

In-company workshop: solar radiation measurement

Experts from Hukseflux explain and discuss at your company recent developments in solar radiation measurement for PV system performance monitoring

An accurate measurement of solar radiation is the backbone of PV system performance assessment. In our in-company workshop, we present developments in monitoring, the IEC 61724-1 standard and measurement with pyranometers. Get the latest insights in instrument performance according to ISO 9060, data availability, the new ASTM G213 standard on uncertainty evaluation and good practices for maintenance and calibration.



Figure 1 Improving data availability and measurement uncertainty; heated versus unheated instruments

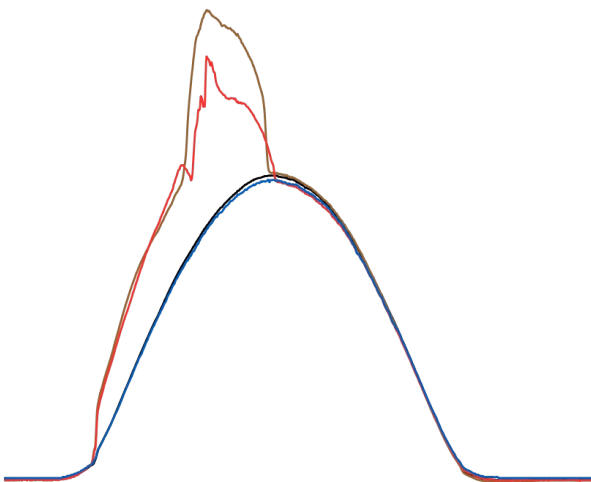


Figure 2 Example of the effect of frost on the measurement; black and blue are reference measurements, brown and red are measurements made with pyranometers with frozen domes, like the one in front in Figure 1

Objective of the workshop

The in-company workshop is offered to you free of charge by Hukseflux Thermal Sensors. It will give you insights in the latest developments in solar radiation measurement as well as arguments to base choice of sensors on.

Management summary

Asset managers increasingly insist on having the highest accuracy monitoring systems according to the latest IEC 61724-1 standard for PV system performance monitoring. The standard requires instruments with the right paperwork (according to ISO and ASTM standards), ventilation and heating, and regular recalibration to act as proof of performance.

A perfect monitoring record increases the PV power plant's value. This high-level quality assurance also proves its value when legal issues arise, for example in support of warranty claims.

The latest trends in PV monitoring are:

- measurements according to IEC 61724-1 class A, including quality assurance: regular cleaning and re-calibration
- use of digital sensors for easy instrument exchange, and cost savings on cabling
- use of highest accuracy - secondary standard – instruments
- individually tested instruments, supplied with test certificates for directional and temperature response (following ASTM 2848 and ISO 9060 requirements)
- improvement of data availability by ventilation and by heating
- uncertainty evaluation according to ASTM G213

Each topic is discussed during the in-company workshop and (briefly) on the following pages:

Major update of IEC 61724-1

The IEC 61724-1: *Photovoltaic system performance monitoring – Guidelines for measurement, data exchange and analysis* – has been updated. The new scope not only defines the measuring system components and procedures (as in the 2008 version), it now also aims to keep measurement errors within specified limits. It does so by establishing accuracy classes for monitoring systems.

The new standard includes:

- 3 accuracy classes, A, B and C, for monitoring systems, to be used in conformity declarations
- accuracy requirements for monitoring equipment per class
- required quality checks (i.e. calibration and maintenance) per class
- recommended minimum number of instruments used as a function of the PV system scale

