



The pv magazine/CEA/Gsola test program

The results so far: summary and observations

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Company Snapshot

- CEA is a solar PV advisory firm that is able to provide unrivaled insight into the manufacturing process to ensure the success of solar energy projects worldwide

More than

60 Employees

Over

35 Engineers

Over

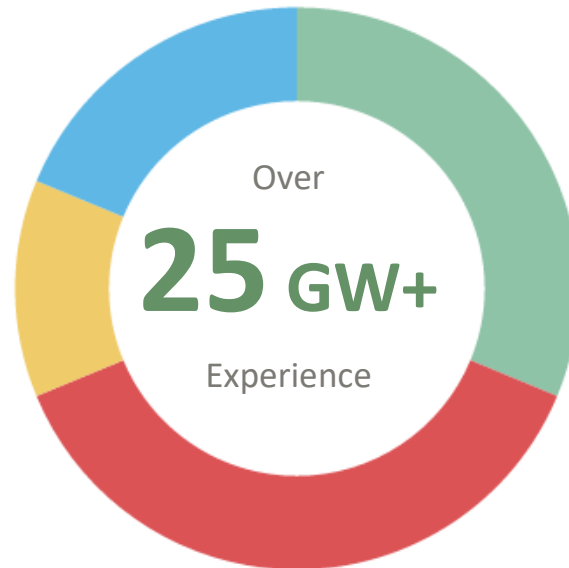
10 Years history

A presence in

10 Countries

Technical Advisory

Engineering Services



Supply Chain Management

Quality Assurance

Client engagements in

35+ Countries



Audited over

125+

Solar Factories
Worldwide



Certified by

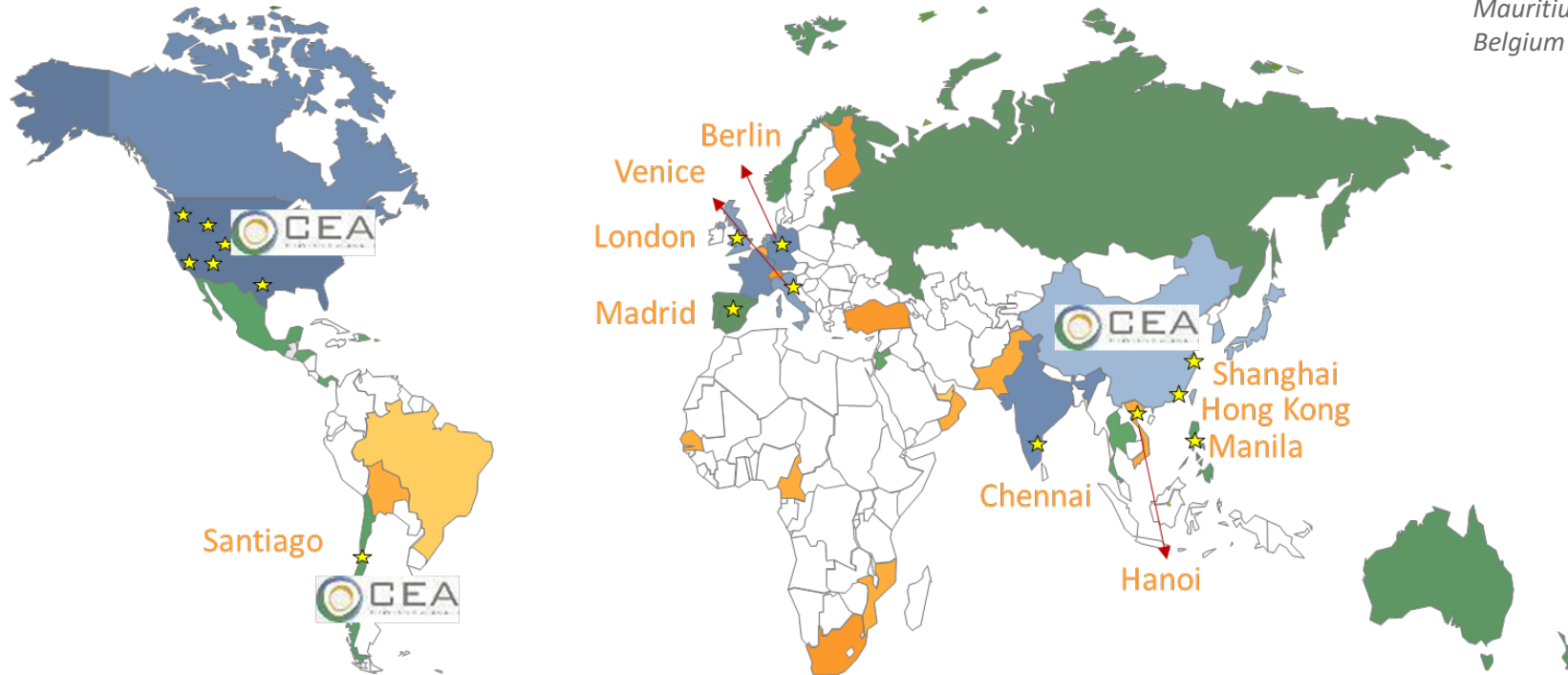
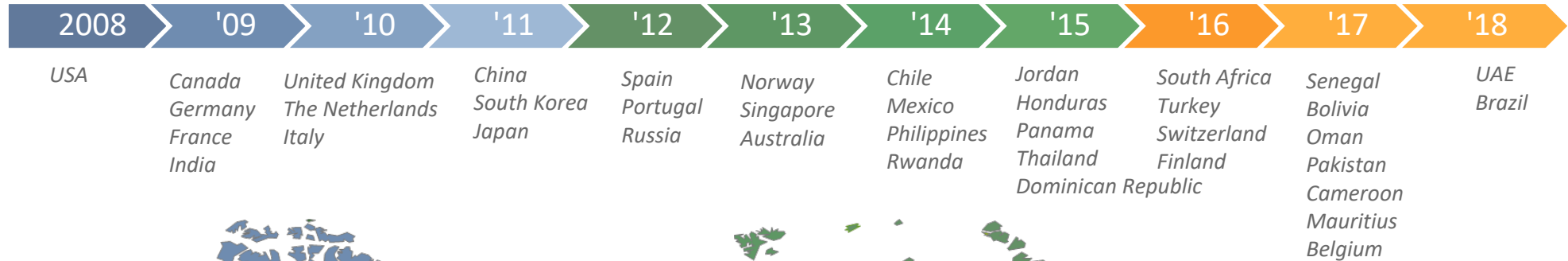


