Warranty claims management from an IE perspective

Warranties | PV module manufacturers, O&M companies, owners, insurance companies and financial stakeholders employ independent engineers (IEs) to conduct plant surveys at critical milestones, such as impending plant warranty expiration (e.g. EPC warranty), or on a periodic basis. The result of the plant survey is a status report that identifies improvement potential and, in the case of specific failures or failure indicators, their corresponding root causes. Mitigating actions are mediated by the IE with all the involved stakeholders. Bill Shisler and Matthias Heinze of TUV Rheinland describe a procedure and a sample case for identifying and investigating the performance and possible safety shortcomings of PV modules, triggered by an impending asset sale

Warranties and insurance policies provide cover for various aspects of a PV system's components and life cycle. Warranties must be managed to ensure that plants are built with the specified performance and that production targets are met during operation, as well as to ensure that the system is safe under normal operation. A PV power plant consists of many elements and components, and while all contribute to production, their relative importance varies. Inverter and module warranties are the most critical, with terms ranging from 7 to 10 years for inverters, and from 20 to 25 years for modules (typical). Although inverters have shorter warranties, they often have self-reporting features that enable the operator to apply specific scheduled and unscheduled maintenance procedures. PV module power, on the other hand, generally has initial out-of-the box degradation, then begins a slower, less noticeable, descent from the moment of installation until the end of system life. Dramatic failures of PV modules are typically found during installation, but material degradation can become a reliability issue over time.

Warranty terms set the trigger mechanism, i.e. when the warranty is invoked. Thus a proper warranty contract is essential in asserting the asset value and risk. In addition to covering manufacturer defects that result in total loss of performance or in safety issues, it is essential that warranties and insurance policies be analysed for early detection of 'degradation beyond specification' resolution. PV module warranties often fall into two categories – workmanship and performance. Workmanship includes such aspects as modules being clear of defects and material issues resulting from manufacturing mistakes, material wear-out, or glass cracks not resulting from impact within typically 5 or 10 years. Power output guarantees are often listed as 90% power at 10 years or 80% power at 25 years from the date of purchase – each based on the lower tolerance limits of the module's rated nameplate power, or on more-specific terms of the contract. In the example project discussed in this paper, the guarantees given for the PV modules were five years for materials and workmanship, 90% power at 10 years and 80% power at 25 years.

"A proper warranty contract is essential in asserting the asset value and risk"

A warranty assessment model was developed by TUV Rheinland, on the basis of research performed at Arizona State University, and modified for practical use on large-scale utility-grade power plants [1]. The plant in the example project was commissioned 5 years ago. It had not been certified by an accredited IE, and DC-side health had not been properly established

