Annual Degradation Rate Analysis of Qcells Modules

Qcells continuously tests and monitors PV modules in numerous test fields around the world. In this paper long term monitoring data of PV installations with Qcells modules on our test field at the global R&D headquarters in Germany have been evaluated. The resulting annual degradation rates range from 0.2% per year to 0.4% per year. This is well within the warranty expectations.

Qcells Test Sites

Qcells provides a 12 year product warranty and a 25 year performance warranty for its products in general. In addition special products come with a 25 year product warranty or a 30 year performance warranty. In order to provide such long warranty periods it is important for Qcells to fully understand and quantify the effect of long term outdoor exposure on Qcells modules. Along with accelerated testing and detailed modelling Qcells operates a number of test sites and reference installations around the world to effectively assess the long term performance of its modules (Fig. 1).

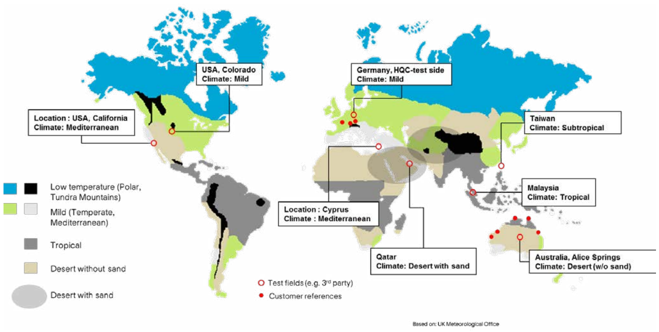

Fig. 1 Qcells global test fields and reference installations

Data for Degradation Analysis

Qcells operates a large outdoor test field near the global R&D Headquarter in Germany (Fig. 2). The main purpose of this test facility is to generate high quality yield and degradation data for products and prototypes under field conditions. Typically the results are used for characterisation of products, components and as input for simulations.

The location in Germany is the longest running test field operated by Qcells and contains PV installations with more than a decade of high quality monitoring data. In order to determine reliable degradation rates of PV-systems long term data of several (ideally more than 5) years of operation is essential. In this white paper we used data from this test field to analyze degradation rates of Qcells products.

Four systems were analysed. System 1 and 2 consist of modules with BSF-type cells. With 11 years of operation system 1 is one of Qcells longest running test installations. System 2 was installed 8 years ago. System 3 and 4 were built with modules containing Qcells Q.ANTUM cells and were installed 8 and 7 years ago, respectively. They are among Qcells oldest Q.ANTUM/PERC-type systems and are therefore ideally suited for degradation rate analysis. All these systems have been continuously monitored since installation and continue to operate. They are monitored individually, with key electrical characteristics recorded every 10 seconds. Alongside meteorological data such as humidity, pressure, ambient temperature, precipitation and irradiation is also captured.

Fig. 2 Module string at Test Field in Germany

Determination of Annual Degradation Rate

The calculation of the degradation rates is performed employing a year–on-year approach based on the python package RDTOOLS [1], which has been published by NREL in 2018 [2] and has been continuously improved thereafter. The tool is employed by many institutions resulting in numerous scientific publications. For this year-on-year approach normalized performance values are calculated for each day, and degradation rates are calculated for each pair of two days in adjacent years. For instance the performance value of July 1st of one year is compared to July 1st of the previous year, resulting in a day-to-same-day-next-year rate. From all of these day-to-same-day-next-year rates the median is determined and assumed to be the effective degradation rate of the system. The RDTOOLS package offers two different approaches for application of the described analysis.

The clear-sky approach intends to enable degradation rate analysis even for sites with poorly maintained metrology. It calculates the normalized performance values based on idealized, modelled temperature and irradiation assuming clear-sky conditions. Nevertheless site irradiation data is still required to identify clear-sky conditions, since only these data points can be used for analysis. During our analysis the clear-sky approach was found to be unsuitable for the climatic conditions in Germany, as it requires a higher amount of clear-sky-days than available to deliver sufficiently stable results.

The sensor based approach included in the RDTOOLS package calculates the normalized performances for each day based on sensor measured temperature and irradiation. It assumes that the used sensors are calibrated and well maintained. The test field at Qcells global R&D headquarters in Germany is carefully monitored. All sensors are regularly checked and calibrated to ensure proper function. When these conditions are fulfilled, the approach can give much more precise results. Accordingly the sensor based approach was found to provide stable results and is used in this work to determine degradation rates of the PV systems. It will be referred to as “year-on-year approach” in the following.

