



QUALITY: CURRENT LIMITATIONS, ISSUES, AND SOLUTIONS IN MASS PRODUCTION



QUALITY ASSURANCE FOR THE PHOTOVOLTAIC INDUSTRY

COMPANY SNAPSHOT

- French company established in China
- Team of European and Chinese experts from PV manufacturing / Quality fields
- Developed proprietary quality standards for the PV industry
- Unique working model: Individual module certification on mass production scale
- 215,000 PV modules tested by STS



COMPANY SNAPSHOT

SCOPE OF SERVICES

Standard Services

- Factory Auditing
- Product Individual Certification
- Production Monitoring
- Onsite Inspections

Specific Services

- Products Benchmarking
- Research and Publications
- Specific Testing

COOPERATING MANUFACTURERS



COMPANY SNAPSHOT

OUR TESTING CENTER

- Located in a low-carbon emission park, in Kunshan, China
- 3,000 m² of high technology
- Semi-automatic testing lines
- IEC certified class AAA flash test equipment
- High resolution EL imaging equipment
- Protocols in accordance with ISO 17025 Standards

EXTENSIVE CONTROL OF EACH MODULE

58 Checking points

CAPACITY

1200 panels / day
100MW / year





12 PREJUDICES ABOUT QUALITY IN PV INDUSTRY

- 60% of the PV modules being installed worldwide are produced in China
- There are several hundred manufacturers of PV modules in China
- Over 85% of the manufacturers are certified against IEC and/or UL standards
- 95% of the manufacturers provide a product and performance warranty
- Prices have decreased by more than 50% in the last 12 months

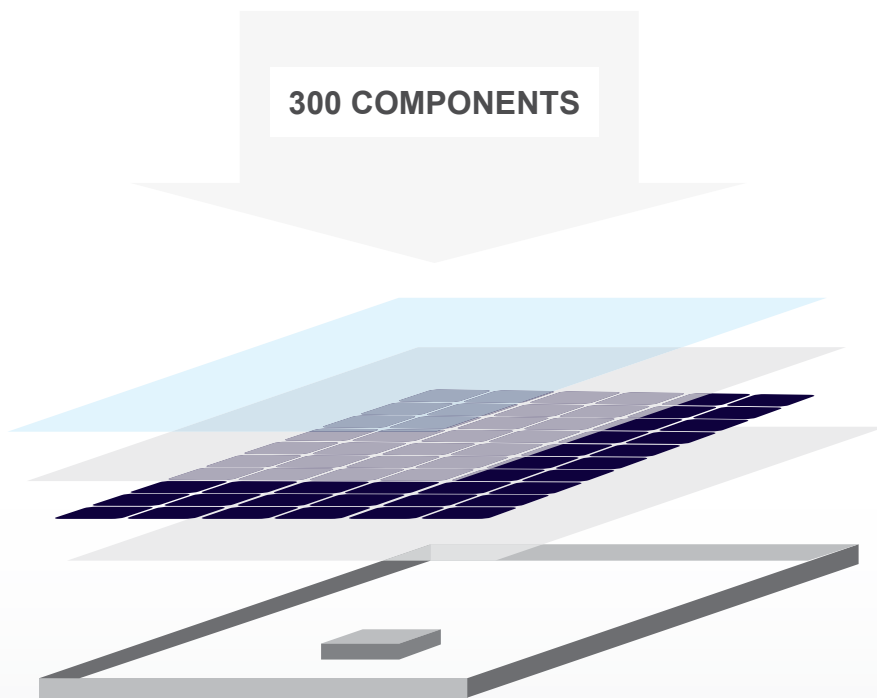


PREJUDICE 1 / QUALITY CONSISTENCY

“A PV module is a simple product, the quality level is consistent between all products.”

PREJUDICE 1 / QUALITY CONSISTENCY

SERIOUS CONSEQUENCES ON QUALITY

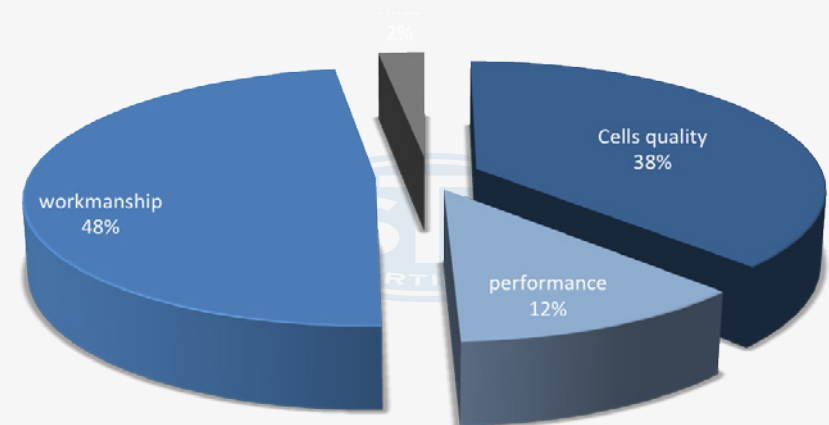
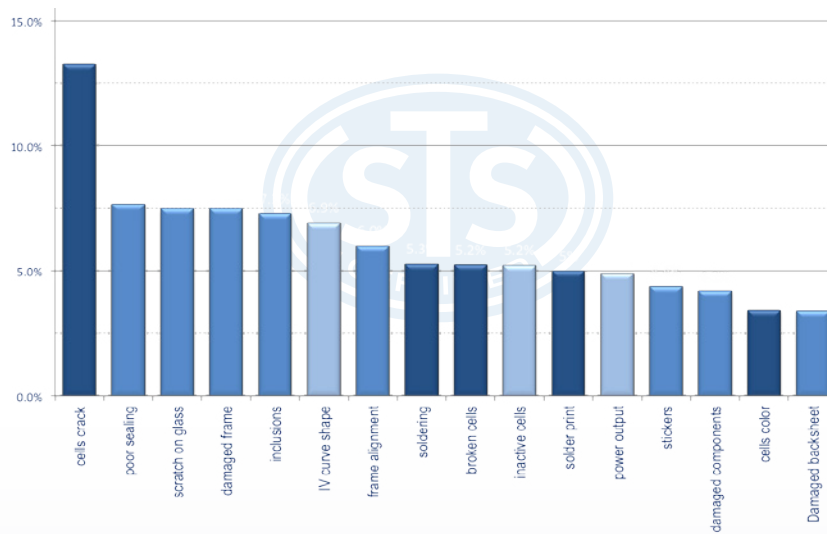


1 MODULE = 50 MANUFACTURING PROCESSES

Polysilicon crystallization	Surface cleaning	Tabbing
Ingot growing	Etching	Stringing
Ingot cutting	Texturing	Lay out
Ingot slicing	Diffusion	Lamination
Cleaning	PSG removal	Curing
Sorting	Isolation	Framing
	Front contact	Cleaning
	Back contact	Packing
	Firing	

PREJUDICE 1 / QUALITY CONSISTENCY

SERIOUS CONSEQUENCES ON QUALITY



PREJUDICE 1 / QUALITY CONSISTENCY

CONSEQUENCES OF DEFECTS





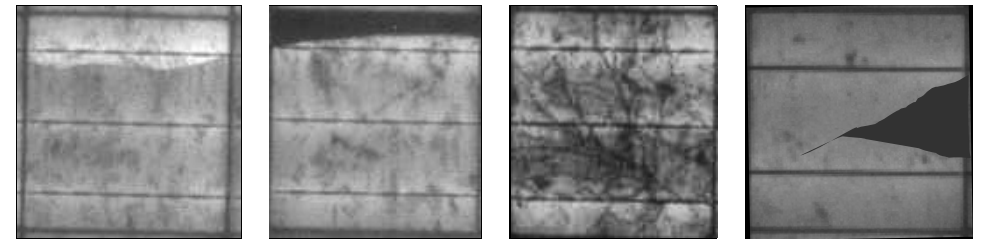
PREJUDICE 2 / QUALITY DEFINITION

“Acceptable quality level is clear for everybody, there is no need to be specific.”

PREJUDICE 2 / QUALITY DEFINITION

LIMITATIONS OF MANUFACTURERS

- No international standard on electroluminescence
- No international standard on visual appearance



Electroluminescence revealing micro-cracks



Examples of visual appearance defects



PREJUDICE 3 / FIELD FAILURES

“There is no failures in the field.”

PREJUDICE 3 / FIELD FAILURES

- Field failures are not reported.
- Most manufacturers do not publish Recall issues
- Problems are yet to happen due to the youth of installations

SANYO
Mexico
2002-2008

300,000 modules
Insulation defect

SOLARFUN
Italy
2010

1,320 modules
Various defects

SUNPOWER
USA - Germany
2005

54,000 modules
Lower performance

SANYO
Hawaii
2011

1.2 MWp
Short circuit

SHARP
Europe
2011

Unknown
Delamination

Undisclosed
Italy
2011

1MWp
Delamination

SUNTECH
USA
2010

300 installations
Fire hazard

FIRST SOLAR
USA
2008-2009

30 MWp
Lower performance

**AUSTRALIAN
AUTHORITIES**
Australia, 2010

2000 households
Risk of electrical fire

SNAIL TRAILS
Various
2012

Canadian Solar.
CEEG, Trina Solar,
Chaoi, CNPV,
Jinko, IBC solar,
LDK, LG, Q-Cells,
REC, Risen,
Schuco, etc.



