太陽能模組無人機清洗暨相關檢測實務

艾思特能源股份有限公司

July 2019

艾思特能源簡介

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- **Tokyo Electron Limited**

  2009~2013 / 核心團隊成立，負責戶外太陽能測試系統開發與管理

  2013~2015 / 研發與推廣落塵偵測系統DDS

- **UKC Holding**

  2015~2018 / 販售落塵偵測系統DDS與全球市場開發

- **ExTEL Energy**

  2018~ 至今 /UKC Holding 因公司併購改組退出DDS業務，原研發團隊於2018年成立ExTEL Energy 艾思特能源股份有限公司，運用過去十年的經驗與技術，繼續提供創新的運維解決方案給予太陽能系統發電的相關業界。

艾思特能源現場檢測服務內容

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ExTEL Energy On-Site Service

- Drone Module Washer (DMW)
- Drone Infrared Image (DIR)
- On-site Pyranometer Calibration (OPC)
- Warranty inspection Service (WiS)

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農舍類屋頂

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- Location: 彰化芳苑
- System: 鴨寮屋頂
- Capacity: 499kW

難以攀登屋頂，人員難以在從事清洗

校舍建築物屋頂

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- Location: 台中弘光科技大學
- System: 校舍屋頂
- Capacity: 500kW

無維修走道，人員難以在從事清洗

高架型太陽能設置

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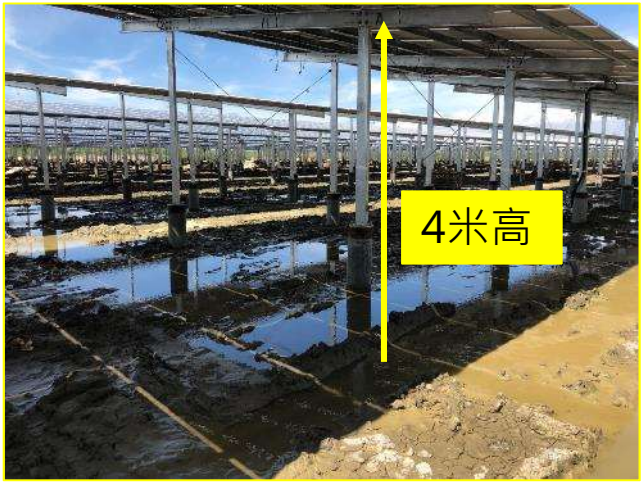
- Location: 雲林、嘉義
- System: 鹽灘高架
- Capacity: >10MW

清洗人員難以攀登至4米高作業清洗



艾思特能源無人機清洗服務

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特點	Technical Characteristic	Remark
無飛行時間限制	AC power 220V	獨立發電機供電
不侵害模組表面	No surface conducting (Ex: no man stands on panels)	
Access Free	高架太陽能設置/建築物屋頂/農舍屋頂	
人力節省	2 persons operation / cleaning drone	
節省水資源	5 liter / panel	
清洗快速	6 panels / min	
抗風等級	<= 7m/sec	瞬間陣風

無人機清洗周邊搭配

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無人機清洗作業報告

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艾思特能源有限公司
EXTEL ENERGY CO., LTD.

CLEANING SERVICE REPORT

PROJECT INFORMATION

Customer: VENA ENERGY
Service Description: Panel Cleaning
Site Location: BRUBECK #1
Capacity: 1.8MW
Date: 2/11/2019

TO: VENA Energy
The description below are the details of requested service.

Item	Details of work
1	Job Item : Panel Cleaning Panel No. : 5630 Panels Members : 4~6 people Cleaning Period : 2019/1/16 - 1/30 Working Days : 11 Days Cleaning Method : Using drone or manual cleaning Cleaning Tools : Drone, Lift Crane, Water Tank Vehicle and clean pad

During Cleaning:

