SolPEG
Solar Power Expert Group

SolPEG GmbH, Normannenweg 17-21, D-20537 Hamburg. Tel.: +49 40 79 69 59 36, Fax.: +49 40 79 69 59 38, E-Mail: info@solpeg.de, Internet: www.solpeg.de

Irradiance level characteristics of PV modules and the need for improved data quality

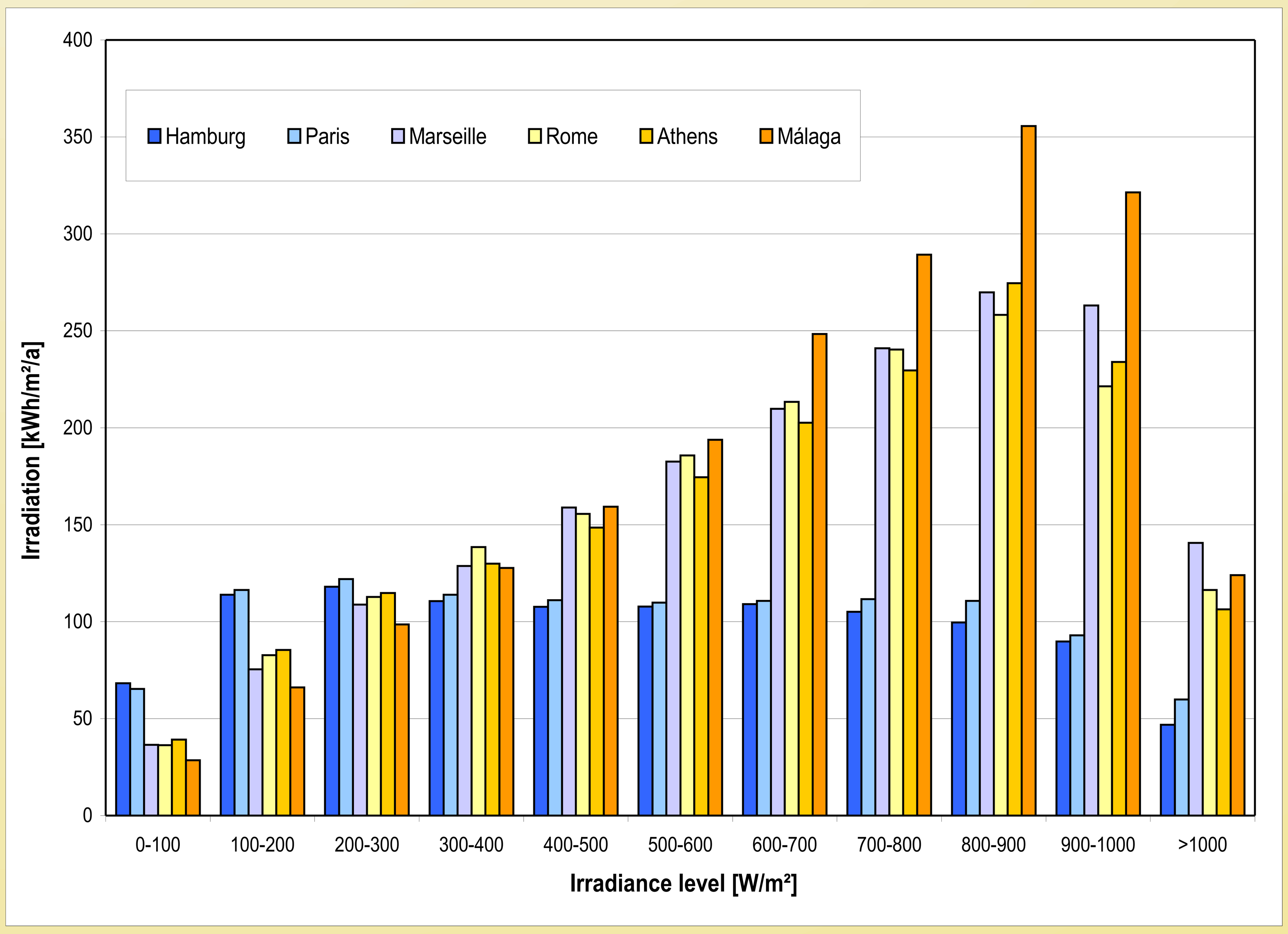
Dipl.-Ing. (FH) André Schumann

1. Purpose

The performance of PV modules under low light conditions can differ significantly even within one module technology. This has a severe impact on the yield of PV systems. The awareness of the relevance and heterogeneity of the irradiance level behavior of PV modules is still quite poor. It is not possible to deduce the exact irradiance level characteristics just from STC data. Hence, it is welcome and important that manufacturers publish I-V-curves for different irradiation levels in their data sheets. This presentation demonstrates that such information should be checked very critically. Photovoltaic has become a big business and will play an important role in future power supply. But this development is affected by the extent, transparency and reliability of technical specifications which limit the accuracy of today's yield calculations important for investment decisions. To allow for better prognoses extended mandatory and controlled test conditions for PV modules are claimed.

2. Irradiance level distributions

The importance of the influence of the irrandiance level on the module efficiency is underlined by the following charts. The displayed irradiance level distributions for selected European cities are based on minute data interpolated by the software Meteo Norm 6.1 for a 30° south inclined plane.