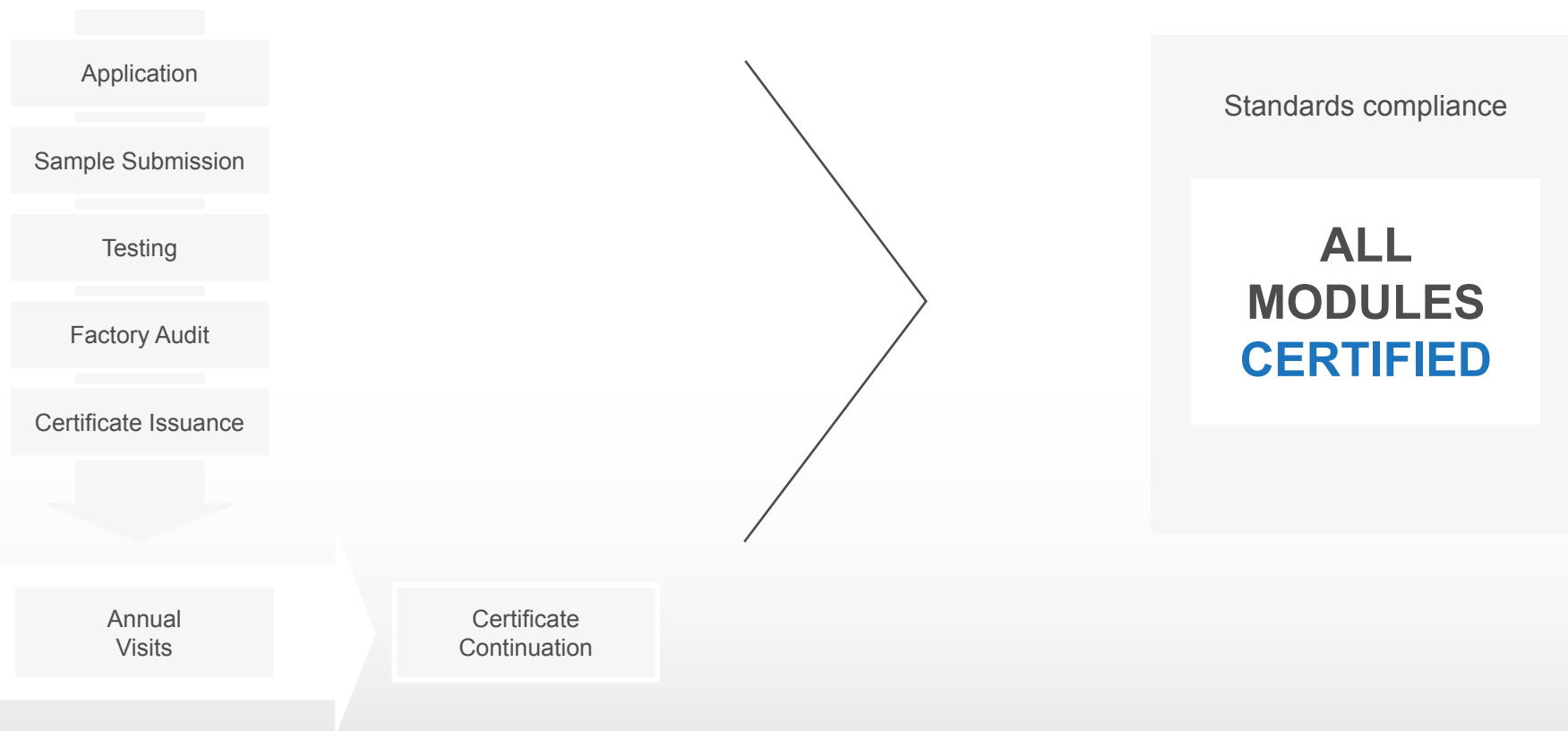
PREJUDICE 4 / CERTIFICATION

“My modules are certified, I won’t have any quality problem.”

PREJUDICE 4 / CERTIFICATION

LIMITATIONS OF STANDARDS

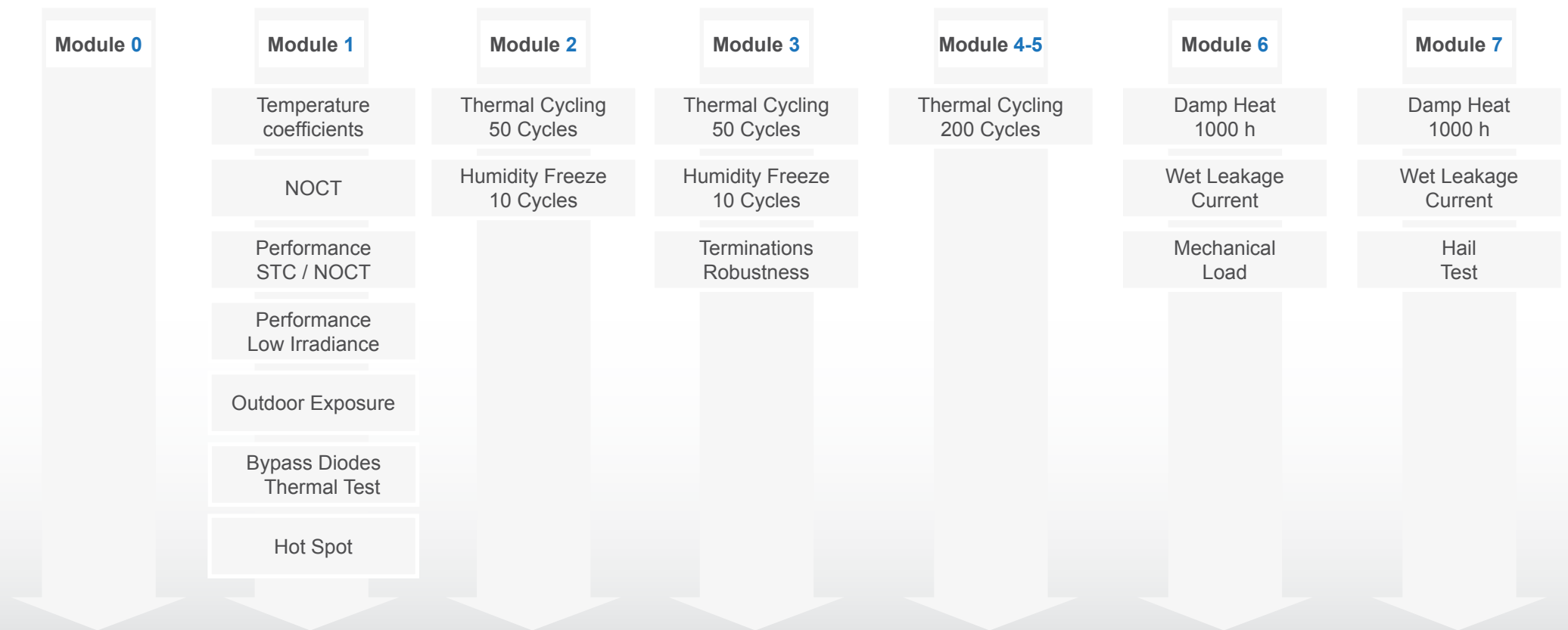
Standard certification flow according to IEC/UL standards:



PREJUDICE 4 / CERTIFICATION

LIMITATIONS OF STANDARDS

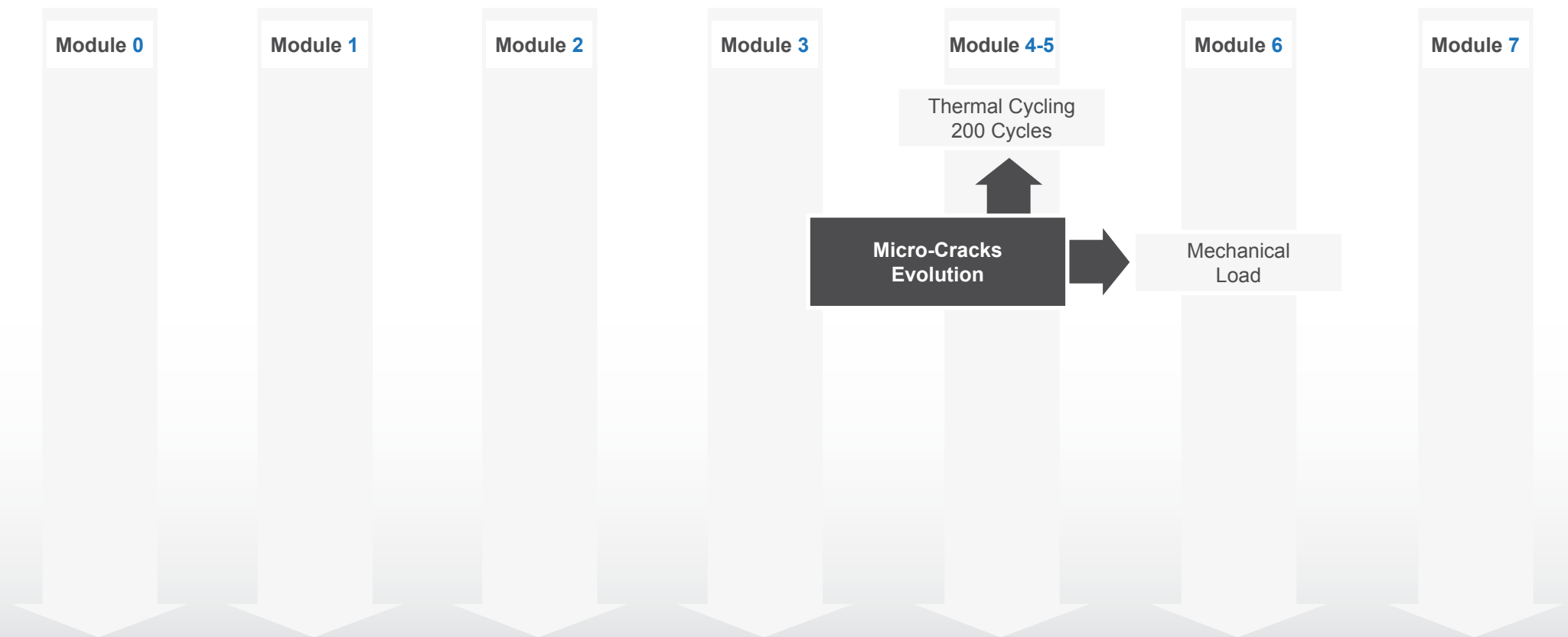
- IEC/UL standards compliance are based on samples (8 units)
- Tested Samples are not representative of the mass production
- Tests performed are not representative of the full life of the PV modules



PREJUDICE 4 / CERTIFICATION

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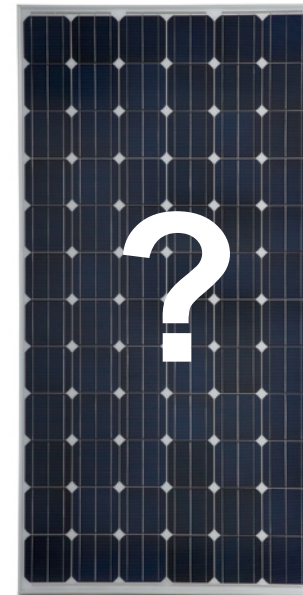


PREJUDICE 4 / CERTIFICATION

LIMITATIONS OF STANDARDS

- Some quality issues are not addressed by the standards
- No factory requirements
- No periodic tests requirements
- No audits requirements to certification bodies

... What is happening in the factory everyday?
... What is the quality of the PV module x?





