PV Industry Trends

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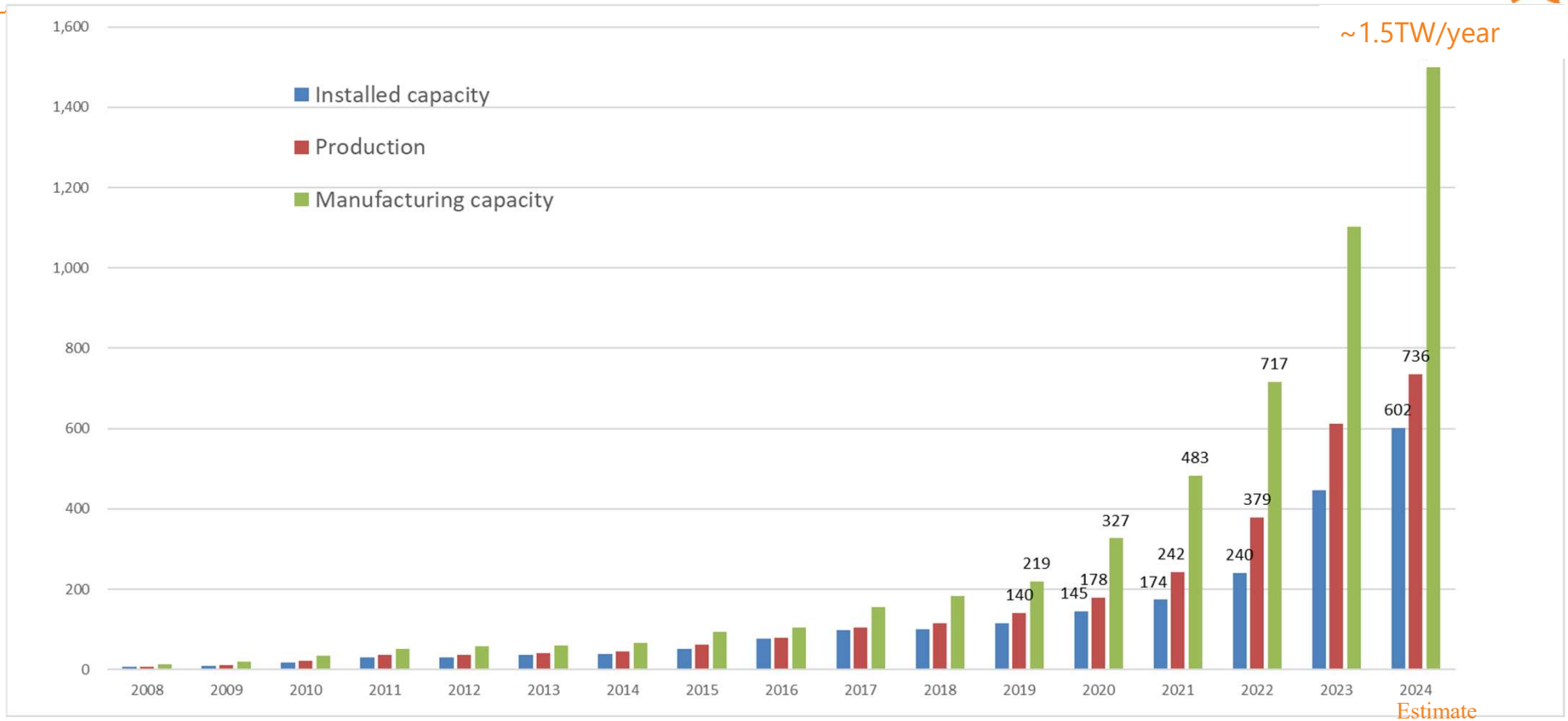
Contents

- Status of global PV industry
  - Trends of demand, supply and manufacturing capacity
  - Share by country and global flow of PV modules
  - Policies affecting local production
  - Price development
  - Evolution of PV technologies
  - Summary

Note: detailed analysis of 2024 status is underway to be published in Trends Report 2025

Installation, PV module production and capacity



- 2023 : 736 GW of production with >1.5 TW/year production capacity
- Capacity enhancement is slowing down in China. Active in USA and India
- Demand supply gap will continue in 2025

Source : IEA PVPS, Trends Report 2024

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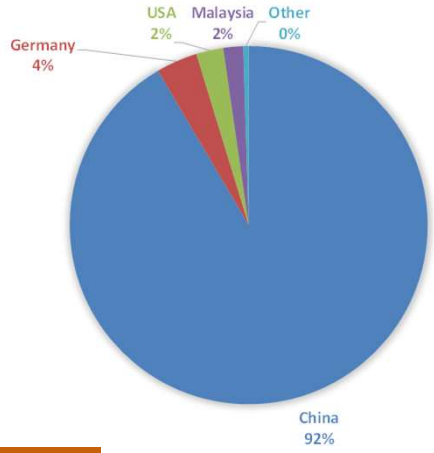
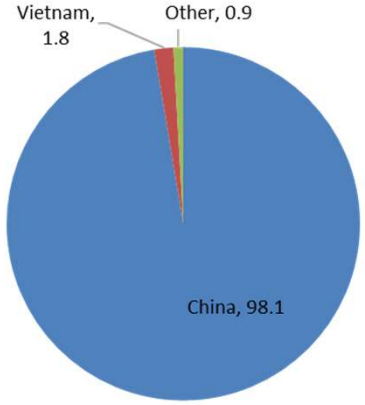
PV Supply Chain and share by country

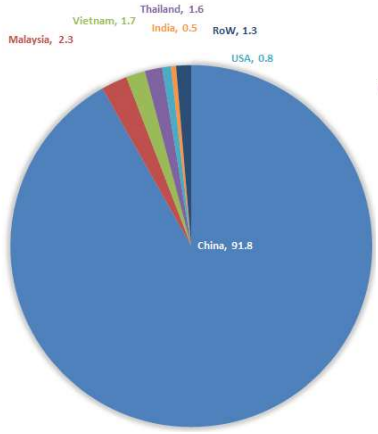
Wafer

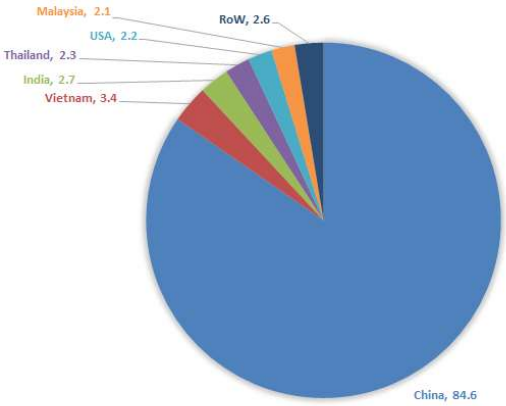
Cell

PV Module









Share of China

2022: 86%
2023 : 92%

2022 : 97.5%
2023: 98.1%

2022 : 84%
2023: 92%

2022 77.8%
2023: 84.6%
2024: 80%

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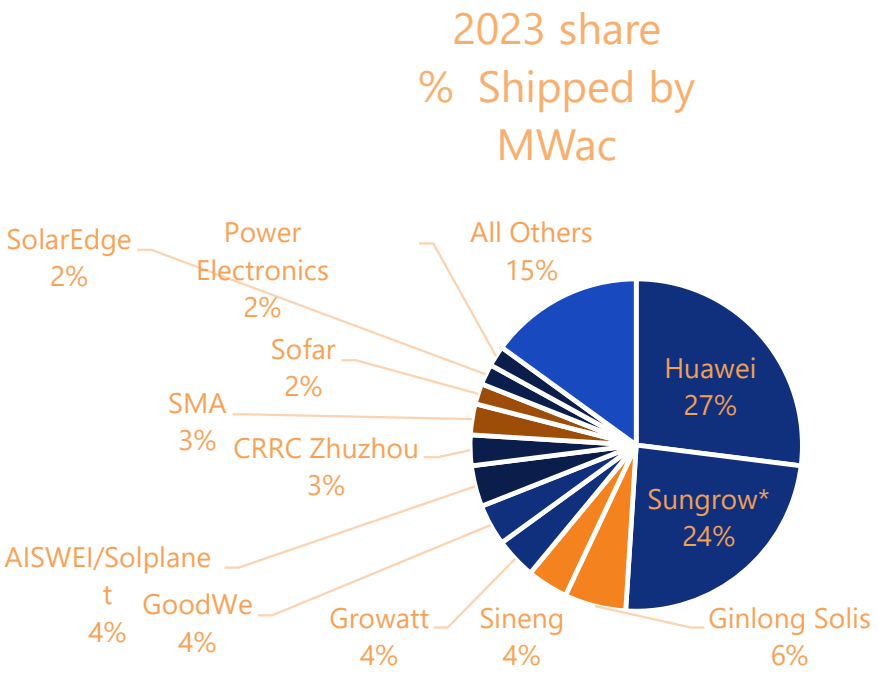
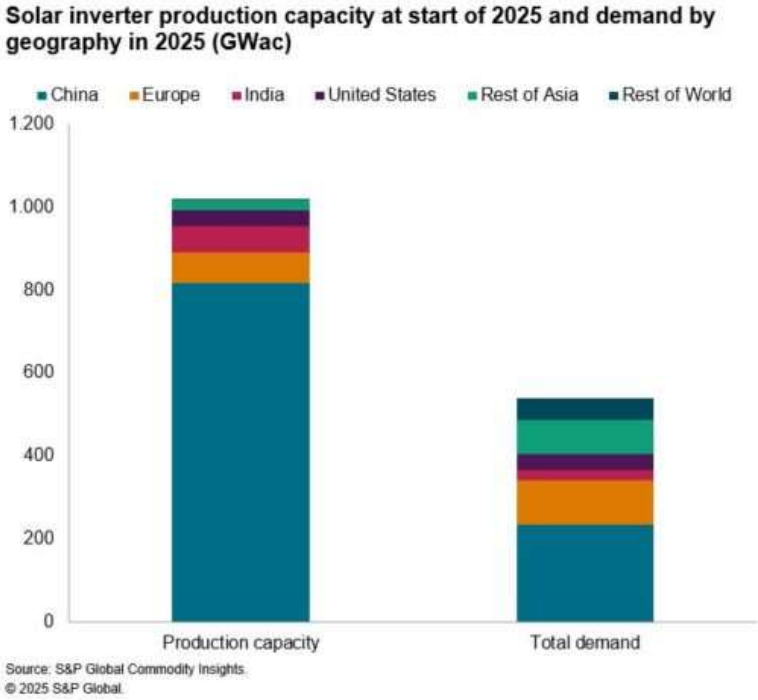
- China increased the share of production along the value chain
- Inverters, materials such as glass, encapsulants, equipment also China dominates
- Trade barriers and measures for local manufacturing contribute diversification of production sites

