



Trends of PV industry

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Technology Collaboration Programme
by **iea**

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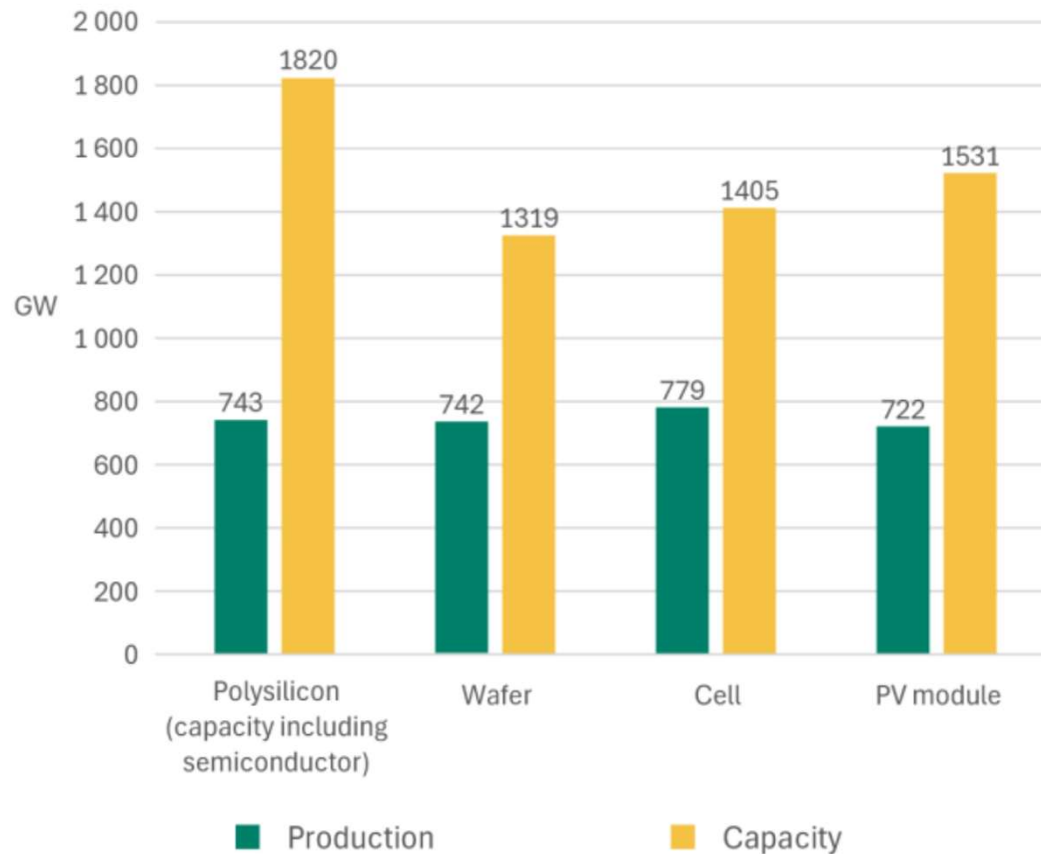
Methodology since 2012



- RTS, a consultancy in Tokyo, established in 1983, responsible for industry analysis of Trends since 2012
- RTS Conducted primary survey for production amount and production capacity with global partners
- Task 1 experts and supplementary information from industry associations also contribute the analysis



Production amount and manufacturing capacity



Source Trends Report 2026

- Production capacity along the value chain is ready for **TW/year production**.
- **Manufacturing location diversified.** USA and India increased PV module manufacturing capacity followed by cell capacity. Still dominance of China will continue
- Low level or minus revenue from PV module manufacturing and new high level standard in China (**GB**) might accelerate industry reorganization in China

PV Supply Chain and share by country



Wafer

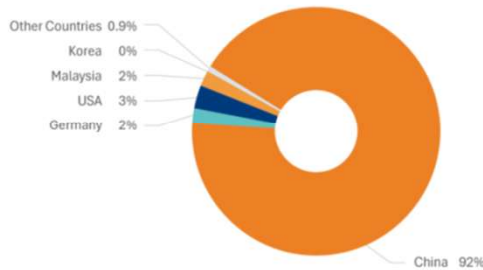


Cell



PV Module

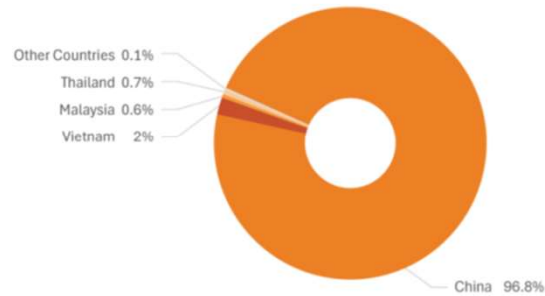
FIGURE 4.4: SHARE OF PV POLYSILICON* PRODUCTION BY COUNTRY IN 2025



* Including polysilicon for semiconductors

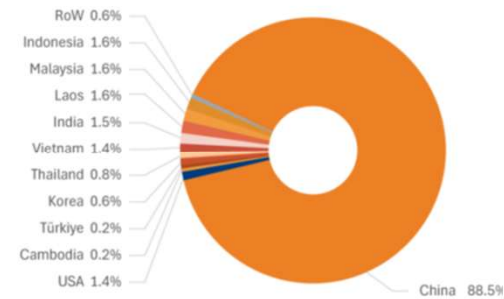
SOURCE: IEA PVPS, RTS CORPORATION

FIGURE 4.6: SHARE OF PV WAFER PRODUCTION BY COUNTRY IN 2025



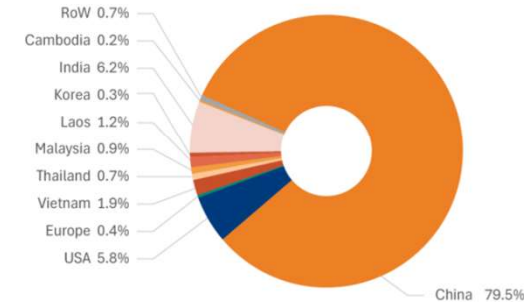
SOURCE: IEA PVPS, RTS CORPORATION

FIGURE 4.8: SHARE OF PV CELL PRODUCTION BY MAJOR COUNTRIES IN 2025



SOURCE: IEA PVPS, RTS CORPORATION

FIGURE 4.10: SHARE OF PV MODULE PRODUCTION BY COUNTRY IN 2025



SOURCE: IEA PVPS, RTS CORPORATION

Share of China

2023: 92%
2024: 94%
2025: 92%

2023: 98.1%
2024: 96.5%
2025: 96.8%

2023: 92%
2024: 90%
2025: 88.5%

2023: 84.6%
2024: 86%
2025: 79.5%

PVPS

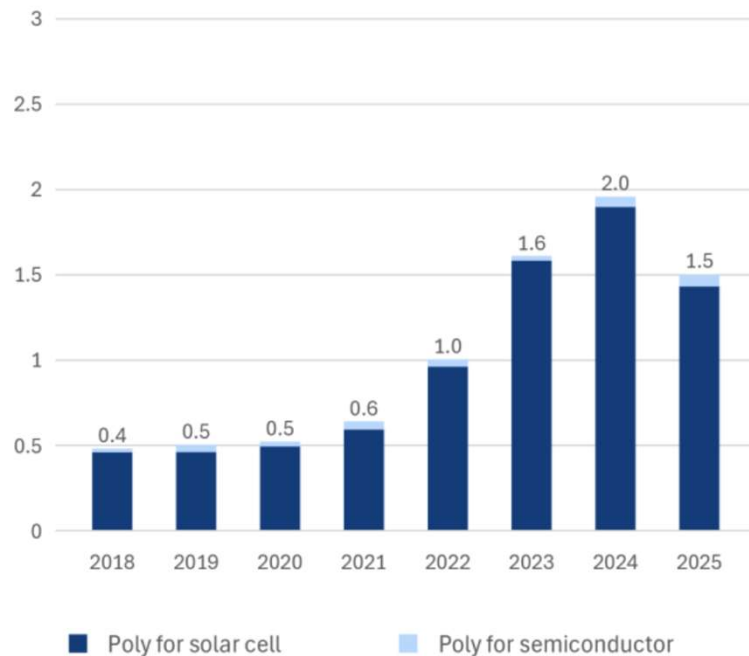
- Chinese dominance has not changed but production bases is being diversified especially in PV module production, following by cell production
- Inverters, materials such as glass, encapsulants, equipment also China dominates
- Trade barriers and measures for local manufacturing and security issues contribute diversification of production sites

