



Trend of Global PV Market & Development of Module Technology

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WisolPro
201510



Agenda

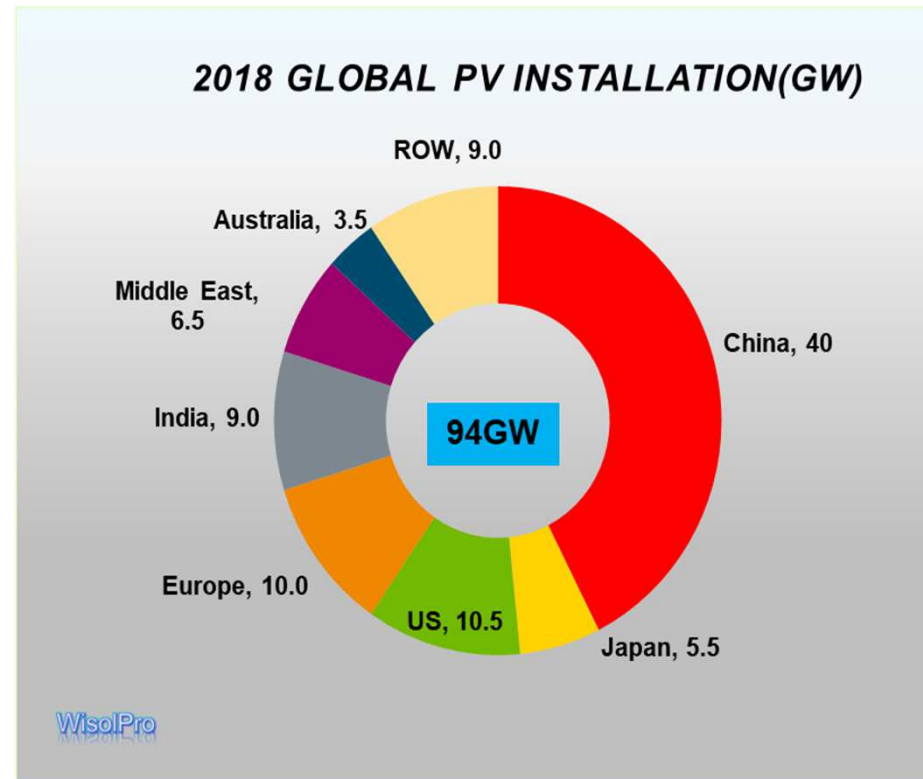
- Analysis of 2018 Global PV Installation
- Forecast of Global PV Installation 2016-2022
- Global Solar Cell Technology Development 2016-2022
- Global N Type Cell Technology Development 2017-2022
- Development of Global Bi-Facial Capacity 2018-2022
- Comparison of Different Module Technologies
- Trend of Glass-Glass Module Development
- Trend of Cell Dimension & P type Module Power Output
- Compatibility of Advanced Module Technologies
- Comparison of String & Micro Inverters
- New design of PV Panel



Global PV Installation 2018

PV Installation :

- ◆ **China** : 40GW due to 531 new policy
- ◆ **US** : 10.5GW
- ◆ **India** : 9.0GW due to SGD
- ◆ **Japan** : ≤ 6 GW due to solar FiT cut
- ◆ **Australia** : ≥ 3 GW
- ◆ **Turkey** : ≤ 1.2 GW due to currency collapsed



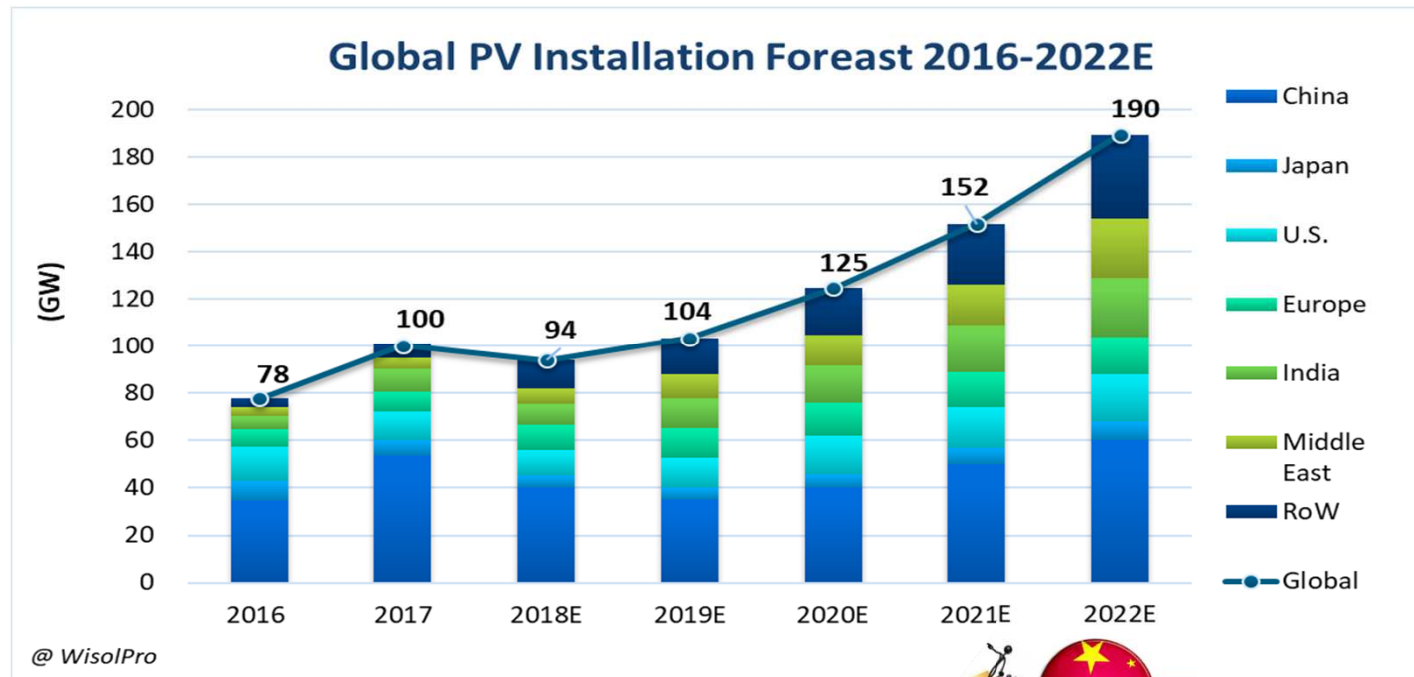
2018 Top 10 PV Installation (GW)	
China	40
U.S.	10.5
India	9
Japan	6
Australia	3.5
Germany	2.8
Mexico	2.2
S. Korea	1.2
Turkey	1.2
Netherland	1.15

