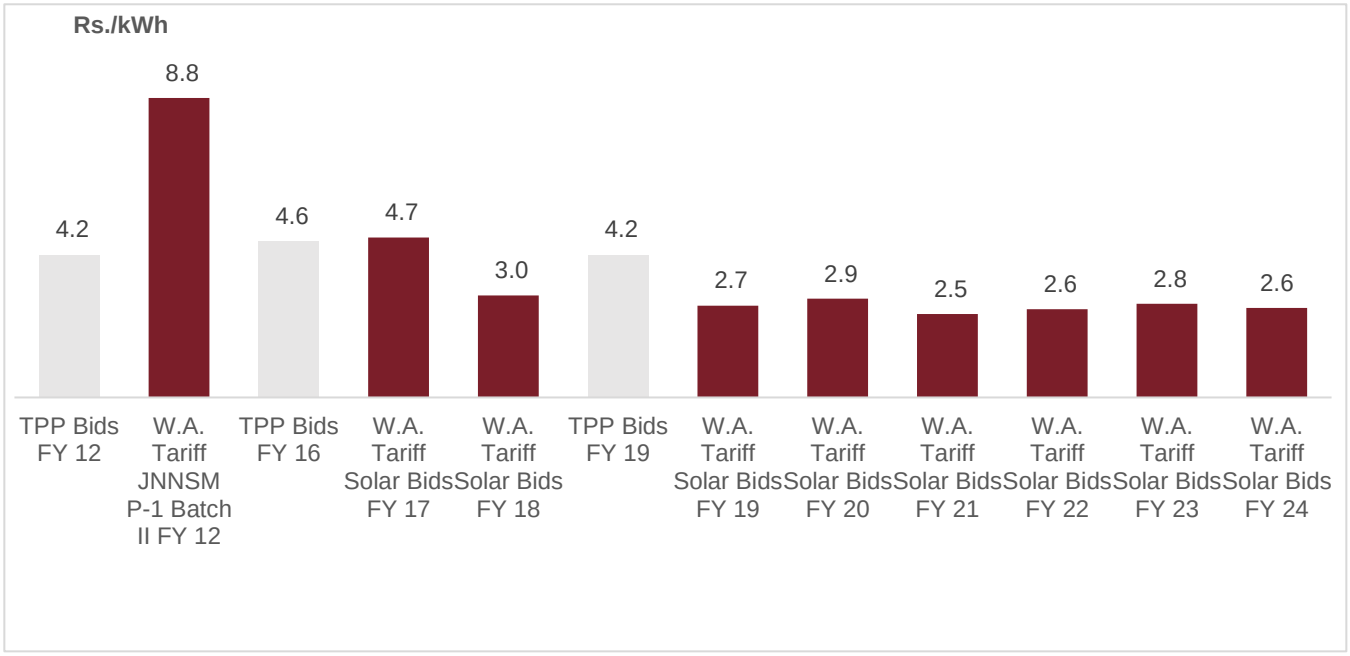
Figure 57: Competitively bid solar power tariffs are much lower than coal-based power tariffs



Note: TPP – Thermal power plant; JNNSM – Jawaharlal Nehru National Solar Mission; W.A. – Weighted average levelised tariffs
Source: Details of Case I bids, Bidding of power from stressed assets, CEA; CRISIL MI&A Consulting

However, while looking at solar tariffs, one will have to increasingly factor in grid integration costs as the penetration level of renewable energy increases. This is expected to increase the procurement cost from solar power plants.

5.2.3.2 Strong government thrust

The GoI has laid significant emphasis on climate change, for which it provided a framework, National Action Plan on Climate change (NAPCC), in 2008, where it proposed an eight-pronged strategy — National Solar Mission (NSM), energy efficiency, sustainable habitat, water planning, Himalayan ecosystem, afforestation, sustainable agriculture, and strategic knowledge on climate change. As can be seen, the GoI has laid significant emphasis on solar power. This is also evident from the 100 GW out of 175 GW target set out by the GoI. Government support to the solar sector in India is reflected by the following:

National Solar Mission

Central-level allocations under NVVN Batch II, JNNSM Phase II Batch III and IV have been almost entirely commissioned.

Operational support to execute solar projects

Apart from providing incentives, the government has lent significant support to the solar power sector for execution of projects.

Solar parks: One of the most important initiatives by the GoI has been setting up solar parks in the country. This is critical given the land-intensive nature (~5 acres required per MW of solar PV) of solar projects, coupled with low average holding (1.16 hectare) per person in India. Under the Solar Park Policy released in September 2014, the government planned to prepare land banks for 20,000 MW of solar projects across 25 states. The capacity of the scheme was doubled from 20,000 MW to 40,000 MW on March 2017, to set up at least 50 solar parks by fiscal 2022. Such parks significantly reduce construction/ execution risk as they include a contiguous parcel of land, evacuation infrastructure (HV/EHV substation evacuating to state grid substation), and other ancillary infrastructure and utilities such as road, water, and drainage.

Currently, 25 states, including Andhra Pradesh, Madhya Pradesh, Gujarat, Rajasthan, Uttar Pradesh, Karnataka, Telangana, West Bengal, Chhattisgarh, Tamil Nadu, Jammu and Kashmir, and a few north-eastern states, have started preparing land banks for solar parks, either through their own implementing agencies or through joint ventures with SECI. As per the available information on CEA, 50 Nos. Solar Parks / UMREPPs of aggregate capacity of 39,785 MW have been envisaged for development in the country as of June 2024. Out of 39,785 MW, 22,489 MW is awarded (Of these, the capacity of 11,416 MW has already been commissioned while 11,073 MW capacity is under construction) and 17,296 MW is under award/tendering process.

Table 23: State wise solar park approved capacity (MW)

Sr. No.	Name of the State in which Solar Parks/UMREPPs are located	Total Capacity of Solar Park/ UMREPP (MW)	Capacity Under Award / Tendering (MW)	Capacity Awarded (MW)	Capacity under construction (MW)	Capacity Commissioned (MW)
1	Andhra Pradesh	4,200	1,150	3,050	0	3,050
2	Chhattisgarh	100	0	100	0	100
3	Gujarat	12,150	2,770	9,380	8,405	975
4	Himachal Pradesh	53	53	0	0	0
5	Jharkhand	1,089	859	230	230	0
6	Karnataka	2,500	500	2,000	0	2,000
7	Kerala	155	50	105	5	100
8	Madhya Pradesh	4,780	2,172	2,608	958	1,650
9	Maharashtra	1,100	850	250	250	0
10	Mizoram	20	0	20	0	20
11	Odisha	340	300	40	40	0
12	Rajasthan	9,568	5,292	4,276	1,185	3,091
13	Uttar Pradesh	3,730	3,300	430	0	430
	Total	**39,785**	**17,296**	**22,489**	**11,073**	**11,416**

Source: MNRE, CRISIL MI&A Consulting

Although the potential of solar energy is high, there exist a few challenges, which are critical to achieving rapid growth of solar power.

Availability of contiguous parcels of land — With rapid capacity additions and stiff competition, it becomes imperative for developers to acquire land at competitive costs and in areas with high levels of solar irradiance. The 40 GW solar park scheme is facilitative in this aspect; however, beyond that capital costs and, hence, tariffs do fluctuate state to state depending on land prices and irradiance quality.

Adequacy of evacuation infrastructure — Grid integration of renewables is key to the growth of the sector. Instances of delay in readiness of transmission infrastructure at solar parks have caused concern amongst developers. However, an aggressive roadmap to add an incremental ~100 GW via new schemes and existing available capacity to the grid should be adequate for the expected additions. However, timely execution is critical.

Availability of low-cost capital — With the emergence of several large players in the sector, scale and experience have aided fundraising to an extent, especially with the backing of several foreign investors. However, a weak rupee, conservative risk appetite of lenders and other added cost pressures make it imperative for developers to maintain prudent capital management to sustain over the long term. To mitigate this, developers have been tapping alternative/ new routes to raise money from time to time.

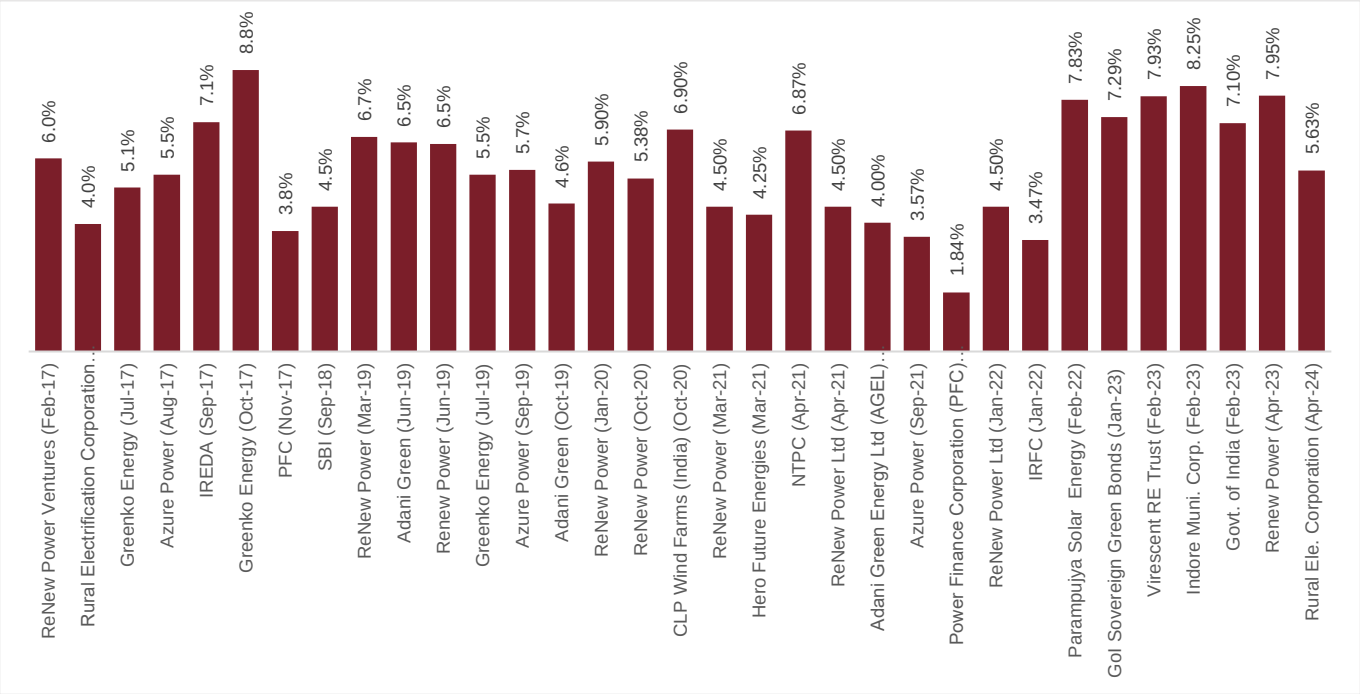
Availability of debt and equity finance to the solar sector

To facilitate growth of renewable energy and, in particular, the solar power sector, the GoI has provided several fiscal and regulatory incentives to developers. These incentives have been elaborated below.

Some steps taken by the government to ensure availability of low-cost finance are as follows:

- *Funding from lending institutions such as IREDA and PFS:* Government financial institutions such as PTC India Financial Services Limited (PFS), Rural Electrification Corporation (REC) and Indian Renewable Development Agency (IREDA) are also financing many solar projects. As of December 2023 (9MFY24), REC has sanctioned Rs. 1250.54 billion loans to RE incl. large hydro. Further, for IREDA, the cumulative sanctions as of March 2023 stood at Rs. 1,025 billion for RE incl. large hydro.
- *Green bond / masala bonds market:* A green bond is like any other bond; however, it invests the proceeds to support green energy or renewable energy projects. The tenure of the bonds typically ranges from 18 months to 30 years and currently they are being issued for a tenure 5 year and 10-year tenure. India is the second country after China to have national-level guidelines for green bonds; in India's case, they were published by SEBI. The green bonds may be issued by the national government; multilateral organisations such as Asian Development Bank, the World Bank or the Export-import (EXIM) bank of the country; financial institutions; and corporations. Some recent instances of green bond issuances in India are given below:

Figure 58: Yields of recent green bond issuances



Note: Excludes certain issuances whose proceeds were not directed towards funding of renewable energy projects in India.
Source: Industry; CRISIL MI&A Consulting

- *Pension funds / endowment funds*: Pension / endowment funds are expected to play a key role in financing solar projects. Long-term 25-year PPAs with limited operational risk are very suitable to this investor category. Mahindra Group and Ontario Teachers' Pension plan has launched RE InvIT named Sustainable Energy Infra Trust (SEIT). Both Mahindra Group and Ontario Teachers' had committed to investing upto Rs. 3050 crore and Rs. 3550 respectively into Mahindra Susten and SEIT. Canada Pension Plan Investment Board (CPPIB) owns more than 50% stake in Renew Power.
- *Private equity investments and debt investments:* In a quest to reduce the cost of capital for projects and further improve project economics, many players have increasingly resorted to private equity and debt investments to

free up capital. The proceeds are used to invest in new projects. Developers have been exploring several diverse instruments / sources to raise finance such as green bond issuances, external borrowings, private placements (qualified institutional buyers), etc. This not only lowers the cost but also frees credit from domestic banks to be used again as initial capital for new projects.

Further, there have been debt investment deals in the renewable energy sector with APG and Piramal Enterprise investing ~$132 million in Essel Green Energy and IFC investing ~$62 million in Ostro Energy.

Table 24: Private equity investments

Name of the company	Type of deal	Investor	Deal value	Date of investment
Fourth Partner Energy	Equity	World Bank IFC, ADB, DEG	$275 Mn	Aug-24
Leap Green	Equity	Brookfield	$200 Mn	Jun-24
Juniper International	Equity	ValueQuest	$35.8 Mn	Jun-24
Ampin Energy	Equity	responsAbility	$35 Mn	May-24
Avaada	Debt	National Bank for Financing Infrastructure and Development (NaBFID)	$535 Mn	Apr-24
Bhadla three SKP Green Ventures	Acquisition	CSEC	$0.46 Mn	Apr-24
ACME	Acquisition	BluPine Energy	$800 million	Mar-24
Fortum	Acquisition	Gentari Sdn Bhd	$200 million	Feb-24
Renew	Acquisition	IndiGrid	$187 Million	Feb-24
Sustainable Energy Infra Trust (SEIT)	Equity	Asian Infrastructure Investment Bank (AIIB)	$58.4 million	Jan-24
Sterling and Wilson Renewable Energy	Equity	Multiple (qualified institutions placement)	$180 million	Dec-23
KPI Green Energy	Equity	Multiple (qualified institutions placement)	$36.08	Dec-23
IREDA	Equity	Multiple (58 anchor investors)	$77 million	Nov-23
Freyer Energy	Equity	EDFI Electrifi, Schneider Electric Energy Asia Fund, Lotus Capital, Maybright Ventures and VT Capital	$6.9 million	Oct-23
Juniper Green	Equity	AT Capital Group and Vitol	$350 million	Sep-23
Adani Green Energy	Equity	INQ Holding LLC	$473 million	July -23
Waaree Energies	Equity	ValueQuest	$122 million	July -23
Fourth Partner Energy	Equity	Norfund	$42 million	July -23
Avaada Energy	Equity	Global Power Synergy Public Company Limited	$233 million	June-23
Virescent Renewable Energy Trust	Acquisition	IndiGrid	$486 million	May-23
Solar Ladder	Equity	Multiple Investors	$1.3 million	May-23
CleanMax Enviro	Acquisition	Brookfield	$360 Mn	Apr-23
Avaada Energy	Equity	Nxtra Data (Bharti Airtel)	$0.29 million	Apr-23

Name of the company	Type of deal	Investor	Deal value	Date of investment
Suncloud Solar (Cleantech Solar)	Equity	DLF Cyber City	$1.03 million	Apr-23
Prozeal Infra	Equity	Alchemie Ventures	$4 million	Apr-23
Tata Power Delhi Distribution Limited	Equity	Asian Development Bank	$18.2 million	Apr-23
Serentica Renewables	Equity	KKR	$250 million	Apr-23
Avaada Energy	Equity	Equity Solar Brookfield	$1000 million	Apr-23
Mytrah Energy	Acquisition	JSW Energy	$1,200 million	Mar-23
Greenko Group	Equity	GIC, ORIX Corporation, Abu Dhabi Investment Authority	$700 million -	Mar-23
Tata Power	Equity	GreenForest New Energies Bidco (GreenForest)	$486 million	Mar-23
Scorpius Trackers	Acquisition	Gensol Engineering Ltd	$16.42 million	Mar-23
Aerem	Equity	Avaana Climate Fund	$5 million	Mar-23
Insolation Energy	Equity	Energy Access Relief Fund (EARF)	$2.5 million	Mar-23
Samta Energy	Acquisition	Virescent Renewable Energy Trust	ND	Mar-23
Hero Future Energies	Equity	KKR	$450 million	Feb-23
SolarArise	Acquisition	ThomasLloyd Energy Impact Trust (TLEI)	$38.5 million	Jan-23
CleanMax Thanos (CTPL)	Equity	Welspun India	$0.46 million	Jan-23
Loom Solar	Equity	Social Investment Managers and Advisors (SIMA)	$2 million	Jan-23
Essel Saurya Urja company of Rajasthan Limited	Equity	Adani Green Energy	$1.85 million	Jan-23
Vayudoot Solarfarms	Acquisition	Aries Renewables	$1.73 million	Dec-22
StrongsunSolar	Equity	Mahindra CIE Automotive	$0.29 million	Dec-22
Name not disclosed	Acquisition	Inox Wind	ND	Dec-22
Vector Green	Acquisition	Sembcorp	$474 million	Nov-22
Serentica Renewables	Equity	KKR	$400 million	Nov-22
Atha Group	Acquisition	BluPine Energy	$245 million	Nov-22
SolarSquare	Equity	Elevation Capital and LowerCarbon	$12.11 million	Nov-22
Clean Electric	Equity	Climate Angles and Kalaari Capital	$2.2 million	Nov-22
Ethan Energy (Vibrant Energy)	Equity	Laurus Labs	$0.48 million	Nov-22
Waaree Energies	Equity	various private investors	$122.4 million	Oct-22
Hygenco	Equity	Neev Fund	$25 million	Oct-22
Refex Energy	Equity	Sunedison	$1.75 million	Oct-22

Name of the company	Type of deal	Investor	Deal value	Date of investment
Sembcorp Energy India Limited	Acquisition	Tanweer Consortium	$1.43 billion	Sep-22
Hero Future Energies	Equity	KKR and Hero Group	$450 million	Sep-22
Mahindra Susten	Equity	Ontario Teachers' Pension Plan Board	$300 million	Sep-22
Apraava Energy	Equity	CDPQ Infrastructures	$82.6 million	Sep-22
Serentica Renewables (SPV of Sterlite Power)	Equity	Hindustan Zinc	$42.88 million	Sep-22
SenseHawk	Acquisition	Reliance Industries	$32 million	Sep-22
Clean Max Kratos	Equity	UPL Ltd	$4.96 million	Sep-22
Navitas Alpha Renewables Private Limited	Equity	Niveshaay, with the participation of Action Tesa Group, Madhusudan Sarda, IVY Growth Associates, and others	$0.86 million	Sep-22
Sprng Energy	Acquisition	Shell	$1,550 million	Aug-22
Mytrah Energy	Acquisition	JSW Neo Energy Limited	$1,320 million	Aug-22
Atha Group	Acquisition	Actis	$264 million	Aug-22
Tata Power	Equity	BlackRock-backed GreenForest New Energies Bidco	$251 million	Aug-22
O2 Power	Equity	Syngene International	$0.38 million	Aug-22
Emmvee	Acquisition	O2 Power	ND	Aug-22
Wind Two Renergy Private Limited	Acquisition	Torrent Power	$4.1 million	Jul-22
Aerem	Equity	Blume Ventures	$2.5 million	Jul-22
Fourth Partner Energy	Equity	Filatex India	$1.29 million	Jul-22

Note: ND: Not disclosed

Source: Industry, CRISIL MI&A Consulting

– *Funding from multilateral banks and International Solar Alliance (ISA):* Further, the government channelises the funds available from multilateral banks and financing institutes such as World Bank and KfW. Funds are also provided to the Indian government under the Climate Investment Fund of the World Bank. For instance, SBI has received ~$625 million of soft loans with a long tenure of 20 years. On the same lines, KfW Germany provided a 1-billion-euro loan through IREDA for funding solar projects. Further, European Investment Bank has signed a long-term loan of 150 million euros with IREDA to finance clean energy projects in India.

The ISA, an association of solar-resource-rich countries, launched by the governments of India and France, aims at mobilising $1,000 billion in funds by 2030. The alliance intends to make joint efforts through various policy measures, such as an international credit enhancement mechanism that is expected to derisk investments and reduce the cost of financing for solar projects. The ISA member countries, in collaboration with the United Nations, the Green Climate Fund, multilateral development banks, investors, insurers, private financial institutions, and other interested stakeholders will finance solar projects.

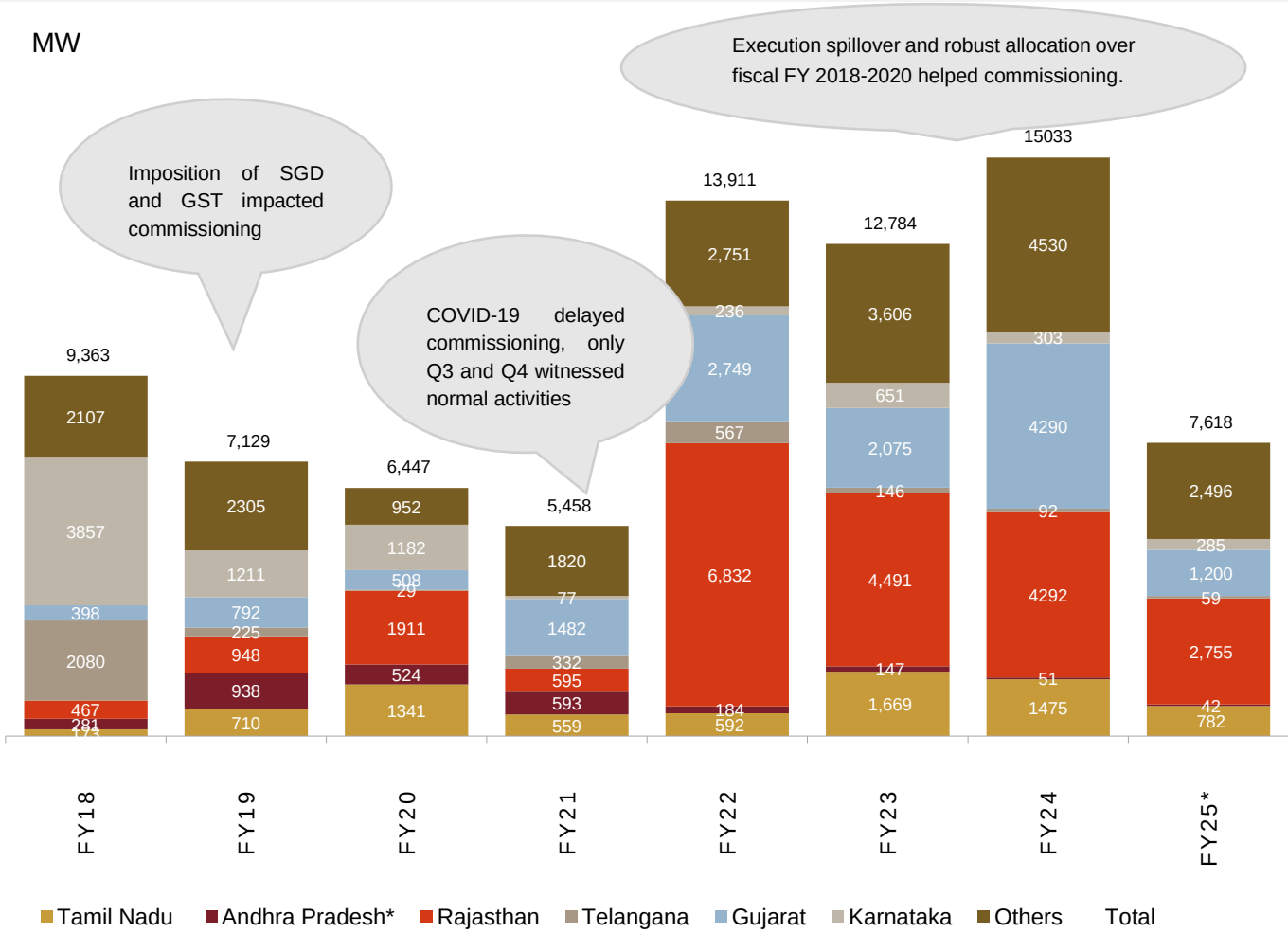
5.3 Solar capacity additions in India from fiscals 2019-2024

5.3.1.1 Robust pick-up in solar additions in fiscal 2023; momentum expected to continue

The GoI imposing solar RPOs across Indian states in 2011, coupled with the sharp drop in capital costs, led to most states releasing solar polices. This resulted in a spur in solar sector investments. Till fiscal 2012, only Gujarat and Rajasthan had state solar policies. After the success of Gujarat's solar policy, other states such as Andhra Pradesh, Tamil Nadu, Karnataka, Madhya Pradesh, and Telangana introduced their respective solar polices.

During fiscals 2018-2024, ~70 GW of solar capacity has been commissioned compared with the expected commissioning of 60-65 GW. Despite the second pandemic wave, ~14 GW of solar capacity was added in fiscal 2022. The momentum continued in fiscal 2023, with robust solar capacity additions of ~13 GW and ~15 GW in fiscal 2024. The first five months of fiscal 2025 saw a capacity addition of ~7.6 GW.

