Quality Roundtable
at PV Taiwan 2017

Quality first: A holistic overview of quality in and for Taiwan, from cell and module, to array.

Initiative partner

DUPONT®

Gold sponsors

CEA Clean Energy Associates

SCHMID Expect Solutions

STÄUBLI

Multi-Contact MC

In collaboration with

semi

PV Guider

pv magazine group

Agenda Part I

09:30 – 10:00	**Registration**
09:55 – 10:00	**Welcome Remarks** *Mr. Jonathan Gifford, Editor at Large, pv magazine*
10:00 – 10:10	**Opening Remarks - City of Taipei initiates and support** *Mr. San-Chung Wang / 王三中, Deputy Commissioner, Department of Economic Development, Taipei City Government*
10:10 – 10:15	**Solar Installation at Urban / High Density Area** *Mr. Leo Kuo / 郭泳欽, Senior Manager, Tatung Co.*
10:15 – 10:20	**Quality Issues in Subtropical Climate and Taiwan** *Mr. Jonathan Gifford, Editor at Large, pv magazine* *Dr. Jay Lin / 林敬傑, Chief Consultant, PV Guider / Technical Committee of CNS National Standards / the Leader of Task Forces in SEMI standard*
10:20 – 10:25	**Floating PV - Taiwan Potential and Quality** *Mr. Cédric Jaeg, General Manager, Ciel & Terre Taiwan*
10:25 – 10:35	**Poor quality case 1** *Mr. Jonathan Gifford, Editor at Large, pv magazine* *Dr. Jay Lin / 林敬傑, Chief Consultant, PV Guider / Technical Committee of CNS National Standards / the Leader of Task Forces in SEMI standard*
10:35 – 10:45	**Quality in cables and connectors** *Mr. Joseph Yang, Division Manager, Stäubli (H.K.) Ltd. Taiwan Branch*
10:45 – 10:55	**Discussion period** *Mr. Jonathan Gifford, Editor at Large, pv magazine*

Agenda Part II

10:55 – 11:10	**ACTIVE BREAK**
11:10 – 11:15	**Selection Rules for High Quality PV Module** *Mr. Hung-Sen Wu / 吳鴻森, Deputy Division Director, Center for Measurement Standards, Industrial Technology Research Institute*
11:15 – 11:25	**Manufacturing Technology, Production Equipment & Quality Assurance** *Mr. Harris Li, General Manager, SCHMID Taiwan Ltd.*
11:25 – 11:35	**Poor Quality Case 2** *Mr. Jonathan Gifford, Editor at Large, pv magazine* *Dr. Jay Lin / 林敬傑, Chief Consultant, PV Guider / Technical Committee of CNS National Standards / the Leader of Task Forces in SEMI standard*
11:35 – 11:45	**Field Research Findings** *Dr. Oakland Fu / 付波, Photovoltaic & Advanced Materials Technical Manager, DuPont*
11:45 – 11:50	**Quality in Manufacturing, Taiwan Module Manufacturer Viewpoint** *Dr. CY Yu / 余承曄, Assistant Vice President, R&D, TSEC*
11:50 – 11:55	**Manufacturing Quality Discussion** *Mr. Jonathan Gifford, Editor at Large, pv magazine* *Dr. Jay Lin / 林敬傑, Chief Consultant, PV Guider / Technical Committee of CNS National Standards / the Leader of Task Forces in SEMI standard*
11:55 – 12:00	**Conclusions**

Part I

I

Opening remarks

II

Solar installation at urban/high density area

都會區太陽光電應用與未來趨勢

10/20/2017

大同公司 太陽能系統處

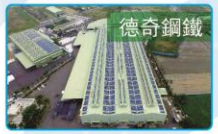
澎湖縣
公有房舍30處
總建置容量
3.5MWp

彰化
私人企業
0.75MWp

台中市
公有房舍43處
預計總建置容量
3.3MWp
私人企業
0.1MWp

台北市
公有房舍74處
預計總建置容量
6.6MWp
福德掩埋場
建置容量
2MWp

金門縣
公有房舍29處
預計總建置容量
4.2MWp



台南、高雄市
公有房舍13處
預計總建置容量
0.7MWp
私人企業
2MWp

新北市
公有房舍68處
預計總建置容量
8.1MWp

桃園市
公有房舍150處
預計總建置容量
15.1MWp
桃園掩埋場
5MWp
埤塘
0.5MWp
私人企業
1.2MWp

東沙島
總建置容量
40kWp

南沙島
總建置容量
40kWp

屏東-林邊
總建置容量
78kWp

南投縣
公有房舍118處
總建置容量
11MWp

新竹縣
公有房舍50處
預計總建置容量
6MWp

案場建置-台北市天母國中

台北市天母國中

- 系統容量：424.8 kWp
- 併網日期：2017.6
- 預估每年發電量：450,000 kWh

案場建置-新北市停車棚

新北果菜市場

- 系統容量：430.08 kWp
- 併網日期：2017.5
- 預估每年發電量：450,000 kWh

案場建置-台北市桃源國小

都會區太陽光電面臨的挑戰

日本都會區太陽能屋頂普及率高

都會區太陽光電面臨的挑戰-案例

台北市士林區蘭雅國小

都會區太陽光電面臨的挑戰-案例

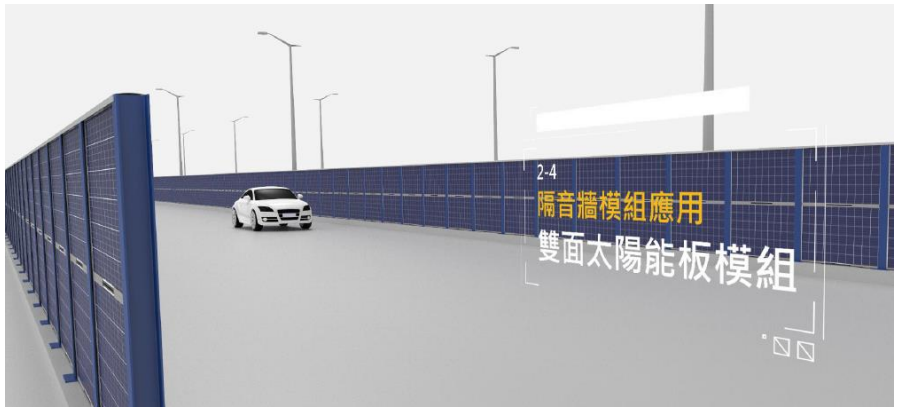
台北市松山區民權國小

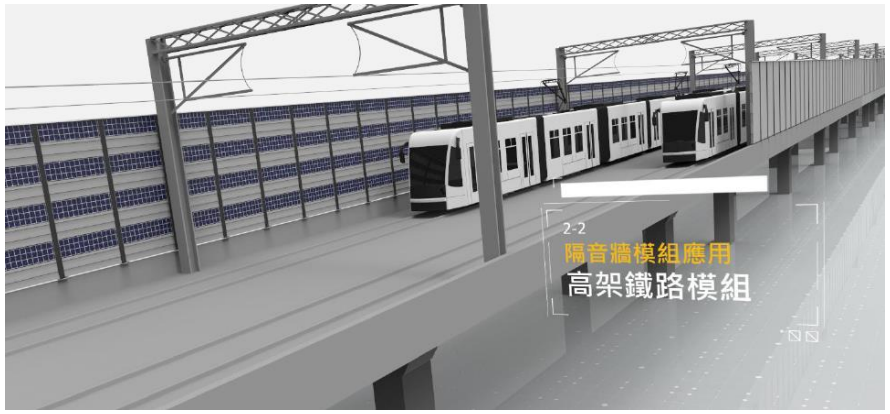
都會區太陽光電面臨的挑戰-案例

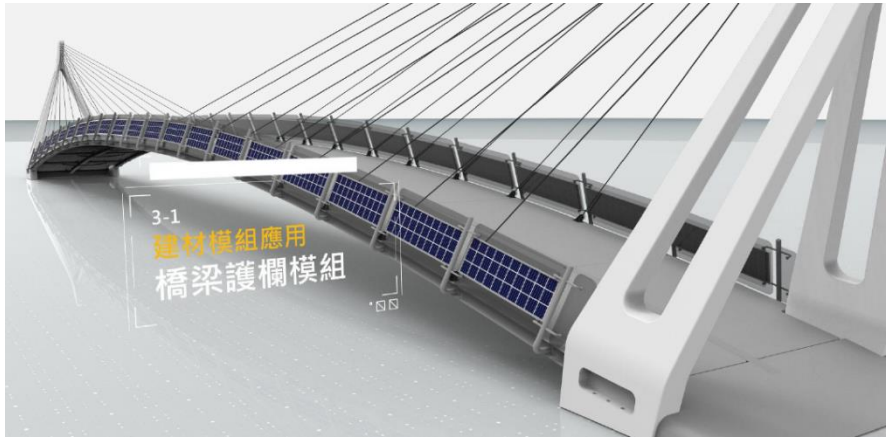
陽明山永公路透天民宅
裝置容量:11.8kWp

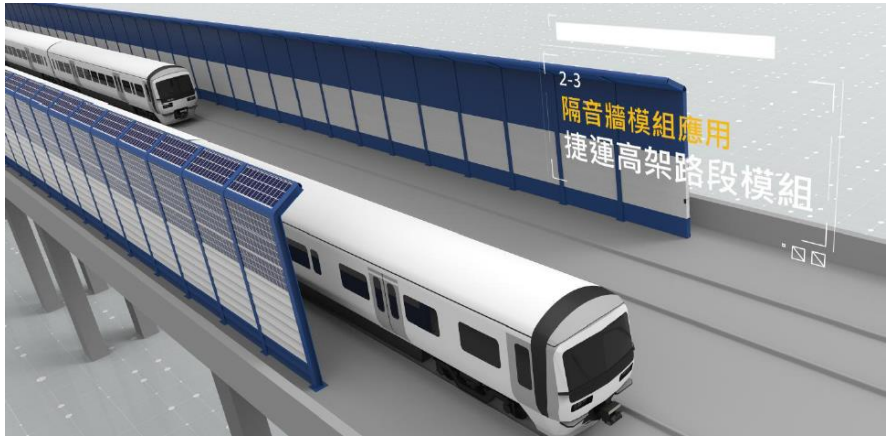
太陽光電發展趨勢-模組應用1

- 交通設施隔音牆
- 橋梁、道路、護欄模組



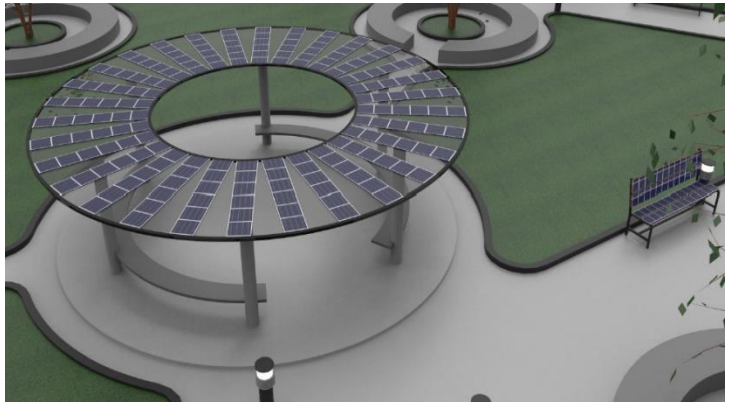


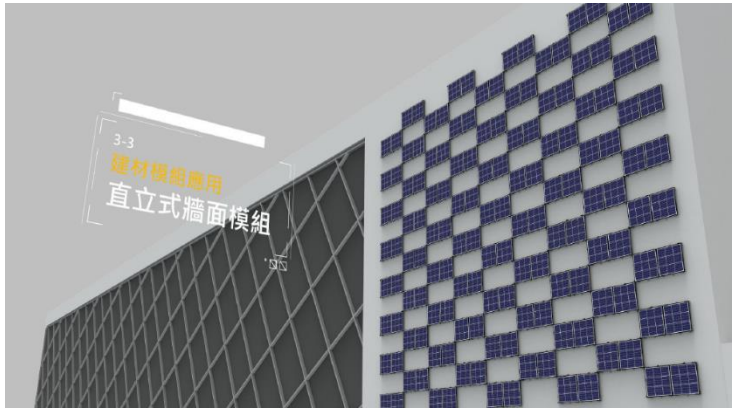


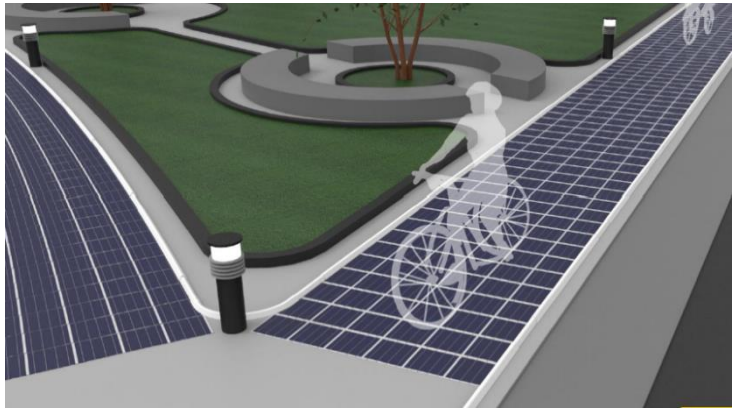


太陽光電發展趨勢-模組應用2

- 休閒用品應用、建材應用
- 生活設施、公園、涼亭、路燈、桌椅、車道模組







Thank you

III

Quality issues in subtropical climate & Taiwan

Quality Issues in Subtropical Climate and Taiwan

PV Guider

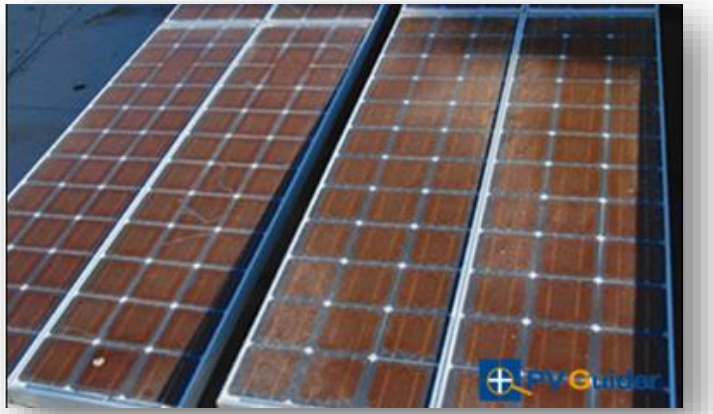
Jay/ Chief Consultant

Keep Green Gold Shining!

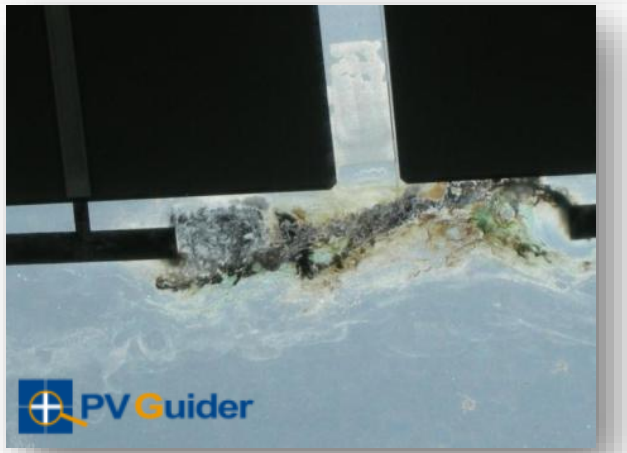
Challenges in Taiwan

- High irradiance/ UV
- High temperature
- High humidity
- Salty environment
- Typhoon
- Plants grow fast
- Flood and mudslide

High UV + Temperature

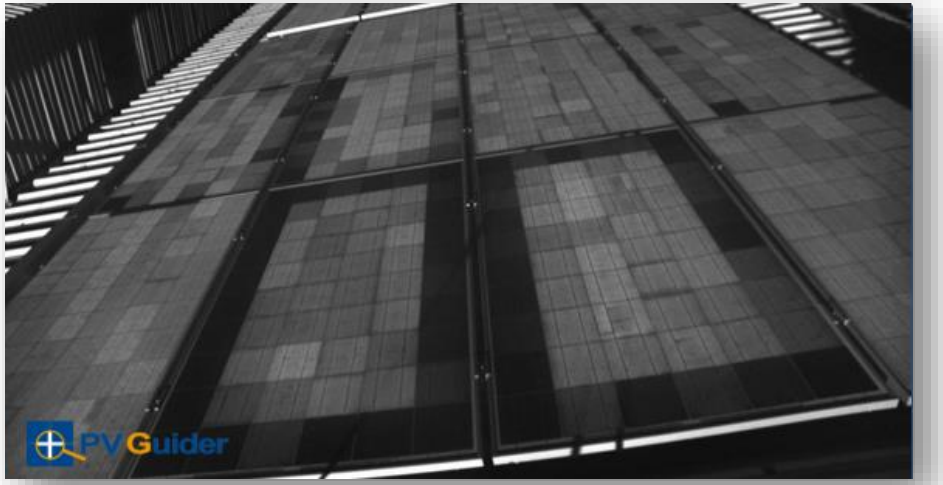


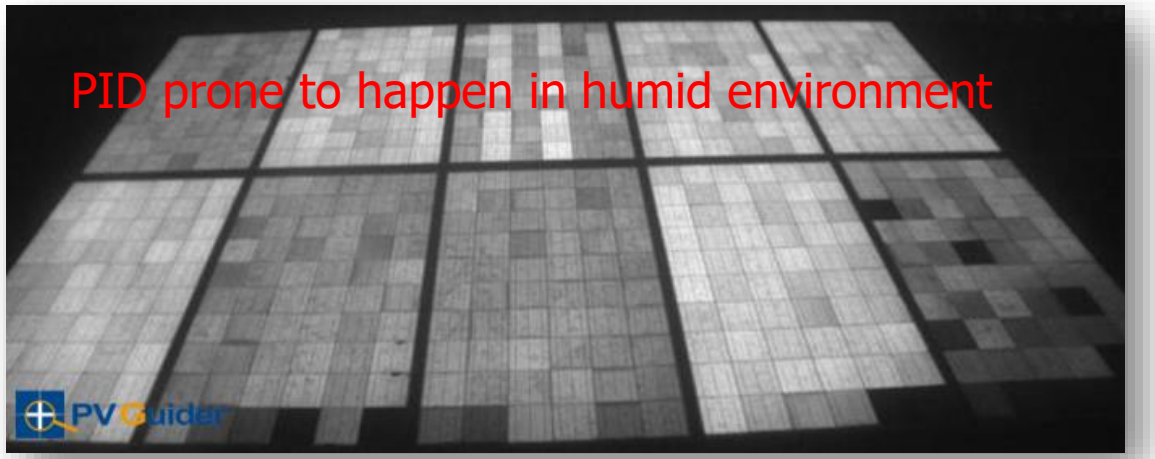
High Humidity



Humidity + Salt

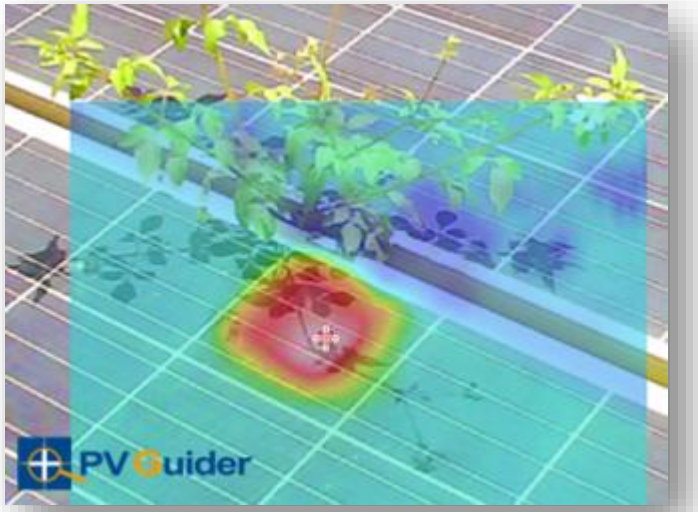
High Humidity





Typhoon

Plants grow fast



Flood & Mudslide

Geological survey is important!