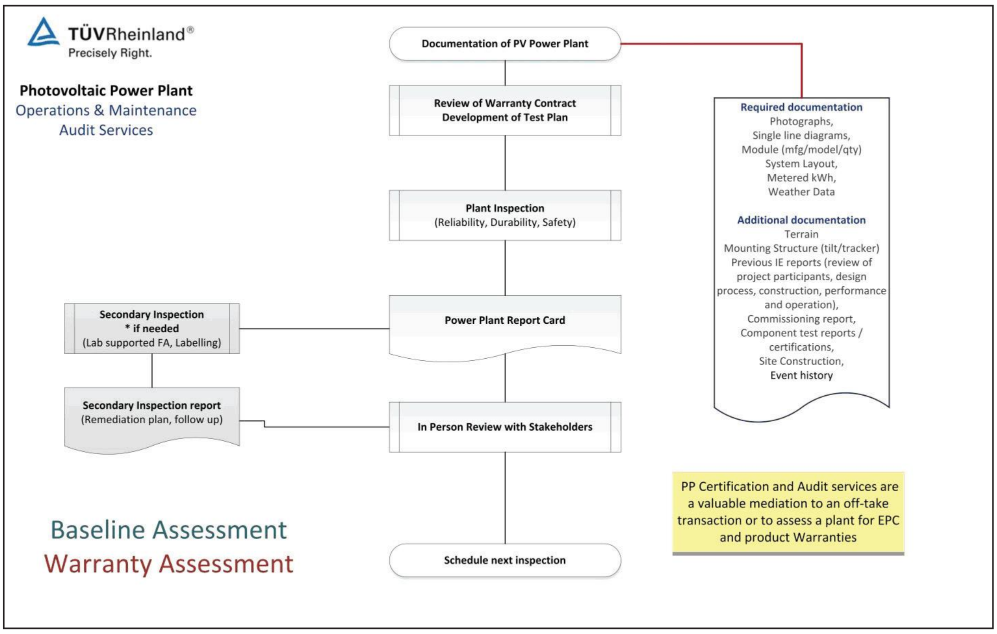

Figure 1. Baseline assessment and review of existing documentation.

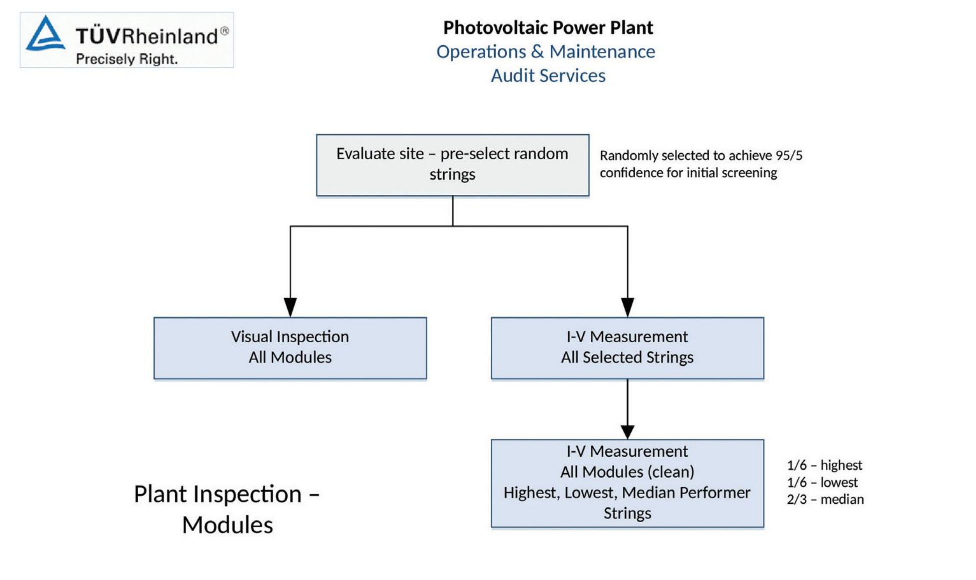

Figure 2. Screening evaluation for warranty claims.

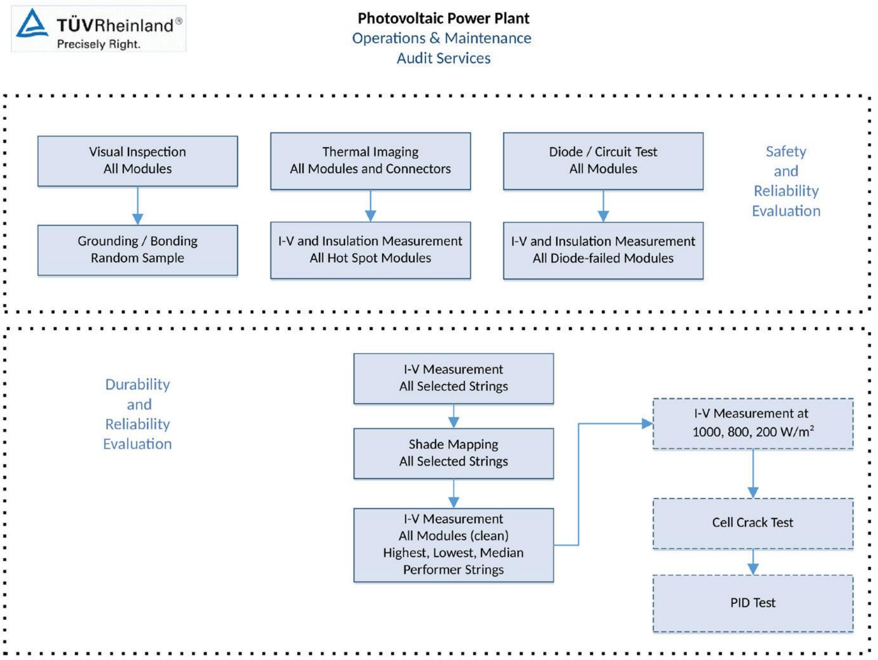

Figure 3. Detailed chart of the resulting audit.

