



PV Industry Trends

Izumi KAIZUKA, Deputy Manager, Task 1 IEA PVPS/ Principal Analyst, RTS Corporation, Tokyo

23rd October 2023, 61st Task 1 Expert Meeting, Adelaide, Australia



Technology Collaboration Programme

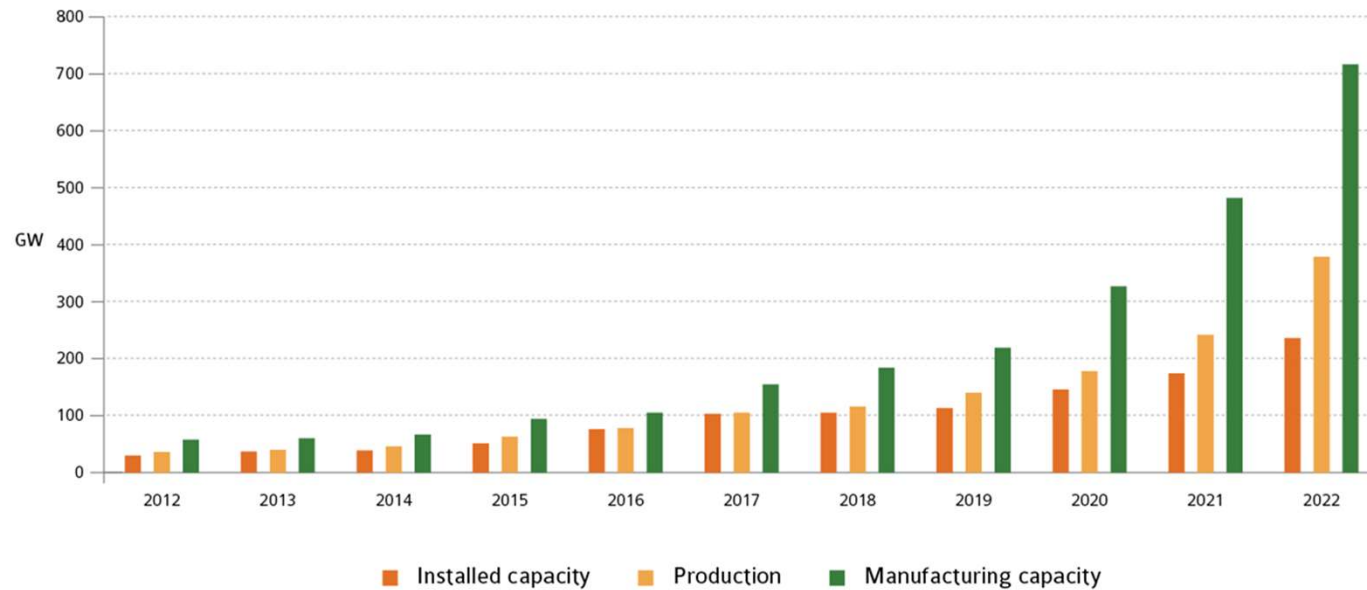
by **iea**

Contents



- 2022 status: demand, production and production capacity, country share of production
- 1H 2023 status: price, production in China, major companies production capacity
- Manufacturing capacity planned in USA and India
- Some topics
 - TopCon capacity
 - Standardization of PV module size by major PV module manufacturers
 - Perovskite PV
 - Flexible crystalline silicon
 - Price hike of Cu

Installation, production, manufacturing capacity

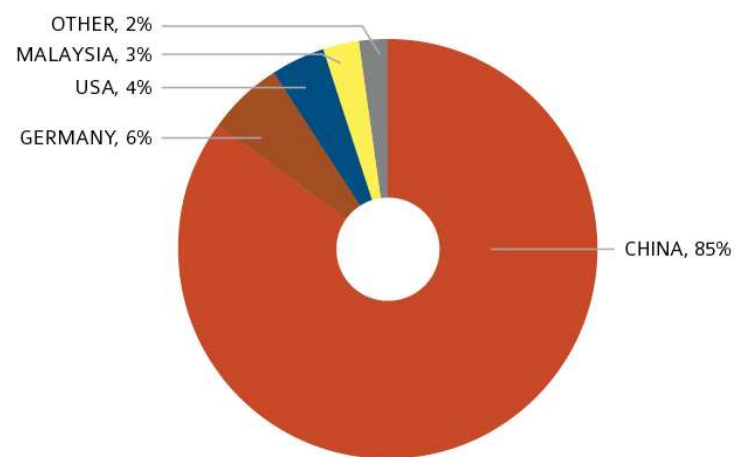


NOTE: REVISED BASED ON CPIA DATA AND RTS SURVEY

SOURCE IEA PVPS, RTS CORPORATION

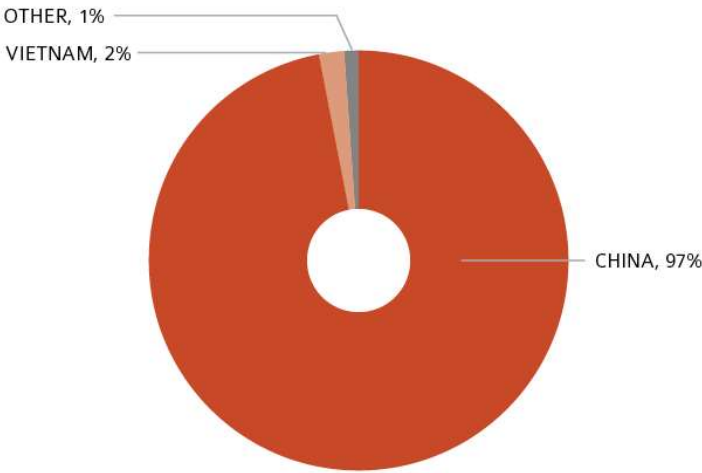
- Manufacturing capacity
 - 2023 : >800GW/year
 - 2024: 1TW/year ???

