

PERC Bifacial PV BiFi cell, module, and system



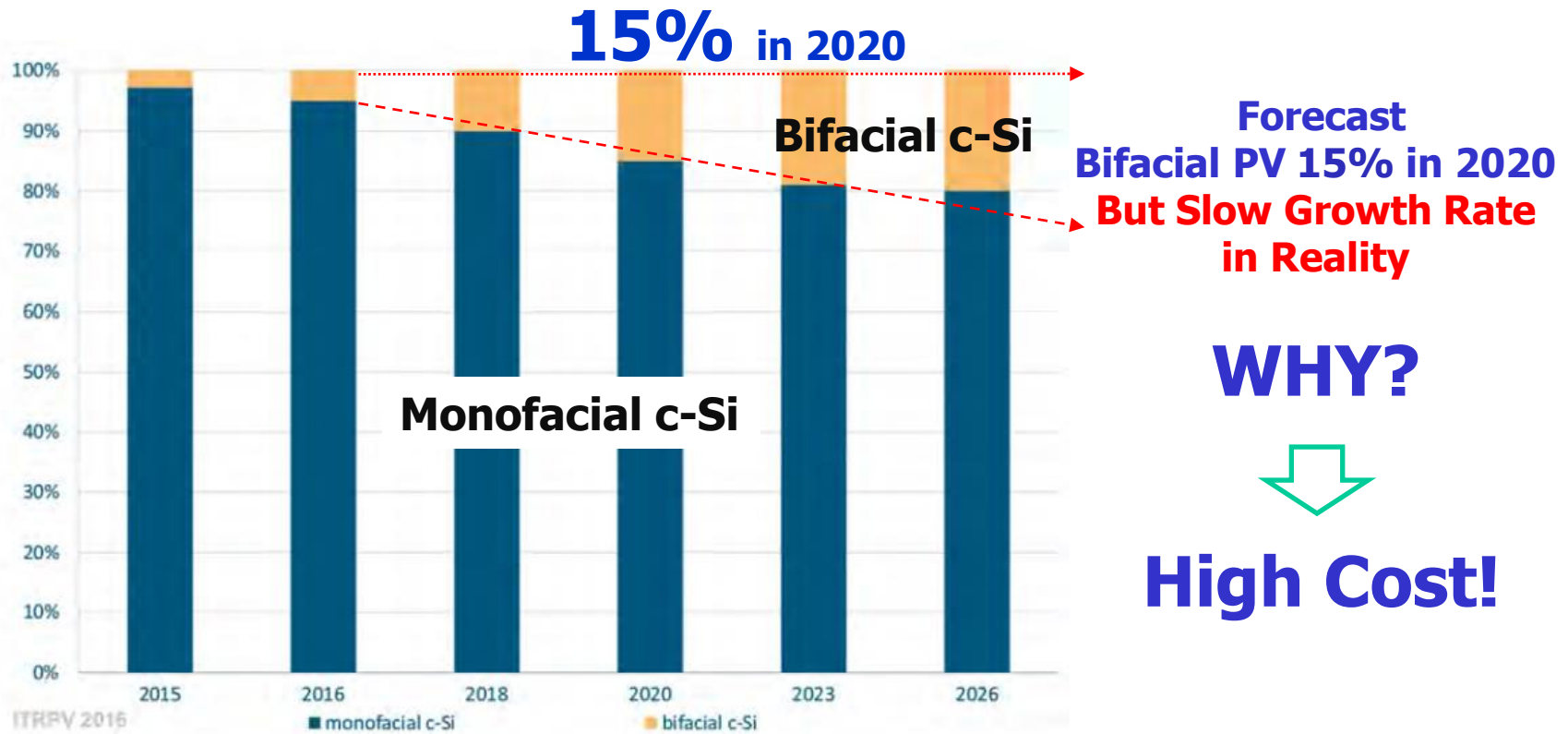
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Outline

- **Market of Bifacial PV and PERC**
- **Bifacial solar cell and module technologies**
- **NSP's BiFi cell and module products**
- **System IRR comparison**
- **Summary**

Bifacial market share 15% in 2020

ITRPV roadmap 2016



- **Bifacial PV market share** is forecasted to be **15% in 2020**. **However, its growth rate is quite slow in reality.**
- **High cost** is main issue for expanding market share of bifacial PV.

