



REPORT ON SOLAR POWER

BUILDING THE SOLAR SYSTEM: REVOLUTIONS IN THE FUNDING SPACE

AUGUST 2024



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EXECUTIVE SUMMARY (1/2)



Solar energy grows on climate imperative and surging electricity consumption, utility-scale additions to be further boosted by structural transformations in PPAs

Electricity consumption is on the ascendancy in India with both energy and power demand scoring above estimates in FY24. During FY24, ~32 GW of capacity was added, with solar energy leading the charge at a record annual addition of ~15 GW. To meet the FY30 target of ~293 GW, the current pace of solar capacity additions needs to double. Current tendering trends suggest that 50-60 GW will be added over the next two years. By FY30, solar will constitute ~38% of installed capacity (~19% as of Jul'24), yet would generate only ~23% of the electricity (~6% in FY24) owing to technical limitations in CUF. This implies substantial long-term growth, further supported by increasing adoption of FDRE contracts which necessitate overcapacity.

Going beyond utility additions, new sources such as commercial and industrial (C&I) and rooftop will become drivers helped by governmental push

Significant growth is anticipated in the C&I and rooftop solar segments, which together account for ~30% of the current solar capacity. ~4 GW/year each are expected to get added in the next couple of years. The growth in the C&I segment will be propelled by companies forming group captive arrangements to benefit from tariff waivers, allowing them to secure power that is reliable, cost-effective (compared to the C&I rates of most state DISCOMs), and environmentally friendly (as they receive renewable energy credits, unlike grid-sourced power). Additionally, the PM Surya Ghar Muft Bijlee Yojana (PM-SGMBY) supports this growth by promising up to 300 units of power per month per household.

With the demand side secured, the lack of domestic upstream capacity for key components casts eco'systemic' supply-side shadows

The primary constraint in achieving capacity targets is the insufficient domestic upstream manufacturing infrastructure. The existing nameplate capacity of ~72 GW for modules is inadequate. Capacity deficits are even more pronounced further upstream, with no polysilicon production facility and limited cell and wafer manufacturing capacity. Contributing factors include the scarcity of raw materials, high capital investment requirements, extended gestation periods, and rapid technological advancements, all of which perpetuate a cycle of uncompetitive costs and limited scale. This means India remains extensively reliant on imports of both cells (~81% of need in FY24) and modules (~23% of need in FY24), with the major source of imports remaining geopolitically sensitive China, posing a risk in meeting energy security goals.

Recognising the shortfall, government incentives are in place to make setting up upstream solar capacities attractive and procurement of domestic panels by projects viable

Two PLI schemes, with a total of four sub-schemes tailored to various levels of integration, have been introduced. Among these, PLI-I and one sub-scheme of PLI-II are fully integrated, while the remaining two sub-schemes of PLI-II exclude certain upstream capacities. Additionally, a BCD of 40% on modules and 25% on cells has been instituted to deter inexpensive Chinese imports. Furthermore, to qualify for any government incentives, most projects are mandated to utilise modules from the ALMM, which exclusively comprises domestic producers. Collectively, these measures are expected to greatly increase upstream capacities, with integrated capacity dominating cell and wafer stages, and the fragmented module space gradually consolidating. Besides the module value chain, developing sufficient capacity of ancillary components such as inverters and transformers also remains key to success.

Adding the 'solar system' piles up another mountainous funding requirement and terrain of the funding landscape changes as we move downstream

The addition of solar projects alone is projected to necessitate an investment of ~Rs. 2 trn over the next two years. Beyond this, considering the announced capacity expansions, an additional ~Rs. 1.2 trn in capital investment will be essential to establish the complete value chain. Financing this intricate value chain demands a nuanced understanding of the capital requirements at each stage. While generation projects typically require long-term capital expenditure debt, upstream entities are predominantly dependent on working capital and non-fund-based facilities due to their extensive engagement in foreign trade.

EXECUTIVE SUMMARY (2/2)



Lenders navigate their terrain as per their strengths: banks dominate working capital and non-fund facilities across the value chain while FIs lap up rupee term loans

Incremental credit by banks to the power sector has been eclipsed by the contributions of key FIs. For instance, the incremental credit extended by key FIs in F23 and FY24 at ~Rs. 600 bn, is nearly 2x the incremental credit extended by banks to the entire power sector!

- Non-fund-based facilities and working capital for upstream enterprises remain firmly with banks. An analysis of major module manufacturers revealed that banks held a ~90%+ share in such instruments. Banks also maintain a dominant position in the realm of foreign currency loans
- Conversely, key FIs command a substantial portion of rupee-denominated term loans across the value chain, particularly those of smaller ticket sizes. Additionally, larger entities have a significant scope to issue bonds and tap into the capital markets

A stabilising and growing sector, favourable regulatory regime, and increasing need for capital is set to create a flare of asset recycling opportunities

With strong demand pushing the sector towards a critical mass, a colossal reservoir of renewable energy has been built up. The top 10 players have a total of 35 GW operational capacities. At the same time, there is a governmental push and favourable regulatory climate for InvITs. Given a mere fraction of the immense potential of the top 10 players (2 GW) has been harnessed till now through InvITs, we could see a flurry of assets offloaded through the InvIT conduit to generate capital of ~Rs. 2.4 trn. This strategic move is well-founded, as ~75% of this capacity is held by players with upstream aspirations who will require capital to realise their ambitions. Additionally keeping investors interested will be the vast under-construction capacity ensuring a steady supply of assets, RPOs securing demand, and storage solutions promising an upside.

Buzzing M&A activity to consolidate a fragmented sector, enable entry/exit of financial investors

Deal value in renewables jumped by a stunning 70% y/y in CY23. This is based on consolidation in a highly fragmented space which has kept returns limited across the value chain. It is epitomized by the fact that the top 5 solar generation players account for just 27% of the total installed capacity while the number for thermal power stands at 45%. Going forward, more consolidation is expected with strong interest from foreign funds and MLIs, and improving sectoral outlook

Climate imperatives and surging electricity consumption have secured demand for the long-term, and the ~50-60 GW capacity likely to be added in the next two years are just a beginning. This spells a multiplication of opportunities for not only solar project developers, but also players in the 'solar' system, right from manufacturers of components to EPC contractors. The funding landscape remains lush and capable to generate the Rs. 3.2 trn needed in the medium term, with a diversity of options from banks to FIs catering as per their strength to each niche. More is expected to come from the capital markets, taking advantage of a growing mass of operational capacities and favourable regulations for products like InvITs.

This success is contingent on blowing away the clouds related to dependency on geopolitically sensitive China for upstream components. With government initiatives geared to mitigate this, the solar story is ready to blaze a path towards the Sun

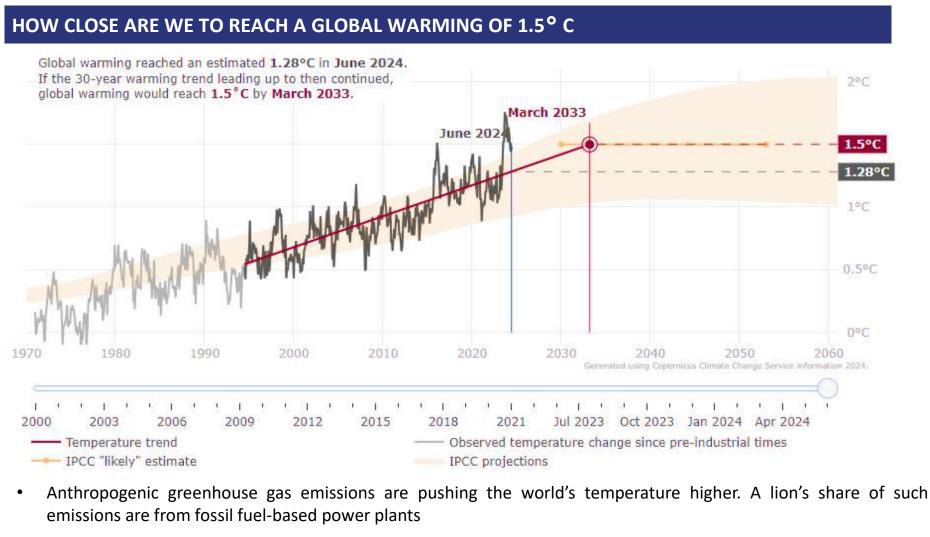


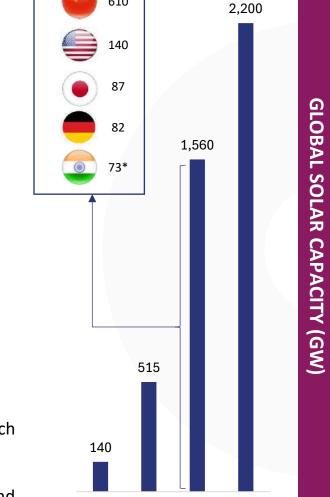
SOLAR SHINES AS CLIMATE IMPERATIVE HEATS UP



GLOBAL CLIMATE GOAL PUSHES MOVE TOWARDS SOLAR ENERGY







- Given rising population and prosperity, the only solution is to replace dirty sources of energy with renewables, and solar will play the leading role in this transition globally