Wind Speed <7m/sec

3

4

After Cleaning

無人機清洗與人工清洗對照

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Drone IR Fly Routing

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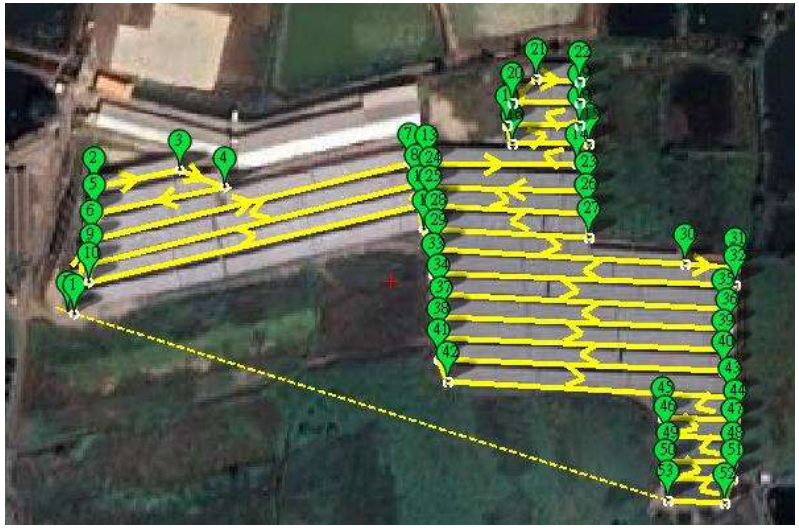
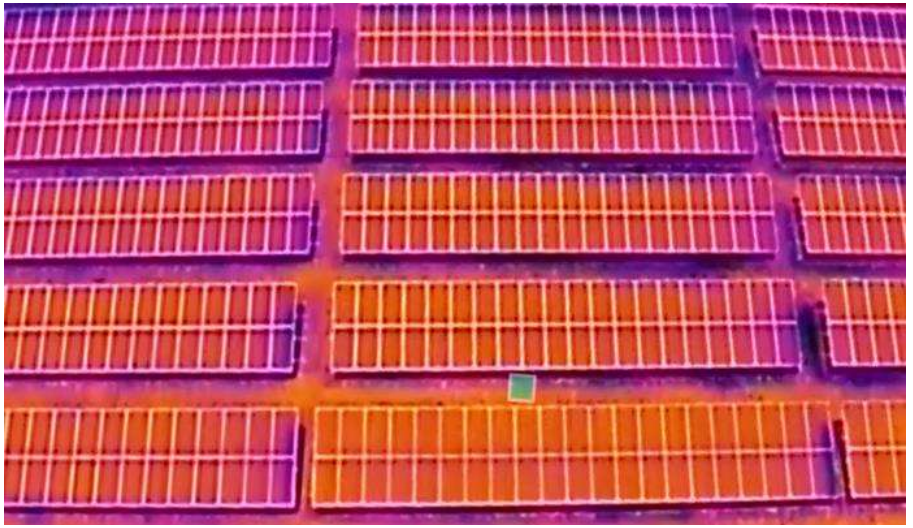
- ❑ **太陽能模組的熱像檢測，若能在模組表面清洗後執行後更能有效的判別異常。**
- ❑ 依照太陽能案場的型態與Layout，來計劃飛行路線。
- ❑ 並依照IEC 62446-3 規範提供報告給予客戶。





Drone IR - Aerial Thermography Features

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IEC

IEC Standard

Follow IEC 62446-3 thermography standard

PV Expertise

Professional Team with 10+ year PV experience

5~10 MW per day

Inspection speed (one drone)

Assessment Report

Detail inspection report with recommendation

DIR Inspection

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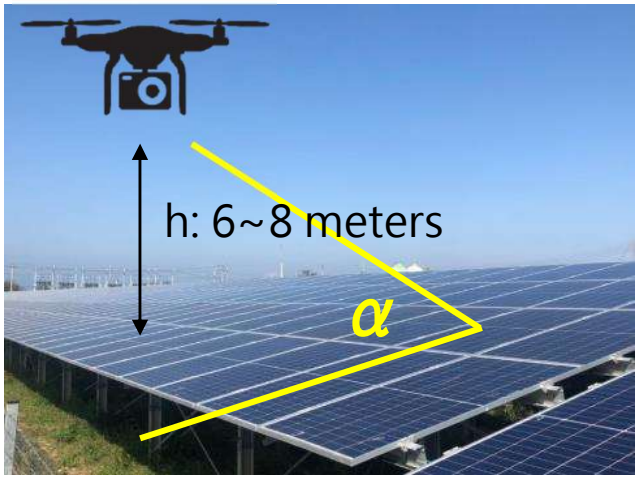
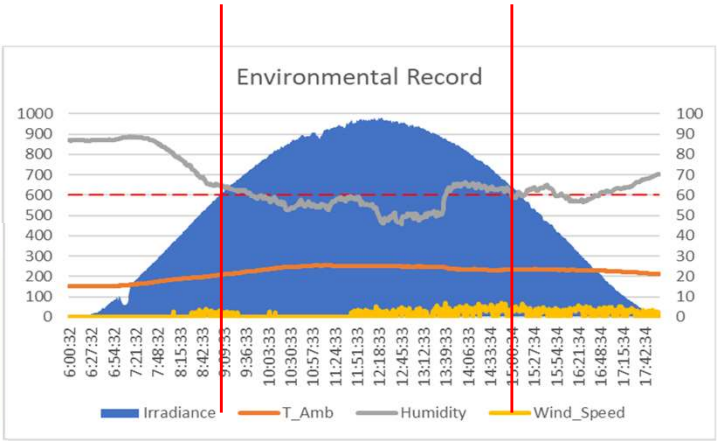
- Scanning(fly) speed: ***1.5~2 meter/sec***
- Camera view angle(α): ***50 degrees***
- Distance from camera to PV(h): ***6~8 Meters***
- Irradiance range: >***600W/m2***
- Wind speed: ***< 5 m/s***
- *PV Soiling:* ***Minor*** *(comply IEC* standard)*



