Degradation in REC panels
Ensuring long-lasting high performance of REC panels

Customers typically invest in a solar system with an expected annual energy production year on year. Any reduction in this ability to produce worsens the financial investment and the overall profitability of a system. As a quality manufacturer, REC strives to reduce the effects of degradation through smart design and reliable production. Here, we look at the performance of REC panels in the most common and demanding degradation scenarios and how we minimize its effect to ensure reliable and durable energy generation.

LIGHT INDUCED DEGRADATION

What is Light Induced Degradation?

A known but not very well understood phenomenon seen in silicon solar panels is a small loss in power upon first exposure to sunlight. This phenomenon, known as Light Induced Degradation (LID), is generally ascribed to minor impurities and oxygen concentration in the wafer material[1]. It takes effect immediately and stabilizes after the first few days of exposure, but is irreversible in field mounted panels and is therefore a permanent loss of power.

What effect does LID have on my solar installation?

LID affects every solar panel to different extents depending on factors such as the intensity of sunlight and the wafer type used for the cell. Although it is not practical prior to purchase to test how much a particular panel will be affected by LID, due to REC's control of production at wafer, cell and panel levels, the effect of LID can be kept to a minimum.

Image 1: LID can have a serious impact on the overall performance and profitability of solar installations

Solar panels are sold by watt classes which are measured using equipment called a sun flasher. There are strict standards describing the measurement system and method which REC strictly adheres to. For practical reasons, the standards do not include exposure of solar panels to light and therefore the panels sold to customers are not compensated for LID. As a quality oriented company, REC uses all its experience and works hard to achieve the highest quality product with the lowest levels of LID.

How does REC reduce the effect of LID on its panels?

LID is caused by the amount of oxygen in the silicon wafer, so it stands to reason that the less oxygen it contains, the higher the quality of the wafer. In building and improving its modern, integrated factory in Singapore, REC has consistently invested in highly automated wafer, cell and panel manufacturing facilities, which reduce sources of variation in the product. One example of this is the special furnace technology developed by REC, which minimizes the oxygen content in the silicon melt, ensuring that the source of LID is as low as possible.

REC sources only the highest quality silicon to produce its wafers, limiting the impurities present in the mix. For further protection, REC uses its own unique coating technology, an automated process where the crucibles used to melt silicon are coated with silicon nitrate to protect the melt from any contamination. REC is able to control the application of the coating in-house, leading to higher quality wafers and demonstrating one example of where REC's high level of control over production assures product repeatability and an advantage over other manufacturers.

At certain times, REC may also purchase cells from external suppliers in order to make up any difference in production capacity. Our vast experience with silicon, wafer and cell production techniques means that REC has used its knowledge and long-term expertise to develop close collaborations with the same suppliers to select only the best cells from the best suppliers. These cells undergo the same demanding qualification testing and manufacturing processes as cells made in our Singapore factory to ensure that all REC panels perform to the high standards expected and are equally as resistant to LID.

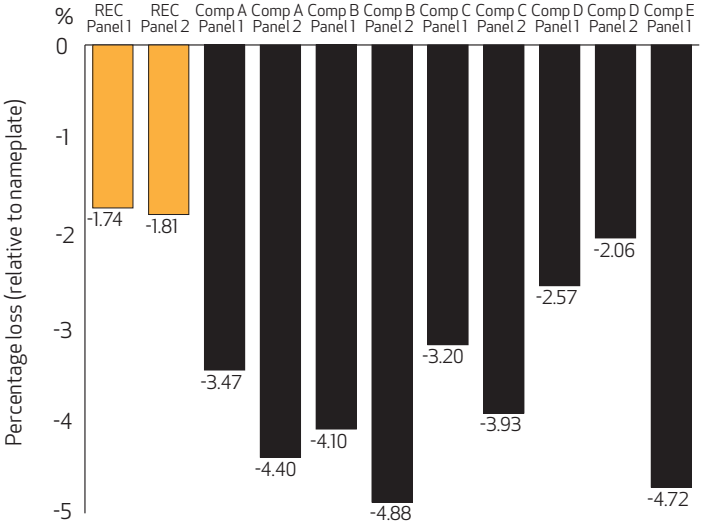
How does the effect of LID compare between manufacturers?

To assess the impact of LID in leading polycrystalline solar panels, in December 2013, the independent test institute SERIS (Solar Energy Research Institute of Singapore) purchased a number of panels from leading Tier 1 Chinese competitors on the open market and REC in order to perform a comparative analysis of the rate of LID.

