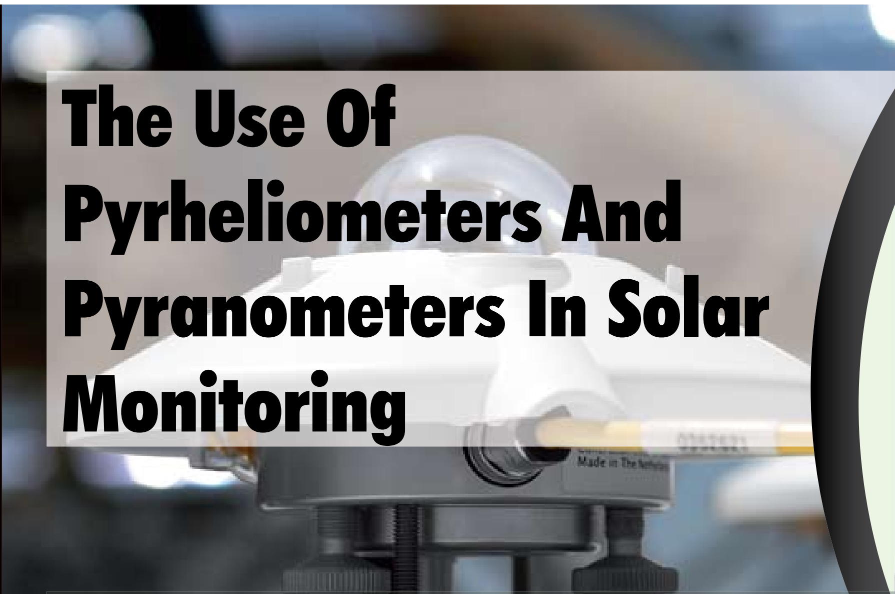


The Use Of Pyrheliometers And Pyranometers In Solar Monitoring

Ruud Ringoir Product Manager , Kipp & Zonen B.V.

The monitoring of a solar power plant is a complex process with many stages, from solar energy input to electrical power output. For all these stages separate sensors and associated software are is available to monitor the whole process. The importance of monitoring the available input from the sun is often underestimated, or thought of as less relevant, because the solar radiation cannot be controlled or improved. The following article will explain the importance of accurate solar monitoring with the right equipment.

Location Monitoring

It all starts with prospecting, or finding the optimal location. Because most countries have mountains, lakes or sea shores the (micro) climate will change over these areas and therefore cloud formation and the received solar radiation are different. The decision to build the power plant at location A or location B is based on the local solar radiation conditions.

Monitoring in advance will not only help you choose the optimal location, it will also give you a good estimate of the available solar energy for calculating the bankability of a project.

Monitoring in Operation

The next step is monitoring when the power plant is in operation. In this stage the efficiency, or performance ratio, is the most important factor. Independent of the technology used (PV, CPV or CSP) a thermopile radiometer will provide accurate and independent solar radiation data.

Both the pyranometer and pyrheliometer radiometers measure the irradiance in W/m2, and when integrated over a day the exact amount of available solar energy in Watt Hours or Joules can be determined. Compared to the electrical output of that day this will give you the overall efficiency of the power plant.

Apart from the efficiency, additional information can be derived from the data. Gradual changes in efficiency may indicate pollution of panels or mirrors, so cleaning actions can be scheduled. More sudden changes may indicate a defective section, or a cable and connection problem, so further service actions are required to investigate the problem.

Monitoring Differences for PV, CPV and CSP

To monitor a power plant, in fact only one accurate radiometer is required. But often two are used for redundancy. When one is out for calibration, the second will still supply the required data for monitoring.

The difference between Photovoltaic (PV) and Concentrated Solar Power (CSP) or Concentrated PV systems is not only the technology used but also which part of the solar radiation is used.

Concentrating power plants use mainly the direct solar radiation because the direct beam of the sun is focused with mirrors (CSP) or lenses (CPV). The direct radiation is measured with a pyrheliometer pointed at the sun. This radiation is called Direct Normal Irradiance, or DNI.

