Solar Industry Ask Me Anything with Kuntal Shah (Oct'24)

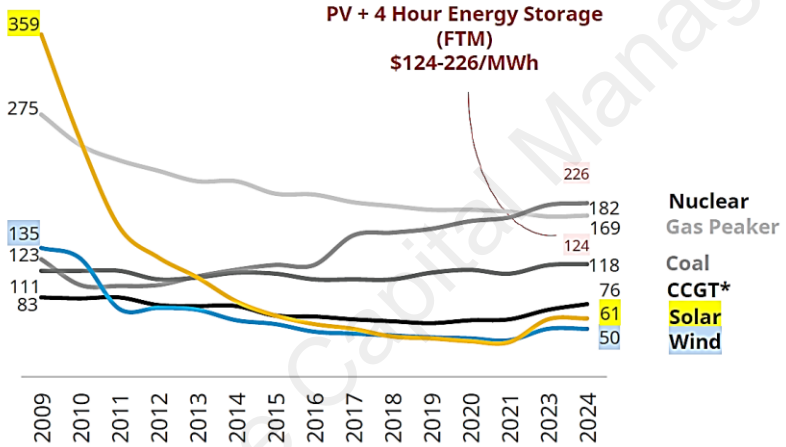
Global Solar Energy Adoption

Q1- As battery prices drop, can solar, wind, and energy storage replace thermal power as the main way we generate electricity? What lessons can we learn from other countries using this combined approach?

Ans- Yes, combining solar, wind, and storage is becoming more feasible with lower battery costs. Here's how it works and what global experiences have shown:

- **Diverse Power Sources:** Modern economies need multiple energy sources. With costs decreasing, renewables combined with storage are transformative for clean energy.
- **Reliability:** Renewables with storage can meet energy needs as reliably as thermal power, providing a steady supply at a competitive cost.
- **24/7 Power:** This setup can deliver round-the-clock electricity—solar in the daytime, wind in the evening and night, and storage to fill gaps.
- **Global Trends:** Around the world, newer and replacement energy demand is being met by renewables, reducing fossil fuel reliance.
- **Simple, Scalable Tech:** Proven technologies, like large-scale solar panels and LEDs, are easy to adopt and expand, making rapid growth achievable.

Mean Unsubsidized Levelized Cost of Energy (LCOE) and Levelized Cost of Storage (LCOS), $/MWh



Source: S&P Global, Wood Mackenzie, Lazard 2024 LCOE and LCOS reports. *CCGT = Combined Cycle Gas Turbine.

Q2- If nuclear power plants begin operating on a large scale, could this pose a threat to the growth of solar energy, or even to other forms of renewable energy that are scalable?

Ans-

- Nuclear power has high upfront cost, long lead times, lower availability and disposal issues at the end of plant life. Consequently, the cost of nuclear power has gone up over the last decade.
- Solar power is not only cost-effective at the outset but also proves to be the most economical option when accounting for overall costs, including any overruns.

Project type	Mean cost overrun (%)	Projects (A) with ≥50% overruns (%)	Mean overruns of A projects (%)
Nuclear power	120	55	204
Hydroelectric dams	75	37	186
Fossil thermal power	16	14	109
Wind power	13	7	97
Solar power	**1**	**2**	**50**

Source: Flyvbjerg Database

Q3- Hydrogen and specifically green hydrogen is being developed as a fuel for the future to be used for mobility, conversion to ammonia, methanol etc. For a wide-scale pickup in hydrogen production, large scale renewable projects would be needed. It is estimated that around 20 GW of renewable energy is needed to produce 1 MTPA of hydrogen. Besides improvements in electrolyser systems what it would take to create a breakthrough post which renewable capacity addition could further pick up pace.

Ans- Green hydrogen is already seeing use in industries like ammonia production, but for wider adoption, especially in transportation, there are some key challenges:

- Mobility Challenges: Using hydrogen for cars and consumer vehicles is still a way off because it's highly explosive and requires complex infrastructure. But hydrogen could be promising for larger vehicles and public transit.
- According to experts we have spoken to, they believe hydrogen in mobility is still very distant, given the explosive nature of it. Hydrogen as a fuel isn't new; in fact, the first internal combustion engine, invented in 1806, ran on a mix of hydrogen and oxygen. Instead, hydrogen looks more promising for commercial transport and mass transit.

India is committed to scaling up green hydrogen production, aiming for 5 million metric tons per year by 2030 under COP28 goals. Today, India's demand for hydrogen—5-6 million metric tons annually—mainly comes from refineries, fertilizer, and ammonia production. Although industry has been using grey hydrogen at $1.5–$2/kg (based on natural gas prices), the cost of green hydrogen is still higher, currently $3.17–$3.78/kg.

To make green hydrogen cost-competitive, more is needed:

1. Increase Demand: Focus on domestic production of ammonia and fertilizers.
2. Create Purchase Requirements: Establish mandatory green hydrogen use in industries that are hard to decarbonize.
3. Extend Incentives: Provide long-term incentives beyond the current three years to ensure project viability.
4. Introduce a Carbon Tax: Tax grey hydrogen to help close the price gap with green hydrogen.

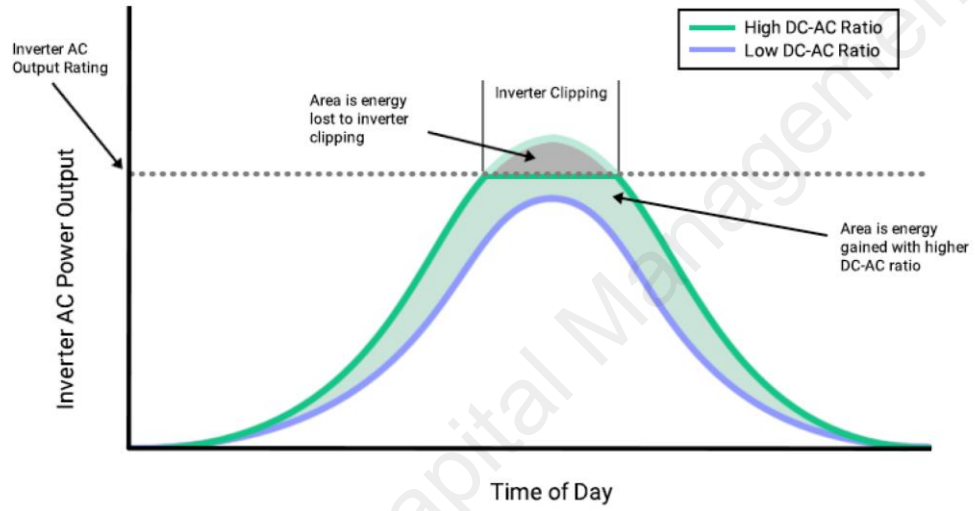
With government support, green hydrogen could reach $1/kg, making it a more viable energy source across industries.

Demand & Supply

Q4- While there is widespread anticipation for high demand for solar modules, what is your perspective on the supply side of the equation, particularly with many players establishing production capacities in India and the U.S.?

Ans-

- The demand for solar modules is expected to be higher than the government's capacity addition plans due to the practice of pairing inverters with oversized DC module capacity
- To reduce the levelized cost of power, it is common industry practice to pair inverters with oversized DC module capacity. A 1 MW DC solar plant typically does not produce a full 1 MW of power, as solar modules operate at peak efficiency primarily during noon and only in select months. By employing DC overloading, plants can enhance generation during non-peak hours. Globally, DC overloading is implemented at ratios ranging from 1.2x to 1.6x, depending on geographical and other contextual factors.
- The below chart shows energy gained with higher DC-AC ratio



Supply

China dominates the global solar PV manufacturing value chain, accounting for 80% or more of most parts of the production process.

In 2010, China held only around 30% of the installed polysilicon manufacturing capacity, but today that figure has surged to approximately 94%.

