

## CEA | 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.

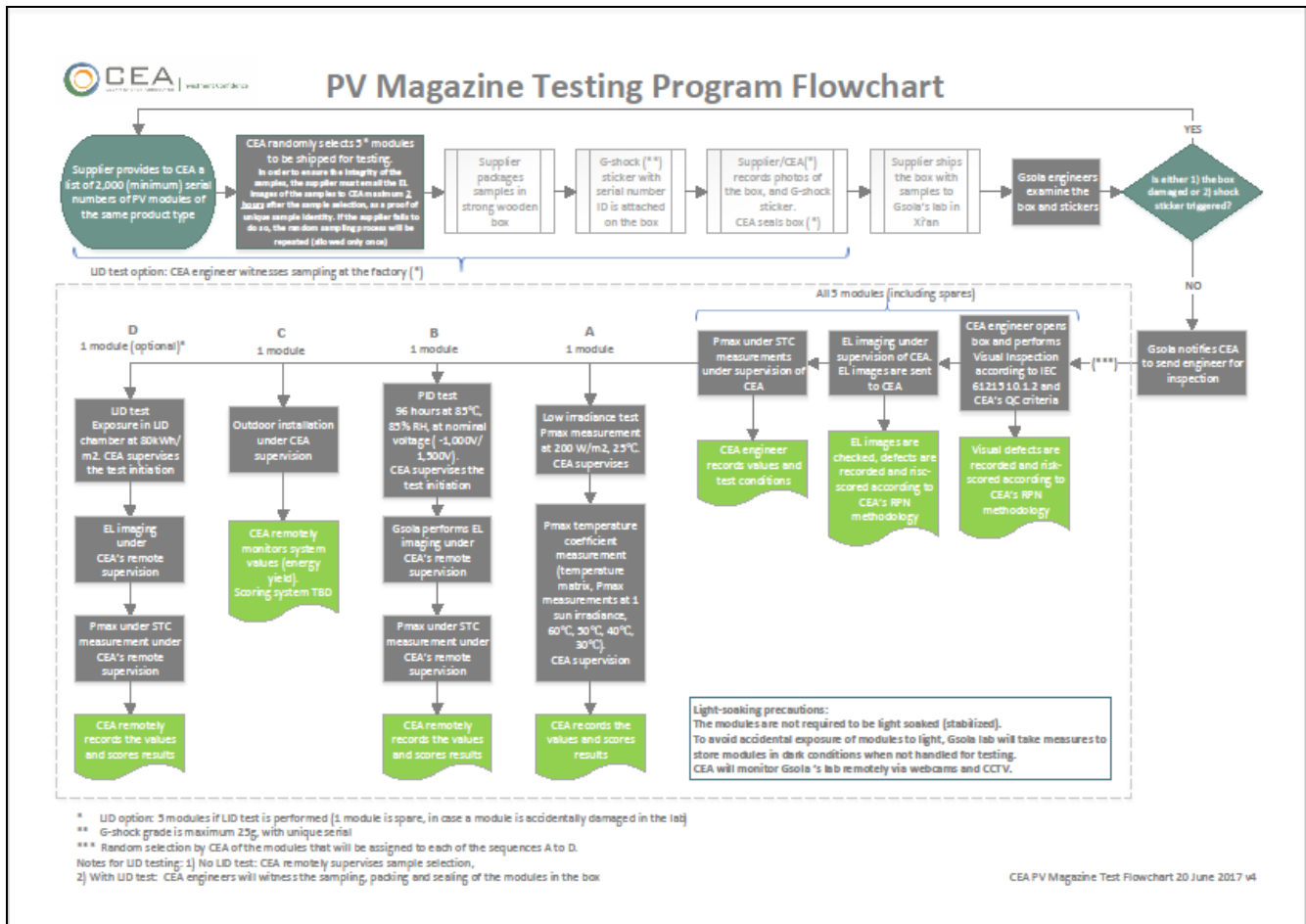


Figure 1 Test flowchart

## 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	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%

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.

### 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	Lab code
1	LRR504039190608400970	PVT190715A-01
2	LRR504039190608400901	PVT190715A-02
3	LRR504039190608401146	PVT190715A-03
4	LRR504039190608401412	PVT190715A-04
5	LRR504039190608401185	PVT190715A-05