Figure 59: States that helped drive solar capacity addition in India



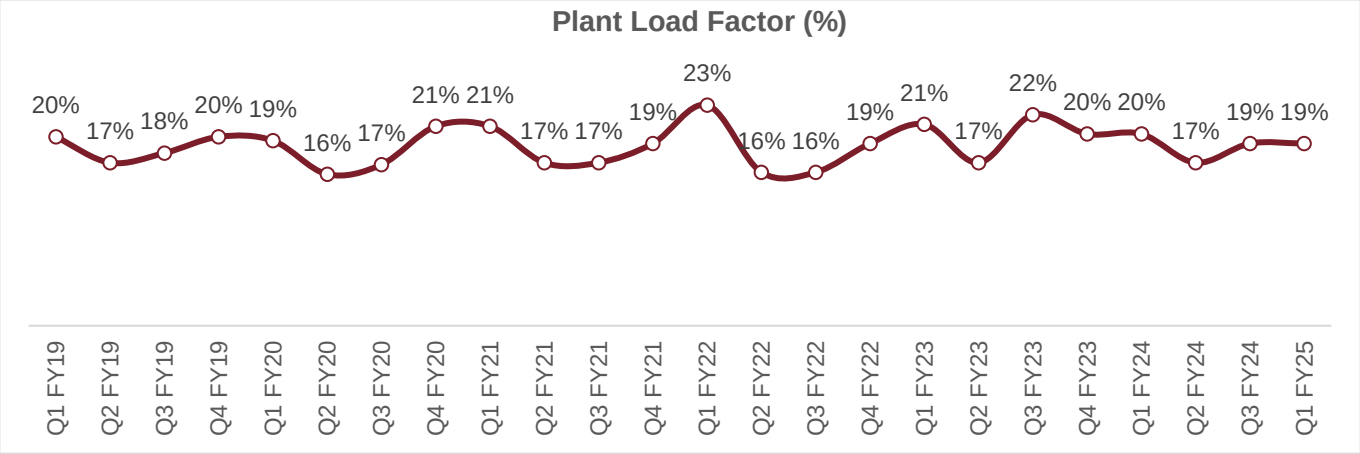
Source: MNRE; CRISIL MI&A Consulting

Commissioning activity has been concentrated in the key states of Rajasthan, Gujarat, and Tamil Nadu, where of ~10 GW capacity was added in fiscal 2024; ~65% share was concentrated in these three states combined. In the previous fiscal as well, the installation trend was driven by the same states.

Scheme-wise commissioning was driven by several large projects under SECI ISTS hybrid 1200 MW tranche-I, SECI ISTS hybrid 1200 MW tranche-II, SECI ISTS 2000 MW Tranche IX, SECI 2000 MW CPSU Tranche-I and CPSU scheme Phase-II Tranche I, which got commissioned in the third quarter of the previous fiscal.

The performance of operational projects remains stable with healthy PLFs of 18-20% over the past 12 quarters. However, there is a dip in the second quarter of each fiscal due to monsoons. Players have been designing projects with DC (direct current) overloading, which entails connecting more modules on the DC side of the plant to generate incrementally more in the non-peak generation hours. This has helped improve PLFs for larger developers / newer projects to 25-28%. Players have been known to utilise DC overloading up to 30-50% of the AC (alternating current) side capacity.

Figure 60: Average PLF of the operational projects



Source: Company Filings; CRISIL MI&A Consulting

5.3.1.2 Policy changes, pandemic-related relief and renegotiation have impacted execution momentum

Robust capacity addition is expected from fiscals 2022 to 2024 due to a strong pipeline nearing the end of timeline extensions. Capacity additions slowed since fiscal 2019-2021 in the segment due to several policy and execution-related challenges as mentioned below.

- **Abeyance of ALMM:** The ALMM mandate has been kept in abeyance for a year and was not be applicable if a project is commissioned before March 31, 2024. The draft was introduced to give momentum to solar additions which declined in fiscal 2023 due to the unavailability of domestically manufactured modules. The mandate was introduced in 2021 to boost domestic manufacturing by approving the list of manufacturers who could participate in the solar development projects bid out by the government. The mandate was later extended to the government's open-access projects as well. However, the ALMM is reinstated from April 1, 2024.
- **COVID-19 restrictions:** The pandemic led to mobility and labour-related challenges in the first quarter of fiscal 2022 and the first half of fiscal 2021, which hampered execution. Further, the MNRE provided 7.5 months of extension for the segment, which was a positive move for developers but delayed commissioning schedules.
- **Power sale agreement (PSA) delay**: Auctioned solar projects, tendered by the Solar Energy Corporation of India (SECI) were delayed because of challenges in finding offtakers, with PSAs remaining unsigned. This was largely due to state distribution companies (discoms), which are the major offtakers, increasingly deferring the signing of the PSAs amid low tariffs of Rs 2.3-2.5 per unit. However, with the government's plan for stricter adherence to renewable purchase obligations (RPOs), higher penalty in case of non-compliance, and revision of

tariff in manufacturing-linked tenders from Rs 2.92/kWh to 2.54/kWh, PSA signing activity has improved. SECI saw tariff adoption for ~4.1 GW in fiscal 2023 and ~5.2 GW in fiscal 2024.

- **Infrastructure issues**: Land availability and grid connectivity challenges delayed 5-6 GW of projects. Land acquisition challenges arise since many stakeholders must be involved to acquire large tracts of land in a single location as well as reported delays in solar park infrastructure, leading to a slowdown in the pace of project execution.
- **Payment delays:** After the record-breaking tariffs of Rs 2.44 per unit in the Bhadla solar park auctions in May 2017, several state discoms became hesitant to go through with fresh bids, which were at higher tariffs. This created a fear of discoms reneging on commitments, especially for the duration in which PPAs remained unsigned after the auctions.

Post this, the Andhra Pradesh incident and positive result for the developer has helped stem such activities. The high court judgment provided positive reinforcement to the Andhra Pradesh renegotiation incident. However, the prolonged litigation did lead to a build-up of receivables over three years and offtake issues. The Andhra Pradesh High Court settled a crucial three-year-old matter concerning the state's attempt to renegotiate the PPA. The court had directed the discoms to make interim payments to power generators and make payments of all the dues at the rate mentioned in the PPA within six weeks. The decision was made conclusively in favour of generators and the court affirmed that the primacy of the contract will boost confidence in the renewable energy sector. This confidence will also support execution momentum for the industry.

Out of 108 GW of allocations under competitive bidding from fiscal 2018 till June 2024, ~4.7 GW projects have been cancelled. Delays were also observed owing to land and transmission issues, several projects were also granted extensions by MNRE in late December 2022 pushing the pipeline to further years. Also, several projects in key states of Rajasthan and Gujarat are experiencing further delays due to transmission issues. Several projects were stuck in the habitat of the Great Indian Bustard, due to blanket ban by supreme court, on overhead transmission lines being installed for evacuation of power passing from GIB habitat areas. In the latest update however, Supreme Court has changed its stance and is now considering a balanced approach between development and wildlife protection. Decisions are now being in made on case-to-case for commissioning transmission lines overhead with bird divertors.

Additional duty investigations on solar sector inputs: Various players from the Indian domestic solar component manufacturing industry (mainly modules) filed additional duty petitions against imports. The key in this regard was a safeguard duty investigation filed by the Indian Solar Manufacturer’s Association (ISMA) in front of the DGTR.

However, despite the duty levy, imports continued to dominate module supplies. With the safeguard duty ending on July 29, 2020, five Indian producers, including Mundra Solar and Jupiter Solar, filed applications through ISMA to review and extend the safeguard duty for another four years. After initiating a probe to decide on the continuation of the safeguard duty on solar imports and further to applications invited from domestic companies for the same, DGTR extended the imposition of safeguard duty for another year, with the duty being levied at 14.9% from July 30, 2020, to January 29, 2021, followed by 14.5% from January 30, 2021, to July 29, 2021. The safeguard duty cannot be levied for more than four years with decreasing rates every year (this is in accordance with international regulations); hence, it was removed post-July 2021.

The MoP alternatively levied a BCD effective April 1, 2022. The imposition of BCD of ~40% on modules and 25% on cells led to a 20-25% increase in capital costs for projects based on imported modules and Rs 0.2-0.5 per unit rise in tariffs, with tariffs ranging from Rs 2.6-2.8 per unit.

GST issues: Initially, a GST rate of 5% was imposed on solar modules; other electrical equipment (such as power cables, transformers, and inverters) was classified under 18%. The GST rate on solar components was later revised to 12%. Further, due to the disparity in rates for solar components and other electrical equipment, there was a lack of clarity on the rate for solar projects in general. The GST Council later clarified that all such contracts would be

taxed by splitting the overall value into a 70:30 ratio, with 70% taxed at a 12% rate and 30% at the applicable GST rate for services, i.e., 18%. This raises the applicable GST rate for such contracts to 13-14%, a further cost pressure on developers. Additionally, developers have been facing delays in obtaining the input tax refund from corresponding counterparties (SECI/NTPC/discoms).

5.4 Review of competitive bidding

Positive changes to bidding guidelines undertaken to support bidder interest

For solar projects over 2009-2013, most states signed PPAs at FiTs determined by the state commission on the fixed regulated equity return of ~16%. While for wind energy projects, states followed the FiT mechanism till March 2017. However, from fiscal 2018, the sector veered towards competitive bidding.

Following section discusses the solar competitive bidding guidelines after the amendment of certain key provisions in September 2020 by MNRE:

- Expanded the definitions of force majeure and outlined the definitions of adjusted equity, debt due and other key terms of the agreement
- Outlined that in case a state discom is not party to the tripartite agreement (an agreement between state governments, SECI, NTPC and the RBI to ensure payment security), the state will either provide some alternate state government guarantee or pay an additional risk premium of Rs 0.10 per unit towards the payment security fund maintained for paying developers in case of payment delays / defaults. However, the implementation has been lax
- It also states that to maintain the payment security fund (fund maintained by SECI /NTPC to support payment of at least three months' billing), the intermediary may collect Rs 5.0 lakh/MW from the solar power generator. This will be mentioned in the PPA
- The new guidelines also outline a grant in extension of the scheduled COD (SCOD) deadline as defined in the PPA terms if:
    1. The applicable state electricity regulatory commission delays adoption of tariffs post competitive bidding, and
    2. There is any delay in land allotment from the side of the state government
- Reduction in lock-in periods for solar project developers was enabled. Project developers now need to maintain a controlling shareholding of 51% in the special purpose vehicle (SPV) or project company executing the PPA for one year from the COD of the project, reduced from three years earlier
- Bidders can now furbish earnest money deposit in the form of a bank guarantee or a letter of undertaking, unlike earlier when only bank guarantees were considered

Further, the Ministry of Finance, in November 2020, reduced performance security deposits from 5-10% to 3% of the value of the contract for all existing contracts. However, the benefit of the reduced performance security will not be given to contracts under dispute wherein arbitration/court proceedings have already been started or are completed. All tenders/contracts issued/concluded till March 31, 2023, will also have the provision of this reduced performance security.

Also, on July 23, 2021, MNRE announced amendments in guidelines for the tariff competitive bidding process for the procurement of power from wind-solar hybrid (WSH) projects. Following are the key changes:

a. SECI will be treated as a procurer, and not a nodal agency

b. Hybrid power generator will be allowed to commission the project even partly or fully before the scheduled commissioning date (SCD), provided transmission connectivity is available

c. An appropriate regulatory commission will approve deviation from guidelines, which was done by the ministry earlier

d. Discoms can directly procure power from hybrid power generators, which would help them to procure power at a lower tariff by eliminating the trading margin they had to pay to SECI

e. Interstate and intra-state transmission systems at delivery point and transmission infrastructure for which the generator applies for connectivity must be completed before the project's SCD

The MoP has also made amendments to the bidding guidelines for procurement of round-the-clock (RTC) power. The original order dated July 22, 2020, stated that during the bidding process, if the allocated quantum of power to the bidder quoting the least weighted average levelised tariff (L1), is less than the total quantum of power to be contracted, then the remaining qualified bidders would be asked to match their tariff with the L1 tariff. Hence, the bidder willing to match the L1 tariff will be allocated the remaining quantum of power, or the quantum offered by it. If some quantum is still left, it will be allocated to the next lowest bidder, and so on. However, the amendment in the order dated February 3, 2022, states that during the bidding process if the allocated quantum of power to the bidder quoting the least weighted average levelised tariff (L1) is less than the total quantum of power to be contracted, then the remaining qualified bidders will be on the basis of bucket filling, which means that capacity will be first allocated to the L1 bidder at the L1 rate, then the capacity will be allocated to the next lowest bidder at the rates quoted by him till the tender capacity is completely exhausted.

On June 6, 2022, the government also made amendments to the open access regulations through the Green Energy Open Access Rules, 2022, via energy banking regulations, changes in minimum contract demand, standardising calculation of charges, etc. These regulations are a positive step towards promotion of the open access market as it ensures:

a. Centralised procedure for registration and applications of open access to remove variability across states

b. Standardisation of some key policy aspects such as procedures and banking provisions

c. Concessions for green energy by removing certain ancillary charges where applicable, again eliminating state-wise variability

d. Creating a mechanism for the discoms to supply green energy and certify the same to promote competitiveness

Overall, the above amendments are a positive for the developers as these amendments grant extension in SCOD for events that have been hampering commissioning, stipulate some form of state government guarantee and ease liquidity in the sector by way of introducing alternative payment security mechanisms, provide positive boost to the open access market and simplify procedures or provide provisions to stimulate bidder interest. However, the sector requires consistent positive regulatory support to spur capacity additions, despite a healthy pipeline.

Table 25: Bid tariffs quoted over fiscal 2018 to Jan 2024

Sr no	Bidding scheme/Tender	Month of bidding	Lowest tariffs discovered (Rs/unit)
1	1 GW ISTS SECI auctions (SECI – I)	Feb 2017	3.46
2	0.5 GW Tamil Nadu	Aug 2017	3.42
3	1 GW ISTS SECI auctions (SECI – II)	Oct 2017	2.64
4	0.5 GW Gujarat	Dec 2017	2.43
5	2 GW ISTS SECI bidding (SECI – III)	Feb 2018	2.44

Sr no	Bidding scheme/Tender	Month of bidding	Lowest tariffs discovered (Rs/unit)
6	2 GW ISTS SECI bidding (SECI – IV)	Mar 2018	2.51
7	1.2 GW ISTS NTPC	Aug 2018	2.77
8	1.2 GW ISTS SECI	Sep 2018	2.76
9	1.05 MW ISTS SECI	Dec 2018	2.64
10	1.2 GW ISTS SECI	Feb 2019	2.55
11	0.8 GW ISTS SECI	May 2019	2.7
12	0.25 GW BERC	Jun 2019	3.15
13	1.2 GW NTPC	Oct 2019	2.93
14	0.5 GW MSEDCL	Nov 2019	2.9
15	1.2 GW* SECI	Nov 2019	2.88
16	7 GW SECI	Jan 2020	2.92
17	1.2 GW SECI	Jan 2020	6.3
18	1.2 GW SECI	Feb 2020	2.5
19	0.5 GW UPNEDA	Feb 2020	3.18
20	0.3 GW GUVNL	Mar 2020	2.63
21	2 GW NHPC	Apr 2020	2.55
22	2 GW SECI	Jul 2020	2.37
23	0.2 GW KSEB	Nov 2020	2.97
24	1.07 GW SECI	Nov 2020	2.00
25	0.75 GW SECI	Feb 2021	2.70
26	0.3 GW Torrent Power	Feb 2021	2.22
27	0.19 GW NTPC	Feb 2021	2.25
28	0.5 GW GUVNL	Mar 2021	2.20
29	0.5 GW MSPGCL	May 2021	2.51
20	0.1 GW GUVNL	May 2021	2.64
31	0.5 GW MSEDCL	May 2021	2.43
32	0.5* GW MSEDCL	May 2021	2.62
33	0.5 GW RUMSL	July 2021	2.44
34	0.45 GW RUMSL	Jul 2021	2.35
35	0.5 GW RUMSL	Aug 2021	2.14
36	0.25 GW BREDA	Aug 2021	3.11
37	5 GW IREDA	Sep 2021	2.45
38	2.5** GW SECI	Oct 2021	3.01
39	500 MW MSEDCL (KUSUM)	Oct 2021	3.05

Sr no	Bidding scheme/Tender	Month of bidding	Lowest tariffs discovered (Rs/unit)
40	500 MW PSPCL	Nov 2021	2.33
41	1300 MW MSEDCL	Dec 2021	3.00
42	1.785 GW SECI	Dec 2021	2.17
43	487 MW MSEDCL (KUSUM)	Dec 2021	3.10
44	200 MW UPNEDA	Jan 2022	2.98
45	444 MW MSEDCL (KUSUM)	Jan 2022	3.10
46	1200 MW SECI	Feb 2022	2.35
47	500 MW GUVNL	Mar 2022	2.29
48	1200* MW SECI	May 2022	2.53
49	600# MW RUMS	May 2022	3.21
50	500 MW GUVNL	Jun 2022	2.30
51	431 MW MSEDCL (KUSUM)	Jul 2022	3.10
52	500 MW MSEDCL	Aug 2022	2.90
53	500 MW MSEDCL	Sep 2022	2.82
54	750 MW GUVNL	Sep 2022	2.49
55	750* MW RUMS	Sep 2022	3.03
56	105# MW MSPGCL	Oct 2022	3.93
57	300# MW RUMS	Nov 2022	3.89
58	255* MW TPDDL	Dec 2022	3.00
59	500 MW MSEDCL	Dec 2022	2.90
60	250** MW MSEDCL	Dec 2022	9.00
61	500 MW GUVNL	Jan 2023	2.51
62	1250 MW RECPDCL	Apr 2023	2.55
63	500 MW RECPDCL	Apr 2023	2.69
64	1000 MW* RUMSL	Apr 2023	3.99
65	200 MW* SECI	Apr 2023	4.64
66	500 MW MSEDCL	Apr 2023	2.87
67	500 MW GUVNL	Apr 2023	2.71
68	600 MW GUVNL	May 2023	2.73
69	1000 MW RUVNL	May 2023	2.61
70	150 MW CESC*	May 2023	3.07
71	40 MW AVVNL Rajasthan (KUSUM-C)	May 2023	3.33
72	31 MW JVVNL Rajasthan (KUSUM-C)	May 2023	3.43
73	27 MW JdVVNL Rajasthan (KUSUM-C)	May 2023	3.55

Sr no	Bidding scheme/Tender	Month of bidding	Lowest tariffs discovered (Rs/unit)
74	800 MW GUVNL Tranche XX	July 2023	2.70
75	200 MW SECI Tranche XI	July 2023	2.60
76	200 MW PSPCL	Jull 2023	2.53
77	300 MW RUMSL#	Aug 2023	3.79
78	1,200 MW RUVNL (Storage hybrid peak power)	Aug 2023	6.68
79	50 MW APDCL	Aug 2023	3.90
80	70 MW APDCL	Aug 2023	3.92
81	225 MW TPC-D Hybrid	Sep 2023	3.27
82	18 MW PEDA	Sep 2023	2.63
83	810 MW RUVNL	Oct 2023	2.64
84	3,000 MW NHPC	Nov 2023	2.52
85	1,500 MW Hybrid peak power	Nov 2023	4.38
86	420 MW TANGEDCO (KUSUM A)	Nov 2023	3.28
87	1000 MW SECI Tranche XII	Dec 2023	2.52
88	500 MW GUVNL Tranche XXII	Dec 2023	2.63
89	500 MW NTPC*	Dec 2023	3.35
90	2000 MW SECI Tranche VII	Jan 2024	3.15
91	500 MW# GUVNL, Hybrid Tranche I	Jan 2024	2.99
92	600 MW GUVNL Tranche XXI	Jan 2024	2.54
93	750* MW REML Hybrid Storage	Jan 2024	4.25
94	1500 MW SJVN	Feb 2024	2.52
95	1500* MW, NHPC WSH	Feb 2024	3.48
96	1500* MW SJVN WSH Tranche I	Feb 2024	3.43
97	1500* NTPC (Firm power)	Feb 2024	4.55
98	1125 MW GUVNL Solar Tranche XXIII	Mar 2024	2.62
99	1500 MW SECI Tranche XIII	Mar 2024	2.56
100	1500 MW, NTPC Pan India Solar Tranche III	May 2024	2.68
101	500 MW, GUVNL Pan India Solar Tranche XXIV	Jun-2024	2.67
102	1200 MW, SJVN Pan India Solar Tranche II	Aug-2024	2.52
103	500 MW SECI Pan India Solar Tranche XVI	Aug-2024	2.48
104	1200 MW NHPC Pan India Solar	Sep 2024	2.56

*Note: *WSH capacity, **RTC- solar-wind-conventional-storage hybrid, #Floating solar*
Source: CRISIL MI&A Consulting

5.5 Review of project economics and levelised tariffs for solar PV power plants in India

A tariff of Rs 2.5-2.6 p.u. would be required to generate a 12-14% IRR, tariff pared by falling costs

CRISIL MI&A Consulting's base-case analysis is for an independent power producer (IPP) undertaking EPC in-house and using domestic modules as per ALMM implementation in fiscal 2025. Additionally, due to variations in land prices, the model has been based on a solar park scenario, with charges modelled for the Fiscal 2024 tariffs. CRISIL MI&A Consulting has not assumed any other source of income like income from carbon credit.

For analysis of project economics, following key assumptions were made based on interactions with project developers and bankers:

- **Capital cost:** CRISIL MI&A Consulting has assumed an equipment cost of Rs. 38-42 million per MW (including DC side overloading at 40%) for a project based on domestic make modules. Further, CRISIL MI&A Consulting has factored in some inverter overhaul charges in the 13th year of the project. These assumptions are based on domestic module costs of USD 0.21-0.23. The final capital cost factors a BCD of 25% on cell along with a GST of 12.5%.
- **Capacity utilisation factor (CUF):** CRISIL MI&A Consulting has assumed a CUF of 26.5% based on an all-India average CUF and the favourable impact of DC side overloading, which has been assumed at 40%. DC side overloading implies that PV arrays (DC side) of the higher-than-rated capacity of inverters could be connected to generate more output (number of units) from inverters, essentially adjusting for losses in the system design. However, given that there is no restriction on the power that can be fed to the grid and also no cap on the prices of such additional power, players are optimising system design to generate more CUF at an incremental cost. However, CUF could vary significantly from location to location, depending on the level of irradiance.
- **Debt to equity:** CRISIL MI&A Consulting has assumed a debt-equity ratio of 75:25, based on the typical capital structure of projects under operations.
- **Foreign borrowing costs:** CRISIL MI&A Consulting has assumed the cost of debt at 9%, with developers availing of various routes to lower the cost of debt, including the option of refinancing debt once assets become operational and the entry of several global participants, who would be privy to lower cost of funding.

Based on the above assumptions (factoring in DC overloading), CRISIL MI&A Consulting believes that a levelised tariff of Rs 2.5-2.6 per unit is necessary for an equity IRRs of 12-14% at current module prices. This is applicable for IPPs, which generally do not avail of AD (the accelerated depreciation benefit allows depreciation of 40% of the capital cost in the first year of commissioning).

Table 26: Sensitivity analysis of capital costs and bid tariffs

Equity IRR	Tariffs (Rs per unit)						
Capital cost (Rs million/MW)		2.3	2.4	2.5	2.6	2.7	2.8
	35	10%	12%	14%	16%	17%	19%
	37	10%	11%	13%	15%	17%	19%
	39	9%	11%	13%	14%	16%	18%
	41	9%	11%	12%	14%	15%	17%
	43	9%	10%	12%	13%	15%	17%
	45	8%	10%	11%	13%	14%	16%
	47	8%	10%	11%	12%	14%	15%

Source: CRISIL MI&A Consulting

Further, PLFs are another important aspect of tariffs; a 1% change in PLFs can increase equity IRRs by 125-175 bps. Consequently, projects located in high irradiance states, where projects have reported PLFs of 24-27% (without overloading based on irradiance), would enjoy higher IRRs.

Table 27: Sensitivity analysis of equity IRR to CUFs and Bid Tariffs

Equity IRR	Tariffs (Rs per unit)						
CUFs		2.3	2.4	2.5	2.6	2.7	2.8
	24%	5%	7%	8%	10%	11%	13%
	24.5%	6%	8%	9%	11%	12%	14%
	25%	7%	8%	10%	12%	13%	15%
	25.5%	8%	9%	11%	12%	14%	16%
	26%	8%	10%	12%	13%	15%	17%
	26.5%	9%	11%	12%	14%	16%	18%
	27%	10%	11%	13%	15%	17%	18%
	27.5%	10%	12%	14%	16%	18%	19%

Source: CRISIL MI&A Consulting

Finally, cost of debt also plays an important role in determining returns to the industry.

Table 28: Sensitivity analysis of equity IRR to interest rates and bid tariffs

Equity IRR	Tariffs (Rs per unit)						
PLFs		2.3	2.4	2.5	2.6	2.7	2.8
	7.50%	10%	12%	14%	15%	17%	19%
	8.00%	10%	11%	13%	15%	17%	18%
	8.50%	9%	11%	13%	14%	16%	18%
	9.00%	9%	11%	12%	14%	16%	18%
	9.50%	9%	10%	12%	14%	15%	17%
	10.00%	8%	10%	12%	13%	15%	17%
	10.50%	8%	10%	11%	13%	14%	16%
	11.00%	8%	9%	11%	12%	14%	16%

Source: CRISIL MI&A Consulting

Hence, CRISIL MI&A Consulting believes that the tariffs required to generate a 12-14% IRR would fall in the range of Rs 2.5-2.6 per unit, for a project based on domestic modules.

New business models, however, warrant higher tariffs to maintain returns

With a large quantum of the pipeline already in place for solar/ wind only projects, nodal authorities are now resorting to issue tenders, which improve the quality of power supplied to off-takers. Some key changes were made to tender structures with respect to the generation profile available from RE plant and the ability to match demand requirements of the off-taker.

Three new tender structures have been issued so far to solve the above aspects – assured peak power supply (PPS), RTC, and the relatively newer firm and dispatchable RE (FDRE). A key feature across these tenders is the increase in the quantum of generation, which was required to be supplied and the PPS tender for stipulating the power to be provided during peak hours. The PPS tender also mandated the use of storage, as that would be essential to supply

power during peak hours. The government agencies have released FDRE tenders of over 14 GW in fiscal 2024 and Q1 of fiscal 2025 cumulatively.