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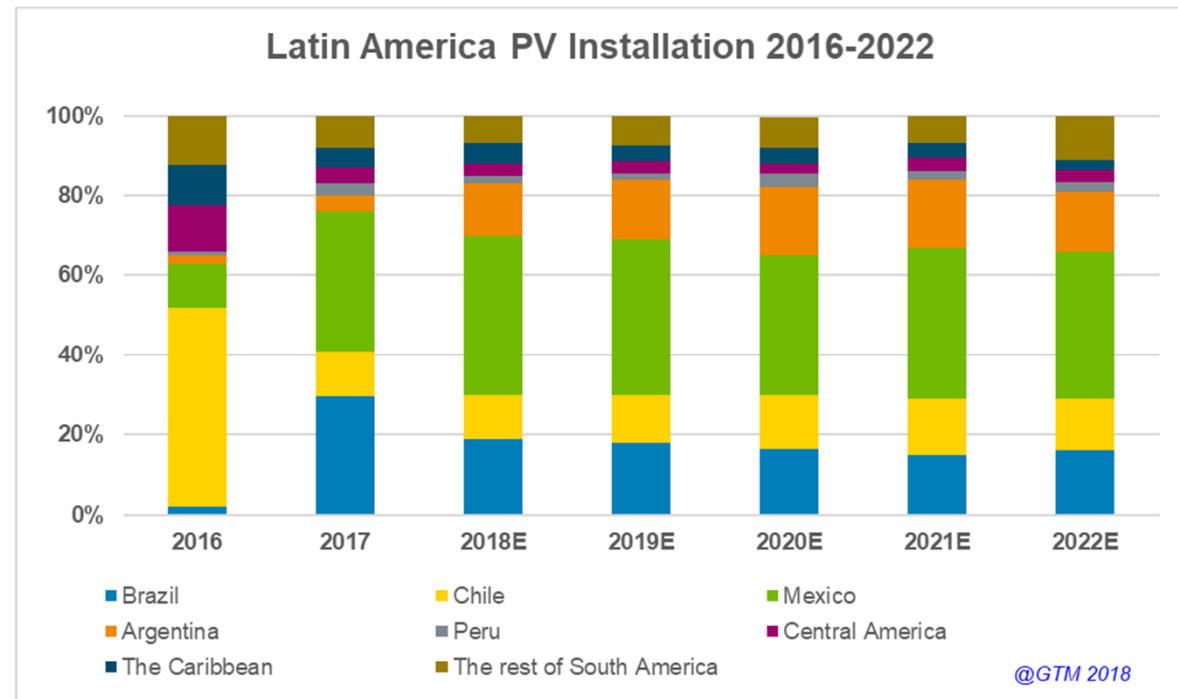
Forecast of Global PV Installation 2016-2022

- ◆ China PV demand will boost again after 2020 by 14th Five Year Plan & lower LCOE
- ◆ The global PV installation will surpass 100GW again in 2019; China is still top one PV demand country as NEA raising up 13rd Five year PV target from 105GW to ≥ 210 GW on Nov 2nd, 2018
- ◆ More PV demand in emerging countries (e.g. Africa, Middle East & Latin America)