Source : IEA PVPS, Trends Report 2026

Polysilicon production trends

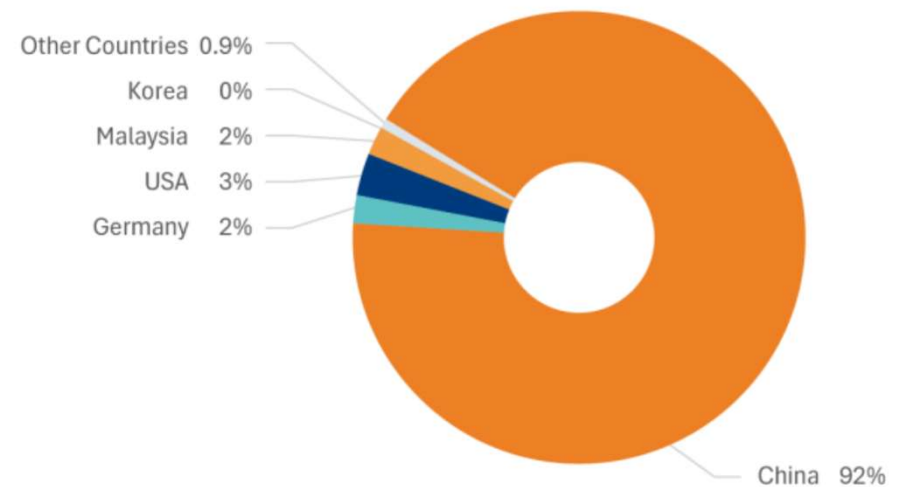


FIGURE 4.3: GLOBAL POLYSILICON PRODUCTION
(IN MILLION TONS)



SOURCE: IEA PVPS, RTS CORPORATION

FIGURE 4.4: SHARE OF PV POLYSILICON* PRODUCTION
BY COUNTRY IN 2025

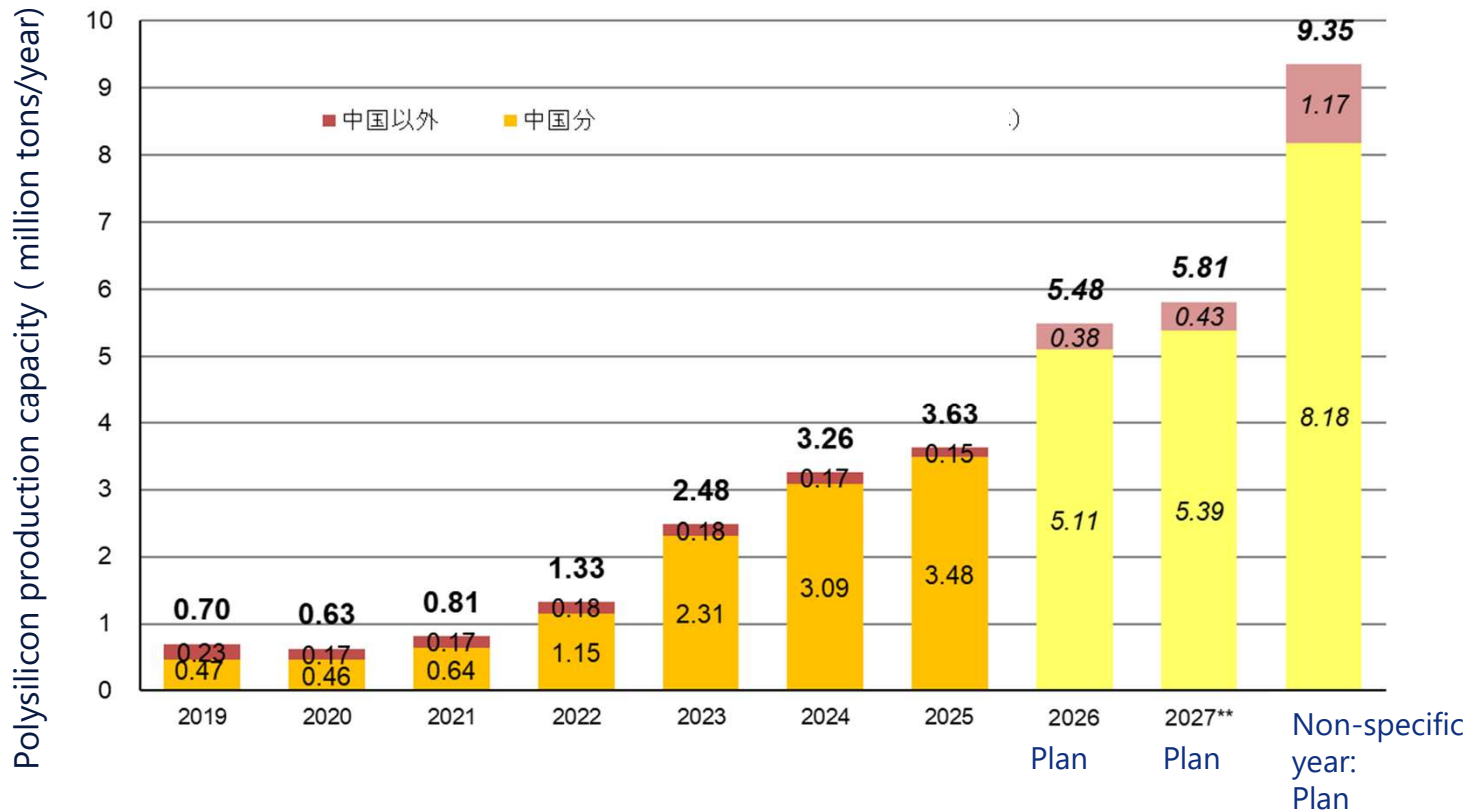


* Including polysilicon for semiconductors

SOURCE: IEA PVPS, RTS CORPORATION

- Production in 2025 was 1.5 million tons, decreased – 24% due to addressing over supply issues by Chinese manufacturers

Production capacity by location



PVPS

- Current status of manufacturing capacity is below planned capacity. Enhancement slowed down in China
- New polysilicon production initiatives have been reported in India, Oman, Morocco, the USA, Europe, and Australia, supported by industrial policies aimed at strengthening domestic PV supply chains. Dominance of China remains to continue

GB of Energy Consumption of PolySi manufacturing



- GB is Chinese mandatory standard for PV manufacturing
- Products are classified into 3 grades
 - Grade 1: Industry target; advanced standard
 - Grade 2: Minimum standard to be met when constructing a new factory
 - Grade 3: Minimum standard to be met by existing factories
- From January 1, 2027, onwards, the sale of products falling below the Grade 3 standard will be prohibited.

Maximum energy consumption per unit (Unit: Coal equivalent Kg (kgce) /kg)

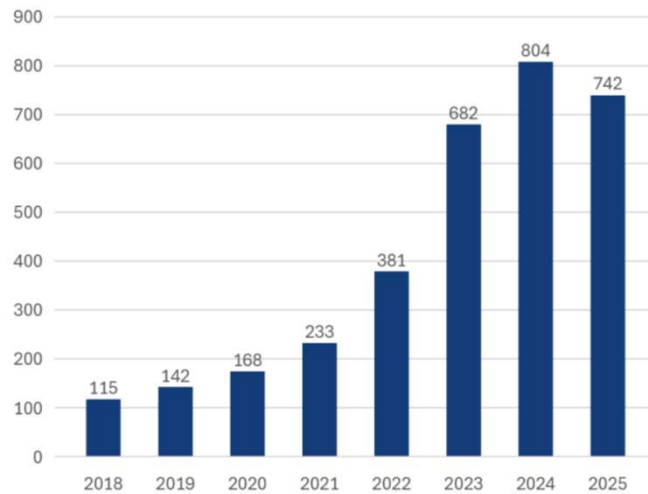
Manufacturing process	Grade1		Grade2		Grade3	
	Current standard	Final standard	Current standard	Final standard	Current standard	Final standard
Trichlorosilane process	7.5	5.0	8.5	5.5	10.5	6.3
FBR process	-	3.6	-	4.0	-	4.6

- 2025 Average energy consumption was 6.8 kgce/kg
→ producers can not meet Grade 3 may leave the market

Wafer Production trends

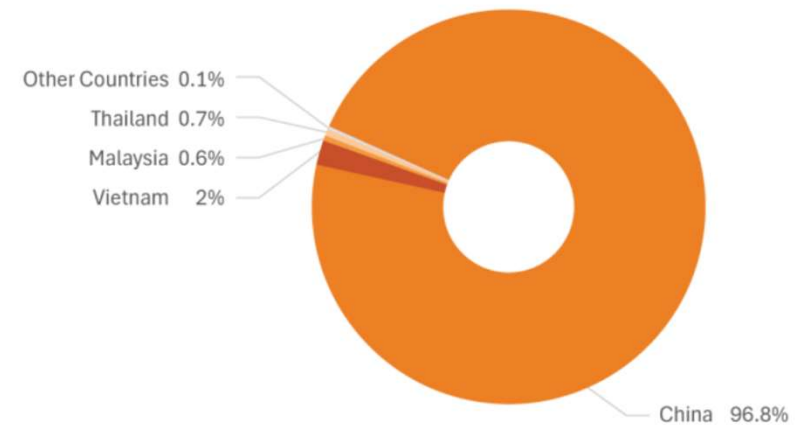


FIGURE 4.5: GLOBAL WAFER PRODUCTION
(IN GW)



