RCT solutions

a member of RCT Group

Simplified. Photovoltaic. Solutions.

Global Visions, Local Realities

Shaping the Future of Solar Production

Solar Technology Conference

India 2025

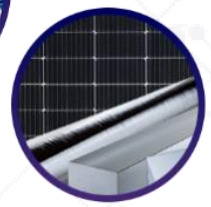
Prof. Dr. Peter Fath
Founder & CEO - RCT Solutions GmbH
April 2025

RCT Solutions GmbH

One-Stop Renewable Solutions Partner

About **RCT Group at a glance**

RCT solutions



Conceptual & Detailed Engineering

Training & On-site Installation

Financial & Business Modeling

2012
Founded, privately owned

72 GW
Supporting PV manufacturing capacity

26
Countries

62
Factories worldwide

World's First
Fully integrated giga-scale factory installation

76 GW
Ingot & Wafer integration

RCT power

RCT Power Residential Batteries & inverters

RCT Power C&I/ Utility Battery Energy Storage

2015
Founded, privately owned

20GWh
production capacity, fully automised

Fully EES manufacturing
Residential, commercial, utility scale (from KWh to MWh)

>12.5 GWh (7 GWh USA)
Total shipment

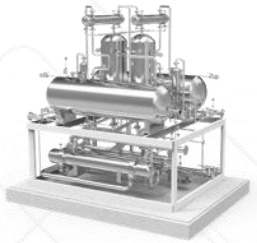
Best Storage
Awarded in Germany

EU&China&USA Based
Battery production & Operations

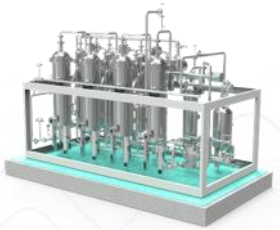
RCT hydrogen

Electrolyser stack

Re-fueling station



Gas Seperation System



Hydrogen Purification System

Made/Engineered in Germany
Hydrogen equipment & engineering service

Factory Output
250MW (Target)

The Global Top Brand for
Renewable Manufacturing

Headquarter
Germany

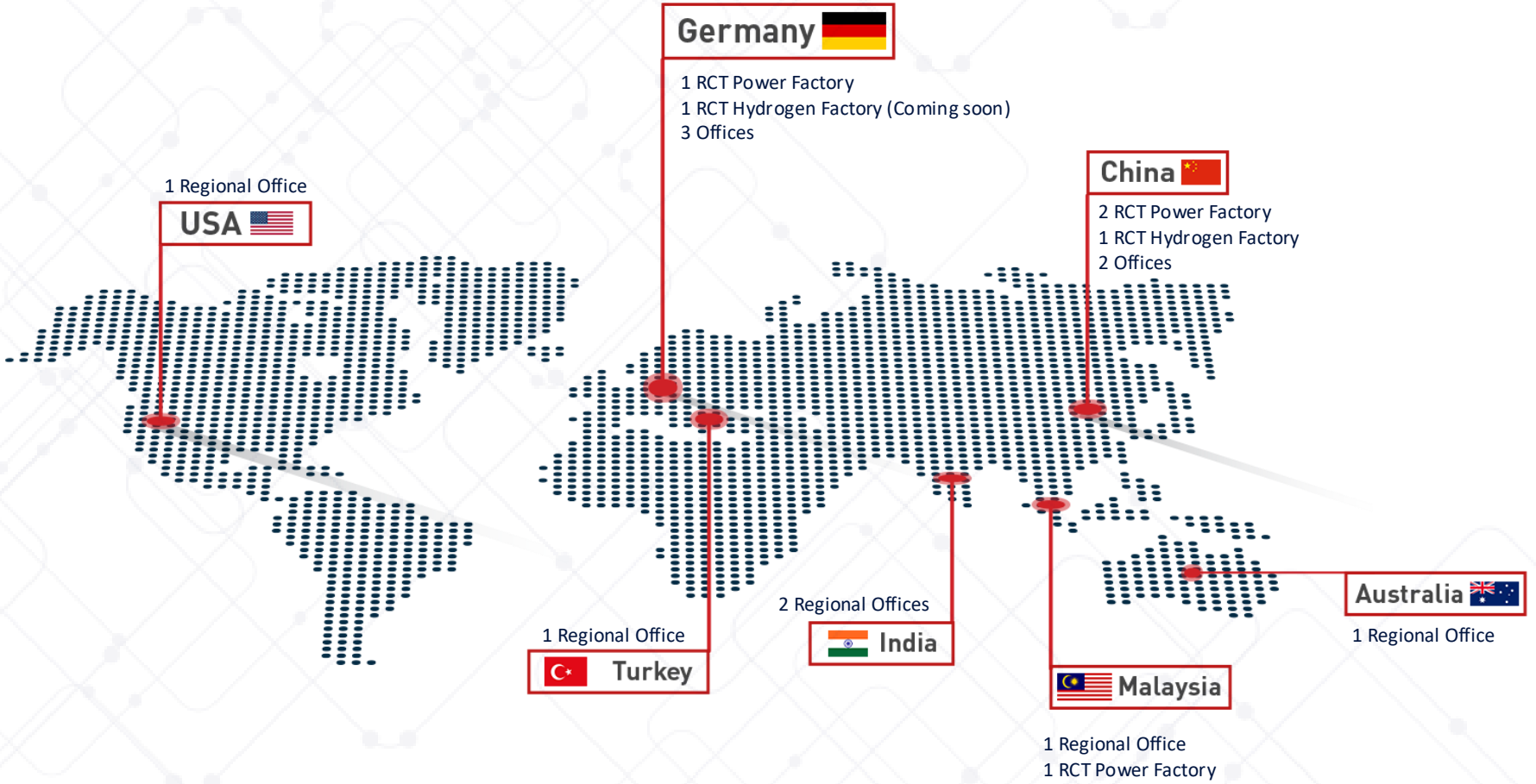
Employees
650+

Manufacturing
Germany, China, Malaysia

Cumulative Shipment
12.5GWh

27 Countries
Active Services

73 GW
Executed PV Engineering



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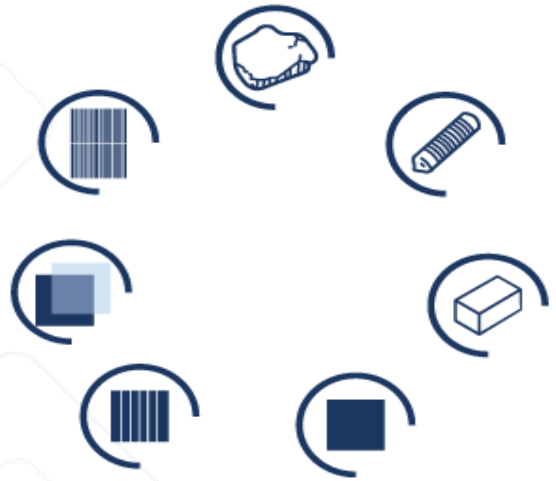
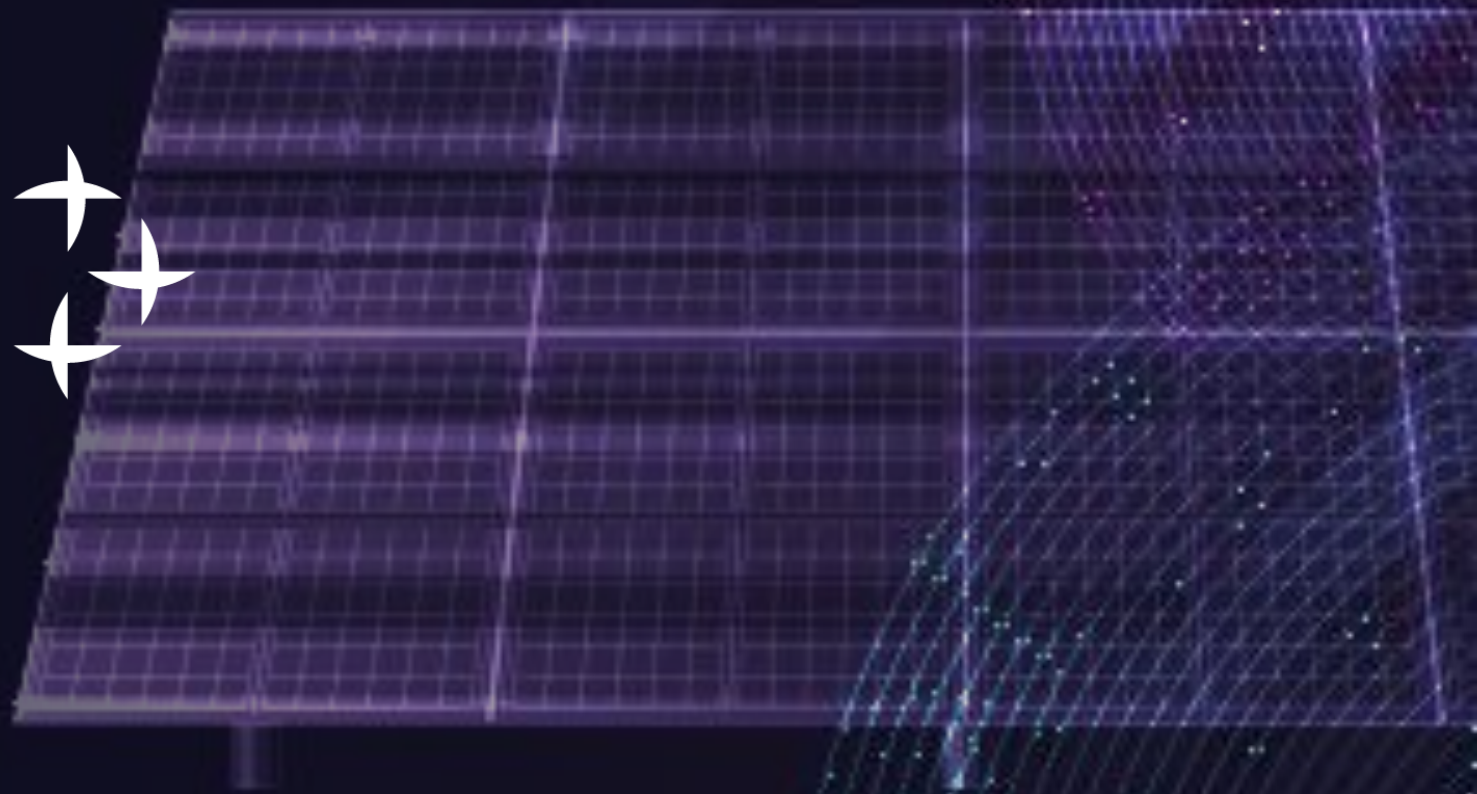
Agenda Today