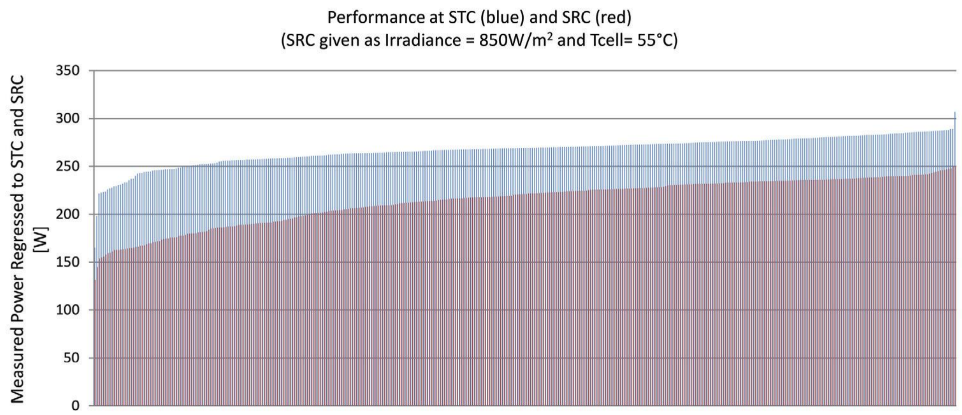

Figure 4. Translation of SRC into STC.

at Year 0 or Year 1, so a baseline assessment and review of the existing documentation had to be conducted (see Fig. 1).

Plant production guarantees are associated with utility metered AC performance. For older systems, monitoring systems do not always include the monitoring of detailed DC performance. Even if historical DC data were available, these would still only represent one-third of the relevant information necessary for determining PV module health with respect to warranty – the other information would have to be obtained through physical inspection (visual and infrared) and selective *I–V* curve traces.

In this example, a 95% statistical confidence level is utilised for performance, and a visual inspection was performed at a 100% level – even if this meant a large initial effort for the plant (see Fig. 2). Note that one-sixth of the modules must come from PV strings in the bottom one-sixth of distribution, one-sixth of the modules must come from strings in the top one-sixth of distribution, and two-thirds of the modules must come from strings in the middle two-thirds of distribution.

"The temperature coefficients of modules change over time, which means that they must be re-evaluated periodically"

A detailed chart of the resulting audit is given in Fig. 3.

When complete original DC-side health data is not available, assumptions must be made in favour of the module supplier in terms of original performance versus current performance (i.e. degradation rate). The lower tolerance limit of the nameplate, along with the negative side measurement tolerance from the IE, was assumed at the plant's commissioning. For the sake of convenience, a 100W ±5% nominally rated module is used as the example:

100W nominal

– 5% (nameplate lower limit)

– 2.5% (measurement tolerance)

= 92.5W assumed baseline power

Although PV modules typically do not operate anywhere near the standard test condition (STC) of 25°C cell temperature when the solar irradiance is 1,000W/m², as identified on the product nameplate and datasheet, the performance guarantees are nevertheless associated with these values. This means that IEs might choose to remove several modules from the field and send them back to the lab, or use an expensive flash tester on site. Each of these options has its own issues: flashers do not present the true solar spectrum and operating condition of the modules, and shipping presents a risk of breakage. Neither of these options is necessary, however, if proper control and high-precision instruments are used for taking measurements of the PV modules – even when the modules are still operating on the mounting racks or trackers.

An assessment of the actual operating DC power of the PV modules is essential in order to understand the performance over time on the basis of site conditions, and ASTM E 2939 methods provide guidance on determining the expected capacity of a site in terms of reporting conditions (RC). Reporting conditions for a site are dictated by the local geographical environment, and consist of total global irradiance, ambient temperature and wind speeds at the site.

