

Combatting LeTID in 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 degradation phenomenon in high powered solar panels. Known as LeTID, this can lead to high levels of system power loss, over and above that seen with the known LID effect. REC has worked hard to ensure its panels are not susceptible to this phenomenon and has participated in third-party testing to 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 those using cell passivation technology, e.g., PERC.

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

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 (positively charged (doped), e.g., with boron). The cause of LID is the combination of oxygen in the silicon with the boron dopant. Such complexes capture electrons and holes in the cell matrix rendering them permanently unavailable for the energy generation. LID occurs upon first exposure to sunlight until the power level stabilizes after a short period.

As the name suggests, LeTID is exacerbated by higher operating temperatures and higher light intensity. Unlike LID, LeTID can occur over a much longer period of time, showing that the development rate of LeTID in the cell is slower than any boron/oxygen combination process.

Under what conditions is LeTID most likely to occur?

There is currently no agreed single threshold where it can be said that an occurrence of LeTID is likely. However, most research into the phenomenon has looked at module temperatures above 50°C (122°F), a regular occurrence during summer and at peak times in hot climates.

What causes LeTID to occur in solar panels?

Though the cause of LeTID in a solar cell is not yet fully understood, studies have observed that, unlike the internal processes seen in LID, power loss is independent of the oxygen levels in the cell. Current understanding is that LeTID results from an interaction between the passivation layers at higher temperatures during the firing process in manufacturing and it is "wafers that undergo a fast firing process typical for industrial solar cell production [that] show a significantly stronger degradation than samples subjected to the same peak temperature but with slower heating and cooling rates."²

The study, by Fraunhofer ISE and Freiberg Materials Research Centre in Germany, concludes that LeTID is caused by mobile hydrogen reacting with intrinsic crystal defects, with occurrence influenced by carrier injection conditions and elevated temperatures.³ Similarly in 2017, researchers from the University of Konstanz presented a study into the impact of temperature and doping on LeTID in PERC cells. Measuring degradation by differences in effective minority charge carrier lifetime, it concluded that the higher the temperature, the faster the degradation, demonstrating that LeTID "increases in strength with higher peak firing temperature and depends on the presence of hydrogen rich layers during firing"⁴.

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. 2017; Elsevier Ltd. 1876-6102

³ ibid

⁴ 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, 2017.

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?

TU Bergakademie Freiberg showed that LeTID can occur even after 1000 hours of accelerated lab tests (equivalent to roughly three years field operation, dependent upon location and irradiation). Extreme cases can cause upwards of 7% power degradation⁵ - a significant drop in long term power capacity, leaving customers unable to generate the energy expected. With such a dramatic change, the levelized cost of energy (LCOE) would be severely impacted if a site were to suffer from such a drop.

What testing has REC made to ensure resistance to LeTID?

As one of the first manufacturers to research and resolve the issue of LeTID in PERC cells, bringing its solution to industrialization in 2015 in the REC TwinPeak Series panel, REC has demonstrated its technology and quality leadership. REC was also part of the committees that later established the test protocols. As wider awareness of the phenomenon has grown, REC has continued to make a series of studies into its products to assess their sensitivity to LeTID:

Laboratory testing:

REC's LeTID internal testing procedures match those originally proposed in the IEC 61215-2 committee draft (CD). This test protocol was added in 2019 to a separate Technical Specification (TS) for LeTID by the TC82 committee as a module quality LeTID detection test and is to be carried out after completion of the regular stabilization step. In testing, each panel is put through 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, as suggested in the originally proposed IEC 61215-2 CD.