Under FDRE, the project developer is required to supply RE power in a Firm and Dispatchable manner, matching the demand profile(s) provided by the Buying Entity. To provide firm power, developers are required to install mandatory energy storage system (either battery energy storage system or pumped hydro storage system) which are charged through renewable energy and discharged as per power requirement of buying entities. Further, To meet the energy obligations under the power purchase agreements developers generally install higher renewable energy capacity than the contracted capacity.

Modelling the above three tender structures with assumptions, coupled with industry interactions, we believe that the higher generation quantum mandated by these newer tenders could either be met using storage components or scaling up the plant capacity, i.e., setting up the plant of capacity larger than its rated capacity.

This has resulted in the expected tariff ranges required to maintain the equity IRRs of 12-14%, which are currently seen in regular tenders, to be higher than the norm of Rs 2.5-2.6 per unit, approaching the range of Rs 3-5 per unit. This increase will mainly be driven by higher capital and operating costs resulting from either the inclusion of a storage element or the need for higher capacity. Some moderation was observed only in the RTC tender, where the stipulated escalation in tariff will lead to higher tariffs.

Table 29: Higher tariff range at Rs.3-5 /kWh to maintain returns similar to regular trend

	Plain hybrid	FDRE	Round the clock	Peak power supply
Weighted average tariff	Rs 3.05/unit	Rs 4.58/unit	Rs 4.21/unit	Rs 4.76/unit
Capacity allocated till 1QFY25	15 GW	4.2 GW	1.7 GW	1.2 GW
Key player participation	Many developers	Acme, Juniper, Tata, ReNew, O2, Hero and 9 players	NTPC, Ayana, Shell, Torrent, O2, ReNew, Acme and Tata	Hero, ReNew, Acme and Amp

FY25*: as of June -2024

Source: CRISIL MI&A Consulting

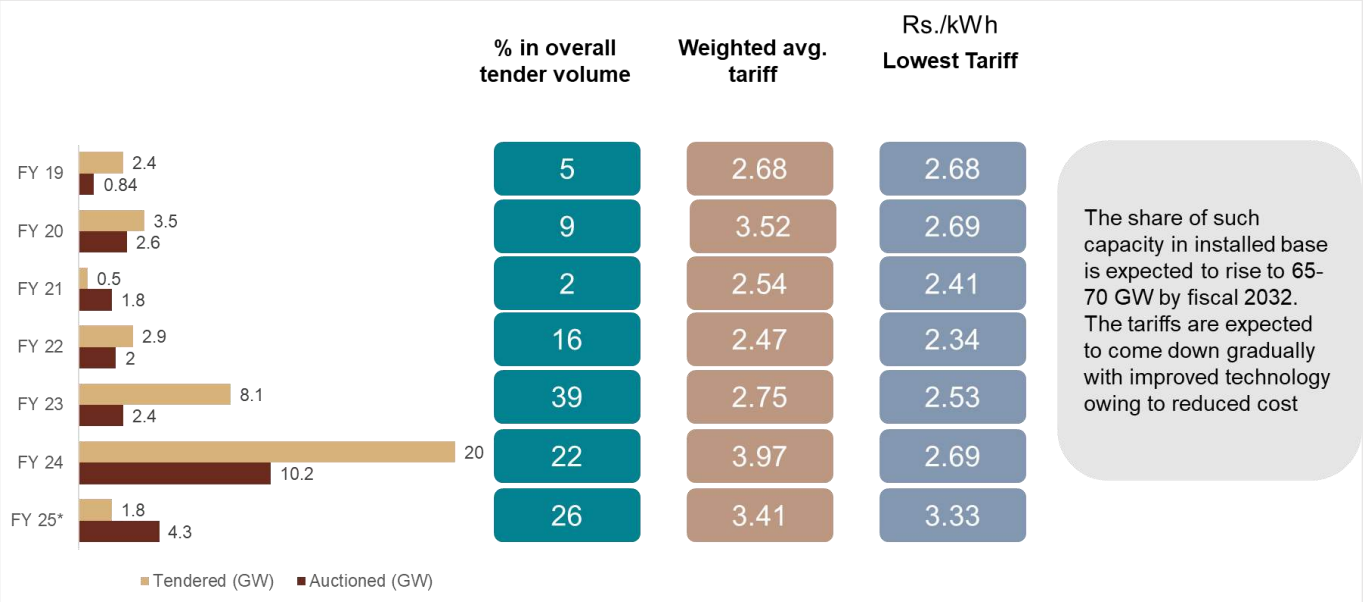
So far, all these tender models have seen successful allocations, with FDRE at 4168 MW and the RTC at 1710 MW driven by central entities. In the third type of tender, bundled, thermal energy can be sourced either from existing plants or from a new setup, each with its own set of challenges. While in existing plants, power may already be tied up, funding would be a key hurdle if power is sourced from a stranded asset or a new setup.

The lowest tariff discovered in the FDRE tender is Rs. 4.38/kWh which is lower than that of many thermal plants and in fact below the APPC of many of the state utilities. The bid tariffs in the FDRE tenders are impacted by the tender conditions such as high availability requirement, supplying power during specific hours of the day, demand fulfilment ratio, etc. Hence, tenders with different conditions and complexities result in different tariffs. However, most of the good resource locations are already taken up for project development and limited availability of good resource locations may put upward pressure on tariffs.

The rising power demand force discoms to purchase electricity from power exchanges and through bilateral trading. The average prices at power exchanges for day ahead market hover around Rs 5 – 6 per kWh (average price during fiscal 2024 was Rs. 5.35 per kWh) and for bilateral trading the prices have gone beyond Rs 8 per kWh in fiscal 2024. During fiscal 2023, states such as Gujarat, Rajasthan Punjab, Telangana, Andhra Pradesh, Maharashtra, Tamil Nadu were the major buyers from day ahead market of power exchanges which procured power at a weighted average price of about Rs 6.34/kWh. The price of exchanges is more than the price discovered under recent RTC and firm power tenders. These new age tenders not only provide competitive tariffs but are also an alternative sustainable

source of power as compared to conventional power sources. Moreover, with the fall in BESS prices, the tariffs discovered under FDRE tenders would become more competitive in the medium term.

Figure 61: New business models for tendering & allocation



Source: CRISIL MI&A Consulting

The share of the new model tenders in the overall tender volume has grown approximately 5 times between fiscal 2019 and Q12025, indicating a push from central and state agencies to address the intermittency problem. The first quarter of fiscal 2025 has witnessed a robust start for new model tenders, with the Hybrid model dominating the tender share. While only ~1800 MW of tenders were released, FDRE dominated the share at 67%. The share of new business models in the total tendered volume has already exceeded last year's share in fiscal 2025 and as the need of the hour requires consistent round the clock power supply, the share is expected to sustain in fiscal 2025.

Capital cost to moderate as basic custom-duty imposition is offset by falling module prices

In fiscal 2025, CRISIL MI&A Consulting expects overall capital costs to fall due to reduction in upstream photovoltaic pricing despite an increase in BOS costs.

The MNRE and Ministry of Finance have approved a BCD of 40% on PV modules. The duty had a direct impact on capital costs, raising them by 10-15%, despite module prices falling from $0.30 per Wp in March 2018 to $0.25 per Wp by September 2018. This declining duty trajectory provided relief and made procurement possible after June 2019 for all new bids at a duty rate of 15%. DGTR further extended safeguard duty at 14.9% from July 30, 2020, to January 29, 2021, and 14.5% from January 30, 2021, for another six months. Declining duty led to easing of cost pressures, and tariffs also started to reduce. However, with the imposition of BCD from April 1, 2022, capital costs increased to Rs 55-60 million/MW for imported mono-crystalline modules, and corresponding tariffs would rise accordingly depending on the module procurement .

A key factor determining capital costs is component pricing, which is mainly imported from China. The cost of purchasing solar modules accounts for about 55-60% of the total capex for a solar project. However, with the decline in polysilicon prices and overall commodity prices, such as copper and aluminum (used in mounting structures and other components), have led to current capital costs declining to Rs 40-45 million/MW, including a BCD of 25% on imported cells as used in domestic modules. This is as a result of the demand and supply mismatch in the global component scenario. With an oversupply of components due to manufacturing capacity expansion and decline in

demand due to high interest rate scenario in EU countries hampering additions, module prices have moderated from their elevated levels of 2022 and 2023.

Post the reapplication of ALMM, the domestic module prices are expected to inch up on quarterly basis as demand for domestic module grows. However, the fall in cell prices will mean that the domestic prices will still be 10-15% down on year in fiscal 2025 to Rs 0.21-0.23/wp. On, the other hand, the international module prices are expected to register a higher fall of 20-25% owing to oversupply. Further, while the balance of system cost is expected to increase owing to an increase of 4-6% in copper prices, the fall in upstream component prices is expected to offset the impact the impact on capital cost.

Falling prices raise question on returns

The current oversupply scenario has caused downward spiral of solar component prices. Fiscal 2024 witnessed over 25% fall in component prices with polysilicon and wafers registering over 40% drop on year. Prices continue to register a fall as global traded module and cell prices have fallen 15% and 24% in Q1FY25 over Q4FY24. The upstream component prices are expected to register a fall in fiscal 2025 as supply from China overceeds the anticipated demand. While China is expected to add 200 GW of solar energy additions, the roadblocks to exports with ban from the US economy on imports and inventory built up in EU has forced manufacturers to sell components, especially cells, at cheap prices. After the reimposition of ALMM in India, the door to imported module for solar projects (barring BTM and those qualifying under ALMM specification on 31st March 2024) are shut. However, with limited 16 GW of nameplate cell manufacturing capacity as of March 2024, the economy is expected to rely on imports of cell to cater the domestic demand of 25-30 GW in fiscal 2025. The falling prices has worried the international markets as well. A price war on solar components has resulted in loss for big firms in China while small firms are expected to face bankruptcy woes. Nearly 20 GW of polysilicon, 42 GW of wafers and 20 GW of cell capacities announced in 2023 has been indefinitely postponed to avoid further crash in prices. The Chinese government is reportedly expected to intervene to support the segment. Meanwhile, back at home, concerns loom over the viability of new manufacturing additions for those who are expected to add cell to module capacities and those who have won capacities under PLI II as international cell prices remain cheap.ee

Increase in GST rate to 12% also adds to cost woes

The GST imposition has also increased the taxation rates across all components required to develop a solar power plant, as indicated in the chart below. For instance, pre-GST, solar modules were exempt from any additional custom duties and from value-added tax (VAT) in several key states; however, GST imposition now implies an additional IGST component (apart from existing BCD) on imports and 12 % CGST + SGST for modules procured domestically (replacing VAT/CST).

The government has recently revised the taxes from for solar power generating systems (entire system, all equipment) under the 12% GST slab while electrical equipment, such as transformers, inverters and cables, have been classified under the 18% category applicable from October 1, 2021. Additionally, all services involved in the development of the project are also classified under the rate of 18%.

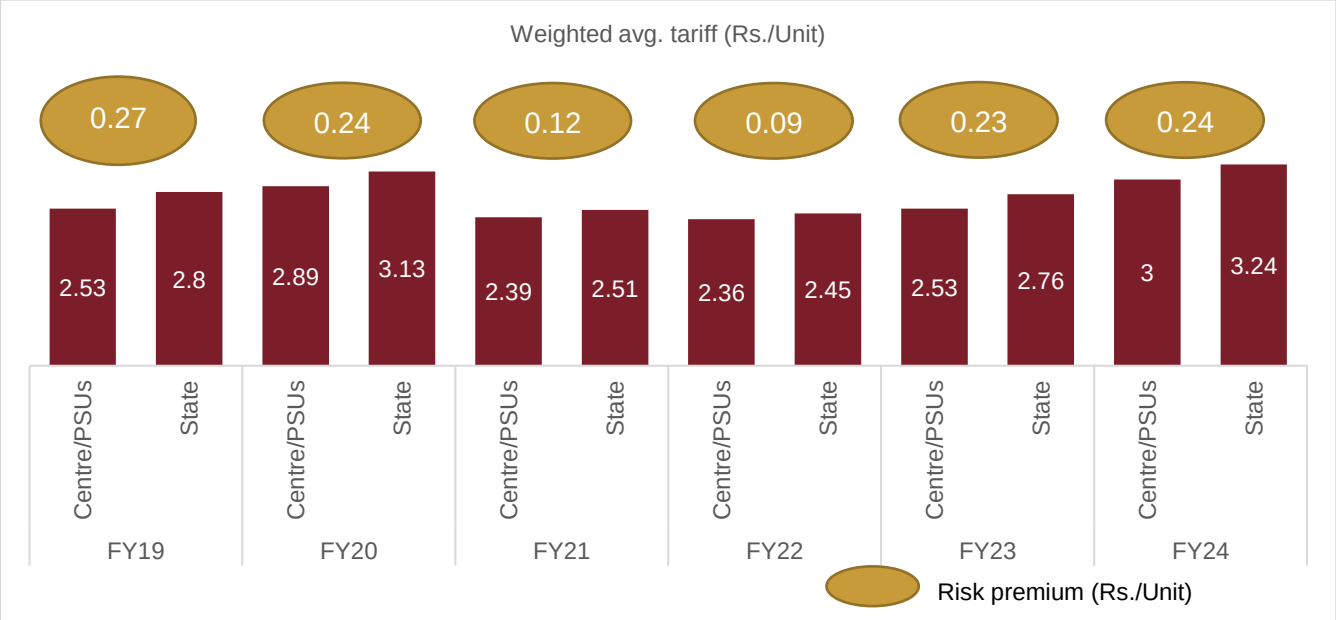
This has caused much consternation in the sector as most projects are set up in EPC mode only, as in procurement and services together. Even a simple supply order usually involves a service component which would again attract the GST rates applicable to EPC contracts. The final tax rate would be in the 13-14% range instead of the earlier expected 5%.

Counterparty risk felt, as sector faces delayed payments

The financial health and payment track record of state counterparties have become a cause for concern over the past 1–1.5 years, as power generators face prolonged delays in payments. The average payment cycle over the past 15 months for state counterparties has been 4-5 months, while certain states, such as Andhra Pradesh and Tamil Nadu, have been paying beyond six months. This leads to increased cost for developers in terms of working capital

needs. In comparison, central counterparties and Gujarat are known to pay within the two months' time frame stipulated in agreements. The following chart shows the counterparty risk premium that the industry has attached to state bids over the past four fiscals.

Figure 62: Industry attached ~Rs 0.24 per unit as counterparty risk premium in FY24



Source: CRISIL MI&A Consulting

The counterparty risk premium was higher in fiscals 2019 and 2020, as the renegotiation incident initiated by the AP state government led to investor appetite dipping, which forced state agencies to be more lenient in their approach in terms of tariff ceiling. The risk premium was lowered to Rs.0.12 per unit in fiscal 2021 and Rs. 0.09 per unit in fiscal 2022, mainly due to a better mix in terms of state counterparties. However, this went up to Rs. 0.23 per unit in fiscal 2023 and Rs. 0.24 per unit in fiscal 2024 due to allocation seen in low-activity states like Assam where bids were allocated at high tariff rate.

The LC payment mechanism order implemented by the government from August 1, 2019, is a positive step towards resolving the payment issue; however, on-ground implementation remains plagued by challenges. Structural reforms are required to be made to discoms' financial position and the government has expressed intent to work towards resolution of key pain points of the sector.

Developers have also been factoring in delays in payments from utilities when bidding; hence, the premium charged, plus projects of large / established developers, also have the comfort of group support.

Lastly, going forward, CRISIL MI&A Consulting believes majority tendering and allocation is going to happen under the umbrella of central agencies like SECI and NTPC, which have better bargaining power compared with individual IPPs. However, as more and more projects come online under these agencies, wherewithal of these firms also remains to be tested.

Tariffs rises as developers account for volatality in component prices; new tender type to take over

The project allocations in fiscal 2022 witnessed average bid prices at Rs 2.4/unit. However, allocation under the National Solar Mission for open category projects has witnessed bid prices falling as low as Rs. 2.00/unit. Tariffs remained at an average of Rs. 2.4/unit for solar only projects awarded in fiscal 2022, which was a decline from the weighted average of Rs 2.45 per unit in fiscal 2021, mainly due to global participation and a lower interest rate regime. Tariffs surged to Rs 2.79 in fiscal 2023 on account of lack of module availability amid supply chain pressure. However,

tariffs for plain solar fell in fiscal 2024 to Rs 2.63 owing to sharp fall in raw material prices. The tariffs, however, has seen an increase in Q1FY25 to Rs 2.69 as developers account for volatility in the component prices. With imposition of ALMM, domestic module prices are expected to witness a rise on quarterly basis in the near term. CRISIL MI&A Consulting believes that the current tariffs are enough to attain an equity IRR of ~15%, assuming current capital cost (Rs 38-42 mn/MW), 9% finance cost and 26.5% PLF. Further, CRISIL MI&A Consulting expects the share of new business models to pick up in order to resolve intermittency issues.

However, few of the key monitorables that can lead to rise in tariffs are highlighted below:

- Given the relatively large scale of projects, players are banking on bargaining on module prices as well as balance of plant (BoP).
- Some of these bids are placed for projects to be set-up in solar parks, which reduces the construction life cycle of projects by 6-8 months (time taken for land acquisition and evacuation infrastructure) and provides pre-developed infrastructure.
- The PPAs for these projects will be signed between the developer and SECI/NTPC/NVVN, which mitigates the risk associated with off-taker credibility considerably, making it more bankable. SECI/NTPC/NVVN have much better credibility and payment track records as compared to discoms and in addition to this are a part of the tripartite payment security agreement (between certain PSUs, government and RBI) that ensures payment from state budget allocations in case these entities default on payments. Also, some central-scheme PPAs also ensure the setting up of a payment security fund covering 2-3 months of payments to generators.
- Players' portfolios also impact the extent to which they can bid aggressively. For e.g., a higher weighted average tariff for a player's overall portfolio would enable it to bid aggressively in a few auctions just to enlarge one's portfolio or if that specific auction is lucrative

However, following factors are also key to determining tariffs:

- *Counterparty of bid:* As mentioned before, counterparty for the bid is vital, as a weak payment track record increases the risk to the developer.
- *Increase in project size*: With the availability of land under solar parks and availability of grid infrastructure, the average size for allotment of projects has increased from ~15 MW under NSM Phase II Batch I, to 600 MW in solar ISTS tranches. With increase in project size, the capability of developers to bargain with suppliers and EPC players increases, leading to decrease in per MW cost of projects.
- *Availability of foreign funds*: Solar market is established in India, with solar capacities providing satisfactory PLFs, which has given comfort to funding agencies for sanctioning loans to new capacities. Further, many large conglomerates with strong promoter backing have entered this segment, which has led to a fall in the cost of capital for new capacities. Despite that, sustained investor confidence and continued availability of low-cost funding remain keys to keeping bid tariffs low.
- *Type of tender*: Increasingly, tenders with unique structures are being issued by nodal agencies such as SECI. Since these are first time constructions, bid tariffs for such tenders may be higher than the Rs 3-5 per unit range.

5.6 State-wise status of solar RPOs in India

To fulfil their RPO targets, as per respective trajectories, there has been increased tendering by states. Solar capacity allocated by states over previous few fiscals are as follows:

- Gujarat allocated 11197 MW

- Maharashtra allocated 5855 MW
- Rajasthan allocated 2410 MW
- Madhya Pradesh allocated 2290 MW
- Karnataka allocated 615 MW
- Punjab allocated 1450 MW

Additionally, as of March 2024, the following states have tendered the below mentioned capacity for allocation:

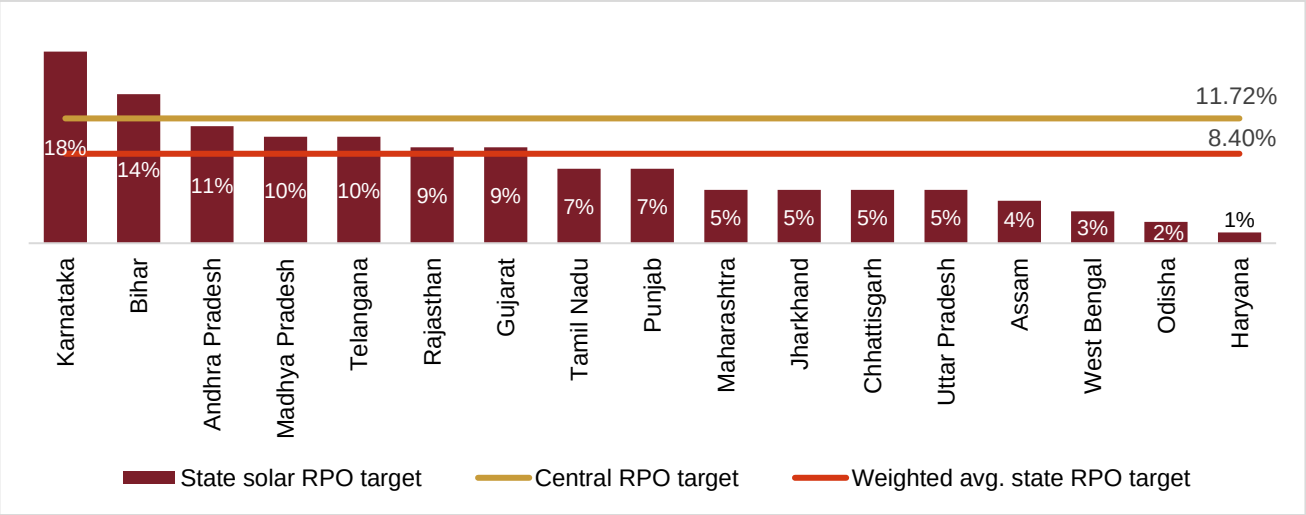
Table 30: State-wise capacity tendered

State	Tendered capacity (MW)
Maharashtra	9,675
Gujarat	2,185
Uttar Pradesh	2,600
Rajasthan	9,000
Madhya Pradesh	285

Source: CRISIL MI&A Consulting

Compliance estimated at 91% as focus on solar helps meet state RPO targets

Figure 63: Weighted average state solar RPO target lower by 300-350 bps compared to even half of MoP target set for other sources for FY23



Source: MNRE; distribution utility tariff orders, CRISIL MI&A Consulting

To promote the installation of solar power systems across various Indian states, the government amended the National Tariff Policy in fiscal 2016, proposing an increase in the solar RPO target to 10.5% by fiscal 2022. Consequently, several states set RPO targets based on their respective RE potential. However, the MoP issued a revised trajectory in June 2018 as follows:

Table 31: RPO trajectory

Category	FY17	FY18	FY19	FY20	FY21	FY22

Non-solar	8.75%	9.50%	10.25%	10.25%	10.25%	10.50%
Solar	2.75%	4.75%	6.75%	7.25%	8.75%	10.50%
Total	11.50%	14.25%	17.00%	17.50%	19.00%	21.00%

Source: Ministry of Power, CRISIL MI&A Consulting

The revision has allowed for inter-replacement of non-solar and solar RPO. Backlog, if any, would be carried forward.

In October 2023, the Central Government modified the trajectory for RPO. The new segment called 'distributed renewable energy (DRE)' has been introduced, allowing RE projects with a capacity of less than 10 MW to qualify for RPO for distribution companies and open-access consumers.

Table 32: RPO targets

Category	FY25	FY26	FY27	FY28	FY29	FY30
Wind	0.67%	1.45%	1.97%	2.45%	2.95%	3.48%
Hydro	0.38%	1.22%	1.34%	1.42%	1.42%	1.33%
Distributed RE	1.50%	2.10%	2.70%	3.30%	3.90%	4.50%
Other RE	27.35%	28.24%	29.94%	31.64%	33.10%	34.02%
Total	**29.91%**	**33.01%**	**35.95%**	**38.81%**	**41.36%**	**43.33%**

Source: Ministry of Power, CRISIL MI&A Consulting

The revised trajectory shall come into force from 1st April, 2024 and till then, the previous RPO trajectory specified in September 2022 shall be applicable. As per the new RPO guideline, any excess energy consumption under "Other" RE component in a particular year, may be utilised to meet the shortfall in achievement of stipulated Wind or Hydro renewable energy consumption.

The overall solar RPO compliance was estimated at 75-80% in fiscal 2022, thanks to the over-achievement of the existing RPO targets by Karnataka, Andhra Pradesh, and Telangana, which have seen rapid solar capacity additions. These three states exceeded their solar RPO targets, and collectively accounted for ~29% of the total installed base in May 2022.

Another contributor is the low RPO targets set by state commissions compared with the MoP's trajectory set in June 2018. However, states such as Odisha, Punjab, Chhattisgarh, and Uttar Pradesh are yet to realign their RPO targets with the MoP's new trajectory.

Higher compliance is also on account of lower targets set by most states and factoring in the non-solar-rich states that are much behind in terms of capacity additions. Going forward, unless states can purchase the required number of RECs or intra-state RE power, compliance is unlikely to go up in the face of steeply rising RPOs as per the trajectory. Hence, while Telangana, Karnataka, Andhra Pradesh, Rajasthan, and Gujarat may be able to comply due to the rapid addition of solar capacities, Delhi, Uttar Pradesh and Punjab may still lag. Despite continuing non-compliance by most states, there has been limited enforcement on obligated entities – discoms and open access and captive power users – to meet RPO targets. CRISIL MI&A Consulting believes this is primarily because of the weak financial health of state discoms. However, instances of penalty imposition have increased over the past year. For instance, in June 2021, the Uttar Pradesh regulator asked Uttar Pradesh Power Corporation Ltd (UPPCL) to deposit Rs 7,244.7 crore by January 2022, to meet RPO obligations for fiscal 2022 and clear past dues. Nevertheless, uniform imposition of penalties is still lacking, with imposition cases currently being few. While a few states, as mentioned above, have taken some action, success has been limited.

That said, lower solar REC prices on the exchange are expected to support an increase in compliance levels. Lower REC prices will help discoms buy more RECs from the exchange to meet their RPO targets.

CRISIL MI&A Consulting believes that strict enforcement is critical for significant improvement and fair distribution of RPO compliance across states. The MoP has proposed an amendment to the Electricity Act, 2003, stipulating a penalty on RPO non-compliance to the tune of Rs 1-5 per unit for the extent of shortfall as determined by the Central Electricity Regulatory Commission. However, this has not been passed so far. MNRE also set up an RPO Compliance Cell in May 2018, but strict enforcement of RPO targets is lacking.