- Global PV industry: India as a key player?!
- Global Competitiveness: India's potential
- Technology & Manufacturing trends:
  - Should India go its own way in technology?
  - Equipment supply? Made in EU, Made in China, Made in India?
  - Increasing patent disputes : IP Matters
- Challenges and Opportunities for India: In the new world of increasing trade issues
- Setting up new manufacturing: Know-how transfer and capacity building
- Building out a fully solar ecosystem in India: a vision or need?



Global PV industry
India as a key player



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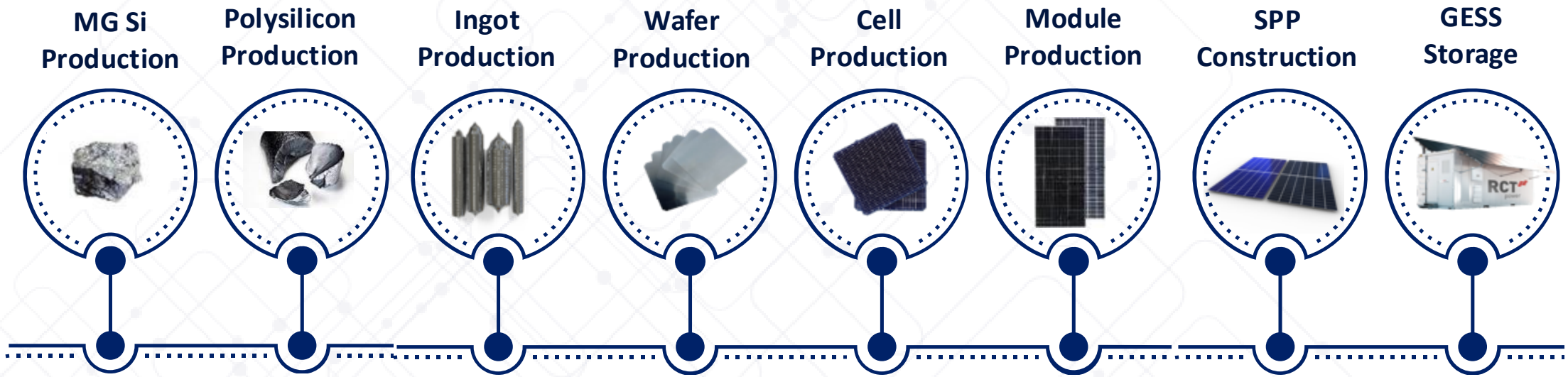
Major value chain in PV Industry

Vertical & Horizontal full integration into Giga scale PV



- Quartz
- Prebaked electrode
- Coal

- Graphite chuck
- Gases (HCl, N_2, H_2, Cl_2)

- Hot zone
- Crucible
- Ar

- Diamond wire

- Ag paste
- Screens
- Chemicals
- Gases

- Glass
- Encapsulation material
- Al frames
- Junction box& ribbons etc

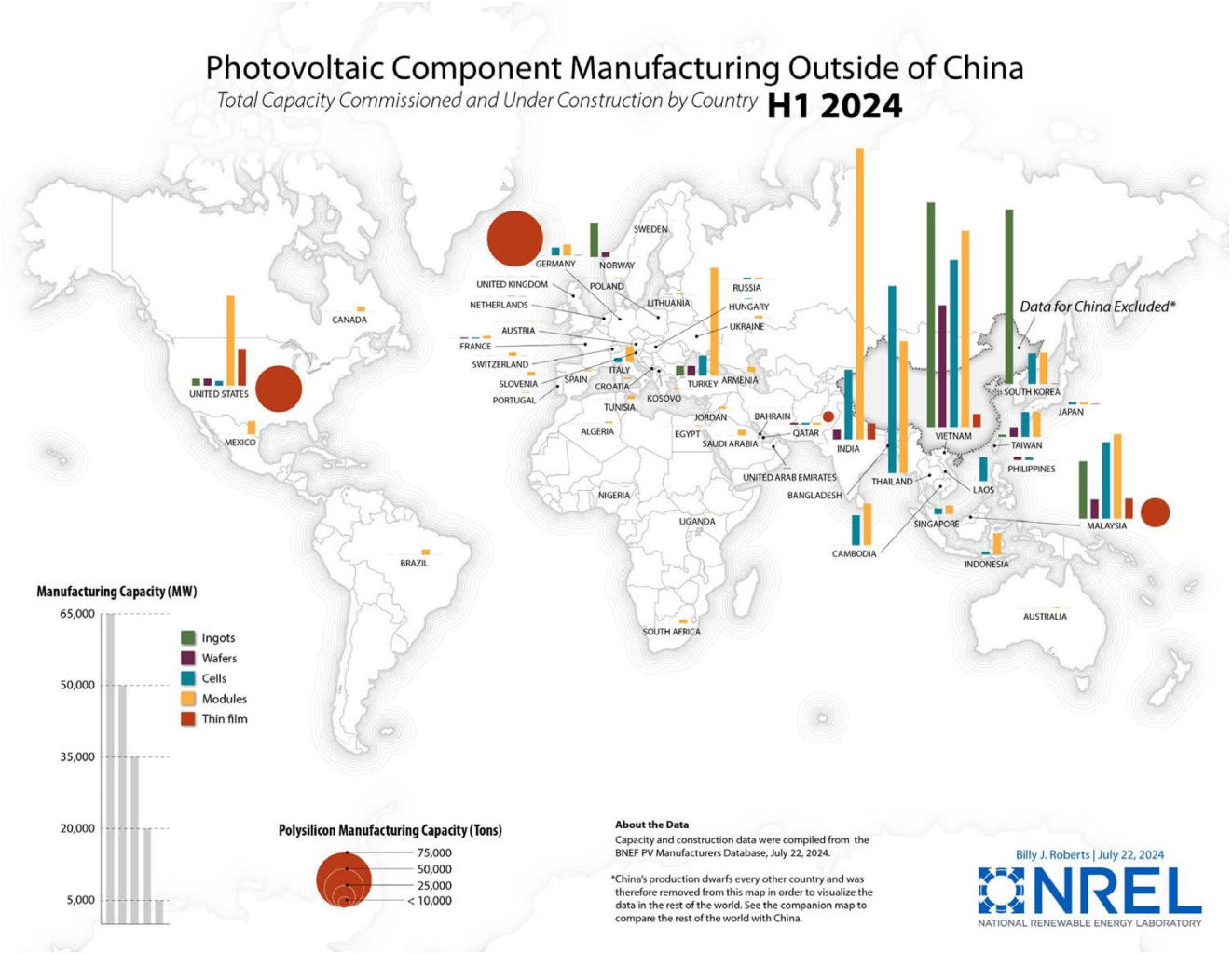
Perspective on Global PV Manufacturing cost and pricing

Our recent assessment

- Production locations for PV manufacturing are diversifying globally from the domination China and Southeast Asia
- Incentive programs available in India, USA, Turkey and in-sight for Europe

