

CEA I PV MAGAZINE PROGRAM TEST REPORT

SUPPLIER | TW SOLAR

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Date: 8 April 2024

Form Version: V1.3



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GSOLAR POWER CO.,LTD

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1. INTRODUCTION

As part of CEA's engagement in developing and supervising PV Magazine's test program at Gsola, CEA has developed a testing protocol and flowchart, a scoring system, a methodology and a reporting structure that it will be used to run this program. This report presents the test results and scoring grades for this product.

2. SCORING SYSTEM

2.1. Test flowchart and protocol

The following is a high-level flowchart of the testing procedure, describing the steps, and tests to be followed. Detailed checklists have been delivered to Gsola, that will also serve as records of the process.

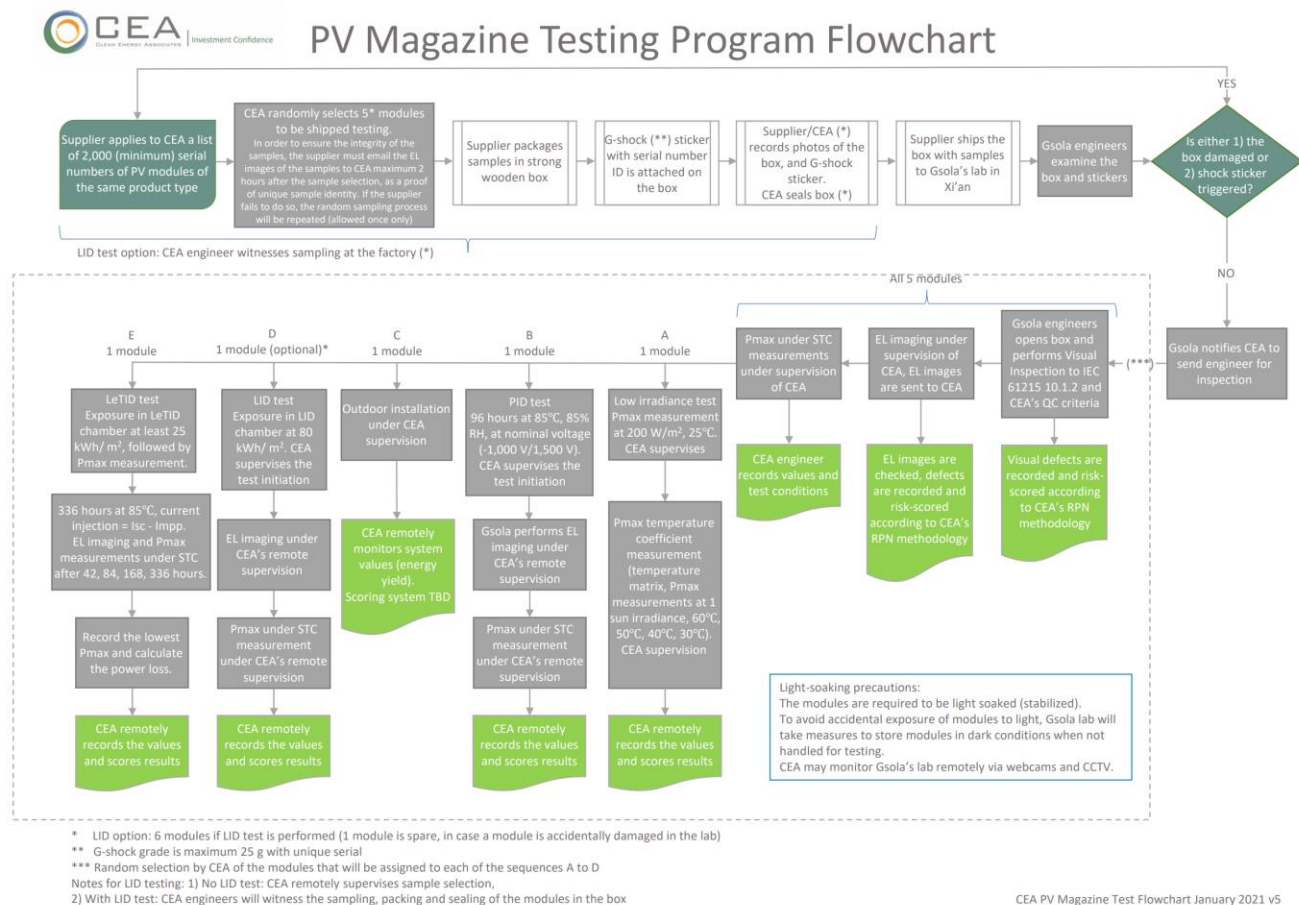


Figure 1 Test flowchart

2.2. Scoring methodology

For every product, 5 samples have been shipped to Gsola's lab to conduct the tests and inspections according to the above flowchart.

The following table describes the inspections and tests that have been applied on all products:

Table 1 Test/inspection grading system overview

	Test/inspection	# of samples	Method	Values	Average grade weight	Grades
1	Visual inspection	5	Inspection	RPN Scores	10%	1-100
2	EL image inspection	5	Inspection	RPN Scores	10%	1-100
3	Low irradiance efficiency loss	1	Test	%	25%	1-100
4	Pmax Temperature coefficient	1	Test	%/°C	25%	1-100
5	PID loss	1	Test	%	30%	1-100
6	LID loss (optional)	1	Test	%	NA	1-100
7	LeTID	1	Test	%	NA	1-100
8	Outdoor installation and yield measurement	1	Energy Yield Monitoring	Periodic kWh/kWp	NA	NA

Notes:

1. The RPN scoring method has been developed by CEA and is used to evaluate and create risk scores of Visual and EL defects.
2. The weights are used to calculate the average grade for tests 1-5.