CY13

CY18

CY23 CY25P

INDIA'S SOLAR POTENTIAL NEEDS TO BE TAPPED TO ACHIEVE NET ZERO GOALS



INDIA'S JOURNEY TO NET ZERO – THE DREAM...¹

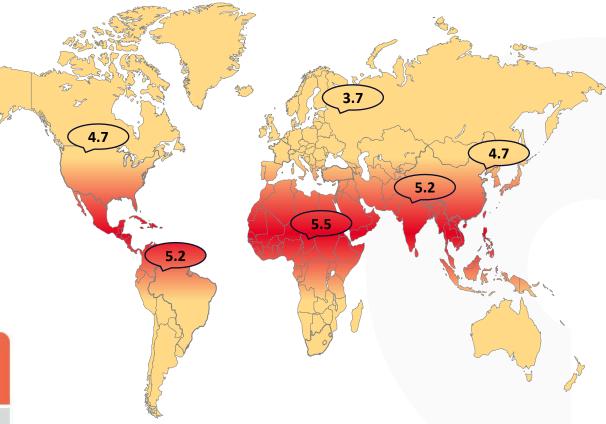
Ethanol Self-reliance **NGHM** to blending in in industry, **Easing climate** make India a fuels to reach focus on finance green H, hub 20% by 2025 electrification 2.5-3 bn 3-fold tonnes of Climateaddition CO2 increase in resistant nuclear sequestration smart cities by forests by power 2030

... AND THE REALITY²



POOR

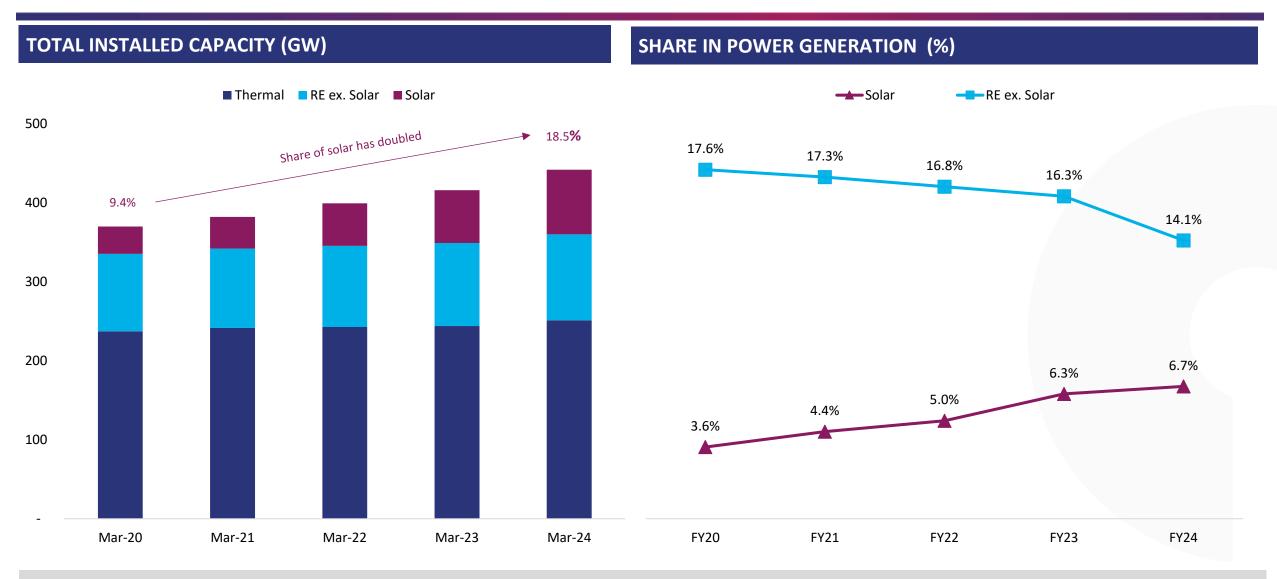
SOLAR IRRADIATION POTENTIAL – WORLD MAP (kWh/m²/day)



- India's net zero target needs to be overachieved to meet global warning targets. Solar will be key towards this
- Its higher solar irradiation than global average, supporting more capacities (big market size) and higher PLFs (superior IRR) will be key

SOLAR POWER BRIGHTENS THE GRID, DOMINATING CAPACITY ADDITIONS

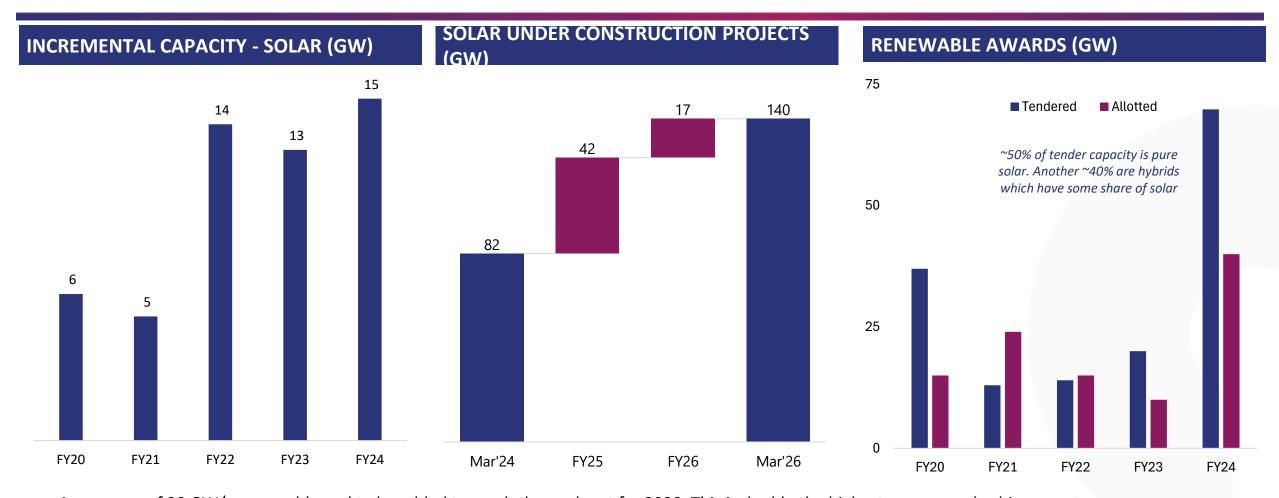




THE GOAL FOR SOLAR CAPACITY FOR 2030 IS 293 GW. BY THIS TIME, THE SHARE OF SOLAR ENERGY IN CONSUMPTION IS EXPECTED TO REACH 23%

SOLAR ADDITION PACE SET TO DOUBLE IN THE MEDIUM TERM



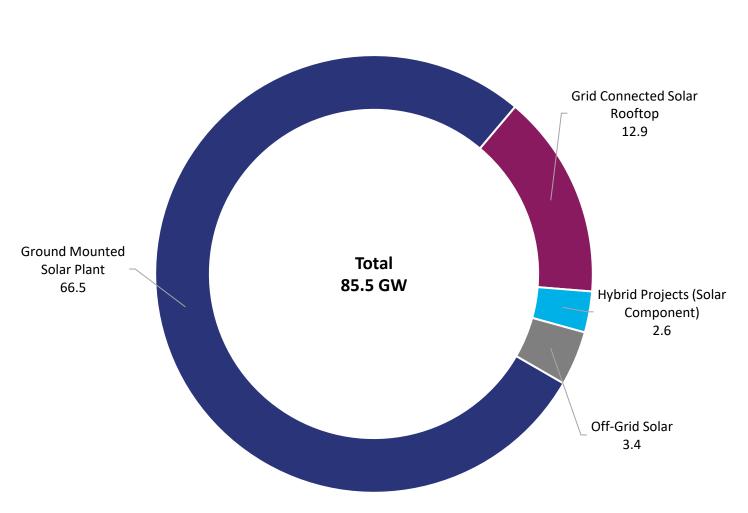


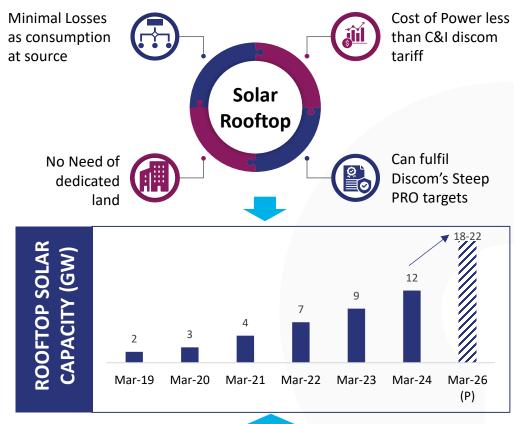
- An average of 30 GW/year would need to be added to reach the goals set for 2030. This is double the highest ever annual achievement
- Under-construction pipeline and trend of tendering shows that this run rate is possible. ~50-60 GW are set to get added in the next 2 years
- The RPO trajectory implies a further 40 GW over and above the goals set would be needed in solar