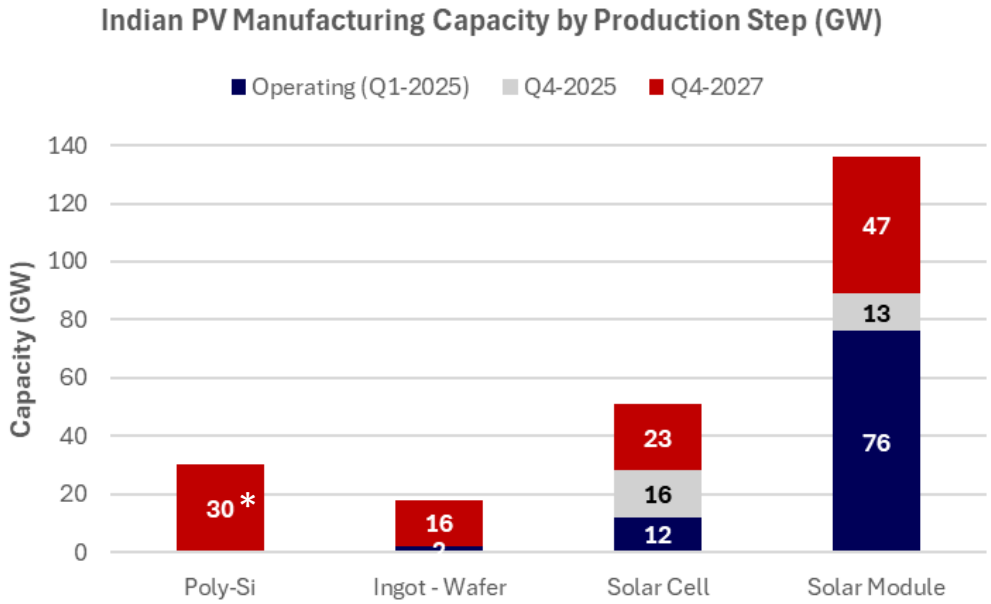
Question of investors and governments in PV manufacturing

- Which are the main cost drivers at each production stage along the PV value chain?
- What are the cost differences for PV production in different global regions?



Solar PV Manufacturing Landscape in India

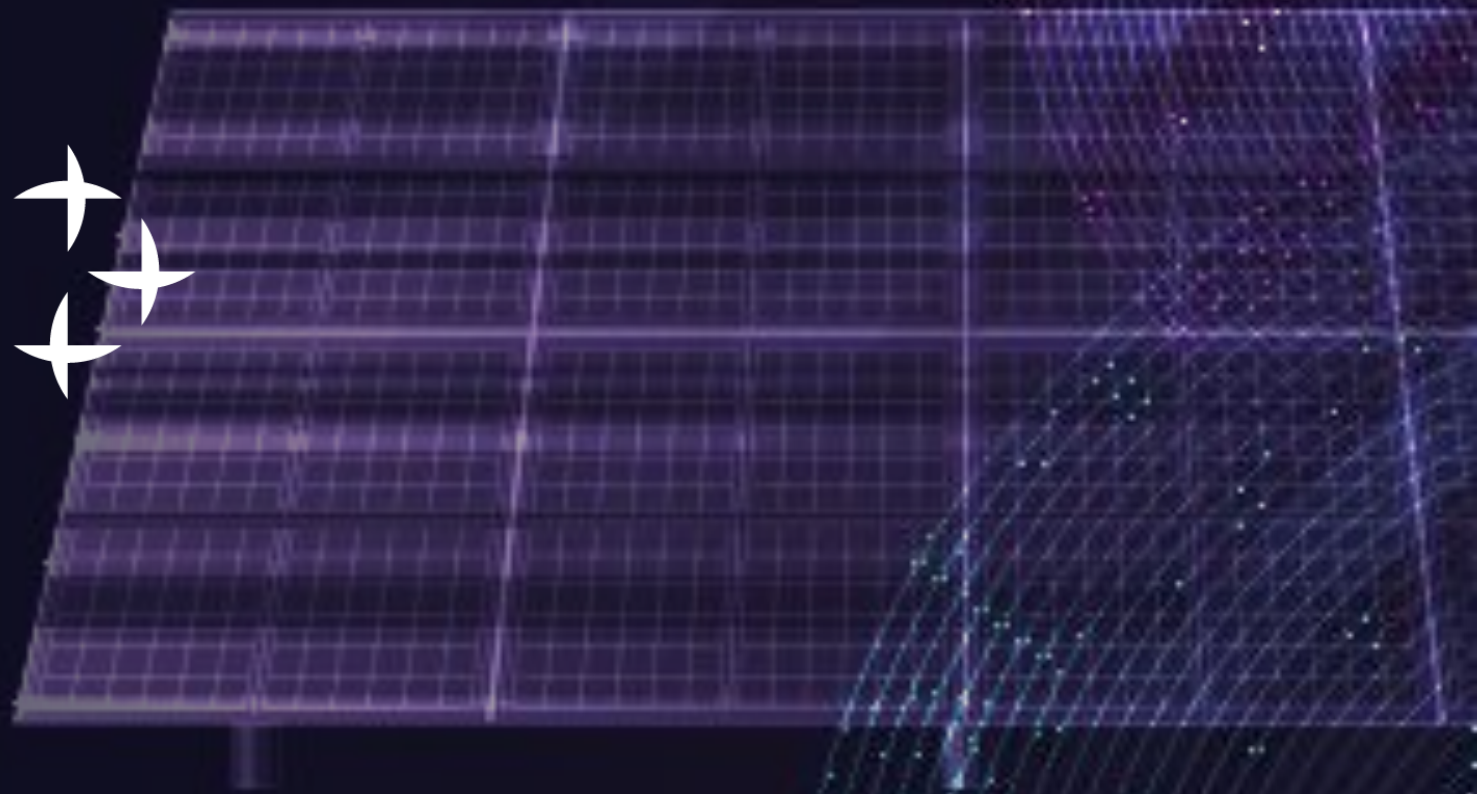
Solar module dominated, but other stages grow



*It seems unlikely that 30 GW of poly-Si capacity will be installed by 2027.

Global Competitiveness

India's significant potential



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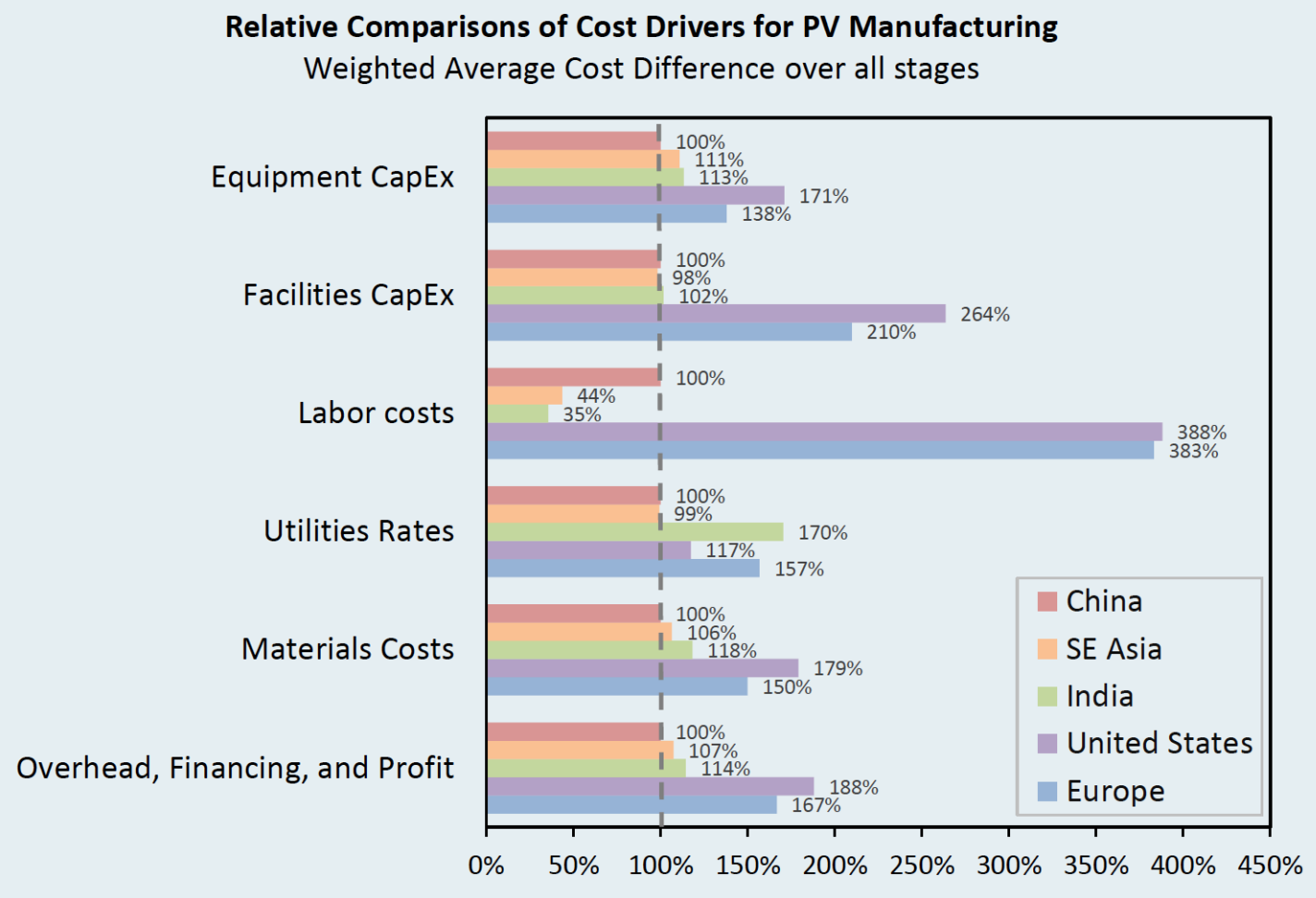
Comparative Global PV Manufacturing cost and pricing
Excellent potential for low-cost manufacturing in India