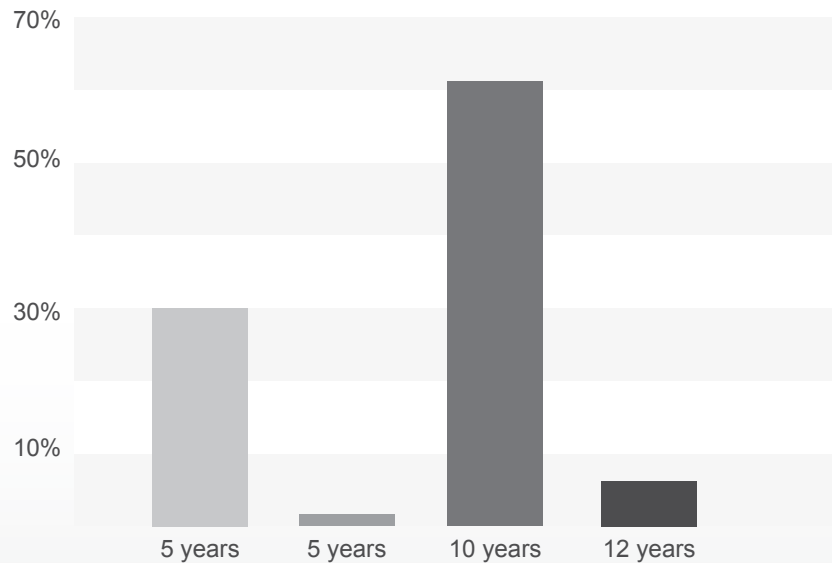
PREJUDICE 5 / WARRANTY

“It doesn’t matter if I have quality issues with my modules, my product warranty will cover me.”

PREJUDICE 5 / WARRANTY

LIMITATIONS OF WARRANTIES

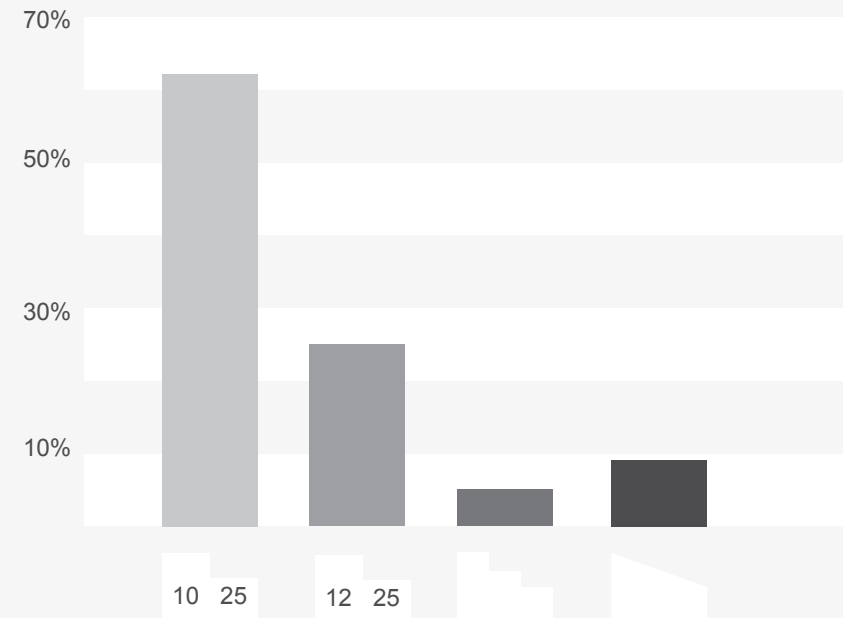
- Product warranty vs. manufacturer continued existence?



Product Limited warranty distribution by manufacturer

- Specific environments such a marine environment are not covered
- Only a few manufacturers offer linear performance warranty
- Cost of transportation, removal, re-installation are not covered
- Loss of revenue are not covered

High cost of Quality claims.



Performance warranty distribution by manufacturer

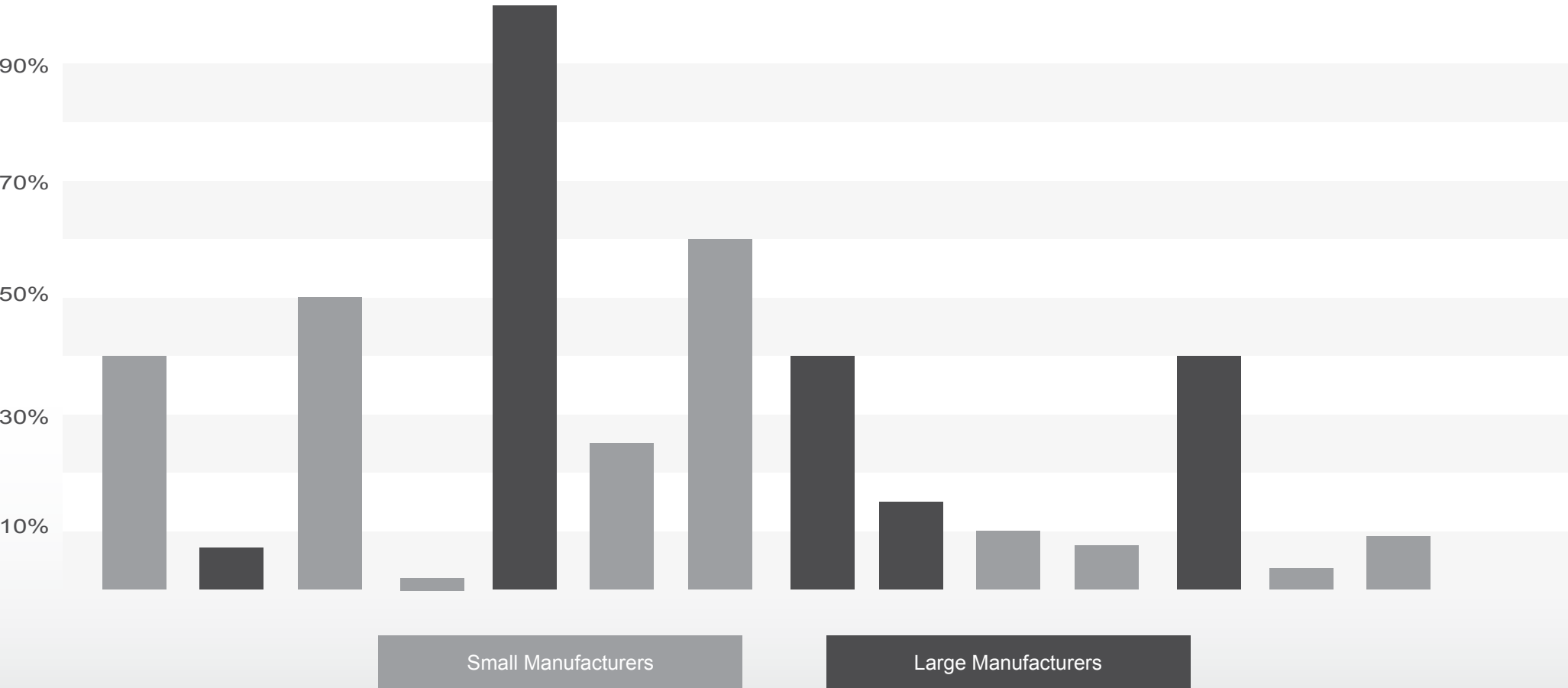


PREJUDICE 6 / MANUFACTURERS

“I won’t have quality problems because I buy from a big manufacturer.”