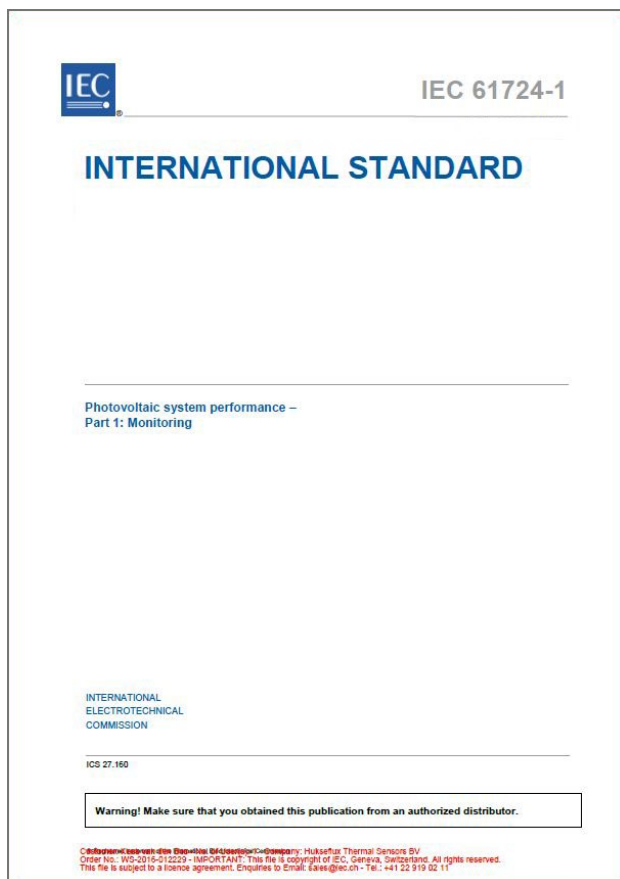


Figure 3 Cover of the new IEC 61724-1 standard, published in February 2017

From analogue to digital

While traditional pyranometers have analogue outputs, the latest pyranometer models communicate over RS-485.

Advantages:

- exchangeable sensors
- no possibility to manipulate data
- on-board calibration history records
- save costs on cabling

Potential disadvantages are:

- not all calibration laboratories can handle these digital sensors
- not all manufacturers allow access to the internal software to correct the sensitivity after recalibration. Hukseflux does !

Increasing instrument performance

Use of lower than secondary standard class instruments and use of PV reference cells is decreasing; these sensors are not sufficiently stable and not universally applicable with every cell type. This is now formally acknowledged in the latest IEC 61724-1 and ASTM 2848 standards. Nowadays, it is common to require pyranometers with tested temperature dependence covering all climate zones (-30 to + 50 °C).

Formalities: test certificates with every instrument

The approach of investors tends to get more formal. When auditing PV monitoring systems, investors ask for documented proof of performance verification during production and later calibration, as well as field maintenance records.

ASTM 2848-11, covering test methods for PV systems, states: "pyranometers are sensitive to both temperature and the angle of incidence of irradiance" and recommends: "that pyranometer responsivity be characterized to the extent practicable".

Focus on data availability

Dew, frost and snow deposition cause significant non-availability of data; as shown in Figure 2.

The latest trends to improve data availability are:

- ventilation of pyranometers
- heating of pyranometers

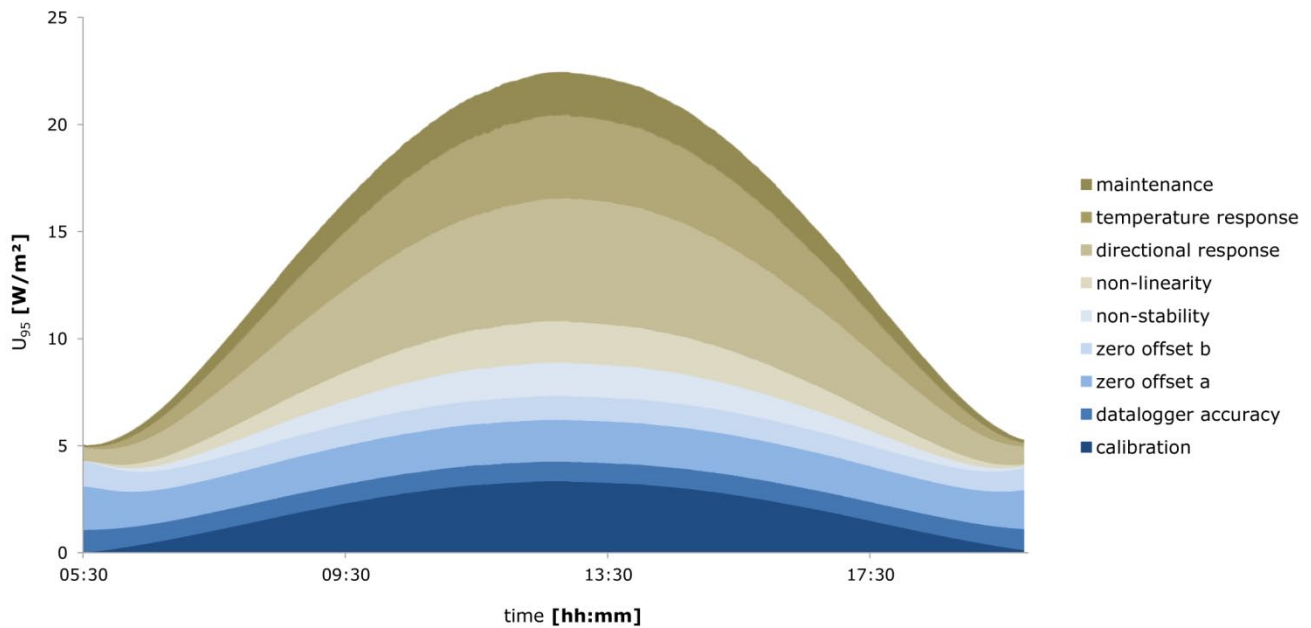


Figure 4 Uncertainty evaluation according to the ASTM Guide G213 of a measurement of Global Horizontal Irradiance (GHI) on a sunny day, expressed in W/m². The maximum value around solar noon is 1000 W/m². The different colours represent different error sources