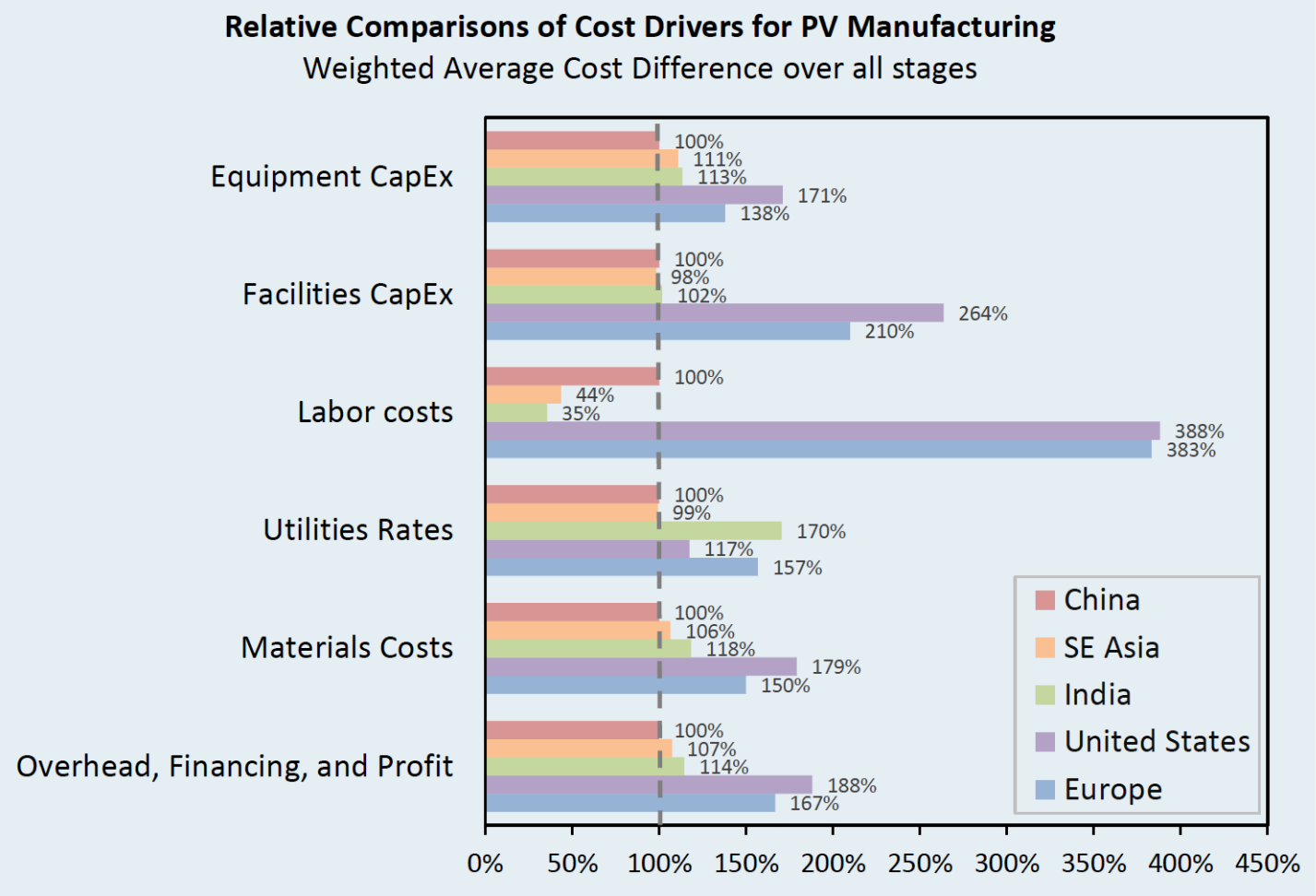


Key cost drivers: India vs China:

- Only slightly higher equipment CAPEX (+13%)
- Comparable Facilities CAPEX
- Lower Labor cost (-70%)
- Higher Utility cost
- Only slightly higher material cost (+15%)
- Only slightly higher overhead and financing cost (+14%)

Source: RCT Solutions/NREL, Fhg ISE

Comparative Global PV Manufacturing cost and pricing
Relative comparisons of cost drivers for PV Manufacturing



Source: RCT Solutions/NREL, Fhg ISE

Key Cost Drivers in Europe and US in comparison to China / India

Equipment CAPEX
- 40-70% higher (w/ Western Equipment)

Building and Facility CAPEX
- 2.1-2.6 x higher construction costs

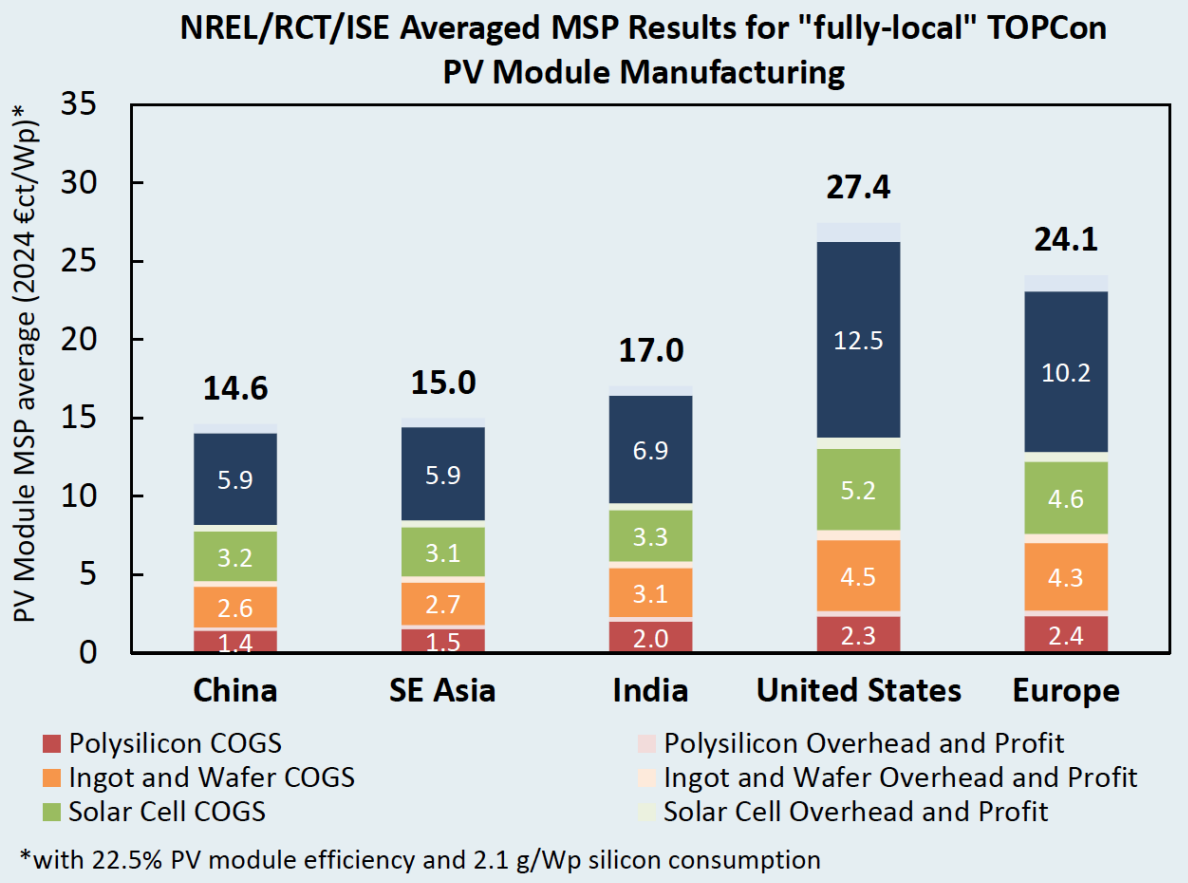
Labor costs
- 3-4 x higher: wages & working hours