The wafer manufacturing stage, the most critical step in the process, is almost entirely controlled by China.

In China, for modules the effective capacity is 95%+ of the rated capacity. However, for smaller capacities like those in India and US, the effective capacity is between 70-80%, as the companies can't have dedicated production lines for modules with different specifications.

- Due to overcapacity in China, capex plans worth $ 25 bn have been cancelled till now, however Chinese companies are setting up Polysilicon and Wafer capacities in Middle East to supply in US.
- US- We are more confident in the near-term outlook, largely due to the lead time required to build additional capacity. However, this makes the long-term forecast more uncertain.
- The upcoming election will play a significant role, as the Inflation Reduction Act (IRA) subsidies and tariff structures could be subject to change. If tariffs increase, prices will rise, potentially incentivizing additional buildout—either in the U.S. or abroad, as companies seek to circumvent anti-dumping and countervailing duties (AD-CVD).

- However, in the near term, higher prices may negatively impact demand. On the other hand, if future IRA subsidies are reduced alongside higher tariffs, the anticipated U.S. buildout may not materialize, which would likely keep prices elevated and limit demand growth.
- The expected demand and supply for solar modules in US over next few years is as follows:

	2023	2024E	2025E	2026E	2027E
US Solar PV Demand					
US Solar Capacity Addition	35	41	46	50	53
DC Overload factor	1.3	1.3	1.3	1.3	1.3
US module consumption	46	53	60	65	69
US Supply					
Module	12	35	45	55	62
Cell	-	8	15	30	30
Wafer	-	-	8	15	20
Polysilicon	6	6	6	6	6
Thin Film	4	7	10	13	14

Source: CPIA, Goldman Sachs, CLSA, Samsung Securities

- While there have been numerous capacity announcements for both modules and cells, many have not yet begun construction, and some are likely to be cancelled. Any facility breaking ground after the upcoming election is expected to take approximately two years to complete, meaning new capacity would likely come online no earlier than 2027.
- Additionally, some manufacturers have officially cancelled plans for wafer and cell facilities, citing financial non-viability. Notable cancellations include Meyer Burger's 2 GW cell plant and Cubic PV's 10 GW wafer plant.
- The solar module industry, comprising an assembly of various components, is projected to face overcapacity in the Indian market. In contrast, solar cell manufacturing is more capital-intensive, and technology driven. Current players in the solar cell sector are likely to experience higher returns over the next few years; however, by 2028, this segment is also expected to encounter oversupply challenges. At present, it seems like vertically integrated companies involved in polysilicon, ingot, and wafer production are poised to differentiate themselves and gain a competitive advantage over their peers
- The expected demand and supply for solar modules in India over next few years is as follows:

	2023	2024E	2025E	2026E	2027E
India Solar PV Demand					
India Solar Capacity Addition	35	41	46	50	53
DC Overload factor	1.3	1.3	1.3	1.3	1.3
India module consumption	46	53	60	65	69
Export demand	3	6	9	14	17
Total demand	**15**	**34**	**44**	**63**	**77**
India Supply					
Module	40	63	85	100	110
Cell	6	13	32	42	47
Wafer	-	-	2	7	22
Polysilicon	-	-	-	-	-
Thin Film	-	3	3	3	3

Source: Frost & Sullivan

Q5.i. - Currently, cell players are making 40%+ margins because of the DCR policy. What is India's DCR module demand annually? Where do you see this going in the next 3 to 5 years? Given the government has announced ALCM for cell players as well, do you think that because of this policy, margins of cell players can remain higher (more than 30%) for a much longer period?

ii. Given, ALCM, where do you see the prices and margins for DCR modules going for players that use in-house cells from a 1-2 years' perspective?
iii. Given setting up cell capacity is time taking and difficult to scale up, where do you see cell capacity going in India by the end of CY26?
iv. Currently DCR cell manufacturers are enjoying close to 40% EBITDA margins. How is the pricing for DCR cells decided? (fixed price, capped price range, cost plus, etc). Is there any further scope of margins increasing?

Ans-

- Currently DCR modules are mandatory for projects where government is involved either in terms of giving subsidy or projects through PSUs. The annual demand from such projects is currently between 12-15 GW.
- If the government imposes ALCM (ALMM for cells), and if that list includes only Indian manufacturers, the demand for locally made cells will shoot up dramatically. Given the regulatory framework around ALCM is not yet announced, it is difficult to comment on demand and margins over next few years, it must be revisited as and when policy announcements are made.
- Based on the current announcements made, India is expected to have 42 GW of cell manufacturing capacity by end of 2026, however ground level work for some of these capacities has not yet started, so one needs to keep a track of how capacities are coming up. Currently the pricing for DCR cells is on cost plus basis.

Q6. Indian government is planning to install around 40 GW solar per year, according to you what might lead slower capacity addition.

Ans- As of today, power evacuation and grid connectivity pose meaningful limitations for the wider adoption of renewables globally.
In India, the two main risks which can lead to slower capacity addition of solar power- Land acquisition and grid stability
Land - The National Institute of Solar Energy (NISE) has estimated India's solar potential at approximately 748 GW, if 3% of the country's wasteland area is covered by solar PV modules. Currently, 1 MW of solar capacity requires 4 acres of land, for larger projects they need contiguous land. Land being a state subject, central government must pursue states to get land parcels. Also, states are coming up with policies to support solar power as it is economically cheaper compared to other power sources. The central government has come up with a policy on solar parks which will ease land availability. Also, unlike other infra projects like road construction where government provides land, in solar power projects the bidder must acquire the land.
Grid Stability - the government is coming up with various policies and incentives to tackle this issue. The peak power demand varies across states, making ISTS (Inter-State Transmission System) critical for balancing and optimizing power flow throughout the year (e.g., MP from April to Sept, UP from Oct to Mar complement each other). According to SECI Chairmen RP Gupta, majority of the new renewable energy tenders will be either RTC or FDRE which are with energy storage, this will reduce the load on grid.

Q7. What is the market size of rooftop solar projects and solar pumps, and what are the typical margins in the residential space? Additionally, what are the steady margins for solar EPC companies, considering that margins reported by companies like SW Solar and Waaree Technologies vary significantly?

- As per Crisil, the expected demand from PM Surya Ghar (rooftop solar) is 25-30 GW and PM Kusum (solar pump) is 35 GW.
- The margins for residential EPC players should converge to that of utility EPC players

Supply Chain

Q8. i. Solar Equipment Dependence on China: India has faced challenges with Chinese equipment in the thermal power sector. Can the solar sector avoid these pitfalls? What strategies can India adopt to reduce reliance on Chinese-made solar components and ensure higher operational efficiency?
ii. Impact of China's Potential Wafer and Cell Technology Restrictions- China is considering draft regulations to restrict the export of wafer and cell technology. What potential impact could this have on the global solar industry? Could Indian companies effectively find alternative sources for this technology, and how might this affect their competitiveness?

Ans-

- All the equipment used in the solar PV manufacturing chain is produced in China, as well as in other countries such as Germany, Japan, South Korea, and the United States. However, in terms of cost, companies outside of China struggle to compete with Chinese manufacturers unless they receive significant government support.
- Currently, we are not seeing any traction on companies setting up equipment manufacturing plants in India. Unless, the government comes out with strong policy support, equipment will be imported in India. Also, even if a company wants to set up an equipment manufacturing plant, they will have to do a technology tie up with any of the global companies.
- Some key suppliers outside China (not an exhaustive list) for critical processes in solar PV value chain are:

Step	Process name	Company
Polysilicon	Chemical Vapor deposition	GT Advanced Technologies in USA, and German companies like- GEC GmbH, Schmid Silicon Technology GmbH, Silicon Products Technologies GmbH, SiTec GmbH
Ingot	Czochralski (CZ) Furnaces	Linton (HQ- USA, Production in China), PVA TePla AG (Germany), Ferrotec (Japan), S-Tech (Korea)
Ingot	Diamond wire cutting	Disec (S Korea), MTI (US), Precision Surfacing Solutions (Switzerland), Thermocompact (France), Well Diamond Wire Saws (Germany), and Japanese companies like- Komatsu NTC, Nakamura, Toyo Advanced Technologies

Q9. What are the prospects for diversifying the polysilicon supply chain beyond China, considering its environmentally harmful and energy-intensive production? How feasible is it for other countries, like India or the U.S., to build competitive supply chains in this space?

