Independent pyranometer tests

Independent testing confirms good performance of Hukseflux pyranometers

Hukseflux is proud to notice that its pyranometers are consistently among the top performers during independent testing. For example, testing at Sandia National Laboratories by PV Performance Labs (a consultant to the PV industry), calibration experiments at NREL, and analysis of public datasets show strong performance. We are curious to see the results of ongoing experiments at the Technical University of Denmark.

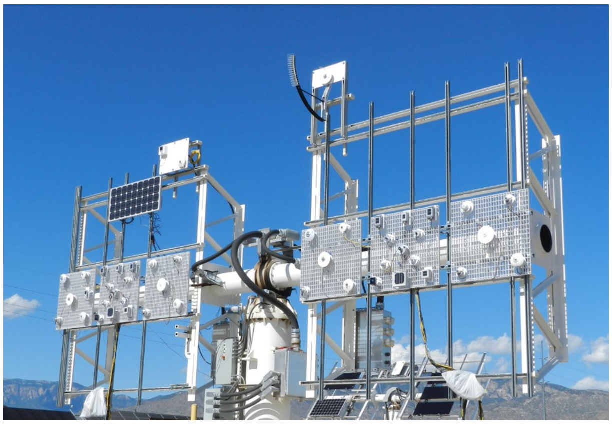

Figure 1 *The 2-axis tracking facility at Sandia National Laboratories. Photo credit: Daniel Riley.*

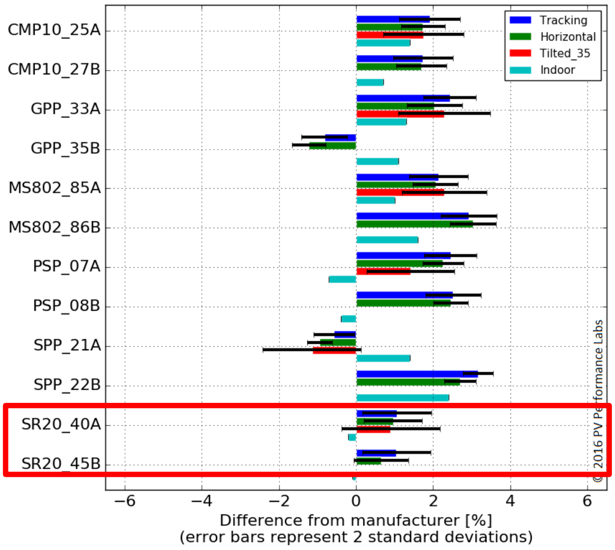

Figure 2 *Comparison results for Class A pyranometers when subject to four different methods of testing. The coloured bars show the difference between the local calibration reference and the pyranometer reading using the factory sensitivity. Thus, the shorter the bars, the better. The test employs two pyranometers of every model. Hukseflux SR20 is displayed at the bottom (red box). The black error bars show the variability of the measurements. The uncertainty of the Class A pyranometer factory calibration is in the order of 1 % (k = 2). Copyright: PV Performance Labs, 2016.*

Introduction

Hukseflux tests all its pyranometers in production. Class A pyranometers are tested for:

- temperature dependence
- directional response
- sensitivity (calibration)
- (optional) sensor tilt angle

At present, there are no independent test institutes doing the same indoor testing. However, there are some occasions when independent outdoor testing was done:

- 2016 testing at Sandia National Labs
- 2024 testing at National Renewable Energy Laboratory (NREL), USA, at the yearly BORCAL experiments
- 2025 analysis by PV Performance Labs of data measured by NREL
- 2024-2025 Ongoing test Denmark Technical University by Adam Jensen

Sandia testing in 2016

The purpose of the test was to determine the sensitivity of pyranometers and semiconductor solar irradiance sensors using four different methods, and to compare these sensitivities to the one supplied by the manufacturer. The comparison tests were carried out under four different conditions:

- indoor under a solar simulator
- outdoor horizontal
- outdoor tilted at a constant tilt angle
- outdoor on a 2-axis tracker (see Figure 1)

The tests were carried out using four different instrument types:

- Class A pyranometers
- Class C pyranometers
- semiconductor solar irradiance sensors
- PV reference cells

The test results at Sandia

Test results are presented in graphs, as the one in Figure 2. Among the different instrument types, the secondary standard pyranometers show the least variability. The performance of Hukseflux's model SR20 (the predecessor of model SR200, model SR30, and model SR300) is remarkably consistent under different test conditions. The report concludes that it is too early to draw final conclusions about the absolute accuracy. We think the causes of the good consistency are SR20's low zero offsets and high calibration accuracy.
Now in 2025, models SR200, SR30, and SR300 perform even better than model SR20.

