# Perspectives on risk mitigation measures for PV power plants: insurance and quality assurance

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**Risk |** In the previous issue of *PV Tech Power*, quality assurance was considered as a key measure in maximising PV power plant performance and ensuring safety. Building on this train of thought, Thomas Sauer and Georg Fischer from EXXERGY examine insurance as a risk mitigation measure, based on analysis of more than 3,600 insurance claim cases

When it comes to managing PV power plant risks, on the one side, quality assurance is a viable mitigation measure. However, even with quality assurance measures implemented, there are limitations when it comes to backstopping financial losses in the event that the performance deteriorates more than predicted and warranted by the manufacturers, or if at the time of incidental power degradation beyond calculated limits, the manufacturers or EPCs are no longer in business.

In such instances, insurance solutions seem to provide an additional risk mitigation measure. Most insurance solutions on the market, however, cover only against externally induced risk exposures, e. g. severe weather, theft. Most of these insurance solutions follow a certain minimum standard. A few insurance products offer performance insurances where general cover is less standardised. All this triggers the question of how to look at insurance solutions. The interests of an insurance company are generally different than those of the insured stakeholders.

This article will consider these different viewpoints and discuss selected warranty and insurance aspects. Recently, more than 3,600 insurance claim cases have been statistically analysed. Selected results of this analysis will be discussed. The article closes with an outlook of how insurances can likewise mitigate their risk exposure – at last, insurances are just as good as the balance of the solvency resulting from their business model, or in the terminology of the insurance sector, the loss ratio must be at an acceptable level.

## General thoughts on risk mitigation measures

In a recent article published in PV Tech Power [1], failure assessments of actual PV systems were discussed in detail. There are various factors explaining why a PV power plant can underperform or completely fail for technical reasons. Besides the technical effects, most importantly, underperformance of a PV power plant negatively influences the equity side in the very first place. Hence, the investors are first in the queue to suffer financially from underperforming assets. In some cases, technical performance deteriorations are so severe that even the debt side of the financing scheme is negatively affected to the extent that the redemption of the loan and part of the interest payment can no longer be serviced. As a result of such a situation, the bank typically holds a strong position to exploit the asset if taking recourse from the senior lender is not an option. When it comes to performance deterioration, the main questions are whether the quality assurance measures – if any – have been sufficient and, more importantly, whether the gap between planned performance and current performance are covered, either by any warranty claim or by an insurance wrap that can legitimately be expected to cover most part of the financial consequences resulting from underperformance.

**Lightning is just one of a range of risks for which PV plant owners may use insurance to safeguard against financial losses**

Insurances differentiate greatly between externally and internally induced damages that cause underperformance or other losses. Externally induced damages are related to events that are not caused by the PV power plant itself, examples are damages resulting from severe weather conditions (e. g. hail, thunderstrikes, storm), natural disasters (e. g. earthquakes) or from unexpected human intervention (e. g. theft). Internally induced damages are related to events that are caused by defects resulting from insufficiencies during component manufacturing, PV power plant design, construction, and/or operation.

Regardless, in the given damage event, the key question remains whether compensation for performance losses can be claimed or not.

## Risk mitigation I: Considerations on quality assurance measures

As part of an overall PV power plant project due diligence, the financial sector currently bases its investment decisions, lending commitments etc. on technical assessment reports. These assessment reports also outline all measures that have been taken during the project execution to assure the quality of the end product. Up to now, no encompassing international standards existed, neither when it comes to the quality assurance nor to the assessment report itself. Depending on the assessor, these reports vary significantly in terms of thoroughness, accurateness, completeness, reliability, validity, transparency etc.

Two important consequences derive from this situation. (1) The quality assurance measures may or may not be sufficient to ensure that the planned performance will actually materialise throughout the planning horizon of typically 20 and more years. Especially when it comes to the re-sale of the asset in the secondary market, the originally applied quality measures are an important factor for the fungibility of an asset as available documentation may be partly missing. (2) The diversity of technical assessment reports (lacking any standards) results in a high workload on the receiving side (e.g. banks), and more importantly, in uncertainties evaluating the true risk exposure of a PV power plant project.

Other aspects indirectly related to quality assurance are: (1) The lack of consistency of tenders among government bodies and other institutions inviting to participate in tenders – oftentimes, the quality requirements per se as well as the quality assurance measures are not precisely specified; and (2) the untapped potential of optimised PV power plant performance resulting from inaccurate work results.

