One Year Round Robin Testing of Irradiation Sensors Measurement Results and Analyses

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Table 1:
The Mounted Sensors Verified in the Round-Robin-Test

Producer: Type	Technology	Amplifier	Calibration Protocol
Apogee Instruments: PYR-PA5	Silicon Diode	Yes	Yes
ESTI: ESTI-Sensor	c-Si.	No	No
IKS: ISET*Sensor* amorph	a-Si	No	Yes
IKS: ISET*Sensor* CdTe	CdTe	No	Yes
IKS: ISET*Sensor* EFG	EFG	No	Yes
IKS: ISET*Sensor* mono	c-Si.	No	Yes
IKS: ISET*Sensor* poly	mc-Si.	No	Yes
Kipp & Zonen: CM 11	Thermopile	No	Yes
Kipp & Zonen: SP Lite	Silicon Diode	Yes	Yes
LI-COR: LI-200SA	Silicon Diode	Yes	Yes
Mencke & Tegtmeyer: Si-02-PT100-K	c-Si.	No	Yes
Mencke & Tegtmeyer: Si-10TC-K	c-Si.	Yes	Yes
NES: SOZ-03	c-Si.	No	Yes
NES: SOZ-03 pA	c-Si.	Yes	Yes
Skyeinstruments: SKL 2650	SiliconDiode	Yes	Yes
Solarc: MacSolar Sensor	c-Si.	Yes	Yes
Tritec: Spektron 100	c-Si.	No	No
Tritec: Spektron 300	c-Si.	Yes	No

Colour Coding		Technology		
		Pyranometer	Sensors with Measuring Cell	Active Sensors with Measuring Cell
Price	From 0,- to 200,- €			
	From 200,- to 400,- €			
	Beyond 400,- €			

Introduction

In October 2007 a Round-Robin-Test was started on the part of the Fraunhofer IWES Kassel and the University of Applied Sciences Munich in cooperation with BEC-Engineering with 18 irradiation sensors on two identical experimental setups located at the two sites under similar field conditions. In focus thereby are the sensor values which are analyzed as instantaneous values (in terms of diurnal variations at different locations and under specific weather conditions) or as daily, monthly or annual energy sums. The first complete year of measuring data from the Round-Robin-test is available (2008) and was analyzed.

Set-up of the Round-Robin-Test

In the Round-Robin-Test altogether 18 different irradiation sensors (13 solar cell sensors and 5 pyranometers – as listed in table 1) are measured in a sequence of 15 seconds to seize the dynamic procedures of the weather well and relative exactly. The pyranometer CM 11 is used as a reference sensor in the following evaluation, because for this sensor detailed information about angle dependency, temperature stability, spectral sensitivity and empirical values over the long-term stability are present.

Conclusion

The comparison of the instantaneous values of the individual sensors and their succession into diurnal variations documented clearly how important it is to know about the operational behaviour of the specific sensor used in each case.

Intelligible and definable becomes the sensor behaviour in evaluating the energy sums in viewing different time periods. To define typical sensor behaviour for sorted sensor groups was not possible. It is definitely necessary to have knowledge about the individual sensors.

The largest fraction of the sensors showed a consistent operating performance at both locations. But also here exceptions were visible. One type of sensor completely sampled out due to enclosure problems at both locations after several months.

The Round-Robin-test keeps running in the year 2009. The results underline the necessity for these evaluations. Particularly because these sensors supply the data elementarily important for PV-systems.

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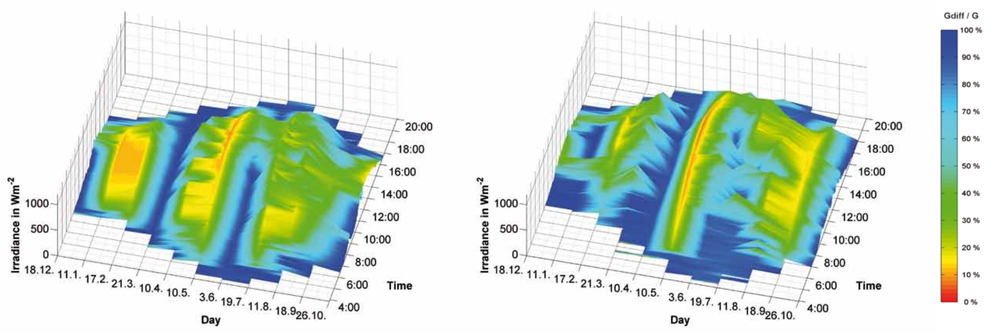

Figure 1 illustrates the diurnal variations of the weather situation at the selected reference days at the two locations Munich (on the left-hand side) and Kassel in a four dimensional graph. As fourth dimension over the colouring a statement is integrated to the diffuse radiation fraction of the irradiation performance.