PREJUDICE 6 / MANUFACTURERS

MANUFACTURER DEFECT RATE



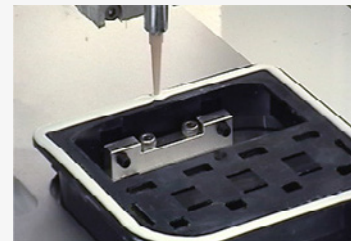
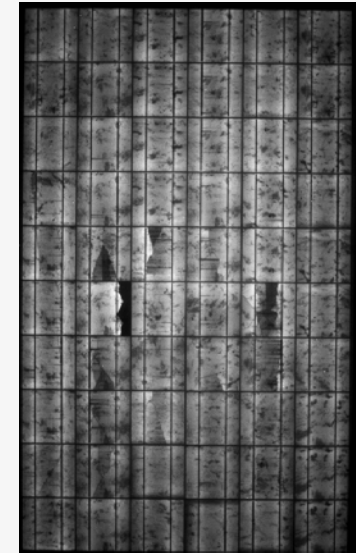
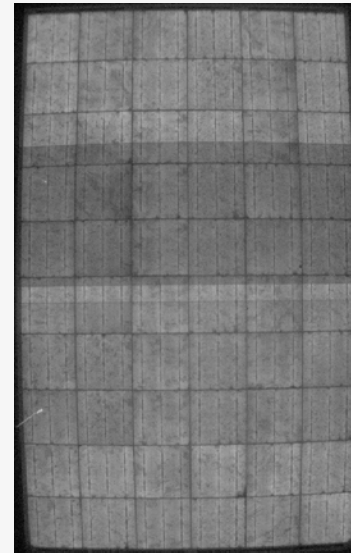
PREJUDICE 6 / MANUFACTURERS

LIMITATIONS OF MANUFACTURERS

Different equipment used
Sub contracting
Different internal quality standards

=

DIFFERENT QUALITY





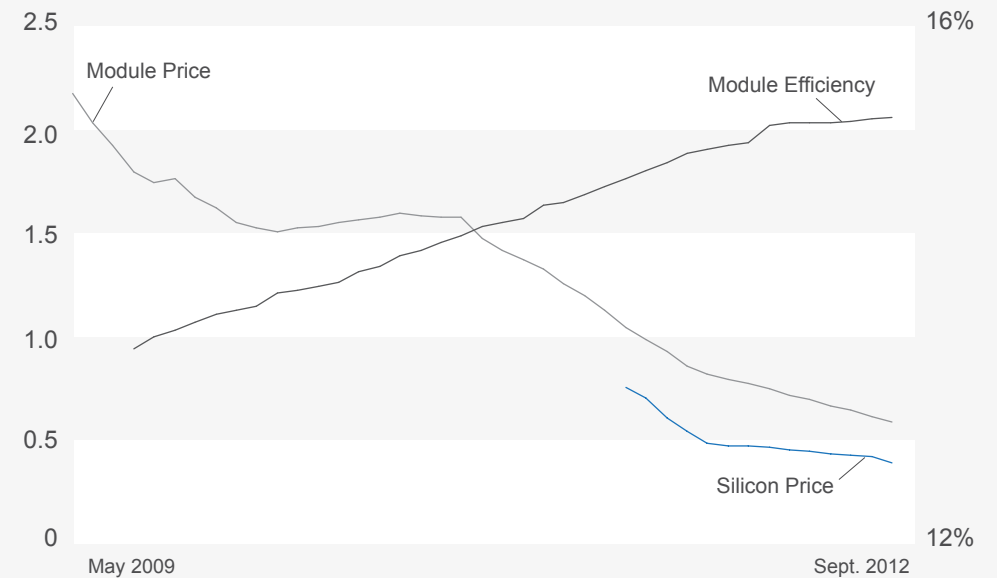
PREJUDICE 7 / COST KILLING

“The costs are low thanks to technology improvement and production efficiency.”

PREJUDICE 7 / COST KILLING

QUALITY VS. TECHNOLOGY

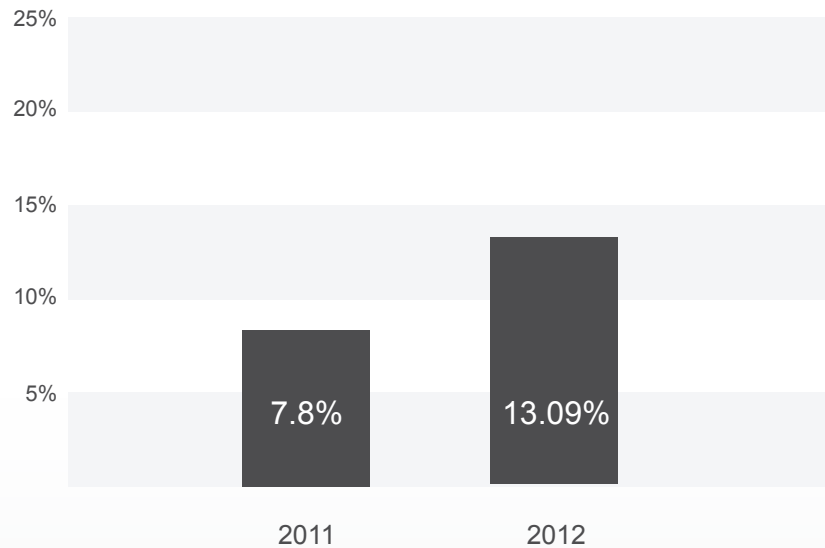
- Use of cheaper material
- Sub contracting
- Precarious technology improvements
- Internal quality standard downgraded
- Misleading marketing names



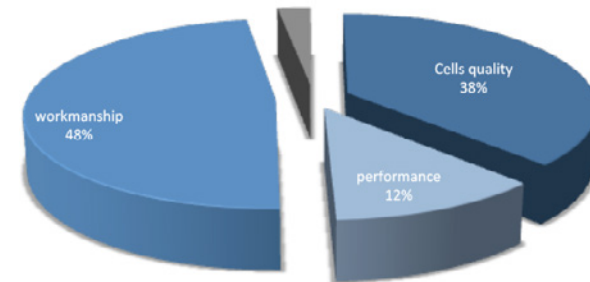
Price evolution vs. [efficiency](#)

PREJUDICE 7 / COST KILLING

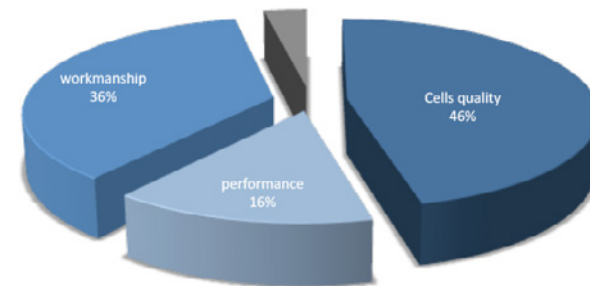
DEFECT RATE EVOLUTION



2011



2012



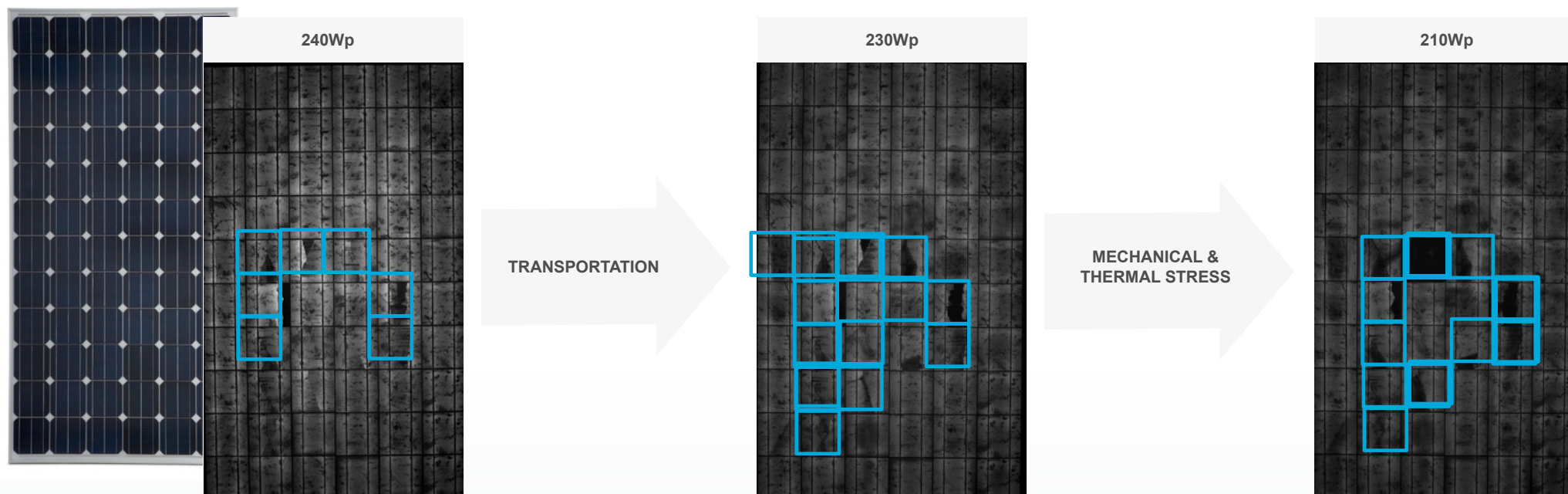


PREJUDICE 8 / PERFORMANCE EVOLUTION

“If the performance is good now, my module will perform well during 25 years.”