Proud member of



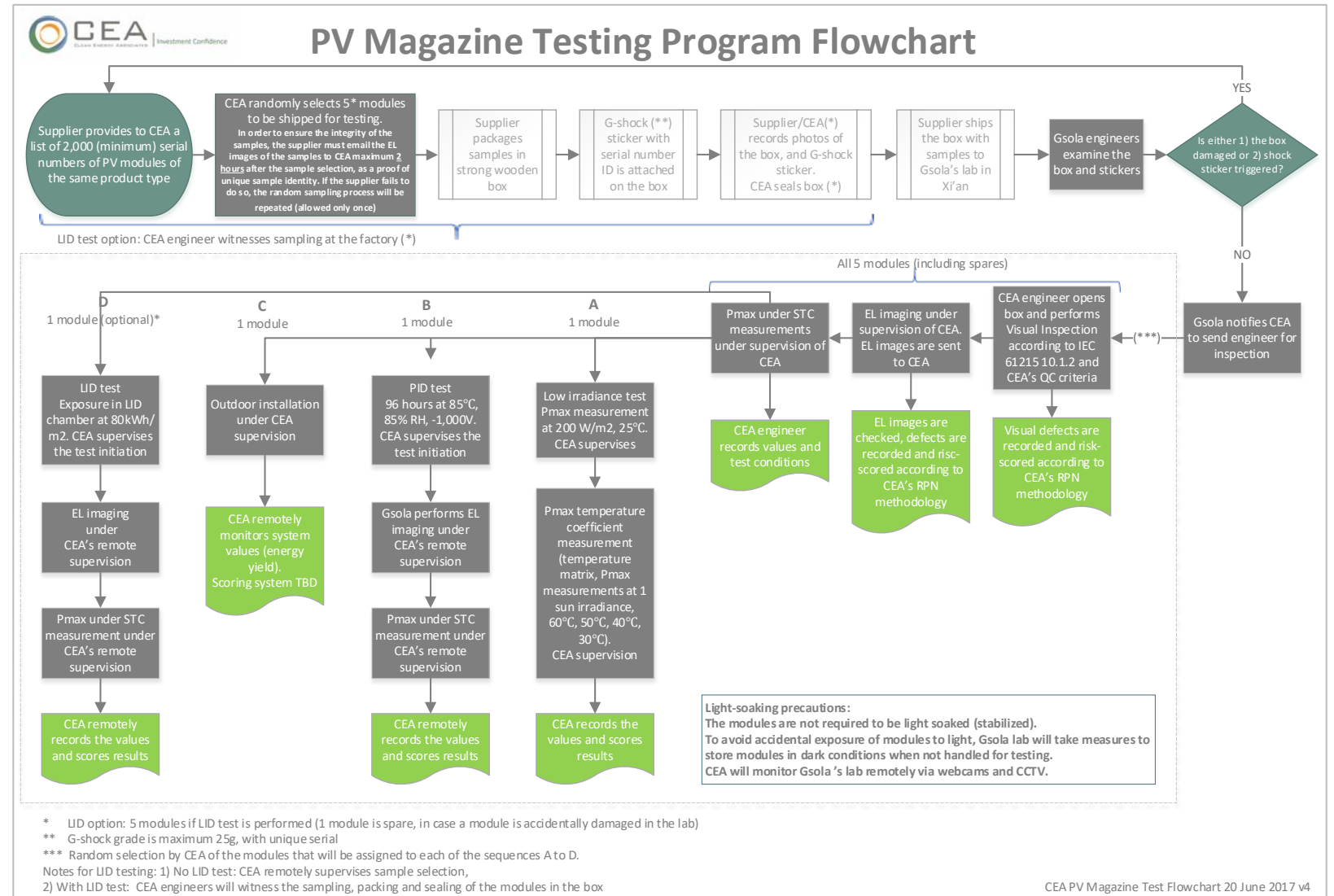
Global Footprint

- Since 2008, CEA has developed successful client engagements in 35+ countries and increased employee presence across 10 countries



A lighter approach to module testing

- The pv magazine test is not meant to replace certification or reliability testing.
- It has been designed to be executed in 1 week (apart from the outdoor performance test).
- At the same it must be relevant and useful to buyers and sellers.
- The test has been designed and is monitored and supervised by CEA.
- It takes place at Gsola's lab in Xi'an, China.



