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Evaluation of a new approach to measure the direct normal irradiance without a sun-tracker

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In this work, we introduce and analyze a new cost-effective solution to measure the direct normal irradiance (DNI) without the need of a sun-tracker. While the state-of-the-art setup to measure the DNI is comprised of a pyrheliometer assembled on a sun tracker, the EKO MS-90 [1] (formerly known as MS-05 [2]) measures DNI based on the MS-093 sunshine duration measurement concept [3,4] which doesn't require a solar tracker to align the sensor aperture with the sun disk, presenting a relatively lower cost solution for sensor networks to measure DNI.

To measure DNI the MS-90 sensor body is set up with a fixed tilt optimized according to the location latitude. The direct beam is reflected to the sensor head by a 45° tilted rotating mirror. Each revolution of the mirror has a period of 15s, reflecting the direct beam radiation to the sensor head once every period. A pyroelectric detector then measures the signal pulse, which is proportional to DNI.

We present a comprehensive study of the EKO MS-90 measurement accuracy. To quantify the measurement error of this new sensor we compare the MS-90 DNI measurements with reference pyrheliometers assembled on a sun tracker measured at two test sites, EKO in Tokyo, Japan, and at the National Renewable Energy Agency (NREL) in Colorado, USA. The MS-90 DNI data is acquired continuously every minute since February 2017 at EKO, and since October 2017 at NREL.

The preliminary results show for both test sites that the cost-effective MS-90 sensors measure the DNI with deviations from the reference within $\pm 5\%$, for solar zenith angles smaller than 75° and DNI values higher than 700W/m^2. Larger deviations practically within $\pm 10\%$ are observed for greater incidence angles and lower DNI values depending on seasonal effects.

[1] J.M. Pó, K. Hoogendijk, I. Chiba, A. Akiyama, W. Beuttell, Direct Normal Irradiance Measurements Using a Tracker-Less Sunshine Duration Measurement Concept, in 35th European Photovoltaic Solar Energy Conference and Exhibition, pp 1676 – 1678, 2018

[2] M. Sengupta, A. Habte, C. Gueymard, S. Wilbert, D. Renné, Best practices handbook for the collection and use of solar resource data for solar energy applications: Second edition. NREL technical report, NREL/TP-5D00-68886, pp 3-27-28, 2017

[3] MS-093 Sunshine duration sensor manual, EKO Instruments, accessed January 2019

[4] WMO, 2008, Guide to Meteorological Instruments and Methods of Observation, seventh edition, Annex 1.B, subscript point 5, and 8.1.3