Note: The photo is to demonstrate the risk, but not actually happened in Taiwan.

Solutions

- Component selection
- System design
- Maintenance frequency
- Geological survey in advance

Quality to Survive in Taiwan

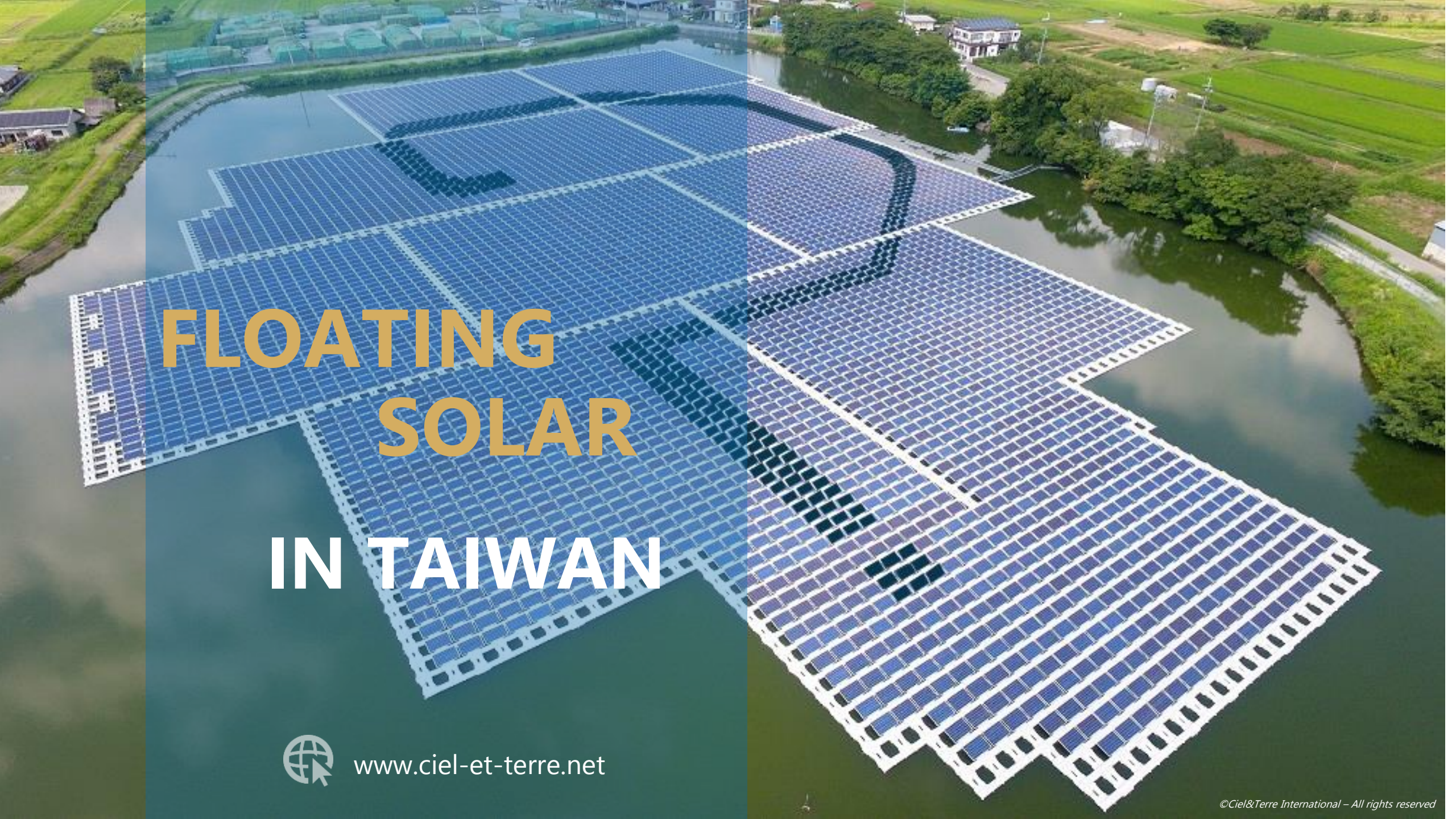
Dr. Jay Lin
Mobile：+886 989-832-421
Email：Jay@pvguider.com

網站：www.PVGuider.com
Website: English.PVGuider.com

Keep Green Gold Shining!

IV

Floating PV – Taiwan potential & quality



FLOATING SOLAR IN TAIWAN

www.ciel-et-terre.net

WHY FLAOTING SOLAR ?

ENVIRONMENTAL

- Minimizes water evaporation (water & ecosystems conservation)
- Improves water quality and reduces algal bloom
- Limits erosion of reservoir thanks to wave action
- Neutral/Positive impact
- Make PV possible when there is a lack of space

ECONOMIC

- Converts unused spaces into profitable areas
- Smoothest & fastest development processes
- Enhances electricity generation thanks to the cooling effect
- Reduces grid-connection costs and major infrastructures investments

SOCIAL

- Preserves valuable lands for other uses
- Rehabilitates contaminated and unusable areas with clean energy
- Compatible with recreational activities
- Environmental amenity, positive aesthetics

Ciel & Terre

FLOATING PV BENEFITS

FLOATING PV APPLICATIONS

HYDRELIO® SOLUTION

KATO-SHI
Japan
2.8 MWp

PIOLENC
France
15 kWp

YOTHATHIKAN
Thailand
5 kWp

SOBRADINHO
Brazil
4.9 MWp

Industrial water ponds

Quarry/Mine lakes

Aquaculture farms

Dams and Canals

SAWA-IKE
Japan
1.1 MWp

KUNDE
USA
10 kWp

QUEEN ELIZABETH II
UK
6.3 MWp

GODLEY
UK
2.9 MWp

Irrigation reservoirs

Desalinization reservoirs

Drinking water surfaces

Water treatment sites

WHY IN TAIWAN ?

THE COUNTRY IN FIGURES

Total area
35 980 km²

Mountainous area
21 588 km² (60 %)

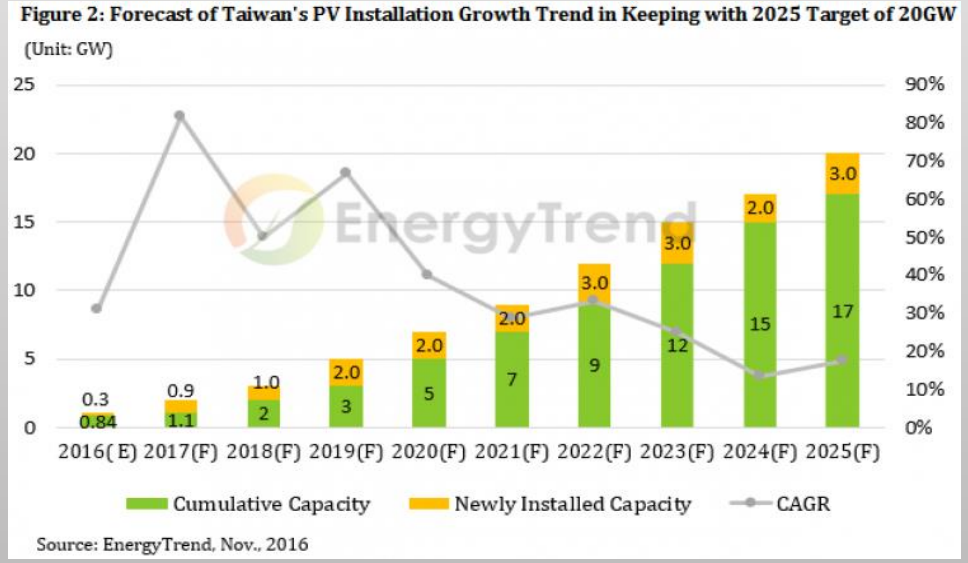
Water area
3 921 km² (10.9 %)

Irrigated area
3 820 km² (10.6%)

Agricultural lands
8 617 km² (22.7%)

Population Density
650/km²
(14th of the world)

TAIWANESE PV POLICY



FLOATING PV DRIVERS IN TAIWAN

More than 2,000 lakes and ponds that have been identified

TARGET 2025 : 20 GW in solar
whose 2 GW are floating solar

Yield of 1250 kWh/kWp/year on Southern Taiwan

No need of license to sell electricity for projects under 500kW

High cost of land due to land scarcity

No need of license to sell electricity for projects under 2MW by 2017

Typhoon zone up to 210 km/h

Good regulatory framework, legally safe, dedicated FiT

6% bonus for high-efficiency solar panels regulated by MOEA rules

15% bonus for solar plants installed in North Taiwan

Potential is much more : >40 GWp of FPV

HYDRELIO® SOLUTION

HYDRELIO® **BENEFITS**

RESISTANT TO SALT & UV **CORROSION**

HDPE
Blow-molding

+20 YEARS
Lifetime

5-20 YEARS
Warranty

DRINKING WATER **COMPLIANCE**

BS 6920:2000
water drinking

EXTREME WIND **RESISTANCE**

OVER 210 km/h
(130 mph)

TESTED BY ONERA®
Aerospace laboratory

SAFE MOUNTING & **MAINTENANCE**

EASY & QUICK
Installation | Dismantling | Recycling

SAFE
Access

HIGH POWER PRODUCTION

CONSERVE VALUABLE LANDS

CONTAIN WATER EVAPORATION

ECO-FRIENDLY 100% RECYCLABLE

CIEL ET TERRE

C&T TAIWAN RECORD

KEY DATES

December 2016: Establishment

April 2017: Grid connection of 481 kWp
Taoyuan Beihu power plant

June 2017: Grid connection of 2,300 kWp
Agongdian power plant

KEY FIGURES TAIWAN

2.78 MWp
Total floating PV capacity installed [July 2017]

+42 MWp
Total on-going projects so far planned to be connected in 2017-2018

C&T GROUP - WORLDWIDE

7 PATENTS + community trade marks registered

82 MWp
Total capacity installed

180 MWp
Total on-going projects

262 MWp
Total portfolio

ACTIVITIES

- ENGINEERING
- PROJECT DEVELOPMENT
- FINANCING
- PROCUREMENT & CONSTRUCTION
- OPERATION & MAINTENANCE

THANK YOU FOR YOUR ATTENTION !

QUESTIONS ?
IDEAS ?
ANY COMMENTS ARE WELCOMED !!

www.ciel-et-terre.net

v

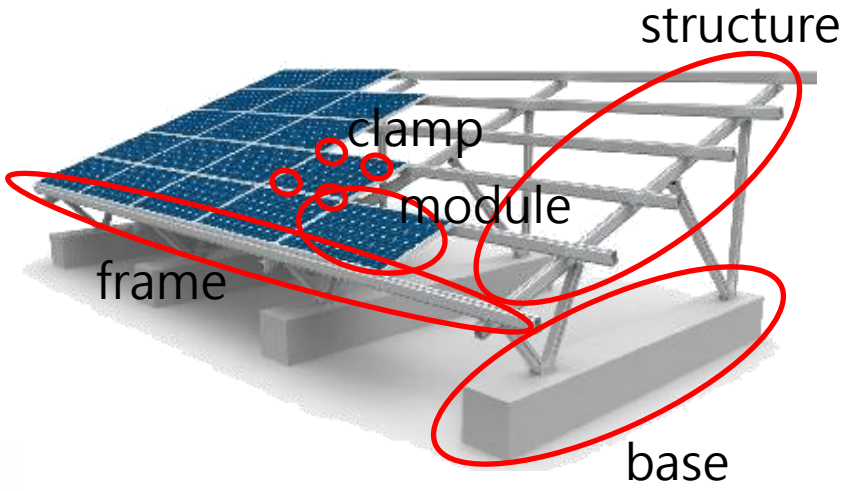
Poor quality case I

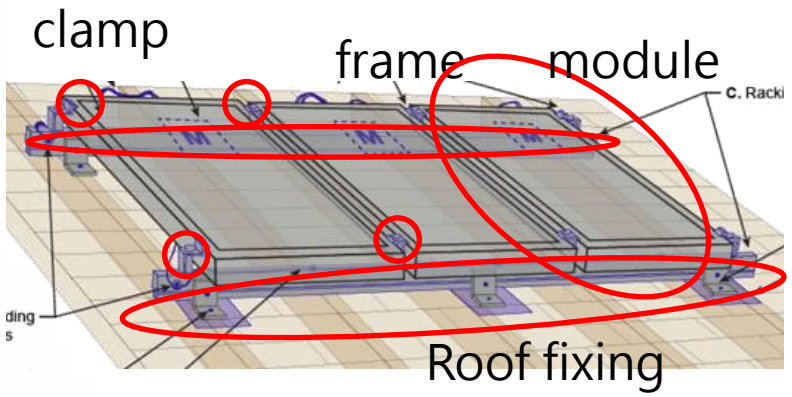
Poor Quality Case 1

Typhoon Damage

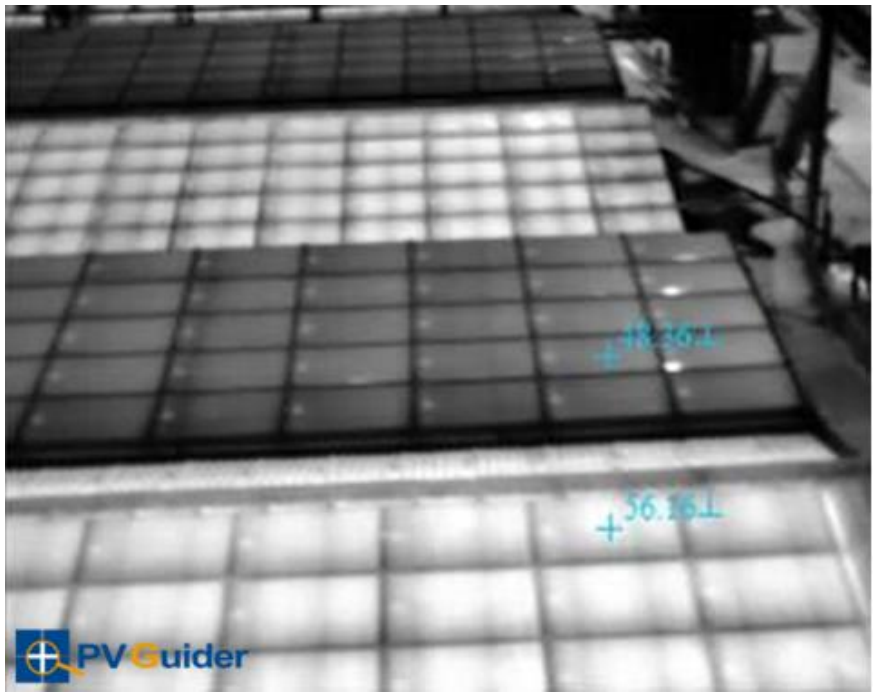
Keep Green Gold Shining!