Utility (Electricity, Water, …)
- 20-60% higher

Material Costs:
- 50-80% higher (with local BOM)

Overhead, Financing, and Profit
- Same margin adding more to MSP

Fully-local PV Manufacturing along the Value Chain



Impact on "fully-local" in Europe or US manufactured TOPCon PV Module

Difference in Europe & US in comparison to China / India

- Polysilicon ~1.1 €ct/Wp
- Polysilicon-to-Wafer 2.0 - 2.2 €ct/Wp
- Wafer-to-Cell 1.6 - 2.3 €ct/Wp
- Cell-to-Module 4.8 - 7.3 €ct/Wp

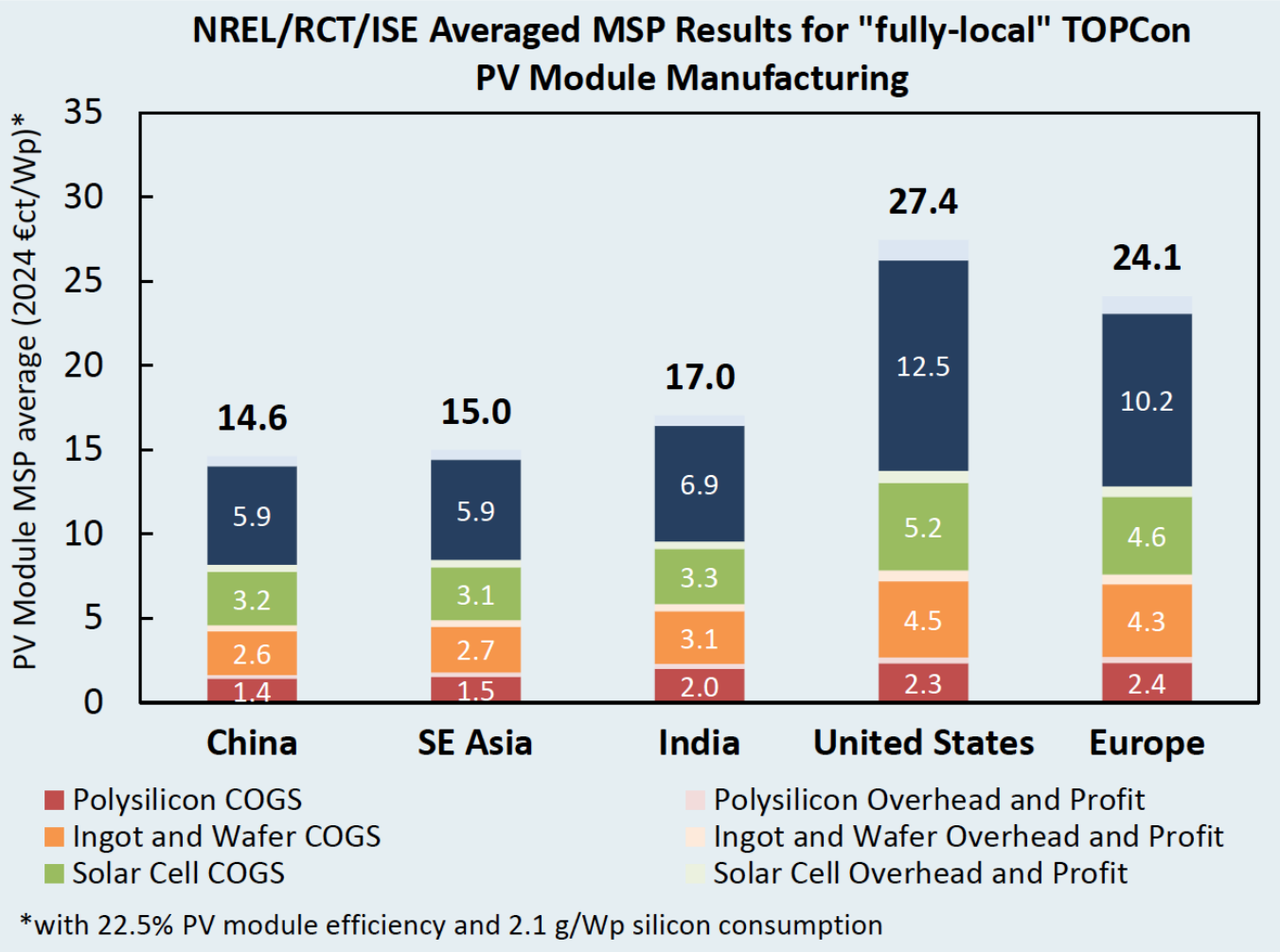
Main cost differences for Materials and Labor.

MSP difference 9.5 – 12.8 €ct/Wp

for "fully-local" manufactured TOPCon PV Module.

In Southeast Asia similar, in India slightly higher MSP.

Fully-local PV Manufacturing along the Value Chain
Excellent potential for low-cost manufacturing in India



Potential for India to be in the group of low-cost producers globally

New Opportunities for India
India's role in PV globally

Short Term (Current)	Medium Term (2025-2027)	Long Term (2028 onwards)
Local Content Buildup	Global Competitiveness	RE Industrialization Hub
Established LCOE price baseline	Balanced LCOE & local content	Balanced LCOE & local content
Kick-start supply chain development	Setup of solar clusters	Export focus RE supply chain

India to play a critical role and becoming a hub for renewable energy

- Simplicity
- Already existing manufacturing culture
- Hydrogen, Storage, Solar, Wind Investments
- Cost-effectiveness
- Energy sovereignity
- Diversification of Economy

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Technology trends:

Should India go its own way in technology?

Equipment supply? Made in EU, Made in China, Made in India?

Increasing patent disputes : IP Matters

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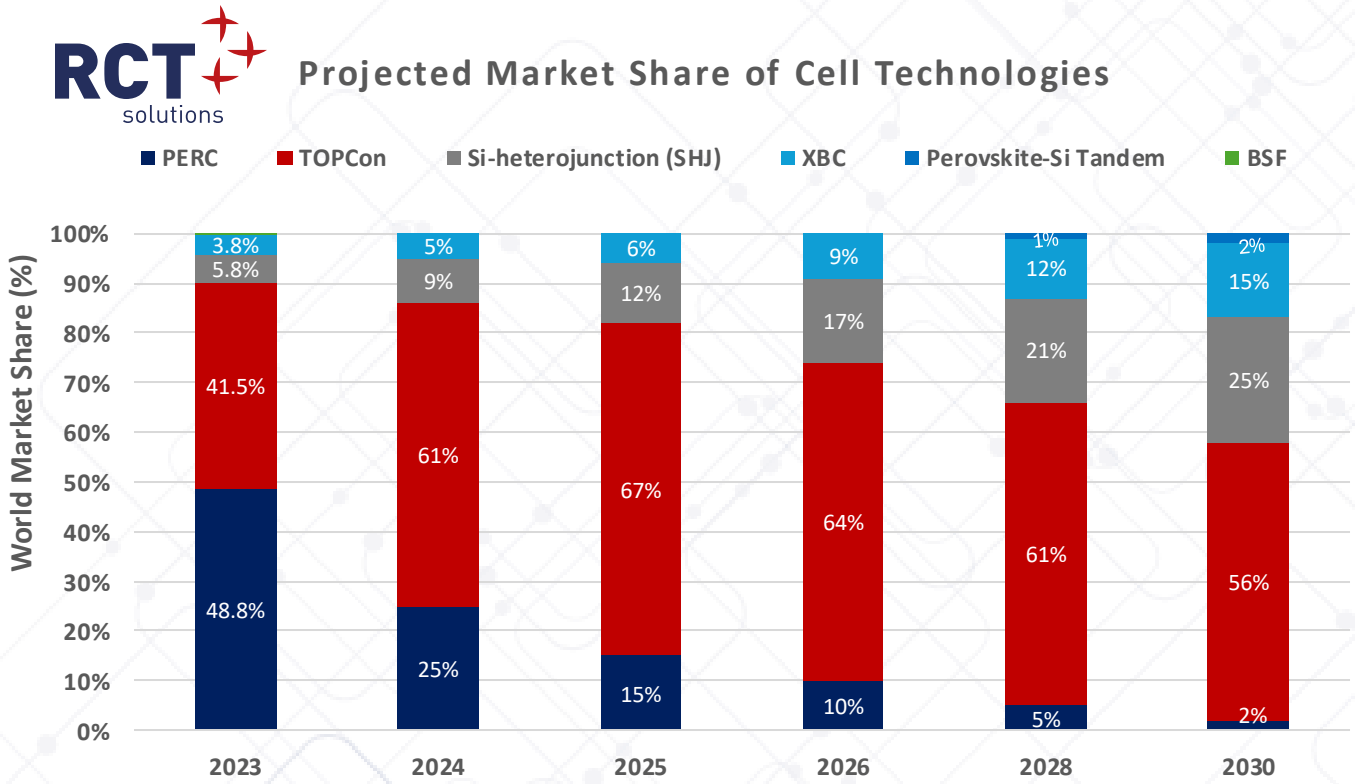
Projected solar cell technology share till 2030
TOPCon clearly dominating



- TOPCon will have more than 60% market share by end of 2024.
- SHJ and XBC technologies slowly gaining momentum and expected to have 25% and 15% market share at the end of 2030, respectively.
- Perovskite/Si tandem may get 1-2% market share by 2030 if the technological problems are mitigated.

