Reducing risk through testing

The worldwide installed base of photovoltaic capacity currently is around 890 GW, generating 994 TWh solar energy in total. A growth of more than 200% is expected before the end of 2026, translating to an installed PV capacity of around 1,900 GW. But how can manufacturers ensure that PV modules perform to expectations, even after some time in operation?

The key markets for photovoltaics are expected to be China, Europe, the United States and India, but considerable growth potential is also visible in sub-Saharan Africa and the Middle East.

From this overall installed PV base, utility-scale projects continue to provide the majority of all solar PV additions worldwide. This means that a large number of new solar power plants will be built in the next few years.

These PV power plants initially require a large financial investment. One of the largest parts of this investment is the actual solar modules. They are the key component in providing the expected return on investment, from the first day and then for as long as the plant operates.

Operating solar plants will require maintenance and observation in respect to what they are able to produce after some years of operation and to make sure that they

operate within the expected power range. An unexpected event, e.g. a natural severe weather occurrence, might also force a closer look at the already installed module base.

Why is it recommended to test solar modules again?

These days a solar module is profoundly tested when leaving the factory. In nearly every factory, several quality assurance tests are applied, followed by a similarly high number of tests during the module production process, for example electroluminescence tests and power measurements. Most tests are performed inline, providing a 100% coverage over the products leaving the factory.

However, it is a good idea to test the modules yet again when they arrive onsite. It is a question of ensuring that what has been promised has been delivered and can be accepted with confidence. This testing makes sure that no improper handling during packaging, inadequate packing or any other event during solar module transport has interfered with the goods.

With this in mind, onsite module testing is not only beneficial when planning the construction of a new solar power plant, but it will also provide a more detailed inside view into a running plant.

Benefits of testing during installation of a new solar park

When looking at the different scenarios of in-field module testing, one very useful timeframe is when the installation of a new solar park starts. A very efficient way to avoid delay and extra work later in the project is an incoming goods inspection directly onsite.

This means the modules will be tested when they arrive onsite or even earlier, when they arrive at port. A test lab can be right there with a clear advantage: no need to transport hundreds of modules to an off-site test lab and thus, add further stress to the modules and cost for the transport to the overall bill. And there are more advantages for the project.

The qualification of suppliers becomes much easier and more cost-effective and the detection of hidden problems ensures yield