** Standard is referring:* ***IEC 62446-3*** *Photovoltaic modules and plants - Outdoor infrared thermography*

Effective IR operation period



ExTEL解決方案 (DIR)

知道甚麼才是對的與精確的IR檢測

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- **On-site Pyranometer Calibration (OPC)**
- Warranty inspection Service (WiS)

日照計校正的困擾

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- 整個校正流程曠日廢時
- 拆卸期間沒有日照計判斷太陽能發電
- 進出關通關流程文件往返沒有經驗

ExTEL解決方案 (OPC)
On-site Pyranometer Calibration

拆卸

通關出口

寄送

校正 @1000 W/m2

送回

重新安裝

遵循 ISO 9874 戶外日照計檢測校正

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ISO 9060

Specification and Classification of Instruments for Measuring Hemispherical Solar and Direct Solar Radiation. These are the standards recommended by the World Meteorological Organization (WMO) and are used by every manufacturer of quality solar radiation sensors. They are also used by many major meteorological organizations to make their own re-calibrations. Otherwise, instruments are normally returned to the manufacturer. Re-calibration is recommended every two years.

For the purpose of Pyranometers, the applicable standard is ISO 9847 and this calibration procedure allows 2 methods:
1/ Field calibration of the test pyranometer by comparison with a 'working standard' instrument that is of similar or higher quality. This comparison is done under a clear sky with the sun near zenith.
2/ Calibration in a laboratory of the test pyranometer by comparison with a 'working standard' instrument of the same generic type. This calibration is done under a lamp that approximates to the solar spectrum. This is the method used by Kipp & Zonen.
A 'working standard' Pyranometer is an instrument that has been calibrated outdoors against the World Radiometric Reference (WRR) at the World Radiation Centre (WRC) in Davos, Switzerland and issued with a calibration certificate. This specifies the sensitivity under the conditions at the time of the calibration (typically temperature and solar zenith angle/air mass). This sensitivity should be corrected for the conditions in the specific test laboratory.

The laboratory test method is closely defined in WMO 9847 to minimize errors. No calibration lamp simulates the solar spectrum well enough for an absolute indoor calibration. The comparison method is designed so that a 'traceable' calibration lamp is not needed and is not actually of any benefit. In the past the lamp was usually Tungsten Halogen, but Kipp & Zonen now uses a Metal Halide lamp that has better stability and less infrared heat output. The specific lamp is not critical because it is a comparison test with a working standard pyranometer calibrated at WRC under clear skies with low aerosol content (almost no pollution).

Kipp & Zonen manufactures and sells the CFR Calibration Facility, which meets the WMO / ISO recommendations. The manual can be downloaded from our website and gives details of the full procedure. Our factory calibration equipment is similar, but the procedure is automated. A full calculation of uncertainties in the calibration chain can be provided.

Many organizations around the world, such as NIST in the USA, offer calibration services to industry. They characterize light sources and light detectors, particularly those used in manufacturing processes, safety applications and illuminance (LUX) measurement. However, they are not set up for the calibration of instruments for the measurement of solar radiation.

NIST and similar organizations do not offer an ISO 9847 calibration service and, as explained, the only acceptable traceability is to the World Radiometric Reference (WRR) at the World Radiation Centre in Davos.

Source:
https://www.kippzonen.com/ProductGroup/112/Calibration-Standards

Field calibration

ISO 9847

Allows for calibration of a pyranometer indoors (as at the factory in Delft) against a reference pyranometer of similar type, or outdoors. Outdoors a field pyranometer can be calibrated over several days against a 'reference' pyranometer of similar or (ideally) higher quality with a reliable, recent, and traceable calibration.

