WEBINAR

Trinasolar 25TH

Inside the empirical data analysis supporting the global adoption of ultra-high power PV modules

DATE: 9th June 2022

TÜVRheinland® Precisely Right. | CPVT 国家光伏质检中心 | PVTECH | TECHTalk

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PVTECH TECHTalk

Trinasolar 25

Vertex

The Industrialization Progress of 600W+ Modules

Dr. Franck Zhang
Head of Global Product Strategy and Marketing
June, 2022

OUTLINES

1. TrinaSolar’ s 100GW of PV modules have been shipped
2. 600W+ modules are becoming mainstream
3. Vertex 670W modules bring lower LCOE
4. Compatibility , reliability and bankability of Vertex module


Trinasolar
25TH
2022 is the 25th Anniversary of Trinasolar
PVTECH TECHTalk
The Accumulative PV Module Shipments of Trinasoalr reached
100GW+
Total Global Installed PV Module capacity is about 1000GW

TOP2 module supplier in 2021!

PVTECH TECHTalk Trinasolar 25

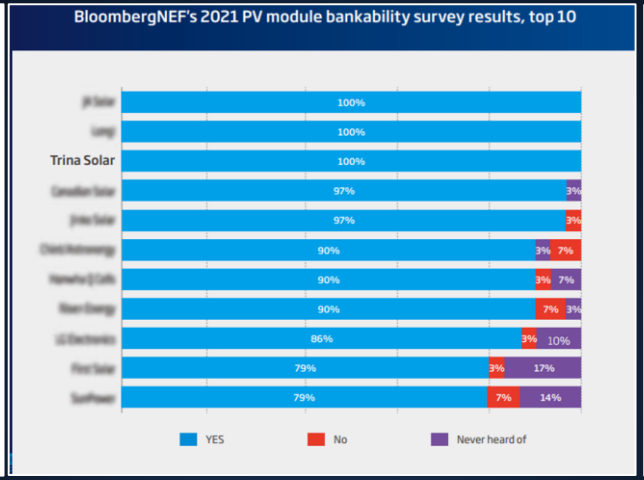
Top 10 Module Suppliers in 2021
(by shipment volume)

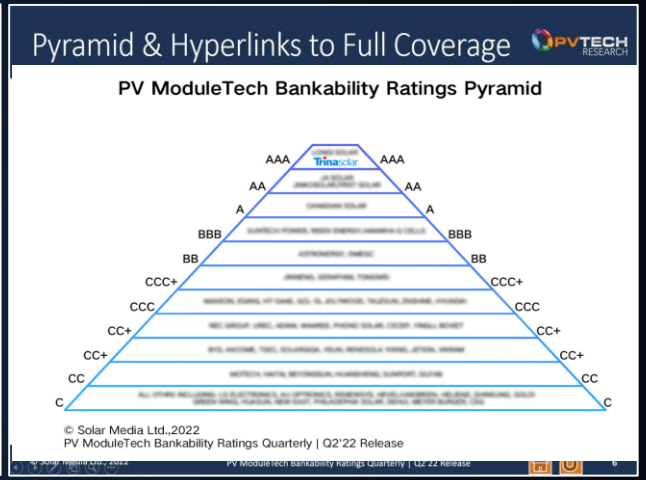
Rank	Module Supplier
1	** Solar
2	Trina Solar 24.8G
3	* Solar
4	* oSolar
5	** ian Solar
6	** Energy
7	** Solar
8	** ch Power
9	** anwha Solutions)
10	** nergy (Chint)

Source: *PV Manufacturing & Technology Quarterly* report, November 2021 release; updated January 2022.

PVTECH RESEARCH

Independent 3rd party reliability & bankability endorsement --PVEL ,BNEF, PV TECH



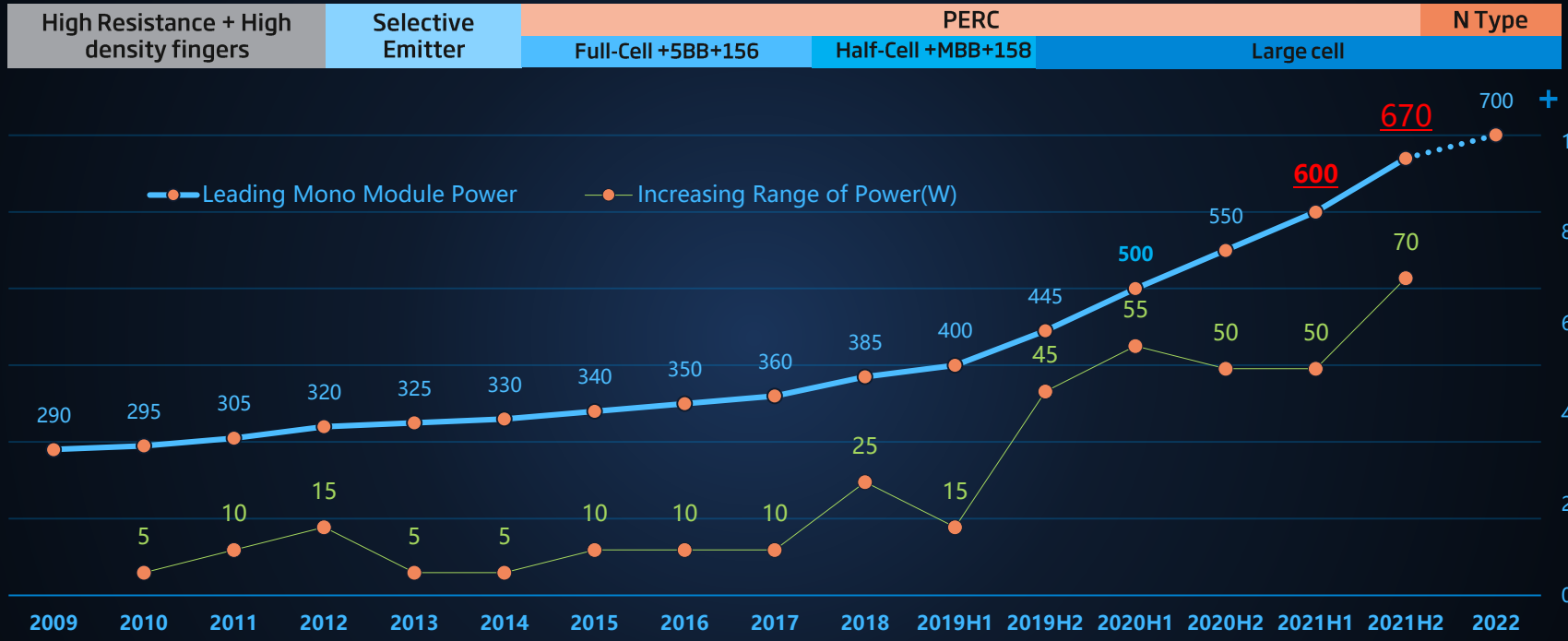


TrinaSolar has won the **8th** consecutive "**Top Performer**" in the PVEL reliability test. Especially, **Vertex 670W modules** have achieved top performance in all PQP (Product Qualification Program) sequences.

TrinaSolar is **the only** module manufacturer that keeps 100% in BNEF bankability Survey for **6** consecutive years, which indicates that the global financial marketing are confident in the reliability and system value of Trinasolar's modules.

Trinasoalr has just been awarded **AAA** rating(the highest grade) in the latest Q2'22 PV Module Tech Bankability Ratings report. The rating system combines both the manufacturing and financial health of the companies.

Trina Solar - leading The Industry's Ultra-high Power Module Era



- The PV 6.0 Era has already come, the BOS cost and LCOE have decreased significantly with increased module power.
- The Vertex 670W module was launched in Mar, 2021,which has been delivered globally.

600W+ modules are becoming mainstream

Trinasoalr-670W

JINKO-610W

JA-625W

CSI-690W

Photowatt(EDF)-660W

Luxor-700W

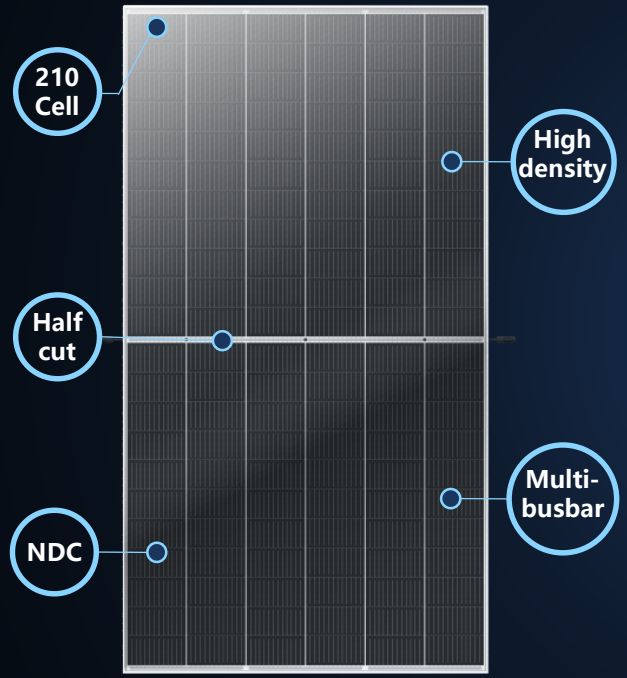
JW-635W

GCL-700W

Tier 1,2 module vendors	Cell size	Mainstream module power	Highest power rating	600W+ announce date
Trina	210	550~670W	670W	2021
JA	210/182	545W~605W	625W	2021
Jinko	210/182	545W~615W	615W	2022
CSI	210/182	545W~670W	670W	2021
Risen	210	550W~670W	670W	2021
Suntech	210/182	545W~670W	670W	2022
Chint	210/182	545W~670W	670W	2022
Huansheng solar	210	550~670W	670W	2021

- At EU Inter solar in May 2022 More than 10 companies exhibited 600W+ new products!
- Almost all tier 1 and tier 2 companies have 600W+ products.