SHARE OF PV POLYSILICON PRODUCTION IN 2022



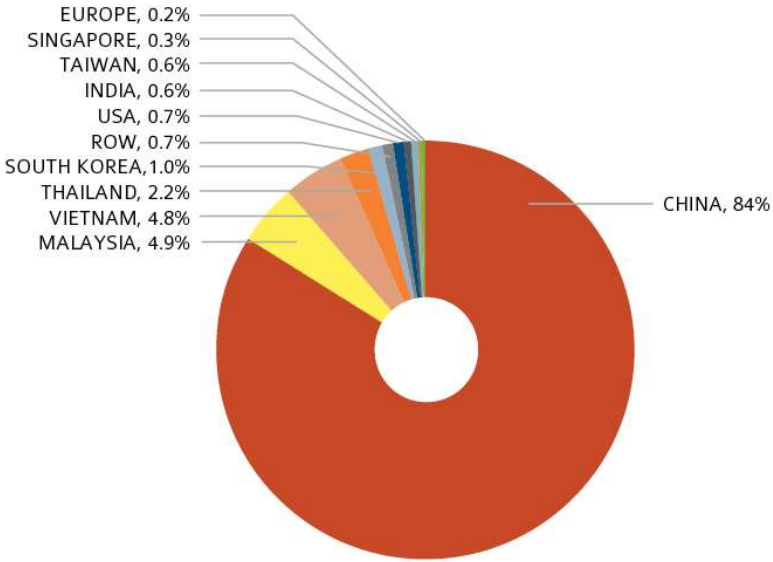
SOURCE IEA PVPS, RTS CORPORATION
* INCLUDING POLYSILICON FOR SEMICONDUCTORS

SHARE OF PV WAFER PRODUCTION IN 2022



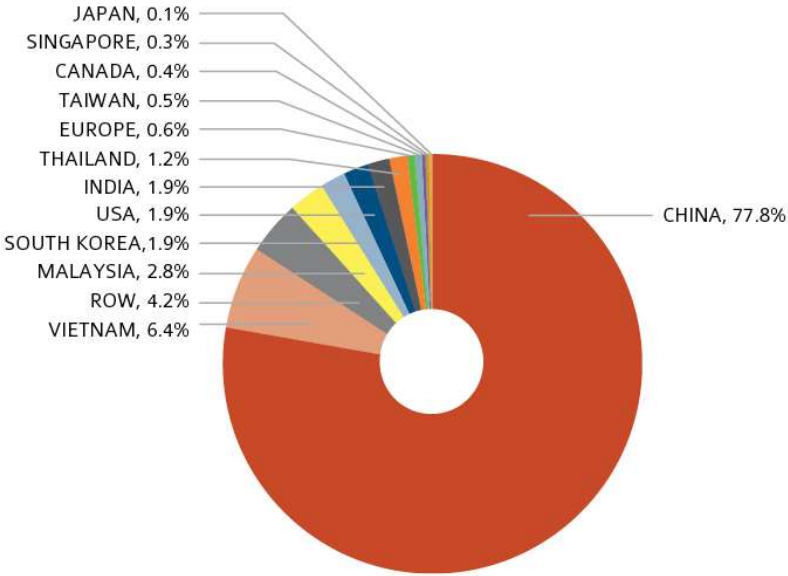
SOURCE IEA PVPS, RTS CORPORATION

SHARE OF PV CELL PRODUCTION IN 2022



SOURCE IEA PVPS, RTS CORPORATION

SHARE OF PV MODULE PRODUCTION IN 2022

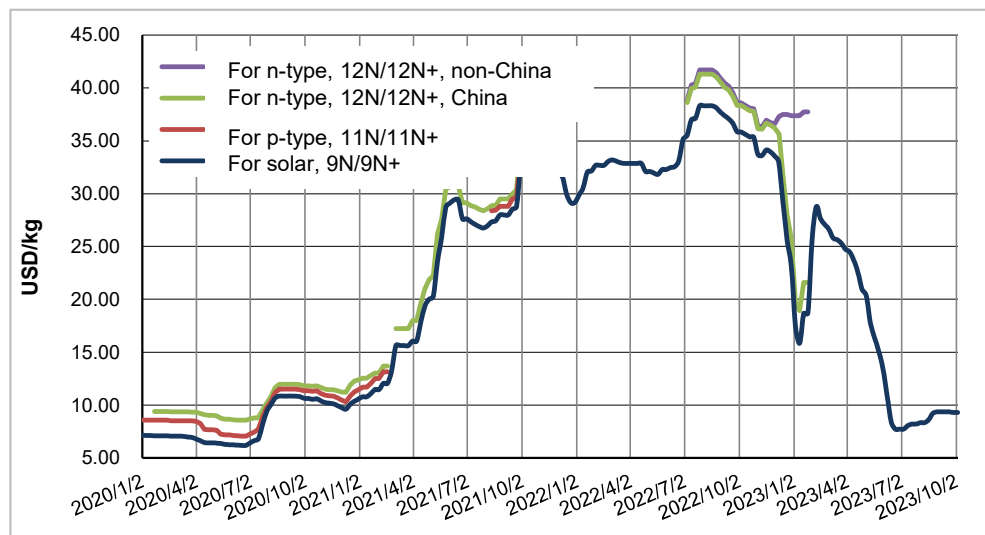


SOURCE IEA PVPS, RTS CORPORATION

Price Trends

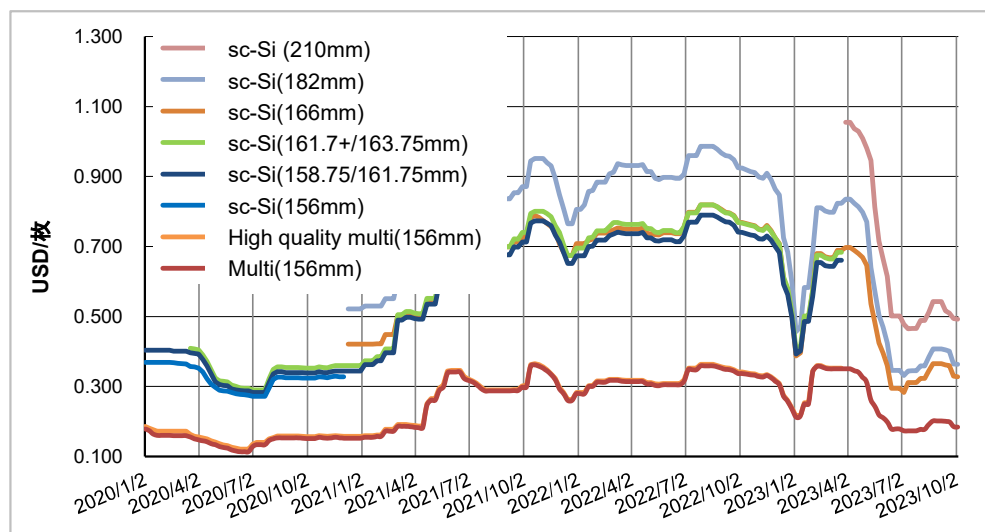
Poly spot price

- The average US dollar spot price of polysilicon has gradually increased from \$7.72/kg at the end of June to \$9.35/kg at the end of August.
- After that, the price leveled off, and at the end of September it began to trend downward due to the drop in module prices.
- Although production volume did not increase in September and there was a feeling that there was a shortage of polysilicon supply, the supply volume is expected to increase in the future.



Wafer spot price

- The average price of wafers (182mm products) fell from 40.7 US cents/wafer at the end of August to 36.4 US cents/wafer at the end of September.
- Although wafer production is increasing, wafer production is not progressing and inventory is increasing.