Damages in Typhoon



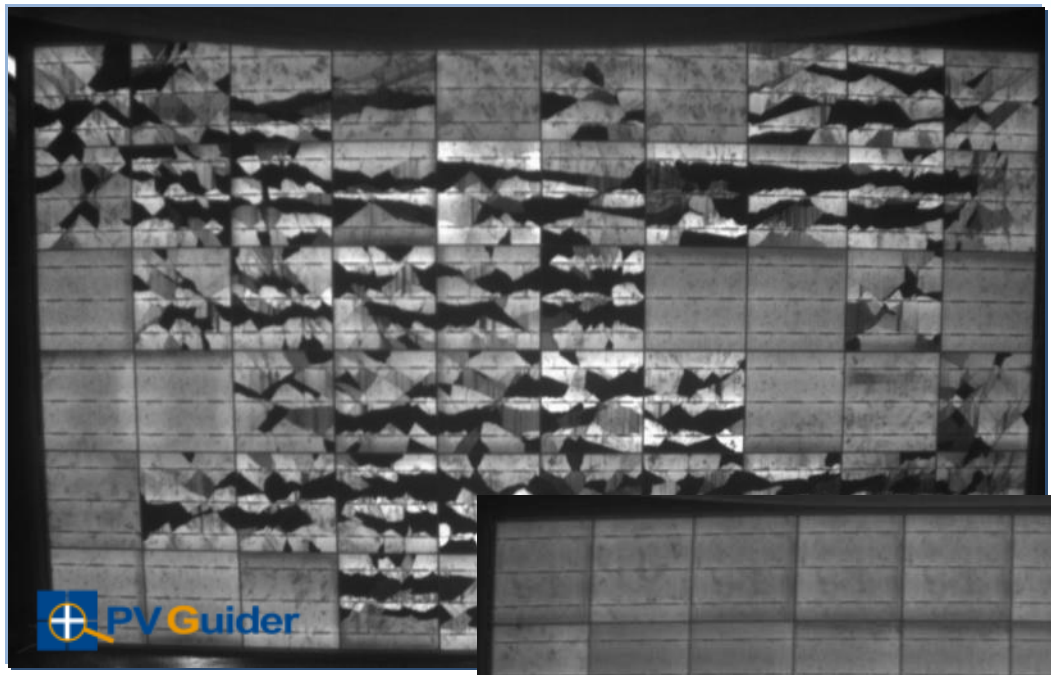


IR with drone

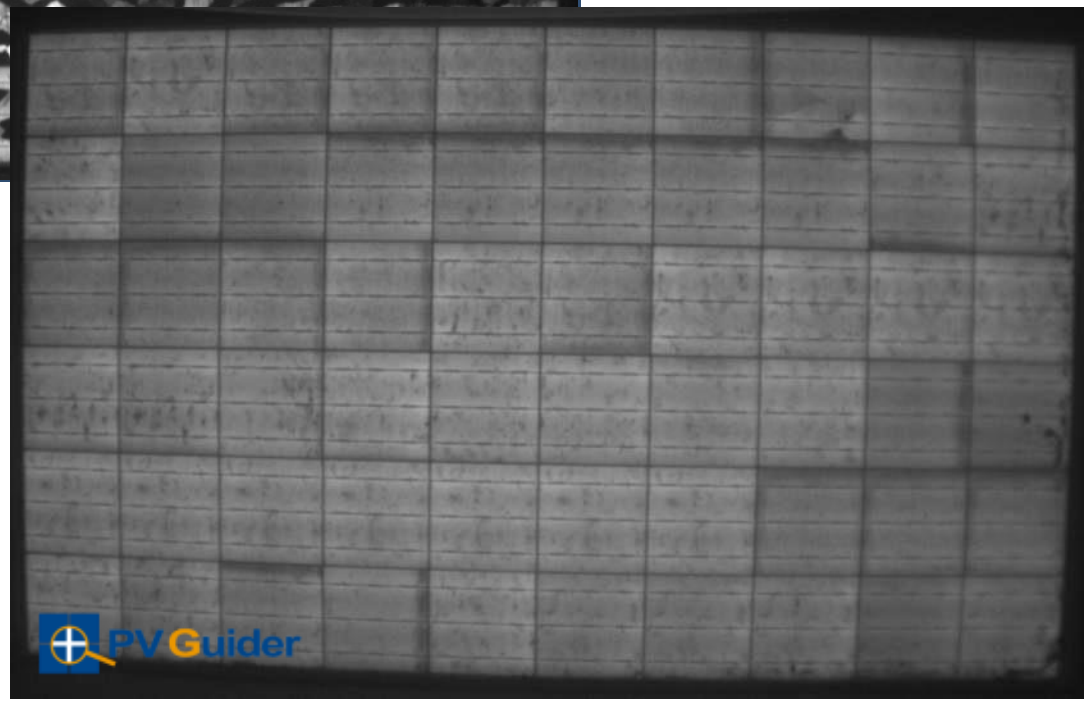


Modules at the edge of the array were damaged

EL of dropped modules



Serious damage, compensate by insurance



No damage, reinstalled

Dispute after Typhoon

Who is responsible for modules blown away?

Module Supplier: It's system design and installation problem, not module's problem

Frame Supplier: The system designer picked wrong frame spec, not frame's problem.

EPC: Module and frame are too weak to resist the strong wind, they should be responsible.

Owner: It's your problem, I don't care whoever's fault, just recover my system !

Insurer: I don't want to pay for wrong design or installation!

Who is responsible?

Keep Green Gold Shining!

VI

Quality in cables & connectors

Small components. Big impact.
Cabling of PV installations

QRT REI | 20st Oct. 2017 | Joseph Yang, Division manager

Failures and their financial impact

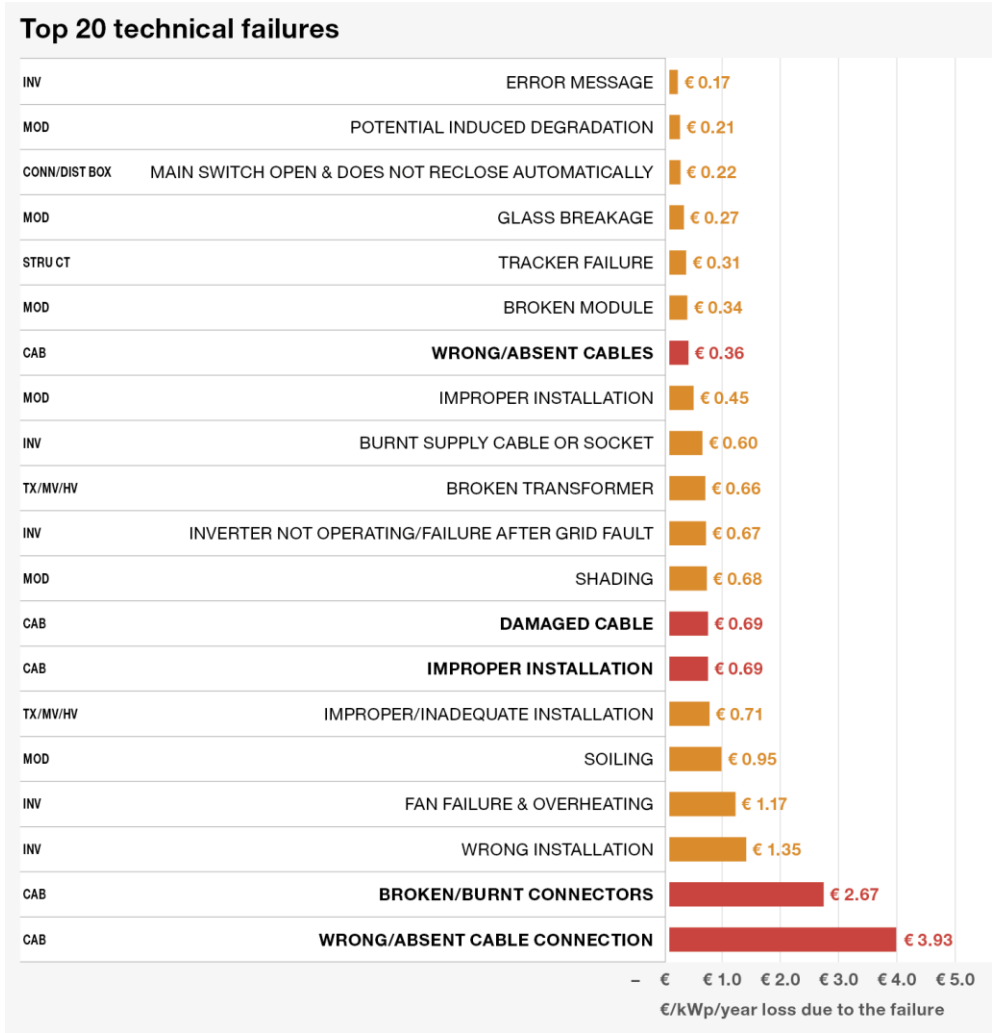
CPN (cost priority number) based on FMEA (Failure Modes and Effects Analysis) Solar Bankability project by European Commission's Horizon 2020

Common practice for professional risk assessment which aims to reduce risks associated with investments in PV projects

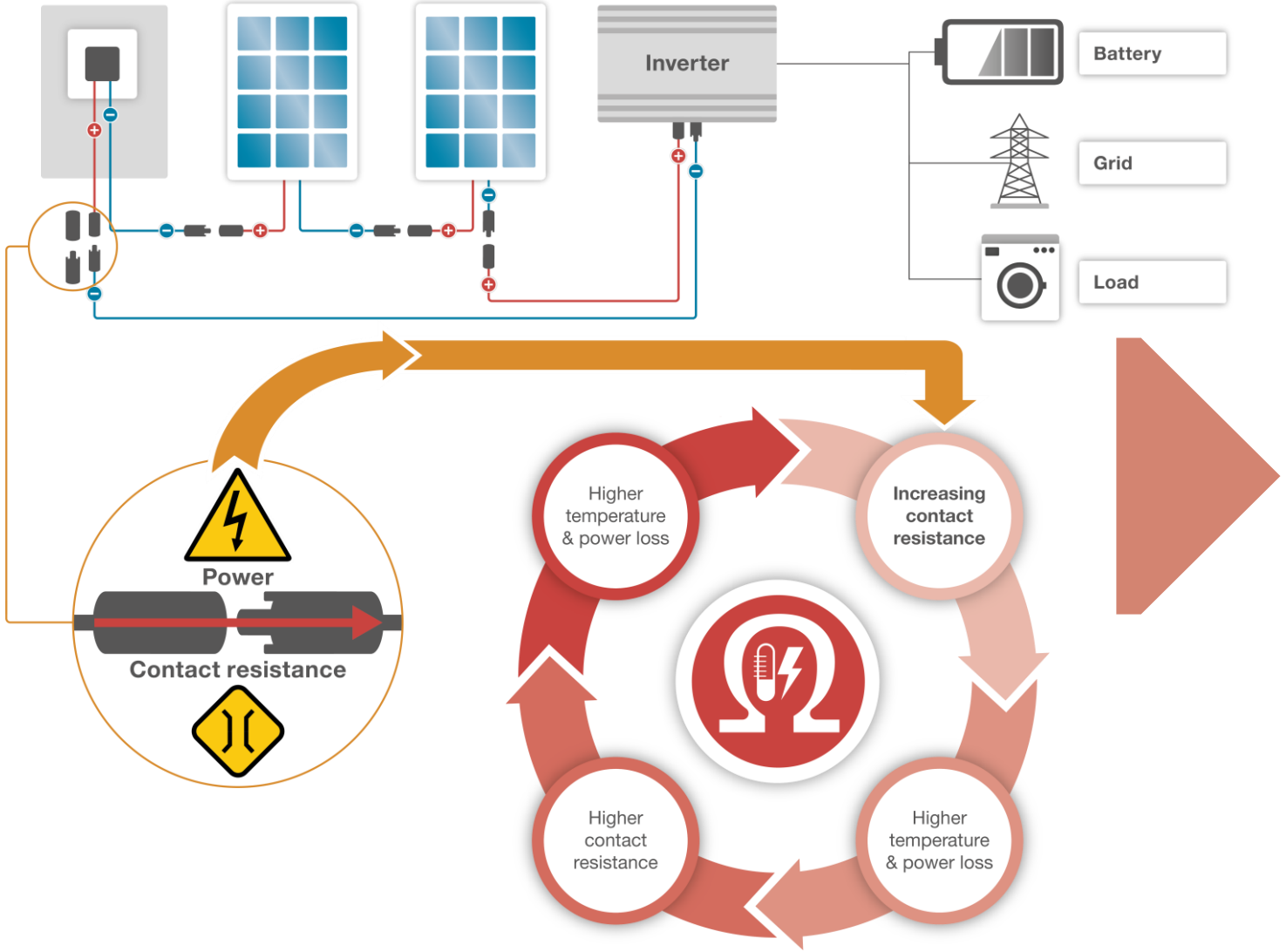
- **Technical failures/risks and their economic impact** due downtime and/or power loss & repair/substitution costs
- **Indication**/ estimation of the **economic risk** (in average) of a specific technical risk
- Cost Priority Number (CPN) = **cost-based** failure mode and effects **analysis**
- Method was applied to a database of **over one million documented failure** claims (empirical and statistical)

→ Cable & **connector with huge financial impact** (€/kWp/year loss due to the failure)

→ **Risk mitigation measures** should be selected with an objective to **minimize the LCOE** by optimizing the **balance** between the **CAPEX and OPEX**



Why connectors have a big impact



Consequences:

- High risk for (partial) connector failures
- Performance losses, higher PPM-rates and downtimes of modules, strings or plants
- High service/maintenance and spare part costs for repairing
- Hotspots and fire in PV system and reconstruction costs
- High costs for legal disputes due to undefined liabilities

3 sources of risk

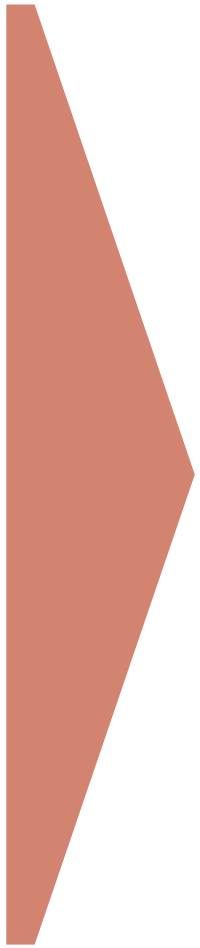
Product

1. Quality vs.
   Low-end Product

Handling of product/ installation

2. Cross-Connection

3. Defective
   Installation/Crimping



0,001 % Potential Savings

service hours
spare parts costs

restruction
costs due fire

legal costs

CAPEX + OPEX

Energy Yield

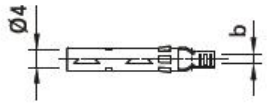
lost kWh
contact resistance

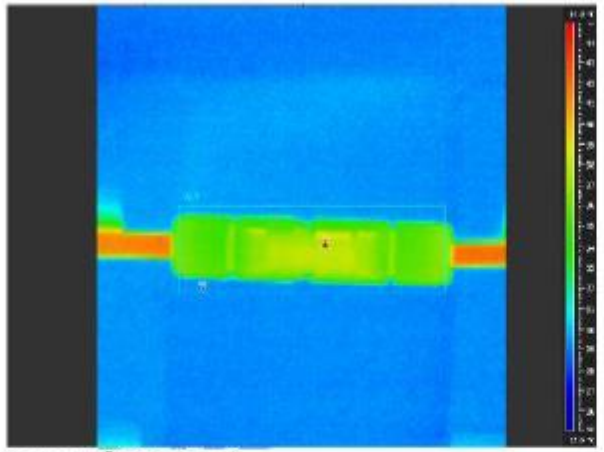
lost kWh
downtime

Key takeaway

- What is MC4 ?

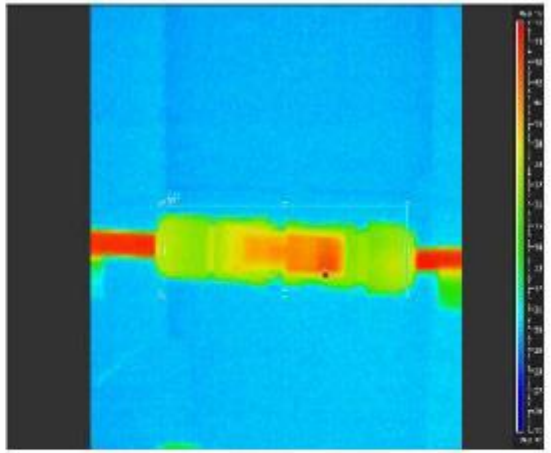
- Cable & connector with huge financial impact in a PV project.