Higher Power and Lower LCOE of Vertex 670W modules



Dimension： 2384*1303

Weight： 38.3kg

Module Power

670W+

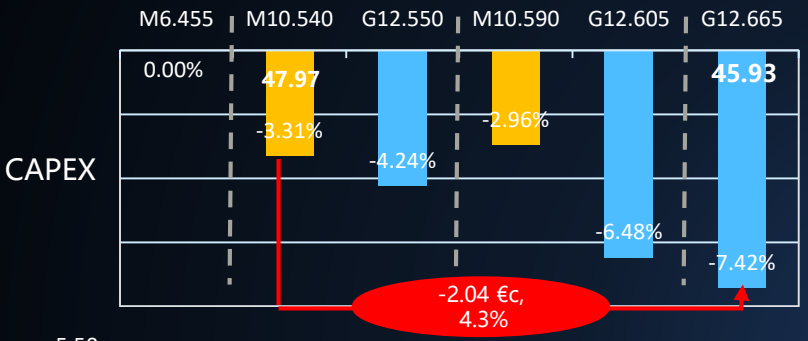
Module Efficiency

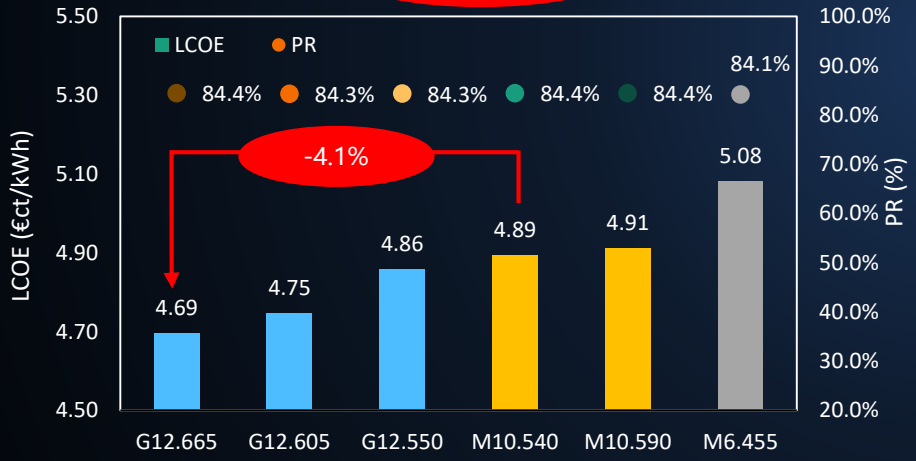
21.6%+

	Vertex 670W	Industry Reference	Remark
Module Power(W)	670	545	125
Module efficiency	21.60%	21.10%	+0.5%
String power(W)	18,480	14,040	32%
Open Circuit Voltage(V)	46.3	49.5	3.2
Short Circuit Current (A)	18.5	13.85	
Module Quantity/String	28	26	-20 ℃ @ 1500V

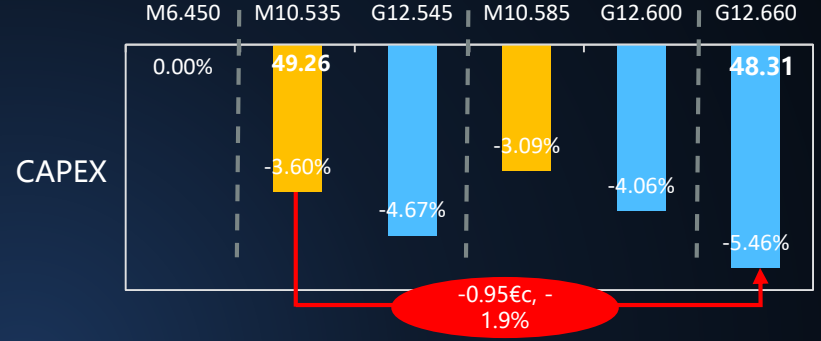
CAPEX,LCOE Assessment

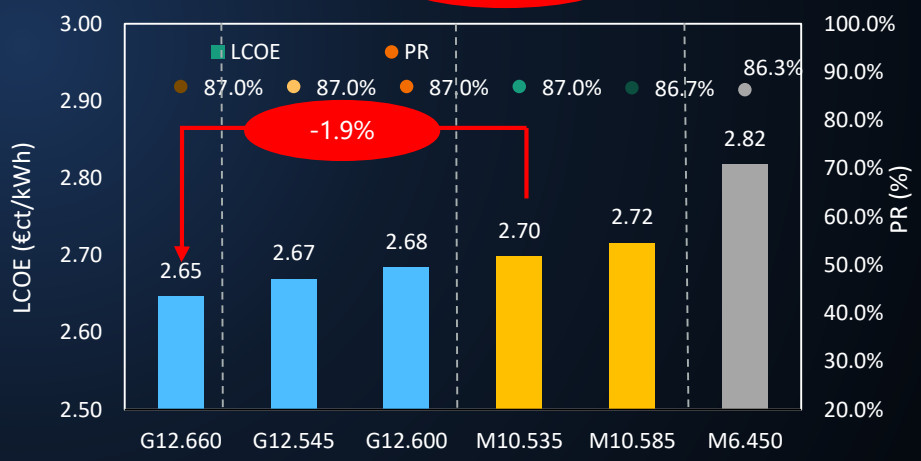
Germany: Mono-facial module+ Fixed tilt system





Spain: Bifacial module +1P tracker system





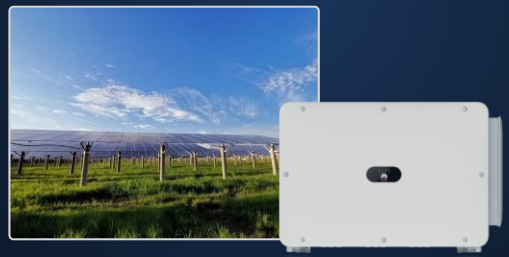
Compare with 540W M10-72，Vertex 660W can achieve CAPEX saving up to 0.95-2.04€ct/Wp，
LCOE saving up to 1.9-4.1%

Vertex 670W Modules Compatibility with Inverters

--200+ types from 22 Mainstream Inverter manufacturers

112MW On-grid Qinghai Dachaidan Power Plant

670W Vertex Module+ Sineng Inverter



Luotian 130MW PV+ Agriculutre complementary power plant

670Module + Huawei smart Inverter

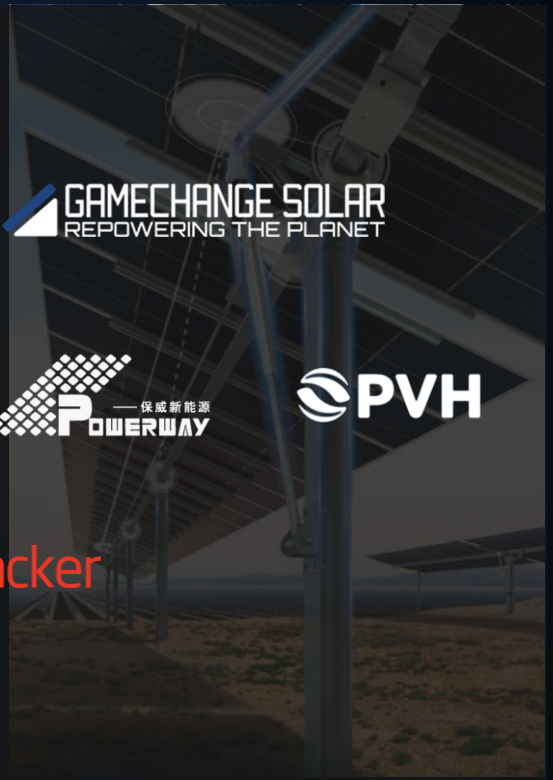
Hebei Nandagang 70MW PV+Fishery Complementary Project (under construction)

670W Vertex Module + Sungrow Inverter

Vertex 670W Modules Compatibility with Trackers

--30 models of Tracker from 14 Top Suppliers are compatible with Vertex

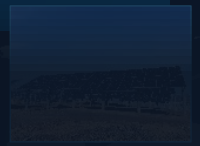
Company Name	Product Type	210@550W	210@600W	210@670W
Arctech Solar Holdings China	1P	√	√	√
	2P			
Array Technologies Inc. USA	1P	√	√	√
Clenergy (Xiamen)	1P	√	√	√
	2P			
FTC Solar Inc., USA	2P	√	√	√
GameChange Solar LP. USA	1P	√	√	√
	2P			
Grace	1P	√	√	√
IDEEMATEC Germany	2P	√	√	√
	2P			
Nextracker Inc. USA	1P	√	√	√
Powe	1P,2P	√	√	√
PV HARDWARE Spain				
STI Norland S.L., Spain	1P-Dual/Muilt	√	√	√
SOLTEC Spain	2P	√	√	√
Soltigua S.R.I, Spain	1P	√	√	√
Trina Solar Co., Ltd.	1P	√	√	√
	2P			



Global application cases of Trinasolar Vertex Modules

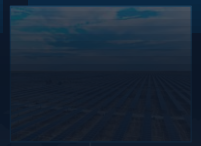
Under Construction Completed

Spain
176MW & 202MW


Lingshou Hepei
China
50MW


Nangong Hepei
China
400MW

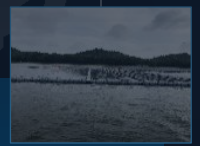

Luotian Hubei
China
100MW


Dachaidan
Qinghai China
112MW


Japan
Bison Energy
2.85MW

Vertex modules **20GW+** shipping record!