TUV Rheinland has taken the same approach for the characterisation of PV modules, the major difference being that the site reporting conditions (SRC) use module cell temperature instead of local ambient air temperature. The SRC can then also easily be translated into STC for comparison with the nameplate ratings (see Fig. 4), and is a useful tool for understanding the degradation of the modules as they age in actual operation.

The temperature coefficients of modules change over time, which means that they must be re-evaluated periodically in order to properly regress the sample population to the STC warranty rating. In this case a limited set of modules across the sample distribution must be evaluated for coefficients, so that the new values can be applied in the assessment. A few modules were therefore removed and taken back to the lab in order to work out the proper temperature coefficients, though far fewer modules are needed for this than for performance measurement. (It is understood that some technologies have seasonal behaviour, so it is important to schedule the periodic assessments at the same time of year for a given power plant.)

PV modules are also sensitive to the

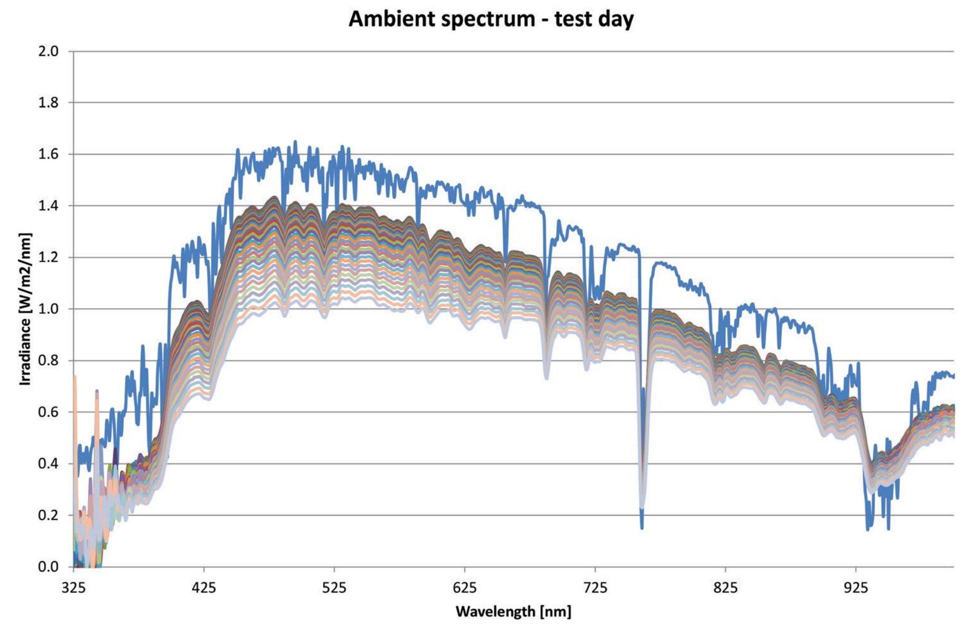

Figure 5. Measured spectrum vs. the spectrum in the ASTM standard.

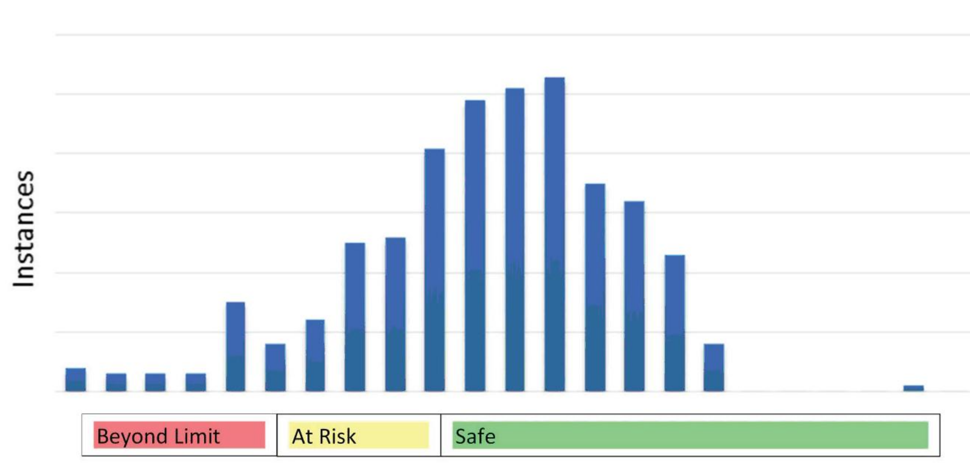

Figure 6. Deviation from the nameplate lower limit after five years of operation.