SOURCE: IEA PVPS, RTS CORPORATION

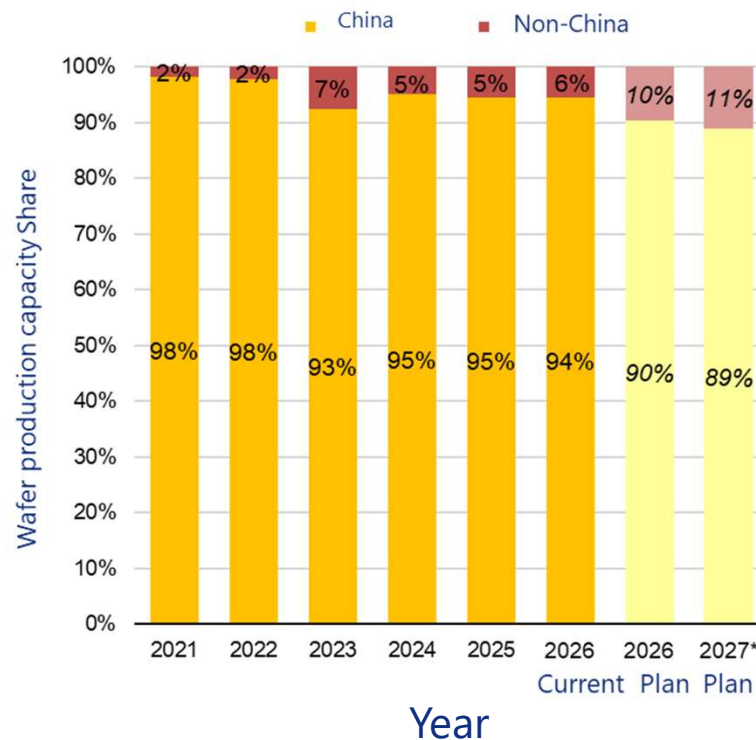
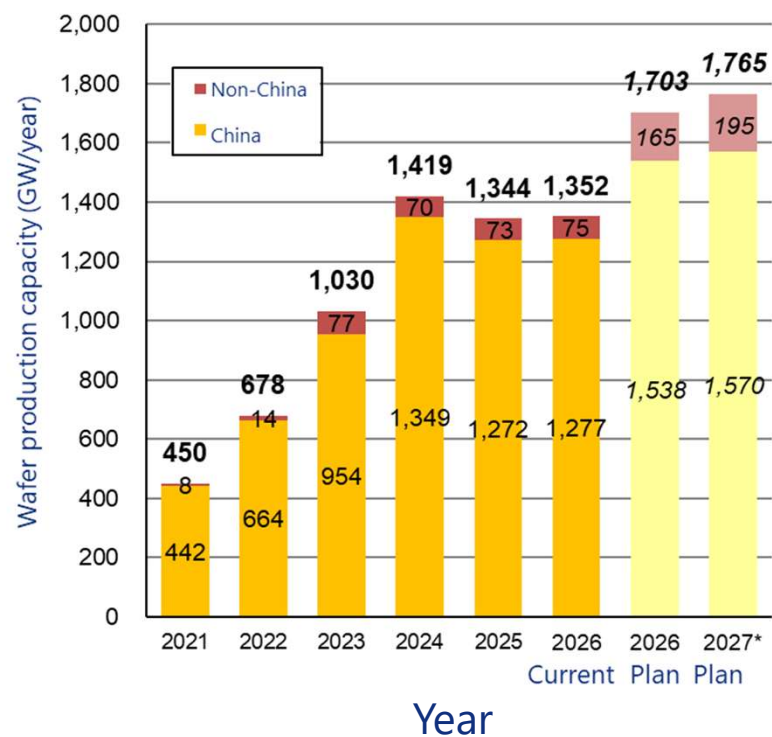
FIGURE 4.6: SHARE OF PV WAFER PRODUCTION
BY COUNTRY IN 2025



SOURCE: IEA PVPS, RTS CORPORATION

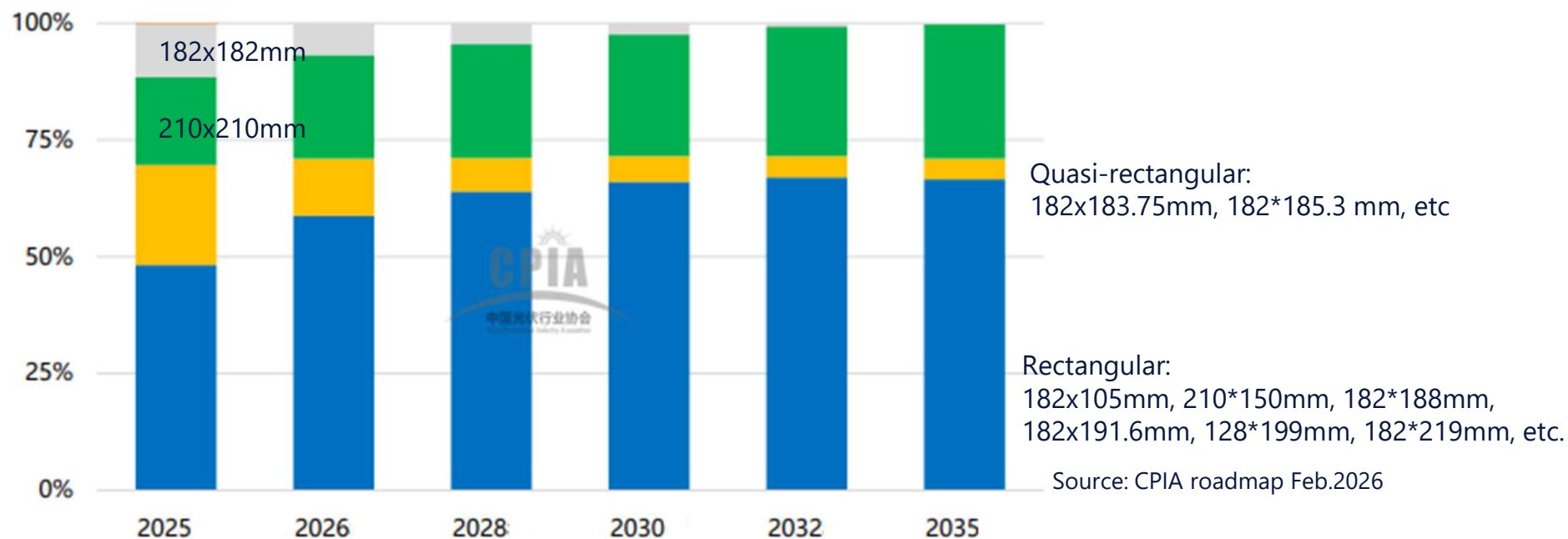
- Wafer production also declined, falling from 804 GW in 2024 to 742 GW in 2025, a year-on-year decrease of approximately 7.6%.
- In the USA, Corning commenced operations at a crystalline silicon ingot and wafer manufacturing facility in the third quarter of 2025. Additionally, Qcells, a subsidiary of Hanwha Solutions (Korea), is establishing a vertically integrated plant in Cartersville, Georgia.
- N-type wafer is the majority of the market. For space application
- P-type is still used because of excellent radiation resistant for space application

Wafer production capacity



- Pace of production capacity enhancement in China slowed down
- Current capacity is almost the same as 2025, smaller than the planned
- However dominance of China remains to continue. New GB may reduce Chinese capacity.

Wafer sizes goes larger and rectangular in different sizes



- Different sizes of wafers:
 - ✓ Rectangular wafers has expanded rapidly, reaching 48% in 2025.
 - ✓ M10 wafers (182 mm × 182 mm) was approximately 11%
 - ✓ G10 wafers (182 mm × 182 mm) accounted for around 19%
 - ✓ G12 wafers (210 mm × 210 mm) for approximately 21%
 - ✓ M6 (166 mm × 166 mm) wafers fell to below 1%.

GB of energy consumption of sc-Si wafer



Sc-Si wafer	Grade 1	Grade 2	Grade 3
Energy consumption (Unit : kgce/1 million pieces)	Draft: 6,760 Final : 5,900	Draft: 7,370 Final: 7,005	Draft: 9,590 Final: 9,590

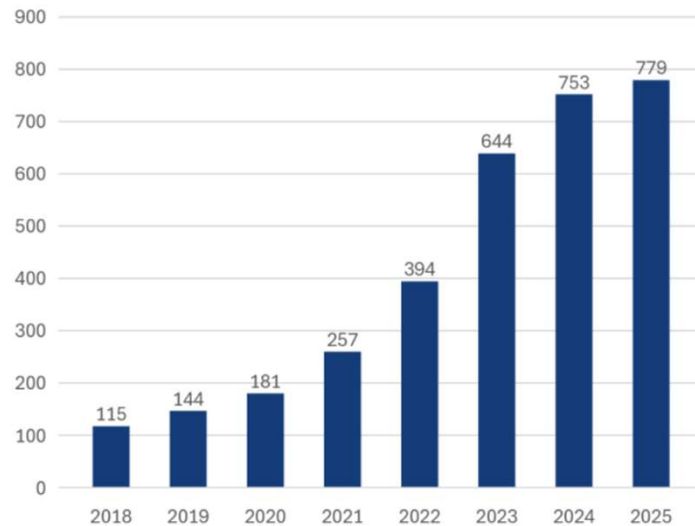
*Based on 182 mm × 210 mm wafer. Factors are used for other sizes, calculating standard value ÷ (182 mm × 210 mm)

- Assumed average consumption in 2024 : 9,704 kgce / 1 million pieces
- Only companies with efficiency operation can keep the capacity → inefficient factory may stop operation

