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Huasun Energy

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Zero busbar and high efficiency HJT

7 May 2024

10:00 am – 11:00 am | CEST, Berlin
12:00 pm – 1:00 pm | Dubai
4:00 pm – 5:00 pm | CST, Beijing

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Welcome!

pv magazine webinars

Do you have any questions? ❓ 🙋

Send them in via the Q&A tab. 👉 We aim to answer as many as we can today!

You can also let us know of any tech problems there.

We are recording this webinar today. 📹

We‘ll let you know by email where to find it and the slide deck, so you can re-watch it at your convenience. 👀 💡

The state of the art 0BB Products of Huasun

Anhui Huasun Energy Co., Ltd

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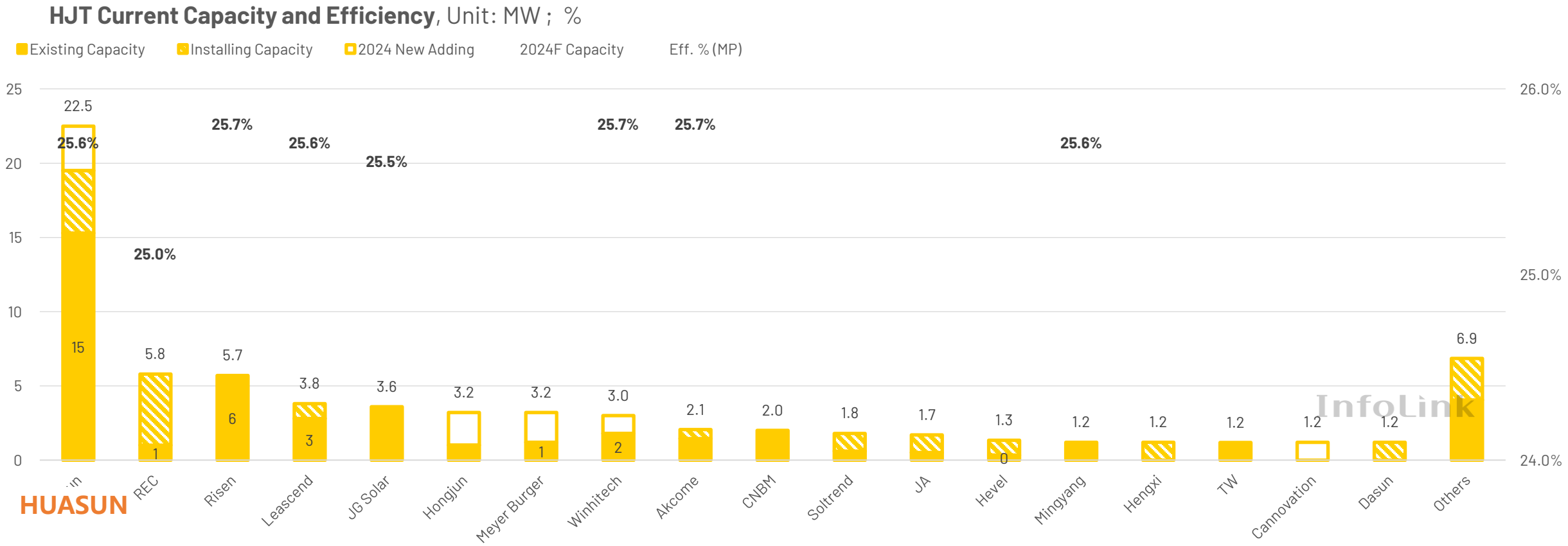
1.1 HJT Technology Trends

1.1 Current Status of HJT Technology



- In 2023, The global HJT capacity ~50GW, the global shipment ~8GW, the shipment of **HUASUN is over 3GW**
- The new HJT line will be equipped with double-sided microcrystalline technology, with an efficiency of **25-25.5%**
- The capacity of HUASUN is over **20GW**

1.2 About HUASUN

Anhui HUASUN Energy Co., Ltd. (hereinafter referred to as "HUASUN"), founded in July 2020, is a technological innovation enterprise specializing in the development and application of ultra-high efficiency N-type silicon based heterojunction (HJT) solar technology as well as the products' large-scale manufacturing.

Focusing on the R&D of high-efficient HJT technology as well as its production, HUASUN strives to provide customers with the most effective clean energy solutions of greater performance and better returns.

Headquarters
Xuancheng·Anhui

Sales Center
Nanjing·Jiangsu

Founded in
2020.07

Core Tech/Product
HJT Solar wafer/Cell/Module

1.2 About HUASUN

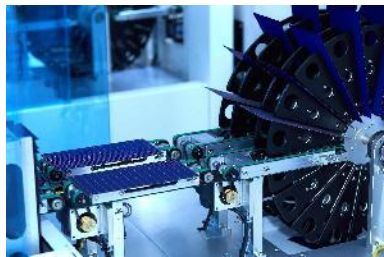
40GW+

Production capacity by 2025E

20GW@2023E

To build a TOP enterprise in the high-efficient HJT solar industry

Tier1 BloombergNEF



1.2 About HUASUN

Super Team

HUASUN proactively responds to climate change solutions. By gatherring the most experienced talents in HJT field , a super R&D team led by industrial experts is formed to explore effective approaches to improve the conversion efficiency of solar products, and realize the low-cost but productive mass production of HJT cells and modules.

15Y+
Team members'average experience in tech development and management in top solar companies

200+
Talents in HJT field

4 Industrial Scientists

4 Leading Talents in HJT Field

20 Ph.D

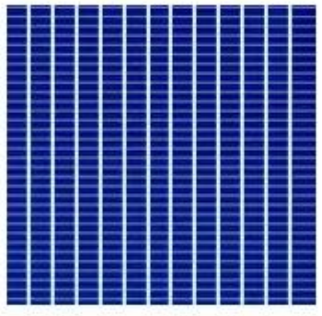
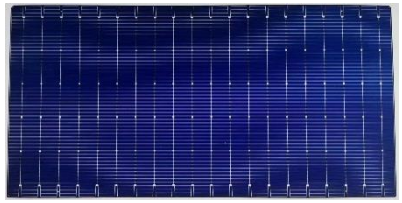
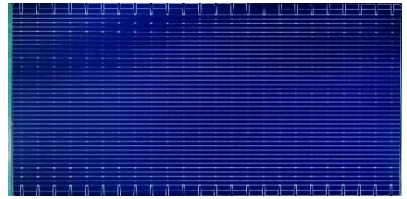
100 Masters

Contents

2.1. HJT Technology Trends

Evolution of Busbar Design for Solar Cells

2BB-6BB → MBB(9-15BB) → SMBB(≥16BB) → 0BB(No Busbar)

Advantages of increasing busbars:

- Increase module power
- Reduce package losses
- Reduce manufacturing costs

Advantages of 0BB:

- Reduce consumption of silver paste
- Compatible with thinner silicon wafers
- Improve module reliability

2.1. HJT Technology Trends

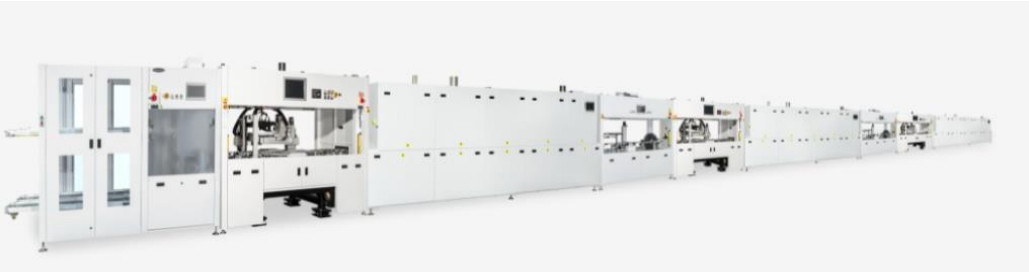
Four Different Technical Routes

Source： PV Infolink

Type	Technological Process	Encapsulating Material	Key Point	Alloying	Advantage	Disadvantage	Equipment	Company
SWCT	Copper-coated ribbons are positioned by a transparent foil. This foil-wire assembly (FWA) interconnects cells. Copper-coated ribbons and cells are firmly combined through lamination.	Composite Film+ Encapsulant	Copper wire composite film	Lamiation	Strong adhesion, High conductivity	Prefabricated copper wire composite film, EL testing can only be done after lamination	Meyer Burger	
Integrated Film Covering (IFC)	Interconnecting cells by placing ribbons to their front and rear sides through IFC. Ribbons and cells are firmly combined through lamination.	Skin film+ Encapsulant	Skin film	Lamiation	Strong adhesion, No welding process	Skin film required, EL testing can only be done after lamination	XN Automation, Maxwell	REC,ASTRO
Dispensing	Between fingers. Place ribbons to cells by dispensing. Ribbons and cells are firmly combined through lamination.	PVB/EVA Skin film + EVA/	Gum-printing UV curing	Lamiation	Simple process, No welding process	Skin film and encapsulant are needed for encapsulation, Insufficient adhesion	Autowell, AUTO-ONE, XN Automation, Autowavs, Lead Intelligent	Risen, Tongwei, Jinko
Welding + Dispensing	Welding ribbons to cells (cell interconnection and ribbon-cell combination take place simultaneously). Stick ribbons to cells using dispensing.	Standard EVA	Welding Dispensing UV curing	Infrared welding	No need for load-bearing film, Strong adhesion, Good hot-spot resistance	High precision requirements for dispensing	Maxwell	HUASUN

2.2. Advantages of HUASUN HJT-0BB

1) Single Printing Technology



Reduction: paste, equipment, energy, cost

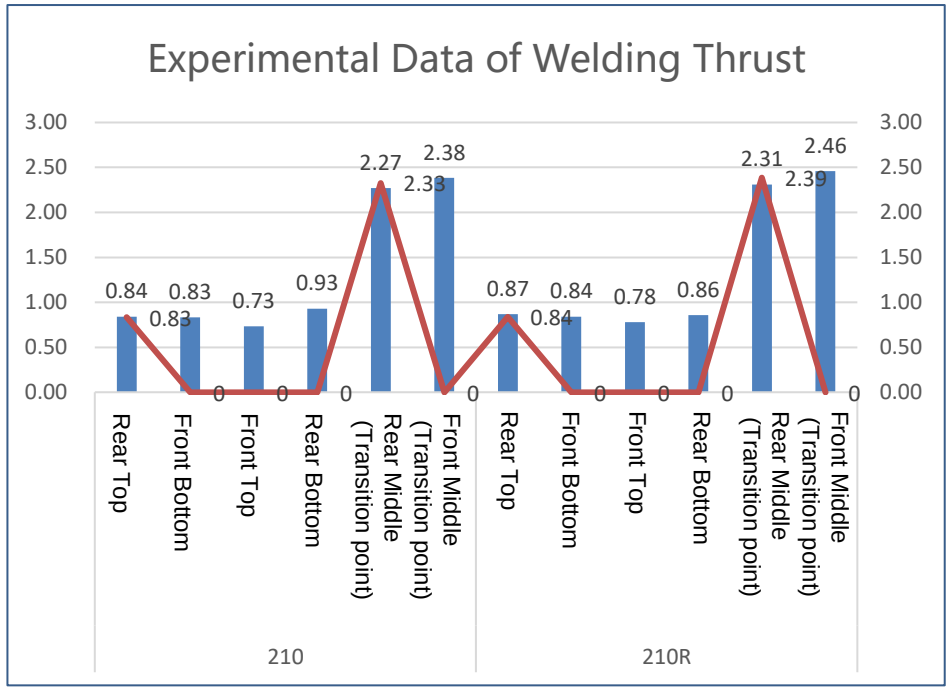
Improvement: efficiency, power, reliability

4 steps: rear finger, rear busbar, front finger, front busbar

2 steps: Rear finger+pad, front finger+pad

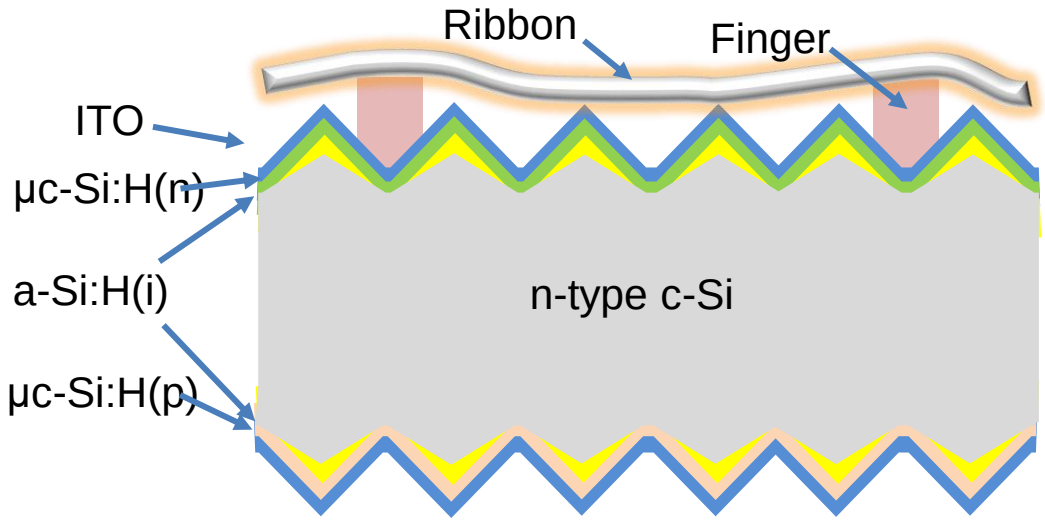
Cell Type	Test Position	Average/N	Total Average
210R	Rear Top	0.84	0.83
	Rear Bottom	0.83	
	Front Top	0.73	
	Front Bottom	0.93	
	Rear Middle (Pad point)	2.27	2.33
	Front Middle (Pad point)	2.38	
210	Rear Top	0.87	0.84
	Rear Bottom	0.84	
	Front Top	0.78	
	Front Bottom	0.86	
	Rear Middle (Pad point)	2.31	2.39
	Front Middle (Pad point)	2.46	

Statistical analysis table of welding thrust at different points of 0BB-24 ribbon

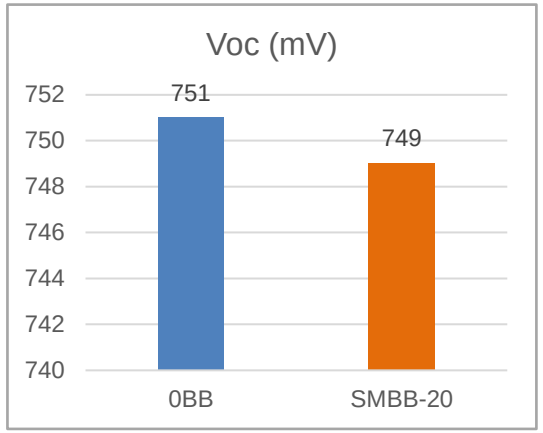


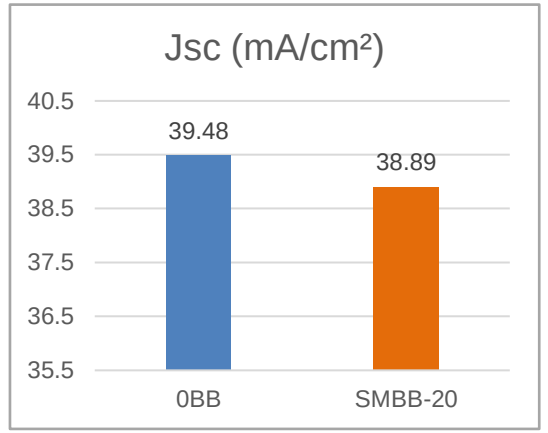
2.2. Advantages of HUASUN HJT-0BB

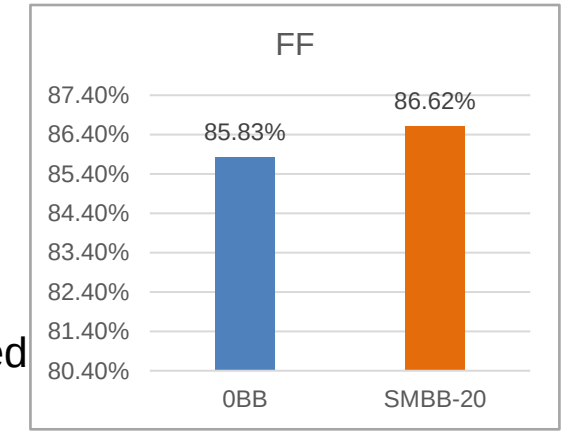
1) Single Printing Technology

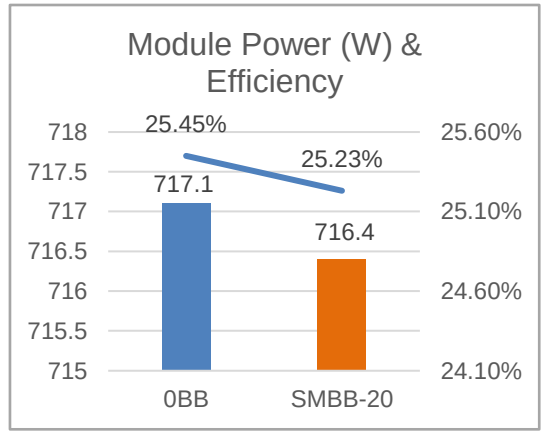


- Decreasing the electrical resistance within the solar cell
- More efficient movement of electrons
- Increasing conversion efficiency









- Matching the interfaces of ITO/finger/ ribbon, and ITO/ ribbon
- Improving the carriers transport at those interfaces
- Optimizing the CTM performance of the modules are optimized