Ans- According to our understanding, India and US have the right building blocks in place to backward integrate in polysilicon, however the capacities will come over longer term. Given the capital-intensive nature of production, government support will be a key for this segment.
The Right to win in polysilicon and ingot wafers are as follows:

- **Low cost of capital** - Both polysilicon and wafer production are highly capital-intensive. According to estimates by the IEA, the capex for polysilicon production in India is approximately $140 million per gigawatt (GW), while in China, costs are 40% lower. Therefore, companies able to secure capital at a lower cost will hold a significant competitive advantage in this sector.
- **Low-cost consistent power supply**- In China, power accounts for approximately 50% of the cost of polysilicon production. As a result, most Chinese manufacturing facilities are located in provinces like Xinjiang and Inner Mongolia, where access to cheap power is readily available. In India, utilizing a captive distressed thermal power plant in the coal belt could be an ideal solution for reducing production costs. The Adani Group holds a clear advantage in this regard, and Reliance has also explored acquiring distressed coal plants, such as the SKS power plant. In the

future, round-the-clock (RTC) renewable energy could serve as an alternative power source for polysilicon production.

- **Economies of Scale -** As a rule, the production costs for a large-scale polysilicon producer with a capacity of around 10,000 tons can be over 40% lower than those of a small-scale producer with a capacity of 1,000 tons. Larger plants benefit from economies of scale but require significantly more capex, highlighting the importance of raising capital at lower rates. This reinforces the competitive advantage for companies that can secure financing at a lower cost.
- **Technology-** The modified Siemens process is the predominant method for polysilicon production, while the Czochralski (CZ) process is utilized for ingot manufacturing. Currently, the equipment employed in these processes is largely standardized, and the stringent quality standards leave little room for significant modifications. Given that no Indian players possess the foundational technology required to initiate production, they will need to import standard equipment and collaborate with technology providers to establish manufacturing units. At this juncture, we believe that all players are essentially on equal footing in terms of technology.
- **Raw Material**- High-quality quartz is available in various states across India, including Andhra Pradesh, Rajasthan, and Gujarat. However, the production process also requires low-ash-content coal, which must be imported. Given the Adani Group's extensive network of ports, power plants, and cement operations, they possess significant expertise in coal procurement and supply chain management. This capability provides the Adani Group with a distinct advantage over competitors in securing the necessary raw materials for polysilicon production.

Q10. US Government incentivizing backward integration: Earlier this week, the US Government announced that Solar ingot and wafer manufacturing facilities and equipment in the US will qualify for the 25% investment tax credit under CHIPS and Science Act. Qcells, a unit of Seoul-based Hanwha Solutions Corp, has an under-construction US factory to produce 3.3 GW of ingots, wafers, cells and solar panels, which will be eligible for these incentives. Will Waaree be able to compete in the long term if they are not backward integrated in the US? Will this also affect exports to the US?

Ans-

- Solar wafers as discussed above is capital intensive, technologically challenging and for some processes labour intensive. Module manufacturing is more automated and continuous process, on the other hand some processes and wafer and cell manufacturing are batch processes and with higher requirement for labour.
- With these reasons, making wafers and cells might not be economically viable in US. A lot of companies have announced plans for cell manufacturing; however, it seems to be running on delays. In wafer manufacturing, a large player Cubic PV has cancelled their 10 GW wafer plant. One needs to keep tracking the upcoming manufacturing capacity in US.
- Based on current regulations and incentives, cell manufacturing is economically viable in US, however going back all the way to polysilicon is currently not viable. Waaree is setting up Module capacity in USA taking advantage of favourable IRA policies and government inclination to cut out Chinese imports. In long run the more backward integrated you are in every major geography better would be the prospects given the fact that most economic blocs are vying for energy security in long run.

Q11. Given the complexities of the solar cell and wafer value chain, will backward integration in these areas prove to be a successful strategy for Indian solar companies? Companies expect margin improvement, but is this likely to be a smooth or volatile journey?

Ans-

- Majority of the countries are trying to build their own solar PV manufacturing facilities for energy security, the policies are also supportive of this.

- Given that currently, non- Chinese manufactured components like polysilicon, wafers, cells and modules trade at a premium, we believe if the current sentiment persists the prices of domestically made wafers and cells will be higher and will support the IRRs of the companies.

Q12. How long does it typically take to stabilize solar cell manufacturing operations? Regarding the visa restrictions for Chinese experts, is it realistic for Indian engineers to acquire the necessary skills by visiting Chinese factories, or will this hinder the learning curve?

Ans-

- Solar cell manufacturing stabilization depends on the type of equipment ordered, if the order is given to a single credible vendor, stabilization can be as fast as a couple of months.
- However, if the order is given to multiple vendors who in turn have given orders to other companies, stabilization can take 6-9 months due to coordination efforts required and resulting back and forth.
- Currently, Chinese engineers are required to stabilize the cell line, over time as more cell capacity comes in India, domestic engineers might be able to learn the relevant skills. Also, the visa restrictions to Chinese experts have been withdrawn.

Q13. Players like NTPC are suggesting that module makers are profiteering from non-tariff barriers, what is your view on it?

Ans-

- We believe that the profits earned by solar module manufacturers will enable them to invest in backward integration, contributing to India's clean energy security. The incentives and higher profitability will create incentives to backward integrate and create a manufacturing base in long run is the expectation of GOI policies.
- Several independent power producers (IPPs), such as Tata Power, Adani Green, and ReNew Power, have already backward integrated into the manufacturing of modules, cells, and wafers, strengthening their supply chains and reducing dependency on external sources. Conversely, some IPPs like JSW Energy have opted to withdraw from module manufacturing, because of lower expected IRRs.

Q14. i. Across the entire value chain of solar (Manufacturing EPC and O&M), how will the profit pool be divided and what will be the competitive intensity in each step of the chain?
ii. Which segment/part of the Solar value chain has the highest potential?
iii. Where do the value lies today - in which part of Value chain - in Solar space where the new allocation should be made?
iv. Who is the potential leader from listed space?

Ans- Value in Solar chain is a function of demand and supply, so global and domestic ratio of supply / demand decides the direction. From India perspective having integrated operations, scale and execution capability would be the most attractive areas.

Q15. What's the level of impact of solar glass dumping on manufacturers in India like Borosil Renewables? It seems that even after the 10% import duty, the cost of imported solar glass from China is still lower. What's the outlook here? Is the only solution anti-dumping duty or can we make Solar glass at lower cost?