Prior to testing, panels were flash tested by SERIS in order to measure their actual power. Thereafter they were exposed outdoors to sunlight to an accumulated irradiation of 40 kWh/m².

After testing, the results showed that REC panels experience the lowest power drop of all participants and were the only panels to lose less than 2% (Table 1). This excellent performance is credited to the quality of the panel production process, the capability of the machines and the ingredients used to make the wafers.

Table 1: The Light Induced Degradation of REC and competitive panels seen in tests performed by SERIS



1 Light-induced Degradation in Crystalline Silicon Solar Cells, Jan Schmidt, Solid State Phenomena Vols. 95-96 (2004) pp. 187-196, online at www.scientific.net, © 2004 Trans Tech Publications, CH

When classifying panel output, REC uses the same positive sorting tolerance common across the industry; this means a panel's exact output at the flash test is rounded down to the nearest watt class. However, the above results prove that over time, the customer will get more out of REC panels because they degrade less than the competition, giving a higher level of stabilized power.

ANNUAL DEGRADATION RATES

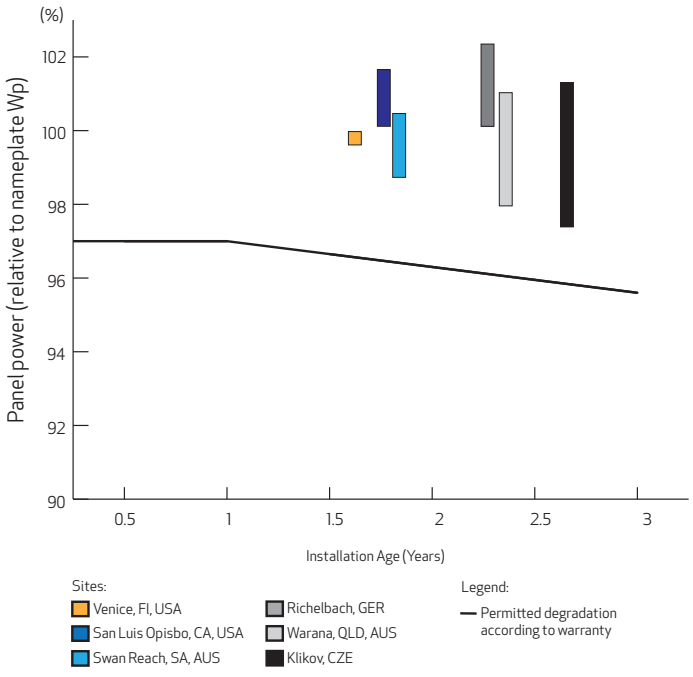
Degradation does not just occur on first exposure to light. After stabilizing post-LID, panels continue to degrade at a more linear rate, usually less than 0.7% per year. This 'natural' degradation is catered for by manufacturers in their warranty conditions.

To ensure continued adherence to our warranty and to assess the general trends of panel degradation, REC carries out an annual degradation study of panels of different ages and from climates from real-world installations in order to track power loss over time.

The most recent study, completed in late 2013, showed that of the six sites, none were performing below expectations, even when maximum flash test tolerances were applied to the results. Table 2 shows the degradation spread for all panels tested.

Comparing these to the degradation permitted by the warranty, even the oldest sites showed a performance above expectations. This demonstration on real sites and across different climates is further confirmation of the quality of the design and manufacturing process at REC.

Table 2: Spread of degradation rates at six installations of REC worldwide (showing results spread - max. and min.)



POTENTIAL INDUCED DEGRADATION

What is Potential Induced Degradation?
Potential Induced Degradation (PID) is often considered as the most serious degradation threat to a solar plant today. Described in simple terms, PID is a drop in output caused by high voltage, high humidity and high temperature environments.

In a solar panel, voltage differences can occur between the frame and the solar cells, leading to the unwanted leakage of current. The industry journal Photon reported in December 2010[2], that leakage due to PID can result in losses of 20% or more. Any losses are exacerbated by hot and humid conditions – making PID a particular concern in tropical regions.