5.7 Review of solar rooftop segment in India

5.7.1 Grid connected rooftop capacity stands at ~12.5 GW as of May 2024

Rooftop projects are small-scale PV installations on roofs of buildings (detailed view of the operating models at the end of this section). Rooftop projects may or may not be connected to the grid.

The government had proposed to achieve 100 GW of solar energy by fiscal 2022, of which 40 GW was proposed to be added under rooftop-based solar systems. This was extended to fiscal 2026. However, it is estimated that ~ 12.5 GW of rooftop capacity was installed till May 2024, with ~593 MW added in two months of fiscal 2025 against 620 MW in two months of previous fiscal. Additions are seen across Gujarat (36%), Kerala (18%) and Maharashtra (12%). While additions in Gujarat and Maharashtra were driven through Surya Urja Yojana 2023 scheme, Kerala presents an opportunity for additions with large roof per capita. The expansion of the market can be attributed to several factors, including increased consumer awareness, advancements in technology, and proactive subsidy initiatives implemented by both central and state governments. Additionally, global solar module prices have reached a historic low, standing at just USD 0.09-0.10 per watt-peak in June 2024, which is expected to stimulate growth in solar power capacity.

CRISIL MI&A Consulting expects that 25-30% of the installed base was residential while the balance was corporate. The residential segment, which lagged in the past, is now on the cusp of expansion. In January 2024, a boost was provided to residential rooftop segment with the launch of PM surya yojana that aims to solarise 1 crore households.

PM Surya Ghar Yojna: In order to further sustainable development and people's well-being, Central Government in February 2024 launched the PM Surya Ghar: Muft Bijli Yojna. This project is expected to add Rs. 75,000 crore of investment and aims to light up 1 crore households by providing up to 300 units of free electricity every month.

Subsidy for residential households

- Rs. 30,000/- per kW up to 2 kW
- Rs. 18,000/- per kW for additional capacity up to 3 kW
- Total Subsidy for systems larger than 3 kW capped at Rs 78,000

The MNRE on February 20, 2024, has declared that only applications received after February 13, 2024, will be considered for CFA under PM Surya Ghar Muft Bijli Yojana. Further, it was also clarified that this a whole new scheme and all previous schemes have been lapsed.

Further, state initiatives such as Telangana State Renewable Energy Development Corporation Ltd.'s (TSREDCO) aim to install solar panels on 500 school buildings, promoting decentralized electricity generation and mitigating power shedding issues in the state, are contributing to the sector's growth in various regions of India.

Fiscal 2024 marked a record year with 2.9 GW of additions driven by Gujarat and Karnataka.

From a pan-India perspective, roadblocks hindering the growth of the segment include the higher cost of rooftop projects compared with utility-scale, limited availability of finance for rooftop projects, lack of uniform policies across the states, weak infrastructure of power distribution companies, divergence between state policies and the regulatory commission, and cheaper solar power available from ground-mounted projects.

Although the Ministry of New and Renewable Energy (MNRE) has entrusted the Solar Energy Corporation of India (SECI) with the implementation of large-scale, grid-connected rooftop PV projects, with subsidy support from the National Clean Energy Fund (NCEF), the release of subsidy has been delayed by more than six months in some cases.

Nevertheless, rooftop solar projects have attracted interest from players in the entire solar value chain, ranging from module manufacturers (Tata Power Solar, Waaree Energies, Vikram Solar, etc.) to system integrators (Rays Power, Jakson Engineers) and independent power producers (Welspun Solar, Azure Power, SunEdison, Mahindra Solar, etc.) owing to falling costs and favorable regulatory policies in key states (net metering, exemption on electricity duty, wheeling and cross-subsidy charges).

5.7.2 Regulatory support required to drive the sector

The central government's target of 40% of the 100 GW generation capacity target under the National Solar Mission (NSM) from this segment by 2022 fell short by ~31 GW. Thus, government support is critical to boosting growth to achieve the target till fiscal 2026.

For instance, the central government's 30% capital subsidy for rooftop projects. The MNRE had increased its financial assistance sum (in form of capital subsidy) eightfold to Rs 50 billion over the years (fiscals 2016-20). This subsidy was sufficient to support ~4.2 GW of rooftop projects in the residential category of consumers and for public institutions (government hospitals, schools, etc.) across various sectors.

The newly launched Surya Yojana in 2024 has been hence planned to boost the residential offtake of solar rooftop, specifically by tackling the cost hurdle targeting to install solar rooftop in 1 crore households in the country. Subsidy levels have increased from Rs 18,000 to Rs 30,000 on a per kW basis for plant size up to 2 kW. For a plant size of 3 kW, maximum subsidy available is Rs 78,000 in total, with this remaining as a cap for project sizes larger than 3 kW. Along with this, free electricity of upto 300 units per month per household has been announced. This essentially means, the 66% jump in subsidy support has been directed mainly to the smaller sized rooftop projects, which as per market estimates would comprise the majority of solar rooftop potential in India and would also face affordability concerns the most due to small sizing. This scheme is expected to boost 20-25 GW of residential rooftop additions taking the installed base to 22-27 GW from 2.65 GW in fiscal 2024.Central-level benefits provided for rooftop projects are detailed below.

Figure 64: Policy provisions at a glance

Capital subsidy	1. Central Government provides 30% capital subsidy to residential consumers, government buildings, social and institutional sector such as hospitals, educational institutions etc. 2. **Subsidy reduces the generation cost by ~Rs 1.4/unit to Rs 3.0-3.2/unit** and payback (which without subsidy is ~**75-80 months**) by ~20 months
Tax incentives	1. **Accelerated depreciation (AD) of 40% and** an additional depreciation of 20% are allowed on solar assets in the first year of operations. This reduces the taxable income and reduces generation cost by **Rs 1.0-1.1/unit** 2. The sunset clause for solar power developers for availing 10 year tax holiday under section 80 IA is now withdrawn, effective 1st April 2017.
Generation-based incentives by various states	1. States such as **Delhi** provided generation-based incentives over and above the feed-in tariff. The incentive provided was Rs. **2/unit which** improved the internal rate of return by **100-300 bps**.
Lower cost of financing	1. The Indian Renewable Energy Development Agency (IREDA) provides loans at cheaper rate of interest **(8.45% to 9.40% p a)** to system aggregators and developers. This is critical as every 50 bps reduction in interest cost leads to 10-15 paise per unit (or up to 5%) reduction in the generation cost.
Availability of capex and RESCO modes of operation	1. Under the **capex mode of operation**, the developer of the project owns the rooftop, while under the **RESCO (opex) mode of operation** the developer leases the rooftop with the rooftop owner, with the liberty of captively consuming the entire power or trading electricity under net-metering mechanism. 2. Allocating projects under both these models allow the project developer to enjoy the benefits of offsetting expensive grid power by cheaper solar rooftop generation.
Other central level initiatives	1. Central level agencies such as SECI allocate city-wise capacities under both capex and RESCO modes. Further SECI provides 30% capital subsidy to along with other available tax incentives to project developers. 2. As per the new Reserve Bank of India norms, renewable generators can get loan of up to Rs 15 crore, while home owners can get ~Rs 10 lakh (~20 kw project could be installed) of loan for setting up rooftop projects on which the interest paid is tax deductible 3. Government has launched National Rooftop Portal to promote growth in the segment.

Source: CRISIL MI&A Consulting

In most state policies, net metering is allowed for residential and C&I consumers.

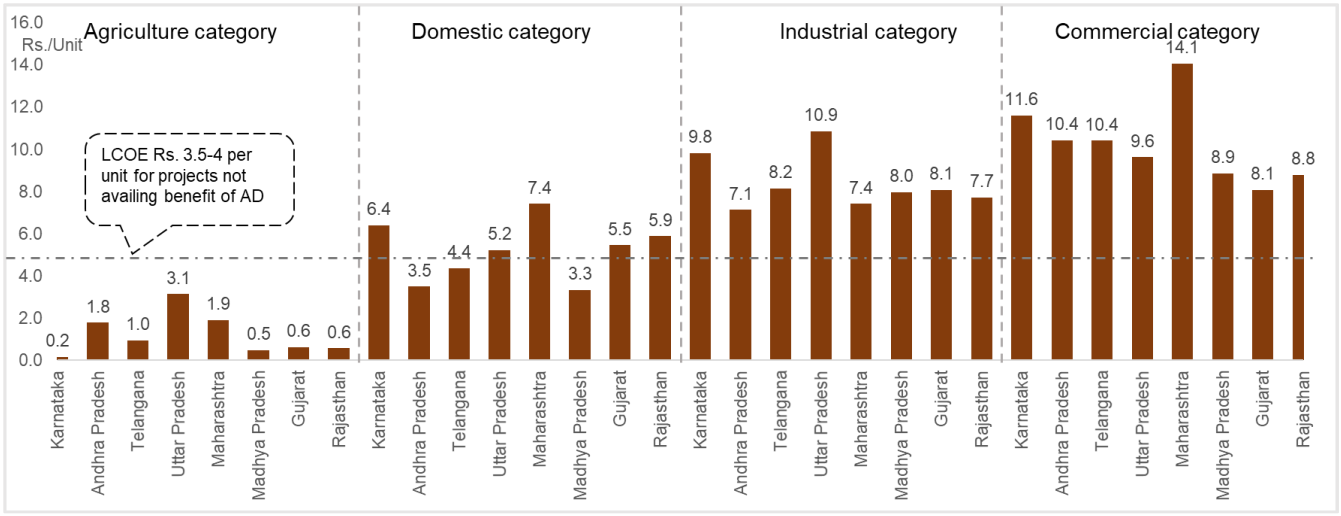
- All discoms are to utilise units generated from solar rooftop power plants to comply with their solar RPO targets if the consumer is not an obligated entity. Further, any excess unit generated by the obligated entity, i.e., over and above its obligations, would be utilised by discoms to meet their solar RPO targets
- Discoms alone will meet their RPO targets from the units injected into the grid, if FiT are paid by discoms

Given lower capital cost, rooftop projects have become attractive for C&I consumers. In particular, the net-metering scheme – under which power generated can be consumed captively and the balance/excess sold to the grid – is

attractive for consumers paying tariffs upwards of Rs 4.5 per unit to discoms. The cost of generating solar power from rooftop projects is estimated at Rs 3.5-4.0 per unit (without availing AD).

C&I consumers are best placed to claim the AD benefits and increase their project returns/reduce generation costs. This group includes all high-tension consumers and commercial consumers such as malls, hospitals, government establishments, and high-consumption group residential complexes.

Figure 65: Average tariff for different categories of customers



Note: Tariffs as of fiscal 2021; Fiscal 2022 from PFC report has not shared category wise split for states
Source: PFC, CRISIL MI&A Consulting

Conversely, residential and agricultural consumers have no economic incentive to set up rooftop projects on a net metering basis since their tariffs are low because of high cross-subsidy. For such consumers, the economics would be favourable only if they were allowed to install projects sized more than ~2.5 times their connected load (currently the restriction is 0.5-1 times their load, on average). This would enable them to meet their electricity needs and earn revenue for additional electricity sold to discoms at average power purchase cost (APPC) tariffs. Further, discoms have set limits for the maximum capacity of plants that could be installed under the net metering mechanism as 0.5 kW to 1,000 kW, which dampens interest in such projects.

5.8 Outlook of solar energy capacity additions in India

Fiscal 2025 is projected to witness 16-18 GW of solar projects, including 3.1-3.3 GW of open access projects. The large base will be on account of execution of pipeline projects which were affected in fiscal 2023 and fiscal 2022, due to supply chain issue. The imposition of duty on imported solar modules had also led to an increase in pricing of imported modules. The projects were also delayed due to land and transmission line issues. The commissioning momentum, however, saw a revival in fiscal 2024, with ~15 GW being commissioned during the year. Pent-up pipeline from previous years started coming to fruition combined with temporary abeyance of ALMM, led to high commissioning rate during the year.

As on March 2024, domestic manufacturing capacities have touched 63 GW where global module capacity is estimated at 949 GW in 2024. This is expected to help supply-side constraints to abate considerably. Already, prices of modules and upstream components have fallen owing to an oversupply scenario. Abeyance of ALMM till March 2024 had already resulted in easing pressure on developers, however, reapplication of ALMM from fiscal 2025 with relief for selected projects (i.e those in advance stage of construction and few projects on case to case basis where modules had reached the site before 31st March 2024) will also aid additions in fiscal 2025, with the open access

market expected to account for ~19% of the additions. But it should be noted that while the industry has a healthy medium-term project pipeline, with close to 2.5 GW already commissioned in first two months of fiscal 2025, a 137% rise compared to same duration previous fiscal.

Scheme-wise, additions in fiscal 2024 and fiscal 2025 YTD were driven by several large projects such as manufacturing linked scheme and others as listed below:

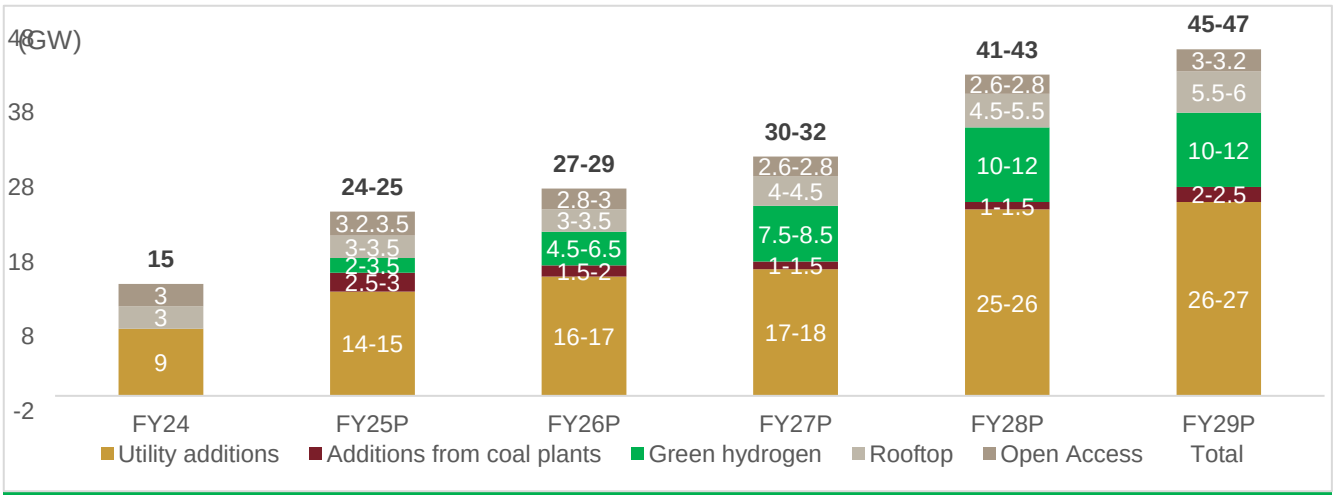
Table 33: Rajasthan and Gujarat alone garners over 8.6 GW of 15 GW capacities commissioned in FY24

Developer	Project location	Scheme	MW
Adani Green Energy	Gujarat	SECI Manufcaturing linked tender	1825
ReNew	Rajasthan	SECI 2000 MW ISTS Tranche-IX	290
UPC Renewables	Madhya Pradesh	SECI 1200 MW ISTS Connected Projects (ISTS-VI)	250
ACME Solar	Rajasthan	SECI 750 MW Rajasthan Tranche-I	200
Adani Green Energy	Rajasthan	SECI 1200 MW ISTS Connected Projects (ISTS-V)	165
NTPC	Rajasthan	SECI 1070 MW Rajasthan Tranche-III	150
NTPC	Rajasthan & Gujarat	CPSU Scheme (Tranche-II, 1500 MW)	100
ReNew	Rajasthan	SECI 2000 MW ISTS Tranche-IX	98
Juniper Green	Maharashtra	MSEDCL Solar Tranche-VII	75

Source: Industry; CRISIL

The solar additions momentum in fiscal 2023 witnessed flat movement at ~13 GW owing to cost pressures arising from supply chain disruptions. However, with increase in capacity additions and ease of supply chain pressures, fiscal 2024 added 15 GW. This will be supported by moderating raw material prices.

Figure 66: Solar capacity additions of 137-142 GW expected over fiscals 2025-2029



Source: CRISIL MI&A Consulting

Potential long term growth drivers:

- **NSM**: The entire NSM Phase II Batch II Tranche I of 3,000 MW has been commissioned. Under NSM Phase II, Batch III, and Batch IV, SECI through its state specific VGF has tendered out ~7 GW of capacities, most of which has been completed.
- **Other central schemes**: The Solar Energy Corporation of India (SECI) has also started tendering projects outside the JNNSM Batch programme. It has initiated the Inter-State Transmission System (ISTS) scheme,

wherein projects are planned for connection with the ISTS grid directly. Under this, the SECI has already allocated ~35 GW (including hybrid) while 6 GW is tendered.

- **State solar policies**: ~24 GW of projects are under construction and are expected to be commissioned over fiscals 2025-2029. Based on tendered capacities by states at the end of June 2024, a further ~24 GW capacity of solar projects is expected to be up for bidding over the same duration.
- **PSUs**: The Central Public Sector Undertaking (CPSU) programme under JNNSM has been extended to 12 GW in February 2019. The government is also encouraging cash-rich PSUs to set up renewable energy projects. Group NTPC (NTPC Limited) has commissioned 3,618 MW as on 30.06.2024 and outsourced projects are 5,273 MW. Similarly, under construction capacity is 9,214 MW for the Group and 8,810 MW on outsource basis. It has a target of installing ~60 GW of renewable energy capacities by fiscal 2032. Similarly, NHPC Limited had allocated 2 GW of projects in 2020, while the Indian Railways has committed to 20 GW of solar power by 2030. Other PSUs such as NLC India Limited, defence organizations, and governmental establishments are also expected to contribute to this addition.
- **Rooftop solar projects**: CRISIL MI&A-Consulting expects 20-22 GW of rooftop solar projects (under the capex and opex mode) to be commissioned by fiscal 2029, led by by industrial and commercial consumers under net/gross metering schemes of various states and by the residential consumers through the Surya Yojana scheme.
- **Open-access solar projects**: CRISIL MI&A-Consulting expects 13-15 GW of open-access solar projects (under the capex and opex mode) to be commissioned by fiscal 2029, led by green energy open access rules 2022, sustainability initiatives/RE 100 targets of the corporate consumers, better tariff structures and policies of states such as Uttar Pradesh and Karnataka, which are more long term in nature.
- **Push for Green hydrogen**: Production for green hydrogen is expected to start from fiscal 2026 with production of 0.5-1 million tonnes of production. The government has set the target production of 5 million tonnes of green hydrogen by 2030. As per announcement, we expect 2.5-3 MTPA of green hydrogen to commission which can lead to further upside of solar capacity of 32-37 GW, by fiscal 2029. However, since developers may tie-up via grid / open access and not go to the captive route generation under this segment will remain a monitorable.

5.8.1 Key factors driving capacity additions

a. Central and state tendering grows multi-fold with a healthy pipeline giving comfort; resolution of execution-related hurdles critical

In June 2015, the Union Cabinet approved the revision of cumulative targets under NSM, from 20 GW by 2021-22 to 100 GW over the same period. Hence, phase II of the NSM comprised a variety of schemes to attract investments in solar.

In April 2021, ~14 GW under various schemes had been tendered under NSM phases I and II, comprising:

460 MW in phase I, Batch I and II – fully commissioned

680 MW in phase II, Batch I – fully commissioned

3,000 MW under NVVN Batch II, Tranche I

This scheme was created to lower the cost of solar power by bundling it with thermal power from NTPC's power stations in the ratio of 2:1 (MW terms) and then selling it to discoms. In Tranche I of Batch II, 3,000 MW of projects (of which some capacity was allocated in the domestic content requirement or DCR category) has been fully awarded. The scheme was initially planned in three tranches and for a cumulative capacity of ~12 GW. However, with solar tariffs falling below thermal power tariffs, the scheme has been restricted till Tranche I.

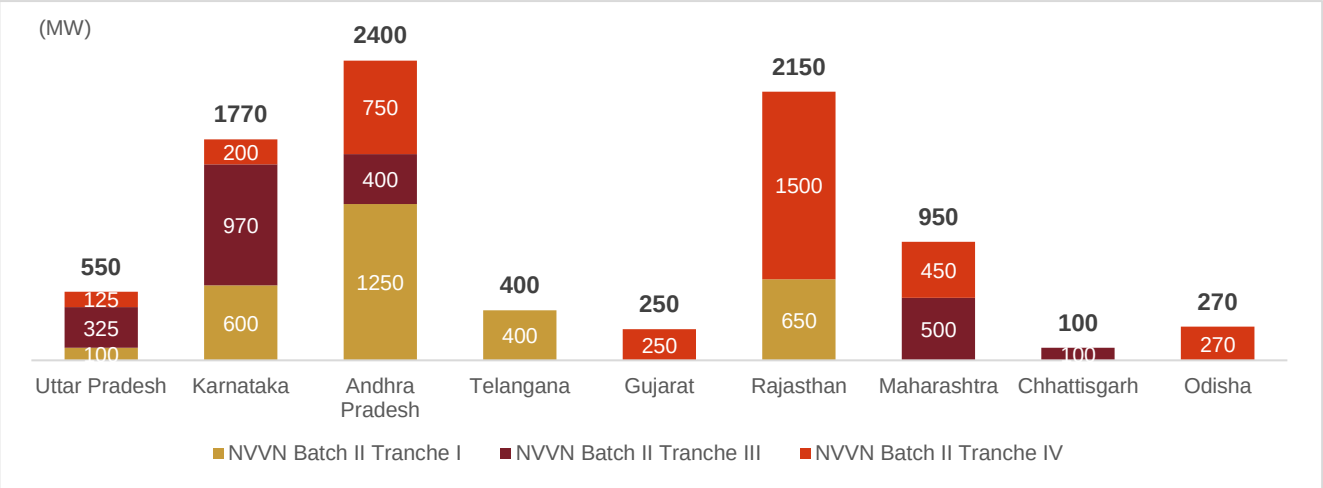
5,840 MW under Batch III and IV of NSM in various locations

Under NSM phase II, Batch III, 2,000 MW of solar PV capacity was envisaged to be installed through a state specific VGF scheme by SECI, but 2,300 MW has already been tendered in this batch, which is estimated to be fully commissioned.

Subsequently, the next batch under the same scheme, i.e., phase II, Batch IV VGF scheme, was envisaged for ~5,000 MW, with ~3,545 MW already tendered and most of the capacity commissioned in this scheme.

The state specific VGF scheme received approval from Cabinet Committee on Economic Affairs (CCEA) and budgetary sanction of ~Rs 7,000 crore (~Rs 1 crore/MW) for VGF disbursement.

Figure 67: Phase II, Batch III and IV (SECI) – state-wise break-up of allocated capacities



Source: CRISIL MI&A Consulting

b. 12,000 MW (2,027 MW allocated by SECI) under NSM's CPSU programme, 357 MW to be set up on defence establishments.

Through the CPSU programme under JNNSM, the government is encouraging cash-rich central PSUs to set up renewable energy projects. The government expanded the CPSU programme from 1 GW to 12 GW in February 2019, to provide impetus to the domestic solar module manufacturing industry, as procurement by CPSUs for self-consumption is exempt from the WTO ban on DCR. Apart from the CPSU programme, CPSUs such as NLC and NTPC have been tendering capacities to set up solar assets outside of this programme, in a bid to diversify portfolios.

With a significant chunk of phase 1 executed, under phase II (programme expanded in February 2019), SECI has issued two tenders of 2,000 MW and 1,500 MW. Both SECI's and NTPC's tenders failed to attract sufficient interest from CPSUs, due to which they undersubscribed (SECI 2 GW, subscribed for only 932 MW and 922 MW allocated, SECI 1,500 MW only ~1,104 MW allocated). However, after that, for a 5 GW tender, the entire capacity has been allocated under CPSU Tranche III and is under construction.

NTPC, for instance, has already commissioned ~2,120 MW of projects under its capacity addition at the end of September 2022. It has commissioned large-scale solar projects of 250 MW each in Andhra Pradesh, Madhya Pradesh, and Rajasthan to achieve the ~60 GW solar target by fiscal 2030.

NTPC is expected to continue robust capacity additions of solar, with the following key tenders allocated/ pending allocation by it as of June 2024:

* 450 MW allocated at SECI 1.2 GW Wind-Solar Hybrid in August 2021.

* 1990 MW allocated at IREDA's 5 GW CPSU Tranche III in September 2021.

* 500 MW allocated at SECI's 1785 MW Rajasthan Tranche IV in December 2021.

* 450 MW allocated at Wind-Solar hybrid tranche-V in May 2022.

* 75 MW allocated at MSEDCL phase VIII in Sept 2022

* 90 MW allocated at RUMSL 300 MW floating solar in Nov 2022

* 150 MW allocated at MSEDCL 250 MW storage in Dec 2022

* 550 MW allocated at RECPDCL 1250 MW ISTS solar tranche I in Apr 2023

* 500 MW allocated at REMCL 960 MW RTC in Apr 2023

* 200 MW allocated at GUVNL 500 MW Phase XVII in May 2023

* 900 MW allocated at PFC Consulting 1250 MW Solar in December 2023

* 200 MW allocated at REMCL 750 MW RTC project with/without storage in January 2024

* 50 MW allocated at SJVN 1500 MW ISTS Solar in February 2024

*250 MW allocated at SECI Solar Tranche XIII in March-2024

*225 MW allocated at GUVNL Solar Tranche XXIII in March-2024

There are several tenders that NTPC releases from time to time and are pending allocation and will form part of the pipeline over the medium to long term.

Similarly, NLC aims to achieve a 2.1 GW renewable portfolio in the medium term and a 6 GW+ renewable portfolio in the long term. It had awarded EPC tenders to BHEL and Jakson Engineers Ltd for a 130 MW (~650-acre) project in Neyveli, Tamil Nadu, which was commissioned in January 2018. It also completed the commissioning of another 500 MW in Tamil Nadu in March 2019. Further, it has won 510 MW under wind-solar hybrid Tranche IV and is yet to be commissioned. It also has 4 GW+ under the planning stage, comprising more than 2.5 GW of solar. It has announced plans to set up 500 MW projects in Odisha (300 MW), Andaman Islands (50 MW), etc. based on the availability of land and other necessary infrastructure. However, these are still in the planning phase. NLC also won 709 MW under the Tamil Nadu – TANGEDCO 1,500 MW auctions in June 2017, which is now fully commissioned.

