Solar Irradiance Monitoring: an essential guide
PV installations made simple

When it comes to rooftop installations, Building Integrated Photovoltaic (BIPV) systems and small, ground-mounted PV plants (kW range), solar radiation measurements significantly improve the monitoring of the performance of the solar energy system.

For example, in most smaller PV installations, if any monitoring is done, it is usually a comparison of the output from one PV panel to another PV panel. Typically, you then monitor the relative efficiency and detect a faulty panel or connection. Although useful, it actually doesn’t tell you whether you get the maximum out of your system. As long as you do not measure the input of solar radiance into to the PV installation, you will not know whether you should be satisfied with the output of your PV installation.

To monitor the energy yield of the PV installation, a tilted pyranometer is installed at the same angle as the panels to measure plane of array (POA) irradiance. A horizontal pyranometer can be added for global horizontal irradiance (GHI) measurements – this allows comparison of the on-site data to other sites and to data received from meteorological stations.

Cost-efficient low-maintenance smart pyranometers SMP3 (ISO 9060 Second Class) and SMP10 (ISO 9060 Secondary Standard) are ideal for small scale installations. Smart pyranometers have internal digital signal processing, an amplified analogue output (4 to 20 mA or 0 to 1 V) and a RS-485 serial communication with Modbus® protocol. They can be directly connected to modern inverters and easily integrated into digital supervisory control and data acquisition (SCADA) systems.

Taking it to the next level

In medium and large PV installations (over 1 MW), the uncertainties in the efficiency of energy generation have considerable impact on the project’s profitability. A measurement uncertainty of as low as a couple of percent for a plant of nominal capacity of several MW can mean a significant difference in energy production forecasts and can therefore directly impact profit or loss!

Measurements of POA and GHI irradiance are crucial for determining performance ratios and monitoring energy yield efficiency. Performance ratio monitoring requires high quality measurement instruments and reliable data collection. It is recommended to use ISO 9060 Secondary Standard pyranometers for the highest quality of the measurements.

“The overall effect of aerosols on the incoming radiation can simply be measured by solar irradiance sensors, but to study the type of aerosols to improve predictions of solar energy available over time, one should use a sky radiometer.”
For large scale plants a high quality solar monitoring station is recommended for measurement of all three components of solar radiation (GHI, DHI and DNI). This data can be complimented by monitoring POA irradiance at several sites on the plant, typically feeding into the array inverters.

Smart pyranometers with RS-485 Modbus® are addressable, can be linked to a single network loop and can be integrated into the SCADA system of a solar plant for easy and practical monitoring and reduced cable costs.

Large projects often span an area where meteorological conditions might vary due to differences in microclimate. In these cases solar monitoring stations and weather stations may need to be placed in several parts of the plant to closely monitor the local conditions.

Using two or more solar monitoring points ensures redundancy of the measurements. When some of the instruments need to be replaced or sent for calibration, the data collection will remain continuous.

“...a typical CSP solar monitoring station uses high precision instruments with low uncertainty for the measurements of direct, diffuse and global irradiance”

Tracking system considerations

PV systems with one- or two-axis tracking can considerably increase the output of solar panels by ensuring higher received irradiance during the day. To monitor the performance of the system the POA irradiance should be measured, along with the GHI, using high quality pyranometers (ISO 9060 Secondary Standard). The pyranometers can be mounted on the solar panel tracker or on a dedicated high precision sun tracker.

