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A review on concentrator Photovoltaic system

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Abstract: A concentrating photovoltaic (CPV) system converts light energy into electrical energy in the same way that conventional photovoltaic technology does. There are two main types of concentrating optical systems in use today: refractive types that use Fresnel lenses, and reflective systems that use one or more mirrors. The main problem in traditional photovoltaic system is having lower efficiency and suffers from temperature degradation in hot climates resulting in up to 20%+ lower energy output than the rated level. It is also dependent on large amounts of photovoltaic material. The cost reduction path for the technology is also limited by the cost of the silicon which composes the bulk of the system. We can overcome this problem by using solar concentrating photovoltaic system. Concentrating solar power plants utilize the same approach as traditional electrical generation plants but replace fossil fuels with sunlight in driving the steam turbines. Concentrating solar power has maturity in the market and has shown reasonably low cost solar electricity generation in large installations. In this research we find out the variation between DNI, amb_temp, conc_temp, power and efficiency.
Keywords : Photovoltaic; concentrator; cell; DNI.

I. INTRODUCTION

Concentrator photovoltaics (CPV) are a photovoltaic technology that generates electricity from sunlight. Contrary to conventional photovoltaic systems, it uses lenses and curved mirrors to focus sunlight onto small, but highly efficient, multi-junction solar cells. In addition, CPV systems often use solar trackers and sometimes a cooling system to further increase their efficiency. Ongoing research and development is rapidly improving their competitiveness in the utility-scale segment and in areas of high isolation. This sort of solar technology can be thus used in smaller areas. There are two fundamental reasons to concentrate. The first reason is cost. Areas for, optics in a concentrator system are less expensive than the photovoltaic cell. The basic concept is that if the amount of cell area per unit cans be reduced, then the overall cost of the system will drop. In the case of high concentration, it is common to find a cell of 1square centimetre being fed from an optical system that captures more than 500 square centimetres of sunlight. To a first approximation, most solar cells are linear in operation; they will put out proportionally more energy with increasing sunlight, so in the above example, the photovoltaic cell will transform 500 times more energy in the concentrator than it would if simply exposed to the direct sun. This means that the cell, per unit of energy, costs 1/500 as much. The second reason lies with manufacturability and reliability. Solar Concentrator systems are mechanical assemblies, and can make use of inexpensive, field-proven materials and manufacturing techniques, such as are used in the automotive and disk drive industries.

II. PHOTOVOLTAIC CELL

Photovoltaics are best known as a method for generating electric power by using solar cells to convert energy from the sun into a flow of electrons. The photovoltaic effect refers to photons of light exciting electrons into a higher state of energy, allowing them to act as charge carriers for an electric current. The term photovoltaic denotes the unbiased operating mode of a photodiode in which current through the device is entirely due to the transducer light energy. Virtually all photovoltaic devices are some type of photodiode. Solar cells produce direct current electricity from sun light, which can be used to power equipment or to recharge a battery. The first practical application of photovoltaics was to power orbiting satellites and other spacecraft, but today the majority of photovoltaic modules are used for grid connected power generation. Inverter is required to convert the DC to AC. Photovoltaic power capacity is measured as maximum power output under standardized test conditions (STC) in "Wp" (Watts peak). The actual power output at a particular point in time may be less than or greater than this standardized, or "rated," value of solar cell, depending on geographical location, time of day, weather conditions, and other factors. Solar photovoltaic array capacity factors are typically under 25%, which is lower than many other industrial sources of electricity. Therefore the 2008 installed base peak output would have provided an average output of 3.04 GW (assuming 20% × 15.2 GWp). This represented 0.15 percent of global demand at the time.

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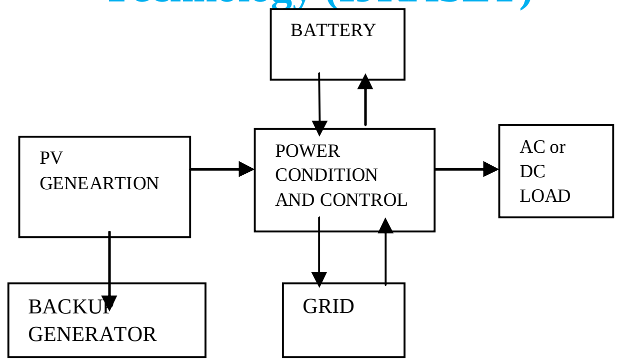

Fig. 1 Block diagram representation of a PV system

The structure of a PV systems start up with a PV module mounted on a mechanical support and possibly, a sun tracking system for better efficiency. The charge generated by the panel passes through required power conditioning and control circuit and charges the battery bank. In case of excess power being generated it is transferred to the main grid through an inverter. The battery is used to drive the load even in the absence of the PV generation.