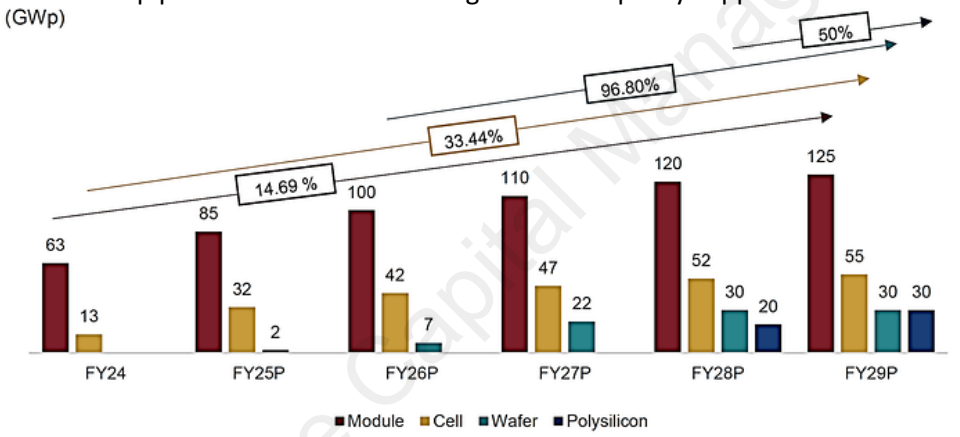
Ans- Raw material and power cost are two biggest items for Solar glass, after 10% duty and 4-5% premium which domestic companies enjoy Borosil expects 20% EBITDA margin which is decent in our opinion. While foreign operations of Borosil struggle due to higher energy and labour costs.

Q16. i. Given the import duty hikes and prohibition of China specific restrictions imposed by some of the largest solar cell/module end-user countries such as US, where would the largest Chinese manufacturers e.g. Tongwei, Trina etc could dump/direct their current inventories?
ii. Per my current understanding solar cell manufacturing cost in India would be 4x that of China. How likely would this cost come down or be comparable to that of China in coming 18-24 months? Do we have an expected scalability projection and/or govt policy support to make that possible?
iii. Do you see a significant detrimental impact of solar manufacturing and profitability in India?

Ans-

- China has been dumping their inventories in Europe and China has started putting capacities in Middle east so Middle east might be used as base for exporting Chinese companies' products like Southeast Asia was used earlier
- Chinese output is destined to Europe as of now and given that China has a competitive advantage and early lead in the whole supply chain including critical equipment and RM, it is very likely that China will use that lead and dominance to globalise its manufacturing base and sully from multiple location to different parts of the world.
- Setting up base in MENA is one such derisking move by Chinese player. They are also setting up base in North America.
- If both the Chinese and Indian OEM procure wafer at some prices, then the Cell costs are competitive. Hence the need to constantly backward integrate to get supply chain assurance, cost parity and scalability needed to serve global clients.

The scale-up plans of Indian OEM with government policy support are as follows



Source: Crisil

Q17. Smaller players like Alpex and Insolation who are not based near ports are also going for decent sized module expansions (2.5-4 GW). Will their location hamper their capacity utilizations and margins because of difficulties in sourcing of RM and extra freight costs?

Ans-

- Solar is a business of scale and backward integration. These two will be needed in the long run for companies to prevail.
- Given the current, demand supply scenario is favourable even small module players can deliver high margins. However, going forward as Significant capacities come up in module and cell, we believe only large integrated players will be able to make margins on a sustainable basis and deliver viable outcomes

Q18. Do the renewable energy producers (Tata Power, Adani Green etc) stand to advantage (Vis-à-vis traditional players using Thermal/Coal etc.) from the decline in global decline in module prices? Spready between Cost of production and selling price etc.

Ans- A falling cost curve permits faster adoption and hence imparts Scale. Whether they manufacture internally or buy from others, falling prices enable them to take a larger market share of the energy pie. More so when the cost of alternative technologies like thermal etc is increasing.

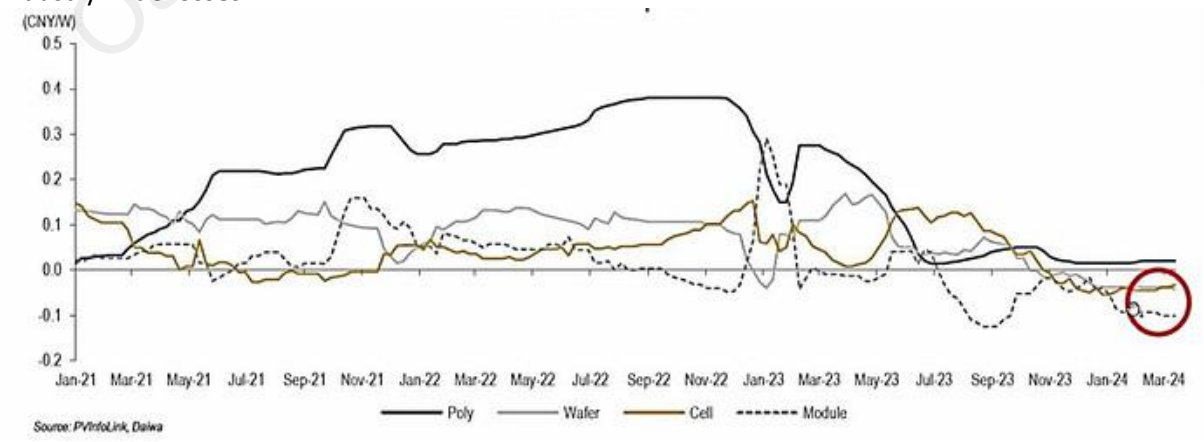
Q19. Do we have an idea on the Cost Structure and Profit Margins on the various processes on Solar Manufacturing and installation and whether there are any listed peer companies for across the world to compare the valuation with for each of the processes
For e.g. some of the lifecycle stages

- Poly Silicon Manufacturing
- Ingot Manufacturing
- Cell Manufacturing
- Module Manufacturing
- Inverter and which technology
- Transformers (Inverter Duty Transformers / Power Transformers)
- EPC Players
- Service & Maintenance
- Any other?

Ans-
Some companies in the value chain are as follows:

- Poly Silicon Manufacturing- GCL Poly, Daqo, wacker, OCI
- Ingot Manufacturing-Longi Energy, Zhonghuan
- Cell Manufacturing-Shanghai Aiko, Drinda
- Module Manufacturing- JA Solar, First Solar, hanwa,
- Inverter and which technology-Sungrow, soalredge, Enphase
- Transformers (Inverter Duty Transformers / Power Transformers)- majorly small and big companies supply these
- EPC Players-Many
- Service & Maintenance- Many
- Any other: Inverter has been the most profitable segment in China and US. Other segments include Junction box companies and offering comprehensive solutions including cables etc

Movements of Net Profit Margins across main PV industry chains- Profits have markedly diminished across diverse segments, and certain sectors are encountering challenges stemming from prevalent industry-wide losses.



Q20. Which are the proxy industries like Solar Cables etc which can be the beneficiaries to the growth in the Solar Industry?

Ans- All sub-components of the value chain like cables, aluminium frames, glass, inverters, etc all will benefit including evacuations and grid connectivity components like transformers, SCADA etc

Q21. Different type of Transformers is required in a Solar Project. Considering this, what is the contribution of Inverter Duty Transformers (Step Up transformers) & Power Transformers in a Solar Project.

