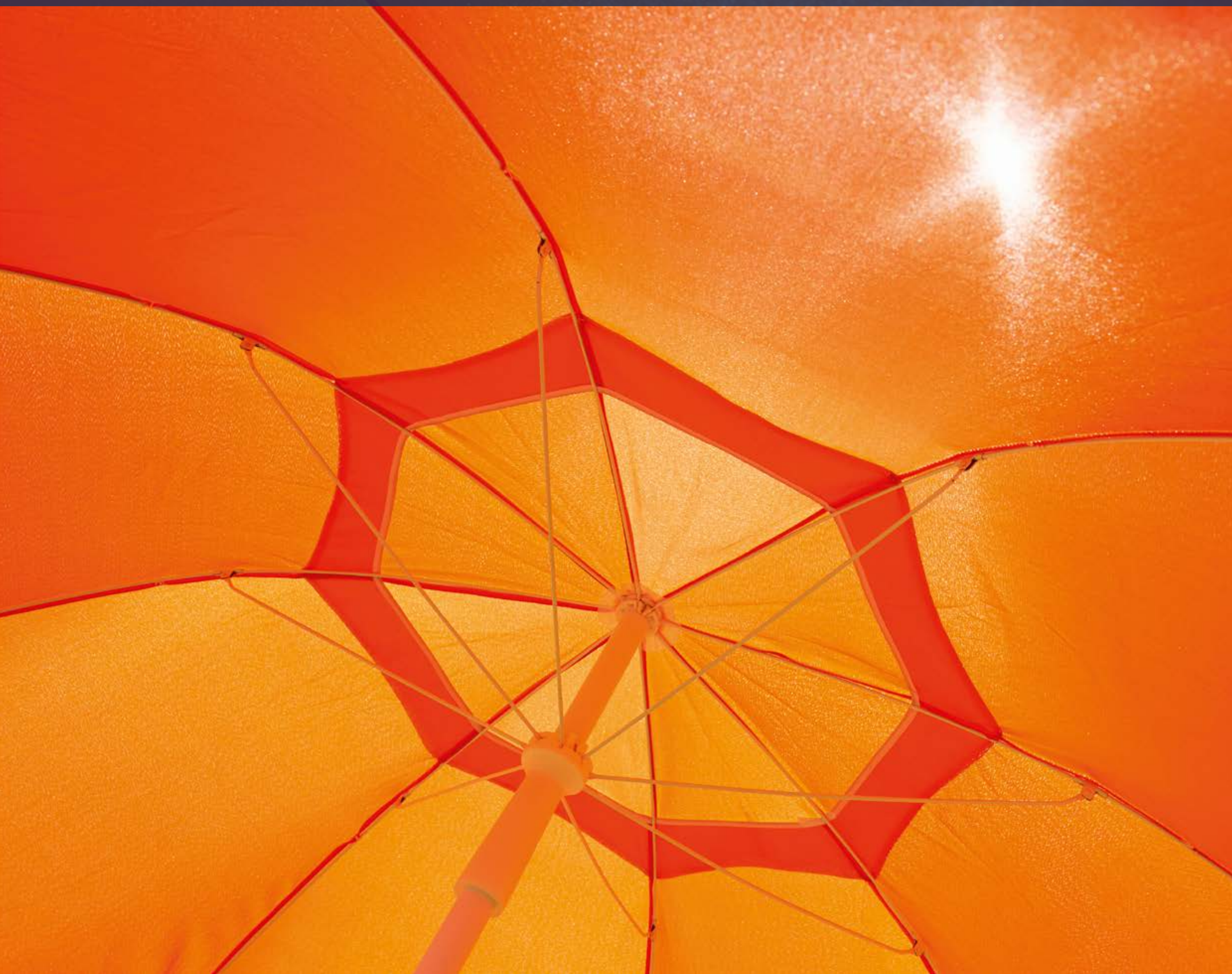
Whitepaper

How to safeguard the long-term profitability of solar PV investments with quality assurance and PV Warranty Insurance



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Outline

1 Introduction

To drive demand for photovoltaic (PV) investments, the market needs confidence that PV systems will operate safely, reliably and profitably for 30+ years under different climatic conditions around the world.

According to VDE Renewables and Munich Re, who have entered into a strategic partnership for the installation and operation of solar PV systems, this includes long-term performance guarantees with tailored insurance solutions. The aim of the partners is to strengthen the confidence of the banking, finance and insurance sectors in solar investments by creating new market standards for the bankability and insurability of PV modules and systems.