Source: TÜV Rheinland

Temperature rising of male and female parts of the same connector family



Temperature rising of male and female parts made by different connector manufacturers

VII Discussion

Break

Part II

I

Selection rules for high quality PV modules

PV Taiwan 2017
Taiwan Int'l Photovoltaic Exhibition
Oct. 18-20 Taipei Nangang Exhibition Center, Hall 1

優質太陽光電模組選擇方案

Selection Rules for High Quality PV Module

Hung-Sen Wu

CMS/ITRI

PV系統建置環境多元

- 地面型太陽光電
  - 水域空間
  - 鹽業用地
  - 地層下陷區域
  - 掩埋場/受汙染區域
  - 沙漠地區
  - 屋頂/建築相關

優質太陽光電模組考量項目

影響模組發電與安全的分級

嚴酷度	評分
嚴重影響發電與安全	10
嚴重影響發電	8
中度影響發電	5
輕微影響發電	3
不影響發電	1

模組失效模式對發電與安全的評比

失效模式	評分
封裝材變色	3
嚴重脫層	5
背板絕緣失效	**10**
背板失效	1
電極變色、序列阻抗增加	5
電極失效、焊接失效	**8**
熱斑	**10**
電池破裂	5
旁路二極體/接線盒 失效	5
玻璃破裂	5
永久髒汙	2
電致衰減(PID)	**8**
框變形	3

資料來源：Photovoltaic failure and degradation modes, *Prog. Photovolt: Res. Appl.* 2017

選擇方案-1

經濟部能源局 Bureau of Energy, Ministry of Economic Affairs

TAIWAN EXCELLENT PV 優質太陽光電產品評選活動-金能獎

TAIWAN EXCELLENT PV AWARD

優質太陽光電模組選擇方案-2

環境 (Environment)	驗證方案 (Test Plan)
強風 (Strong Wind)	2 X DML, ML 3 X(5400/2400)
農牧腐蝕 (Corrosion)	Ammonia corrosion test (IEC 62716)
屋頂/高溫使用 (Roof/ High temp.)	Operation at high temperature (Hot Spot, UV, TC, Bypass Diode)
沙漠 (Desert)	UV at 80 °C or 100°C (Dose: > 120 kWh/m2) + chamber test

II

Manufacturing technology, production equipment & quality assurance

Confidential

III Poor quality case II

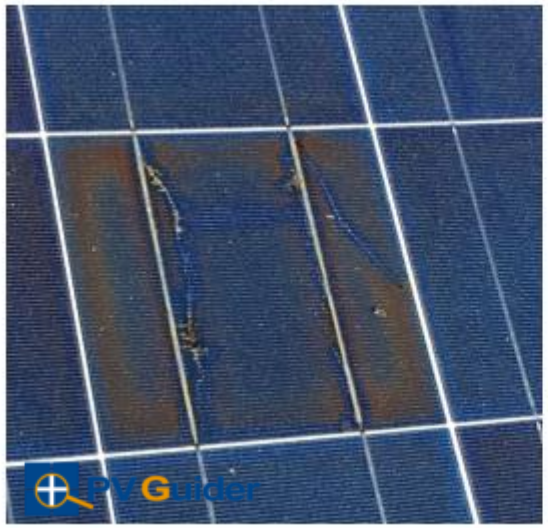
PV Guider

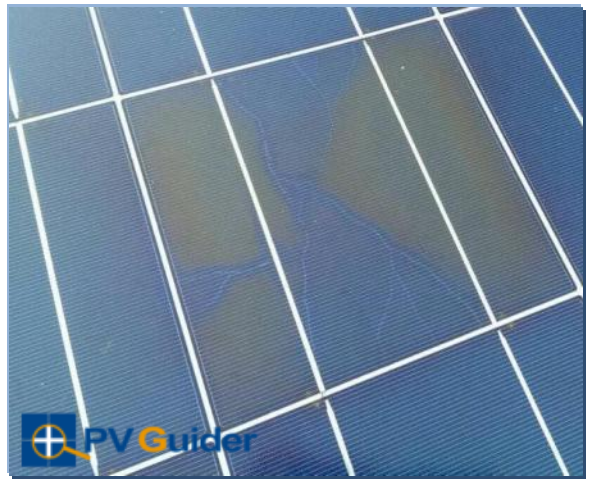
Poor Quality Case 2

Hot spot and micro cracks

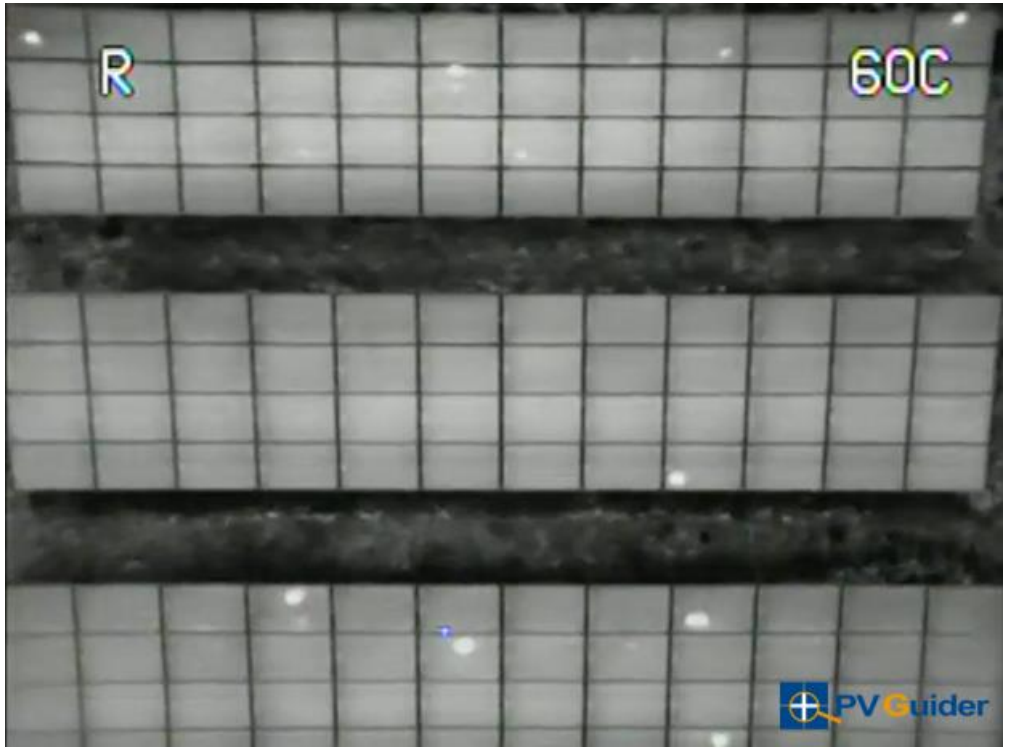
Keep Green Gold Shining!

Phenomenon



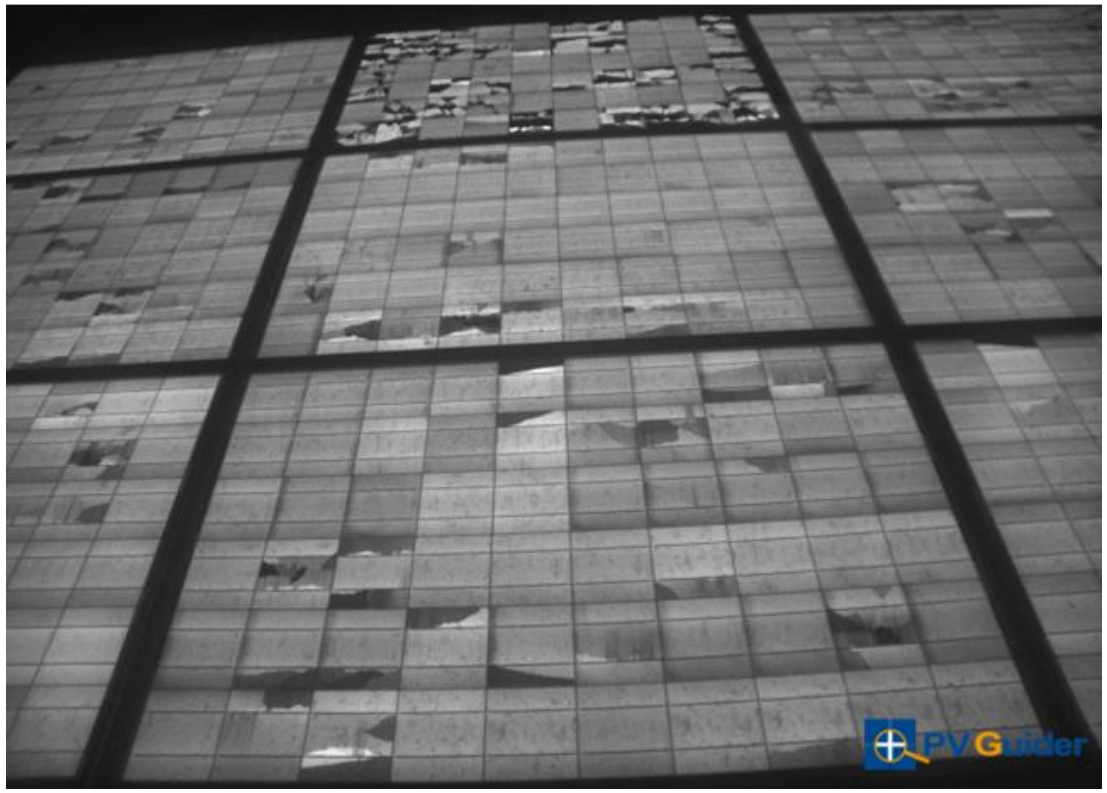


IR Image



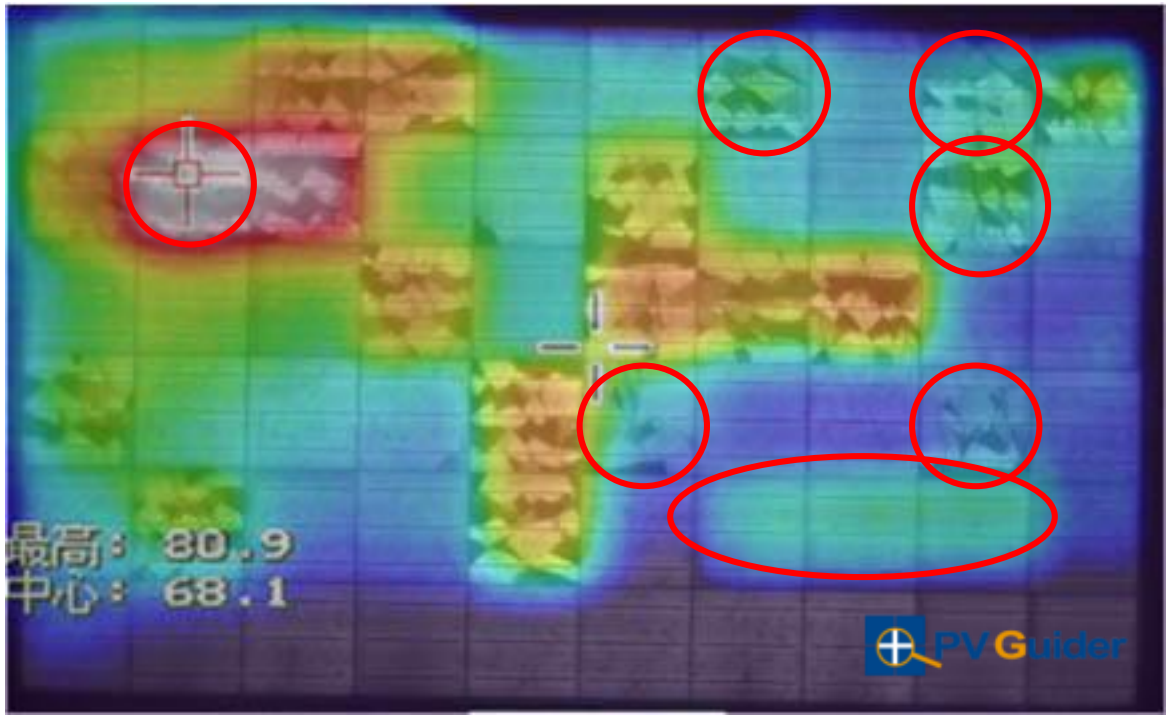
IR image taken from Drone

EL Image



EL image of the PV modules

IR vs. EL



- Highest temperature is at the cell with serious cracks
- Serious cracks does not necessarily have high temperature
- High temperature does not necessarily have cracks

Dispute

Module Supplier: The cracks result from the installation problem, not module supplier's responsibility !

Owner: How do you prove it is installation problem but not module defect ?

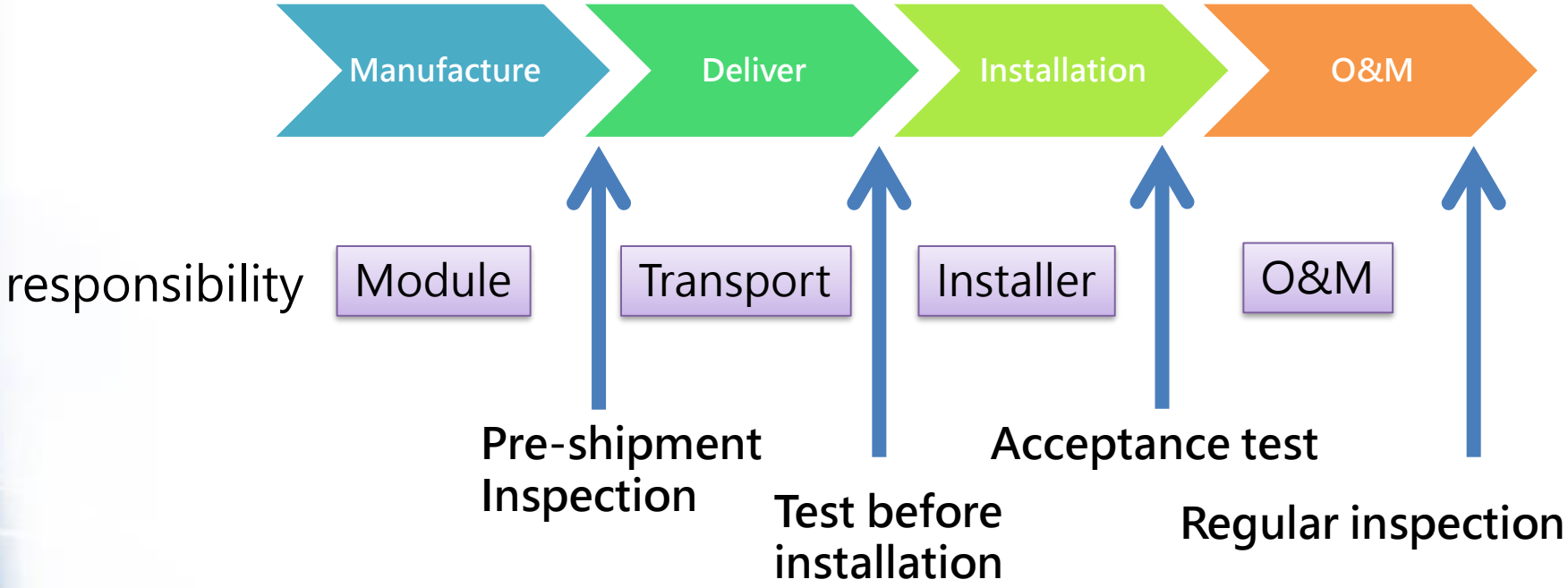
Module: The power is still within the power guarantee, no compensation !

Owner: The cracks result in larger degradation and hot spot, I want new modules now !

Owner: Even it is the installer walking on the module, the installation manual did not say it is not allowed!

Module: It is common sense no walking on modules.

Responsibilities



Who is responsible?

Keep Green Gold Shining!