Source : IEA PVPS, Trends Report 2024

Inverter shipment share by Company





- ✓ Grid forming inverters to support grid stability
- ✓ Distributed PV: Hybrid inverter market increase with tools to optimizing electricity usage
- ✓ Size of string inverter getting larger, 400 kW
- ✓ 1500V to 2000 V???
- ✓ Cybersecurity

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PV modules : flow of the shipment

Jan . to Nov. 2024
Imported value: 10.5 Billion EUro

TOP5 exporting countries	Share (%)
China	**98%**
Singapore	0.58%
Malaysia	0.30%
USA	0.28%
Vietnam	0.25%

※Removed EU regional trading

Jan. to Dec. 2024
Exported value: 27.9 Bill. USD

TOP5 Exported region/country	Share (%)
EU 27 member countries	39%
Brazil	9%
Pakistan	7%
Saudi Arabia	7%
India	7%

Jan. to Dec. 2024
Imported value: 11.5 billion USD

TOP5 exporting countries	Share (%)
Vietnam	39%
Thailand	24%
Cambodia	11%
Malaysia	8%
India	7%

※Crystalline Silicon only

Jan. to Nov, 2024
Imported value: 2.8 billion USD

TOP5 exporting countries	Share(%)
China	**77%**
Vietnam	15%
Malaysia	3%
Singapore	2%
Hong Kong	2%

- USA: Trade barriers and UFLPA prevented importing PV modules from China.
- US imports PV modules from SE Asian countries
- India increased share in 2024

Source ：RTS Corporation based on customs statistics as of mid-February 2025

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Support measures for domestic PV supply chain

	Manufacturing	Domestic products	Barriers for import
	- Tax credit for production under IRA (incentive for produced amount and incentive for CAPEX), Augst 2022 - ??? Trump Administration???	- Bonus tax credit for domestic content for projects - ??? Trump Administration???	- AD and CVD (2012, 2014) - Safeguard Duty(2019) - Sec.301 Punitive tariffs on Chinese imports (2018) - **Uyghur Forced Labor Prevention Act (UFLPA) (2020)** - Anti Circumvention (2022) - **CVD for MY, TH, VT and KH (Oct 2024)**
	- PLI program (incentive for produced amount), Selection in 2021 and 2022	- **ALMM (qualification) (2021 -), mandate for solar cell from April 2026** - Domestic content for SECI auctions - Auctions for production and projects	- **Basic Custom Duty (BCD)(Apr. 2022)** - AD and CVD for materials for PV modules (EVA:2019, BS:202、Glass:2019, 2017)
	- EU Innovation Fund (CAPEX) - Incentive by member countries (DE, NL, ES, FR, HU, PR….)	- Resilience Auction based on Net Zero Industry Act -	- Ban on distribution of products produced using forced labor guideline being developed)

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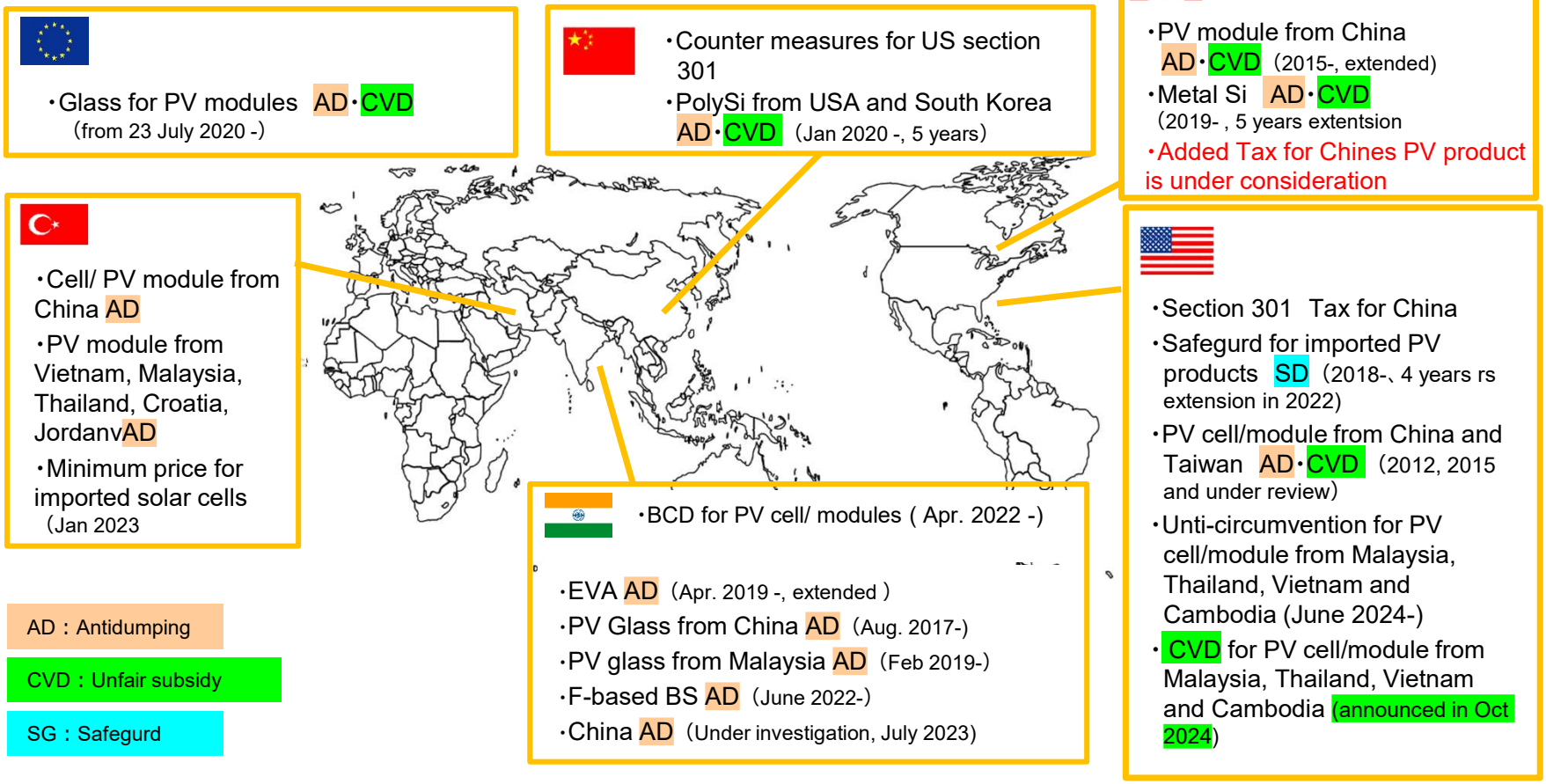
Trade issues affecting production bases



Source : RTS Corporation as of August 2024

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PV supply chain in the USA

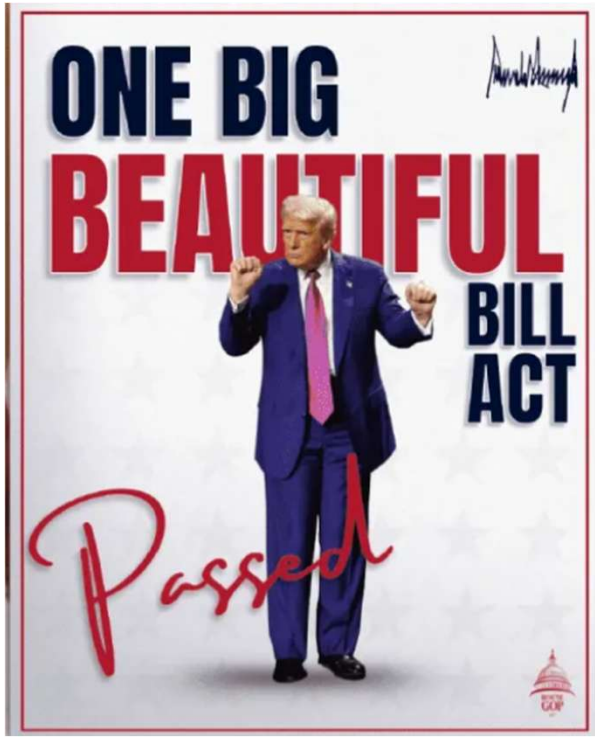
- The United States is supporting manufacturing PV products through incentives under the Inflation Control Act (IRA) and implementing imposing multiple tariffs for imported products from specific countries
- With the support of the IRA, the production capacity of solar cell modules is rapidly increasing. Solar cell production has also resumed since 2019 for the first time in five years.
- Meanwhile, polysilicon production capacity is decreasing after Norway's REC Silicon gave up on restarting operations at its Moses Lake plant in Washington state.
- Focusing production in USA: Corning (USA), Suniva (USA), and Heliene (Canada) have announced a partnership to produce all polysilicon, wafers, solar cell cells, and modules in the United States