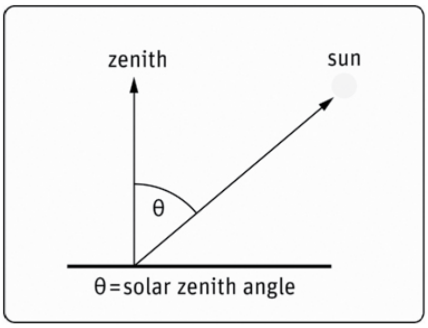
PV panels with a fixed construction are located with an optimal tilt angle to catch the maximum amount of sun during the whole year. These flat panels not only use the direct part of the solar radiation but also the Global Diffuse Irradiance or GDI. In this case a pyranometer is used that measures both direct and diffuse radiation. This radiation is called Global Horizontal Irradiance, or GHI, when measured horizontally. For fixed PV panels an additional pyranometer is mounted tilted at the same angle as the panels, and then the Global Tilted Irradiance (GTI) is measured. One axis or two axis moving PV

panels follow the sun and make more efficient use of the direct radiation.

Many meteorological stations measure the Global Horizontal Irradiance and when there is a station nearby (< 25 km) this data can be used for reference or for historical comparison at that location.

The relationship between the Global, Direct and Diffuse components of solar radiation is as follows:

GHI = GDI + (cos x DNI) where is the solar zenith angle as shown in the diagramme below.



Larger solar monitoring stations often measure all three components and cross-check using the formula above to verify the individual components.

Smart Monitoring

Thermopile radiometers generate an output signal from the incoming solar radiation. This means they do not need a power supply, but consequently the output signal is rather low. A typical radiometer gives about 25 milli-Volt output on a bright sunny day. These signals have to be recorder by a sensitive data logger, or an extra amplifier is needed to increase the signal level. This also means that every re-calibration of the radiometer also requires a modification of the amplifier or data logger.

In order to simplify this process there are pyranometers and pyrheliometers available with a Smart interface built-in. This means that the radiometers have both an amplified analog output and a digital output, to make it easier to interface with existing computer networks or PLC's.

This Smart series of radiometers has RS-485 digital communication with Modbus® protocol and temperature correction over the whole operating range. The Smart interface also provides faster response times and access to the radiometer model, serial number, calibration data and history.

Monitoring Maintenance

Because maintenance is often a major part of the cost of ownership, extending the maintenance interval will lower these costs. High accuracy radiometers normally have drying cartridges filled with a desiccant to keep the interior of the instrument dry. This prevents condensation of water inside the dome or window and prevents measurement errors. They must be inspected by regularly checking the color of the desiccant material. Orange means that it is still active, whereas transparent indicates that it needs to be changed. Depending on the location of the radiometer, mounted on a mast or located at a remote site, this can require significant time and cost.

There is currently one pyranometer available with internal desiccant that has a guaranteed lifetime of 10 years. This means no regular inspection and change of desiccant is needed. Moreover, with every re-calibration or service by the manufacturer the desiccant is replaced and will last for a further 10 years.

To further minimize the pyranometer maintenance interval and improve data quality, a ventilation unit can be added to keep the dome free of dew, raindrops, pollution and dust. Frost and snow will be removed because of the built in heaters. One of the latest developments is a ventilation unit with a radial ventilator that provides a continuous rotating flow of clean air around the dome that keeps even the top clean.

Monitoring Compared to Satellites

In addition to local ground-based monitoring, satellite data is often available. This is a useful tool to get an idea of the available solar radiation in a certain area. However the uncertainty of this data is about 10%. The time interval of the satellite data is 1 hour or more and the spatial resolution is usually over 10 km2. To monitor the efficiency of a 100 MW power plant this 10% error is 10 MW.

The best well-maintained pyranometers and pyrheliometers can provide measurements of solar radiation with an uncertainty of 1 or 2%. This shows the importance of accurate local measurements with high quality and precise instruments.