



## CEA I PV MAGAZINE PROGRAM TEST REPORT

SUPPLIER | Longi

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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.

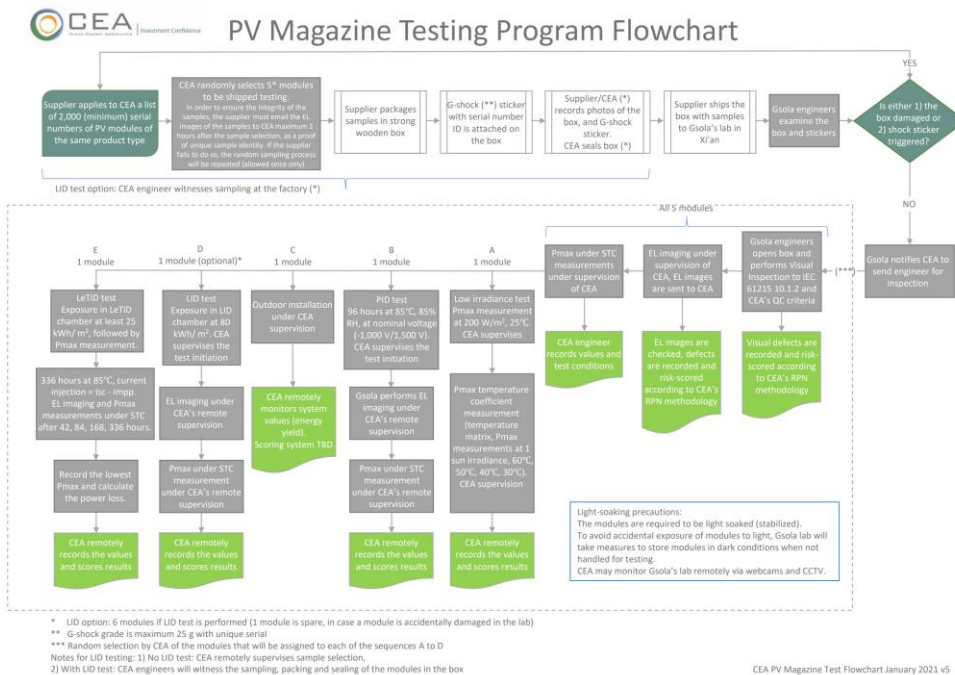


Figure 1 Test flowchart

## 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%

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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

- The testing sample selection method has the following 3 categorization:
- 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

This LR5-72HGD-585M testing sample is suitable for selection 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	LRPI04136230901601489
2	LRPI04136230901601549
3	LRPI04136230901601534
4	LRPI04136230901601497
5	LRPI04136230901601532

Table 4 Product information

Model	LR5-72HGD-585M
Cell technology	HPDC (TOPCon)
Cell number	144
Cell format	182x182 mm
Number of busbars	18
Junction box	IP68, 3 bypass diodes
Laminate construction	Glass
Bifaciality ratio	80±5%

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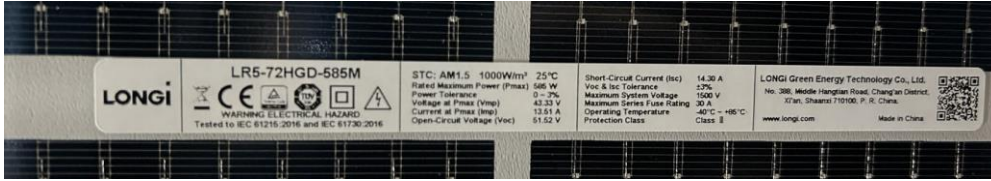
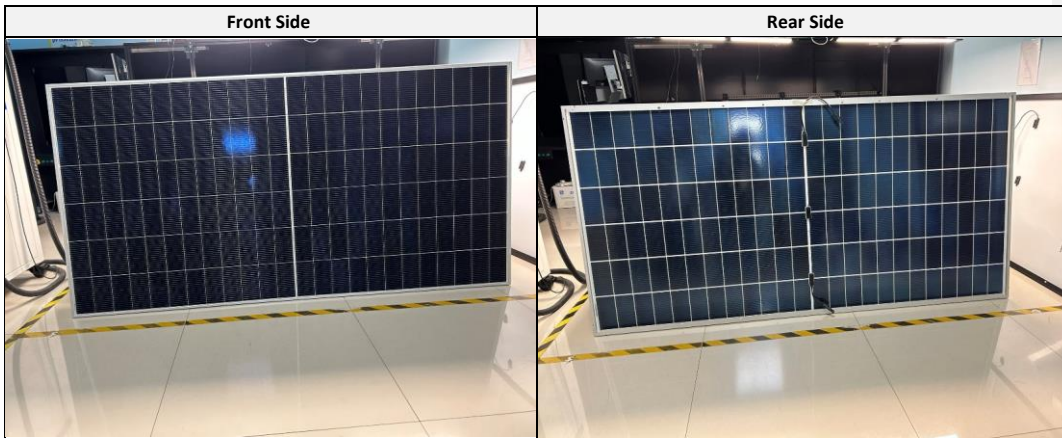


