

are in accordance with the values for a flat plate rack mounted CIGS module (Maturi et al., 2014), indicating that there is no detectable overheating caused by the type of integration.

3.2 Field Test Results

3.2.1 Measured electricity production

From the data collected by the loggers, it is possible to have an idea about the performances of the two modules. Examining the production curves in a clear sky day a difference is apparent in Fig. 6. The difference exists despite a similar shape and irradiation pattern because of the electrical layout.

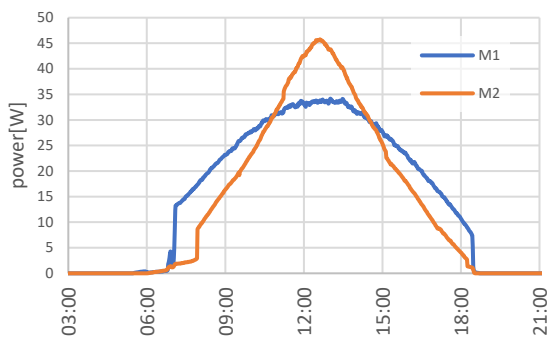


Fig. 6 – The power output of the two modules for August 8, 2016

In general M2 technology outperforms the other around noon by generating a narrower and somewhat sharper profile. Given the higher nominal power declared by the producer (M1=47 W, M2=70W), which is almost proportional to the highest power at noon (e.g. M1 = 33W, M2= 45 W), it is plausible that M2 suffers a drop in efficiency in the morning and the afternoon. This could be explained by stronger current mismatch effects when the irradiation pattern is more asymmetrical (i.e. the sun is east or west). Considering the cumulative energy production over an analysis period of 10 days (from August 26 to September 5, 2016) M1 shown a higher energy production (M1 126kWh M2 117kWh).

3.2.2 Simulated electricity production

The simple formula used in equation 1 shows a good level of agreement with the measured data. An overestimation of the power is apparent during the morning hours, this is due to a lag in the sunrise time between the location of the experiment and the pyrhelimeter at ABD (Fig. 7).

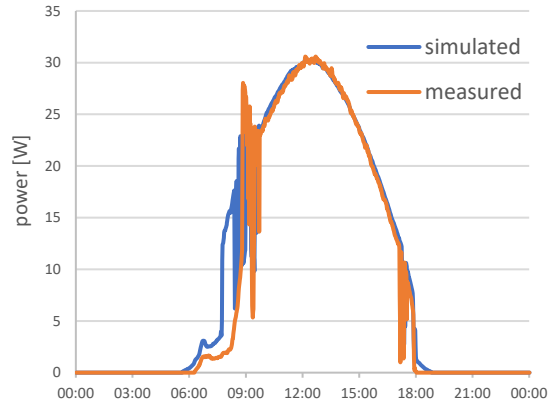


Fig. 7 – Simulated and measured power output for the M1 module for August 31

The error in the days from August 26 to September 5, 2016 was analyzed. The data were filtered and only the core hours (from 9:30 to 15:30) the simulated power production and the measured one are shown in Fig. 8

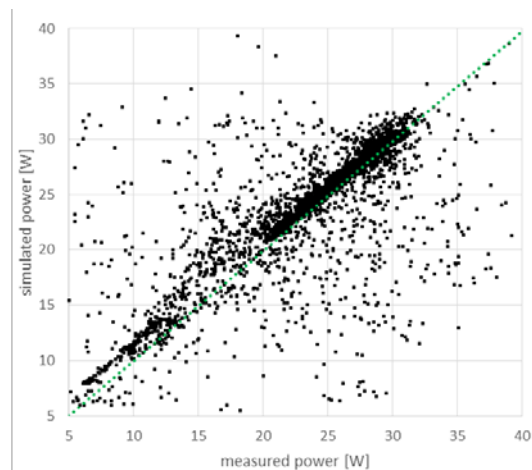


Fig. 8 – Dispersion diagram of simulated vs. measured power from August 26 to September 5, 2016. The data were filtered removing the morning hours

The error (measured – simulated power) resulted from a Kolmogorov-Smirnov test of significance level 0.1 to be drawn from a normal population of mean -0.28 W and standard deviation 1 W.