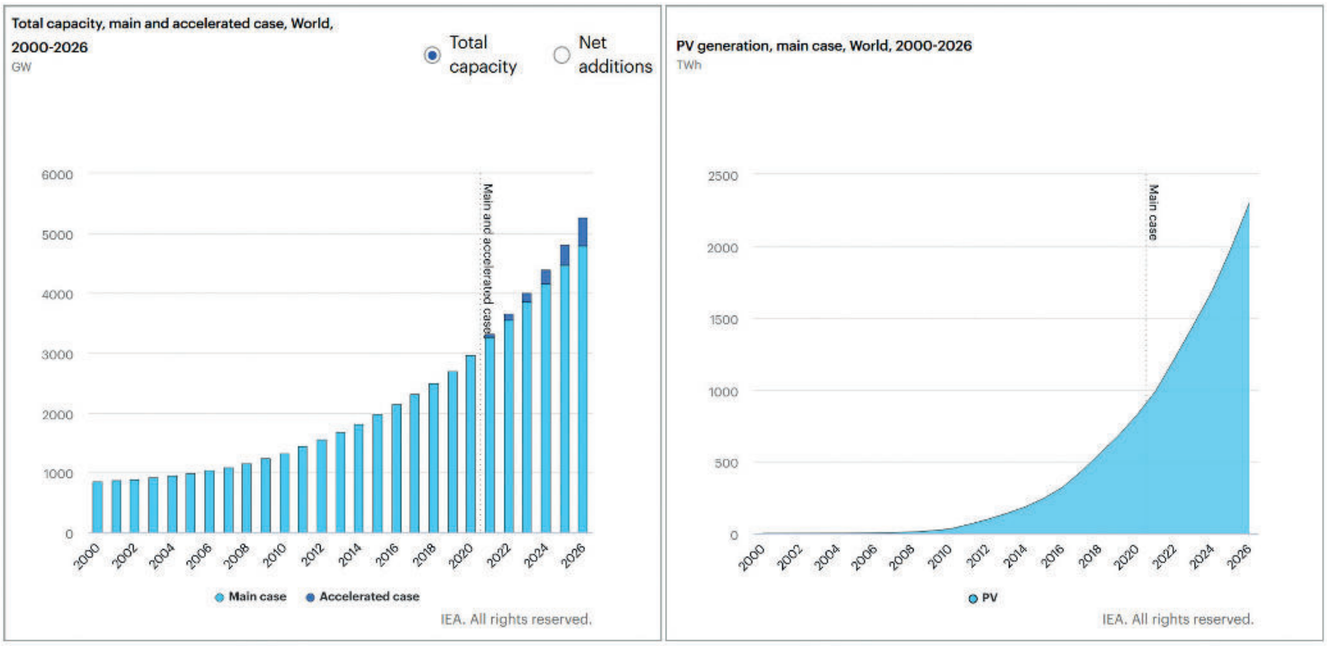

Figure 1 Forecast of the total installed worldwide PV

over the long module lifetime. Complaints can be directly addressed before module installation and any deficiencies in the transport chain can be detected and solved. Also, a documentation history of the delivered module quality is created and only 'good modules' are installed in the plant. Employees are briefed how to handle the modules and therefore an overall, higher security investment is achieved.

A recommendation for incoming goods tests

The recommended minimum test for solar modules onsite should be a module power measurement, but much better is an additional electroluminescence (EL) test. The EL test will show cracks and micro cracks that are not visible to the human eye and will show cracks that have not yet had an impact on the module's power creation, but will have in the near future. These problems will not necessarily show in a solo module power measurement.

Over the lifetime of the modules these cracks can lead to severe loss in module power, particularly through environmental influence, e.g. through heat and cold temperature cycles. When an infrared inspection for hot spot detection and a diode check is added, the most common module issues can be caught before installation.

A 100% test of all modules arriving onsite is not feasible. A widely adopted approach is an AQL sample test according to ISO 2859-1. It describes a product sampling system in which a defined number of all products are tested for verification against certain product features. The small number of randomly chosen products, ideally chosen from several different lots or crates, are tested to gain confidence in the overall order. It is meant to encourage the seller to uphold their product quality promise, while limiting the risk of the buyer and strengthening their trust in the continued product quality. This procedure ensures that only an occasional poorer quality product, out of a much larger good quality order, will occur in the delivery.

A simple example of an AQL based test for incoming goods in a solar park could be to randomly test 500 out of a total shipment of 20,000 modules arriving. This number is defined by the AQL sample size map in the section 'sample size Code letters', at general inspection level III.

A second table, the acceptance quality limit, will now give feedback on the number of products with no, minor or major defects allowed in the random sample set of 500 pieces. In our example, the agreement with the seller is to accept a quality level of zero critical, safety related defects, 1.5% with major defects and 2.0% with minor defects.

The second table defines the exact number of modules creating a rejection of all modules in the shipment: should one critical defect be found in a solar module the inspector has the right to decline the shipment. According to the AQL table this is also true for 15 modules found with a major defect or 22 modules found with a minor defect.

Instead of a direct refusal, it can also be feasible to change the test procedure to a much higher sample number if an unacceptable number of defects occur,

Figure 2 Installation of a PV power plant

SAMPLE SIZE CODE LETTERS

Lot Size	General Inspection Levels I	II	III	Special Inspection Levels S1	S2	S3	S4
2 to 8	A	A	B	A	A	A	A
9 to 15	A	B	C	A	A	A	A
16 to 25	B	C	D	A	A	B	B
26 to 50	C	D	E	A	B	B	C
51 to 90	C	E	F	B	B	C	C
91 to 150	D	F	G	B	B	C	D
151 to 280	E	G	H	B	C	D	E
281 to 500	F	H	J	B	C	D	E
501 to 1200	G	J	K	C	C	E	F
1201 to 3200	H	K	L	C	D	E	G
3201 to 10000	J	L	M	C	D	F	G
10001 to 35000	K	M	N	C	D	F	H
35001 to 150000	L	N	P	D	E	G	J
150001 to 500000	M	P	Q	D	E	G	J
500001 and over	N	Q	R	D	E	H	K