Other CPSUs such as NHPC, ONGC and GAIL also plan to generate solar power. The Indian Railways has also committed to generating 25% of its power consumption needs through renewables by 2025, and targets 5 GW of solar capacity for the same. To this end, railways also allocated 750 MW RTC tender in January 2024.

a. Other schemes – SECI/MNRE

As of June, 2024, SECI is driving certain other schemes:

- ISTS Scheme – ~15 GW allocated across various tranches
- Wind-solar hybrid scheme – ~8 GW allocated (part of the capacity will be wind)
- Other schemes – ~6.7 GW allocated across various states

ISTS scheme

Under this, SECI has already allocated 15 GW. Projects under this scheme shall be directly connected to PGCIL 's ISTS network and can be located in any part of the country. Land and transmission connectivity costs would be borne by the developer.

Wind-solar hybrid schemes

Under this, SECI has already allocated ~8 GW and would entail setting up of projects with both solar and wind resources to better utilise resources, enhance the energy generation pattern (solar and wind can be complementary in terms of energy generation hours), and ensure better grid stability.

Other schemes – SECI has also been actively issuing tenders other than the ISTS and hybrid schemes. It has issued the following so far:

Table 34: Schemes allocated by SECI as of June 2024

Sr. No	Name of the scheme	Capacity allocated (MW)
1	SECI 2000 MW Hybrid Tranche VII	594
2	SECI Solar Tranche XI	2000
3	SECI 1200 ISTS hybrid tranche VI (energy storage & Peak power)	1581
4	SECI 1.2 GW Wind Solar hybrid-Tranche V	400
5	SECI Rajasthan - Tranche IV	1785
7	SECI Karnataka - Tranche X	1200
8	SECI RTC - II (Bundled with Thermal)	1150
	Total	8710

Source: SECI, CRISIL MI&A Consulting

c. Manufacturing capacity-linked projects

SECI had floated an expression of interest (EoI) with the proposition of linking solar project tendering to the setting up of module manufacturing capacities. The initially floated proposal was for 5 GW of manufacturing capacities linked to 10 GW of solar projects. This was subsequently reduced to 3 GW of manufacturing capacities but linked to 10 GW of projects. Under the initiative, developers would have had to comply with a 1:3 ratio between manufacturing capacities and projects and adhere to timelines; failure to do so would attract strict penalties. Additionally, developers could only import polysilicon. The remaining manufacturing chain, from silicon wafers to modules, was to be set up. However, they were not necessarily required to use modules manufactured in these capacities for the projects to be set up concurrently; modules from other sources could be used for the purpose.

However, the above tenders failed to attract bidder response, except for a bid from Azure Power for 600 MW of manufacturing capacity and 2,000 MW of solar projects. However, the bid was cancelled due to a disagreement over the final bid price (no auction was conducted, given there was only one bidder).

SECI reissued the tender in January 2019, having reduced the manufacturing component to 1.5 GW and solar project capacity to 3 GW. The tender saw several bid extensions again due to low developer interest. The tariff cap was also set low, at Rs 2.7 per unit. Despite the extensions, the tender could not be allocated, and in June 2019, SECI issued a similar tender again. This time, it was for 2 GW of manufacturing capacity and 6 GW of solar projects, but with a tariff cap of Rs 2.7 per unit. This tender was also extended several times. In October 2019, the tender was scaled up to 7 GW of power generation capacity linked to 2 GW of PV manufacturing capacity. This also included a green-shoe option that developers could avail of if they wished. The tender got allocated in January 2020, with a 1 GW oversubscription (several clauses were amended, and the tariff ceiling was raised). Adani Green Energy (6W of power generation) and Azure Power (2 GW) won the bid. The companies also availed 2 GW each under the green-shoe option. Both these companies recently signed PPAs with SECI for ~4.67 GW and 2.3 GW, respectively.

The generating capacity for manufacturing-linked tenders are scheduled to come online in phased manner with close 1.8GW already commissioned in fiscal 2024. Additionally, in September 2021, SECI revised the tariff to Rs 2.54/unit from Rs 2.92/unit. This led to a pick-up in PSA signing activity for manufacturing-linked tender with 1 GW of PSA signed by TANGEDCO, 0.5 GW by GRIDCO, and the remaining capacity signed by AP discom. In August 2023, Adani Green Energy commissioned a 2 GW solar cell and module factory under the manufacturing linked tender by

SECI in Mundra, Gujarat. Further in March 2024, it added an additional 1 GW capacity in Khadva, Gujarat under the same tender.

d. Capacity additions of ~23 GW under construction from different state policies, ~15 GW in tendering stage

To fulfil their RPO targets, as per respective trajectories, states have increased tendering activity. Solar capacity allocated by states over previous few fiscals are as follows:

- Gujarat allocated 11,197 MW
- Maharashtra allocated 5,855 MW
- Rajasthan allocated 2,410 MW
- Madhya Pradesh allocated 2,290 MW
- Karnataka allocated 615 MW
- Punjab allocated 1,450 MW

e. Considerable under-construction capacity expected to be commissioned

Solar tariffs have been trending downward in the recent past, led by lower capital costs amid falling module prices, the availability of cheaper debt, and a short window of duty pass-throughs, among other factors. This resulted in a record low tariff of Rs 2.36 per unit in the SECI ISTS-IX auctions in June 2020 and an even lower ~Rs 2.0 per unit tariff bid in the SECI Rajasthan-III auctions in November 2020. However, developers have kept bids in the range of Rs 2.3-2.5 per unit in most auctions, be it central or state, as the supply-side pricing surge has led to a rise in tariffs.

Solar tariffs were on an upward trend in fiscal 2023, led by various factors such as higher capital cost amid increasing module prices and higher interest rates on debt. This led the solar tariff to increase to Rs 2.79 per unit in fiscal 2023. However, module prices started falling in fiscal 2024 leading to decline in tariff to the tune of ~7% and reaching Rs 2.61 per unit.

Having said that, state bids unlike central ones have higher variability in terms of payment security, provisions of infrastructures, penalty clauses, and commissioning schedules. Additionally, state income credibility and back-down incidents in the state also influence state bids. As a result, bid tariffs are influenced by these factors and vary between auctions.

f. 20-22 GW of rooftop solar capacity addition expected over fiscals 2024 to 2029

Rooftop projects are small-scale solar PV installations on roofs of buildings. In the government's 100 GW target, 40 GW is attributed to rooftop solar projects. Total solar rooftop installed capacity as of May 2024 is estimated at ~12.5 GW, which is quite far from the required target.

Although the MNRE has entrusted SECI with the implementation of large-scale, grid-connected rooftop PV projects with subsidy support from the NCEF, inherent technical and operational issues associated with discoms, coupled with delayed clearances, have slowed growth in capacity additions. This issue is proposed to be resolved via the Solar Rooftop Implementation for Solar Transfiguration of India (SRISTI) scheme. It has been proposed by the MNRE with an approval of Rs 11,000 crore and is aimed at making state distribution utilities the nodal agency for the central rooftop subsidy programme, while providing incentives to promote rooftop installations in their areas of jurisdiction.

The newly launched Surya Yojana in 2024 has been planned to boost the residential offtake of solar rooftop, specifically by tackling the cost hurdle targeting to install solar rooftop in 1 crore households in the country. Subsidy levels have increased from Rs 18,000 to Rs 30,000 on a per kw basis for plant size up to 2 kW. For a plant size of 3 kW, maximum subsidy available is Rs 78,000 in total, with this remaining as a cap for project sizes larger than 3 kW. Along with this, free electricity of upto 300 units per month per household has been announced.

Considering the new policy and focus by the Government to drive growth in the residential segment, while factoring in the spurt in installations by commercial, industrial, and government organizations, CRISIL MI&A Consulting projects 20-22 GW of rooftop solar capacity additions over fiscal 2025-2029. The execution of Surya Yojana scheme is expected to add additional upside of 9-11 GW of module demand, the execution of which remains a key monitorable. CRISIL MI&A Consulting expects Karnataka, Andhra Pradesh, Telangana, Rajasthan, Tamil Nadu, Maharashtra, and Gujarat to account for over 50% of total additions, led by favourable economics and incentives.

g. 500 GW non-fossil target by 2030 under COP26 to drive solar capacity additions

India set an ambitious goal at the COP26 summit. Addressing the UN's Climate Change Conference in Glasgow in November 2021, Indian Prime Minister announced that India would achieve a net-zero emissions target by 2070, revised the non-fossil-based target from 450 GW to 500 GW by 2030, and pledged to reduce the carbon intensity of the country's economy by 45% within the decade. Further, the MOEFCC has stated that 50% of the installed power generation capacity will likely be from renewable energy, indicating increased thrust towards renewable capacity additions. This is expected to ensure continued positive regulatory support, which is a critical enabler of capacity additions in the segment.

h. PLI scheme for domestic module manufacturing

On November 11, 2020, the government introduced the PLI scheme for 10 key sectors to enhance India's manufacturing capabilities and exports under its *Aatmanirbhar Bharat* initiative.

One of the 10 sectors for which PLI was approved is high-efficiency solar PV modules, for which, the MNRE has been designated as the implementing ministry. The financial outlay for the PLI scheme is Rs 4,500 crore over a five-year period. This was later increased to Rs 24000 crore.

The scheme is aimed at promoting the manufacture of high-efficiency solar PV modules in India and thus, reducing import dependence in the area of renewable energy. The MNRE will implement the scheme through IREDA as the implementing agency. For Tranche II, SECI was given the responsibility of conducting bidding process.

Beneficiaries of the scheme were to be selected via a bidding process. To qualify, a manufacturer was required to set up a plant of minimum 1,000 MW capacity. Manufacturers were also required to fulfil the following minimum performance parameters:

- Minimum module efficiency of 19.50% with the temperature coefficient of Pmax better than -0.30% per degree Celsius, or
- Minimum module efficiency of 20% with the temperature coefficient of Pmax equal to or better than -0.40% per degree Celsius

In September 2021, IREDA, the implementing agency, released the list of PLI scheme participants, and the scheme received a response of 54.8 GW worth of bids for a 10 GW scheme. Bids of ~19 GW were submitted for the manufacture of polysilicon, 32 GW for wafers, and 54.8 GW for cells and modules.

Reliance New Energy Solar's PLI award amount was Rs 1,917 crore for a capacity of 4 GW. Shirdi Sai Electricals was Rs 1,875 crore for 4 GW and Adani Infrastructure's was Rs 663 crore, out of the total quoted amount of Rs 3,600 crore for a capacity of 737 MW under the bucket-filling method.

In March 2023, the government, through SECI, allocated 39.6 GW of domestic solar PV module manufacturing capacity under the PLI scheme (Tranche-II) to 11 companies, with a total outlay of ~Rs 14,000 crore. Total manufacturing capacity of 7,400 MW is expected to become operational by October 2024, 16,800 MW by April 2025, and the remaining 15,400 MW by April 2026.

Table 35: Capacity awarded (in MW) under the PLI scheme (Tranche-I and II)

Player	Polysilicon	Wafer	Cells	Modules
Shirdi Sai Electricals Ltd.	4,000	4,000	4,000	4,000
Reliance New Energy Solar Ltd.	4,000	4,000	4,000	4,000
Adani Infrastructure Pvt. Ltd.	737	737	737	737
Total PLI Tranche I	**8,737**	**8,737**	**8,737**	**8,737**
Indosol	6,000	6,000	6,000	6,000
Reliance	6,000	6,000	6,000	6,000
First Solar	3,400	3,400	3,400	3,400
Waaree		6,000	6,000	6,000
Avaada		3,000	3,000	3,000
ReNew		4,800	4,800	4,800
JSW		1,000	1,000	1,000
Grew		2,000	2,000	2,000
Vikram			2,400	2,400
AMPIN			1,000	1,000
Tata Power Solar			4,000	4,000
Total PLI Tranche II	**15,400**	**32,200**	**39,600**	**39,600**
Total PLI Tranche I+II	**24,137**	**40,937**	**48,337**	**48,337**

Source: MNRE, SECI, IREDA, CRISIL MI&A Consulting

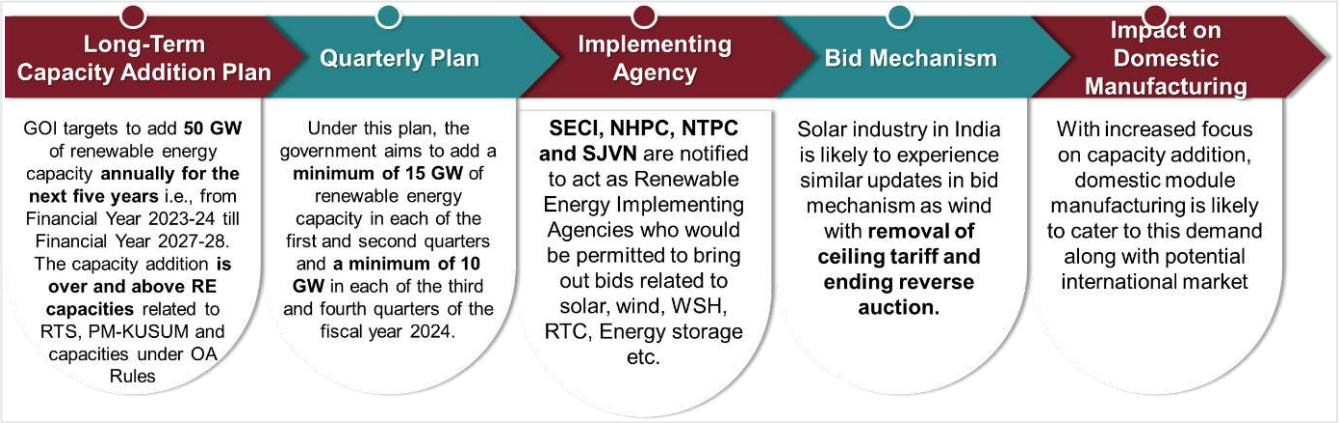
i. Bidding of 50 GW annual capacity

The Government has decided to invite bids for 50 GW of renewable energy capacity annually for the next five years i.e., from fiscal 2024 till fiscal 2028. These annual bids of ISTS (Inter-State Transmission) connected renewable energy capacity will also include setting up of wind power capacity of at least 10 GW per annum.

Bidding trajectory will enable the power procurers, including the distribution companies, to manage their RE procurement plans effectively. The bid trajectory will also provide a fillip to the RE manufacturing industry in the country by indicating the demand that would be created for their equipment.

In addition to this, the Ministry has declared a quarterly plan of the bids for fiscal 2024, which comprises of bids for at least 15 GW of renewable energy capacity in each of the first and second quarters of the financial year (April-June 2023 and July-September 2023 respectively), and at least 10 GW in each of the third and fourth quarters of the financial year (Oct-December 2023 and January-March 2024 respectively).

Figure 68: Long term RE capacity additions through bidding

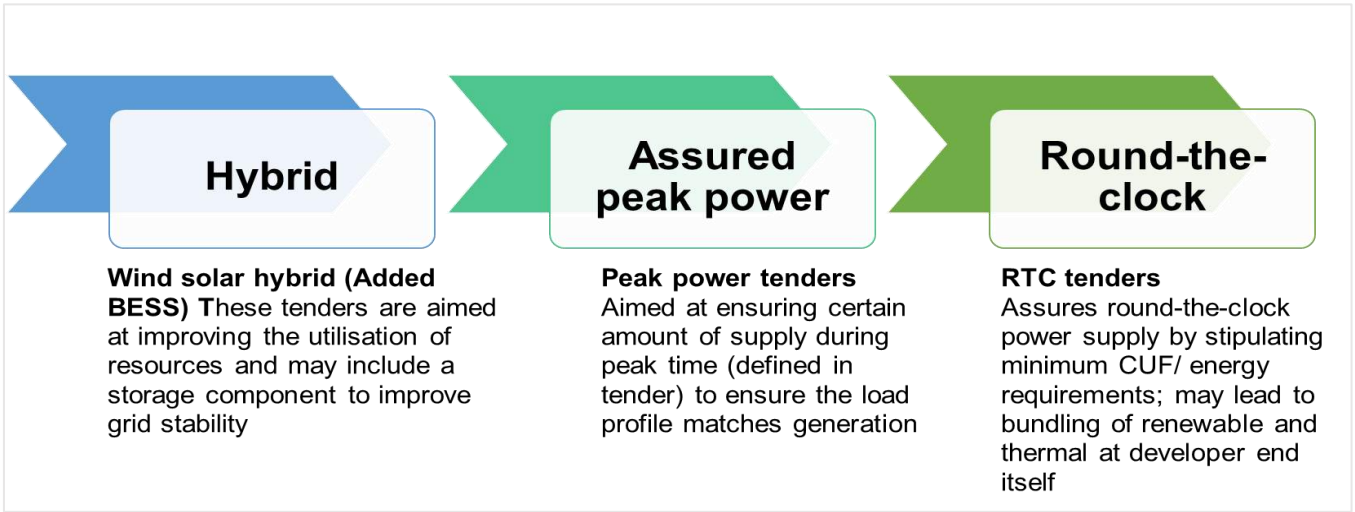


Source: MNRE; Industry, CRISIL MI&A Consulting

5.8.2 Key risk factors

Supply-side disruptions, additional taxes, and intermittent hurdles such as the Great Indian Bustard (GIB) litigation have often led to a pile-up of tenders in the market or an increase in bid tariffs, prolonging the time taken to sign PSAs with distribution utilities. Robust allocations over fiscals 2018-2020 propped up a healthy pipeline for commissioning over fiscals 2023 and 2024, where fiscal 2021 remained a weak year due to the pandemic-related halt to activities. However, allocations and consequent addition to the pipeline has turned weaker post-fiscals 2018 and 2019, comparatively, as allocation gets delayed. However, allocations rose in Q1 fiscal 2024, which then saw decline in Q2 and Q3, before rising again in Q4 to the highest levels observed in last 16 quarter. During Q4 fiscal 2024, allocations rose to close to 18 GW. This was owed to increased impetus from centre and state government to meet targets and rising power demand. Having said that nodal agencies generally, especially central ones, are keen on allocating large tenders hereon, such as the manufacturing-linked 7 GW tender, or the tenders in the range of 1.2-2.5 GW in the current scenario. However, RUVNL in May 2024 did release a tender for allocation of 8,000 MW solar capacity. SECI has also outlined the agenda of experimenting with tender structuring to solve other incidental issues related to renewable energy, especially with regard to grid balancing via its tender provisions. A few structures are outlined below:

Table 36: Unique tender structures issued by SECI



Source: SECI, CRISIL MI&A Consulting

This may lead to allocations being larger in size, but more concentrated in terms of developers and/or locations/types.

Other risks and monitorable

Apart from the tendering and allocation speed there are other issues impacting the sector's outlook.

a. Revision in the GST rate from 5% to 12% in October 2021 for solar project components has added to the cost pressure, where module prices have already surged last fiscal, coupled with the imposition of a 40% BCD on imported modules.

b. The Approved List of Models and Manufacturers (ALMM) requirement has been reimposed in fiscal 2025, with relief only being provided on case-to-case basis. A temporary abeyance was granted for projects commissioned before 31st March 2024 which has now lapsed.

c. As per CRISIL MI&A Research estimates, ~55-65, GW of module capacity is expected to be added by fiscal 2029 due to the boost from PLI. Also, the Rs 12,500 crore allocation specifically assigned to backward integrated setups out of the remaining Rs 19,500 crore would encourage the setting up of the entire value chain in the domestic solar manufacturing market. Effective implementation of the same is needed to ensure domestic supply chain robustness.

d. Litigation over transmission equipment harming GIBs: The Supreme Court (SC) has ordered that transmission lines be laid underground in the areas where GIBs are found, which is a challenge for developers, given that they will need to incur an additional ~ Rs 4 billion in expenses, and this could impact under-construction RE projects in Rajasthan and Gujarat to the tune of ~20 GW. Finally, as per the SC order dated April 20, 2022, projects in Rajasthan and Gujarat were required to have bird diverters installed before July 20, 2022; however, final decision on which areas and which projects is still to be finalized. In early 2023, the Central Electricity Authority proposed that only power lines below 33 KV need to go underground and the rest be fitted with bird divertors. Conservationists have objected to the proposal and say the move could lead to the “extinction” of the bird. In the latest update, Supreme Court is now considering a balanced approach between development and wildlife protection. Decisions are now being in made on case-to-case for commissioning transmission lines overhead with bird divertors. Shifting of transmission lines underground is now being taken up on case to case basis, with a committee being developed for the same.

   There are other issues as well where it is imperative that there is overall policy coherence from the government’s side. While on one end, there has been much confusion created by policies under other government agencies, in addition to renegotiation cases in states such as Andhra Pradesh and the long payment delays witnessed by the sector so far, there has also been significant support from the government in terms of allocations and incentives.

   For instance, clarification on GST procedures and their implementation for solar projects, and the quick guidance on the extension of commissioning timelines for pandemic relief as allowed by the MNRE for another five months in August 2020 were quick support measures by government entities.

Overall, the outlook for the sector is positive as the government remains focused on clean energy goals. Further, the June 2018 and July 2021 amendments by the MoP have provided a fillip for the renewable energy market in India:

- The July 2021 amendment waived off the interstate transmission charges and losses on solar power for projects that are granted extension of the SCOD on behalf of the government, provided these are commissioned no later than the extension date beyond June 30, 2025. However, as per the order dated November 23, the waiver on ISTS charges for renewable energy would be phased out gradually beginning June 30, 2025. ISTS charges levied would increase 25% annually till June 30, 2028, by when, 100% of the charges would be applicable. This would have some negative impact post the aligned period on the open access and utility interstate transactions as it would raise costs. Waiving of interstate charges also allows for large industrial consumers to offset their RPO requirements by executing long-term power purchase contracts from solar capacities located far away from

the consumption centre. This will also help consumers reduce their power bills considerably, given that presently, the price of competitively bid solar projects is lower than the tariffs charged by discoms for industrial consumers.

e. Land acquisition, transmission infrastructure, and fund availability critical to successful implementation of solar projects

Following are the key constraints to solar capacity growth:

Land availability

Land acquisition is difficult, considering that average land holding in India is small, at 1.16 hectares (NABARD 2014); to acquire large tracts of land in a single location, many stakeholders need to be involved, which slows down the project execution pace. The central and state governments have taken the following measures to accelerate the land acquisition process.

The government has planned to prepare land banks for 40,000 MW (enhanced from 20,000 MW earlier in March 2017) of solar projects spread across 25 states in India, under its Solar Park Policy released in September 2014.

Under this policy, a state-designated nodal agency (SNA) will construct solar parks of 500-1,000 MW size each, in association with either SECI or a PSU or in a joint venture with a private developer under the PPP model. The GoI will provide budgetary support of Rs 20 lakh/MW to the entity undertaking the solar park projects with necessary infrastructure such as land, transmission, roads, drainage, water, and warehousing.

Currently, 25 states, including Andhra Pradesh, Madhya Pradesh, Gujarat, Rajasthan, Uttar Pradesh, Karnataka, Telangana, West Bengal, Chhattisgarh, Tamil Nadu, Jammu and Kashmir, and a few north-eastern states have started preparing land banks for solar parks, through either their own implementing agencies or joint ventures with SECI.

The GoI and World Bank have signed a $98 million loan agreement and $2 million grant agreement in November 2017. The said funds will be used to fund solar park infrastructure in various states via IREDA under the MNRE's solar park implementation scheme. The first two solar parks to be supported were in the Rewa (750 MW) and Mandsaur (250 MW) districts of Madhya Pradesh. The agency is also looking at other solar parks in the country in Odisha, Haryana, and Chhattisgarh, among other states. Previously, the World Bank had also provided $25 million to develop the transmission infrastructure for the Rewa solar park on concessional loan terms. Further, the world bank approved $1.5 billion to finance green energy in India in June 2023.

Availability of transmission infrastructure

Large-scale, grid-connected solar plants are usually located in far-flung areas devoid of transmission infrastructure. Thus, robust transmission planning to optimise costs, utilisation levels, and losses associated with transmission systems, and transmit the power generated from the solar plants to load centres (cities and industrial areas) is critical.

The industry had been raising concerns regarding connectivity for renewable projects. Considering this, nodal agencies (PGCIL, SECI) have planned schemes to alleviate grid congestion and improve connectivity to RE projects.

The grid capacity additions will come under two main schemes, namely the Green Energy Corridor Scheme and Renewable Energy Zones (REZs), both of which, were to be implemented by fiscal 2022, but the timelines are now delayed. This would add ~80 GW of transmission grid capacity to an existing ~24 GW, taking the grid capacity planned for RE integration to ~100 GW.

The GEC scheme is aimed at developing specific evacuation corridors for renewable energy in key renewable-rich states. The government has planned to integrate renewable energy into the national grid by setting up interstate and intra-state schemes for the evacuation of power from wind and solar projects, termed as green energy corridors. The interstate component of the scheme was completed in March 2020, while the intra-state

component is seeing delays in execution. A total of 8,940 ckm length of transmission lines have been constructed under the intra-state scheme as of July 2023, with Madhya Pradesh and Gujarat leading the execution as per the last available information for the scheme. Additionally, the cabinet approved intra-state transmission system GEC-II to facilitate grid integration and power evacuation of ~19 GW of renewable energy power projects in Gujarat, Himachal Pradesh, Karnataka, Kerala, Rajasthan, Tamil Nadu, and Uttar Pradesh. The transmission systems will be created over fiscals 2022 to 2026.

PGCIL has also come up with a scheme for setting up grid infrastructure in identified REZs. Under this scheme, key areas with a concentration of existing/planned renewable energy projects have been identified in the country's western and southern regions. Of this, 20 GW of grid capacity will be added for solar projects in the western region and 10 GW in the southern region. These would be known as solar energy zones, and 10 GW of this 30 GW will come up in Phase I (December 2020), and the remaining 20 GW in Phase II (December 2021). However, clarity on the scheme's implementation and its progress are limited as on date.