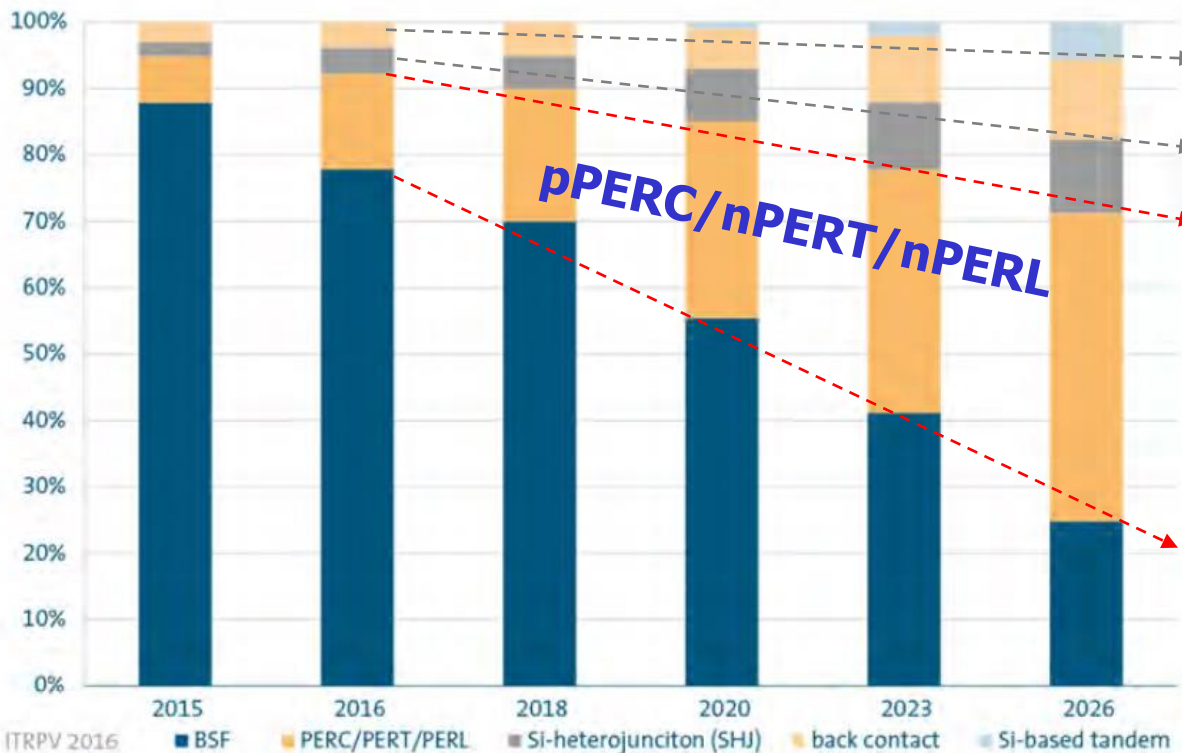
Bifacial solar cell and module technology comparison on material and tools invest

	nPERT/nPERL	SHJ	PERC BiFi
Cell Eff.	21.x%	22.x%~23.x%	21.x%
Wafer type	6" N-type	5"/6" N-type	6" P-type ★
Ag usage	Double-side Ag	Double-side Ag	One-side Ag ★
Cell Tools	New tools + Existing tools	New tools	Existing tools ★
Module Tools	Existing tools	New soldering	Existing tools ★
Cost	High	High	Low ★

- nPERT/nPERL/SHJ are using **high-cost n-wafers and double-sided Ag paste.**
- nPERT/nPERL/SHJ cell and module process need **more tool investment** than PERC BiFi.
- **PERC bifacial is using existing process tools and same materials as pPERC, enabling cost reduction for bifacial PV.**

PERC market share 25% in 2020

ITRPV roadmap 2016



nSHJ 7.5% in 2020

5%

pPERC+nPERT+nPERL

30% in 2020



pPERC share

25% in 2020

- PERC market share is forecasted to be 25% in 2020.
- PERC bifacial can be a new way for expanding market share of bifacial PV by leveraging PERC technology.