GOVERNMENT SCHEMES TO MAKE ROOFTOP SOLAR BECOMING MORE POPULAR



INSTALLED SOLAR CAPACITY (GW)





PM - Surya Ghar Muft Bijlee Yojana

30 GW Capacity Addition

- Central financial assistance to Residential rooftop solar
- Free electricity up to 300 units per month to 10 mn households
- Outlay of Rs. 750 bn will result in electricity of 40 BU/year

C&I SEGMENT TO SUSTAIN GROWTH MOMENTUM IN OPEN ACCESS SOLAR



Open Access enables large power consumers with more than 1 MW connected load to buy relatively cheaper power directly from power producers

This is typically Rs. 1-2/unit. It is waived off for captive and group captive in some states, making C&I open access lucrative

Charges through open access for C&I are in many cases lower than grid power for consumers. The producers also often get superior IRRs

Gives large consumers stable source of power without depending on vagaries of DISCOMs

For green energy, the limit has been reduced from 1 MW too 100 kW. This has allowed smaller customers to access open access power

Consuming green energy through open access helps in meeting ESG targets, and green certificates may be earned from the same

OPEN ACCESS BUSINESS MODELS

THIRD PARTY SALE

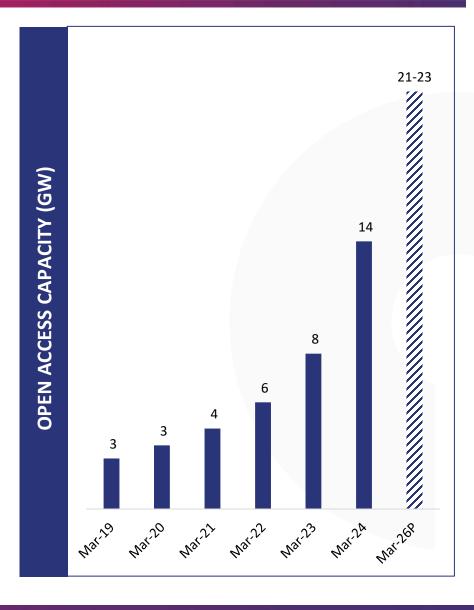
- No upfront investment by C&I buyer
- C&I buyer signs long term PPA (10 yrs or more) with power generator.

CAPTIVE/GROUP CAPTIVE

- C&I buyer(s) make upfront equity investment
- In group captive model, multiple off-takers must have combined equity of >26% and procure minimum 51% power.
- C&I buyer(s) sign long term PPA with power generator.

OPEN ACCESS CHARGES

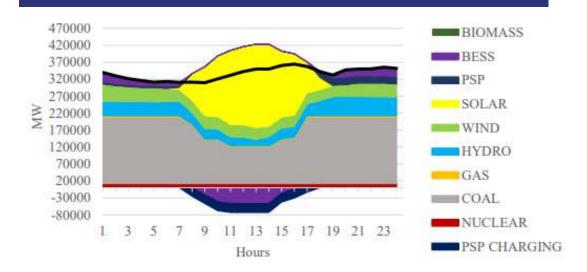
- **Cross Subsidy Surcharge**
- Additional Surcharge
- Wheeling Charges
- **Banking Charges**
- Wheeling Loss
- **Transmission Charges**
- Transmission Losses



ALLIED GROWTH IN STORAGE TO AUGMENT GRID STABILITY

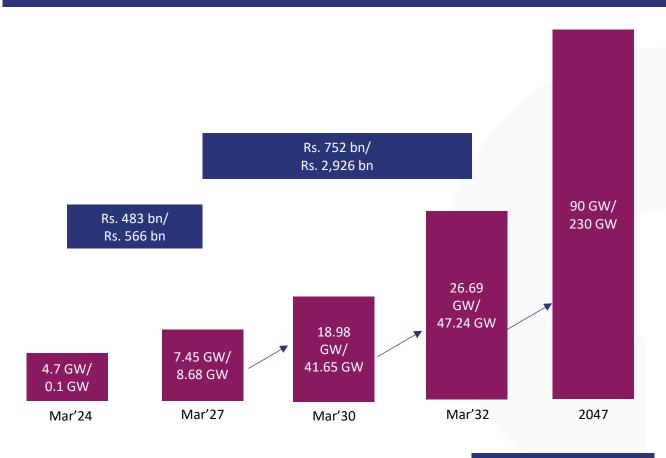


POWER DEMAND ON TYPICAL DAY IN FY32



- Renewables (particularly solar) show significant diurnal variations due to which they are unable to contribute to the evening peak. This can cause grid instability and outages as the grid becomes green. Storage ameliorates this
- ~90% of global energy storage is through PSP. This mix will change as cost of batteries is expected to halve between CY23 and CY30. Other technologies remain nascent
- By FY27, ~6% of peak demand will be met by storage, and this will increase to ~20% by FY32. This necessitates building BESS and PSP facilities in India

