# PV Industry Trends

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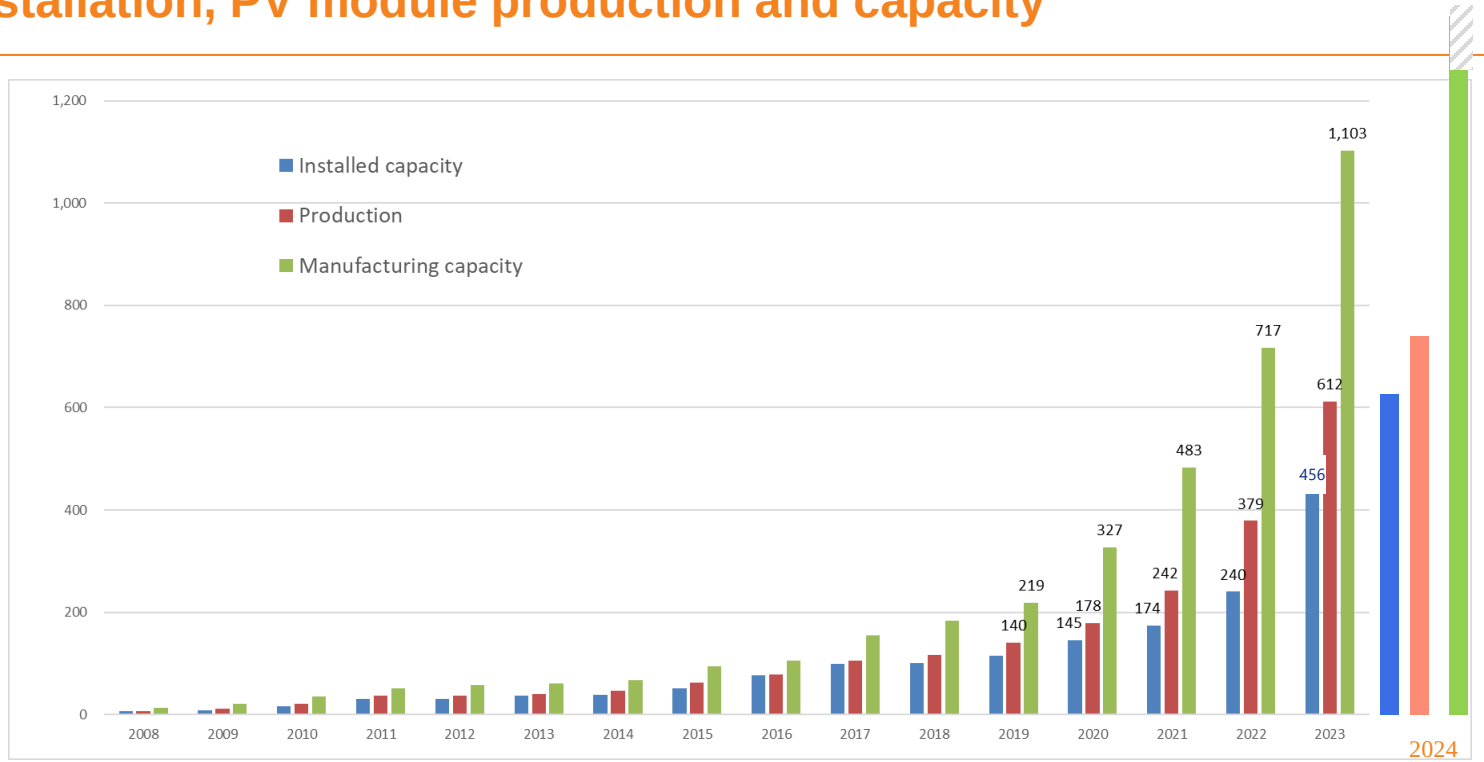
# Contents

- PV module production
  - What amount in 2023,  Where produced & who provide?
- PV technology
- PV module price trends
- PV modules for specific application
- Summary

# Installation, PV module production and capacity




- 2023 : 612GW of production with >1 TW/year production capacity
- Capacity enhancement is slowing down in China.
- Demand supply gap will continue in 2024