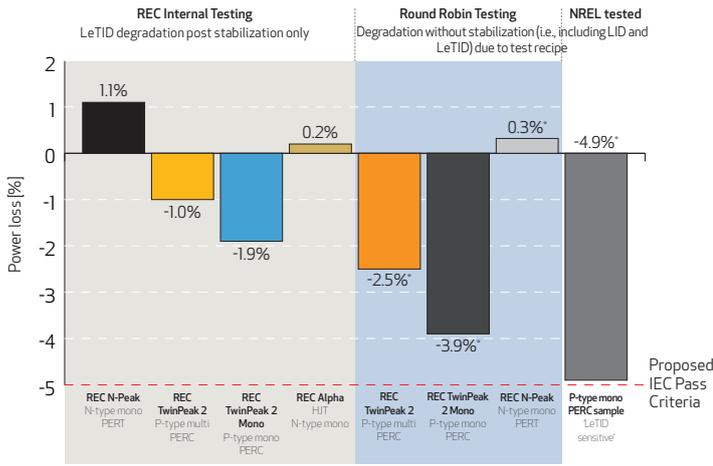
As part of product and component qualification, REC performs this exact testing protocol across all of its multi and monocrystalline as well as heterojunction products to be representative of the wider product range. The results demonstrate a high resistance to LeTID as shown in fig. 1.

To verify the IEC 61215-2 CD protocol, REC has actively participated in a series of round robin LeTID tests organized by the US test institute NREL. Both REC and other Tier-1 manufacturers were tested according to a revised IEC 61215-2 CD protocol (changes included no stabilization before chamber test, repetition of two consecutive 162 hour blocks until power recovery is shown or a period of four weeks was reached). Test results were verified by two test laboratories: NREL and Fraunhofer ISE. Results of both internal and round robin testing showed negligible power loss for REC's n-type monocrystalline products (fig. 1).

⁵ 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.

In a separate study, NREL tested several purchased commercial products according to the same proposed IEC test protocol⁶: a non-REC mono-PERC module in that study showed nearly -5% degradation in testing.

Fig. 1: Median power loss due to LeTID of REC panels, tested according to IEC61215-2 (2019) CD and variation with round robin test recipe



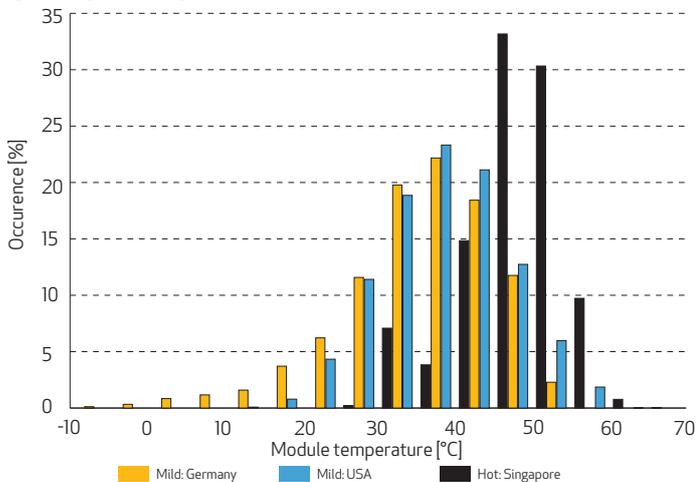
As the chart shows, all REC panels passed well within the proposed IEC power loss mark of -5%. Indeed, the above results agree with the data reported by Kersten et al⁷ reinforcing the reliability of testing and supporting the observations of an increased pronouncement of LeTID in cells with di-electric surface passivation layers. The results also show that LeTID occurrence is reduced with a reduction in bulk defects achieved through quality manufacturing, serving as evidence that REC's approach to cell production is highly effective in suppressing LeTID, even in cells with a rearside passivation (PERC) substrate. Furthermore, the results clearly demonstrate that cell technologies using n-type doping, such as the REC N-Peak and REC Alpha Series, are free from both LID and LeTID.

System climate comparison:

Concurrent to lab testing, REC also runs an annual degradation study where panel degradation rates from real-life installations are compared. This allows the tracking and comparison of degradation across climates. REC has been able to use this to investigate the occurrence of LeTID in its panels.