Solar cell production trends

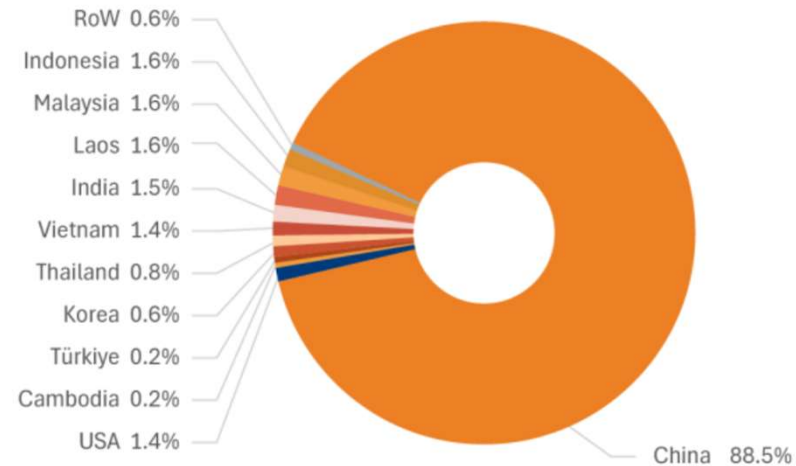


FIGURE 4.7: GLOBAL PRODUCTION AMOUNT OF SOLAR CELL INCLUDING THIN-FILM (IN GW)



SOURCE: IEA PVPS, RTS CORPORATION

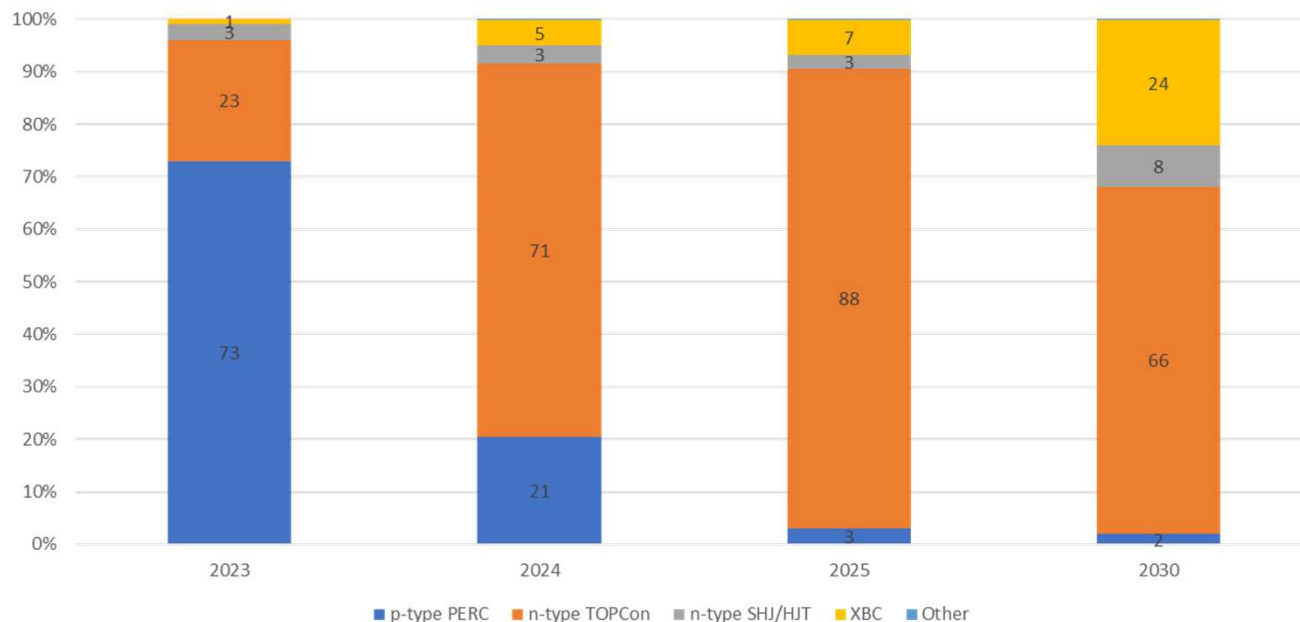
FIGURE 4.8: SHARE OF PV CELL PRODUCTION BY MAJOR COUNTRIES IN 2025



SOURCE: IEA PVPS, RTS CORPORATION

- Global solar cell production increased by approximately 3.5% year-on-year, reaching 779 GW in 2025 with 1,405 GW/year of manufacturing capacity
- Manufacturing location is diversified but still China dominates
 - USA established ~3.2 GW/year capacity in 2025. >20 GW/year addition planned
 - India established ~30 GW/year. >100GW/year addition planned by 2028

Technology Trends (updated)



- In 2023, major technology was PERC. Since 2024 Topcon took over the majority but p-type remains for space application because of its radiation resistance. Also USA manufacturers selected p-type technologies to avoid IP infringement
- Share of HJT and XBC (back contact technologies) are gradually increasing
- Production capacity as of the end of 2025 (estimated by RTS)
- TOPCon : 988 GW/year, HJT : 100 -150 GW/year, XBC: 70 GW/year

Top solar cell producers and module producers



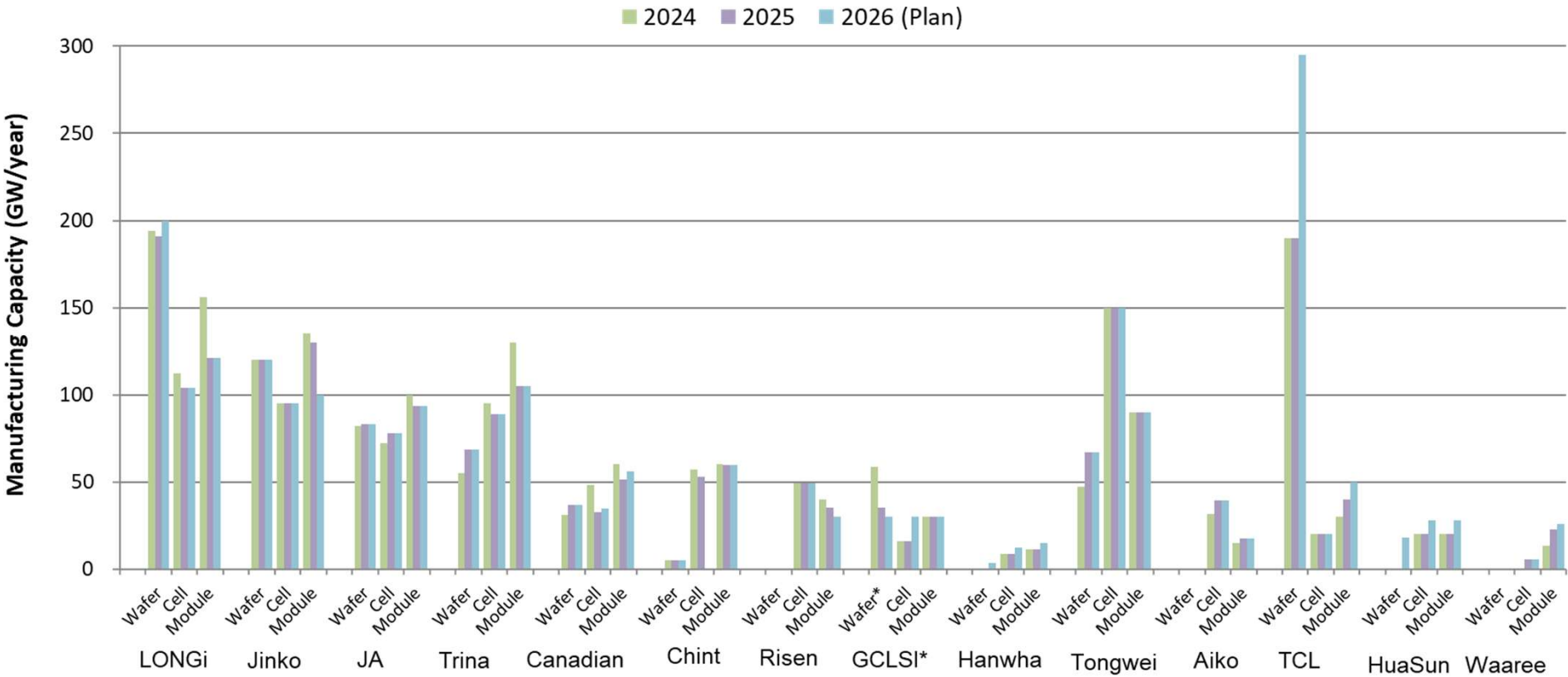
TABLE 4.1: GLOBAL TOP FIVE MANUFACTURERS (BRANDS) IN TERMS OF PV CELL/MODULE PRODUCTION AND SHIPMENT VOLUME (2025)

Rank	Solar cell production (GW)		PV module production (GW)		PV module shipment (GW)	
1	Tongwei Solar	102.4	JinkoSolar	83.8	JinkoSolar	86.8
2	JinkoSolar	83.4	LONGi Green Energy Technology	72.6	LONGi Green Energy Technology	86.6
3	Trina Solar	68.8	Trina Solar	69.5	Trina Solar	67.9
4	LONGi Green Energy Technology	59.8	JA Solar Technology	65.8	JA Solar Technology	66.7
5	JA Solar Technology	53.8	Tongwei Solar	44.9	Tongwei Solar	43.3
NOTE: Production volumes are manufacturers' own production, whereas shipment volumes include commissioned production and OEM procurement						