PREJUDICE 8 / PERFORMANCE EVOLUTION

CONSEQUENCES ON RELIABILITY



DEGRADATION IS DYNAMIC. **QUALITY DEFECTS EXPAND WITH TIME.**



PREJUDICE 9 / INFLUENCE OF DEFECTS

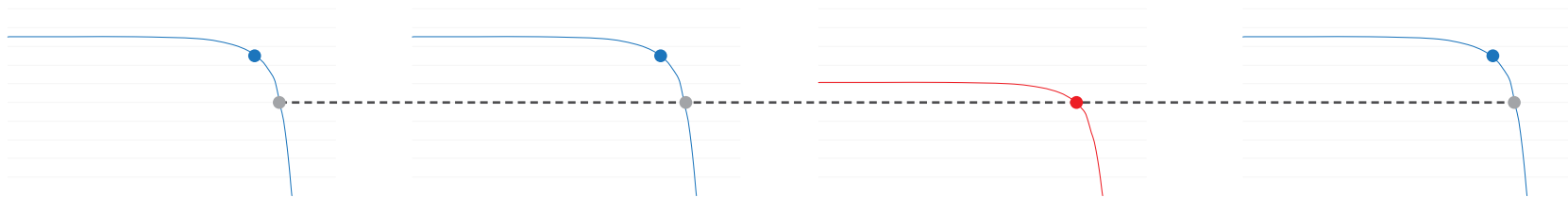
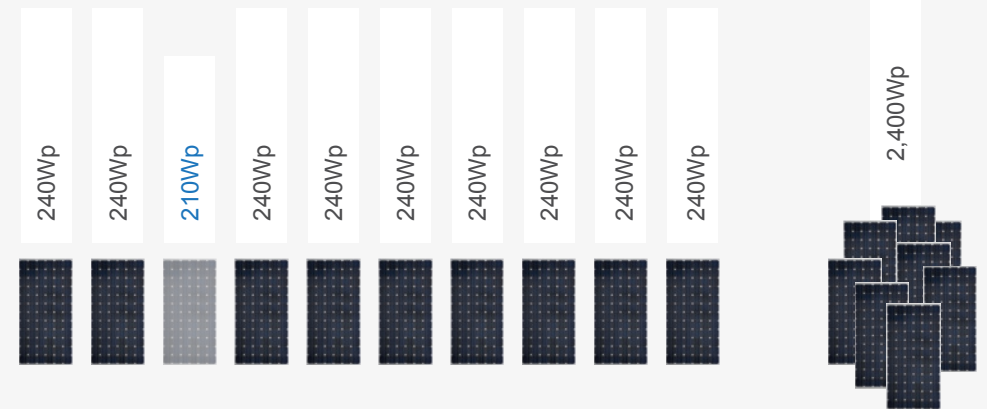
“If a few modules are under performing, it will not significantly affect the global output of my power plant.”

PREJUDICE 9 / INFLUENCE OF DEFECTS

CONSEQUENCES ON PERFORMANCE

MODULES ARRAY:

- 10 pcs mounted in series
- Multi crystalline 240WP

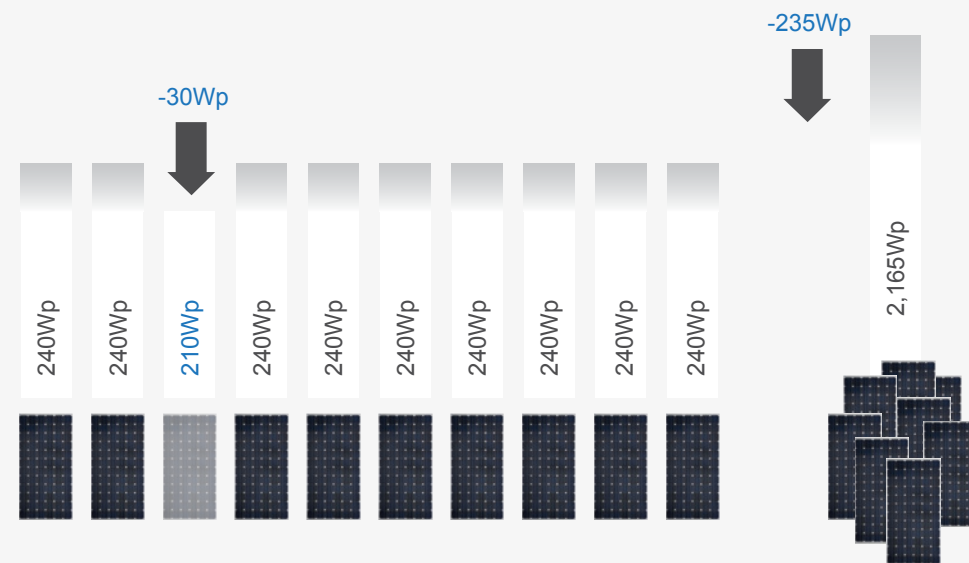


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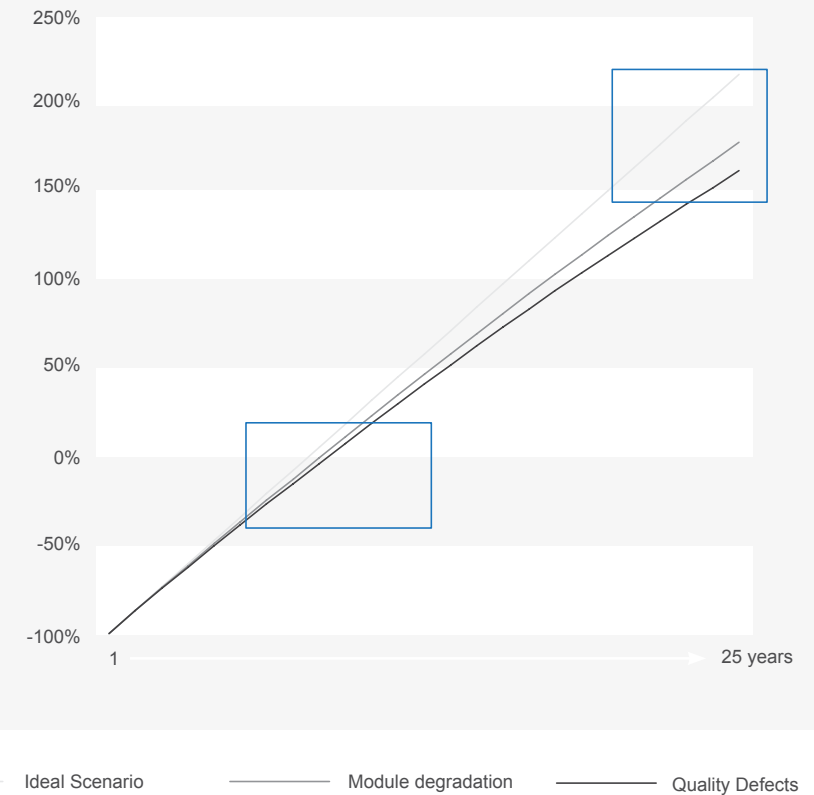


1 SINGLE DEFECTIVE MODULE AFFECTS THE PERFORMANCE OF THE WHOLE STRING

PREJUDICE 9 / INFLUENCE OF DEFECTS

CONSEQUENCES OF POOR QUALITY

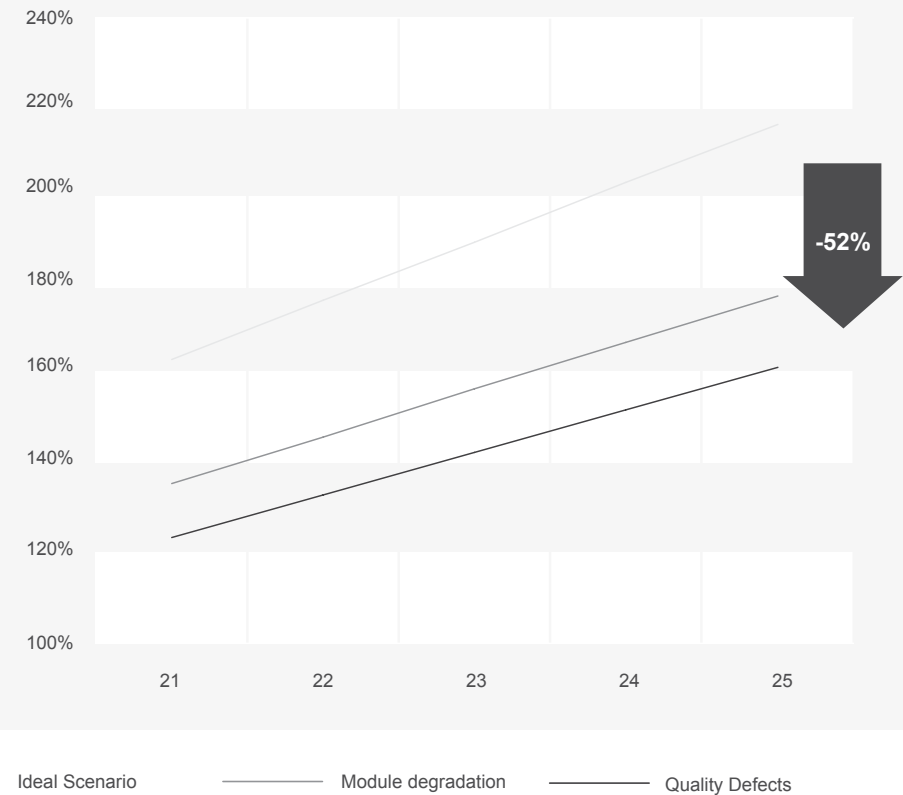
- Return on Investment
- 1MWp installation
- Irradiance: 2153kW/m2/year
- FIT: 10.37 INR / kWh



PREJUDICE 9 / INFLUENCE OF DEFECTS

CONSEQUENCES OF POOR QUALITY

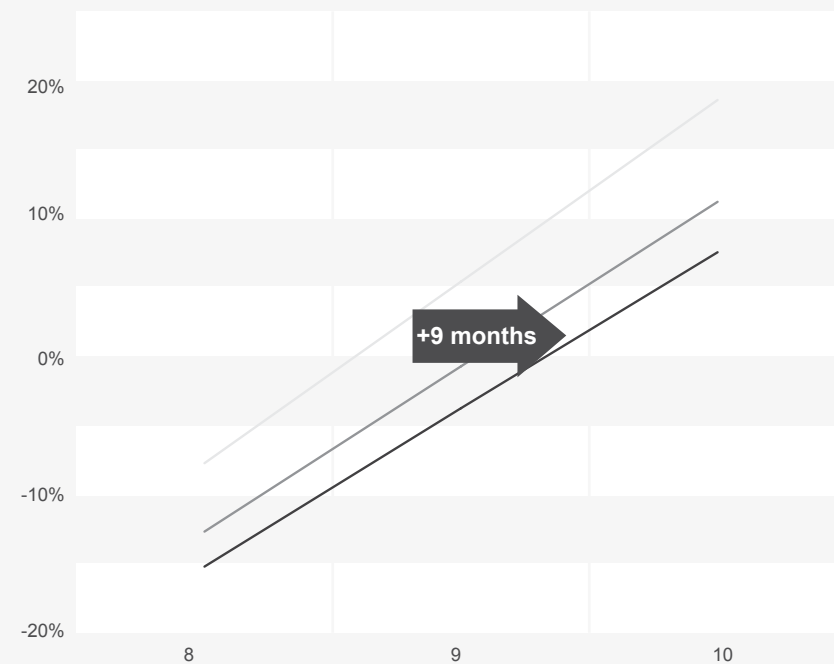
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PREJUDICE 9 / INFLUENCE OF DEFECTS

CONSEQUENCES OF POOR QUALITY

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— Ideal Scenario — Module degradation — Quality Defects



PREJUDICE 10 / THIRD PARTIES

“Quality is not my concern, I will not own the power plant in 5 years.”