戶外日照計檢測校正流程

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ExTEL In-house

Traceable & calibrated Reference Pyranometer

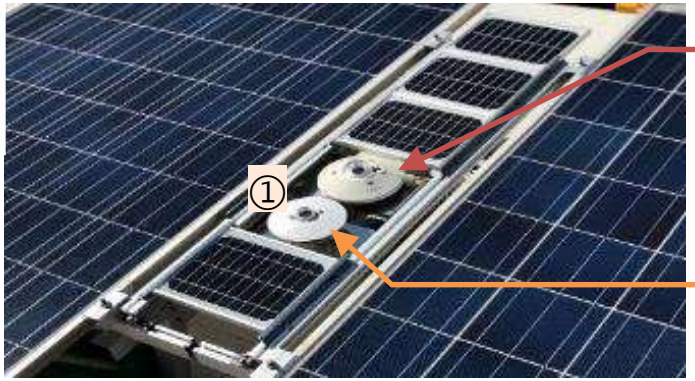
- Trace to PMOD/WRC
- Refer to Secondary Standard Pyranometer (CMP22)
- Follow ISO 9847:1992(E) calibration procedure

Indoor Verification

- Class AAA Sun Simulator
- Follow IEC 60891 standard
- Uncertainty <0.9% (0.07uV/W/m2)

ExTEL On-Site Service

Outdoor Calibration



Traceable & calibrated Reference Pyranometer (CMP22)

Calibration Targets:
① On-site Pyranometers (CMP11,SMP10A)

戶外日照計檢測校正報告

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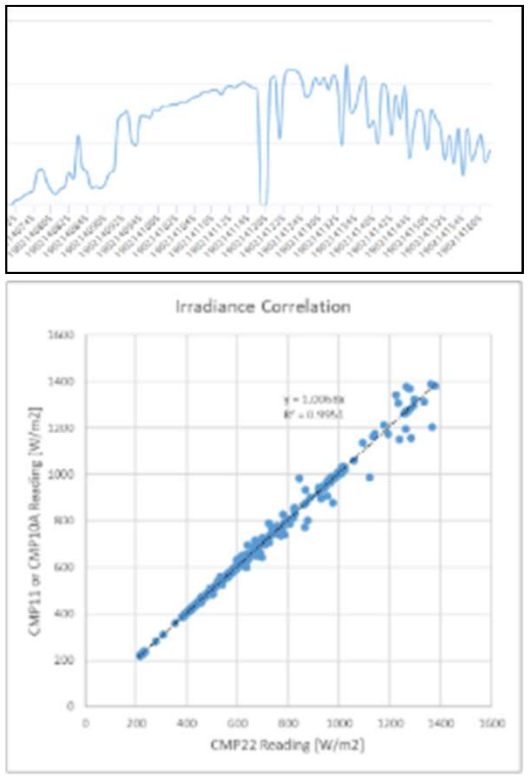
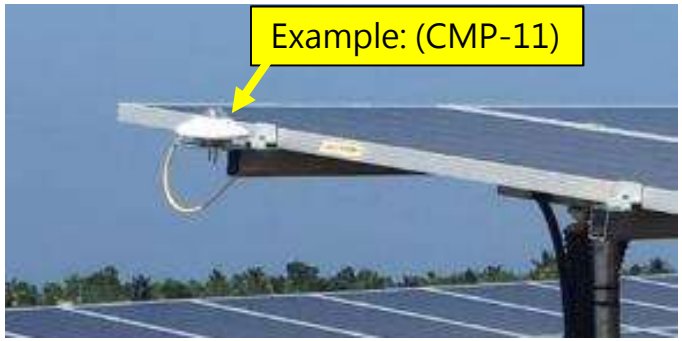
① Each individual Pyraonmeter is correlated to Reference CMP22 from real-time on-site outdoor measurement



② Calculate Correction Factor for each individual CMP11



ExTEL Energy Provide outdoor calibration service on site

$If\ |Correction\ Factor - 1| \leq 1.0\%$
No correction needed

$If\ |Correction\ Factor - 1| > 1.0\%$
Suggest to implement Correction Factor to SCADA

Corrected Irradiance [W/m2]