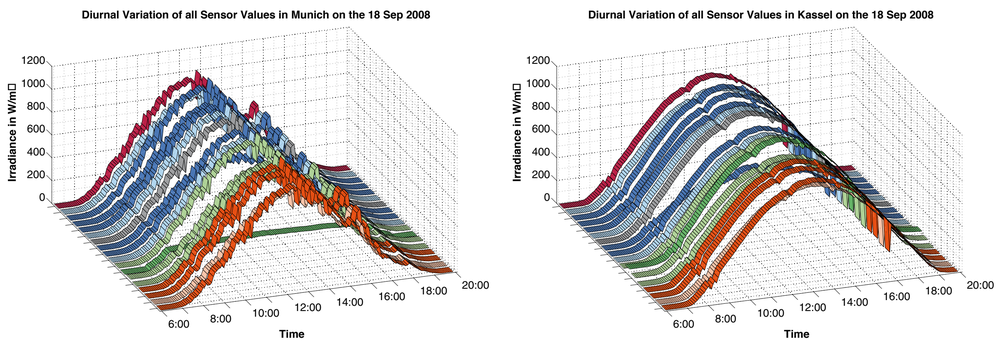

Figure 2 shows the diurnal variations of both reference installations, the operational performance of the individual sensors on one single exemplary day (on 18. September 2008). Not absolute values are of intent but the sensor behavior relatively to each other gives an impression to the usability of individual sensor instantaneous values and the importance of knowledge about the deployed sensors.

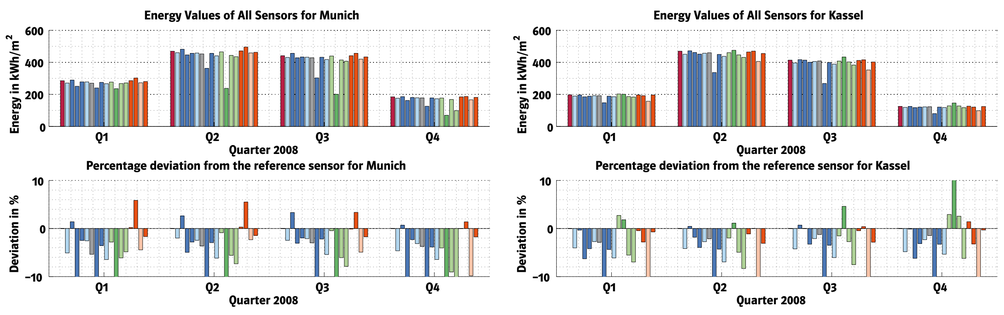

Figure 3: All sensors together are shown in diagrams for the locations Munich and Kassel. The knowledge of the operational behaviour of the individual sensor is of fundamental importance.

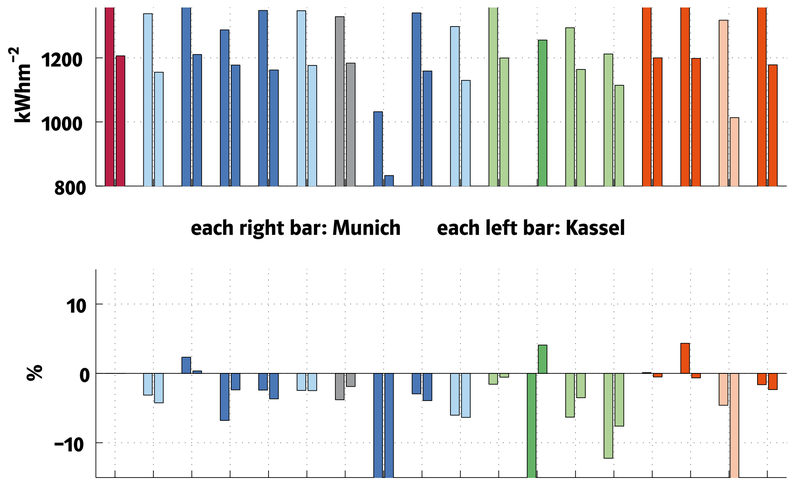

Figure 4: The annual values as overview and summary of other detailed figures out of the publication.