PREJUDICE 10 / THIRD PARTIES

PRESSURE ON PROJECT DEVELOPERS

- Increased pressure from insurance companies
- Increased pressure from banks
- Increased pressure from Investors
- Increased pressure from exploitation companies

CASE STUDIES

- **SPAIN, 2012 [20MW]**
Financing from bank lost after sample testing failure
- **GERMANY, 2011 [4MW]**
Insurance premium doubled following independent audit

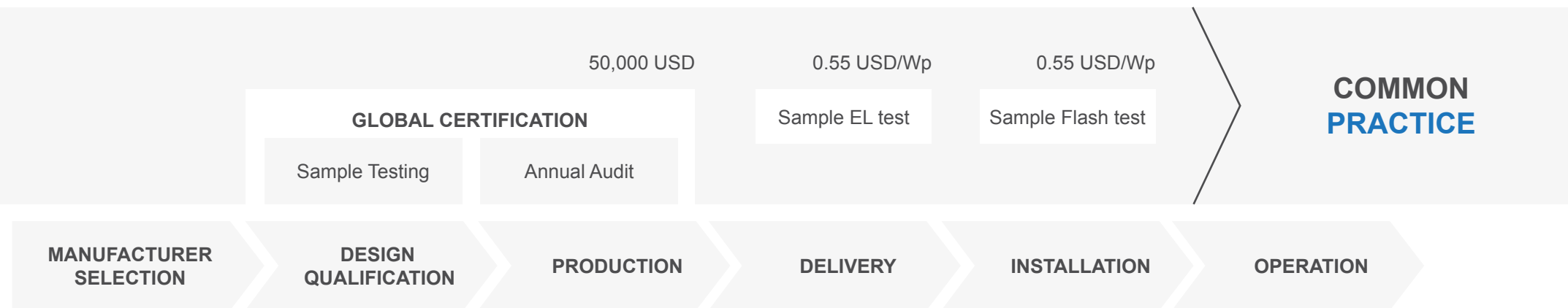


PREJUDICE 11 / TESTING OPPORTUNITIES

“It is impossible to control the quality in mass production other than by sampling a few modules.”

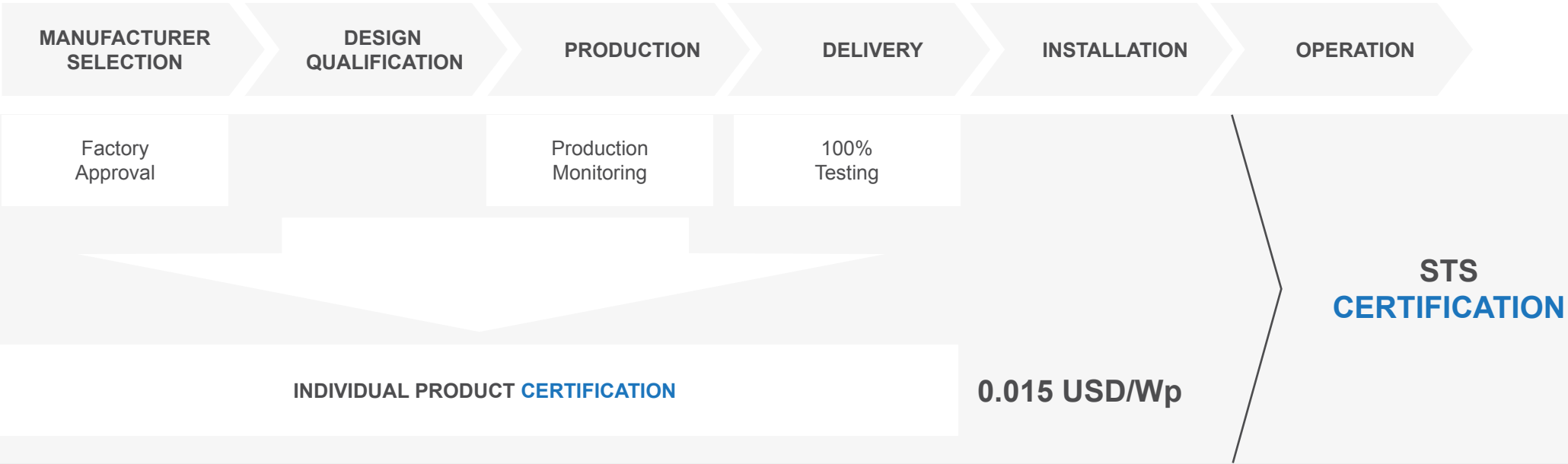
PREJUDICE 11 / TESTING OPPORTUNITIES

QUALIFICATION VS. **VALIDATION**



PREJUDICE 11 / TESTING OPPORTUNITIES

QUALIFICATION VS. VALIDATION

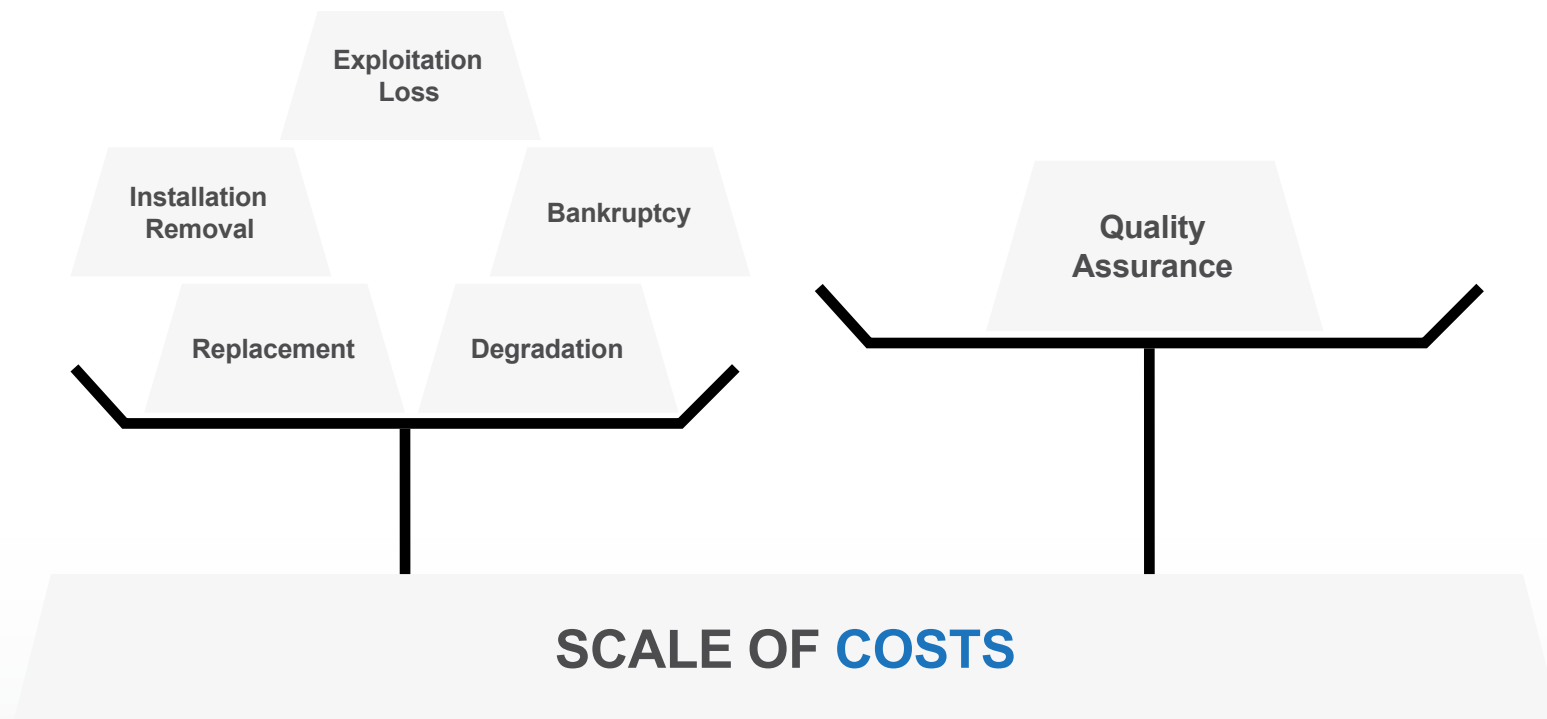




PREJUDICE 12 / COST OF QA

“Quality Assurance cost a lot of money, it s not worth the expense.”