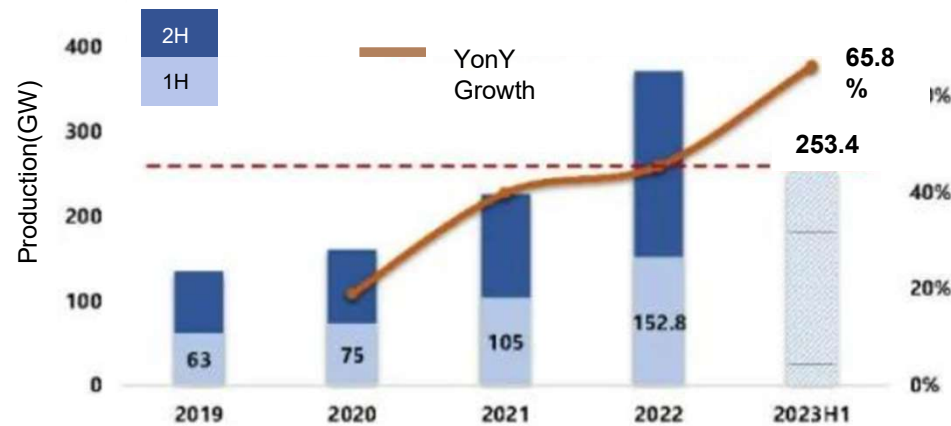
POLY PRODUCTION IN CHINA IN 1H2023



- China's polysilicon production in the first half of 2023 will be 606,000 tons, an increase of 66.1% from the previous year
- The top 5 producers have a total share of 87.1%. As of the end of July 2023, the number of companies producing polysilicon in China has increased to 15.
- Due to the sharp drop in polysilicon prices, some companies have reduced or suspended factory operations in June, but total production is increasing.
- It is estimated that China's polysilicon production in 2023 could reach 630 GW in terms of solar cell modules, and a significant oversupply is expected.

	End of 2022	2023				
		Q1	Q2	Q3E	Q4E	Total
Capacity (10,000 t/year)	116.7	+15.5	+12.5	+65	+75.5	285.2
Production (10,000t)	81.1	30.3	34.7	40	50	155
Import (10,000t)	8.8	2	1.4	1.2	1.2	5.8
Supply (10,000t)	89.9	32.3	36.1	41.2	51.2	160.8
Equivalent PV module (GW)	346	127	141	161	201	630

Wafer Production in China in 1H2023

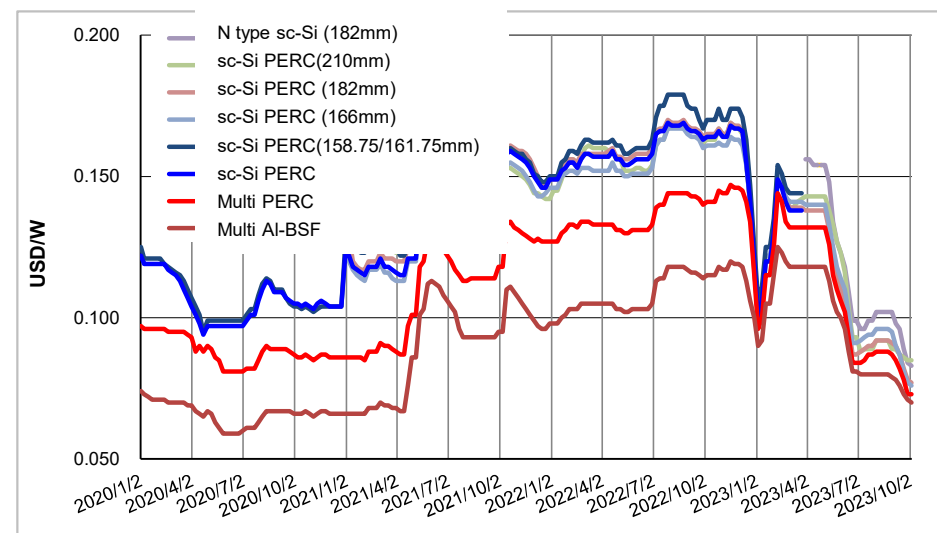


- Crystalline silicon wafer production in the first half of 2023 will be 253.4GW, an increase of 65.8% from the previous year
- Due to the sharp drop in prices, June production decreased by 5.65% from the previous month.
- Demand for n-type crystalline silicon wafers is increasing
- China's wafer production volume in July increased by 18.96% from the previous month to 53.65GW.
- Demand is increasing, and major manufacturers' operating rates are as high as 80-100%.

Price trends

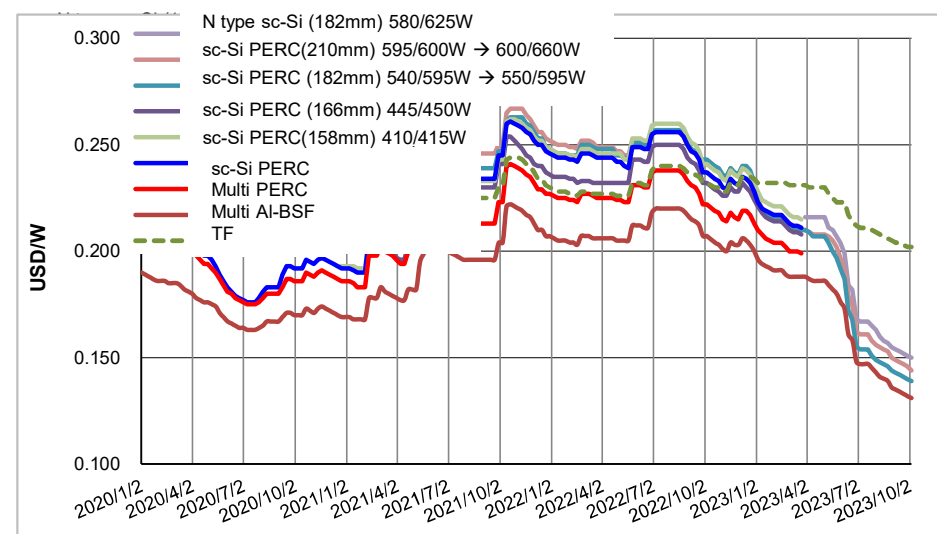
Cell spot price

- The price of monocrystalline silicon PERC (182mm product) fell from 9.1 US cents/W at the end of August to 7.8 US cents/W at the end of September.
- Cell prices also dropped due to the fall in the price of PV modules.
- It is reported that companies plan to continue operating during China's National Day, and the sense of oversupply will likely continue into October.
- Although cell production capacity for N-type products has expanded rapidly within a short period of time, end-of-line market development has not progressed, and inventories are increasing.