Yulin Shaanxi
china
100MW


Singapore
60MW

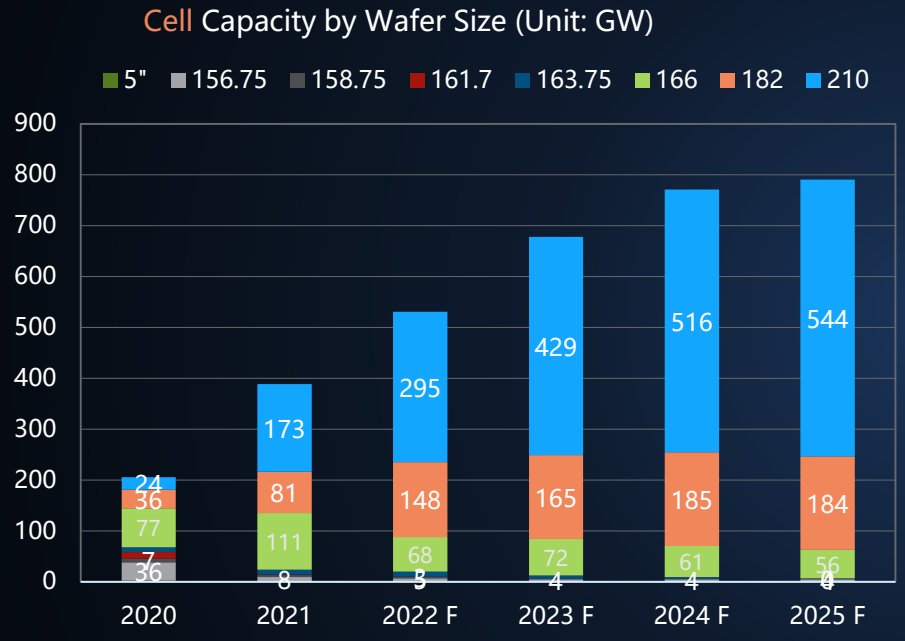

Yonglong
vietnam
49.3MW

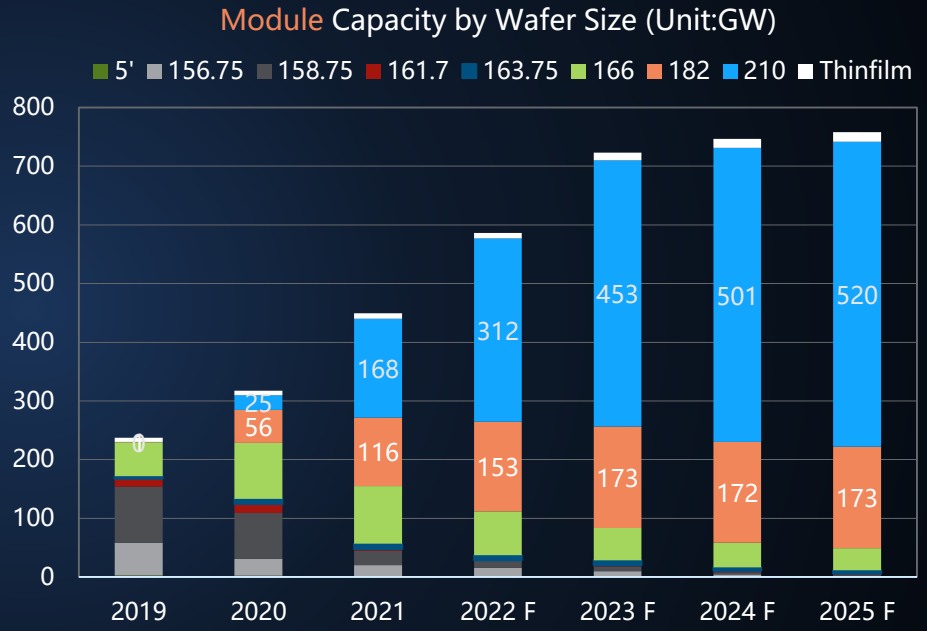

Vietnam
50.6MW


Ho Chi Minh &
Hanoi
Vietnam
40MW

Brazil
715MW & 850MW

210 Cell & 600W+Module Production Capacity is Rapidly Expanding Leading the market





Datasource: PV InfoLink 2022.Apr

- The capacity of 210-size cells and 600W+ modules will reach 295G/312G respectively in 2022;
- There is sufficient supply capacity of 600W+ modules from 2022 onwards.

Trina Solar Global Manufacturing Capacity Outlook

2022 module production capacity

65 GW+

2022 cell production capacity

50 GW+

The final data is subject to Trina Solar 2021 financial report

Summary

1. The accumulative module shipment of Trina Solar have exceeded 100GW; 600W+ modules are becoming mainstream;

2. Vertex 670W modules can further reduce LCOE by 1.9~4.1%, efficiently contribute to the global green energy transition and carbon neutrality;

3. Vertex 670W modules have excellent compatibility, reliability and bankability,which are ready for global application.

THANKS!

Deploying Vertex Modules

Reduce LCOE and Maximize Your ROI

Energy Yield Service: Looking beyond the Standard Test Conditions

TÜV Rheinland Group

Dr. Christos Monokroussos

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TÜV Rheinland's Solar Business

Offering tailor-made solutions for manufacturers, EPCs and investors along the value chain globally.

More than **40** years of experience in PV.

Power plant inspections since **1990**.

More than **500** locations in **59** countries worldwide.

8,000 m^2 of lab testing areas.

250+ PV experts worldwide.

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Energy Yield Service

Agenda

1. Module power rating vs. energy yield
2. Global energy yield measurement of TÜV Rheinland
3. Trina Solar energy yield project

Energy Yield Service

Agenda

1. **Module power rating vs. energy yield**
2. Global energy yield measurement of TÜV Rheinland
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Energy Yield Service

Module power rating vs energy yield

Pricing €/W_P

Based on module power rating measured at STC condition

Decision making

Wp & Simulation

- Module power rating in €/Wp at STC condition, which is deficient to evaluate energy yield
- Normative basis is the series of standards IEC 61853 part 1 to 4, which might have high measurement uncertainty
- PV industry moving away from *Wp-thinking* towards *energy yield driven decisions*

Module characteristics which determine PV module's performance outdoors can be found on datasheets, but are not always trustable.

Energy Yield Service

Module power rating vs energy yield

- **Nominal power rating** (Wp stated power on the label) of a PV module **does not tell much** about the energy delivery
- **Energy delivery (Wh)** of a PV module is influenced by various factors:
  - ❖ **Electrical properties**
  - ❖ **Module construction**
  - ❖ **Site specific conditions**
- **Bifacial technologies** brings energy yield more into the focus of the whole market

Energy yield monitoring with best available accuracy is needed to study the performance of PV modules under the specific conditions of a certain location.

Energy Yield Service

Agenda

1. Module power rating vs. energy yield
2. **Global energy yield measurement of TÜV Rheinland**
3. Trina energy yield project

