is removed by a heat transfer fluid (e.g. synthetic oil, molten salt) flowing in the receiver tube and transferred to a steam generator to produce the super-heated steam that runs the turbine. Mirrors and receivers (i.e. the solar collectors) track the sun's path along a single axis (usually East to West). An array of mirrors can be up to 100 metres long with a curved aperture of 5-6 metres. Most PT plants currently in operation have capacities between 14-80 MW e, efficiencies of around 14-16% (i.e. the ratio of solar irradiance power to net electric output) and maximum operating temperatures of 390°C, which is limited by the degradation of synthetic oil used for heat transfer. The use of molten salt at 550°C for either heat transfer or storage purposes is under demonstration. High temperature molten salt may increase both plant efficiency (e.g. 15%-17%) and thermal storage capacity.

B. Fresnel Reflectors (FR)

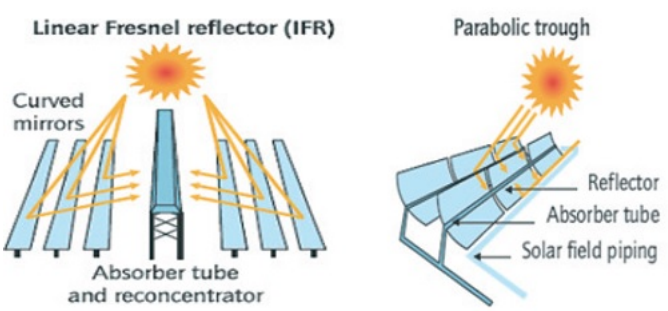

Figure 2: Parabolic Trough and Fresnel Reflector

FR plants (Figure 2) are similar to PT plants but use a series of ground-based, flat or slightly curved mirrors placed at different angles to concentrate the sunlight onto a fixed receiver located several meters above the mirror field. Each line of mirrors is equipped with a single axis tracking system to concentrate the sunlight onto the fixed receiver. The receiver consists of a long, selectively-coated tube where flowing water is converted into saturated steam (DSG or Direct Steam Generation). Since the focal line in the FR plant can be distorted by astigmatism, a secondary mirror is placed above the receiver to refocus the sun's rays. As an alternative, multi-tube receivers can be used to capture sunlight with no secondary mirror. The main advantages of FR compared to PT systems are the lower cost of ground-based mirrors and solar collectors (including structural supports and assembly).

While the optical efficiency of the FR system is lower than that of the PT systems (i.e. higher optical losses), the relative simplicity of the plant translates into lower manufacturing and installation costs compared to PT plants. However, it is not clear whether FR electricity is cheaper than that from PT plants. In addition, as FR systems use direct steam generation, thermal energy storage is likely to be more challenging and expensive.

C. Solar Towers (ST)

In the ST plants (Figure 3), a large number of computer assisted mirrors (heliostats) track the sun individually over two axes and concentrate the solar irradiation onto a single receiver mounted on top of a central tower where the solar heat drives a thermodynamic cycle and generates electricity. In principle, ST plants can achieve higher temperatures than PT and FR systems because they have higher concentration factors. The ST plants can use water-steam (DSG), synthetic oil or molten salt as the primary heat transfer fluid. The use of high-temperature gas is also being considered. Direct steam generation (DSG) 8 in the receiver eliminates the need for a heat exchanger between the primary heat transfer fluid (e.g. molten salt) and the steam cycle, but makes thermal storage more difficult. Depending on the primary heat transfer fluid and the receiver design, maximum operating temperatures may range from 250-300°C (using water-steam) to 390°C (using synthetic oil) and up to 565°C (using molten salt). Temperatures above 800°C can be obtained using gases. The temperature level of the primary heat transfer fluid determines the operating conditions (i.e. subcritical, supercritical or ultra-supercritical) of the steam cycle in the conventional part of the power plant.

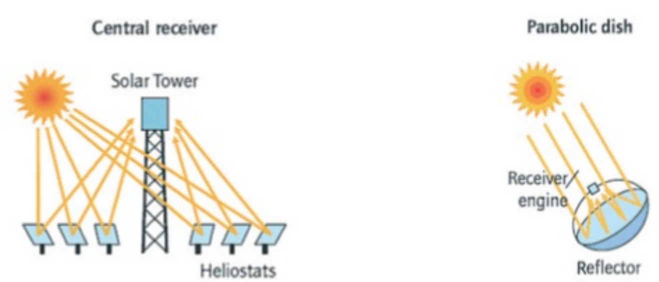

Figure 3: Solar Tower and Solar Dish Concepts

ST plants can be equipped with thermal storage systems whose operating temperatures also depend on the primary heat transfer fluid. Today's best performance is obtained using molten salt at 565°C for either heat transfer or storage purposes. This enables efficient and cheap heat storage and the use of efficient supercritical steam cycles.

D. Solar Dishes (SD)

The SD system (Figure 3) consists of a parabolic dish shaped concentrator (like a satellite dish) that reflects sunlight into a receiver placed at the focal point of the dish. The receiver may be a Stirling engine (i.e. Kinematic and free-piston variants) or a micro-turbine. SD systems require two-axis sun tracking systems and offer very high concentration factors and operating temperatures. However, they have yet to be deployed on any significant commercial scale. Research currently focuses on combined Stirling engines and generators to produce electricity. The main advantages of SD systems include high efficiency (i.e. up to 30%) and modularity (i.e. 5-50 kW), which is suitable for distributed generation.