PV module spot price

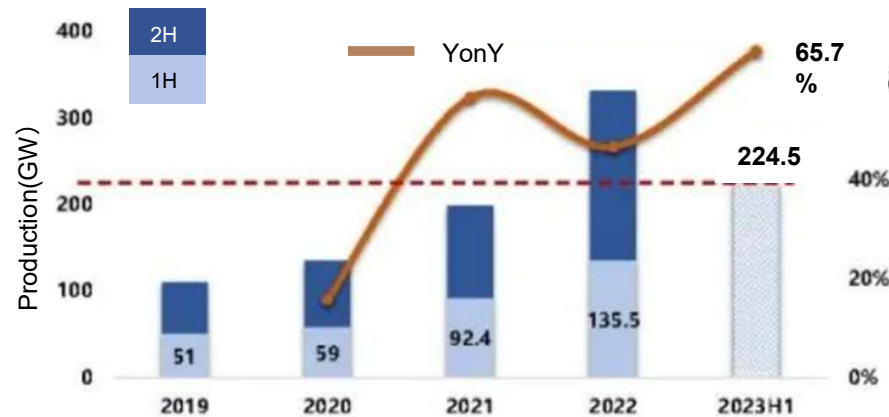
- Prices are continuing to fall, with new records being set for the lowest prices in domestic module procurement auctions in China.
- Module prices are said to have fallen to below cost levels, but as major vertically integrated manufacturers maintain low prices, small and medium-sized manufacturers are trying to avoid losses by reducing production.
- It is reported that many companies put their factories on holiday and reduce production during China's National Day.



Source : PVinsights

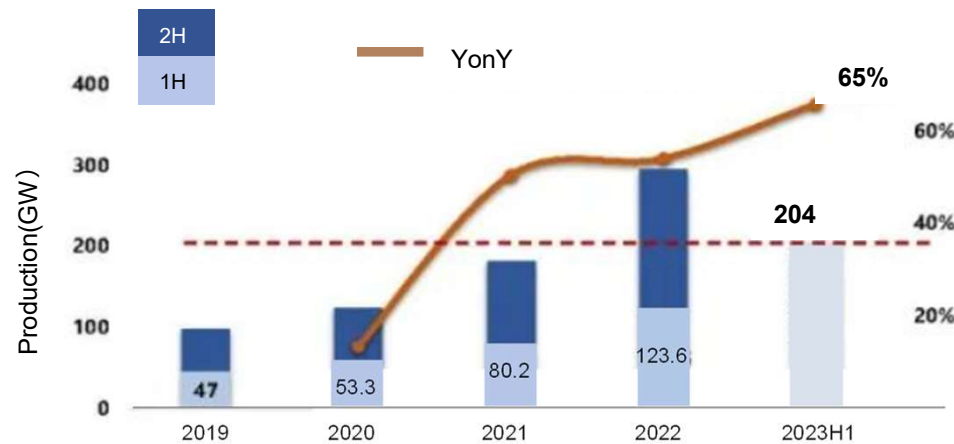
Cell and PV module production in China in 1H2023

Cell production



- China's cell production in the first half of 2023 will increase by 65.7% from the previous year to 224.5GW
- 2H production volume is usually higher in the second half of the year, further increase is expected in the second half of 2023.
- Major manufacturers are rapidly increasing the proportion of N-type products in their production capacity

PV module production



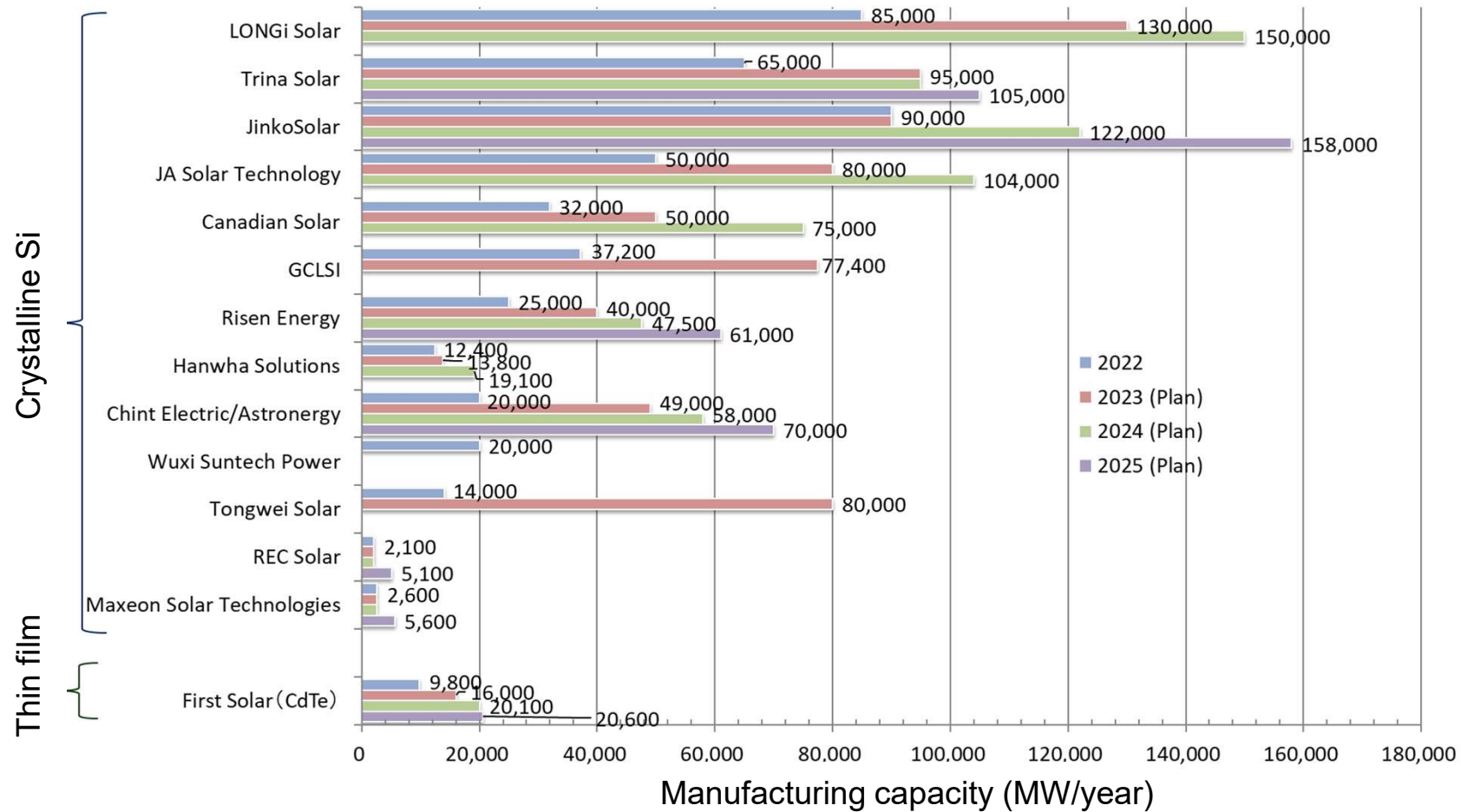
- PV module production in 1H2023, 204GW, an increase of 65% from the previous year
- Production volume is usually higher in the second half of the year, further increase is expected in the second half of 2023.