= Old Irradiance reading x Correction Factor

Secondary Pyranometer Calibration Certificate

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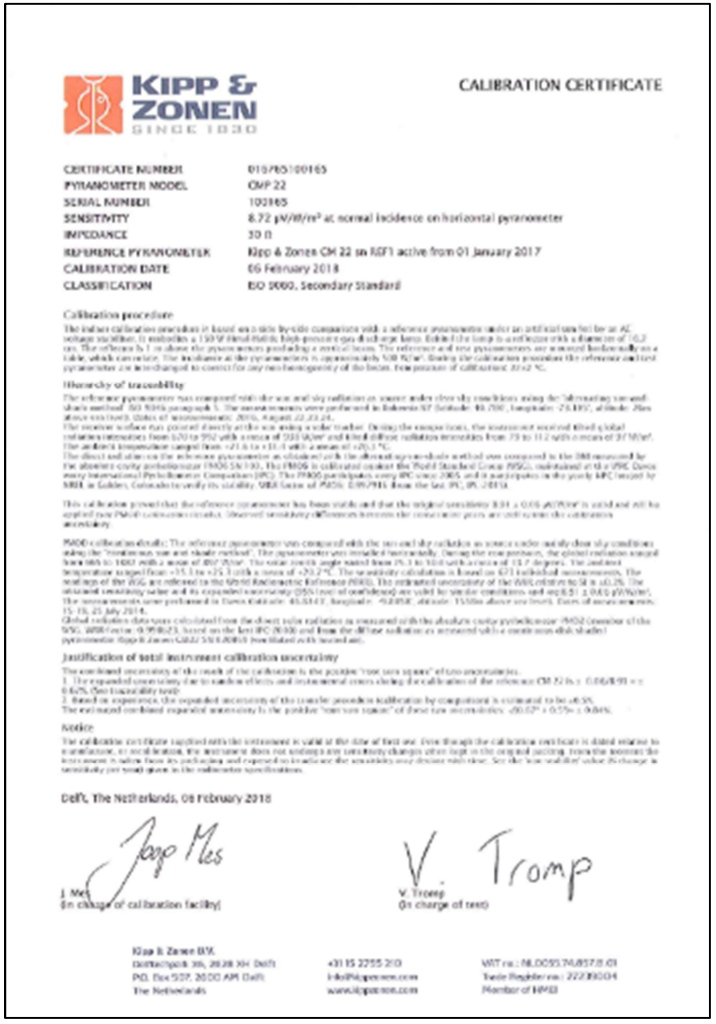
CMP22 Traceable and Calibrated



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SINCE 1830

CALIBRATION CERTIFICATE

CERTIFICATE NUMBER	010765100165
PYRANOMETER MODEL	CMP 22
SERIAL NUMBER	100165
SENSITIVITY	8.72 μV/W/m² at normal incidence on horizontal pyranometer
IMPEDANCE	30 Ω
REFERENCE PYRANOMETER	Kipp & Zonen CM 22 sn 107F1 active from 01 January 2017
CALIBRATION DATE	06 February 2018
CLASSIFICATION	ISO 9060, Secondary Standard

Calibration procedure

Hierarchy of traceability

Justification of total instrument calibration uncertainty

Notice

Delft, The Netherlands, 08 February 2018

J. Mes
(In charge of calibration facility)

V. Tromp
(In charge of test)

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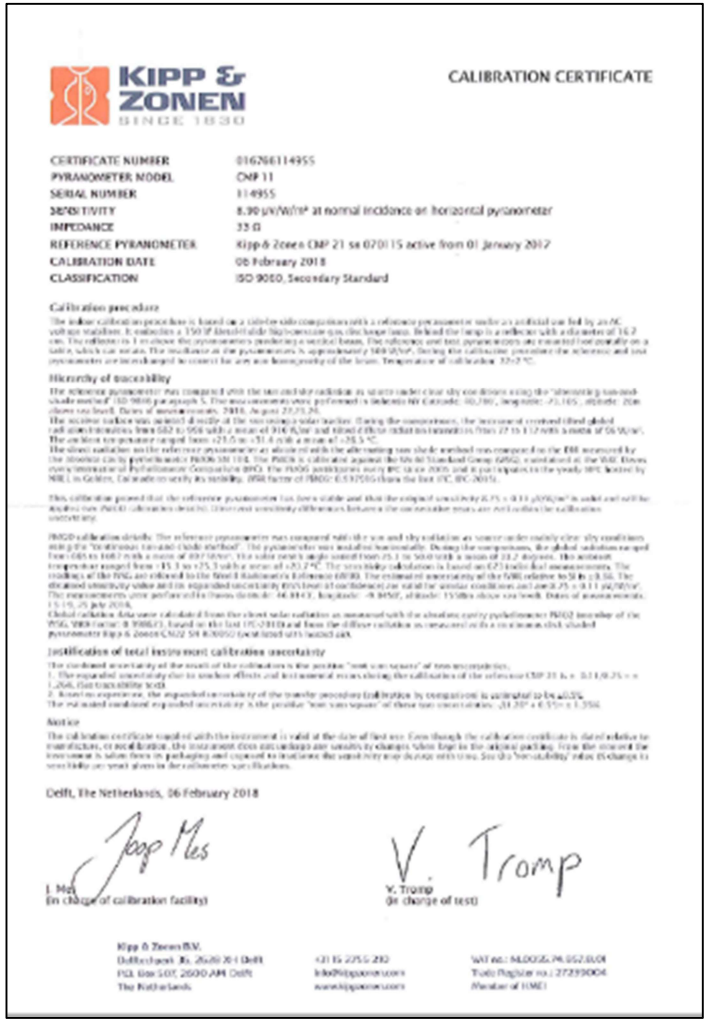
Member of WMO

