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Performance of High 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. Regard less of the chosen optical system; the result is concentrated sunlight being aimed at the sensitive face of the cell, to produce more energy from less photovoltaic material. Solar Concentrator Photovoltaic is one of several solar technologies, all of which provide value in utilizing the sun as a clean, renewable source of power. However, each is suited to different applications and operating environments. The key is in selecting the right solar technology for the right applications Traditional photovoltaic is a mature technology. While lower efficiency than CPV, traditional PV does not require direct sunlight and so in areas where there are clouds or hazy conditions, it is often a good choice. Also, since tracking isn't required it is well-suited to roof-top applications. In this research we find out the variation between DNI, amb_temp, conc_temp, power and efficiency.

Key Words: photovoltaic, Bettery, DNI,

I. INTRODUCTION

The world's major energy sources are non-renewable, and are faced with ever increasing demand, thus are not expected to last long. Besides being non-renewable, these sources, mainly of fossil fuels, contribute tremendously to the perennial problem of global warming. The eminent depletion and pollution problems of the above energy sources make the international community focus attention on alternative sources of energy, and solar energy appears highly promising. This energy is emitted from the sun primarily as electromagnetic radiation in the ultraviolet to infrared and radio spectral regions (0.2 to 3μm). The sun has a reasonable stable life time with a projected constant radioactive energy output of over 10 billion (1010) years. A solar cell performs two functions: photo generation of charge carriers in a light absorbing material and separation of the charge carriers to a conductive contact that will transmit the electricity.

In its simplest form, the solar cell consists of a junction formed between n-type and p-type semiconductors, either of the same material (homo junction) or different materials (Schottky or heterojunction). Solar photovoltaic is growing rapidly, albeit from a small base, to a total global capacity of 40,000 MW at the end of 2010. More than 100 countries use solar PV. Some 24 GW of solar is projected in November 2011 to be installed in that year, pushing up worldwide capacity to roughly 64 GW. Installations may be ground-mounted (and sometimes integrated with farming and grazing) or built into the roof or walls of a building (building-integrated photovoltaic). Driven by advances in technology and increases in manufacturing scale and sophistication, the cost of photovoltaic has declined steadily since the first solar cells were manufactured.

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

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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.

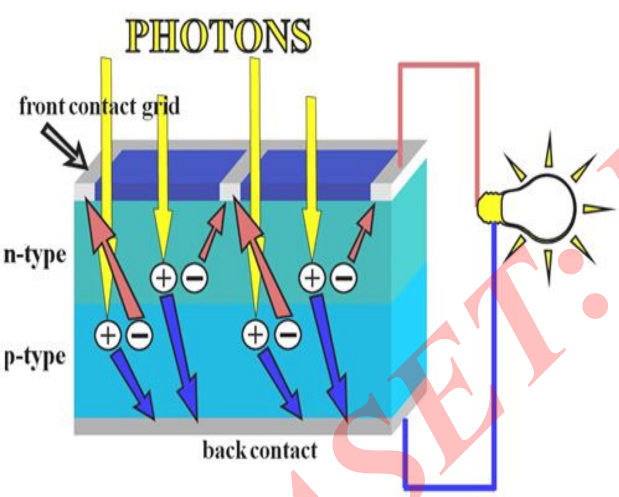

Fig. 1 Mechanism of solar cell

Structure of a PV system

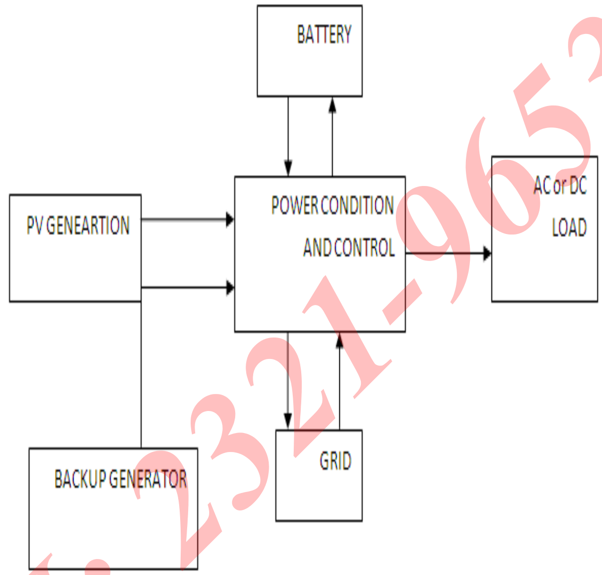

Fig 2 Block diagram representation of a PV system

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. In case of unavailability of sun for a longer period the battery bank uses power from the grid to get charged and give uninterrupted power supply. In worst case of both grid and sun failure a backup generator is kept which charges the battery bank.