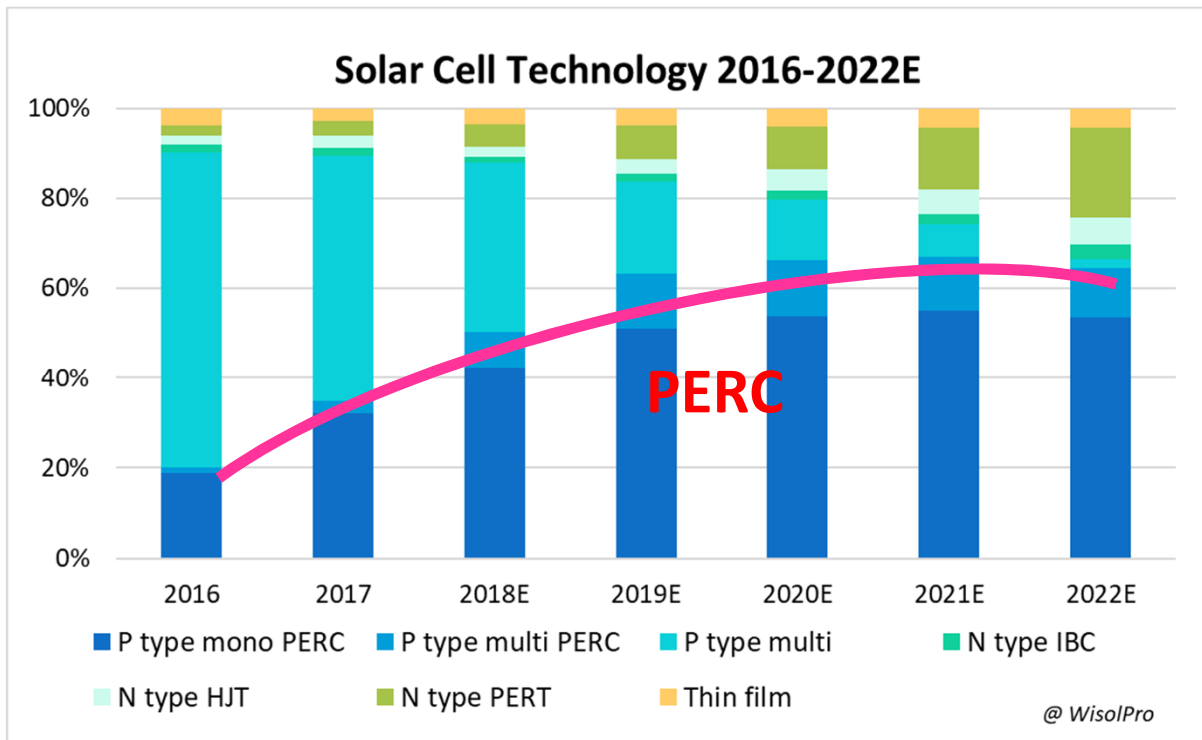


Forecast of Latin America PV Installation 2016-2022

- ◆ 5GW new PV demand is expected in 2018 by GTM
- ◆ Brazil & Mexico are two GW demand countries in Latin America before 2019
- ◆ Argentina is expected to have more than 1GW demand by 2019, Chile will have GW demand by 2020