What's happening?
Patent issues around the world

Reuters World Business Markets Sustainability Legal Breakingviews Technology

First Solar says several large rivals are infringing on patents

By Reuters

Reuters World Business Markets Sustainability Legal Breakingviews

Maxeon says will seek to block asset sale

By Reuters

August 31, 2024 1:00 AM GMT+3 · Updated 4 months ago

Maxeon initiates unitary patent infringement lawsuit against Aiko, partners

Alongside the new lawsuit, which has been filed in Germany, Maxeon has announced it is appealing a preliminary injunction decision recently made by a court in the Netherlands over an ongoing patent dispute with Aiko.

JUNE 19, 2024 PATRICK JOWETT

LEGAL MARKETS MODULES & UPSTREAM MANUFACTURING GERMANY

Image: Maxeon Solar Technologie

Trina Solar, Hanwha Qcells reach settlement on patent dispute

Hanwha Qcells and Trina Solar say they have signed a patent licensing and transfer agreement with each other to end a dispute over their intellectual property.

FEBRUARY 17, 2023 EMILIANO BELLINI

MODULES & UPSTREAM MANUFACTURING TECHNOLOGY AND R&D CHINA SOUTH KOREA

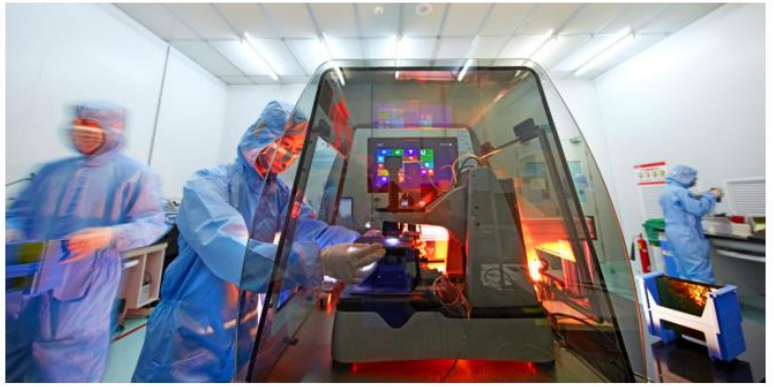


Image: Trina Solar

PVTIME

The 2nd European and Storage Techno

HOME NEWS FINANCE PROJECTS TECHNOLOGY OBSERVATION EXHIBITIONS POLICIES

BREAKING NEWS

Valid! JA Solar's TOPCon Patent Asserted Against Astronergy Upheld by EPO

OCTOBER 21, 2024 BY ALEINA IN NEWS

infringement dispute between two leading solar module manufacturers has ep forward in Europe.

e of the patents asserted by JA Solar, a leading manufacturer of high ducts, against Astronergy, has recently been upheld as valid as a result of oral sition Division of the European Patent Office (EPO) conducted on 2 October ially been filed by the French company Carbon, but Astronergy recently had took part in the oral hearing. The ruling of the Opposition Division confirming nt is still subject to an appeal before the EPO's Board of Appeals, but could have rties' subsequent litigation strategies at the Unified Patent Court (UPC) and, ay increase the pressure on Astronergy.

Intellectual Property Measures
for India Market

Patent Infringement and Litigation

- Cross-border disputes
- Technology replication
- Emerging technologies

Trade Secrets Theft

- Cybersecurity threats
- Insider risks

Regulatory Challenges

- Varying patent laws
- Enforcement gaps

Licensing & royalties

- Disputes over royalty payments
- Mandatory licensing

Recent IP Disputes & Trends

- **Patent disputes and lawsuits on TOPCon technology:** Multiple cases emerged in recent months, involving several companies and several regions
- **Patent Clustering:** The solar industry has seen a surge in "patent clustering," where multiple companies file overlapping patents, creating legal ambiguity.
- **Rise of IP Litigation:** The number of IP-related lawsuits in the solar industry increased by 15% year-on-year, reflecting the growing importance of IP protection.

Discussions & takeaways
for strategic management

discussion
your thoughts?

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Strengthen IP Portfolio

- Conduct regular audits
- Invest in filling patents for emerging technologies (tandem, perovskite and advanced module designs)

Enhance Cybersecurity Measures

- Deploy advanced cybersecurity protocols to protect sensitive R&D
- Train employees on data protection.

Foster collaborative innovation

- Partner with industry consortia & IP-sharing agreement
- Leverage open-source technology frameworks for non-critical components.

Monitor Global IP Regulations

- Hire a dedicated solar expert team watching global market.
- Advocate harmonized global IP Standards through industry bodies.

Conclusion

- IP management is a critical aspect of global solar manufacturing.
- By adopting a proactive approach to IP protection, companies can safeguard their innovations, reduce legal risks, and maintain a competitive edge in the rapidly evolving solar market.
- Prioritize IP as a strategic asset to ensure long-term growth and resilience.

Take advantage and use the leverage of India's rising key player position!

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Challenges and Opportunities for India

In the new world of increasing trade issues

One-Stop Renewable **Solutions** Partner

China-India Solar Trade Challenges
Separating Fact from Fiction

The solar industry is abuzz with reports of a 'blockage' of solar components from China to India. ***Let's examine the facts and uncover the truth behind these claims.***

Reported Issues

- **Logistical Delays:** Reports of extended customs clearance times for Chinese solar components in Indian ports.
- **Alleged Intentions:** Speculation that delays are deliberate, driven by trade tensions or policies to promote domestic manufacturing.

Possible Causes

Real:

- **Policy Measures:** Implementation of **Basic Customs Duty (BCD)** and the **Approved List of Models and Manufacturers (ALMM)** to prioritize local manufacturing.
- **Regulatory Hurdles:** Stricter compliance checks for imported solar modules.

Fake:

- No formal government directive to block imports.
- Delays likely stem from **administrative bottlenecks** rather than political motives.

Impact on Indian Solar Sector

- **Project Delays:** Slower completion of solar projects relying on Chinese imports.
- **Equipment Shortage:** It may increase the chance of ramping up due to the lack of machinery and equipment.
- **Price Surge:** Temporary price increases due to limited availability of critical components.
- **Opportunity for Domestic Growth:** Encouraging Indian manufacturers to ramp up production capacities.

America-India Solar Trade Opportunities

Expanded Market Access and Policy Alignment

Given the evolving landscape, the relationship between India and the U.S. in the solar manufacturing business is poised to grow.

