

# CEA | PV MAGAZINE TEST PROGRAM TEST REPORT

SUPPLIER | RECOM

Author: George Touloupas

Date: 9 October 2017

Version: V2.1



## TABLE OF CONTENTS

<b>1. INTRODUCTION .....</b>	<b>3</b>
<b>2. SCORING SYSTEM .....</b>	<b>3</b>
2.1. Test flowchart and protocol .....	3
2.2. Scoring methodology .....	4
<b>3. TEST RESULTS .....</b>	<b>5</b>
3.1. Visual inspection .....	5
3.2. EL image Inspection .....	6
3.3. Low irradiance efficiency loss .....	7
3.4. Pmax temperature coefficient .....	8
3.5. PID loss .....	9
3.6. Comparison charts and average grade .....	10

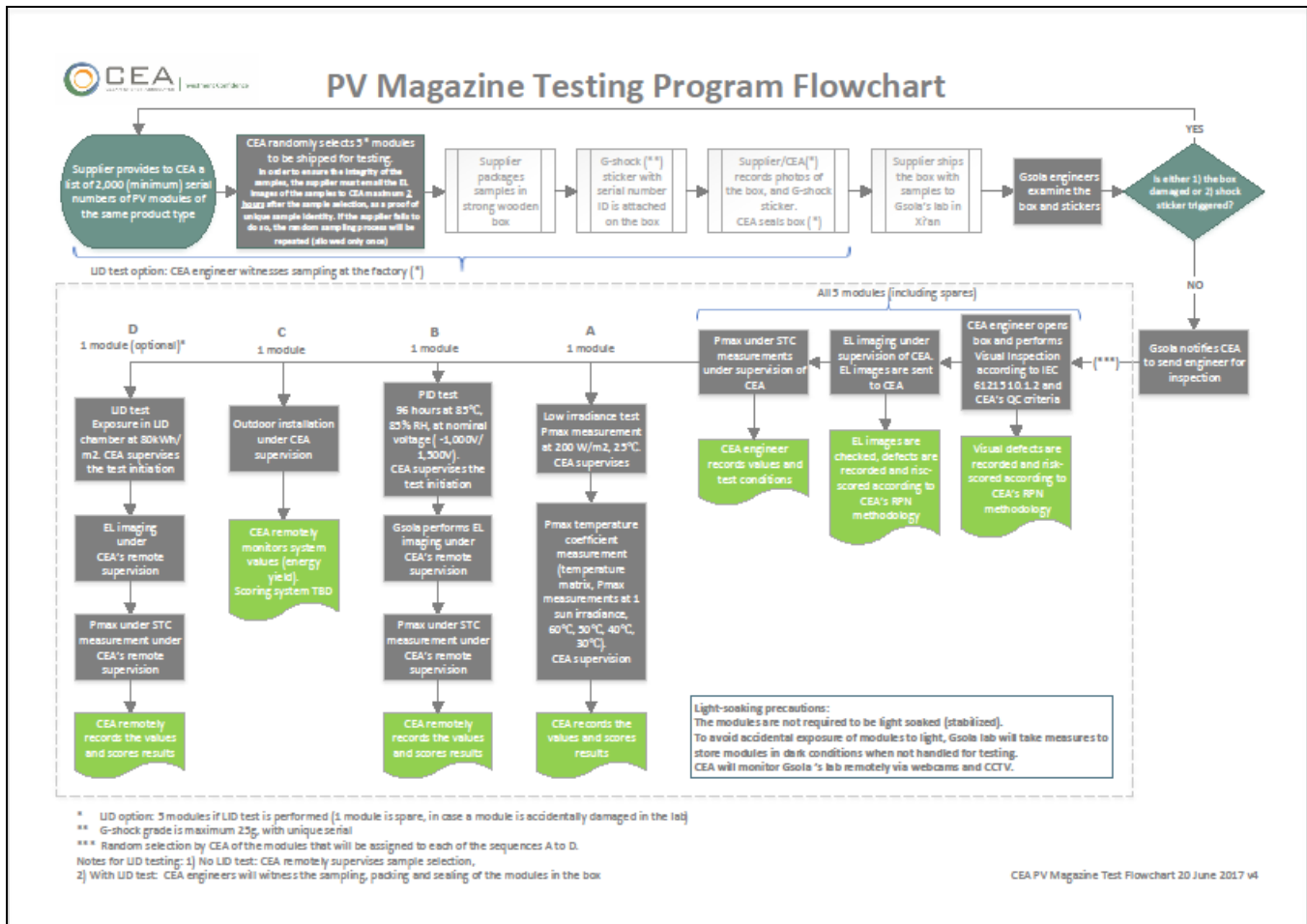
# 1. INTRODUCTION

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.



## 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:

	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 (under deployment)	1	Energy Yield Monitoring	NA	NA	Under development

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:

	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 above grading ranges are preliminary, and will be adjusted as the testing program develops, in order to better reflect the products standing per industry standards.

### 3. TEST RESULTS

The below tables and charts show the scoring of the tested product.

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.


#### 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, and any defect found has been scored 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  $RPN\ score = Severity \times Detectability$ .

The following table shows the Visual Inspection results, normalized for the number of tested modules:

Recom-RCM-275-6MB	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Score	Grade
Visual inspection	C3/Mi	B5/Mi	None	A3/Mi	None	4.6	69

Pictures of the defects:

Defect type	Sample	Defect description	Image
C3/Minor	Recom-RCM-275-6MB Sample 1	Scratch on glass	
B5/Minor	Recom-RCM-275-6MB Sample 2	Ribbon misalignment	

