Solar Radiation Measurements: Why Accuracy Matters

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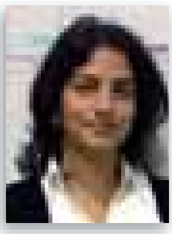
Dr.Jaya Singh discusses the importance if solar radition measurements in India's growing solar market and also brings forward a case study from India.



Increasingly in India, solar power plant owners are becoming cognizant of the need for accurate solar radiation measurements and its direct impact on return on investment. High quality solar radiation data is critical throughout the life-cycle of a solar power project, but is often overlooked until the plant is commissioned and problems surface in performance and efficiency. In this article, we present how seemingly small deviations in solar radiation measurements have a major impact on estimates on performance ratios and plant efficiency.

Although solar radiation measurement equipment present a negligible fraction (less than 1-2%) of the total cost of a solar project, it is often the most neglected aspect of project development in India. In our experience of providing high accuracy solar weather monitoring stations across India, we find that the majority of solar power projects do not include obtaining accurate solar radiation ground measurements on plant site in the initial site assessment or planning stages. Infact, the most critical financial decisions are made on the basis of solar resource maps that are low resolution to begin with, and do not take into consideration local environmental and atmospheric conditions that have a significant impact on solar radiation and plant output, and consequently on the return on investment.

It is estimated that over 65% of solar weather monitoring stations are installed in the project development stage, and now increasingly after the plant is operational. Why this investment in accurate solar and weather monitoing equipment after plant design and operationalizing the plant?

It is only after the plant is functional that plant owners start evaluating performance and begin the process of predicting energy output. As the power output of PV solar panels are approximately proportional to the sun's intensity, it is then that the lacunae on accurate solar parameters becomes evident. There is also a realization that it makes financial sense to validate solar resource databases upon which most plants are designed and investment decisions made, with accurate ground-based measurements during the lifecycle of the plant to reduce uncertainities in energy production.

The mature phase of the solar industry in India is seeing requests for evaluating energy production by accurately measuring incoming solar radiation and validating it with satellite data and advanced solar forecasting models. As plant owners aim to predict their performance and energy output with overall uncertainties of 1 % - 2 % in solar radiation measurements, there is also an increased demand for the highest quality pyranometers and pyrheliometers.

Case Study

A plant owner [solar 5 MW plant] contacted BKC Weathersys six months after plant commissioning to evaluate whether the performance of the plant tallied with existing ground measurements and and estimates made by their EPC contractor.

Once the plant was up and running, the plant's performance and yield were

THE MATURE PHASE OF THE SOLAR INDUSTRY IN INDIA IS SEEING REQUESTS FOR EVALUATING ENERGY PRODUCTION BY ACCURATELY MEASURING INCOMING SOLAR RADIATION AND VALIDATING IT WITH SATELLITE DATA AND ADVANCED SOLAR FORECASTING MODELS

continuously monitored, analysed, and compared with the expected values. The problem faced was the energy output was higher than what could be expected based on performance ratios.

The study included setting up three solar monitoring stations that included a Kipp&Zonen CMP11 pyranometer at three different locations on the plant, and monitoring measurements for a period of over 1 month, and comparing these measurements with the plants existing solar weather monitoring equipment from another manufacturer. The CMP11 (traceable to WRC, Davos, Switzerland) is an ISO-Secondary Standard Pyranometer that allows for accurate measurement of GHI.

The three CMP11 pyranometers were installed at the identical tilt angle as that of the PV modules. One pyranometer had a sensitivity 8.33 microvolt/W/m^2, and the two other pyranometers had sensitivities of 9.16 microvolt /W/m^2. For comparison's sake, at the request of the plant owner, two pyranometers were connected to a data logger, and one pyranometer was connected directly to the plant PLC acquisition system.

Analysis showed that the percentage errors in measuring incoming solar radiation between all three pyranometers was less than 1.5%. However, the percentage difference in the hourly solar radiation measured by the existing solar radiation measurement equipment and the three Kipp&Zonen CMP11 pyranometers was at least 11% (See Figures 1&2), with Kipp&Zonen pyra-