Figure 2 Product nameplate

### 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 have 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

LR5-72HGD-585M	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

LR5-72HGD-585M	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Score	Grade
EL image inspection	None	None	None	None	None	0	100

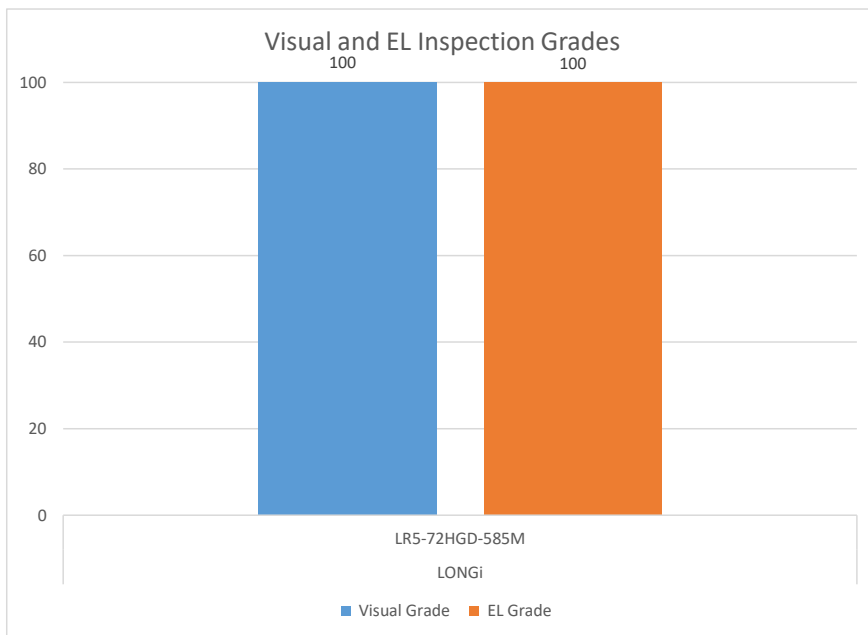


Figure 3 Visual and EL inspection results

### 3.3. Low irradiance efficiency loss test

The efficiency loss is calculated by the following formula:

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

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

Table 8 Low irradiance test results

LR5-72HGD-585M	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side low irradiance efficiency loss (%)	4.99%					59