Along the entire value chain, experts have found that significant risks arise from PV module failures [Köntges2017] or system performance degradation if professional quality assurance is not carried out properly. Quality assurance measures cover due diligence and the manufacture of solar components through to strict factory monitoring. Through the continuous integration of inspection audits directly at the manufacturing level, we can reduce both technical and economic risks and create the basis for high-quality insurance solutions.

Over the last 25 years, market volatility in the PV market has led to a number of PV manufacturers going bankrupt and closing down, as a result of which warranties no longer apply [Greentech2015]. This left investors and plant owners to bear the full risk of panel failure or performance degradation, thereby jeopardising the long-term profitability of their investment.

What protection does the investor have in such cases? The VDE's factory insurance report ensures that potential problems, such as PV module failures, can be identified and rectified at an early stage. But for PID degradation of PV modules [Hacke2018], a relatively common problem, PID tests in the initial phase may not expose the potential leakage currents that can occur under certain manufacturing processes and typically only after a few years of operation. In this paper, we show the potential impact of PID degradation of PV modules after four years of operation on the financial performance of a large PV power plant and the resulting costs and revenue losses. The detailed calculations show the investor how the PV Warranty Insurance can mitigate the financial risks and losses for the buyer and secure the targeted return on investment.

2 Significant risks without quality assurance

A shortfall of just a few per cent in the performance of a PV system can significantly reduce the investor's return, whereas it normally has no effect on a participating lender. For this reason, the investor should pay very close attention to the quality assurance of the PV components. Due to the technical, economic and legal complexity of large PV power plant projects, competent prime contractors are essential to ensure the profitability of the plant. They must smoothly coordinate the interaction between the various suppliers and participants. As a counterpart to the main contractor, the investor should appoint a third party to provide independent quality assurance over all phases of the project, ranging from development, engineering, procurement and construction through to operation.

Independent quality assurance is required to avert risks arising from the enormous cost pressures along the entire PV value chain. PV module test certificates that meet international standards represent a basic qualification. To further reduce performance risks, extended type testing and continuous conformity monitoring in production are strongly recommended. For large batches of PV modules delivered to PV projects, the purchaser should test and ensure the quality of representative samples.

The expert group IEA PVPS Task 13 collects failure data of PV components in the field and analyses their impact on power loss and safety. It has also classified failures according to the climate zone of the installed PV system [Köntges2017].

Figure 1: Failure frequency for PV module defects affecting system performance. The upper graph shows the failure frequency of PV modules with slow degradation over time and the lower graph shows the failure frequency for sudden events [Köntges2017].