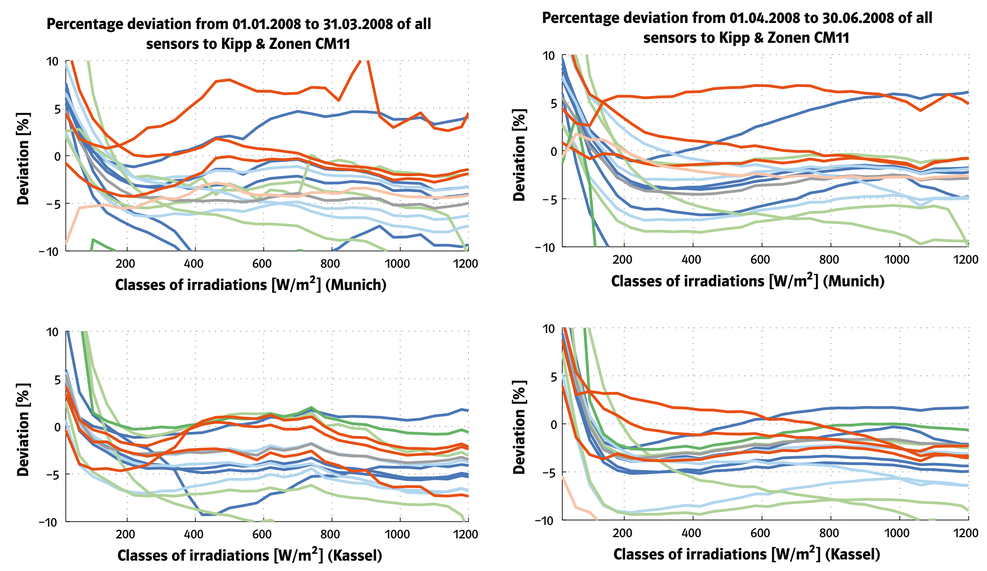

Figure 5: In these diagrams for the two locations and the individual quarters of the year 2008 the proportional deviations for the individual irradiation classes are represented.

Instantaneous Values of Sensors

Within the Round-Robin-Test during the investigation period of the year 2008 12 reference days were selected. In each quarter of the year one day with low, fluctuating and high irradiation was determined and analyzed.

Figure 1 illustrates the diurnal variations of the weather situation at the selected reference days at the two locations Munich and Kassel in a four dimensional graph. This graph gives the information to the operating conditions under those the sensors supplied the instantaneous values and diurnal variations.

Figure 2 illustrates the related diurnal variations of the individual sensors of both reference installations on one single exemplary day.

Energy Values and Deviations

The four pyranometers reflect identical and thus confirming results for both locations Munich and Kassel. The correct and fractional accurate operation is clear to see. The group of the sensors with measuring cell again nearly reflects similar results for Munich and Kassel, showing correct function. With these sensors the measuring cells partly consist of different materials what explains the deviations. Sensors with uniform type of measuring cell showed very similar operational behaviour. The majority of the sensors laid relatively close to the reference values. All sensors of this group underestimated the reference values. Two of the sensors showed different deviations within the course of the year.

The active sensors with measuring cell show differences in the results at both locations. One type of sensor completely sampled out. In the course of the year different varying sensor processes at the two locations were observed. This will be analyzed more exactly. Fig. 3 does not supply a general quality criterion regarding the classifications done. Thus the knowledge of the operational behaviour of the individual sensors is of importance.

The fig. 4 with the annual values gives an overview or a summary of the more detailed figures shown in the paper. The congruence or deviation from results of measurement from Munich and Kassel, as well as the results of the individual sensors are nice to see and chamfer the other results.

Fig. 5 shows the proportional deviations for the specific irradiation classes for the two locations and the individual quarters of 2008. The fast visible higher deviations opposite to the reference sensor in the lower irradiation classes are explainable by the angle behaviour of the sensors. In the high irradiation classes the calibration of the sensors is clearly visible. Also visible are fractional significant differences in the operating characteristics.