CMP11 Traceable and Calibrated



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CALIBRATION CERTIFICATE

CERTIFICATE NUMBER	016706114955
PYRANOMETER MODEL	CMP 11
SERIAL NUMBER	114955
SENSITIVITY	8.90 μV/W/m² at normal incidence on horizontal pyranometer
IMPEDANCE	33 Ω
REFERENCE PYRANOMETER	Kipp & Zonen CMP 21 sn 070115 active from 01 January 2017
CALIBRATION DATE	06 February 2018
CLASSIFICATION	ISO 9060, Secondary Standard

Calibration procedure

Hierarchy of traceability

Justification of total instrument calibration uncertainty

Notice

Delft, The Netherlands, 06 February 2018

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還記得823水患嗎?

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量測標定太陽能模組的困境

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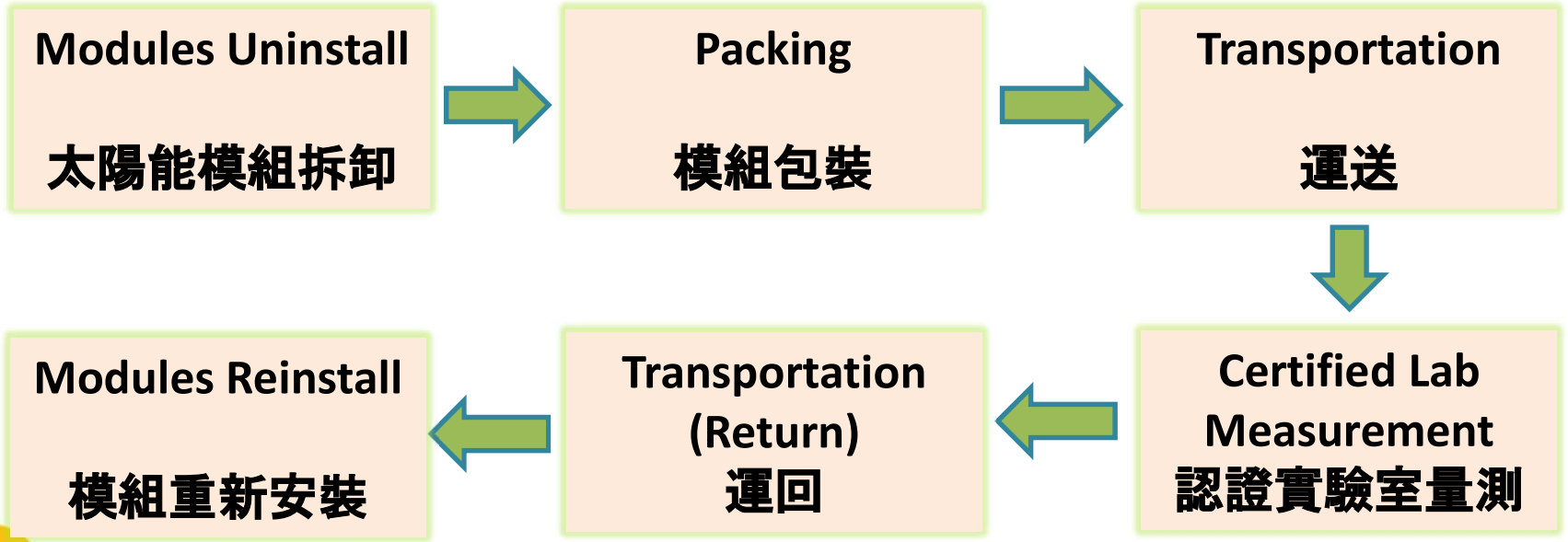
(1) 運送模組到認證實驗室量測標定功率，除了耗時費工外，還有可能因運過程導致模組損壞;
(2) 認證實驗室量測標定需要一定的花費外，同時量測期間也造成發電量損失(時間有時長達數週);
(3) 拆裝、運送與重新組裝的問題，無法大規模量測。