This status quo motivated the member bodies of the International Electrotechnical Commission (IEC) to create an **IEC** conformity assessment system for certification to standards relating to equipment for use in **R**enewable **E**nergy applications, in brief, IECRE. While for wind, first projects have already been certified, the IECRE certification system for PV power plants is on the verge of entering the market. With the adoption of the IECRE certification system, quality assurance is given a common platform, a minimum standard, to enable fair and efficient competition. These minimum standards are supplemented by IECRE plans to develop a technical rating system for PV power plants. This rating system will be essential to enable financial stakeholders to get a nuanced picture of the quality of a PV power plant beyond minimum requirements, a complimentary grading system similar to those common in the financial realm. The IECRE will soon publish the first draft documents outlining scope and intend.

## Risk mitigation II: Insurance solutions

In the context of analysing insurance claim cases, various insurance solutions related to PV power plants have been looked at to understand which insurances have an immediate relation to quality requirements. Initially, the identified insurance solutions have been systemised in two ways, (1) by phases in the lifecycle and (2) by purpose.

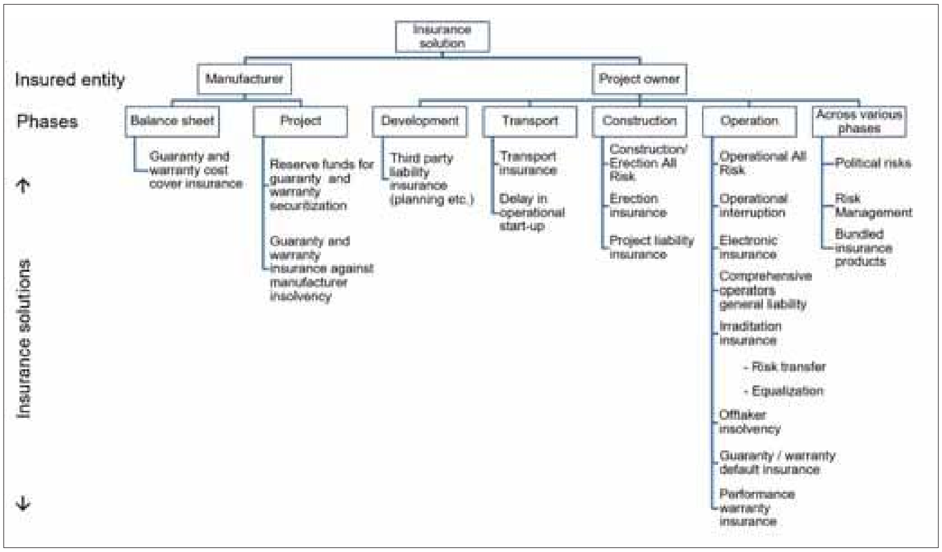

Figure 1. Systematisation of insurance solutions by lifecycle phases

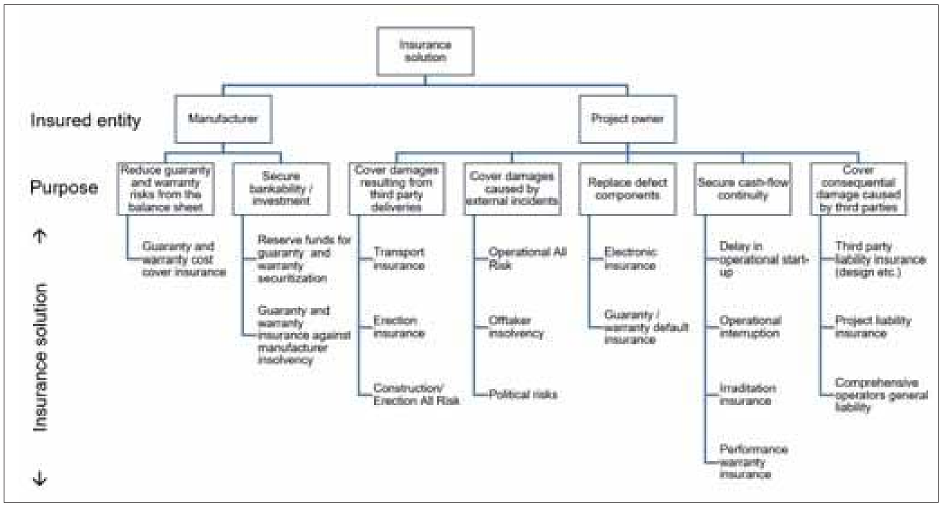

Figure 2. Systematisation of insurance solutions by purpose

### Insurance solutions by risks and phases (insurer's point of view)

Figure 1 illustrates the systematisation of insurance solutions by lifecycle phase on the horizontal axis and the attributed insurance solution on the vertical axis. This system may serve as the reflection of the natural interest of the insurance company.