FUNDING REQUIREMENT FOR ENERGY STORAGE SYSTEM



Legend

Investment needed in PSP/ Investment needed in BESS

Installed Capacity in PSP/ **Installed Capacity in BESS**



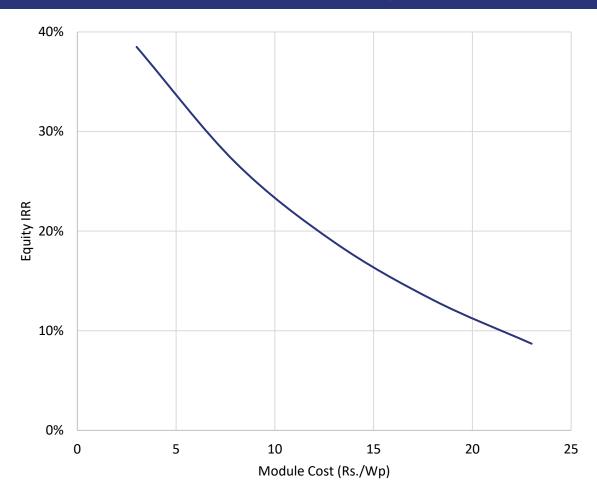
ECO'SYSTEMIC' CLOUDS: OBSCURING A SUNNY FUTURE



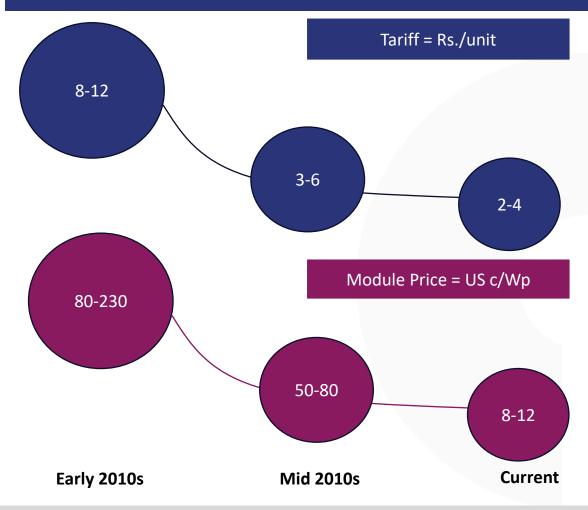
MODULES MOST CRITICAL INPUT IN SOLAR PROJECTS



IMPACT OF MODULE PRICE CHANGE ON EQUITY IRR



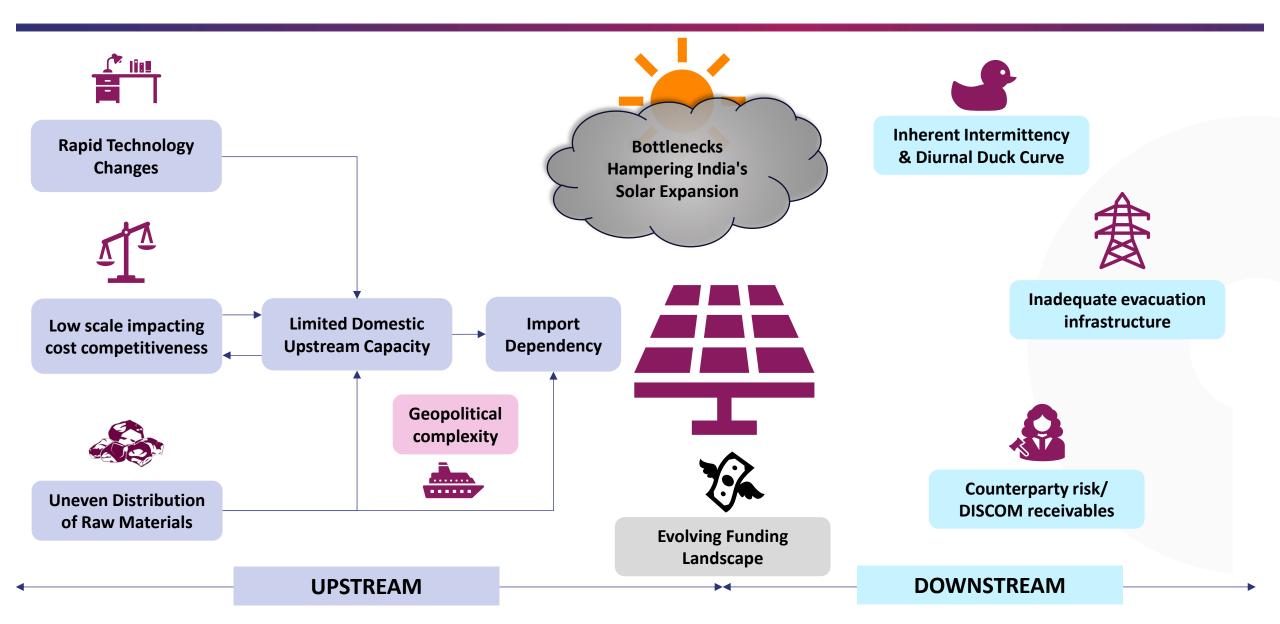
IMPACT OF MODULE PRICE CHANGE ON TARIFF



GIVEN THE CENTRALITY OF MODULE PRICES IN SETTING UP SOLAR PROJECTS (AND HENCE TARIFF AND IRR), WE CLASSIFY THE SUPPLY CHAIN FROM SILICON – MODULE AS UPSTREAM, AND FROM MODULE – USER OF ENERGY AS DOWNSTREAM

CAN CAPACITY ADDITIONS DOUBLE? - CHALLENGES FOR INDIAN SOLAR ECOSYSTEM





LIMITED UPSTREAM CAPACITY AND LOW-SCALE DRIVING COSTS: A VICIOUS LOOP





Stage 1

MG (Metallurgical Grade) silica is melted in a furnace and purified to produce high-purity silicon.

Stage 2

Silicon is cooled and solidified into a single crystal ingot. The wafers undergo surface texturization to improve light absorption.

Doping materials are added to create an electrical field

Stage 3

Metal contacts are printed onto the wafer surfaces to collect electricity generated. The wafer is heated to fuse the contacts onto the silicon surface.

Cells are tested for efficiency and quality.



Stage 4

Solar cells are connected in series and parallel to achieve the desired voltage and current.

Cells are encapsulated between layers of glass and polymer to protect them from the environment.



Polysilicon



Ingots/Wafers



PV Cells





CURRENT CAPACITY

0 GW

0 GW

2 GW

8 GW

72 GW

Limited Reserve

40 GW

53 GW

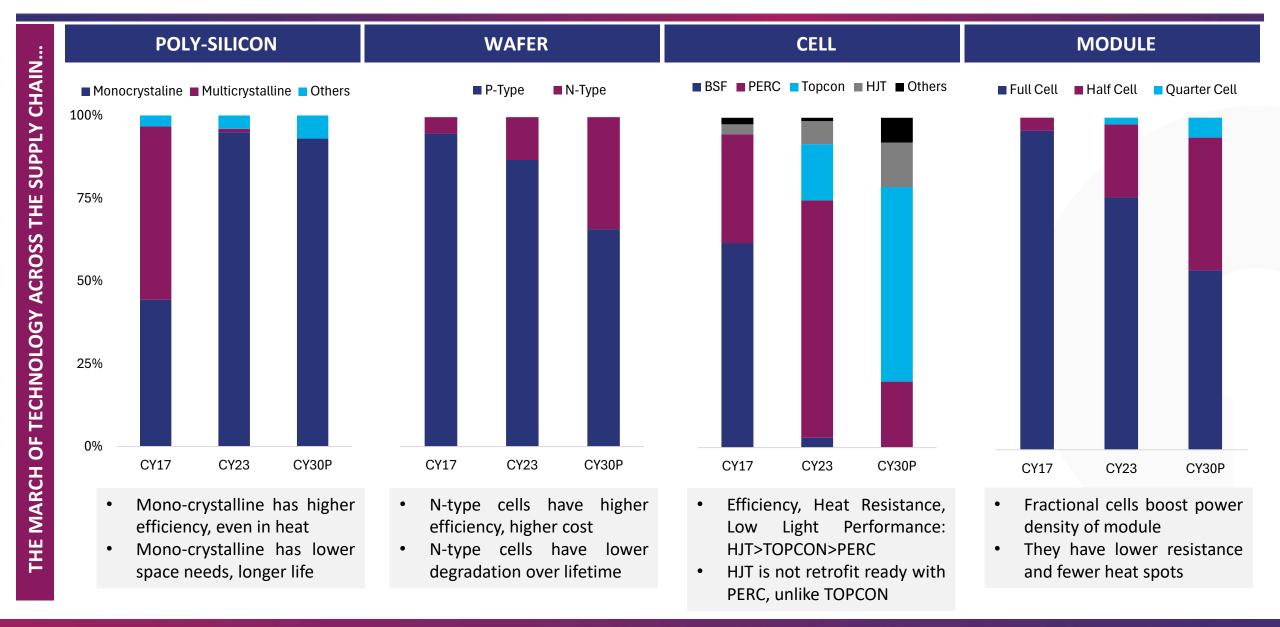
56 GW

56 GW

PLANNED CAPACITY

RAPID TECHNOLOGICAL EVOLUTION INCREASES OBSOLESCENCE RISKS

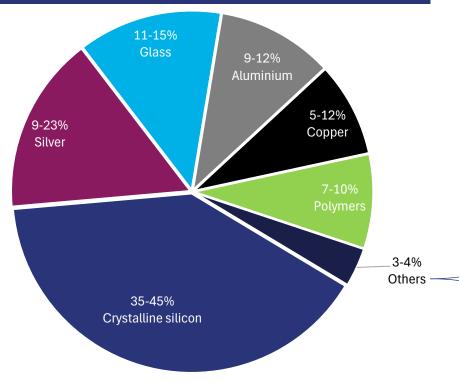




COST AND SUPPLY OF CRITICAL INPUTS A GAME OF GEOPOLITICAL CHINESE CHECKERS

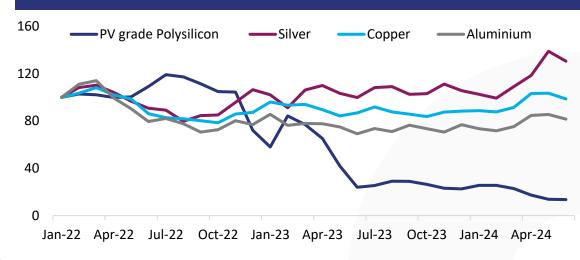


MATERIAL COMPOSITON SHARE OF PV MODULE BY VALUE

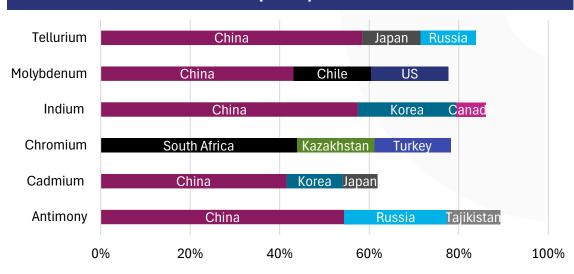


- Significant chunk of cost and value addition is in poly-Si stage, and India has limited reserves of solar-grade Si
- Precious metals make up ~1/4 the cost and are largely imported. Base metal prices are typically a function of Chinese demand/supply
- Rare earths are used minimally but are critical. China has a stranglehold over production (even if mines may be located elsewhere)