Products	Manufacturing capacity in USA	
	2023	2024
Polysilicon	71,000t/year	51,000t/year
Ingot and wafer	-	-
Solar cell (crystalline Si)	-	2.0GW/year
PV module (crystalline Si)	9GW/year	42.5GW/year
PV module (thin film)	6GW/year	10.6GW/year

Source：US DOE, "U.S. Domestic Solar Photovoltaic Manufacturing Map Data" etc, compiled by RTS Corporation

U.S. IRA and One Big Beautiful Bill Act

- The U.S. House of Representatives passed the "One Big Beautiful Bill Act" (OBBBA) on May 22, 2025
- OBBA includes reductions and changes to incentive programs under Inflation Reduction Act (IRA).
- The bill is discussed in the Senate
- It is expected to take longer process to modify IRA by the Internal Revenue Service (IRS)
- OBBA might be challenged as unconstitutional in courts around the U.S.



https://www.themainewire.com/2025/05/one-big-beautiful-bill-of-tax-and-spending-provisions-passes-house-in-late-night-vote-condemned-by-maine-reps-golden-and-pingree/

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Source: Compiled by RTS Corporation based on news and articles

U.S. IRA and One Big Beautiful Bill Act

Tax credit for residential PV systems (Sec. 25D)	- Repeal by the end of 2025
Tax credit for electric vehicle (EV) systems (Sec. 30D, 30C, 45W)	- Repeal by the end of 2025
Tax credit for utility-scale PV systems (Sec. 48E, Sec. 45Y)	- Disqualified from eligibility if construction is not started within 60 days of the enactment of the law, and also if the system is not operational by the end of 2028. - Leasing companies of PV systems are not eligible for the ITC for renewable energy (Section 48E). - Transferability provisions for tax credit are repealed two years after enactment of the law. - In the case of start operation after December 31, 2025, the use of products, raw materials, patents, etc. of "Foreign Entities of Concern (FEOC)*" (as defined in the National Defense Authorization Act for Fiscal Year 2021) is not eligible.

* "Foreign Entity of Concern (FEOC)" Covered Nations: China, Russia, Iran, and North Korea. An entity incorporated in, headquartered in, or performing the relevant activities in a covered nation. A company with at least 25 percent voting rights, board seats, or equity interests held directly or indirectly by the government of a covered nation. An entity that, through a licensing arrangement or other contract with an FEOC, grants the FEOC effective control.

Source: Compiled by RTS Corporation based on news and articles

U.S. IRA and One Big Beautiful Bill Act

Tax credit for clean energy-related factories (Sect. 45X)	- Phased out after 2029, ending at the end of 2032. - Wind power is excluded from 45X incentives after 2028. - Transferability provisions for tax credit repealed immediately after enactment of the law. - After the end of 2025, the use of products, raw materials, patents, etc. of "Foreign Entities of Concern (FEOC)*" (as defined in the National Defense Authorization Act for Fiscal Year 2021) will no longer be eligible.

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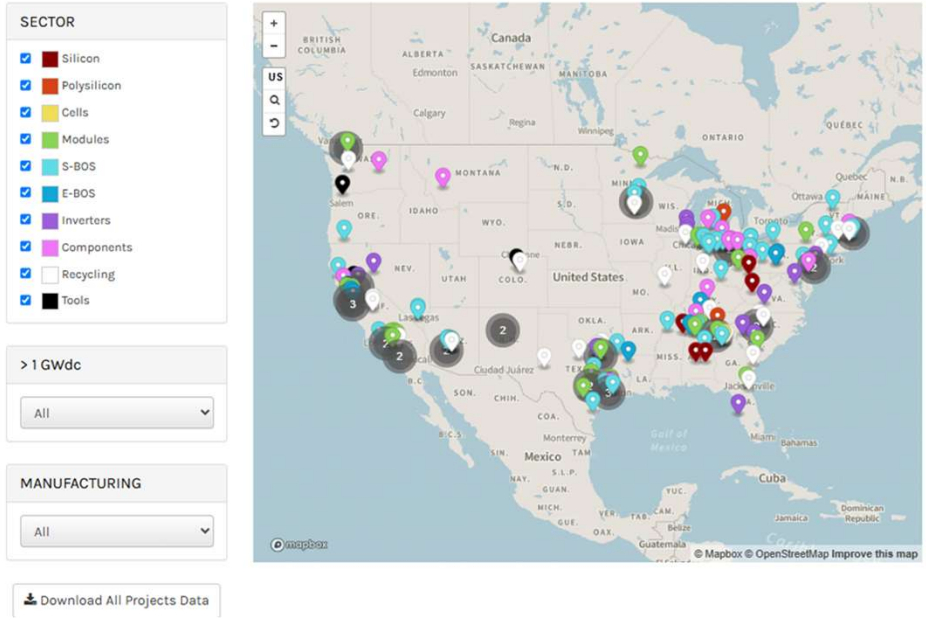
Source: Compiled by RTS Corporation based on news and articles

US manufacturing map for PV supply chain

Construction boom of solar cell/ module plants is fragile due to uncertainties in the continuity and execution of the IRA

- Representative Julie Fedorchak, Republican, North Dakota Proposed legislation to phase out the Production Tax Credit (PTC) and Investment Tax Credit (ITC) for wind and solar.
- Four Senators (Republicans) signed a letter calling for opposition to the full repeal of tax credit provisions, including parts of the IRA
- House Ways and Means Committee announced a budget proposal that would significantly cut the budget for the IRA, including the phase-out of the Sec. 45X ITC and the immediate repeal of the



https://www.energy.gov/eere/solar/solar-manufacturing-map

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AD and CVD for solar cell products imported from Southeast Asia

- The U.S. Department of Commerce (DOC) conducts an anti-dumping and anti-subsidy investigation into solar cell products imported from four Southeast Asian countries (Cambodia, Malaysia, Thailand, and Vietnam).
- The DOC announced the results of its investigation on April 21.
- Based on the results, the U.S. International Trade Commission (ITC) will make a final decision by June 2, 2025, and enforcement actions are scheduled to begin on June 9, 2025.

	Dumping margins	Subsidy rates
Cambodia	125.37 %	534.67 - 3,403.96%
Malaysia	0 - 81.24%	14.64 - 168.8%
Thailand	111.45 - 202.9%	263.74 - 799.55%
Vietnam	58.07 - 271.28%	68.15 - 542.64%

- Levies are scheduled to begin in June, but collection of deposits has already started.
- There is also a move to secure inventory during the grace period of the reciprocal tariff.

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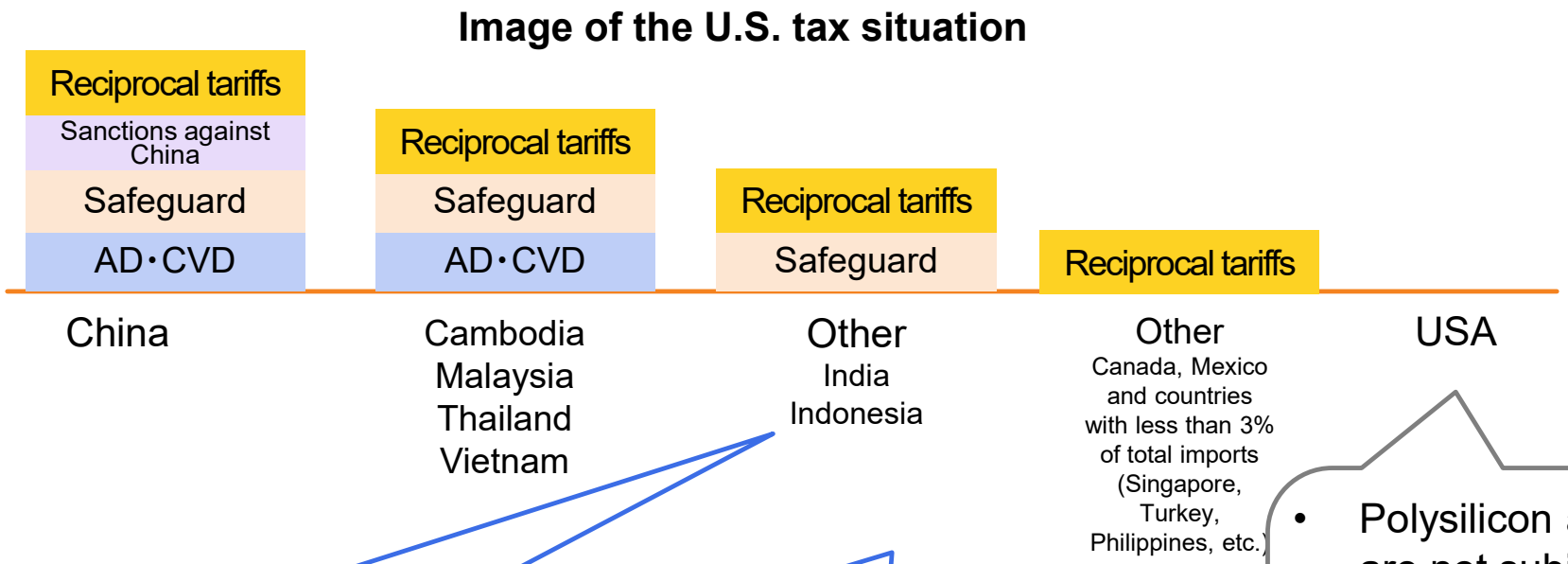
Source: Compiled by RTS Corporation based on materials issued by the USITC

US tariff policy triggers diversification of manufacturing location



- India's production capacity increased to 74 GW/year (modules) and 25 GW/year (cells) as of March 2025
- Gstar (Singapore) constructing ingot and wafer factory in Indonesia

Chint New Energy Technology (Astronergy) of China:Announced a plan for solar cell factory in Turkey

- Polysilicon and wafers are not subject to reciprocal tariffs
- Cells are subject to reciprocal tariffs but with safeguard measures(12.5 GW/year)

Source: RTS Corporation

Support policy and measures for local manufacturing in India

- India is promoting the creation and development of a domestic industry through the Production Linked Incentive (PLI) system to support the establishment of factories, as well as the Already Produced and Manufacturers (ALMM) system for solar cell modules, which is essentially a local content requirement system, and Basic Customs Duty (BCD).
- By 2024, India's production capacity for PV modules is expected to grow to about twice the size of the country's market, and the country is on track to become an exporter of PV modules.

