Combatting LeTID in multi and monocrystalline solar panels: How testing has demonstrated the high resistance of REC solar panels to LeTID degradation, ensuring long term power for lasting performance

Much research has been carried out in recent times into a special degradation phenomenon in high powered solar panels. Known as LeTID, this degradation can lead to high levels of power loss in a system, over and above that seen with the known LID effect. REC has worked hard to ensure that its panels are not susceptible to this phenomenon and provide customers with the highest quality.

What is LeTID?

Having first been noted by Schott Solar AG in 2012, Light and elevated Temperature Induced Degradation (LeTID) has been shown to cause severe degradation in multicrystalline (mc-Si) silicon cells, especially in those with cell passivation technology, e.g., PERC, instead of the typical Aluminium Back Surface Field (BSF).

LeTID, is a form of solar cell degradation which can be seen in the field and is accelerated by high irradiance at higher temperatures after hundreds of hours light exposure. Indeed, a drop in relative conversion efficiency of up to 10%[1] can be seen in cases of LeTID if steps are not taken to adequately prevent its occurrence.

What is the difference between LID and LeTID?

Light induced degradation (LID) is the most commonly observed degradation phenomenon in all p-type silicon solar cells (cells doped to give a positive charge, e.g., with boron). The cause of LID is traces of oxygen in the silicon diffusing across the silicon lattice and creating complexes with the boron dopant. These complexes can capture electrons and holes in the cell matrix rendering them permanently unavailable for the energy generation. This occurs upon first exposure to sunlight until the power level stabilizes after a short period.

As its name suggests, LeTID is similar to LID, but is exacerbated by higher operating temperatures and higher intensities of light. Unlike LID, LeTID can occur over a much longer period of time. This tells us that the development rate of LeTID in the cell is slower than any boron/oxygen complex association and iron /boron disassociation.

Under what conditions is LeTID most likely to occur?

When talking about LeTID in higher temperatures, there is no single threshold where it can be said that an occurrence of LeTID is likely. However, most research into the phenomenon to date has looked at module temperatures above 65°C (149°F).

What causes LeTID to occur in solar panels?

As things stand, there is currently no concensus as to the true cause of LeTID in a solar cell. Studies into the phenomenon have observed that the level of degradation is independent to the dopant and/or oxygen levels inside the cell, so it cannot be due to internal processes between boron and oxygen, or iron and boron.

The current prevailing hypothesis is that LeTID is a result of interaction between the silicon nitrate (SiN_X) and aluminum oxide (AL_2O_3) passivation layers at higher temperatures during the firing process in manufacturing. And it is in wafers that undergo a fast firing process typical for industrial solar cell production that a significantly stronger degradation is shown than in samples that were subjected to the same peak temperature but with slower heating and cooling rates.[2]

Furthermore, at the EUPVSEC conference in 2016, researchers from Fraunhofer ISE and Freiberg Materials Research Centre in Germany presented studies that indicated that LeTID depends on the presence of hydrogen rich layers during the firing process and is caused by this mobile hydrogen reacting with intrinsic crystal defects, demonstrating that its occurrence is strongly influenced by carrier injection conditions and elevated temperatures.[3] Similarly, in 2017, the University of Konstanz presented the results of studies into the impact of temperature and doping on LeTID and regeneration behavior in PERC cells. This study measured the degradation in terms of difference in effective minority charge carrier lifetime and drew the conclusion that the higher the temperature, the faster the samples degrade.

Img. 1: Systems in high irradiation and high temperature locations, such as here in India, may suffer a significant power loss due to LeTID

How does LeTID affect an installation?

It has been shown by TU Bergakademie Freiberg that LeTID can occur between 100 and 1000 hours of operation (dependent upon location and strength of irradiation), and cause up to 7% power degradation.[4] Clearly, this would lead to a significant drop in power capacity in the long term, leaving customers unable to generate the amount of energy expected. With such a dramatic change, if a site were to suffer from such a drop, the levelized cost of energy (LCOE) of the site would be severely impacted.

What testing has REC made to ensure resistance to LeTID?

As awareness of this phenomenon has grown, REC has made a series of studies into its own multi and monocrystalline PERC products in order to assess their susceptibility to LeTID::

Laboratory testing:

The latest testing procedures REC has used match those introduced in the IEC 61215-2 TC82 draft standard. This new standard is being drafted as a module quality LeTID detection test.

Here, testing is carried out after the regular stabilization step has been completed, each panel is put through up to five rounds of 162 hours at maximum power point (MPP) and at 75°C (165°F) (±3°C), with a current injection where $I = I_{SC} - I_{MPP}$. The test has a pass rate of -5% of pre-LeTID testing power loss.