MATERIAL COST INDEX

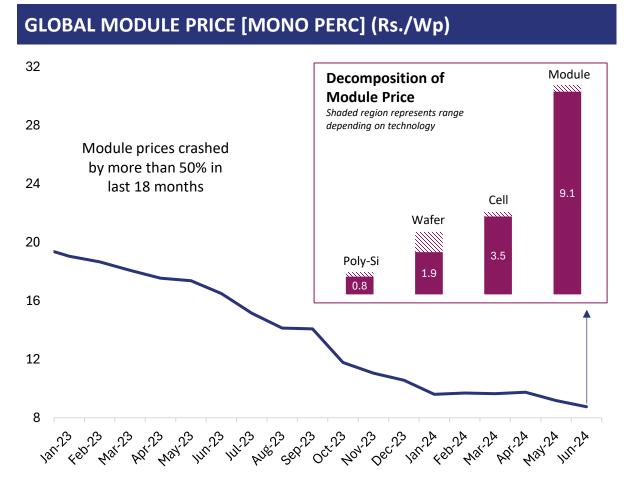


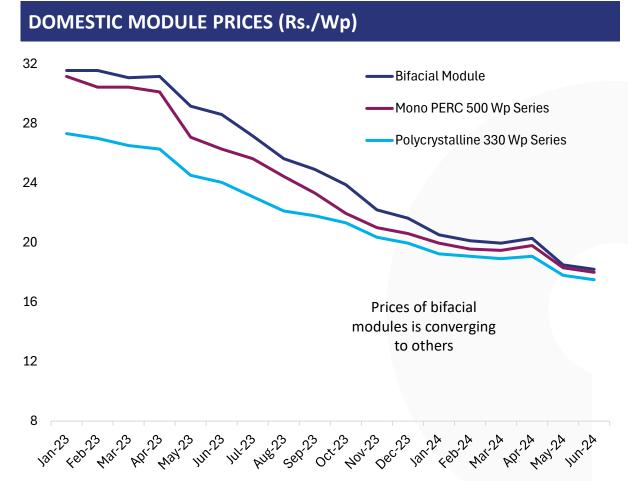
RARE EARTH PRODUCTION (CY21)



THESE FACTORS KEEP DOMESTIC COSTS UNCOMPETITIVE



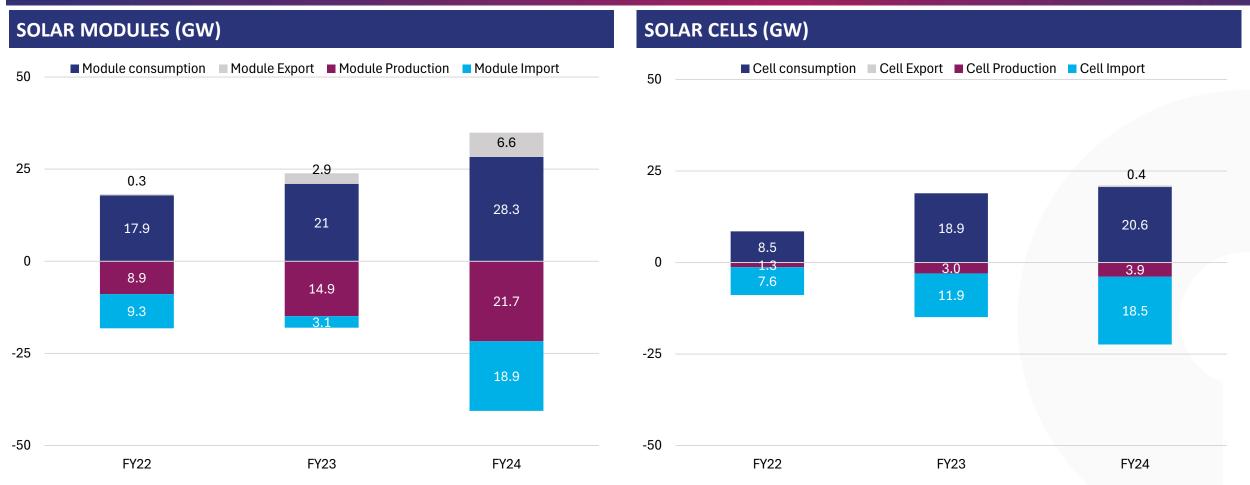




- Global module prices have declined based on falling prices of PV-grade poly-Si from USD 6/kg (in 2018) to USD 4/kg (prices had briefly touched USD 36/kg during COVID-19 due to supply chain disruptions). Further, grams of poly-Si used per cell have reduce 2-2.2 g/Wp from 5 g/Wp in 2016
- Domestic module prices remain on the higher side (~2x of global prices) owing to high demand, lack of downstream cell capacities, and higher depreciation as plants are newer. India's capacity is largely based on PERC (convertible to TOPCON), with minimal HJT

INDIA REMAINS A NET IMPORTER OF CELLS AND MODULES





- At the cell level, production is only ~4 GW (in FY24), as against consumption of 21 GW. Even if cell capacities get scaled up, given standard usability factors of 55-60% (ratio of actual production to nameplate capacity), there is likely to remain a shortfall in cell manufacturing domestically in the years to come
- Module manufacturing, being technically easy and low in capex, is more developed. Even as a significant module imports flooded into India (owing to ALMM deadline), exports were also dominant – this was as domestic manufacturers re-exported modules to USA etc. (which avoid direct Chinese imports)

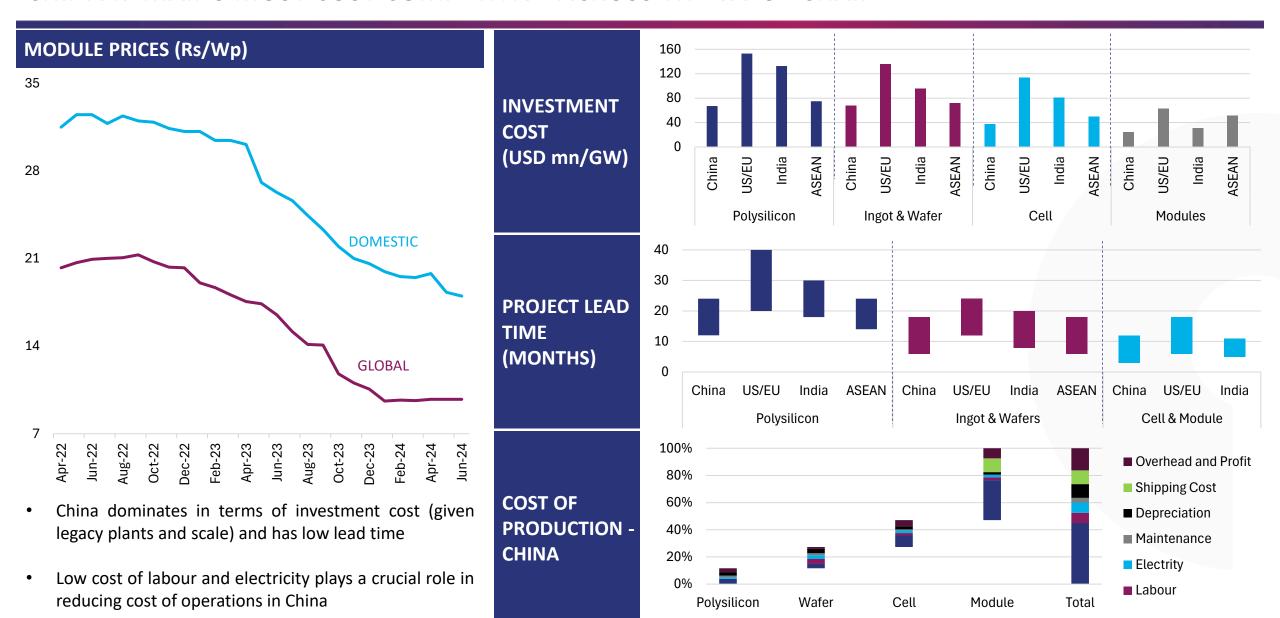


SUPPLY: STRATEGY OVERSHADOWS ECONOMICS?