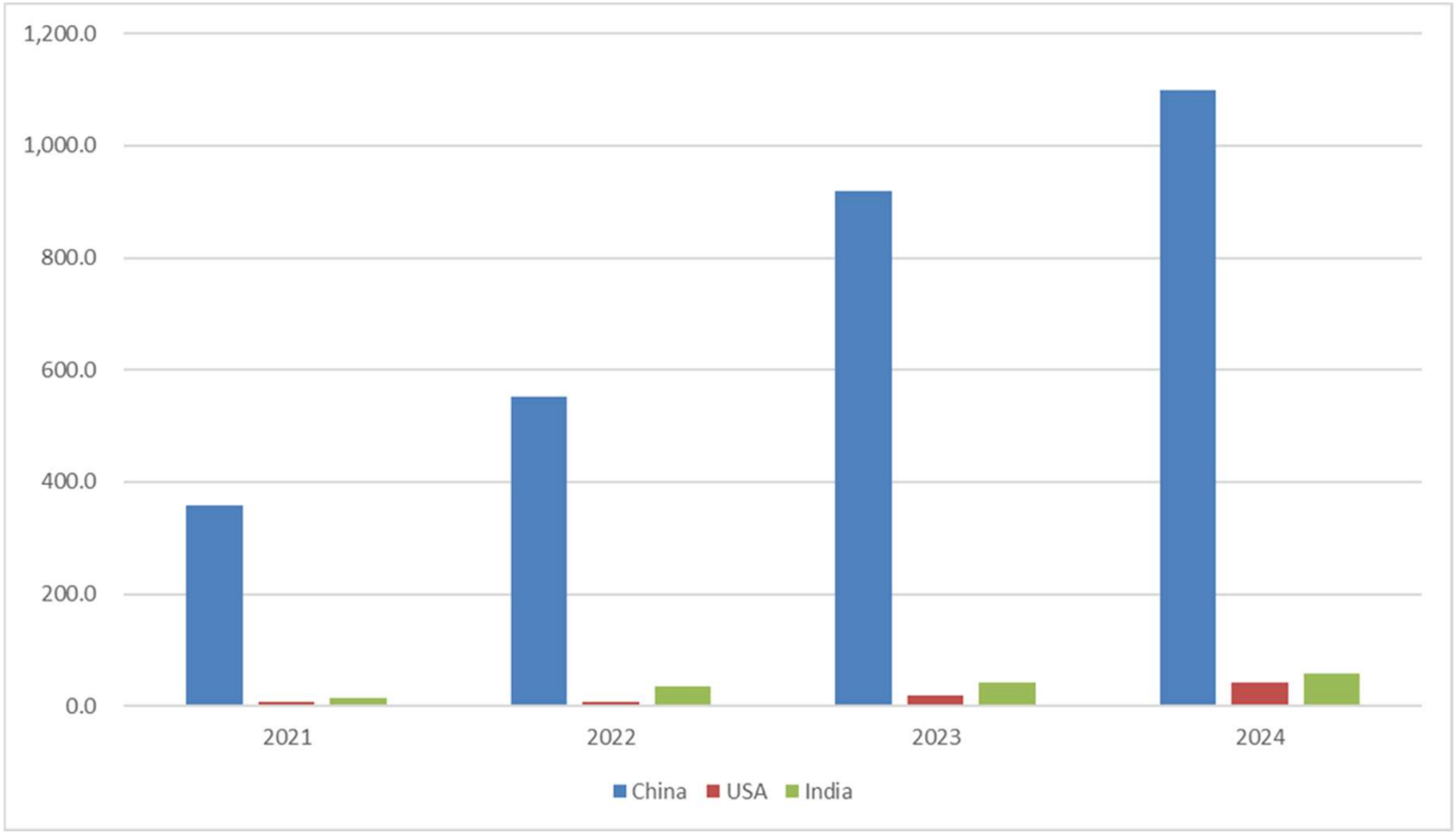
Measures to promote local manufacturing

Measure to promote local manufacturing	Production linked Incentive (PLI)
Measure to promote local products in the domestic market	Approved list of models and manufacturing (ALMM)
Trade barriers	基本関税（Basic Custom Duty）
	AD and CVD

Manufacturing capacity and planned capacity

Products	2024	2030
PolySilicon	0	15,5000t/year
Ingot and wafer	>0	28 GW/year
Solar cell	5.8 GW/year	60GW/year
PV modules	64.5GW/year	129GW/year

PV module manufacturing capacity of China, USA and Inidia



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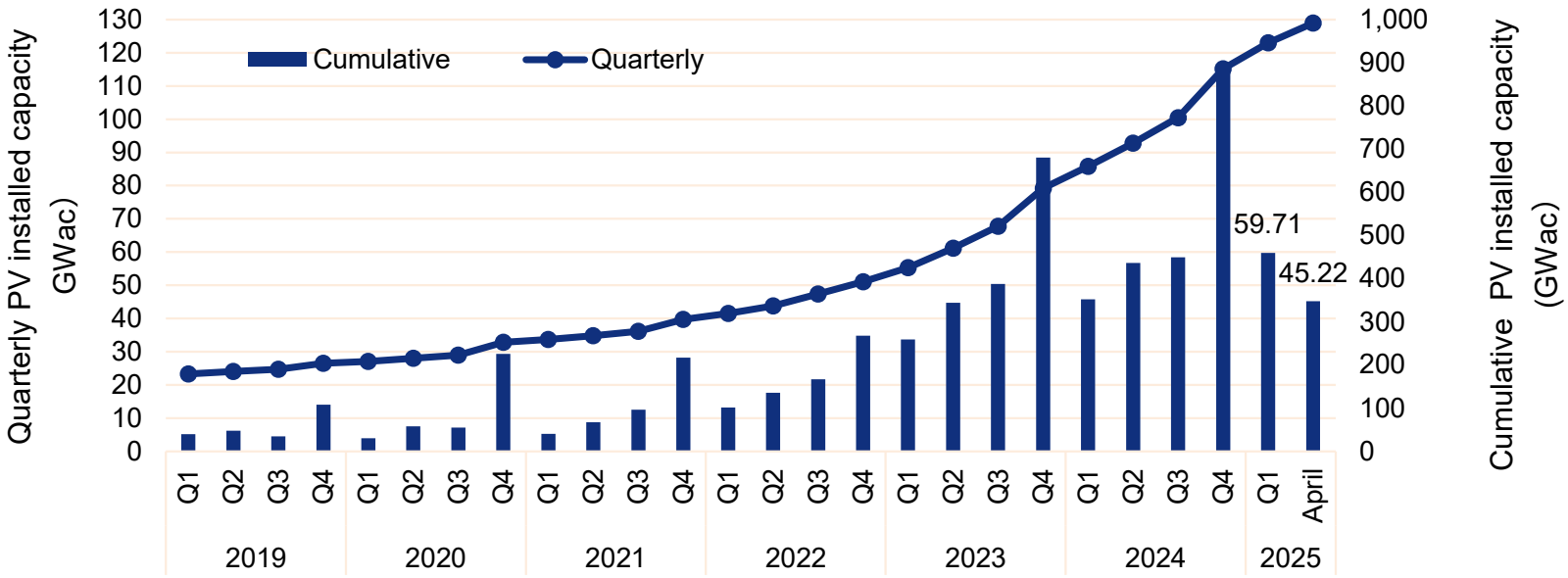
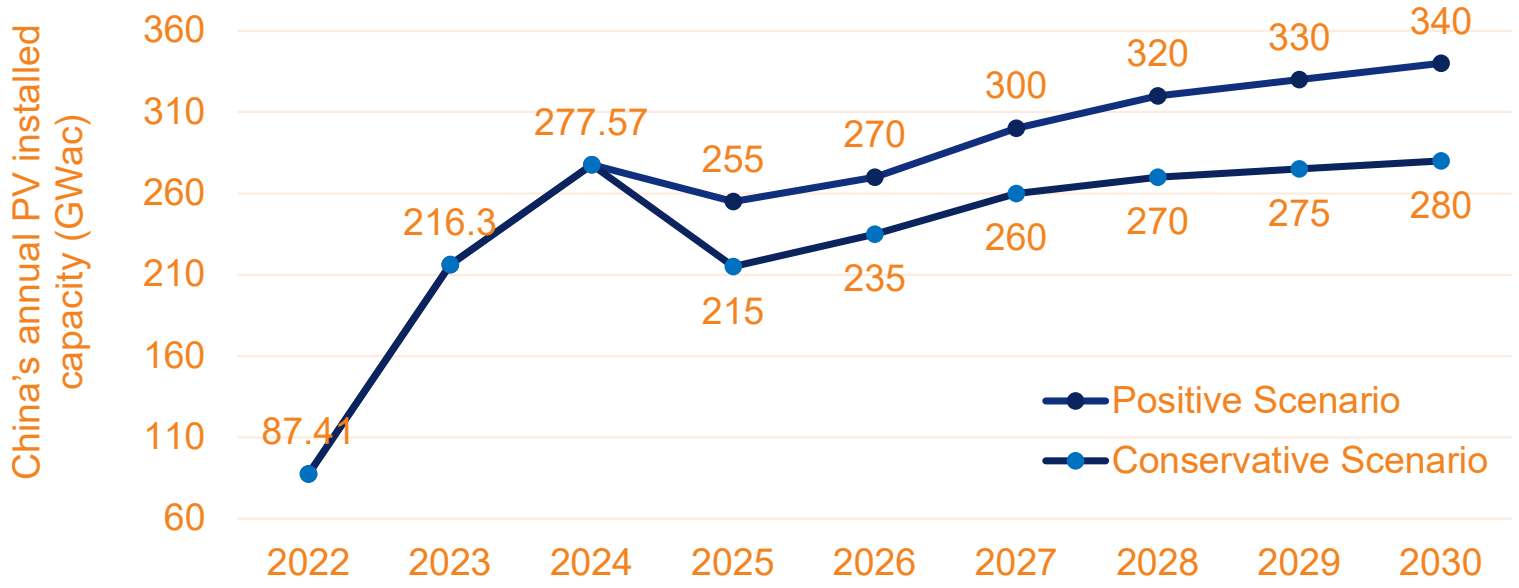
Chinese market impacts on price： Q1 and April market in China