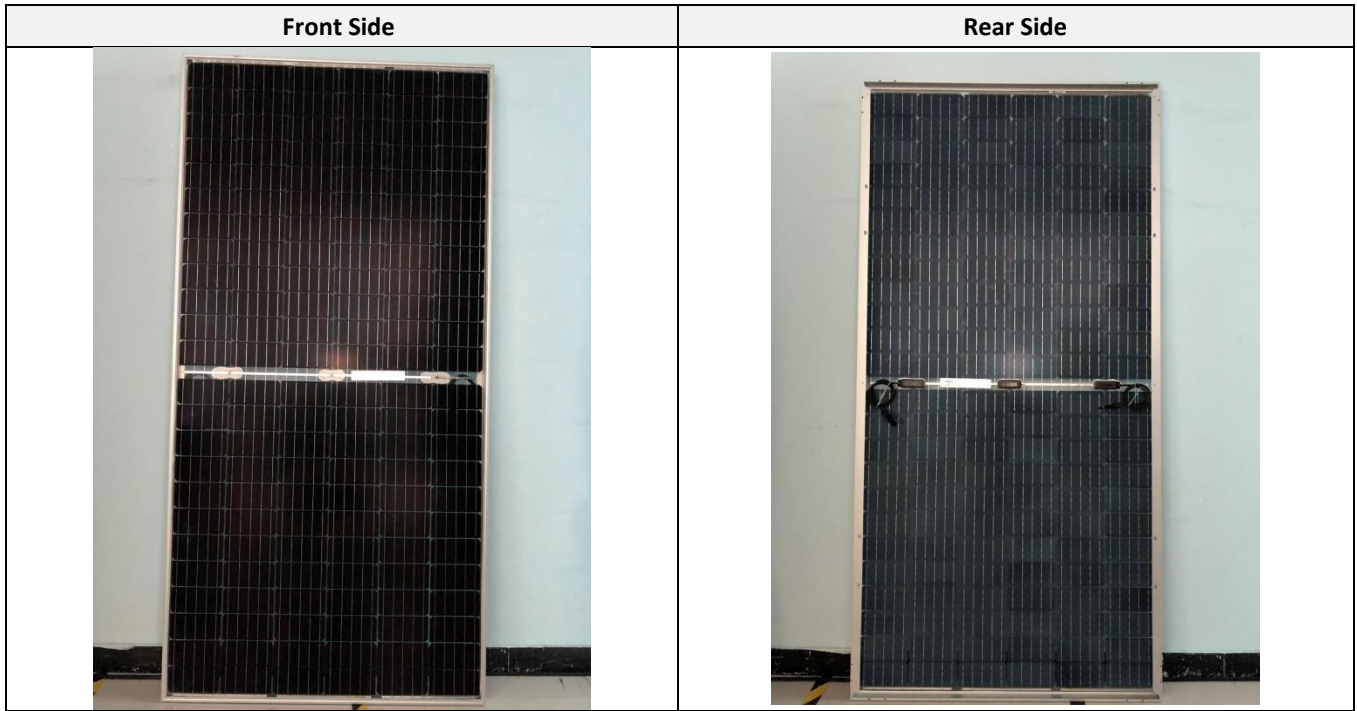
*Table 4 Product information*

Model	LR6-72HPD375
Cell technology	Bifacial Mono PERC
Cell number	144 (6 x 24)
Cell format	Half cut
Number of busbars	5
Junction box	IP67 rated
Laminate construction	Framed

#### 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 x 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

LR6-72HPD375	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 2.

Table 7 EL image inspection results

LR6-72HPD375	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Score	Grade
EL image inspection	None	None	None	None	None	0	100