Global Solar Cell Technology Development 2016-2022

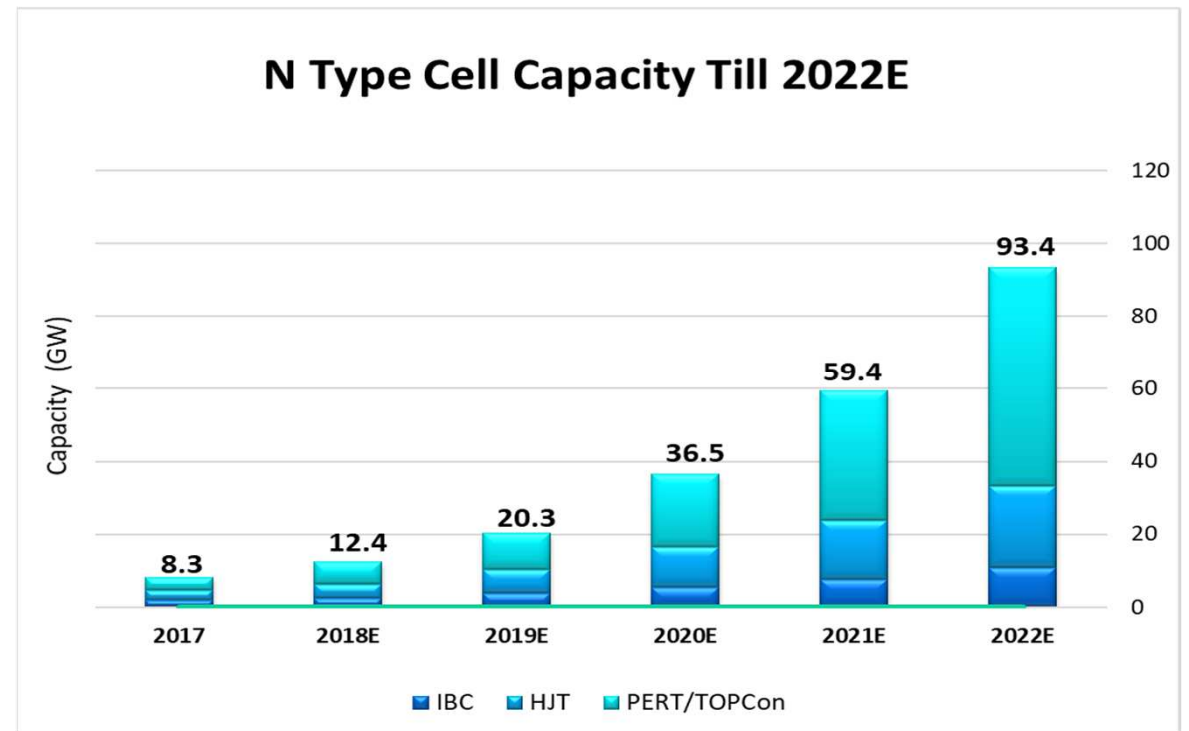


- ◆ PERC market share grows significantly and >50% in 2018 and is expected to dominate the market share in next 10 years
- ◆ HJT capacity grow significantly in 2018. More than 5GW expansion plan of HJT capacity announced after SNEC in 2018
- ◆ The growth of TOPCon is constrained by limited key POLY deposition equipment supplier and silver paste suppliers in 2018, but is expected to boost the capacity by 2019 as the local made equipment suppliers can provide local made equipment with equivalent performance as Europe equipment suppliers



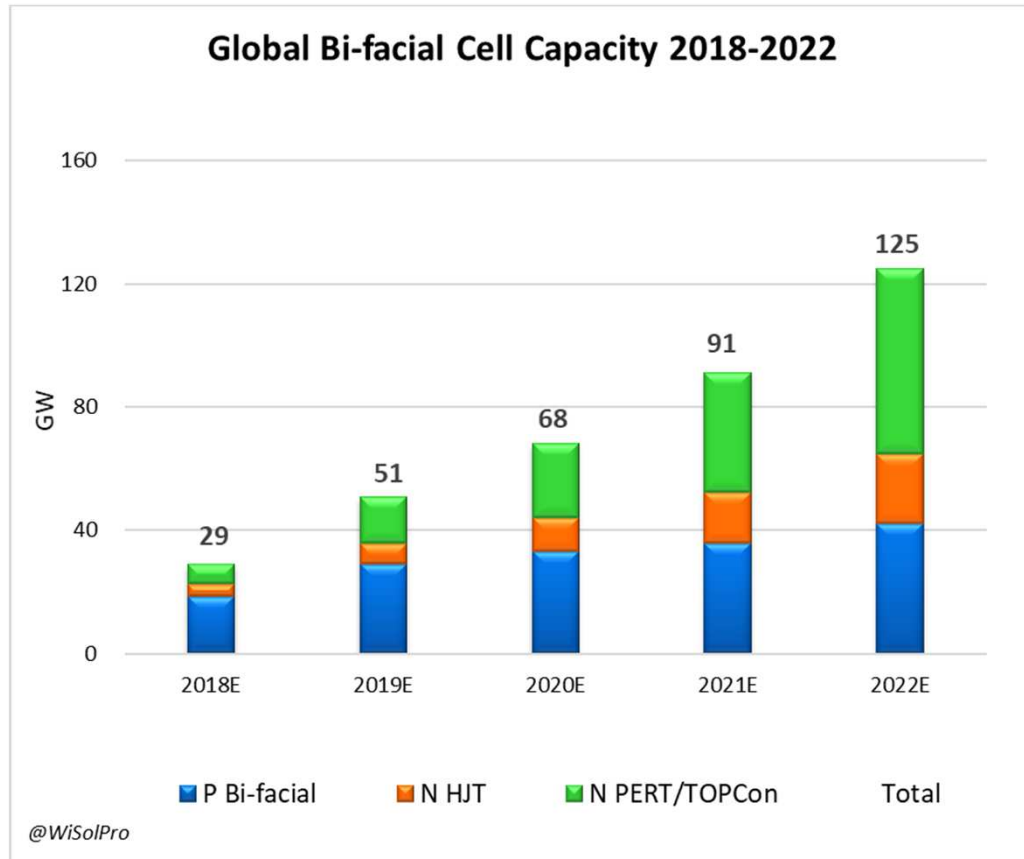
Global N type Cell Technology Development 2017-2022

- ◆ The growth of TOPCon is expected to boost starting from 2019 as the EPC and system developers can accept the at least 10% additional power output came from the rear side and pay additional 8-9% higher price per Watt
- ◆ HJT capacity expanding is expected to happen in 2020 due to higher cell efficiency demand(>24%) as the China local made PVD & CVD are not mature yet
- ◆ The share of IBC increase slowly as higher investment of CAPEX



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Forecast of B-facial Cell Capacity 2018-2022