- In 1Q 2025, China installed 59.71 GWac (up by about 30% year on year)
- In April, 45.22 GW installed due to a rush to get in before the change of policies
- As of the end of April 2025, cumulative installed capacity is 992 GWac
- PV industry is concerned about changes in demand after June

Source: National Energy Administration (NEA), compiled by RTS Corporation

Annual PV installed capacity in China



- China Photovoltaic Industry Association (CPIA) comments that there is some uncertainties in its 2025 outlook
- Especially after June, market size will depend on how Chinese provincial government adapt to the new policies and ensure sufficient RE capacity to meet their mandated RE capacity

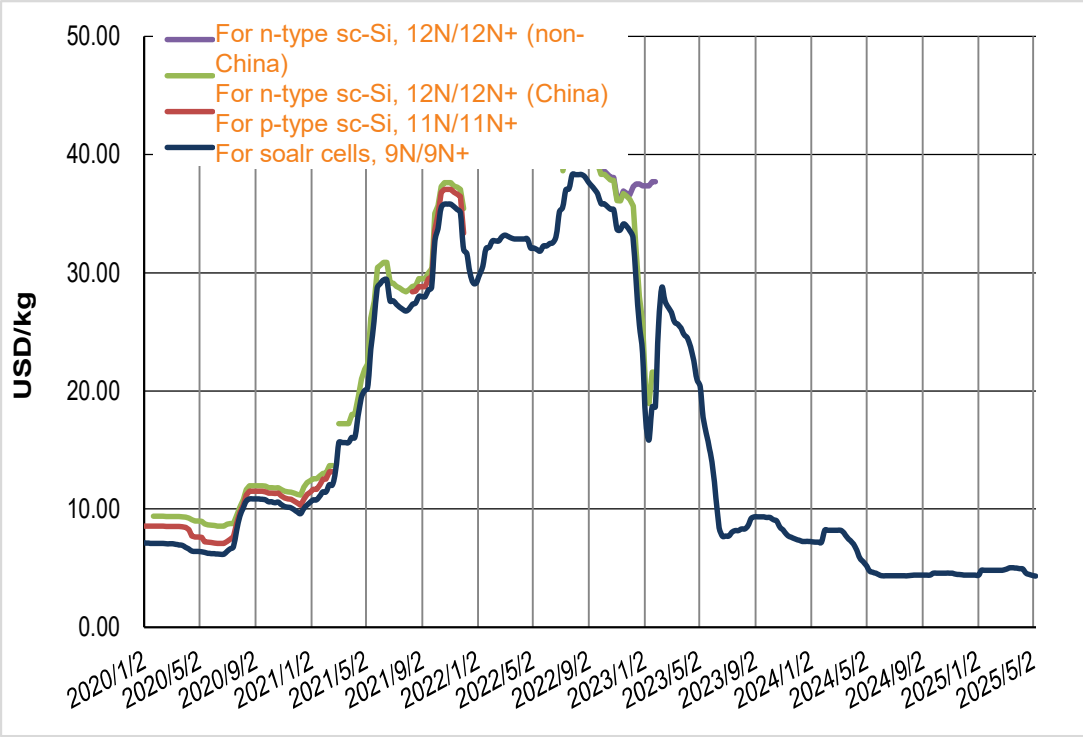
Source: CPIA compiled by RTS Corporation

スライド 19

RTS1 タイトル変更して、X軸のタイトルをシンプルにしました。折れ線グラフの凡例、Case→ Scenarioがよいか。
RTS Japan, 2025-06-06T03:56:11.757

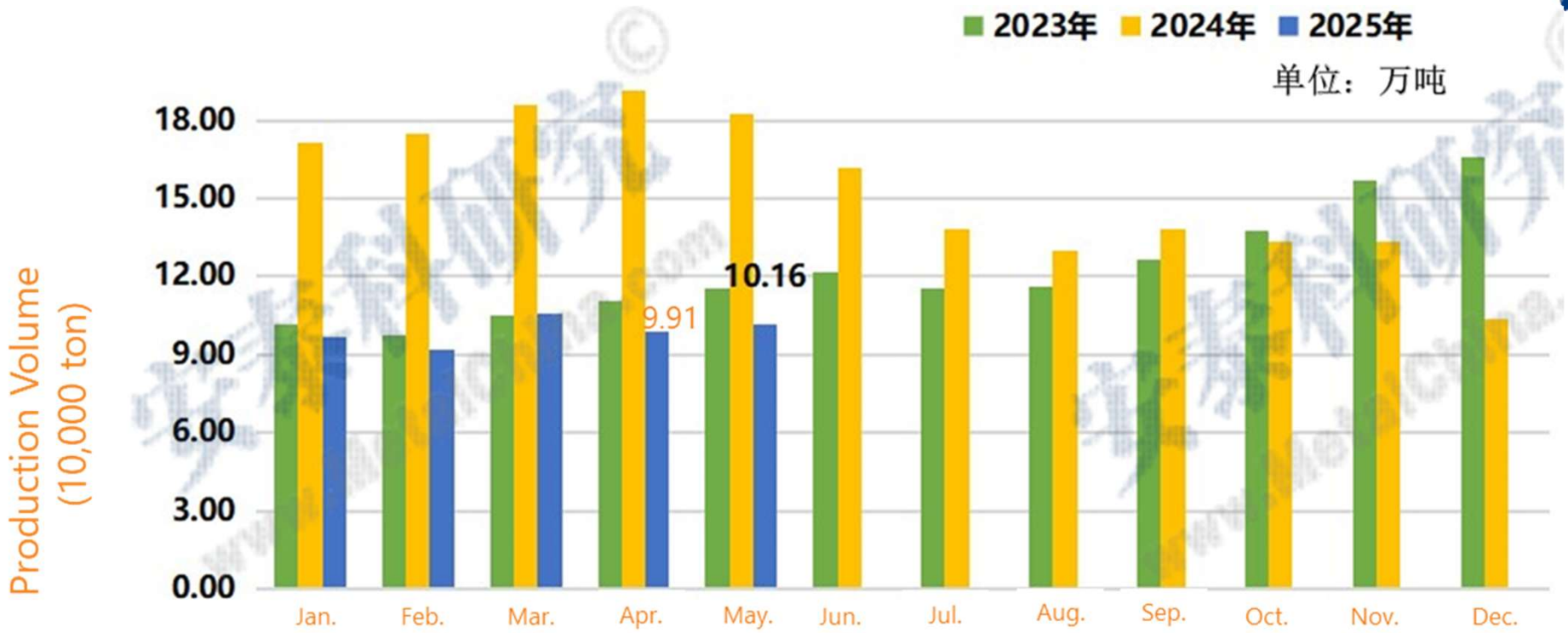
Polysiicon spot price

- Demand for the rush to install to meet China's institutional revision on May 31 ended.
- Uncertainty over demand trends after June causes reluctance in business dealings.
- Production control across the industry continues, with the capacity factor of major manufacturers at 42.34%.
- Chinese production in April was 99,100 t, and is expected to be around 96,000 t in May as 2 manufacturers start maintenance.



Source: PVinsights

Production volume of polysilicon in China



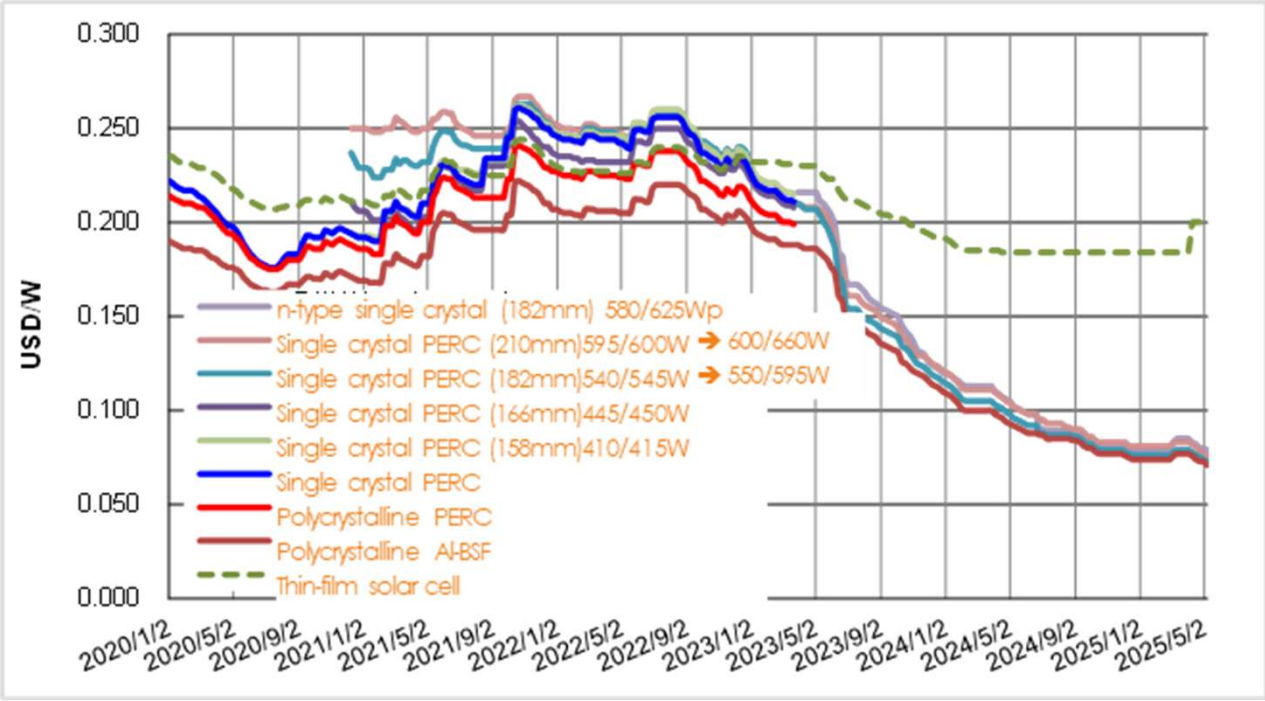
As of the 4th June 2025, 11 out of 19 polysilicon manufacturers in China are operati with low utilization rate, others have temporally stopped operation.