Energy Yield Service

Global energy yield measurement of TÜV Rheinland Group

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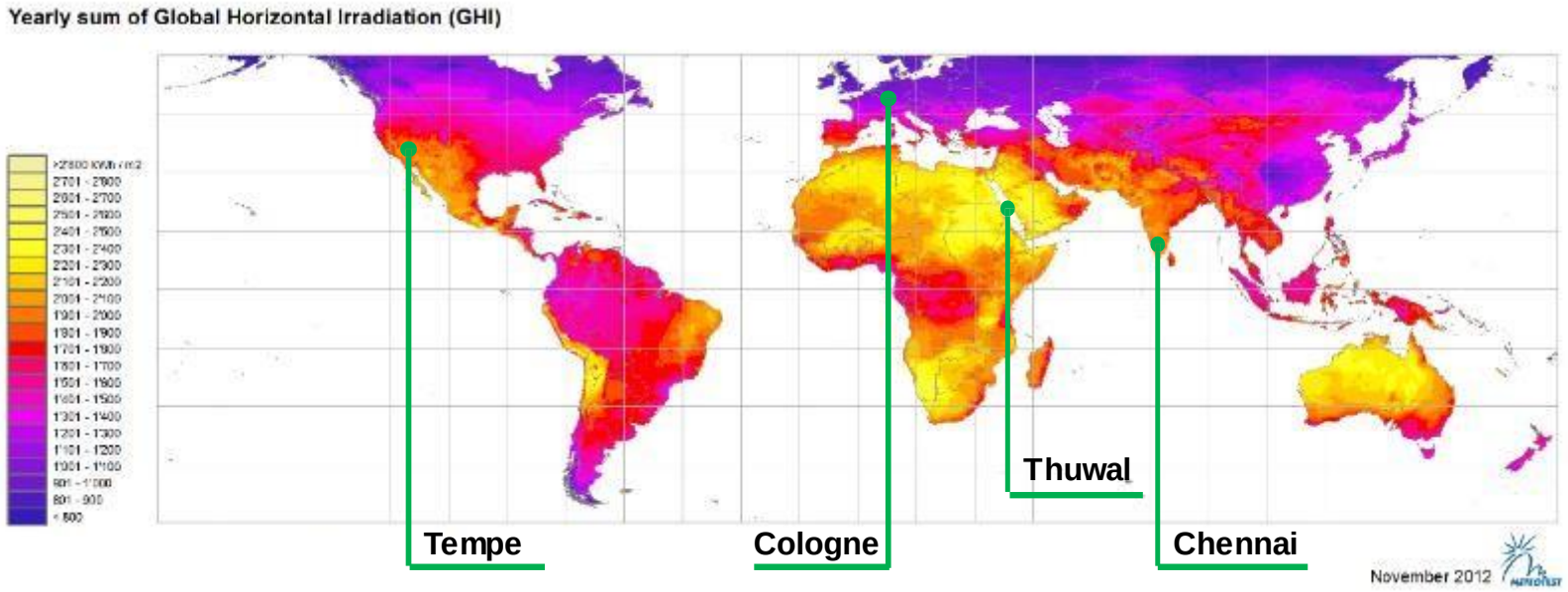
Energy Yield Service

Global energy yield measurement of TÜV Rheinland Group



Location	Country	Climate classification
Cologne	Germany	Cfb (Mild mid latitude, marine west coast)
Thuwal	Saudi-Arabia	Bwh (Dry, sub-tropical desert), sandstorm impact
Chennai	India	Aw (Tropical humid, tropical savanna)
Tempe	Arizona/USA	Bwh (Dry, sub-tropical desert)

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Energy Yield Service

Global energy yield measurement of TÜV Rheinland Group

Test rack and climate data at test location

Cologne, Germany

Thuwal, Saudi-Arabia

Chennai, India

Tempe, Arizona, USA

Location	Köppen-Geiger climatic classification	Tilt angle	Yearly sum of in-plane solar radiation	Fraction of low irradiance (G_{POA} < 200 W/m²)	Average ambient temperature (G_{POA} > 15 W/m²)	Annual precipitation	Average relative humidity
Cologne (Germany)	Cfb (temperate)	35° (Gravel)	1257 kWh/m²	19 %	13,0 °C	774 mm	74.3%
Thuwal (Saudi-Arabia)	Bwh (desert)	25° (Gravel)	2329 kWh/m²	4 %	30,2 °C	70 mm	66.8%
Chennai (India)	Aw (sub-tropical)	15° (Concrete)	2102 kWh/m²	9 %	30,5 °C	1197 mm	74.7%
Tempe (Arizona, USA)	Bwh (desert)	33.5° (Gravel)	2396 kWh/m²	5 %	25,6 °C	219 mm	33.4%

Energy Yield Service

Global energy yield measurement of TÜV Rheinland Group

Measurement instrumentation

View of equipment container with electronic loads and weather station

- Measuring container with air condition
- Comparable hardware at each site
- Shadow free installation of PV modules
- Open rack mounting with different albedos
- 4-wire connection to individual electronic load
- Continuous MPP tracking and periodical tracing of I-V curve

Ventilated pyranometer for measurement of plane of array irradiance

Integrating sphere of spectro radiometer with optical fiber

Weather station on top of equipment container

Two-axis solar tracker for measurements of GHI, DHI, DNI

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Energy Yield Services

Agenda

1. Module power rating vs. energy yield
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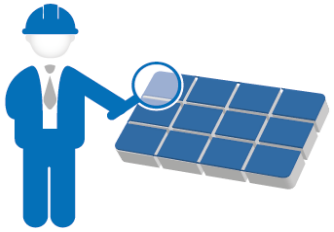
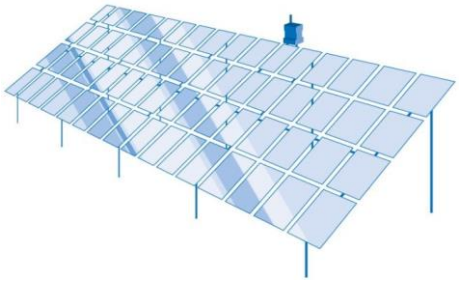
3. **Trina Solar energy yield project**

Energy Yield Service

Trina energy yield project setup





Test sample	Indoor test program	Outdoor EY test program
▪ Very High-Power module Module power rating > 500Wp I_{SC} current close to 20A ▪ Including bifacial module Operation current might reach 25A under irradiance around 1200W/m^2	▪ Indoor test performed in lab of TÜV Rheinland Group ▪ Output power and performance at low irradiance	▪ Cologne & Thuwal test location ▪ Operational efficiency, specific yield and module performance ratio

Sample preparation **TESTING**

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Trina energy yield project setup

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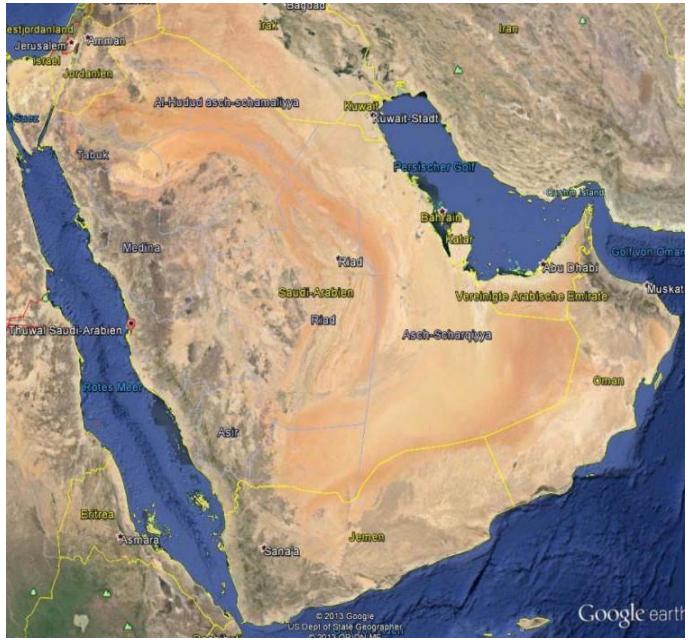
Trina energy yield project setup

Outdoor test duration

Cologne, Germany

From Nov. 2021 to Oct. 2022



Thuwal, Saudi-Arabia

From Dec. 2021 to Nov. 2022

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Trina energy yield project setup

Sample information

Test location	Module type		Rated Power [W]	Module dimension [mm x mm]	Cell width [mm]	Low irradiance ratio	Bifacial ratio
Cologne	A	Monofacial	650	2384 × 1303	210	98.7%	N/A
	B		535	2256 × 1133	182	96.3%	N/A
Thuwal	C	Bifacial	640	2384 × 1303	210	96.4%	69.7% - 71.8%
	D		520	2256 × 1133	182	95.3%	67.4% - 68.5%

Energy Yield Service

Trina energy yield project setup

Irradiance and temperature till Feb. 2022

In-plane global irradiance, Nov. 2021 to Feb. 2022						
Test location	Irradiance	Unit	Nov.	Dec.	Jan.	Feb.
Cologne	Monthly solar irradiance	kwh/m^2	13.7	14.1	13.2	11.3
	Max. irradiance	w/m^2	847.7	774.3	792.2	1068.8
Thuwal	Monthly solar irradiance	kwh/m^2	/	74.8	153.1	84.9
	Max. irradiance	w/m^2	/	1208.8	1343.5	1335.0

Ambient Temperature (ºC, Nov. 2021 to Feb. 2022)					
Test location	Temperature	Nov.	Dec.	Jan.	Feb.
Cologne	Average	7.7	6.2	6.3	8.3
	Max.	13.8	16.2	15.5	14.0
	Min.	-0.2	-3.5	-1.7	-1.9
Thuwal	Average	/	26.7	24.7	25.1
	Max.	/	34.1	32.7	32.8
	Min.	/	16.6	15.8	15.8

Cologne
Irradiance: Low
Temperature: Low

Thuwal
Irradiance: High
Temperature: High

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Trina energy yield project – Specific Energy Yield

The specific energy yield describes the ratio of the module's energy output to the indoor measured power output at standard test conditions (STC) and is calculated by applying the following equation:

$$EY_{spec} = \frac{\sum_{i=0}^{n}(P_{mpp,measure,i} \cdot t_{sample})}{P_{max}}$$

Where:

EY_{spec}	Specific energy yield
$P_{mpp,measured,i}$	Measured P_{max} data outdoors
t_{sample}	Sample time
P_{max}	Module rated power either (acc. to type label or measured at STC in laboratory)

Energy Yield Service

Trina energy yield project – Specific Energy Yield – Cologne

Specific Energy Yield in Cologne [Wh/Wp]							
	Module Type: A			Module Type: B			Type A vs Type B
Test Duration	Sample 1	Sample 2	Average	Sample 1	Sample 2	Average	
Dec.	17.07	17.01	**17.04**	16.36	16.48	**16.42**	**+ 3.78%**
Jan.	15.35	15.33	**15.34**	14.79	14.83	**14.81**	**+ 3.58%**
Feb.	14.74	14.76	**14.75**	14.23	14.21	**14.22**	**+ 3.73%**

Low irradiance in winter season of Cologne (temperate climate).