III. PHOTOVOLTAIC SYSTEM CONFIGURATION

The 1.2kWp 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

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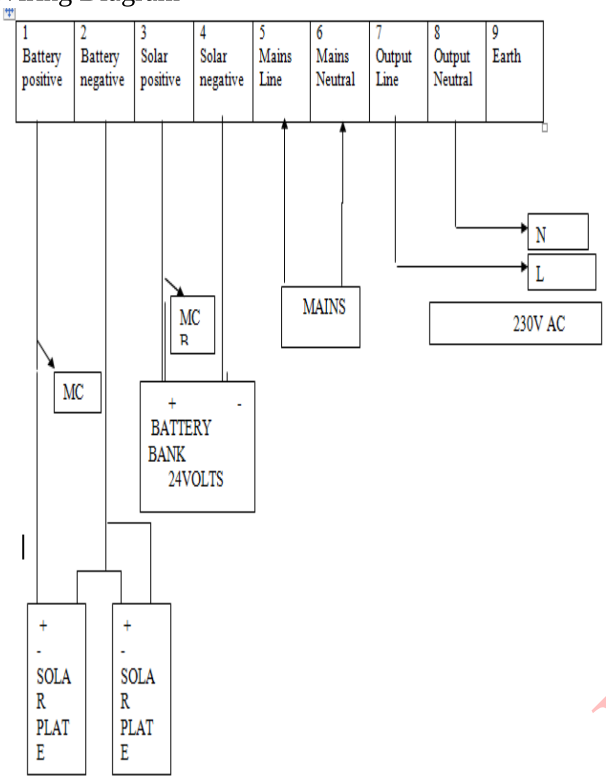
control unit, DC distribution box, MPPT charge controller, battery Bank, Inverter, AC distribution box.

Wiring Diagram



MPPT Charge Controller

It can increase the charge current up to 30% or more compared to conventional controllers because of MPPT. It is of three stage charge controller. This can be configured to optimize charge parameters to precise battery requirements based on battery electrolyte type, battery size in Amp-hours, and battery temperature. The unit is fully protected against voltage transients, over temperature, over current and reverse battery and reverse PV connections. The charge controller employs series pass Pulse Width Modulation (PWM) charge voltage control. This leads to superior charging and enhanced battery performance. To provide optimum charge control on installations where battery load varies widely during charge, the Charge Controller can interface to an external current shunt to provide optimal charge control. The PWM control system uses highly efficient and reliable power MOSFET. The MOSFET's are turned ON and OFF at high frequency to precisely control charge voltage and MPPT. Environmentally sealed high current high reliability relays are used to disconnect the PV array at night to prevent unwanted current drain. Relays are used rather than blocking diodes for improved power conversion efficiency, current boost performance, and true reverse battery polarity protection in an MPPT controller.

Maximum Power Point Tracking

MPPT and associated current boost operation is fully automatic. A PV module is considered as a constant current type device. The system automatically calculates the maximum power voltage (Vmp) corresponding to the maximum power. This process will be continuously done as operating conditions change.

Performance Evaluation of System

The decision for setting up the 1.2kWp test bed, at SEC campus, 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.

IV. SIMULATION AND RESULTS

31 days data 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 & PR values are calculated for each day. The results are shown. The observed performance of the system for 31 days is presented.