Top 10 companies of PV module shipment

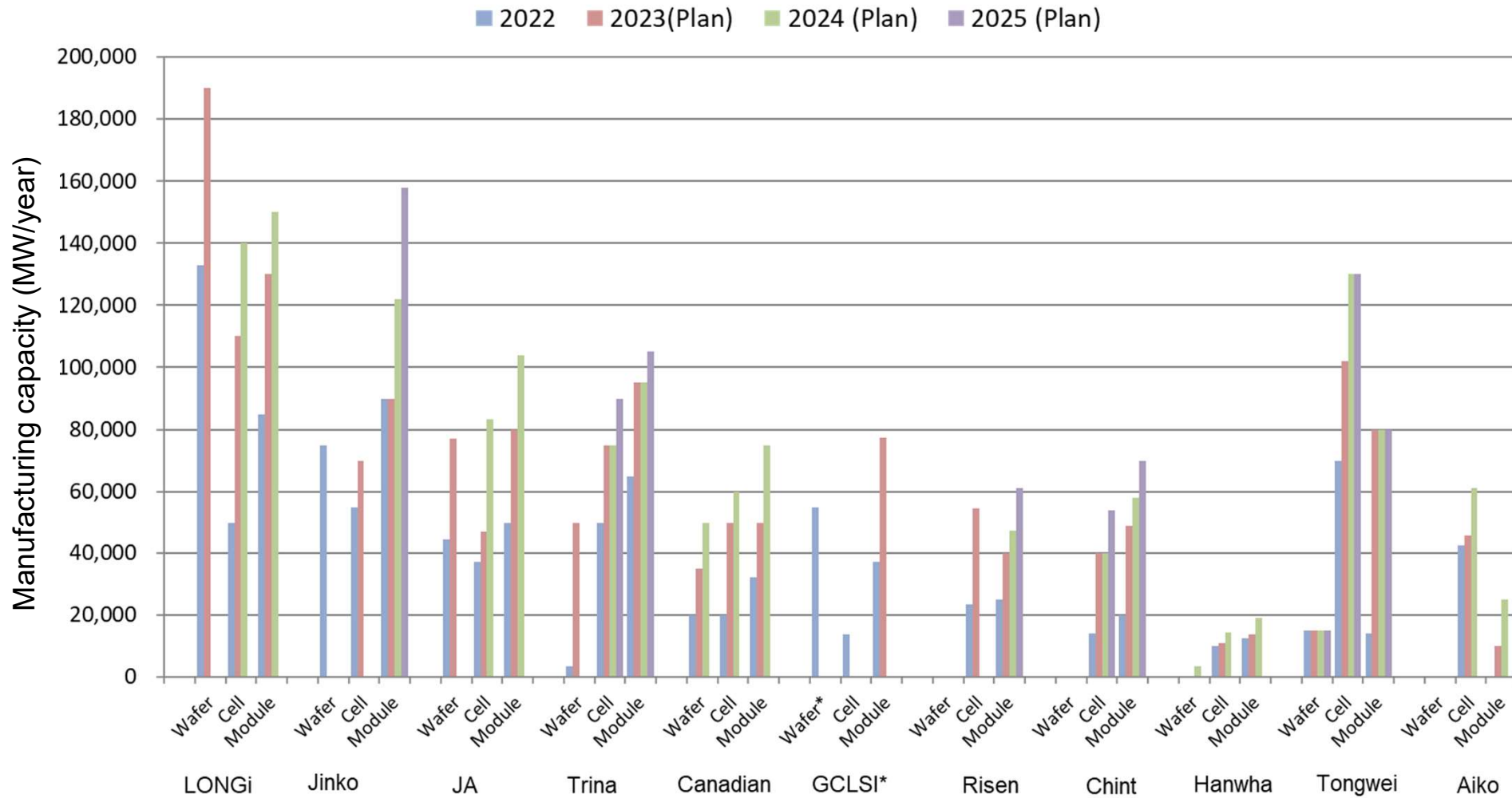
順位	1H 2023 (GW)		2022 (GW)		2021 (GW)	
1	JinkoSolar	30.8	LONGi Green Energy Technology	46.76	LONGi Green Energy Technology	38.5
2	Trina Solar	27.0	JinkoSolar	44.5	JA Solar Technology	25.5
3	LONGi Green Energy Technology	26.64	Trina Solar	43.09	Trina Solar	24.8
4	JA Solar Technology	23.95	JA Solar Technology	39.75	JinkoSolar	22.2
5	Canadian Solar	14.3	Canadian Solar	21.1	Canadian Solar	14.5
6	Tongwei Group	8.96	Risen Energy	13.5	Hanwha Solutions	約9
7	Risen Energy	8.371	Zhejiang Chint Electrics	13.5	Risen Energy	8.1
8	Zhejiang Chint Electrics	8.0	First Solar	9.3	First Solar	7.9
9	DAS Solar	7.5	Hanwha Solutions	9	Zhejiang Chint Electrics	6.3
10	First Solar	4.711	DAS Solar	8.5	Wuxi Suntech Power	4.4

Source : RTS Corporation

PV module capacity of major companies



Capacity enhancement plan by major suppliers



USA manufacturing capacity plan one year after IRA enacted

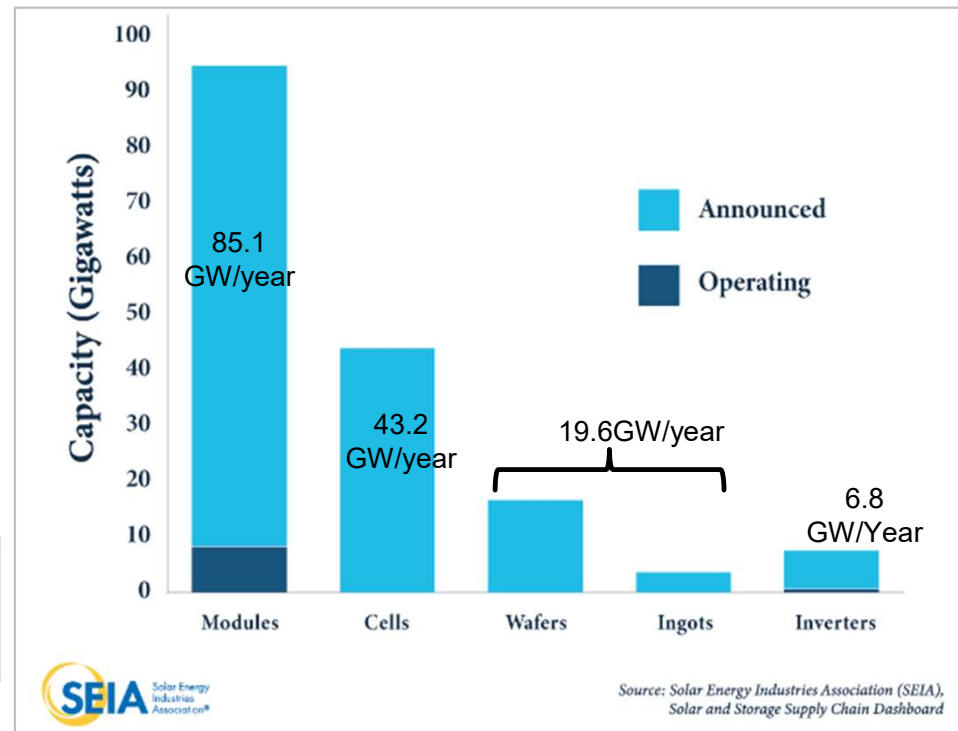
 **\$20B**
of new solar and storage
manufacturing investments