### Insurance solutions by business risks and insurance purposes (operators point of view)

Figure 2 illustrates the systematisation of insurance solutions by purpose on the horizontal axis and again the attributed insurance solutions on the vertical axis. This system may serve as reflection of the natural interest of the insured entity.

## Considerations on selected warranty insurance aspects

Insurers who cover the risk of inherent technical defects and their economic consequences should most likely have an interest in good quality assurance. This is especially applicable for insurers offering performance warranty insurance solutions. Generally, two models are supposedly available on the market to secure a minimum yield of a PV power plant:

- Component manufacturer related: the insurance covers the manufacturer's warranty services (e. g. replacement of inherently defective components) in the event of the insured manufacturer's insolvency. Some insurance solutions offer as well a warranty cover for the event that the manufacturer rejects the warranty service or disputes the obligation to perform in whole or in part (warranty failure insurance). The warranty failure insurance typically compensates the (re-) purchase value or the book value of the defect components plus in some instances the replacement costs and/or loss of revenue.
- Project related: depending on the scope of the insurance, (partial) compensation for losses can be covered, such losses deriving either from technical issues (e. g. excessive performance degradation) or from radiation-related losses. . The performance warranty insurance typically compensates for an inferior energy yield caused by inherent module defects. The trigger for the insurance to become liable varies. As an example, manufacturer insolvency and an inherent defect-related performance shortfall of at least 10% are basic triggers. In addition, a maximum limit of cover is typically provided. The cover payout can be provided in cash (loss of revenue) or in kind (replacement of defect components) or by a combination of both.

Regardless of the insurance solution, it is important to understand the limitations, exclusions or pre-requisites to be met as well as other relevant insurance terms and conditions in detail. These details are relevant for the assessment of the actual effectiveness of this risk mitigation tool and hence, viably concluding whether a tangible risk transfer is taking place in the perceived insured event.

## Insurance claim cases – selected insights

A study of analysing the root causes of insurance claim cases has been conducted. Four of 13 invited insurance companies have responded to an inquiry providing information and data related to claim cases. As a result, 3,666 insurance claim cases have been analyzed in this study, all of which were occurring in the northern hemisphere at latitudes north of 35°. The following outlines an excerpt of a much more detailed study.

The insurance claim records date from the time span between January 2012 and June 2017 so that a history of 5.5 years of insurance claim cases was covered in the study. First commercial operation dates of the PV power plants in the study ranged from 1997 until 2017 offering a time span of up to 20 operational years. However, because of the very limited number of claim cases related to PV power plants having a service life of more than 13 years, only claim cases with maximum 13 years of service lifetime have been analysed in greater detail. The average amount of loss was 2.6% of the investment, or €26 (US$30.7) per €1,000 investment.