Source : IEA PVPS, Trends Report 2024

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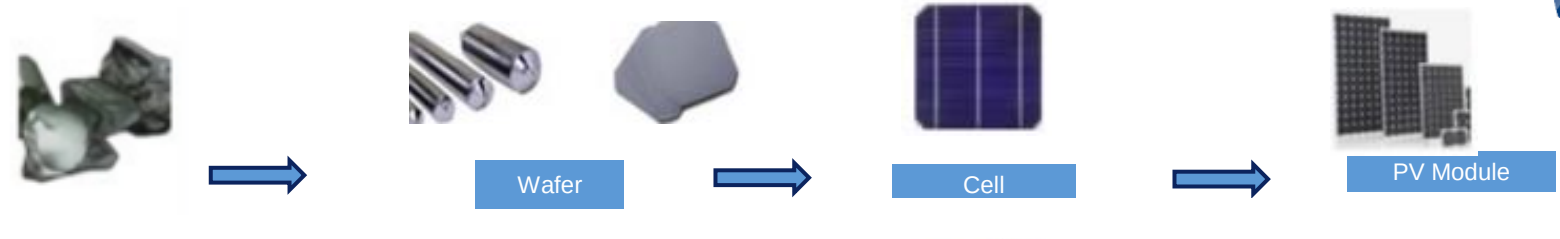
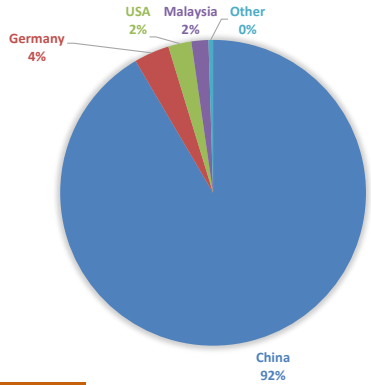
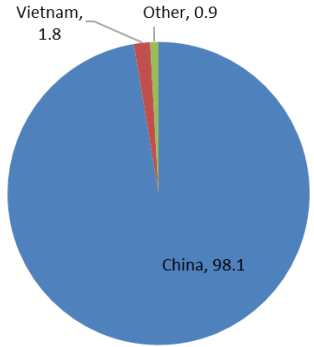
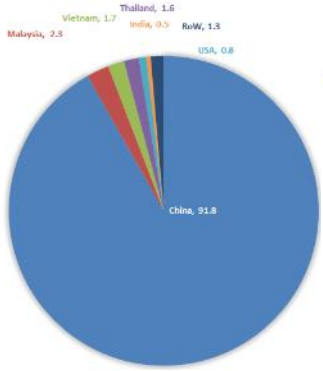
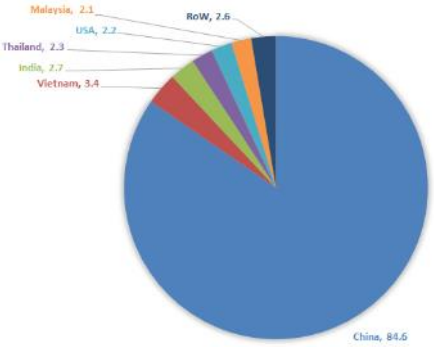
# PV Supply Chain and share by country (2023)




Share of China

2022: 86%
2023 : 92%

2022 : 97.5%
2023: 98.1%

2022 : 84%
2023: 92%

2022 77.8%
2023: 84.6%

- 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

# 1H 2024 rankings of PV module shipment by supplier

| Ranking | 1H2024（GW） | | 2023（GW） | | 2022（GW） | |
|---|---|---|---|---|---|---|
| 1 | JinkoSolar | 43.8 | JinkoSolar | 78.5 | LONGi Green Energy Technology | 46.76 |
| 2 | JA Solar Technology | 38 | LONGi Green Energy Technology | 67.5 | JinkoSolar | 44.5 |
| 3 | Trina Solar | 34 | Trina Solar | 65.2 | Trina Solar | 43.09 |
| 4 | LONGi Green Energy Technology | 31.34 | JA Solar Technology | 55.3 | JA Solar Technology | 39.75 |
| 5 | Tongwei | 18.67 | Tongwei | 31.11 | Canadian Solar | 21.1 |
| 6 | Zhejiang Chint Electrics | 18 | Canadian Solar | 30.7 | Risen Energy | 13.5 |
| 7 | Canadian Solar | 14.5 | Zhejiang Chint Electrics | 28.0 | Zhejiang Chint Electrics | 13.5 |
| 8 | GCLSI | 10 – 11 | Risen Energy | 18.99 | First Solar | *9.3* |
| | DAS Solar | 10 - 11 | DAS Solar | 17.7 | Hanwha Solutions | 9 |
| 10 | Hengdian Group DMEGC Magnetics | 8.1 | GCLSI | 16.4 | DAS Solar | 8.5 |