Tailor-made CPV solutions

CPV systems use optics to concentrate a large area of sunlight onto a small solar cell and are either refractive (with lenses) or reflective (with mirrors). To achieve high concentration ratios, the optics have a narrow field of view and only make use of direct normal irradiance (DNI) from the sun. DNI is most accurately measured by a high quality pyrheliometer mounted on a precise automatic sun tracker to provide reliable data about the solar radiation input. An advanced system with pyranometers measuring diffuse and global irradiance (DHI and GHI) can provide a quality check of the DNI measurements.
Choosing the Right System

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Basic Advanced

- Automatic sun tracker: SOLYS 2
- ISO 9060 First Class pyrheliometer: CHP 1 or SHP1
- ISO 9060 Secondary Standard pyranometers: CMP10 or SMP10
- Weather station

Fixed PV Small

Poa, GHI optional

Smart pyranometers SMP3 or SMP10 integrated into monitoring system

Fixed PV Medium

Poa, GHI

ISO 9060 Secondary Standard pyranometers: CMP10 or SMP10
- Weather station

Fixed PV Large

GHI, at least 2 locations, distributed POA

Automatic sun tracker: SOLYS 2
- ISO 9060 First Class pyrheliometer: CHP 1 or SHP1
- ISO 9060 Secondary Standard pyranometers: CMP10 or SMP10
- Weather station

Tracking PV

DNI

ISO 9060 First Class pyrheliometer: CHP 1 or SHP1

Fixed PV Small

POA, GHI optional

Smart pyranometers SMP3 or SMP10 integrated into monitoring system

Fixed PV Medium

POA, GHI

ISO 9060 Secondary Standard pyranometers: CMP10 or SMP10
- Weather station

Fixed PV Large

GHI, at least 2 locations, distributed POA

Automatic sun tracker: SOLYS 2
- ISO 9060 First Class pyrheliometer: CHP 1 or SHP1
- ISO 9060 Secondary Standard pyranometers: CMP10 or SMP10
- Weather station

Tracking PV

DNI

ISO 9060 First Class pyrheliometer: CHP 1 or SHP1

CPV

DNI, GHI, data logger

Automatic sun tracker: SOLYS 2
- ISO 9060 First Class pyrheliometer: CHP 1 or SHP1
- ISO 9060 Secondary Standard pyranometers: CMP10 or SMP10
- Weather station

CSP

DNI, GHI, DHI, weather, data logger

Automatic sun tracker: SOLYS 2
- ISO 9060 First Class pyrheliometer: CHP 1 or SHP1
- ISO 9060 Secondary Standard pyranometers: CMP10, SMP10, CMP 21 or CMP 22
- Weather station

Concentrating Solar Power (CSP) system needs

Thermal systems use the direct normal irradiance (DNI) from the sun to generate heat, which can be used as the energy source for steam turbine electricity generators. These systems use mirrors to concentrate solar radiation. Unlike PV cells, they can take advantage of the full spectrum of solar radiation, including ultraviolet and near infrared light, leading to high efficiencies. For such systems it is extremely important to monitor the broadband solar radiation with high precision, because sky conditions have a strong influence on the performance of a CSP plant.

To predict the energy yield of a CSP system with a minimum of uncertainty it is crucial to measure solar radiation locally. Satellite measurements and related models don’t take into account the effect of local climatic conditions, such as clouds, nor do they include the effect of local aerosols (dust, sand and other particles). Two CSP plants in different locations with equal direct irradiance totals, according to satellite data, may have very different energy outputs, due to differences in clouds and aerosols in the particular locations, which affect the incoming radiation.

To ensure the reliability and redundancy of the data, a typical CSP solar monitoring station uses high precision instruments with low uncertainty for the measurements of direct, diffuse and global irradiance. This way the direct radiation measurement can be compared with values derived from the global and diffuse radiation. This allows the detection of problems with a particular instrument, for example due to soiling.

The overall effect of aerosols on the incoming radiation can simply be measured by solar irradiance sensors, but to study the type of aerosols to improve predictions of solar energy available over time, one should use a sky radiometer, such as the POM-01 or POM-02.

About the company

Kipp & Zonen provides a wide range of products to measure solar radiation accurately and reliably.

- More than 85 years of experience and expertise in solar radiation measurement equipment
- Worldwide reference customer base
- Worldwide network of representatives: 4 sales offices and 45 distributors around the globe
- Technical services, installation, calibrations and training available worldwide
- Useful accessories for easy installation and maintenance
- Advice on applications and best practices

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