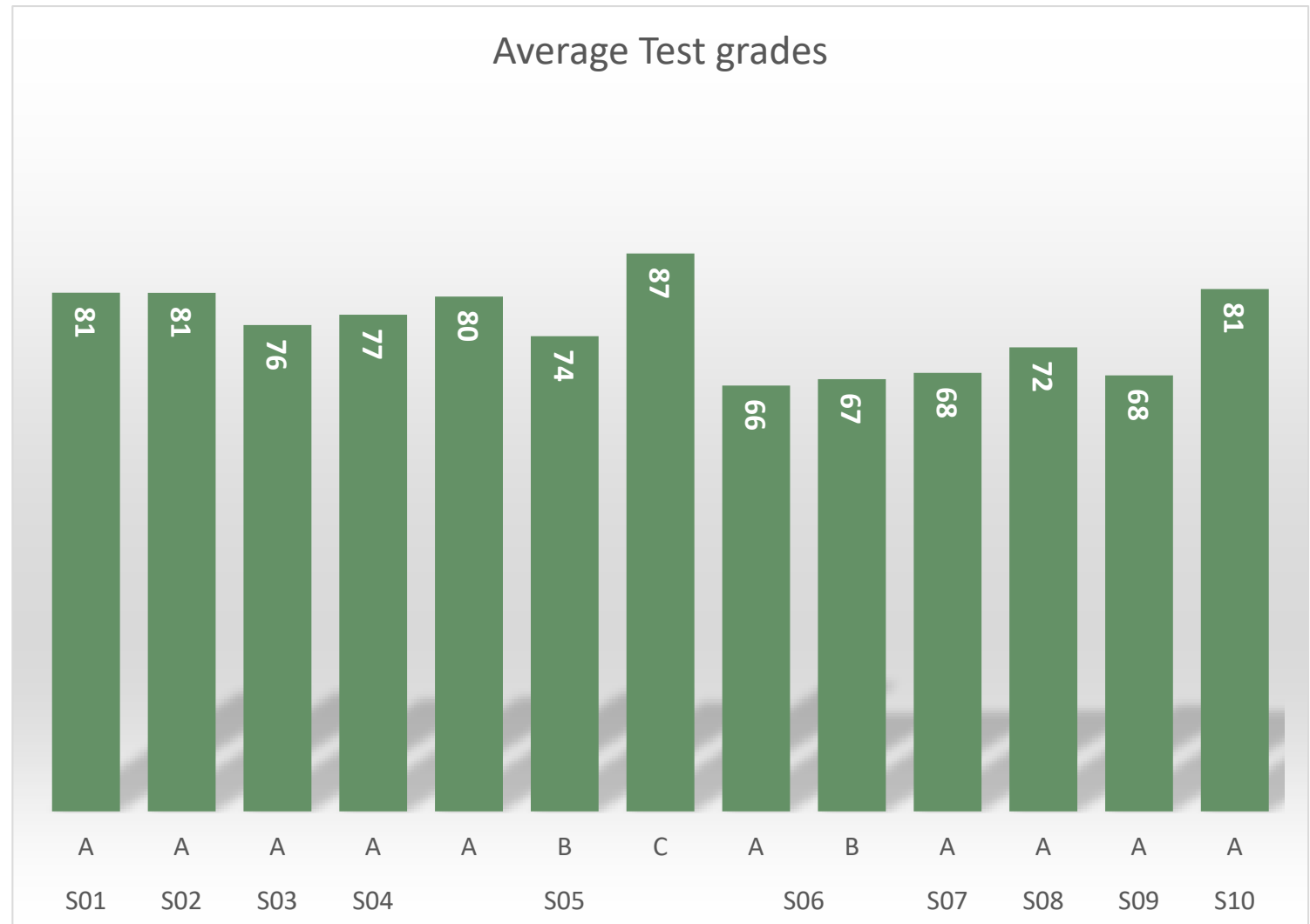
pv magazine test features

- **Benchmark testing**
Results are graded on a scale of 1-100
- **Product quality testing**
Visual inspection
EL inspection
- **Characterization testing**
Low Irradiance Loss
Power Temperature Coefficient
- **Reliability testing**
PID test
LID test (optional)
- **Energy Yield**
Outdoor energy yield performance

#	Test	Weight in average grade
1	Visual inspection	10%
2	EL image inspection	10%
3	Low irradiance efficiency loss	25%
4	Pmax temperature coefficient	25%
5	PID loss	30%
6	LID loss (optional)	Graded separately, not part of average grade
7	Outdoor energy yield	Graded separately