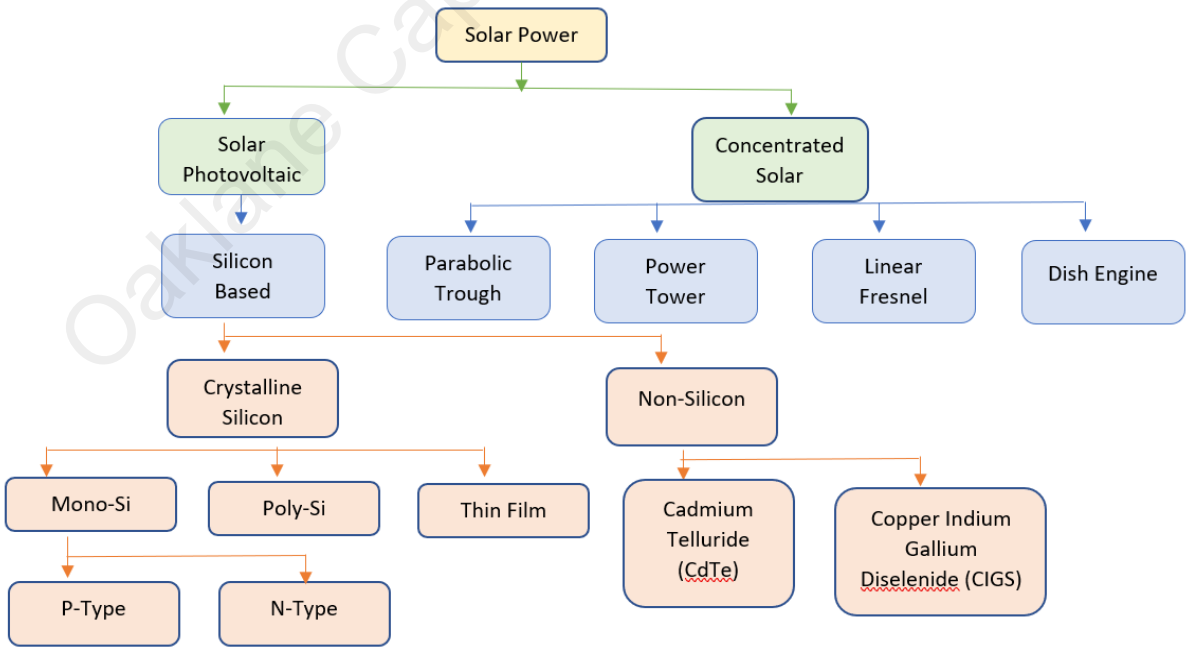
Ans- Our interactions with Transformer companies suggest for 100 MW Solar plant requires 200-300 MVA Inverter duty transformers while Power transformer required should be 100 MVA, assuming power factor of 1.

Technology

Q22.i. What are the key technologies being used in solar module manufacturing globally? Which companies or regions are leading in terms of technological innovation, and can Indian companies access and adopt these newer technologies?
ii. Global Transition to N-Type Solar Technology- Even in China and globally, n-type solar cell capacity is still below 50%. Is this transition happening smoothly, or are there unexpected challenges that could disrupt the shift from p-type to n-type technology?
iii. Challenges of Transitioning from P-Type to N-Type Solar Technology- What are the costs and challenges involved in transitioning manufacturing facilities from p-type to n-type solar cells? If India has an apparent oversupply of p-type capacity, is this truly the case if p-type technology is being phased out? How quickly can manufacturers shift from p-type to n-type technologies, such as TOPCon? Who are likely to be the winners and losers in this transition?
iv. The Indian Institute of Technology (IIT) Madras has developed low-cost, high-efficiency solar cells using N-type Czochralski silicon wafers. Do you foresee such homegrown technologies helping propel India to the solar industry's forefront?
v. It seems like India's rise in manufacturing capacity is benefitting Chinese equipment manufacturers/ consultants, and India has become part of their product lifecycle, wherein we're concentrating more on Mono PERC because of its price advantage and ease of production. On the other hand, the Chinese have moved on to TOPCon and HJT completely in terms of production because of the superior technology and their efficiency in producing these now. In a few years, India will be scaling TOPCon capacity when the Chinese move to HJT/ newer technology. Given this trend, how can India ensure it stays competitive in the global solar manufacturing race, rather than constantly trailing behind China?

Ans- Before delving into solar PV basics, it is crucial to note two primary solar power manufacturing technologies: Photovoltaics (PV) and Concentrated Solar Power (CSP). PV, being more cost-effective, is the prevailing choice for solar power generation.

Understanding Solar Power Technology



Source: CRISIL Research, IEA, US Department of Energy

- Solar PV technology bifurcates into two primary categories based on the primary raw material: crystalline silicon-based and non-silicon-based. The predominant share, exceeding 95% of global capacity, is held by crystalline silicon, with First Solar being the only large contributor in the non-silicon-based module sector
- Within the crystalline silicon domain, the developmental trajectory has transitioned from polysilicon to multi-crystalline and presently to mono crystalline. Mono-crystalline, particularly in N-type cells, is gaining traction due to enhanced efficiency, especially on a smaller scale, superior performance in lower light conditions, and a higher Internal Rate of Return (IRR).
- CdTe (cadmium telluride) ranks as the second-most prevalent PV material post-silicon and finds application in thin film PVs. Another material, copper indium gallium diselenide (CIGS), is utilized in the same context. Despite their cost-effectiveness, these alternatives do not parallel the efficiencies achieved by silicon cells.
- Another material which Is gaining prominence is Perovskite which is also used in thin film cells. Though the efficiencies have matched silicon-based cells in labs, it is yet to become commercially viable for large scale usage.

Within crystalline silicon N-type technology continues to upgrade, with opportunities in cost cuts and efficiency gains- TOPCon may swiftly become a mainstream technology in the industry, the industrialization of HJT will likely accelerate and xBC is poised for a breakthrough in the higher-end market segment.

Fig 37: Demand by cell technology type and forecasts (GW)

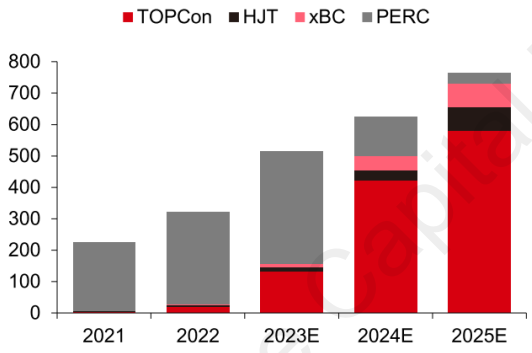
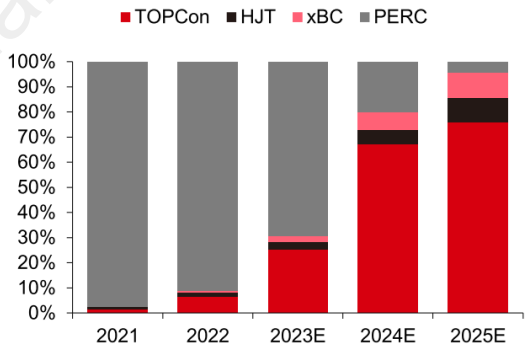