2.2. Advantages of HUASUN HJT-0BB

2) Higher Reliability

SMBB-20BB

Ribbon: Sn43Pb43Bi14 φ0.28mm

Welding Temperature: 230℃

Pre-welding of HUASUN 0BB

Ribbon: Sn43Pb43Bi14 φ0.20mm

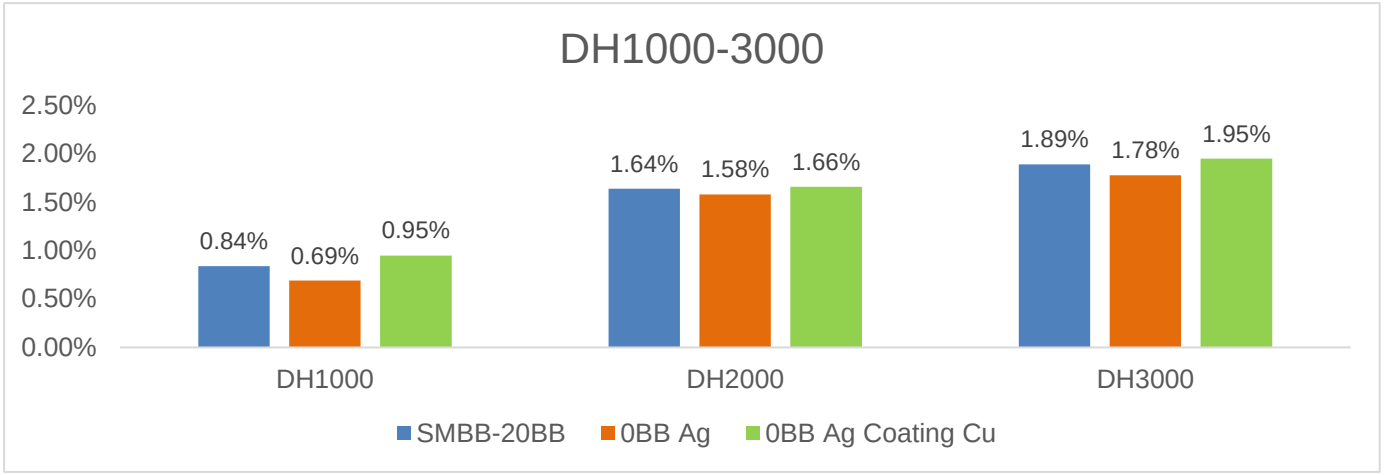
Welding Temperature: 210℃

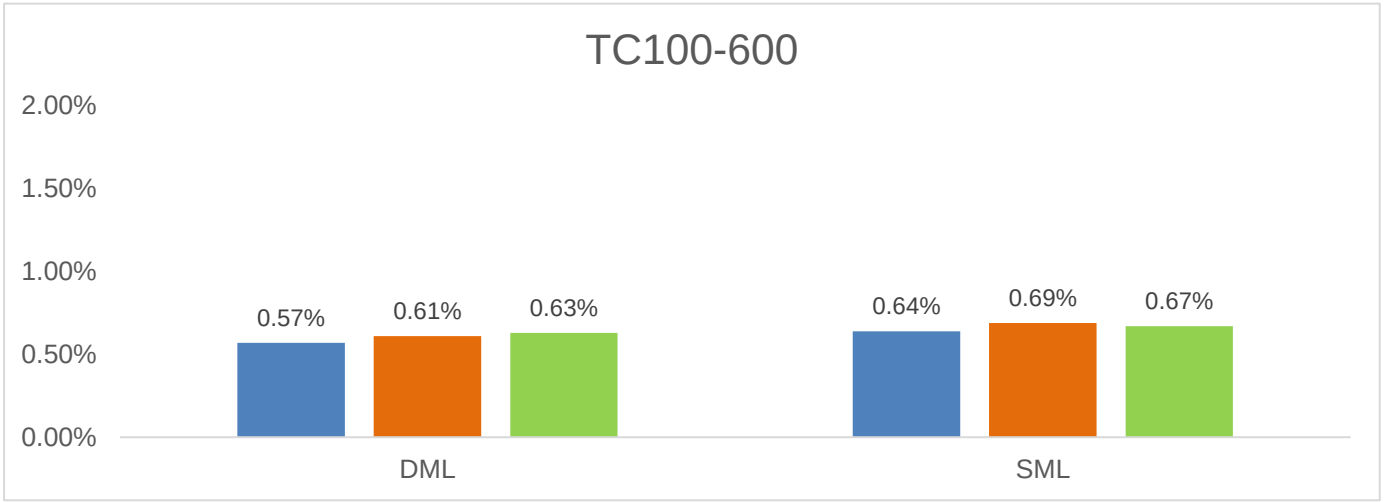
Laminator Welding of Competitor

Ribbon: Sn27Pb41Bi32 φ0.22mm

Welding Temperature: 150℃

Welding before Lamination + PIB sealing



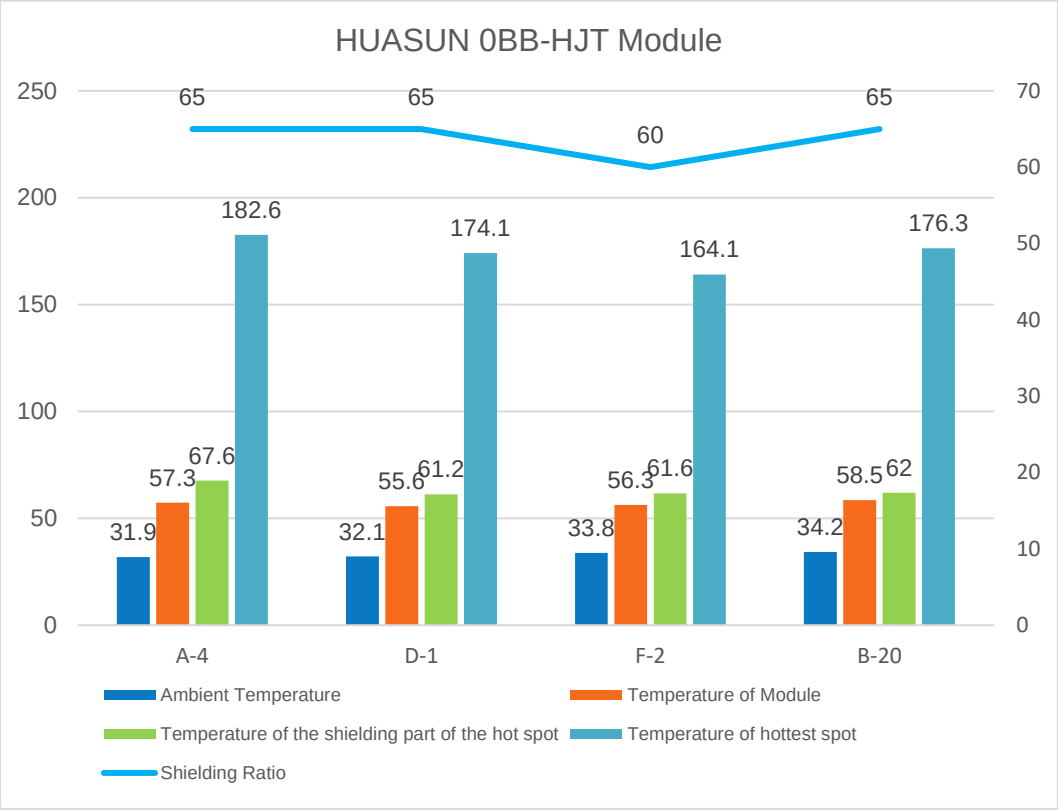


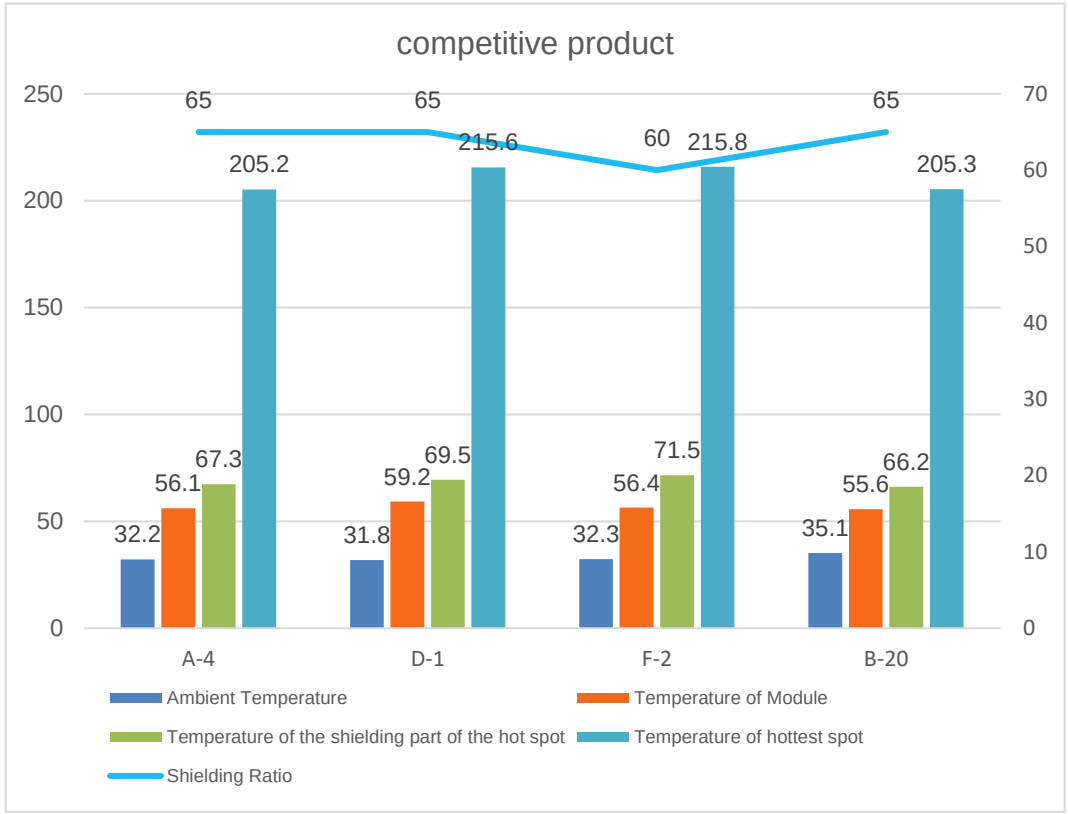
2.2. Advantages of HUASUN HJT-0BB

2) Higher Reliability

Reducing the occurrence of hotspots

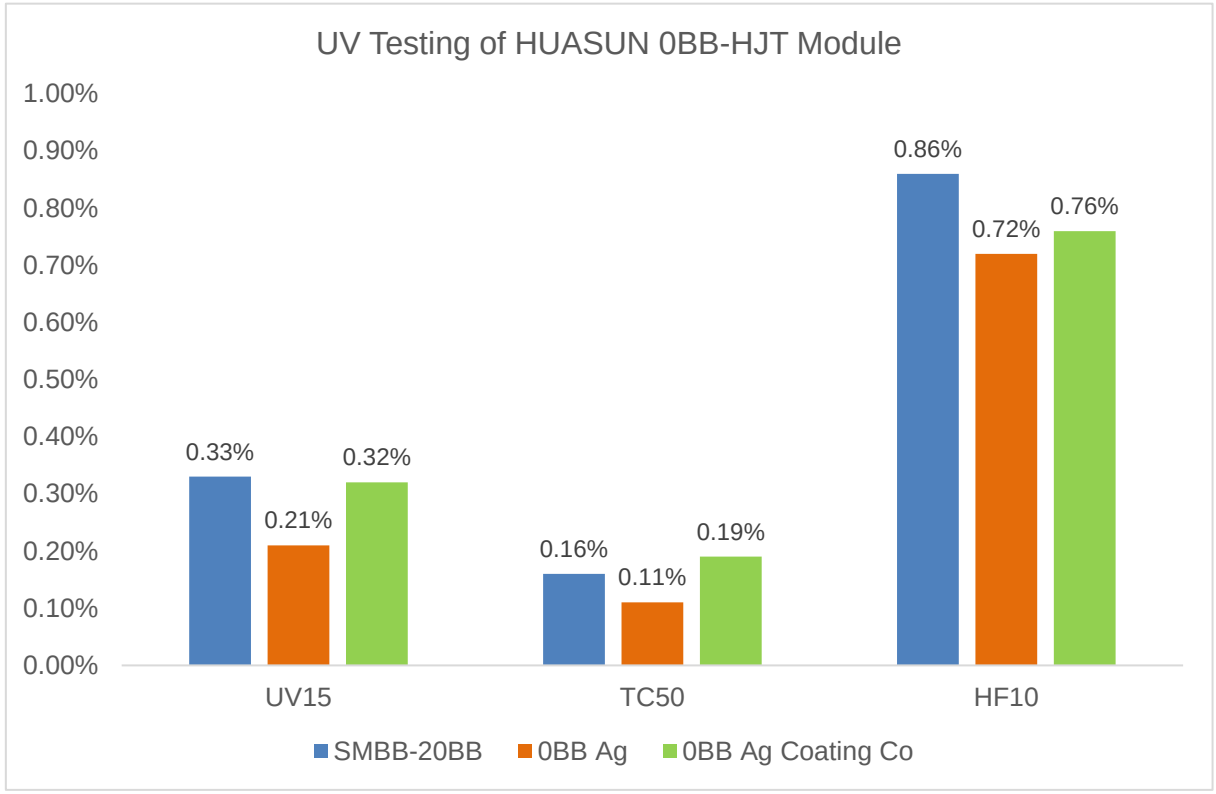
Distributing the electrical current evenly over the surface of the cell

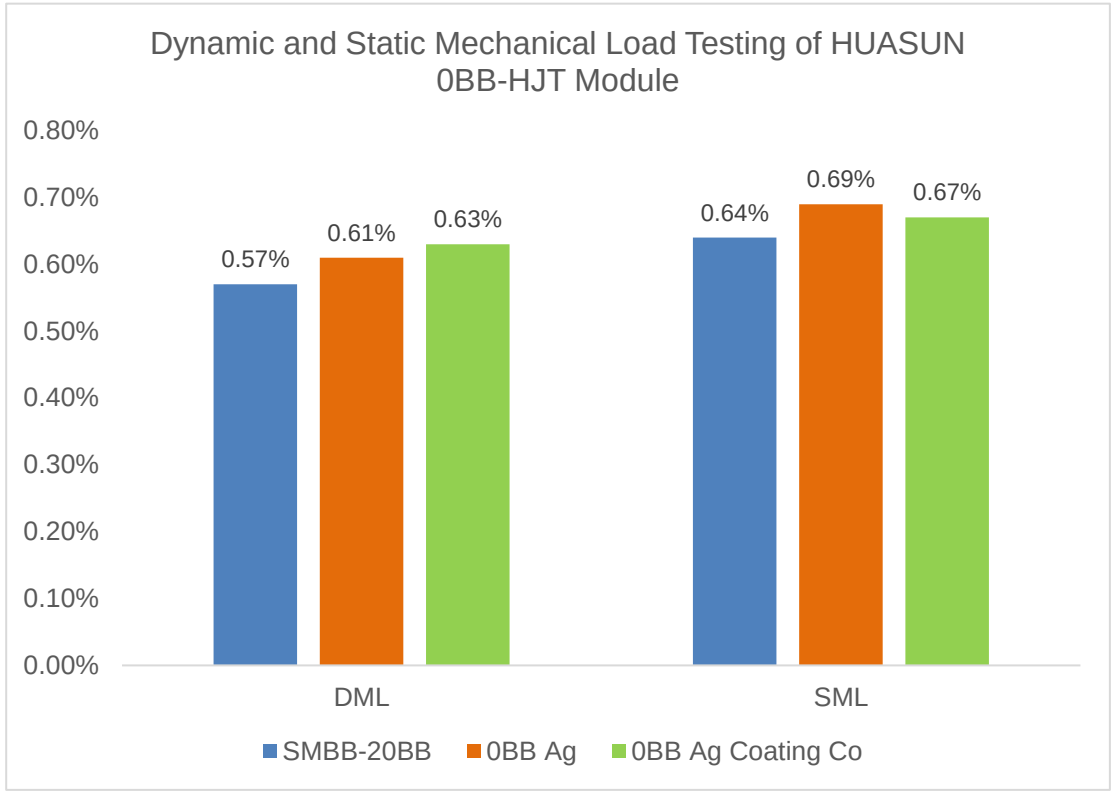




2.2. Advantages of HUASUN HJT-0BB

2) Higher Reliability



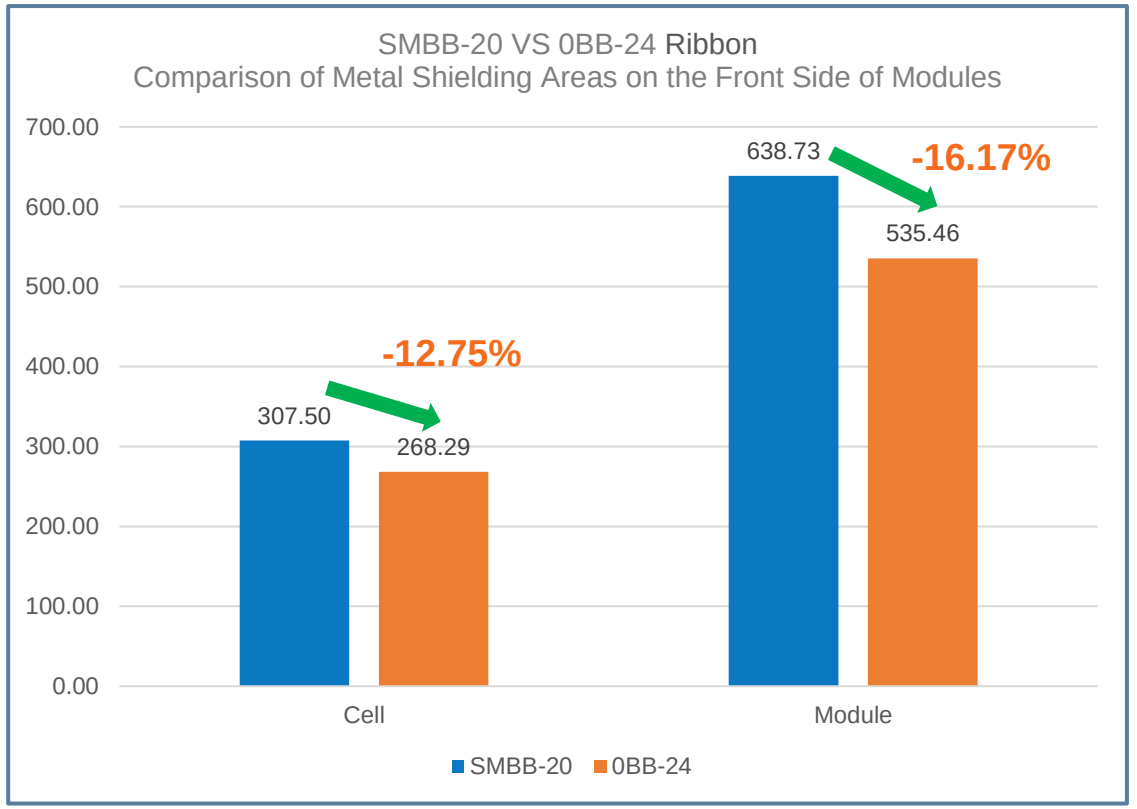


2.2. Advantages of HUASUN HJT-0BB

3) Optical Advantages

The metal shadowing area on the front side is less, More light into the solar cell, Higher efficiency

Type	Mental	SMBB-20 Ribbon (mm²)	0BB-24 Ribbon (mm²)	Difference (mm²)
Cell	Busbar	53.99	64.8	-10.81
	Finger	235.69	186.56	-49.13
	PAD Point	0.73	0	-0.73
	Shaped Like a Harpoon	17.09	16.93	-0.16
	Total	307.5	268.29	-12.75%
Module	Ribbon	392	336	-56
	Overlapping Parts	60.76	68.83	8.07
Total Shielding Area		638.73	535.46	-16.17%

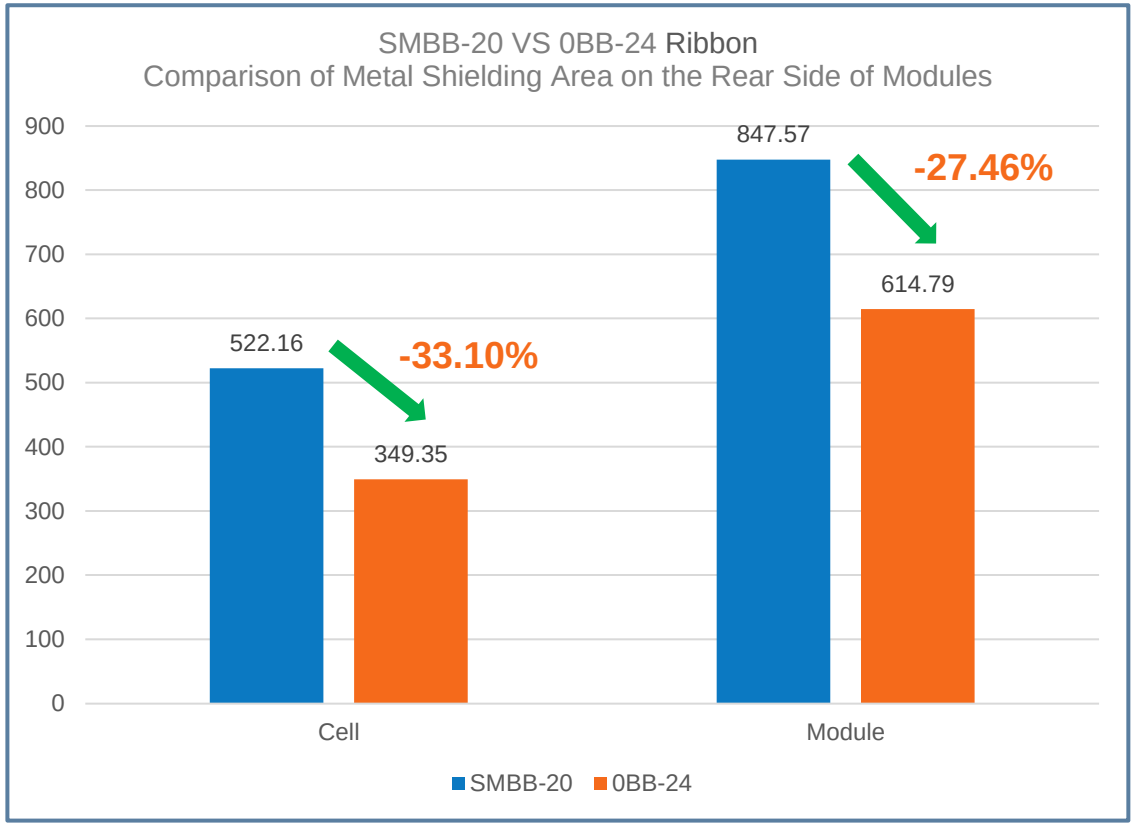


2.2. Advantages of HUASUN HJT-0BB

3) Optical Advantages

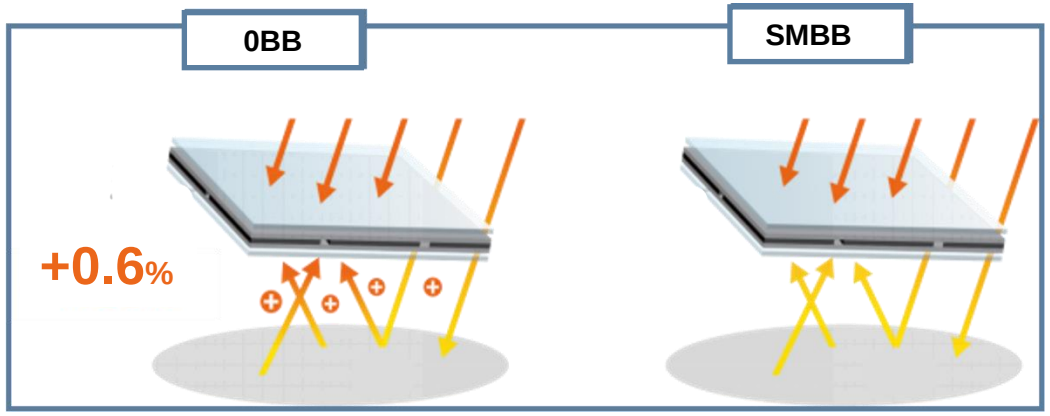
The metal shadowing area on the rear side is less, More light into the module, Higher bifaciality

Type	Mental	SMBB-20 Ribbon (mm²)	0BB-24 Ribbon (mm²)	Difference (mm²)
Cell	Busbar	53.99	64.8	-10.81
	Finger	450.35	267.62	182.73
	PAD Point	0.73	0	0.73
	Shaped Like a Harpoon	17.09	16.93	0.16
	Total	522.16	349	33.10%
Module	Ribbon	392	336	56
	Overlapping Parts	66.59	70.56	-3.97
Total Shielding Area		847.57	614.79	27.46%