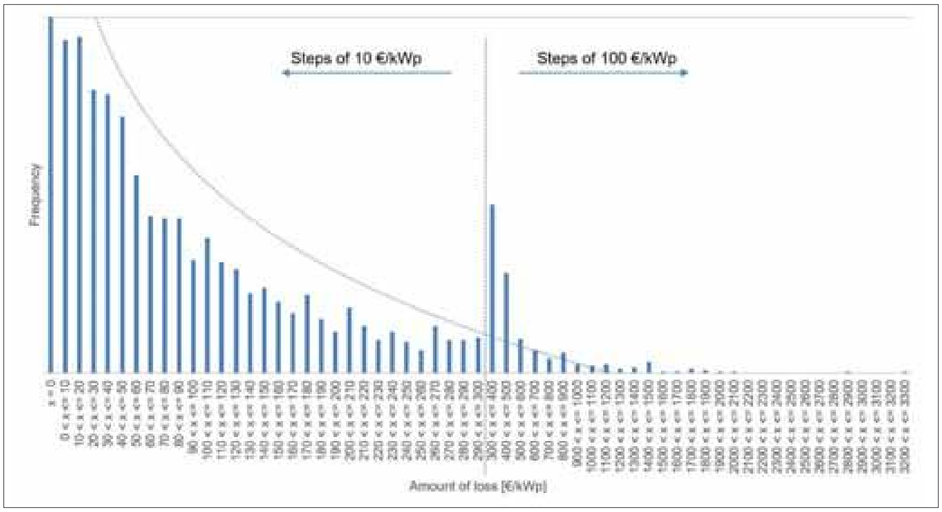

**Figure 3. Distribution of amount of loss classification**

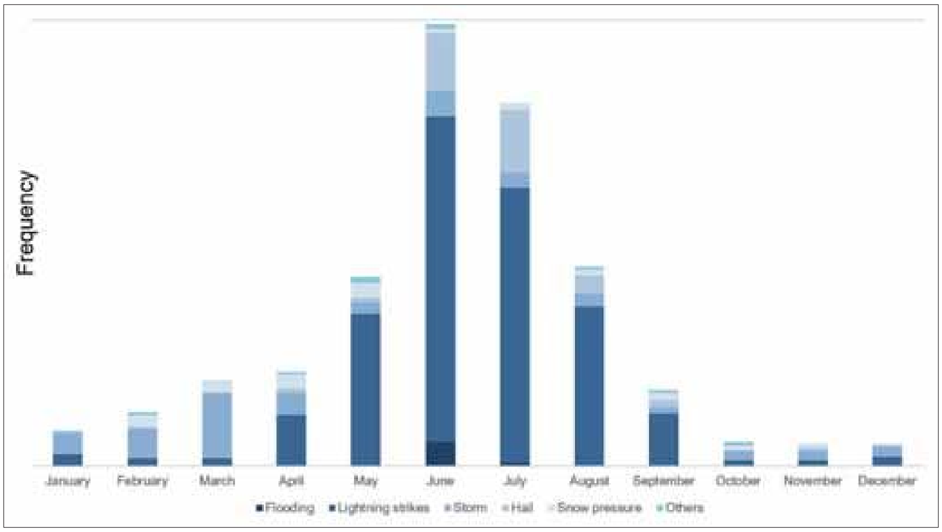

**Figure 4. Frequency of weather related causes of damage across seasons**

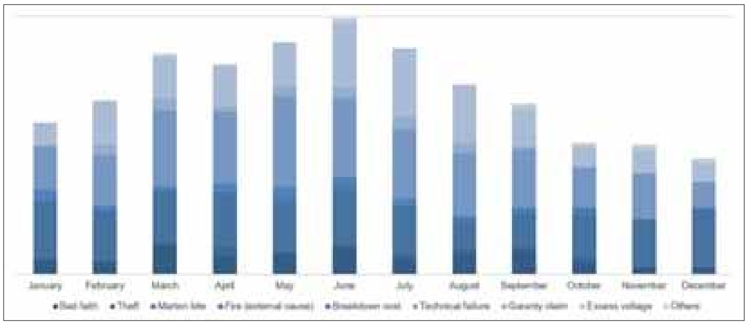

Figure 5. Frequency of weather-unrelated damage causes across seasons

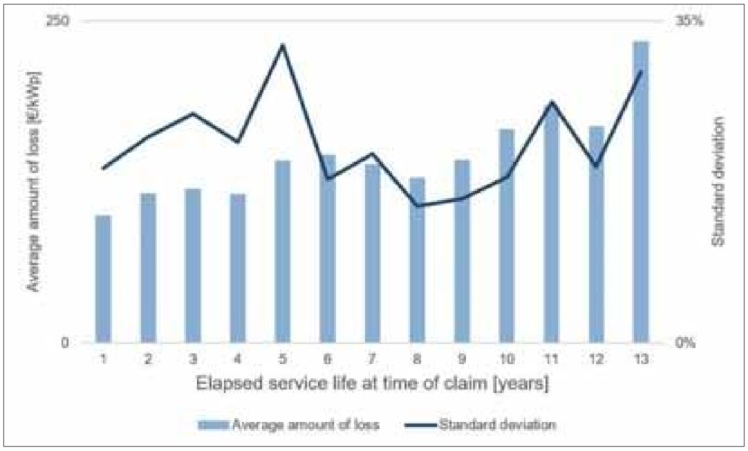

Figure 6. Average amount of loss as a function of service life (all analysed claim cases)