CHINA REMAINS MOST COST COMPETITIVE ACROSS THE VALUE CHAIN

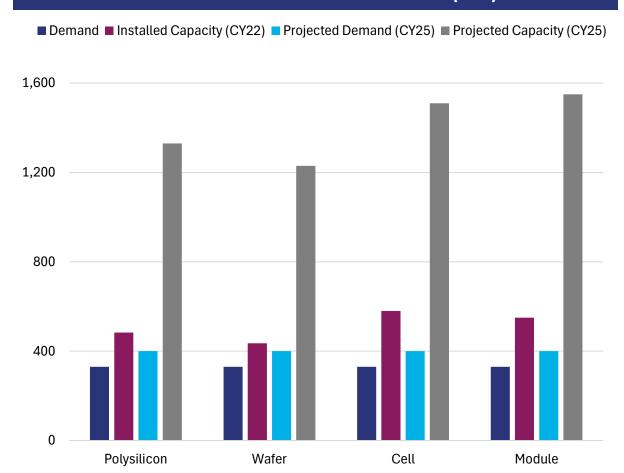




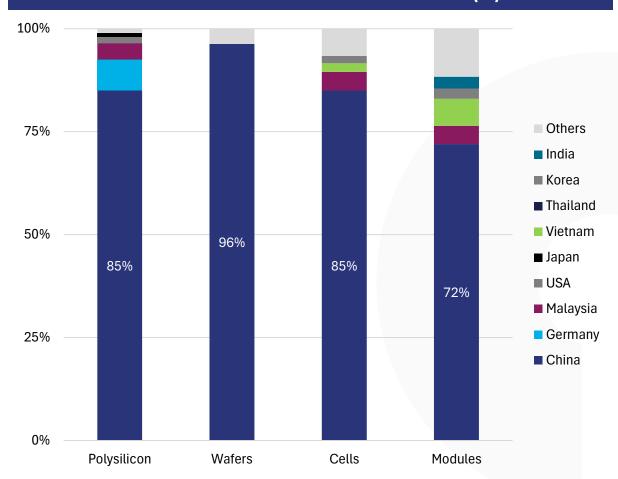
GLOBAL MARKET IN OVERSUPPLY AND IS GOING TO GET SKEWED EVEN MORE







SHARE OF TOP 5 COUNTRIES IN PRODUCTION CY22 (%)



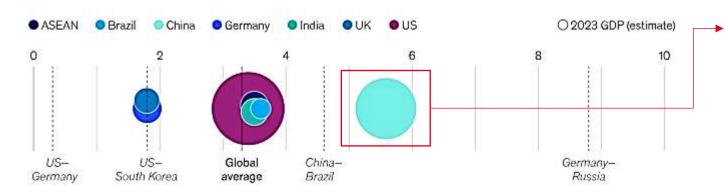
IN THIS GLOBAL SCENARIO OF OVERSUPPLY, THE QUESTIONS REMAINS AS TO WHY COUNTRIES (INCLUDING INDIA) SHOULD EVEN TRY TO CREATE DOMESTIC **UPSTREAM CAPACITIES? WE COVER TWO REASONS IN THE UPCOMING SLIDES**



SELF-SUFFICIENCY FOR STRATEGIC REASONS



GEOPOLITICAL DISTANCE OF TRADE



Notes:

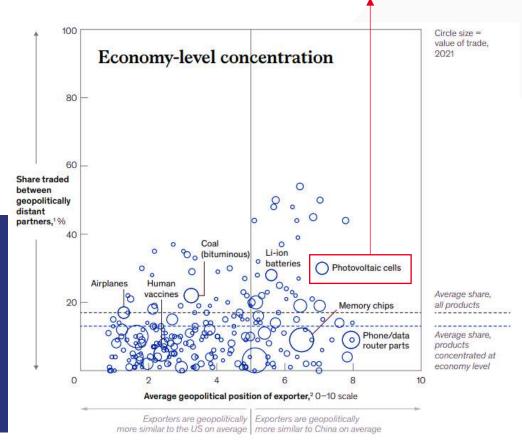
- Index from scores 0-10 with 0 being lowest geopolitical distance and 10 being highest
- Geopolitical distance is based on UN General Assembly votes as a proxy for alignment on global issues

"When the world is in crisis, we must pledge - a pledge which is bigger than the crisis itself. We must strive to make the 21st century India's century. And the path to do that is self-reliance,"

PM Mr. Narendra Modi

GOODS BY GEOPOLITICAL POSITION OF EXPORTER AND SHARE TRADED BETWEEN GEOPOLITICALLY DISTANT PARTNERS

China has high geopolitical distance with major global economies and also has high exports of high concentration products (like solar PV cells)

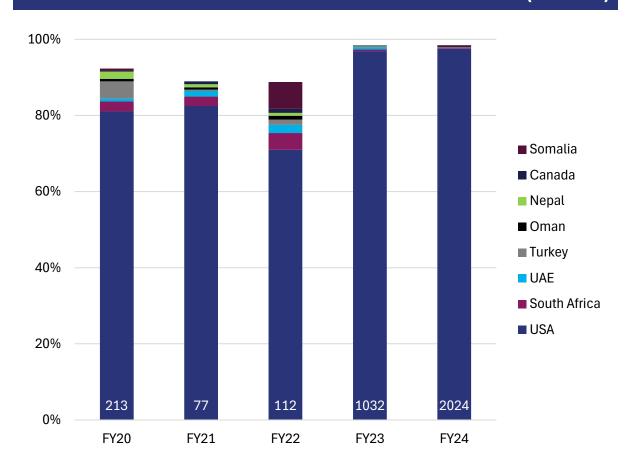


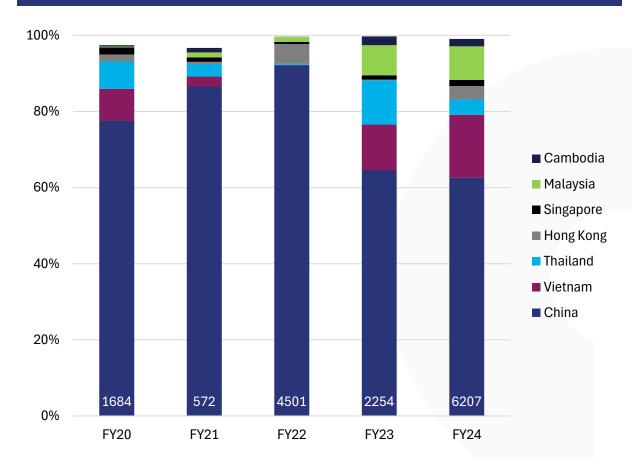
EXPORT PROMOTION BY GAMING THE GEOPOLITICS



COUNTRY WISE EXPORT OF SOLAR CELLS AND MODULES (USD mn)

COUNTRY WISE IMPORT OF SOLAR CELLS AND MODULES (USD mn)





- Solar modules imports grew 6x in FY24 vs. FY23: much of this was to stockpile modules for re-export to USA, taking advantage of ALMM relaxation
- Cells import only doubled during the period, indicating that countries have been much more protectionist about modules than cells

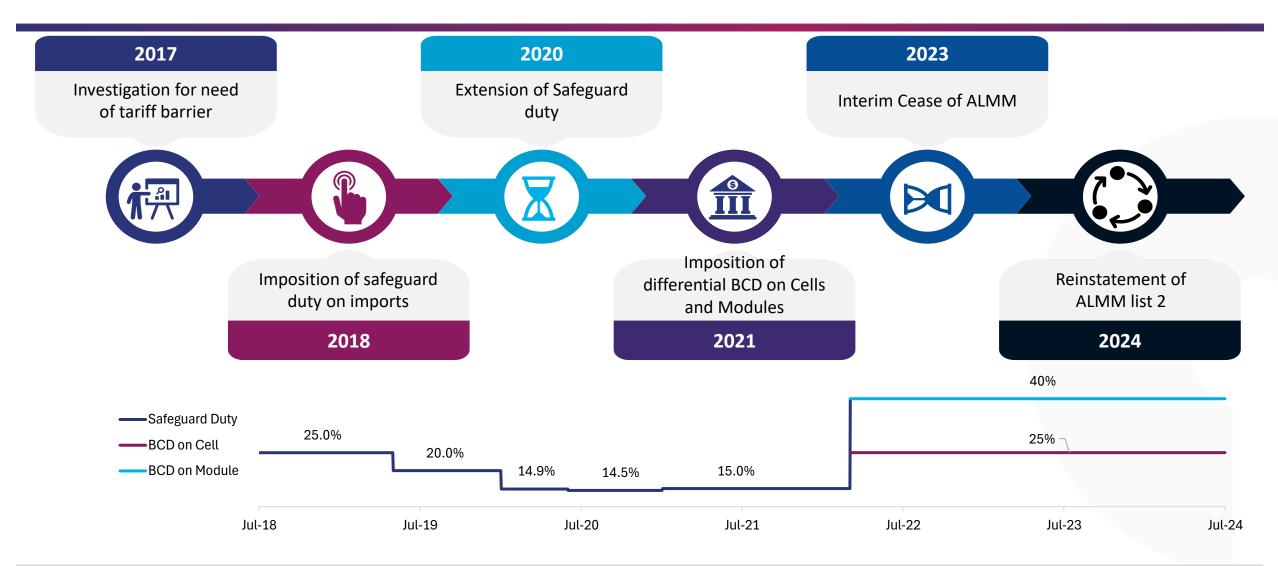


REFORMS TO BRIGHTEN UP THE SUPPLY SCENARIO



PROTECTIONIST ALMM POLICY & DUTIES TO SHIELD MODULE MANUFACTURERS





A TOTAL OF 51 GW OF MODULE MANUFACTURERS (ALL INDIAN) HAVE BEEN ENLISTED IN APPROVED LIST OF MODULE MANUFACTURERS (ALMM). ONLY MODULES FROM ALMM CAN BE USED IN GOVERNMENT-LED SCHEMES. IMPORTED MODULES AND CELLS ATTRACT A BCD OF 40% AND 25% RESPECTIVELY