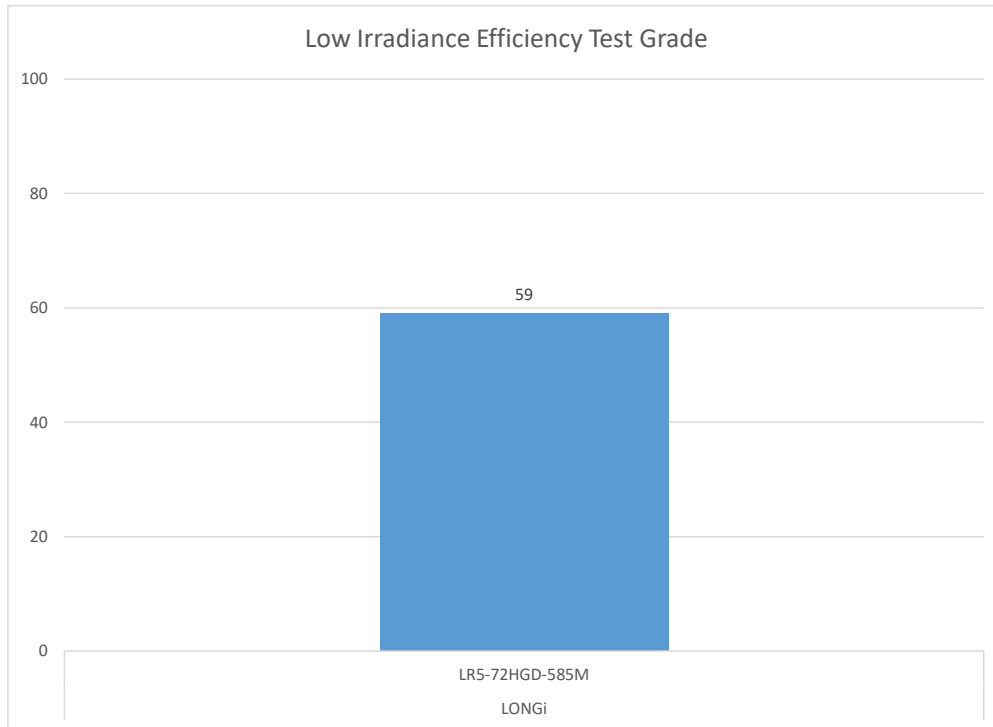


Figure 4 Low irradiance test result



### 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

LR5-72HGD-585M	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Pmax Temperature coefficient (%/°C)	-0.275%					105

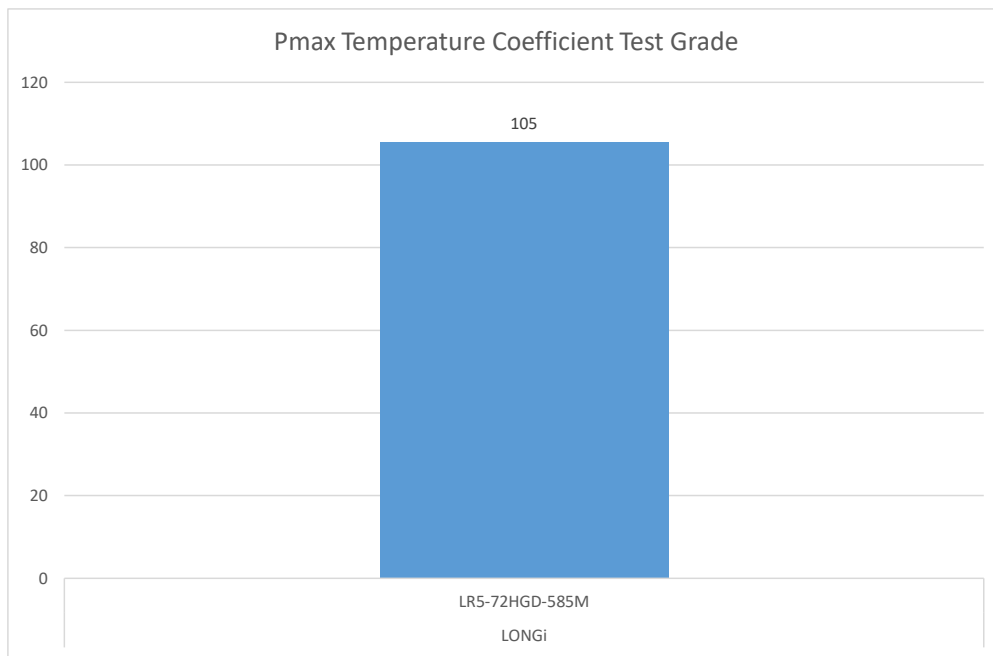


Figure 5 Pmax temperature coefficient test result

### 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

LR5-72HGD-585M	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side PID loss (%)		1.06%				86