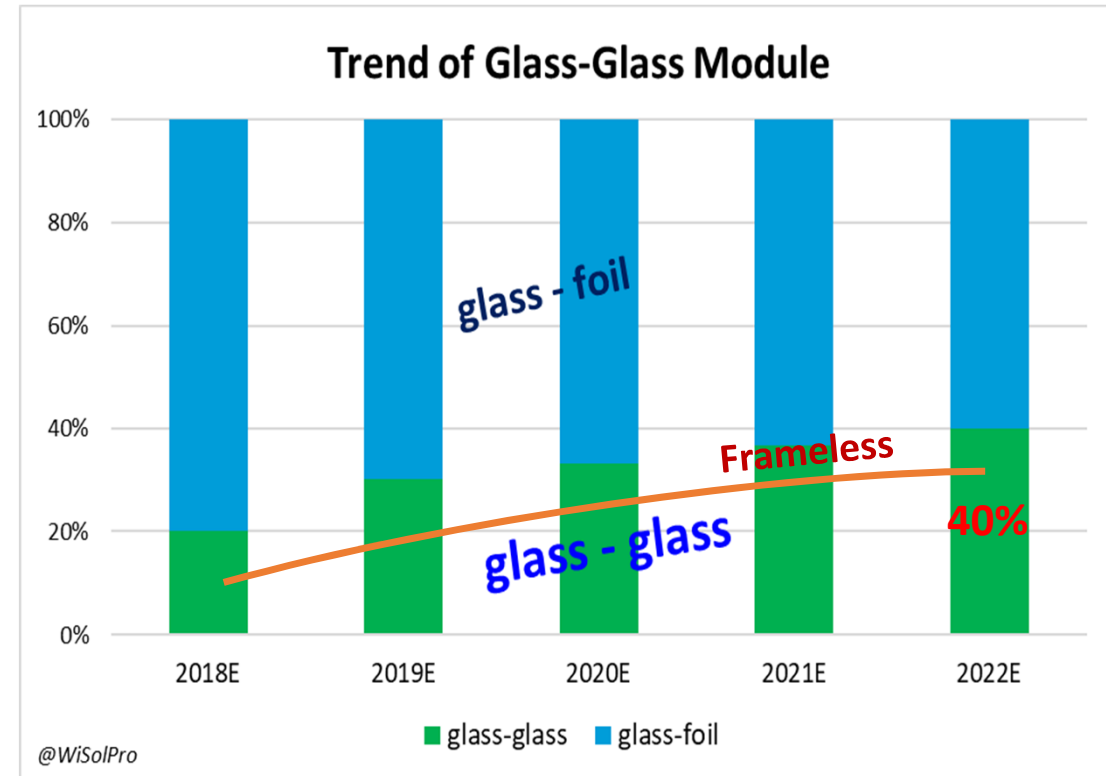


- ◆ More and more bi-facial modules were used for PV projects due to higher power output & lower LCOE (e.g. China Top Runner Projects in 2018)
- ◆ There is also market demand of P type bi-facial module due to lower cost of cell fabrication & no need of equipment upgrade in current cell line
- ◆ The challenges of bi-facial module include optimization cell technology, BOM of module, module packing & installation
- ◆ 125GW bi-facial capacity including both P & N type module capacity is expected by 2022



Trend of Glass-Glass Module Development

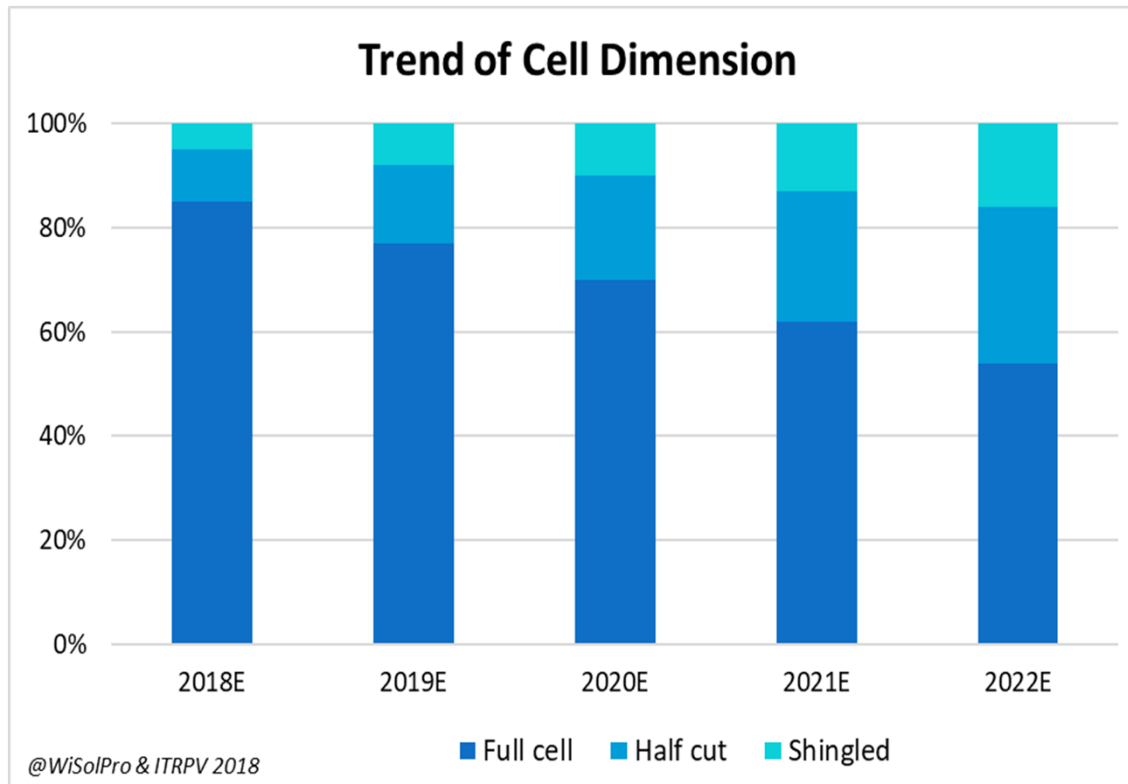
- ◆ Due to higher power output demand of China top runner projects in 2018/2019, the share of glass-glass module is expected to raise up to 40% by 2022
- ◆ Glass-foil(glass-backsheet) module with frame will remain mainstream till 2028
- ◆ Not all double glass modules are applied the frameless design, but share of frameless is linear with the share of double glass