In conclusion, these schemes provide comfort against the estimate of 80-90 GW to be added by fiscal 2027. However, the timely execution of planned capacities is key as renewable energy projects take only 1-1.5 years to come online, while transmission capacities would take 2-3 years.

However, grid stability and maintenance charges are going to be a key risk, going forward, for renewable energy projects. As of March, 2024, total installed renewable energy capacity was ~191 GW out of the total ~442 GW power generation capacity in India. However, based on the units supplied, renewable energy's share amounts to only 22% of the total power supplied. Its share is expected to rise to 25-30% in generation by fiscal 2029, with solar generation estimated to comprise 13-15%. This may result in grid instability due to the variable nature of generation of power from renewable energy sources. Hence, renewable generation may have to be backed down to maintain grid stability.

To address the issue of grid variability, the government has started taking measures such as planning and deploying electricity generation reserves, augmenting transmission infrastructure, creating technical standards and regulations for renewable energy generators, introducing features such as low-voltage ride through (LVRT) and high-voltage ride through (HVRT), setting frequency thresholds for disconnection from the grid, and finalising regulations for active and reactive power generation. Further, the government is planning ancillary services to support electricity grids. These services, regulations, and charges will be partly shared between generators as their direct costs and by consumers as pass-through costs.

Moreover, under/over-injection of power beyond the limits of the forecast schedule will attract penalties, which will hike grid maintenance charges. Several states have also started releasing forecasting and scheduling regulations to start the implementation of the same. This may add to costs for developers, going forward.

Availability of funds for projects

Given the capital-intensive nature of solar power projects, the cost of capital plays an important role in project implementation. In the past, high domestic interest rates, lower repayment tenures, and inadequate and delayed capital subsidy increased the minimum tariffs required to achieve a healthy internal rate of returns (IRR).

However, recently, a reduction in the MCLR, coupled with opening up of other financing avenues, helped players reduce their cost of capital. Further, interest rates across the globe have been declining since the pandemic hit; however, the trend reversed recently, with rates going up to fight inflation.

Over fiscal 2019 and 2020, interest rates were higher due to several macro factors at play. However, with no changes in interest rates by the RBI from the second quarter of fiscal 2021, the MCLR has remained stable after having declined sharply. The low-interest rate regime has been reversed in fiscal 2023 due to a gradual increase in repo rates by the RBI in response to increasing inflation. In fiscal 2024, the rates remained in the range of 8.5-8.65% with a recent increase from 8.5% in November 2023 to 8.65% in December 2023, where it has continued to remain as of June 2024.

Traditionally, domestic lenders have been risk-averse towards lending to the sector due to much stress witnessed in the conventional power segment and assuming the same may happen for renewable energy. Past incidents of renegotiations and delayed payments by counterparties have also caused some concern among lenders. They are also hesitant to lend due to the aggressive bidding seen previously and regulatory uncertainty prevalent in the market. However, over the past two fiscals, with a push from the government to achieve nationwide clean energy targets and ESG-related targets for lenders, funding to the segment from domestic lenders, including PSUs, has gained traction.

In addition, even foreign fund raising has seen some impact:

- A weaker rupee has also led to higher hedging costs, adding cost pressure to ECB or green bond issuances.
- Frequent policy changes and a lack of clarity on the same would make global investors wary of entering/funding the sector. This is highly detrimental to growth in the sector, which requires significant equity over the coming years to continue supporting additions.

Going forward, solar developers will have access to a broader spectrum of cheaper financing options, in addition to prudent capital management, to sustain over the long term. However, at present, fund availability may be a concern for a few projects where viability is sub-par or for those facing project implementation issues, given that the solar sector in India is still maturing.

The GoI and other financial institutions have announced the following measures to improve fund availability to support solar capacity additions.

- SBI has taken several measures to support renewables in the country. It has committed Rs 750 billion in debt funding over the next five years to 15 GW of renewable energy projects, in addition to securing $625 million of credit from the World Bank at a concessional rate to support viable grid-connected rooftop solar PV projects.
- The European Investment Bank has also committed to provide € 200 million at a concessional rate (LIBOR plus 0.99 percentage point) to fund solar projects under the National Solar Mission across India. Other banks and NBFCs are also actively supporting the sector, with Yes Bank, Axis Bank, and IDFC First Bank going for bond issuances (green bonds) to procure funds for financing renewable energy in the country.
- Multilateral funding agencies such as ADB and IFC, and several other private equity funds are funding many solar projects, even at concessional credit terms.
- Government financial institutions such as PTC India Ltd, REC, and IREDA are financing many solar projects.

Many entities active in the sector are utilising diverse areas of fundraising such as green/masala bond issuances, plans to use infrastructure InvITs, and listing on global exchanges such as the Alternate Investment Market (London) or the Nasdaq to lower the cost of capital in their quest to become more competitive. An estimated $16.9 billion worth of green bonds have been raised by Indian entities till date (September 2022), raised by both corporate and financial institutions. However, the purpose of these funds is not only to fund growth capital, but also to refinance existing debt. Nevertheless, this does provide developers an option to raise lower-cost debt later in the lifecycle of assets once they are operational.

Consequently, while there are ways to lower the cost of debt for developers, players would have to actively manage the same as a rising interest rate regime and other factors, as detailed above, impact borrowing costs. This remains a key monitorable for the sector.

Other key risks to which the sector is sensitive are as follows:

- A rise in the capital cost on account of a weakening in the rupee or supply side issues, resulting in expensive imported modules (which account for 55-60% of the total capital cost)

- Further worsening of the financial health of state distribution utilities, which could lead to power offtake issues, as well as potential payment delays/defaults
- Aggressive bidding despite execution challenges

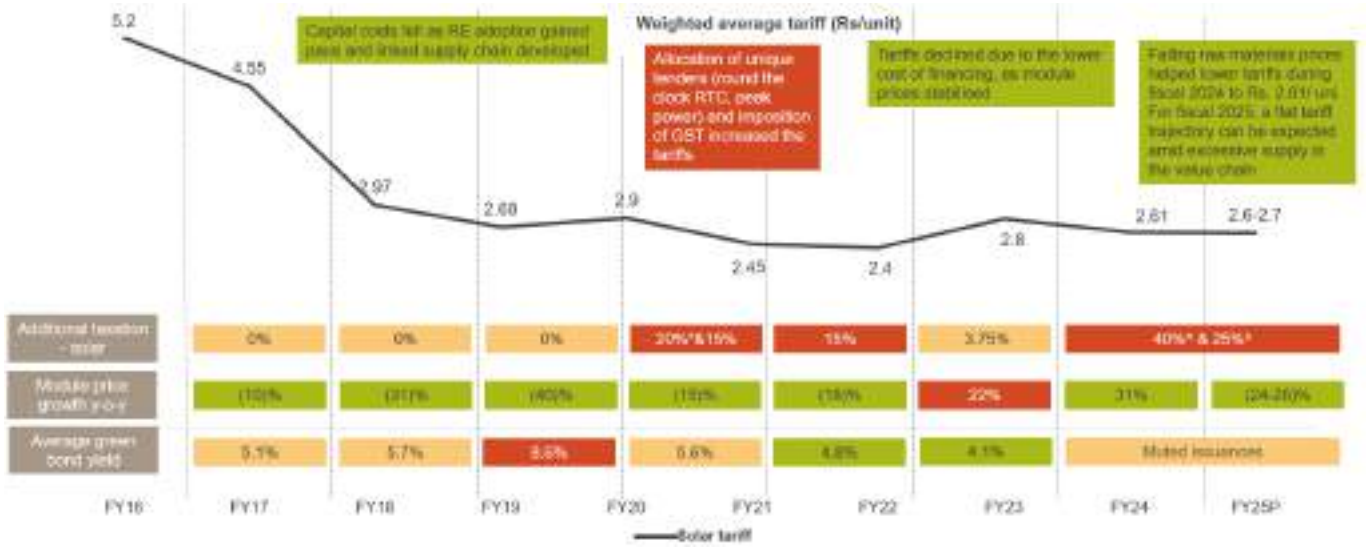
5.9 Outlook on levelised tariffs for solar PV power plants in India

On the pricing front, solar tariffs declined rapidly from fiscals 2016 to 2020, with a rapid fall in component pricing, technological improvements in efficiency, and the government's policy push. While declining module prices contributed to a reduction in tariffs over fiscals 2017 to 2019, access to low-cost financing was the primary driver for the decline in tariffs over fiscals 2020 to 2022, where global investments in the Indian renewable energy segment picked up via green bond issuances and external commercial borrowings, helping lower the cost of debt for the space.

The participation of global players and entities with strong credit profiles (CPSUs) has helped tariffs remain in the Rs 2.4-2.6 per unit range even until fiscal 2022, when supply-side disruptions started to emerge. Tariffs recorded 16% uptick in fiscal 2023, when it rose to Rs 2.8 per unit before declining to Rs 2.61 per unit in fiscal 2024, a drop of close to 7%. Tariff drop in fiscal 2024 was majorly on account of price decline in upstream components, mainly solar cells, where prices fell by ~47% in fiscal 2024.

The global energy crisis, geopolitical tensions, and supply-side disruptions at key locations in China have led to a reversal in module pricing, with prices climbing to USD 0.25 per Wp in fiscal 2023 for mono-crystalline technology. The increase in module prices, coupled with policy changes impacting the sourcing of modules for new projects and the rising cost of debt in an uncertain global climate, has led to an increase in weighted average tariffs to Rs 2.8 per unit in fiscal 2023. In 2024, the tariffs for vanilla solar decreased due to the decreasing upstream and commodity prices. The prices of various materials like poly silicon, wafers, cells, and metals like steel, copper and aluminum moderated in fiscal 2024, easing the pressure on capital costs. Bid tariffs stood at Rs 2.61 per unit in fiscal 2024. A key point to note is that historically, tariffs have not risen or fallen at the same pace as the rise or fall in module prices. Therefore, despite a steep 31%year-on-year fall in module prices, tariffs didn't fall at the same pace, as EPC players and developers exercise caution.

Figure 69: Weighted average solar tariff trend



*Note: * Represents the duty rate for six months each in the fiscal. ^ Represents imposition of 40% and 25% BCD on solar cells and modules, respectively.*

Source: CRISIL MI&A Consulting

5.10 Outlook on open access utility scale segment

The C&I users consume ~51% of the electricity generated in India, but only a small percentage of their energy procurement comes from renewable energy sources. C&I users have emerged as an important standalone business segment in recent years in the renewable energy market, indicating their huge untapped potential. Although the present market size is small, specialised developers catering to C&I consumers have emerged with innovative business models and competitive prices. The C&I segment already accounts for 70-80% of the country's rooftop solar installations and is making headway in the utility-scale solar space as well through open access and group captive routes.

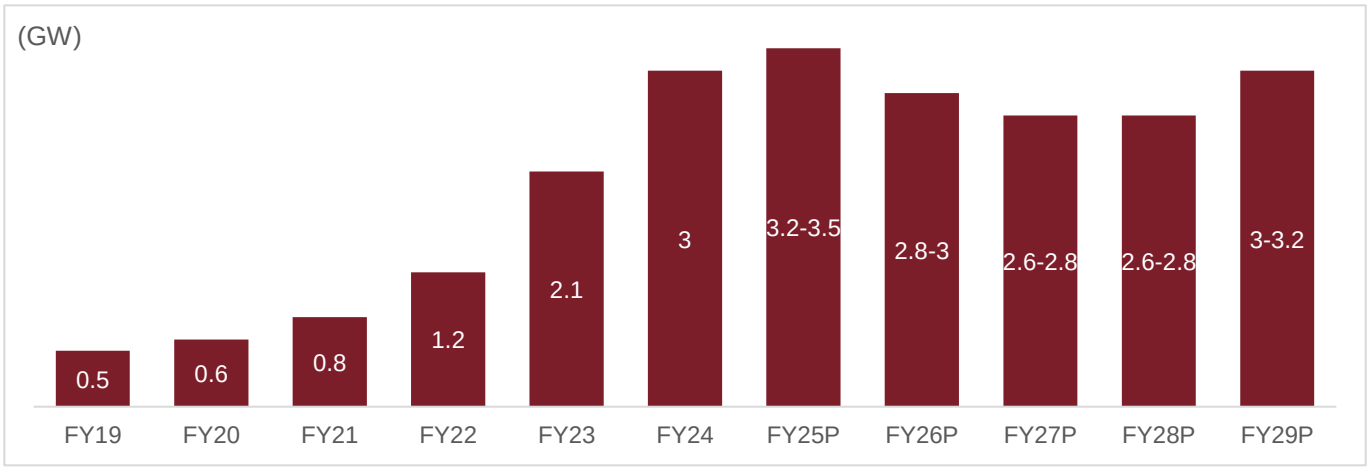
The Indian C&I solar sector added ~10+ GW over fiscals 2019 to 2023, with the total installed capacity as of December 2023 at ~25+ GW. Capacity additions picked up in the last two years in response to the easing of pandemic restrictions and increasing power demand. Further, the market has gained momentum over the last few years, with consumers keen on reducing their power bills, as well as carbon emissions. Increasingly, there is also very strong interest among investors with leading independent power producers, private equity funds, and other institutional investors committing huge sums to this market.

Solar power is preferred over other renewable energy sources by C&I consumers due to its ease of implementation, versatility, and negligible operating costs. Moreover, solar power prices have declined significantly over the past few years, making it more affordable for C&I consumers. In contrast, state discoms continue to charge C&I consumers very high tariffs compared with residential and public sector consumers to provide subsidies to agricultural and below poverty line consumers. Thus, large industries across segments and commercial consumers, including metro corporations, railways, airports, hotels, and multinational corporations, can generate substantial savings by meeting their electricity requirements through solar power-based captive, group captive, and open access projects.

CRISIL MI&A Consulting expects 13-15 GW of projects to be commissioned under the open access utility segment over the next five years through 2029, led by the go-green initiatives/sustainability targets of C&I consumers, effective long-term policies in key states such as Uttar Pradesh and Maharashtra, and lower offtake risk.

Additionally, in the proposed Draft Electricity Amendment Act 2022, several progressive measures have been proposed for the solar sector, including the introduction of a pan-India RPO with a strict penalty mechanism. Discoms and other large electricity customers are obligated to purchase a specific percentage of their power from solar energy sources under these RPOs. These measures will provide a significant boost to the uptake of rooftop solar in the C&I segment.

Figure 70: Open access utility scale capacity additions (FY25-FY29)



Note: Historical installed capacity is based on internal estimates. P: Projected
Source: Industry; CRISIL MI&A Consulting

5.11 Policy support in terms of incentives for C&I capacity addition

C&I capacity addition is largely influenced by the policy and regulatory framework governing open access. Some of the policies have helped in the C&I segment's growth, whereas certain provisions have acted as obstacles to capacity addition. State-wise variations, coupled with different interpretations of provisions, has constituted a major challenge. To avoid ambiguities, the MoP has issued a few rules to provide greater clarity in various OA-related provisions.

a. Electricity (Promoting Renewable Energy Through Green Energy Open Access) Rules, 2022

Highlights of Green OA Rules 2022:

- Multiple avenues (own generation, captive, open access, and from distribution licensee) provided to generate, purchase, and consume renewable energy
- Consumers having contracted demand or sanctioned load of 100 kW and above eligible to take power through green energy open access
- No limit on supply of power for captive consumers taking power under green energy open access
- A central nodal agency to set up and operate a single-window green energy open access system for renewable energy
- After registration at a centralised registry, all applications routed to the concerned nodal agency for the grant of green energy open access
- Concerned nodal agency: Short-term OA: load dispatch centre (LDC); medium-term OA: state transmission utility (STU); long-term OA: central transmission utility (CTU)
- Monthly banking allowed at least 30% of the total monthly consumption of electricity from the distribution licensee by consumers
- Charges to be levied on green energy open access consumers clearly defined
- CSS on a C&I consumer shall not be increased, during 12 years from the date of operating of the generating plant using RE sources, by more than 50% of the surcharge fixed for the year in which open access is granted
- Obligated entities can meet their RPO targets by purchasing green hydrogen or green ammonia
- Cross-subsidy surcharge and additional surcharge shall not be applicable if green energy is utilised for the production of green hydrogen and green ammonia

b. Waiver in ISTS transmission charges

The MoP, in August 2020, waived the inter-state transmission system (ISTS) charges and losses on all solar and wind projects commissioned before June 30, 2023. In June 2021, the waiver was extended up to June 30, 2025. However, this time, only the ISTS charges were waived off, and losses remained applicable. Subsequently, in November 2022, the waivers were amended as follows:

RE Source	ISTS Charge Waiver	Remarks
Solar	Yes	Waiver available for useful life of 25 years
Wind	Yes	Waiver available for useful life of 25 years
Pumped storage hydro plant	Yes	Waiver available for 25 years, provided minimum 51% of pumping energy from wind/solar sources
BESS	Yes	Waiver available for 12 years, provided minimum 51% of charging energy from wind/solar sources
GTAM/GDAM	Yes	Only for trading energy from solar/wind/PSP/BESS in GTAM/GDAM

Green hydrogen	Yes	Waiver available for 8 years for green hydrogen production using solar/wind/PSP/BESS sources

Waivers are available for projects commissioned by June 30, 2025. Hoverer, post June 2025, an annual increase of 25% in the ISTS charges will be applicable for solar, wind, hydro PSP, and BESS sources, resulting in the applicability of 100% of ISTS charges from July 2028.

Subsequently, in February 2023, it was clarified that green hydrogen and green ammonia projects would get a waiver of ISTS charges for 25 years if the projects are commissioned before June 30, 2025.

New hydro power projects:

The MoP has decided to extend the waiver of ISTS charges on the transmission of power from new hydro power projects, for which, construction work is awarded and PPAs are signed on or before June 30, 2025.

ISTS charges will be levied for the transmission of power from hydro power projects where construction work is awarded and PPAs are signed after June 30, 2025, as follows:

S. No.	Award of construction work + signing of PPA	ISTS charges
1.	01-07-25 to 30-06-26	25% of applicable ISTS charges
2.	01-07-26 to 30-06-27	50% of applicable ISTS charges
3.	01-07-27 to 30-06-28	75% of applicable ISTS charges
4.	from 01-07-28	100% of applicable ISTS charges

The waiver/or concessional charges, as shown in the table above, shall be applicable for 18 years from the date of commissioning of the hydro power plants. The waiver shall be allowed for inter-state transmission charges only and not losses. The waiver would be made applicable from the prospective date.

c. Cross-subsidy and additional surcharge

Captive power projects are exempt from paying CSS, as per Section 42(2) of the Electricity Act 2003.The Supreme Court, in its judgement dated December 10, 2021, ruled that captive power consumers are not liable to pay an additional surcharge under Section 42 (4) of the Electricity Act, 2003.

5.12 Outlook on rooftop solar PV capacity additions in India

a. Rooftop solar additions of 20-22 GW expected over fiscals 2024-2029

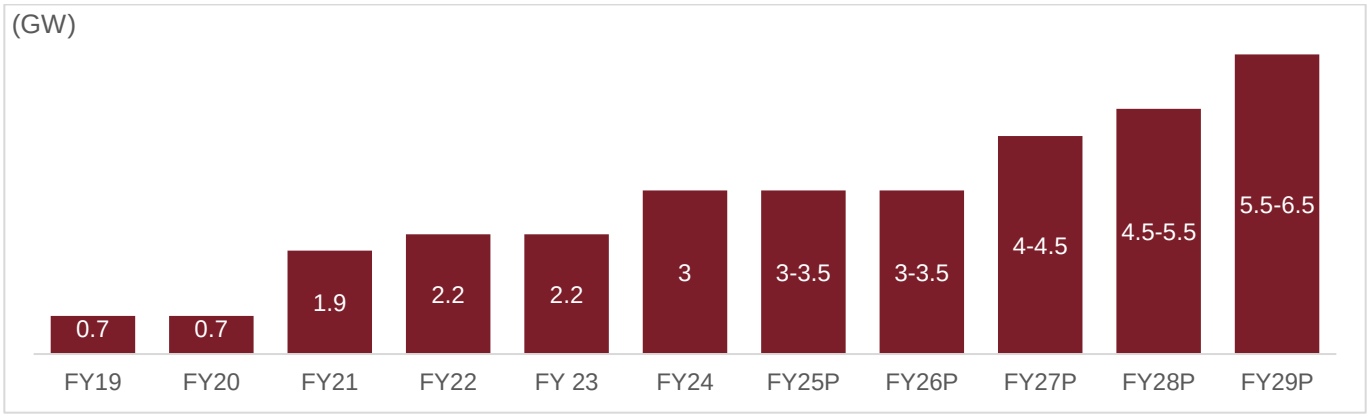
CRISIL MI&A Consulting expects 20-22 GW of projects to be commissioned under the solar rooftop segment over the next five fiscals (2025-2029), mainly led by industrial and commercial space of ~12-14 GW under net/gross metering schemes of various states; and the balance from GW added by residential rooftop consumers. Along with this, effective implementation of Surya Yojana provides an additional upside of 9-11 GW of module demand, the execution pace and success of which remains a key monitorable. Further, the ministry's approval of allowing net metering up to 500 kW would give a much-needed fillip to the sector, leading to an increase in demand for rooftop installations. Also, MNRE provides central financial assistance for all rooftop projects constructed by the residential category of consumers: 70% for special category states and 30% for other states. Furthermore, to promote quicker adoption of residential rooftops, the MNRE has issued a simplified procedure for such consumers; the key highlights are as follows:

- A national single portal will be developed to register applications from such beneficiaries
- Rooftop solar plants can be installed by the consumers themselves or through any vendor of their choice

- Household beneficiaries who wish to install rooftop solar (RTS) under the new mechanism will apply on the national portal; the subsidy amount can be availed to install the RTS plant
- The beneficiaries need to install the plant within a specified period; otherwise, the application would be cancelled, and they would have to re-apply

Solar power can act as an alternative for states with high load shedding, such as Tamil Nadu, Uttar Pradesh, and Punjab, which are also serviced by diesel generator sets, and for rural areas with poor grid connectivity

Figure 71: Projected rooftop capacity additions over fiscals 2025-2029



Source: MNRE; CRISIL MI&A Consulting

b. Concentration risk within select states and supply risk to shape additions over the next five fiscals

Over 50% of the new capacity additions would be undertaken by Gujarat, Rajasthan, Maharashtra, Andhra Pradesh, Telangana, Karnataka, and Tamil Nadu. However, limited availability of modules with higher capacity wattage (>500 Wp) coupled with the domestic content requirement for the rooftop segment can have ramifications and impact 1-1.5 GW of rooftop additions over the next five fiscals.

On concentration of capacity, the states were analysed on the following parameters. Each parameter was assigned a weight and scored on a scale of 1 to 5. The weighted average score was computed, and a potential achievement rate was assigned to state-wise MNRE targets to arrive at the outlook.

1. **Industrial and commercial load**: Since rooftop solar is profitable for C&I consumers, states with more loads under this category are expected to witness higher additions. Thus, Gujarat, Maharashtra, and Tamil Nadu, which had over 50% annual sales in this category, will drive additions.
2. **Average tariffs for C&I consumers**: The higher the discom tariffs, the more favourable the economics of rooftop projects. Consequently, consumers in states such as Maharashtra and Tamil Nadu, where average tariffs are Rs 8-9 per unit, will drive additions.
3. **Net/gross metering regulations**: States with clearly defined regulations are more likely to attract investments in rooftop projects, as clarity in regulations (technical parameters, clearances, interconnectivity, and invoicing approvals) would result in discom officials acting swiftly on applications. Some states, such as Tamil Nadu, Maharashtra, Andhra Pradesh, Telangana, and Delhi, have covered most of the necessary parameters in their policy/regulations, while others have not formulated detailed guidelines.
4. **Availability of feed-in-tariffs (FiTs):** FiTs are typically attractive as they are computed on a cost-plus model, which ensures healthy project returns. Delhi offered FiTs of Rs 2 per unit. In case FiTs are not available, there is a provision for supplying compensating units to a grid at the APPC. Hence, states with high APPC will be preferred, as they would help reduce the payback period.

5. **CUF**: States with higher solar irradiance and sunny days would generate more units and, hence, reduce the payback period, attracting more investments. States such as Maharashtra, Rajasthan, Gujarat, Andhra Pradesh, and Telangana have high solar radiation [Global Horizontal Irradiance (GHI) of 5.6-6.1 kWh/square meter per day) compared with states such as Kerala, Bihar, and Odisha (GHI of 5.03-5.4 kWh/square meter per day).
6. **Other regulatory charges**: Karnataka, Andhra Pradesh, and Tamil Nadu provide concessions to their C&I consumers on cross-subsidy surcharges, wheeling and banking charges, and electricity duties levied on normal open-access consumers. Hence, such states would be preferred.
7. **AT&C loss**: Discoms in states with higher AT&C losses would prefer to bring down their share of electricity supplied to agricultural and residential consumers, supporting the rooftop initiatives for such consumers.

5.13 Impact of large RE capacity additions on grid security

Domestic RE energy penetration varies greatly across the various states. There is vast difference in the share in RE-rich states and others. In fact, some RE-rich states have higher RE shares than those of some countries internationally. That said, the high RE penetration is causing system integration issues for certain states.

India aims to increase its non-fossil-fuel-based installed electricity generation capacity to 500 GW by 2030. RE will be at the core of achieving this target, with around 450 GW RE expected to be added by 2030. Some of the key challenges due to higher RE penetration include fluctuations in hourly demand, increasing ramping requirements, frequency, and voltage-related grid issues.

Variability affects system management as well as scheduling challenges due to the intermittency associated with RE output. As a result, RE-rich states would have to export some power to other states, back down or avoid coal-based power, and curtail RE for the sake of grid security.

Potential sources of power system flexibility, including demand-side flexibility, power plant flexibility, and storage (pumped storage hydro and batteries) and grid flexibility, should be prioritised to maximise the value of solar and wind.

India has already adopted measures to manage variability using different products, such as wind-solar hybrid tenders and energy storage solutions, including pumped hydro storage.