PLI TO DEVELOP VERTICALLY INTEGRATED MODULE MANUFACTURING CAPACITY



PLI - I

Incentives of Rs. 44.5 bn

3 years commissioning

Efficiency of 19.5% and above

Highest base rate

PLI – II A

Incentives of Rs. 75.7 bn

3 years commissioning

Efficiency of 20.5% and above

~40% Less base rate than PLI

PLI – II B

Incentives of Rs. 53.1 bn

2 years commissioning

Efficiency of 20.5% and above

~ 60% Less base rate than PLI

Other key parameters:

- Local value addition
- Temperature coefficient
- Tapering factor

PLI – II C

Incentives of Rs. 10.5 bn

1.5 years commissioning

Efficiency of 20.5% and above

~80% Less base rate than PLI 1

Stage 4 **PV Cell -> Module**

Stage 1 MG Silica -> PolySilicon

Stage 2

PolySilicon -> Wafer

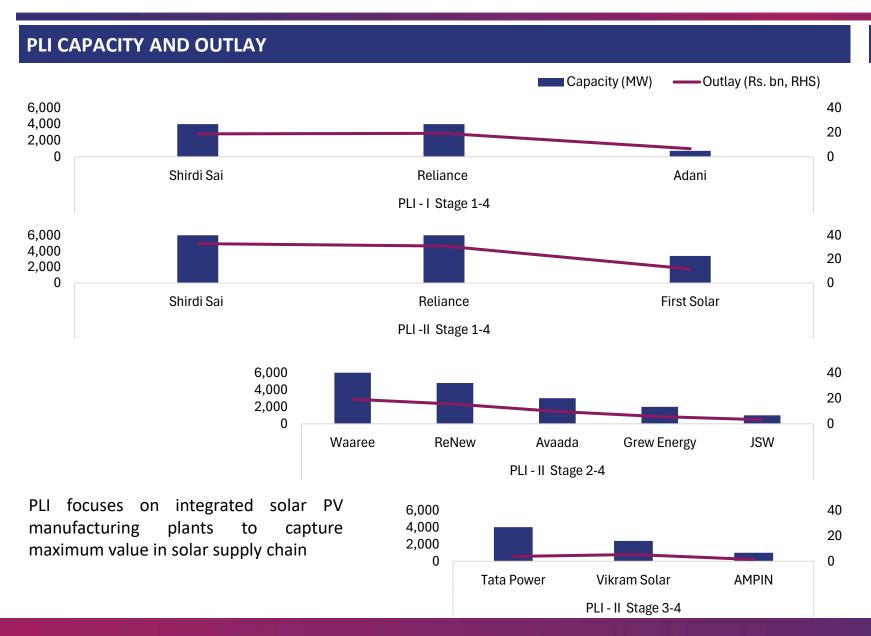
Stage 3

Wafer -> PV Cell

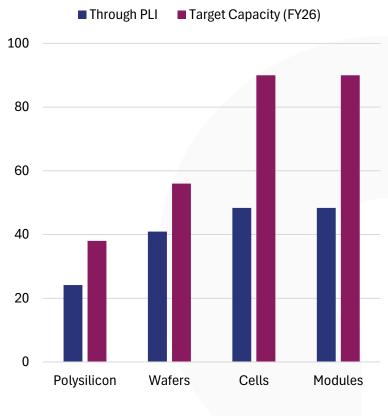
TOTAL OF 8,737 MW AND 39,600 MW OF MANUFACTURING CAPACITY IS EXPECTED TO BE BUILT BY FY26 THROUGH PLI 1AND PLI 2 RESPECTIVELY, OF WHICH 24,137 MW WILL BE FULLY INTEGRATED CAPACITY. INCENTIVES WILL BE DISBURSED FOR MAXIMUM 5 YEARS FROM SCHEDULE COMMISSIONING DATE

LEADING INDIA TO BECOME SECOND LARGEST MODULE MANUFACTURER





TARGET INSTALLED CAPACITY (GW)



PLI scheme will be sufficient to meet the domestic demand. It is below announced target capacity

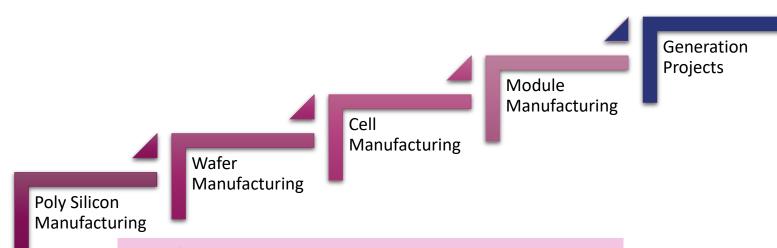


FUNDING THE LIGHT AT THE END OF THE TUNNEL



NUANCED FUNDING NEEDS EXIST ACROSS THE VALUE CHAIN





Capital Investment

- For building project, a significant chunk of outstanding debt
- FIs have extensive role in funding, so do banks.
 Larger entities use bond markets
- Equity: Developers, Funds

Working Capital

- For O&M expenses and receivables (DSRA), generally small component
- Largely by banks in form of CC/BG

Capital Investment

- For building project, reduces as we go downstream
- FIs have extensive role in funding, so do banks. Larger entities use bond markets
- Equity is brought in by developer

Working Capital

- Large share of total debt of entities
- For import of raw materials and export of finished products such as modules
- Largely by banks in form of LC/BG

Ancillary Opportunities

Third Party EPC

Funding performance guarantees and equipment

Transmission Infra Funding capital investment in building lines

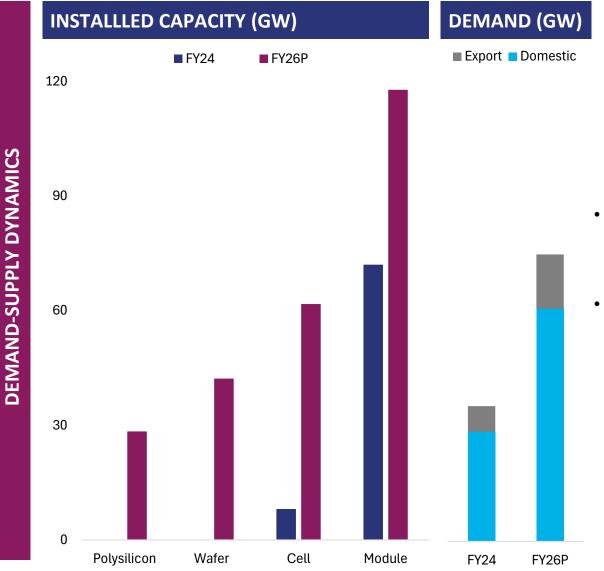
Balance of System Mfg.

