OPTIMIZATION AND PERFORMANCE ANALYSIS OF SOLAR PV & CSP SYSTEM

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ABSTRACT

Solar PV power plant is a key technology option as an attractive alternate electricity source in the future. But solar photovoltaic has limitation that it does not use in night and rainy condition. Now in this paper we develop molten salt base thermal energy storage system which absorbs exceed thermal energy of the heat produced in the solar field during the daytime. This heat is then stored in a molten salt mixture of 60% sodium nitrate and 40% potassium nitrate. This process almost doubles the number of operational hours at the solar thermal power plant per year. This paper presents the working of Solar PV systems and CSP (Concentrating Solar Power Plant). In this Paper the Different Types of CSP plants are also explained with their liabilities. Simulation results are compared for the Electricity generation by both Sources using SAM (System Advisor Model) software. The Comparison and results shows that CSP plant has electricity generation capacity in Night Duration with high efficiency compare to Solar PV System.

Keywords— PV, CSP, SAM, TES, etc.

INTRODUCTION

The sun is the most plentiful energy source for the earth. All wind, fossil fuel, hydro and biomass energy have their origins in sunlight. Solar energy falls on the surface of the earth at a rate of 120 petawatts, (1 petawatt = 1015 watt). This means all the solar energy received from the sun in one days can satisfied the whole world's demand for more than 20 years. We are able to calculate the potential for each renewable energy source based on today's technology. (Figure 1) Future advances in technology will lead to higher potential for each energy source. However, the worldwide demand for energy is expected to keep increasing at 5 percent each year. Solar energy is the only choice that can satisfy such a huge and steadily increasing demand. [1]

There are several applications for solar energy, for instance: electricity generation, photochemical, solar propulsion, solar desalination, and room temperate control. The collection of solar energy and its transfer to electricity energy will have wide application and deep impact on our society, so it has attracted the attention of the researchers.

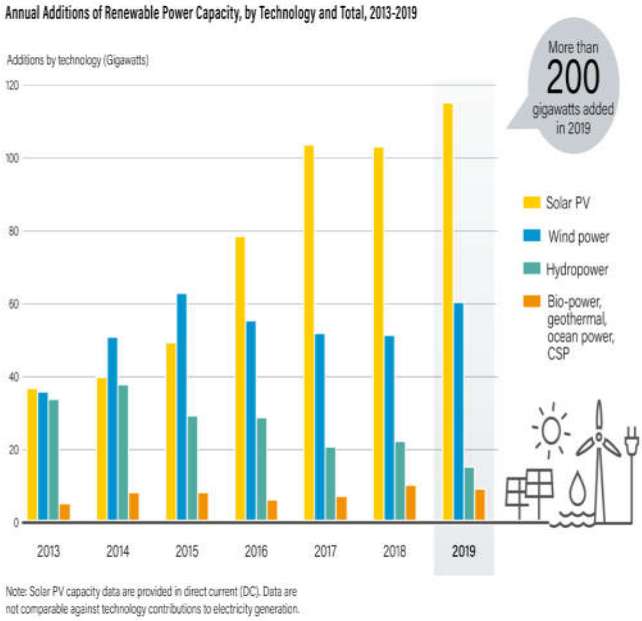


Figure 1- The Potential for Renewable Energy Sources [1]

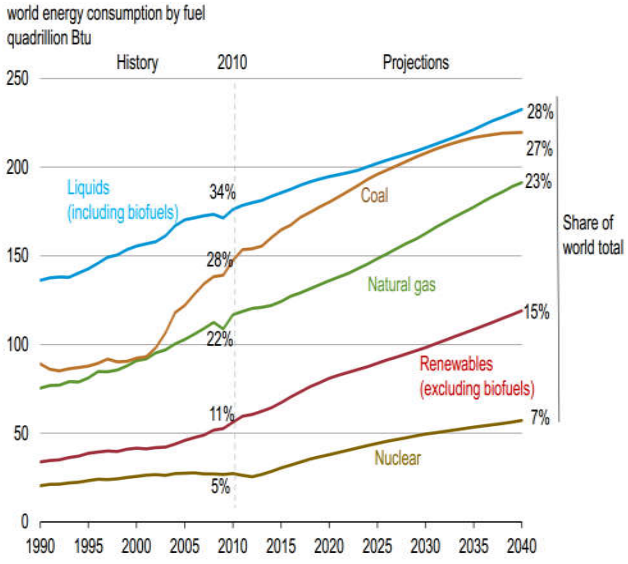


Figure 2- World Energy Demand and Forecast [1]

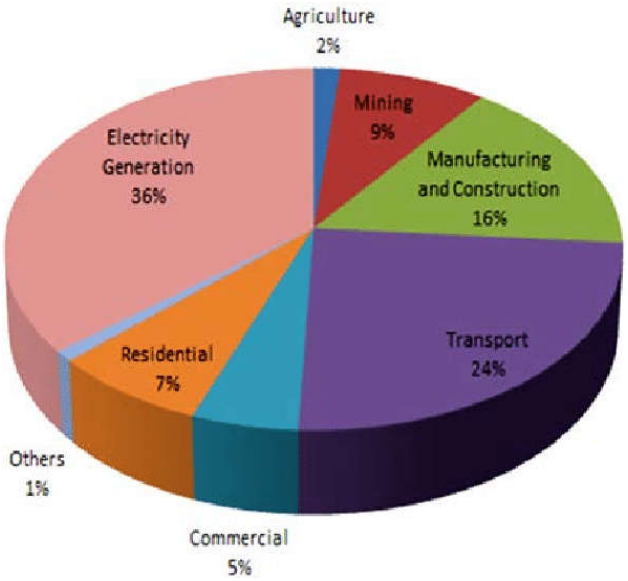


Figure.3- Electricity Energy Consumption Percentage of Total Energy Production in 2018 [1]

According to 2010 *Energy Balance for World Report* provided by International Energy Agency (IEA), about 30 percent of the total energy produced is consumed by electricity generation sectors with an efficiency rate of 42.6 percent.