Source：RTS Corporation, including estimated number

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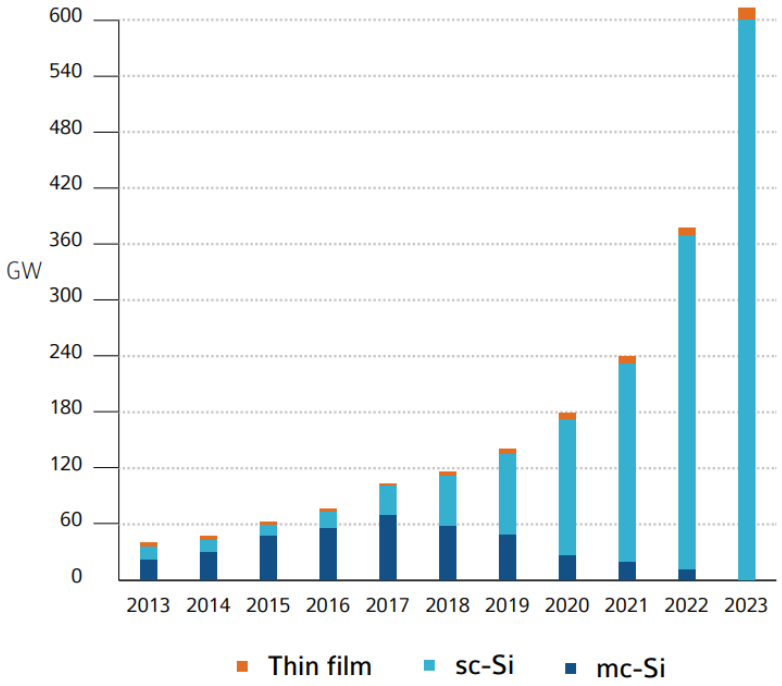
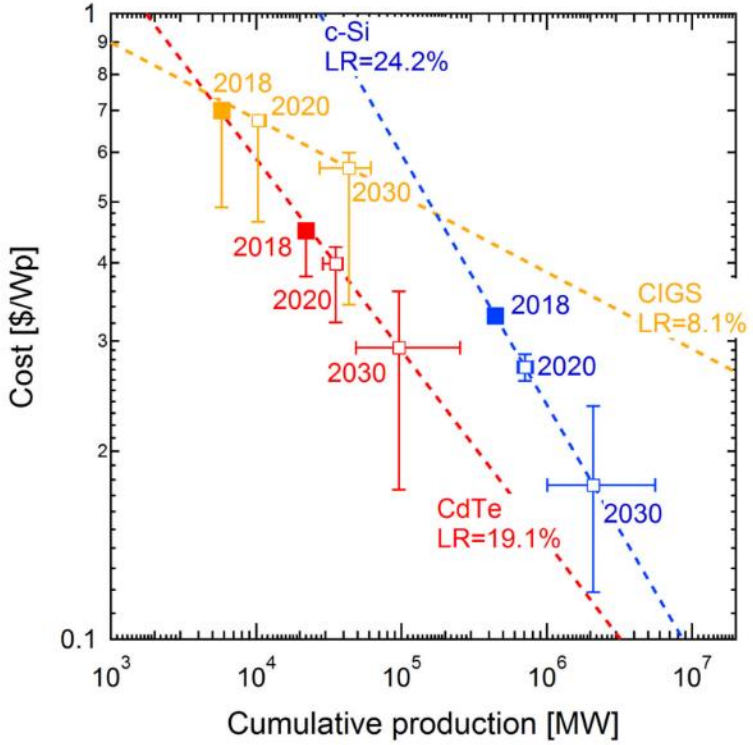
# PV module share by technology




- In 2023：multi-crystalline Silicon PV module decreased to almost zero
- Single crystalline Silicon (sc-Si) dominates the market
  PERC: 73%
  TopCon: 23%
  Hetero Junction (HJT): 2.3%
- Thin-film has a small share ~2%,
  - Mainly CdTe thin-film PV module by First Solar

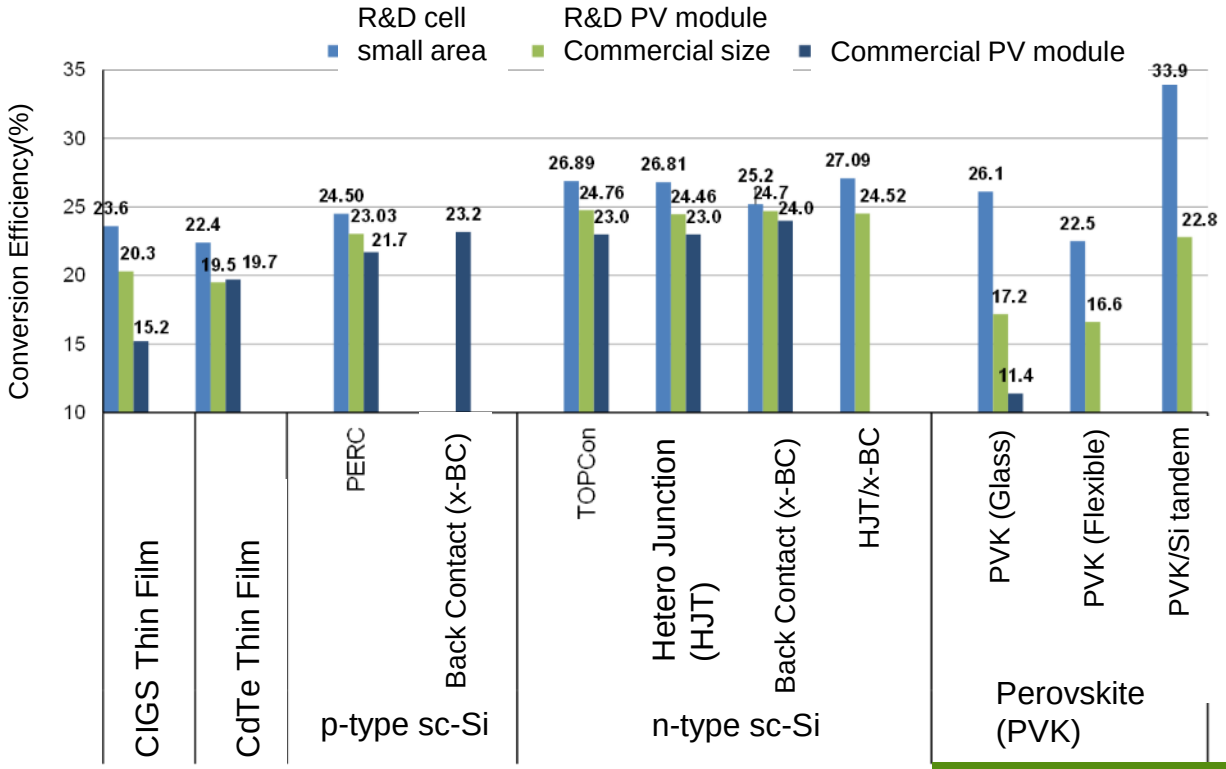
# Why crystalline silicon dominate the market?
# → Different learning curves by technologies