 **51**
new or expanded solar
manufacturing facilities

 **475k**
American jobs

669
gigawatts

 enough to power
every home east of
the Mississippi River



Source : SEIA, impact of the Inflation Reduction Act

<https://www.seia.org/blog/policy-prosperity-solar-supercharging-american-communities-after-one-year-energy-incentives>

Year-wise Solar Manufacturing Capacity

Year-end	Capacity based only on PLI (GW/year)				Total Capacity (GW/year)
	P	W	C	M	M
existing		0	4.3	18	
2023		0	4.3	18	
2024	0	12	16.3	30	
2025	12	40.8	52.5	69.6	
2026	24	40.8	52.5	69.6	110 *

*

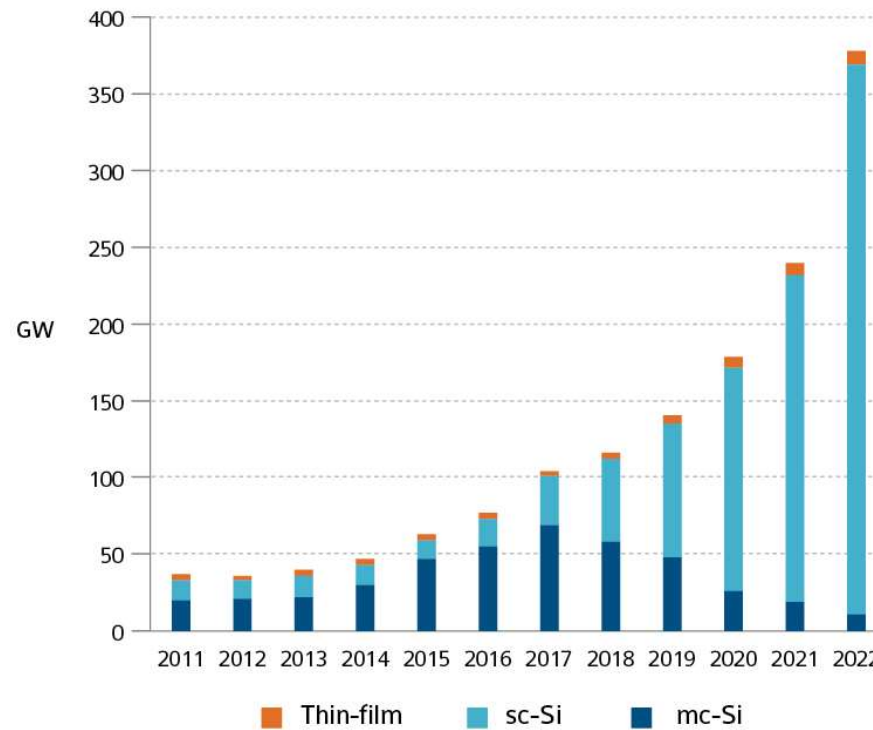
Gulia, J. et al., "India's Photovoltaic Manufacturing set to Surge," JMK Research and Analytics (2023)

Mercom, "State of Solar Manufacturing in India" (2023)

Estimate of Ministry of New and Renewable Energy (MNRE)

- Many existing solar manufacturers **who did not bid for PLI**
- With PLI and non-PLI, **module manufacturing will reach ~ 100-110* GW/year by 2026**. Caveats ...
- Since domestic requirement by 2026 will be only ~ 30 GW/year, **India will emerge as a major exporter of solar**. Quality and performance must meet global standards
- **Export potential of 60-70 GW/year by 2026-2027**

PV MODULE PRODUCTION PER TECHNOLOGY IN 2022



SOURCE IEA PVPS, RTS CORPORATION

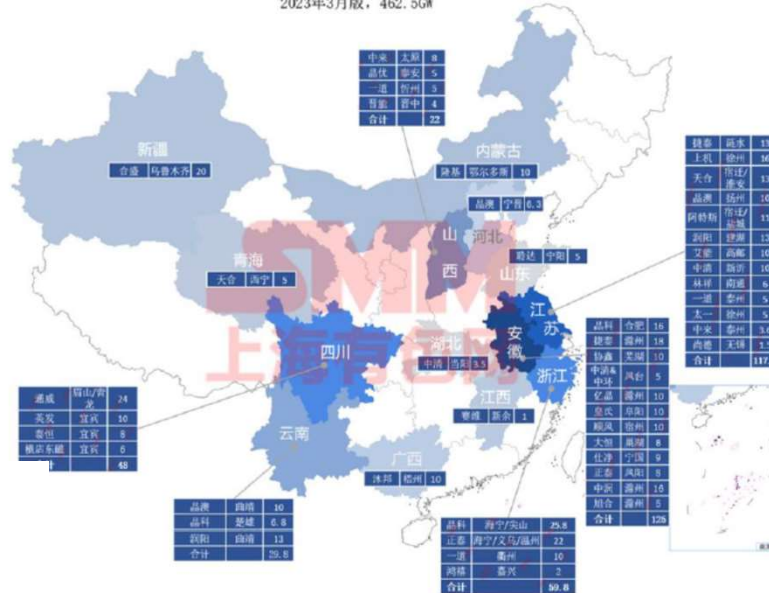
- N-type increasing.
- Share of PO and EPE encapsulants also increased

Topcon Capacity by the end of 2023 [GW]

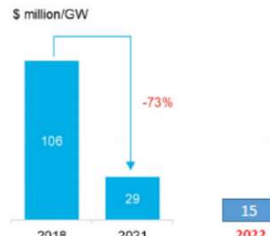


2023E年底TOPcon电池产能分布 (单位: GW)

2023年3月版, 462.5GW



Equipment cost for TOPCon cell production, per unit



Source: BloombergNEF, Jolyonov. Note: By announcement date. Equipment purchase and installation cost included. An exchange rate of \$1=7 RMB is used.