To enable higher RE capacity, areas with high solar and wind energy potential need to be connected to Inter-State Transmission System (ISTS) so that the power generated could be evacuated to the load centres. The gestation period of wind and solar generation projects is much lower than that for associated transmission systems, so the transmission system has to be planned well in advance.

In a significant step towards achieving the planned RE capacity by 2030, CEA has planned a transmission system for about 537 GW of RE capacity. The transmission system has been planned for major RE potential zones, such as the RE park in Leh, Ladakh; Fatehgarh, Bhadla, and Bikaner in Rajasthan; the Khavda RE park in Gujarat; Anantapur and Kurnool RE zones in Andhra Pradesh; and offshore wind farms in Tamil Nadu and Gujarat. The transmission schemes have been factored in energy storage in order to meet the requirement of RTC power. Several high-voltage direct current transmission corridors have also been planned for the evacuation of power from large potential RE zones.

5.14 Battery Storage and its impact on solar capacity additions

Solar energy may not always align with peak energy demand periods. The highest demand for electricity typically occurs during summer afternoons and evenings when power usage peaks. However, during these times, solar energy

generation starts dipping. The generation of solar energy can be influenced by various factors such as seasonal variations, time of day, cloud cover, dust, haze, and obstacles like shadows, rainfall, snow, and dirt.

The utilization of storage technology enables solar energy to contribute to the electricity supply even during periods when sunlight is unavailable. Additionally, storage systems can assist in mitigating fluctuations in the flow of solar energy on the grid, thereby ensuring a more consistent and stable power output.

Incorporating a solar battery into a solar power system is a crucial enhancement. A solar battery plays a vital role in storing surplus electricity, which can be utilized by owners/developers during periods when solar panels are unable to generate sufficient energy.

Technology disruptions can boost capacity addition, especially with the advent of battery storage solutions

With India setting an ambitious target of 175 GW of renewable energy capacity by 2022, several measures have been taken to effectively integrate the high penetration of renewables into the grid. The measures include making conventional generation flexible, maintaining generation reserves, and introducing ancillary services. Though energy storage has been around for a while, its role in energy systems is starting to become important only now. On account of the rise in intermittent renewables, energy storage is needed to maintain a balance between demand and supply.

Rapid innovation and a rise in the global scale of production have helped gradually lower the prices of battery storage systems from 2011 onwards. Prospects of using battery-based storage for grid-scale projects are gaining wider acceptance amid rapid progress in battery technologies, such as lithium-ion. The technologies, which were earlier developed to support the electric vehicle industry, have elicited equal interest from rooftop solution providers on account of rising grid electricity prices and falling costs of modules and batteries.

RE projects, along with battery storage, can provide firm power supply for a longer duration in on-grid as well as off-grid applications, helping utilities and consumers meet energy requirements efficiently and, in an environment-friendly manner. Globally, deployment has already started picking up.

The introduction of battery storage in the power system network will support higher integration of RE sources, such as wind and solar, into the grid. Amid rising adoption of battery storage and maturing technology, newer business models based on storage will evolve, which will change the present market structure of electricity production and consumption.

Further, as per CEA's report on optimal generation mix 2030, the likely requirement of BESS would be 42 GW/208 GWh by fiscal 2030 and 47 GW/236 GWh by fiscal 2032 under base case scenario. To support BESS installations, the government also approved VGF scheme for 4 GWh BESS projects which would be developed by fiscal 2031. An initial outlay of Rs 9,400 crore including budgetary support of Rs 3,760 crore has been provided under the scheme. The VGF would be provided from fiscal 2024-26 and will be capped at 40% of the capital cost. As per MNRE, the cost of BESS is anticipated to be in the range of Rs 2.40 to Rs 2.20 Crore/MWh during the period 2023-26 for development of BESS capacity of 4GWh, which translates into Capital Cost of Rs 9,400 Crores.

Table 37: Tariffs discovered in recent Energy Storage Tenders

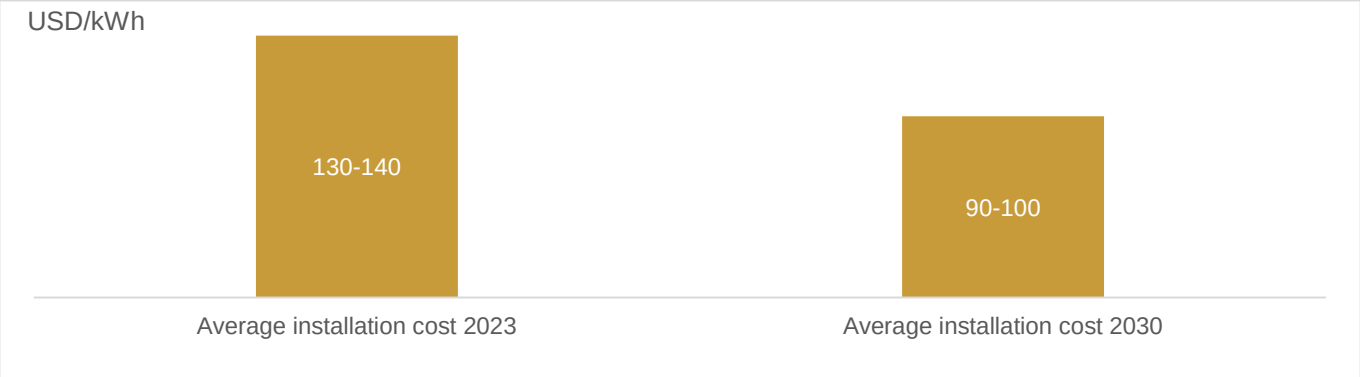
Sr. no.	Tender name	Capacity (MW/MWh)	Result date	Bid allocation basis	Lowest bid
1.	SECI Rajasthan Tranche - II	1000 MW / 2000 MWh	Sept 2024	Capital cost bid	Rs 4.57 Mn/MW/year
2.	SECI (Solar+Storage)	600 MW/1200 MWh	Jul 2024	Tariff	Rs 3.42/kWh
3.	GUVNL	250 MW/500 MWh	Mar 2024	Capital cost bid	Rs 4.48 Lakh/MW/month
4.	RUVNL	1200 MW (Auctioned only 600 MW)	Aug 2023	Capital cost bid	Rs 6.69/kWh

Sr. no.	Tender name	Capacity (MW/MWh)	Result date	Bid allocation basis	Lowest bid
5.	PCKL	1000 MW /8000 MWh	Mar 2023	Capital cost bid	Rs 14.75 Mn
6.	NTPC Storage	500MW/3000 MWh	Dec 2022	Capital cost bid	Rs 2.79 Mn/MWh/year
7.	SECI Rajasthan	500MW/1000 MWh	Aug 2022	Capital cost bid	Rs 1.08 Mn/MWh/month

Source: Industry, CRISIL MI&A Consulting

Usage of battery storage is expected to be strong across the generation, transmission, and distribution segments as well as at the consumer end. The National Renewable Energy Laboratory has also forecasted a fall in the price of storage solutions, especially lithium-ion technology. The increased adoption of lithium-ion battery storage, improvement in battery efficiency, and large-scale manufacturing are expected to decrease the four-hour utility-scale lithium-ion battery installation costs to $90-100 per kWh in 2030 from $130-140 per kWh in 2023.

Figure 72: Projected levelised cost of four-hour lithium-ion battery technologies



Source: NREL; CRISIL MI&A Consulting

Falling costs of energy storage and increase in distributed energy sources are expected to bring a paradigm shift in the way electricity is generated and consumed. Traditional business models in the electricity space are expected to evolve into a more dynamic marketplace, where consumers will become “prosumers” (producers + consumers).

Wider deployment of energy storage can benefit power utilities by improving grid performance and reliability, avoiding investments in the peaking generation capacity. More conventional sources of electricity (coal, crude oil, and gas) will be replaced with solar/wind-plus-storage systems, where storage can address variability in wind speed/solar radiation, which was the biggest impediment in making renewables the primary source of energy in the electricity value chain.

5.15 Impact of Energy storage solutions in countering intermittent supply of RE power

To enhance the integration of RE generation with the grid and mitigate the challenges posed by weather conditions, governments have implemented various measures. Some of these measures include:

a. Construction of Intra-State and Inter-State transmission systems for evacuation of Renewable power.

b. Setting up of Renewable Energy Management Centers (REMCs) for accurate forecasting of renewable power and for assisting grid operators to manage variability and intermittency of renewable power.

c. Innovative products like solar-wind hybrid projects, Round the Clock RE projects, RE projects with energy storage systems and supply of RE power balanced with power from non-RE sources started to reduce intermittency.

d. Implementation of Green Term Ahead Market (GTAM) and Green Day Ahead Market (GDAM) for sale of renewable power.

e. Flexibility in Generation and Scheduling of Thermal/Hydro Power Stations through bundling with Renewable power and Storage Power.

f. Notification of Energy Storage Obligation trajectory till 2029-30.

As of now, PSP and BESS are the major feasible options to store RE. The PSPs have long gestation period, and their capacity is dependent on location, however, they have longer life. On the other hand, BESS have short gestation periods, are non- dependent on location but limited by availability of minerals and technology.

The present installed capacity of PSPs in the country is 4745.6 MW and another 1500 MW capacity is under active construction.

Energy storage plays a crucial role in smoothing out the delivery of variable or intermittent resources like wind and solar power. By storing excess energy during periods of high generation, such as when the wind is blowing or the sun is shining, energy storage systems can then release this stored energy when generation is low, such as during calm or cloudy periods. This balancing effect helps ensure a more consistent and reliable energy supply, reducing dependence on immediate availability and improving overall grid stability.

Energy storage systems are not limited to supporting variable renewable resources alone. They can also play a vital role in efficiently delivering electricity for inflexible, baseload resources. When rapid changes in demand occur, requiring flexibility in electricity supply, energy storage can provide the necessary support by injecting or extracting electricity as needed. This capability allows energy storage to precisely match the load requirements, ensuring electricity is delivered efficiently and on-demand, regardless of location or time. Thus, energy storage offers versatility and adaptability, serving as a valuable asset in meeting fluctuating energy demands and optimizing grid operations.

5.16 Overview of Indian wind solar hybrid market

WSH is fast becoming the preferred RE option in India. Although the MNRE has not yet set a generation target, the nascent sector has received strong support from SECI and several state governments. There are two types of WSH projects — pure-play ones and those with storage. There are also projects that may come up under the government's RTC power scheme, which has a mandatory 51:49 blend of RE and thermal.

India has introduced RTC generation tenders, including hybrid tenders to strengthen clean generation combining solar, wind and storage technologies. The MNRE introduced the National Wind-Solar Hybrid Policy on May 14, 2018. The main objective of the policy is to provide a framework for the promotion of large grid-connected wind-solar PV hybrid systems and efficient utilisation of transmission infrastructure and land. It also aims to reduce the variability in renewable power generation and achieve better grid stability. As on June 30, 2024, hybrid projects of aggregate capacity 12,884.35 MW are under construction in the country. It is expected that India will witness 21-24 GW of WSH capacity in the next five years (fiscal 2024 to fiscal 2029) out of which around 12-13 GW will be from wind.

5.17 Key growth drivers

Wind Solar Hybrid segment in India is experiencing rapid growth, driven by several key factors:

- **Potential:** India has around 696 GW (120 m hub height) wind potential and around 750 GW of solar potential. Currently only around 10% of the potential is developed and balance 90% potential yet to be exploited. This provides huge opportunities for wind and solar development.

- **Geographical advantages:** India's coastline provides high wind speed as well as excellent solar potential. State such as Gujarat, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh have excellent wind as well solar potential. Such advantage provides great opportunity for hybridisation. Depending on the project requirements, the hybrid projects can be co-located or located in different locations also making it more flexible even if natural resources are located in different places.
- **Complementary resources:** Wind and solar source complements each other. Due to their inherent characteristics, they generate power during different times of the day as well as seasons. Wind power is at its maximum during nighttime whereas solar power is available only during the day. Therefore, for 24X7 supply, they complement each other and hence WSH projects provide more reliable power and can be used for round-the-clock (RTC) supply.
- **Resource optimisation:** Co-located WSH plants can help in resource optimisation. With optimum land utilisation, infrastructure sharing, the wind and solar resources can be optimally utilised leading to better CUF as well as cost optimisation. With energy storage facilities, the WSH plants help in better grid management and higher penetration of renewable energy into existing power systems.
- **Policy push:** Government of India's policy push has also helped the WSH segment. With increased RPO targets, VGF funding, PLI schemes, solar park schemes, simplified land allocation has helped both the resources to thrive.

5.18 Support policies for WSH plants

National Wind-Solar Hybrid Policy 2018

This policy aims to encourage new technologies, methods and way-outs involving combined operation of wind and solar PV plants. The aim is to reduce renewable energy variability and improve grid stability.

Capacity: A wind-solar plant will be recognised as hybrid if the rated power capacity of one resource is at least 25% of the rated power capacity of other resource.

Integration: The policy provides for integration of both energy sources, wind and solar, at alternating current (AC) and direct current (DC) level.

RPO: The power procured from the hybrid project can be used for fulfilment of solar RPO and non-solar RPO in the proportion of rated capacity of solar and wind power in the hybrid plant.

Hybridisation of existing wind/solar PV plants: Existing wind or solar power projects, willing to install solar PV plant or WTGs to avail benefit of hybrid project may be allowed to do so under certain conditions.

Incentives: All fiscal and financial incentives available to wind and solar power projects will also be made available to hybrid projects.

Battery storage: Battery storage may be added to the hybrid project to reduce the variability; providing higher energy output for a given capacity and ensuring availability of steady power during a particular period.

State level policies

Based on the MNRE's WSH policy, governments of RE-rich states have also introduced their own WSH policies. Gujarat was the first to come up with such a policy in 2018. Rajasthan, Andhra Pradesh, and Karnataka followed. This has helped set up open access WSH projects and encouraged corporates to procure RTC power from such projects. These policies provide clarity in terms of various provisions, such as RPO, banking, settlement period, various waivers and incentives, applicability of transmission and wheeling charges and waiver in electricity duty etc.

Table 38: State-wise WSH policies

Parameter	MNRE	Gujarat*	Andhra Pradesh	Rajasthan	Karnataka
Issued in	May 2018	October 2023	January 2019	December 2019	April 2022
Capacity targets	-	-	5,000 MW	3,500 MW by fiscal 2025	-
RPO	RPO can be fulfilled separately for solar and non-solar	RPO can be fulfilled Separately as well as commonly depending on the project type	RPO can be fulfilled separately for solar and non-solar	Mandatory for discoms to purchase power equivalent to 5% of their RPO targets under this policy	RPO can be fulfilled separately for solar and non-solar
Banking	-	Rs.1.50 per unit	5% banking charges	10% banking charges	2% banking charges
CSS	-	Captive: 100% exemption Third-party sale: 25% concession	50% waived for third-party sale for projects set up within the state	-	-
Additional surcharge	-	Captive: 100% exemption Third-party sale: 25% concession	-	-	75% exemption
Transmission and wheeling charges	100% exemption for already existing plants	No waivers	50% exemption in transmission and wheeling charges for new projects developed within the state	**Hybrid:** 50% concession for captive/ third party sale for 7 years from project commissioning. **Hybrid + storage:** 75% concession for captive/ third party for 7 years from the year of commissioning	Charges will be applicable for additional transmission capacity
Electricity duty	-	100% exemption for intrastate consumption	50% exemption for intrastate consumption	100% exemption for intrastate captive consumption	100% exemption for intrastate consumption applicable for third parties

**Gujarat has issued a new RE Policy in 2023 which includes hybrid projects. Thereafter a Tariff Order for procurement of WSH power was issued in March 2024. The aforementioned provisions are as per GERC's WSH Tariff Order*

Sources: MNRE, respective state policy documents, CRISIL MI&A Consulting

5.19 Constraints in setting up hybrid power plants

Lack of good sites

WSH projects require wind and solar plants to be co-located to inject power into the same pooling station. This means the ideal location should have good irradiation and experience high wind speeds. But such locations are hard to find, especially as all major windy areas with strong grid evacuation facilities have been saturated. Hence, the industry has demanded that wind and solar plants of a WSH project be allowed to operate from different locations. This will also help bring down tariffs owing to better plant optimization levels. The only advantage of co-location is better optimization of transmission infrastructure. However, CRISIL MI&A Consulting believes the advantage from reduced tariff (when wind and solar units are located separately) is much higher than the benefit of improved transmission capacity optimization (with co-location).

Grid balancing requirement poses implementation risks

Developers are required to balance the grid before injecting electricity generated from a co-located WSH plant. This means they need to simulate the ideal wind and solar generation mix from the plant, in order to optimize the hybrid curve. This may lead to additional implementation risks for a developer.

Optimal sizing

The size of the WSH plant differs from state to state depending on the resource availability. Optimal sizing of storage is also a pertinent question. Overloading or oversizing may lead to underutilisation during the peak generation period (daytime in summers or night-time in monsoons) resulting in storage capacity remaining unutilised or idle.

Higher tariff

The average tariff for WSH projects is Rs 3.15-3.20 per kWh today — higher than solar tariff, which has dropped to Rs 2.55- 2.56 per kWh in recent bids, and comparable to wind tariff, which has remained sticky at Rs 3.40-3.75 per kWh. And although cross-subsidising costly wind power with low-cost solar will provide some price cushion at the lower end, the pricing needs to be attractive to make WSH competitive.

6 Assessment of EPC solar market in India

Executive Summary:

- EPC contracts help in the bankability of the project by allocation of different risks.
- Construct of an EPC contract includes scope, obligations of parties involved, representation and warranties, Force Majeure and Termination Clauses
- Features of an EPC contract includes Performance security/guarantee, Defect liability period (DLP), Retention money, liquidated damages and change of scope.
- To reduce costs, more developers are opting to carry out their own EPC rather than outsourcing to a contractor.
- Standalone, large EPC firms are diversifying their portfolio towards building their own generation capacities to stay competitive.

6.1 Introduction

A typical EPC solar project covers design, civil works, equipment purchase and installation, and commissioning. However, with constrained returns, the scope of an EPC solar project has been evolved and now includes O&M services also. Most of the EPC players provide integrated and customised solutions as per the client requirements through a consultative approach. Favourable government initiatives, increased demand for clean and green energy, rooftop installations by C&I Consumers have provided impetus to solar installations. The EPC services can be classified into various subcategories based on the scale and type of installations, i.e., utility scale and rooftop solar installations.

Some of the key players in EPC are Waaree Energies, Tata Power, Sterling & Wilson, Vikram Solar, BHEL, Prozeal Infra, L&T and Jakson etc. Most of these players are also present in rooftop solar installation's EPC.

The development of solar power projects in India requires a detailed and extensive process, from conceptualization to commissioning and regulatory approvals. The processes can be broadly divided into following stages:

- Conceptualization: Identification of a project location, followed by a feasibility study and project proposal preparation.
- Engineering: Design and engineering of the solar power plant, including layout, electrical infrastructure, and civil works.
- Procurement: Acquisition of equipment, materials, and services.
- Construction: Site preparation, installation of equipment, and construction of civil infrastructure.
- Commissioning: Pre-commissioning, commissioning, and performance testing to ensure the plant meets performance guarantees.
- Regulatory Approvals: Obtaining necessary permits and approvals in the during the construction and commissioning phase, including Consent to establish, Consent to operate, Fire NOC, Environment Clearance, Forest Clearance, Grid Connectivity Approval, and registration with the State Nodal Agency etc.

The regulatory framework in India is administered by the Ministry of New and Renewable Energy (MNRE), Central Electricity Regulatory Commission (CERC), and State Nodal Agencies, with key regulations and policies including the Renewable Purchase Obligation, Open Access Policy, Grid Connectivity etc. The entire EPC process typically

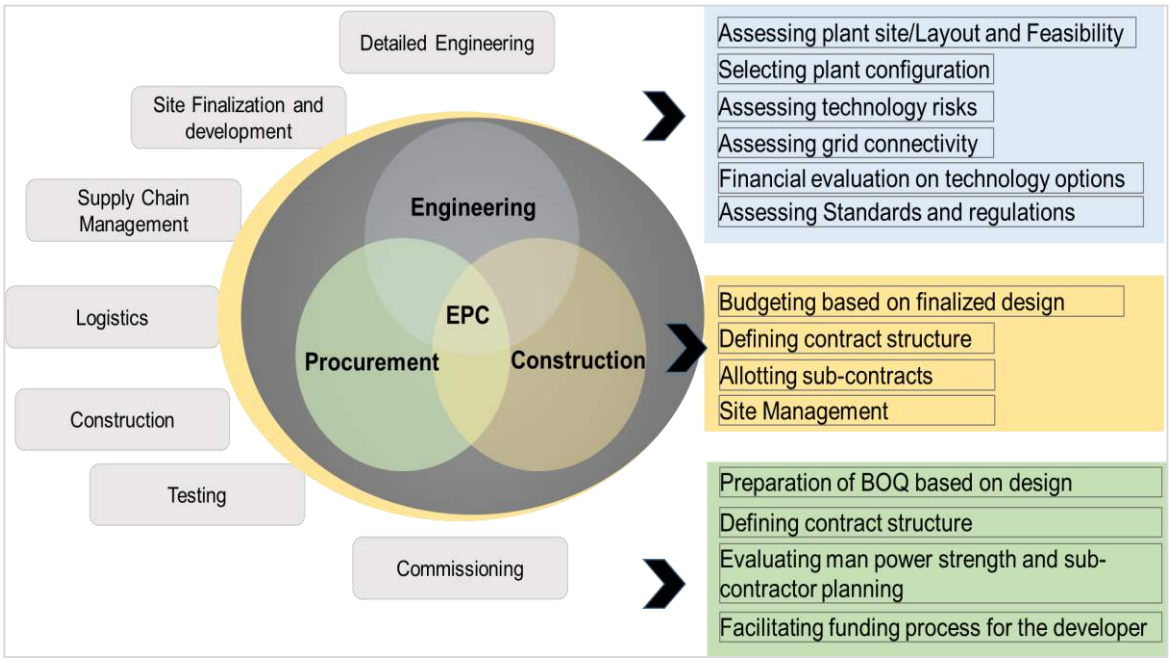
takes around approximately 12-18 months, with an additional 3-6 months for regulatory approvals. However, the process can be challenging, with common obstacles including land acquisition, grid connectivity, off takers, environmental and social impact, and financing.

The overall project works is classified as supply (material) contracts and services contracts and are awarded to different entities instead of one single EPC contractor. The capital-intensive items, such as modules, transformers, inverters and cables, covering around 75-80% of the project cost are being procured by developers. The developers enter into third-party contracts for services part, covering civil works, commissioning, erection and mounting of equipment, which forms around 20-25% of the project cost. However, some solar module manufacturers insist on buying the entire package and not just solar modules, since they also provide EPC services.

6.2 EPC project: Turnkey versus balance of plant

Nations, majorly developing ones, have been investing heavily on large infrastructure projects through public as well as private investments. To ensure efficient and timely construction, it is imperative to have an effective model which ensures timely project execution, minimise construction delays and improve transparency. The EPC model is primarily used in construction and O&M of solar plants.

Figure 73: Checklist of an EPC model



Source: CRISIL MI&A Consulting

Under turnkey project structure, the contractor holds full responsibility of design and execution of the works, including EPC. Therefore, the contractor makes the facility ready to be used at the turn of a key. The project must be delivered at a pre-determined time and pre-determined cost and the contractor must adhere to project specifications. In case of deviations, the contractor is liable to pay monetary compensation.

In case of balance of plant (BoP) structure, the entire project is broken into multiple packages with a major chunk contracted through EPC route and the rest through BoP. For a solar plant, solar modules and inverters constitute the maximum cost and may be contracted singularly whereas the supporting components and systems (wiring, switches, battery banks, power conditioners, mounting structures) may be procured from various manufacturers. Additionally, for the BoP project structure, the owner would have to appoint an external consultant or anoint the principal contractor for holistic project management and act as an interface between subcontractors.

6.3 What is an EPC contract in solar space?

Project development involves various risks such as construction risks, operational risks, legal risks, financial risks and political risks. EPC contracts are of primary importance, as they help in the bankability of the project by allocation of different risks. EPC contracting helps in the achievement of a coordinated approach among several stakeholders by establishing a single point of responsibility to the owner. In assessing the bankability of an EPC contract, investors and lenders look at a wide range of factors to assess the contract as a whole. The key features of an EPC contract are the following:

- Fixed construction price
- Fixed completion schedule
- Responsibilities and guarantees with respect to project performance and warranties
- Liquidated damages for delay and performance gaps
- Single point of responsibility on the EPC contractor
- Termination and dispute resolution

In terms of contract structuring for turnkey projects, a single contract is prepared, and the contractor owns full responsibility of the risks incidental to the project. In case of BoP projects, contracts may be structured in either of the three ways including: (a) procurement and project management services (PMS); (b) procurement only [P stage]; (c) procurement and construction [P + C stage].

a. *One 'wrapped' contract*: The solar panel supplier or the BoP contractor or an external project management consultant act as a third party and take full responsibility for coordination and delivery of the works. Such contract typically has lesser risk due to aggregation effects.

b. *Two or more different contracts (supply only):* Different components for the project are procured from different suppliers. The procurement (P stage) of BoP component is subcontracted. Potential suppliers are contacted and depending on quotations and technical specifications, works are awarded. The principal contractor is responsible for installation of the different works and deliver the plant in one piece.

c. *Two or more different contracts (Supply and installation):* Different components for the projects are procured from different suppliers and installed on site by the respective suppliers. The procurement and construction (P stage and C stage) of BoP components are subcontracted. The principal contractor monitors the works of the subcontractors. In case of noncompliance with performance specifications and /or time to delivery, the subcontractors are liable to pay liquidated damages.

6.4 What are the key criteria for selection of an EPC contractor?

Globally, the selection of an EPC contractor for any project is done in two stages:

- Initial selection: Using a checklist of qualification requirements and assessing the contractor on each of the points. The assessment may be done on a pass/fail basis against the criteria/ qualification requirements. Finally, the EPC contractor is selected if it surpasses the minimum pass/fail requirements.

Figure 74: Steps of selection for an EPC contractor

Source: World Bank, CRISIL MI&A Consulting

- Once the bidder/ proposer is deemed qualified, submitted bids/proposals are evaluated. The final selection is based on the quality of the proposal and in some cases on the cost of services (as quoted).