- Learning curves: Each doubling of production, costs fall by a certain percentage (LR: learning rate)
- In an analysis each technology has different LR
- Crystalline Si has better learning rates with the scale of economy and technological progress

Source: https://www.researchgate.net/publication/328242035
Y. Cheng, et. al, "From Laboratory to Production: Learning Models of Efficiency and Manufacturing Cost of Industrial Crystalline Silicon and Thin-Film Photovoltaic Technologies", IEEE Journal, oct. 2018

# Comparison of highest efficiencies by technologies (as of the end of 2023)




Source：RTS Corporation

# Technology drives further cost reduction

**Mono-Si, N-type, Thinner and larger, square → rectangular**
P-type → n-type
Thinner P-type: ~150μm
N-type: 100~130μm
182mm（M10）/
≧210mm（G12）
182mm×18X/19X/210mm (182R/210R)

**Cell cutting,**
½,
1/3…1/6+Shingle,
Damage-less cutting,
Half cut ingot

**Multi Busbar**
（MBB/SMBB - Super MBB）
**Busbar less**
（0BB（multi-wire, smart wire（SWCT, ZBB）
**Electrodes**
（LECO,LEF）

**Novel interconnection**
（High-density cell interconnection）
Shingle, Tiling),Paving/Gapless/ narrowed-spacing

+

**Bifacial**
(Glass/Glass, Glass/BS

+

**Internal cell connection**

+

**MPPT control (with MLPE)**

+

**Higher efficiency（post-PERC）:** HJT, TOPCon, xBC, Tandem：PBK/Si or CIGS or OPV、III-V/Si, etc.

**BIPV, Glass-less PV (light-weight, bendable), colored or printed**

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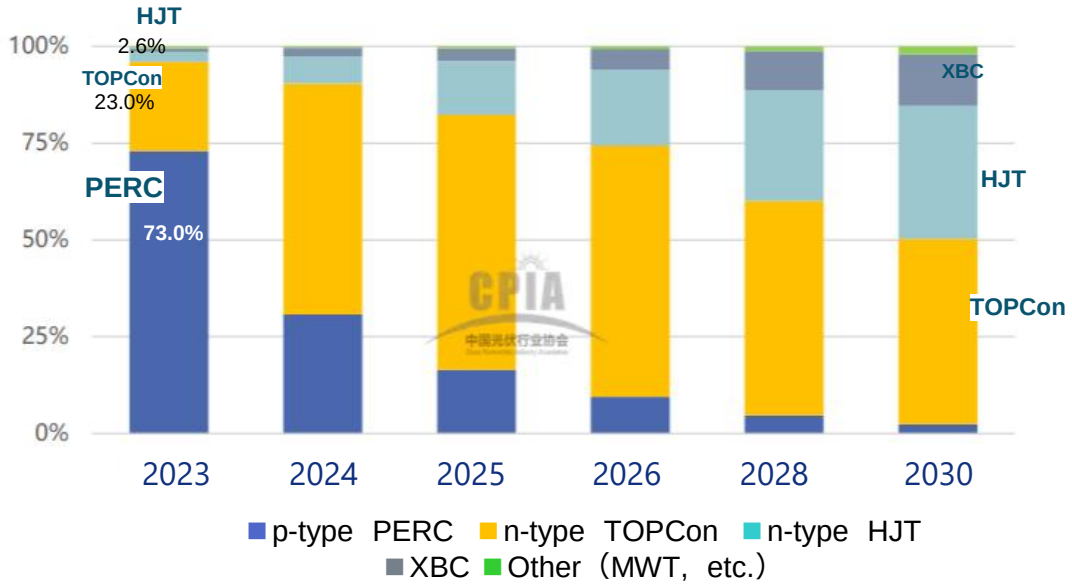
# Share of PV cell technology and outlook by CPIA

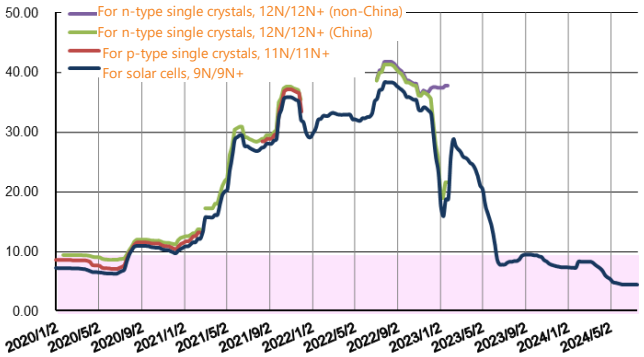
- PERC : 2022: 88% → 2023: 73% (standard products)
- N-type TOPCon : 2022: 8.3% → 2023: 23% → 2024: standard products
- N-type: HJT: 2022: 0.6% → 2023: 2.6%