REC has performed this exact testing protocol across its multi and monocrystalline products as representative of the wider product range,

1 F. Kersten, P. Engelhart, H-C. Ploigt, A. Stekolnikov, T. Lindner, F. Stenzel, M. Bartzsch, A. Szpeth et al. Degradation of multicrystalline silicon solar cells and modules after illumination at elevated temperature. Solar Energy Materials and Solar Cells 2015;142:83–86.

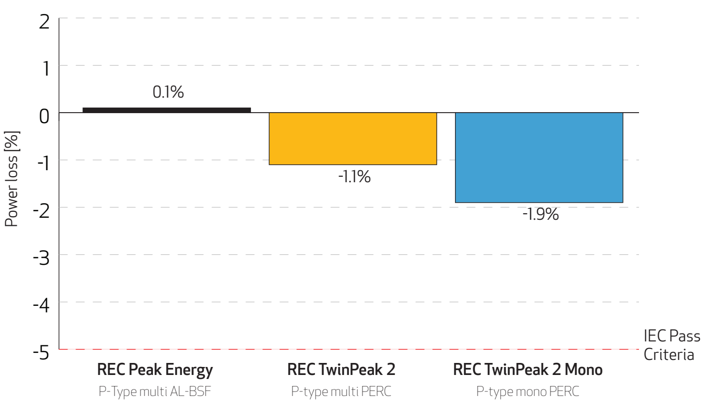
2 R. Eberle, W. Kwapil, F. Schindler, M. Schubert, S. Glunz. Impact of the firing temperature profile on light induced degradation of multicrystalline silicon. 2016; Wiley VCH Verlag GmbH & Co. KGaA, Weinheim

3 D. Sperber, A. Herguth, G. Hahn. Investigating possible causes of light induced degradation in boron-doped float-zone silicon. 33rd European Photovoltaic Solar Energy Conference, 2015.

4 F. Kersten, F. Fertig, K. Petter, B. Klöter, E. Herzog, M. Strobel, J. Heitman, J. Müller. System Performance Loss Due To LeTID. 7th International Conference on Silicon Photovoltaics, SiliconPV 2017, Elsevier Ltd 1876-6102.

including the REC TwinPeak 2S 72 and REC TwinPeak 2S Mono 72 Series. The results demonstrate a high resistance to LeTID as shown in fig. 1:

Fig. 1: Mean power loss due to LeTID of REC panels, tested according to IEC 61215-2 TC82



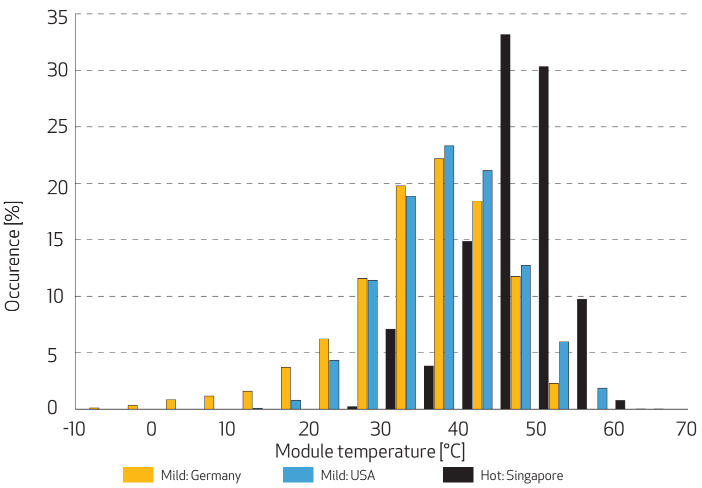
As can be seen above, all panels passed well within the set power loss limit of -5% in the draft IEC standard. Indeed, the REC testing agrees with the data reported by Kersten et al,[5] which reinforces the reliability of the testing. The results support the observations regarding an increased pronouncement in cells with di-electric surface passivation layers, and also concurs that the occurrence of LeTID is reduced with reduced bulk defects as achieved through quality manufacturing. These results testify that REC's approach to cell production is highly effective in suppressing the occurrence of LeTID, even in cells with a rearside passivation (PERC) substrate.

System climate comparison:

Concurrent to the lab and system testing, REC also runs an annual Degradation Study into its panels that compares degradation rates in real-life installations worldwide. This allows tracking of degradation and direct comparison across climates. REC has been able to use this study to investigate the occurence of LeTID in its PERC panels.