Funding factories to manufacture inverters and transformers

UPSTREAM SOLAR PV MODULE MANUFACTURING: A SUNRISE SECTOR



- Module manufacturing will approach self-sufficiency in the medium term
- Given effective capacity is usually 55-60% of nameplate, cells will need to be imported partially

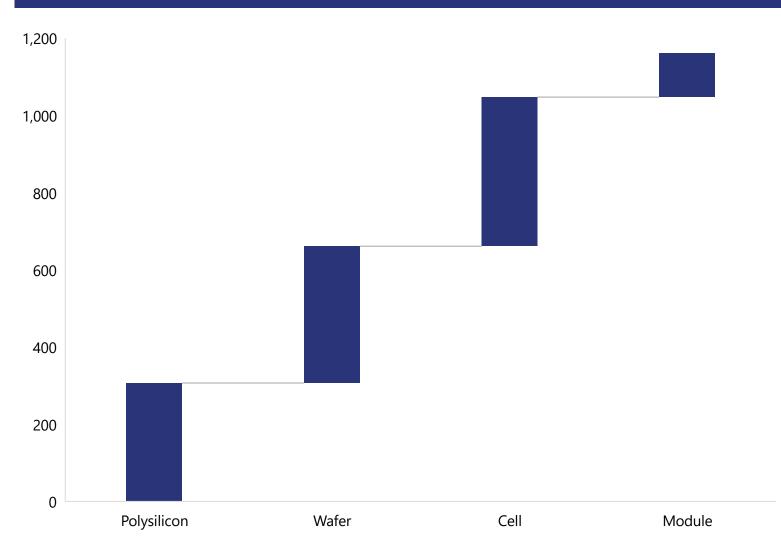


- Polysilicon, wafer manufacturing will take time to scale up, necessitating copious imports
- Export opportunities to EMs will ensure low stranded asset risk for the overcapacity post FY26

MAKING PANELS WHILE THE SUN SHINES: A Rs. 1.2 trn OPPORTUNITY



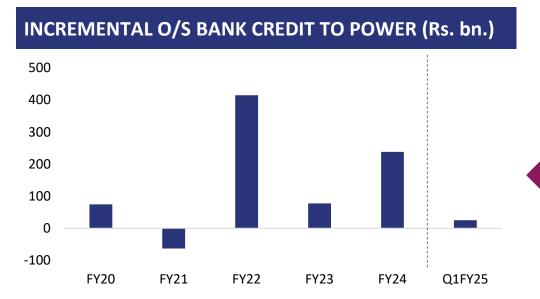
FUNDING REQUIREMENT IN FY25 AND FY26 (Rs. bn.)



- Upstream opportunities dominate due to currently low capacity mixed with high investment density
- Actual requirements could shoot up due to:
 - Low operating to nameplate capacity ratio
 - Newer bidding structures which emphasize fixed despatch requiring overcapacity
 - Export potential to EMs
 - Green Hydrogen exports
 - Change in technology to HJT (non-retrofittable with PERC unlike TOPCON)
- This would add on to the already huge ~Rs. 2 trn requirement for solar generation projects till FY26

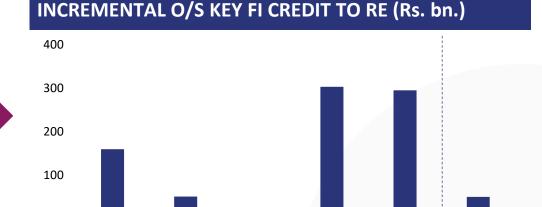
BANKS COULD INCREASE THEIR ROLE ACROSS THE VALUE CHAIN





Banks have gradually lost share in power credit to key FIs in past few years

This trend is set to reverse, with banks once again gaining exposure



FY22

Increasing vertical integration of players reduces risks for procurement of panels, dipping cost and time overruns. Also mitigates geopolitical and currency risk



Proposed higher provisioning norms & larger risk weights for project finance could push banks to go beyond renewable project funding into the supply chain



scheme to improve viability panel manufacturing. Further, protectionist tariffs and ALMM provide additional cushion of comfort



DRIVERS OF THE SHIFT



-100

FY20

FY21

Improved asset quality and ample capitalisation in most banks. Banks are now well positioned to lend to the manufacturing segment

FY23

FY24

Q1FY25



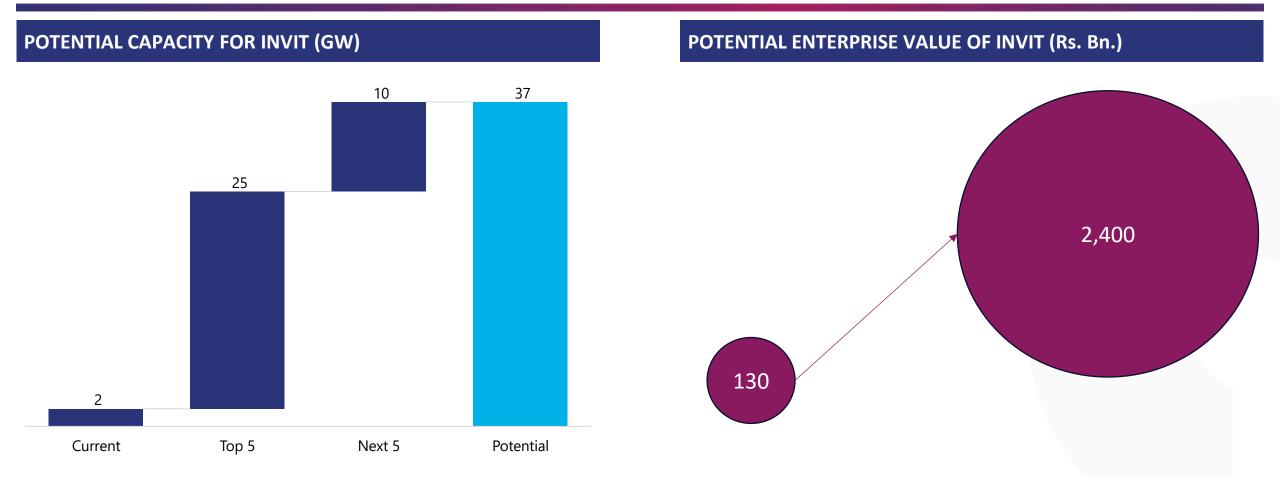
Increased safeguards in infrastructure projects and reasonable tariffs driving improved project economics. IBC allows for better recoveries



Regulatory and investor mandate to green portfolio to reduce climate risks

RECYCLING OPERATIONAL ASSETS COULD FREE UP CAPITAL FOR INTEGRATED PLAYERS

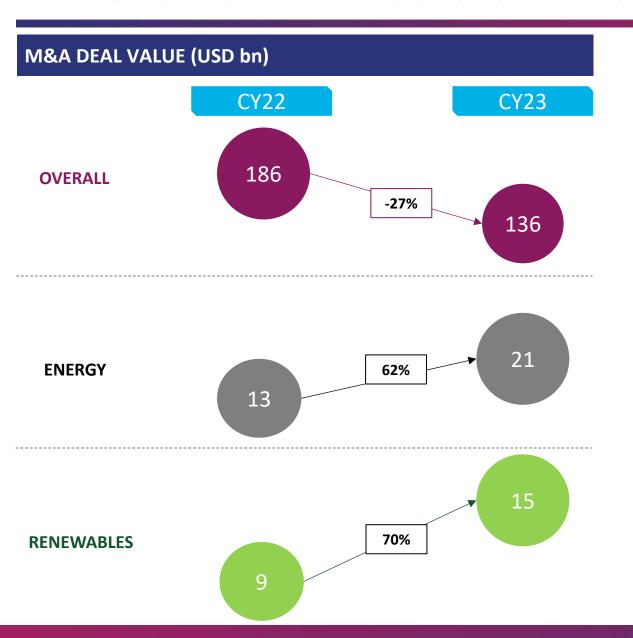


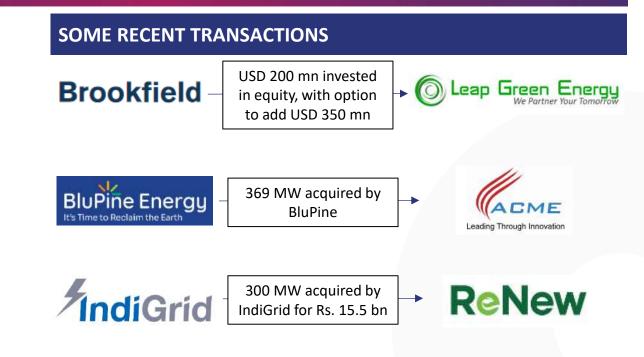


- 6 out of the top 10 players by solar capacity in India (accounting for 75% of their capacity) are integrated players. Much of this consists of upcoming upstream capacities which need capex. Given their significant operational solar project portfolio, creating InvITs could be an important source of capital
- ~30 GW of capacity is upcoming for these players beyond currently operational, this will ensure a steady flow of assets to be added to the InvITs, offering investors long-term visibility

BLAZING M&A ACTIVITY REFLECTS LONG-TERM POTENTIAL ACROSS VALUE CHAIN







- In CY22 and CY23, India accounted for 20% of Asia's renewable energy M&A deal value (as per Deloitte). Cross-border deals in energy sector soared in CY22 and CY23
- Renewable energy dominated energy deals in CY23, and deals in the segment were driven by inbound PE deals. Portfolio diversification by companies to enter clean energy led deals in CY22 and CY23
- Outlook for CY24 remains coruscant with several deals in the C&I segment also blooming, besides the mainstay of utility solar. There could also be traction towards outbound acquisitions in the storage space



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