Picture 1: Annual irradiance level distribution for an 30° south inclined plane at different European cities

Even for the most sunny site Málaga most of the annual irradiation is collected below 1000 W/m² at which PV modules are rated. The following section estimates the influence of the irradiance level distribution on the yield and performance of a PV system. Tracking PV planes of course receive higher irradiations - the low light module efficiency is less important but still makes differences in the performance.

3. Influence of irradiance level on PV module performance

PV modules can show very different low light responses even within one technology. The following table shows the resulting yields and performances that can be reached at the examined sites with modules of good and bad low light response. The underlying module efficiencies are based on real measurements of different poly crystalline modules and represent worst and best case scenarios. Typical low light responses lie somewhere in the middle of the presented results.

Table 1: Possible yields and performances with the examined irradiance level distributions

City	Module 1 (good low light response)	Module 2 (bad low light response)	Difference Module 1 to Module 2
Hamburg	Yield: 877 kWh/kWp PR 81.4 %	Yield: 797 kWh/kWp PR 74.0 %	10.0 %
Paris	Yield: 905 kWh/kWp PR 80.5 %	Yield: 824 kWh/kWp PR 73.3 %	9.8 %
Marseille	Yield: 1424 kWh/kWp PR 78.4 %	Yield: 1338 kWh/kWp PR 73.7 %	6.4 %
Rome	Yield: 1370 kWh/kWp PR 77.8 %	Yield: 1282 kWh/kWp PR 72.8 %	6.8 %
Athens	Yield: 1349 kWh/kWp PR 77.5 %	Yield: 1263 kWh/kWp PR 72.6 %	6.8 %
Málaga	Yield: 1560 kWh/kWp PR 77.5 %	Yield: 1474 kWh/kWp PR 73.3 %	5.8 %