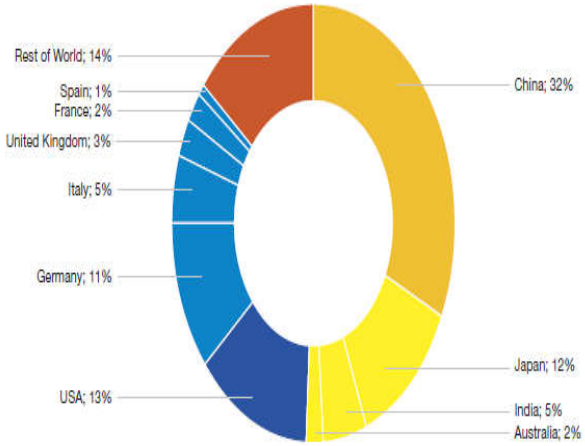
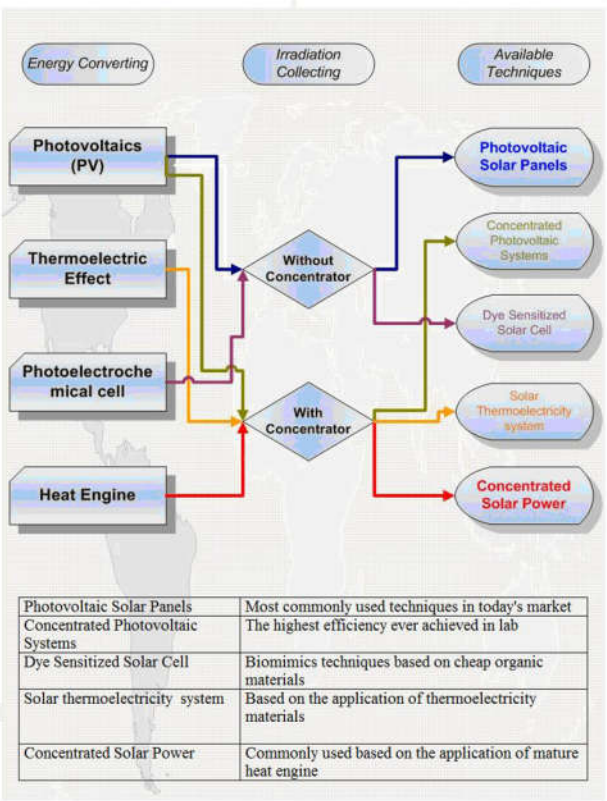


Figure.4- Global Top 10 solar PV markets total installed shares by end of 2017 [1]

Electricity is high grade energy. This means it can be easily transferred into other forms like mechanical energy or heat. If we are able to generate economic and plentiful electricity energy, together with the easy transportation electricity energy transmission, the electric power will increase its shares in demand sectors dramatically. Performance of PV system is affected by the environmental condition such as change in solar insolation and temperature.

SOLAR TECHNOLOGIES

There are several kinds of solar techniques that are currently available. However, each of them is based on quite different concepts and science and each has its unique advantages. Analysis and comparison between different technologies will help us to adopt the most efficient and beneficial technology given a specific set of conditions. Generally speaking, non-concentrated photovoltaic solar panels (PV) and concentrated solar power (CSP) are the two most mature technologies. They have been commercialized and expected to experience rapid growth in the future, thus our emphasis will be on these two technologies. Solar thermoelectricity systems (STA), dye sensitized solar cell (DSPV) and concentrated photovoltaic systems to our reader emerging technologies and under intensive study. Eventually, they may claim a significant share of the solar energy market if they achieve the necessary technical breakthroughs to make them sufficiently competitive to be commercialized.



Photovoltaic Solar Panels	Most commonly used techniques in today's market
Concentrated Photovoltaic Systems	The highest efficiency ever achieved in lab
Dye Sensitized Solar Cell	Biomimics techniques based on cheap organic materials
Solar thermoelectricity system	Based on the application of thermoelectricity materials
Concentrated Solar Power	Commonly used based on the application of mature heat engine

Figure 5- Overview of Solar Technologies [1]

Some reports characterize them into the other two domains – CPV, DSPV into PV domains and STS into CSP domains, however, each uses unique mechanisms, structures and materials. Their mechanisms will be discussed, and their advantages and drawbacks will be listed. Then, photovoltaic solar panels and concentrated solar power will be discussed in detail, including their technologies, subcategory, structures, deployment and trend of improvement in future.

Solar energy is a highly renowned alternative energy type. The intensity of the sun's irradiation that reaches the globe yearly is equivalent to 92 billion tons of petroleum. A calculation from 2002 states that the energy received from the sun in one hour was greater than the world used in one year. Due to the latter, the investigation of this source has lasted for years and continues to be a matter of great importance and relevance today.

There are two main ways of taking profit of the sun's energy, which are photovoltaic plants and solar collector plants.

Photovoltaic plants

These types of plants employ solar panels that take profit from the sun's light (*photo*) and convert it into direct current electricity (*volts*). This phenomenon takes place thanks to the light detection cells contained in the panels, which are made of photovoltaic material. The photovoltaic effect is closely related to the photoelectric effect in which electrons are ejected from a material upon energy exposure, such as lig radiation. In the photovoltaic effect however, these generat electrons are forced to flow within the material, which resu in an electric current and the build-up of voltage. In 2010 F energy was generating electricity in more than 100 countrie However, photovoltaic plants are not yet profitable industrial level. Although PV technology has develop substantially in the past years, the obtaining costs of composing cells are still high. In addition to this, t efficiency with which these plants convert light into electrici is approximately 13%, a low level in relation to the surfa that solar PV plants occupy.