* Glass-foil module including glass-transparent backsheet



Trend of Cell Dimension



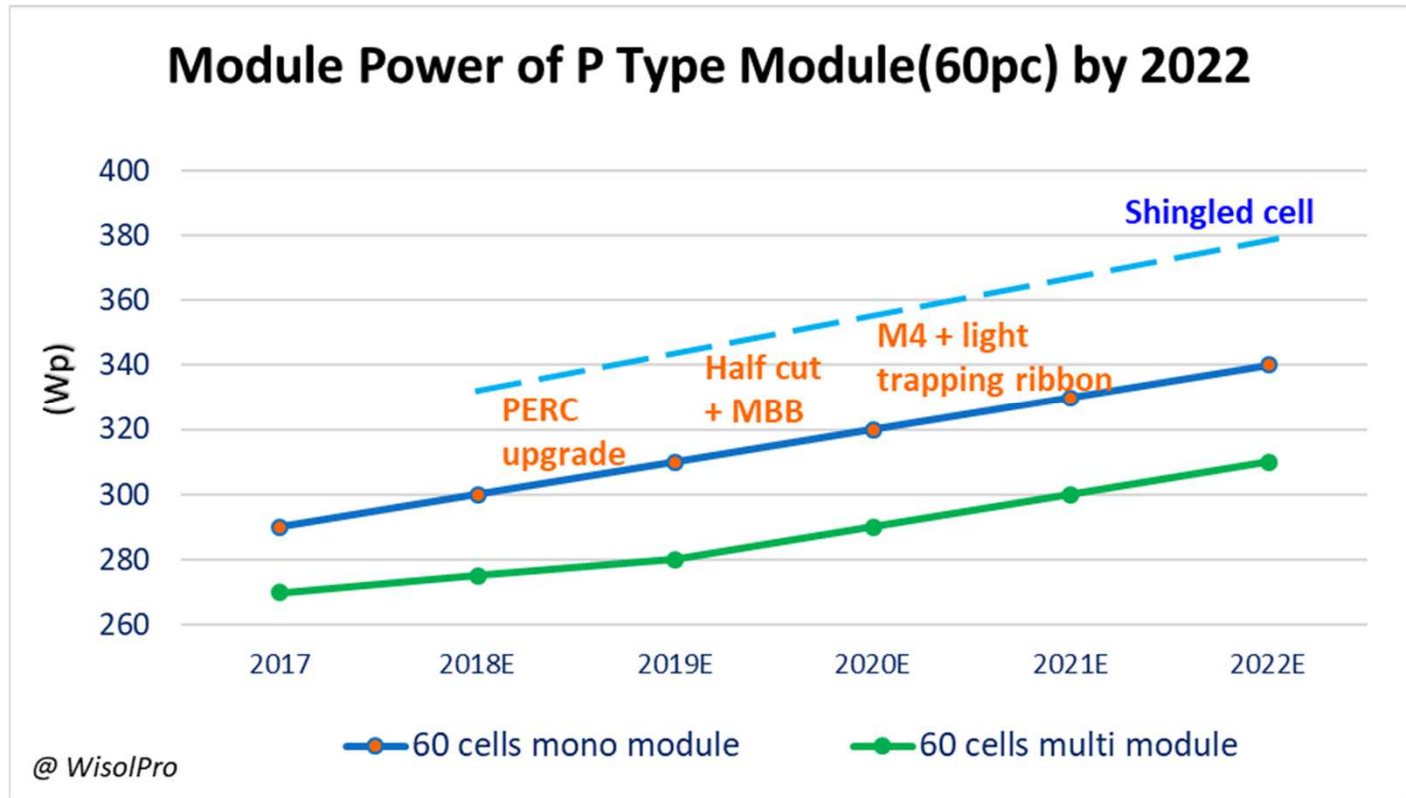
- ◆ The capacity of half cut is more than the share because most of PV module makers expect the module lines can be flexible & switchable among full cell , half cut & bifacial module technologies
- ◆ The growth of shingled cell module will be constrained by
 - 1) IP of shingled cell which are owned by SunPower, Flextronics & Solaria. The major growth of shingled cell module is expected to occur in China(non-IP concerned region)
 - 2) The development of conductive adhesive



Trend of P type Module Power Output

Power gain in advanced module technologies (60 cells module) :

- ◆ Half cut module : $\geq 5W$
- ◆ MBB(12BB) : $\geq 5W$
- ◆ M4 wafer(161mmx161mm) : $\geq 10W$
- ◆ Light trapping ribbon : $\geq 3-7W$
- ◆ Shingled cell : $\geq 10\%$ power gain