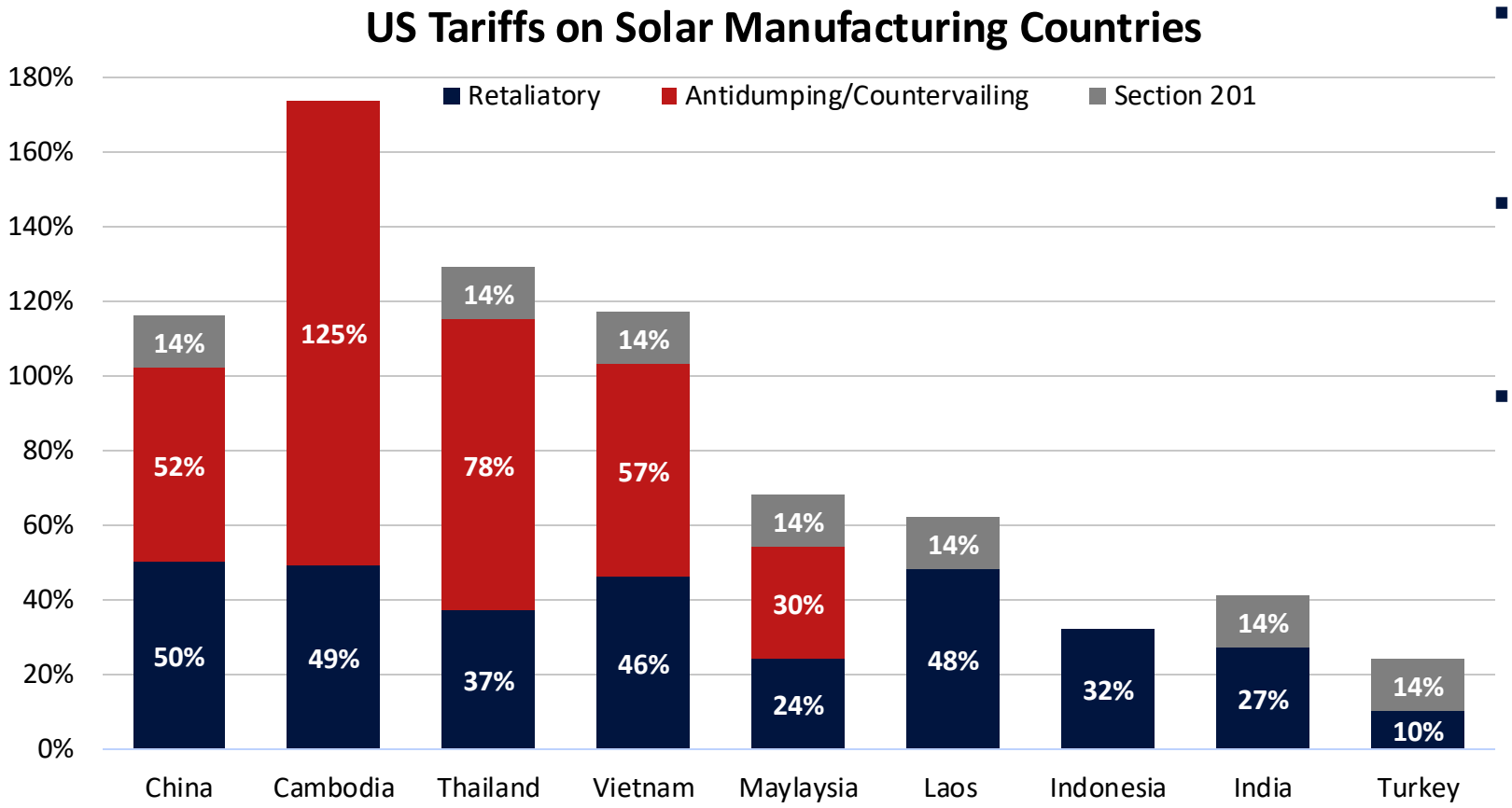
Collaboration & JVs

Investment in U.S. Solar Supply Chain

Localized Manufacturing & Assembly in US

Geopolitical Shift in Solar Supply Chains

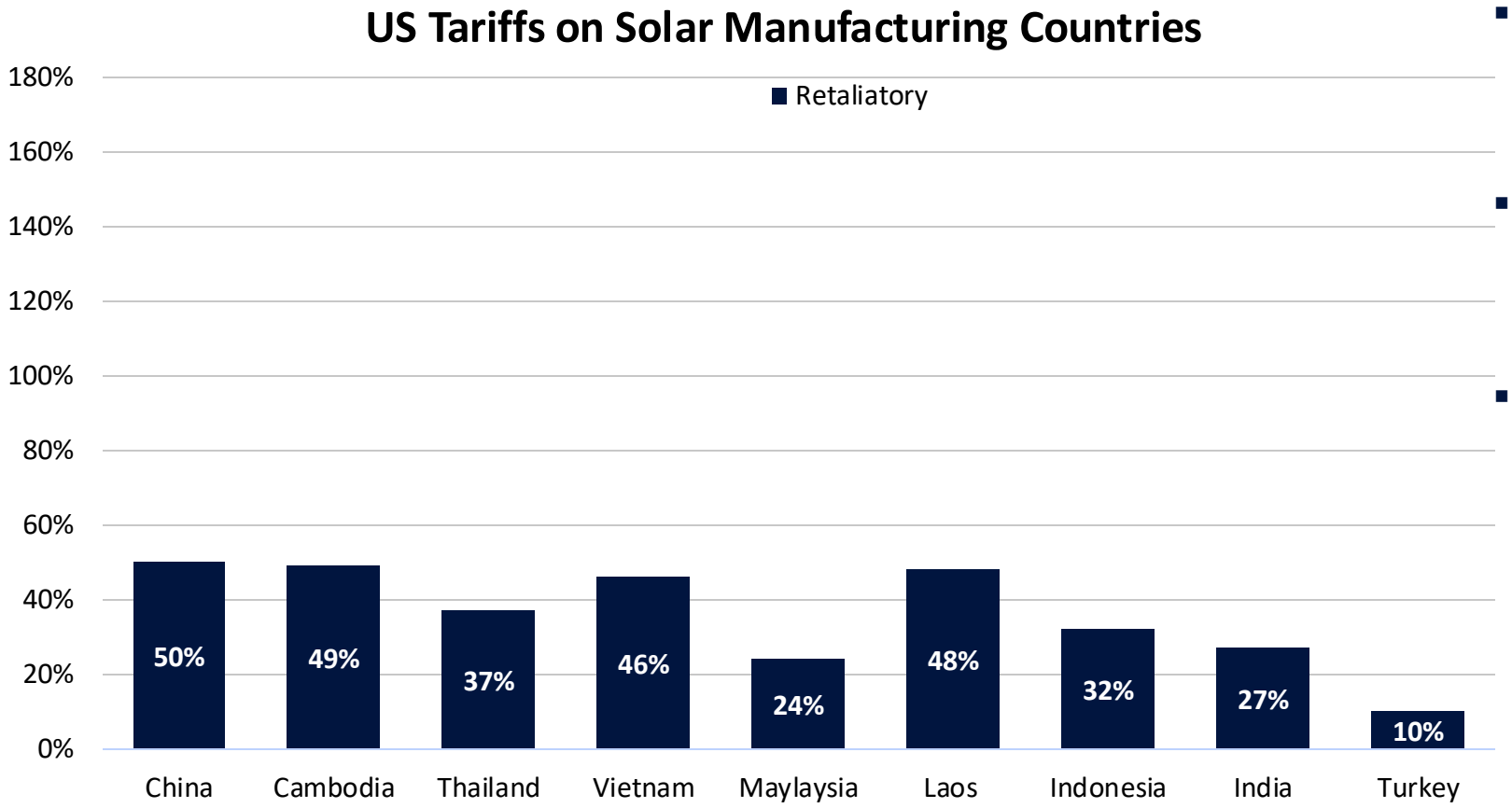
US Tariffs on Solar Manufacturing Countries: India vs China, SE Asia, and Turkey



Source: Above graph has been generated using data provided by the BloombergNEF, US Dept. of Commerce

- A reciprocal tariff of 26% imposed on PV modules India by the United States in April 2025.
- 20-25% of the domestically produced solar module is exported (most of it to the US).
- As shown, China and most of **Southeast Asia faces significantly higher tariffs** compared to India, primarily due to steep antidumping duties and retaliatory tariffs. This highlights the strategic relevance of India for diversifying PV manufacturing supply chains. Only Indonesia and Turkey have lower tariffs when compared to India.
- There is no as such duty on solar module in EU for any of the countries.

US Tariffs on Solar Manufacturing Countries: India vs China, SE Asia, and Turkey



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RCT solutions

Setting up new manufacturing

Know-how transfer and capacity building

Leason learnt for China and past 20 years of solar manufacturing in India

One-Stop Renewable Solutions Partner

Ramp-up Experiences & Challenges

Master planning and execution

•Developed and strictly followed efficient master plans. → Result: Inefficient factory management

Third-Party Management

•Effectively handled construction contractors. → Result: Lack of understanding of a solar factory

Warehousing Solution

•Improved environmental conditions for better material storage. – **Warehouses are a challenging issue in India** → Result: Quality problems, lifetime of consumables & machinery

Workforce Challenges

•High turnover rate of Engineers due to the boom of Solar sector in India. → Result: High costs, knowledge transfer, IP issues

Material Logistics

•Managed raw material shortages and ensured proper supply chains. → Result: Expired consumables, reducing equipment lifetime