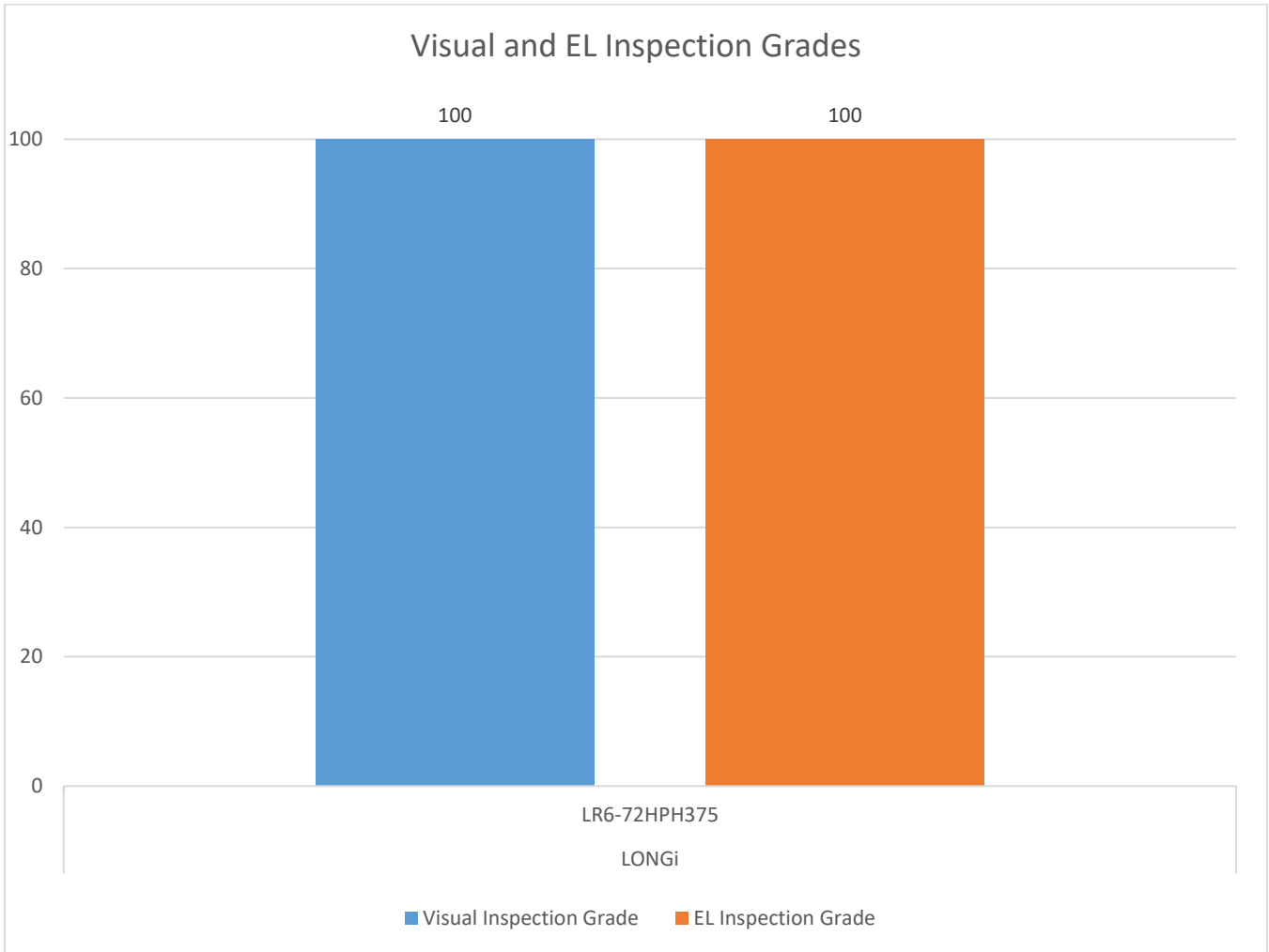


Figure 2 Visual and EL inspection results

### 3.3. Low irradiance efficiency loss test

The efficiency loss is calculated by the following formula:

$$\text{Efficiency loss} = 1 - \left[ \left( \frac{\text{Pmax at low irradiance conditions}}{\text{Pmax at STC}} \right) * \left( \frac{1,000}{200} \right) \right]$$

Table 8 and Figure 3 show the low irradiance efficiency test results for the front side.

Table 8 Low irradiance test results

LR6-72HPD375	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side low irradiance efficiency loss (%)	4.30%					64

