IEC 61724-1: what's it all about?

System monitoring | The international standard guiding the monitoring of PV systems has been revised to include greater emphasis on accuracy. Will Beuttell of EKO Instruments explains some of the key aspects of the revised standard and how it will help satisfy the maturing PV industry's appetite for better quality data on plant performance


Credit EKO Instruments

While many countries have raced over the last decade to install PV), the community developing the standards has struggled to keep pace. In addition, the larger projects have required greater amounts of data and analysis to track system efficiencies. As these projects have become larger, so has the risk associated with financing and ensuring profitability. How can you assure investors that the project is producing the financially needed power as predicted if the sensors and metrics are ambiguously defined and/or vaguely understood? What could be causing your project to under- or perhaps over-perform? High fidelity data is needed, but in what format and how can you get it?

If you were an owner of multiple sites, would a small commercial site report match your utility-scale project? One monitoring company may provide variables that are not needed or in other cases lacking when compared to another. With this high amount of variability in monitoring information, a detailed standard was needed. The International Electrotechnical Commission (IEC) in 1998, published a standard labelled 61724:1998, and while it has served some purpose, a more mature industry requires greater direction and precision than in the past. This article seeks to shed some light on the recent changes to the IEC 61724 standard especially as it pertains to section one (IEC 61724-1), 'Photovoltaic system performance-monitoring'.

The need for better data

Most of the changes to the standard include additional information on measurements, which has facilitated a clear and welcome monitoring system classification. By providing this classification system, all stakeholders can assess the quality of their monitoring efforts as well as decide what modifications to the monitoring system will yield in tangible results. The adherence to this classification system should be explicitly stated in a declaration of conformity. This declaration is used in the final commissioning and due diligence of the project. As an EPC, a plant owner, or an ISO, you now know your monitoring system is at a particular level of justified performance.

Besides the simple calculation of performance ratio, standardised monitoring systems provide stakeholders with information about trend analysis and potential faults or problem areas, as well as insight into alternative configurations and placements of various instruments to help them gain the information and validation the plant needs. The original 61724 standard understood the basic connection of many variables such as irradiance and power output as well as their coupling to one another, but there was a limited understanding of the variability in the quality and performance of the instruments/sensors as well as the data those sensors provide.

While the case for higher accuracy is perhaps intuitive for utility-scale projects, what is large in one region may not be in others. California Independent Service Operator (CAISO) making a broad requirement may not be extrapolatable to the solar industry in Japan. Therefore, one approach cannot work for everyone. Going from 1MW to 100MW is an entirely different effort and any vagueness of specifications could cause problems down the road, costing thousands or millions to the owners. However, placing strict requirements of high-level monitoring on a commercial project may result in an unjustified cost for measurements. The IEC standards group realised this situation and defined distinct levels of classification to help maximise the monitoring of all projects.

Standards for the accuracy of sensors is one of the key aspects of the new IEC 61724-1

Classification

As mentioned earlier, part of the major improvements to the standards was the establishment of a course classification system. This system defines three levels or classes of monitoring systems with emphasis placed on the following areas:

- Accuracy of individual sensors and measurements
- Frequency at which the measurements are made and data recorded
- Recommend number of measurements based on the size/scale of a project
- Requirements for servicing and maintaining the instruments (cleaning, calibration, etc).

Once a monitoring system is installed, users can perform whatever analytics they

Parameter	Symbol	Units	Monitoring Purpose	Required? Class A High Accuracy	Class B Medium Accuracy	Class C Basic Accuracy
Irradiance						
In-Plane Irradiance (POA)	G_I	$W \cdot m^{-2}$	Solar resource	√	√ or E	√ or E
Global Horizontal	GHI	$W \cdot m^{-2}$	Solar resource, connection to historical and satellite data	√	√ or E for CPV	
Direct Normal Irradiance	DNI	$W \cdot m^{-2}$	Solar resource, concentrator	√ for CPV	√ or E for CPV	
Diffuse Irradiance	G_D	$W \cdot m^{-2}$	Solar resource, concentrator	√ for CPV with <20x concentration	√ or E for CPV with <20x concentration	
Circumsolar Ratio	CSR		Solar resource, concentrator			
Environmental Factors						
PV Module Temperature	T_{mod}	°C	Determining temperature related losses	√	√ or E	
Ambient Air Temperature	T_{amb}	°C	Connection to historical data, plus estimation of PV temperatures	√	√ or E	√ or E
Wind Speed		$m \cdot s^{-1}$	Estimation of PV temperatures	√	√ or E	
Wind Direction		degrees	Estimation of PV temperatures	√		
Soiling Ratio	SR		Determining soiling-related losses	√ if soiling losses expected to be ≥2%		
Rainfall		cm	Estimation of soiling losses	√	√ or E	
Snow			Estimation of snow-related losses			
Humidity			Estimation of spectral variations			

Source: IEC-61724-1

Table 1. Irradiance and environmental measurements required for each classification.

choose as long as the system provides them with the needed data. Each monitoring system classification provides a guideline as to what analysis a user can expect to perform. Each monitoring system class places higher requirements on these areas as well as the accompanying data analysis. Similar to the variation in PV project cost using these monitoring systems, there is a variation in cost for the monitoring system. The IEC standard committee took this into consideration for the classification system. Information on the required measurements can be found below in Table 1.