CAPEX comparison

8GW以上を公表している企業
[\$ million /GW] \$1=7 RMB

PERC	Topcon	SHJ
19-19.5	25-27	50-55

SOURCE: 总产能166GW | 2022-2023最贵硅电池产能点: 华晟、隆基、金刚、日升、明阳、爱康、华谊、设备厂商迎来巨大市场机遇 (qq.com)

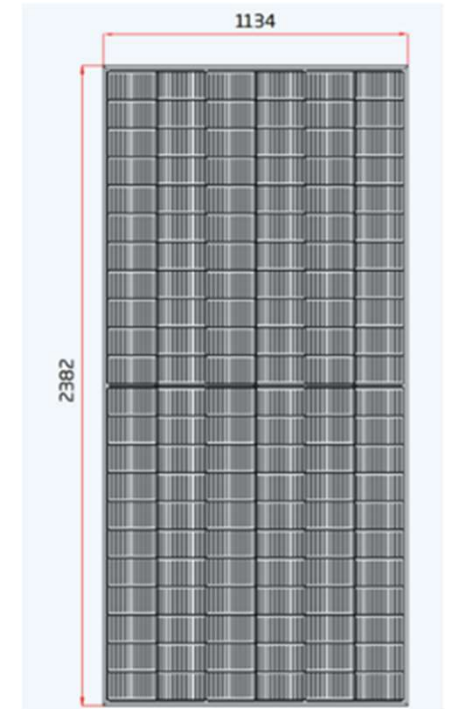
- Planned Topcon capacity in China will reach 462.5GW/year by the end of 2023
- According to SolarBe, 530GW/year of TopCon capacity and 350GW/year of HJT capacity planned (Feb. 2023)

Source: Maruwan Damurin, Toyal/ Osaka University























































<https://www.solarbeglobal.com/n-type-capacity-ramps-up-over-900-gw-announced-by-60-manufacturers/#:~:text=HJT%3A%20350%20GW,production%20capacity%2C%20totaling%20350%20GW>

Standardization of wafer size : contributing further cost reduction

- Nine major PV module manufacturing companies jointly proposed a size of “2,382 mm x 1,134 mm” for PV modules using rectangular wafers.
- This will reduce the impact of differences in module size on the supply chain such as container loading efficiency, and system cost reduction.
- It is also recommended that the hole spacing on the long side of the module be 400mm / 790mm / 1,400mm
- 9 Companies proposed this standard
 - Chint New Energy Technology (Astronergy)
 - CSI Solar, DAS Solar, JA Solar Technology
 - JinkoSolar, LONGi Green Energy Technology
 - Risen Energy, Tongwei Group, Trina Solar



Companies entering into Perovskite and Tandem technologies

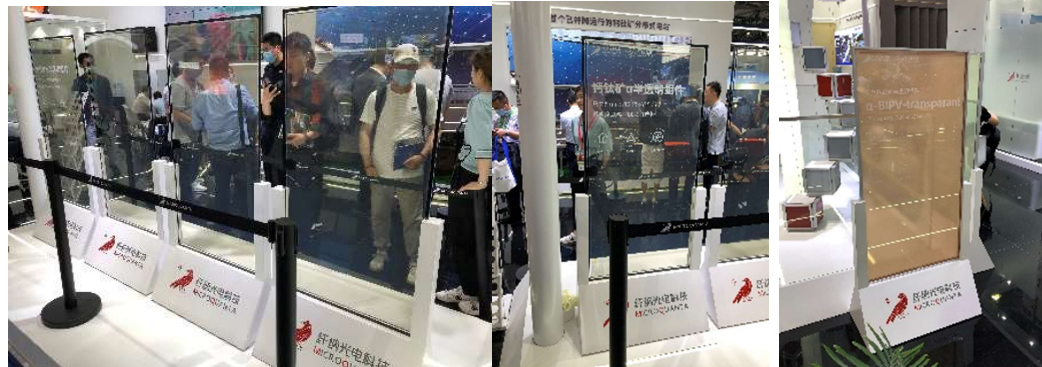
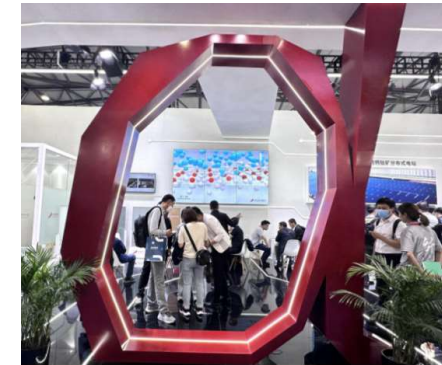
Type	Japan	EU	USA	Asia Pacific
Single junction	        	   	   <p>(1366 TechnologiesとHunt Perovskite Technologiesの合併)</p>   <p>(タンデム型向けペロブスカイト開発)</p>	    <p>(印)</p>  <p>(ブラジル)</p>   
Tandem (on Si)	   	   <p>Giga PV (?)</p>	   <p>First Solar. CdT/Sii</p> 	           <p>(カナダ・中国)</p>
Tandem (on TF)	 <p>(Solar Frontier)</p>		   	

Source : RTS Corporation

@SNEC 2023: Perovskite by Hangzhou Microquanta Semiconductor



@RTS



@RTS



写真@Hangzhou

Microquanta
Semiconductor

<https://www.microquanta.com/newsinfo/85969E45B97C0EA6/>

- World's first commercial perovskite PV module "α" (1.2m x 0.6m, 90W)
- Semi-transparent products with different transmittance and various color products
- Roof tile-integrated module 'and color patterned BIPV module ``Butterfly BIPV Series.'"

@SNEC: Perovskite PV modules at GCL booth



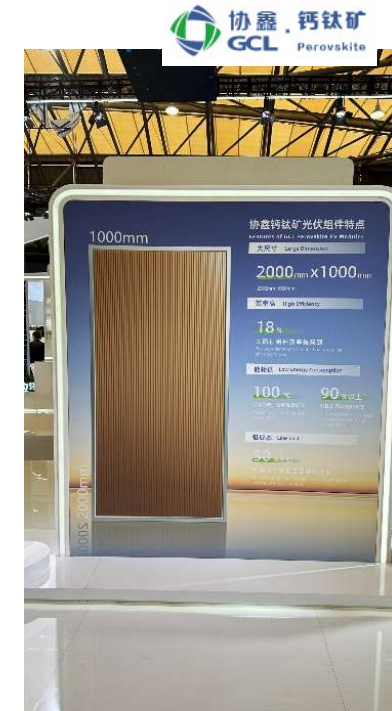
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@CINNO Research
<https://c.m.163.com/news/a/I5RU0Q8E0511CS15.html?referFrom=>