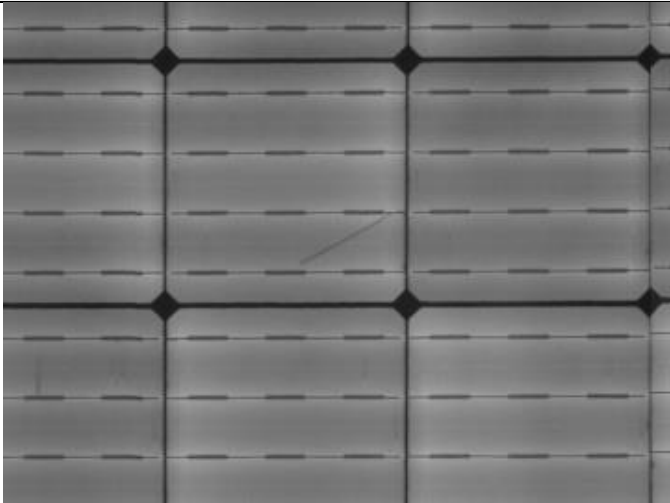
### 3.2. EL image Inspection

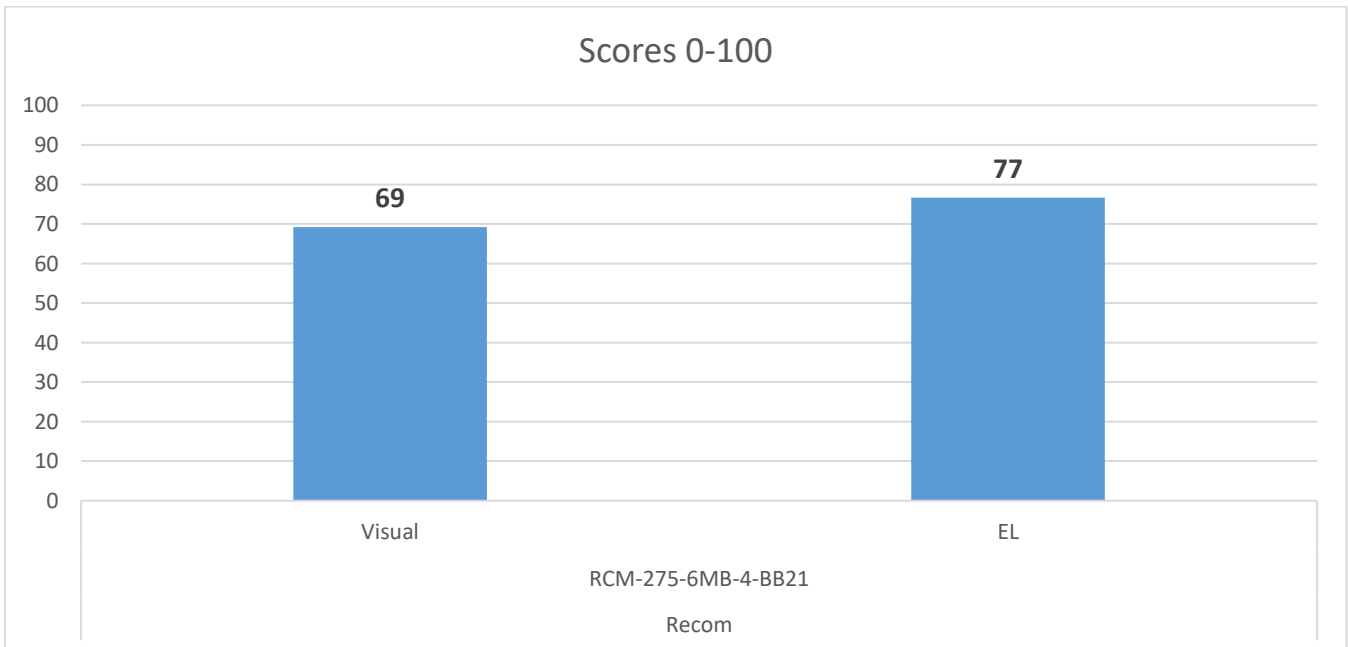
The same sample lot was inspected for EL defects. As an example, the following table shows the RPN score of Product RCM-275-6MB:

This table shows the EL scores and grades for the product:

Recom-RCM-275-6MB	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Score	Grade