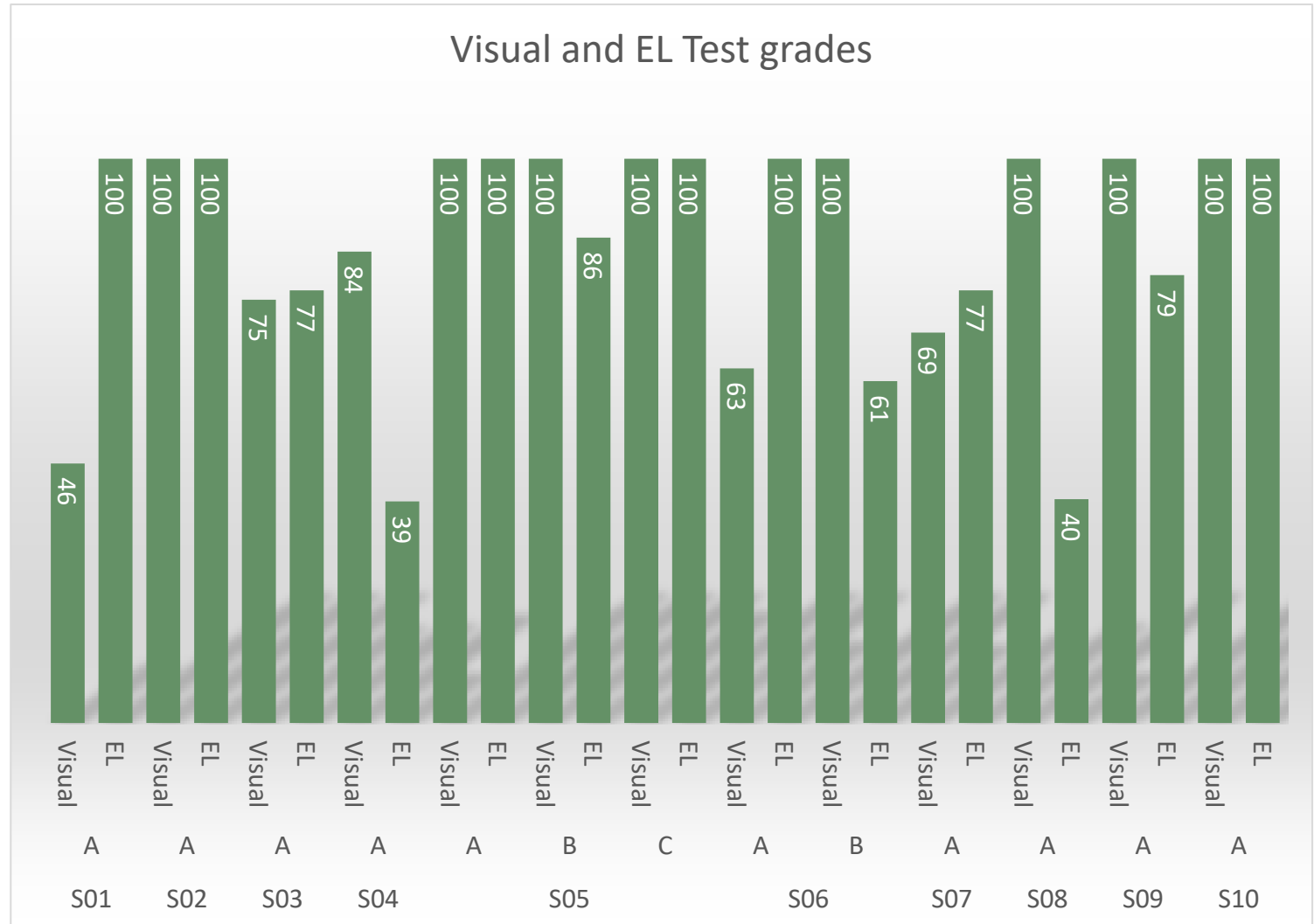
pv magazine test average grades

- 13 products from 10 manufacturers have been tested so far.
- Each test or inspection result is given a grade from 1-100.
- The grading system is detailed in the December 2017 issue of pv magazine.
- The average grade depicts the average performance of tests 1-5.
- LID, which is optional, and outdoor energy yield, will be benchmarked separately.