ExTEL解決方案 (WiS)
Warranty inspection Service



On Site Warranty inspection Service (WiS)

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- 艾思特能源從事戶外的太陽能模組衰減量測服務，以判定模組是否在保固的範圍，截至目前已經量測操過10,000片，多達20家不同的廠牌種類的太陽能模組，服務地域已涵蓋台灣、日本、菲律賓與泰國等。
- 工程技術人員直接到現地，量測單片太陽能模組的發電損失，以判定個片的衰減程度。
- **所有WiS現地量測的結果，已和多家第三方的認證實驗室量測結果相當。**

* Configurable Multi-Channels measurement
  - 4 modules
  - 7 modules
  - 11 modules

* High throughput (200+ panels/day)

WiS vs CSSC I-V Flasher @Thailand

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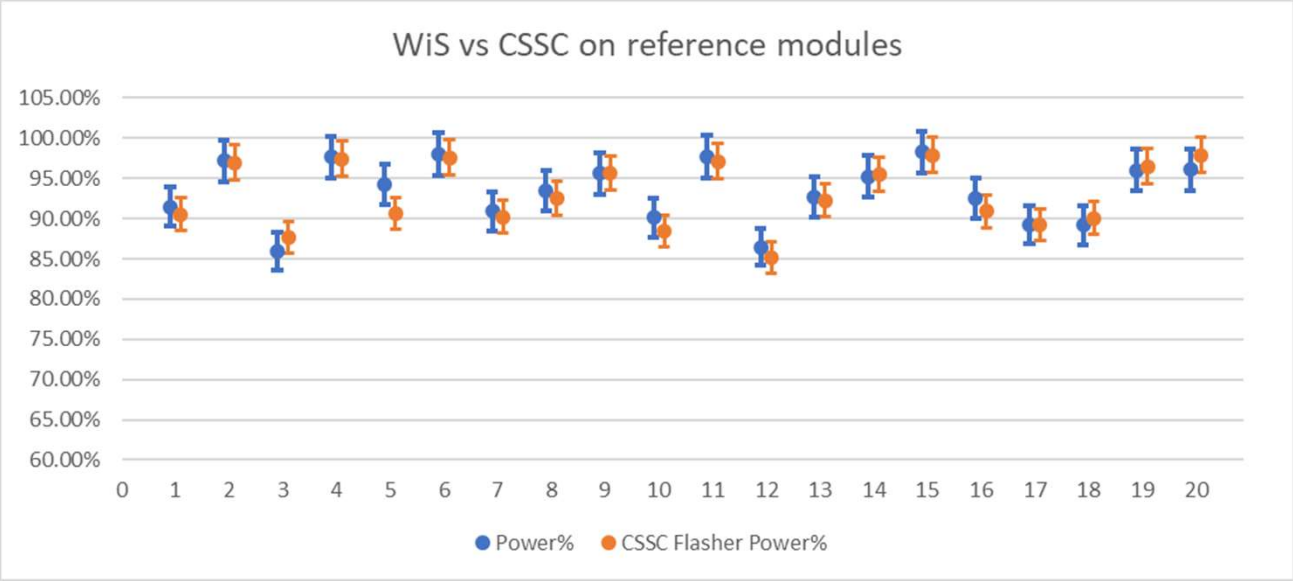

- Extel Energy WiS measurement uncertainty: 2.7%
- CSSC I-V Flasher measurement uncertainty: 2.24%
- Measurement results are all within the uncertainty of both techniques on 20 reference modules
- **The average difference of Power% measurement between WiS and CSSC I-V Flasher is only 0.34%**

Excellent Correlation ! !