2024 BORCAL calibrations at NREL

Every year, the National Renewables Energy Laboratory (NREL) performs independent, publicly available calibrations. In this Broadband Outdoor Radiometer Calibration (BORCAL) procedure, pyranometer responsivity is measured outdoors over the course of a clear-sky day. This test is a combination of a calibration and a directional response test.

Figure 3 shows the responsivity of Hukseflux's model SR30 and two competing pyranometer models as a function of solar zenith angle. Ideally, the responsivity would be constant, because it should not depend on the solar position and time-of-day. However, the responsivities of EKO's model MS-80S and Kipp & Zonen's model SMP12 vary by more than 11 % versus zenith angle. In contrast, the SR30's responsivity only varies by up to 1.8 %, which is more than 6 times better. At small zenith angles, SR30 outperforms the other models by a factor of 4.

These differences are highly significant for the uncertainty of key performance metrics such as the Performance Ratio (PR), since directional response errors dominate the total uncertainty at small solar zenith angles, which are most relevant for the calculation of the PR.

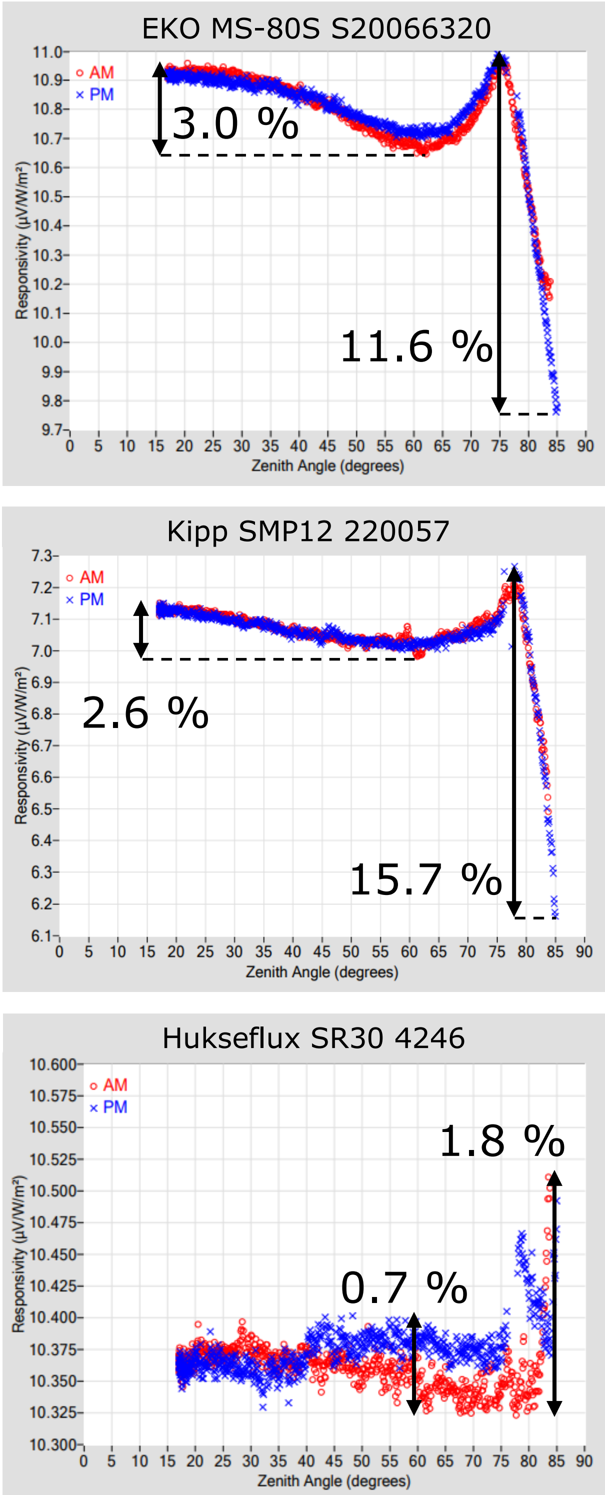

Figure 3 *Extract from the NREL 2024-03 BORCAL report showing the responsivity of EKO's model MS-80S with serial number S20066320 (p.19), Kipp & Zonen's model SMP12 with serial number 220057 (p.13), and Hukseflux's model SR30 with serial number 4246 (p.16) versus zenith angle. The maximum deviation over all angles and over the domain of lower zenith angles is indicated for every instrument.*

2025 PV Performance Labs analysis of NREL data

In August 2025, PV performance Labs, at the request of Hukseflux, analysed the data measured by NREL at the Solar Radiation Research Laboratory (SRRL) at their Baseline Measurement System. SRRL ensures that instruments are well-maintained and cleaned every day, and puts the data measured with these instruments on the internet for all to use.