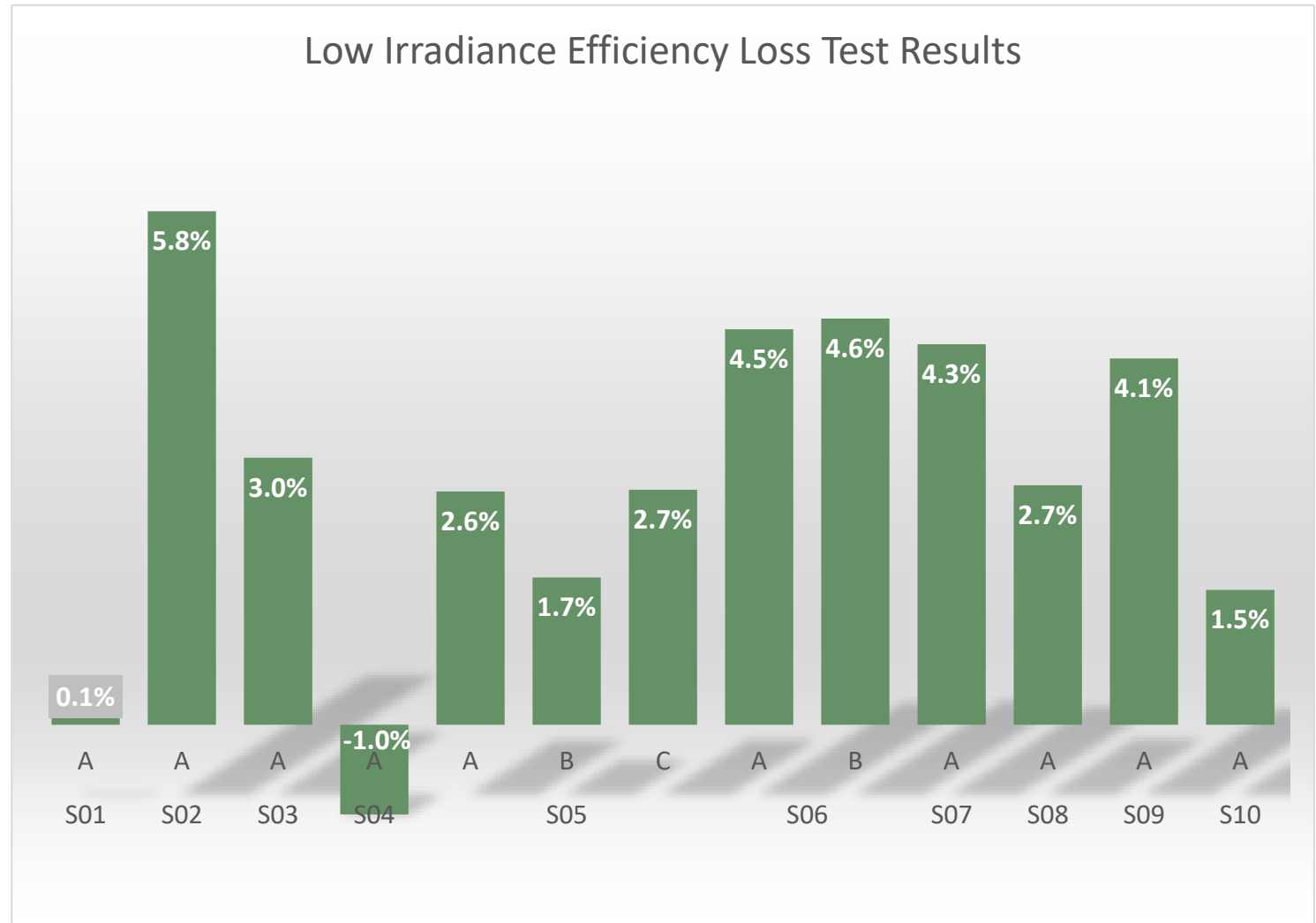
Visual and EL test grades

- Manufacturer S05, has submitted 3 products (A, B and C) for testing, and got very high grades in the total 6 visual and EL inspections: 5 times a perfect grade of 100 and 1 time a very high grade of 86.
- This shows a very good quality level in production, as there were very few defects.
- Random sampling from a large quantity ensures a level playing field for all manufacturers.