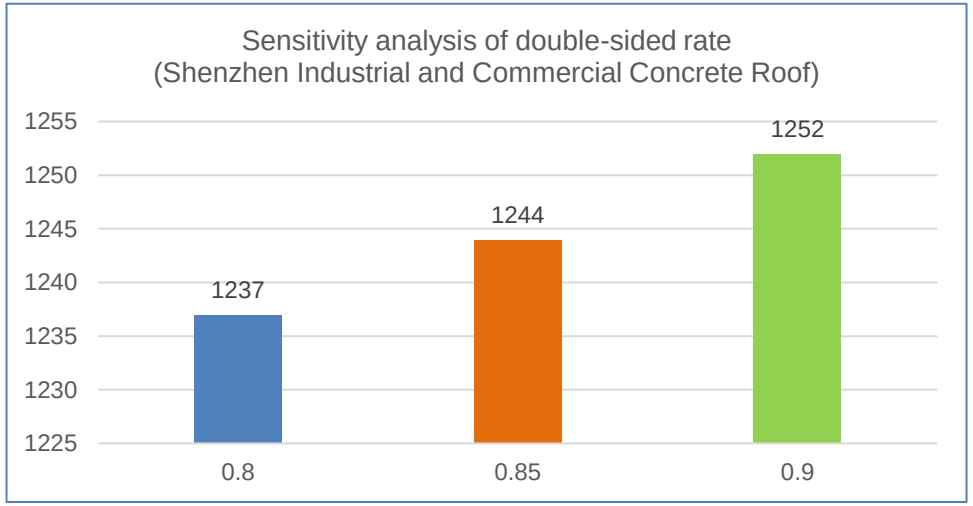


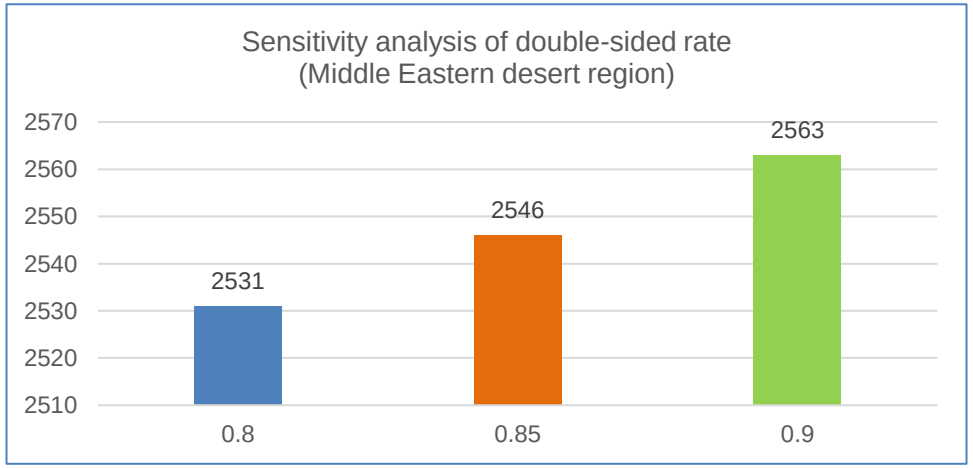
2.2. Advantages of HUASUN HJT-0BB

3) Optical Advantages



Advantages: The **90%** bifacility HJT module generates approximately **1.26%** more electricity per watt than the **80%** bifacility TOPCon module.

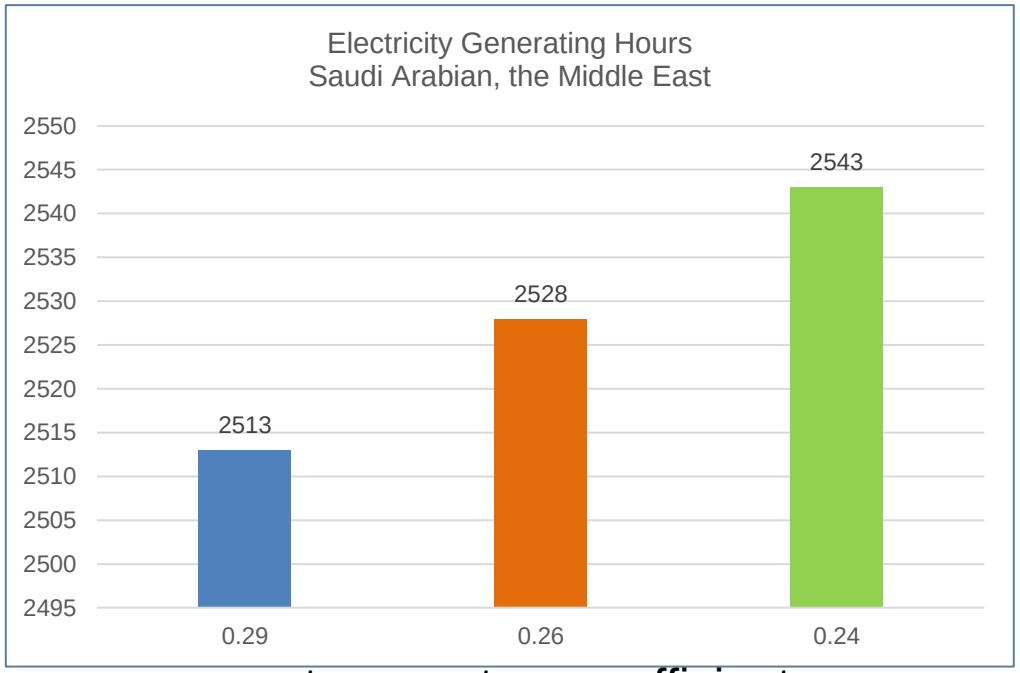




2.2. Advantages of HUASUN HJT-0BB

4) Low Temperature Coefficient **-0.24%/℃**

Product	Temperature Coefficient of Pmax %/℃	Power Loss of Modules with a Nominal Power of 720W at 65 ℃	Power Loss under High Temperature
SMBB	-0.26	74.88W	10.4%
0BB	-0.24	69.12W	9.6%
Δ	-0.02 ↓	5.76W ↓	0.8% ↓



temperature coefficient

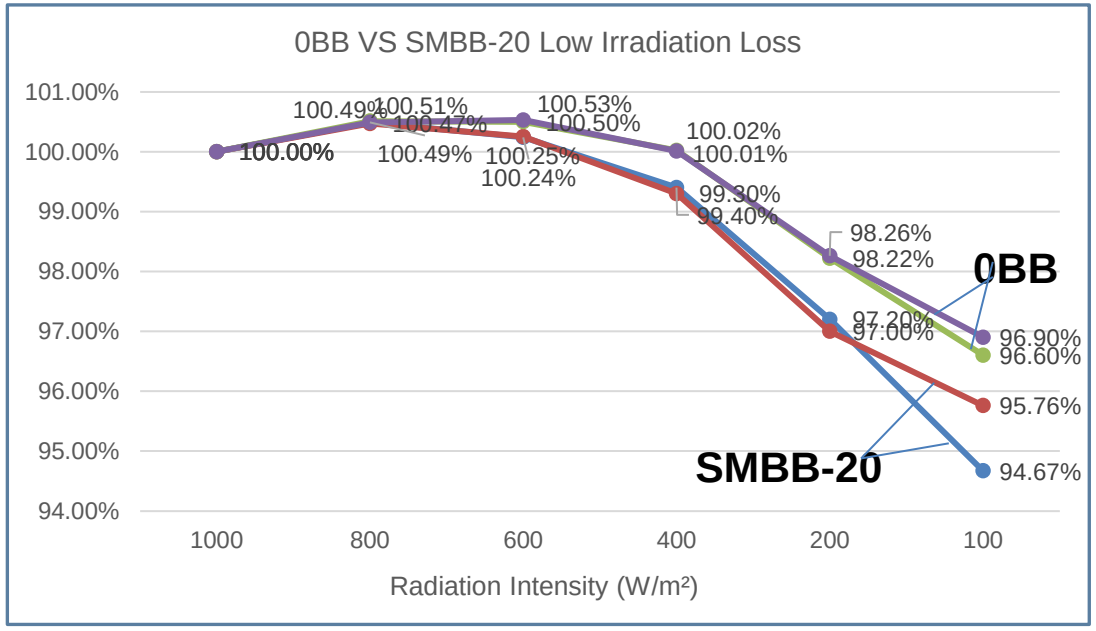
Lower temperature coefficient, lower power losses

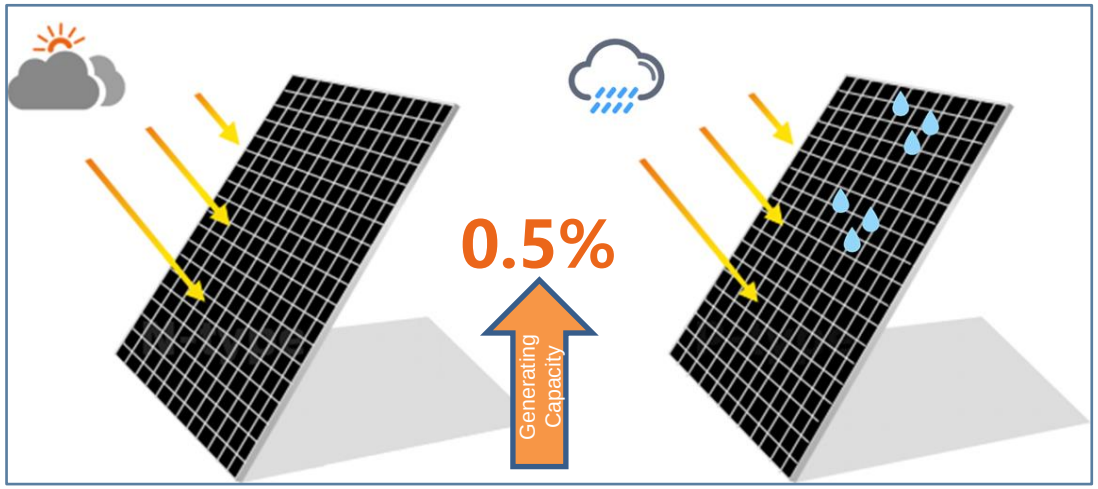
The **power loss** of HJT-0BB module is **5.76W lower** than SMBB module.

2.2. Advantages of HUASUN HJT-0BB

5) Better Low Irradiation Effect

The HJT-0BB cell has better low irradiation effect compared to HJT-SMBB cell, contributing approximately **0.5%** higher power generation per watt than double-sided HJT-SMBB cell.

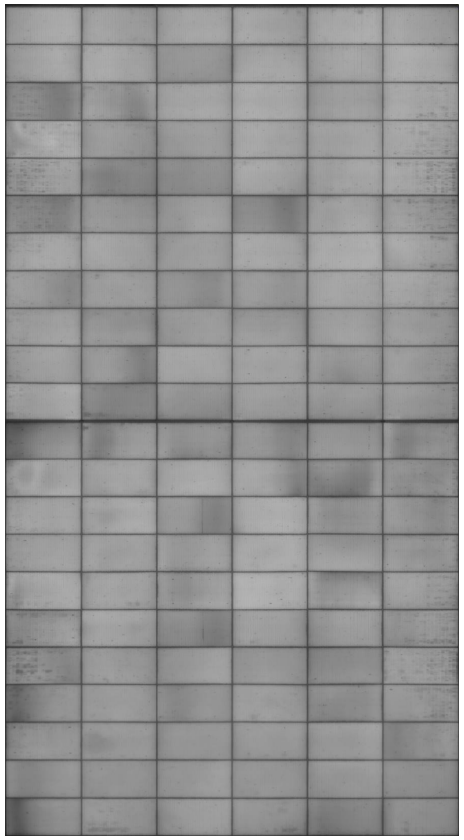




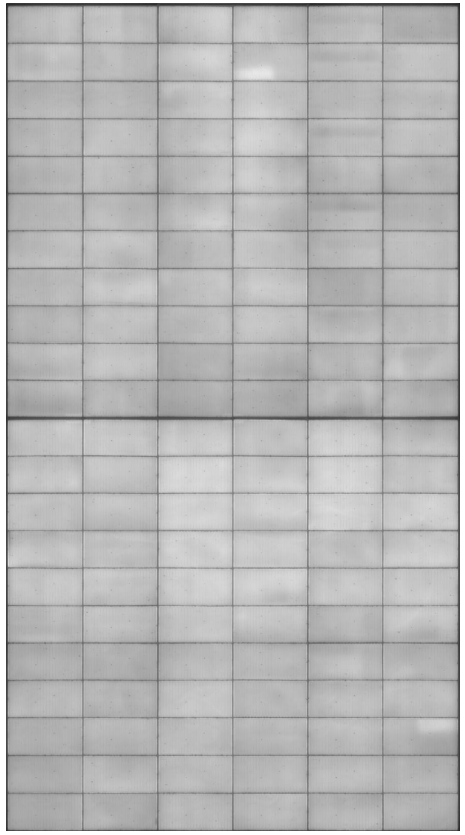
W·m-2	SMBB-1	SMBB-2	0BB-1	0BB-2
1000	100.00%	100.00%	100.00%	100.00%
800	100.49%	100.47%	100.51%	100.49%
600	100.24%	100.25%	100.50%	100.53%
400	99.40%	99.30%	100.02%	100.01%
200	97.20%	97.00%	98.22%	98.26%
100	94.67%	95.76%	96.60%	96.90%

2.2. Advantages of HUASUN HJT-0BB

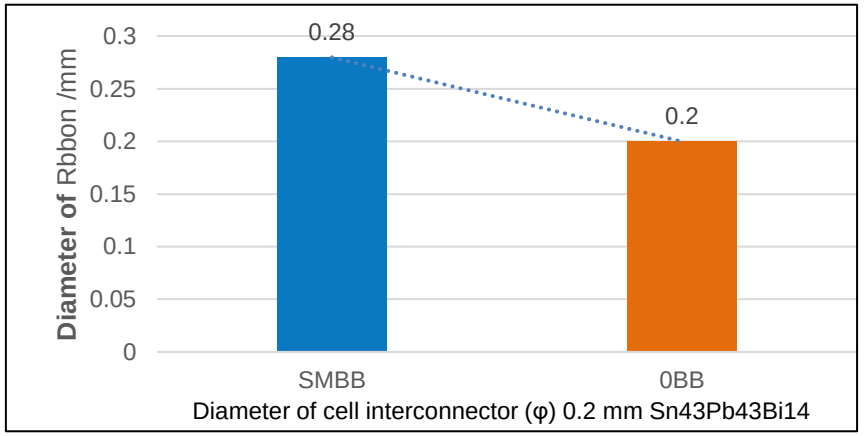
6) Higher Reliability and Low cost

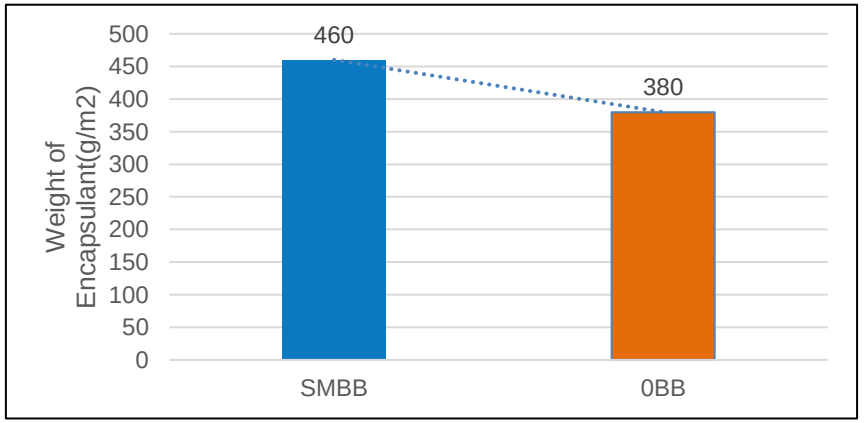


DML of SMBB Module
from Competitor



DML of HUASUN 0BB Module

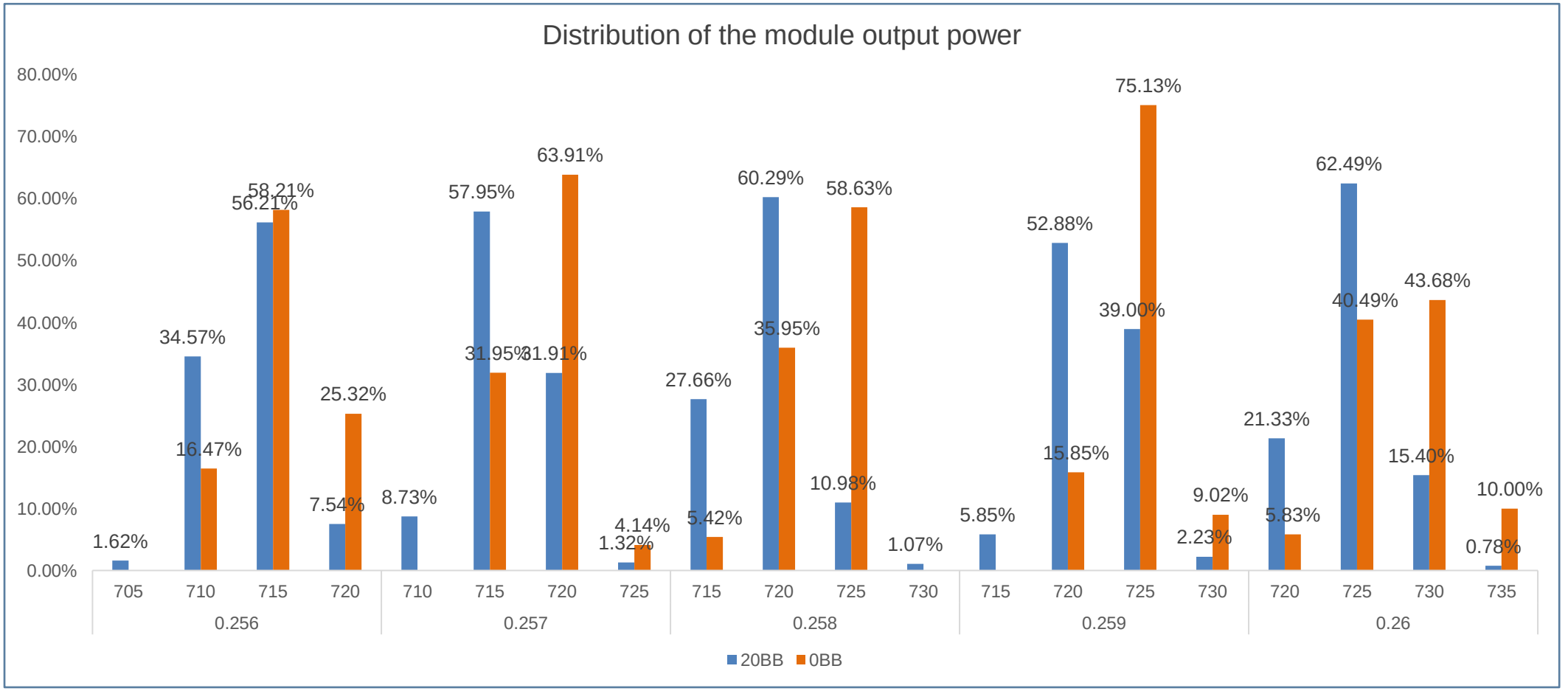




Weight of Encapsulant < 380 g/m^2

2.2. Advantages of HUASUN HJT-0BB

7) Higher output power

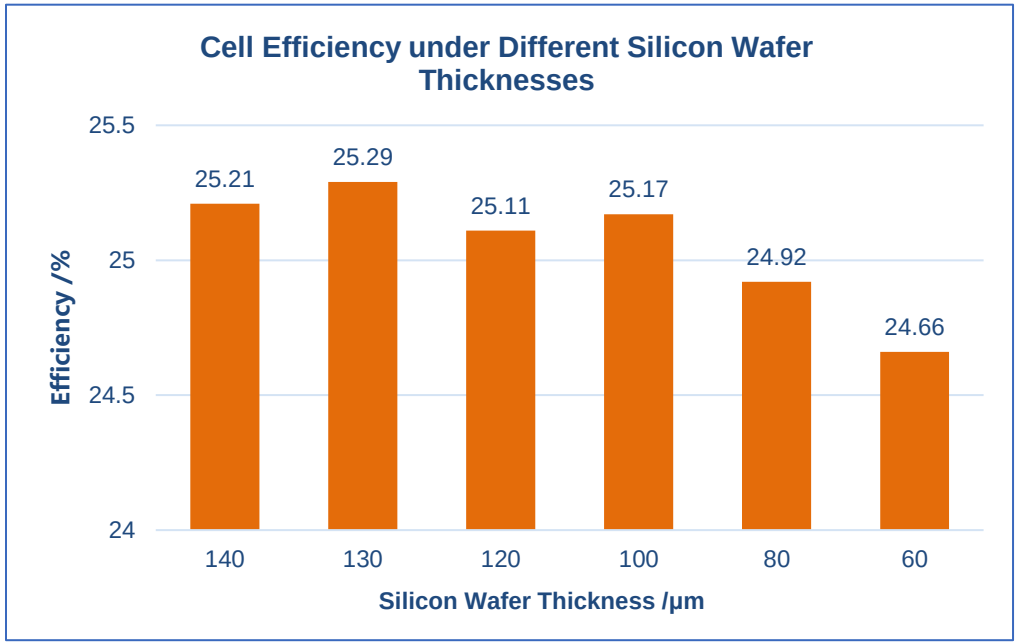


Advantages: the module power of 0BB is 2-5W higher than that of the SMBB.