A number within the 1-100 range will be used to grade the results, so that the overall ranking of the products will reflect general industry practices and requirements:

Table 2 Detailed scoring system

	Grade range:	100	90	80	70	60	50	40	30	20	10	0
1	Visual inspection (RPN scores)	0	0.74	2.20	4.39	7.30	10.94	15.30	20.39	26.20	32.74	≥ 40
2	EL image (RPN scores)	0.00	2.03	4.62	7.75	11.43	15.65	20.43	25.75	31.62	38.03	≥ 45.00
3	Low irradiance loss	≤ -2.00%	-0.02%	1.78%	3.41%	4.87%	6.16%	7.27%	8.21%	8.98%	9.58%	≥ 10.00%
4	Pmax Temp. coefficient	≥ -0.300%	-0.343%	-0.382%	-0.417%	-0.448%	-0.475%	-0.498%	-0.517%	-0.532%	-0.543%	≤ -0.550%
5	PID loss	≤ 0.0%	0.7%	1.6%	2.7%	4.0%	5.5%	7.2%	9.1%	11.2%	13.5%	≥ 16.0%
6	LID loss (optional)	≤ -0.50%	0.35%	1.20%	2.05%	2.90%	3.75%	4.60%	5.45%	6.30%	7.15%	≥ 8.00%
7	LeTID	≤ 0%	0.30%	0.60%	0.90%	1.20%	1.50%	1.80%	2.10%	2.40%	2.70%	≥ 3.00%

Notes:

1. The Visual and EL Inspection RPN scores will be divided by the number of samples, to normalize the score, as the total number of samples may vary.
2. The correspondence of the scores/test results to the grades follows a binomial or linear relationship, anchored to certain key values that are generally accepted and employed in the PV industry. For example, a PID loss of 5%,

which is the pass/fail threshold of the related IEC standard, will give a grade close to 50. In this sense, grades below 50 indicate a product performance that is below a generally acceptable threshold.

The scoring system shown in Table 2 is preliminary, and will be adjusted as the testing program develops, in order to better reflect the products standing per industry standards.

2.3. Selection methodology

We follow three testing sample selection methods:

- 1: Sample randomly selected by CEA from a large production lot
- 2: Sample purchased from the market by CEA
- 3: Sample provided by supplier, without random selection

The Tongwei TWMND-72HD570 testing samples were selected according to method 3.

3. TEST DETAILS

A sample lot consists of 5 modules, one of which has been used as a spare for the chamber and outdoor testing, in case a module is accidentally damaged during handling at the lab. Refer to Table 3 and Table 4 for test sample and product information.

Table 3 Test sample information

Sample #	Serial number
1	YF202401220007S72TW182E216D3126
2	YF202401220007S72TW182E216D3130
3	YF202401220007S72TW182E216D3129
4	YF202401220007S72TW182E216D3127
5	YF202401220007S72TW182E216D3128

Table 4 Product information

Model	Tongwei TWMND-72HD570
Cell technology	N Type
Cell number	144
Cell format	182x182 mm
Number of busbars	16
Junction box	IP68, 3 diodes
Laminate construction	Glass
Bifaciality ratio	80±5%

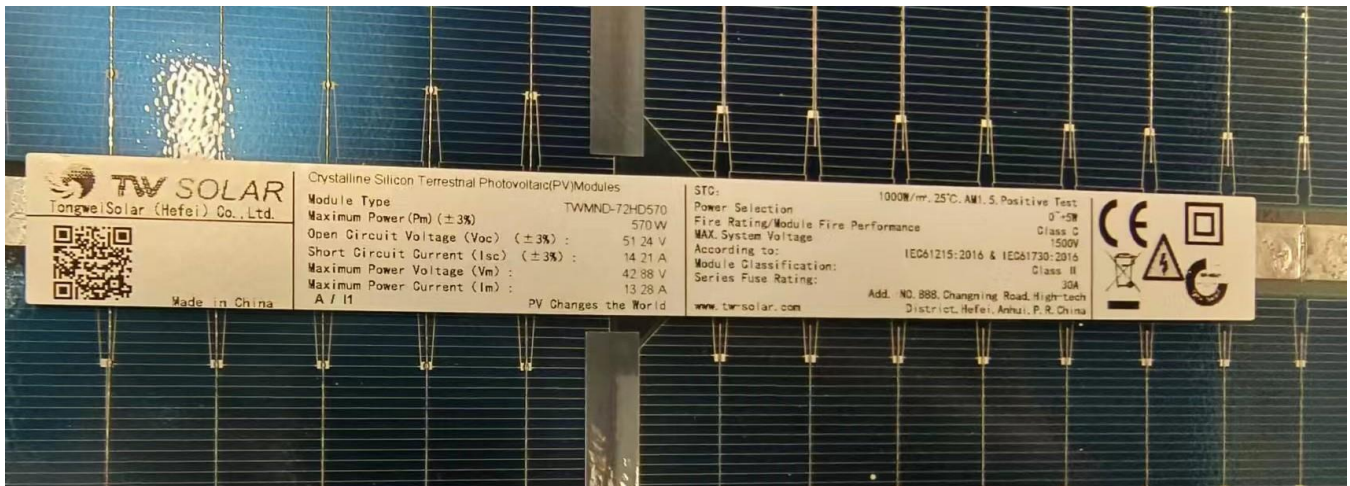
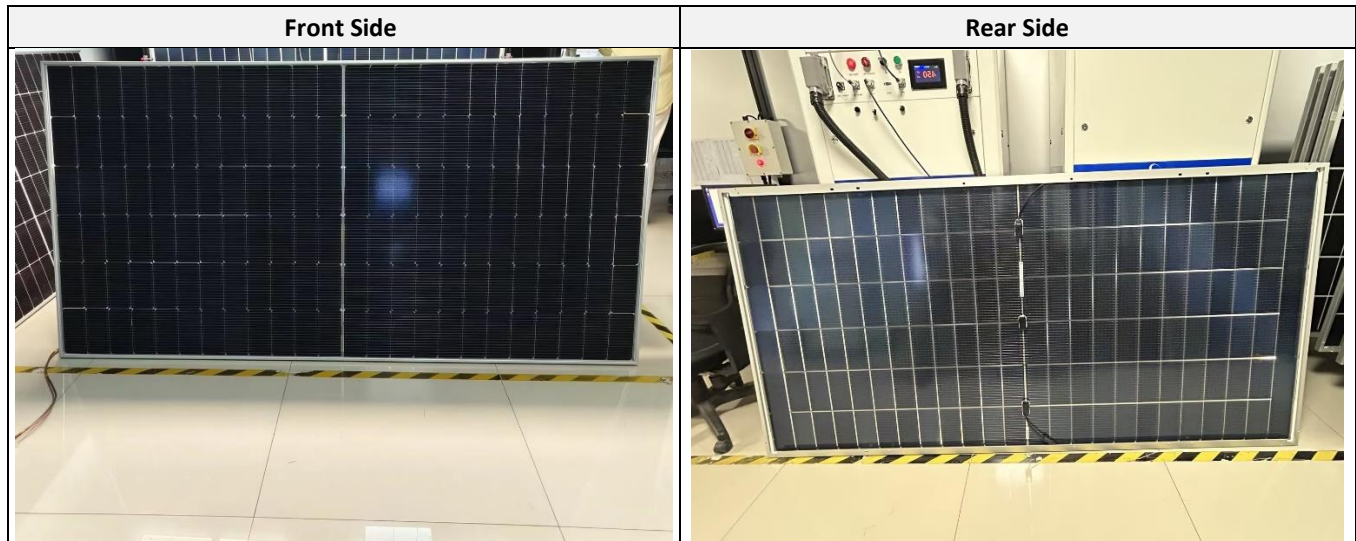


Figure 2 Product nameplate

3.1. Visual inspection

All 5 modules of each product sample lot have undergone visual inspection, according to CEA's quality criteria for visual inspection. The defects found has been evaluated according to CEA's scoring system. The scoring system is a modified version of CEA's proprietary RPN (risk priority number) system, based on the formula $RPN\ score = Severity \times Detectability$.