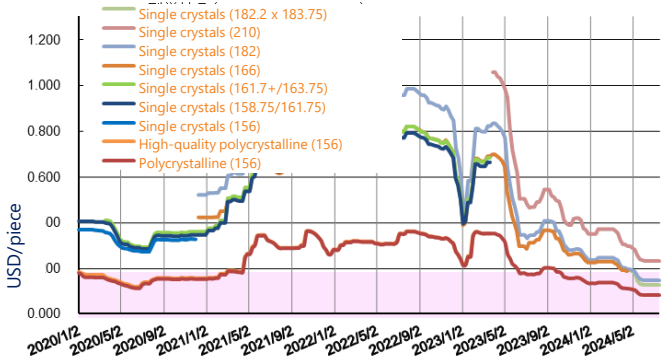

Source：CPIA, China PV Industry Development Roadmap 2022-2023 (February 2024)

# Price trends along the value chain : Prices goes far below forecast

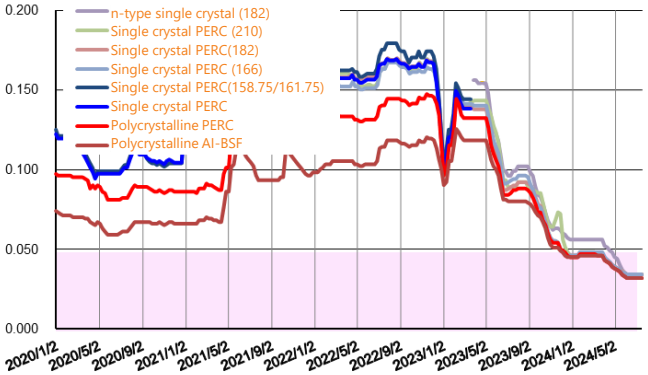
## Polysilicon (USD/kg)