Results of Degradation Analysis

The measured performance data was analysed with the year-on-year approach, explained in the previous section. In Figure 3 the results of the four systems are shown. Results for systems 1 and 2 with modules containing BSF-type cells are presented on top, results for system 3 and 4 with modules containing Qcells Q.ANTUM cells are shown at the bottom. The degradation rates for the BSF installations are determined to be 0.2% and 0.39%, respectively. For the Q.ANTUM installations, degradation rates of 0.39% and 0.17% are obtained. It can be seen that the degradation rate is not a fixed value representing a module or system type, but rather a range where the individual value varies from system to system and depends on many factors, location, system setup, weather and many more. The found range of degradation rates of 0.2-0.4% is well below Qcells linear performance warranty of max. 0.6% degradation per year for these products, confirming the high quality and reliability found in laboratory tests.

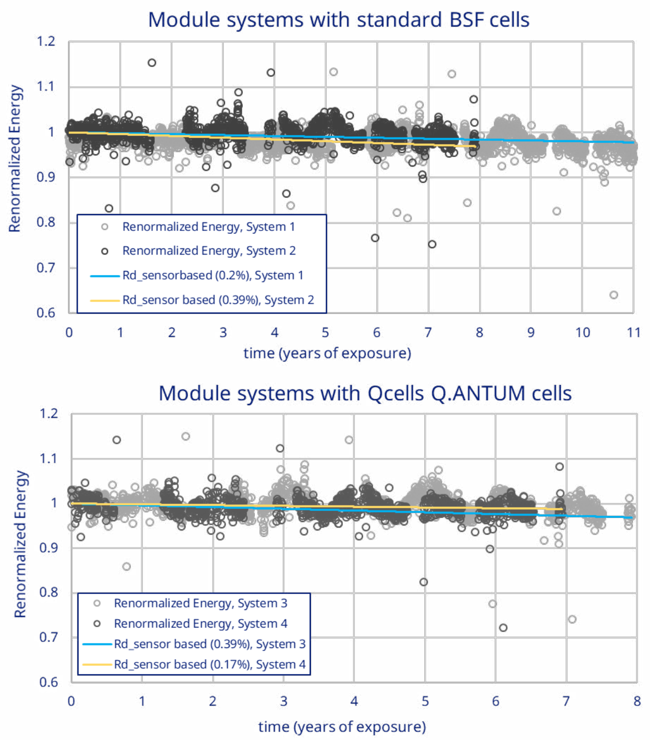

Fig. 3 Normalized outdoor performance of four PV-systems at Qcells R&D headquarters in Germany [circles] and determined degradation rates using the year-on-year approach [solid lines]

Outlook

Qcells continuously improves performance and reliability of its PV products. The current Q.PEAK DUO-series show improved reliability in accelerated laboratory testing and modelling due to further improved cell stability of the half-cell design and increased crack tolerance due to an increased number of cell busbars. Therefore a linear performance warranty of max. 0.54% degradation per year can be provided for Q.PEAK DUO modules. With the new Q.PEAK DUO-G9, -G10 and -G11 series including gapless technology the reliability could even be further improved, which enabled Qcells to give an enhanced linear performance warranty of max. 0.5% degradation per year. With the Q.TRON module series Qcells introduces its new Q.ANTUM NEO cell technology, the next evolutionary step in the Q.ANTUM technology. Due to excellent performance stability of the Q.ANTUM NEO cell, Qcells can give an even better linear performance warranty of max. 0.33% degradation per year for Q.TRON modules. The outdoor performance of these products will also be monitored in our test fields in order to confirm the outstanding performance found in laboratory testing.

Conclusion

In this paper long term monitoring data of PV installations have been evaluated in order to determine annual degradation rates. Four PV installations on the R&D test field in Germany with Qcells modules have been analysed using a year-on-year approach. The resulting annual degradation rates cover a range of 0.2% to 0.4% per year. This shows that there is not a single value representing the degradation rate of a module- or system- type, due to many influencing factors. It is more reasonable to assume a range of possible degradation rates. The found range of degradation rates for the four analysed systems are well within Qcells linear performance warranty for these products, confirming their high quality and reliability.

References

[1] Michael G. Deceglie, Ambarish Nag, Adam Shinn, Gregory Kimball, Daniel Ruth, Dirk Jordan, Jiyang Yan, Kevin Anderson, Kirsten Perry, Mark Mikofski, Matthew Muller, Will Vining, and Chris Deline RdTools, version 2.0.3, Compuer Software, https://github.com/NREL/rdtools.

[2] Dirk Jordan, Chris Deline, Sarah Kurtz, Gregory Kimball, Michael Anderson, “Robust PV Degradation Methodology and Application”, IEEE Journal of Photovoltaics, 8(2) pp. 525-531, 2018 DOI: 10.1109/JPHOTOV.2017.2779779