Table 5 Product picture



The following table shows the visual inspection results, normalized for the number of tested modules:

Table 6 Visual inspection results

TONGWEI TWMND-72HD570	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Score	Grade
Visual inspection	None	None	None	None	None	0	100

3.2. EL image Inspection

The same sample lot was inspected for EL defects.

Table 7 shows the EL inspection results normalized for the number of tested modules. Visual and EL inspection scores are shown below in Figure 3.

Table 7 EL image inspection results

TONGWEI TWMND-72HD570	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Score	Grade
EL image inspection	None	None	None	None	None	0	100

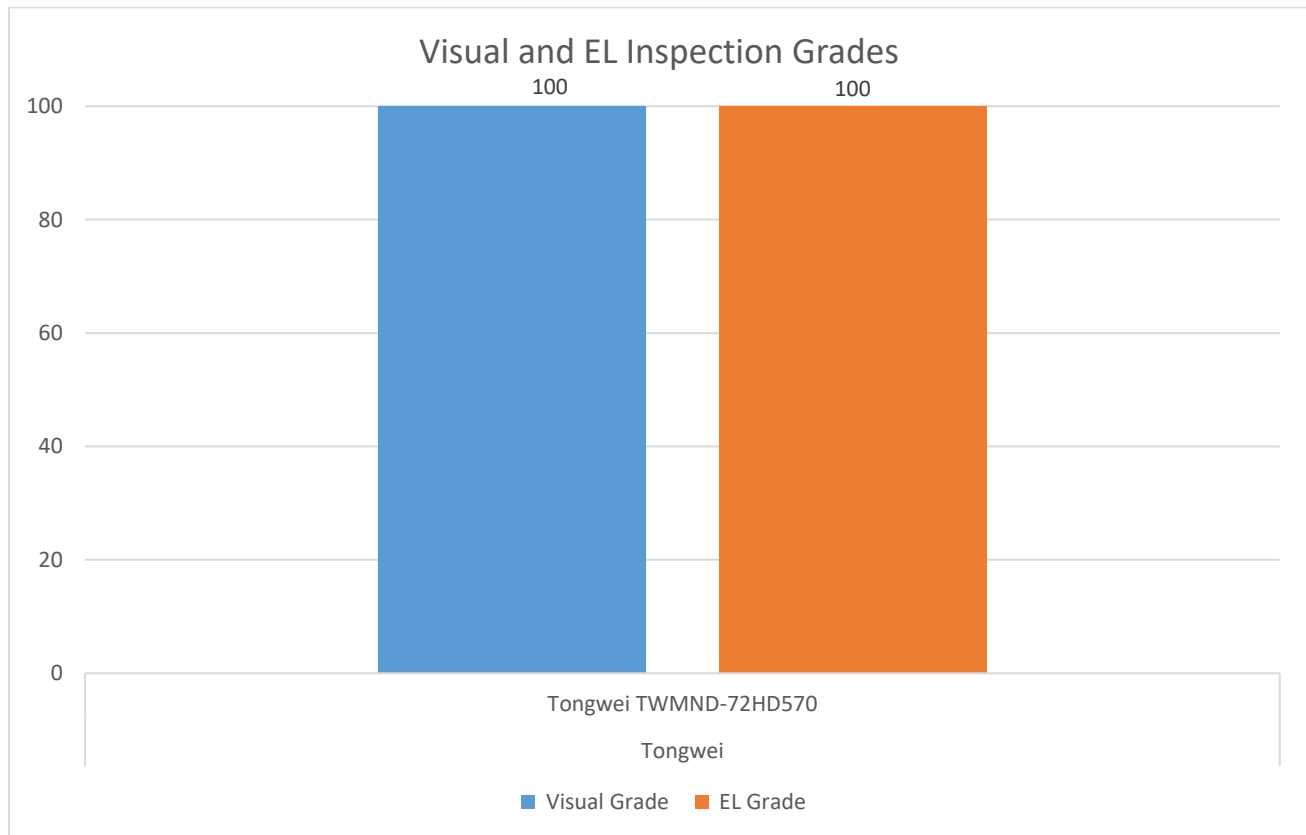


Figure 3 Visual and EL inspection results

3.3. Low irradiance efficiency loss test

The efficiency loss is calculated by the following formula:

$$\text{Efficiency loss} = 1 - [(P_{\text{max at low irradiance conditions}} / P_{\text{max at STC}}) * (1,000/200)]$$

Table 8 and Figure 4 show the low irradiance efficiency test results for the front side.

Table 8 Low irradiance test results

TONGWEI TWMND-72HD570	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side low irradiance efficiency loss (%)	3.06%					72