SOURCE: RTS CORPORATION

Source : IEA PVPS, Trends Report 2026

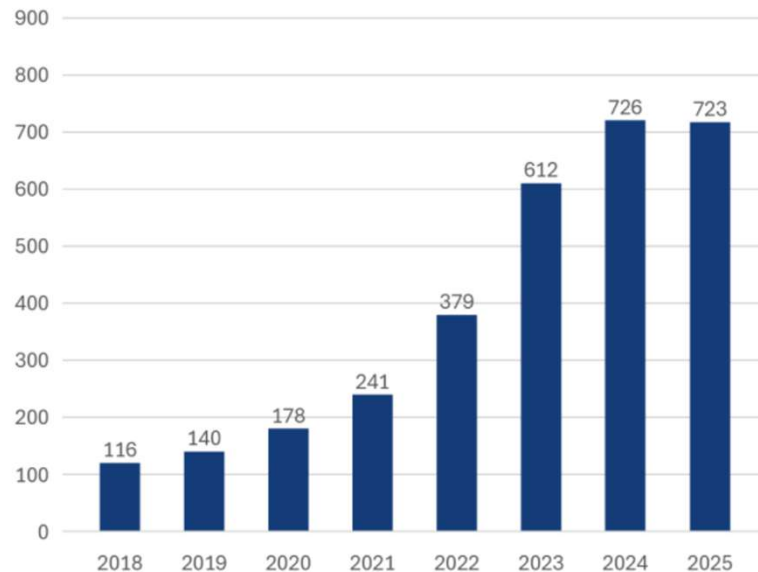
Production capacity of major companies along the value chain



PV module production trends

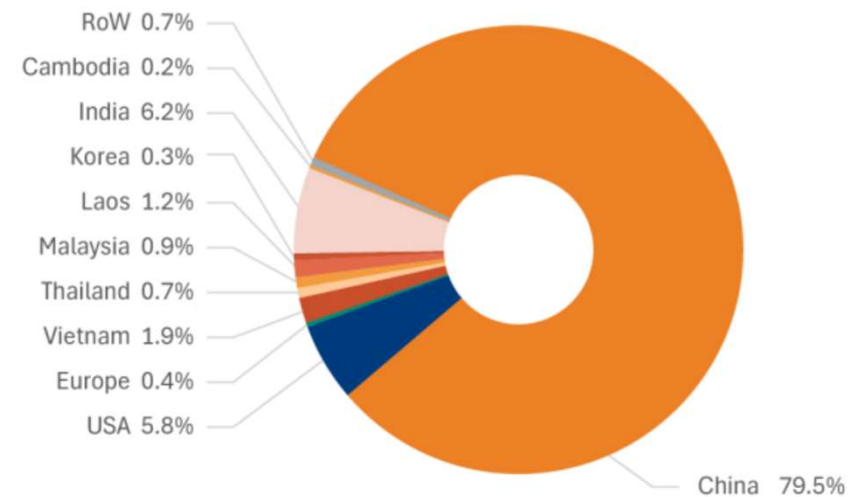


FIGURE 4.9: GLOBAL PV MODULE PRODUCTION
(IN GW)



SOURCE: IEA PVPS, RTS CORPORATION

FIGURE 4.10: SHARE OF PV MODULE PRODUCTION
BY COUNTRY IN 2025



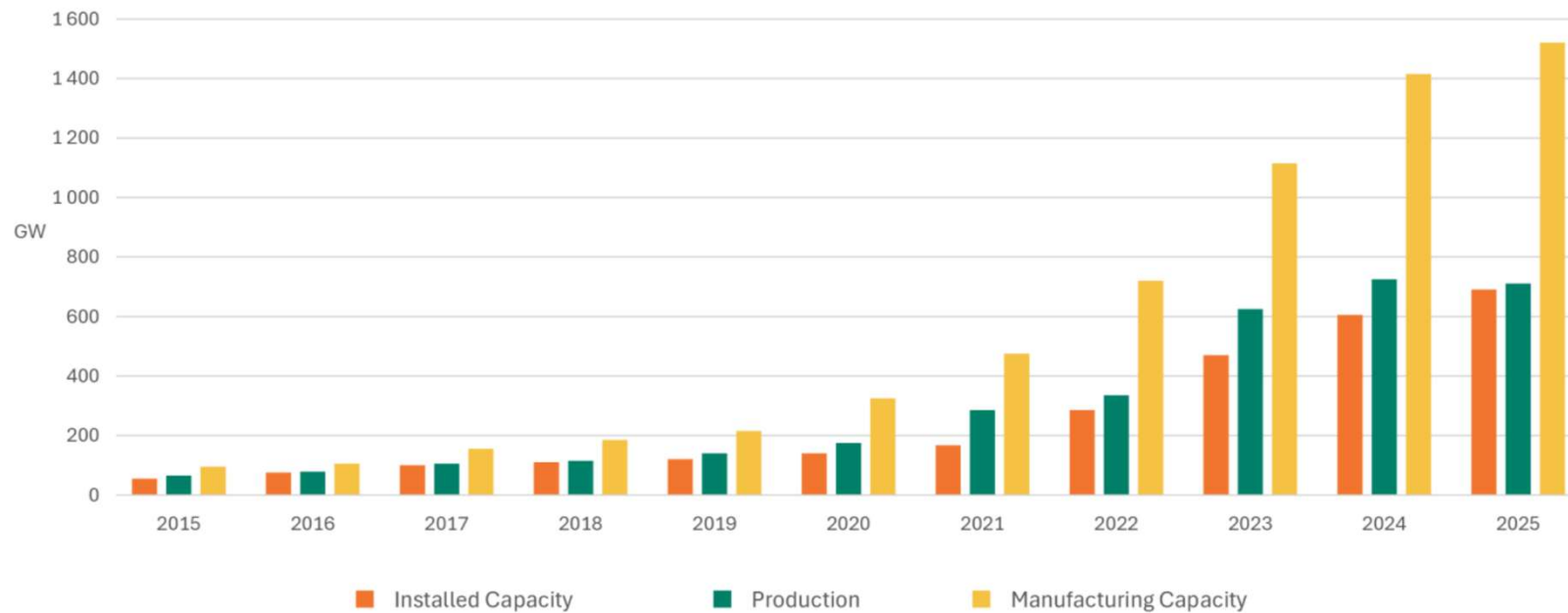
SOURCE: IEA PVPS, RTS CORPORATION

- Global production of solar modules (including crystalline silicon and thin-film technologies) in 2024 was 726 GW, up 19% from the previous year; the growth rate from 2022 to 2023 was 62%
- China produced 627 GW (86%).
- Other countries: India produced 24 GW, the United States 23 GW, Vietnam about 20 GW, Thailand about 10 GW, and Malaysia about 7 GW in 2024