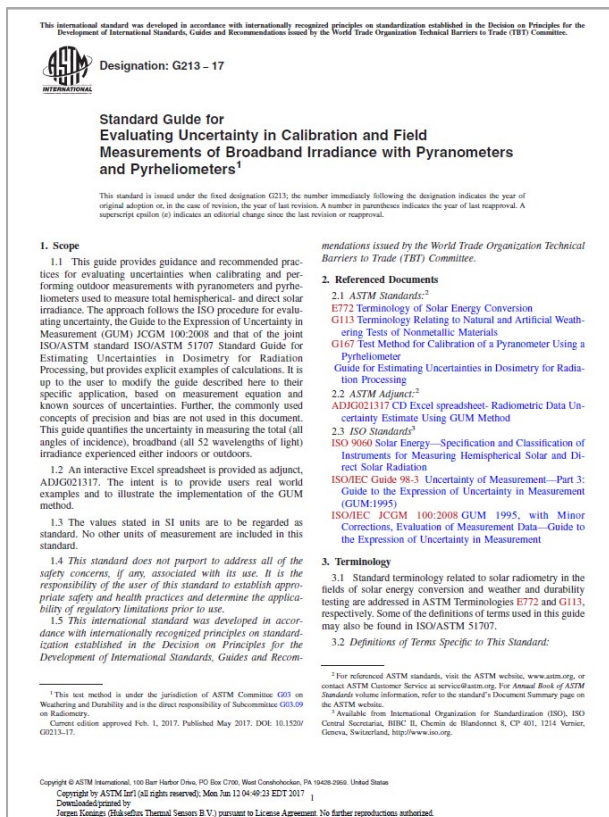


Figure 5 Cover of the new ASTM G213-17 standard, published in June 2017

NEW: uncertainty evaluation / data analysis using ASTM G213

Measurement accuracy does not only depend on instrument properties, but also on measurement conditions:

- a very accurate instrument, like the secondary standard class sensors mostly used in the PV industry, will quickly underperform without a regular schedule of maintenance and calibration.
- assessment of data availability and rejection of data are integral parts of the evaluation of the measurement. Data is eventually presented including a measurement uncertainty.

ASTM International has released the G213-17 “Standard Guide for Evaluating Uncertainty in Calibration and Field Measurements of Broadband Irradiance with Pyranometers and Pyrhemometers”. It provides guidance and recommended practices for evaluating uncertainties when calibrating and performing outdoor measurements with pyranometers and pyrhemometers. In conformity declarations, providers can now refer to this standard.



Figure 6 *Individual testing of every instrument; Hukseflux performs individual testing of temperature response and directional response of all secondary standard instruments*

Hands-on with the sensors

During the workshop, several sensors can be demonstrated. Users will be able to find out for themselves how easy their use is.

Cost of ownership

Asset managers increasingly accept the need for regular recalibration of the PV plant monitoring systems. Calibration of secondary standard pyranometers is not easy, and can only be performed by a limited number of organisations. For pyranometers under a professional maintenance regime, the cost of ownership over

the instrument lifetime will be not only be determined by costs of purchase but also more and more by maintenance costs.

The role of monitoring parties

Asset managers increasingly separate the responsibilities for PV plant operation and performance monitoring. The role of the monitoring party will, in our opinion, concentrate on the analysis and quality assurance of the data, including instrument maintenance and calibration. A major challenge is to perform maintenance and recalibration of pyranometers efficiently.

About Hukseflux

Hukseflux Thermal Sensors offers measurement solutions for the most challenging applications. We design and supply sensors as well as test & measuring systems, and offer related services such as engineering and consultancy. With our laboratory facilities, we provide testing services including material characterisation and calibration. Our main area of expertise is measurement of heat transfer and thermal quantities such as solar radiation, heat flux and thermal conductivity. Hukseflux sensors, systems and services are offered worldwide via our office in Delft, the Netherlands and local distributors.

Interested in having this workshop
at your company?

E-mail us at: info@hukseflux.com