Due to lower demand, they are reportedly considering to start annual maintenance earlier.

Source: China Nonferrous Metals Industry Association(CNMIA), compiled by RTS Corporation

Wafer Price

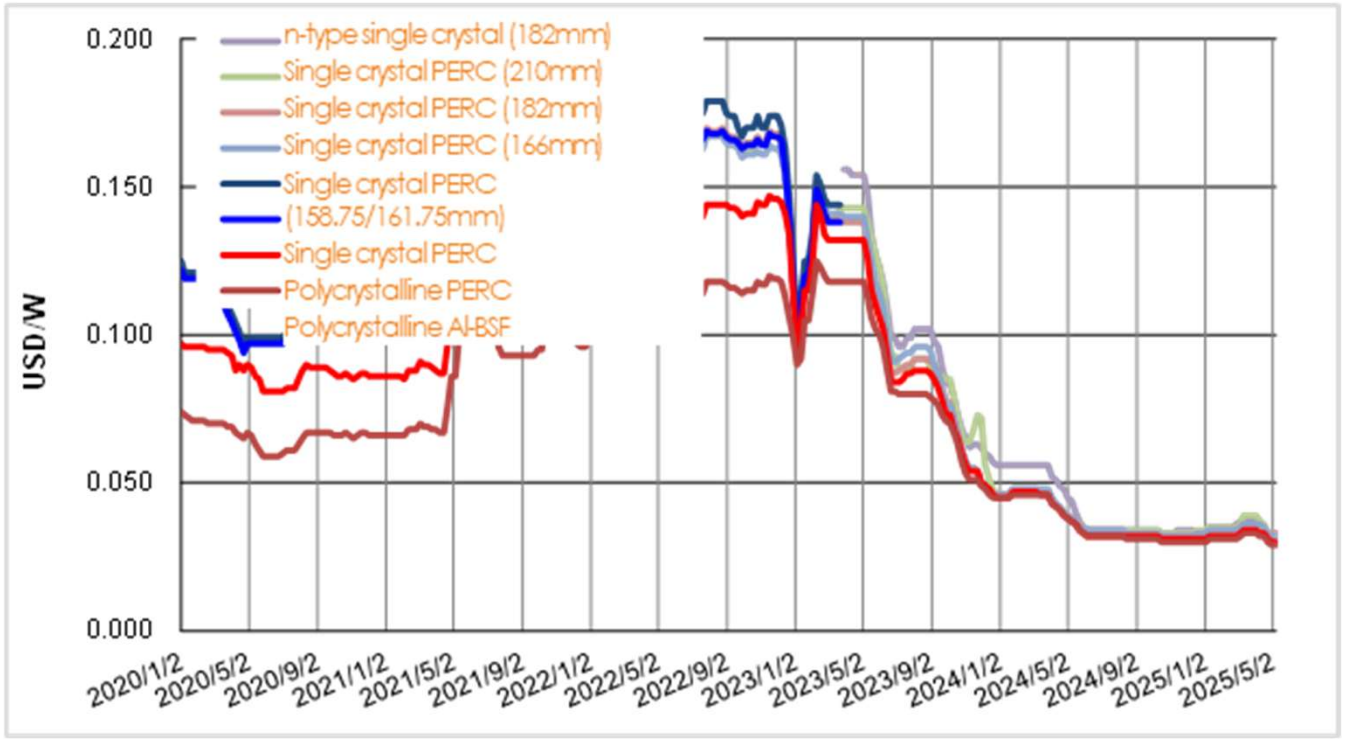
- Prices rose in early April due to the earthquake in Myanmar at the end of March.
- Oversupply issue reappears as installation rush in China ended.
- Small- and medium-sized manufacturers started dumping inventories for clearance.
- Production is expected to decrease in May.



Source: PVinsights

Crystalline Silicon Solar Cell Price

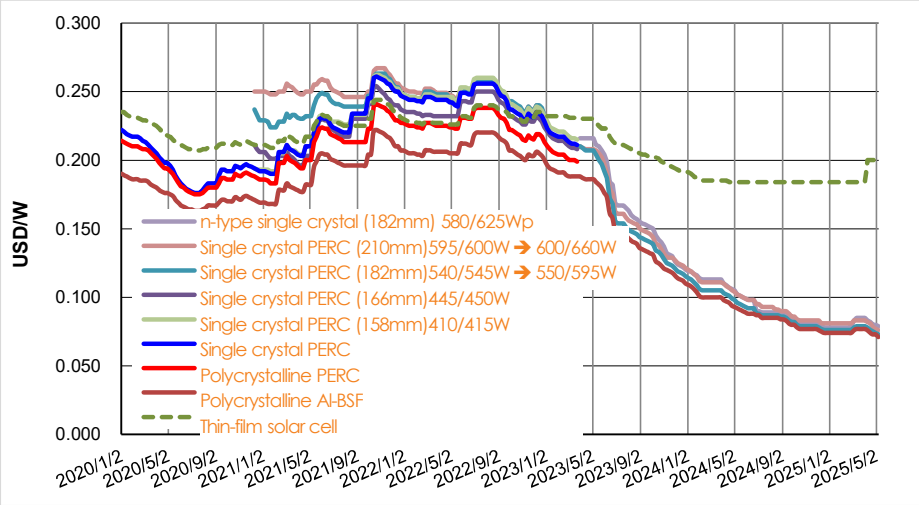
- Prices rose in March, falling trend in April.
- Major manufacturers plan to reduce production due to uncertainty in demand after May.
- Depending on the upcoming market size and prices, small- and medium-sized manufacturers could be weeded out gradually.



Source: PVinsights

PV Module Price

- Compared to upstream, price fluctuations were small, remaining stable or slightly downward in April.
- Major manufacturers reduce production by, for example, cutting back on OEM orders.
- Small- and medium-sized manufacturers started selling at lower prices to reduce inventories.



Source: PVinsights

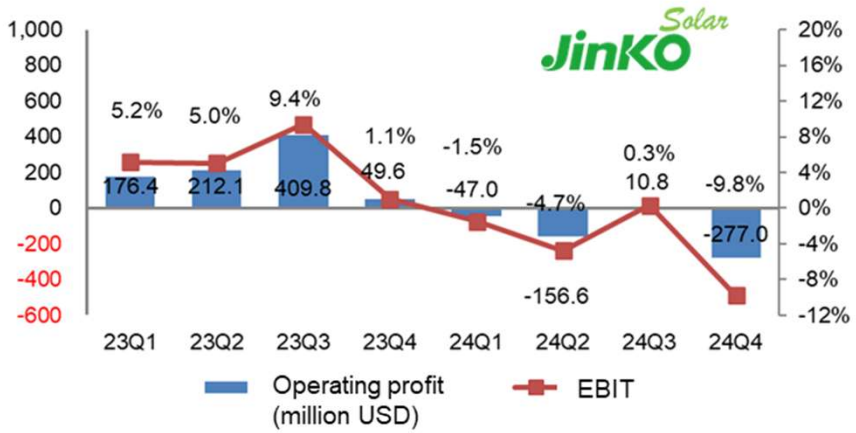
2024 rankings of PV module shipment by supplier

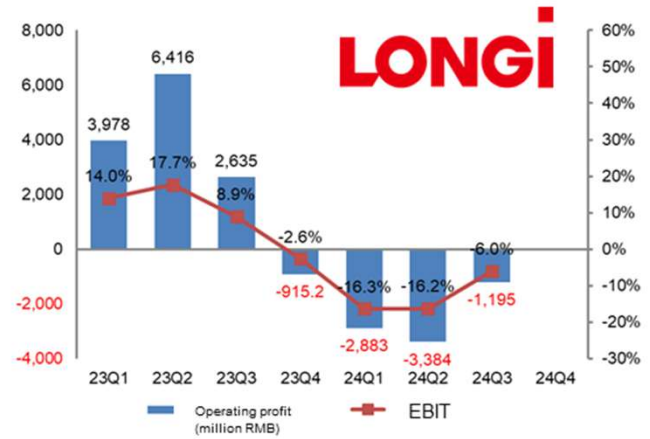
Ranking	Shipment in 2024 (GW)		Shipment in 2023 (GW)		Shipment in 2022 (GW)	
1	JinkoSolar (China)	92.9	JinkoSolar (China)	78.5	LONGi Green Energy Technology (China)	46.76
2	LONGi Green Energy Technology (China)	75.8	LONGi Green Energy Technology (China)	67.5	JinkoSolar (China)	44.5
3	JA Solar Technology (China)	74.2 (including cells)	Trina Solar (China)	65.2	Trina Solar (China)	43.09
4	Trina Solar (China)	70.47	JA Solar Technology (China)	55.3	JA Solar Technology (China)	39.75
5	Tongwei Group (China)	45.7	Tongwei Group (China)	31.11	Canadian Solar (Canada)	21.1
6	Zhejiang Chint Electrics （Astronergy） (China)	42.6	Canadian Solar (Canada)	30.7	Risen Energy (China)	13.5
7	Canadian Solar (Canada)	31.1	Zhejiang Chint Electrics (China)	28.0	Zhejiang Chint Electrics (China)	13.5
8	DAS Solar (China)	25 - 26	Risen Energy (China)	18.99	First Solar (USA)	*9.3*
9	Yingli Solar (China)	24.8	DAS Solar (China)	17.7	Hanwha Solutions (South Korea)	9
10	GCLSI (China)	21.4 (including cells)	GCLSI (China)	16.4 (including cells)	DAS Solar (China)	8.5