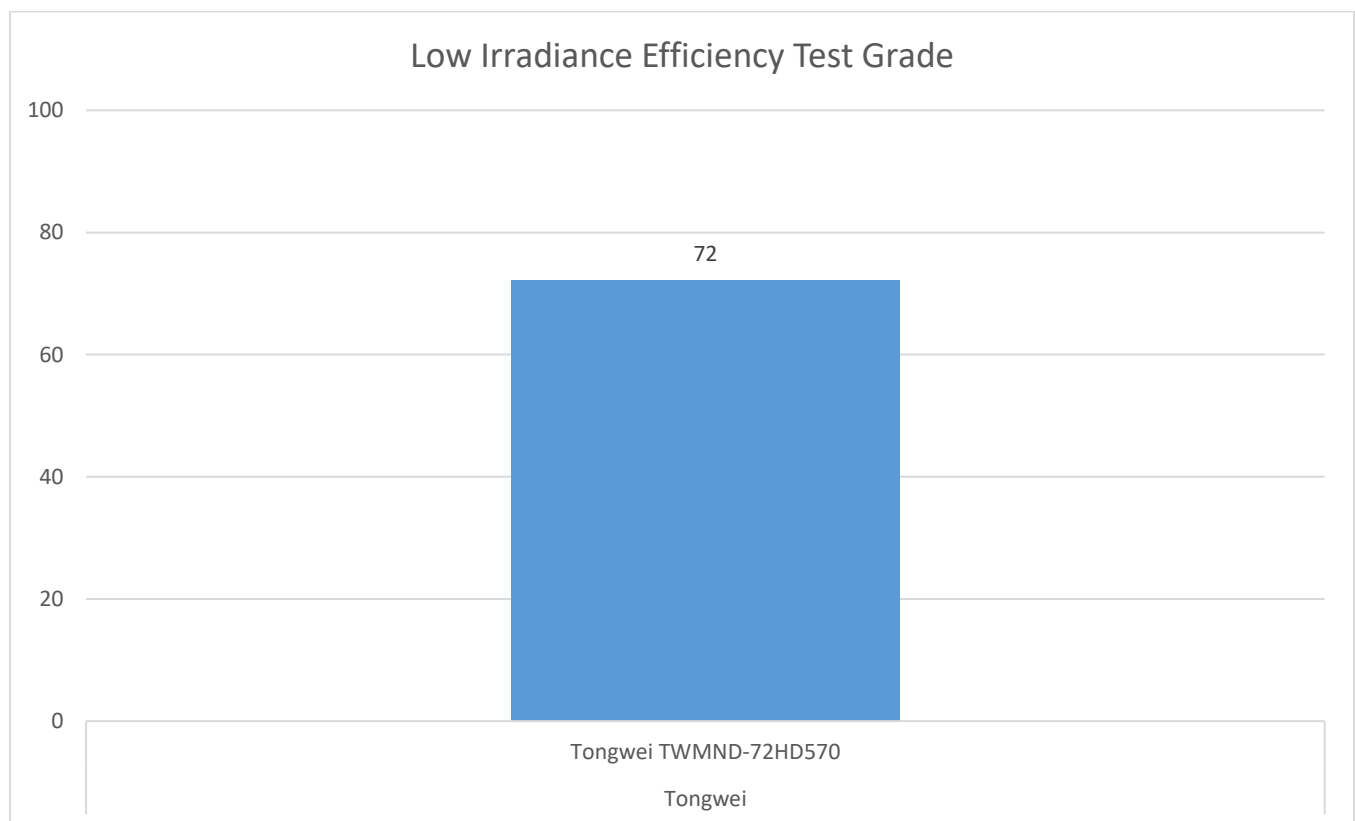


Figure 4 Low irradiance test result

3.4. Pmax temperature coefficient test

Table 9 and Figure 5 depict the Pmax temperature coefficient test results.

Table 9 Pmax temperature coefficient test result

TONGWEI TWMND-72HD570	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Pmax Temperature coefficient (%/°C)	-0.27%					106

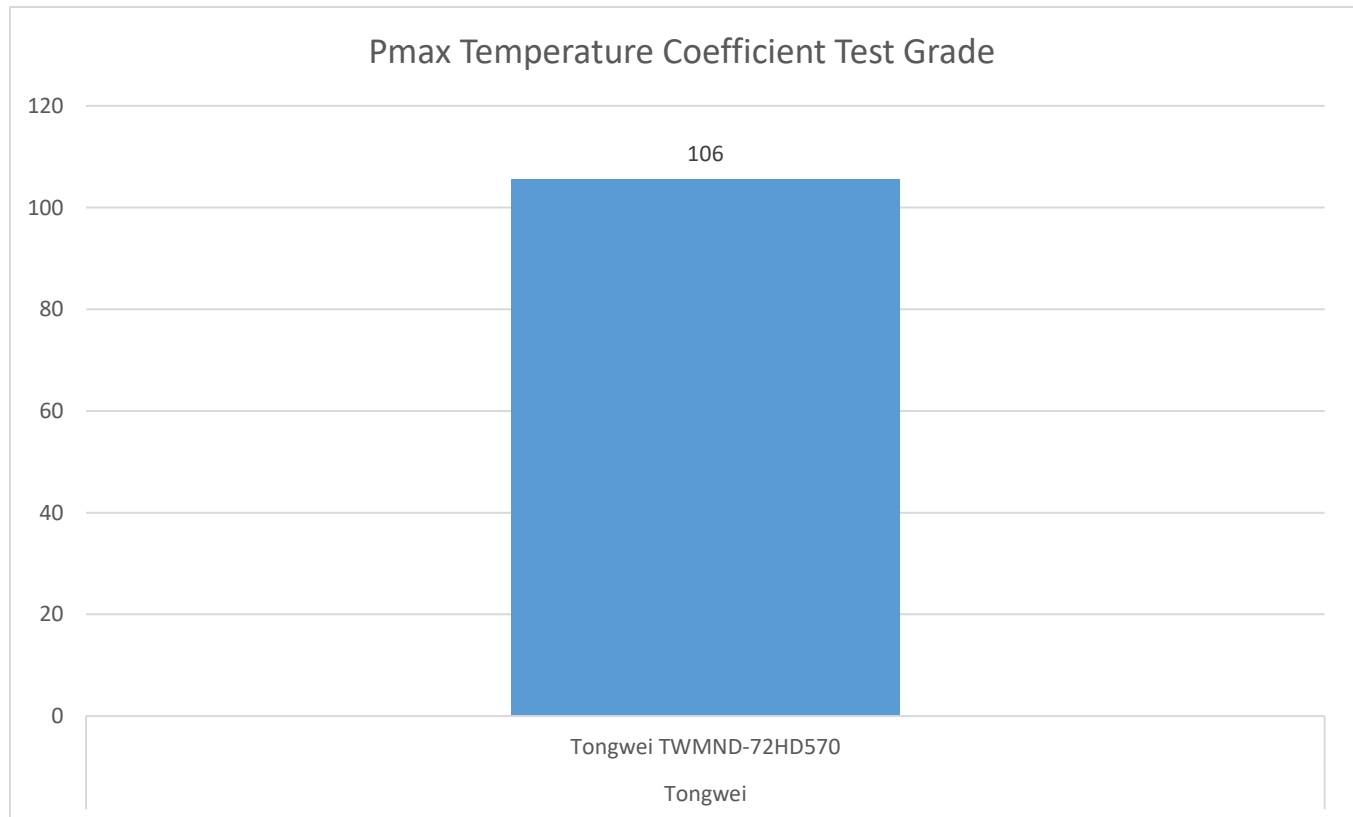


Figure 5 Pmax temperature coefficient test result

3.5. PID loss test

Table 10 and Figure 6 depicts the PID loss test results for the front side at **1500 V**:

Table 10 PID loss test result

TONGWEI TWMND-72HD570	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side PID loss (%)		0.93%				87

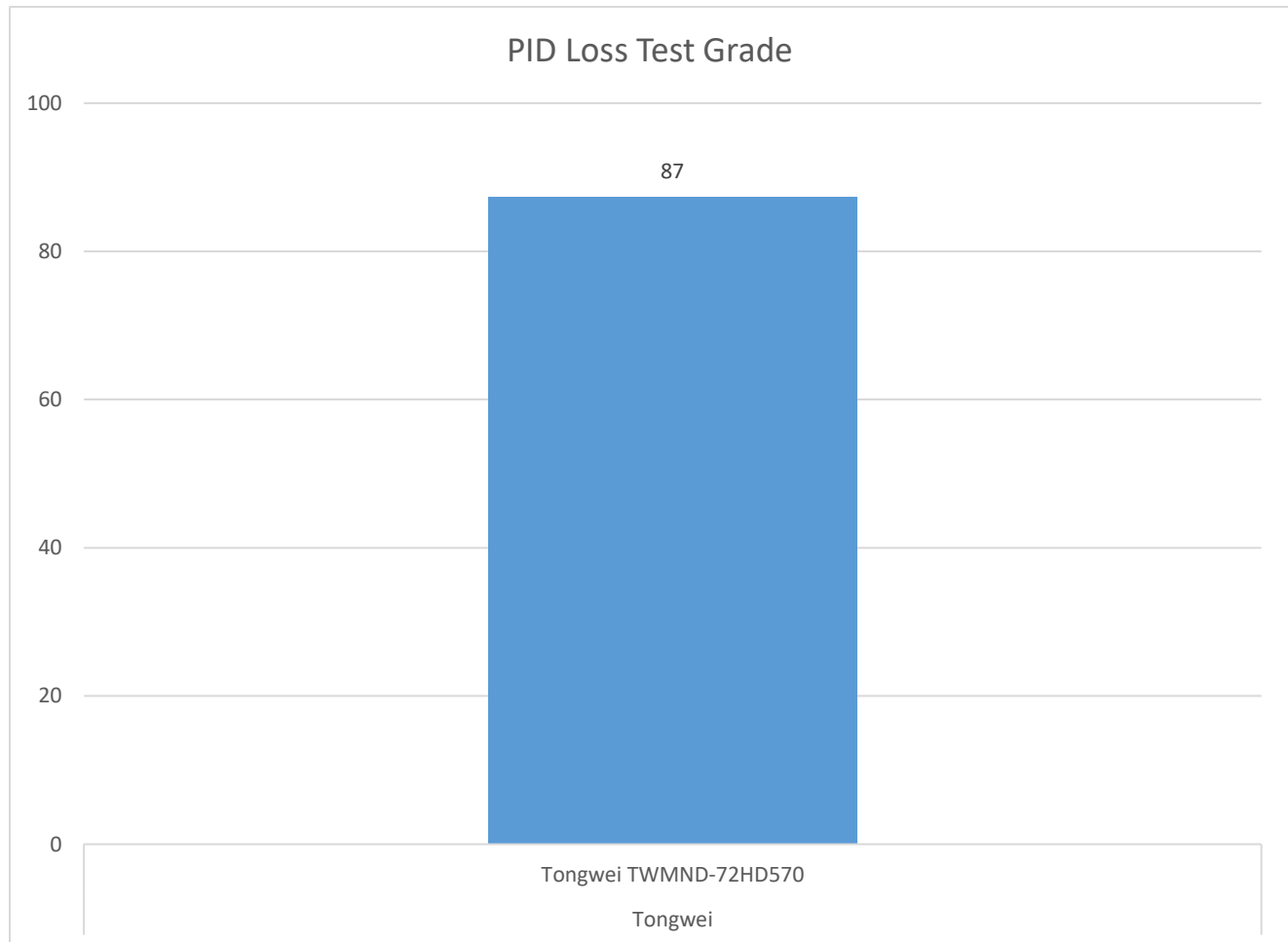


Figure 6 PID loss test result

3.6. LID loss test

Table 11 and Figure 7 depicts the LID loss test results for the front side:

Table 11 LID loss test result

SKA611HDGDC	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side LID loss (%)		0.42%				89