From lowest cost and requirements, you have class C, which represents the basic accuracy required by IEC, followed by the medium accuracy system of Class B. Lastly, at the top, is the premiere Class A system. The only consistently required values across the classes being reported are solar irradiance and ambient temperature. As your classification level increases, so do your requirements for measurements, calibrations and maintenance. Table 1 provides insight into what applications plant operators can perform or achieve with each class of monitoring systems with IEC 61724-1.

Each class has a particular user group that will find the requirements more in line with their project efforts and goals. Starting with class C, we can see this to be the minimum requirements to having a successful monitoring system. Smaller commercial and primarily residential users will find this approach best for their application. With having only a basic system assessment, the user is free from additional hurdles and able to install less expensive instrumentation. While not the most accurate, the user will still be able to correlate system performance based on the prescribed inputs but with reduced confidence compared to the higher classification systems. Class B yields better accuracy but requires additional measurements and analysis. Most likely this level will not be used for residential applications but for small commercial and very small utility projects. Class A requires the highest level of accuracy of measurements and analysis. This class would be reserved for the projects and clients most interested in validating their design and detecting trends towards assuring a financially successful PV project.

Irradiance measurements

Why so much new interest or emphasis on the irradiance measurements? For years, irradiance sensors as part of required weather stations have troubled the industry and at times been problematic in the monitoring system. While some companies strived for low-cost solutions some companies wanted highest accuracy but no one could agree on how many sensors would yield real results. Problems became more evident when high-quality monitoring systems were installed in locations but with an irradiance sensor that had serious limitations due to the specific sensor technology. Certain technologies have different strengths and weaknesses. Some sensors have angular response or spectral issues, others have issues with thermal offsets, and the range of response times can vary by approximately two orders of magnitudes (0.3 seconds to 30 seconds @ 95%).

For almost 30 years, the International Organization for Standardization (ISO) and the World Meteorological Organization (WMO) have established a course classification system for these solar radiometers. Each class defines specifications for properties of the sensors that contribute to overall measurement uncertainty. ASTM will soon follow in creating their own classification system. Having quality measurements aids in developing a dataset that allows the decision makers to effectively optimise their power generation periods. While forecasting offers to potentially answer this problem, you must start with quality measurements of solar irradiance.

Now that higher accuracies and reduced uncertainties are required for better monitoring systems, the use of high-quality thermopile detector pyranometers is explicitly defined and needed. ISO 9060 gives more detailed information on the classification of pyranometers. In this document, the standards community sought to provide insight into the performance areas of the devices and to classify the sensor into three groups. From lowest to highest quality you have second class, first class and secondary standard. There is no primary standard for pyranometers so if you want the best you

System Size (AC)	Number of Sensors: Irradiance Measurements	PV Module Temperature Measurements
< 5 MW	1	6
≥ 5 MW to < 40 MW	2	12
40MW to < 100 MW	3	18
100 MW to < 200 MW	4	24
200 MW to < 300 MW	5	30
300 MW to < 400 MW	6	36
400 MW to < 500 MW	7	42
≥ 750 MW	8	48

Source: IEC 61724-1

Table 2. Number of sensors to be deployed for the respective PV project size. Depending on the classification (A, B, or C) the user will need to install all corresponding irradiance measurements in the necessary numbers shown

go with the ISO secondary standard. The same idea applies for the WMO classification of pyranometers. From Table 1, opposite, you can see that the Class A monitoring systems require a much higher quality sensor for measuring irradiance than the Class B and Class C systems.

The user of IEC 61724-1 will also see the suggestion – and in certain cases, a requirement – for adding a heater and ventilator to the pyranometers. This is an additional add-on. Depending on the manufacturer the cost can vary. Since the standard does not require a pyranometer to have heaters, ventilators and tilt sensors installed internally, all major manufacturers can still comply with IEC 61724-1. This is an important issue to avoid when writing standards. If the standards harm the industry by requiring equipment that is not easily available then the standard will simply be less successful. Most major manufacturers have heaters and ventilators available as external add-ons. Historically it has been considered a best practice to install your pyranometers with a ventilator heater combination [1]. In the case of projects that adhere to this standard, the ventilator will be very helpful at mitigating the effects of soiling and precipitation, especially frozen precipitation. The benefits of heating and ventilating can be seen below.

