Fraunhofer ISE

CalLab PV Cells

Fraunhofer ISE CalLab PV Cells changes to new spectral distribution in IEC 60904-3 standard

The measurement principles for terrestrial photovoltaic devices are defined in the IEC60904-3 standard. One of the main parts of the standard testing conditions (STC) is the spectral distribution of the irradiance known as AM1.5G spectrum. The definition of these spectral data is based on realistic atmospheric and environment parameters. These parameters are:

- Tilt of incidence plane to horizontal
- Ground reflectance albedo
- Atmospheric water content
- Atmospheric ozone content
- Turbidity

The software tool used to calculate the standard spectral distribution listed in the IEC60904-3 Ed. 1(1989) [1] including these atmospheric properties was the BRITE model.
The dataset tabulated in Ed.1 (1989) had several shortcomings:

- It could not be reproduced by the BRITE model
- The solar receiver geometry was not well defined
- The resolution of the data was low with irregular spacing
- The meteorological data applied in the model were inconsistent
- In the tabulated data in Ed.1 (1989) are typographical errors

To overcome these inconsistencies the spectral distribution was revised by the technical committee (TC) 82 of the International Electrotechnical Commission (IEC).
The new IEC60904-3 Ed.2 (2008) [2] has a new meteorological parameter set, higher resolution, a wider wavelength range in the UV region and is based on an up-to-date SMARTS computer model. Anyone interested in the data is able to calculate the data by himself [3], otherwise the data are available at the IEC for purchase.

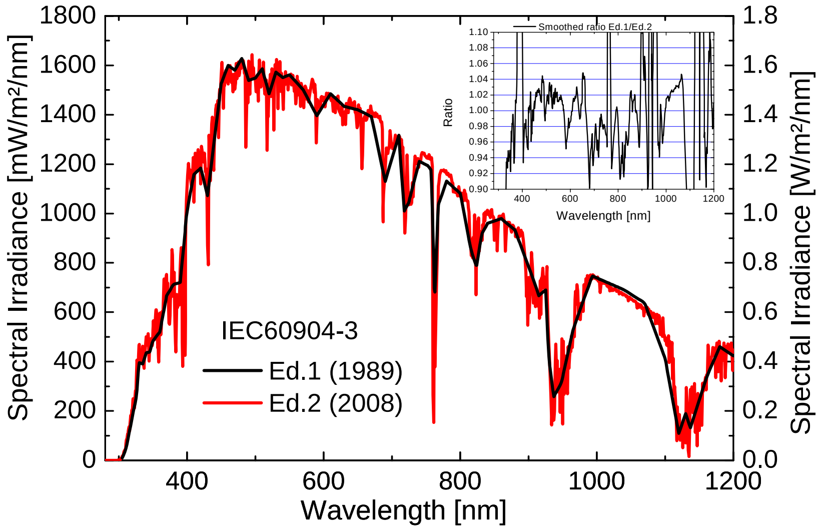

Fig. 1: Previous (Ed. 1 (1989)) and new (Ed.2 (2008)) data of the IEC60904-3 spectral distribution. The ratio between the spectra, smoothed in 10nm intervals, is plotted in the insert.

The comparison in Fig. 1 clearly shows the higher resolution of Ed. 2 (2008). Please note also the change in the units from [mW/m²/nm] to [W/m²/nm]. The data differ in some regions not only due to the higher resolution, although systematical differences occur. They are caused by the changed input parameters and the different model used.
These differences in the spectral distribution of IEC60904-3 Ed. 1 (1989) in comparison to that defined in IEC60904-3 Ed. 2 (2008) may cause changes in the STC values of photovoltaic devices. The short-circuit current (I_{SC}(STC)) of a photovoltaic device changes (in first order) linear with the irradiance and it can be calculated using the spectral response ($SR(\lambda)$) of the device by the following equation:

$$I_{SC}(\mathrm{STC}) = \int SR(\lambda)\mathrm{E}_{\mathrm{AM1.5G}}(\lambda)\mathrm{d}\lambda \qquad \textbf{eqn. 1}$$

with the respective standard spectral distribution $\mathrm{E}_{\mathrm{AM1.5G}}(\lambda)$.

The short-circuit currents of photovoltaic devices with different spectral response ranges may increase or decrease when changing the standard spectral distribution from Ed.1 (1989) to Ed.2 (2008) (Fig. 2). These changes can be calculated, if only the relative spectral response (sr) of the photovoltaic device is known, according to:

$$\Delta I_{SC} = \frac{\int sr(\lambda)E^{\mathrm{Ed.1}}_{\mathrm{AM1.5G}}(\lambda)\mathrm{d}\lambda}{\int sr(\lambda)E^{\mathrm{Ed.2}}_{\mathrm{AM1.5G}}(\lambda)\mathrm{d}\lambda} - 1 \qquad \textbf{eqn. 2}$$

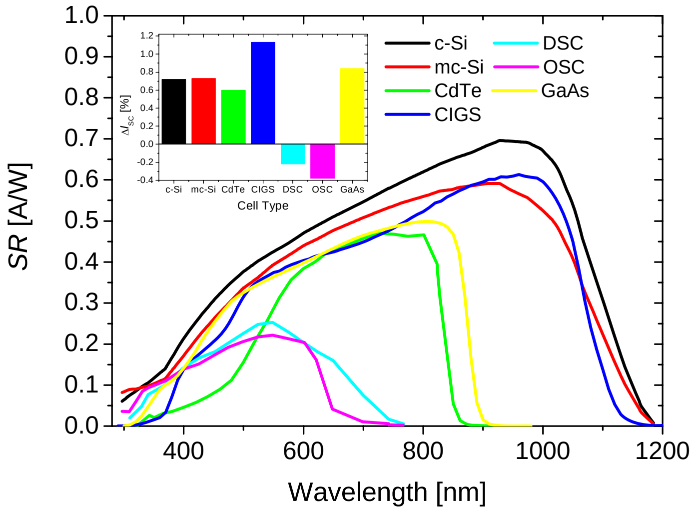

Fig. 2: Typical spectral response of various solar cell types and relative change of I_{SC} according to eqn. 2.

The Fraunhofer ISE CalLab Cells is calibrating photovoltaic devices according to IEC60904-3 Ed.2 (2008) with full traceability back to the PTB (PTB is the National Metrological Institute - NMI - of Germany) starting November 24, 2008. For comparison and further use, the I_{SC} value of the device according to IEC60904-3-Ed.1 (1989) will be stated additionally in the calibration documents as a informational value calculated from the measured data. This allows the customer to recalibrate reference devices within the usual recalibration interval and to choose the changeover to the new standard conditions by their own timescale in accordance with any other parties involved. Further publications are [4] and [5].

1. IEC 60904-3, *Photovoltaic devices - Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data*. 1989.
2. IEC 60904-3 *(Ed. 2)*, *Photovoltaic devices - Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data*. 2008.
3. C. Gueymard, *SMARTS, A Simple Model of the Atmospheric Radiative Transfer of Sunshine: Algorithms and Performance Assessment.* Professional Paper FSEC-PF-270-95, 1995.
4. S. Winter, D. Friedrich, and A. Sperling, *Effects of the new Standard IEC 60904-3:2008 on the Calibration Results of Common Solar Cell Types*. in *Proceedings of the 25th European Photovoltaic Solar Energy Conference,* 2010. Valencia, Spain
5. M.A. Green, K. Emery, Y. Hishikawa, and W. Warta, *Solar Cell Efficiency Tables (Version 34).* Progress in Photovoltaics, 2009. **17**(5): p. 320-326.