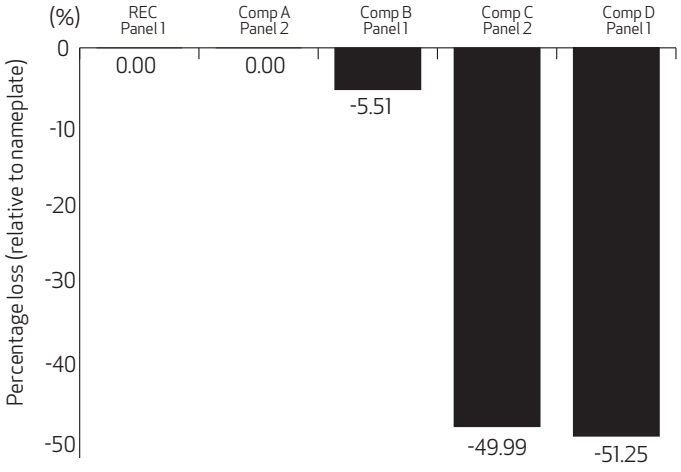
What effect does PID have on a solar installation?
As per Photon, the occurrence of PID can lead to a drastic reduction in system performance – even early on in a panel's life. The extent of PID is very much location and climate dependent but if severe enough will drag performance below expected returns and create a large mismatch in power across the system. This mismatch will cause further losses as time continues as the system requires uniform characteristics to optimize output.

Although PID is preventable by negatively grounding the installation, this practice is not always common as it increases system cost. However, over time the occurrence of PID in an installation can lead to irreparable damage of the affected cells and therefore an irretrievable reduction in the power generation of the system.

How does the effect of PID compare between manufacturers?
Any look through industry magazines will see advertisements for PID-free panels from many different manufacturers. However, upon closer investigation, some of these claims are only valid for a select range of products, which are often sold at a higher premium or allocated to specific regions, meaning customers can rarely be sure whether their panel is PID-free or not.

As an extension to the LID test above, SERIS subsequently performed an analysis of panel performance under PID inducive conditions. For this study SERIS used the IEC/NREL PID test protocol. Subjecting all panels to 96 hours at 60°C and 85% humidity with a negative voltage of -1000 V, the results showed that REC panels remained unaffected by PID, whereas the majority of the competition were affected, with some even seeing a drop in output of around 50%!

Table 1: The Potential Induced Degradation of REC and competitive panels seen in tests performed by SERIS



What is REC doing to reduce the effect of PID on its panels?
As the above results show, REC works hard to ensure its panels are PID-free. Through much research and development, REC has succeeded in introducing unique treatments at cell and panel level which protect against PID conditions.

These unique solutions for PID ensure that a measurable and sustainable advantage is provided to customers, giving consistent energy yield in all climates. The use of such technology is further confirmation of REC's quality and the consistency at which REC can reproduce this at its manufacturing facilities.

When it comes to panels that use cells from external suppliers, REC's thorough expertise in cell production allows us to select only the most suitable cells and work with suppliers to achieve the same level of quality as with REC-produced cells. Once again, these cells are subject to the same stringent qualification criteria and manufacturing processes at panel level as additional mitigation actions which ensure that they prevent PID.

What assurance does REC give customers that its panels are free from PID?
REC ensures the same treatment is given to 100% of its production, meaning that every single REC panel is capable of withstanding the PID test protocol mentioned above, no matter where it is installed. As the test results clearly show, such claims are not always true of the competition.

CONCLUSION

In general, degradation is a natural process and all solar panels will degrade in performance over time. The rate of degradation is dependent on the panel materials and processing conditions. As a leading manufacturer of solar panels, REC takes utmost care to keep its manufacturing processes under control and quality assure all components before they are introduced into a panel.

Through the testing and analysis of panel performance, we see results that show REC's outstanding performance against different types of degradation. While annual studies show year on year rates well above expectations, independent performance tests confirm that REC offers better peace of mind than the competition.

Where some manufacturers advertise with eye-catching slogans without it applying across the product range; with REC, there are no hidden catches, simply a guarantee that every single panel and its components passes the same testing standards and goes through the same automated production procedure. This reinforces the results from the SERIS tests and shows that when investing in solar and assessing different types of degradation on a system, REC remains the safest choice.

What can I do to protect my solar panels from degradation?
There are a few minor things that system owners can do to ensure their installation is protected as much as possible from degradation and ensure maximum performance:

- Mishandling during installation can lead to increased and accelerated degradation. During installation, installers must ensure that the panels do not suffer any damage, e.g.: scratches on the rear of the panel and by properly routing cables and connectors.
- Regular maintenance and cleaning is important. For further information on cleaning REC panels, see our Guide to Panel Cleaning, available to download from the REC website.

These simple steps will not be able to prevent all degradation, but will help to minimize the effects and create the best conditions for long-lasting and high performance energy production.

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