Module **type A** has shown Higher Energy Yield, due to its **better low irradiance performance**.

Energy Yield Service

Trina energy yield project – Specific Energy Yield – Thuwal

Specific Energy Yield in Thuwal [Wh/Wp]							
	Module Type: C			Module Type: D			Type C vs Type D
Test Duration	Sample 1	Sample 2	Average	Sample 1	Sample 2	Average	
Dec.	71.44	72.44	71.94	71.87	71.19	71.53	+ 0.58%
Jan.	146.42	148.49	147.46	147.62	145.65	146.63	+ 0.56%
Feb.	98.02	99.30	98.66	99.14	97.97	98.55	+ 0.10%

The higher Energy Yield output of module **type C** could be attributed to the **higher bifacial ratio** of the module.

There was **no significant difference in the operation temperature** between different type of modules.

Conclusions

- **Nominal power rating** (Wp stated power on the label) of a PV module **does not tell much** about the actual energy delivery that a module will provide in the field.
- **Energy delivery** (Wh) of a PV module is influenced by various factors, such as **electrical properties, module construction and site specific conditions.**
- The **return of a PV investment** can be **significantly increased** by considering climatic impact factors on PV module performance.
- The **Energy Yield Service** introduced by TÜV Rheinland provide a **complete overview** of the factors, which affect the energy yield of PV-modules.
- Trina Solar's project is studying the performance of **4 different modules types** (**monofacial** and **bifacial**) in **2 different locations** that represent distinct climates (**Saudi Arabia** and **Cologne**).
- Module **type A** has shown **higher energy yield** in Cologne, due to **better low irradiance performance** than type B.
- The **higher energy yield** output of **type C** than type D in Saudi Arabia could be attributed to **its higher bifacial ratio**.

Thank you for your attention!

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Analysis of Outdoor Testing Results for High Power Module (210 vs 182)

National Center of Inspection on Solar Photovoltaic Product Quality(CPVT)

Yun Min

Content

1 Introduction of Yinchuan outdoor testing base facilities

2 Analysis of demonstration data for High Power Module (210,182)

PART 1

Introduction of Yinchuan outdoor demonstration base facilities

Characteristic & Qualification

- In 2007, CPVT was approved to established by State Administration for Product Quality Supervision
  (Now this government department is named State Administration for Market Regulation of China).

- In 2008, CPVT got qualification accreditation and acceptance by the SAPQC and was officially put into operation.

- First national statutory inspection agency for PV products in China

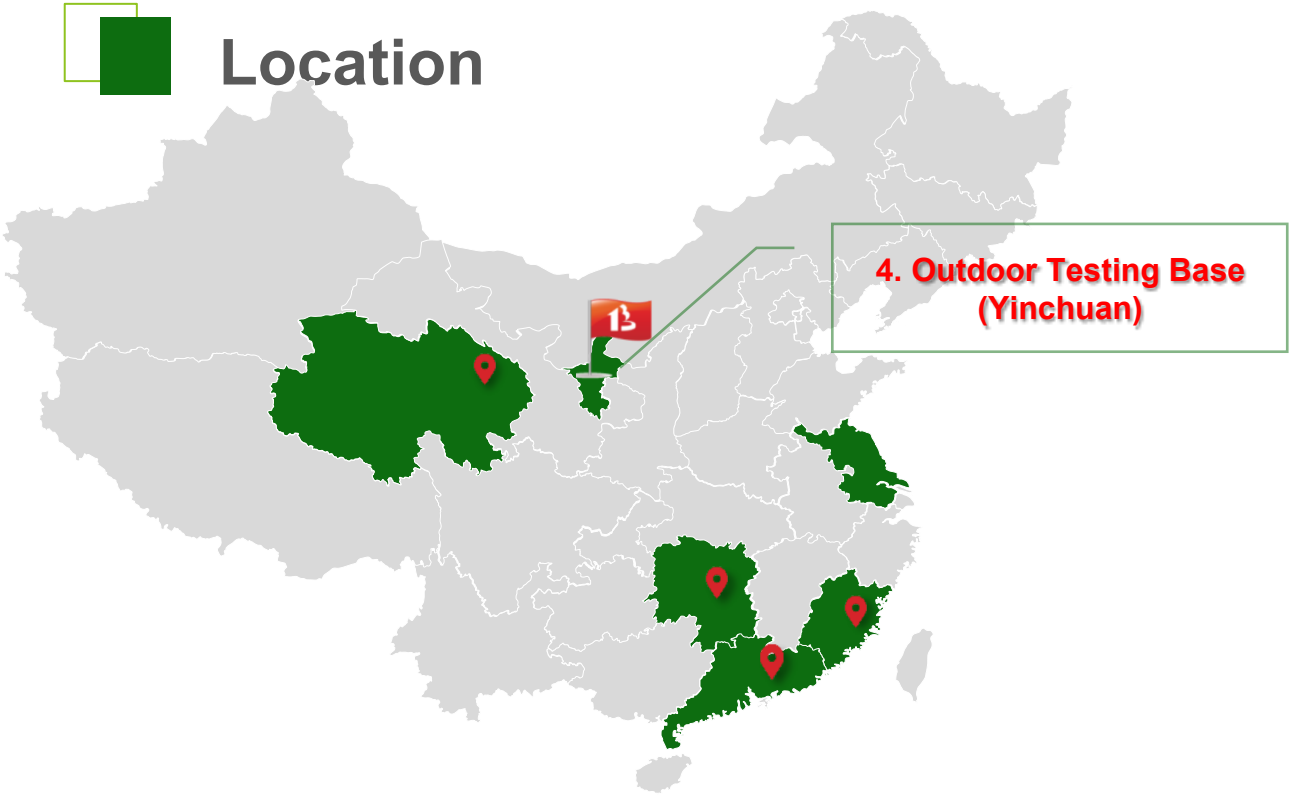
- The Mother-company of CPVT is Wuxi Institute of Inspection,Testing and Certification

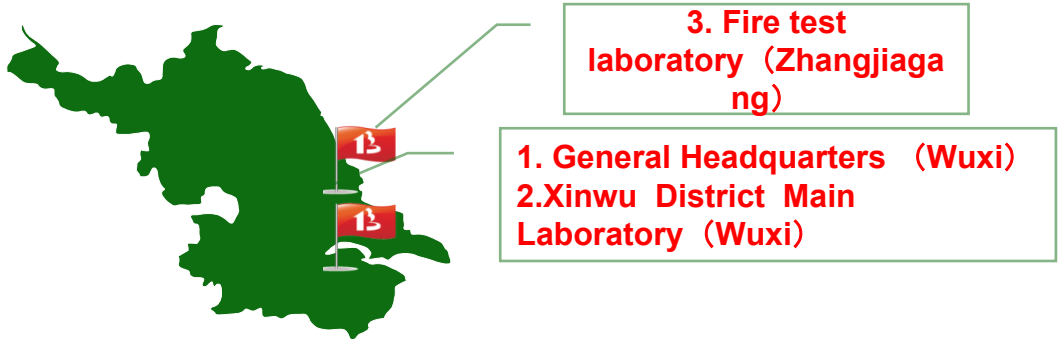
CMA

IECEE CBTL

CNAS

Location

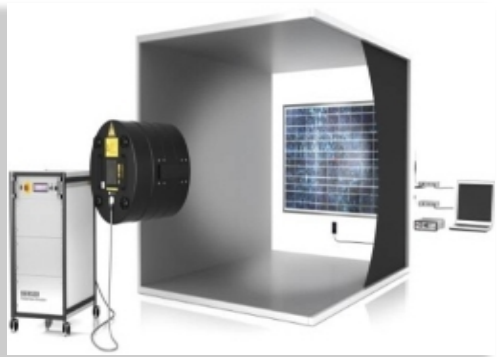




- The total laboratory and office area is about 20,000㎡.
- Yinchuan Outdoor testing base is covering an area of 130,000 ㎡, including office and laboratory for 3,700 ㎡.