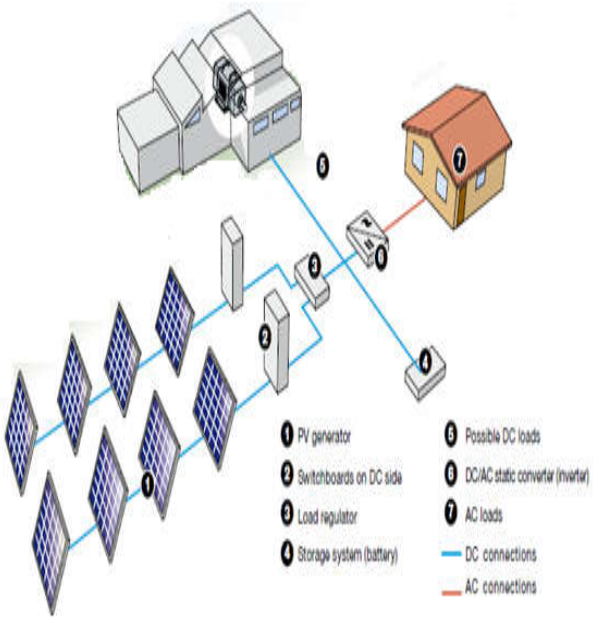


Figure. 6: Standalone PV Plant [2]

Solar energy is nature dependent and so photovoltaic working requires MPPT as an essential component. Solar energy is nature dependent and so photovoltaic working requires MPPT as an essential component. Under normal day condition it is easy to extract the power from the solar energy but it is difficult to track power during shading or partial shading condition.

Grid-connected Plants

Grid connected Plants are permanently connected to grid and takes power during insufficient solar power generation to satisfy the requirement of consumer. And at the time of low consumer load the excess of power generated by the solar power plant is given to the grid. The energy generated near the load have higher value the conventional power from grid which is transmitted from longer distance. Also, the power generated during peak hours by the solar plant reduce the need of grid during insolation hour that is when demand is higher.

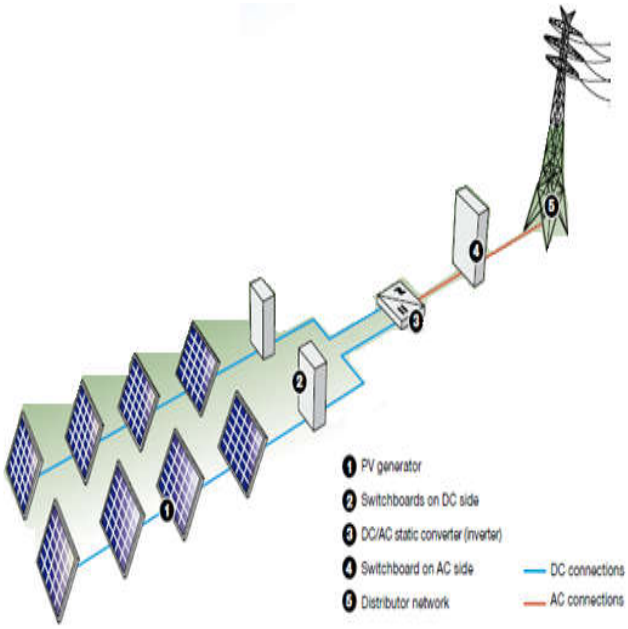


Figure. 7: Grid-connected plants [2]

Concentrating solar power

These types of plants use gadgets such as lenses and mirrors to concentrate a large surface of sun exposure into a small area. This concentrated sunlight is then transformed into the heating of a particular fluid, which can be used directly to produce renewable heat, or can also be used to produce electricity. In the case of electricity production the heated fluid will drive a heat turbine (usually a steam turbine) which mechanical power will be then transformed into electricity by an electrical power generator.

Today there are four main types of concentrating technologies: Parabolic trough, dish Stirling, concentrating linear Fresnel reflectors and solar power towers. Each one of them has its own advantages and disadvantages regarding its applications and their working. They also vary from one another in the way they focus and concentrate the sun's irradiation. [2]

Parabolic trough

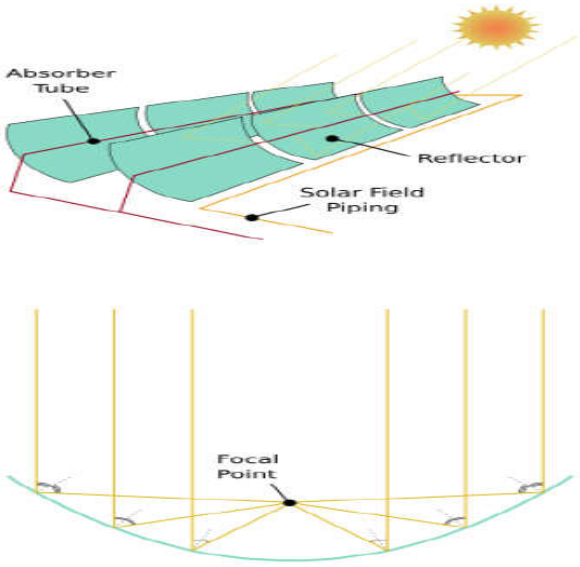


Fig 8 Parabolic trough functioning scheme [2]

These types of energy collectors consist on long, parabolic mirrors. Throughout the whole length of these mirrors, runs a tube that is positioned at the focal point of these parabolas. Sun irradiation is reflected by the mirror and, due to the implanted geometry, concentrated on the tube. The troughs can be aligned in a north-south position or an east-west position and they rotate during the day to track the sunlight during daylight hours. Inside the tube, at the focal point, runs a heat transfer fluid (usually oil) that absorbs the concentrated sun irradiation and rises its temperature up to 400°C. The heat of the high-temperature oil is used to produce steam, which will run through a steam turbine, producing mechanical power. The latter is then transformed into electrical power by an electrical power generator. As it will be explained with further detail in following sections, some of the plants that use parabolic troughs also count with an energy storage system that stores heat power using molten salts. [2]

OPTIMIZATION OF SOLAR PV & CSP

Optimization of Solar PV and CSP Plant using SAM

The optimization and analysis of PV and CSP shows the Comparison between these two plants. The hourly energy of plant, the DNI and Hourly energy of plant, Electric load and Electricity to grid during 1 year from both plant all these results shown in fig below. From that results we can derive the comparison between these two plants which also shown in the table below the results. In the SAM (System Advisor Model) software the real time data analysis is carried out using Geographical locations; the latitude and longitude is selected for the location. Accordingly the Solar Radiation and temperature is considered from the NREL through online in the SAM software. The normalized electric load condition is taken for both solar PV and CSP plant result analysis.