Installation, PV module production and capacity

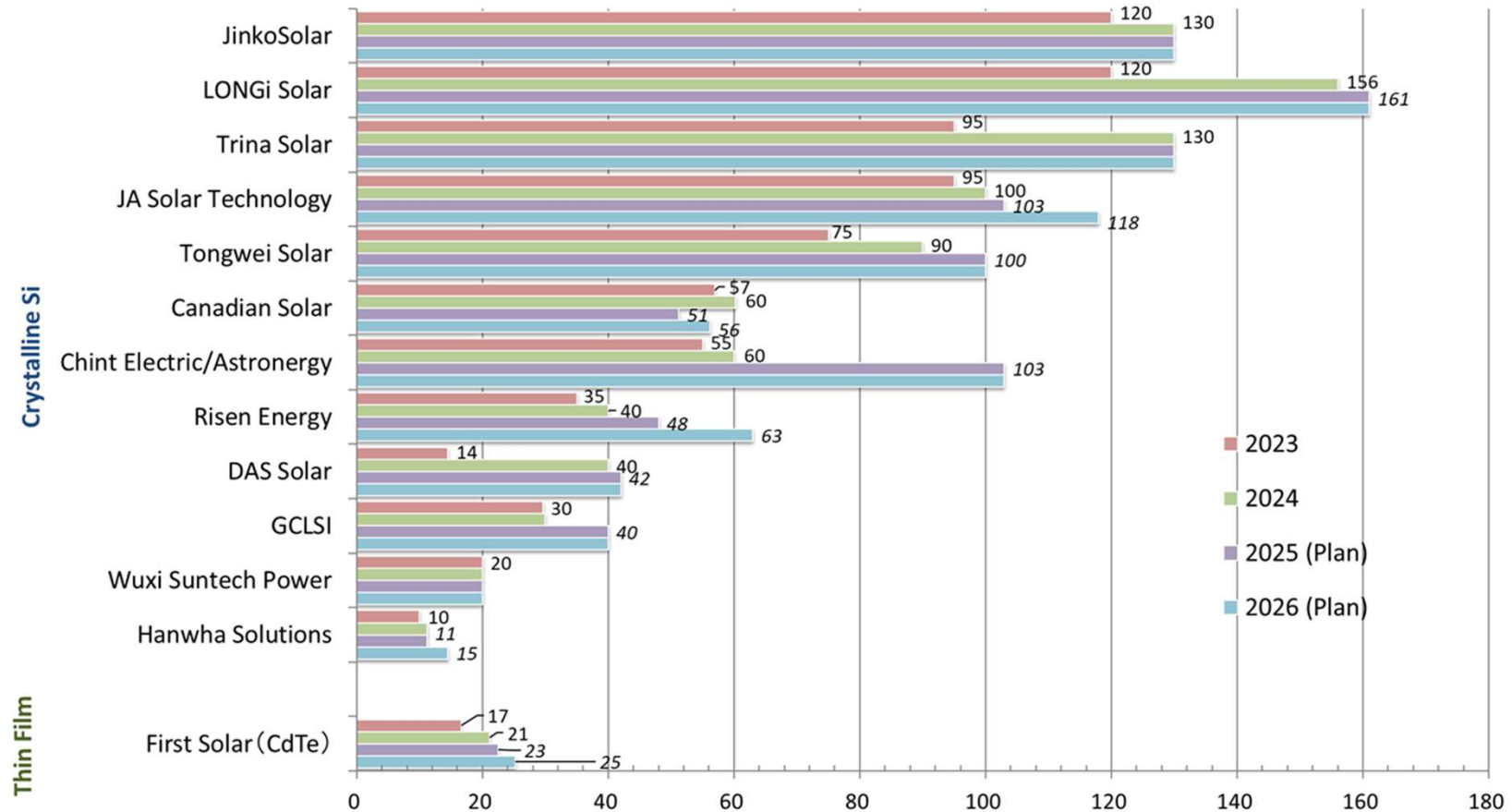


FIGURE 4.1: YEARLY PV INSTALLATION, PV PRODUCTION AND PRODUCTION CAPACITY 2015-2025



- Capacity enhancement is slowing down in China. Active in USA, India and more diversified locations

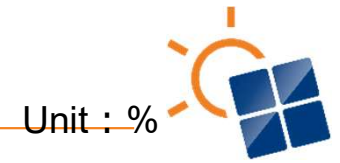
Manufacturing capacity of major PV module manufacturers



PVPS

- Most of Chinese major manufacturers are now quiet about enhancement.

GB of PV module efficiency



Minimum value of PV module performance (BIPV, Perovskite/Tandem are exception) efficiency standard

Product	Grade 1	Grade 2	Grade 3
	Efficiency(%)	Efficiency(%)	Efficiency(%)
TOPCon PV module	≥ 24.0	≥ 23.7	≥ 23.2
HJT PV module	≥ 23.8	≥ 23.5	≥ 23.2
BC PV module	≥ 24.2	≥ 23.9	≥ 23.5

- In case of TOPCon, minimum output is 630 W (2025 Average was 630 W)
- It is reported that 30% of manufacturing capacity would decrease
- Before the enforcement, Jan 2027, companies reorganize product portfolios and carry out inventory clearance
- If the manufacturing capacity would decrease, price might increase

Top 10 PV module shipment companies 1H2026, 2025 and 2024



	1H 2026 (GW)		2025 (GW)		2024 (GW)	
1	LONGi Green Energy Technology	29.93	JinkoSolar	86.8	JinkoSolar	92.9
2	JinkoSolar	29.66	LONGi Green Energy Technology	86.58	LONGi Green Energy Technology	75.8
3	Trina Solar	25.0	Trina Solar	67.88	JA Solar Technology	74.2
4	JA Solar Technology	22.25*	JA Solar Technology	66.69	Trina Solar	71.0
5	Tongwei	13.07	Tongwei	43.25	Tongwei	45.7
6	Zhejiang Chint Electrics (Astronergy)	11.9	Zhejiang Chint Electrics (Astronergy)	35.60	Zhejiang Chint Electrics (Astronergy)	42.6
7	Hengdian Group DMEGC Magnetics	12.0*	GCLSI	25.18	Canadian Solar	31.2
8	Aiko Solar	9.39	Hengdian Group DMEGC Magnetics	24.69	DAS Solar	26.0
9	TCL Zhonghuan	8.5	Canadian Solar	24.26	Yingli Green Energy	24.8
10	Yingli Green Energy	8.0	Yingli Green Energy	22.0	GCLSI	21.4

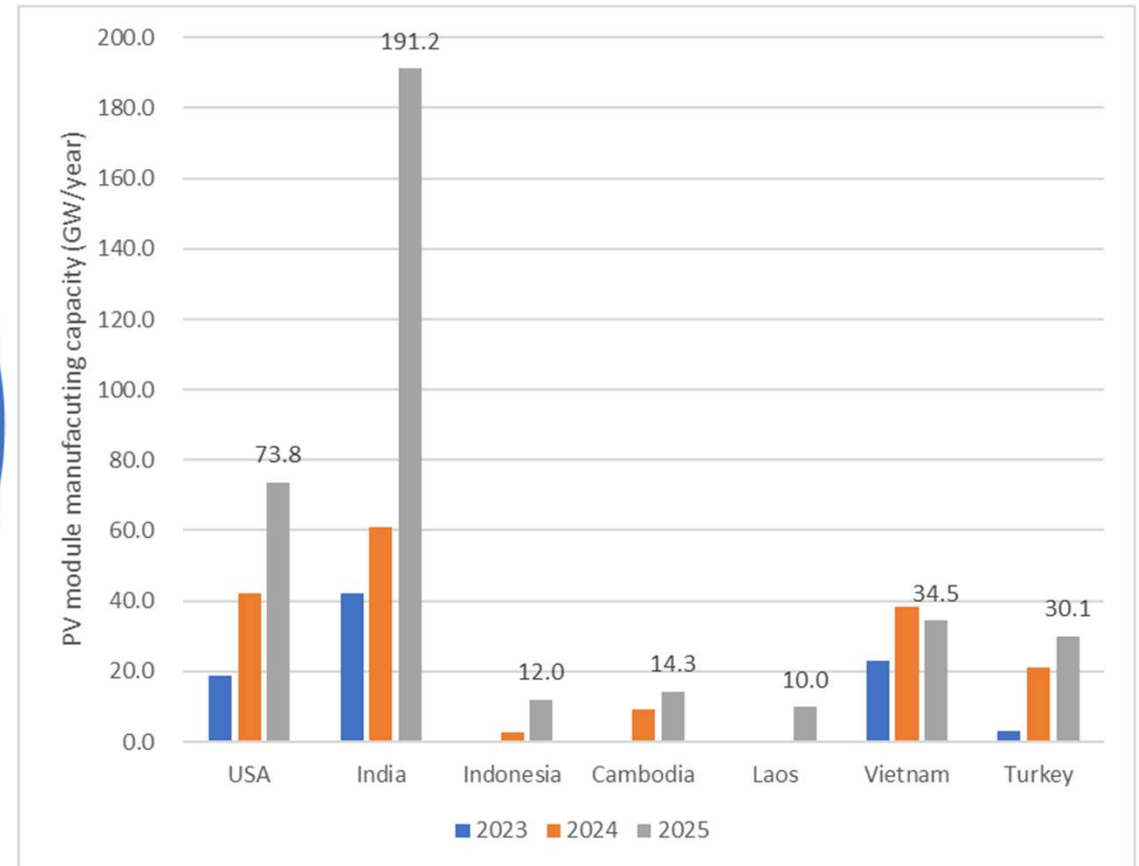
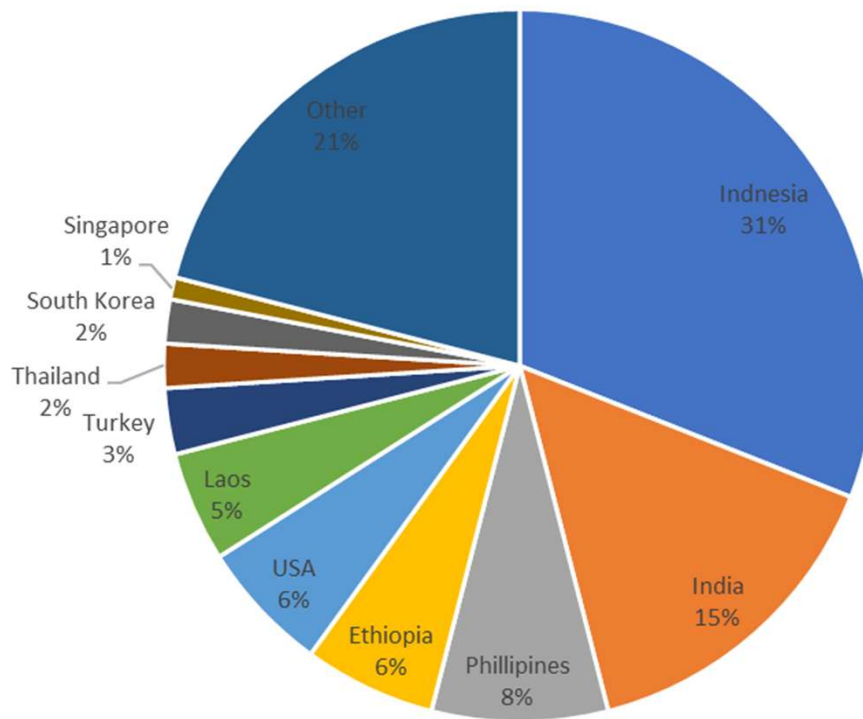