PREJUDICE 12 / COST OF QA



PREJUDICE 12 / COST OF QA

COSTS OF QA IMPLEMENTATION

- 30MWp power plant
- Multi crystalline 240Wp
- 5 manufacturers

	Category	Allocation	Testing
Manufacturer A	A	30%	25%
Manufacturer B	A	25%	25%
Manufacturer C	C	10%	100%
Manufacturer D	B	15%	50%
Manufacturer E	B	20%	50%

QA PACKAGE:

- Manufacturers auditing
- Initial validation
- Mass production testing & monitoring

QA implementation cost: 380,000 USD
0.0125 USD/Wp

Acc. net savings: Y3: 84,640 USD
Y10: 2,103,029 USD
Y25: 9,684,965 USD

QUALITY DOES NOT COST MONEY, THE LACK OF QUALITY COSTS MONEY

KILL THE 12 PREJUDICES

- Quality is fluctuating between products
- The definition of acceptable quality is not the same between manufacturers
- There are problems in the field although they are not advertised
- Certification of products is necessary but not sufficient
- Warranty will not cover all costs related to a claim
- The size of manufacturer is not a guarantee of the quality level
- Cost killing is often made at the expense of quality
- The performance of a whole power plant is affected by a few quality defects
- The quality and performance of a product will evolve with time
- Financing is more and more dependent on quality of product
- It is possible to test products on a large scale
- Quality Assurance is an investment, not a burden