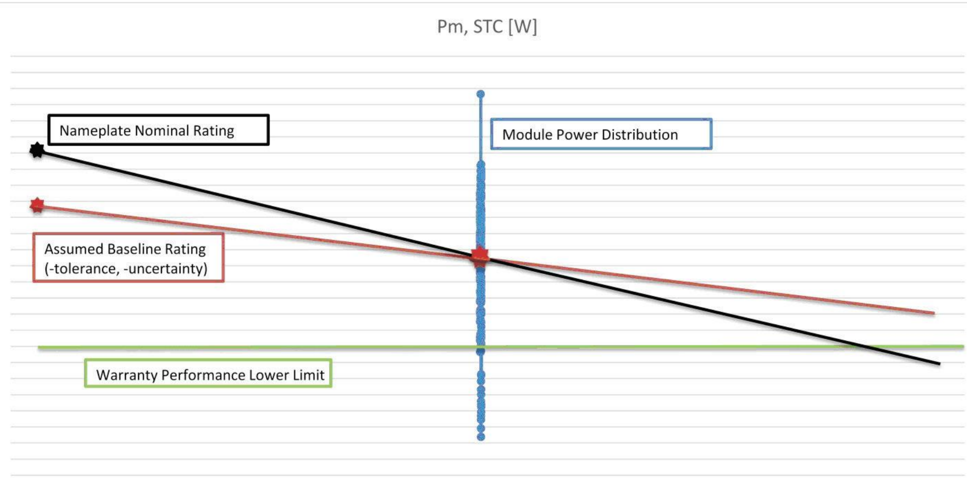

Figure 7. The challenge to commonly held assumptions.

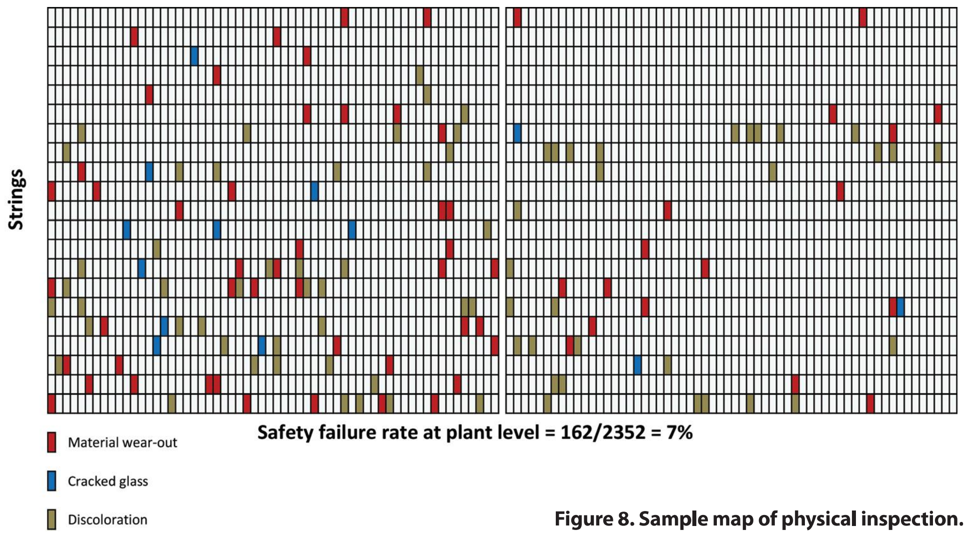

Figure 8. Sample map of physical inspection.

solar spectrum. Fig. 5 shows the measured spectrum versus the spectrum described in the ASTM standard. The coloured lines represent measurements at different times of the test day. Because it was a clear sky day – verified through spectral measurement – the amplitude of the current could be corrected by means of the corrected irradiance via a direct relationship.