* Including cell shipment

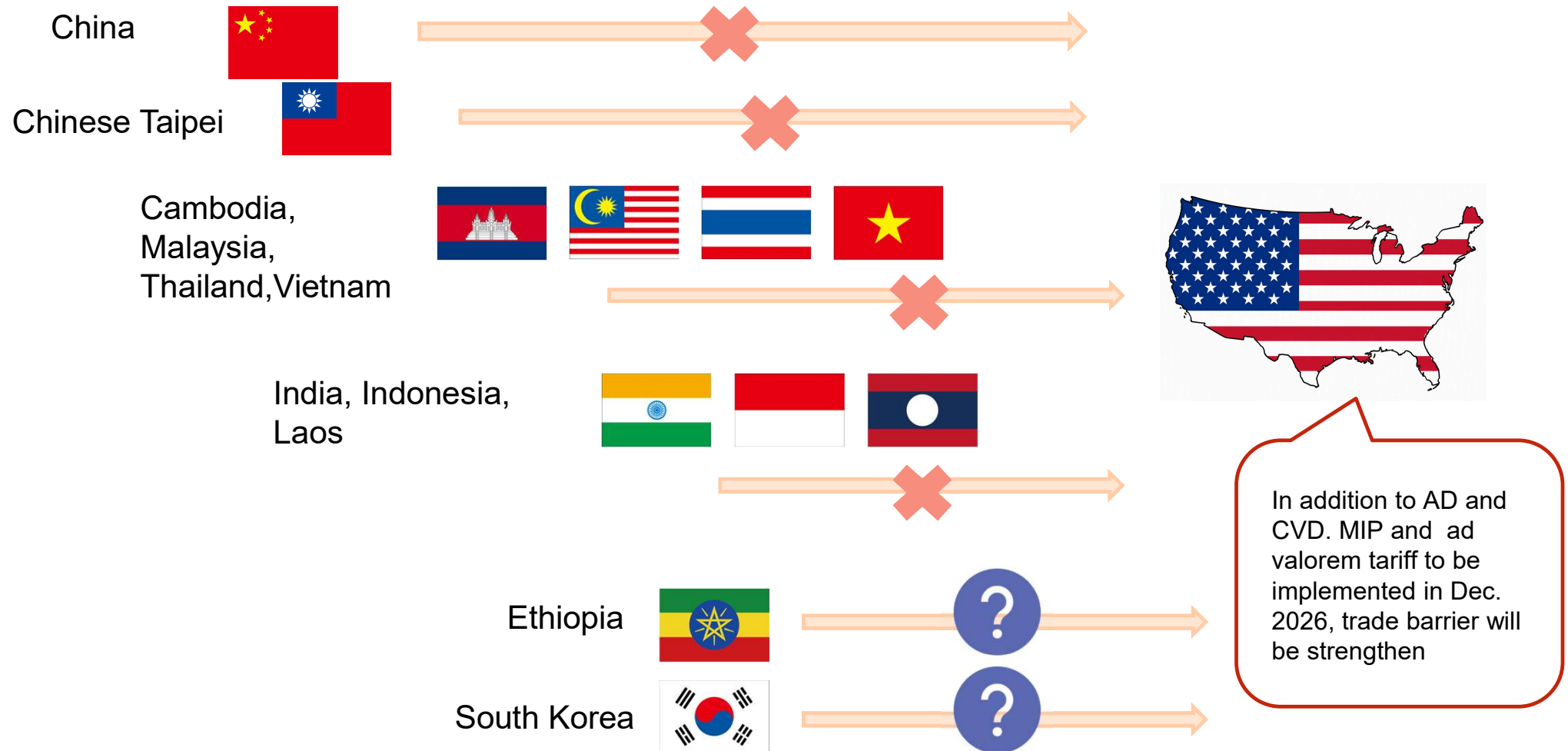
PV module production location expanding



Destination of solar cell from China in 1H2026



History of imposing duties on PV by USA

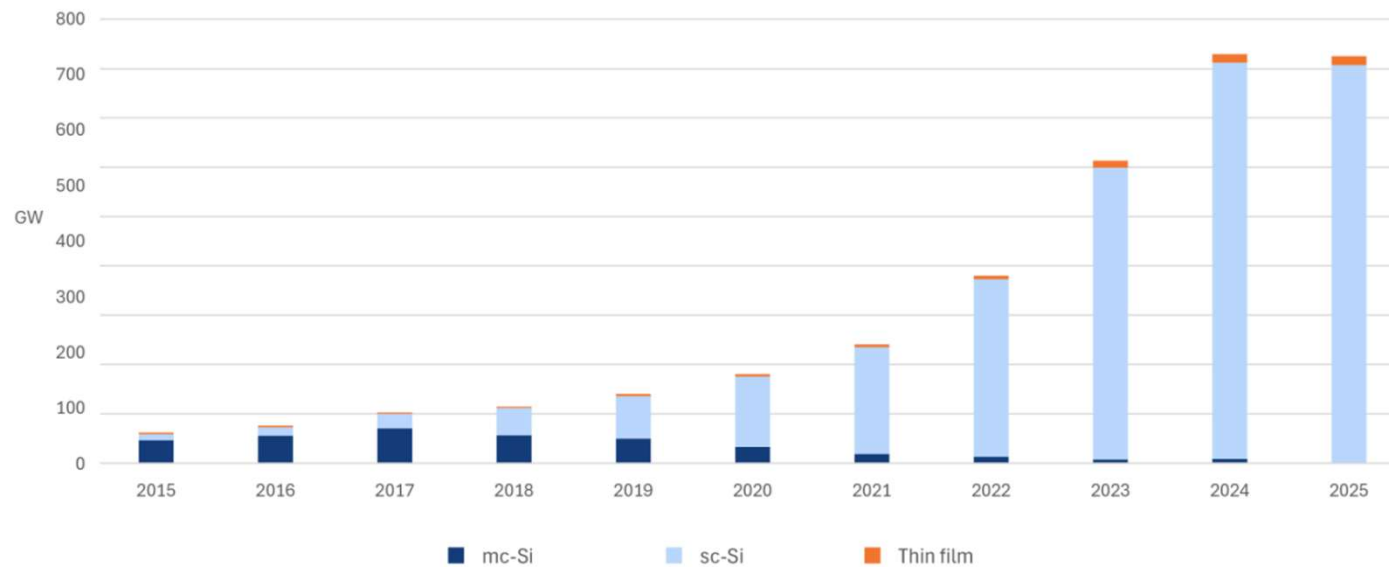


Source: RTS

PV module technologies



FIGURE 4.11: PV MODULE PRODUCTION PER TECHNOLOGY



SOURCE: IEA PVPS, RTS CORPORATION

- 98% of production was crystalline Si (mainly monotype)
 - Bifacial glass-glass: 70%
 - Encapsulant: EVA ~53%, EPE 41% (2024: 37%)
- Thin film: mainly CdTe technology

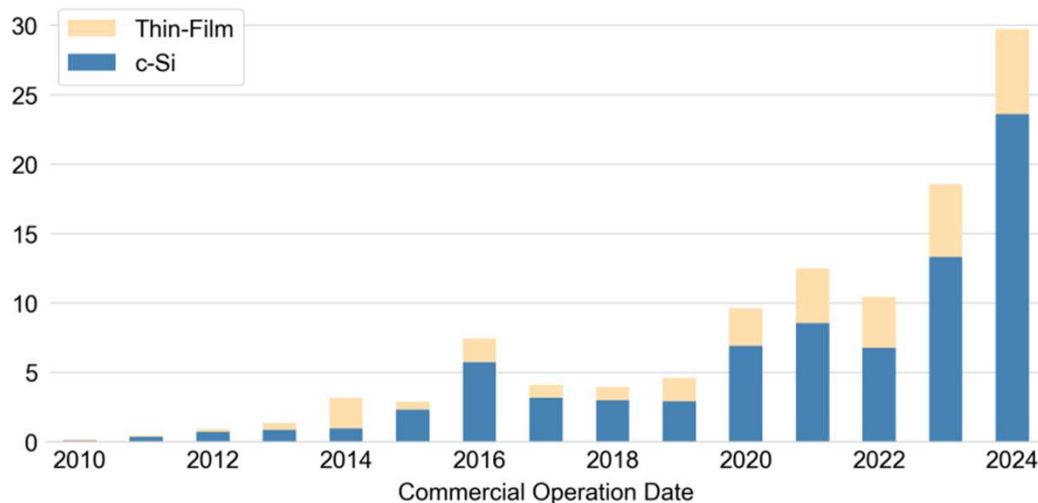
In USA, Thin-Film has ~20% share in utility scale projects



Use of c-Si modules grew in 2024 to 79% of added capacity

PV project sample: 1,747 projects totaling 110 GW_{AC}

Annual Capacity Additions (GW_{AC})



Note: The 2024 sample includes 2 projects (0.3GW_{AC}) without conclusive module type data which are excluded from the graph above

c-Si modules have been the dominant module technology at large-scale solar projects in the US since 2015. After a temporary decline in 2022, c-Si modules expanded their market share in 2024 to 79% of newly installed capacity.

Thin-film modules grew in popularity between 2016 and 2022. In 2024 they reached a new annual deployment record of 6 GW_{AC}, even though their market share declined.