IV Field research findings

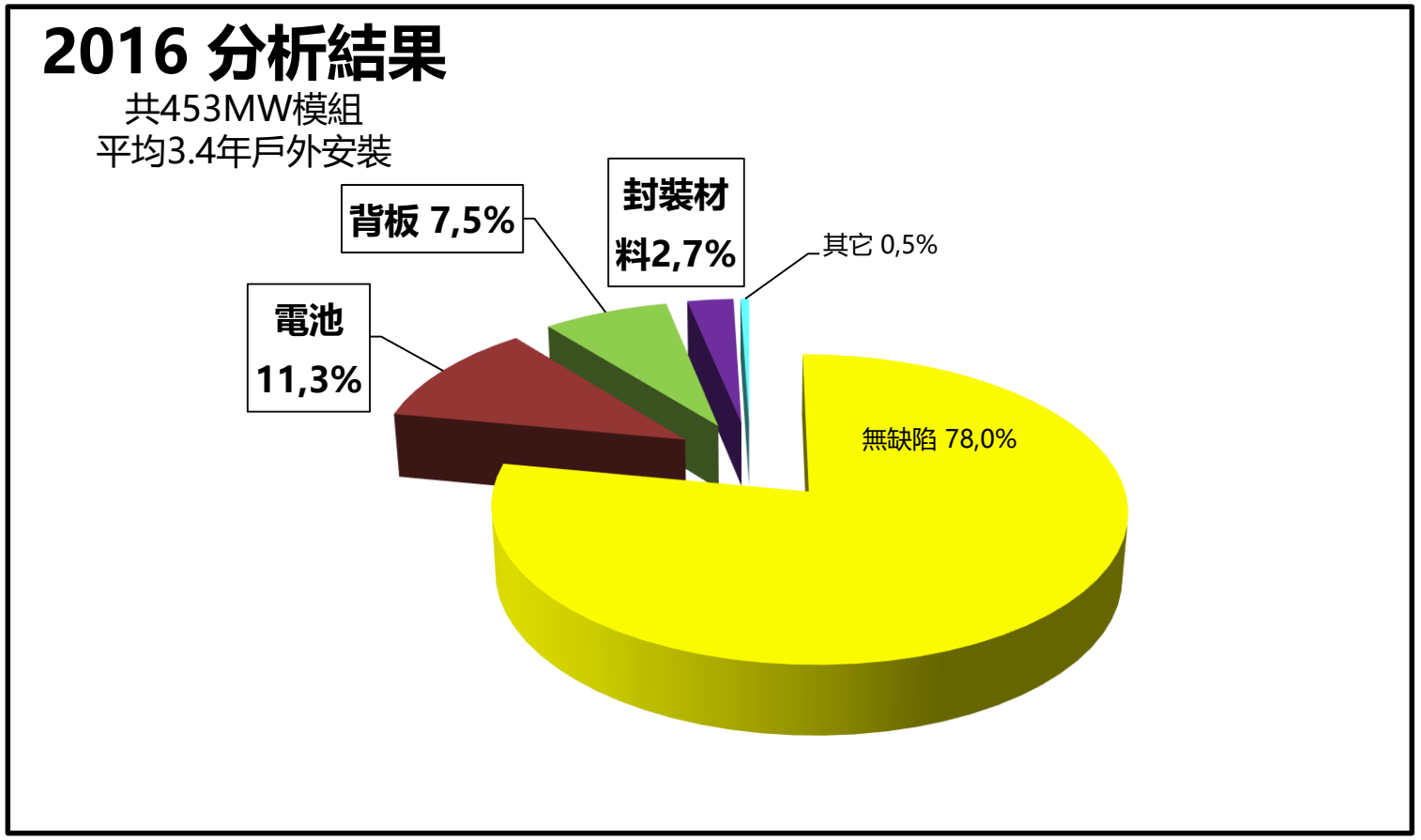
Learning From Field Study

太陽能系統案場實例調查分析

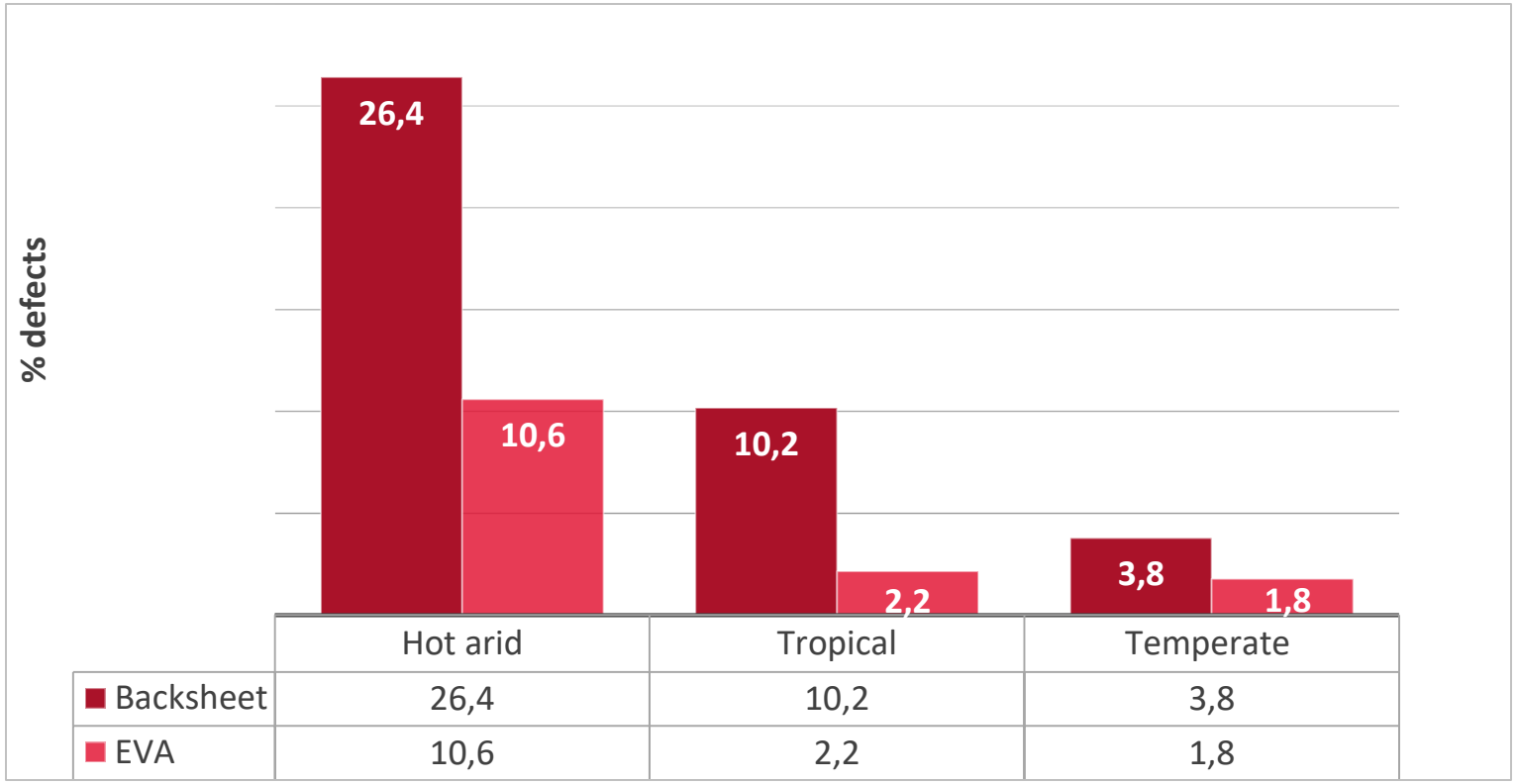
傅波

杜邦太陽能解決方案

杜邦全球戶外模組研究



嚴苛環境下模組背板和EVA封裝材料失效比例高



	Hot arid	Tropical	Temperate
Backsheet	26,4	10,2	3,8
EVA	10,6	2,2	1,8

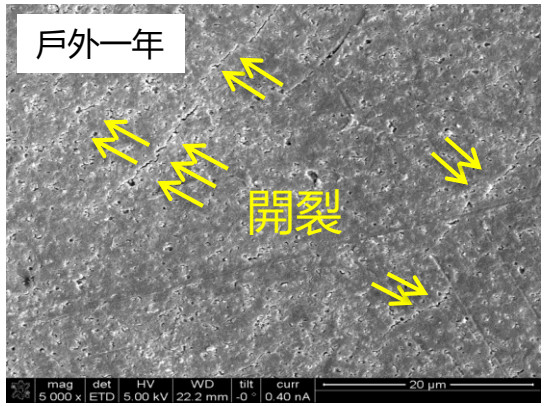
即使通過嚴格IEC測試，模組背板仍出現大面積戶外失效

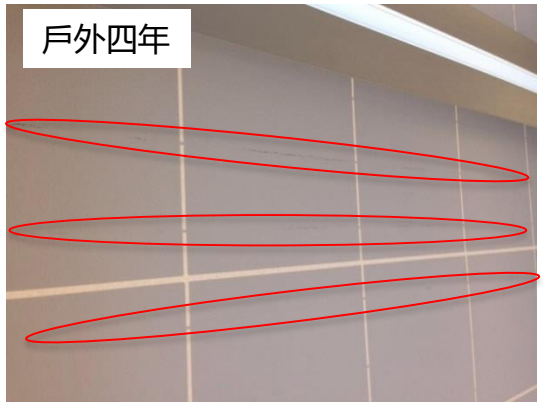
歐洲
- 模組安裝於 2012年，檢測於2015年
- 背板深度開裂，脫層，水氣侵入導致腐蝕

中國西部
- 模組安裝於 2012年
- 2013年發現微小開裂
- 2016年發現開裂變大

中國東部
- 漁光互補電站並網第2年，電站月度發電量與第一年同比下降10%左右
- 抽樣模組邊緣及中部電池片EL發黑，發生嚴重PID，功率衰減49.4%，
- 模組背板發生開裂

使用該背板的模組出現大規模開裂，現已退出市場





現行的單項加速老化測試無法模擬戶外綜合老化應力，不能有效檢測材料的長期老化性能

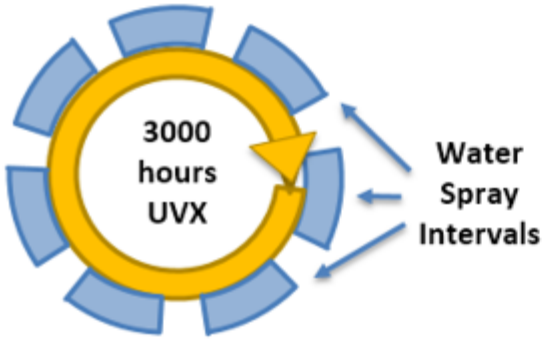
濕熱環境 - PET聚酯背板戶外4年出現嚴重開裂

- 安裝於西班牙，濕熱氣候
- 2.3 MW模組，兩種模組類型，戶外使用4年
- 所有PET聚酯背板都出現開裂，開裂沿焊帶方向
- 一些模組未通過濕漏電測試
- 電站所有者無法獲得更換的模組

背板開裂會導致模組失效和安全風險

解決方案: 模組加速序列老化測試（MAST）

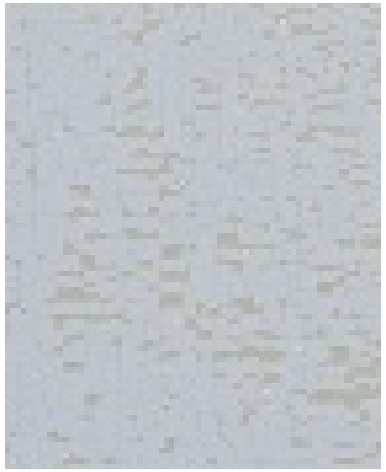
PET聚酯和PA聚醯胺背板在MAST老化測試後發黃開裂



DuPont MAST- Module Accelerated Sequential Test 3

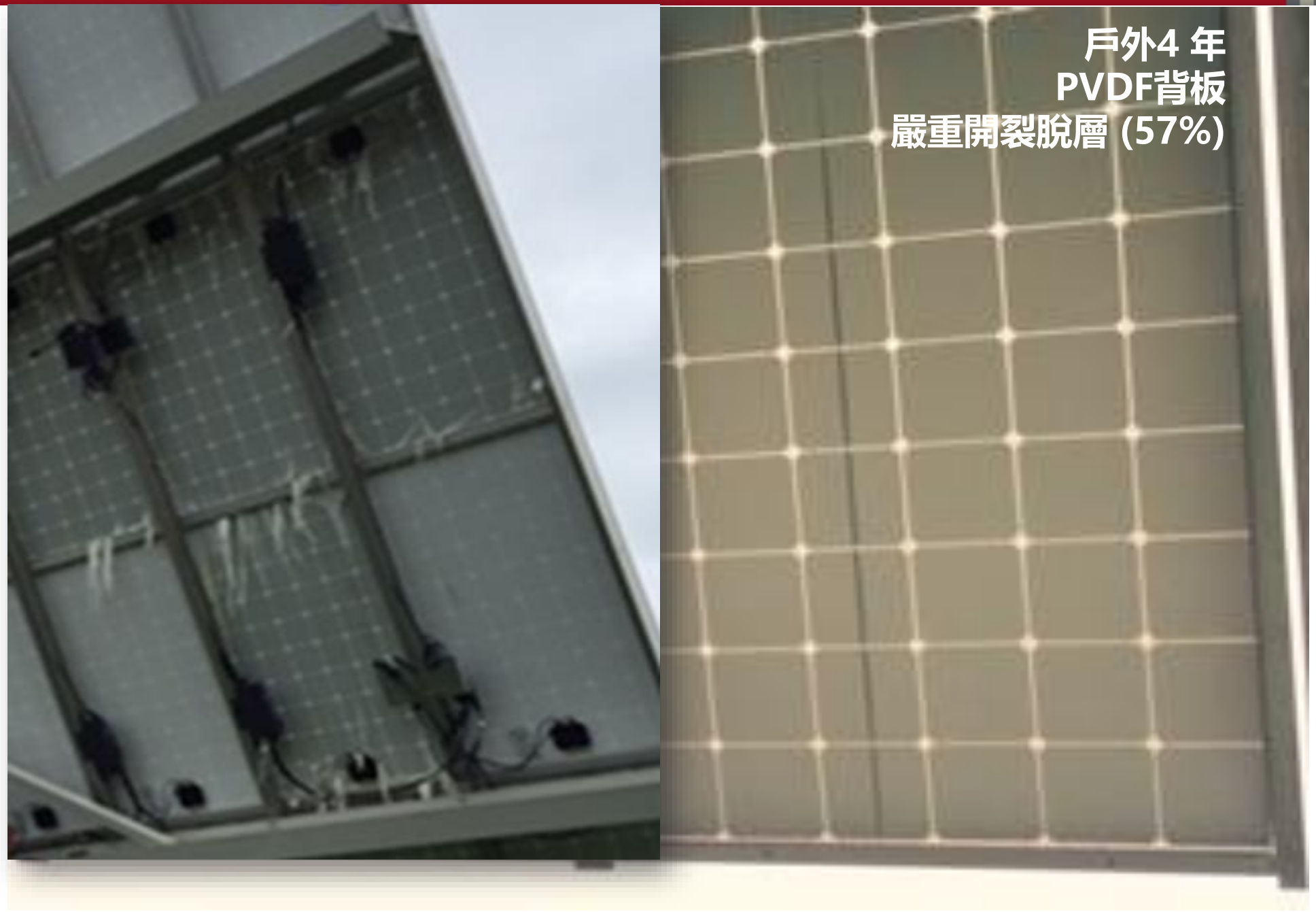
	Double Sided Fluoro		Single Sided Fluoro		Non-Fluoro		
Measurement	Tedlar® PVF	PVDF	Tedlar® PVF	PVDF	PA (Polyamide)	HPET (Hydro-stabilized)	PET
Yellowing	●	●	●	●	●	●	●
Mechanical Loss - Cracking	●	●	●	●	●	●	●

● Excellent ● Fair/Yellowing ● Poor/Cracking ● No Data

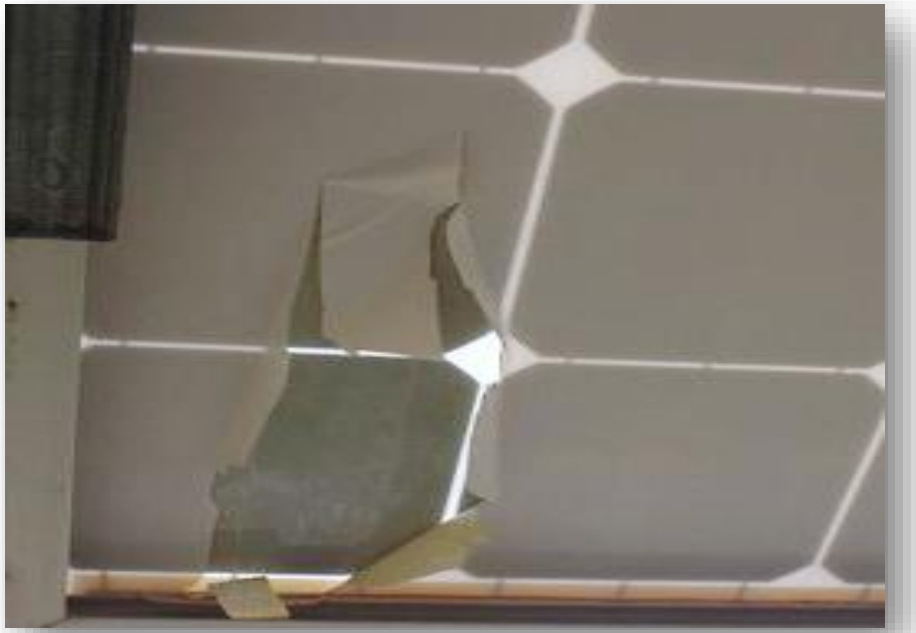


PA背板測試開裂

PET背板測試後黃變


戶外4 年
PVDF背板
嚴重開裂脫層 (57%)

戶外5 年
PVDF背板
嚴重開裂脫層



解決方案: 模組加速序列老化測試 (MAST)

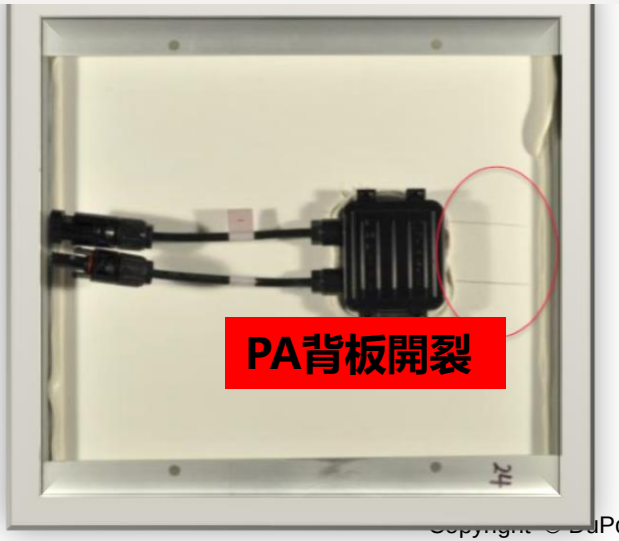
PVDF聚偏氟乙烯和PA聚醯胺背板在MAST老化測試後開裂

冷熱、濕熱和紫外應力以序列形式綜合
Sequential combination of Thermal, Humidity, UV

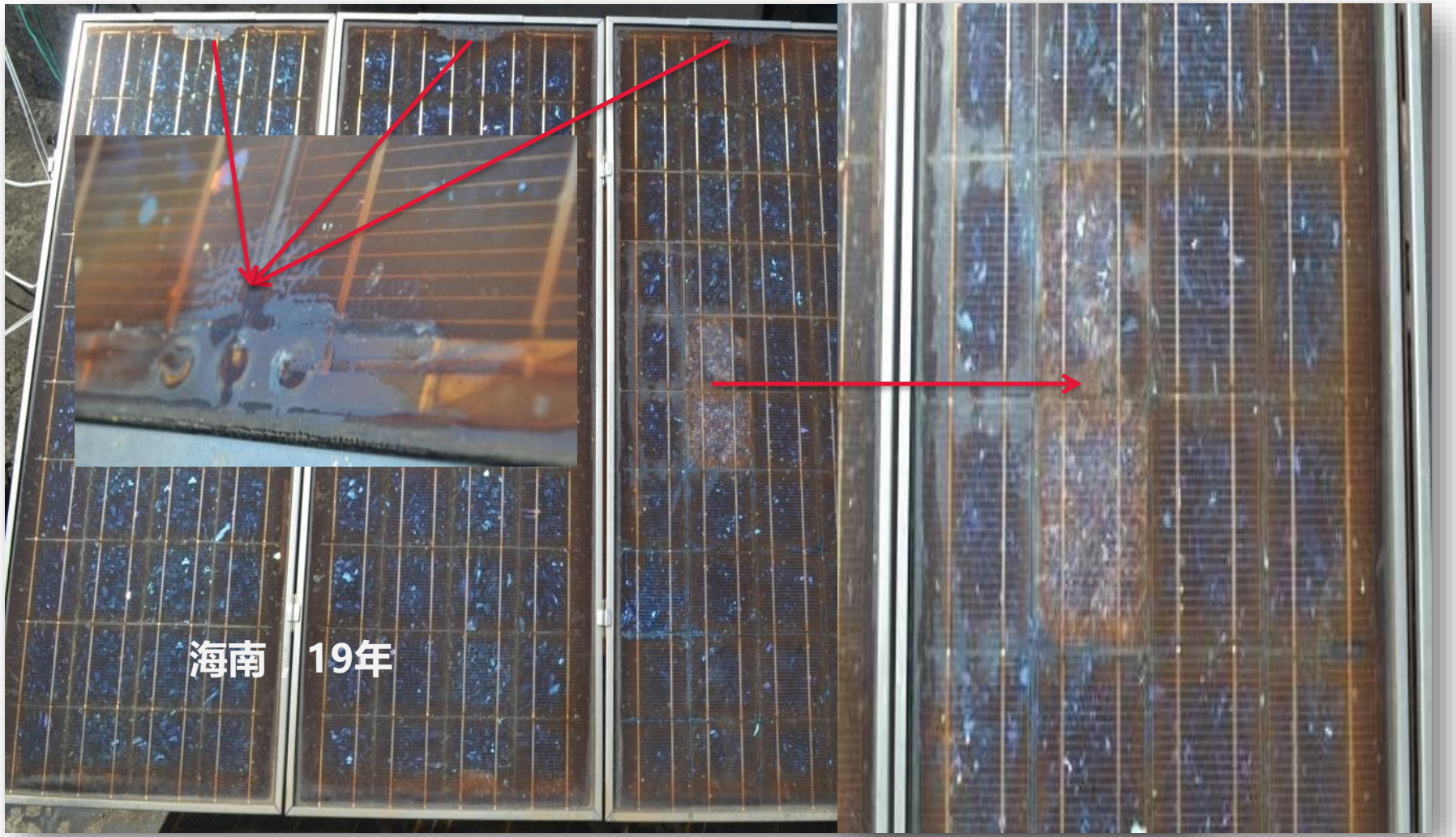
1000小時濕熱老化
1000 Hours in a Humidity Chamber
相當於戶外 25 年以上的濕熱老化應力
Amounts to >25+ years worth of stress