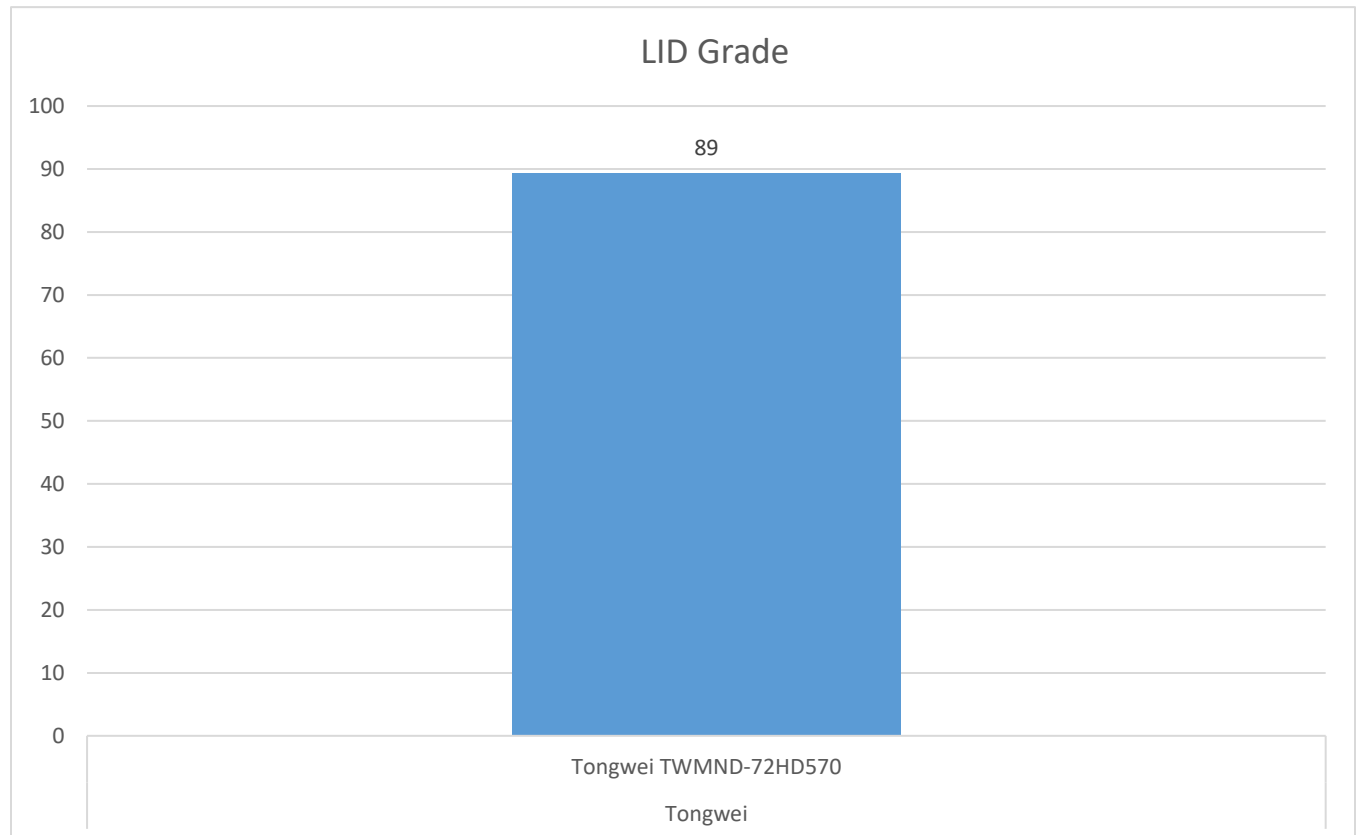


Figure 7 LID loss test result

3.7. Bifaciality ratio

The bifaciality ratio test result is not graded. We list the results here for informational purposes. The table below shows the bifaciality ratio results:

Table 12 Bifaciality ratio test results

TONGWEI TWMND-72HD570	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Average
Bifaciality ratio (%)	79.54%	78.89%	79.24%	79.27%	79.32%	79.25%

The bifaciality ratio is calculated from the following formula:

$$\text{Bifaciality ratio} = (\text{Pmax rear surface} / \text{Pmax front surface}) * 100\%$$

3.8. Score overview

Figure 8 shows the overview of the test scores. Figure 9 shows the average score.

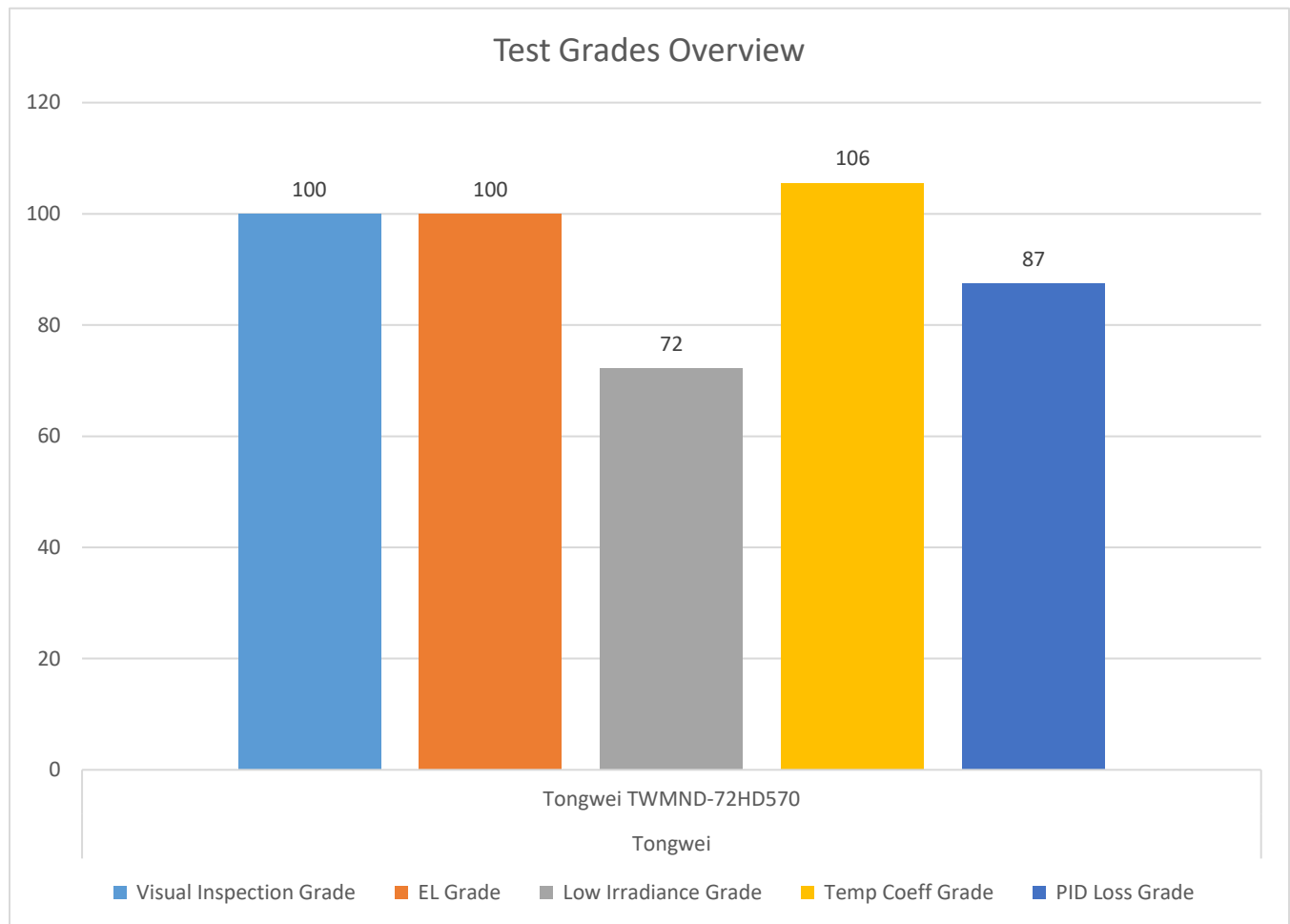


Figure 8 Test results overview

NOTE: The Average grade does **NOT** include the LID test, as it is optional and not performed for all products.