Figure 4 shows the directional response estimates of different instruments based on the analysis of data from June 18, 2025. For more information, please refer to the full report.

SR30 outperforms SMP11, SMP12, and MS80S, and behaves equally well as the quartz-dome CMP22.

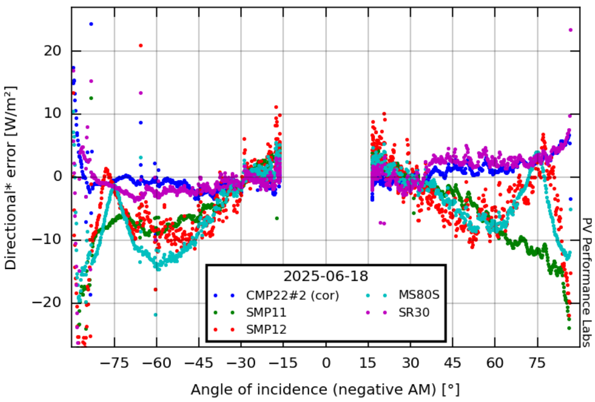

Figure 4 *Estimate of the directional error of different instruments based on NREL data on July 18, 2025. Source: PV Performance Labs 2025.*

2024-2025 testing at DTU

At Denmark Technical University, Adam Jensen carries out an intercomparison of several different instruments used for PV system performance monitoring:

- 12 pyranometers
- 4 pyrheliometers
- 8 diffusometers

The reference instruments are a pyrheliometer and a pyranometer with a shading ball. Results have not yet been published, however an project update was presented at the PVPMC workshop of 2025.

Figure 5 *Rooftop setup at Denmark Technical University showing a collection of pyranometers, diffusometers, and a rotating shadowband pyranometer. Source: DTU, Adam Jensen.*

References

Anton Driesse, Willem Zaaiman, Daniel Riley, Nigel Taylor, Joshua S. Stein, *Investigation of Pyranometer and Photodiode Calibrations under Different Conditions*, conference paper presented at IEEE PVSC 2016, published on internet, accessed 10-Oct-2016.

A. Andreas, *BORCAL-SW Calibration Report 2024-03*, National Renewable Energy Laboratory (NREL), Solar Radiation Research Laboratory, Golden, CO, June 7, 2024.

A. Jensen, *Measuring the Sun*, PVPMC workshop Albuquerque 2025.

Source for NREL data:
A. Andreas; T. Stoffel; (1981). NREL Solar Radiation Research Laboratory (SRRL): *Baseline Measurement System (BMS)*; Golden, Colorado (Data); NREL Report No. DA-5500-56488.

About Hukseflux

Hukseflux is the leading expert in measurement of energy transfer. We design and manufacture sensors and measuring systems that support the energy transition. We are market leaders in solar radiation and heat flux measurement. Customers are served through our headquarters in the Netherlands, and locally owned representative sales offices in the USA, Brazil, India, China, Southeast Asia and Japan.