600次冷熱循環
600 Thermal Stress Cycles
模擬戶外所見的冷熱循環應力
Mimics thermal stresses seen in the field

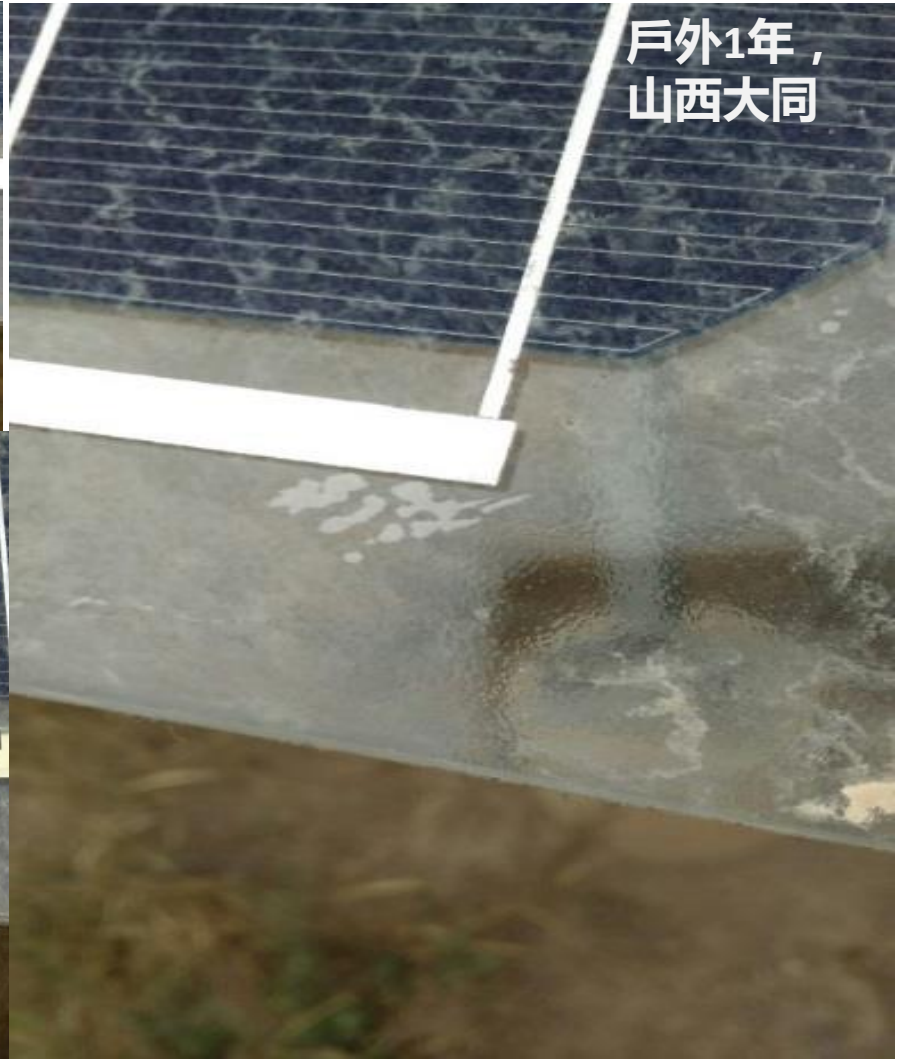
1676 小時 紫外老化
1676 Hours in a UVA Chamber
相當於戶外 20 年的紫外老化應力
Amounts to ~20 years desert dose of UV



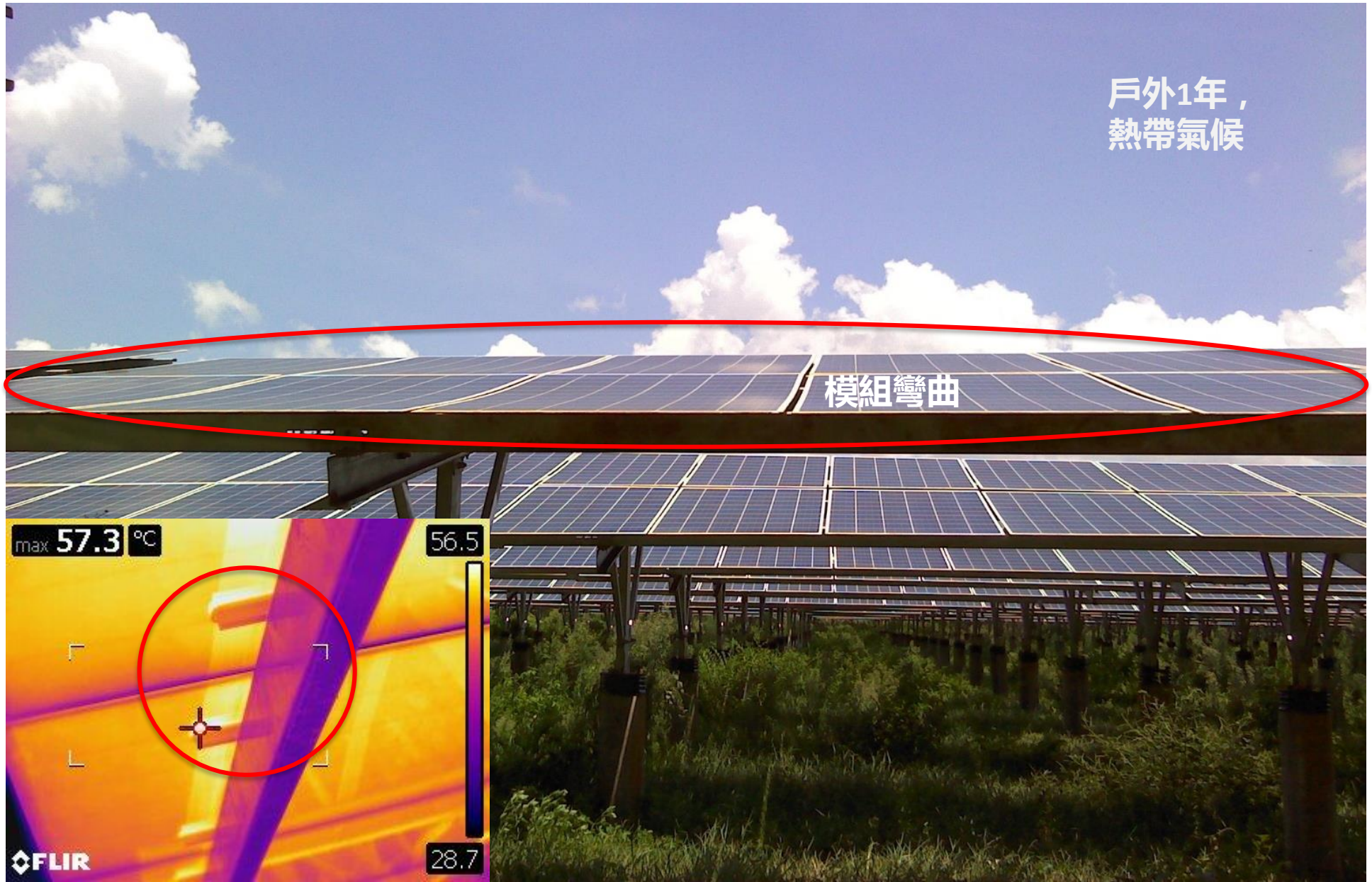
濕熱環境 - 水氣進入雙玻模組導致脫層和電池腐蝕



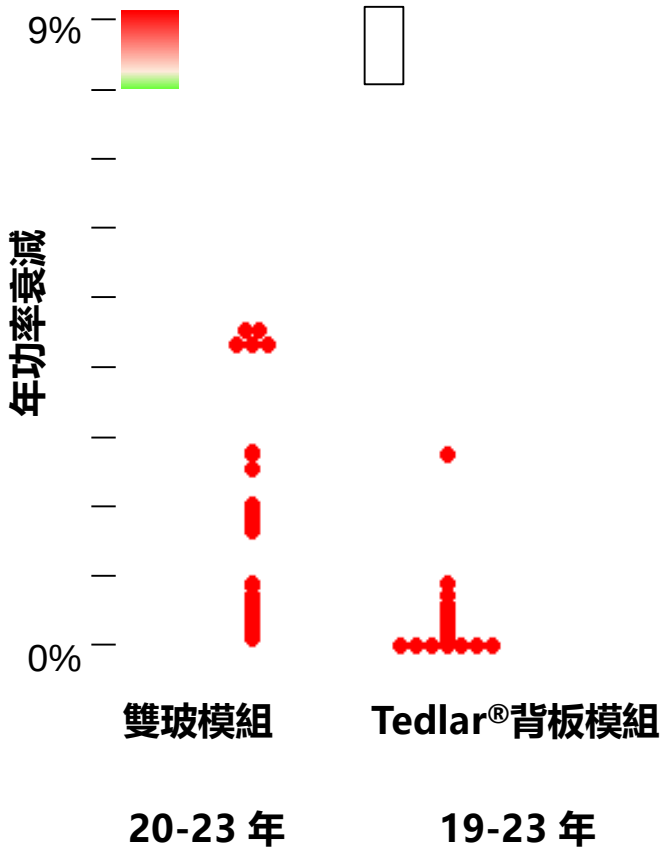
雙玻模組邊緣脫層



無框雙玻模組嚴重彎曲，掛鉤處散熱不良溫度高



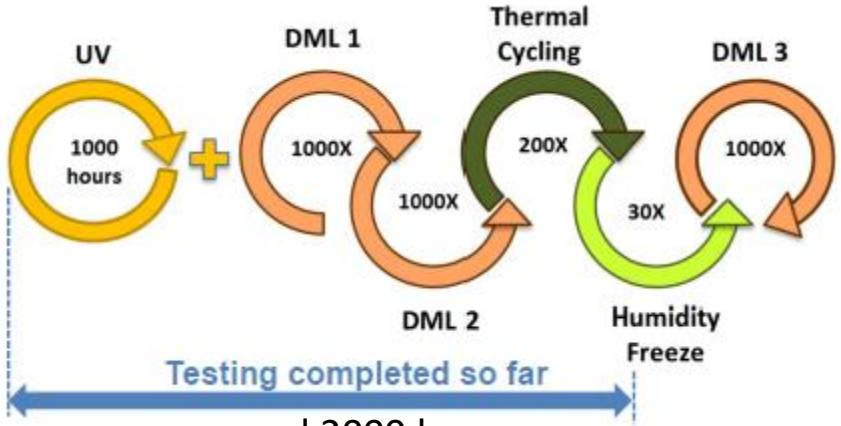
協力廠商研究機構長期戶外研究證明雙玻模組功率衰減嚴重



Source: Joint Research Centre (Italy)

解決方案: 模組加速序列老化測試 (MAST)

雙玻模組在MAST老化測試後脫層



around 2000 hrs

Protocol

- **UV exposure**: 65kWh/m² on the front
- **DML 1**: 1000 cycles of ±1500 Pa of loading @ 1/6 Hz
- **DML 2**: 1000 cycles of ±1500 Pa of loading @ 1 Hz
- **TC200** = Thermal Cycling, -40°C ⟷ 85°C, ramp and hold per *IEC62782*, 200 cycles
- **HF30** = Humidity Freeze, 30 cycles

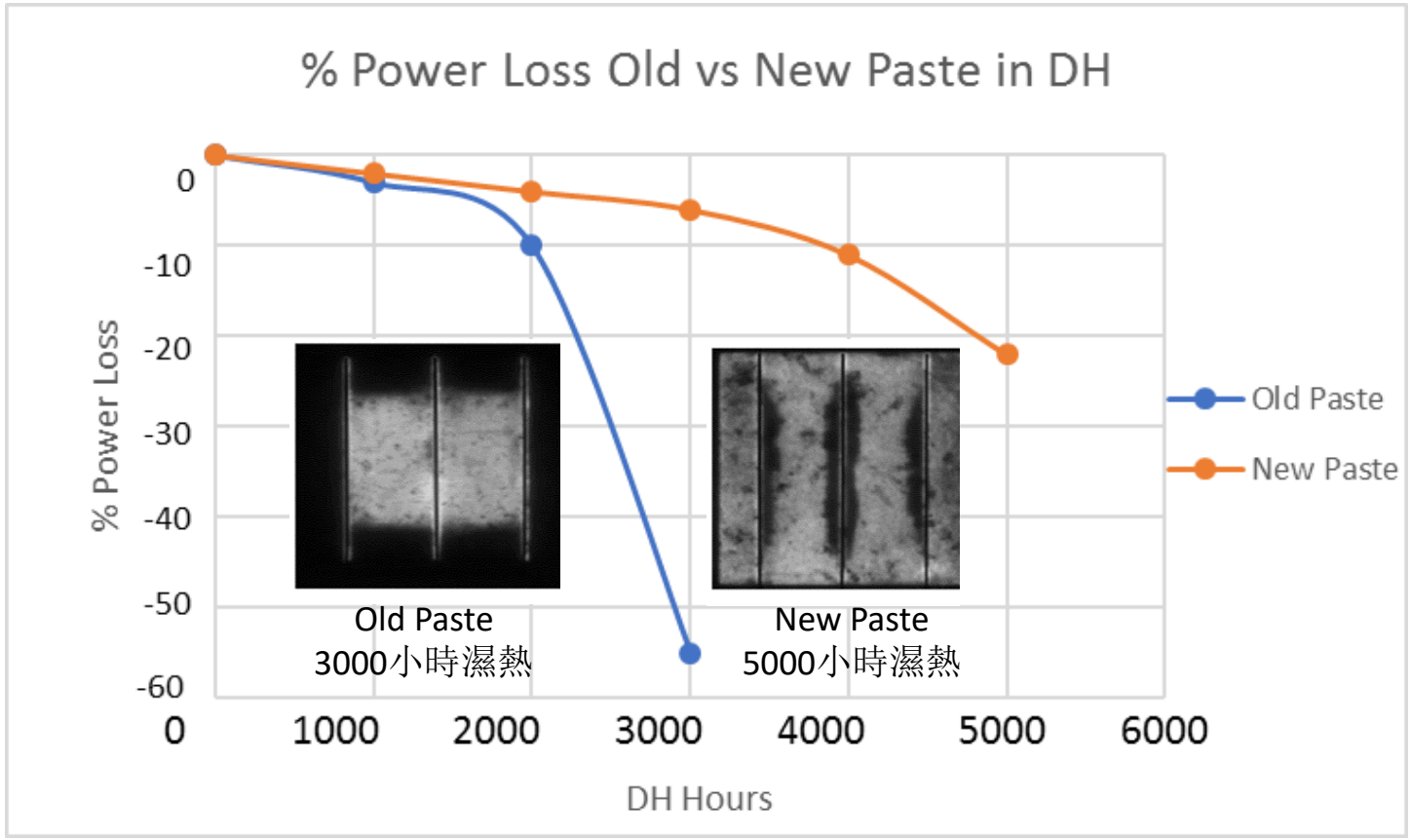
Optional

- **DML 3**: 1000 cycles of ±1000 Pa of loading @ 4 Hz

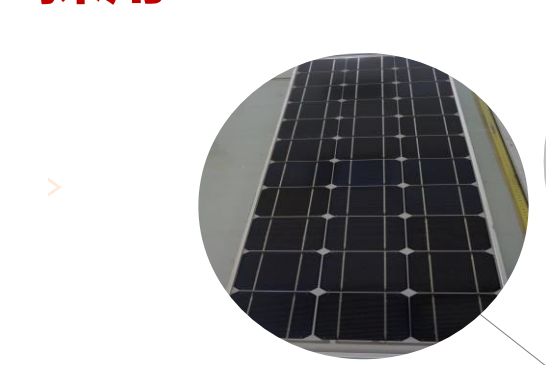
Sequence	G/G modules	G/Backsheet modules
DML 1	No change	No change
DML 2	Slight **delamination** on front	No change
TC 200	**Delamination** on front, **encapsulant voids** on back	No change
HF 10	**Severe delamination** on front, more **encapsulant voids** on the back	Slight yellowing of backsheet, no delamination