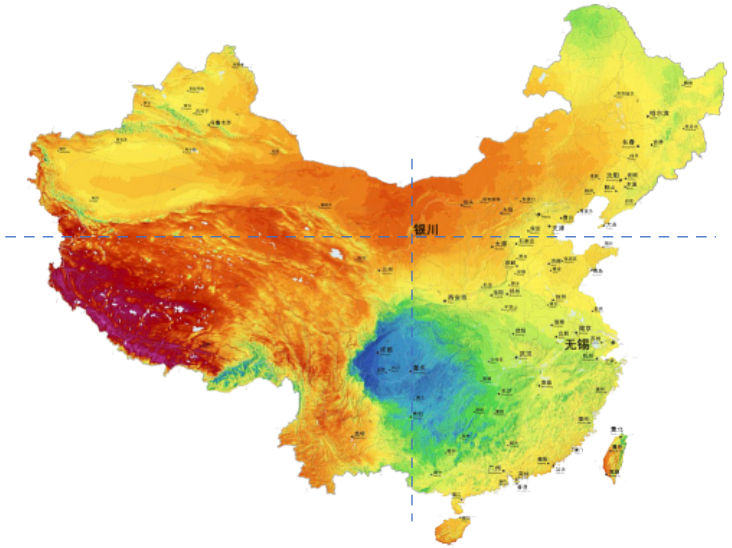
Equipments

- Over 1000 sets professional testing equipments
- 80% are imported from Euro, USA and Japan
- Value of equipments is nearly RMB 170 million

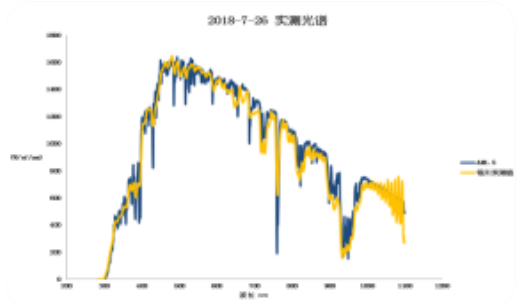


Institution Cooperation

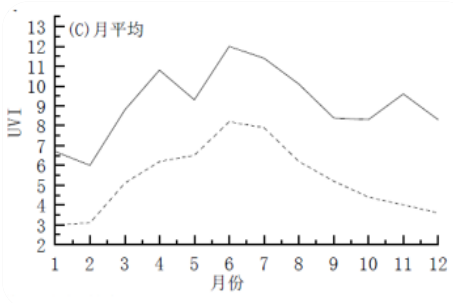
Climatic conditions of Yinchuan Outdoor Testing Base



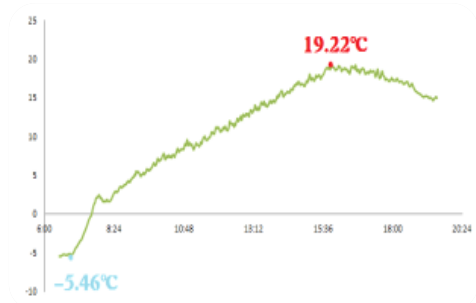
Yinchuan City，North East China
North latitude 38°36’56.77
East Longitude 106°0’52.27



Irradiance Spectrum



UV Index



Maximum temperature difference on same day 25℃

+

Both the biggest PV power station and wine production base of China

- Class I area of Solar Radiance， Mean daily exposure ~ 18.9MJ/m^2, 4.5~5h standard irradiance(1000W/m^2), Spectrum similar with AM1.5 (some month match **95%**)。
- Altitude 1100m, Dry ,Heat, High temperature difference(eg. **25℃)**
- **Maximum wind speed ＞25.06m/s**(force 10 wind)， also can research for mechanical experiment；

Facilities of Yinchuan Outdoor Testing Base

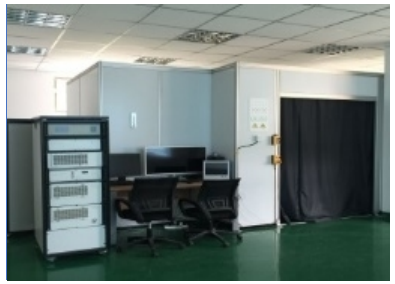
Glass/backsheet ageing

NMOT

Module string ageing

System demonstration

Testing bus
For power station



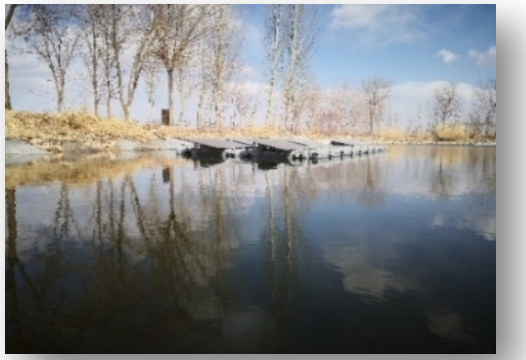
Solar Simulator

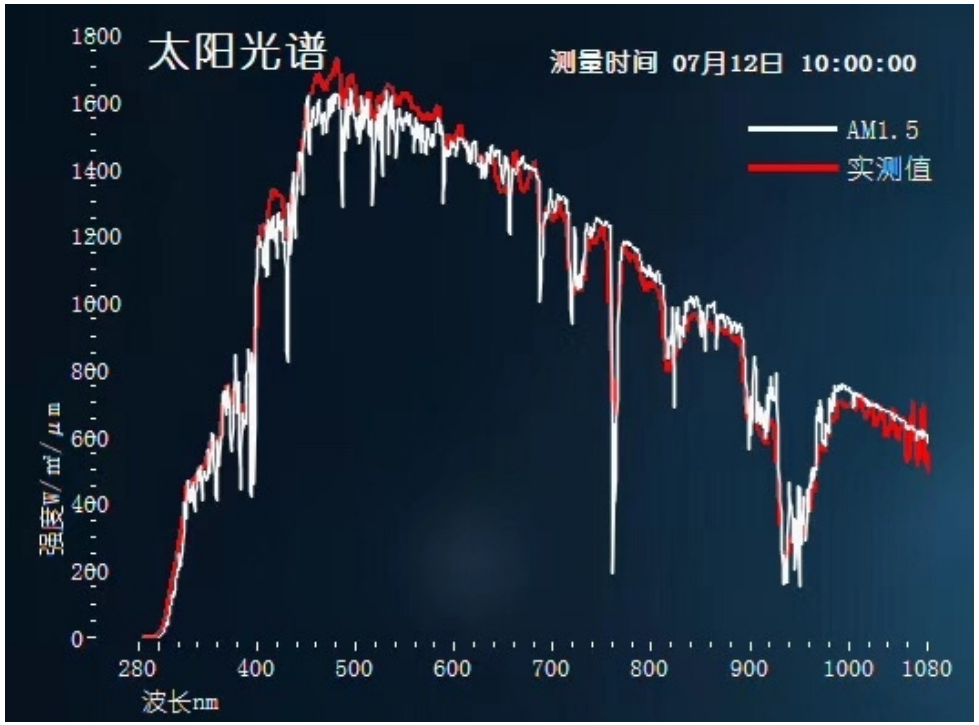
Climate monitor

Data Analysis

BIPV

Total area 133000 m^2, 10 function zone, can load 16000 modules.





Red AM1.5 / White real spectrum

- Agriculture-PV
- Lake-PV
- BIPV
- PV tree
- Household PV
- PV + Car Charging

PART 2

Analysis of demonstration data for High Power Module (210,182)

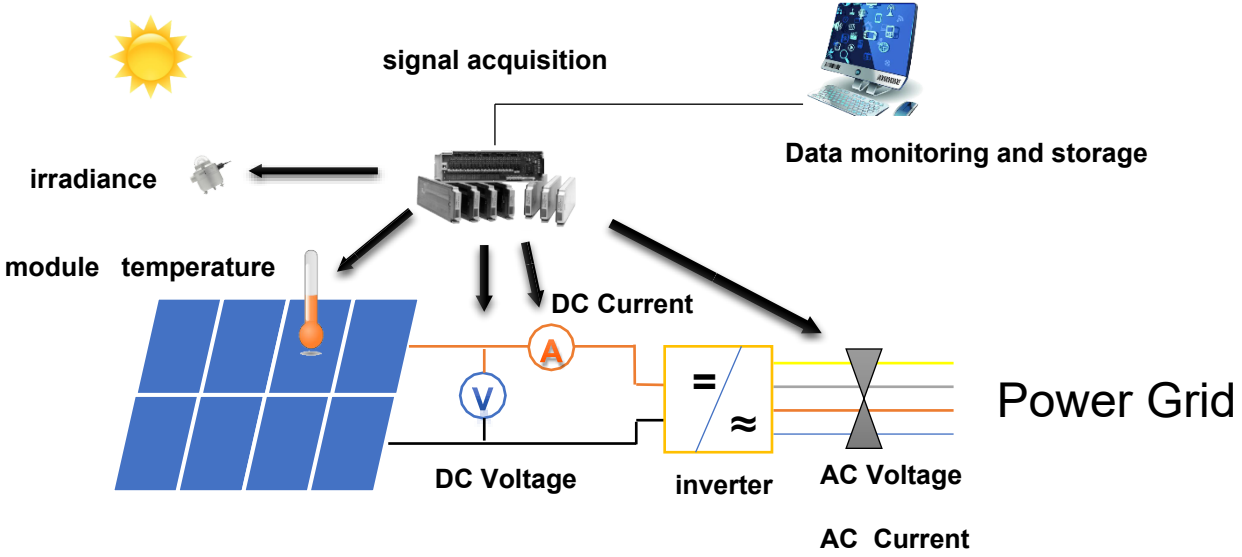
Module Group

Module Type	Comparison module 540W	Start date	Status
210-55 mono-facial	**182 -72 mono-facial**	2021.04.01	About to close
210-55 bifacial	**182-72 bifacial**	2021.04.01	About to close
210-66 mono-facial	**182-72 mono-facial**	2021.11.01	On going

- 210-55 type modules started to be tested from April 2021 and operated for more than one year.
- 210-66 type modules started to be tested from Nov 2021 and are now on going.