2.2. Advantages of HUASUN HJT-0BB

8) Matching the thinner silicon wafers

No busbar, Thin ribbon,
Small stress, Low cracks

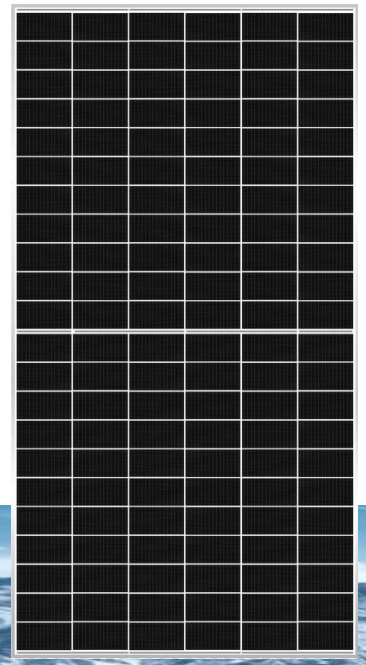


Advantages:

1. Both side using the same paste，the expansion coefficient matching, reducing the warping risk
2. Smaller diameter of ribbon (φ ≤0.20 mm), reducing the stress, less crack risk, more sever life, higher yield

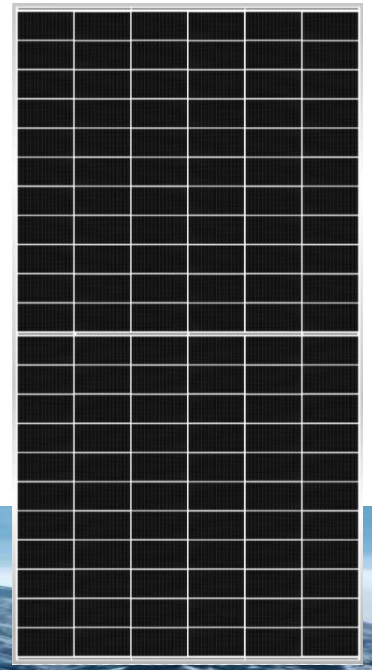
2.3. HUASUN HJT-0BB Products

G12-132
2384*1303*35/33mm
700~730W 23.5%

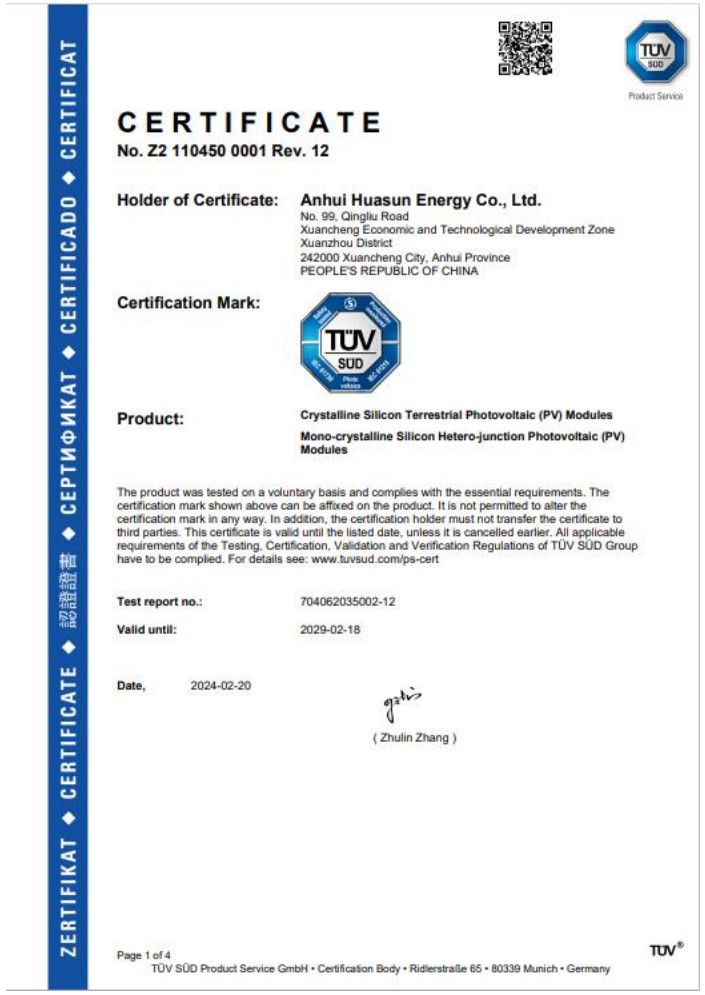


- Double-side microcrystal cell
- N-type 210/210Rmm solar cell
- 0BB no busbar cell and module
- Half-cut ingot
- > 90% bifaciality

G12R-132
2382*1134*30mm
600~640W 23.7%



2.3. HUASUN HJT-0BB Products



ZERTIFIKAT ◆ CERTIFICATE ◆ 認證證書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

Product Service

CERTIFICATE

No. Z2 110450 0001 Rev. 12

Holder of Certificate: **Anhui Huasun Energy Co., Ltd.**
No. 99, Qingliu Road
Xuancheng Economic and Technological Development Zone
Xuanzhou District
242000 Xuancheng City, Anhui Province
PEOPLE'S REPUBLIC OF CHINA

Certification Mark:

Product: **Crystalline Silicon Terrestrial Photovoltaic (PV) Modules**

Mono-crystalline Silicon Hetero-junction Photovoltaic (PV) Modules

The product was tested on a voluntary basis and complies with the essential requirements. The certification mark shown above can be affixed on the product. It is not permitted to alter the certification mark in any way. In addition, the certification holder must not transfer the certificate to third parties. This certificate is valid until the listed date, unless it is cancelled earlier. All applicable requirements of the Testing, Certification, Validation and Verification Regulations of TÜV SÜD Group have to be complied. For details see: www.tuvsud.com/ps-cert

Test report no.: 704062035002-12

Valid until: 2029-02-18

Date, 2024-02-20

(Zhulin Zhang)

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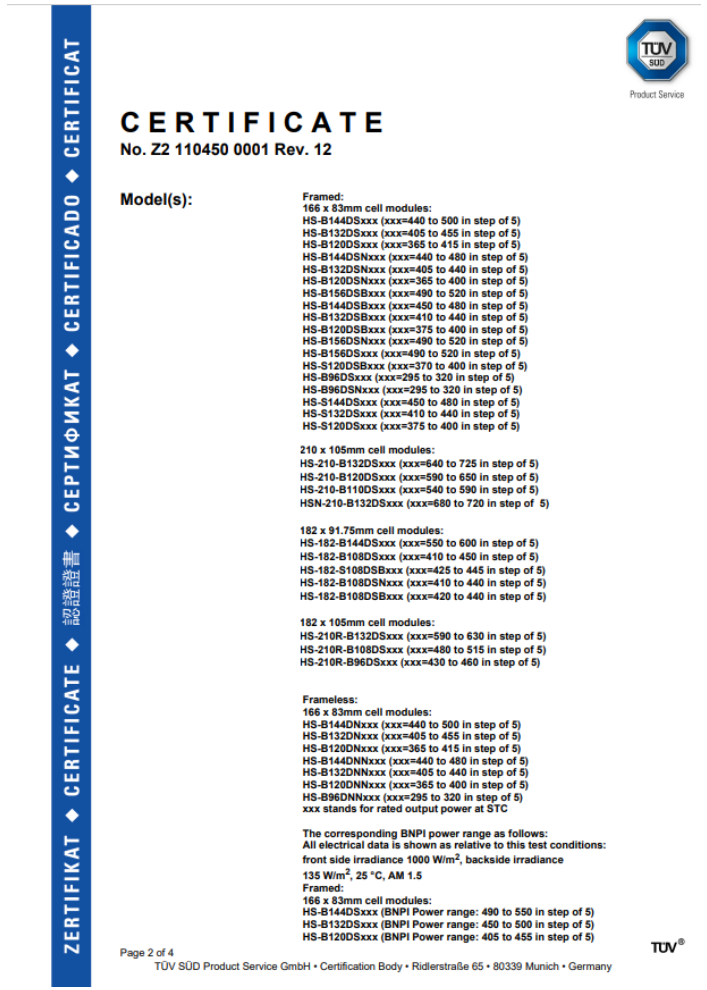
TÜV®



ZERTIFIKAT ◆ CERTIFICATE ◆ 認證證書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

Product Service

CERTIFICATE

No. Z2 110450 0001 Rev. 12

Model(s):

Framed:
166 x 83mm cell modules:
HS-B144DSxxx (xxx=440 to 500 in step of 5)
HS-B132DSxxx (xxx=405 to 455 in step of 5)
HS-B120DSxxx (xxx=365 to 415 in step of 5)
HS-B144DSNxxx (xxx=440 to 480 in step of 5)
HS-B132DSNxxx (xxx=405 to 440 in step of 5)
HS-B120DSNxxx (xxx=365 to 400 in step of 5)
HS-B156DSBxxx (xxx=490 to 520 in step of 5)
HS-B144DSBxxx (xxx=450 to 480 in step of 5)
HS-B132DSBxxx (xxx=410 to 440 in step of 5)
HS-B120DSBxxx (xxx=375 to 400 in step of 5)
HS-B156DSNxxx (xxx=490 to 520 in step of 5)
HS-B156DSxxx (xxx=490 to 520 in step of 5)
HS-S120DSBxxx (xxx=370 to 400 in step of 5)
HS-B96DSxxx (xxx=295 to 320 in step of 5)
HS-B96DSNxxx (xxx=295 to 320 in step of 5)
HS-S144DSxxx (xxx=450 to 480 in step of 5)
HS-S132DSxxx (xxx=410 to 440 in step of 5)
HS-S120DSxxx (xxx=375 to 400 in step of 5)

210 x 105mm cell modules:
HS-210-B132DSxxx (xxx=640 to 725 in step of 5)
HS-210-B120DSxxx (xxx=590 to 650 in step of 5)
HS-210-B110DSxxx (xxx=540 to 590 in step of 5)
HSN-210-B132DSxxx (xxx=680 to 720 in step of 5)

182 x 91.75mm cell modules:
HS-182-B144DSxxx (xxx=550 to 600 in step of 5)
HS-182-B108DSxxx (xxx=410 to 450 in step of 5)
HS-182-S108DSBxxx (xxx=425 to 445 in step of 5)
HS-182-B108DSNxxx (xxx=410 to 440 in step of 5)
HS-182-B108DSBxxx (xxx=420 to 440 in step of 5)

182 x 105mm cell modules:
HS-210R-B132DSxxx (xxx=590 to 630 in step of 5)
HS-210R-B108DSxxx (xxx=480 to 515 in step of 5)
HS-210R-B96DSxxx (xxx=430 to 460 in step of 5)

Frameless:
166 x 83mm cell modules:
HS-B144DNxxx (xxx=440 to 500 in step of 5)
HS-B132DNxxx (xxx=405 to 455 in step of 5)
HS-B120DNxxx (xxx=365 to 415 in step of 5)
HS-B144DNNxxx (xxx=440 to 480 in step of 5)
HS-B132DNNxxx (xxx=405 to 440 in step of 5)
HS-B120DNNxxx (xxx=365 to 400 in step of 5)
HS-B96DNNxxx (xxx=295 to 320 in step of 5)
xxx stands for rated output power at STC

The corresponding BNPI power range as follows:
All electrical data is shown as relative to this test conditions:
front side irradiance 1000 W/m², backside irradiance 135 W/m², 25 °C, AM 1.5
Framed:
166 x 83mm cell modules:
HS-B144DSxxx (BNPI Power range: 490 to 550 in step of 5)
HS-B132DSxxx (BNPI Power range: 450 to 500 in step of 5)
HS-B120DSxxx (BNPI Power range: 405 to 455 in step of 5)

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Contents

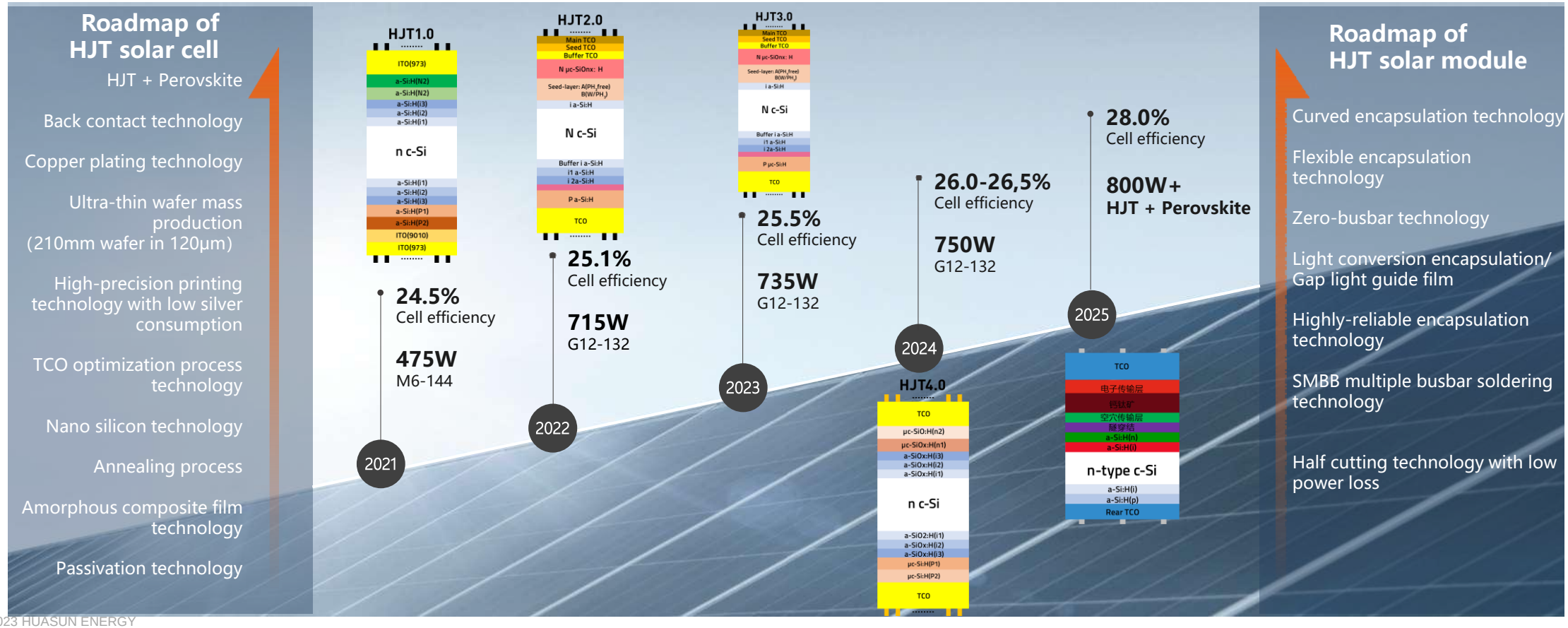
3.1 Technology Roadmap

We expect an efficiency increase of 0.5% [abs] yearly

From 2025, based on HJT, perovskite will jump efficiency by >1% [abs]

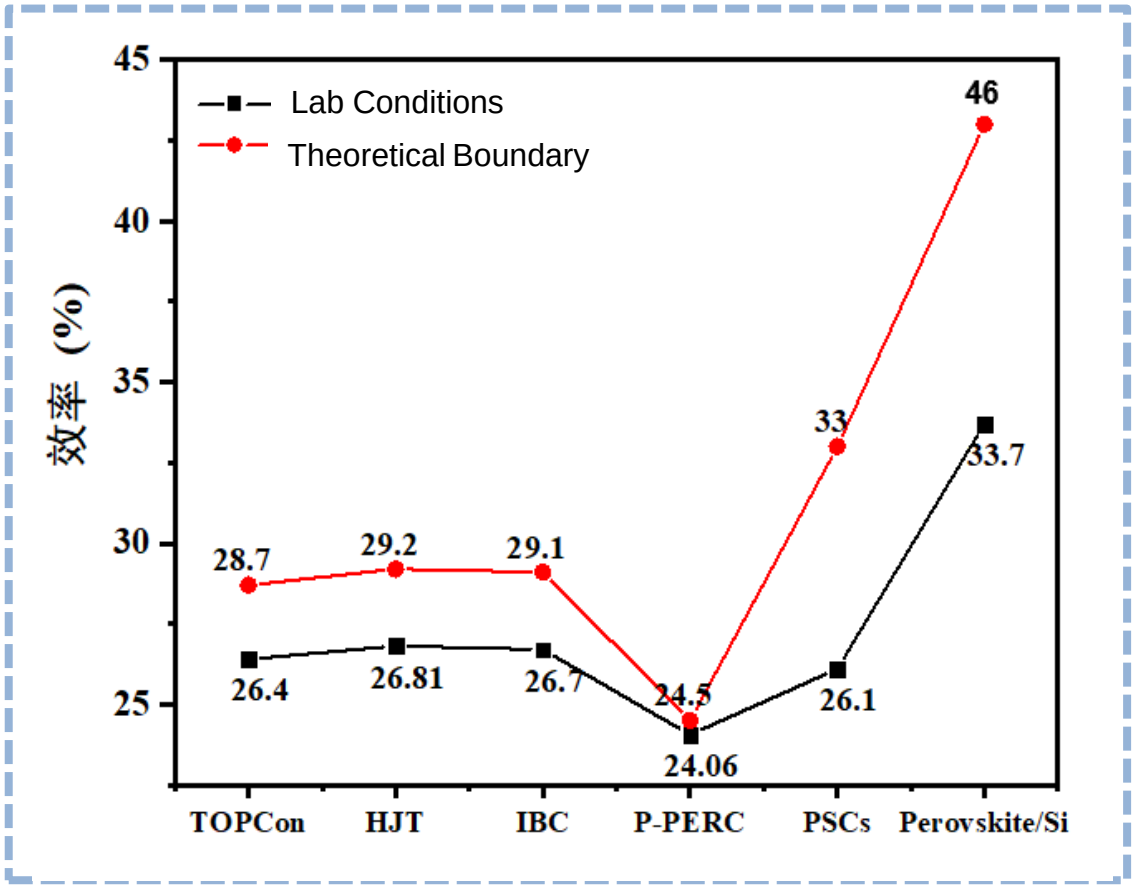
800W+

HJT+Perovskite+210mm wafer
Module power over 800W



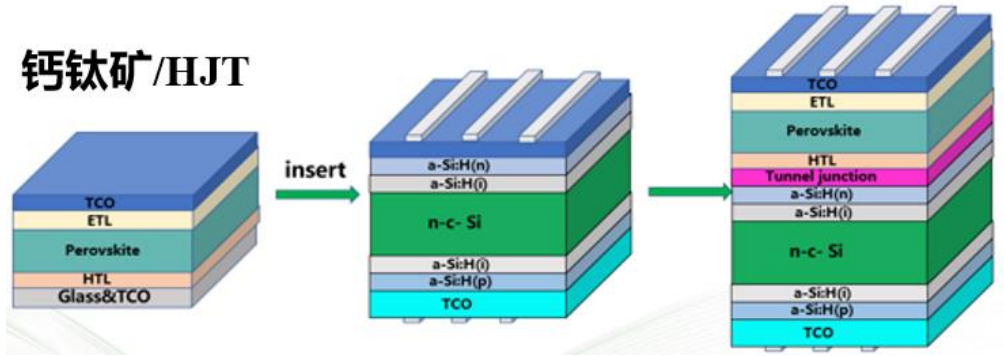
3.2 HUASUN Future

Perovskite/silicon tandem efficiency limit



Source: NREL

- Perovskite/silicon tandem efficiency limit ~46%



Perovskite cell can combine with HJT or TOPCon solar cell, **as an update for the current PV industry.**

3.2 HUASUN Future

Perovskite/c-Si tandem

roadmap	cell → interconnection → encapsulation → module
fab size	cell area M6-G12（275-441cm²）
typical size	■ ← **Only 1/132**