解決方案: 電池片濕熱老化試驗

採用耐腐蝕電池金屬漿料



採用Tedlar® PVF薄膜的背板的模組經受嚴苛氣候長期考驗

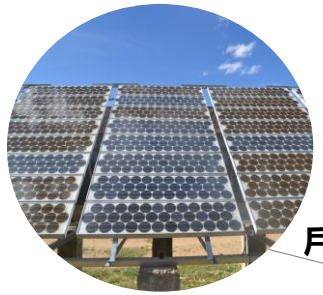


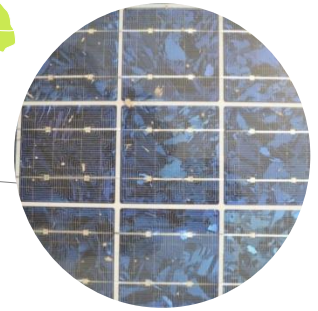
戶外>15年，93.0% 功率

戶外27 年, ~90% 功率

戶外14年

戶外18年，88.2% 功率





荒漠/ 高原

大陸性氣候

亞熱帶/ 熱帶

北京

上海

0.66 %

<0.47 %

0.33 %

0.78 %

0.57 %

0.68 %

0.39 %

0.27 %

1

2

3

4

5

6

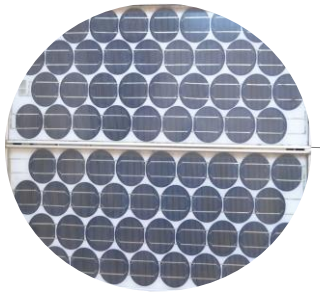
7

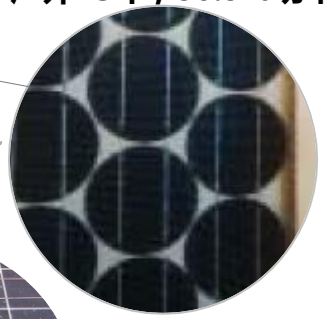
8

9

戶外17 years, 86.7% 功率

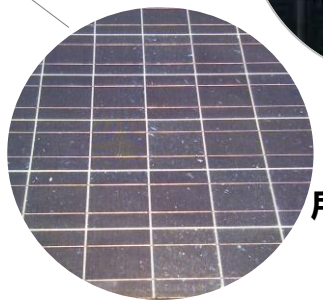
戶外23年，86.9%功率





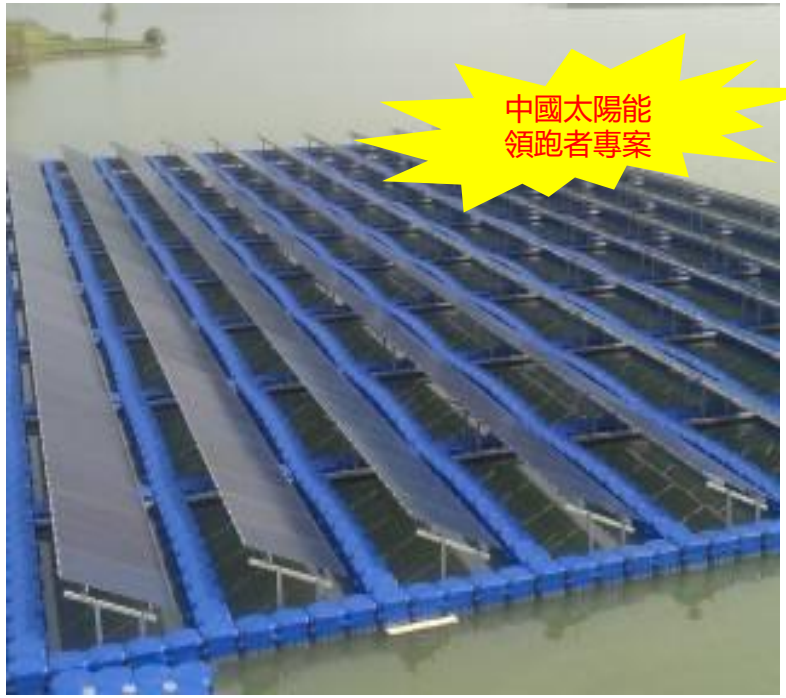
戶外20 年, 92.3% 功率

戶外23年, 93.9% 功率



戶外11年, 92.5% 功率

領先的太陽能電站開發商選用優質模組材料清單，提高電站收益



中節能採用杜邦™ Tedlar® 背板的晶矽模組應用於大型水上漂浮太陽能電站項目

單位：中節能太陽能科技有限公司
項目：中節能埇橋朱仙莊70兆瓦採煤沉陷區水面太陽能發電項目。
項目概況：項目規劃建設水面漂浮式太陽能電站70兆瓦，一次性建設完成。項目為安徽省兩淮採煤沉陷區國家先進技術太陽能示範基地領跑者專案。

photovoltaics.dupont.com

DUPONT®

The miracles of science™

V

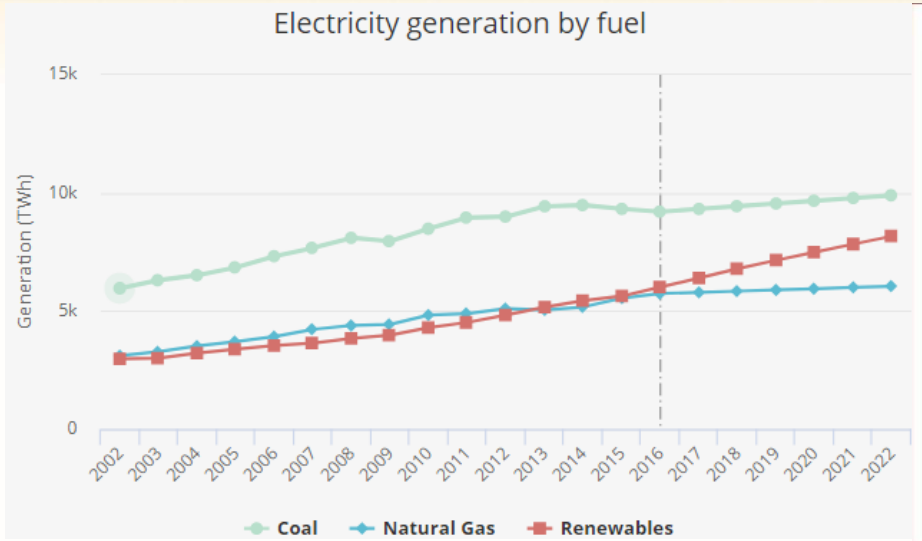
Quality in manufacturing, Taiwan module manufacturer view point

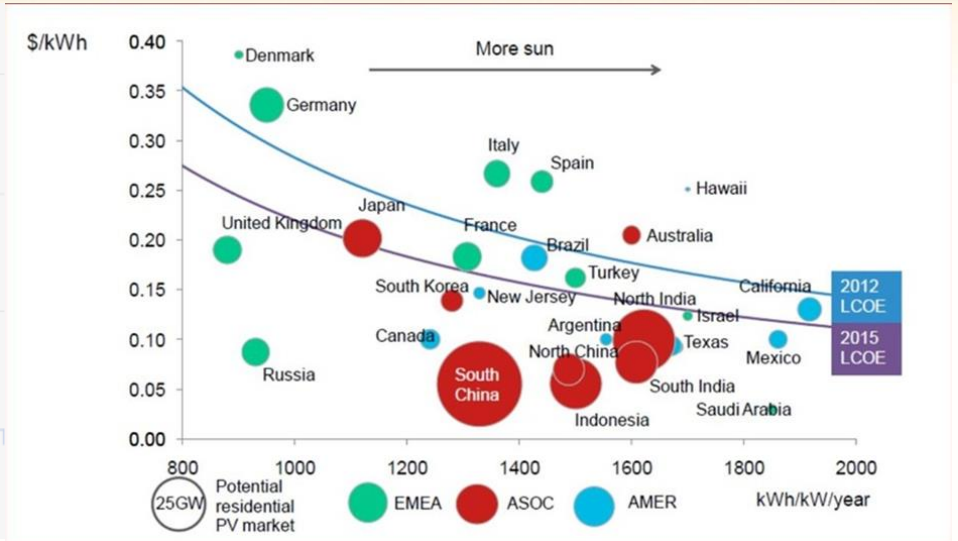
PV Taiwan 2017
Taiwan Int'l Photovoltaic Exhibition
Oct. 18-20 Taipei Nangang Exhibition Center, Hall 1

Quality in manufacturing, Taiwan module manufacturer viewpoint

Speaker : Dr. C.Y. Yu

Introduction

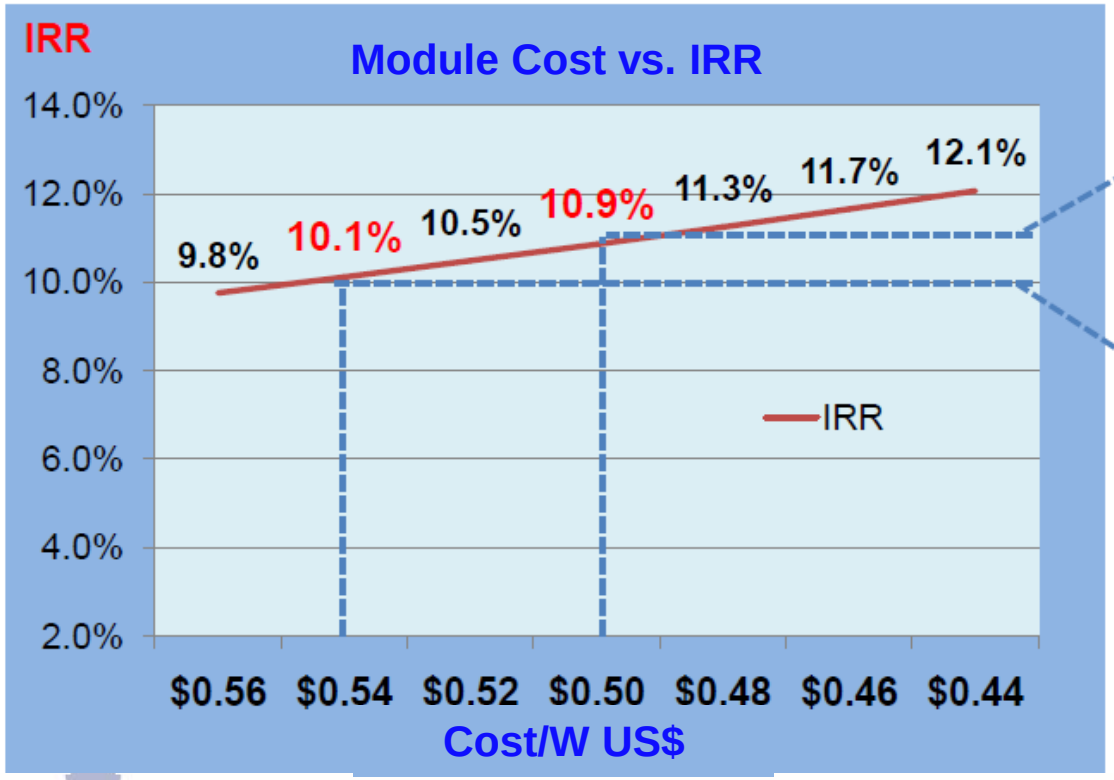




- **Thanks to rapid advances in technology and globalization, the levelized cost of electricity (LCOE) of solar energy continues to reduce.**
- **It is a one-way ticket toward "cost down", in the meantime, "Quality" also matters.**

Source : IEA, Renewables International)

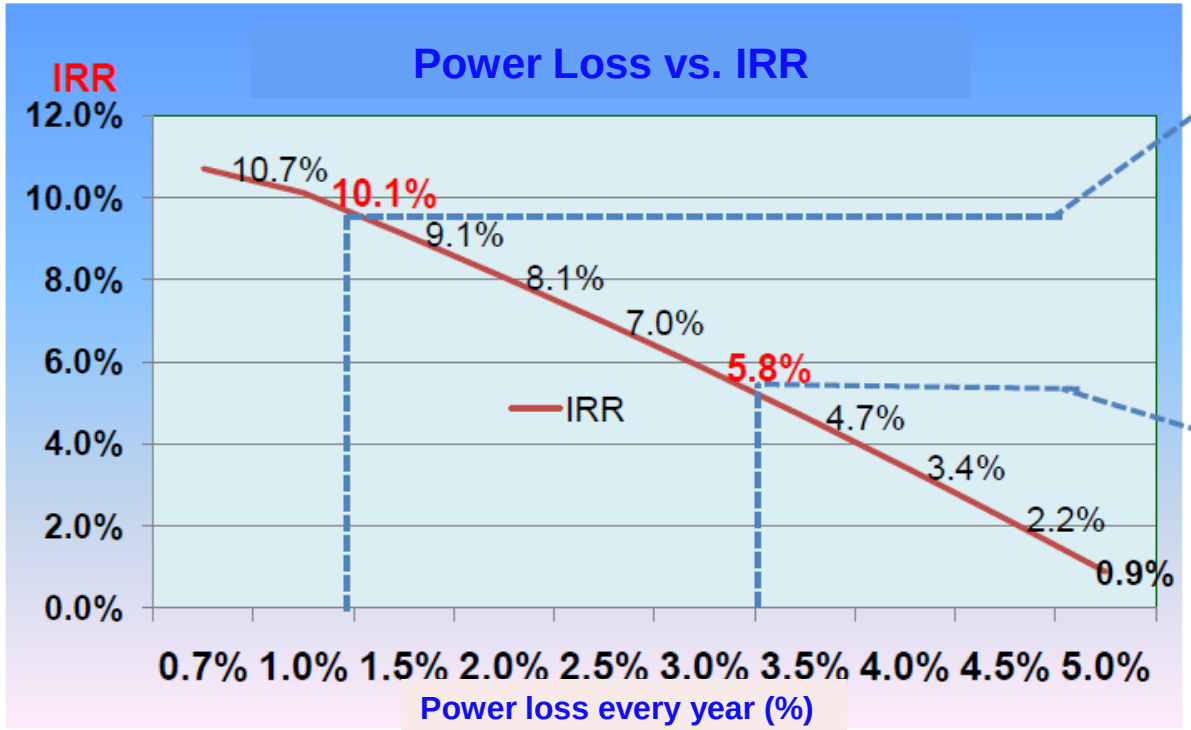
Module Cost vs. IRR



Module Cost from USD 0.54/W reduces to USD 0.5/W.

=> The IRR only increases 0.8%. (10.1% → 10.9 %)

Power Loss vs. IRR



Power decay increases from 1% to 3%.

=> The IRR decreases 4.3%. (10.1% → 5.8 %)

"Quality" more matters!!

What we do?

TSEC Business

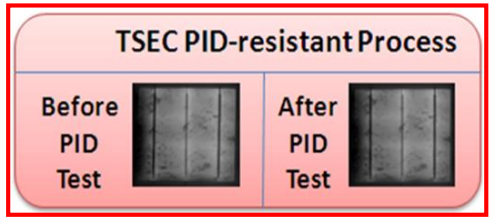
Polysilicon	Wafer	Solar Cell	Solar Module	Systems
結晶矽	晶片	太陽能電池	模組	系統

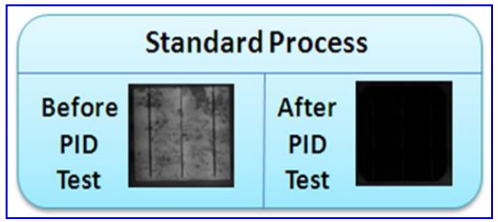
TSEC provides a whole wide range of products and services including solar cells, modules, power stations, and EPC service to fulfill clients demands.

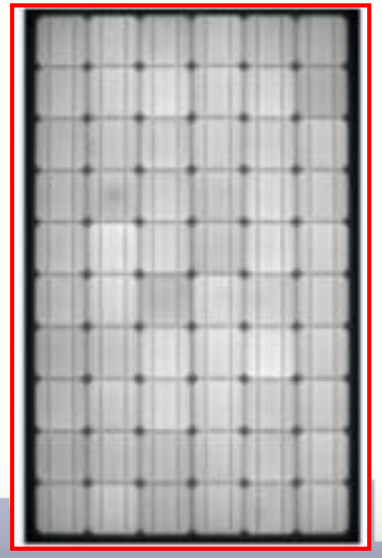
PID Effect

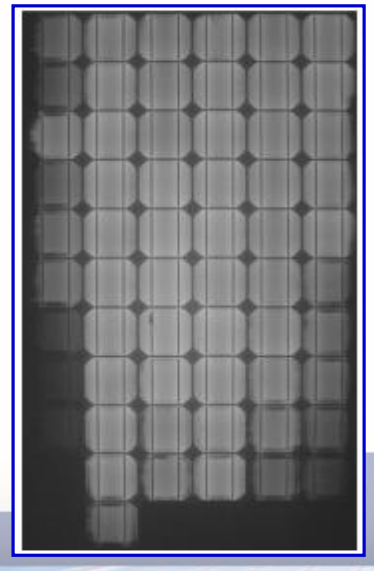
TSEC guarantee our high-performance solar cell/module with PID-free:

- **Pass PID test by TUV: 85℃ / 85% RH, -1000V, 1000hr.**
- **Pass PID test by UL: 85℃ / 85% RH, -1500V, 300hr. (Bare Cell)**









6. Apply voltage stress to modules in climate chamber.
   - Chamber air temperature: 85 °C ± 2°C,
   - Chamber relative humidity: 85 % ± 5 % RH,
   - Test duration: 300 hours
   - Voltage: module rated system voltage and polarities. (-1500 Vdc)
7. Perform IEC 61215 Clause 10.2 (MQT 02) maximum power determination between 2 h and 6 h after completion of Clause 4.2.2 or 4.2.3. Maintain the module indoors at 25 °C and out of direct sunlight until ready for the maximum power determination.
8. Perform electro-luminescence imaging at 3 A inputs current.
9. Perform IEC 61215 Clause 10.3 Insulation Test.
10. Perform IEC 61215 Clause 10.1 visual inspections.

