

Advanced weather monitoring solutions for irradiance monitoring and forecasting



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The price of photovoltaic (PV) systems continues to decrease, adding PV as a cost effective cleaner energy solution. While solar photovoltaic grid penetration increases worldwide, new technical challenges arise in the electric grid side. Little progress has been made to incorporate managing schemes in solar power systems to improve the utility management.

PV growth, its drivers and implications to the grid

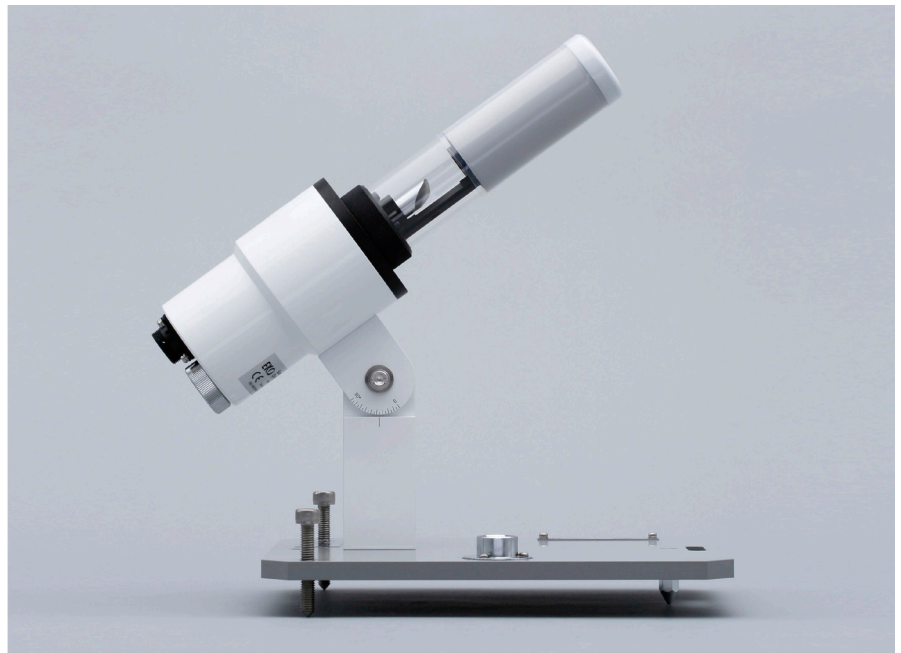
However, many technological solutions have been presented to facilitate the grid side. For example, using bifacial PV modules setup vertically to shift the electric energy generation peaks to match the peak

of electricity demand are currently under study and are now becoming attractive due to cost effectiveness of PV.

Developments in electronic household appliances now also offer the possibility of connecting a device to the internet and communicate with the grid, realizing the

concept of Smart Grids, in which interconnectivity and live data sharing between both the devices producing and consuming electricity allow a better understanding of demand and supply of electricity. Additionally, the storage systems, one of the missing links to the efficient solar power integration, are following the same trend as PV in terms of cost reduction, opening new possibilities for managing the energy sector.

Managing the energy flow from a solar power plant requires an effective solar monitoring system to characterise the available solar energy resource for electricity generation, and this involves a comprehensive set of equipment. By means of providing a diversified set of measurement instruments



MS-90 direct normal irradiance sensor

Novel technology to measure DNI

The state of the art setup to measure the DNI is comprised of one pyrheliometer assembled in a sun tracker, such as the EKO MS-57 thermopile pyrheliometer assembled in an EKO STR-21G Sun tracker. A new low-cost solution that does not require a sun tracker has recently been introduced by EKO. The MS-90 is based on an innovative method with rotating mirror, which reflects the sunbeam onto a thermal detector. Both thermal sensor and mirror employed have a nearly flat spectral characteristic responding well to changes in the solar spectrum, presenting a solution

suitable for solar energy monitoring and meteorological applications.

