

# Solar Radiation Measurements : Accuracy Matters



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High quality solar radiation data is critical throughout the life-cycle of a solar power project. Although solar radiation measurement equipment present less than 2% of the total cost of a solar project, we often see compromised quality of instrumentation for measuring solar radiation. In this article, we describe solar radiation measurement equipment, and present a case study where ground measurements for a solar power plant client in Maharashtra were compared to satellite and model derived solar radiation forecasts. This analysis established the inadequacy of instrumentation for the solar project needs, and that an initial cost-saving in investment was not worthwhile for the client in the long run.

**H**igh quality solar radiation data is critical throughout the life-cycle of a solar power plant. Once a plant has been set-up and is operational, high quality solar radiation data is required for maximizing operational efficiency, scheduling maintenance, monitoring performance, and for output forecasting. Errors in the solar radiation measurements can significantly impact upon the return on investment for solar projects.

## How is Solar Radiation Measured?

All solar power plants require high quality solar radiation measurement instruments in order to accurately measure the amount of solar energy incident at that location. A combination of pyranometers and pyrgeometers for measuring GHI, DNI and DHI constitutes a "Solar Monitoring Station". High quality instruments provide solar radiation data that is accurate enough to allow comparison with data from other sites as well as with data from other sources such as satellite data.

High quality ground-based measurements

of solar radiation are made by radiometers that have a flat spectral response over a wide spectral bandwidth. These radiometers use a thermopile detector that absorbs the incoming radiation and converts the increase in temperature into a small electrical signal. Instruments that employ silicon based detectors instead of a thermopile, are lower cost but highly compromised in accuracy. The case study reported below also illustrates this.

Along with solar radiation parameters, meteorological parameters such as wind speed, wind direction, ambient temperature, relative humidity and other environmental factors such as cloud cover and dust also impact the solar energy at any given site. Consequently, solar plants also require a high quality weather monitoring stations. Solar Weather Monitoring Stations are normally connected to a data logger that records and stores the readings. Data can be forwarded in real-time via telemetry or periodically downloaded for processing and analysis.

A large site may have two or more Solar Weather Monitoring Stations. For one client in Charanka Solar Park, Gujarat, we have installed four high quality Solar

Weather Monitoring Stations at a single plant to accurately capture data that allows for accurate nowcasting and forecasting of energy output.

## World Standards for Solar Radiation Measurement Instruments

With the wide range of solar radiation measuring instruments available in India, we often get questions from clients enquiring about the standards and price-effectiveness of available technologies. Our recommendation is to use pyranometers and pyrhemometers that meet performance specifications calibration standards laid down by the World Meteorological Organisation (WMO) and the International Standards Organisation (ISO). Instruments that comply with WMO and ISO classifications provide accurate measurements of the solar radiation under all weather conditions.

Through partnership with Kipp and Zonen B.V, The Netherlands, other leading OEMs, BKC Weathersys Pvt. Ltd. provides turn-key solutions for Solar Weather Monitoring



Stations and also provides services for data analysis during plant operation. We also correlate ground measurements with satellite data and advanced solar models to ensure accuracy as you will see in the case study

measuring the Global Horizontal Radiation (GHI). To gauge the operational efficiency of the plant, they wanted to correlate ground-measurements with satellite data. We employed the automated solar forecasting workstation developed at BKC WeatherSys Pvt. Ltd. to carry out this analysis.

cannot be relied upon for either monitoring plant efficiency or making output forecasts as ground measured radiation data is in error of over 50%.

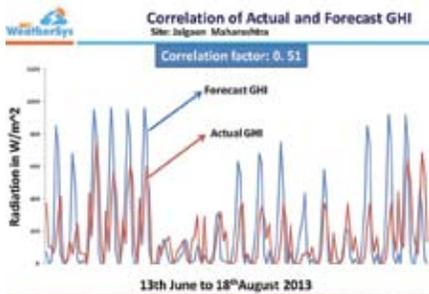


Figure 1

Furthermore, we carried out a correlation of ground measurements and satellite based forecasts at two other sites, one in Gujarat (Figure 2) and the other at our project office in Uttar Pradesh (Figure 3), where we have installed Solar Weather Monitoring Stations that employ thermopile detector based radiation sensors from Kipp and Zonen, The Netherlands.

In contrast, ground measurements and satellite based forecasts at two other sites, one in Gujarat (Figure 2) and the other at our project office in Uttar Pradesh (Figure 3), where we have installed Solar Weather Monitoring Stations that employ thermopile detector based radiation sensors from Kipp and Zonen, The Netherlands, have good correlation factors. These Solar Weather Monitoring stations included various sensors including a Kipp and Zonen CMP11 Pyranometer. The CMP11 (traceable to WRC, Davos, Switzerland) is an ISO-Secondary Standard Pyranometer that allows for accurate measurement of GHI.

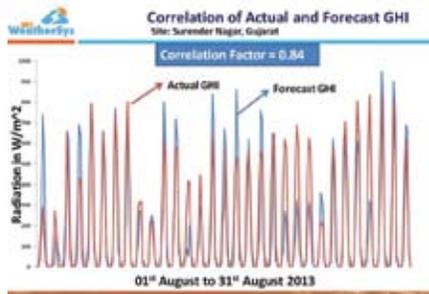


Figure 2

**Figure 1.** Plot of Global Horizontal Irradiation (GHI), Actual and Satellite derived Forecast, from 13th June to 18th August 2013 at client site in Maharashtra. Actual GHI is in red and Forecast GHI is in blue, and the values are poorly correlated. Ground measurements were obtained using silicon-based radiation sensors.

These results are not a surprise. Silicon based radiation sensors are known to have limitations arising from temperature fluctuation, spectral range, and degradation and cannot be relied upon for accurate measurement of solar radiation under all weather conditions.

below.

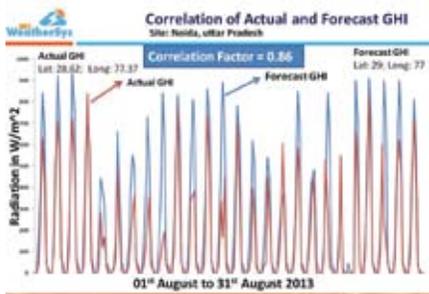


Figure 3

**Figure 2.** Plot of Global Horizontal Irradiation (GHI), Actual and Satellite derived Forecast, from 01st to 31st August 2013 at BKC WeatherSys Pvt. Ltd. project office in Noida, Uttar Pradesh. Actual GHI is in red and Forecast GHI is in blue, and the values are well correlated. Ground measurements were obtained using a Kipp and Zonen CMP11 pyranometer.

## Impact of Inaccurate Data on Return on Investment

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. In conclusion, investment in reliable solar radiation instruments pays off during plant design as well as the entire life cycle of the project.

### Case Study: Correlating Solar Forecasts with Solar Monitoring Station Data for a client in Jalgaon, Maharashtra

A client had installed a Solar Monitoring Station in Jalgaon in Maharashtra, India. The Solar Monitoring Station included a silicon based solar radiation sensor for

**Figure 3.** Plot of Global Horizontal Irradiation (GHI), Actual and Satellite derived Forecast from 01st to 31st August 2013 at client site at Surender Nagar, Gujarat. Actual GHI is in red and Forecast GHI is in blue, and the values are well correlated. Ground measurements were obtained using Kipp and Zonen radiation sensors (CMP 11 pyranometer).

After analysis by our team (see Figures 1, 2, & 3), we found that the correlation factor between the forecasted GHI value and the actual GHI value as measured by the client's silicon based sensor is very poor (0.51). Their current solar monitoring station