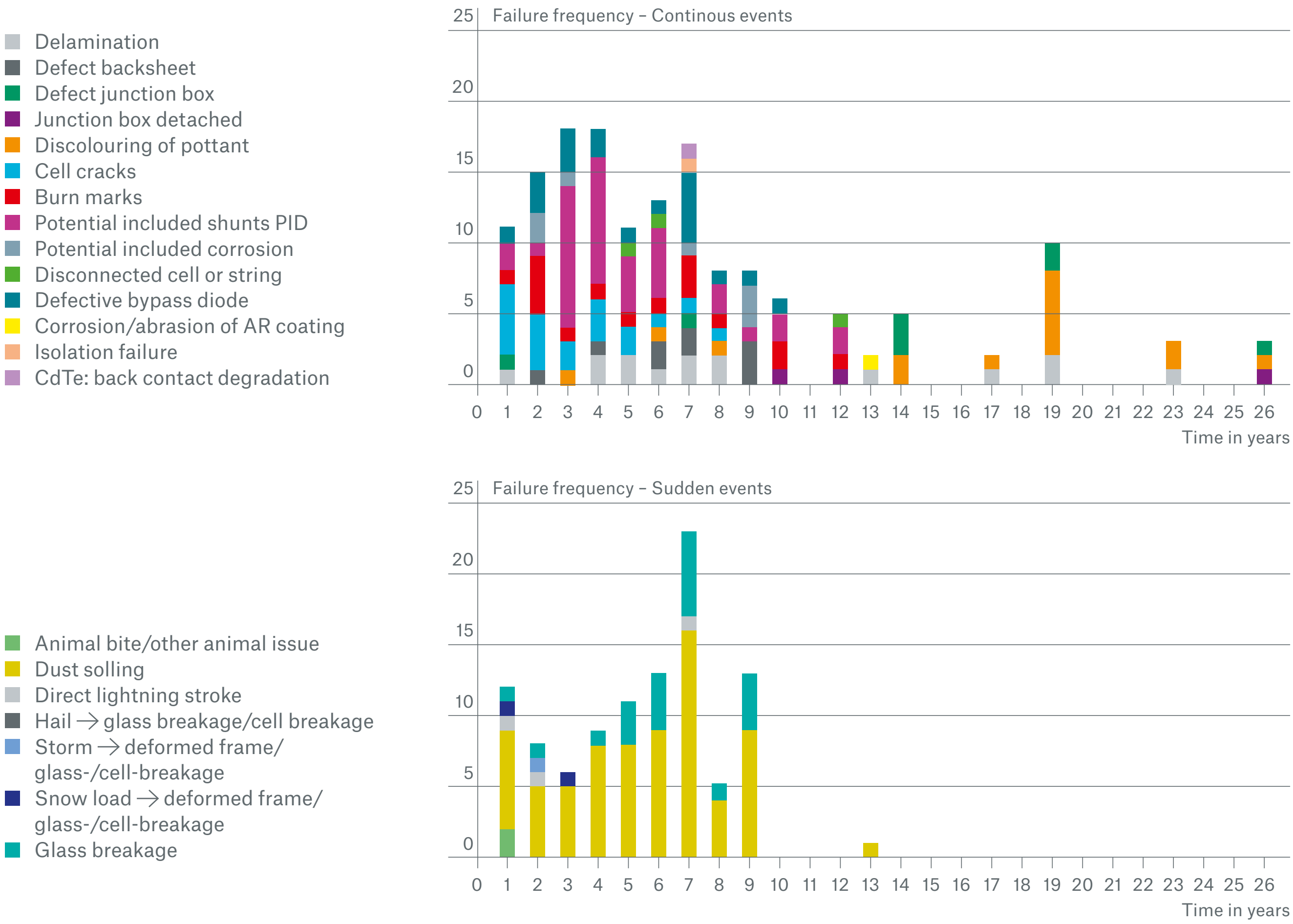

Figure 1 shows the frequency distribution for PV module failures that affect the electricity generation of PV systems. The distribution is divided into failures leading to degradation and sudden failures. Most power loss failures are reported in the first 10 years of operation. This is to be expected, as it is often too expensive to repair PV systems that are older than 10 years. As a result, no detailed analysis is carried out. The report “Assessment of Photovoltaic Module Failures in the Field” concluded that potential induced degradation (PID) effects, cell cracks and defective bypass diodes seemed to dominate failure statistics in the first seven years. In addition, the failure type “burn marks” was detected more frequently. In the sudden events shown in Figure 1, the failures of glass breakage and dust soiling predominate in the failure statistics of PV modules in the field [Köntges2017]. A collection of typical PV component failures can be found in [Herz2021] with a brief description of each failure, an assessment of the risk and impact, and recommendations for mitigating or avoiding such failures.

The CPN (Cost Priority Number) was developed in the early 2000s to address the fact that FMEA cannot be used for quantitative financial assessments. A cost-based FMEA was therefore proposed. For PV plants, the CPN methodology allows accurate economic quantification of PV degradation modes and other performance-degrading impacts of PV plant operation. It has thus enabled risk assessments of investments in PV power plant projects [Jahn2018].

The CPN method allows an estimation of the economic impact of failures on electricity costs and PV project business models, and was developed not only to determine the economic impact of technical risks, but also to evaluate the effectiveness of mitigation measures. Specific failures need to be investigated to derive recommendations to mitigate the economic impact of issues such as soiling or potential induced degradation (PID). Some failures can be prevented or mitigated by adopting specific measures at different stages of the project (e.g. for PID); others (such as dust soiling) can be prevented or mitigated by more general measures. For example, performance monitoring or visual inspections of the PV system can be considered general mitigation measures that can have a positive impact on reducing the CPN of many outages. In practice, it is important to understand how mitigation measures can be considered as a whole in order to calculate their impact and thus evaluate their effectiveness.

Case Study

The application of the risk quantification approach is demonstrated with a real case study of a free-standing 10 MW PV power plant with PID-affected PV modules. The measured energy loss due to PID was –25% after the first four years of operation. Taking into account the real investment (CAPEX) and operating costs (OPEX), as well as the annual revenue (PPA), the 20-year financial revenue projection results in a loss of 45% of the rated power if no mitigation measures are taken. In terms of cumulated cash flow after 20 years, the financial return will drastically decrease from the expected 225% of CAPEX to 115% of CAPEX [Herz2021].

Two different mitigation measures (MM) were selected, and their costs were calculated and included in the cash flow for 20 years of operation:

- The installation of PID boxes helped to reverse the power losses (MM1).
- PV modules that could not be fully recovered were replaced with new modules and rearranged by sorting modules of the same power (MM2).