The heater removes frost and snow while the ventilator help reduce thermal offsets of the sensor by keeping the sensor closer to ambient temperature. Ventilators could also remove dew and soiling of the pyranometer outer dome. The heaters would not usually be operated continuously but instead would be switched on, based on conditions. IEC 61724-1 also requires Class A system to use inclinometers with digital outputs as well as GPS receivers for making pyranometer orientation measurements. While the pyranometer specified can be a high accuracy device, if it is installed improperly then the improved measurements are lost due to user error. Inclinometers and orientation equipment will be important as the problems caused by misalignment are rather large [2]. The issues caused by these alignment errors have been known for quite some time as evident in Figure 1. Fortunately, these positioning devices are easily available in the industry. By levelling and orienting your sensors properly as well as keeping the optics clean and clear, you will reduce user errors, decrease your measurements uncertainty and increase the fidelity of your data.

As mentioned earlier, the classification of irradiance sensors has greatly improved in this version of the standard. In addition, the classification places new requirements on the recalibration periods and cleaning schedules. Calibrations are critical to maintaining the highest level of confident performance throughout a project's lifetime, thus having the highest accreditation of calibrations from the beginning is needed. Class A irradiance sensors under IEC 61724-1 need to be recalibrated annually.

In addition to recalibration, properly maintaining a clean sensor is important. Usually this means wiping the dome and removing the deposited material. Sometime water is needed to lift off the material. Rarely if ever is alcohol or some cleaning solution is needed. Depending on the location the sensors are deployed in, rain can provide some ability to clean the sensors but in other cases the rain can actually deposit more material. This all must be considered by the site operators and the operations and maintenance (O&M) companies. This rain or dew also affects the measurements. Frost too can occur, which is why IEC places a requirement for ventilators and heaters.

Clipping and curtailment

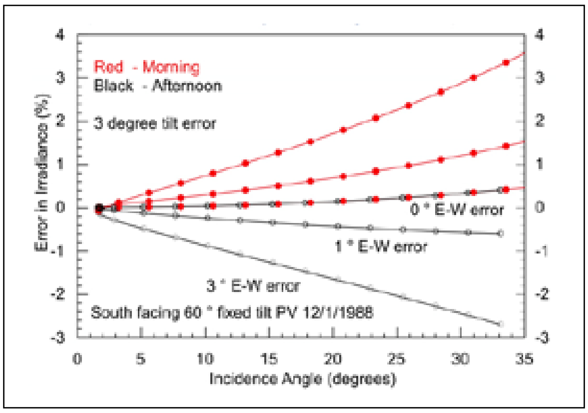
Curtailments and clipping are large concerns for renewable energy projects. Fossil fuel generation uses a model where the fuel costs are relatively fixed and the power can be made at any time. Renewables have no cost for fuel so there are no saved expenses by not being in operation, and in the case of solar, there is only a portion of the day where you can achieved peak power. Accurately predicting and planning for produced power helps grid operators maintain stability and help plant owners achieve profitability. Through adherence to improved metrics via IEC 61724-1, the PV industry should be able to reduce the number of issues that occur while operating a PV site.

While it has been somewhat common to oversize inverters, having more accurate site data will aid in predicting the amount of energy available as well as gained or lost due to inverter capabilities. In the case of a time of use pricing structure, the oversized array-to-inverter ratio will help produce more power during periods of higher payment.

If curtailment is a problem then this standard should help in reducing the frequency and duration of the curtailment period, all adding to the overall profitability of the solar project. While the improved accuracy of the data through adherence to IEC 61724-1 is nice to see in real time, the calculated metrics using that data are more important as they provide operators the ability to more accurately know current and to predict future power production. This prediction, if more accurate, will help regions reduce curtailment by reducing the conventional power generation source contribution to the baseload due to the inherent variable generation of PV. While additional resources will also be needed such as increased storage capabilities, this increase in highly accurate data is a critical first step. IEC 61724-1 provides much more detail on the required metrics to accurately show plant power output.

In summary, we will need to see how the industry adopts this standard completely. As for the USA, it seems every region has its own rules. Perhaps the standard will bridge those gaps and create some consensus on how to measure and report data. Hopefully moving forward, the industry does not change so much that the standard becomes obsolete too soon.

The new standard is available from webstore.iec.ch.



Credit EKO Instruments Japan

Figure 1. Levelling error in irradiance measurements

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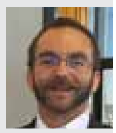

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