Fig 38: Market penetration rate by cell technology type and forecasts



Source: Infolink Consulting, CITICS Research

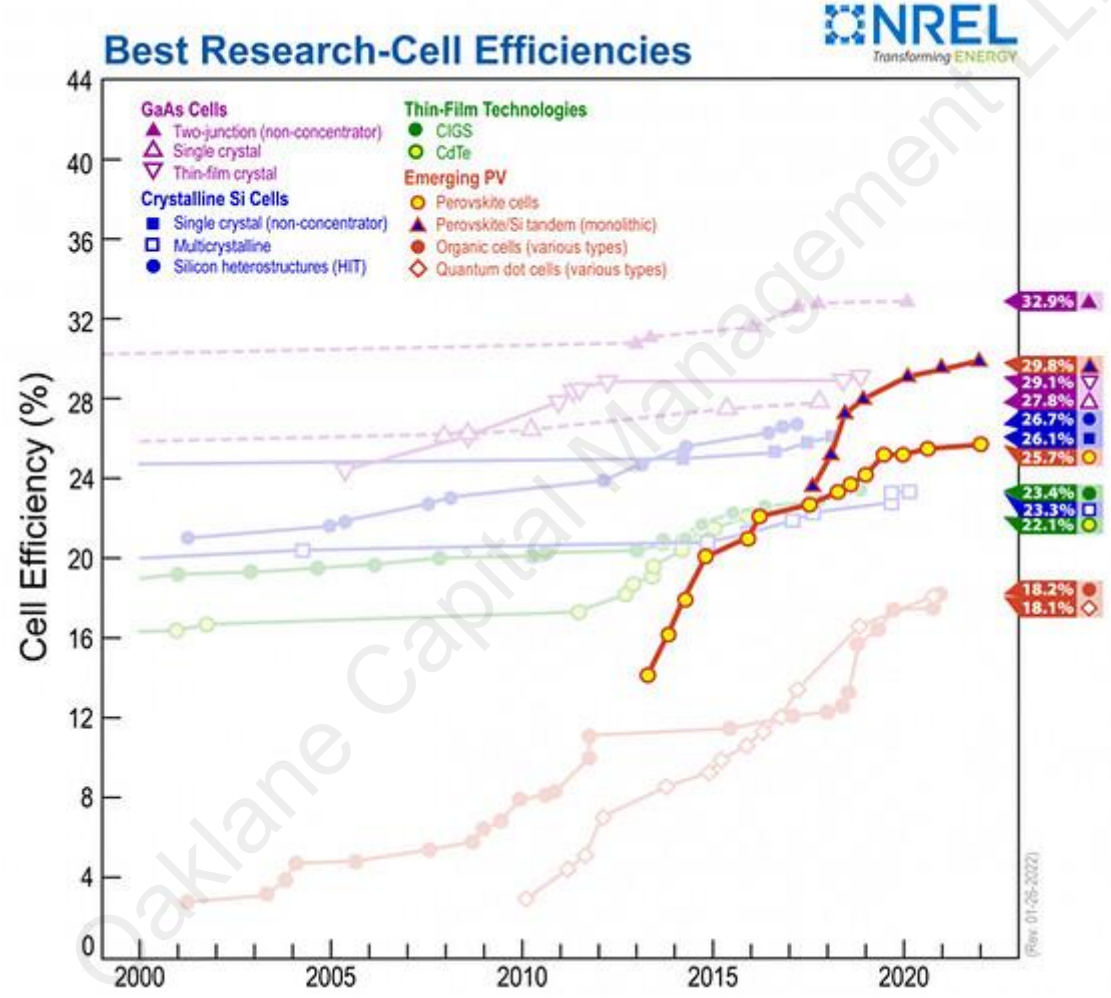
Technology cycle

- Historically, a new technology has come every 3 years and companies have had to tweak their plant & machinery accordingly. In 2022, with super normal profits for Chinese companies, this technology cycle was faster, and they moved swiftly from Mono PERC to TOPCon.
- Currently, CLSA believes solar technology innovation is progressing slower than anticipated due to reduced willingness to invest in solar capital expenditures during the sector's down-cycle. Among the key technology introductions for 2024, only laser-enhanced contact optimization (LECO) is on track, while the adoption of 0 bus bar (0BB) and HJT technologies may proceed more slowly than expected. This situation could benefit Indian players, as capex planned around a three-year technology cycle may be extended by one to two years.
- Chinese companies are the technology leaders along with First Solar for Thin Film, currently Indian companies have been doing tech tie-ups to get latest technologies. Research institutes in India are focusing on developing new technologies, however this may take its time. Waaree Energies has collaborated with IIT Bombay for R&D.

- Transition from Mono PERC (P type) to TOPCon (N type) is at solar cell level, which can be done with an incremental capex of 100-150 cr. At solar module level there are no changes in the manufacturing process.

Q23. Can we expect significant improvements in solar module efficiency in the coming years, or have we reached a plateau? What emerging technologies could drive the next wave of efficiency improvements?

Ans- Companies and research institutes are working on multiple technologies to further increase efficiencies. The below chart shows the efficiency of different technologies in lab conditions.
Of all the technologies, HJT, Tandem, Back Content and Pervoskite seem to be the most promising ones, however, none of them are commercially competitive today but hopefully with the Cost curve falling one can expect more adoption as usual with such technologies



Q24. What is the market's perception of the quality of solar panels manufactured in India compared to those from China? Can Indian manufacturers match the quality standards of their Chinese counterparts?

Ans-

- The feedback from customers has been a mix of Indian panels at par with Chinese counterparts and some say Indian panels are a bit inferior to Chinese counterparts. The writing is not yet on the wall but if Indian OEM succeeds in gaining larger share of global markets via exports the same will be laid to rest.
- As per our understanding, Waaree Energies has got repeat orders from the same customers in US, which makes us believe their panels are of acceptable quality.

- For US customers certifications of panels are very critical, as the lender would check all the documents and certifications before processing the loan. Also, credibility of OEM to deliver in timely manner and guarantee performance over the contract period would be in focus from purchaser end.

Q25. Thin-film Solar: with increasing efficiency and environmental advantages, will thin-film solar technology see wider adoption, especially in the Indian market? Considering its success in the U.S. as a "100% American" alternative, what is the potential for thin-film solar in India?

Ans-

- Thin-film CdTe (cadmium telluride) panels are made from cadmium which is a waste product from mining industry but is highly toxic and it must be recycled. Because of its toxicity, some countries in Europe have banned CdTe panels. Also because of toxicity and lower efficiency than crystalline silicon panels, these are not used in rooftop solar, as it can also become a health hazard.
- First Solar, has also setup a 3 GW manufacturing plant in India for domestic and exports market, it is also enlisted in ALMM to be able to sell to domestic IPPs. However, because of limitations of CdTe and technology only with 1 player, we believe Indian manufacturing capacity will be dominated by crystalline silicon
- R&D is happening to add certain chemicals and additive to the process and success in same could lead to addressing of above concerns.

Q26. How does the efficiency of Solar cell/modules change over a period of time (5 years-10-years etc after installation) and do the players like Waaree/Premier Energies have any backend liabilities attached to the operational efficiency of the components supplied by them?

Ans-

There is standard degradation curve related to technology used in all PV. There are performance warranties given to Consumers based on the above.
Insurance is available and replacements are given which are invariably cheaper due to the falling cost curve making replacement not that onerous on the OEM

Regulations

Q27. Impact of US Circumvention Duties on India's Solar Exports- The U.S. has imposed circumvention duties on solar products from Vietnam, Cambodia, Malaysia, and Thailand, primarily based on the origin of the wafers used in solar cell production, which are often sourced from China. Although India is not currently affected, there is a possibility of facing similar duties in the future. Given that securing domestic wafer production capacity is essential for maintaining access to the U.S. market, can India sustain its competitive edge in solar exports to the U.S.?

Ans-

- The world needs an alternative to China in the Solar value chain. India is one credible option that is led by a vibrant democracy and trade connectivity.
- "President Biden and Prime Minister Modi welcomed the U.S.-India Roadmap to Build Safe and Secure Global Clean Energy Supply Chains, which launched a new initiative to accelerate the expansion of safe and secure clean energy supply chains through U.S. and Indian manufacturing of clean energy technologies and components." – this was a joint statement made in Sept'24 and hence we believe anti-dumping or anti-circumvention duties on Indian players is highly unlikely.
- Election is scheduled in the USA next month and policies of new administration are being eagerly awaited by the industry.

Q28. As a financial incentive, accelerated depreciation encourages the adoption of solar power by making renewable energy projects more economically feasible, thus contributing to India's renewable energy targets. To understand this in India's respect, how has the availability of accelerated depreciation benefits influenced the growth of solar in other countries over the past decade, and how will it play out in India?

Ans-

- Government incentives have been instrumental in driving solar energy adoption by enhancing the financial viability of solar projects. In the U.S., the Modified Accelerated Cost Recovery System (MACRS) allows solar investors to depreciate solar assets over five years, providing substantial tax benefits. Combined with the Investment Tax Credit (ITC), which can offset installation costs, businesses can recoup nearly 50% of their solar investment over a five-year period.
- In India, the adoption of accelerated depreciation, currently set at 40%, is expected to have a similar impact. This policy reduces taxable income and shortens the payback period, making solar investments more appealing for businesses.

Q30. Can there be dynamic electricity pricing in India in future?