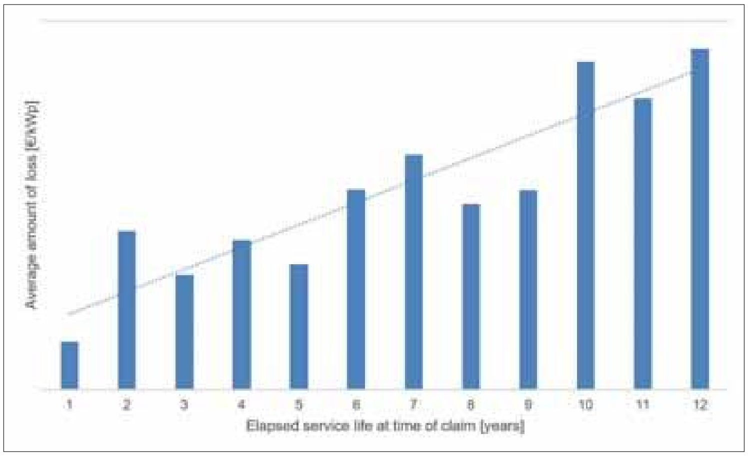

Figure 7. Average amount of loss as a function of service life (internal defects)

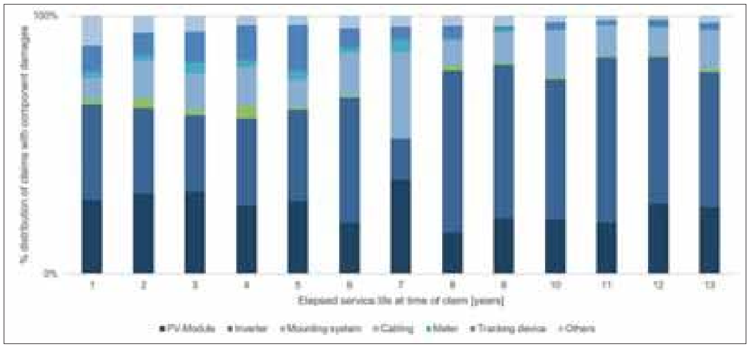

Figure 8. Damaged components in % of all damages as a function of service life

The spread, however, is significant with a peak value of more than 110% relative to investment (>€1,100 per €1,000 investment). Looking at the relation of damage to nameplate power, the maximum damage was €3,250/kWp installed capacity. Note that the maximum numbers originate from different claim cases. Not surprisingly, for neither relation, neither for the damage amount versus investment nor for the damage amount versus the installed capacity, could a linear correlation be drawn. The decline in frequency of claimed damages over the amount of loss nearly follows a logarithmic relationship: damage cases with high amounts of loss are rare whereas minor damage cases occur more frequently. Figure 3 shows the frequency of damage claim cases as a distribution of the amount of loss data in €/kWp for those approximately 3,600 claim cases for which the amount of loss data has been available.

Going into more detail of the analysis, 24% of the insurance claim cases could not be analysed by IT tools in terms of root cause analysis since the information available did not contain a taxonomy that could be IT evaluable with reasonable effort. Nearly 3% of the insurance claim cases had multiple causes, and because of the relatively small relevance will not be discussed here in further detail. Some 6.7% of the claim cases neither had a time stamp for the time of incident nor for the time of claim. Including cases with no time stamp (2,676 = 73% of all cases), 20% have been caused by internal defects, 65% by external causes. Nearly 12% have been caused by excess voltage excluding lightning strikes. The analysis was inconclusive as to whether cases of excess voltage without proven lightning strikes have been caused by lightning strikes or by internal defects or by grid instabilities. The remaining 3% of the claim cases have been caused by other causes that are not reviewed in more detail.

Analysing insurance claim cases that are caused by weather phenomena, the frequency of damages increase significantly in the months of May through August showing a significant peak in June (see figure 4). This can commonly be explained by increased occurrence of convective weather activity and the resulting thunderstorms during the summer time.

Other causes of damages, outlined in figure 5, show that the distribution across seasons is more spread out, with excess voltage showing a significant increase in the summer months. This phenomenon can be attributed to the fact that records were inconclusive as to whether the excess voltage came from the grid (cause may be lightning strikes as well) or from the system. Remarkable is the relatively high percentage of technical failures that can be attributed largely to internal defects of the system.

This conclusion leads to analysing the amounts of loss propagation over the service life of a PV power plant. A view on Figure 6 clearly evidences that, while standard deviation varies between 14.8% and 32.5%, the average amount of loss significantly increases with service lifetime of a PV power plant.