Taking into account the additional costs of the two mitigation measures of €3,233,000, the cumulative financial revenues result in a deviation from expected revenues of only –5% for the first and second measure (MM1 and MM2) for the 20-year financial perspective. These calculations show the importance of determining whether the benefits of the mitigation measure justify its cost.

3 Reduction in financial losses with PV Warranty Insurance

It will now be shown how PV Warranty Insurance could have reduced the financial losses in this real case. Specifically, PV Warranty Insurance would aim to indemnify the cost of the mitigation measures MM1 and MM2 described above up to €3,233,000. A very simple business interruption (BI) component can also help reduce revenue losses caused by module defects and their repair.

The general structure of PV Warranty Insurance has been described elsewhere [Sastrawan2020]. Several insurance structures will be applied to this case and the differences between them discussed.

One important precondition must be met for a warranty risk event to occur and allow the project owner to approach the insurance company directly: The module supplier must have gone out of business and be no longer able to honour its warranty obligations. In all other cases, the project owner is obliged to settle and manage all warranty claims directly with the module supplier, and only the module supplier contacts the insurance company.

In general, claims handling will consist of two parts in this case study. Firstly, the determination of the loss that the project owner suffered, which must be an eligible loss under the terms of the Warranty Insurance policy. And secondly, calculation of the pay-out for the loss using the insurer's structural parameters.

In order to determine the loss, the insurance company requires certain essential information about the project and the magnitude of the underperformance. Table 1 summarises the essential information. Two values are needed to assess the magnitude of the warranty claim: the number of defective modules, and the amount of the underperformance in Wp. In order to determine the number of defective modules and the amount of the underperformance, a sample test may be carried out on a small, statistically relevant number of PV modules, rather than testing all modules individually.

Table 1: Essential information on the project and the claim detection as required by the insurance company.

Project Information		
Initial DC capacity		10,000,000 Wp
Sum insured	The initial purchase price of the warranty-insured modules (10 MWp @ 1.60 €/Wp).	€16,000,000
Insured performance warranty	The module performance may degrade 2.5% in year 1, and 0.7% (absolute) in each of the years 2–25.	97.5%–0.7% p.a. for 25 years

Claim detection in year 4		
Guaranteed DC capacity in year 4	The claim was detected in year 4. The performance warranty therefore still guarantees 95.4%.	9,540,000 Wp
Number of defective modules	30% of the modules were replaced, while the rest were recovered by MM1 (PID boxes).	30%
Amount of underperformance	On park level, the underperformance of DC capacity was 40% compared to the guaranteed 9,540,000 Wp.	3,816,000 Wp
Market price in year 4	Sourcing new modules at a price of 0.97 €/Wp	0.97 €/Wp

Using this information (Table 1), the insurance will determine the maximum eligible loss amount. The insurance will accept repair or/and mitigation actions provided they are more cost-effective than the maximum eligible loss amount. In order to calculate the maximum eligible loss amount, the insurance will compare two perspectives:

- The depreciated value of all defective modules
- The cost of purchasing additional modules to compensate for the underperformance

These options reflect the options specified in the original supplier's warranty, and the insurance will choose the most cost-effective option. The insurance of the supplier's warranty generally follows the supplier's (product and performance) warranty. The supplier's Warranty Insurance transfers to the project owner in the event of the supplier's default and comes with procuring warranty-insured modules. Table 2 shows the comparison of both perspectives, resulting in €3,701,520 as the maximum eligible loss amount for this case study.

Table 2: Determining the maximum eligible loss amount by choosing the most cost-effective option.

Determination of maximum eligible loss amount		
Depreciated value of all defective modules	For a 25-year performance warranty, the annual depreciation is 4.0%. In year 4, the sum insured of €16,000,000 has depreciated accordingly and 30% of these modules are defective.	€4,032,000
Cost of buying additional modules to compensate for the underperformance	The market price of 3,816,000 Wp at 0.97 €/Wp	€3,701,520

This means that the project owner can claim the costs incurred – related to repair, mitigation, and/or replacement of the modules – up to an amount of €3,701,520. The cost of the mitigation measures (MM1 and MM2) of €3,233,000 are therefore eligible under the terms of the insurance policy.

For our case study, it is further assumed that the project can prove a revenue loss of €800,000 directly caused by this warranty risk event, corresponding to some 25% of its expected annual revenue with a feed-in tariff of €0.25/kWh. This revenue loss can be counted as an additional eligible loss if a BI (business interruption) component is included in the insurance policy.