Smaller film deposition area

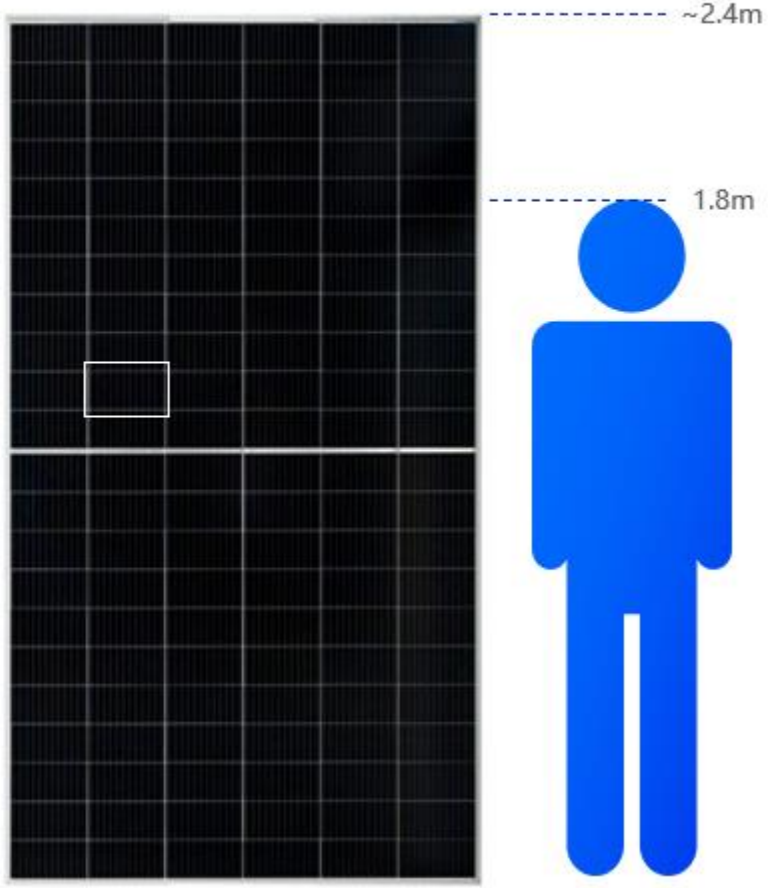
Lower industrial difficulty

Cell classification for better module efficiency

Larger efficiency improvements

Module size

132pc G12half ~31,000 cm²



HUASUN HJT Product & System Solution and Case Study

Product Development & Management Center

Anhui Huasun Energy Co., Ltd

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1. Technical leadership of HUASUN HJT

TAIYANGNEWS
ALL ABOUT SOLAR POWER

TaiyangNews Top Modules: Highest Efficient Commercial Solar Modules 3-2024

Rank	Company	Series	Model	Wafer type	Cell Size	Cells No.	Cell Tech	Module Technology	Power (W)	Efficiency (%)
1	AIKO	ABC White hole	AIKO-A620-MAH72Mw	n-type	182	144	ABC	Half-cell, Back Contact	620	24.0
2	LONGi	Hi-MO X6	LR5-72HTH-600M	p-type	182	144	HPBC	Half-cell, Back Contact	600	23.2
3	HUASUN	Himalaya	HS-210-B132DS	n-type	210	132	HJT	Bifacial, Half-cell, MBB	715	23.02
4	TW SOLAR	-	TWMHF-66HD715W	n-type	210	132	HJT	Bifacial, Half-cell, MBB	715	23.0
4	Maxeon	Maxeon 6	SPR-MAX6-445-E4-AC	n-type	166	66	IBC	Back Contact	445	23.0
6	ASTRONERGY	Astro N5	CHSM72N(DG)/F-BH	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	590	22.8
6	TW SOLAR	-	TWMND-72HS590W	n-type	182	144	TOPCon	Half-cell, MBB	590	22.8
6	SPIC	ANDROMEDA 3.0	SPICN6(LDF)-60/BIH	n-type	166	120	TBC	Back Contact, Half-cell, MBB	410	22.8
9	JinkoSolar	Tiger Neo	JKM585N-72HL4-BDV	n-type	-	144	TOPCon	Bifacial, Half-cell, MBB	585	22.65
10	JOLYWOOD	Niwa Pro	JW-HD108N	n-type	182	108	TOPCon	Bifacial, Half-cell, MBB	440	22.53
11	risen	Hyper-ion	RSM132-8-700BHDG	n-type	210	132	HJT	Bifacial,		
11	Trinasolar	Vertex N	TSM-NEG21C.20	n-type	210	132	TOPCon	Bifacial,		
11	DAS SOLAR	-	DAS-DH156NA	n-type	182	156	TOPCon	Bifacial,		
11	JA SOLAR	DeepBlue 4.0 Pro	JAM72D42 630/LB	n-type	182	144	TOPCon	Bifacial,		
11	Canadian Solar	TOPHiKu6	CS6W-580T	n-type	182	144	TOPCon	Half-cel		
11	DMEGC SOLAR	Infinity	DM580M10T-B72HSW	n-type	182	144	TOPCon	Bifacial,		
11	RUNERGY	-	HY-DH144N8	n-type	182	144	TOPCon	Bifacial,		
18	Eging PV	STAR Pro	EG-580NT72-HL/BF-DG	n-type	182	144	TOPCon	Bifacial		

715 W

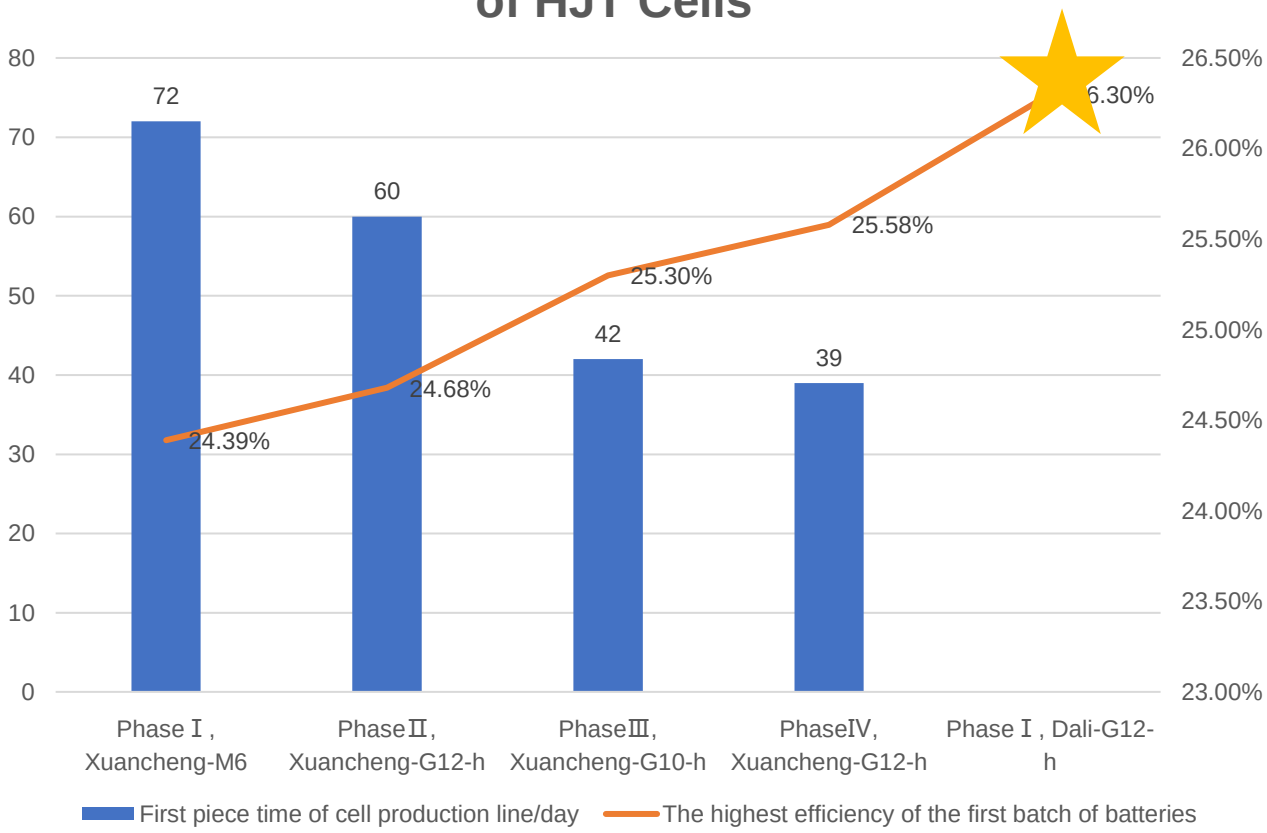
23.02%

TaiyangNews Top Modules-Mar, 2024

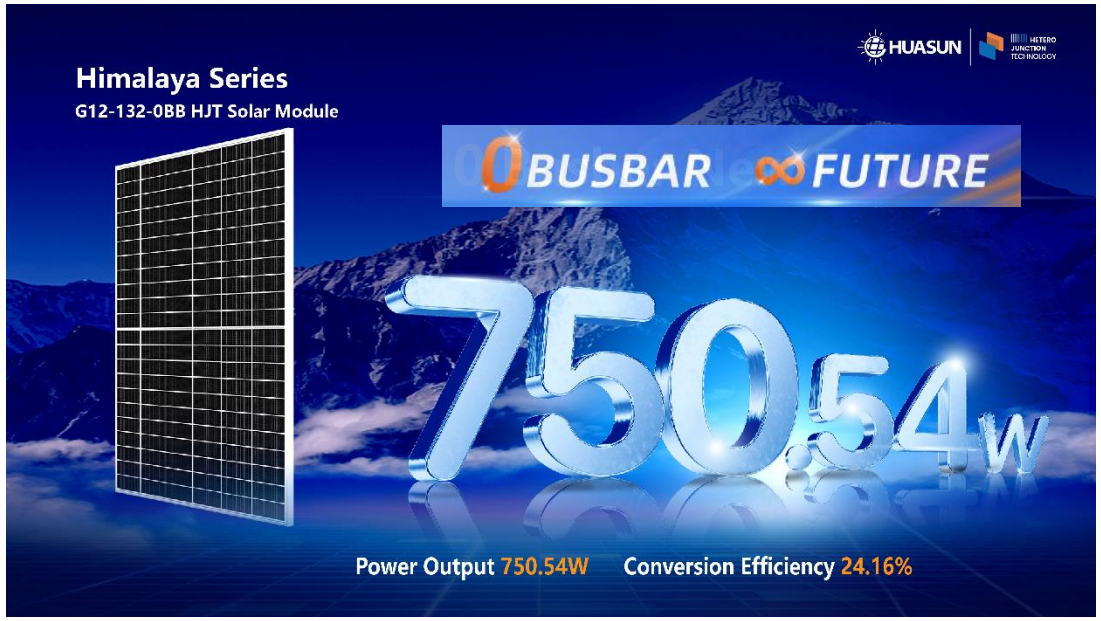
1. Technical leadership of HUASUN HJT

Himalaya·G12 Series

The latest world record for mass production of HJT Cells



NEW RECORD!!!

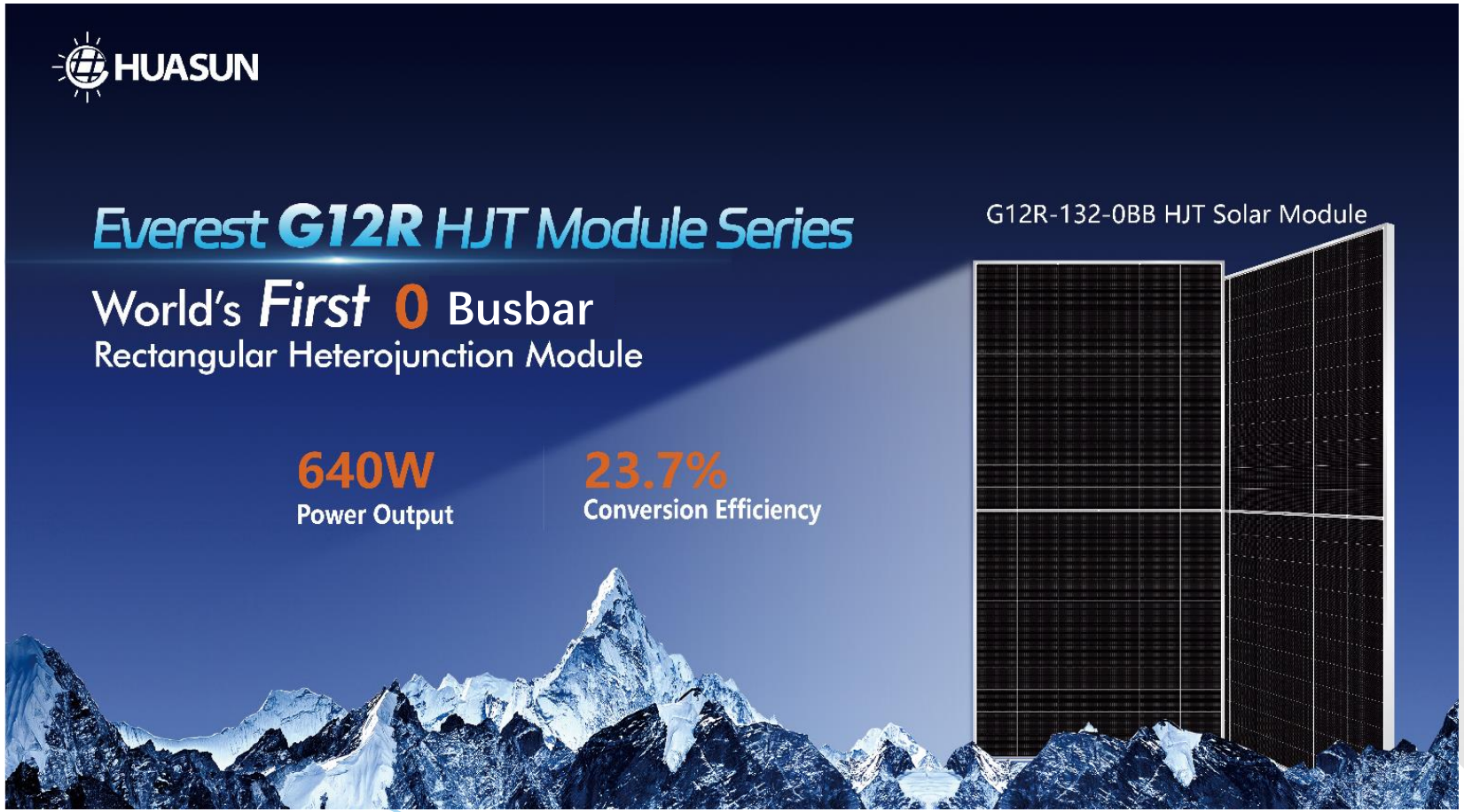


G12-132 Module

Power of Champion 750.54W

1. Technical leadership of HUASUN HJT

Everest·G12R Series



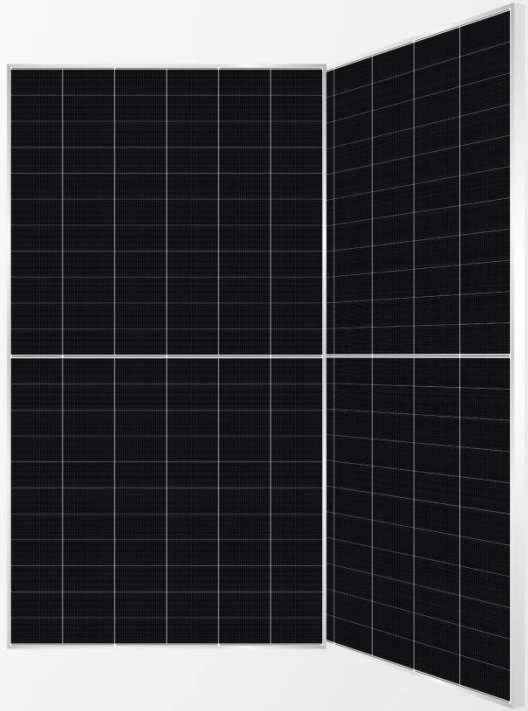
- High Efficiency
- High Power
- High Power Generation
- Low BOS
- Low LCOE

CONTENTS

2. System Solutions in Different Scenarios

Advantages of HUASUN HJT

- High Module Power – **Lower BOS cost**;
- Low Temperature Coefficient – **- 0.24%/℃**;
- High Bifaciality – **90%**;
- Excellent Weak Light Performance;
- High Reliability – **PIB** Edge Sealing Technology

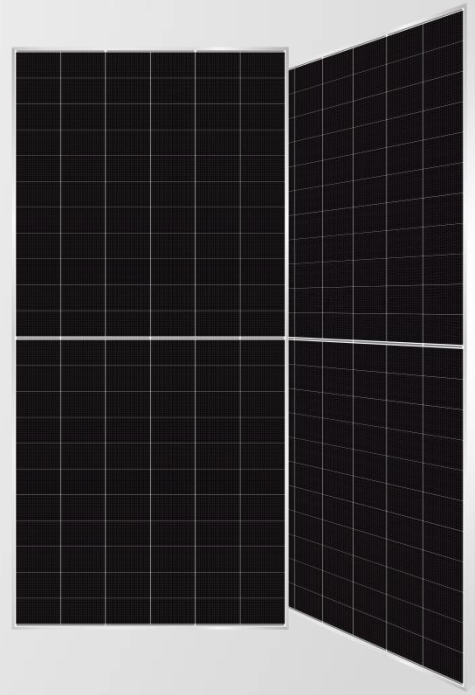


Himalaya

G12-132

2384*1303*33mm

700-730W



Everest

G12R-132

2382*1134*30mm

600-640W

SOLAR RADIATION

Global horizontal irradiation	GHI	1711.6	kWh/m²
Direct normal irradiation	DNI	1653.6	kWh/m²
Diffuse horizontal irradiation	DIF	731.8	kWh/m²
Ratio of diffuse to global irradiation	D2G	0.428	
Global tilted irradiation at optimum angle	GTI opta	2037.4	kWh/m²
Optimum tilt of PV modules	OPTA	38	°
GHI seasonality	GHI season	2.4	
DNI seasonality	DNI season	1.2	
Ground surface albedo	ALB	0.26	

Resource: Solargis Irradiation

HJT

The Gobi Desert scenario

Location: **Gansu, China**

Capacity: **Fixed-axis DC118.3MW**

Local conditions: **Extremely arid and large temperature difference**

2. System Solutions in Different Scenarios

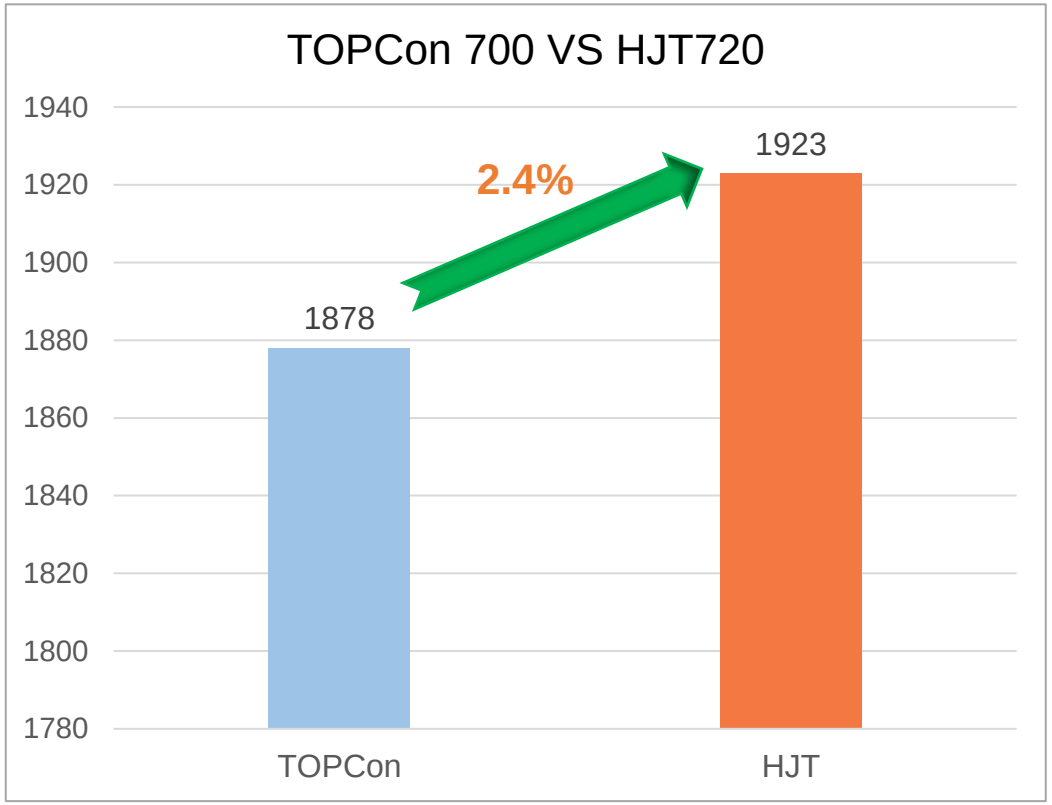
2.1 HJT module applies in the Gobi Desert scenario in Gansu, China (Fixed-axis DC118.3MW)

Category	TOPCon 700W	HJT 720W	Differences
Module Power (W)	700	720	Power +20W
Module Dimension (mm)	2384*1303*33	2384*1303*35	Module Length 0*0*+2mm
1st year Power Degradation	1%	1%	/
Annual Degradation	0.4%	0.375%	Annual Degradation -0.025%
Bifaciality	80%	95%	**Bifaciality +15%**
Array	2P	2P	/
Installation Tilt (°)	38°	38°	/
Modules in Series	26	26	/
P_{nom} Ratio	1.19	1.19	/
Number of Strings	6500	6320	Number of Strings -180
Number of Modules	169000	164320	Number of Modules -4680
AC System Capacity (MW)	99	99	/
Land Area (ha)	199.6	195.9	Land Area -3.7ha