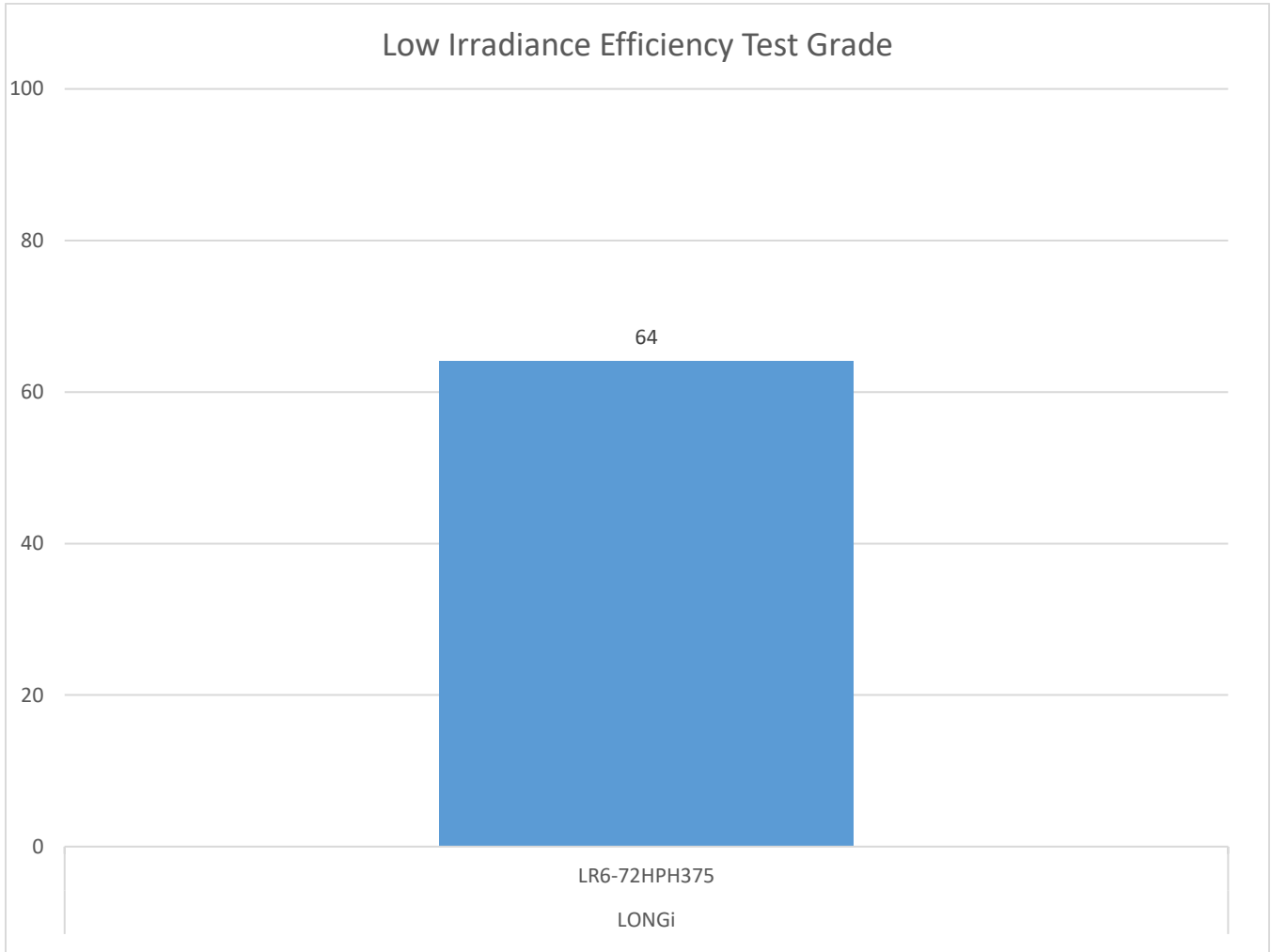


Figure 3 Low irradiance test result



### 3.4. Pmax temperature coefficient test

Table 9 and Figure 4 depict the Pmax temperature coefficient test results.

Table 9 Pmax temperature coefficient test result

LR6-72HPD375	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Pmax Temperature coefficient (%/°C)	-0.39%					77

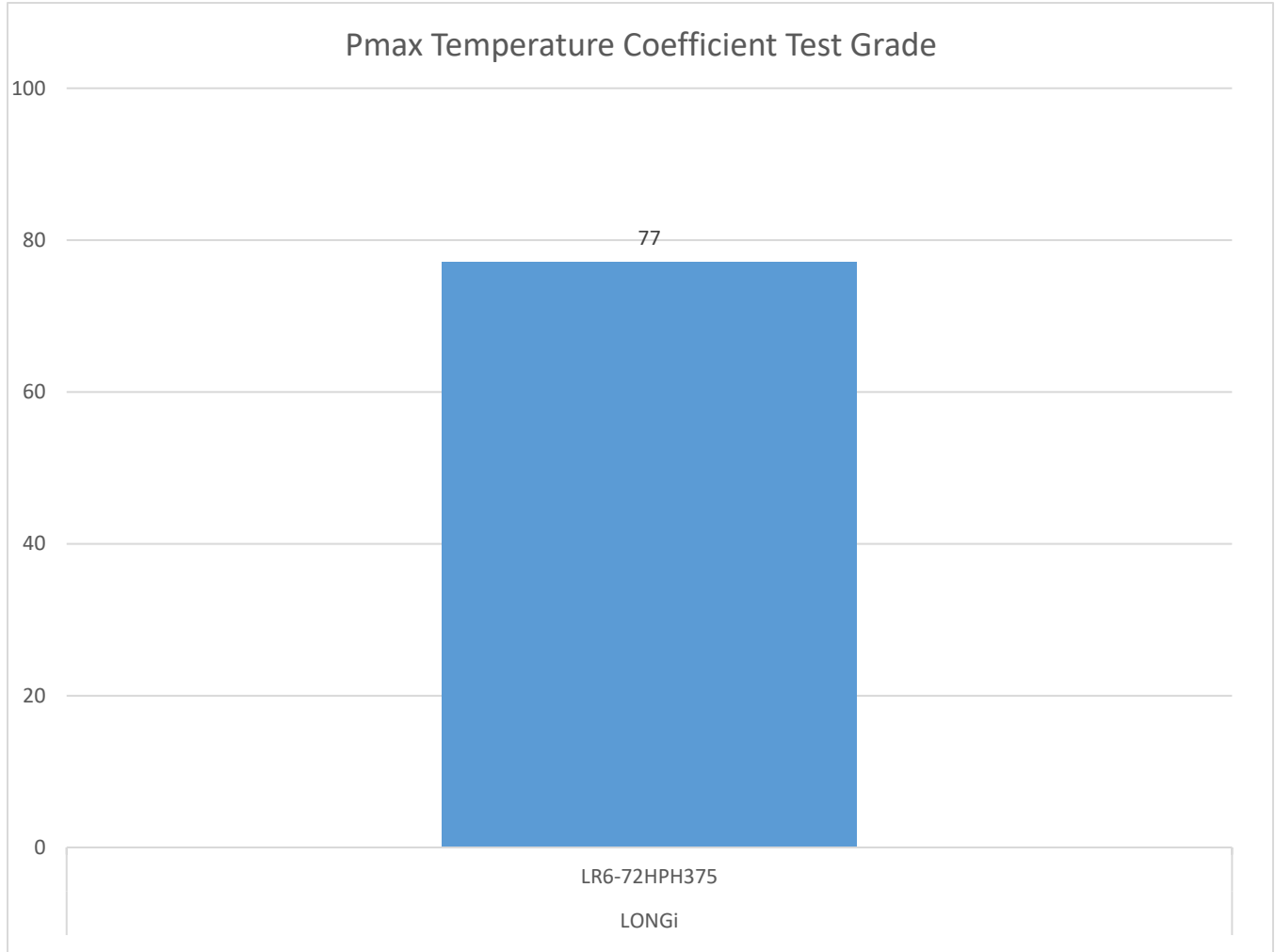


Figure 4 Pmax temperature coefficient test result

### 3.5. PID loss test

Table 10 and Figure 5 depicts the PID loss test results for the front side at 1500 V:

Table 10 PID loss test result

LR6-72HPD375	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side PID loss (%)		0.38%				94

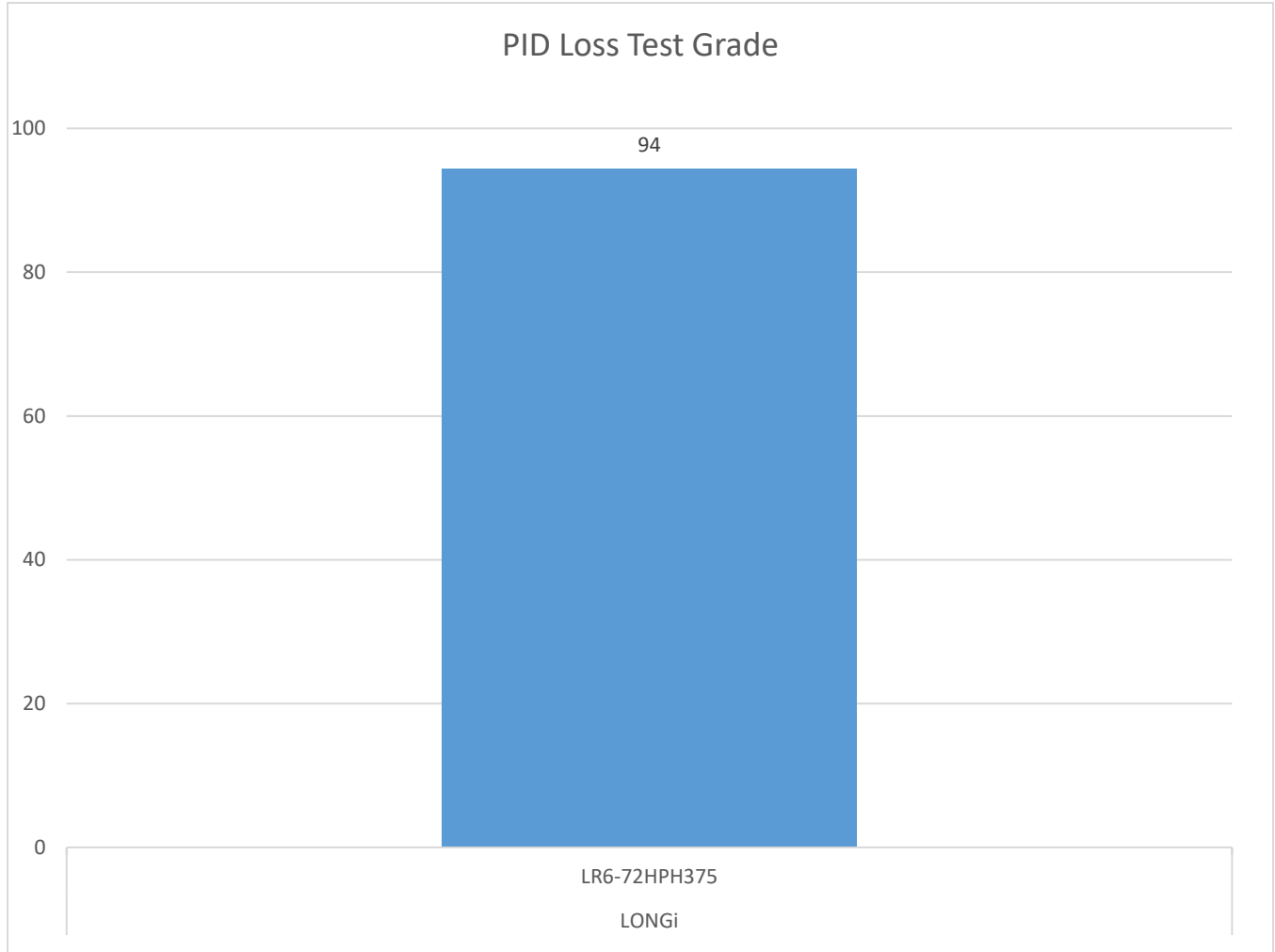


Figure 5 PID loss test result

### 3.6. Score overview

Figure 6 shows the overview of the test scores. Figure 7 shows the average score.