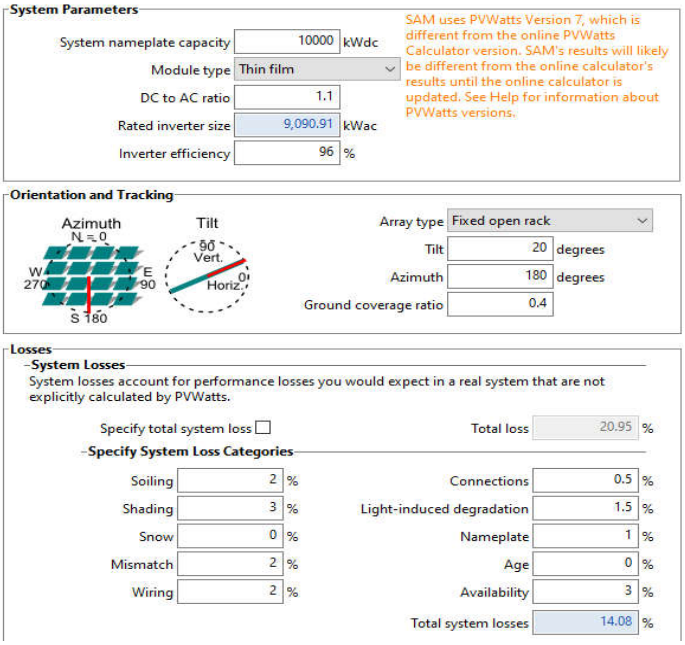


Fig 9- System Design Parameters for Solar PV in SAM

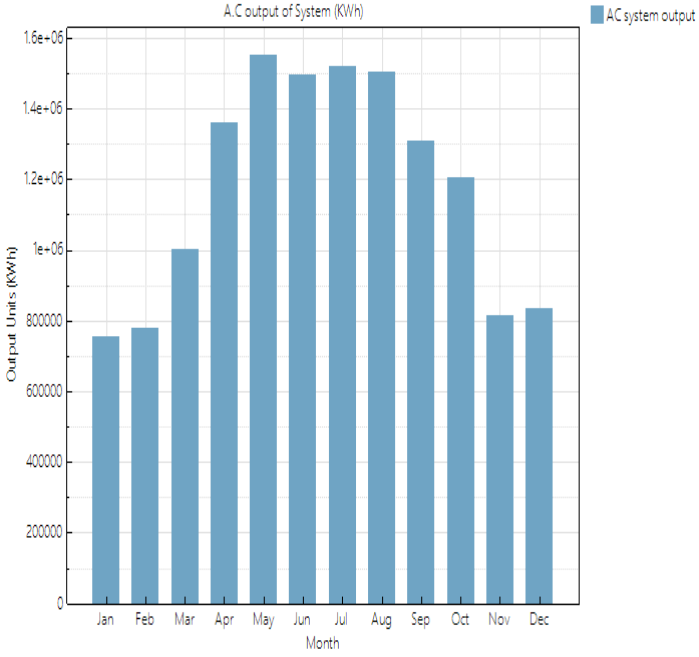


Fig 10- A.C Output of the solar PV system

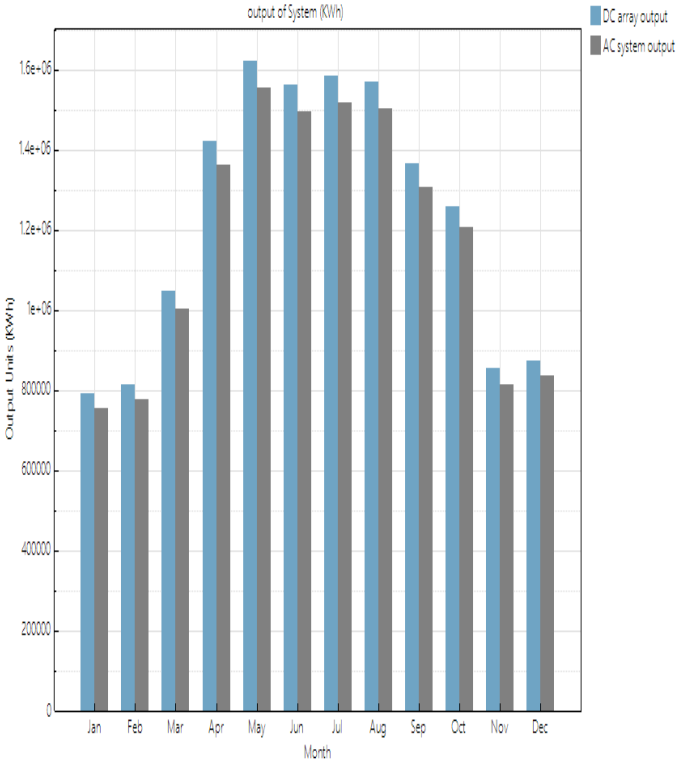


Fig 11- Comparison of DC array output and AC system of Solar PV

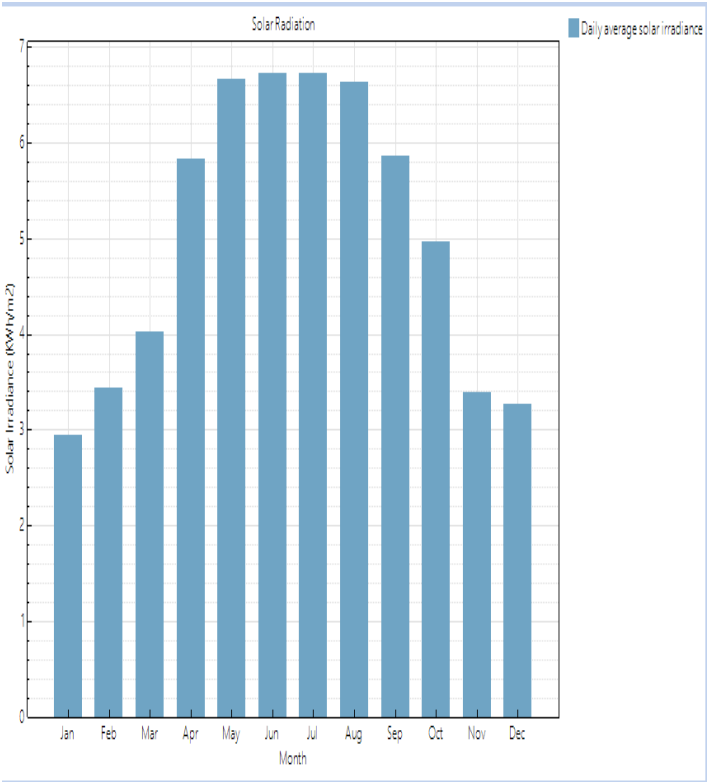


Fig 13- Solar Radiation Data month wise

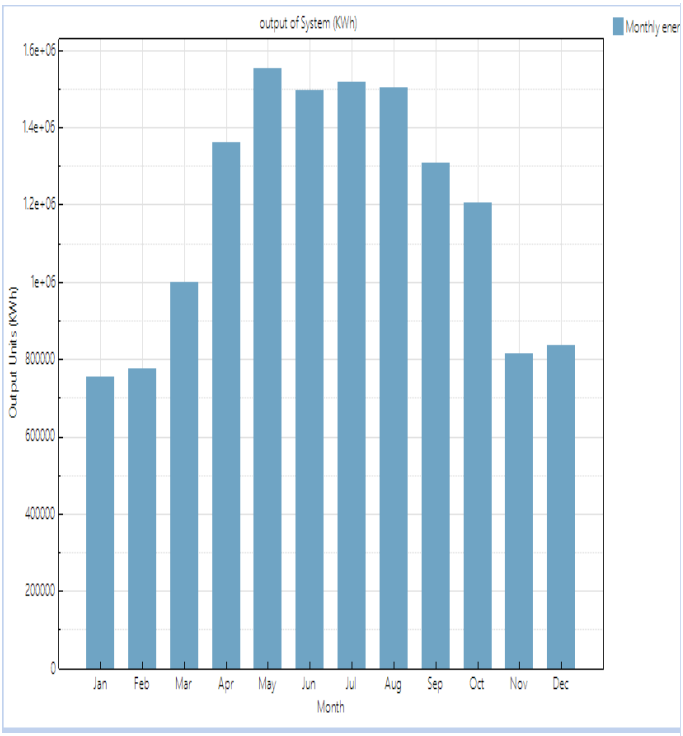


Fig 12- Monthly Energy Generation of Solar PV of o/p in the system month wise

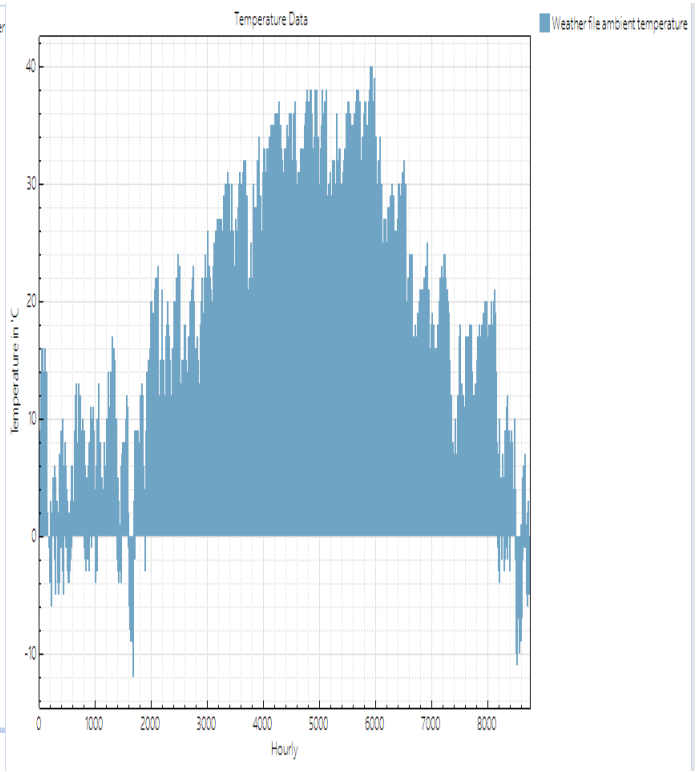


Fig 14- Temperature Data of system month wise

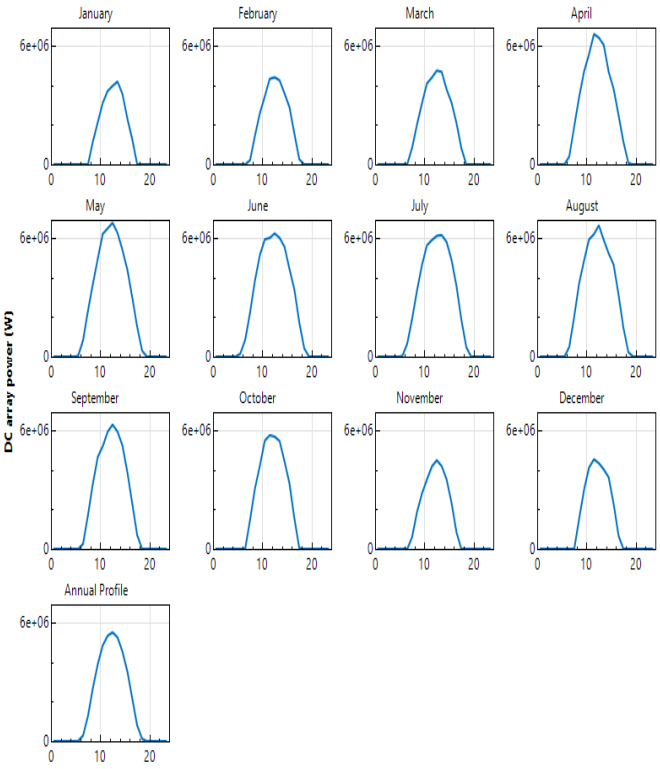


Fig 15- Month Wise DC output power of Solar PV