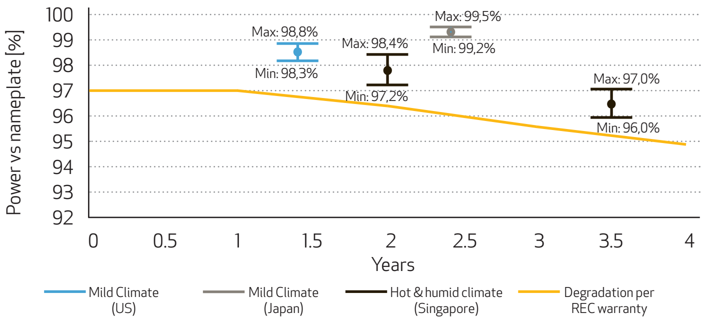
Looking at over four years of data taken from sites across the world to give a distinct comparison between hot and mild climates in real-world situations, the study demonstrated, that in the hot Singaporean climate, the weighted average temperature of the panel reached 50-55°C (122 - 131°F), with rare occurences above 60°C. The mild climates showed a weighted average panel temperature of 35-45°C (95 - 113°F), meaning the operating temperature of an REC module will generally be well below any kind of threshold for the occurence of LeTID (fig. 2).

Fig. 2: Weighted average temperature of REC panels in different climates:



Due to the more intense climatic conditions, the systems in Singapore tested saw more degradation over time compared to the sites in mild conditions with 2-3% system degradation observed after nearly four years of operation. A degradation to 7% after three years of operation - as based on data from Cyprus[6] - was not observed in REC's testing, strengthening the argument that REC panels are free from LeTID as shown in fig. 3.

Fig. 3: REC's degradation study shows no LeTID in mild or hot climates over time:



Looking closer at the individual panel results from high temperature locations, there is no sign of any LeTID-caused degradation (fig. 3). In particular, the panels from a hot climate show only ~3% loss. Mild regions, in this case the US and Japan show 1-2% loss after 1.3 and 2.5 years respectively. Through this testing, similar and consistent results are seen, indicating no occurence of LeTID and performance well above REC's warranted levels. This is supported by the fact that with multicrystalline PERC products in the field since early 2015, and in excess of 2 GW installed, REC is yet to receive a single report or feedback from customers of degradation due to LeTID.

What makes REC panels resistant to LeTID?

In choosing a panel, it is crucial to look for the highest level of quality in order to ensure the best protection against LeTID. As REC has shown, the risk of LeTID occurrence can be significantly reduced by ensuring the cell processing sequence is of high quality and crystalline defects are minimized. With over five years experience in the development, testing and mass production of p-type PERC multicrystalline cells, and having been the first manufacturer to bring PERC to the multi platform, REC can implement its extensive knowledge in the application of this technology to ensure that customers are guaranteed a high level of quality in its p-type mono PERC products as well.

Conclusion:

Given the range of temperatures seen across the world and the different operating temperatures and irradiation that panels can see, the occurence of LeTID is not a given for every location. However, installations in areas with high ambient temperatures and high irradiation levels, are at higher risk of such a phenomenon. The effect of the potential power loss, makes LeTID a justifiable concern for investors in solar projects and installations.

This is where the choice of a high quality product is critical for ensuring the utmost protection against LeTID. REC is known throughout the solar market as an award-winning and high quality panel manufacturer whose manufacturing processes have been regularly audited by independent third-parties and always received an incredibly high rating, firmly placing REC as a leading manufacturer and solar's most trusted company.

It is a fact that REC has had multicrystalline PERC cells in mass production and in the field longer than any other manufacturer, with over 2 GW installed worldwide in different and demanding climates. In this time, not a single panel has been notified or returned to REC with an LeTID defect.

This is backed up at product level by the accelerated lab testing of REC's panels as per the draft IEC 61215-2 standards, where all panels performed well above the given IEC pass mark. At system level, when comparing different climatic sites, such as Germany and Singapore, the degradation seen in real-life installations has been in line with the expectations for annual power loss in the silicon cell, as opposed to any severe degradation rates caused by LeTID.

In conclusion, the above means that as far as lab testing and field results can demonstrate, all REC multi and mono products are not affected by any significant LeTID, reinforcing the reliability of REC's products. This status that can be attributed to the high quality of manufacturing throughout the solar value chain, and the special attention REC pays to preventing degradation, meaning more reliability for customers.

5 Kersten et al. Degradation of multicrystalline silicon solar cells and modules after illumination at elevated temperature.

6 ibid.