Unlike other CSP options, SD systems do not need cooling systems for the exhaust heat. This makes SDs suitable for use in water-constrained regions, though at relatively high electricity generation costs compared to other CSP options. The SD technology is still under demonstration and investment costs are still high.

III. World scenario for CSP

CSP plants require high direct solar irradiance to work and are therefore a very interesting option for installation in the Sun Belt region (between 40° north and south of the equator). This region includes the Middle East, North Africa, South Africa, India, the Southwest of the United States, Mexico, Peru, Chile, Western China, Australia, southern Europe and Turkey. The technical potential of CSP-based electricity generation in most of these regions is typically many times higher than their electricity demand, resulting in opportunities for electricity export through high-voltage lines.

However, the deployment of CSP is still at an early stage with approximately 2 GW of installed capacity worldwide up to 2012, although an additional 12 GW of capacity is planned for installation by 2015. Today's installed capacity of CSP is very small when compared with approximately 70 GW of solar photovoltaic (PV) plants already in operation globally, and the 30 GW of new PV installations completed in 2011. The total installation cost for CSP plants without storage is generally higher than for PV. However, it is expected that these costs will fall by around 15% by 2015 owing to technology learning, economies of scale, and improvements in manufacturing and performance, thus reducing the levelled costs of electricity from CSP plants to around USD 0.15-0.24/kWh. By 2020, expectations are that capital costs will decline even further by between 30% and 50%. Like PV, an advantage of CSP plants is that their output, when no thermal storage is used, follows closely the electricity and heat demand profile during the day in Sun Belt regions. The significant advantage of CSP over PV is that it can integrate low-cost thermal energy storage to provide intermediate- and base-load electricity. This can increase significantly the capacity factor of CSP plants and the dispatch ability of the generated electricity, thus improving grid integration and economic competitiveness of such power plants. However, there is a trade-off between the capacity of heat storage required and capital cost of the plant.

Another advantage offered by CSP technology is the ease of integration into existing fossil fuel-based power plants that use conventional steam turbines to produce electricity, whereby the part of the steam produced by the combustion of fossil fuels is substituted by heat from the CSP plant. Similar to conventional power plants, most CSP installations need water to cool and condense the steam cycle. Since water is often scarce in the Sun Belt regions, CSP plants based on "dry cooling" are the preferred option with regards to efficient and sustainable use of water. However, such plants are typically about 10% more expensive than water-cooled ones. Compared with PV, CSP is still a relatively capital-intensive technology with a small market. However, CSP plants could become economically competitive as a result of the significant potential for capital cost reductions. In addition to renewable heat and power generation concentrating solar plants have other economically viable and sustainable applications, such as co-generation for domestic and industrial heat use, water desalination and enhanced oil recovery in mature and heavy oil fields. CSP technology deployment also has the potential for substantial local value addition through localisation of production of components, services and operation and maintenance, thus creating local development and job opportunities.

IV. Potential and Barriers

According to Emerging Energy Research (2010), the total installed CSP capacity in Europe could grow to 30 GW by 2020 and to 60 GW by 2030. This would then represent 2.4% and 4.3% of EU-27 power capacity in 2020 and 2030, respectively. The IEA's CSP technology roadmap estimates that, under favourable conditions, the global CSP capacity could grow to 147 GW in 2020, with 50 GW in North America and 23 GW each in Africa and the Middle East. By 2030, the global CSP capacity could rise to 337 GW. The Global CSP Outlook (i.e. ESTELA-Greenpeace, 2009) explores three scenarios (business-as-usual, moderate and advanced) accounting for increasingly favourable policies and trends for CSP deployment and a rapid growth of HVDC transmission lines.

The three scenarios also include two options for future electricity demand with a 28% and 94% increase by 2030, thus accounting for two different rates of energy efficiency implementation measures. Other key assumptions include CSP annual capacity growth, increasing plant size and capacity factors and declining capital costs. In the moderate scenario the cumulative installed CSP capacity is about 68 GW by 2020 and 231 GW by 2030, with CSP electricity meeting one percent of global demand in 2020 and up to 12% by 2050. The IEA CSP Technology Roadmap (i.e. IEA 2010a) suggests that CSP could represent up to 11% of the global electricity production by 2050.

From 2010 to 2020 CSP deployment is expected to be sustained by policy incentives and emissions trading. The global CSP capacity would reach 148 GW by 2020, producing 1.3% of the global electricity with an average capacity factor of 32%. From 2020 to 2030, CSP could become competitive with conventional base-load power due to cost reductions and the increasing prices of CO2 and fossil fuels. Incentives to CSP will gradually disappear, and HVDC lines will reach a global extension of some 3,000 km. The global installed capacity would reach 337 GW, producing 3.8% of the 2030 electricity demand, with an average capacity factor of 39%. Beyond 2030, CSP cumulative capacity could reach the level of about 1,090 GW by 2050, providing about 9.5% the global electricity with an average capacity factor of 50%. The United States, North Africa, India and the Middle East would be the largest producers and exporters, while Europe would be the largest importer from the MENA Region via HVDC transmission lines. In the long term, low-cost CSP electricity would compensate for the additional costs of electricity transmission.

V. CONCLUSION

We can say that the growth of CSP will rapidly increase in the future due its advantages and features compare with the solar pv cells. It is also better in compare with the other natural energy sources. Concentrating solar power plant has other different kind of feature is also available of hybrid connection. Efficiency is better compare to other energy sources. The only barrier along with the CSP is high initial cost but due to government subsidy the growth and investment in CSP technology increase in future.

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