AQL sample testing according to ISO 2859-1

SINGLE SAMPLING PLAN FOR NORMAL INSPECTION

Acceptance Quality Levels (Normal Inspection)

Code Letter	Sample Size	0.4 ✓	0.4 ✗	0.65 ✓	0.65 ✗	1.0 ✓	1.0 ✗	1.5 ✓	1.5 ✗	2.5 ✓	2.5 ✗	4.0 ✓	4.0 ✗	6.5 ✓	6.5 ✗
A	2	↓		↓		↓		↓		↓		↓		0	1
B	3	↓		↓		↓		↓		↓		0	1	↑	
C	5	↓		↓		↓		↓		0	1	↑		↓	
D	8	↓		↓		↓		0	1	↑		↓		1	2
E	13	↓		↓		0	1	↑		↓		1	2	2	3
F	20	↓		0	1	↑		↓		1	2	2	3	3	4
G	32	0	1	↑		↓		1	2	2	3	3	4	5	6
H	50	↑		↓		1	2	2	3	3	4	5	6	7	8
J	80	↓		1	2	2	3	3	4	5	6	7	8	10	11
K	125	1	2	2	3	3	4	5	6	7	8	10	11	14	15
L	200	2	3	3	4	5	6	7	8	10	11	14	15	21	22
M	315	3	4	5	6	7	8	10	11	14	15	21	22		
N	500	5	6	7	8	10	11	14	15	21	22				
P	800	7	8	10	11	14	15	21	22						
Q	1250	10	11	14	15	21	22								
R	2000	14	15	21	22										

↑ : Use first value above
↓ : Use first value below

Figure 3 AQL decision matrix for product sampling plans

depending on the agreement between seller and buyer.

In this example, 2.5% of all modules ordered will be inspected onsite to ensure the investment. Ideally, a detailed test report is provided, including the results sorted by the serial numbers of the tested modules and a statistical summary. This is best done by an independent test service provider to avoid a conflict of interest and before installing the modules into their final position in the solar park. It will cost a fraction of the total cost of the park and it will provide confidence about the investment.

Test during live time

Another important scenario to test in the field and make sure that the investment is on tract is when the solar park's power output is not matching expectations. Ideally, the root cause should be found out quickly to avoid losing money over time. This case might happen after obvious events like bad weather, but it could also be due to other causes. Some issues might not be obvious and directly visible to the human eye.

The benefits of regular tests, or tests after an unexpected event during operation, include increased performance and operation efficiency. It also means complaints are reduced due to the continuous checks. With efficient damage detection and repair and insurance companies getting more information in the case of damage, a deep assessment will help secure the investment when buying an existing solar park.

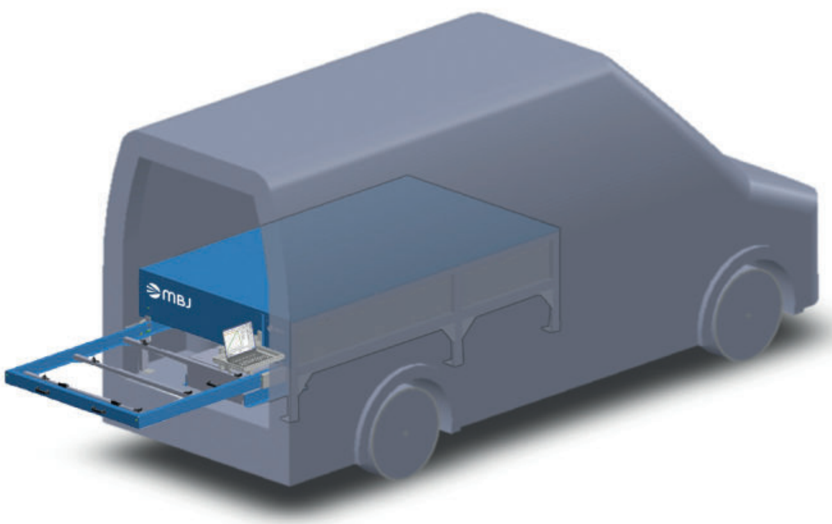

Figure 4 MBJ Mobile Lab 5.0

What changes due to large module sizes

Due to the new development in cell sizes and the resulting new module sizes and types in module production, equipment manufacturers have been forced to develop matching production equipment. The larger modules have arrived in the market and naturally changes, to handle these modules during installation, have to follow.