SOLUTIONS

IMULATOR

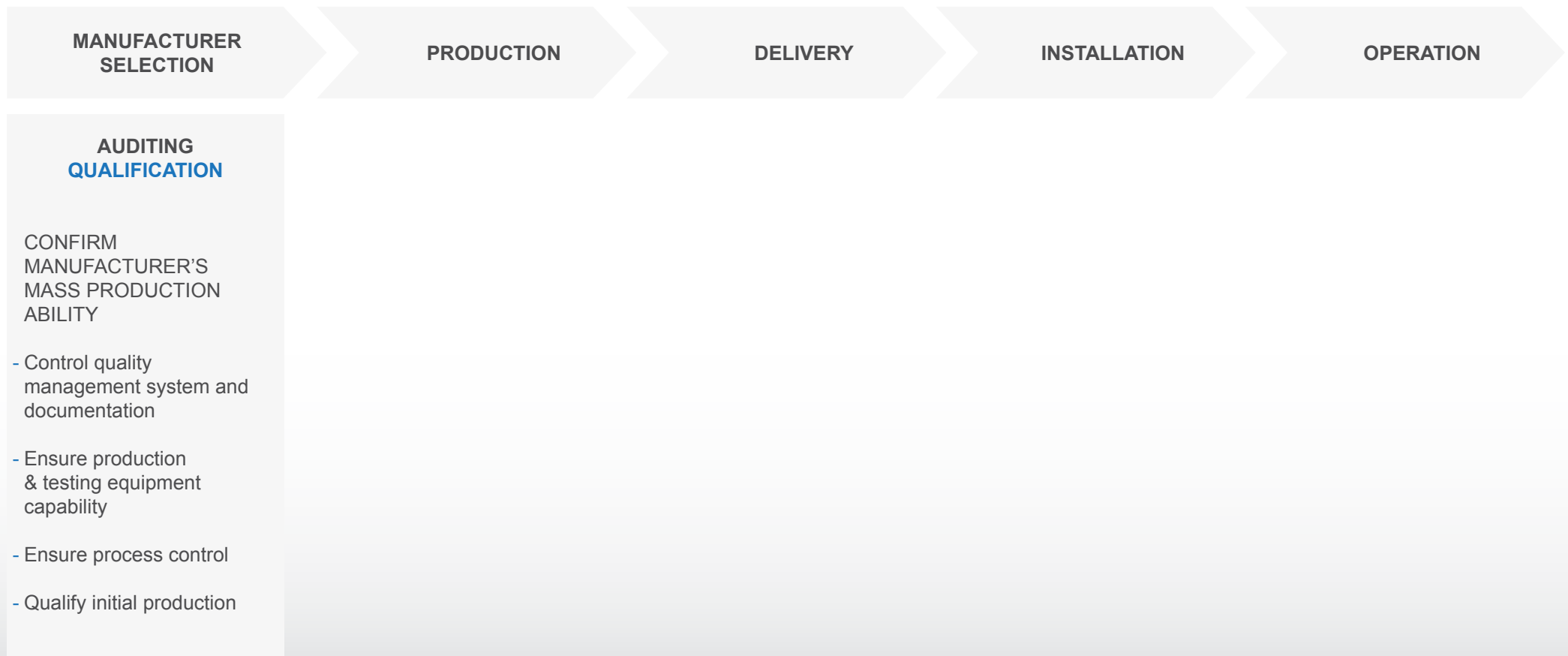
QUALITY ASSURANCE / OVERVIEW

QUALITY ASSURANCE **AT ALL STEPS**



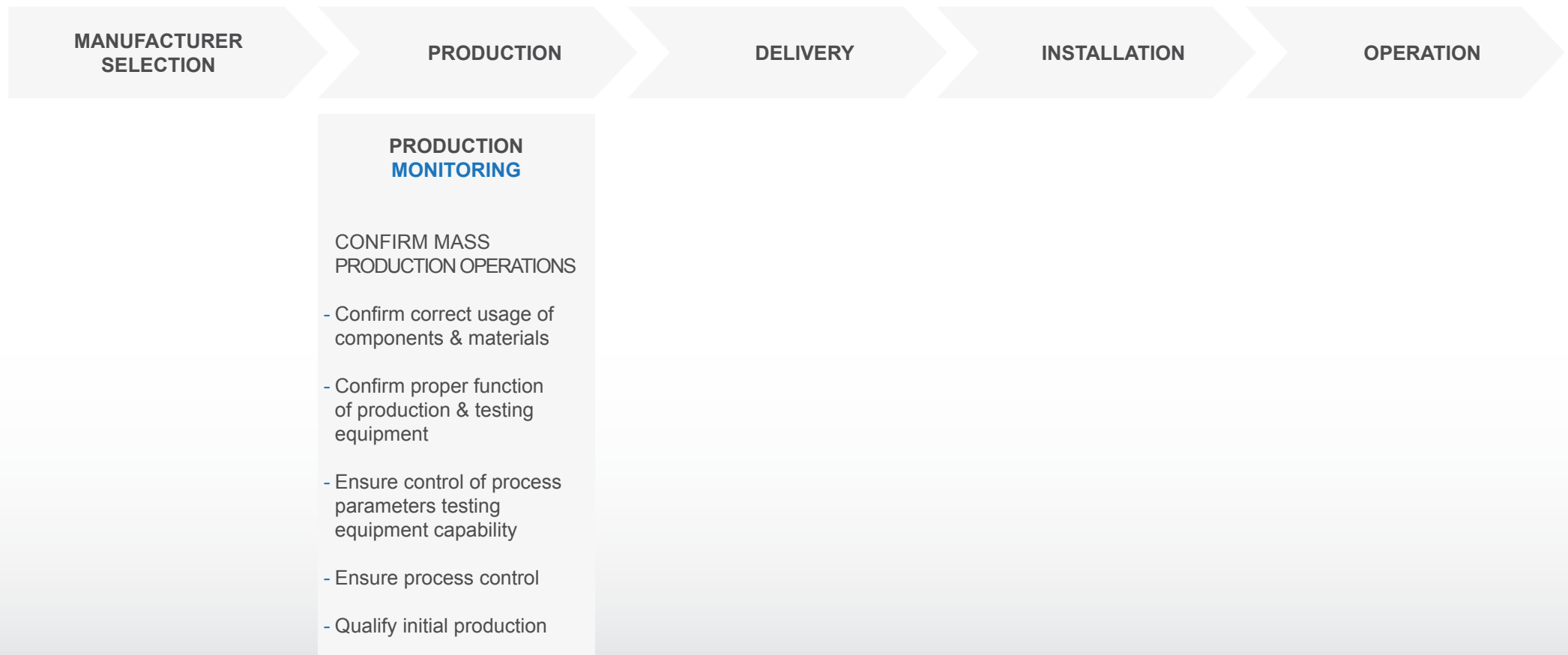
QUALITY ASSURANCE / OVERVIEW

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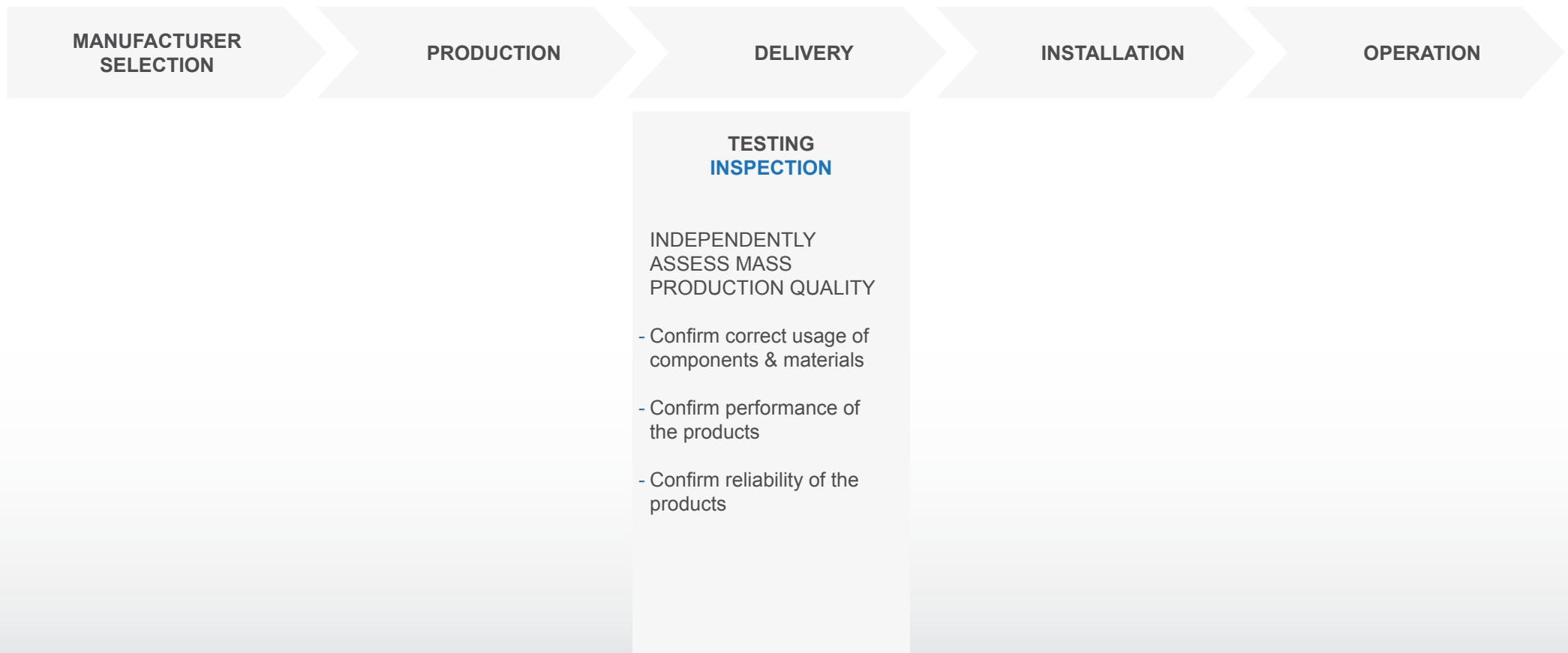
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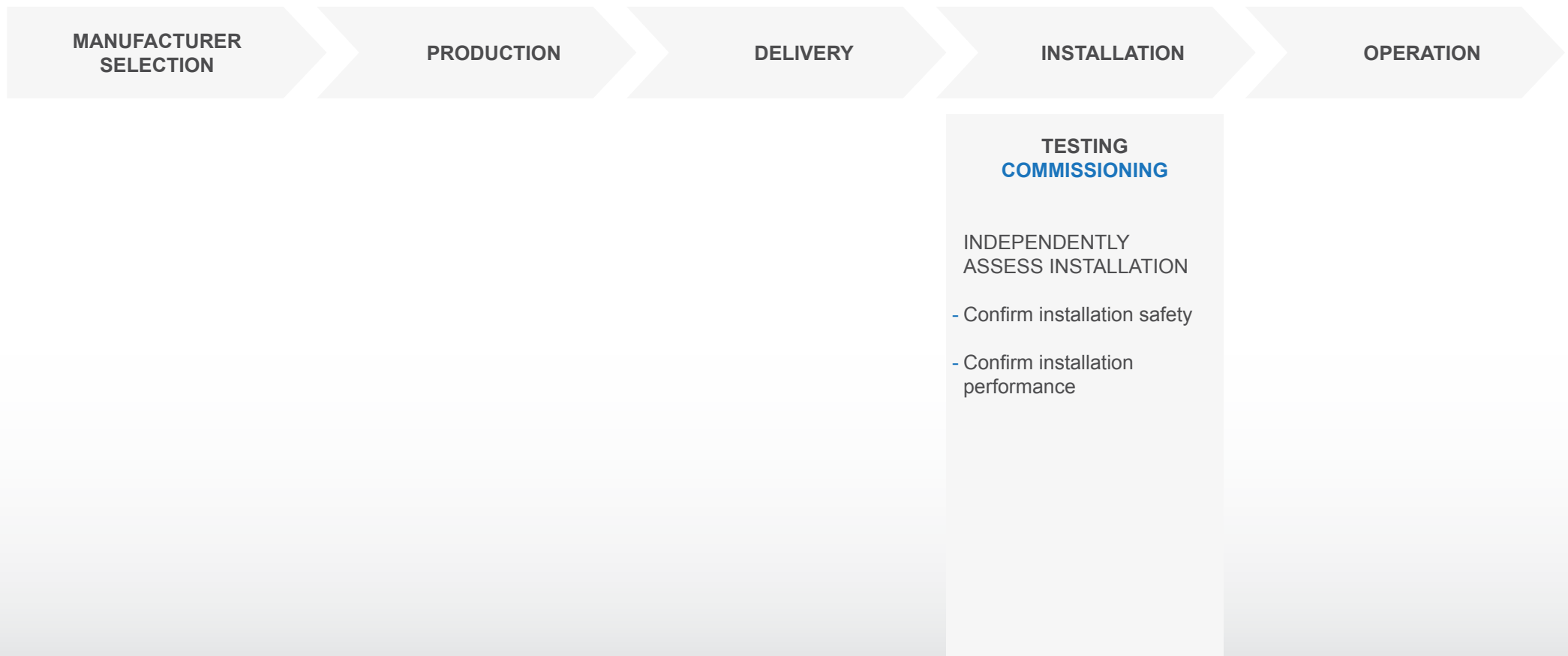
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QUALITY ASSURANCE **AT ALL STEPS**



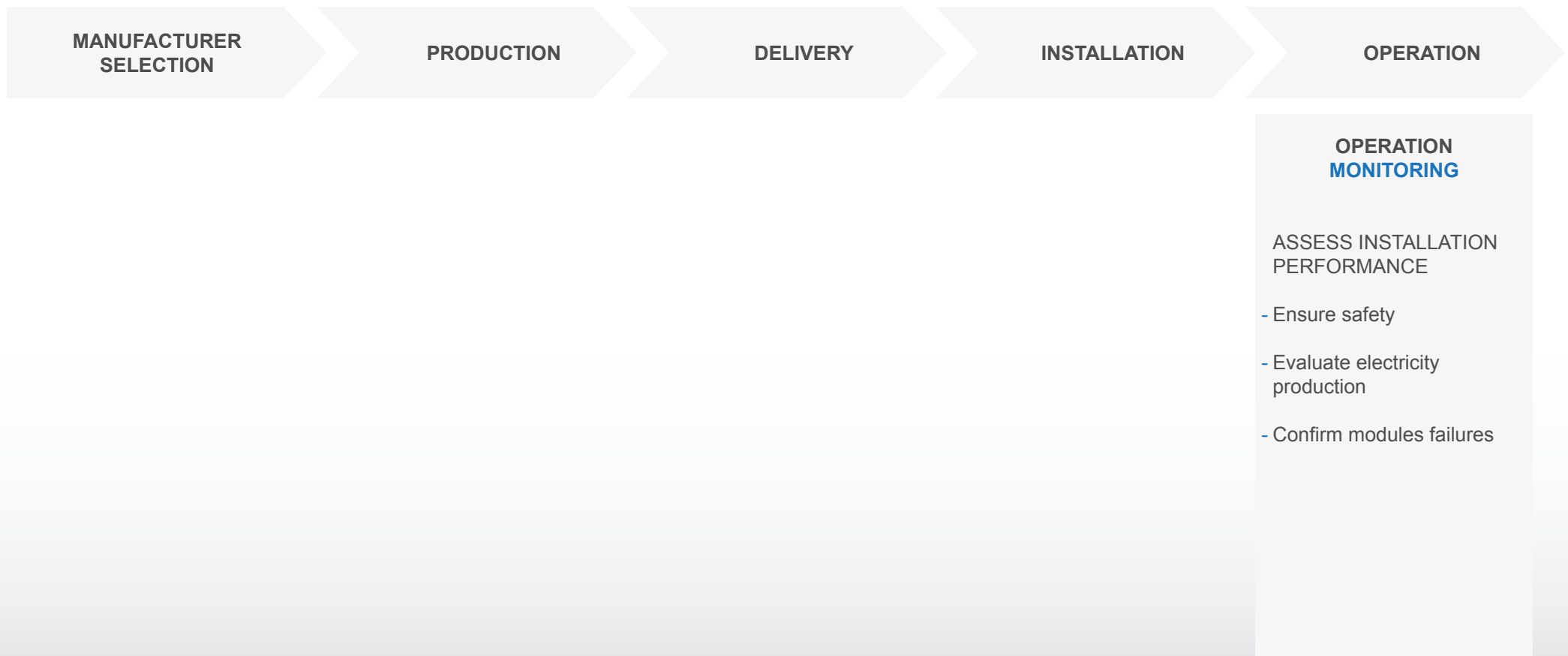
QUALITY ASSURANCE / OVERVIEW

QUALITY ASSURANCE **AT ALL STEPS**



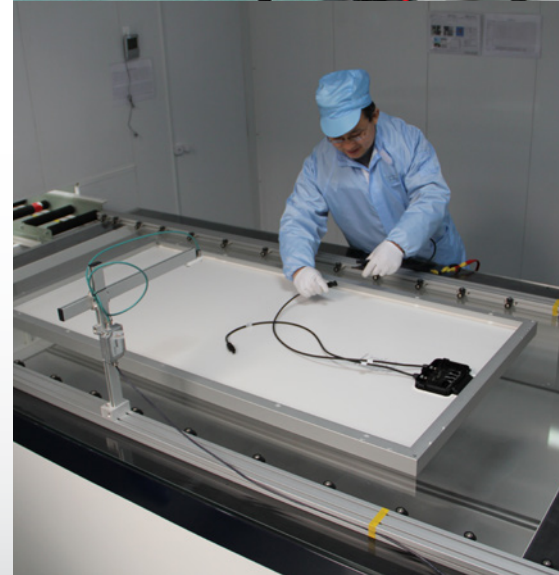
QUALITY ASSURANCE / OVERVIEW

QUALITY ASSURANCE **AT ALL STEPS**



CONCLUSION / KEY SUCCESS FACTORS

- Ensure quality at all stages of the projects
- Careful selection of partners
- Clarification of acceptable quality standards
- Independent assessment of the quality
- Control of representative quantities of the products (100%)





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