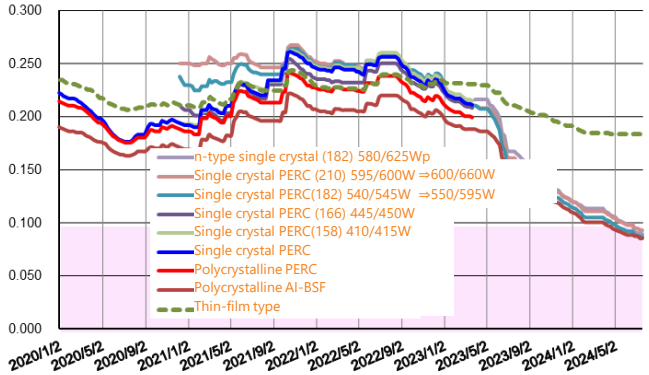

## Silicon wafers (USD/Piece)




## Solar cells (USD/W)




## PV modules (USD/W)

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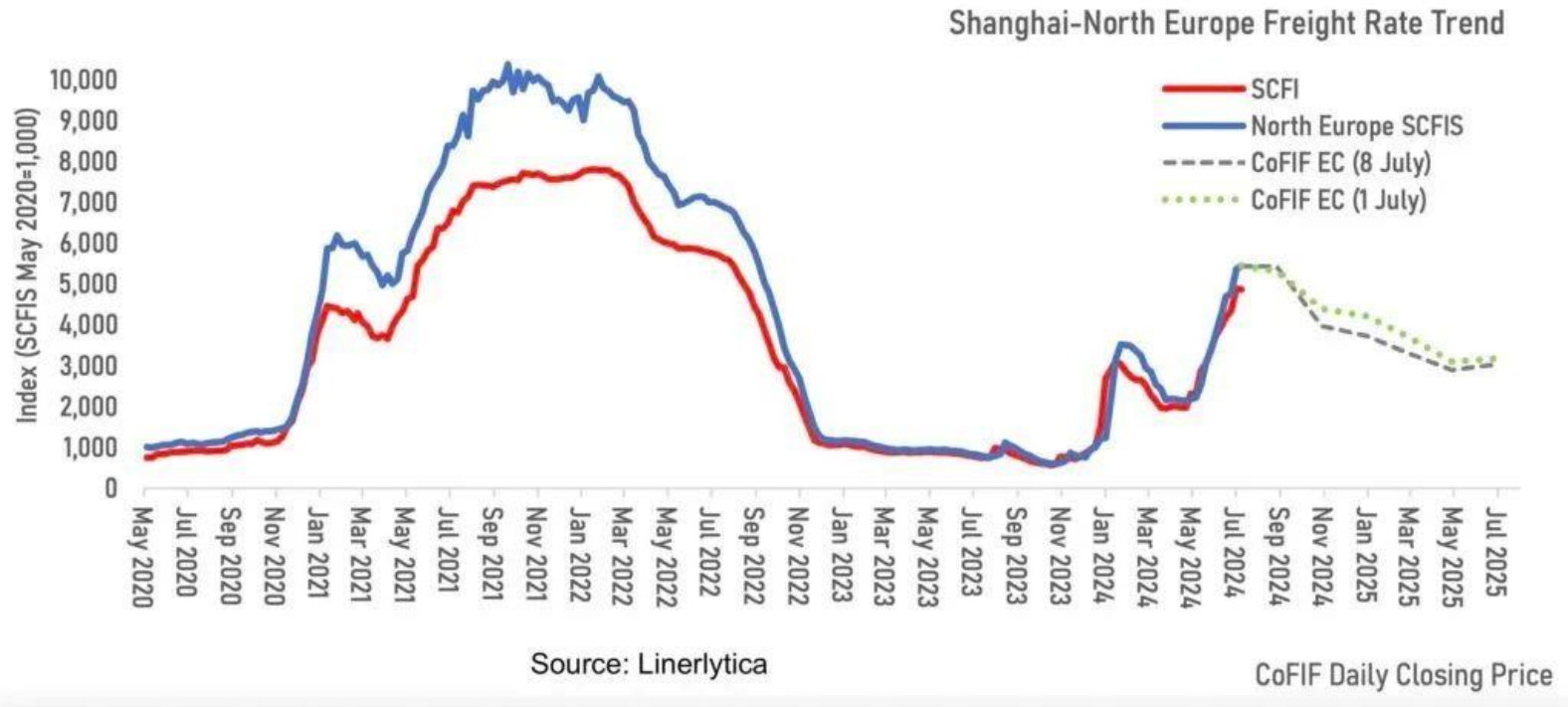
*Sources: PVinsights (Published from January 2, 2020 – July 2024, 28), compiled by RTS Corporation*

# Shipping cost from China

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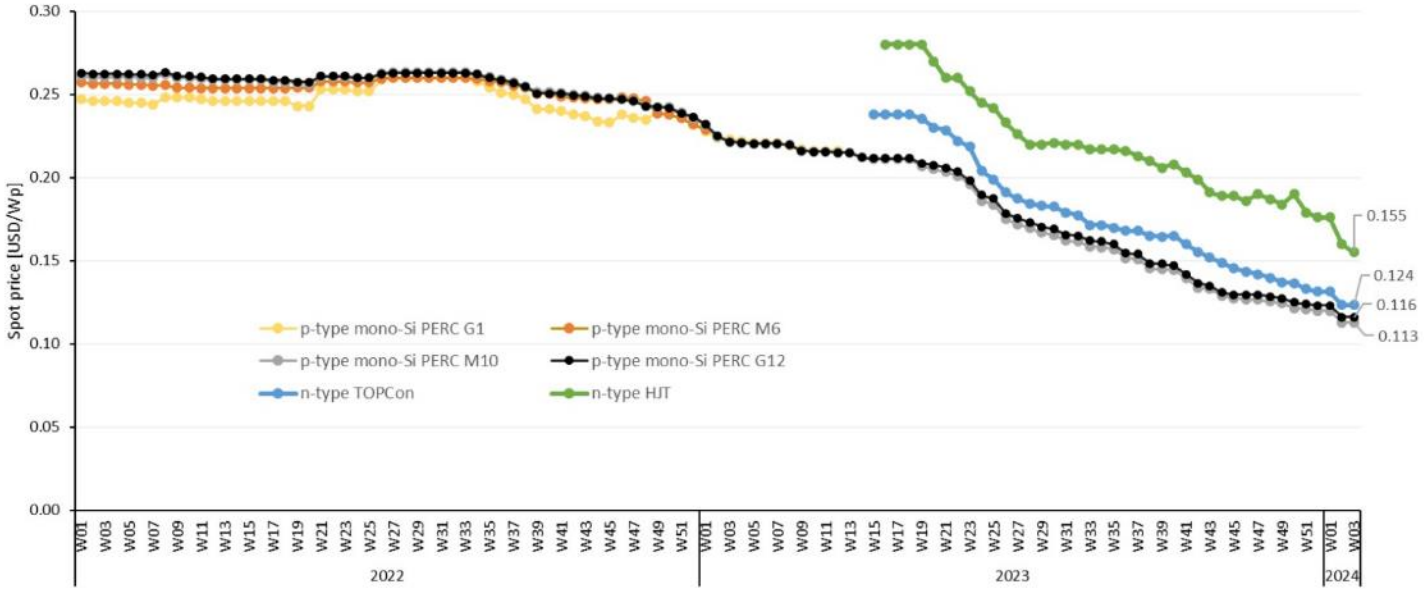
# Further cost reduction?