Black21_BiFi

P-type PERC bifacial solar cell



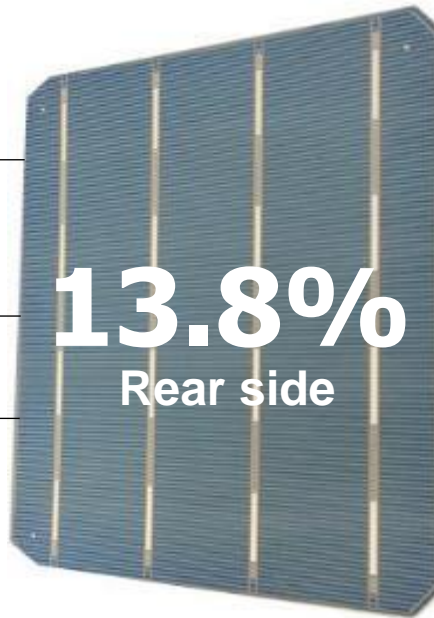
BiFi

Bifaciality=65%

H-Grid Pattern

High Peeling Force

13.8%
Rear side

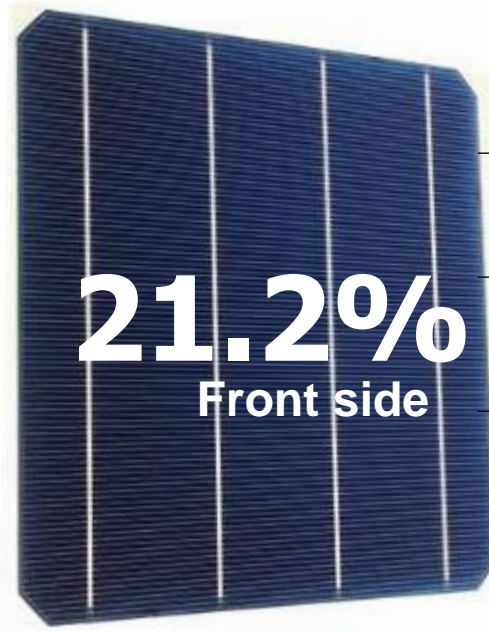


4 BusBar/5 BusBar

P-type M2 wafer
156.75mm

H-Grid Pattern

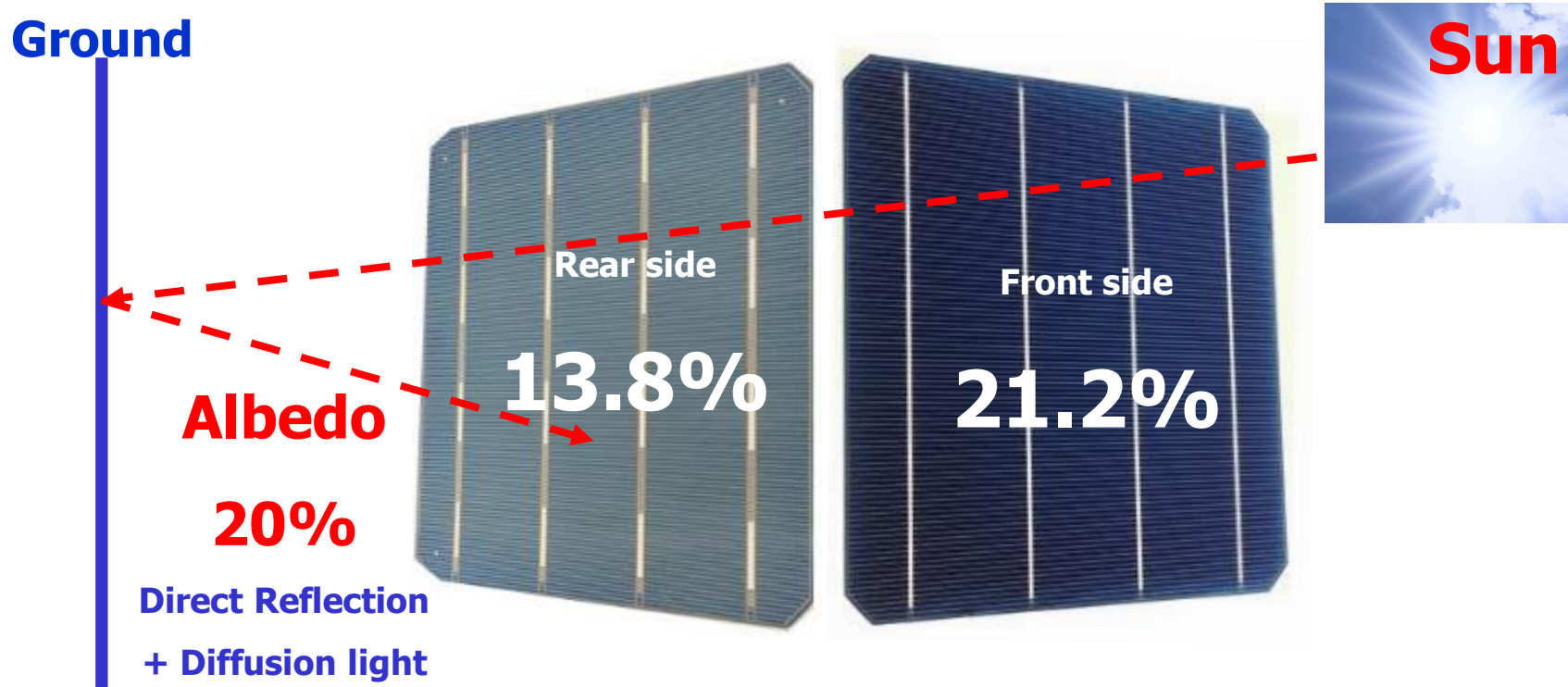
21.2%
Front side



- **Black21_BiFi is a p-type PERC bifacial solar cell with 21.2% front-side efficiency and bifaciality=65%.**

Equivalent eff. = 23.96%