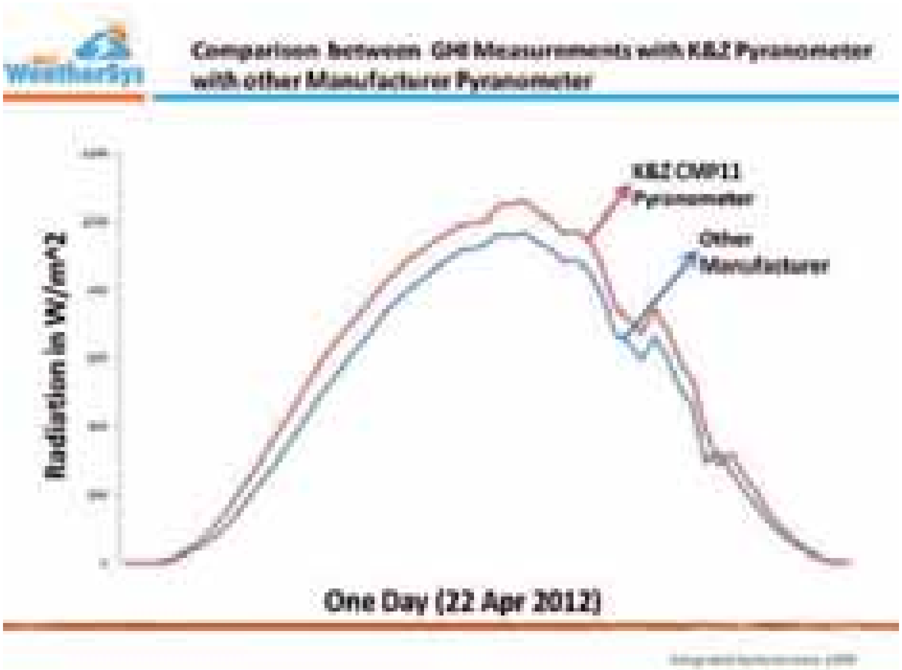


Figure 1. Plot of Global Horizontal Irradiation (GHI) obtained over a 24 hour cycle on April 22, 2012 at client site in Uttar Pradesh. Measurements obtained by Kipp&Zonen CMP11 pyranometers is in red and measurement by other manufacturer is in blue. Measurements from other manufacturer under reported incoming solar radiation. For the PV plants, as the energy ouput is proportional to incoming radiation, deviations in ground measurements provide erroneous data for determining plant output and efficiency.

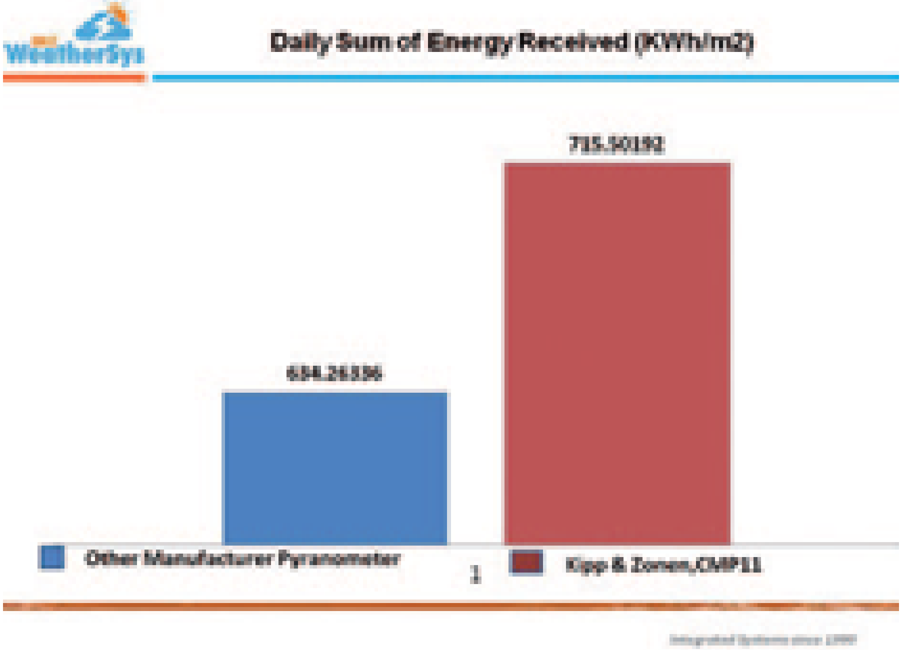


Figure 2. Daily sum values of energy as determined by ground measurements of solar irradiance. Kipp&Zonen CMP11 pyranometer in red and other manufacturer in blue. The energy production differs by over 11%, too substantial an uncertainity for making operational decisions.

nometers showing a higher irradiance than the older, existing pyranometer.

While a 11% difference in energy output in a given hour may not seem much at first glance, for a 5MW plant, this translates into a significant difference in plant output over a 24 hour cycle (Figure 2). As PV systems produce power in proportion to the intensity of sunlight striking the solar array surface, the difference in the actual output of a solar power system could be substantial.

HIGH PRECISION IRRADIATION MEASUREMENTS IN PV POWER PLANTS FORM AN ESSENTIAL INFORMATION BASE FOR YIELD AND PERFORMANCE RATIO ASSESSMENT

Because the existing solar radiation measurement equipment was under reporting the incoming solar radiation, the performance of the plant as calculated on the basis of incoming solar radiation seemed better than it it actually was. Once more accurate ground measurements were obtained, the plant owner could ascertain module performance and plant efficiency with more confidence. The increased accuracy in solar radiation measurements also allowed the plant owner to make decisions on periodic maintenance and cleaning of PV modules.

In summary, high precision irradiation measurements in PV power plants form an essential information base for yield and performance ratio assessment. Once up and running, the plant's performance and yield are continuously monitored, analysed, and compared with the expected values.

Conclusion

The use of low quality radiation measurement instruments for reference purposes and for providing data for informing key decisions like scheduling maintenance and cleaning of panels, monitoring performance, and even predicting plant output is fraught with error.

As solar radiation measurement equipment present less than 1-2% of the total cost of a solar power project, investing in high quality instruments makes sound financial sense. Poor quality data can compound errors in plant design, performance and output forecasting, negatively impacting return on investment. Investment in high accuracy solar weather monitoring stations has a significant pay-off throughout the lifecycle of a solar power plant.

Even though the majority of projects are designed and commissioned on the basis indirect estimates of solar radiation from solar databases, even after the plant is commissioned, it is critical to obtain accurate ground measurements to reduce uncertainties in energy production. In addition, ground measurements must be quality controlled by an expert to ensure that there are no errors in the data. Only high-precision measurement data collected on-site can provide meaningful and realistic conclusions about the performance of a PV power plant.