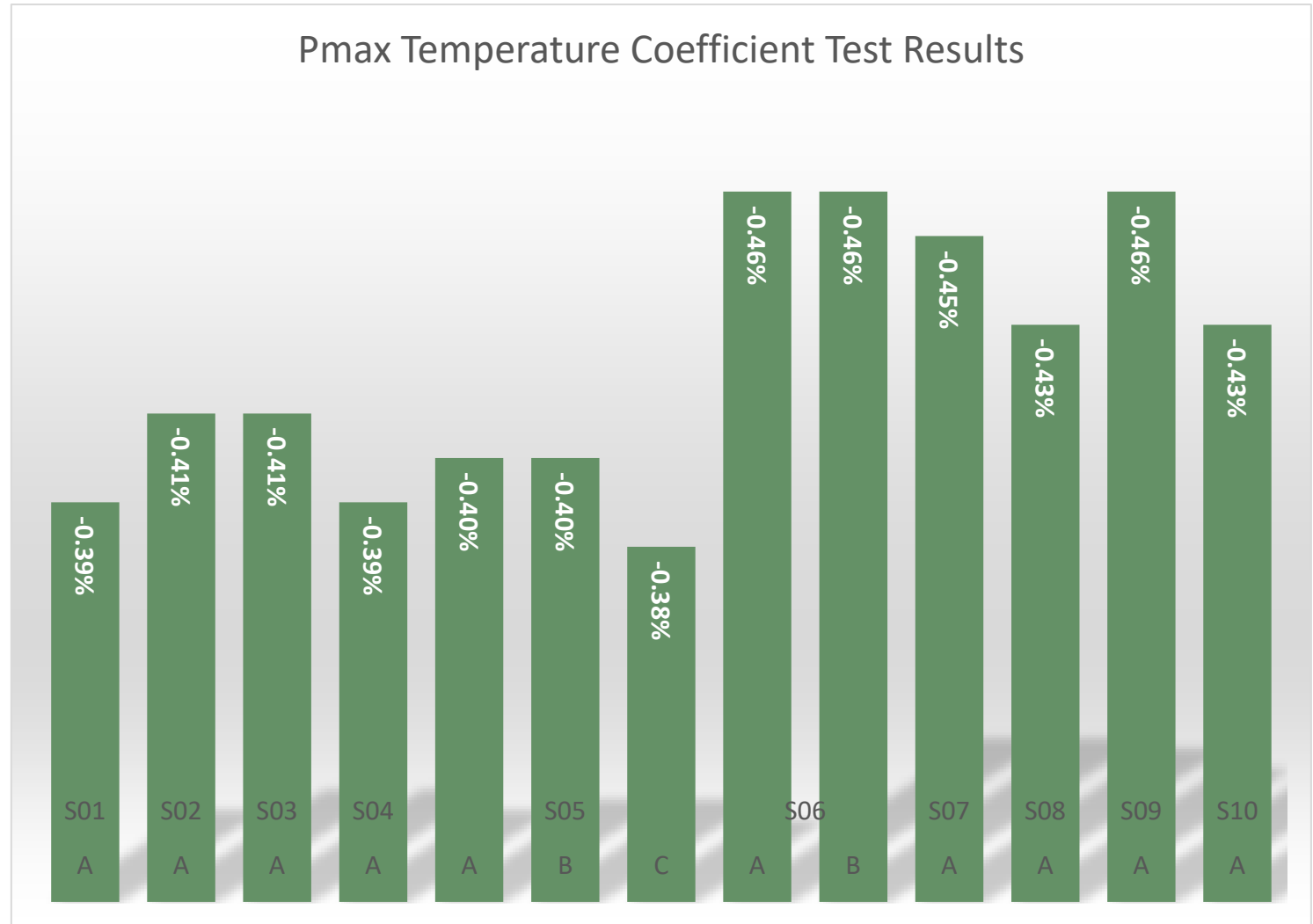
Low Irradiance Efficiency Loss

- The product of manufacturer S01 has almost zero loss, which is very beneficial for installations with low light conditions.
- Manufacturer S04 has a negative loss, which is effectively a gain, meaning that the module efficiency improves in low light
- Manufacturers S05 and S10 also have very low losses.
- This can be explained by the advanced cell architectures employed, that show better efficiency in low light than conventional cell types.