PV costs have reduced dramatically thanks to:

1. Technical improvements (efficiency gains, larger and thinner wafers, etc.)
2. Learning by doing : economies of scales (excess capacity) and standard
3. Policies that stimulated market growth through CN target

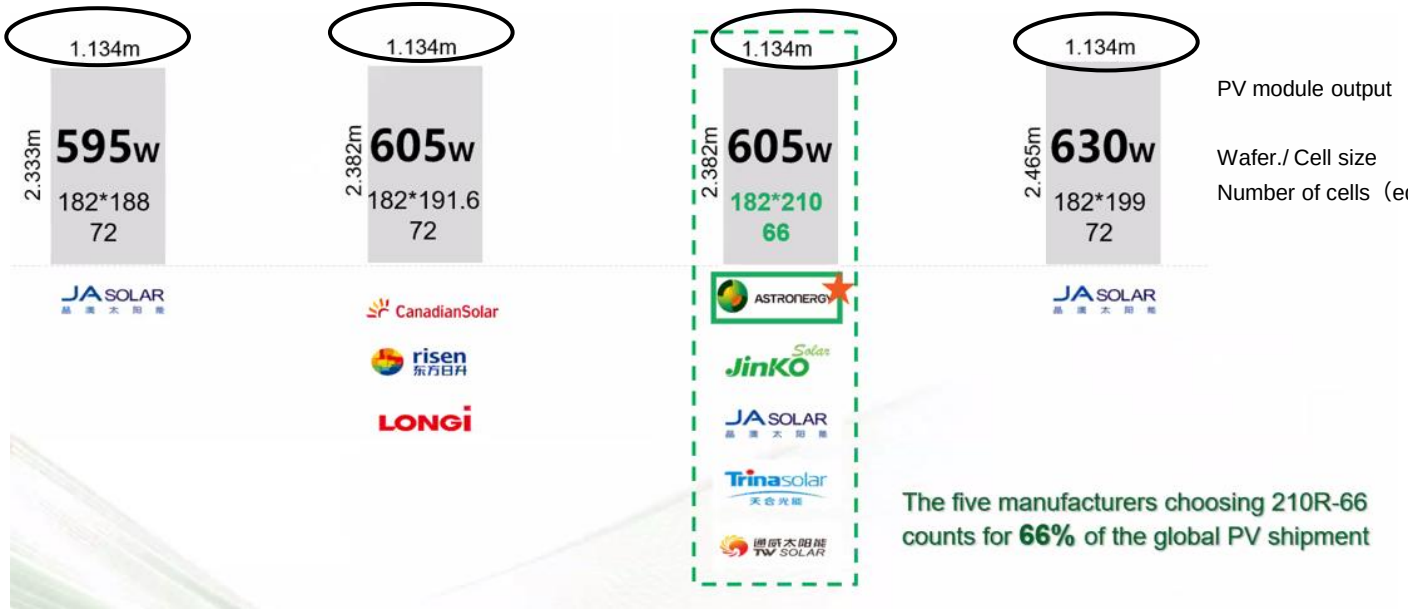
Source : IEA PVPS, Trends Report 2024

# Cost reduction opportunity: Silver consumption

- In 2023, solar cells represent the 16% 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）

# Application trends : Dual use PV systems




# Rooftops

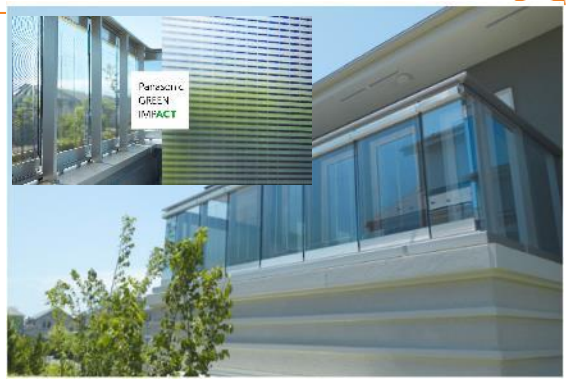
Credit: EPFL, C. Balif

# Windows, and facades, balcony

## Crystalline Si



Kaneka, Japan




Panasonic, Japan

## See-through Organic PV


France・ACSA

## Transparent PV Glass

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# Wall/ Facade

## Crystalline Silicon

(Kaneka and Taisei Corporation, Japan)

「アスロックレールファスナー太陽光パネル設置工法」(仮称)により
太陽光パネルを壁付けした建物のイメージ図

(AGC＋Nozawa, Japan)

実施した試験の様子

## CIGS

(AVANCIS, Germany)

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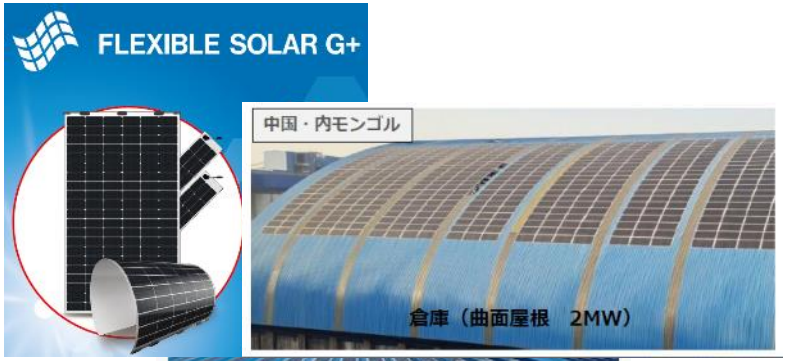
# PV modules for curved roofs and roof with low load capacity