4. State of data quality

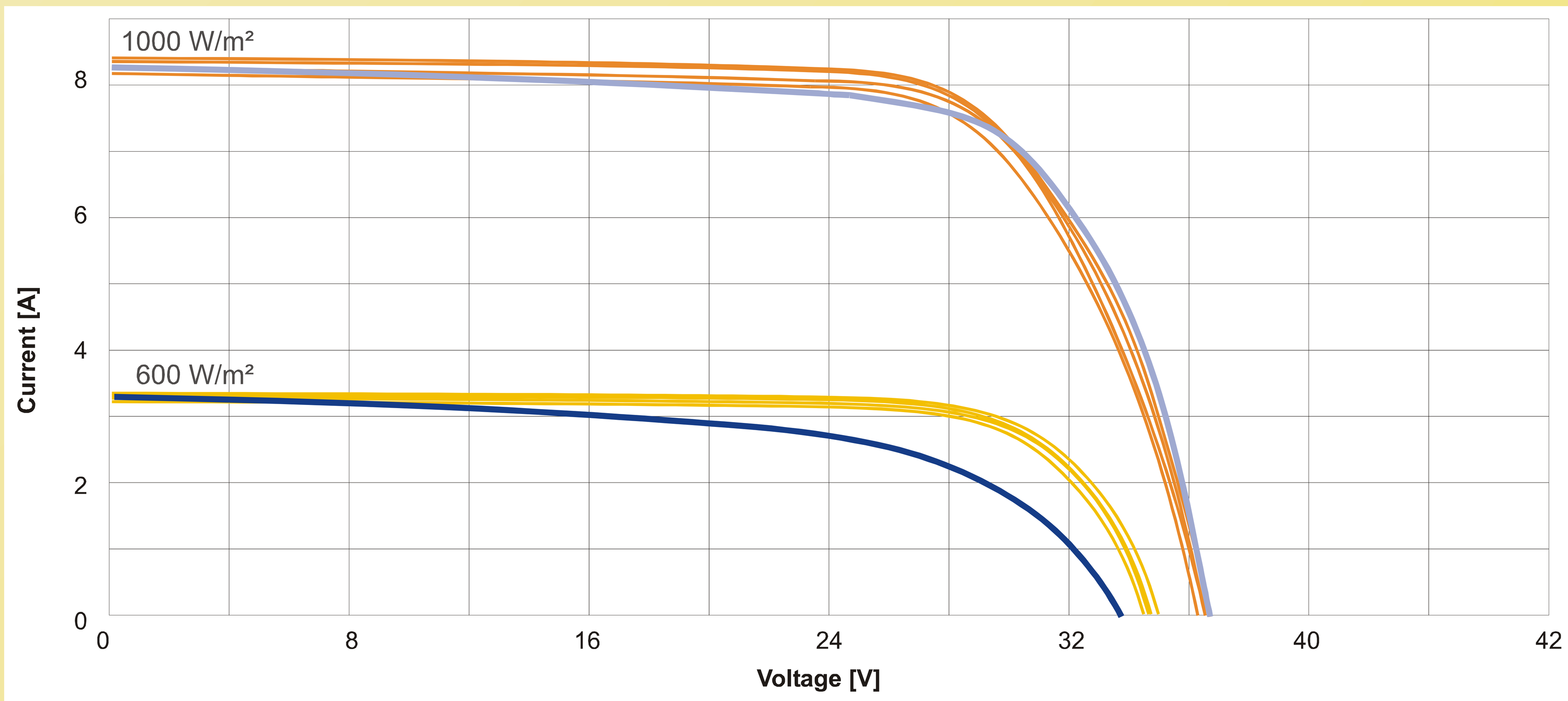
The actual irradiance level distributions and the individuality of PV modules' low light responses demands for accurate module specifications. But still manufacturers' are only obligated to publish STC data that does not allow for an exact determination of the irradiance level behavior. Hence new mandatory standards need to be implemented.
This claim is underlined by the following examples that reveal doubts of today's manufacturers' information even if it is given for other conditions than STC.

Example 1 shows results of independent laboratory measurements of two modules that are sold as identical products (manufacturer, module type, wattage). Since there are no rules and regulations the manufacturer is free to publish the good irradiance level characteristics of module 1 in the data sheet and not an average response representative for the whole range of this product.

Table 2: Measured data of two modules of one type of product

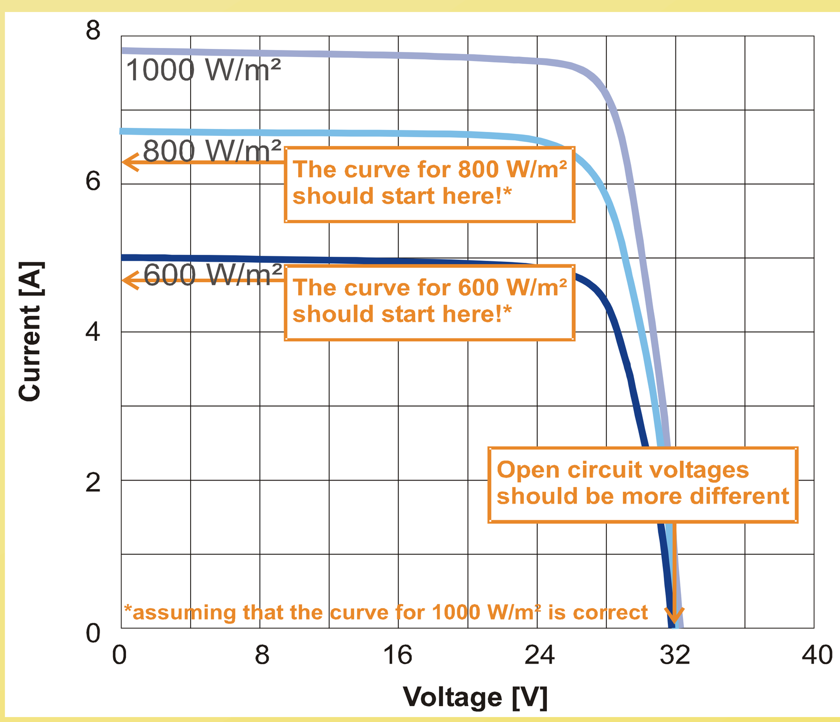
Irradiation	Power Module 1 (good low light response)	Power Module 2 (bad low light response)	Difference Module 1 to Module 2
1000 W/m²	165.95 W	166.04	-0.01%
100 W/m²	14.41 W	13.42	7.38%