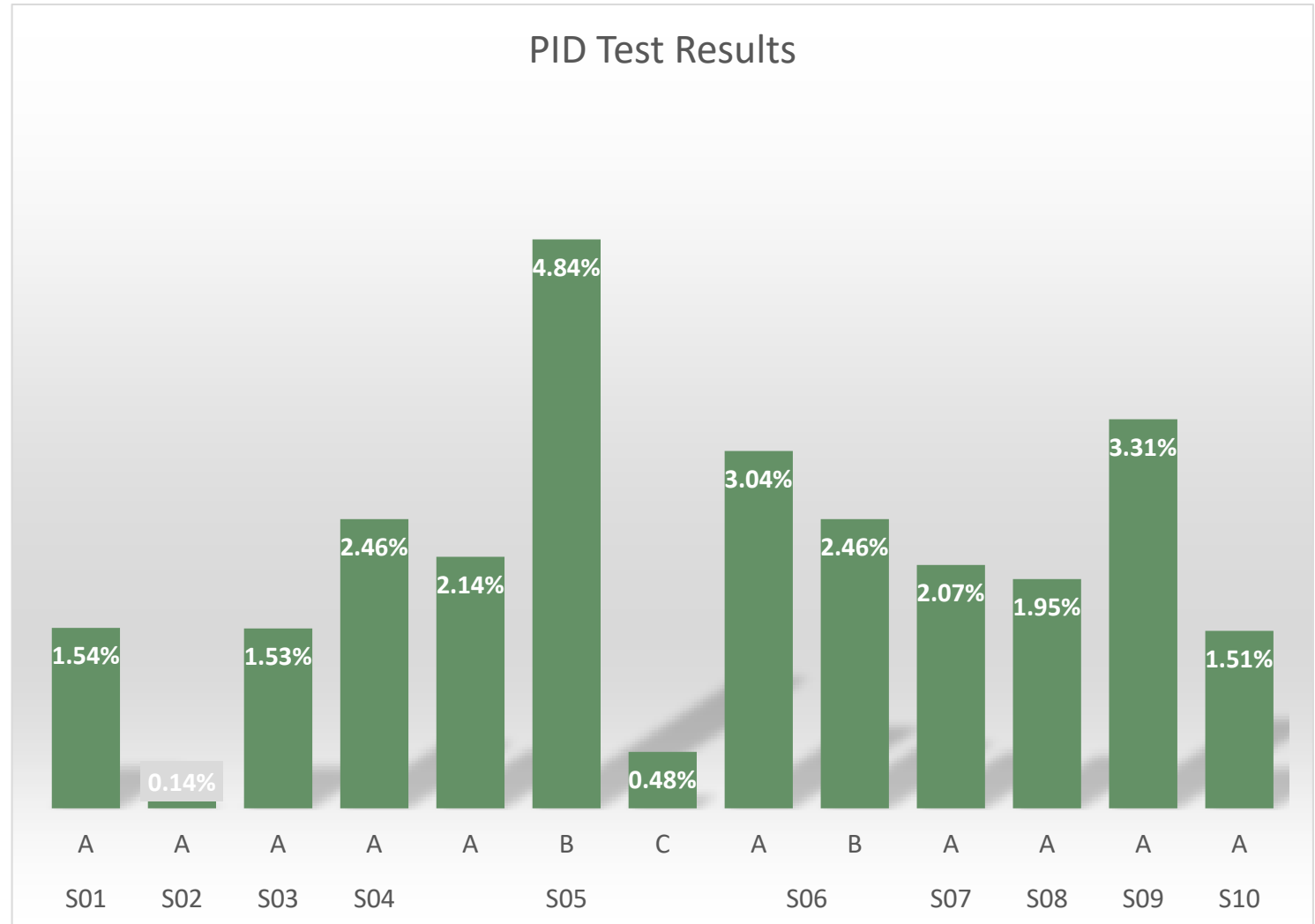
Pmax Temperature Coefficient

- We observed that advanced cell architectures exhibited better (lower absolute values) temperature coefficients, typically between $-0.40\%/^{\circ}\text{C}$ and $-0.38\%/^{\circ}\text{C}$.
- Conventional cells reached even as high as $-0.46\%/^{\circ}\text{C}$, which can be very detrimental to energy yield in hot climates.



PID loss

- Manufacturer S02 had almost 0% PID, and this is due to a very special cell architecture that is not prone to PID.
- Manufacturer S05 had mixed results, with one sample showing very high degradation and another one showing very low. The high result may be due to an unsuitable encapsulant but is also amplified by the fact that the cell was bifacial, as bifacial modules are more sensitive to PID than monofacial modules.