The change in module size is mainly due to the new cell sizes of M10, with a 182mm edge length and G12, with a 210mm edge length. When reading through the data sheets of the main module manufacturers, using these new cell sizes, the resulting module dimensions for modules with the highest power output are 2,465 mm x 1,134 mm, based on M10 cells, and up to 2,384 mm x 1,303 mm for G12 cell size based modules.

Next to the change in dimension, further changes in the layout of solar modules take place, such as the number of cells in one string or the number of strings on a module. Most modules based on M10 or G12 cells are half cut or triple cut cells with multi-busbar layout.

It also seems to turn out that the largest of the new module formats are mainly used for utility scale projects. The handling of larger and heavier modules is easier in the open field than on a rooftop. This all leads to a need for new onsite test equipment, to be able to measure the larger module formats.

New MBJ Mobile Lab 5.0 handles all large modules size

MBJ Solutions has followed the market and updated the existing mobile lab for onsite measurements. The new MBJ Mobile Lab 5.0 supports all of the upcoming larger module sizes, up to a max size of 1,400 mm x 2,750 mm. Additionally, the whole system has undergone a face lift and is now more compact while keeping all the high quality measurements available in the previous versions.

With the latest innovation of an integrated electroluminescence, the full system, in width and length, is not much larger than the size of the modules to be tested. The system has a total size of 1,700mm x 2,995mm with a height of 850mm.

This allows completely new use cases. The system can be placed as a standalone lab system in your container or onsite housing or it can be integrated into your transporter, truck, trailer or shipping container. Due to the new reduced size, the system does fit into many standard size transport trucks. Another benefit is that this system has less movable internal parts, making it a lot simpler and more robust.

While reduced in size, the Mobile Lab 5.0 still provides all the latest test technologies required in the solar industry. This includes the full spectrum long pulse A+A+A+ LED sun simulator according to IEC60904-9 Ed.3 standard, the high-resolution electroluminescence tester with up to 30MPixel resolution, an electrical connection test and an innovative diode test.

The LED sun simulator is suitable for the I/V-curve measurement of framed and frameless glass-glass or glass-foil modules and bifacial modules. With its extended spectrum into the infrared region, the measurement performs accurately on PERC modules. With the stepwise measurement function the measurement of modules with capacitive effects, like HJT cells, is no problem. Other cell material e.g. in thin film nodules can also be measured.

While several manual steps are involved when operating the system, a module to module measurement duration of down to just 60 seconds per module can be achieved. The workflow of the system follows these steps: read the barcode of the module with a handheld barcode reader, load the module sunny side up into the module drawer, and electrically connect the module to the system. The measurement is started automatically when the drawer is closed. All measurements are done without the need to move the module during measurements.

Problems in a solar park should be solved quickly. This is also true when it comes to warranty cases, or when a claim to an insurance company needs backup. This is a huge help in being successful with any claims.

All measurement results taken with the system will be stored in detail in a local database. After finishing the job, a detailed report including statistical graphs, I/V measurement curves and EL images can be created and shared with all sides. The MBJ Mobile Lab can be used as an independent module tester, it is already proven and well known in the market, and will bring additional credibility into a warranty case or insurance claim.

Figure 5 MBJ Mobile EL_4.0

About MBJ Solutions

MBJ Solutions GmbH specializes in the development and sale of test and measurement systems for the photovoltaic industry. MBJ offers sun simulators, electroluminescence test systems and test systems for insulation and grounding tests for the solar module production. Through the acquisition of the MBJ Services GmbH in 2021, MBJ Solutions GmbH now also offers mobile test and measurement systems for the onsite testing of solar modules.

The company has sold more than 450 test systems worldwide since it was founded in 2009. The headquarters of the MBJ Group is in Ahrensburg, Germany. We develop and produce all our products in Germany. Since many of our customers are based in Asia, and a service office in Taiwan.

Innovative solutions and customer orientation are a matter of course, with customers including well-known institutes and manufacturers of the PV industry. Many years of experience and a motivated team make MBJ the perfect partner for PV projects.

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