Measurements in this example were taken and regressed to STC. All tolerances were calculated in the manufacturer's favour. A summary of the result (corrected to STC and taking into consideration all measurement tolerances) is given in Fig. 6.

The measurements conducted in the field and in the laboratory resulted in a linear regression of degradation that fell outside the extrapolated tolerance limit. The paradox here is that initial measurements (at commissioning) would have shown higher than planned production on the DC side, as opposed to the assumed lower limits. The inverters also clipped at the upper performance end (the AC performance would therefore remain stable for several years, even as the modules continually degrade).

Fig. 7 illustrates the challenge to commonly held assumptions. Whereas the red line shows the expected degradation at the lower limit as specified, and the green line shows the absolute design life limit, the black line represents a linear regression without warranty remediation. The difference is the understanding of when the modules are projected to fall below the warranty limit. The actual projection might be at a higher negative slope than the assumed rate. And even more likely, the module degradation during the first year was probably higher and has levelled off since. With two or three data points by this time (at commissioning, at the 1-year anniversary and after 5 years) the owner of the power plant can properly evaluate the DC health, better employ O&M and prepare for contingencies with the supplier.

Power output guarantees represent one-half of the warranty assessment. The safety and reliability evaluation means that additional modules might be identified as 'critical' candidates for warranty replacement. The overlapping of those modules identified as critical during inspection and measurement means that the total is not simply the sum of the two processes, although the two issues are compounded. The sample map of physical inspection is presented in Fig. 8; the different colours here represent different criticalities of defect.

In the example project, the nominal loss as a result of module degradation and safety/inspection failures amounted to more than 5% of production as of the day of measurement. The cumulative loss without correction (i.e. warranty invoked) for a plant of more than 40MW could be in double digits of millions of US$ over the plant life.

Summary

The determination of root cause required careful statistical analysis and then a combination of in-lab and on-site experiments by the global science team. The result for the plant owner is the recovery of long-term performance by having the IE mediating the warranty terms and module issues with the EPC and manufacturer. One would also surmise that better due diligence would have detected any issues much earlier. It is advisable that O&M utilise qualified IE audits at key milestones, to ensure forward-looking asset performance. Related to the root cause analysis for this sample project, specific detection procedures were designed and recommendations given for preventing recurrence in future plants. ■

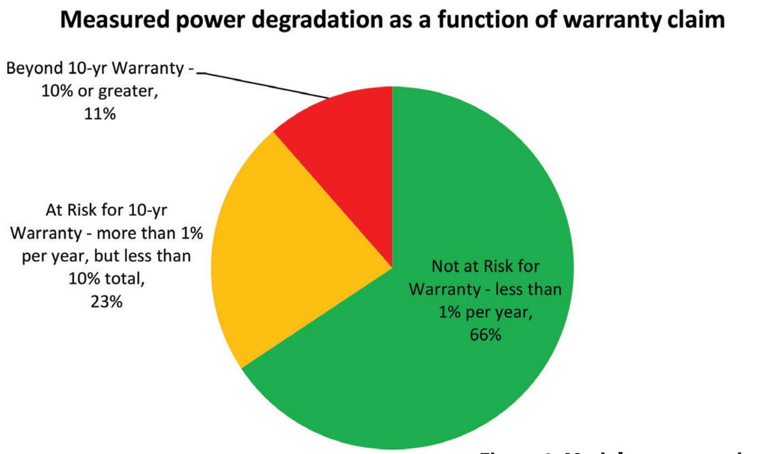

Figure 9. Module report card.

Authors

Bill Shisler is the business field manager of the Solar – North America division at TUV Rheinland PTL, based in Tempe, Arizona, USA.

Matthias Heinze is the director of business development of the Global Business Field Solar division of the TUV Rheinland Group.

Reference

[1] Tamizhmani, G. (ASU Photovolt. Rel. Lab.) 2014, "Reliability evaluation of PV power plants: Input data for warranty, bankability and energy estimation models", PV Mod. Rel. Worksh. 2014, Golden, Colorado, USA.