III. LITERATURE SURVEY

The solar energy focusing photovoltaic generate electricity is the effective way of solving current questions about shortage of energy exhaustion of resources, environmental pollution [1]. Under the condition of the same output power of the photovoltaic system, using low cost superiority of the high concentrator material in place of the expensive solar cell to reduce the comprehensive cost of the photovoltaic system and realize the highly effective and the efficient unification of the focusing photovoltaic system. In this paper, concentrating photovoltaic power generation system technical problems are analyzed, and put forward improvement scheme. In addition, at the end of the paper, in combination with high concentrator solar photovoltaic power generation data collection and monitoring system, the high concentration photovoltaic system part of the operation data were analyzed briefly. Test data analysis indicates that, on the optimal design and analysis can improve the efficiency of solar photovoltaic power generation system.
Solar Photovoltaic (PV) produces electricity from the sun's rays by directly converting photons to electrons using semiconductor materials. By contrast, Concentrating Solar Power (CSP) produces electricity by reflecting sunlight via solar collectors to heat a receiver to high temperatures [2]. This heat is transformed first into mechanical energy, by turbines or Stirling engines, and then to electricity. CSP has several advantages over PV by having higher efficiencies, lower investment costs and an inherent thermal storage capacity that enables power generation during cloud cover or after sunset and a better hybrid operation capability with other fuels to meet base-load demand at night. Establishing a CSP plant creates jobs and helps develop existing local industries.
Solar power generation is an important means to solve energy shortage and environmental pollution [3]. In order to improve the efficiency of power generation of high-efficiency solar concentrating photovoltaic power generation system at present, it is required to begin with improving the tracking accuracy of solar concentrating photovoltaic power generation system and improving overall light focusing efficiency, put forward a new solar azimuth all-weather adaptive two-dimensional auto-tracking control method suitable for different weather conditions, utilize real-time control strategies and control parameter auto-optimization methods to realize flexible timing tracking and photoelectric tracking control, make the system be able to monitor weather changes in real time, and perform adaptive selection and control on solar azimuth tracking mode according to different weather conditions to improve solar azimuth tracking precision and the power generation efficiency of photovoltaic power system and reduce the energy consumption of tracking system.
In recent years, solar energy has established itself as one of the chief non-conventional energy sources, promising to be the energy source of the future. Owing to the impending energy crisis due to exhaustion of fossil fuels, it has become necessary to develop techniques that will help exploit solar energy in a better, more efficient way [4]. The paper presents a photovoltaic system incorporating one such technique: Solar Position Tracking. The goal was to design an efficient and cost-effective solar tracking system for small photovoltaic panels, such as those used in domestic applications like water heating. We have developed a micro controller-based single axis tracking system. Experimental results have demonstrated a marked increase in the average output power for a photovoltaic panel having the tracking system,as compared with an identical fixed-tilted photo voltaic panel.

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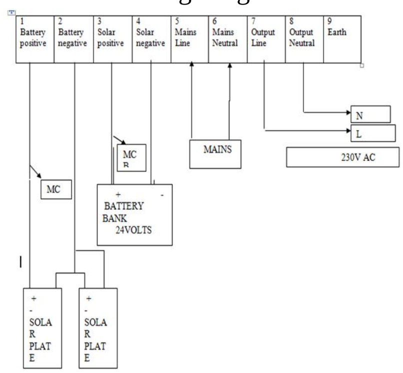
IV. SIMULATION RESULT

The 1.2 kWp system consists of six modules with the tracking system and its control unit. The operating voltage of the array is 40V DC. The system has distribution boxes for AC and DC, Charge Controller (MPPT), Battery Bank, and Inverter. The charge controller is of maximum power point tracking (MPPT) type. The system consists of concentrator photovoltaic modules (Six numbers), the array structure, the tracking system and control unit, DC distribution box, MPPT charge controller, battery Bank, Inverter, AC distribution box.

Wiring Diagram



The decision for setting up the 1.2 kWp test bed was taken with a view to study, analyze and evaluate the performance of CPV technology modules. Also, this test bed is useful for evaluating other balance of system (BOS) components like inverters; charge controllers, batteries etc. under stand alone mode as well as grid interactive mode. Though the complete monitoring system for 1.2 kWp test bed with effective data acquisition system was functional, the one week data has been included here, keeping in mind the wideness of present thesis.