Example 2: The data sheet states extreme bad low light behavior of the considered module in this example. On inquiry the manufacturer confirms the data sheet characteristics. A testing of a sample of 4 modules in an independent laboratory reveals a contrary performance as shown in picture 2.

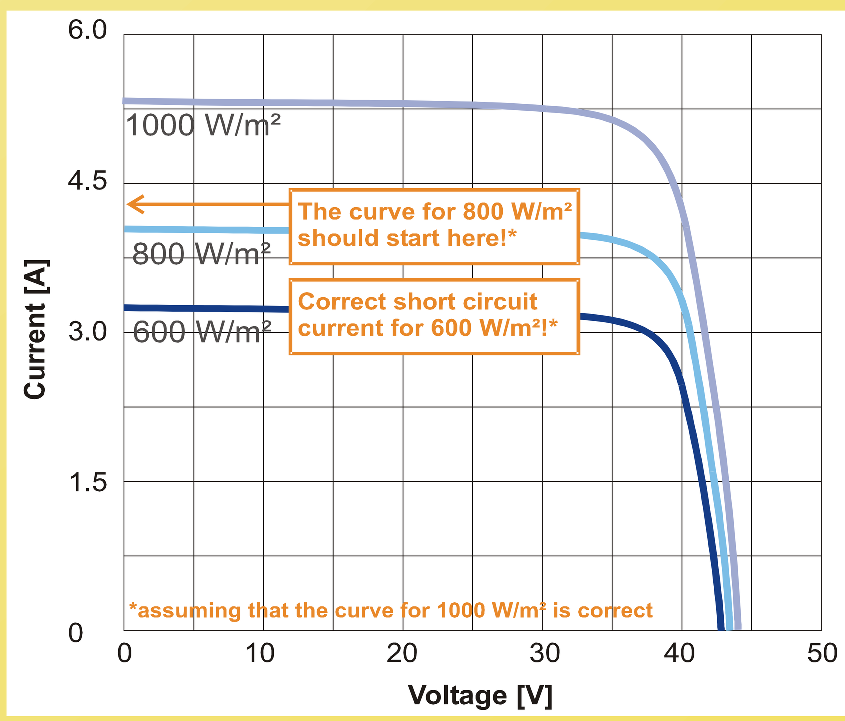


Picture 2: Measured (orange) and specified (blue) characteristics

Example 3: The characteristics in picture 3 and 4 are taken from two different original data sheets. The short circuit current should be proportional to the irradiance. Thus, the displayed information is physically doubtful.



Picture 3: Doubtfully specified characteristics #1



Picture 4: Doubtfully specified characteristics #2

5. Summary

Irradiance level distributions and yield simulation results underline the importance of knowledge about the exact reaction of PV modules to varying conditions. The low light behavior can differ within the same module type. Some available data sheets show physically doubtful behavior and high deviations from real laboratory tests. For the manufacturers such information is not mandatory and not controlled by any independent third party.

Conclusion: The Standard Test Conditions cannot be considered as an adequate standard anymore for the current state of PV technology. Investment decisions should not be made upon poor or even wrong information. But also a weighted efficiency over the whole irradiance level range similar to the Euro-efficiency for inverters is not very significant when considering the the irradiance level distributions at different sites. Thus characteristics should be given for at least 200, 500, 800 and 1000 W/m² as certificated conformance for PV modules.