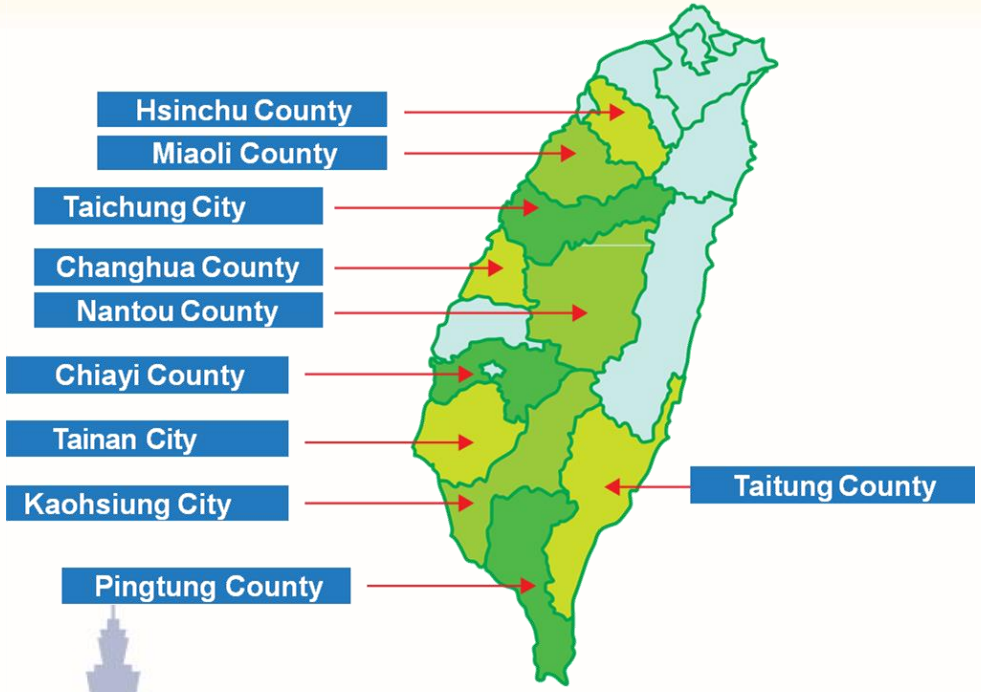
TABLE: Comparison of Maximum Power (P_{mp}) at STC of PID testing samples

Test Date/Initial		2015/07/22	
Test Date/Final		2015/08/06	
Module temperature [°C]		25	
Irradiance [W/m²]		1000	
Sample#	Condition	P_{mp} [mW]	Variance
10407C02593-02	Initial	4.27	-4.45 %
10407C02593-02	Final	4.08	
10407C02593-03	Initial	4.23	-1.89 %
10407C02593-03	Final	4.15	

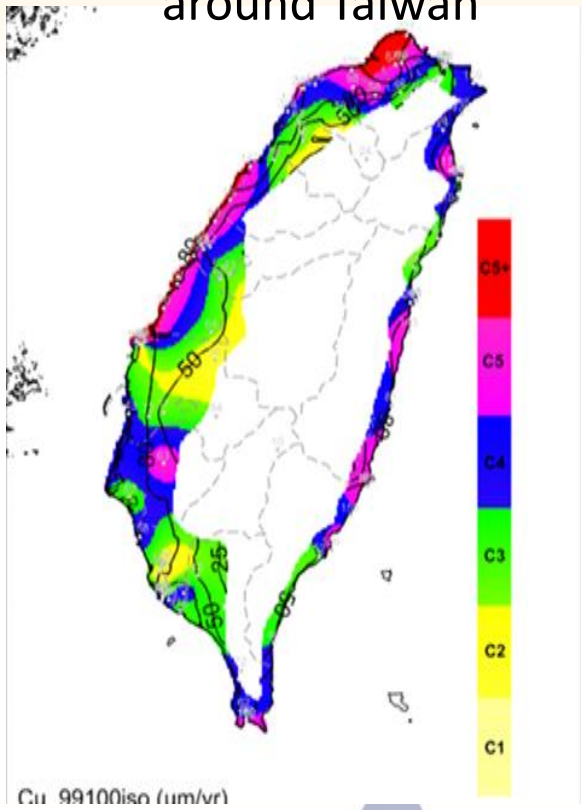
Supplementary information:
1. The results were not corrected by spectral mismatch factor.
2. The Variance is defined as:

$$\frac{(P_{max,final} - P_{max,initial}) \times 100\ \%}{P_{max,initial}}$$

Salt Damage Resistance

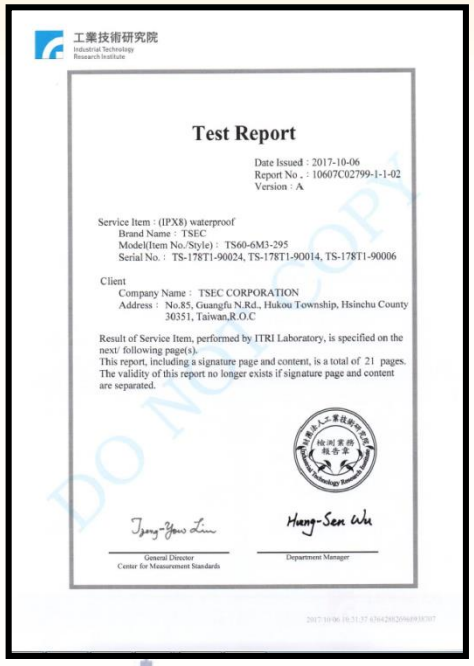


Salt damage affected regions around Taiwan



- **TSEC EPC Projects throughout Taiwan**
- **High-risk area of salt damage:**
  Different design for different environment challenge

IPX8 Test (5% salt water)



工業技術研究院
Industrial Technology Research Institute

Test Report

Date Issued : 2017-10-06
Report No . : 10607C02799-1-1-02
Version : A

Service Item : (IPX8) waterproof
Brand Name : TSEC
Model(Item No./Style) : TS60-6M3-295
Serial No. : TS-178T1-90024, TS-178T1-90014, TS-178T1-90006

Client
Company Name : TSEC CORPORATION
Address : No.85, Guangfu N.Rd., Hukou Township, Hsinchu County 30351, Taiwan,R.O.C

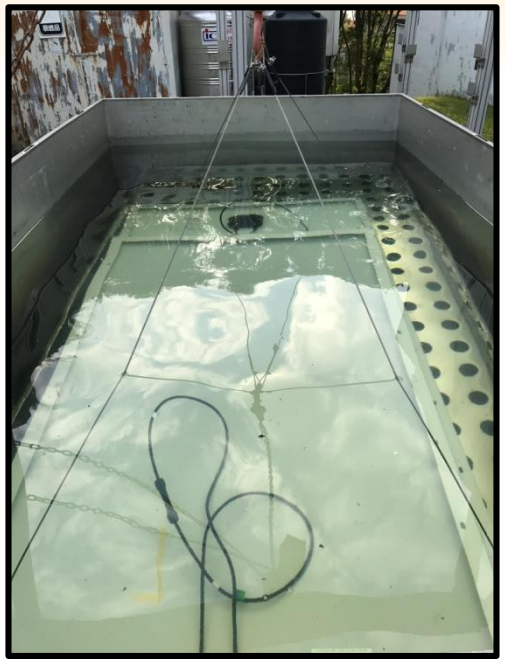
Result of Service Item, performed by ITRI Laboratory, is specified on the next/ following page(s).
This report, including a signature page and content, is a total of 21 pages.
The validity of this report no longer exists if signature page and content are separated.

檢測業務報告章

Tzong-Yow Lin
General Director
Center for Measurement Standards

Hung-Sen Wu
Department Manager

DO NOT COPY



- **Outdoor Test by 3-rd party.**
- **Average test temperature is 35℃.**
- **Power decay only ~0.5%.**

TABLE: Maximum power determination (Initial)

V_{oc}[V]	I_{sc}[A]	V_{mp}[V]	I_{mp}[A]	P_{mp}[W]	FF [%]	Degradation[%]
39.22	9.913	31.39	9.334	293.0	75.4	-
39.72	9.802	32.08	9.207	295.3	75.9	-

TABLE: Maximum power determination (3 Days)

V_{oc}[V]	I_{sc}[A]	V_{mp}[V]	I_{mp}[A]	P_{mp}[W]	FF [%]	Degradation[%]
39.35	9.831	31.60	9.259	292.6	75.6	**-0.14 %**
39.71	9.785	32.04	9.188	294.4	75.8	**-0.30 %**

TABLE: Maximum power determination (7 Days)

V_{oc}[V]	I_{sc}[A]	V_{mp}[V]	I_{mp}[A]	P_{mp}[W]	FF [%]	Degradation[%]
39.22	9.824	31.15	9.355	291.4	75.7	**-0.55 %**
39.64	9.767	32.07	9.166	294.0	75.9	**-0.44 %**

Conclusions

- Quality can be achieved by design.
- Different design for different environment challenge.
- From the cell/module/system manufacturer viewpoint, besides LCOE, Quality matters more!

VI

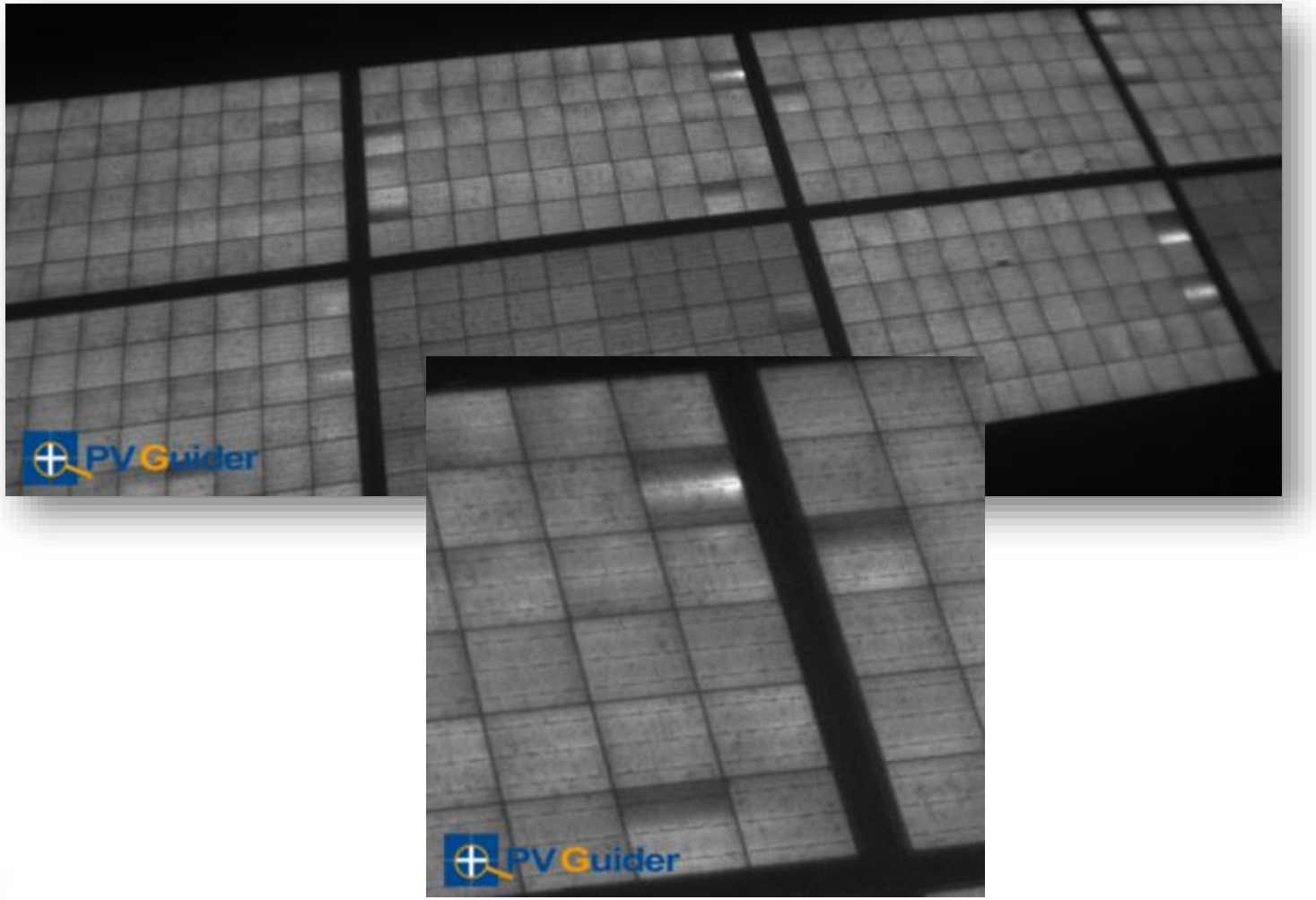
Manufacturing quality discussion

Manufacturing Quality Issues

Jay Lin / Chief Consultant

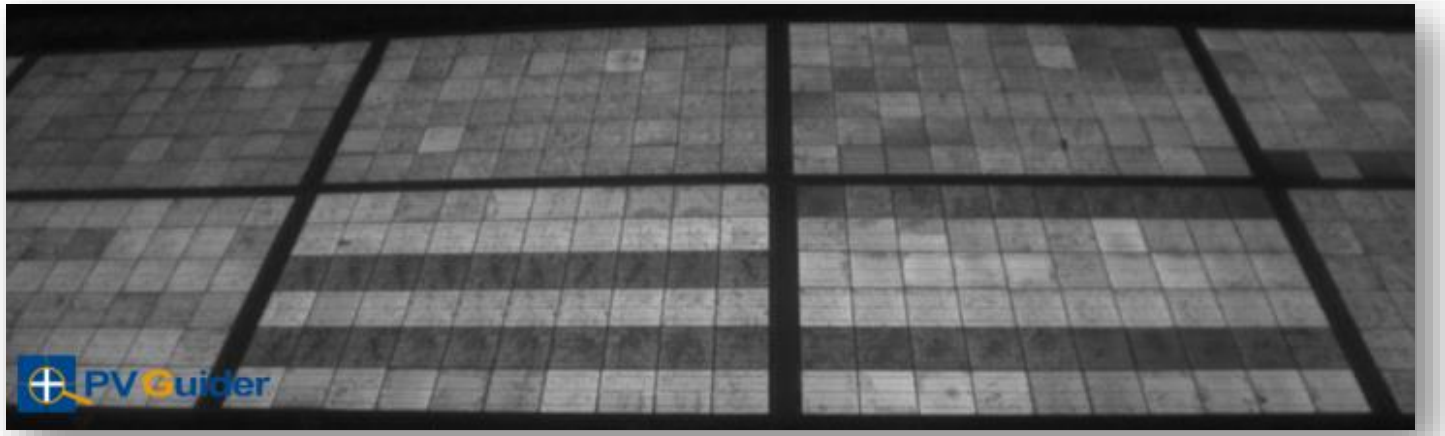
Keep Green Gold Shining!

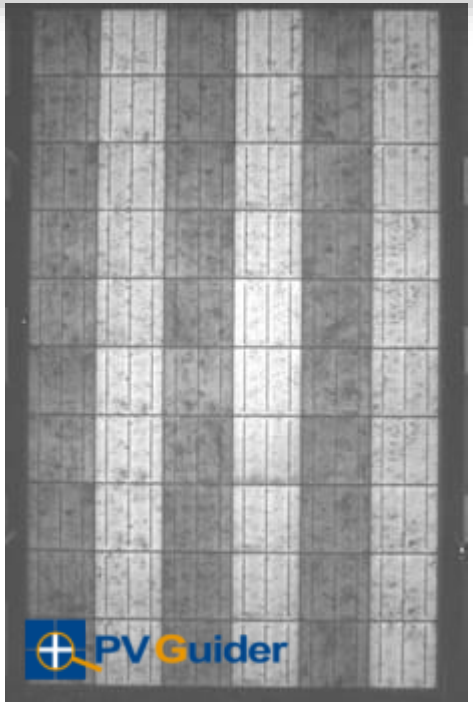
Soldering defect

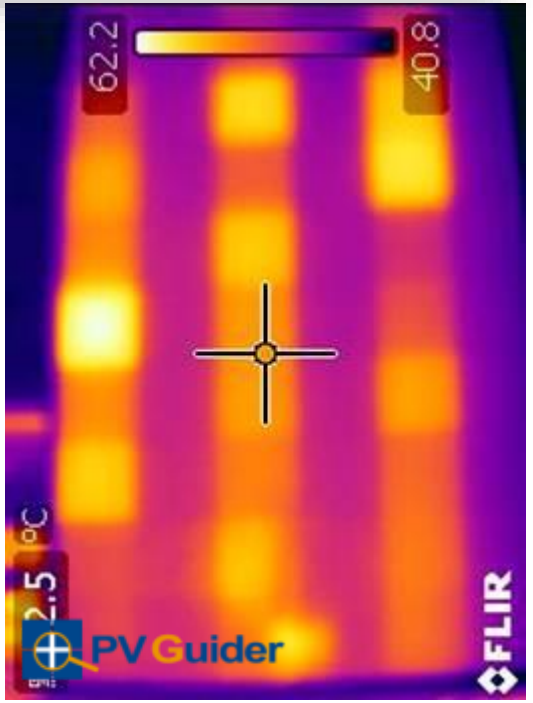


EL image of modules with soldering defects

Cell Mismatch

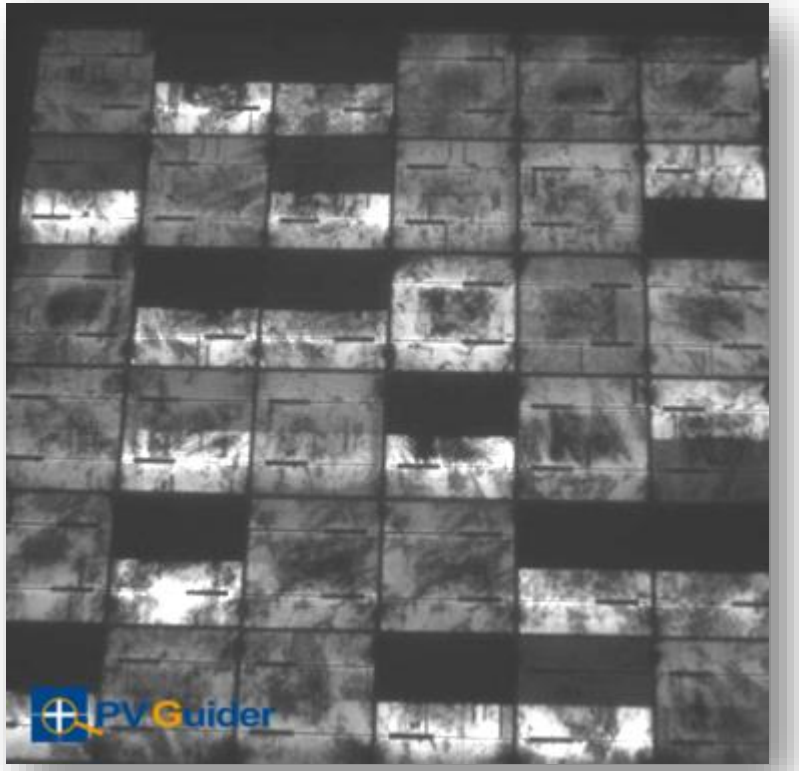






Delamination

Dark Area along Busbar



Fault in Production

Keep Green Gold Shining

Dr. Jay Lin
Mobile：+886 989-832-421
Email：Jay@pvguider.com

網站：www.PVGuider.com
Website: English.PVGuider.com

Keep Green Gold Shining!

VII Conclusions

Quality Roundtable
at PV Taiwan 2017

Quality first: A holistic overview of quality in and for Taiwan, from cell and module, to array.

Initiative partner

DUPONT®

Gold sponsors

CEA Clean Energy Associates

SCHMID Expect Solutions

STÄUBLI

Multi-Contact MC

In collaboration with

semi

PV Guider

pv magazine group