During the mentioned period, the system including GP TRONICS made inverter has been connected to following local load requirements. Day time load: Morning 10.00 hrs to evening 05.00 hrs) CPV Control room.

V. DATA LOGGER

A data logger (also data recorder) is an electronic device that records data over time or in relation to location either with a built in instrument or sensor or via external instruments and sensors. Increasingly, but not entirely, they are based on a digital processor (or computer). They generally are small, battery powered, portable, and equipped with a microprocessor, internal memory for data storage, and sensors. Some data loggers interface with a personal computer and utilize software to activate the data logger and view and analyze the collected data, while others have a local interface device (keypad, LCD) and can be used as a stand-alone device.

Data of 31 days were collected from10:00Hrs to 16:00Hrs on each day. From the Collected data, performance parameters like Total DNI incident, Average Ambient Temperature, Average Array Temperature, and Power generated, Efficiency of the system, Energy Yield, Reference Yield & Performance Ratio values are calculated for each day. The observed performance of the system for 31 days is presented.

Total Input Energy is considered as DNI. We take data in every 15 minutes. The data is stored in data logger and we took data from data logger and then convert that data in excel sheet from notepad. Here we are showing the calculated data of one day.

Total DNI in w/m² = 7577.519

We took data per 15 minutes. So DNI will be wh/4.

Total DNI in wh/m² = 7577.519/4 = 1894.38

We convert DNI in kwh/m^2 because we are analysing the performance of 1.2kWp power plant.

Total DNI in Kwh/m² = 1894.38/1000 = 1.89438

The solar concentrating photovoltaic system converts sun rays into electricity. So here we check the total power generation in whole day.

Total Power Generation in watt = 8569.646

Total Power Generation in kw =8569.646/1000 = 8.569646

Again we took data per 15 minutes. So convert total power generation in kwh by using kw/4.

Total Power Generation in kwh = 8.569646/4 = 2.142412

Total input = total DNI in Kwh/m²*total area of array = 2.044395*8.424 = 17.22198

Final Yield: Total Power Output/ plant Capacity

Final Yield = 2.142412/1.2=1.785343

Reference Yield: DNI (Total Input Energy) /850 KWH

Reference Yield = 2.40517

P.R Value = Final yield/Reference yield = 0.742294

Efficiency = Total output/Total input = 12.43998

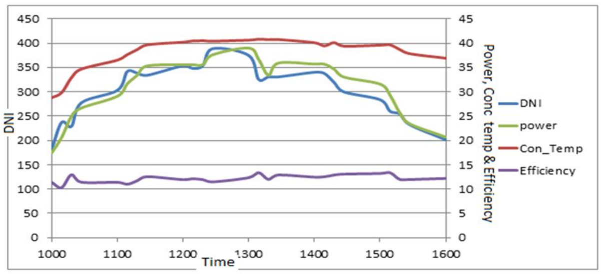


Fig. 2. Graph Between power, DNI, Conc_temp & efficiency

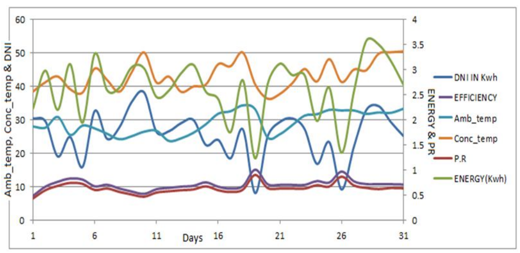


Fig. 3. Graph between DNI, Efficiency, Amb_temp, Conc_temp, PR, Energy of 31 days for Solar concentrator power plant.

The temperature of concentrated cell vs efficiency shows that the efficiency does not vary much with the temperature. The Power generated by the solar concentrator is directly proportional to DNI. As DNI increases the power generated by solar concentrator is also increases. The PR values of concentrator PV are almost constant. A peculiar response of concentrator PV is observed in efficiency curve of Concentrator PV, DNI was 8.143kWh (i.e. low DNI day) and efficiency of solar concentrator was higher to other days. PR, Efficiency, Amb_temp, and Conc_temp, behaves linearly with each other.