Ans- This is only possible with smart metering in place where meters can track consumption on time scale. Current Infrastructure in India doesn't permit this. However, with advanced smart metering technologies becoming viable, time of day pricing will be possible

Miscellaneous

Q29. Given that the modules have a 30-year warranty, but the current products haven't been in use for that duration, what is your perspective on the reliability of this warranty, and how might this uncertainty affect companies relying on such products?

Ans-

- All solar modules come with a 30-year performance warranty, typically following a degradation curve as applicable to that particular technology used.
- When evaluating solar module manufacturers, it's important to consider the warranty risk. However, this risk can be mitigated by insuring the products. Insurers assess various certifications before issuing coverage, so it may be reasonable to assume that companies with insured modules are producing modules of acceptable quality.
- Historically, when warranties have been invoked, module manufacturers have often replaced the panels, which can be beneficial to them due to the declining cost of solar modules over time.

Q31.i. How do you value a business like a Solar Manufacturer - what is the heuristic that one should use?
ii. What can go wrong with the solar thesis?
iii. What goes into making a Deep Dive note?

Ans- Solar manufacturing is just like any industrial manufacturing activity driven by

- falling cost curves
- demand supply imbalances
- Tariff and non-tariff barriers

What distinguishes the industry is the falling Levelized cost of energy promoting the transition leading to an accelerated adoption curve and hence scalability to players who can execute at scale. It gets valued like any other manufacturing company with caveat of faster equipment write offs and necessary capex needed to constantly upgrade technology.
Given the importance of energy in economic activity, there is a high degree of trade barriers and policies that dictate outcomes and profitability. This policy risk becomes key monitorable from investors' perspective

Regards to Indian solar players, key risks are:

- Access to RM and Equipment
- term of trade and advances from ROCE perspective
- Competitive intensity, and Execution are key like any other business

Deep dive requires constant monitoring and reassessment of key data points and hypotheses. As they say, business is not a still picture but an evolving movie.

Q32. For Solar farms & commercial projects, what is the % of String Based Inverter vs Central?
Ans- Solar string inverters are best suited for solar systems with fewer than 15 panels. They offer high efficiency, easy maintenance, and a relatively lower cost.
On the other hand, central inverters are more suitable for larger commercial or industrial solar systems with 15 or more panels.
Solar Power Systems: String Inverter or Central Inverter? | Novergy Solar

Waaree Energies

Q33. i. The solar energy production value chain involves several technologically intensive processes, including sourcing polycrystalline silicon as a raw material and producing silicon wafers and ingots from it. Currently, only Adani group produces these wafers and ingots in India for internal use. Waaree has no solar cell manufacturing capabilities as on date(?). It plans to set up a 6gw capacity ingot-wafers, solar cells and modules manufacturing facility at Odisha and has earmarked ₹2,500 crore from the IPO proceeds for this purpose. It takes a company around 2-3 years to set up and operate technologically complex cell manufacturing facilities and uncertainties related to the efficiency and reliability in-house production. In this context, premier energies, which has set up a new 2gw solar cell and module manufacturing plant, is already way ahead of Waaree energies?
ii. Is it a fair argument when one says Waree's only competitive advantage right now is its demand security because of its strong export capabilities and substantial government policy support and US's protectionist trade policies against China. Despite such strong financial performance, industry experts think Waaree energies does not have a strong enough moat to evince investor interest like premier energies because it does not yet have an operational solar cell manufacturing facility. And that they would need extensive funding to develop new moats in the long run.

Ans- Waaree Energies is undertaking backward integration into cell and wafer manufacturing. The company's 5.4 GW cell line is projected to commence operations by the end of Q4 FY25, with an initial 1.4 GW capacity expected to be operational by the end of Q3 FY25. Additionally, Waaree is expanding into complementary sectors, including electrolysers for green hydrogen and battery storage, to diversify its business beyond solar modules. Monitoring management's execution in these new ventures will be essential.

Current Capacity & proposed expansion-

- The current operational capacity stands at 13.3 GW, distributed across five distinct plants and 20 production lines spread across 136 acres of land. The company has strategic plans to augment this capacity to 21 GW by incorporating additional capabilities through the establishment of two new plants located in Odisha, and Texas.
- The maximum capacity utilization can be 85%, as the production lines must change specifications for different orders.

MW	FY27E	FY26E	FY25E	FY24	FY23	FY22	FY21	FY20
Module Capacity								
Surat, Gujarat*	230	230	230	230	230	230	500	500
Tumb, Gujarat	1000	1000	1000	1000	1000	1000	1000	1000
Nandigram, Gujarat	1100	1100	1100	1100	1100	1280	500	500
Chikhli, Gujarat	9660	9660	9660	9660	9660	6490	2000	-
Noida, UP	1300	1300	1300	-	-	-	-	-
Dhenkanal, Odisha	6000	6000	-	-	-	-	-	-
Houston, Texas	1600	1600	1600	-	-	-	-	-
Total Module Capacity	**20990**	**20990**	**14990**	**11990**	**11990**	**9000**	**4000**	**2000**
Effective Capacity	-	-	-	-	6500	2080	1540	-
Capacity Utilisation	-	-	-	43%	40%	46%	53%	-
Cell Capacity								
Chikhli, Gujarat	5400	5400	5400	-	-	-	-	-
Dhenkanal, Odisha	6000	-		-	-	-	-	-
Total Cell Capacity	**11400**	**5400**	**5400**	**-**	**-**	**-**	**-**	**-**
Wafer Capacity								
Dhenkanal, Odisha	6000	-	-	-	-	-	-	-
Total Wafer Capacity	**6000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

* The Surat facility's capacity was derated because better quality modules were produced from the same line, reducing its stated capacity.

Upcoming Cell Production Lines:

- A 1.4 GW Mono PERC cell line is scheduled to begin production in November 2024, with an anticipated stabilization period of 20-25 days to achieve an efficiency of 23.5%. The company has deployed 40 Chinese engineers on-site to oversee the commissioning and stabilization process.
- According to management, one of the competitors took 6-9 months to stabilize their cell line, as the machinery was originally designed for Chinese conditions and required reconfiguration to suit Indian conditions. This reconfiguration process was further complicated by the challenges posed by the COVID-19 pandemic.
- 4 GW TOPCon cell line is anticipated to begin production by the end of FY25. The capacity also features LECO technology which enhances cell efficiency by 0.3%.

Q34. Is the declining trend not a cause for concern:

- Export sales have declined 45% YoY from 2,414 cr in Q1FY24 to 1,340 cr Q1FY25
- YoY top-line growth has declined from 137% in FY23 to 69% in FY24, and further to just 2.5% in Q1 FY25
- Order book has dropped from a peak of around 20 GW in FY24 to approx. 17 GW in Q1 FY25.
- RoCE has decreased from approx. 32% in FY23 to 9.45% in Q1 FY25.

Ans-

- Sales growth in Q1FY25 was lower as the company prioritized high EBITDA margin projects. We believe the rest of FY25 will have a higher growth rate with margins greater than that of FY24.
- The slowing order book presents a concern; however, we anticipate growth to resume once the U.S. capacity is operational. Additionally, the domestic business—spanning both utilities and franchisees—has shorter execution cycles, which we will be able to monitor more closely post-listing.

Healthy Profitability –

Buoyed by margins, return ratios were strong in FY24. Before FY23, the ROE ranged from 2% to 38%. The trend of healthy return ratios is anticipated to persist, driven by sustained robust margins and higher asset turnover resulting from improved capacity utilization.