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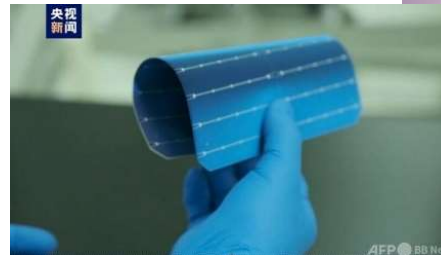


写真@RTS

- 1m×2m PV module (efficiency 18%, ~half of production cost in comparison with Si)
- Semi-transparent and colored modules were displayed

Light-weight and flexible crystalline Si

- Semi-flexible PV modules are commercialized by several manufacturers



- Flexible product developed by Shanghai Institute of Microsystems and Information Technology (SIMIT), Chinese Academy of Sciences (May 2023)
- Developed a processing method to smooth the edges of silicon wafers. By changing the microstructure and mechanical properties of the edge, the wafer has been improved to increase flexibility without affecting its light absorption ability \Rightarrow Thinner to 50 to 60 μm thick

<https://www.nature.com/articles/s41586-023-05921-z>

Sunman

Theft of Cu cables reported

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SUNGROW

RE100EP100

No.1

THE WORLD'S MOST

No.1 bankable for 4 con

The only inverter suppli

Weekend read: ‘Solar crime’ on the rise

With copper prices rising, inflation driving up the cost of living, and organized criminal gangs stepping up operations in the United Kingdom and across Europe, solar project owners need to be more conscious than ever of security.

APRIL 15, 2023 MAX HALL

UTILITY SCALE PV EUROPE GERMANY UNITED KINGDOM



smart-energy.com/industry-sectors/energy-grid-management/cable-theft-a-growing-problem-around-the-world/

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Energy & Grid Management

Cable theft: A growing problem around the world

Shenzhen ClouMay 31, 2023

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The issue of cable theft continues to plague utilities, telecommunications and the transportation industry, with the German railway system being the latest victim.

At the Enlit Africa event in South Africa in May 2023, I seized the opportunity to engage with industry leaders and discuss strategies for preventing cable theft. The exchange of ideas and collaboration among attendees at the conference served as a valuable platform for progress in combatting cable theft and

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abc.net.au/news/2023-05-19/copper-theft-telcos-power-infrastructure-damage-danger-alert/102362744

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Copper thieves target telcos, transport, power infrastructure causing \$400,000 damage

ABC Central Victoria / By Shannon Schubert

Posted Fri 19 May 2023 at 9:44am

Cable theft refers to the act of stealing telecommunications networks and other metals, which has led to rising costs for consumers.

The types of cables targeted by thieves are copper or other valuable metals. They are often used by smelters or exporters.

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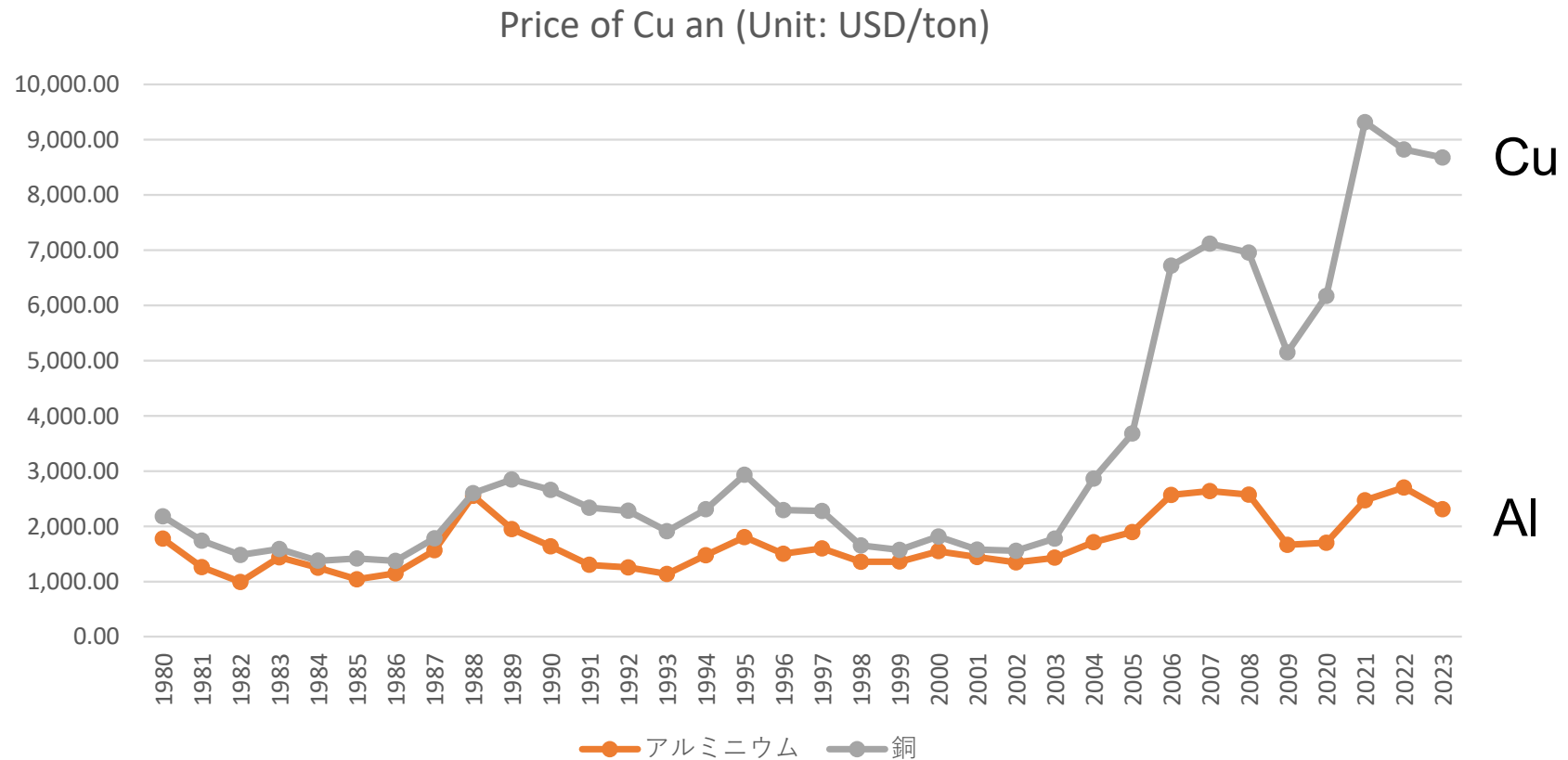
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Al cables could be good replacement



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ご清聴ありがとうございました

Acknowledgement for the support of PVPS activities



New Energy and Industrial Technology
Development Organization

Contact : Izumi KAIZUKA, RTS Corporation, kaizuka@rts-pv.com