Compatibility of Advanced Module Technologies

- Most of the advanced module technologies can be combined to achieve the target power output of module
- PV makers can combine manifold module technologies(e.g. double glass + MBB + half cut + light trapping ribbon + multi JB) to customize the higher power output of customer's demand
- **Yield, Cost** & **Reliability** are key factors for PV module makers combine different module technologies

	Doubled Glass	Half Cut	MBB	Shingled Cell	Light trapping ribbon
Doubled Glass		✓	✓	✓	✓
Half Cut	✓		✓	X	✓
MBB	✓	✓		X	✓
Shingled Cell	✓	✓	X		X
Light trapping ribbon	✓	✓	✓	X	

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Comparison of String & Micro Inverters

Both string inverters and micro inverters convert the Direct Current (DC) solar panels generate into an Alternating Current (AC),



String inverter



Micro inverter

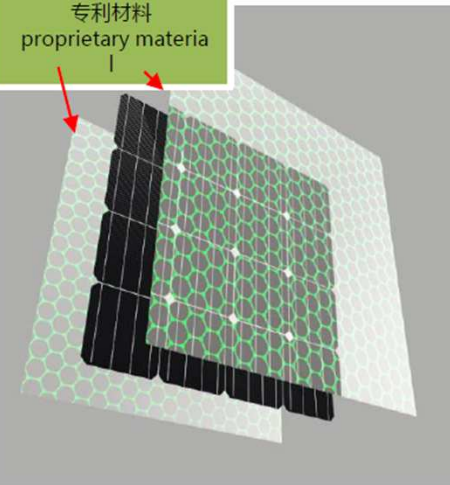


	Advantage	Disadvantage
String inverter	<ol style="list-style-type: none"> 1. Easy PM 2. Low cost 	<ol style="list-style-type: none"> 1. Short warranty 5-10yrs
Micro Inverter	<ol style="list-style-type: none"> 1. Yield more solar electricity 2. Longer warranty 25yrs 3. Individual panel & system monitoring 	<ol style="list-style-type: none"> 1. Higher cost - \$1k higher in 5kW project 2. Not easy to install on roof PV