Spectral irradiance data sets are critical to many environmental science and energy applications. To acquire reliable in situ spectral irradiance data, ground based spectroradiometers are commonly deployed. The state of the art spectral DNI is measured by continuously tracking the sun during the day, and pointing a collimated spectroradiometer, so that only the sun rays that come straight from the sun disk are measured by the detector.

For spectral measurement of the three irradiance components we took a different

for all weather monitoring, EKO stands ready to assist the industry and research in solar energy projects.

The international standards for PV system monitoring (IEC 61724-1) define criteria how to perform actual measurements of solar irradiance and meteorological parameters. Having quality measurements aids in developing a dataset that allows the decision makers to effectively optimize their power generation periods. It is common practice quantify the solar energy in terms of global horizontal irradiance (GHI), plane of array (POA), diffuse horizontal irradiance (DHI), and direct normal irradiance (DNI). Depending on the application, acceptable level of uncertainty and cost, different approaches can be pursued to measure each component.



MS-711 Rotating Shadow Band Spectroradiometer



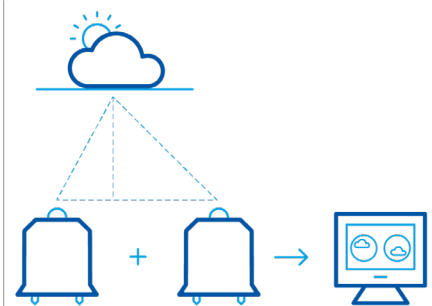
STANDARD

Set-up and control software Imager performs all-weather acquisition of high-resolution images with network storage,



OPTIONAL

Find-clouds software. The Find Clouds software allows the calculation of the sun position



OPTIONAL

Cloud-base height software Using two ASI-16 imagers and the additional CBH software, a stereoscopic method can be applied to a pair of synchronized images to determine the cloud-base height.

approach. A Rotating Shadow Band (RSB) spectroradiometer configuration offers an alternative to tracking, which lowers the costs associated with the instrumentation required, and, since only one detector is used, it also minimises the discrepancies associated with sensor calibration and the mutual differences regarding measurement performance when measuring the spectral irradiance components.

Accurate results of the DNI measurements can be obtained from a MS-711 spectroradiometer with RSB comparing with the MS-711 DNI spectroradiometer on a sun-tracker. The comparison between the outputs spectral DNI from the two configurations reveals a consistency in the methods and provides all 3 irradiance components. EKO will provide the RSB solution for all spectroradiometer models.

New eyes on the sky

With the solar resource depending on location and time of the year, the characterisation of the solar energy resource is crucial for solar energy applications. However, with variable weather conditions the energy output from solar power plants becomes quite complex, presenting large impacts and concerns for the utilities operation during the passage of clouds, and although monitoring irradiance in situ already provides significant information for operation and maintenance, it is not sufficient to anticipate changes in irradiance and assist utilities to respond to the variability.

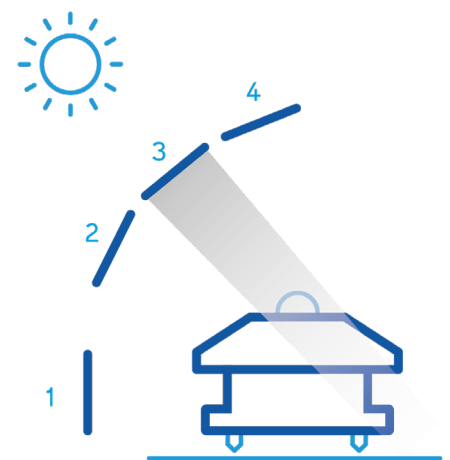
Clouds have generally an attenuating effect on the irradiance, which are dependent on the cloud characteristics. To cover these

aspects, more advanced weather monitoring systems, which are capable of forecasting solar irradiance and anticipate power production, are of most importance. Accurate forecasting of irradiance will permit forecasting power drops in PV plants, presenting enormous potential to improve dispatchability, and optimise grid stability.