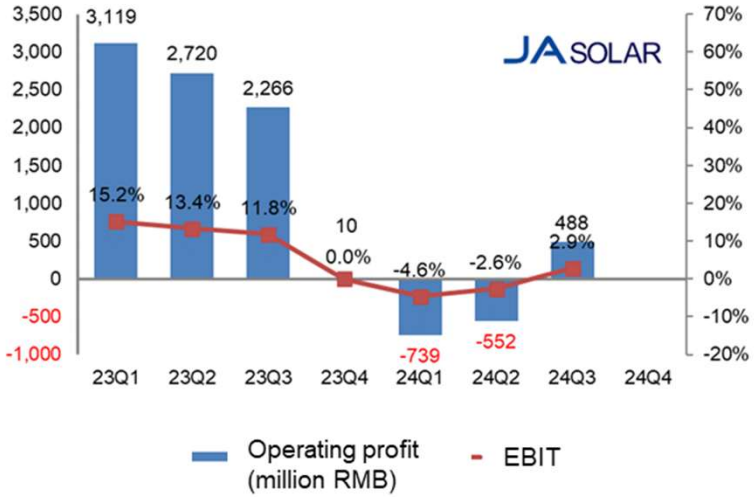
*Shipment volume includes consignment production (OEM/ODM production), sales volume including outsourced procurement, etc., and shipments to own development projects (only when disclosed).

Source: Compiled by RTS Corporation, including some estimates (May 2025)

Operating profit and EBIT of top 4 PV manufacturers







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FY 2023/2024 net income (loss) of major listed manufacturers

		Net income (loss) attributable to shareholders 2023	Net income (loss) attributable to shareholders 2024
Poly-silicon	Daqo Energy (Listed subsidiary in China)	5.76 billion RMB	(2.72 billion RMB)
	GCL Technology	2.51 billion RMB	(4.75 billion RMB)
	Xinte Energy	5.11 billion RMB	(4.04 billion RMB)
Solar cell	Hainan Drinda New Energy Technology	0.82 billion RMB	(0.59 billion RMB)
	Shanghai Aiko Solar Energy	0.76 billion RMB	(5.32 billion RMB)
PV module	JinkoSolar (Listed subsidiary in China)	7.44 billion RMB	0.99 billion RMB
	LONGi Green Energy Technology	10.75 billion RMB	(8.62 billion RMB)
	JA Solar Technology	7.04 billion RMB	(4.27 billion RMB)
	Trina Solar	5.53 billion RMB	(3.44 billion RMB)
	Tongwei Group	13.57 billion RMB	(7.04 billion RMB)
	Canadian Solar (Listed subsidiary in China)	2.90 billion RMB	2.25 billion RMB
	GCLSI	160 million RMB	68.29 million RMB

Source: Compiled by RTS Corporation based on financial reports of each company.

Disclosure of manufacturing cost of PV module by CPIA

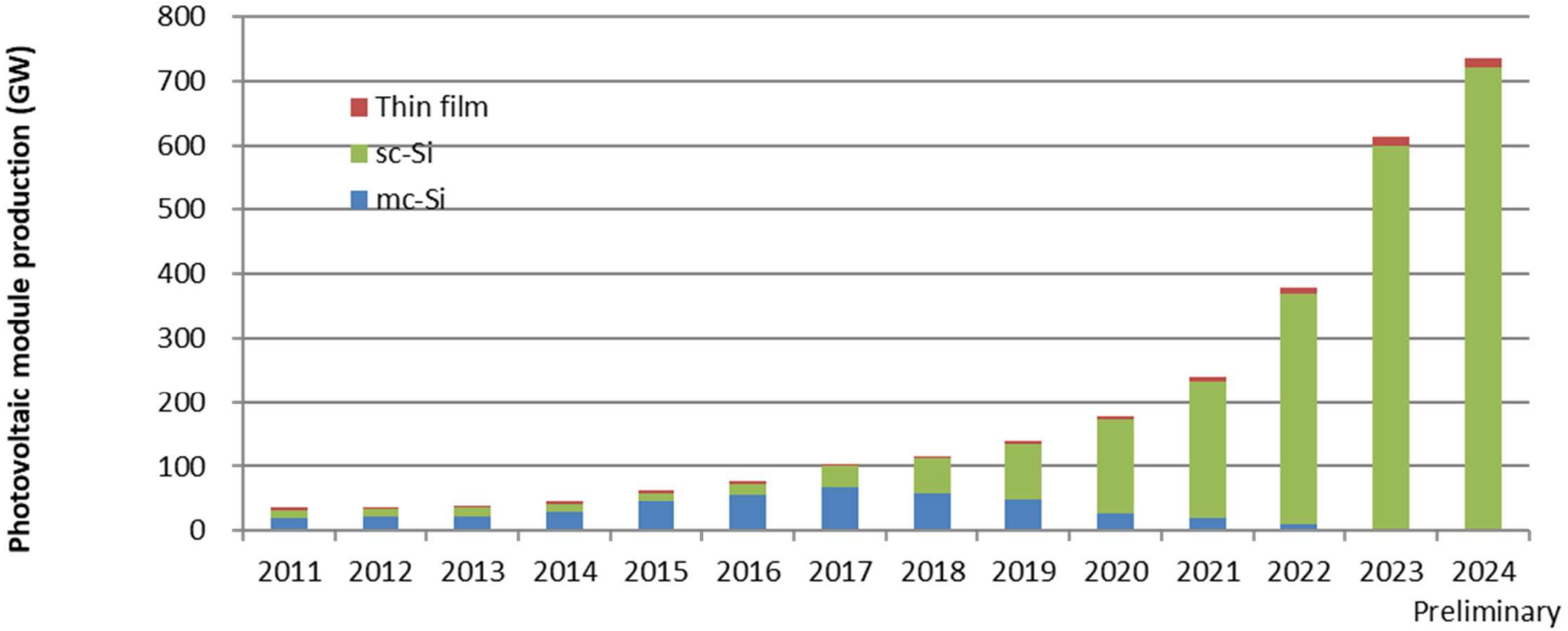
- CPIA expressed that bidding below cost in China violate the Tender Law of the People's Republic of China
- CPIA disclosed the cost price: 0.69 RMB/W (9.5 US cent/W), including tax, excluding transportation and miscellaneous expenses of standard PV module (double-glass, n-type PV modules using M10/ G12R wafers as of Nov. 2024
- The "cost" announced by the CPIA will be considered the "minimum price" for bidding in China
- CPIA also requested to appropriate transportation costs (0.015 RMB/W/km in December 2024) to be taken into account in addition to the "cost."

PV module cost disclosed by CPIA (as of Dec. 2024)

	Cost w/o Tax	Unit	Items
Polysilicon	34.368	RMB/kg	Metal Silicon, SiHCl3, Silicon rod, electricity, labor, etc.
Wafer	0.124	RMB/W	Crucibles, hot zone parts, power, electricity, diamond wire, etc.
Cell	0.263	RMB/W	Silver paste, silk screen, electricity, labor costs, etc.
PV module	0.605	RMB/W	Silver glass, sealing material, frame, labor cost, etc.
Total	**0.692**	**RMB/W**	**Total cost ; PV module cost plus minimum additional cost**

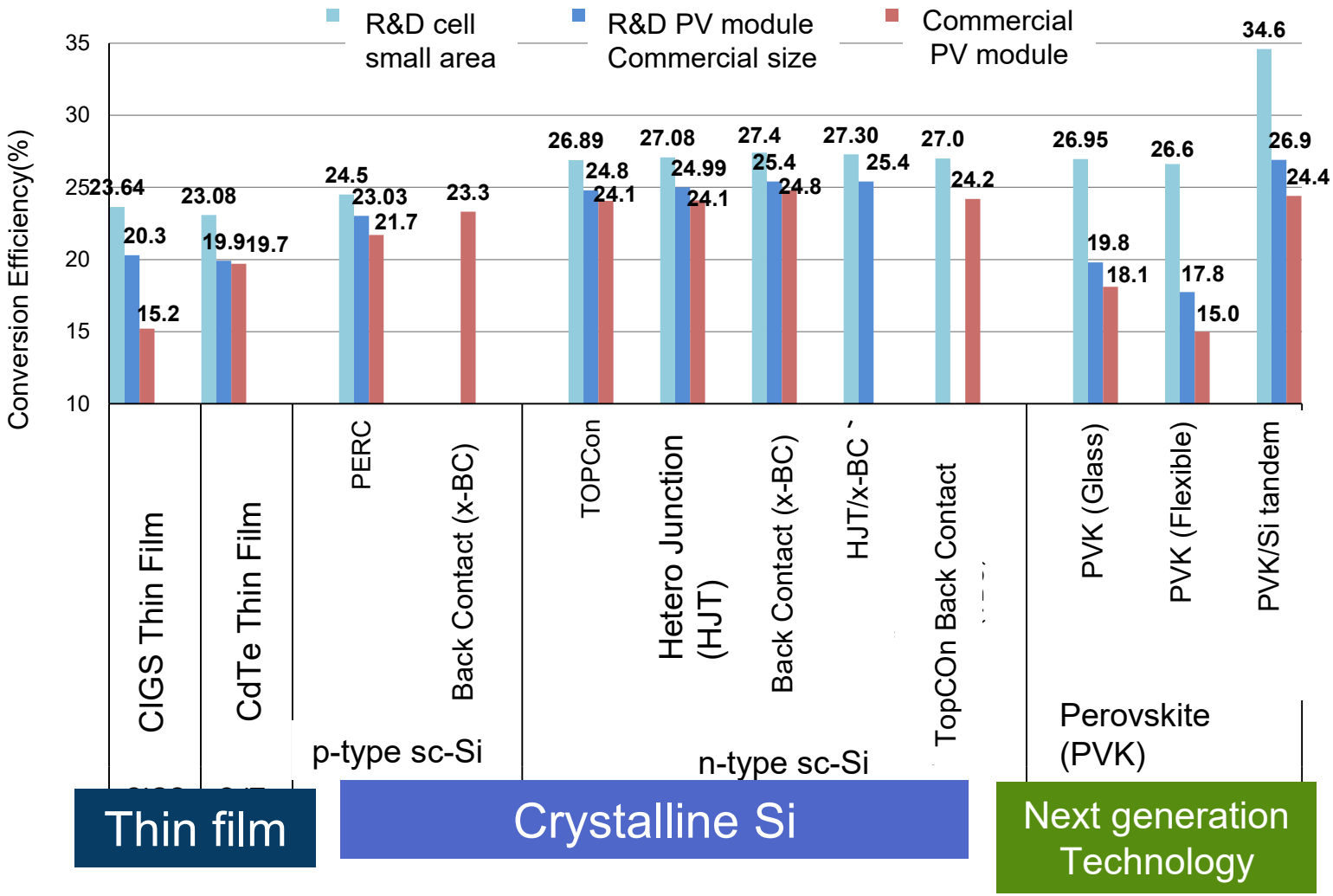
Source :CPIA, compiled by RTS Corporation

