Solar Resource Assessment: Making Sense of Data

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Accurate assessment of solar radiation is the foundation upon which profitability of the solar energy industry rests. Precise on-site ground measurements with calibrated equipment is the gold standard for ensuring an accurate assessment of solar irradiance. However, what happens when you've bought the right equipment and are still not getting the kind of performance you'd expected? Is the equipment at fault? Or have all aspects of the site-geography, environmental conditions, and local weather conditions been considered? This article describes a situation where the measured radiation was out of the expected range and radiation measurement equipment was deemed faulty. BKC found that by taking into account existing weather and environmental conditions for that particular geographical location, the measurements were in fact accurate.
BKC Weathersys Pvt. Ltd. is the leading provider of Solar Resource Assessment and site prospecting in India and offers integrated solutions for accurate measurement of solar radiation and correlation ground observations with satellite data and advanced solar models.

While setting up a capital intensive solar power plant, an estimate of accurate solar radiation should be the first step to evaluate the energy output that at a certain site. Initial estimates using historical data (TMY) are a good starting point, but they remain just that--a starting point. For estimates of solar energy yields that can ultimately formulate bankable reports for establishing solar plants, accurate ground measurements on-site are imperative.

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. temperature and relative humidity, and environmental factors such as cloud cover and dust also impact the solar energy at any given site. Thus, accurate measurement of all of these parameters using high accuracy instruments is invaluable for solar project development and R&D purposes. Through partnership with Kipp and Zonen B.V, The Netherlands, other leading OEMs, BKC Weathersys Pvt. Ltd. provides turn-key solutions for solar monitoring stations and also monitors data output for accuracy. Ground measurements can also be correlated with satellite data and advanced solar models to ensure accuracy as you will see in the case study below.

A client that had a solar monitoring station on a glacier in the Himalayas was having problems. Something was wrong with their set-up. Off-late, their numbers seemed off, way-off the detection limit of the instruments. Could we please look at the data and decipher what was going on? We did as you will see in the case study below.

Case Study: Reflection of Solar Radiation at Yala Glacier, Himalayas (Nepal).

Introduction: A research institute had installed a solar monitoring station

at a glacier in the Upper Himalayas and reported faulty radiation data. The solar monitoring station included a Kipp & Zonen CNR4 net radiometer that measures short-wave upper, short-wave lower, long-wave upper & long-wave lower radiation along with other weather parameters. They reported a problem in that the solar radiation measured had exceeded a threshold of 1,367 W/m^2. This solar monitoring station had been recently installed and was functional for a month before problems were reported. The problem was attributed to faulty instrumentation and set-up.

Instrumentation: The solar monitoring station included 7 sensors including a Kipp and Zonen CNR 4 net radiometer (See Figure 1). The CNR4 net radiometer is a high quality, reliable instrument with proven performance in polar conditions. The CNR 4 net radiometer consists of a pyranometer pair, one facing upward, the other facing downward, and a pyrgeometer pair in a similar configuration. The pyranometer pair measures the short-wave radiation while the pyrgeometer pair measures long-wave radiation. The CNR 4 net radiometer measures the energy balance between incoming short-wave and long-wave Far Infrared Radiation (FIR) versus surface-reflected short-wave and outgoing long-wave radiation. Apart from radiation measurement sensors, two temperature sensors, a Pt-100 and Thermistor, were also integrated to correct the infrared readings for the temperature of the instrument housing of CNR4. Data output from all sensors was integrated to a RTDL-11 data logger from Real Time Solutions Pvt. Ltd. A solar panel bundled with a battery charger and controller was used to power up the weather station.

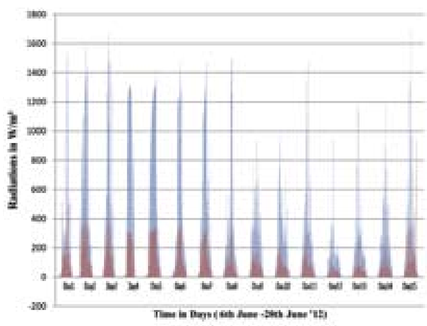
Figure 1. Solar monitoring station at Yala Galcier, Nepal. The station includes 7 sensors including a CNR 4 net radiometer from Kipp & Zonen integrated with a data logger and a solar panel bundled with a battery charger and controller to power the weather station.