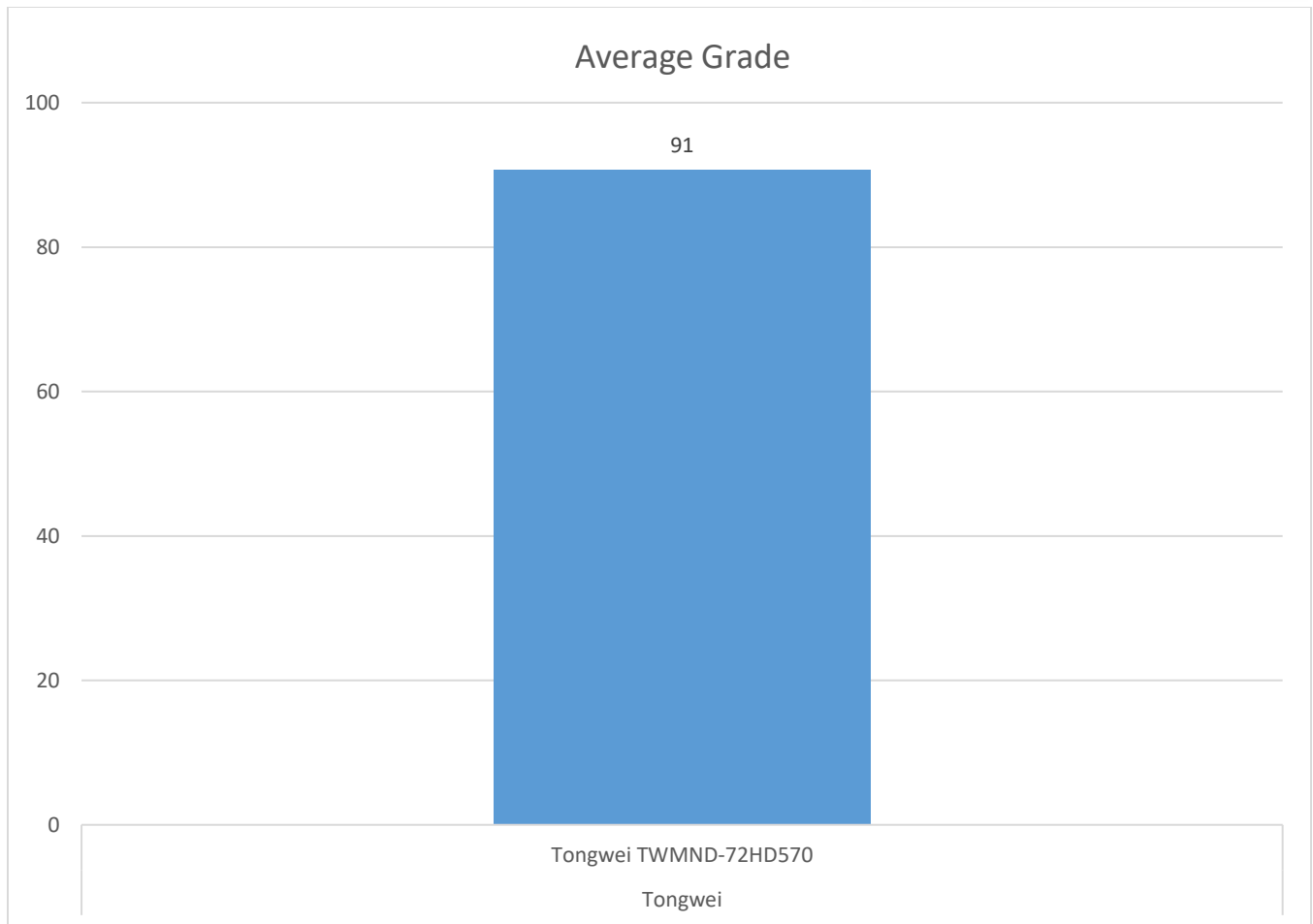
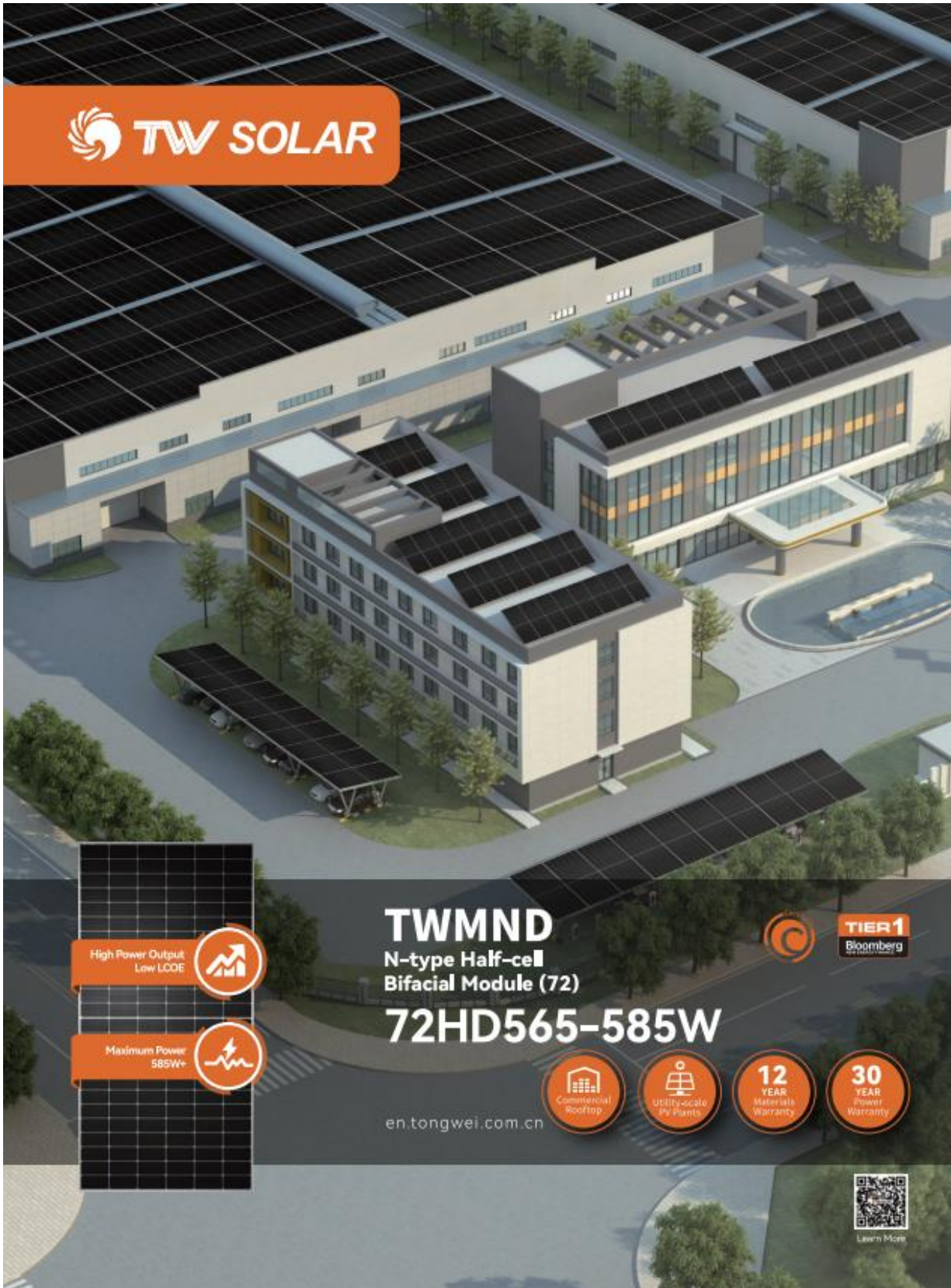