2. System Solutions in Different Scenarios

2.1 HJT module applies in the Gobi Desert scenario in Gansu, China (Fixed-axis DC118.3MW)

Year	TOPCon 700W	HJT 720W	Add hours
Year 1	1878	1923	**45**
Year 2	1870.41	1915.72	45.30
Year 3	1862.82	1908.43	45.61
Year 4	1855.24	1901.15	45.91
Year 5	1847.65	1893.86	46.22
Year 6	1840.06	1886.58	46.52
Year 7	1832.47	1879.30	46.82
…	…	…	…
25 Life Time	44673.64	45889.77	**1216.14**

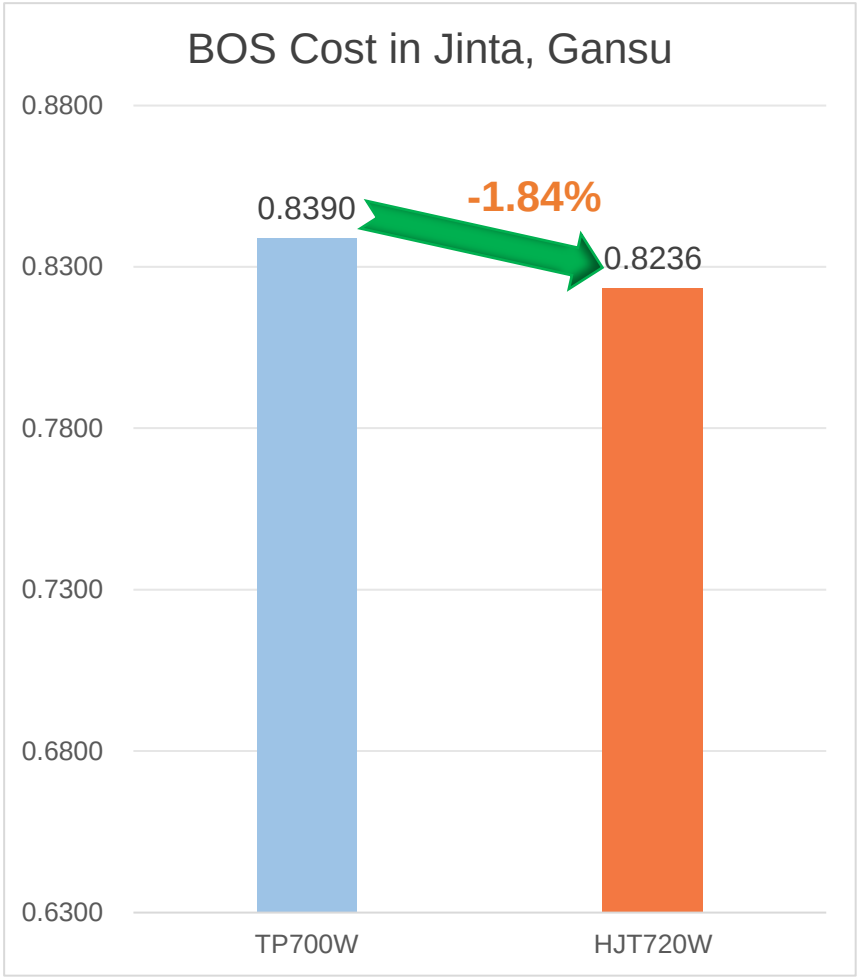


In Jinta, by leveraging fixed-axis, the system yield of the first year of HJT 720W modules are **45 hours** higher than TOPCon 700W modules, and a total of **1216.14 hours** higher in 25 years.

2. System Solutions in Different Scenarios

2.1 HJT module applies in the Gobi Desert scenario in Gansu, China (Fixed-axis DC118.3MW)

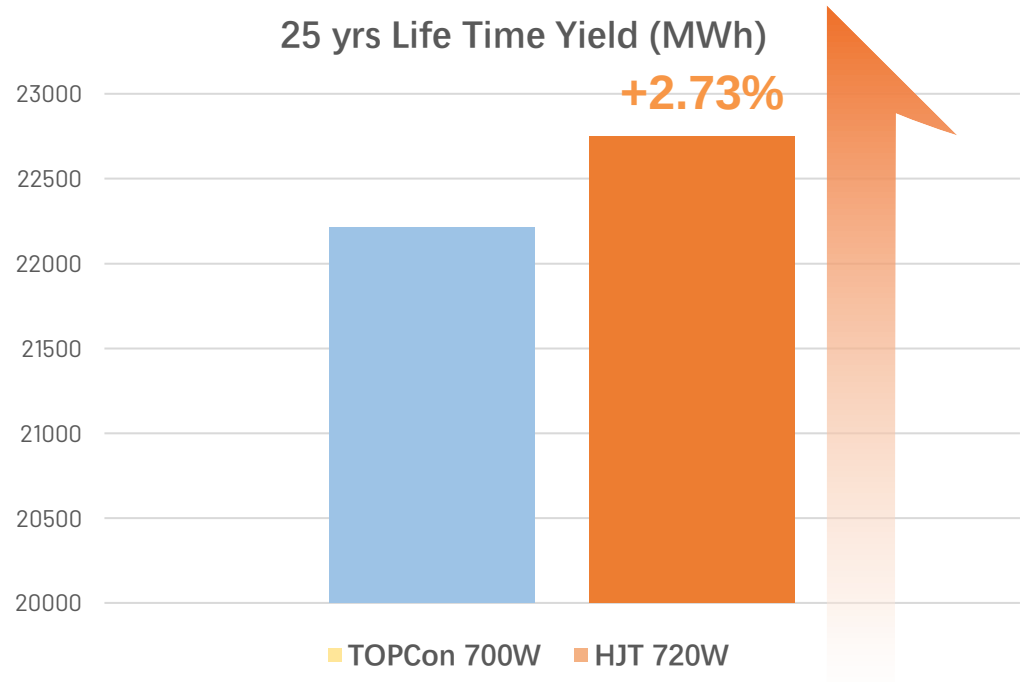
System Configuration			700W TOPCon		720W HJT		Cost Variance (HJT-TP)
		Unit	Quantity	Unit Cost (RMB /W)	Quantity	Unit Cost (RMB /W)	
1	**PV Module**						
1.1	700W	Pcs	169000				
1.2	720W	Pcs			164320		
2	**Structure**						
2.1	Bracket	t	3016.65	0.2066	2933.11	0.2008	-0.0057
2.2	Piling	Pcs	22750	0.0727	22120	0.0707	-0.0020
3	**LV Cable**						
3.1	PV Cable	km	983.00	0.0506	962.28	0.0495	-0.0011
3.2	DC Cable	m	66024	0.0448	66024	0.0448	0.0000
4	**Inverter & Transformer**						
4.1	SG1100UD	Pcs	30	0.1495	30	0.1494	
5	**Combiner Box**						
5.1	20 to 1	Pcs	330	0.0088	330	0.0088	
6	**Land Area**	ha	199.6	0.0190	195.9	0.0186	-0.0004
7	**Others (Road, fence, lightning, etc)**	Units	1	0.1100	1	0.1069	-0.0031
8	**Labor cost**	Units	1	0.1771	1	0.1739	-0.0032
Total	BOS Cost		0.8390		0.8236		**-0.0154**



2. System Solutions in Different Scenarios

2.1 HJT module applies in the Gobi Desert scenario in Gansu, China (Fixed-axis DC118.3MW)

Conditions	TOPCon 700W	HJT 720W
Capacity (MW)	118.300	118.310
Ratio	1.1949	1.1951
1st Year Yield (h)	1878	1923
1st Year Yield (MWh)	22216.74	22751.09
25 yrs Life Time Yield (MWh)	528489.12	542923.74
BOS Cost (RMB/W)	0.8390	0.8236
Grid Purchase Price: Peak (RMB/kwh)	0.4617	0.4617
Flat (RMB/kwh)	0.3078	0.3078
Valley (RMB/kwh)	0.1539	0.1539
IRR(%)	8.888	9.129



First Year Yield Adder	+2.40%
IRR	+0.24%
BOS	-1.84%
LCOE	-1.68%

SOLAR RADIATION

Global horizontal irradiation	GHI	1711.6	kWh/m²
Direct normal irradiation	DNI	1653.6	kWh/m²
Diffuse horizontal irradiation	DIF	731.8	kWh/m²
Ratio of diffuse to global irradiation	D2G	0.428	
Global tilted irradiation at optimum angle	GTI opta	2037.4	kWh/m²
Optimum tilt of PV modules	OPTA	38	°
GHI seasonality	GHI season	2.4	
DNI seasonality	DNI season	1.2	
Ground surface albedo	ALB	0.26	

HJT

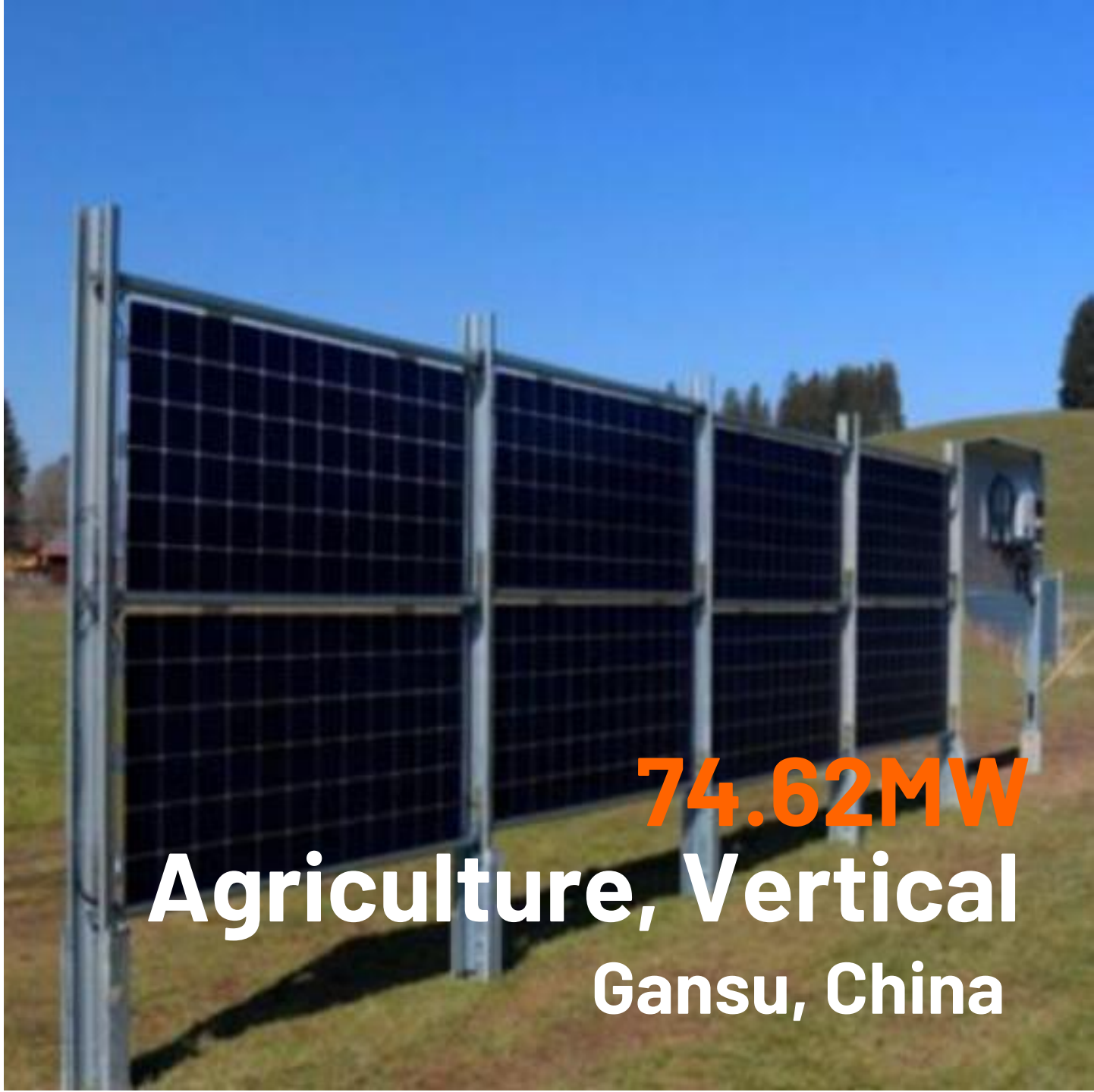
Resource: Solargis Irradiation

The Agriculture and Vertical Application Scenario

Location: **Gansu, China**

Capacity: **Vertical installation, DC74.62MW**

Local conditions: **Limited space, power curtailment**



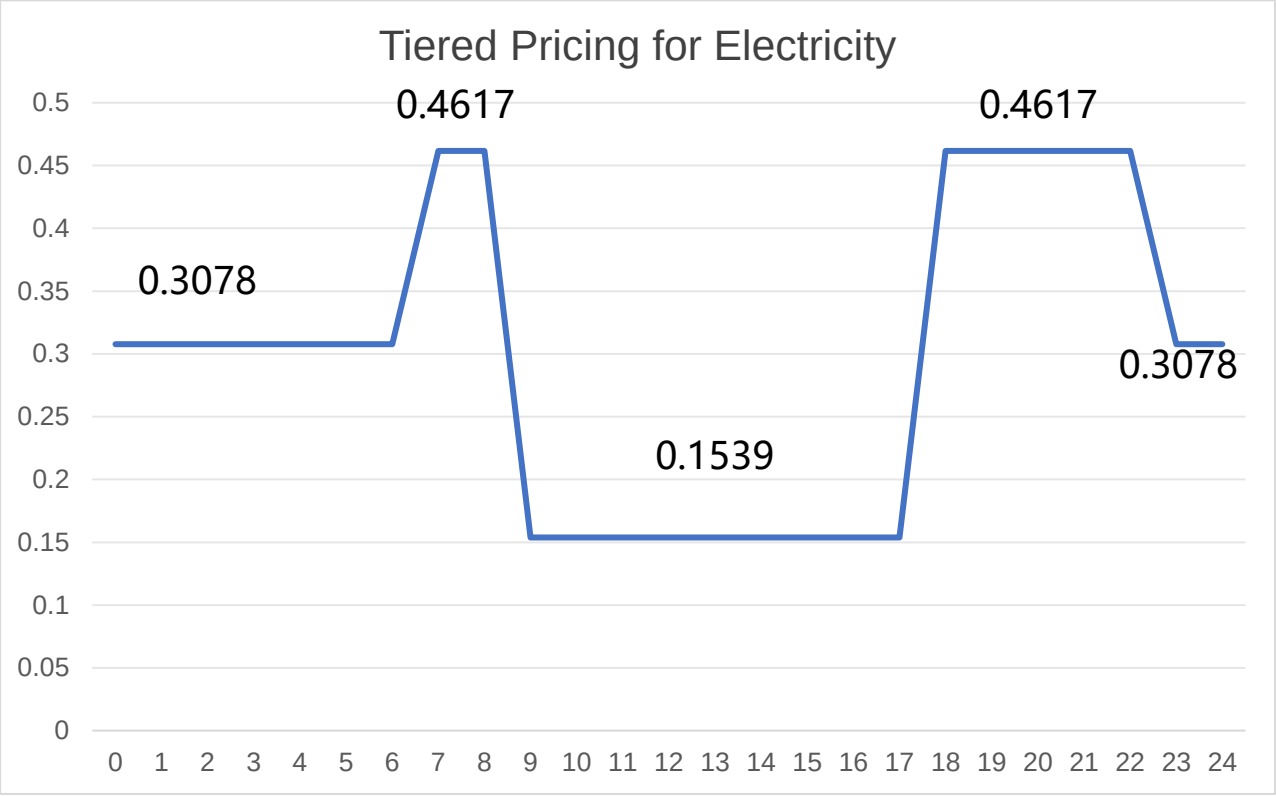
2. System Solutions in Different Scenarios

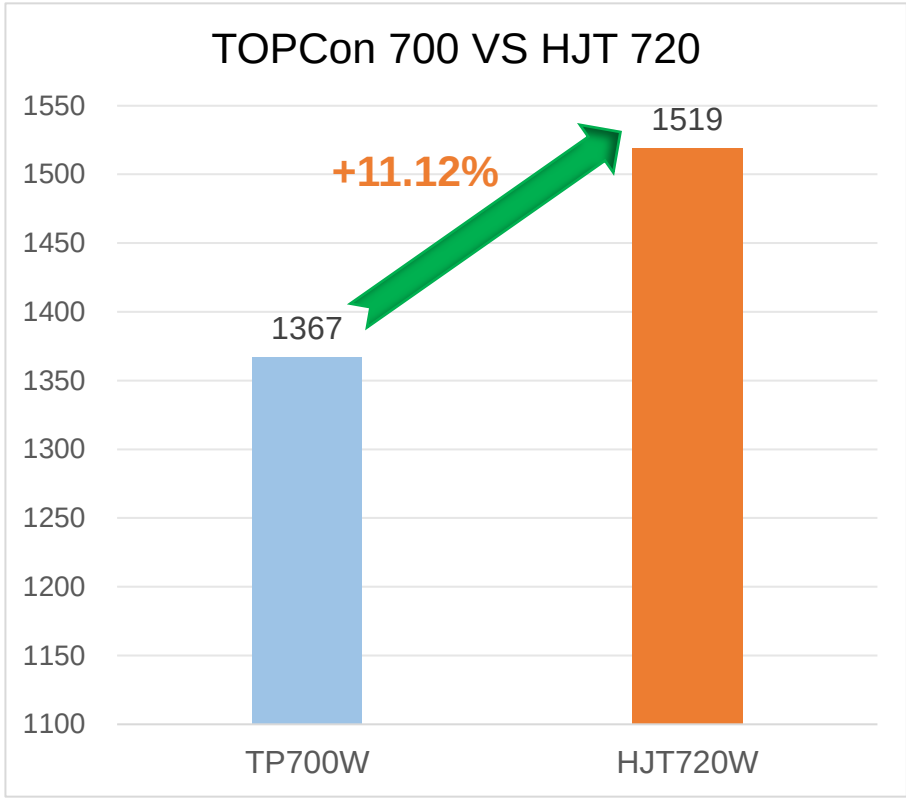
2.2 HJT module applies in the agriculture and vertical application scenario in Gansu, China (Vertical installation, DC74.62MW)

Category	TOPCon 700W	HJT 720W	Differences
Module Power (W)	700	720	Power +20W
Module Dimension (mm)	2384*1303*33	2384*1303*35	Module Length 0*0*+2mm
1st year Power Degradation	1%	1%	/
Annual Degradation	0.4%	0.375%	Annual Degradation -0.025%
Bifaciality	80%	95%	Bifaciality +15%
Array	2H	2H	/
Installation Tilt (°)	90	90	/
Facing Direction	West	West	/
Modules in Series	26	26	/
P_{nom} Ratio	1.51	1.51	/
Number of Strings	4100	3986	Number of Strings -114
Number of Modules	106600	103636	Number of Modules -2964
AC System Capacity (MW)	49.5	49.5	/
Land Area (ha)	82.47	81.47	Land Area -1ha

2. System Solutions in Different Scenarios

2.2 HJT module applies in the agriculture and vertical application scenario in Gansu, China (Vertical installation, DC74.62MW)



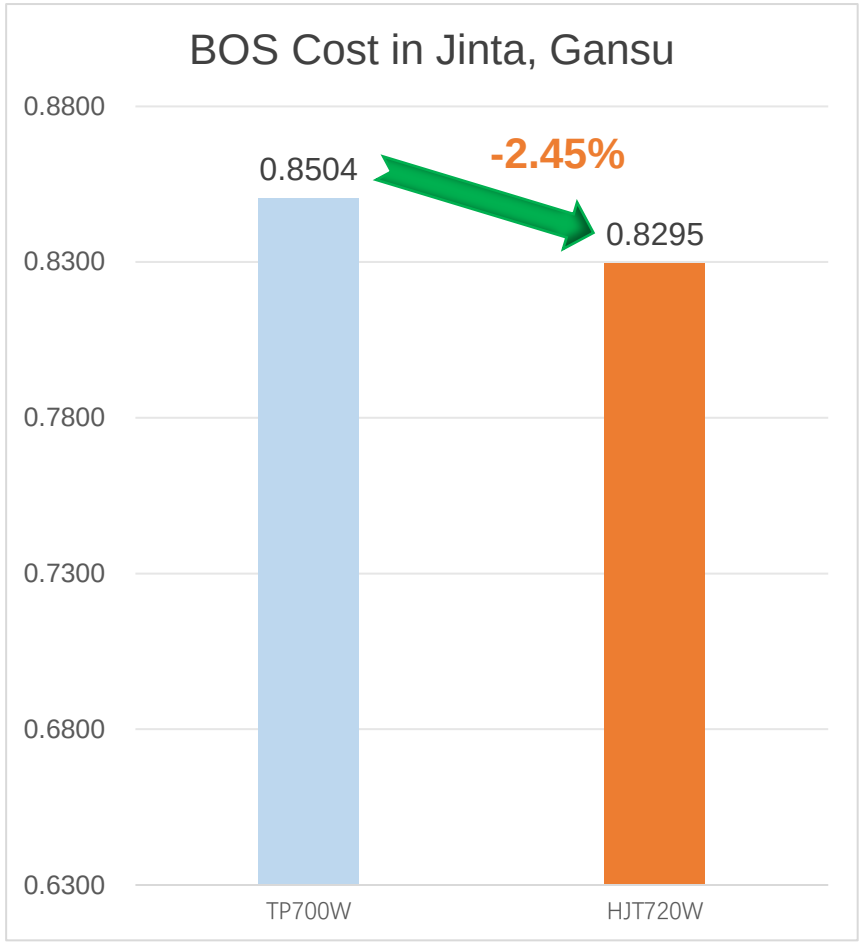


In Jinta, using vertical installation, the yield of the first year of HJT 720W modules are **152 hours** higher than TOPCon 700W modules.