EL image inspection	H2/Ma	None	None	None	None	5.6	77

Pictures of the defects:

Defect type	Sample	Defect description	Image
H2/Major	Recom-RCM-275-6MB Sample 1	Micro cracks	



### 3.3. Low irradiance efficiency loss

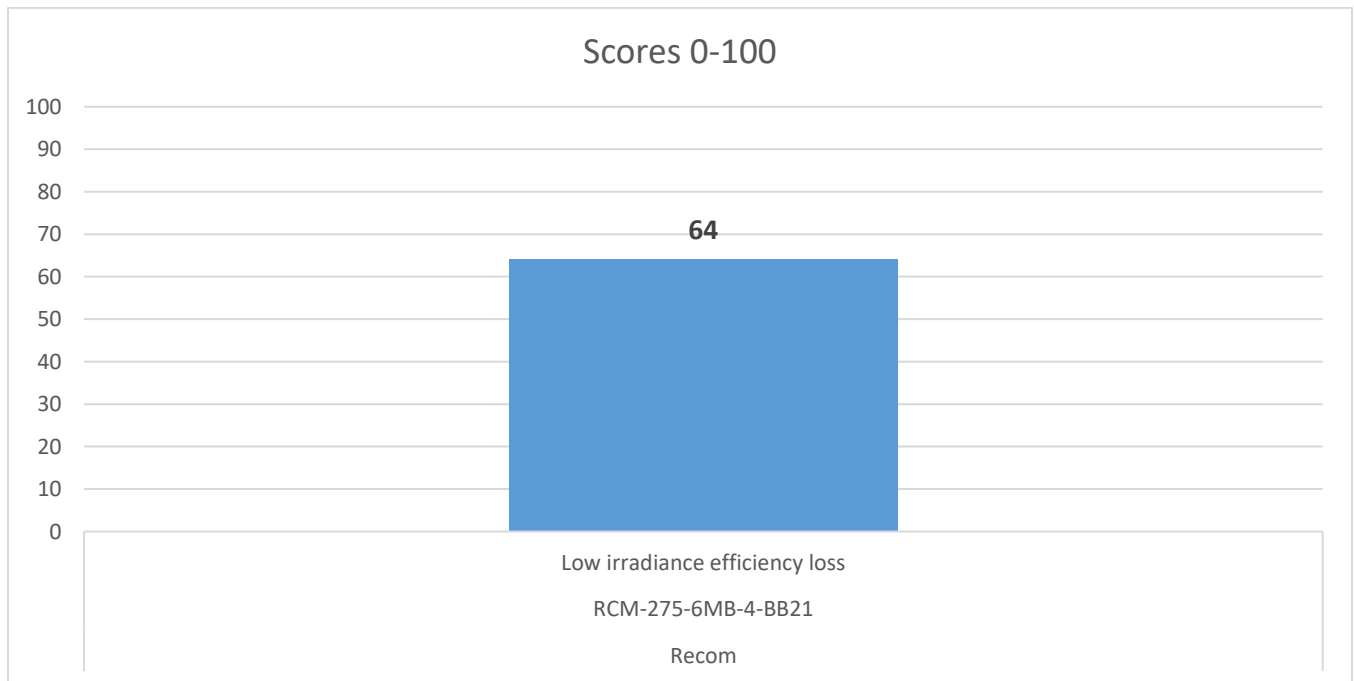
The table below depicts the low irradiance efficiency test results:

Recom-RCM-275-6MB	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Low irradiance efficiency loss (%)	4.29					64

The efficiency loss is calculated by the formula:

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

The chart below depicts the grade:

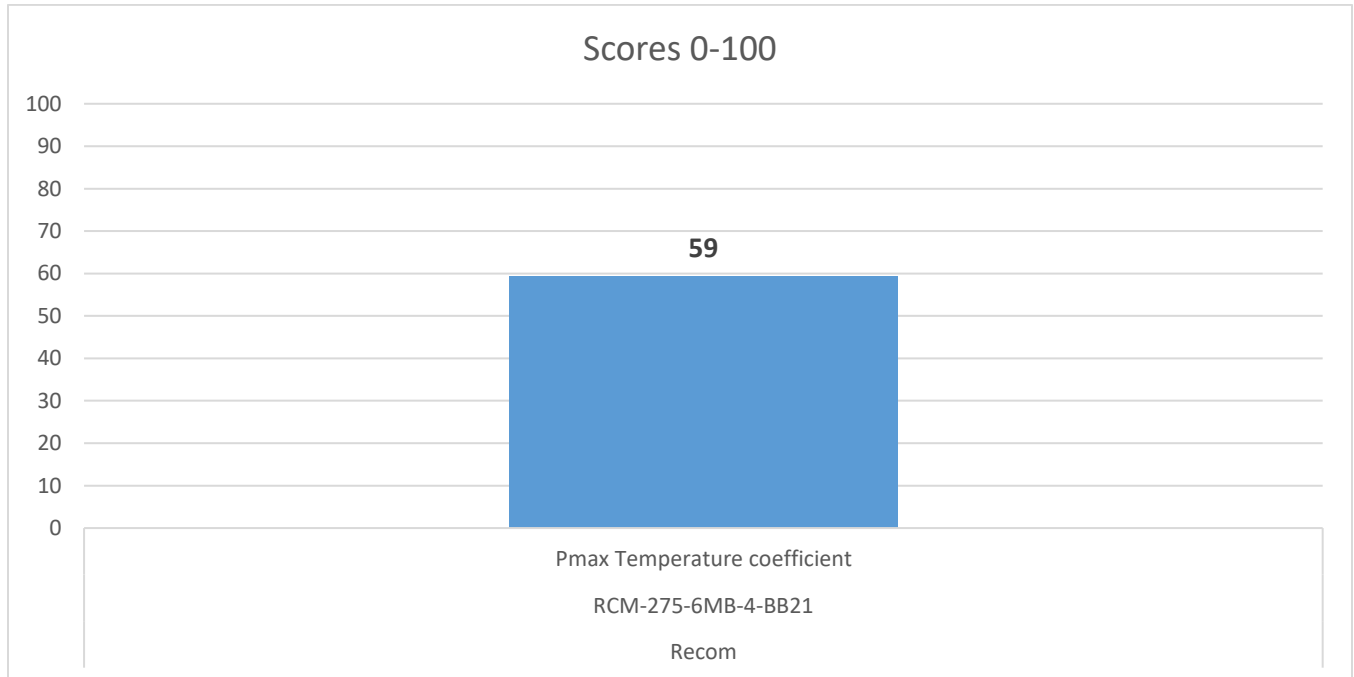


### 3.4. Pmax temperature coefficient

The table below depicts the Pmax temperature coefficient test results:

Recom-RCM-275-6MB	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Pmax Temperature coefficient (%/°C)	-0.45				-	59

The chart below depicts the grade:



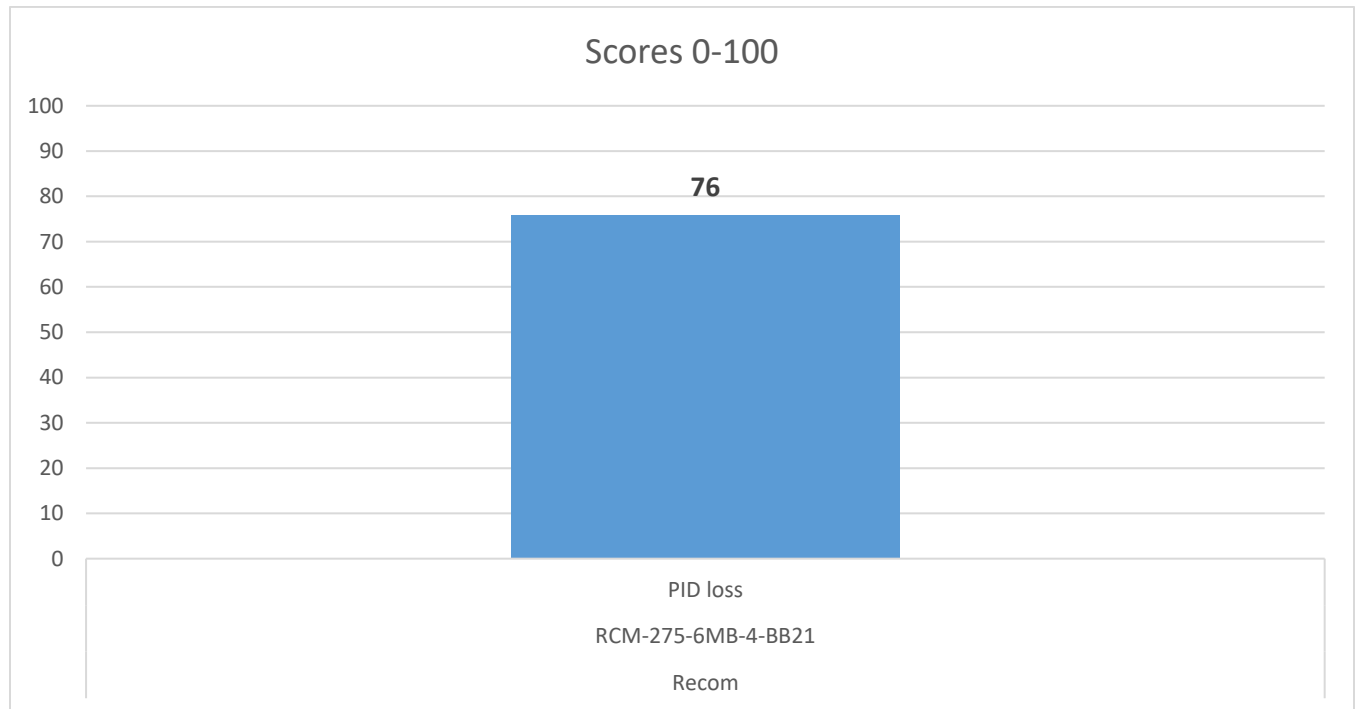


### 3.5. PID loss

The table below depicts the PID loss test results:

Recom-RCM-275-6MB	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
PID loss (%)		2.07				76

The chart below depicts the grade:



### 3.6. Comparison charts and average grade