Demonstration/Testing conditions

- On-grid period： From April 2021
- Testing period : 1 year
- Install angle of inclination： 40°
- Module lower edge for ground： 1m
- Ground with sand and small rock
- String Inverter 20kW for each module string
- high accuracy current meter



Schematic diagram of measuring system

210-66 mono-facial

210-55 bifacial

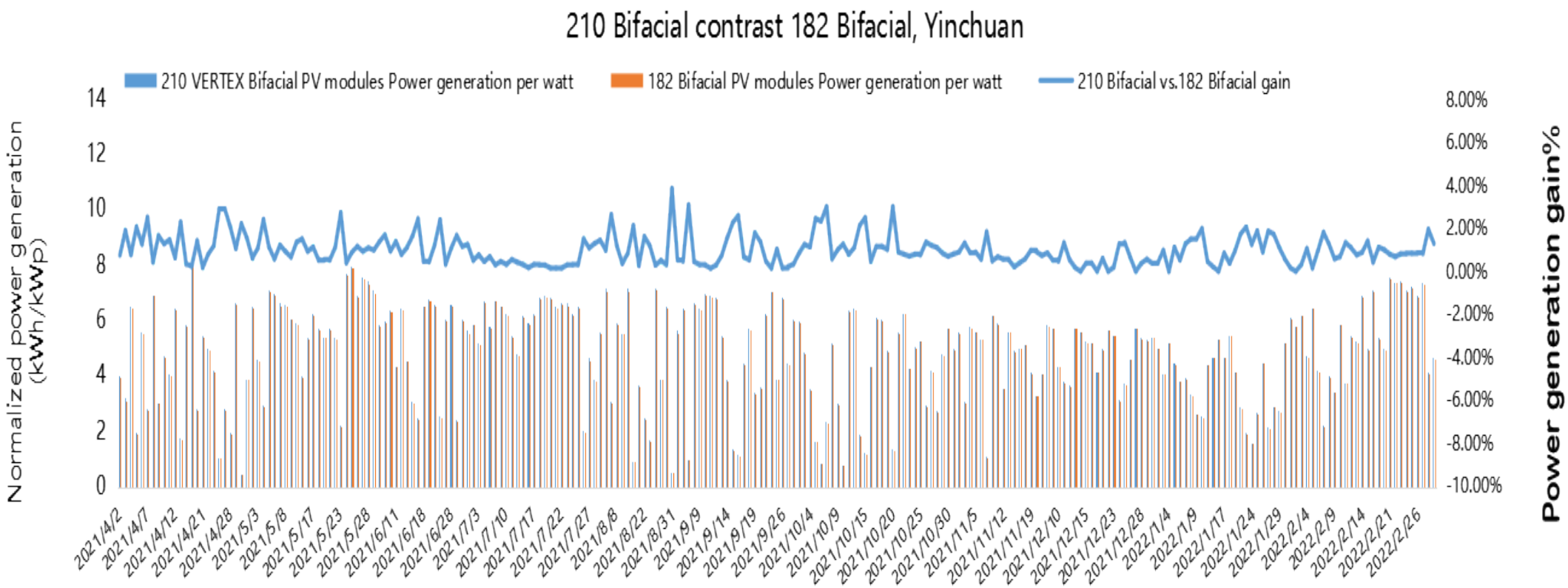
210-55 mono-facial

182-72 bifacial

182-72 mono-facial

Power Generation Compare

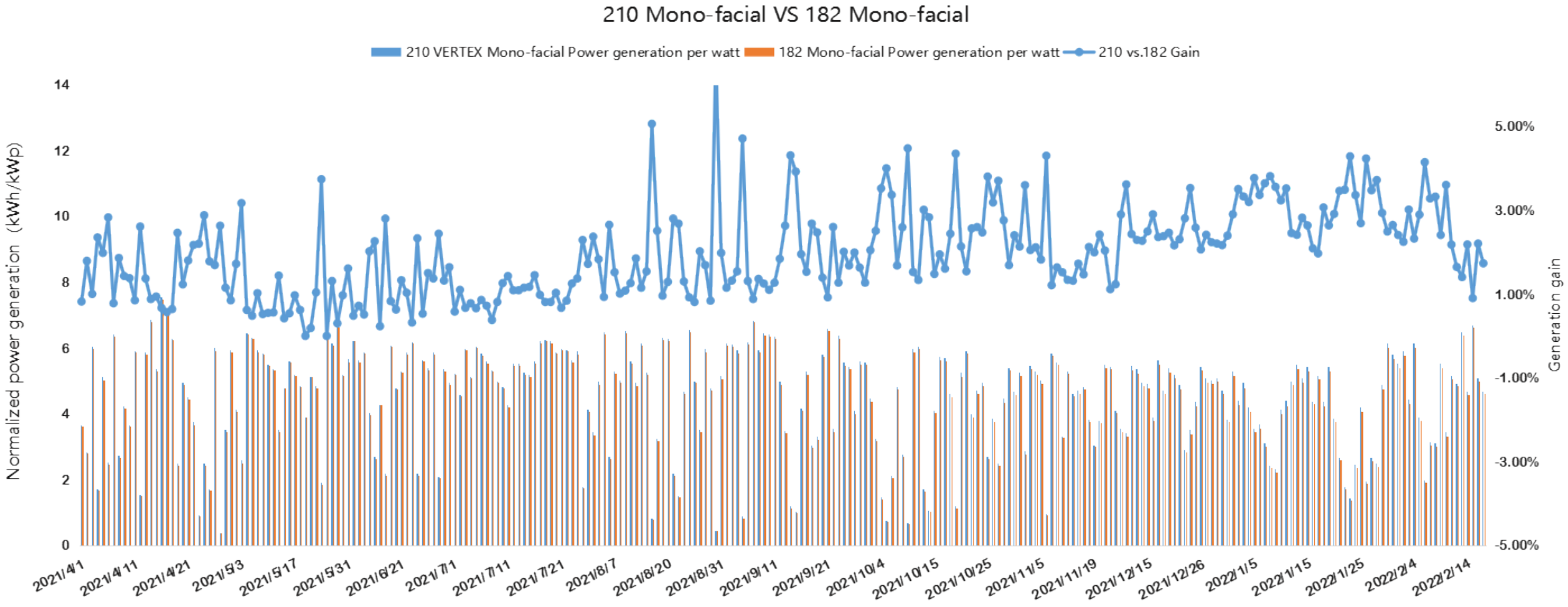
210-55 VS 182-72 from April 2021 to February 2022



The average normalized power generation of 210 module is 1.7% higher;
In most month, the average reflectivity of sand-rock is about 15%--17.8%, only in Feb and Nov, the percentage is around 11%.

Power Generation Compare

210-55 VS 182-72 from April 2021 to February 2022

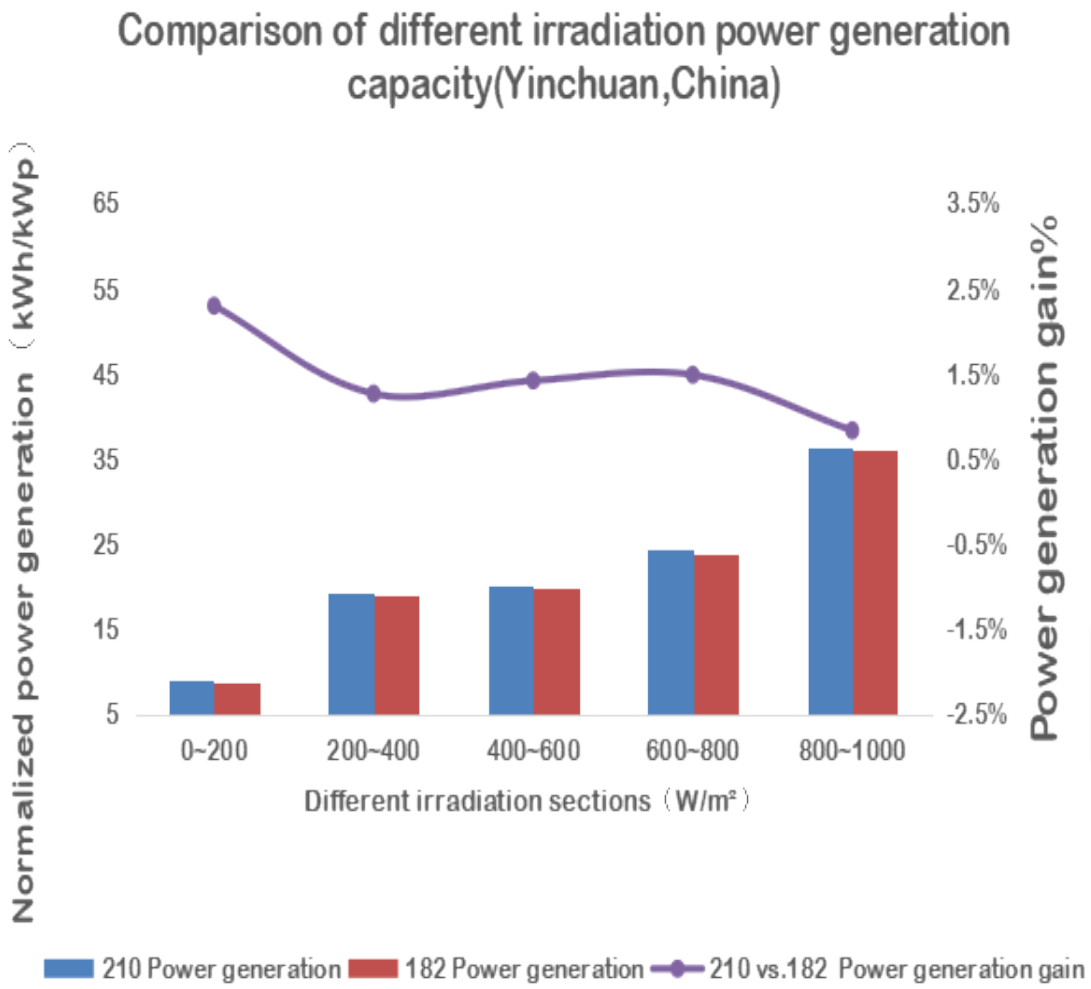


Mono-facial Module with 210 -55 cell vs 182 -72 cell

The average normalized power generation of 210 module is 1.4% higher

Generation vs Irradiation

210 VS 182



Irradiance < 800W/m², Power generation 210 > 182 about 1.5 ~ 2.5%;