Figure 9 Average test grade

Appendix 1 – TONGWEI TWMND-72HD570 Datasheet



TW SOLAR

TWMND
N-type Half-cell
Bifacial Module (72)
72HD565-585W

High Power Output
Low LCOE

Maximum Power
585W+

en.tongwei.com.cn

Commercial Rooftop

Utility-scale PV Plants

12 YEAR
Materials
Warranty

30
Power
Warranty

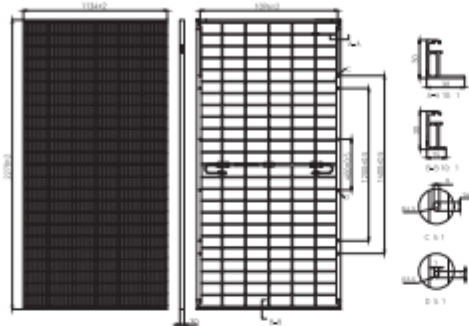
TIER1
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Learn More

TWMND N-type Half-cell Bifacial Module (72)

72HD565-585W

DRAWINGS (Unit: mm)



MECHANICAL PARAMETERS

Cells	TNC (N Type Monocrystalline Cell)
Cell Orientation	144(6×24)
Dimension	2278×1134×2×30mm
Weight	31.5kg
Front Glass	2.0mm high transmittance, AR semi-tempered glass
Rear Glass	2.0mm semi-tempered glass
Frame	Anodized aluminum alloy frame
Junction Box	IP68, 3 diodes
Output Cable	4.0mm ²
Cable Length	+400mm, -200mm, length can be customized
Wind/Snow Load	2400Pa/5400Pa
Packaging	36pcs per pallet, 720pcs per 40' HC

ELECTRICAL CHARACTERISTICS (STC)

Module Type: TWMND-72HDXXX					
Maximum Power: P _{max} [W]	565	570	575	580	585
Open Circuit Voltage: V _{oc} [V]	51.04	51.24	51.44	51.64	51.84
Short Circuit Current: I _{sc} [A]	14.17	14.21	14.25	14.29	14.33
Voltage at Maximum Power: V _{mp} [V]	42.68	42.88	43.08	43.28	43.48
Current at Maximum Power: I _{mp} [A]	13.24	13.29	13.35	13.40	13.46
Module Efficiency: η [%]	21.9	22.1	22.3	22.5	22.6

* STC: Irradiance 1000W/m², Cell Temperature 25°C, Air Mass 1.5, Measuring Tolerance: ±3%

ELECTRICAL CHARACTERISTICS (NMOT)

Maximum Power: P _{max} [W]	424.8	428.6	432.4	436.1	439.9
Open Circuit Voltage: V _{oc} [V]	48.48	48.67	48.86	49.05	49.24
Short Circuit Current: I _{sc} [A]	11.47	11.52	11.56	11.60	11.63
Voltage at Maximum Power: V _{mp} [V]	39.89	39.95	40.00	40.19	40.37
Current at Maximum Power: I _{mp} [A]	10.63	10.70	10.78	10.85	10.90

* NMOT: Irradiance 800W/m², Ambient Temperature 20°C, Air Mass 1.5, Wind Speed 1m/s

ELECTRICAL CHARACTERISTICS (Rear Power Gain)

5%	Maximum Power: P _{max} [W]	593.3	598.5	603.8	609.0	614.3
	Module Efficiency: η [%]	23.0	23.2	23.4	23.6	23.8
15%	Maximum Power: P _{max} [W]	649.8	655.5	661.3	667.0	672.8
	Module Efficiency: η [%]	25.2	25.4	25.6	25.8	26.0
25%	Maximum Power: P _{max} [W]	706.3	712.5	718.8	725.0	731.3
	Module Efficiency: η [%]	27.3	27.6	27.8	28.1	28.3

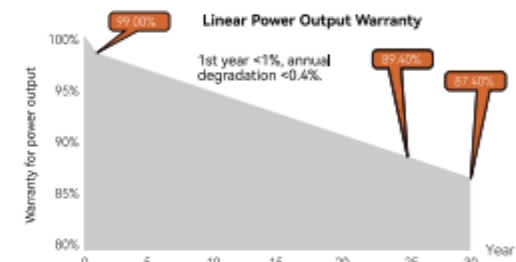
TEMPERATURE PARAMETERS

Temperature Coefficient (P _{max})	-0.30%/°C
Temperature Coefficient (V _{oc})	-0.25%/°C
Temperature Coefficient (I _{sc})	+0.046%/°C
NMOT	45±2°C

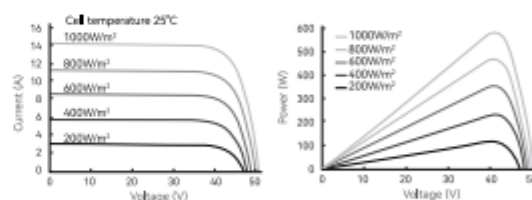
MAXIMUM RATINGS

Operational Temperature	-40°C~+85°C
Maximum System Voltage	1500V DC
Maximum Series Fuse Rating	30A
Power Output Tolerance	0~±5W
Maximum Bifaciality	80±5%

WARRANTY



I-V CURVE



CERTIFICATIONS

Quality Management System and Product Certification

ISO 9001: 2015/Quality management system
 ISO 14001: 2015/Environmental management system
 ISO 45001: 2018/Occupational health and safety management system
 ISO 50001: 2018/Energy management system
 IEC 62941: 2019/Quality system for PV module manufacturing
 IEC 61215/61730, IEC 62804(PID), IEC 61701(Salt),
 IEC 62716 (Ammonia), IEC 60068-2-68(Sand)



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