Current schemes for forecasting irradiance are based on satellite cloud observations with numerical weather prediction. While these methods can provide information up to several days in advance, from approximately 10 to 100 km² spatial resolution, the information still carries significant errors in the estimated irradiance. A path to get higher intra-hour temporal resolution forecasting, with higher spatial resolution can be achieved by means of ground-based measurements such as cloud cameras and radiation sensors spread out and operating within a network.

For such a forecasting scheme all weather solutions to monitor clouds are becoming one of the most desirable solutions. With the new ASI-16 All Sky Imager, EKO offers an advanced solution for cloud monitoring. New eyes on the sky are in demand in order to optimize and forecast the energy output from solar power plants.

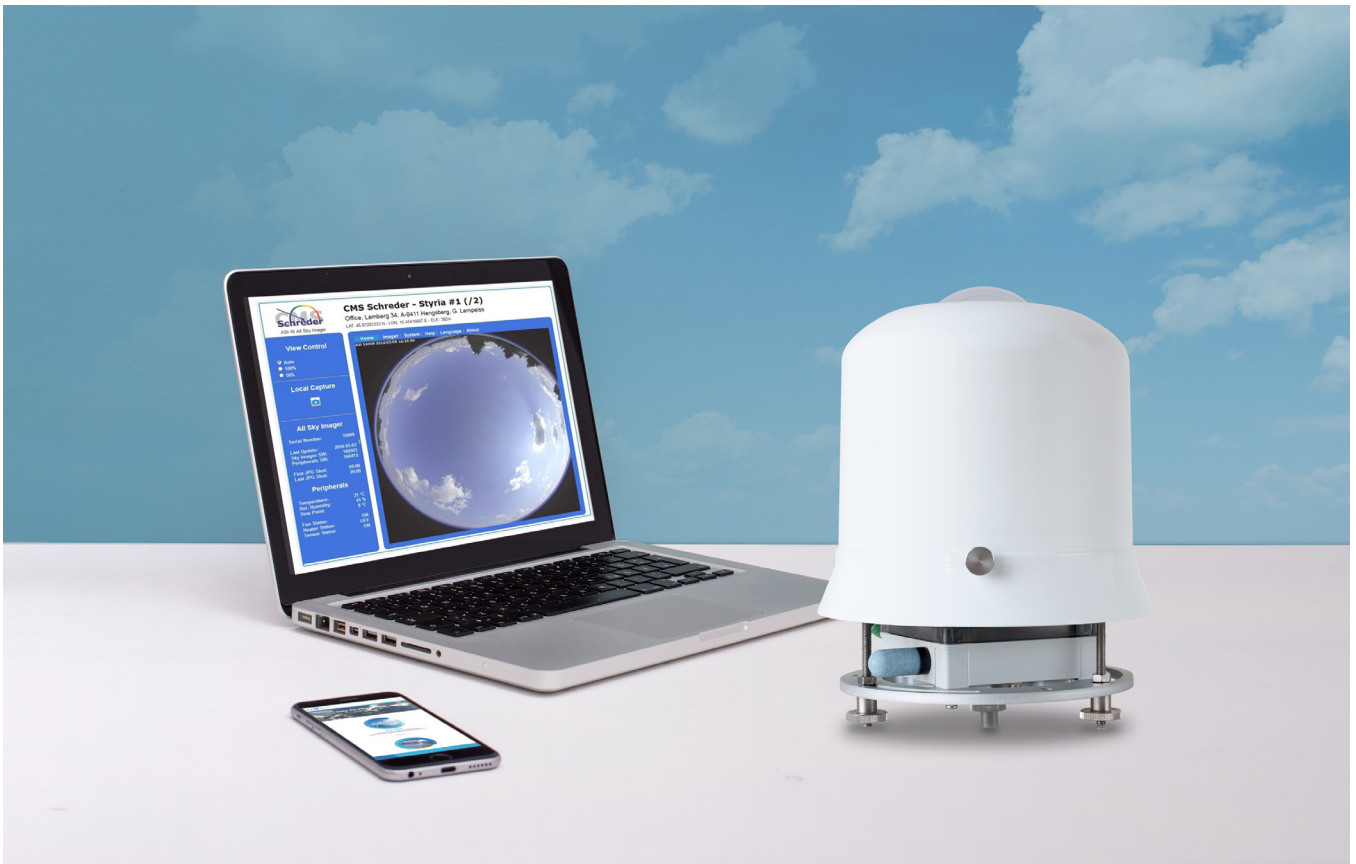
Designed to withstand all weather conditions, the ASI-16 All Sky Imager features a digital camera and fish-eye optics with a 180° field of view assembled under a robust coated quartz dome, avoiding sensor degradation due to direct exposure to the sun and allowing the automated acquisition of high dynamic range (HDR) images of the hemispherical sky.