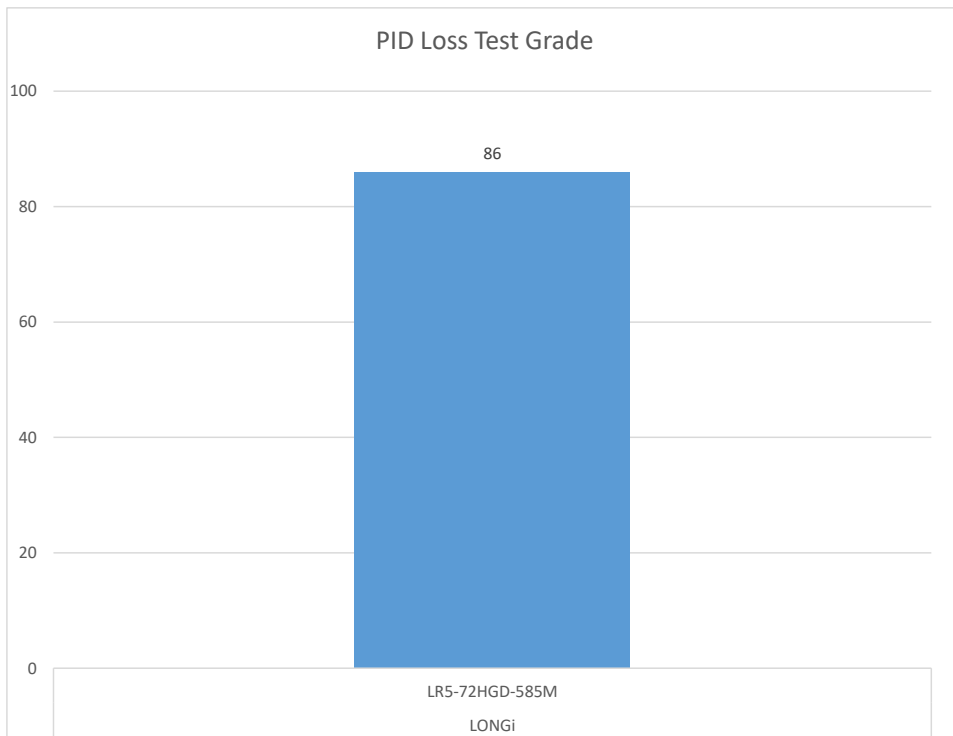


Figure 6 PID loss test result

3.6. LeTID loss test

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Table 101 and Figure 6 depicts the LeTID loss test results:

Table 11 LeTID loss test result

LR5-72HGD-585M	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side LeTID loss (%)						

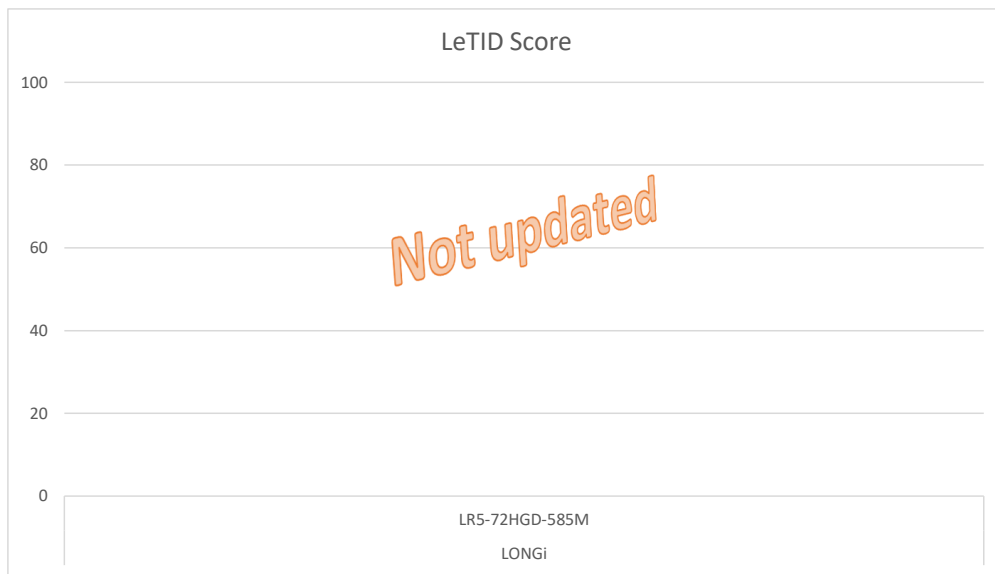


Figure 7 LeTID loss test result

### 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*

<b>LR5-72HGD-585M</b>	<b>Sample 1</b>	<b>Sample 2</b>	<b>Sample 3</b>	<b>Sample 4</b>	<b>Sample 5</b>	<b>Average</b>
Bifaciality ratio (%)	75.49%	76.15%	76.18%	76.29%	75.69%	75.96%

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.