2. System Solutions in Different Scenarios

2.2 HJT module applies in the agriculture and vertical application scenario in Gansu, China (Vertical installation, DC74.62MW)

System Configuration			700W TOPCon		720W HJT		Cost Variance (HJT-TP)
		Unit	Quantity	Unit Cost (RMB /W)	Quantity	Unit Cost (RMB /W)	
1	**PV Module**						
1.1	700W	Pcs	106600				
1.2	720W	Pcs			103636		
2	**Structure**						
2.1	Bracket	t	2611.7	0.2835	2539	0.2756	-0.0079
2.2	Piling	Pcs	28700	0.0727	27902	0.0707	-0.0020
3	**LV Cable**						
3.1	PV Cable	km	644.33	0.0526	628.95	0.0513	-0.0013
3.2	DC Cable	m	21451	0.0231	19908	0.0214	-0.0017
4	**Inverter & Transformer**						
4.1	SG1100UD	Pcs	15	0.1185	15	0.1185	
5	**Combiner Box**						
5.1	20 to 1	Pcs	210	0.0089	210	0.0089	
6	**Land Area**	ha	82.47	0.0124	81.47	0.0123	-0.0002
7	**Others (Road, fence, lightning, etc)**	Units	1	0.105	1	0.1021	-0.0029
8	**Labor cost**	Units	1	0.1737	1	0.1688	-0.0049
Total	BOS Cost		**0.8504**		**0.8295**		**-0.0208**

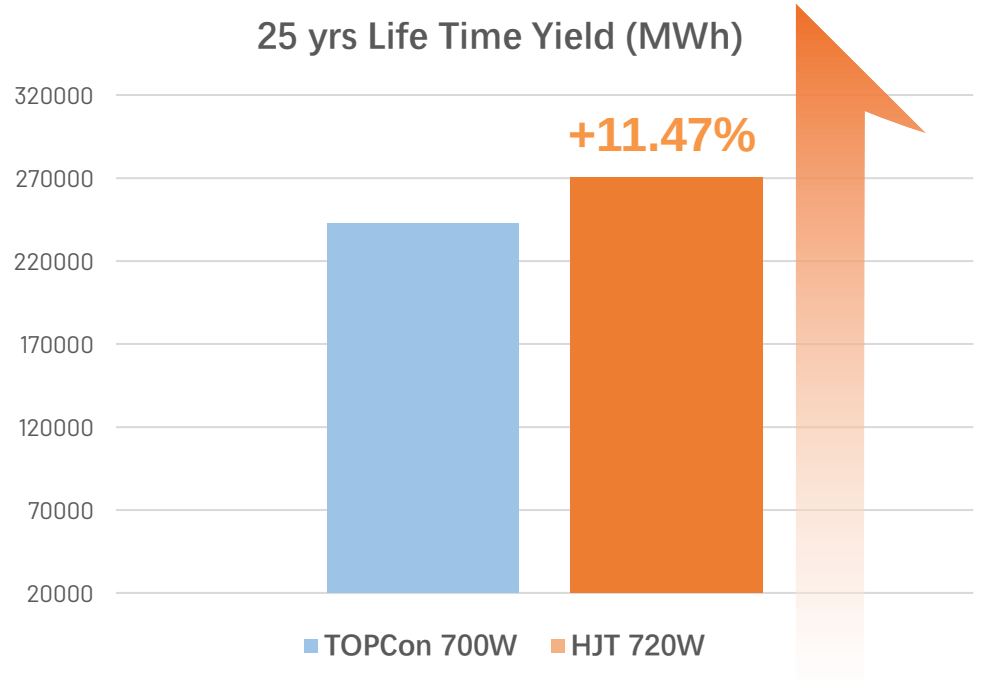


In Jinta, using vertical installation, the BOS cost of HJT720 can save about **2.08** cent/W than TOPCon 700W.

2. System Solutions in Different Scenarios

2.2 HJT module applies in the agriculture and vertical application scenario in Gansu, China (Vertical installation, DC74.62MW)

Conditions	TOPCon 700W	HJT 720W
Capacity (MW)	74.620	74.618
Ratio	1.51	1.51
1st Year Yield (h)	1367	1519
1st Year Yield (MWh)	10200.55	11334.46
25 yrs Life Time Yield (MWh)	242649.54	270481.48
BOS Cost (RMB/W)	0.8504	0.8295
Grid Purchase Price: Peak (RMB/kwh)	0.4617	0.4617
Flat (RMB/kwh)	0.3078	0.3078
Valley (RMB/kwh)	0.1539	0.1539
IRR(%)	6.403	7.785



First Year Yield Adder	+11.12%
IRR	+1.38%
BOS	-2.45%
LCOE	-9.57%

SOLAR RADIATION

Global horizontal irradiation	GHI	1469.8	kWh/m^2	
Direct normal irradiation	DNI	906.7	kWh/m^2	
Diffuse horizontal irradiation	DIF	853.6	kWh/m^2	
Ratio of diffuse to global irradiation	D2G	0.581		
Global tilted irradiation at optimum angle	GTI opta	1529.8	kWh/m^2	
Optimum tilt of PV modules	OPTA	20	°	
GHI seasonality	GHI season	1.8		
DNI seasonality	DNI season	2.4		
Ground surface albedo	ALB	0.15		

Resource: Solargis Irradiation

HJT

C&I Roof Scenario

Location: **Guangdong, China**

Capacity: **DC6MW**

Local conditions: **Limited space, poor cooling effect, high humidity, high electricity prices**

2. System Solutions in Different Scenarios

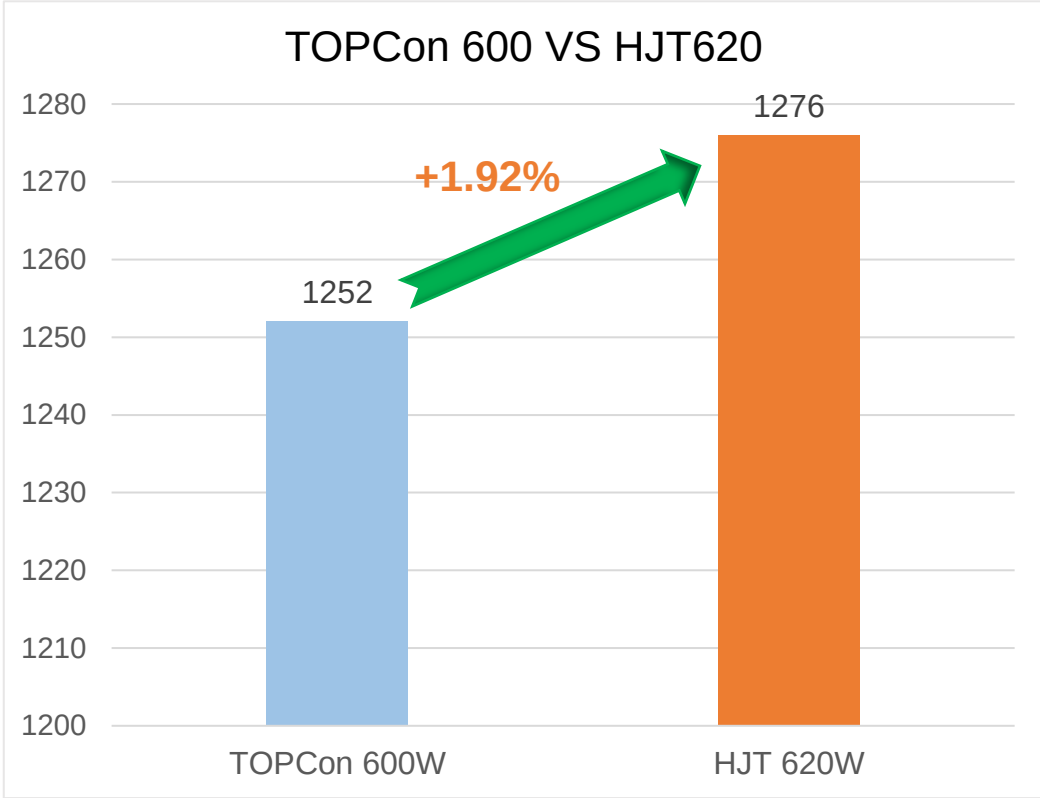
2.3 HJT module applies in roof application scenario in Guangdong, China (DC6MW)

Category	TOPCon 600W	HJT 620W	Differences
Module Power (W)	600	620	Power +20W
Module Dimension (mm)	2382*1134	2382*1134	/
1st year Power Degradation	1%	1%	/
Annual Degradation	0.4%	0.375%	Annual Degradation -0.025%
Bifaciality	80%	88%	Bifaciality +8%
Array	2P	2P	/
Inventor Power (kW)	320	320	/
Number of Inventor	15	15	/
Transformer Capacity (kVA)	1600	1600	/
Number of Transformer	3	3	/
AC System Capacity (MW)	4.8	4.8	/
Modules in Series	28	28	/
Number of Strings	345	345	/
Number of Modules	9660	9660	/
DC System Capacity (MW)	5.796	5.9892	DC System Capacity +0.1932MW
P_{nom} Ratio	1.2075	1.24775	P_{nom} Ratio +0.04
Land Area (ha)	3.265	3.265	/

2. System Solutions in Different Scenarios

2.3 HJT module applies roof application scenario in Guangdong, China (DC6MW)

Year	TOPCon 600W	HJT 620W	Add hours
Year 1	1252	1276	**24**
Year 2	1234.47	1258.46	23.98
Year 3	1229.46	1253.67	24.21
Year 4	1224.46	1248.89	24.43
Year 5	1219.45	1244.10	24.65
Year 6	1214.44	1239.32	24.88
Year 7	1209.43	1234.53	25.10
…	…	…	…
25 Life Time	29497.12	30158.26	**661.14**

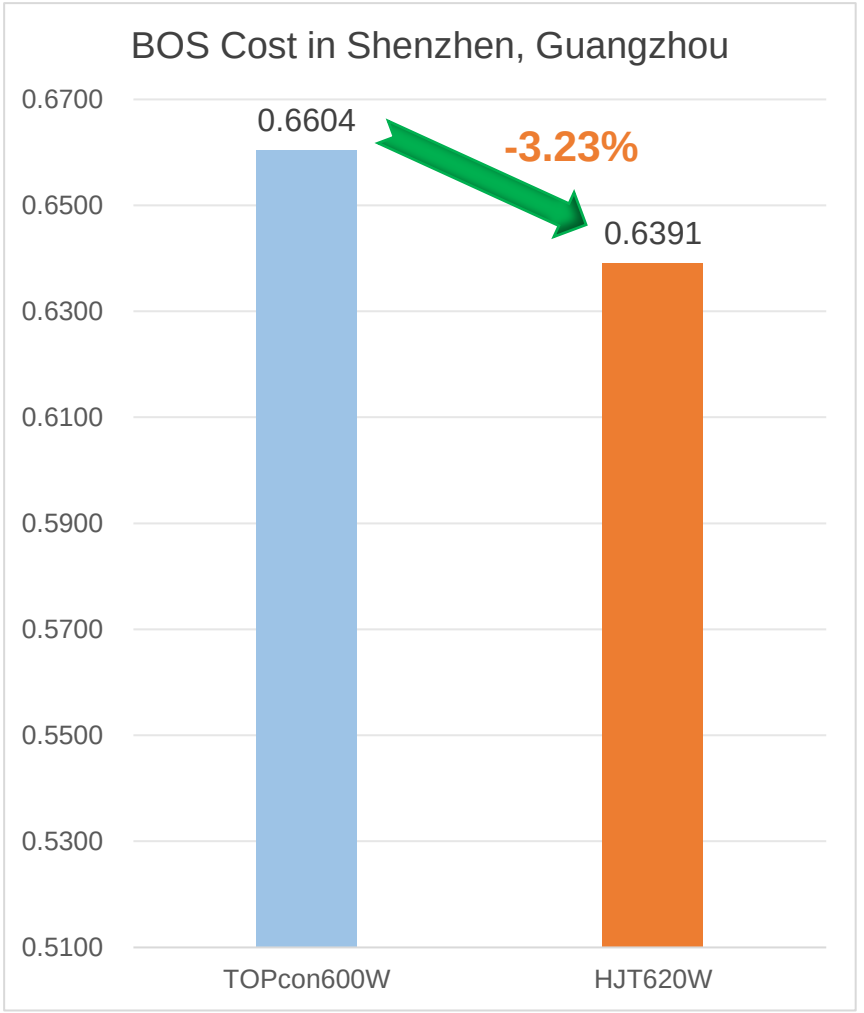


In Shenzhen, Guangdong, the yield of the first year of the HJT 620W in the color steel tile roof scheme are **24 hours** higher than the TOPCon 600W, and a total of **661.14 hours** higher in 25 years.

2. System Solutions in Different Scenarios

2.3 HJT module applies in roof application scenario in Guangdong, China (DC6MW)

System Configuration			600W TOPCon		620W HJT		Cost Variance (HJT-TP)
		Unit	Quantity	Unit Cost (RMB /W)	Quantity	Unit Cost (RMB /W)	
1	**PV Module**						
1.1	600W	Pcs	9660				
1.2	620W	Pcs			9660		
2	**Structure**						
2.1	Bracket	t	14.940	0.0683	14.940	0.0661	-0.0022
2.2	Bolt M8	Pcs	80275	0.0093	80275	0.0090	-0.0003
2.3	Briquette	Pcs	20700	0.0063	20700	0.0060	-0.0002
2.4	Angle Square Clamp	Pcs	29788	0.0136	29788	0.0131	-0.0004
3	**LV Cable**						
3.1	PV Cable	km	48.5	0.0264	48.50	0.0255	-0.0009
3.2	DC Cable	m	3520	0.0416	3520	0.0403	-0.0013
4	**Inverter & Transformer**						
4.1	320KW	Pcs	15	0.1060	15	0.1026	-0.0034
5	**Transformer**						
5.1	1600kVA	Pcs	3	0.2045	3	0.1979	-0.0066
6	**Land Area**	ha	3.265	0.0113	3.265	0.0109	-0.0004
7	**Others (Road, fence, lightning, etc)**	Units	1	0.08	1	0.0774	-0.0026
8	**Labor cost**	Units	1	0.0933	1	0.0902	-0.0030
Total	BOS Cost		**0.6604**		**0.6391**		**-0.0213**

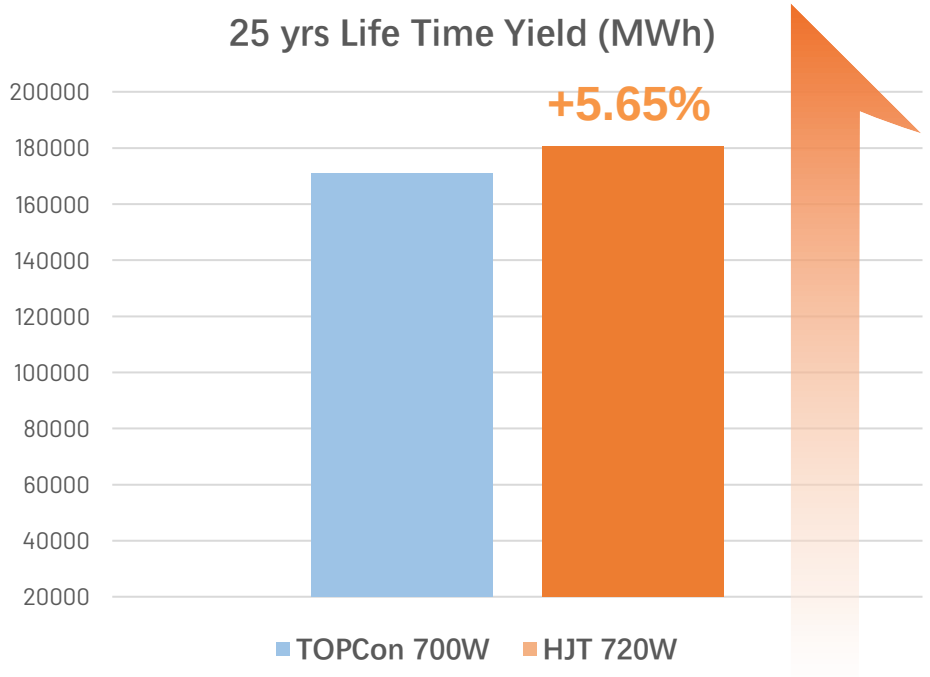


In Shenzhen, Guangdong, the BOS cost of the HJT 620W in the color steel tile roof scheme can save about **2.13** cent/W than the TOPCon 600W.

2. System Solutions in Different Scenarios

2.3 HJT module applies in roof application scenario in Guangdong, China (DC6MW)

Conditions	TOPCon 600W	HJT 620W
Capacity (MW)	5.796	5.9892
Ratio	1.208	1.248
1st Year Yield (h)	1252.00	1276.00
1st Year Yield (MWh)	7256.59	7642.22
25 yrs Life Time Yield (MWh)	170965.31	180623.85
BOS Cost (RMB/W)	**0.6604**	**0.6391**
The user's electricity price is temporarily calculated at a 70% discount (RMB/kwh)	0.7669	0.7669
IRR(%)	8.888	9.129



First Year Yield Adder	+5.31%
IRR	+0.71%
BOS	-3.23%
LCOE	-2.84%

SOLAR RADIATION

Global horizontal irradiation	GHI	2232.1	kWh/m²	
Direct normal irradiation	DNI	2060.8	kWh/m²	
Diffuse horizontal irradiation	DIF	825.1	kWh/m²	
Ratio of diffuse to global irradiation	D2G	0.370		
Global tilted irradiation at optimum angle	GTI opta	2435.5	kWh/m²	
Optimum tilt of PV modules	OPTA	28	°	
GHI seasonality	GHI season	1.9		
DNI seasonality	DNI season	1.5		
Ground surface albedo	ALB	0.38		

Resource: Solargis Irradiation

Desert Scenario

Location: **Riyadh, Saudi Arabia**

Capacity: **Single-axis DC106MW**

Local conditions: **High temperature**

2. System Solutions in Different Scenarios

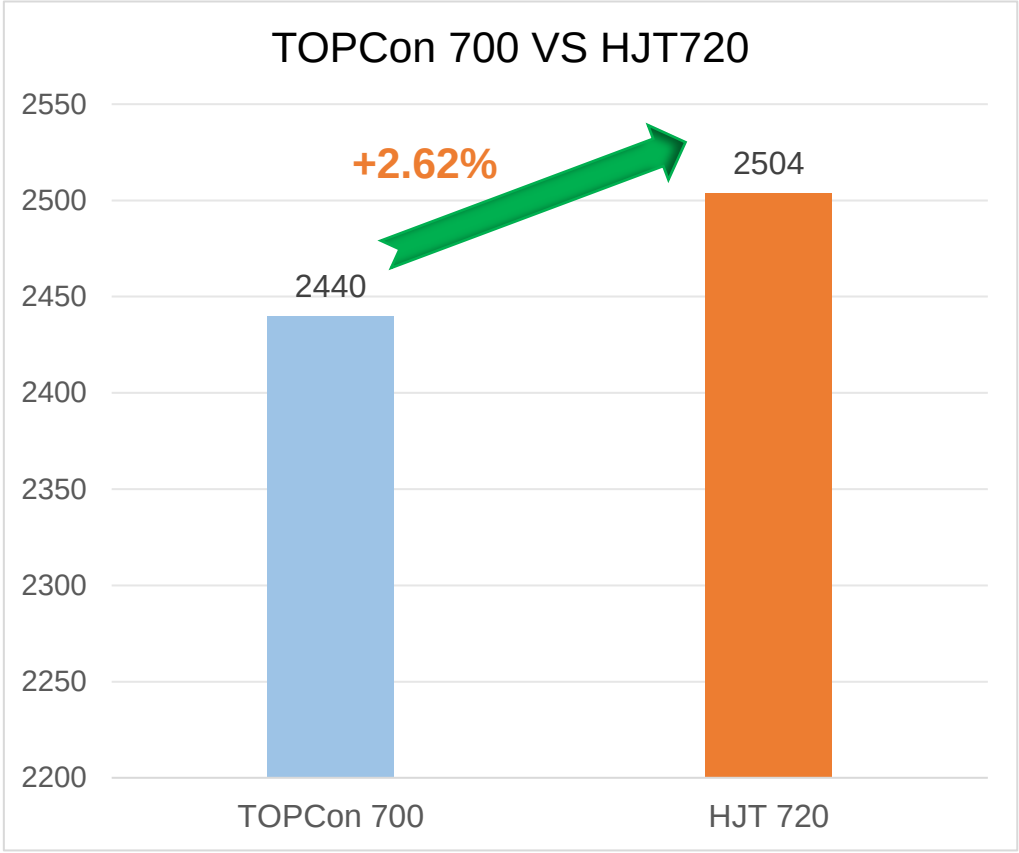
2.4 HJT module applies in desert application scenario in Saudi Arabia (Single-axis DC106MW)