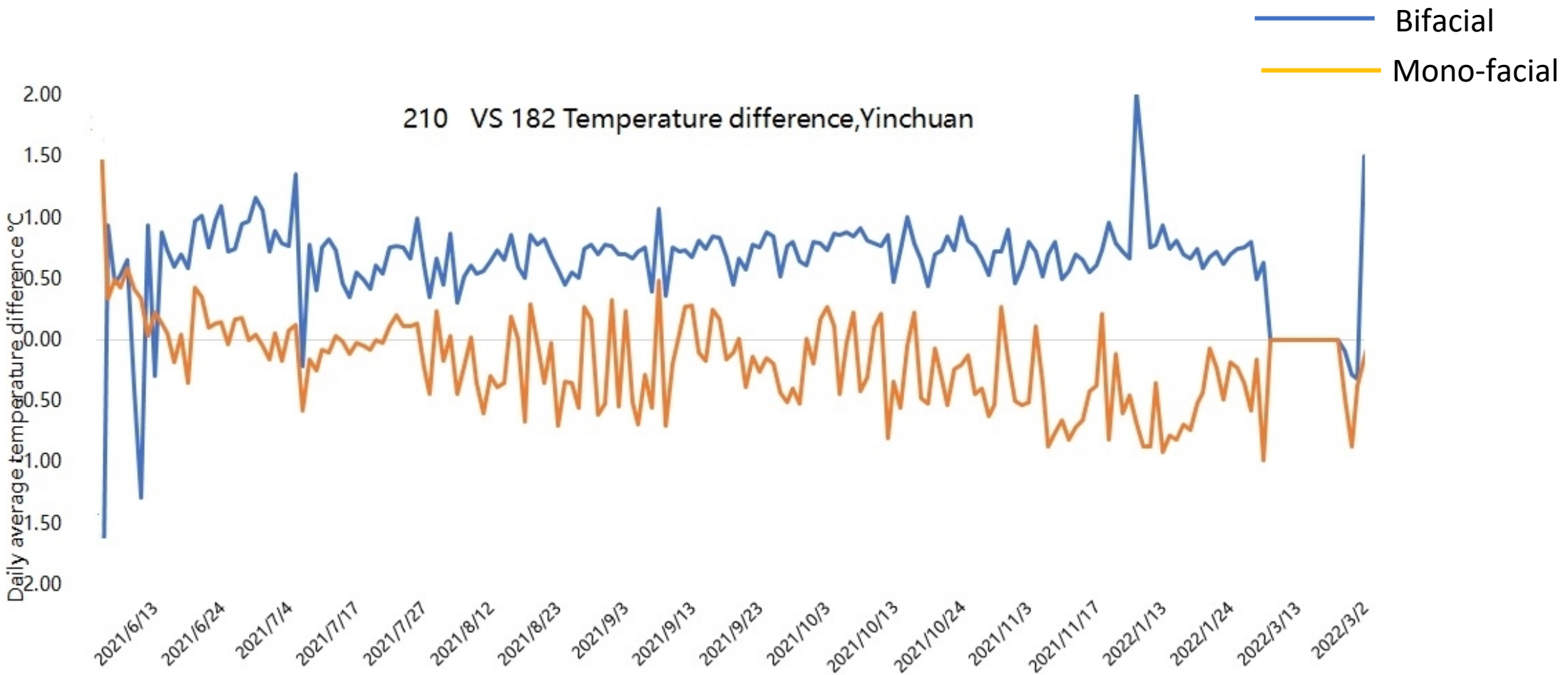
Irradiance ≥ 800W/m², Power generation 210 > 182 about only 0.8%;

Eg. On June 2021, the part of irradiation exceed 1000W/m² is only 3.98%.

the total power generation difference of 210 vs 182 depend on the performance with low irradiance

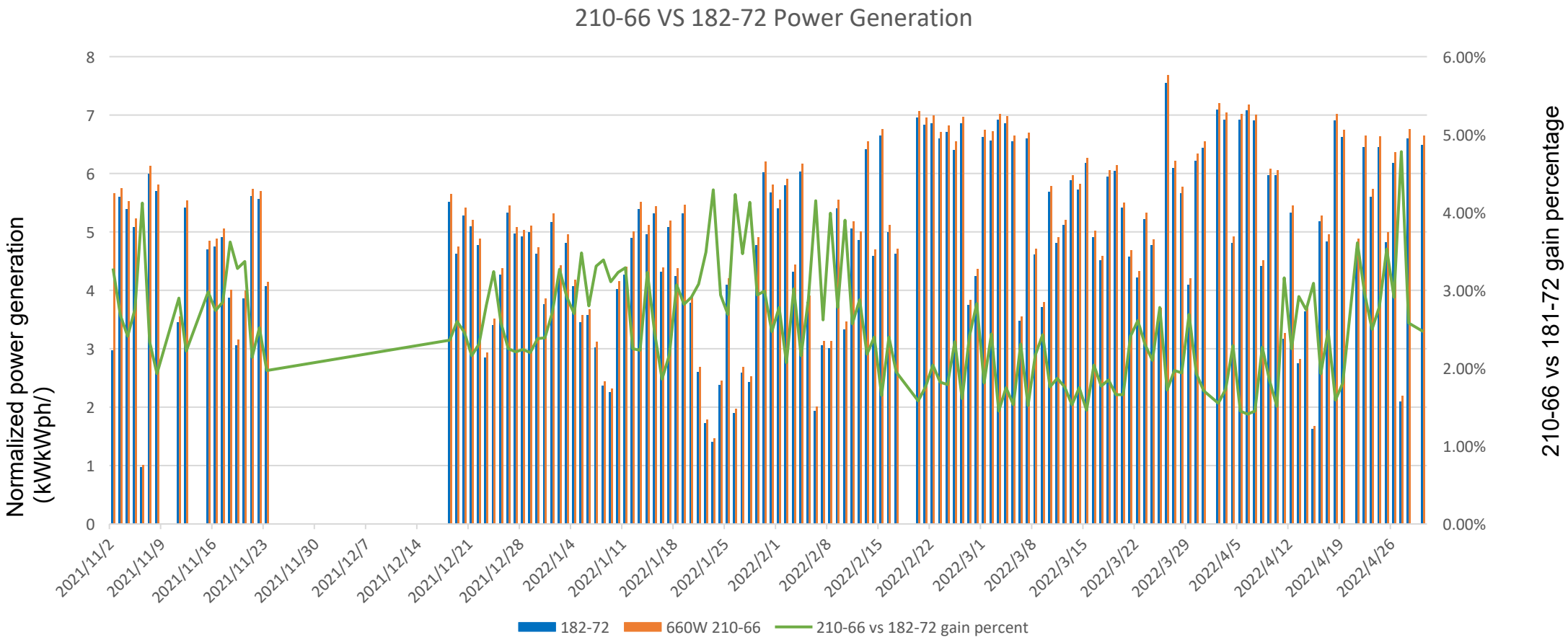
Operating Temperature (OT) difference curve of 210- 55 vs 182-72

The outdoor backsheet temperature measurement deviation is about ± 0.7℃ because of wind
The average OT of 210-55 bifacial module is only 0.4 ℃ higher than that of 182-72 bifacial module,
210-55 mono-facial module is 0.3℃ higher than that of 182-72 mono-facial module



Generation Compare

210-66 mono-facial VS 182-72 mono-facial



From Nov. 2021 to Apr. 2022, the normalized power generation of 210-66 mono-facial modules is 2.5% higher than that of182-72 mono-facial modules.

From November 24 to December 24, equipment measurement calibration test was suspended.

Summary

- The normalized power generation of 210-55 cell module is obviously higher than 182-72 cell module, The gain percentage is about 1.4% of mono-facial module and 1.7% of bifacial module.

- In lower irradiance(below 800W/㎡), the power generation ratio of 210 vs 182 is higher than that in higher irradiance (above 800W/ ㎡), and this is the main reason why 210 cell module generate more power than 182 cell module.

- The average operating temperature(OT) of 210 cell module is about only 0.4℃ (bifacial) and 0.3℃(mono-facial) which higher than 182 cell module.
  Considering of the Outdoor OT measurement deviation is about ± 0.7℃ because of wind,
  The test result shown that there is no influence of power generation coursed by OT difference between 210 and 182.

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Thank You

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