	FY24	FY23	FY22	FY21	FY20	FY19	FY18	FY17	FY16
ROA	14%	10%	4%	4%	5%	9%	2%	3%	0%
Ex Cash ROCE	176%	108%	31%	15%	33%	31%	17%	19%	15%
ROCE	43%	44%	19%	15%	22%	24%	15%	16%	11%
Ex Cash ROE	572%	3381%	131%	10%	22%	133%	24%	23%	17%
ROE	42%	43%	19%	12%	13%	38%	12%	12%	2%
PAT / PBT	73%	74%	67%	69%	69%	78%	59%	51%	21%
PBT / EBIT	134%	101%	175%	105%	87%	103%	50%	64%	29%
EBIT / Sales	11%	10%	2%	3%	3%	6%	6%	8%	8%
Sales / Total Assets	1.01	0.91	1.29	1.51	2.13	2.02	1.25	0.91	1.00
Total Assets / Net worth	2.71	3.98	5.05	3.28	2.76	3.05	6.12	4.85	4.06

ROCE of 9.45% in Q1FY25 is not annualized number, hence cannot be compared with ROCE of full year.

Oaklane Capital Management LLP

Corporate Identity Number: AAA-6130, SEBI Registration Number INP000006624.

Corporate Office: North Court, Lane No. 12, Kalyani Nagar, Pune -411016, India.

Tel: 020 -4121 4014/ 6781 0188 | Email: ir@oaklanecapital.com | www.oaklanecapital.com

Principal Officer: Ashwini Desai | 020- 4121 4014 | Email: admin@oaklanecapital.com

Registration Details

Oaklane Capital Management LLP (***"Oaklane"***) is registered with the Securities and Exchange Board of India (**SEBI**) as a Portfolio Manager with registration number as INP000006624. Oaklane Capital Management LLP provides only portfolio management services. Oaklane does not provide services in the nature of acting as manager or co-manager to issue, acting as an underwriter to issue, merchant banking, investment banking, stockbroker, which will conflict with its operations of Oaklane as a portfolio manager. The author of this research report (i.e., research analyst) has complied with the qualification and certification requirements as provided in SEBI (Research Analyst) Regulations, 2014. The Research analyst is post graduate in Finance (MBA), a CFA Charter Holder and holds NISM-Research Analyst certification.

Disciplinary Actions

No material disciplinary action has been taken by SEBI against Oaklane Capital Management LLP in the past two financial years which may impact the investment decision making of the investor.

Research Analyst(s) Certification

The Research Analyst, with respect to each issuer and its securities covered by him/her in this research report, certify that:

a. All of the views expressed in this research report accurately reflect his or her personal views about all of the issuers and their securities; and

b. No part of his or her compensation was, is, or will be directly or indirectly related to the specific recommendations or views expressed in this research report. Oaklane is engaged in providing only PMS services and accordingly do not provide any conflicting services.

Disclosure of Interest and material conflict of interest

a. Oaklane is engaged only in providing portfolio management services. Associate(s) of Oaklane are not engaged in providing any services related to capital market.

b. Oaklane and its associates and / or its respective personnel and / or its advisors may in future engage in activities that may result in conflict which may not have been captured herein.

c. Oaklane and its associates have policies and procedures in place for addressing such conflicts. Oaklane, its associates and its directors/partners/employees shall exercise a standard of good faith in its dealings.

d. Oaklane Capital Management LLP and/or its associates have not received during the past twelve months any compensation from the subject company(ies) mentioned in this report.

e. Oaklane Capital Management LLP, its partners, its associates, research analysts, his/her relatives have invested in the subject company, and this may have potential conflict of interest at the time of publication of this report on the subject company. Oaklane Capital Management LLP provides only Portfolio Management Services and accordingly do not provide any services to the subject company. Neither research analyst or his/her relatives, nor research entity or its associates has any other material conflict of interest (*other than as identified*) at the time of publication of the research report.

f. Neither Oaklane Capital Management LLP nor its associates or the Research Analyst(s) or his/her relatives individually own one per cent or more securities of the company(ies) covered under this report, at the end of the month immediately preceding the date of the publication of the research report or on the date of the public appearance.

g. In the last twelve-month period ending on the last day of the month immediately preceding the date of publication of the Research Report or public appearance, Oaklane or it's associate(s) **have not:**

   i. managed/co-managed public offering of securities for the subject company.
   ii. received compensation for investment banking/merchant banking/brokerage services or for any other services from the subject company of this research report.
   iii. received any compensation or other benefits from the subject company or third party in connection with the research report.
   iv. engaged in any other transaction involving such securities and earn fees or other compensation as an advisor or lender/borrower to the subject company or may have any other potential conflict of interests with respect to any recommendation and other related information and opinions at the time of publication of Research Report or at the time of public appearance.

h. In the last twelve-month period ending on the last day of the month immediately preceding the date of publication of the Research Report or public appearance, the subject company is or was not a client of Oaklane or it's associate(s).

i. The Research Analyst principally responsible for the preparation of this research report ***or*** their relatives (as defined under SEBI (Research Analysts) Regulations, 2014):
   v. Has invested in the subject company covered under this report.
   vi. Did not receive any compensation from the subject company covered under this report, or from any third party, in connection with this report in the past twelve months or
   vii. Do not have any other material conflict of interest, other than identified above at the time of publication of this report.
   viii. Research Analyst(s) is/are not serving or has served as an officer, director or employee of the subject company covered under this report.

j. Neither research analyst not the research entity has been engaged in market making activity for the subject company.

Basis of Preparation of Research Report and Terms of its use

a. Oaklane is registered with the SEBI as a portfolio manager and provides only portfolio manager services. This report is provided only for general consumption. This Report has been prepared based on the facts, figures and information, which is already available in publicly accessible media. Such information has not been independently verified and **no guaranty**, representation

of warranty, express or implied, is made as to its accuracy, completeness, or correctness. While we would endeavour to update the information herein on a reasonable basis, Oaklane is under no obligation to update the information. Also, there may be regulatory, compliance, or other reasons that prevent Oaklane from doing so. Neither Oaklane nor its partners, employees, agents, or representatives shall be responsible or liable in any manner, directly or indirectly, for views or opinions expressed in this report or the contents or any errors or discrepancies herein or for any decisions or actions taken in reliance on the report or the inability to use or access our service in this report or for any loss or damages whether direct or indirect, incidental, special or consequential including without limitation loss of revenue or profits that may arise from or in connection with the use of or reliance on this report.

b. This research report has been prepared by research analyst(s) working with Oaklane Capital Management LLP to provide information about the subject company(ies) and sector(s), if any, covered in the research report and may be distributed by it solely for the purpose of information of the recipient of this report. This report and/or any part thereof, may not be duplicated in any form and/or reproduced or redistributed without the prior written consent of Oaklane Capital Management LLP. Securities of the Subject Company are not listed on date of publication of this research report, accordingly the provisions related to providing graph of daily closing price of the said security is not applicable.

c. While reasonable care has been taken in the preparation of this report, it does not purport to be a complete description of the securities, markets or developments referred to herein, and Oaklane Capital Management LLP does not warrant its accuracy or completeness. Oaklane Capital Management LLP shall not be in any way responsible for any loss or damage that may arise to any person from any inadvertent error in the information contained in this report. This report is provided for information only and is not an investment advice and must not alone be taken as the basis for an investment decision.

d. The investments discussed or views expressed, or recommendations/opinions given herein may not be suitable for all investors. The user assumes the entire risk of any use made of this information. The information contained herein may be changed without notice and Oaklane Capital Management LLP reserves the right to make modifications and alterations to this statement as they may deem fit from time to time.

e. This report is neither an offer nor solicitation of an offer to buy and/or sell any securities mentioned herein and/or not an official confirmation of any transaction.

f. This report is not directed or intended for distribution to or use by any person or entity who is a citizen or resident of or located in any locality, state, country or other jurisdiction, where such distribution, publication, availability or use would be contrary to law, regulation or which would subject Oaklane Capital Management LLP to any registration or licensing requirement within such jurisdiction. The security(ies) described herein may or may not be eligible for sale in all jurisdictions or to a certain category of investors. Persons in whose possession this report may come, are required to inform themselves of and to observe such restrictions.

g. Views of the Research Analyst on the subject company may vary based on fundamental and technical research.