Emerging technologies: companies developing Perovskite and tandems



Country /Region	Perovskite solar cell (single-junction)		Tandem solar cell	
	Flat glass type	Film type	Perovskite*/crystalline silicon (c-Si)	Perovskite*/thin-film
Japan			(PSC/c-Si and Cu₂O/c-Si)	
Europe	(under First Solar, USA)		France PV Industrie (Joint venture of IPVF and Veltec Solar, France)	
USA	(Perovskite-coat glass for tandem cells) (under Reliance New Energy, India) (Configuration unknown)		(CdTe/c-Si)	(PSC/c-Si) (c-Si thin film)
China				
Other	(AUS/ITA) (Taiwan) (India) (Russia) (Israel)	(AUS/ITA) (India) (Canada) (Brazil)	(Korea) (Taiwan) (Canada/China) (AUS) (Canada) (India) (Singapore)	

<https://www.rts-pv.com/en/points/11531/>

Perovskites PV production capacity of selected Chinese companies

Company	Product	Pilot	Commercial line	Plan
 极电光能 UtmoLight	Single Junction(SJ) (Glass)	150 MW/year	1 GW/year	6 GW/year (2026)
 纤纳光电 MICROQUANTA	SJ (Glass)	100 MW/year	1 GW/year	5 GW/year
	Tandem (4T)	20 MW/year	100 MW level/year	
 协鑫光电 GCL PEROVSKITE	SJ (Glass)	100 MW/year	1 GW/year	5~10 GW/year(2028) →20 GW →30 GW/year
	Tandem (4T)	200 MW/year	1 GW/year	
 万度光能 WONDER SOLAR	SJ (Glass)	200 MW/year	3 GW/year	30 GW/year
 光图科技 SOLAR TECH	SJ (Glass)	200 MW/year	1 GW/year	
 PEROVSKITE 众能光电科技	SJ (Glass)	200 MW/year	3 GW/year	
 DoZheng	SJ (Film)	10 MW/year	100 MW/year	
 凌极光电 LINGJI SOLAR	SJ (Glass)	100 MW/year		
	SJ (Film)	100 MW/year		
 锦华光电 JINHUO SOLAR	SJ (Glass)	150 MW/year	GW level/year	2026
	Perovskite tandem	10 MW/year		

Pilot

Commercial

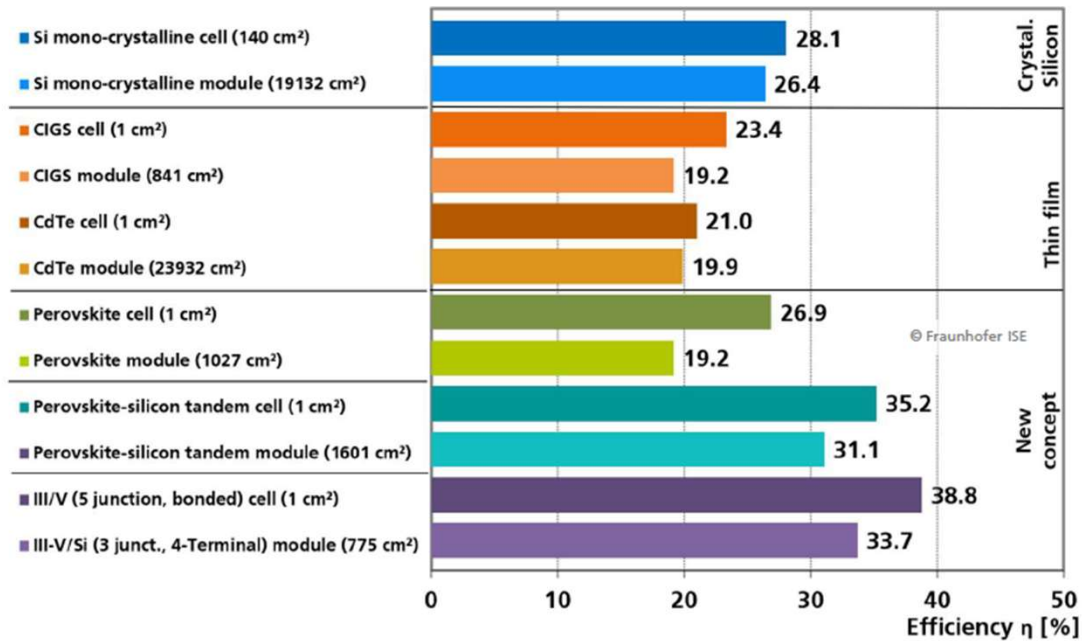
Plan/ construction

Source : From press release, based on RTS sturdy (as of Dec 2026)

Tandem cell/module efficiencies achieved by Chinese major players

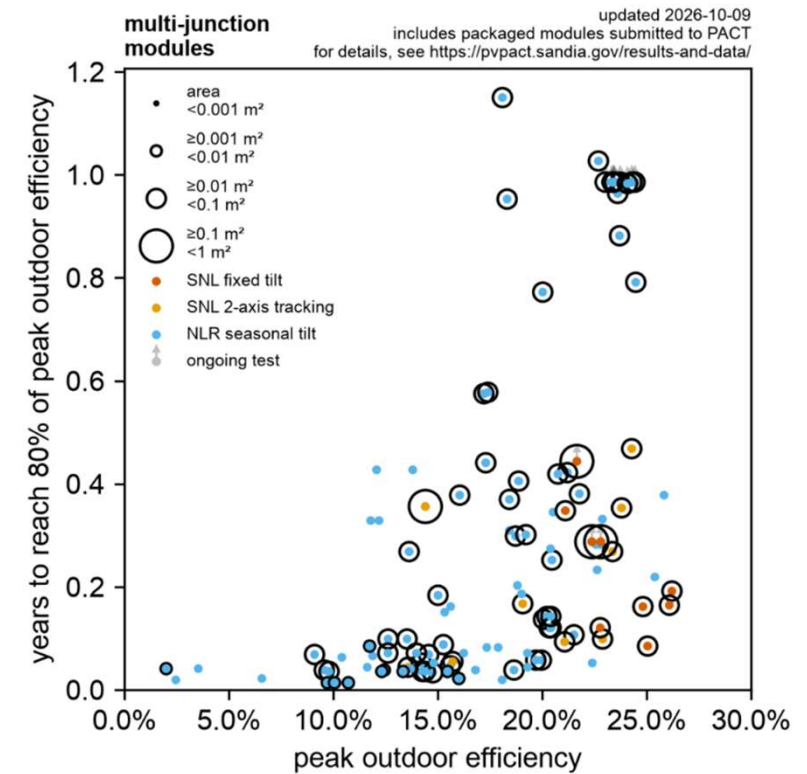
Company	Announcement	Area size	Date
LONGi Green Energy Technology	35.5% (2T perovskite/Si)	??? 1 cm ² ?	July 2026
	34.4% (2T perovskite/Si)	Commercial size wafer 261 cm ²	Nov. 2025
Risen Energy	31.95%, Voc:1,988 mV (perovskite/HJT)	1cm ²	Apr. 2026
Trina Solar	29.2% PV module (907 W) (perovskite/HJT)	2,384 mm × 1,303 mm	Jun. 2026
JinkoSolar	34.82% (perovskite/TOPcon)	Commercial wafer	Jun. 2026
Suzhou Maxwell Technologies	32.5% (perovskite/HJT)	Commercial wafer	Mar. 2026

Major issues of emerging technology: scale up and reliability



Data: Green et al.: Solar Cell Efficiency Tables (Version 68), Progress in PV: Research and Applications 2026. Graph: PSE Projects GmbH 2026. Date of data: 06/2026

Source : Fraunhofer Institute for Solar Energy Systems ISE, "Photovoltaics Report" (July 2026)

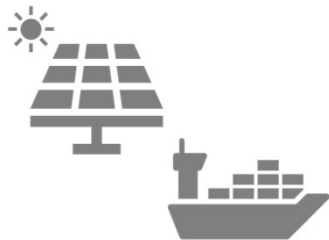


<https://pvpcat.sandia.gov/results-and-data/>



- According to Wood Mackenzie, global shipments of inverters for PV systems reached 523 GWac in 2025, Global inverter manufacturing capacity exceeded 1 TW/year
- China continues to play a dominant role: Huawei and Sungrow had >55% share in 2025 → ~80% produced in China but new GB may enhance dominance of major companies in domestic market
- Trends
 - Hybrid inverters to combine PV power generation and storage batteries
 - String inverter had 75-80% share. Capacity 300-400 kW → 500 kW
 - Central inverter voltage: 1,500 V to 2,000 V is expected to advance.
 - Introduction of grid forming (GFM) inverters with new Grid Code
 - Use of AI to optimizing operation
 - Cybersecurity (Controllability) is an issue : New regulation for products (USA, EU, Japan, etc.)

Summary of PV Industry status: changes from last meeting



Oversupply



Price competition



Lowering margin



Forced labor issues



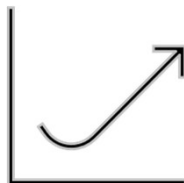
Intensifying trade tensions



Reduced dependency on specific country



Support and protection of local industry



Preparing for TW annual market



Impact of geopolitics!

***Thank you for your kind
attention !***

感谢您的关注

끝까지 경청해 주셔서 감사합니다

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

Acknowledgement :
PVPS Task1 Colleagues



Task 1 meeting in Berlin in 2025

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