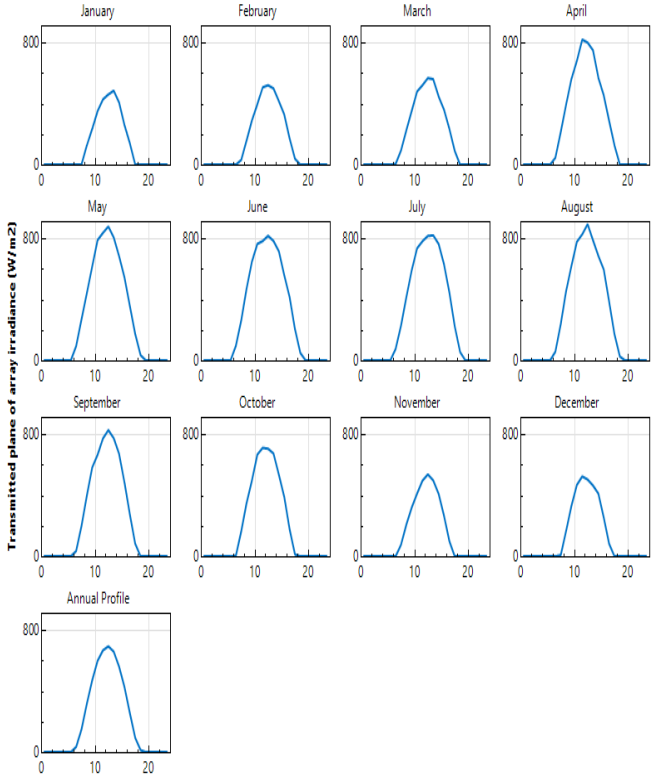


Fig 16- Month Wise Solar Radiation Data of the system

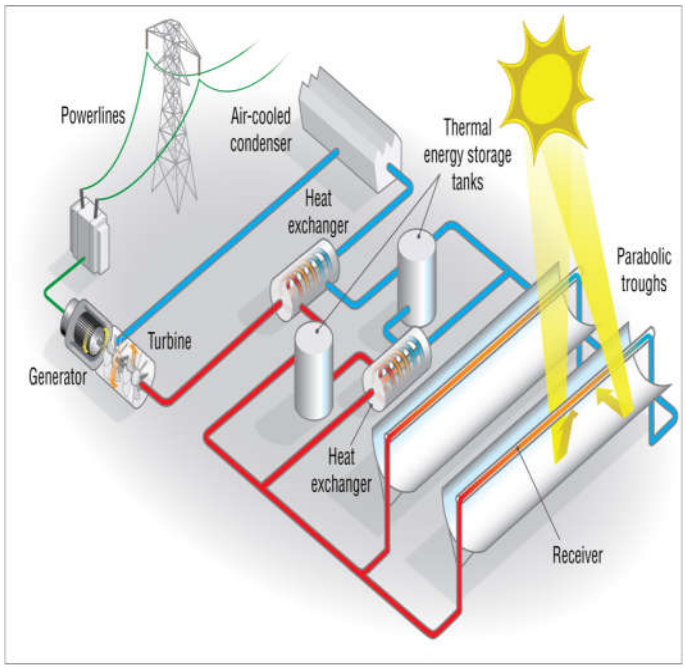


Fig 17- System Layout of CSP Plant in SAM

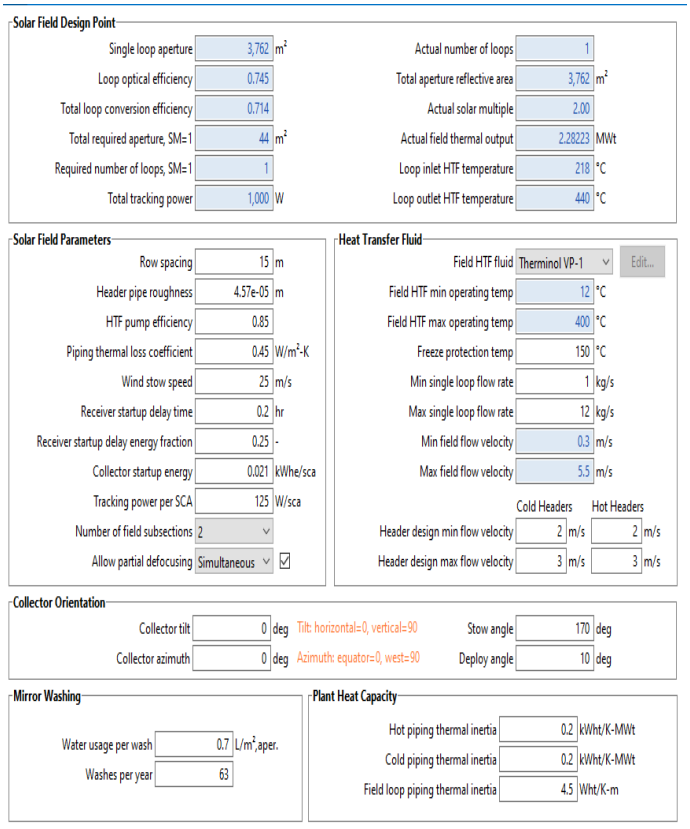


Fig 18- Solar Field and Parabolic Trough Collector Parameters in CSP plant

Comparison of Solar PV and CSP Plant using SAM for 2.5 KWe Commercial System

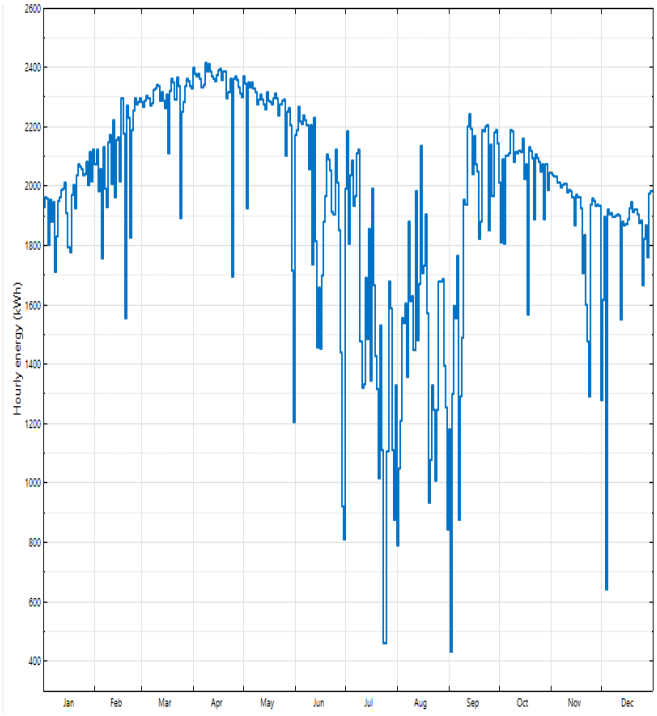


Fig 19-Hourly Energy of PV plant

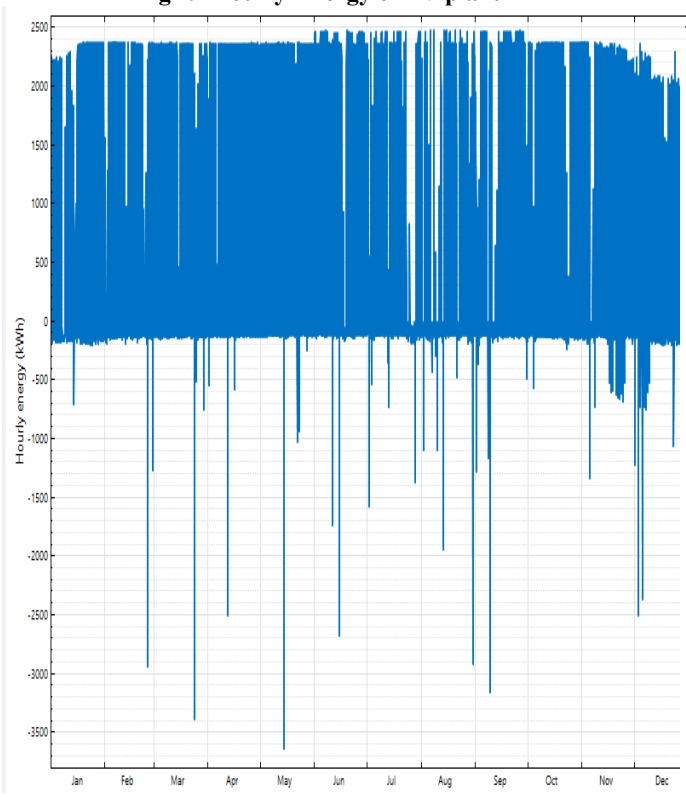


Fig 20-Hourly Energy of CSP

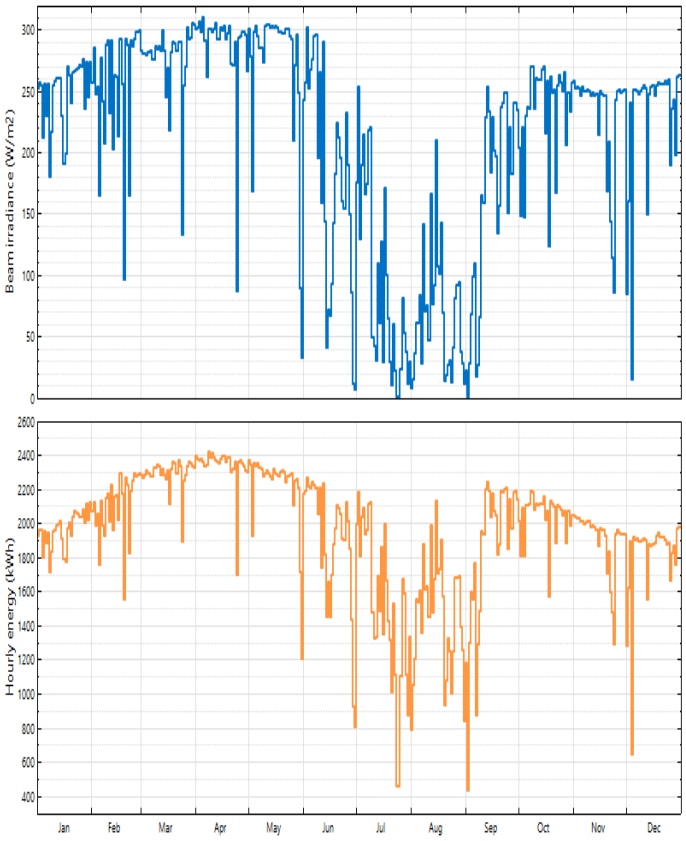


Fig 21-DNI and Hourly Energy of PV plant

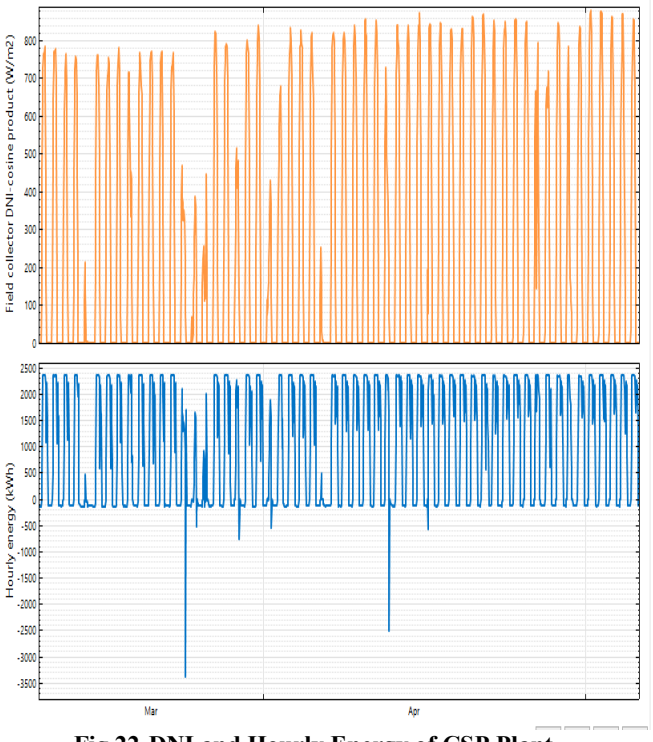