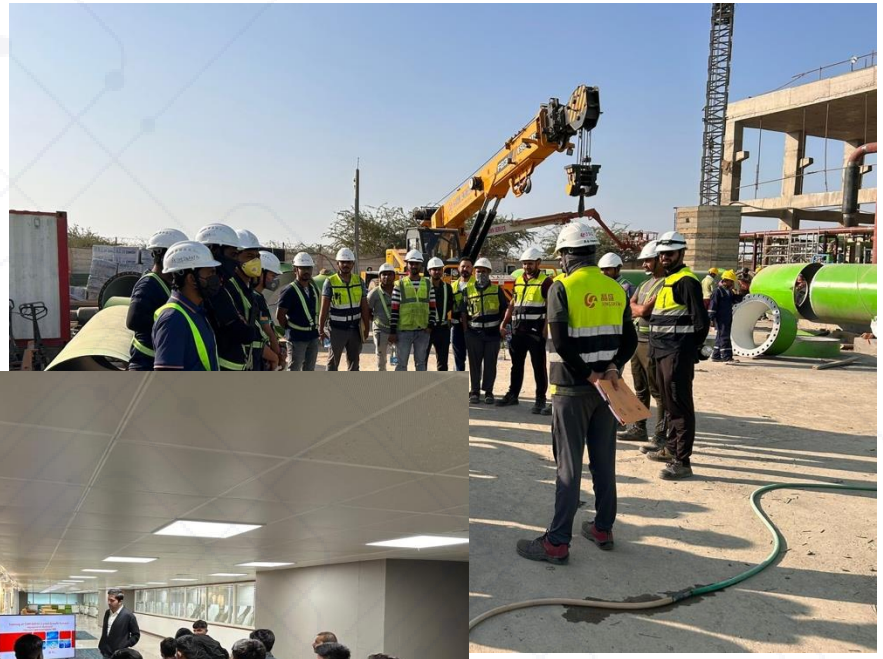
Stock Management

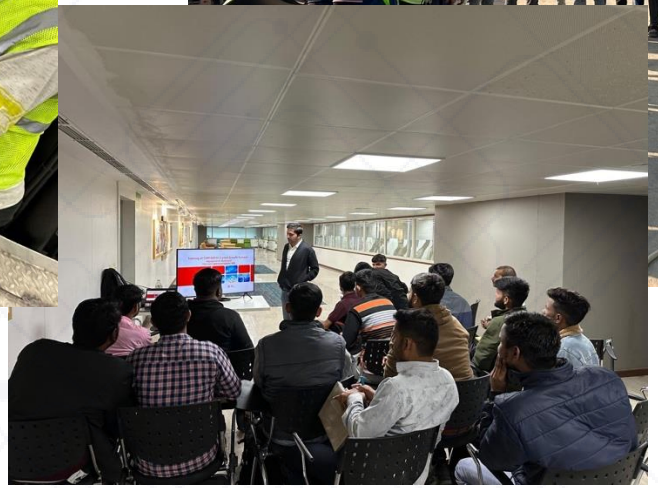
•Maintained minimum 6-month inventory levels. → Result: Stop of the factory

Training is crucial from day zero!

01 **Training network in China**

02 **Launching training services in India**





RCT's role in changing landscape

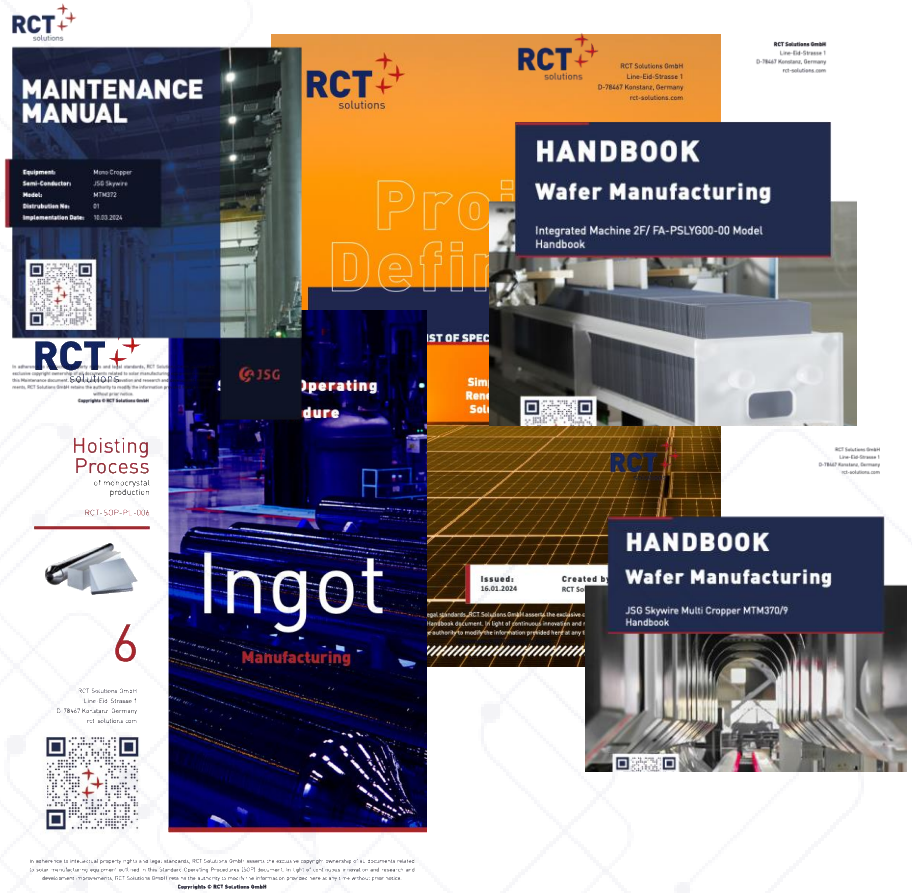
03

Opening of RCT Solutions China Office

04

Full SOP & Manuals Documentation

Over **17000+** pages of documentation & step by step guide of equipment



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Building out a full solar eco system in India: vision or need?

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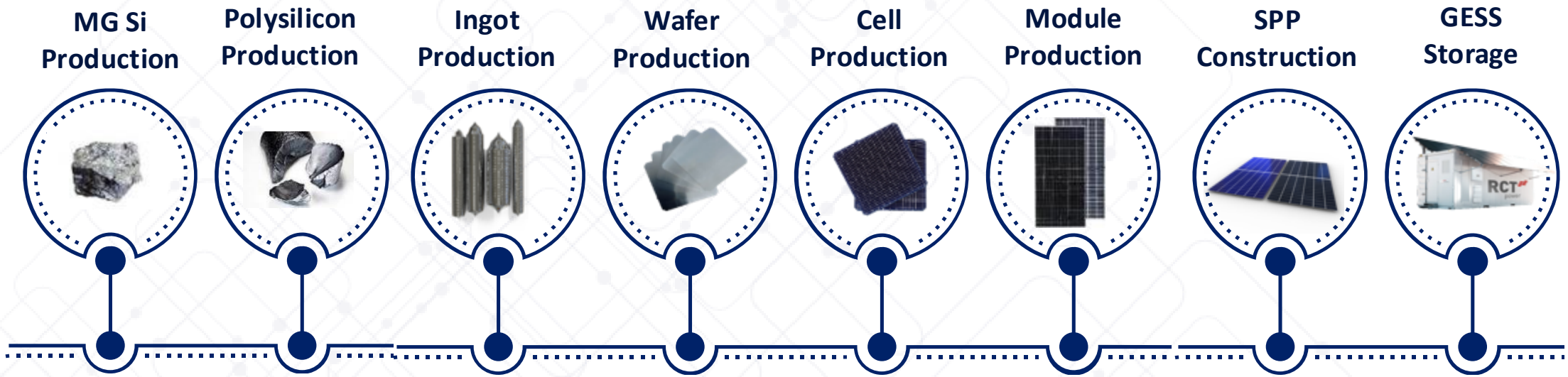
Major value chain in PV Industry

Vertical & Horizontal full integration into Giga scale PV



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- Gases

- Glass
- Encapsulation material
- Al frames
- Junction box& ribbons etc

Integration 1.0: World's First Integrated Factory outside China: Kalyon PV Ankara

Scope: Owner's Engineering, Value Chain, Conceptual Design, Solar Academy

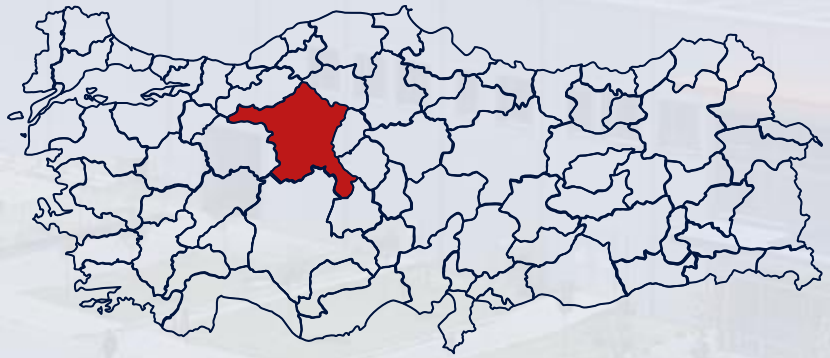
Location: Ankara, Türkiye

Capacity: 2.2 GW, Mono PERC, bifacial

Production: ingot, wafer, cell, module in full production

Technology: Mono PERC, Bifacial, M10&G1

Section	Phase I (MW)	Phase II (MW)	Phase III (MW)	TOTAL (MW)
Ingot	585	160		745
Wafer	616	150		766
Cell	546	673	1.000	2,219
Module	570	519	1.000	2,089



Kalyon PV Factory Present Day

Humans are able positively shaping the world

Kalyon PV 1.3GW solar power plant Karapinar Turkiye

Key takeaways

- **Global PV –** Market turbulences, but unprecedented growth and future
- **India PV** – Further significant growth 30- 40 GW annually to be expected
- **India's PV industry competitiveness** – Potential low-cost manufacturing hub
- **Clear Technology Trend to TOPCon –** Be prepared for patent disputes
- **Trade issues –** Beneficial position of India
- **Homework -** Government policies, supply chain, knowledge transfer
- **Independence** – Move to upstream in mid-term

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Thank you

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Confidential