In the second step, the insurance pay-out will be calculated based on the insurance structure. Table 3 shows three different insurance structures as examples and calculates the differences in the pay-out. All options have the same deductible, which is deducted from the loss amount. The result is the pay-out, which, however, is capped by the limit (the maximum pay-out).

Table 3: Comparison of three different insurance structures and their pay-out for the case study. (BI: business interruption)

	A: Supplier's PV Warranty Insurance	B: With basic Top-Up Cover	C: Top-Up Cover with loss of revenue
Sum insured	€16,000,000	€16,000,000	€16,000,000
Deductible (5% of sum insured)	€800,000	€800,000	€800,000
Limit in % of sum insured	10%	30%	30%
Limit in €	€1,600,000	€4,800,000	€4,800,000
Actual loss from MM1 and MM2	€3,233,000	€3,233,000	€3,233,000
Additional BI component: 20% of eligible loss	–	–	€740,304
Pay-out	€1,600,000	€2,433,000	€3,173,304

Insurance structure A – the supplier's PV Warranty Insurance – has a rather low limit of just 10% of the sum insured. The loss in this case study is already too high, and the pay-out is capped by the low limit. The supplier's Warranty Insurance comes with sourcing warranty-insured modules, and the limit may differ significantly depending on the supplier [Sastrawan2020].

Insurance structure B has an additional Top-Up Cover with a total limit of 30% of the sum insured. The sum insured now provides sufficient protection for the solar park and covers the total claim amount less the deductible. A Top-Up Cover may be placed by the project owner to increase the insurance protection if warranty-insured modules are used.

Insurance structure C adds a BI (business interruption) component to the Top-Up Cover. A loss of revenue may be indemnified if it occurred due to the module defects and their repair. The BI component is an option in the Top-Up Cover that is structured in a very clear way: An additional eligible revenue loss is given as a percentage of the maximum eligible loss amount. In this case study, we assume an additional eligible revenue loss of 20%, i.e. €740,304. It is further assumed that the project has lost 25% of its annual revenue, amounting to €800,000. Thus, only €740,304 will be accepted, as per the insurance structure. Nevertheless, the pay-out for structure C is the most favourable to reduce the financial losses that occurred in this case study.

Conclusions

This case study described a real PV Warranty risk event (i.e. underperforming modules in combination with an insolvent module supplier). The underperformance was detected at an early stage, and all modules were partially recovered (MM1) or were partially replaced (MM2). The loss mitigating effect of PV Warranty Insurance was subsequently investigated, assuming three different insurance structures.

The project owner in this case study could have claimed a loss of €3,701,520. But by applying mitigation measures MM1 and MM2, the actual loss was €3,233,000. The owner could also have claimed the revenue losses caused directly by the module defects and their rectification. Three insurance structures were applied. These could have reduced the financial loss from this warranty risk event by €1,600,000, €2,433,000, and €3,173,304 respectively.

The Warranty Insurance is no replacement for the project developer's due diligence, nor a substitute for regular monitoring, inspection and testing of the PV modules during the operational phase. These serve as early detection mechanisms for potential warranty claims. Preventive measures are always the best option, as the maximum insurance payout – with or without Top-Up Cover – might not cover all losses.

However, PV Warranty Insurance can significantly reduce the financial losses in the event of a warranty claim. It is of equal importance as an insurance against property damage, if the project is destroyed by a storm, for example.

The first step in placing Warranty Insurance is procuring warranty-insured modules from the supplier. In a second step, a Top-Up Cover can be placed with a tailored insurance structure.

In addition to providing compensation during a warranty risk event, PV Warranty Insurance can also be beneficial when selling or refinancing a project.Particularly if the PV module supplier has ceased to operate in the meantime, or quality issues have been reported with similar PV modules in other projects, a PV Warranty Insurance, especially one with a strong Top-Up Cover, can make a big difference.

4 Takeaways

- Quality assurance is key in preventing a PV Warranty risk event. Monitoring and regular module testing are crucial for early detection of underperformance.

- In a case study of a real warranty risk event, underperforming modules were detected early and could be partially recovered, while others were replaced. These costs could have been partially indemnified by the PV Warranty Insurance.

- PV Warranty Insurance is crucial for reducing financial losses in the event where a module warranty claim combines with the supplier's default. It is of equal importance with insurance against property damage, if the project is destroyed by a storm, for example.

- The first step in placing a PV Warranty Insurance is to procure warranty-insured modules from the supplier. In a second step, a Top-Up Cover with a customised insurance structure can be agreed.

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