Technology Trends



- Single crystalline Silicon (sc-Si) dominates the market
- Thin-film has a small share ~2%, mainly CdTe thin-film PV module by First Solar
- TopCon became the main stream product in 2024

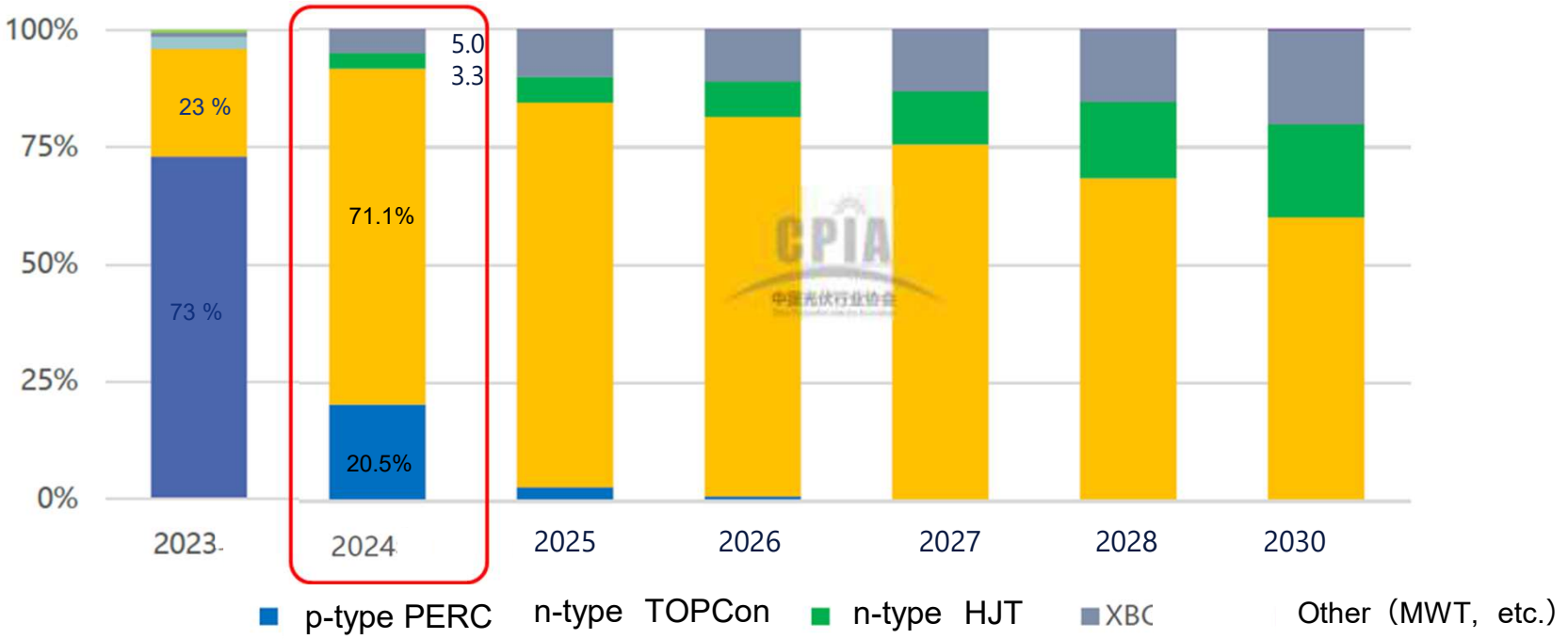
Comparison of highest efficiencies by technologies (2024)



Source：RTS Corporation

Share of PV cell technology and outlook by CPIA

- Most of the solar cell production lines that started operating in China in 2024 were "n-type" technology
- Production capacity in 2024: TOPCON 833GW/year, HJT 50GW/year, XBC 55GW/year

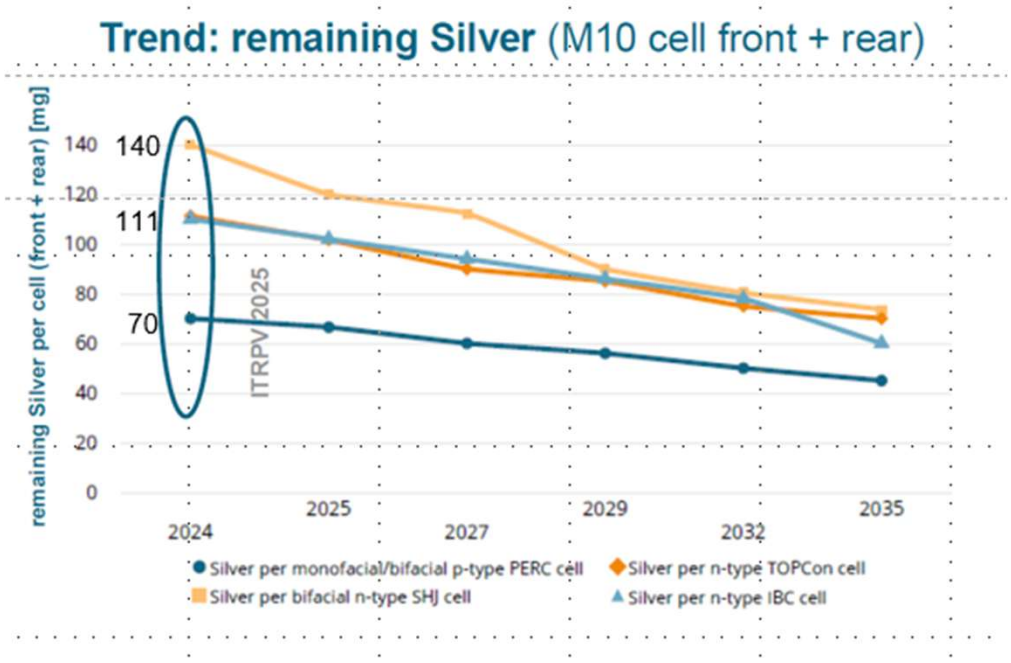


Source：CPIA, Shanghai HIUV New Material, compiled by RTS Corporation

Cost reduction opportunity: Silver consumption

- In 2024, estimated silver usage for PV is ~20% of world consumption of Silver (used for contact)
- N-type cell technology consumes more silver
  - ⇒ Silver consumption levels by top manufacturers (Tier 1) :
    PERC: 7-8 mg/W, TOPCon: 12-16 mg/W, HJT: 17-20 mg/W
- Cu replacement is one of the solutions: Ag-coated Cu

https://tradingeconomics.com/commodity/silver



Rectangular wafers adopted by major manufacturers

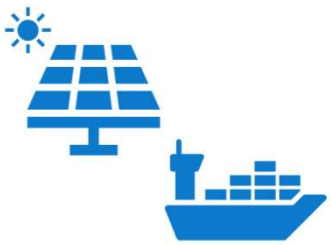
- Major manufacturers are adopting rectangular waferse, mainly for utility scale PV.
- As of Dec. 2023, 5 manufacturers use 182 x 210mm 210R wafers (66 full-size equivalent)
- Rectangular wafers are also used in small 54-cell and 48-cell modules for roofs
- The width of the short side is unified at 1,134 mm

Source：Astronergy(Chint Group)

Summary:

- ✓ PV manufacturing capacity reached 1.5 TW/year in 2024
- ✓ India and USA increased manufacturing capacity with the policy and support measures in 2024 while China continues to dominate supply chain (polysilicon, wafer, cell, modules and other materials + manufacturing equipment and inverters) but
- ✓ Global PV industry has over capacity and PV module manufactures are suffering from lowering profit
- ✓ There are space for cost reduction with standardization, materials, new technologies, while sustainable investment is key and new technologies are need to ensure reliability
- ✓ The industry needs to prepare TW/year market

Issues in the PV industry



Oversupply

Price competition

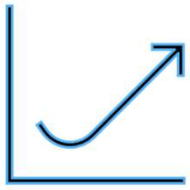
Lowering margin

Forced labor issues

Intensifying trade tensions

Reduced dependency on specific country

Support and protection of local industry



Preparing for TW annual market

出典：㈱資源総合システム作成

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

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NEDO New Energy and Industrial Technology Development Organization

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