This conclusion is even more evident when damages resulting from internal defects are analysed. The trend is clear with average amounts of loss for damages from internal defects being in the same range as the overall average amount of loss across all damage causes.

Analysing the breakdown of components affected, as outlined in Figure 8, reveals that inverters and modules are the most prominent to be affected by damages, another significantly affected component is the cabling.

Looking into more detail related to the main damage causes by component (as far as specified), the following results have been elaborated:

- For modules in particular, external causes for damage were found to be malevolence as the most frequent cause (21.6%), followed by storm (18.6%), and hail (16.9%) while as an internal defect cause, technical failures account for a remarkable 18.4% of all cases.
- For inverters in particular, overvoltage is the most frequent cause of damage (60.8%), 30.5% of which have not been associated to lightning strikes. Technical failures accounted for 31.9% of all specified damages.
- 80.9% of all cabling damage results from marten bites.
- 93.4% of damage to communication equipment results from overvoltage, 20.6% of which has not been caused by lightning strikes. For damage cases to AC protective devices, the relative shares are 58.9% and 63.6%, respectively.

Regarding the documentation of insurance claim cases, the effort of documentation increases with the amount of loss. The mostly used documentation classifications are (%-numbers relative to the total number of claim cases n = 3,666):

- Evidence of insurance policy (98%)
- Insurance claim report (71%)
- Quotation/invoice (44%)
- Photography (28%)
- Severe weather reports (18%)

Other documentation includes expert opinions, particularly for cases with large amounts of loss. Naturally, the extent of documentation typically increases significantly with the average amount of damage. For amounts of more than €250/kWp, mostly five or more documentation classifications have been provided.

Finally, the correlation between component manufacturers and damages has been studied by analysing the quota of damage cases where devices have been affected by internal defects and by externally caused damages (where component quality had an influence on the damage) relative to the total volume components involved in damages by the respective manufacturer. Depending on the manufacturer, internal defects range from 0% to 90% for modules, and 25% to 100% for inverters. However, it is important to note that this analysis only allows a first insight as it is not statistically conclusive. Nevertheless, it is obvious that quality assurance measures in the past have seemingly been insufficient, or else such a high quota would not become evident.

## Concluding thoughts on risk mitigation and on PV power plant economics

While most insurance solutions covering externally caused defects are relatively well standardised, guarantee and performance warranty insurances vary significantly in terms of their concept and cover principles. Relevant factors to look at have already been discussed in [1].

Truly understanding and aligning the interests of the insurance with the interests of the investors is crucial going forward. This train of thought as well as the fact that 20% of all damage cases have been caused by internal defects trigger the authors' concluding remarks:

While having experienced an incredible dynamic growth over the last 20 years, the solar sector currently still represents only approximately 2% of worldwide annual electricity production. To push the energy transition to the next level, it is important to enable the PV sector to push the electricity share generated by PV power plants towards 20% and beyond. At least evenly important, it is of the essence to enhance the profitability for all stakeholders in the PV sector. The relatively low contribution to the electricity generation share means that the PV sector is yet far from maturing. Still today, deploying PV power plants goes along with relatively high soft costs for engineering, due diligence etc. At the same time, the race to reduce the levelised cost of electricity (LCOE) continues; the current benchmark is to deliver electricity from PV power for less than US$18/MWh. The only way to establish profitable business for all stakeholders at such levels of LCOE is to continue reducing costs. One important lever in this race to drive cost down is to establish standards that are valid across the industry, including quality assurance standards. Minimum standards are about to be published by IECRE, and a rating system is being developed helping to assess the risk exposure that goes along with a PV power plant investment in a more effective and uniform way.

The authors therefore recommend insurances (and financing institutions) to request a higher degree of quality assurance – ideally following internationally accepted standards - throughout the lifetime of the PV power plant, and investors to apply more diligence when it comes to quality assurance.

Finally, in mature markets, standardisation has proven to enlarge market potentials that would have been impossible to address without having established standards – for example the market penetration of IT or mobile telecommunication. ■

## References

[1] Sepanski, A., Hupach, U., Vaaßen, W., Schmauder, J., Steland, A., Sauer, T., Fischer, G. 2018, "Failure assessments of actual PV systems demonstrate the importance of elective quality assurance", PV-Tech Power February 2018, pp. 70 – 81.

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