Light weight crystalline Silicon




Sunport Power, China


(3kg/m$^{2,}$)

# Summary:

- ✓PV manufacturing capacity reached 1TW/year in 2023
- ✓China dominates supply chain (polysilicon, wafer, cell, modules and other materials + manufacturing equipment and inverters)
- ✓PV module price lowered and there are still space for cost reduction with standardization, materials, new technologies
- ✓PV modules are developed for specific applications

**Thank you for your kind attention !**

感谢您的关注

끝까지 경청해 주셔서 감사합니다

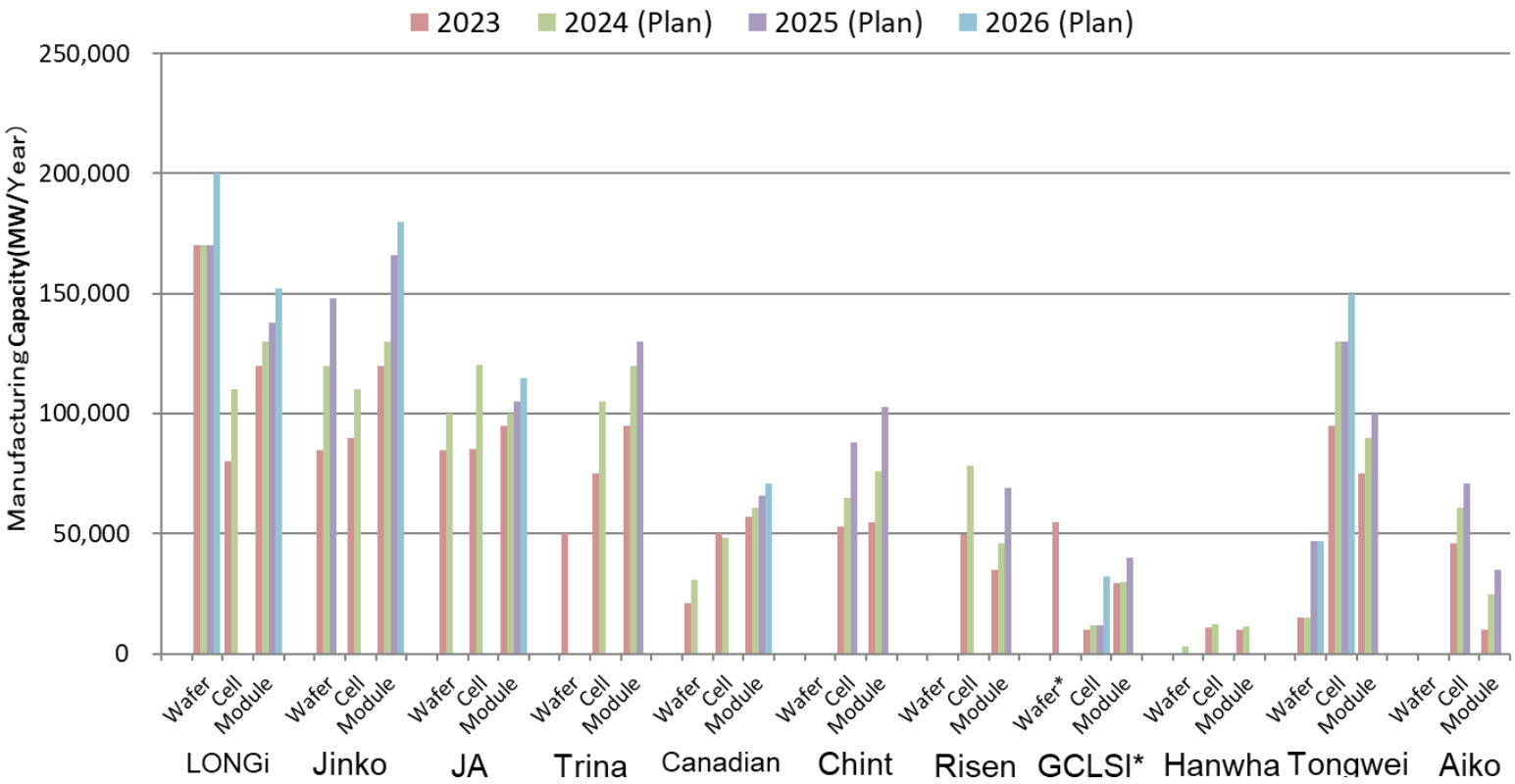
ご清聴ありがとうございました

Acknowledgement for the support of PVPS activities

NEDO New Energy and Industrial Technology Development Organization

Acknowledgement :
PVPS Task1　Colleagues

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


2023
2024 (Plan)
2025 (Plan)
2026 (Plan)
Manufacturing Capacity(MW/Year)
250,000
200,000
150,000
100,000
50,000
0
Wafer
Cell
Module
Wafer*
LONGi
Jinko
JA
Trina
Canadian
Chint
Risen
GCLSI*
Hanwha
Tongwei
Aiko

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