Category	TOPCon 700W	HJT 720W	Differences
Module Power (W)	700	720	Power +20W
Module Dimension (mm)	2384*1303*33	2384*1303*35	Module Length 0*0*+2mm
1st year Power Degradation	1%	1%	/
Annual Degradation	0.4%	**0.375%**	Annual Degradation -0.025%
Bifaciality	80%	**90%**	Bifaciality +10%
Array	1P	1P	/
Installation Tilt (°)	-60-60	-60-60	/
Modules in Series	29	29	/
P_{nom} Ratio	1.095	1.095	/
Number of Strings	5412	**5258**	Number of Strings -154
Number of Modules	151536	**147224**	Number of Modules -4312
AC System Capacity (MW)	106.1	106.0	AC System Capacity -0.1MW
Land Area (ha)	94.4	**91.38**	Land Area -3.02ha

2. System Solutions in Different Scenarios

2.4 HJT module applies in desert application scenario in Saudi Arabia (Single-axis DC106MW)

Year	TOPCon 700W	HJT 720W	Add hours
Year 1	2440	2504	**64**
Year 2	2405.84	2469.57	63.73
Year 3	2396.08	2460.18	64.10
Year 4	2386.32	2450.79	64.47
Year 5	2376.56	2441.40	64.84
Year 6	2366.80	2432.01	65.21
Year 7	2357.04	2422.62	65.58
…	…	…	…
30 Life time	68246.8	70309.19	**2062.39**

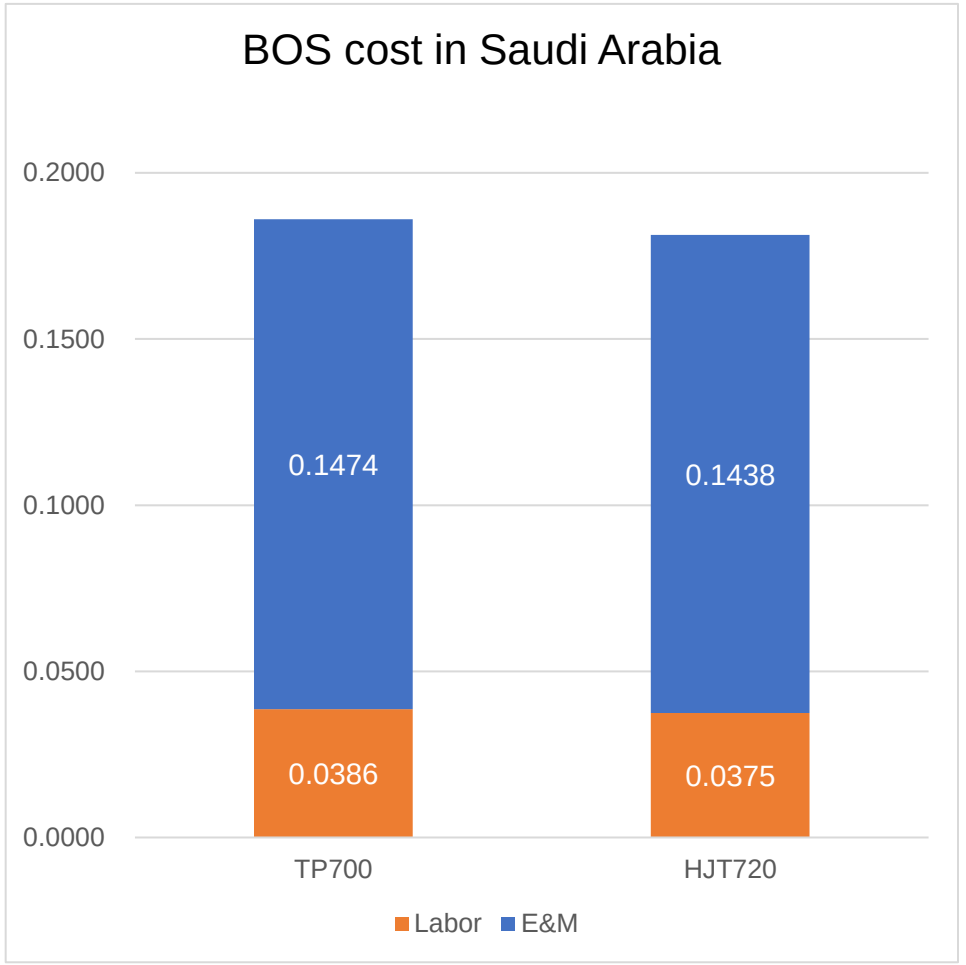


In Riyadh, the yield of the first year of HJT 720W is **2.62% (=64 hrs longer)** higher than TOPCon 700W.

2. System Solutions in Different Scenarios

2.4 HJT module applies in desert application scenario in Saudi Arabia (Single-axis DC106MW)

System Configuration			TOPCon 700W		HJT 720W		Cost Variance (HJT-TP)
		Unit	Quantity	Unit Price (USD /W)	Quantity	Unit Price (USD /W)	
1	**PVModule**						
1.1	700 TOPCon	Pcs	151536				
1.2	720 HJT	Pcs			147224		
2	**Structure**						
2.1	Single-axis	Units	1353	0.0704	1315	0.0685	-0.0020
3	**LVCable**						
3.1	PVCable	km	629.5	0.0026	612.30	0.0025	-0.0001
3.2	DCCable	m	44374	0.0034	41188	0.0031	-0.0002
4	**Inverter&Transformer**						
4.1	8800KW	Pcs	11	0.0245	11	0.0245	0.0000
5	**CombinerBox**						
5.1	24 to 1	Pcs	286	0.0012	264	0.0011	-0.0001
6	**Land Cost**	ha	94.40	0.0023	91.38	0.0022	-0.0001
7	**Cleaning Robot**	Units	1353	0.0172	1315	0.0167	-0.0005
8	**Others (Road,fence,lightning,etc)**	Units	1	0.0258	1	0.0251	-0.0007
9	**Labor Cost**	Units	1	0.0386	1	0.0375	-0.0011
Total	BOS Cost		**0.1860**		**0.1813**		**-0.0047**

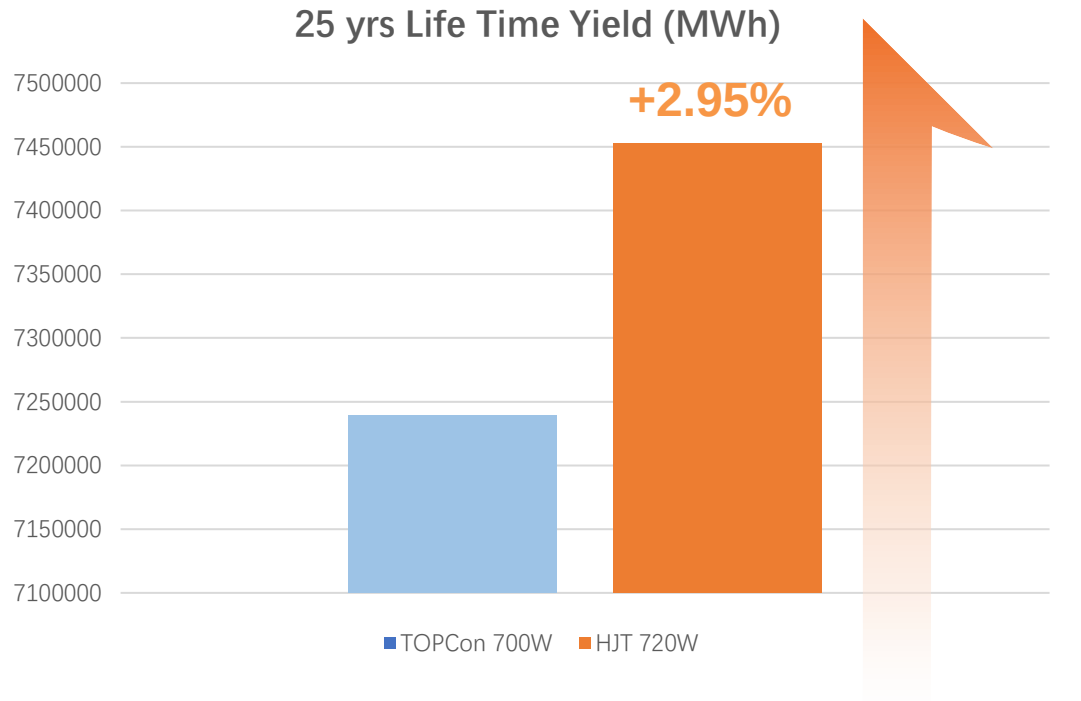


In Riyadh，the BOS cost of HJT 720W can **save about 0.47USD cent/W** than TOPCon 700W.

2. System Solutions in Different Scenarios

2.4 HJT module applies in desert application scenario in Saudi Arabia (Single-axis DC106MW)

Conditions	TOPCon 700W	HJT 720W
Capacity（MW）	106.075	106.001
Ratio	1.096	1.095
1st Year Yield (h)	**2440.00**	**2504.00**
1st Year Yield（MWh）	258823.49	265427.21
30 yrs Life Time Yield（MWh）	7239292.96	7452864.14
BOS Cost (RMB/W)	**0.1860**	**0.1813**
PPA Price(USD cent/kwh)	1.71	1.71



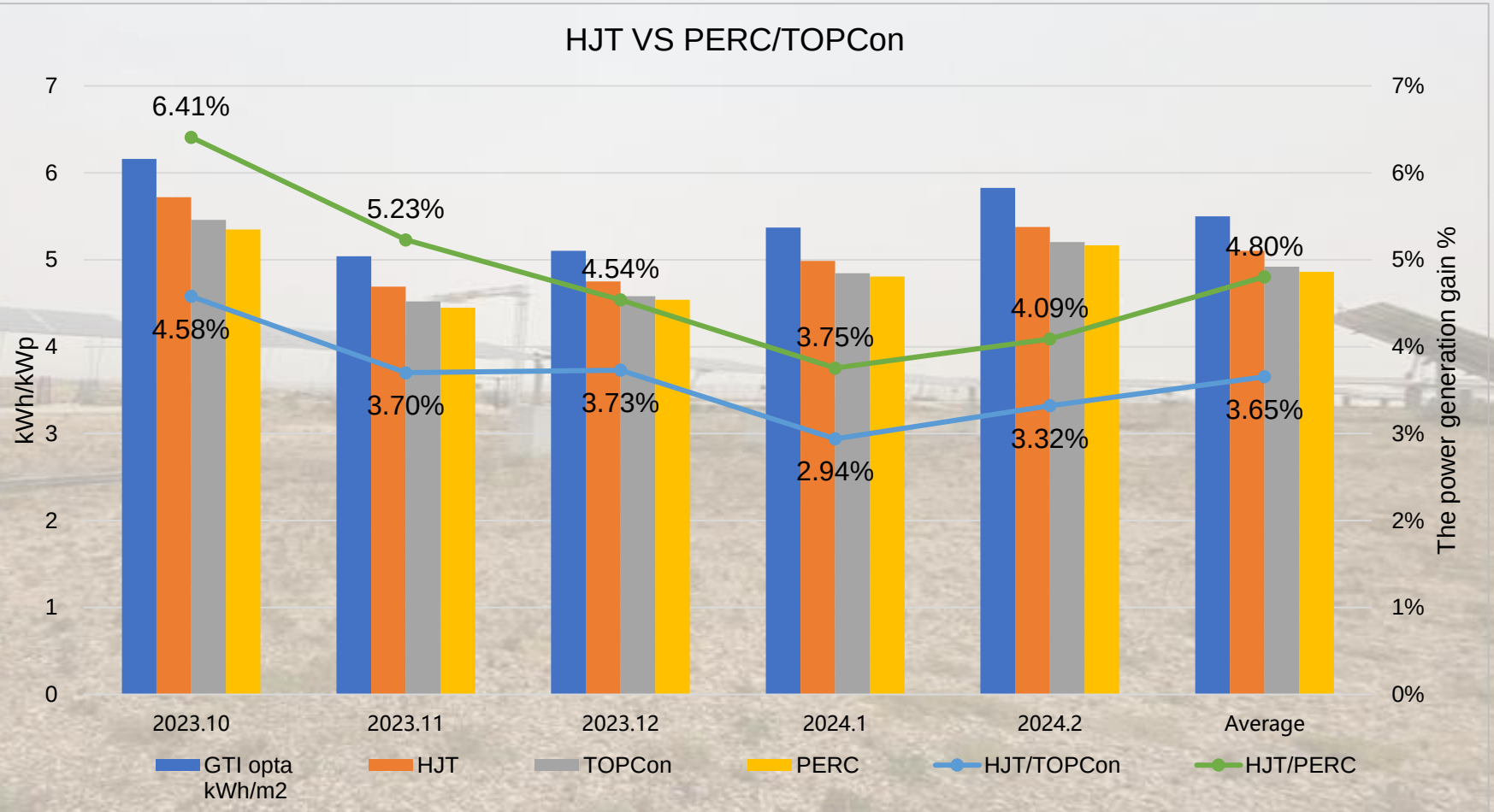
First Year Yield Adder	+2.55%
IRR	+0.23%
BOS	-2.52%
LCOE	-1.72%

CONTENTS

3. Case: HUASUN HJT Generation Demonstration

Case 1: **Saudi Arabia**, the Middle East- HJT vs PERC vs TOPCon

Module Type	PERC	TOPCon	HJT
Module Power/W	660	575	680
Pm Temperature Coefficient	-0.35%	-0.30%	-0.26%
Location	Saudi Arabia		
Orientation	Fixed Orientation Planes		
Latitude/°	26.41		
Longitude/°	50.16		
Number of Module /PCS	8	8	8
Installed Capacity/kW	3.96	3.45	4.08
Plane Tilt/°	26		
Azimuth/°	South		
Height above Ground/m	1.5		
Ground Surface	Concrete		



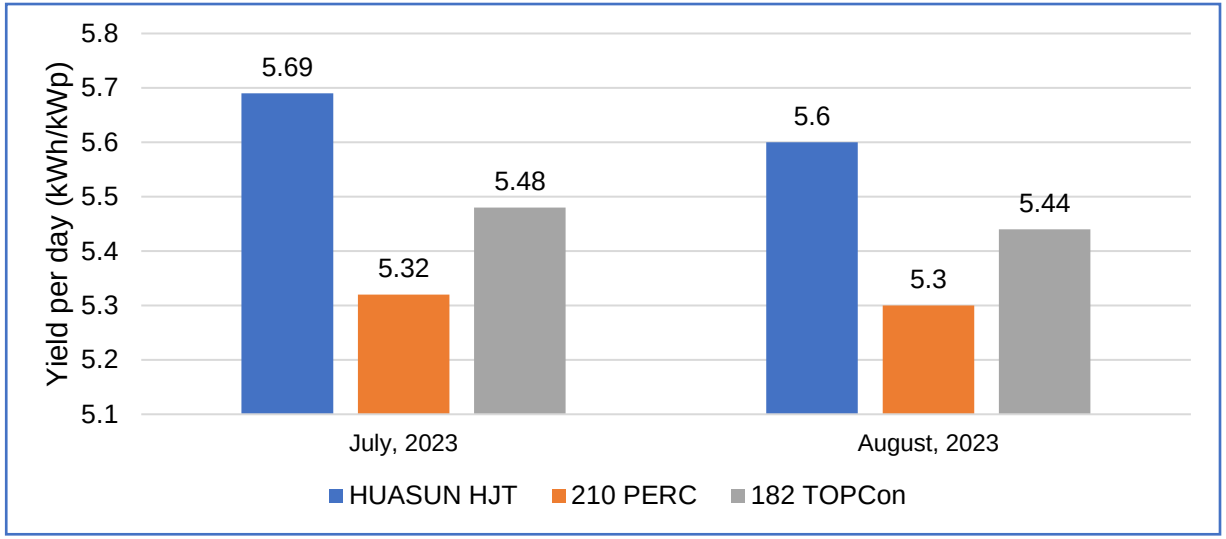
Tips： GTI opta--Global tilted irradiation at optimum angle

HJT VS PERC the power generation gain is 4.80%, HJT VS TOPCon the power generation gain is 3.65%.

3. Case: HUASUN HJT Generation Demonstration

Case 2: Zibo, Shandong, China - HJT vs PERC vs TOPCon

Experiment	Module Type	Yield per day		Total Yield (kWh/kWp)	Experiment A compared to Experiments B and C in terms of power generation gain per watt
		July	August		
A	HUASUN HJT	5.69	5.6	349.94	/
B	210 PERC	5.32	5.3	328.94	**6.38%**
C	182 TOPCon	5.48	5.44	338.38	**3.42%**

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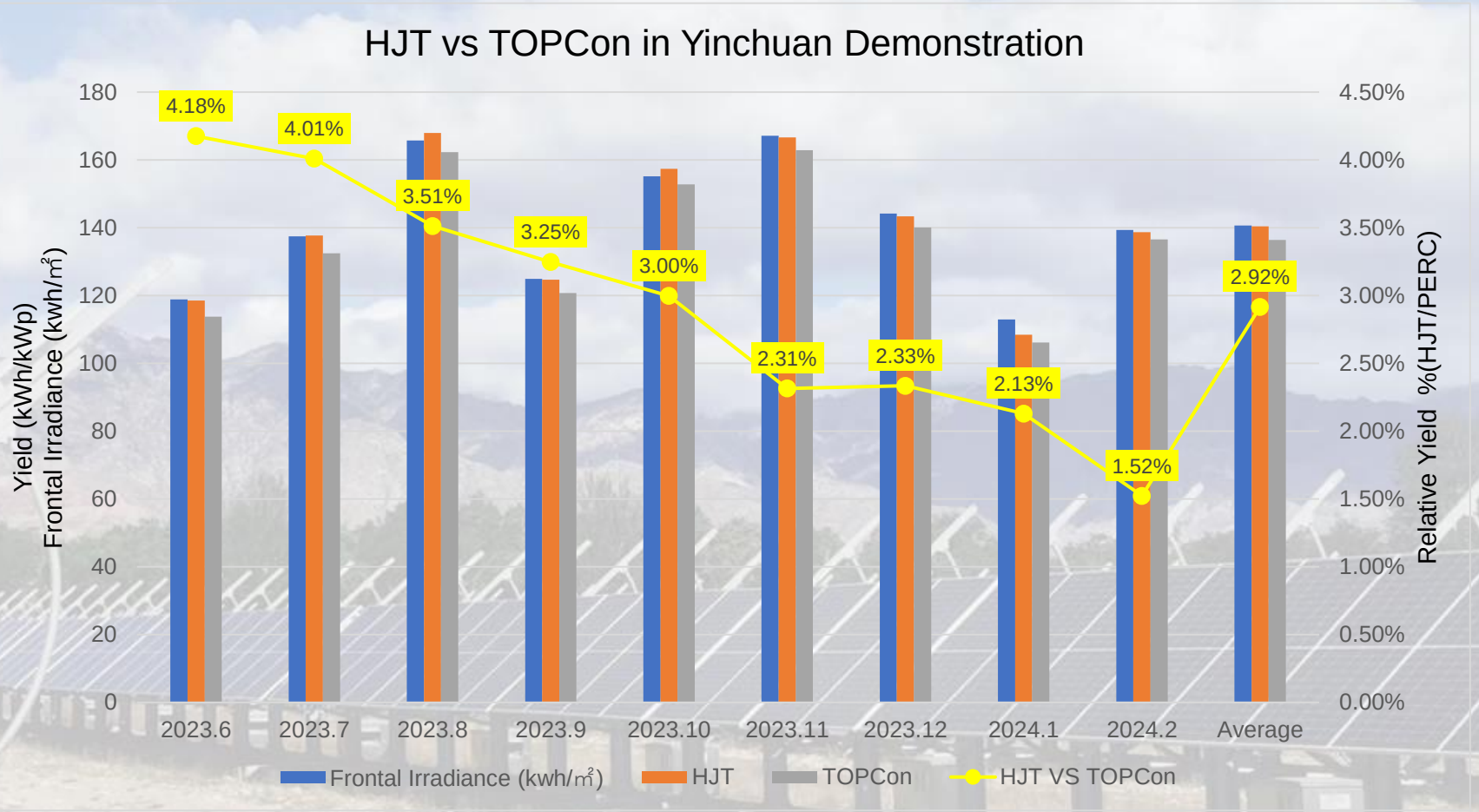
HJT VS PERC the power generation gain is **6.38%**

HJT VS TOPCon the power generation gain is **3.42%** **(From July 2023 to August 2023)**

3. Case: HUASUN HJT Generation Demonstration

Case 3: Yinchuan, Ningxia, China- HJT vs TOPCon

Module Type	TOPCon	HJT
Module Power/W	570	680
Pm Temperature Coefficient	-0.30%	-0.26%
Location	CPVT Yinchuan Outdoor Demonstration Base	
Latitude/°	38.58	
Longitude/°	106.01	
Number of Module /PCS	8	8
Installed Capacity/kW	4.56	5.44
Plane Tilt/°	40	
Azimuth/°	South	
Height above Ground/m	1	
Ground Surface	White Paint	



From June 2023 to February 2024, HJT VS TOPCon the power generation gain is 2.92%.

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