assuming albedo 20%



$$\text{Cell eff.} = 21.2\%_{\text{front}} + 13.8\%_{\text{rear}} \times 20\%_{\text{Albedo}} = 23.96\%_{\text{equ-eff.}}$$

21.2% Black21_BiFi cell electrical parameters

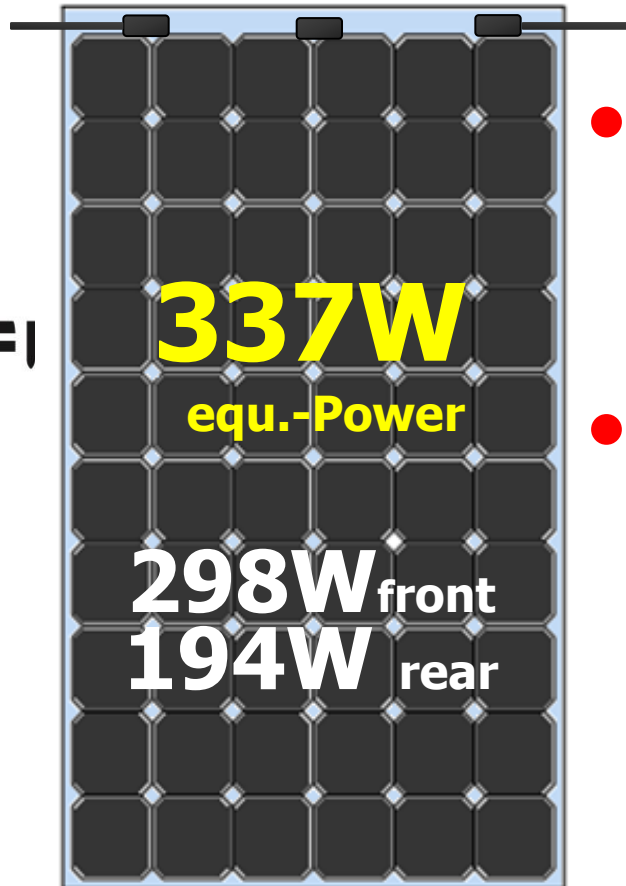


 BIFI		
	Champion	Ave.
Voc	674.4 mV	673.0mV
Isc	9.75 A	9.74A
FF	78.81%	78.44%
eff.	21.2%	21.0%

in-house test with reference cell from third-party certificate

- 21.2% 4BB BiFi cell efficiency has been achieved.