Data: Fifteen days of data from the solar monitoring station were available for analysis. The data comprised of short wave upward radiation obtained with an upper pyranometer, short wave downward radiation from the lower pyranometer, long wave upward radiation from upper pyrgeometer, long wave downward radiation from lower pyrgeometer, net short-wave, net long-wave, net lower radiation & net upper radiation.

The Problem: The maximum solar radiation at the boundary layer is expected to be within 1367 W/m². Under normal conditions, short-wave upper radiation lies within 1000 W/m² while short wave downward, long-wave upward, and long-wave downward radiation do not go beyond 400 W/m. However, during June 2012, the measured short-wave upper radiation exceeded 1,700 W/m².

The Solution: After analysis by our team (see Figures 2 and 3), we concluded that this situation was a rare case that does does not occur in plain geographies. At the glacier, the measured solar radiation exceeded 1,700 W/m² because: a. clouds had acted as a mirror; b. snow played a major role in refulgenting as snow can reflect up to 80% of radiation depending upon the type of snow (fresh, melted or old). Because the weather station is surrounded by snow, the reflectivity is much higher than that typically observed by us in regions like Rajasthan and Gujarat.

From the available data, it was clear that the radiation value surged instantly from



low radiation, remained at that level, and then declined to normal values, indicating that before acceleration there must have been a cloud in the sky. Clear sky conditions remained for a short while, before cloud cover arrived again. The reason for the sharp rise in radiation is because the cloud acted as a mirror, reflecting sunlight to the sensor. This accounted for the surge in reading. This happens at high altitudes with a clear sky and some bright white cumulus clouds (not covering the sun).

Figure 2. Plot of short wave radiation over 15 days at Yala Glacier, Himalayas. Short wave up-welling infrared radiation is in red and short wave down-welling infrared radiation is in blue.

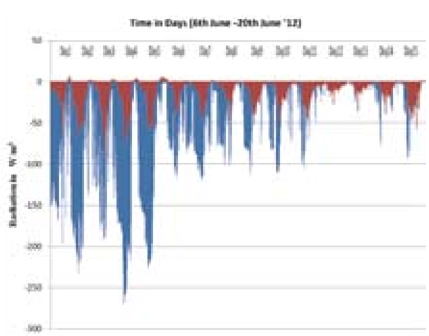


Figure 3. Plot of long wave radiation over 15 days at Yala Glacier, Himalayas. Long wave up-welling radiation is in red and long wave down-welling radiation is in blue.

Figuer 3 shows that each day, the radiation pattern of long wave radiation was similar to that of short wave radiation. Even when short wave radiation values surged, long wave radiation simultaneously increased as well. This could be attributed to cloud particles and snow reflecting radiation which leading to the higher long wave radiation values.

In summary, we concluded that the radiation data being measured at Yala Glacier was accurate and within range. These conclusions were arrived at through analysis of ground measurements. While the values seemed high, these observations are not an isolated case. We have had a similar experience with BKC Weathersys' in-house solar monitoring system in Noida, India in 2011 when during the rainy season, we observed the threshold value of solar radiation being attained in a day. We too observed that radiation had gone beyond 1300 W/m² and the same pattern was followed in this case too. When there are some white cumulus clouds which are not covering the sun, they act as a mirror or reflector, reflecting most of the radiation. Cloud type and their behavior are known to have a measurable impact on radiation; different types of clouds have different effects on radiation.

Recommendations: As per the geographical location of the site, there was no ambiguity in the data recorded at Yala Glacier, Nepal. This analysis of reflection of solar radiation under snowy conditions shows that solar radiation may increase to very high values, especially in the presence of white cumulus clouds not covering the sun at the observation site.

Conclusion: The above case study shows local geography, site topology, meteorological parameters, and environmental conditions have a big impact on incoming solar irradiance. All of these factors need to be taken into consideration while validating the final derived data. In addition, this case study endorses the use of the ground observations at the selected site as the most appropriate and accurate metod of carrying out such research or resource assessment. Our analysis enabled to research institute to not misdirect resources towards fixing "faulty instrumentation" when in fact other conditions accounted for the seemingly faulty out of range data.