Fig 22-DNI and Hourly Energy of CSP Plant

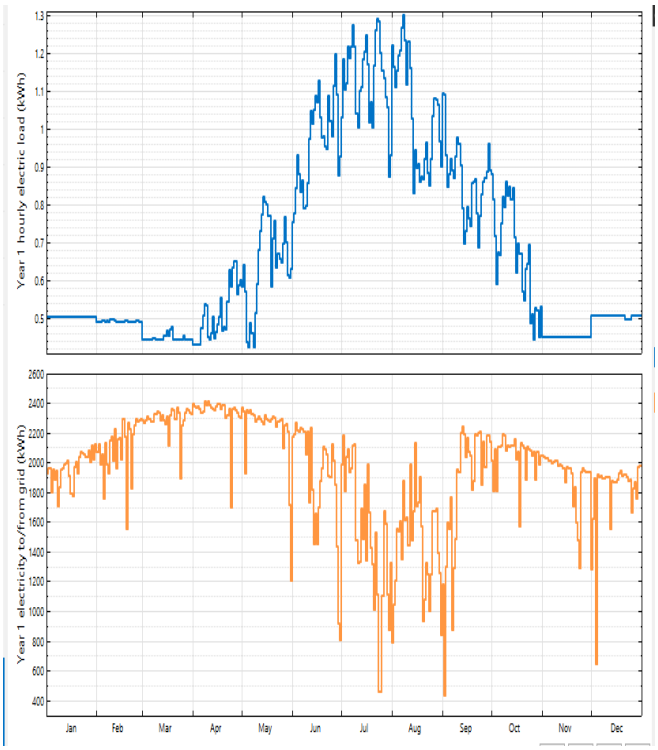


Fig 23-Electric load and Electricity to grid in PV for 1 year duration

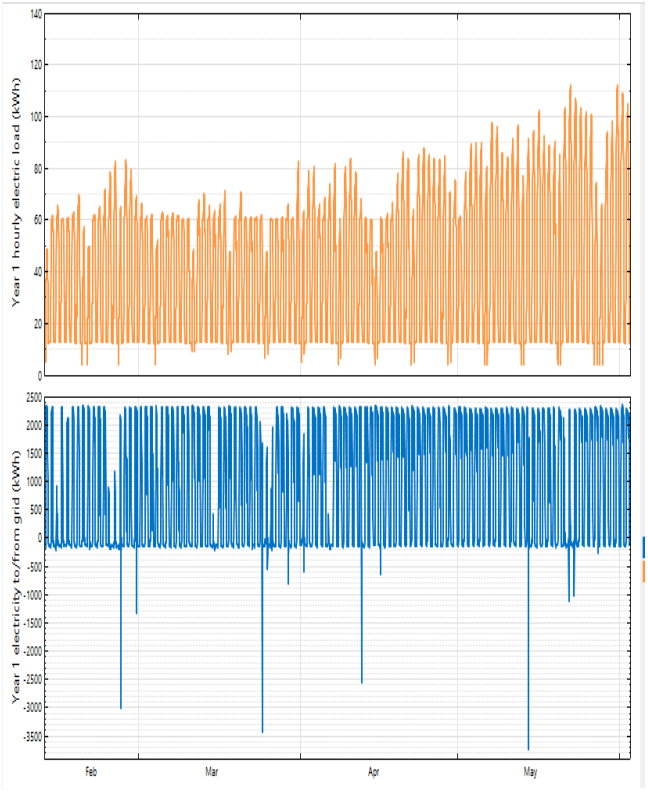


Fig 24 -Electric load and Electricity to grid in CSP for 1 year duration

CONCLUSION

Regarding the previous information, we can conclude that despite of require a lower investment the PV plant does not reach a yearly electrical power comparable with the CSP plants, besides of require a bigger area and to have an EPT much more long than the rest. All of this, plus the environmental emissions provoke the assumption of thinking that nowadays with the present technology a PV plant is not a good solution versus CSPs plants. Apart from the PV plant, that has been demonstrated that nowadays cannot compete with the CSP power plants, we can focus on both CSP plants to determinate which is the most profitable. This paper shows that the competitiveness of CSP plants can be enhanced in the near term by optimizing their capabilities to integrate TES and to be hybridized. In this work the analyses have been performed through the development and implementation of a new multi-variable techno-economic optimization model for CSP plants. This model was used to optimize the sub-system blocks available in contemporary CSP plants, in terms of component sizing and operating strategies. The model has also been used to evaluate the feasibility of new concepts, both at component level (i.e. TES concept) and at system level (i.e. new hybrid schemes), and their impact in the plant performance. Through a number of case-studies it is shown that both sub-system optimization and new concepts can help increase the economic competitiveness of CSP plants. The analysis performed shows that there exists an interrelation between the design of each of the key component-blocks available in a CSP plant, namely the solar field, the power block and the TES system.

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