VI. CONCLUSION

Solar concentrating Photovoltaic performance may be better at places with higher DNI but for a place like Delhi where DNI is not too high, concentrator photovoltaic is not a promising technology. As in this report it is concluded that PR values of concentrator PV, which is a performance indicator, have lower values in comparison to other technologies. Also weather data of Delhi is studied which shows that total global radiation at the latitude position for a year is 1726.673kWh/m² whereas Total DNI is 1217.53w/m². Generally yearly DNI value is higher than yearly Global radiation at fixed tilt at places where concentrating PV works better. Such kinds of trends are observed at many places in European countries. Delhi has a composite weather condition so most of the time in Delhi the proportion of DNI is not well enough around the year to get better performance of concentrated PV technology.

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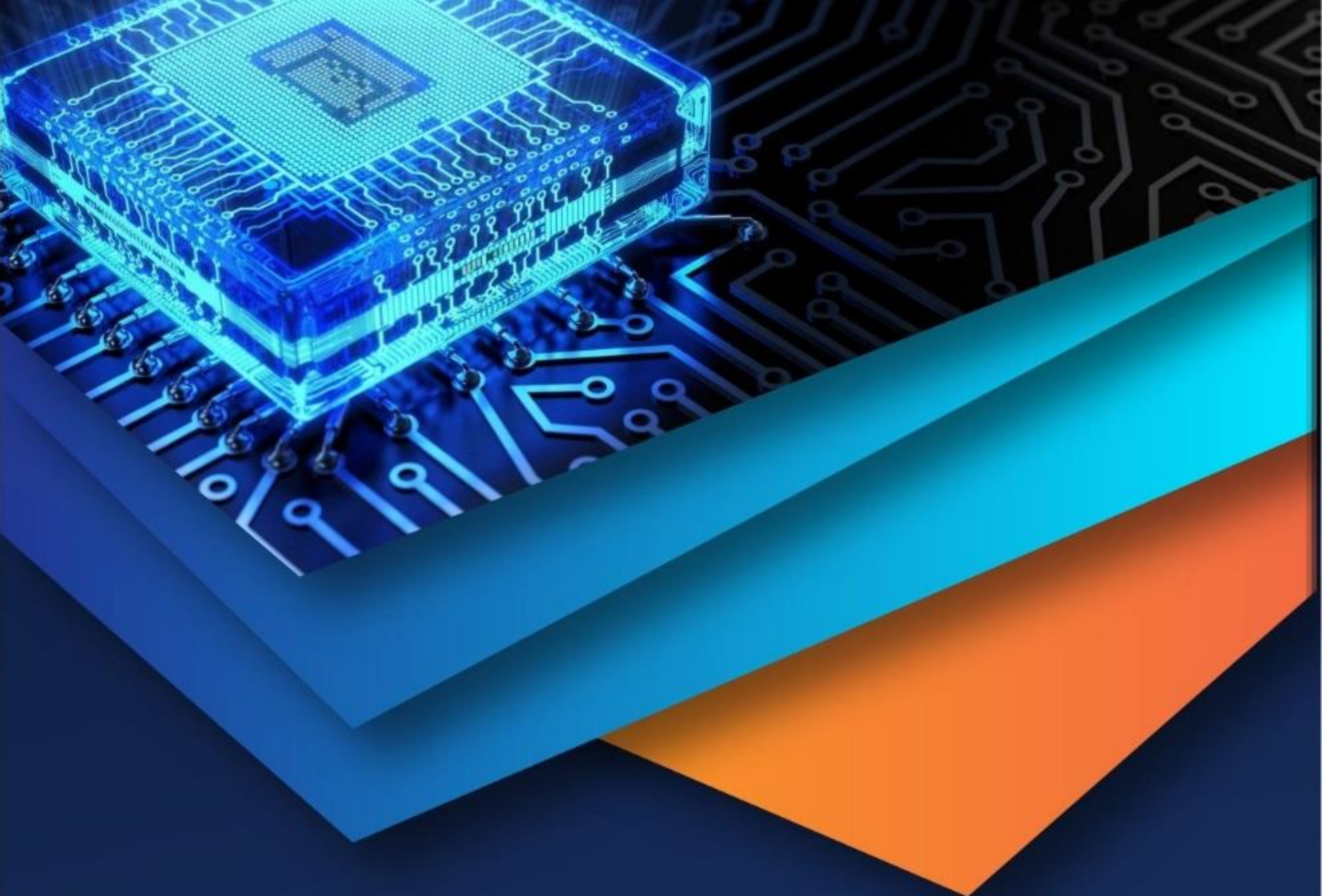

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