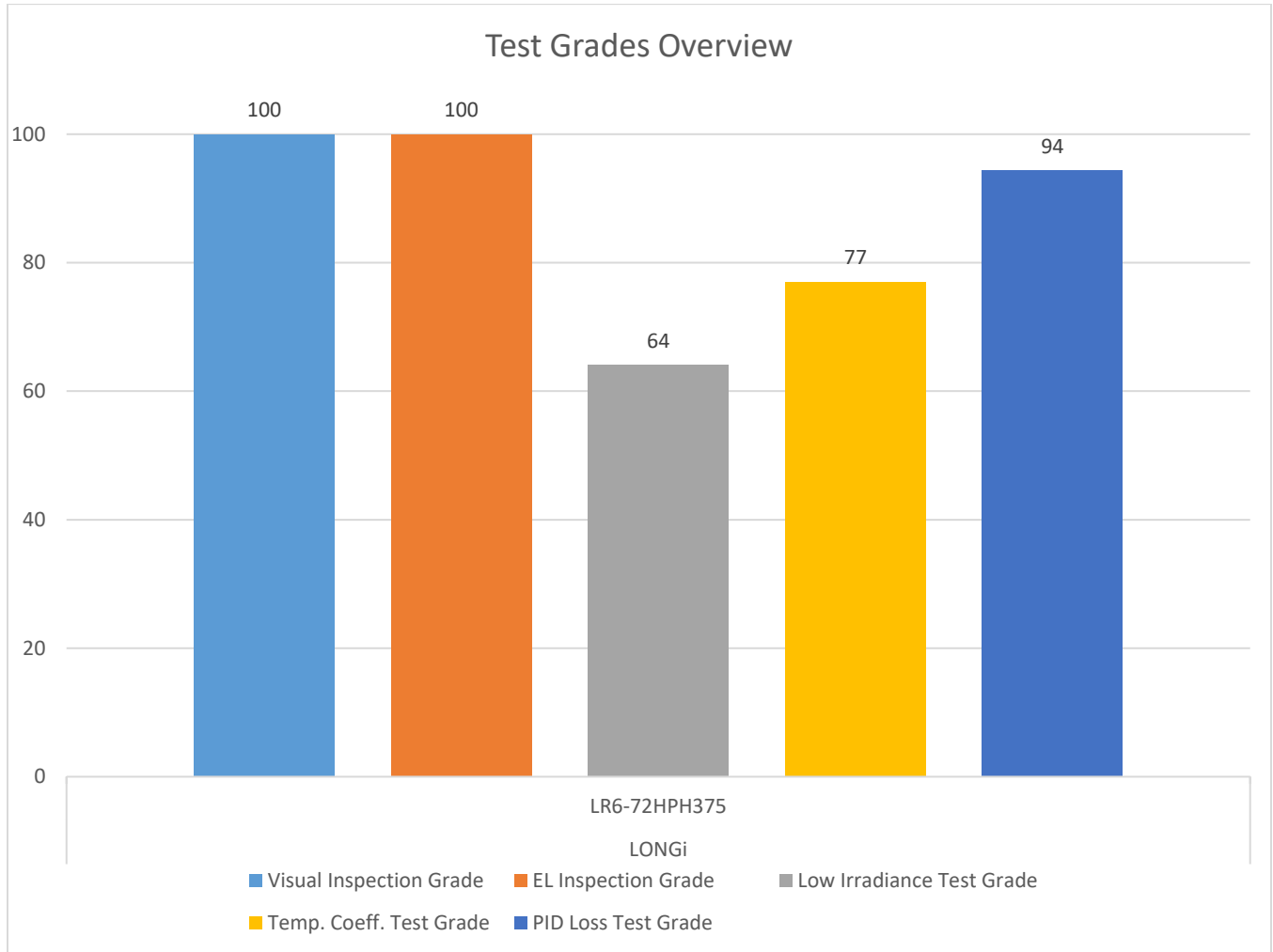


Figure 6 Test results overview

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

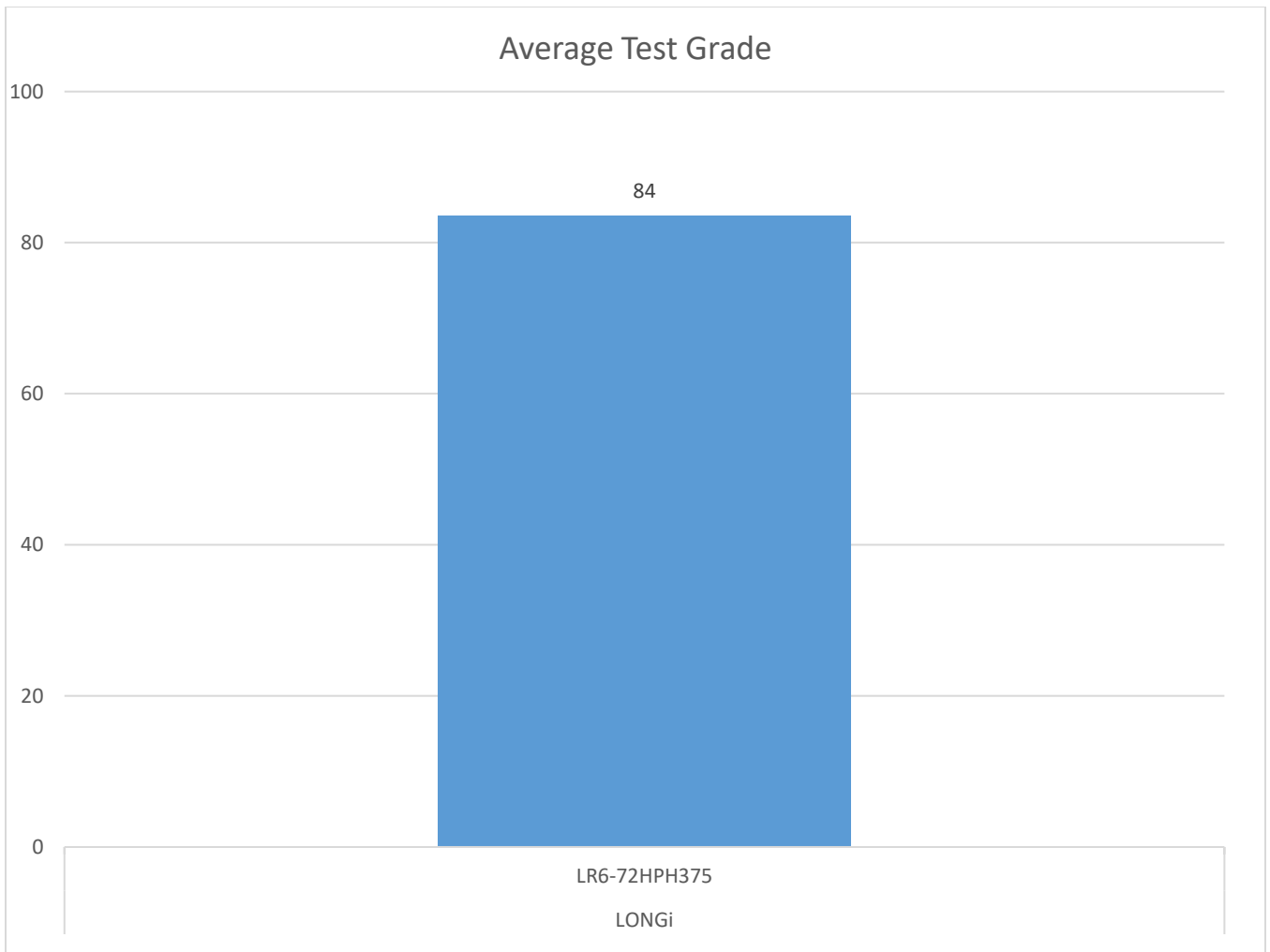
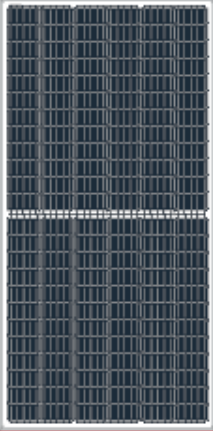


Figure 7 Average test grade

Appendix 1 - LR6-72HBD Datasheet

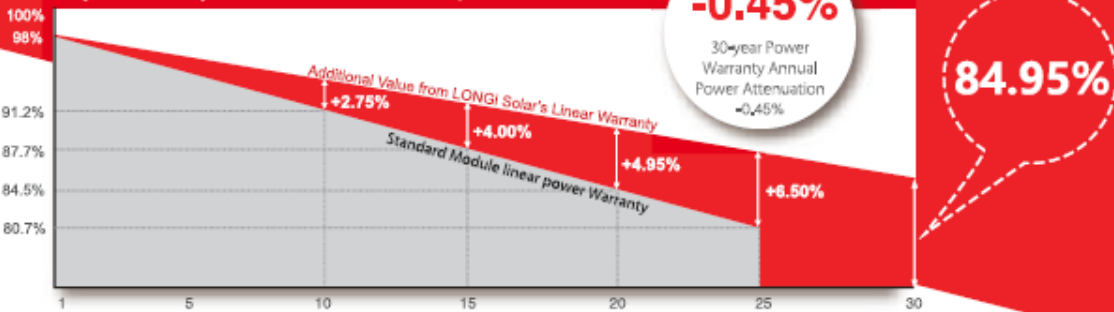


# LR6-72HBD

## 360~380M

**High Efficiency**  
**Low LID Bifacial PERC with**  
**Half-cut Technology**

**10-year Warranty for Materials and Processing;**  
**30-year Warranty for Extra Linear Power Output**



Year	Standard Module linear power Warranty (%)	Additional Value from LONGI Solar's Linear Warranty (%)
1	98.0	98.0
5	96.5	96.5
10	95.0	97.75
15	93.5	97.75
20	92.0	97.75
25	90.5	97.75
30	89.0	97.75

**Complete System and Product Certifications**

- IEC 61215, IEC61730, UL1703
- ISO 9001:2008: ISO Quality Management System
- ISO 14001: 2004: ISO Environment Management System
- TS62941: Guide line for module design qualification and type approval
- OHSAS 18001: 2007 Occupational Health and Safety



\* Specifications subject to technical changes and improvements. LONGI Solar reserves the right of interpretation.