New Design Of PV Panel – SunMan Panel

專利材料
proprietary materia

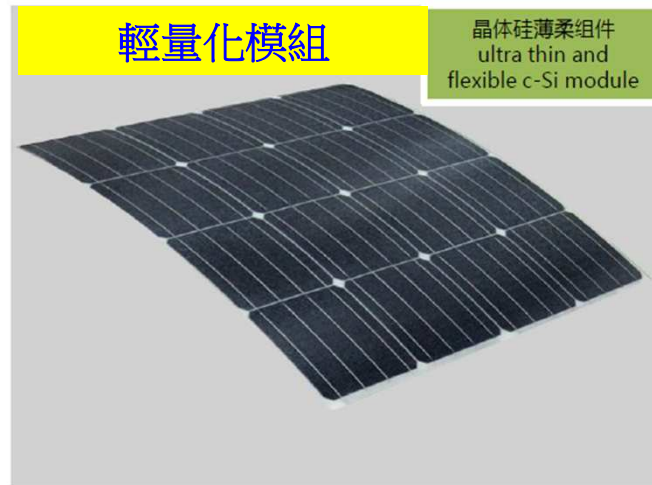


專利工藝
proprietary proces

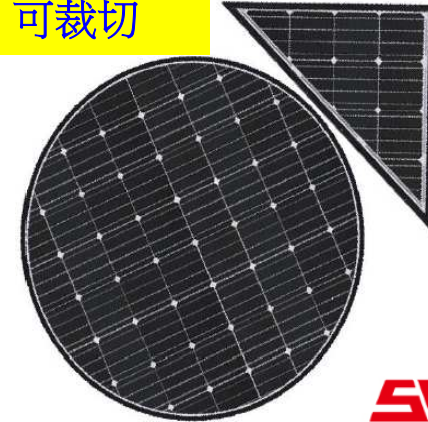


輕量化模組

晶體硅薄膜組件
ultra thin and
flexible c-Si module

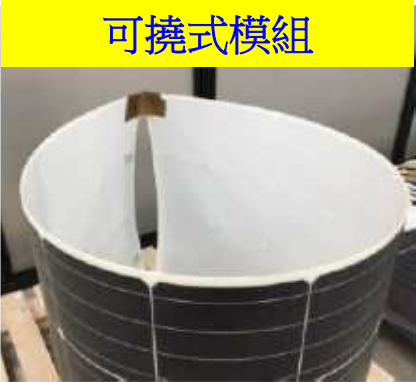


可裁切



SUNMAN
SOLAR SPECIALIST

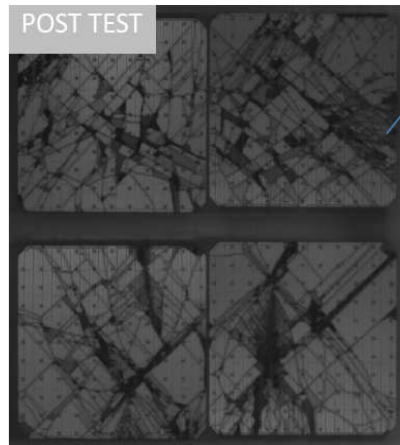
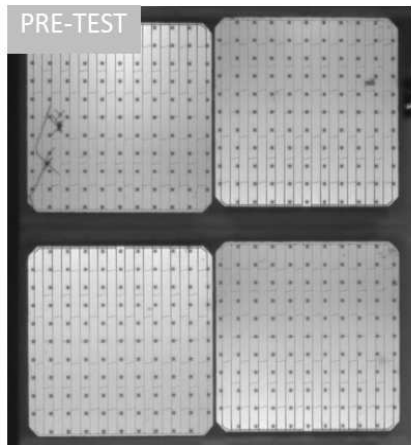
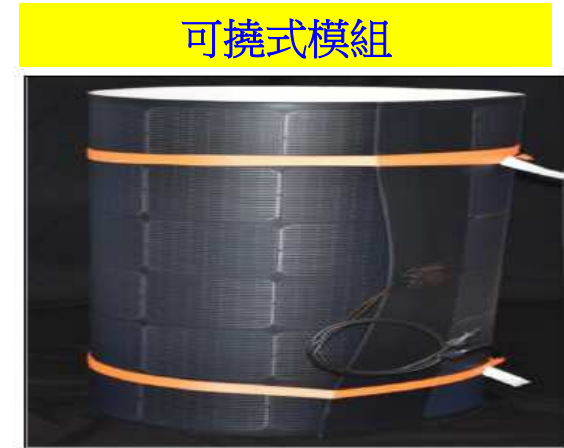
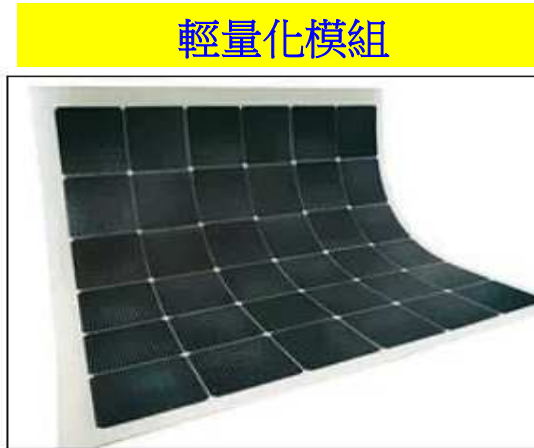
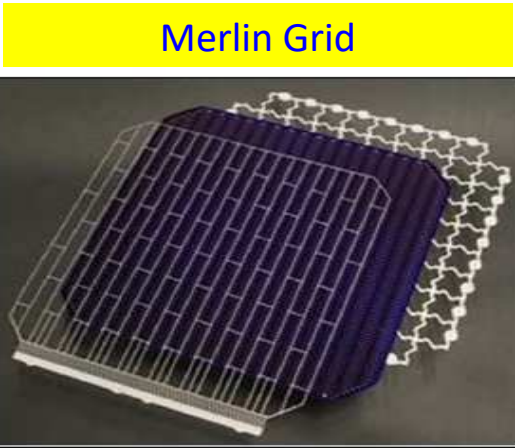
可撓式模組



Source : 上邁 施正榮博士 WSC 2018



New Design Of PV Panel – Waaree Merlin Panel



重壓後仍保有77%原始功率

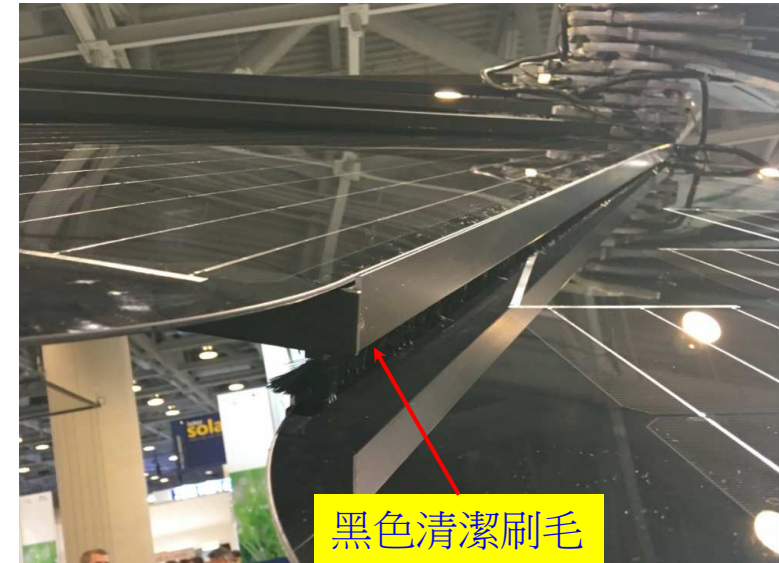
	Isc	Voc	FF	Power (max)
PRE	9.098	3.809	0.775	26.852
POST	8.746	3.662	0.640	20.508
% drop	3.87%	3.87%	17.36%	23.63%

Source : Waaree presentation in WSC 2018



New Design Of PV Panel – Smart Flower

可移動式太陽能模組和
儲能系統



SmartFlower Solar™