運用ExTEL WiS服務案例

@Thailand, 成功賠償9,900片太陽能模組

@Taiwan, 成功賠償5,000片太陽能模組

Summary

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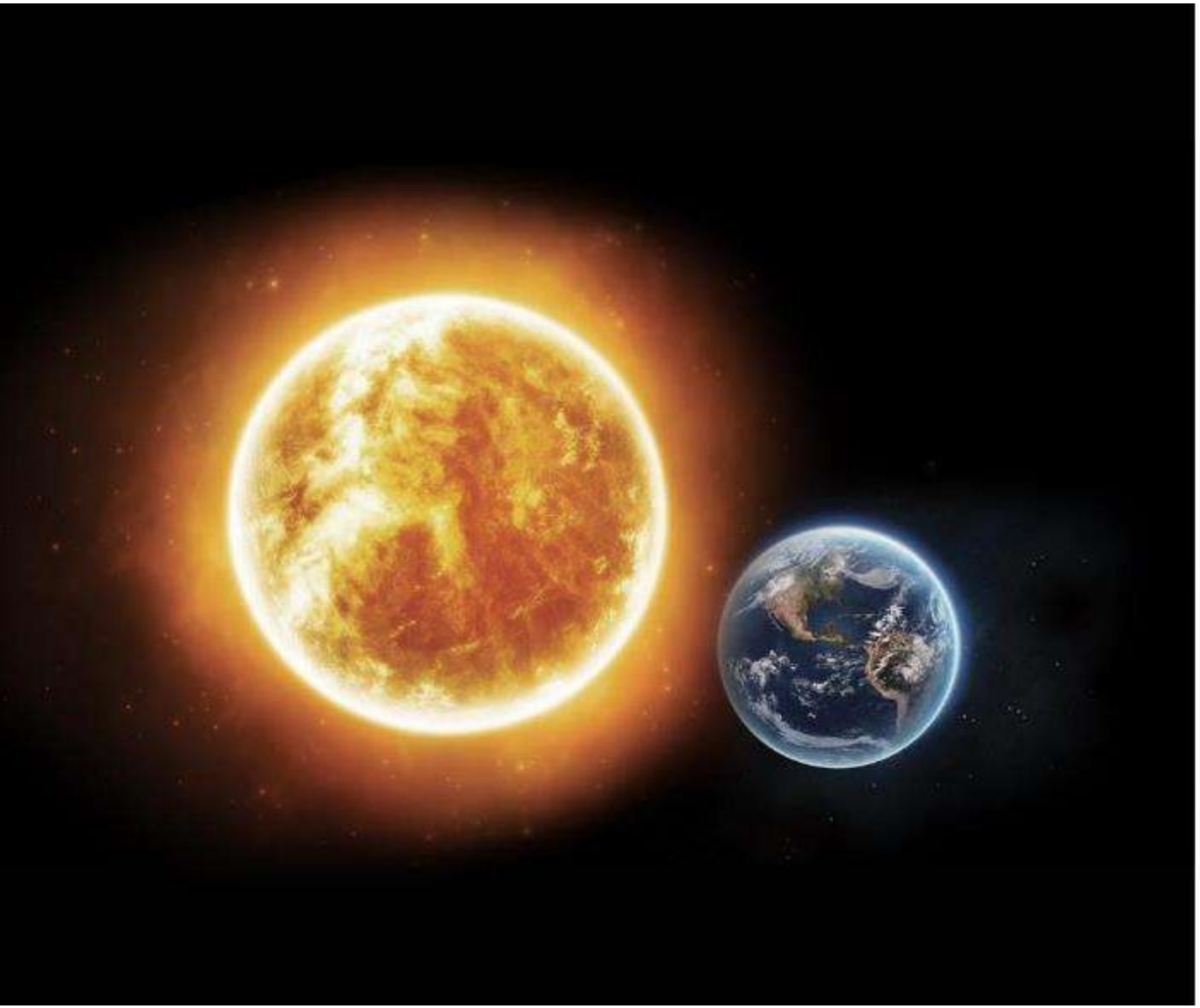
- 早期欠缺運維空間設計的太陽能電站設計，或是特殊高架太陽能架設，對於清洗都是很大的挑戰，透過艾斯特無人機清洗(DMW)的解決方案，可以使得太陽能電站發電效益提高，以實現投資成本確實回收。

- 無人機(DIR)熱像儀的拍攝方式、條件與資料的解讀非常重要，比如在建議的環境條件下，才能避免資料誤判以期達到太陽能電站的作有效的運維。

- 戶外日照計檢測(OPC)可提供客戶另一個校正選擇，特別是可以減少因為外部校正而導致資料收集損失時間。

- 對於天然災害水災、雷擊、颱風、或是地震引起的太陽能電站的損害，可以運用(WiS)的現場量測確認模組是否衰減，進行有統計意義上大量檢測，來確認問題並且協助業者系統復歸與求償。



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