**Front side performance equivalent to conventional low LID mono PERC:**

- High module conversion efficiency (up to 18.9%)
- Better energy yield with excellent low irradiance performance and temperature coefficient
- First year power degradation <2%

**Bifacial technology** enables additional energy harvesting from rear side (up to 25%)

**Glass/glass lamination** ensures 30 year product lifetime, with annual power degradation < 0.45%, 1500V compatible to reduce BOS cost

**40mm frame design** enables easy installation and robust mechanical strength

**Solid PID resistance** ensured by solar cell process optimization and careful module BOM selection

**Reduced resistive loss** with lower operating current

**Higher energy yield** with lower operating temperature

**Reduced hot spot risk** with optimized electrical design and lower operating current



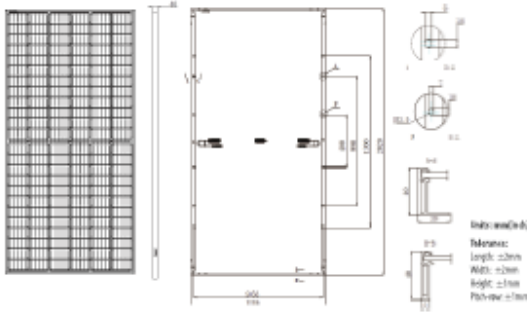
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# LR6-72HBD 360~380M

## Design (mm)



## Mechanical Parameters

Cell Orientation: 144 (6x24)  
 Junction Box: IP67, three diodes  
 Output Cable: 4mm<sup>2</sup>, 300mm in length,  
 length can be customized  
 Glass: 2.0mm coated tempered glass  
 Weight: 26.5kg  
 Dimension: 2020x996x40mm  
 Packaging: 26pcs per pallet  
 130pcs per 20GP  
 572pcs per 40HC

## Operating Parameters

Operational Temperature: -40°C ~ +85°C  
 Power Output Tolerance: 0 ~ +5 W  
 Voc and Isc Tolerance: ±3%  
 Maximum System Voltage: DC1500V (IEC&UL)  
 Maximum Series Fuse Rating: 20A  
 Nominal Operating Cell Temperature: 45±2°C  
 Safety Class: Class II  
 Fire Rating: UL type 6  
 Bifaciality: ≥75%

## Electrical Characteristics

Test uncertainty for Pmax: ±3%

Model Number	LR6-72HBD-360M		LR6-72HBD-365M		LR6-72HBD-370M		LR6-72HBD-375M		LR6-72HBD-380M	
	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT
Maximum Power (Pmax/W)	360	267.7	365	271.4	370	275.1	375	278.8	380	282.6
Open Circuit Voltage (Voc/V)	47.7	44.4	47.9	44.6	48.1	44.8	48.3	45.0	48.5	45.2
Short Circuit Current (Isc/A)	9.64	7.80	9.72	7.87	9.80	7.93	9.87	7.99	9.97	8.07
Voltage at Maximum Power (Vmp/V)	39.4	36.6	39.6	36.8	39.8	36.9	40.0	37.1	40.2	37.3
Current at Maximum Power (Imp/A)	9.14	7.32	9.22	7.38	9.30	7.45	9.38	7.51	9.47	7.59
Module Efficiency(%)	17.9		18.1		18.4		18.6		18.9	

STC (Standard Testing Conditions): Irradiance 1000W/m<sup>2</sup>, Cell Temperature 25°C, Spectra at AM1.5

NOCT (Nominal Operating Cell Temperature): Irradiance 800W/m<sup>2</sup>, Ambient Temperature 20°C, Spectra at AM1.5, Wind at 1m/s

Electrical characteristics with different rear side power gain (reference to 370W front)

Pmax /W	Voc/V	Isc /A	Vmp/V	Imp /A	Pmax gain
389	48.1	10.29	39.8	9.76	5%
407	48.1	10.77	39.8	10.23	10%
426	48.2	11.26	39.9	10.69	15%
444	48.2	11.75	39.9	11.16	20%
463	48.2	12.24	39.9	11.62	25%

## Temperature Ratings ( STC )

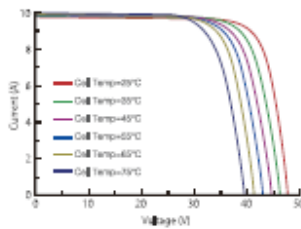
Temperature Coefficient of Isc	+0.060%/°C
Temperature Coefficient of Voc	-0.300%/°C
Temperature Coefficient of Pmax	-0.370%/°C

## Mechanical Loading

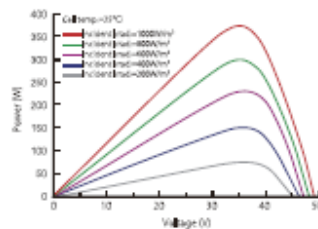
Front Side Maximum Static Loading	5400Pa
Rear Side Maximum Static Loading	2400Pa
Hailstone Test	25mm Hailstone at the speed of 23m/s

## I-V Curve

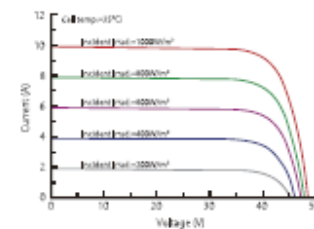
Current-Voltage Curve (LR6-72HBD-370M)



Power-Voltage Curve (LR6-72HBD-370M)



Current-Voltage Curve (LR6-72HBD-370M)



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