Calculation of 66th Julian days

Total DNI in w/m² = 7577.519

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

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

Total Power Generation in watt = 8569.646

Total Power Generation in KW =8569.646/1000 = 8.569646

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 = 1.785343

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Reference Yield = 2.40517

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

Efficiency = Total output/Total input = 12.43998

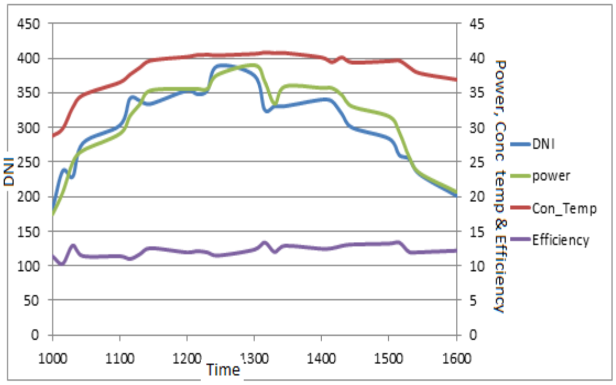

Fig. 3 Graph Between power, DNI, Conc_temp & efficiency

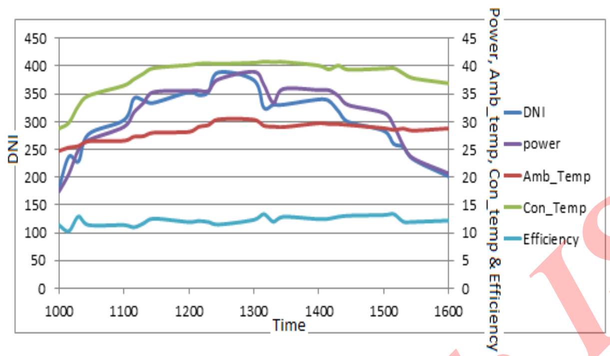

Fig 4 Graph Between DNI, Power, Amb_Temp, Conc_Temp & Efficiency

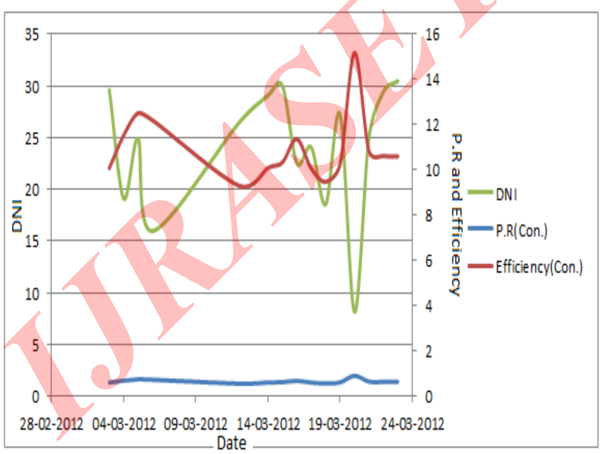

Fig. 5 Graph between DNI, P.R and efficiency of concentrator of 15 days

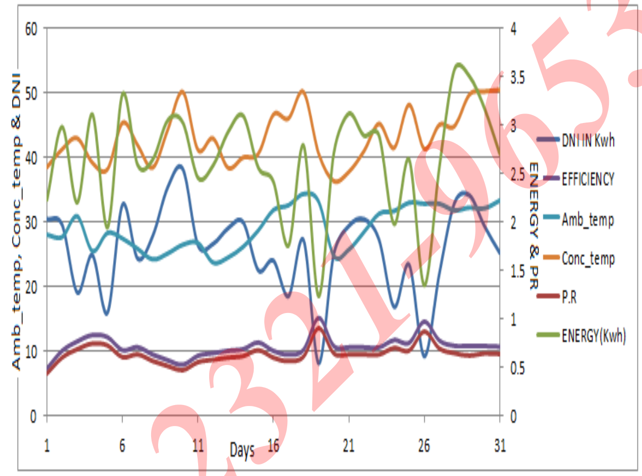

Fig. 6 Graph between DNI, Efficiency, Amb_temp, Conc_temp, PR, Energy of 31 days for Solar concentrator power plant

Temperature of concentrator increases with increase in DNI. The efficiency of concentrator is varying between 10% to 14% . The Power generated by the solar concentrator is directly proportional to DNI. The temperature of concentrated cell vs efficiency shows that the efficiency does not vary much with the temperature.

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 .

V. CONCLUSION

Solar Photovoltaic is one of the promising energy sources in the near future. 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 studied at SEC. Also weather data of 2011 at Delhi is studied which shows that total global radiation at the latitude position for a year is

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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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