337W equivalent power double-glass BiFi module



- **Power Output**


- Front-side power 298W (60 cells)
- Equivalent power 337W(20% albedo)

- **Reliability**

- Double-Glass Protection for Cells
- 3X IEC test level
DH3000hrs/TCT600cycles
- 1500V/Anti-PID

- BiFi double glass module enables **higher power output** and **better reliability**.





298.1W_F/194.2W_R power certificate

 BIFI	
B21_BiFi cell eff.	21.0% eff. x 60 cells
Front power	298.1W Voc=39.8V; Isc=9.9A; FF=75.7%
Rear power	194.2W
Bifaciality	65.1%
Equ. Power Front+Rear x Albedo (Albedo=20%)	337.0W

Certificated by third party.

- **337.0W** equivalent power with **298.1W_F/194.2W_R** was **certificated by third party.**

Equivalent power of BiFi module

Ground Condition	Gray pavement	Grass	White paint	Snow
				
Albedo	10%	20%	30%	40~80%
Equivalent Power Front-side	298W	337W	356W	>375W

- Equivalent power BiFi module is **337W**, assuming albedo=20%.
- Equivalent power BiFi module is **356W**, assuming albedo=30%.

5 benefits from BiFi module

- **Benefit1: High-Power output 298W_F and equivalent 337W**
- **Benefit2: 3X IEC (30yrs) reliability, low degradation rate, and high fire-resistance**
- **Benefit3: 1500V/anti-PID, saving cost in inverter and grounding**
- **Benefit4: Aesthetic appearance with double glass**
- **Benefit5: Higher system IRR than conventional c-Si modules**



IRR simulation for BiFi system

- **ChangHua (彰化) Taiwan**
- **Ground type 500 kW**
- **Leverage from bank**
 - Bank loan percentage: 70%
 - Interest Rate: 3.5%
 - Years of loan: 15 year
- **2017 FIT condition:**
 - NTD 4.4/kWh multi
 - NTD 4.62/kWh incentive for >295W module
- **Modules to compare**
 - 265W Multi c-Si
 - 280W Mono c-Si
 - 295W PERC mono
 - **295W PERC BiFi**

System IRR comparison



265W Multi c-Si
280W Mono c-Si



295W PERC Mono



295W PERC BiFi
20% Albedo

- **NSP BiFi 295W** module enables **higher system IRR** than conventional mono-facial 265W multi c-Si, 280W mono c-Si, and 295W PERC modules.
- **Higher albedo** enables **higher IRR** in BiFi system.

Various application of double-glass BiFi module



IKEA

Flat-rooftop



Prism solar

BIPV



BMW

Carport



Fraunhofer-ISE

Agriculture



Ground Up Solar

Power Plant



Berlin Station

Landmark



PVGS

Snow



Jean-Claude Winkler / Getty

Desert

- **BiFi module has various applications** in solar farm, agriculture, flat rooftop, BIPV, carport, landmark, snow region, and desert region.

Summary

- **Cost reduction** is the key to expand bifacial PV market. **PERC bifacial technology** is a new way to achieve **high-power** and **low-cost module**.
- **NSP BiFi double-glass module** has **high power output** and **better reliability**.
 - **Champion cell efficiency 21.2%**
 - **Champion module power 298W** with 60 cells and equivalent power **337W**.
- **NSP BiFi module** enables **higher system IRR** than conventional mono-facial multi c-Si, mono c-Si, and PERC modules.

Visit NSP's booth in PV Taiwan 2016

Oct. 12-14 at Taipei



The poster features a central logo with 'PV' in blue and yellow squares. To the right, the text '2016 PV Taiwan' is displayed in large, bold letters, with '2016' in orange and 'PV Taiwan' in black. Below this, it says 'Taiwan Int'l Photovoltaic Exhibition'. Further down, the dates 'Oct. 12-14' are written in orange, followed by 'Taipei Nangang Exhibition Center, Hall 1' and the website 'www.PVTAIWAN.com'. A QR code is located to the right of the website. The bottom of the poster shows a blue silhouette of a city skyline with the Taipei 101 tower, and a perspective view of solar panels on a road.

2016
PV Taiwan
Taiwan Int'l Photovoltaic Exhibition

Oct. 12-14
Taipei Nangang Exhibition Center, Hall 1
www.PVTAIWAN.com



Thank You
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