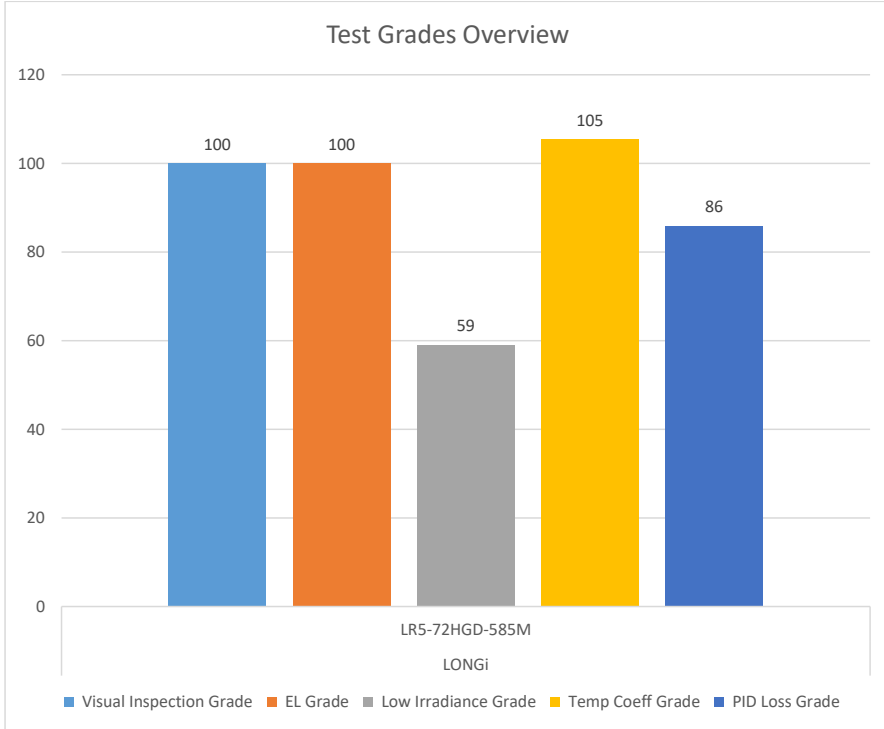


Figure 8 Test results overview

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

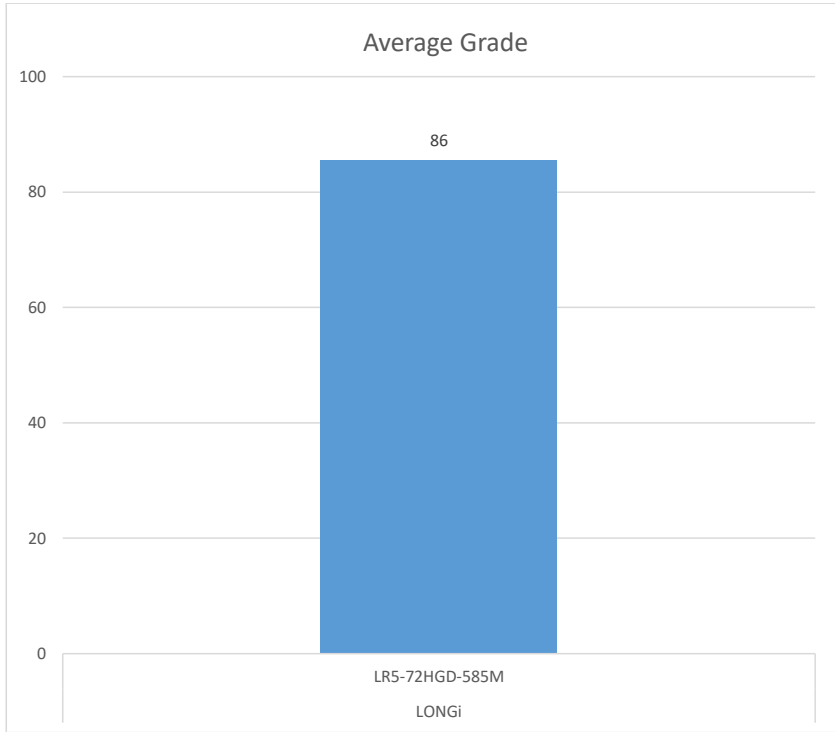


Figure 9 Average test grade

Appendix 1 – LR5-72HGD-585M Datasheet

# Hi-MO 7

## LR5-72HGD 560~590M

- High-performance PV modules for utility power plants
- Advanced HPDC cell technology delivers superior module efficiency and power
- High bifaciality and excellent power temperature coefficient achieves high energy yield
- LONGi lifecycle quality ensures long-term performance

 12-year Warranty for Materials and Processing

 30-year Warranty for Extra Linear Power Output

### Complete System and Product Certifications

IEC 61215, IEC 61730, UL 61730  
ISO9001:2015: ISO Quality Management System  
ISO14001:2015: ISO Environment Management System  
ISO45001:2018: Occupational Health and Safety  
IEC62941: Guideline for module design qualification and type approval