Rotating Shadow Band positions

Different environmental conditions can be experienced depending on the site location. The standard ASI-16 Sky Imager is capable of operating under harsh environments from temperatures as low as -40°C up to 50°C, with an integrated ventilation and heating system, which also prevent condensation on the dome surface and promote the fast removal of raindrops and snow. Furthermore, the imager is powered over Ethernet (POE), with a durable and waterproof cable.

Environment temperature and humidity sensors are also incorporated in the device, and with the possibility of connecting one of EKO's irradiance sensor via Modbus communication protocol, the synchronous data acquisition of several weather



ASI-16 All Sky Imager

parameters is simplified, removing the need of having an independent datalogging system and facilitating the instrument deployment on site. The users can have full control of the imager to perform settings, data acquisition, visualization, and storage, with a web browser-based manager with live video stream and network storage.

The sky imager is complemented with the Find Clouds software, in which the images acquired with can be processed to classify

cloudiness. Using different algorithms to calculate cloudiness, the cloud analysis software, allows the calculation of the sun position in the image as well as to run algorithms such as the blue/red and blue/green channels ratio (BRBG), and the cloud detection and opacity classification (CDOC), to quantify cloudiness on the image set.

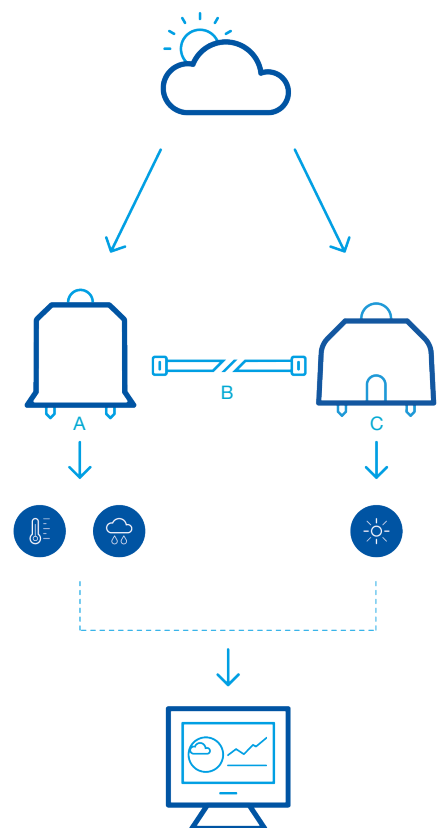
Cloud base height

Further characterization of the clouds can be achieved by determining the clouds base height (CBH), allowing the possibility of estimating the shadows casted by the passing clouds. Using a stereoscopic method, the CBH can be measured with two ASI-16 Sky imagers, where an additional Cloud Base Height software is available to process time synchronized images of two imagers set up at nearby locations.

The features and tools provided with the ASI-16 All Sky Imager make it an innovative solution for cloud monitoring. As additional software tools are under development, more features for this imager are coming soon.

For the solar energy industry more advanced monitoring tools are needed to forecast the amount of energy that solar plants will produce in the short term. EKO is keen to develop new applications and create this value.

<https://eko-eu.com/>



A. ASI-16 all-sky imager
 B. MODBUS communication
 C. MS-80 Pyranometer