- Another interesting observation, not depicted in the charts, is that testing for PID at -1,500V has a non-proportional, enhanced effect on PID, which we observed when testing the same product at -1,000V and -1,500V and found a tripling of the degradation.

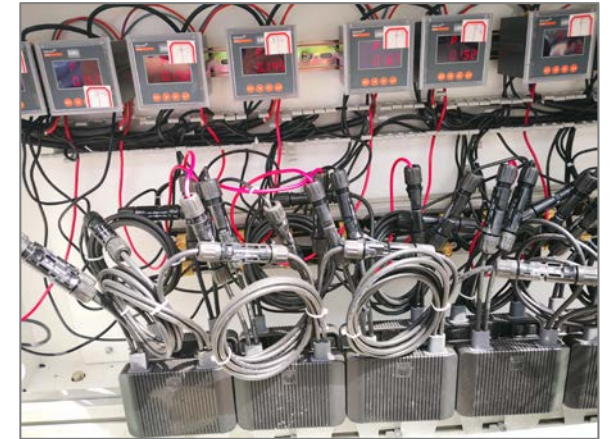


The outdoor test

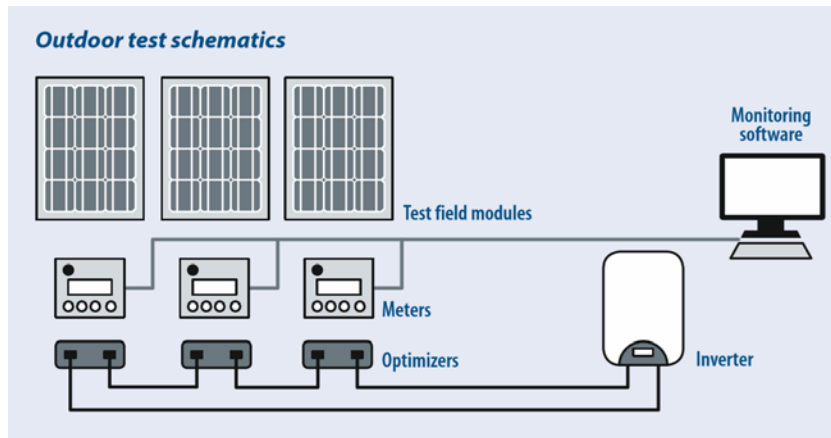
- As part of the pv magazine test program, Gsola has prepared an outdoor installation field in Xi'an, China, on the rooftop of a building that houses its manufacturing facilities and the test lab where the pv magazine tests are conducted.
- Xi'an has a temperate climate, with cold winters and mildly humid, hot summers.
- Each product will be installed in the test field for a 12-month period, and its energy yield (kWh/kWp) will be monitored and measured.
- Dedicated areas have been designed for the monitoring of bifacial modules
- The first results will start coming in July 2018.



Gsola outdoor test field in Xi'an



Optimizers and high precision meters



Monitoring schematic



Weather station



Thank you!