**LONGi**

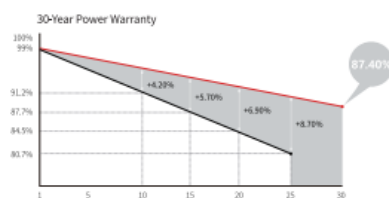


# Hi-MO 7

## LR5-72HGD 560~590M

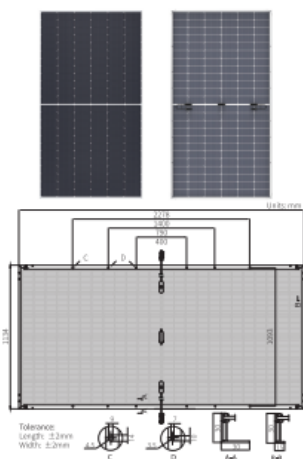
<b>22.8%</b> MAX MODULE EFFICIENCY	<b>0~3%</b> POWER TOLERANCE	<b>&lt;1%</b> FIRST YEAR POWER DEGRADATION	<b>0.4%</b> YEAR 2-30 POWER DEGRADATION	<b>HALF-CELL</b> Lower operating temperature
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### Additional Value



### Mechanical Parameters

Cell Orientation	144 (6x24)
Junction Box	IP68, three diodes
Output Cable	4mm <sup>2</sup> , +400, -200mm/±1400mm length can be customized
Glass	Dual glass, 2.0+2.0mm heat strengthened glass
Frame	Anodized aluminum alloy frame
Weight	31.8kg
Dimension	2278 x 1134 x 30mm
Packaging	36pcs per pallet / 180pcs per 20' GP / 720pcs per 40' HC



### Electrical Characteristics

Module Type	STC: AM1.5 1000W/m <sup>2</sup> 25°C				NOCT: AM1.5 800W/m <sup>2</sup> 20°C 1m/s				Test uncertainty for Pmax: ±3%					
	LR5-72HGD-560M	LR5-72HGD-565M	LR5-72HGD-570M	LR5-72HGD-575M	LR5-72HGD-580M	LR5-72HGD-585M	LR5-72HGD-590M							
Testing Condition	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT
Maximum Power (Pmax/W)	560	426.3	565	430.1	570	433.9	575	437.7	580	441.5	585	445.3	590	449.1
Open Circuit Voltage (Voc/V)	50.99	48.46	51.09	48.55	51.19	48.65	51.30	48.75	51.41	48.86	51.52	48.96	51.63	49.07
Short Circuit Current (Isc/A)	13.89	11.16	13.97	11.22	14.05	11.29	14.14	11.35	14.22	11.42	14.30	11.48	14.38	11.55
Voltage at Maximum Power (Vmp/V)	42.82	40.69	42.91	40.78	43.00	40.87	43.11	40.97	43.22	41.07	43.33	41.18	43.44	41.28
Current at Maximum Power (Imp/A)	13.08	10.48	13.17	10.55	13.26	10.62	13.34	10.68	13.42	10.75	13.51	10.82	13.59	10.89
Module Efficiency(%)	21.7		21.9		22.1		22.3		22.5		22.6		22.8	

### Electrical characteristics with different rear side power gain (reference to 575W front)

Pmax /W	Voc/V	Isc /A	Vmp/V	Imp /A	Pmax gain
604	51.30	14.84	43.11	14.00	9%
633	51.30	15.55	43.11	14.67	10%
661	51.40	16.26	43.21	15.34	15%
690	51.40	16.96	43.21	16.01	20%
719	51.40	17.67	43.21	16.67	25%

### Operating Parameters

Operational Temperature	-40°C ~ +85°C
Power Output Tolerance	0~3%
Maximum System Voltage	DC1500V (IEC/UL)
Maximum Series Fuse Rating	30A
Nominal Operating Cell Temperature	45±2°C
Protection Class	Class II
Bifaciality	80±5%
Fire Rating	UL type 29 IEC Class C

### Mechanical Loading

Front Side Maximum Static Loading	5400Pa
Rear Side Maximum Static Loading	2400Pa
Hailstone Test	25mm Hailstone at the speed of 23m/s

### Temperature Ratings (STC)

Temperature Coefficient of Isc	+0.04%/°C
Temperature Coefficient of Voc	-0.230%/°C
Temperature Coefficient of Pmax	-0.280%/°C



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