Over four years of data from these sites give a distinct comparison between hot and mild climates, and demonstrate that in a hot climate like Singapore, the weighted average panel temperature reached 50-55°C (122 - 131°F), with rare occurrences above 60°C (140°F). Mild climates showed a weighted average temperature of 35-45°C (95 - 113°F), meaning the operating temperature of an REC module will generally be below or at the lower end of any kind of threshold for the occurrence of LeTID (fig. 2).

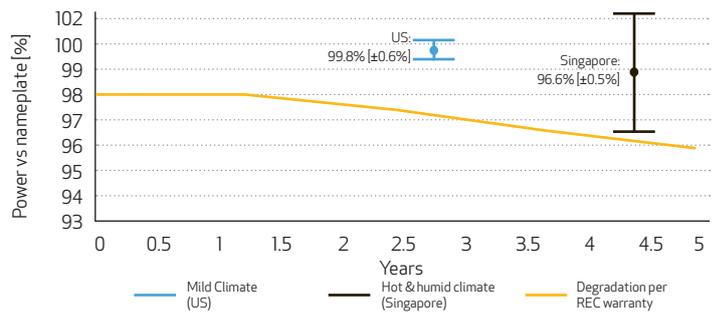
Fig. 2: Weighted average temperature of REC panels in different climates:



Due to the more intense climatic conditions, the systems tested in Singapore saw more degradation over time compared to the sites in mild

conditions with 2-3% system degradation observed after over four years of operation. A degradation to 7% after three years of operation - as based on data from Cyprus⁸ - was not observed in REC's testing, strengthening the observation that REC panels are free from LeTID (fig. 3).

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



Looking closer at the individual results from high temperature sites, there is no sign of LeTID-caused degradation. In particular, the panels from hot climates show only 3-4% loss over 4.5 years. Mild regions, i.e., the US, show less than 1% loss after 2.7 years. This testing, shows similar and consistent results, indicating no occurrence of LeTID and performance above REC's warranted levels - a statement supported by the fact that with multi-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 attributable 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. Indeed, REC was one of the first companies to combat the issue of LeTID and bring a solution to industrialization. As REC has shown, the risk of LeTID can be significantly reduced by ensuring the cell processing sequence is of high quality and that crystalline defects are minimized.

In 2015, REC was the first manufacturer to bring PERC to the multi platform. Now with well over five years experience in the development, testing and mass production of p-type PERC multicrystalline cells, REC uses 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 conditions and irradiation that panels see, the occurrence of LeTID is not a given for all locations. However, installations where there is a high ambient temperature and high irradiation level, 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 choosing a high quality product is critical for ensuring protection against LeTID. REC is known throughout the solar market as high quality manufacturer whose processes have been regularly audited by independent third-parties and always received an incredibly high rating, firmly placing REC as solar's most trusted company. It is fact that REC has had multicrystalline PERC cells in production and in the field longer than any competitor, with over 2 GW installed worldwide in different and demanding climates. To date, not a single panel has been returned to REC with an LeTID defect. This is backed up by the lab testing of REC's panels as per the originally proposed IEC 61215-2 CD standards, where all panels performed well above the pass mark. At system level, the degradation seen in real-life installations in different climatic sites, such as Germany and Singapore, has been in line with expectations for the cell, as opposed to any severe degradation rates caused by LeTID.

In conclusion, as far as internal and third-party lab and field results can demonstrate, REC products are not significantly affected by LeTID, reinforcing their reliability. This can be attributed to high quality manufacturing throughout the value chain and the special attention REC pays to preventing degradation, meaning more reliable products.

⁶ I.L. Repins, K. Terwilliger, C. Deline. Accelerated Testing for Light and Elevated Temperature Degradation (LeTID) of Purchased Modules, NREL Photovoltaic Reliability Workshop, 2020
⁷ Kersten et al. Degradation of multicrystalline silicon solar cells and modules after illumination at elevated temperature.

⁸ ibid.