Methods of selection of EPC contractor:

A. **Quality and cost-based selection (QCBS):** This is the most commonly used method, which takes into account the quality of the proposal as well as the cost of services. The technical and financial proposals are submitted by the bidders at the same time in two separate sealed envelopes. Using pre-assigned weightages on technical and financial proposals (e.g., weight assigned to technical proposal: 75%, weight assigned to financial proposal: 25%), the final weighted scores are determined. The highest final score is deemed to be the winning submission.

B. **Quality-based selection (QBS):** In this method, only the quality of technical proposals is evaluated to secure the most competent candidate. Once the best (highest ranked) technical proposal is determined, the corresponding financial proposal is opened, and the submitter is invited for subsequent negotiation of financial terms. After the conclusion of negotiations, the project is awarded to the contractor.

C. **Least-cost selection (LCS):** The winning submission is determined based on lowest-priced financial proposal. The technical proposals are evaluated only to the extent of assessing minimum technical score.

Using the two-step approach (as mentioned above), the EPC contractor is successfully selected.

The performance specification section of an EPC contract details the performance criteria that the contractor must meet. However, it does not dictate how they must be met and is left to the contractor to determine. Generally, a contract highlights technical and financial eligibility criteria for prospective bidders. It tests previous experience of contractors as well and checks for healthy balance sheets (minimum net worth/ average turnover/ average net gains).

In India, the qualification criteria also majorly consist of technical and financial requirements. The technical requirements for the contractor typically include all or some of the following

a. The bidder should have a minimum of xx MWp (This value xx is a % or higher of total bid capacity) designed, supplied, erected, supervised and commissioned of solar photo voltaic (SPV)-based grid-connected power plant(s), of which at least one plant should have been of AC xx MW (a reference number in the multiples of 5 or 10 MW depending on total project size); the reference plant must have been in successful operation for at least 6 to 12 months prior to the date of techno-commercial bid opening.

b. The bidder should be an Indian company registered in India and should be a group company / holding company / subsidiary company / JV company meeting the above requirements

c. The bids of the JV company shall only be considered in certain conditions, such as the JV formed should be firmed prior to bid submission; JV with only two partners, submit role/scope of all individual partner in JV, LoI, PO and contract agreement shall be carried out with JV company etc.

Financial requirements typically include net worth and turnover requirements as stated below[1]:

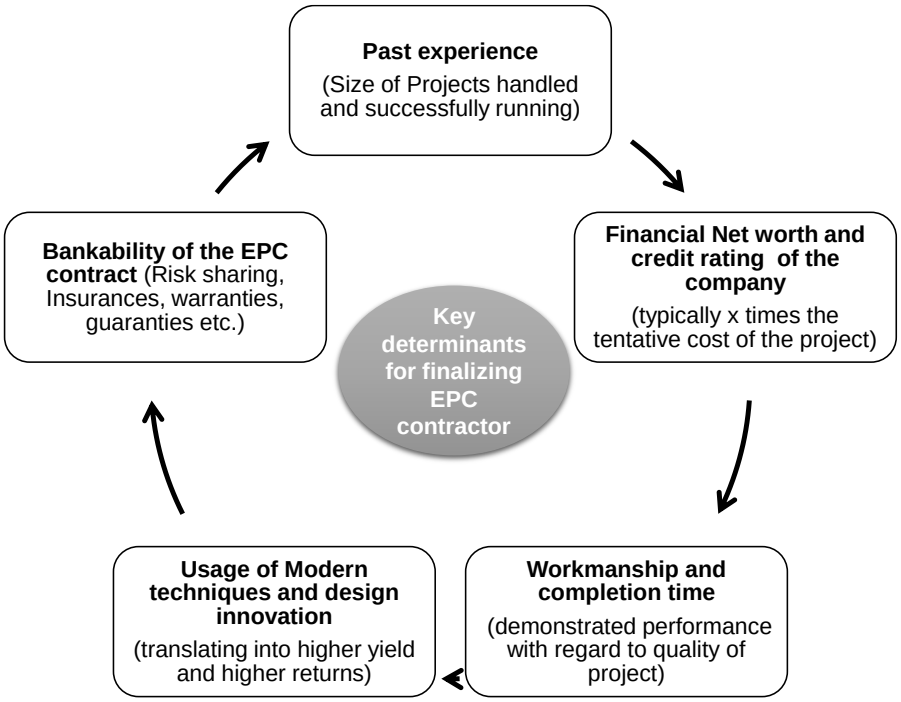
a. The bidder should have cumulative turnover of Rs. XXX for the past three financial years

b. The net worth of the bidder during the last financial year shall be positive

c. The bidder should have a minimum Working Capital of Rs. X as per the last audited financial statement. In case of inadequate working capital, Bidder to submit letter from Bank having net worth not less than Rs. XX, confirming availability of the line of credit for more than or equal to minimum Working Capital of Rs. X.

The bidder may be required to submit a bank solvency certificate of an amount as mandated by the contract. Additionally, summarised sheets of turnover and/or financial statements of the past three years typically need to be furnished.

Figure 75: Key Determinants for selecting EPC contractor



Source: CRISIL MI&A Consulting

6.5 Key covenants of EPC contract

6.5.1 Construct of an EPC contract

A. Scope of the project: Defines the provisions, specifications and standards of the project that the contractor has to adhere to. In case of a solar EPC project, the scope typically consists of the following specifications:

- Aggregate capacity of the solar plant

[1] Taken from various tenders

- Type of solar plant (rooftop/ground-mounted/floating)
- Usage of battery bank (Yes/No). If yes, capacity and specifications of battery bank including model and make of battery, type of battery management systems, power condition unit
- Operation and maintenance for given number of years

Some examples of scope of work as written in EPC tenders are summarised below:

- *"Design, engineering, supply (except PV modules), construction, erection, testing & commissioning of 300 MA (AC) ground mounted solar PV project having 5 years plant O&M"*
- *Design, engineering, supply, erection, testing and commissioning of 62 MW (AC) cumulative capacity crystalline solar PV technology grid interactive solar PV power plant with associated HT overhead transmission line / underground cable along with all required electrical equipment, construction of bays up to the point of interconnection at 220kV bays including 5 years' O&M of solar power plant and evacuation system up to the point of interconnection on EPC basis"*
- *"Design, engineering, procurement & supply, construction & erection, testing, commissioning, associated transmission system and comprehensive O&M for 5 Years of 20 MW (AC) solar PV power plant"*
- *"Design, engineering, supply, construction, erection, testing & commissioning of 100 MW (AC) floating solar PV project having 10 years plant O&M"*

The scope also talks about suppliers' responsibilities for delivering equipment on site, insurance coverage covenants of materials, supervision of assembled and supplied goods, performance testing of the project, comprehensive maintenance tenure of the project (as specified), coverage of risk liability of all personnel engaged with the project, training to O&M personnel for acquaintance of operations of the plant

B. Obligations of the contractor: Underlines the obligations which need to be fulfilled by the contractor, which may include all or few of the following: undertaking survey, investigation, design, engineering, procurement, construction, operation, maintenance of the solar plant. The contractor must also comply with applicable laws and applicable permits, as required, for the performance of its obligations. The section includes provisions and conditions for subcontracting works to other parties.

C. Obligations of the authority: Sets out the obligations of the authority, subject to receiving the performance security, towards the project like providing right of way for land, environmental and forest clearances, work permits to contractor, security on project site, implementing and/or administering safety precautions etc. Obligations of the authority majorly consist of four heads:

i. *Access and right to use of the site*: The authority grants the contractor right of access to, and make available the site to the contractor in accordance with the terms of property rights at the time of execution of the agreement

ii. *Notice to proceed*: The authority issues the notice to proceed to the contractor and the commencement date initiates thereof

iii. *Permits and real estate rights*: The contractor obtains and maintains all applicable permits necessary

iv. *Utilities*: The authority provides the facilities, components and services to be contractor, as required

v. *Safety precautions – protection of the project site:* The authority implements and administers a safety and health program for the contractor, other suppliers and contractors.

D. Representation and warranties: Highlights that the contractor is duly organised and validly exists under the laws of India to execute and deliver the performance obligations under the agreement. Additionally, the section warrants absence of breach of contract, absence of violation or default, injunction or decree of any court for the contractor and constitutes legal, binding obligation, enforceable and valid in a court of law.

E. Force Majeure and Termination Clauses: The parties (authority and / or contractor) are excused from performing their obligations if a force majeure event occurs. Such an event is beyond the reasonable control of the affected party, and the affected party could not have prevented or overcome by exercise of due diligence and has material adverse effect on the affected party. Such events include non-political events (act of God, epidemic,

extremely adverse weather conditions, lightning, earthquake), indirect political events (an act of war, invasion, armed conflict or act of foreign enemy, blockade, embargo, riot, insurrection, terrorist or military action, civil commotion etc.) and political events (change in law, revocation/ refusal to renew approval, consent or exemption required by the contractor). On occurrence of a force majeure event, either party may issue termination notice or subsequently, termination payments will be payable after due assessment.

F. **Other provisions:** May include hypothecation of materials or plant provisions, liability and indemnity by the contractor, and dispute-resolution clauses

6.5.2 Features of an EPC contract

It is imperative to negotiate a well-defined contractual arrangement that sets out the rights and obligations of each party. In practice, lenders and investors are concerned not only about the written terms of the EPC contract, but also the ability of the EPC contractor to perform the terms of the EPC contract as per laid down norms. To shield the EPC contract from counter-party (contractor) risk, emanating from sub-par performance and/or non-adherence with contract obligations, it is standard for the contractor to include checkpoints

1. **Performance security/guarantee:** Irrevocable and unconditional guarantee for specified percentage of the contract price within ~21 to 30 days from the receipt of Letter of Award. Typically, performance guarantee is ~5 to 10% of the contract value. The performance security remains valid for a claim period after the expiry of the Defects Liability Period (DLP); explained below). The authority releases the performance security within the claim period of the expiry of the DLP or issuance of final acceptance certificate. The authority will not be obliged to release the security until all defects identified within the DLP are not rectified by the contractor. Additionally, if a project fails to generate any power continuously for a specified time any time (as stated in the contract) during the O&M period, it may be considered as “an event of default” and the entire bank guarantee will be encashed. Any time during the tenure of the project, the nodal agency/authority reserves the right to forfeit the Performance Guarantee of the bidder, to blacklist the bidders and may also cancel the contract if the bidder is found to be providing false information regarding debarred / blacklisted or conceals the facts in this regard

2. **Defect liability period (DLP):** The period of validity of the warranties given by the contractor commencing at operational acceptance of the facilities, during which the contractor is responsible for correcting all defects and deficiencies with respect to the operation of the facilities. A Defect Liability Period may be for a duration up to the end of the O&M period or as for any duration extended by the mutual agreement of both the parties. The DLP may be extended upon repair/replacement of the facilities. At the end of the period, the contractor’s liability ceases except for latent defects (plant and equipment warranties, spare warranties, etc.).

   Typical DLP clauses from one Tender are reproduced below:
   “The Contractor shall also be undertaking the operation and maintenance of the Facility and consequently shall be required to rectify any defects that emerge during the operation of the Facilities for the entire term of this Contract.
   The Defect Liability Period shall be of twelve (12) months from the date of Operation Acceptance, during which the Contractor must repair any defect identified by the Project Manager / EIC after commissioning of the Plant. All the expenses to repair the defects shall be borne by the Contractor and no additional cost charged to the Owner.
   If during the Defect Liability Period any defect should be found in the design, engineering, materials and workmanship of the Plant and Equipment supplied or of the work executed by the Contractor, the Contractor shall promptly, in consultation and agreement with the Owner regarding appropriate remedying of the defects, and at its cost, repair, replace or otherwise make good (as the Contractor shall, at its discretion, determine) such defect as well as any damage to the Facilities caused by such defect.
   Furthermore, without prejudice to the generality of the foregoing, it is clarified that the Contractor shall also be responsible for the repair, replacement or making good of any defect, or of any damage to the Facilities arising out of or resulting from any of the following causes:
   - *Improper operation or maintenance of the Facilities by the Contractor during operation and maintenance of the Facility; and*

- *Operation of the Facilities outside specifications of the Facilities.*

If the Facilities or any part thereof cannot be used by reason of such defect and/or making good of such defect, the Defect Liability Period of the Facilities or such part, as the case may be, shall be extended by a period equal to the period during which the Facilities or such part cannot be used by the Owner because of any of the aforesaid reasons. Upon correction of the defects in the Facilities or any part thereof by repair/replacement, such repair/replacement shall have the defect liability period of twelve (12) months from such replacement.
Latent defect liability: Notwithstanding, the defect liability period of 12 months above, the plant shall carry a latent defect liability of 5 years from date of operational acceptance towards any design/ manufacturing defects in the equipment supplied by the Contractor"

3. **Delay liquidated damages (DLD):** The contractor is mandated to complete the facilities/ project pursuant to the time of completion. Typically, the timeline for the project is clearly highlighted in the contract and indicative milestones are mentioned.
The table below is a snippet of the project timelines:

Table 39: Typical project timelines

Stage	Reference from Zero Date ("D")
Handing over of project land.	Zero Date (D)
Site development work	D+45 days
Approval of all major drawings	D+100 days
Completion of civil works	D+150 days
Completion of supply of equipment	D+270 days
Installation of all equipment & Interconnection of all equipment and completion of installation	D+330 days
Achievement of Commissioning with entire contracted capacity	D+365 days

Source: Various Bid documents, CRISIL MI&A Consulting

If the contractor is unable to achieve operational acceptance within the stipulated time, it is liable to pay liquidated damages for the delay as mentioned in the contract. Different types of pf DLD clauses are reproduced below:

- *"Subject to Force Majeure Clause, if the Contractor fails to comply with the Time for Completion /successful commissioning or any extension thereof of Plant facilities in accordance with timelines as mentioned under the SCC, then the Contractor shall pay to the Owner a sum equivalent to half percent (0.5%) per week of the Contract Price for the whole of the facilities as liquidated damages for such default and not as a penalty, without prejudice to the Owner's other remedies under the Contract subject to the maximum limit of five percent (05%) of Contract Price for the whole of the facilities……."*
- *"If the contractor fails to maintain the required progress in terms of the agreed time and progress chart or to complete the work and clear the site on or before the date of completion of contract or extended date of completion, he shall without prejudice to any other right or remedy available under the law to the company on account of such breach, pay as compensation/ Liquidated Damages @ half percent (1/2%) of the contract price per week of delay. The aggregate of such compensation/ compensations shall not exceed 10 (ten) percent of the total value as shown in the contract……."*
- *"In case of contractor fails to achieve milestone no.2 (Supply milestone) by the due date indicated in "Time of Completion' then the Owner shall levy the Liquidated Damages on the Contractor at the rate of 5% of total supply price (Milestone no.2) inclusive of taxes.*

  In case the Contractor fails to achieve Milestone no.1, 3, 4 & 5 by the due date indicated in "Time of Completion' then the Owner shall levy the Liquidated Damages on the Contractor at the rate of 1.0% (one

percent) per week of delay or part thereof, subject to a maximum of 5.0% (five percent) of total contract price inclusive of taxes (exclusive of O&M cost).

LD amount will be inclusive of taxes. Also Goods & Service Tax (GST) if applicable on Liquidated Damages (LD) as per GST Law, shall be recovered from any due claim OR payment to the EPC Contractor……"

4. **Performance liquidated damage (PLD):** Performance guarantees are backed by the output, efficiency and reliability of the project, as defined in the scope. Post operational acceptance and until the expiry of the O&M period, the bidder would be required meet the specified conditions in the contract. This may include performance requirements, minimum generation requirements, etc. In case of non-compliance, the bidder is liable to pay compensation in the form of liquidated damages. PLD is generally calculated on the basis of loss in energy incidental due to deviance. Different types of pf DLD clauses are reproduced below:
   - *"If in any case the net actual units (kWh) generated for a year is below the quoted Guaranteed Electrical Energy Generation and up to 2% below quoted Guaranteed Electrical Energy Generation, the Contractor shall be liable to a penalty to the extent of 50% of the loss in revenue…*
     Further if net actual units (kWh) generated is beyond 2% below quoted Guaranteed Electrical Energy Generation, the Contractor shall be liable to a penalty to the extent of 100% of the loss in revenue…."
   - *"Compensation for shortfall in Generation during O&M Period for the project: Shortfall in Generation x per unit rate"*
   - *"If for any Contract Year, it is found that the 'Actual Delivered Energy' is less than 'Base NEEGG for the particular year, the Contractor shall pay the compensation equivalent to INR (PPA rate x 1.25) per kWh shall be charged for the under-generation."*
5. **Change of scope:** The authority may require the contractor to make modifications/alterations to the works before the issue of completion certificate. The contractor may be instructed or requested to make the change of scope involving additional cost or reduction in cost. After determining the time and money for the desired change, a change of scope notice will be issued to the contractor, highlighting modifications in design and/or construction, etc. However, both parties must mutually agree with the proposed changes.

6.5.3 Highlights of contract construct for BoP solar projects

a. **Construction scope and timelines:** A turnkey or full wrap agreement (E+P+C) places full responsibility on the contractor from start to finish, including design, supply, construction, and warranty of the solar plant. However, in many cases, the developer may enter into separate agreements, one for the principal component supply (solar panel) [installation inclusive/ exclusive] and others for procurement and installation of miscellaneous services. The BoP contracts with different equipment suppliers must be matched in major covenants: (a) delivery, (b) project completion, and (c) product and service warranties. The agreements must be aligned with each other such that the different component suppliers work in tandem to ensure completion of the plant on time. Delay at any one of the suppliers' end may jeopardise timely completion. Therefore, scope of work in the BoP agreements needs to clearly highlight timelines and design specifications to ensure standardisation and optimisation.

b. **Startup obligations:** In a typical contract, payments are scheduled depending on achieving specific milestones towards project completion. In a BoP project structure, the owner entrusts a consultant or the major contractor or the individual parts supplier to start and commission the products it supplies. Therefore, performance guarantees, retention money (for claims, repairs, liens) and payment schedules for each party need to be added in the different agreements. The parties may negotiate milestones to manage vendor specific risks and contingencies.

c. **Performance guarantees and warranties:** Warranties obligations for different parties will be to the tune of the service provided. If a contractor is supplying parts and installation services to the solar plant, the owner/developer typically has the right to assert direct claims for the warranties provided by the sub-contractors. In case the contractor is providing only installation services, warranties are limited in scope relative to an equipment provider.

Therefore, the nature and scope of performance guarantees and warranties differ depending on the nature of work sub-contracted to the relevant party. The major differences may include: (a) term of the warranty, (b) type of defect covered in the warranty, (c) warranty limitations, and (d) remedial measures to be taken by the contractor/ sub-contractor in case of defects. The project developer may also include a pass-through clause such that all warranties obtained by the contractor with respect to any parts and systems used in the systems are assigned to the developer.

Table 40: Summary of standard market practices in the solar EPC Industry

Sr. No.	Key determinants under the EPC contract	Tentative ranges based on the industry
1	Performance ratio	75-80%
2	Warranties and guarantees on solar modules and inverters	5–10-year warranties on solar Inverters Performance warranty on PV modules for peak output wattage, >= 90% at the end of 10 years and 80-85% at the end of 25 years)
3	Warranties and guarantees on balance of plants	To be provided by the EPC contractor (or under pass through)
4	Liquidated damage costs /delay penalties	~0.5% to 1% per week of the Contract Price subject to the maximum limit of 5% to 10% of Contract Price
5	Advance bank guarantees	~10% of the contract value, to be released within three months of the end of the contract/tenure
6	Insurance cost	Can be a part of the EPC contract (*To cover execution risk*) or taken separately by the developer (g*eneration loss due to grid unavailability)*
7	Power during construction	To be provided by the developer *(grid interconnection)* or EPC contractor *(diesel-based power)*
8	Liasoning and regulatory approvals	The responsibilities can be shared or can be taken up by either of the parties

Source: CRISIL MI&A Consulting

6.6 Project execution using in-house EPC vs outsourcing to specialised EPC players

The Indian solar market has been booming, with capacity additions rising to average ~9000 MW in the past five years (fiscals 2020-24) from 780 MW in fiscal 2013. Several projects have been commissioned under the central schemes of NVVN Tranche 1 and JNNSM Phase II and Batch III. Complementary central and state government policies coupled with the increasing price competitiveness of solar power has led to a surge in solar installations. However, declining module prices and aggressive competitive bidding on the part of players has led to lower solar power tariffs. This has constrained margins for EPC players. To reduce costs, more developers are opting to carry out their own EPC rather than outsourcing to a contractor. Project developers are becoming system integrators, thereby providing holistic turnkey solutions. Standalone, large EPC firms are diversifying their portfolio towards building their own generation capacities to stay competitive. Smaller EPC firms without the financial prowess for project development are vertically integrating into captive projects and rooftop installations.

Following are some of the key considerations while making decisions.

- Size and complexity of the project
- Budget
- Timelines
- Own level of expertise

- Desired level of control over project

6.6.1 Pros and cons of different business models

Factor	In-house EPC	Outsourcing to large, specialised EPC contractors
Equipment costs	1. Players are likely to get bulk discounts on the prices of solar modules and inverters only if the project size of the developer is large enough (for the equipment supplier, typically >100 MW size). Hence, offering deep discounts is a challenge. 2. Availability of equipment financing possible only for large capacities and long-term relationship/tie-ups.	1. In the case of turnkey EPC contracts, players with large order books benefit from bulk buying/import of components such as modules and inverters. Hence, they can quote competitive rates, with minimal impact on margins. 2. Most large EPC players get the benefit of equipment financing from the module/inverter supplier.
Project management and timelines	1. Project development and meeting deadlines in the case of in-house EPC projects could be a challenge for relatively new and smaller players in the market. 2. In-house EPC players tend to sublet more of their work to smaller contractors resulting in elongation of project completion deadlines.	Led by varied experience across various geographies, project sizes and teams, project management is smoother. Likelihood of timely project completion is higher owing to better supply chain management.
Warranties, guaranties/ Spare part availability	The developer and O&M contractor bear the entire risk arising due to loss of generation led by multiple technical factors. However, it can be controlled by reducing the replacement time of faulty equipment. The problem is aggravated since major components such as solar modules and inverters are imported, resulting in higher lead time. Hence, in the case of in-house EPC projects, O&M contractors are appointed	As large EPC contractors also provide warranties and guarantees post commissioning, the lead time for spare parts to be available at the site is less. This reduces generation loss, especially in the peak power generation summer season.
Risk diversification	Although the solar industry is growing, it is still prone to volatility and uncertainty. Solar panels, the major component for a solar plant, are still majorly imported and susceptible to price fluctuations and local taxes (anti-dumping duty, safeguard duty). With capital costs as well as tariffs coming down due to maturing of the market and rise in competitors, solar project margins have also been coming down. In such a scenario, being vertically integrated across development and EPC contracting gives a company more scope to diversify risks and secure finance.	EPC players aim at playing with scale and cost to improve margins. However, with the top line for the companies falling on a per-project basis (developers not keen to raise EPC and O&M costs), stagnation tends to set in. Most EPC players have already reduced costs by taking strong efficiency measures and more breathing room is unlikely. This leads to risk aggregation and any untoward volatility in the market may distort margins.

Factor	In-house EPC	Outsourcing to large, specialised EPC contractors
Horizontal expansion	Horizontal expansion is restricted to the tune of business expansion.	In order to grab larger market share in the business, large and established EPC players foray abroad. With the emergence of international markets in the solar sector such as Africa, Middle East, South east Asia, and South America, these players are building upon efficiency and low-cost capabilities to win tenders and augment portfolios.
Firm sustenance and continuity	With solar development coming closer to EPC and concept-to-commissioning being offered in one suite, project developers will build on in-house solutions. However, merger deals for vertical integration are unlikely and companies would prefer investing in building in-house capabilities rather than buying specialised EPC firms	With the solar sector in India maturing, the sector may see consolidation and merger deals. With pricing pressures and thinning margins, only large and specialised EPC players are likely to remain in business. Bigger players like Sterling Wilson, Mahindra Susten, and Tata Power Solar will continue to have a strong market presence. However, small firms may not be able to sustain due to lower margins.

	Cons
	Pros
	Cannot be ascertained

7 Overview of solar module manufacturing

Executive Summary:

- China's role in solar PV supply chain has become more critical as it holds more than 75% of cells and module lines, leading to high dependence from a global supply chain perspective.
- Global solar PV manufacturing capacity is projected to approach nearly 1000 GW by 2024 a capacity sufficient to cater to the expected annual demand of nearly ~650 GW by the year 2030 as projected by International Energy Agency (IEA).
- Currently, the solar PV market is predominantly dominated by monocrystalline silicon technology; in future more advanced cell designs such as heterojunction (HJT), TOPCon, and back contact will gain greater market shares
- Global solar PV manufacturers are present across the PV value chain, and operate on a larger scale; hence, enjoy significant cost advantages.
- India's solar PV manufacturing capacity to reach 120-125 GW by fiscal 2029 from 63 GW in fiscal 2024
- It is estimated that only 1/10 of the domestic demand to be import reliant by fiscal 2029
- Cumulative exports between fiscal 2024-29 expected to surpass 50 GW
- Due to sharp decline in module prices, stabilisation of raw material prices and logistics costs, average module prices remained in the range of $0.19-0.26 per Wp in fiscal 2024 for mono-crystalline, higher than fiscal 2022 prices.

7.1 Overview of Global PV Module manufacturing

Over the past decade, there has been a significant geographical transformation in solar PV manufacturing capacity and production. China reinforced its dominant position as a manufacturer of wafers, cells, and modules by increasing its share of global polysilicon production capacity nearly three times. China's role in supply chain becomes more critical as it holds more than 75% of cells and module lines, leading to high dependence from a global supply chain perspective.

In terms of wafers, China faces minimal competition as it dominates the manufacturing sector. However, when it comes to cells and modules, Southeast Asia, particularly countries like Vietnam, Malaysia, and Thailand, possesses significant manufacturing capacity. These countries have emerged as key players in cell and module production, offering strong competition to China in this segment of the solar PV industry.

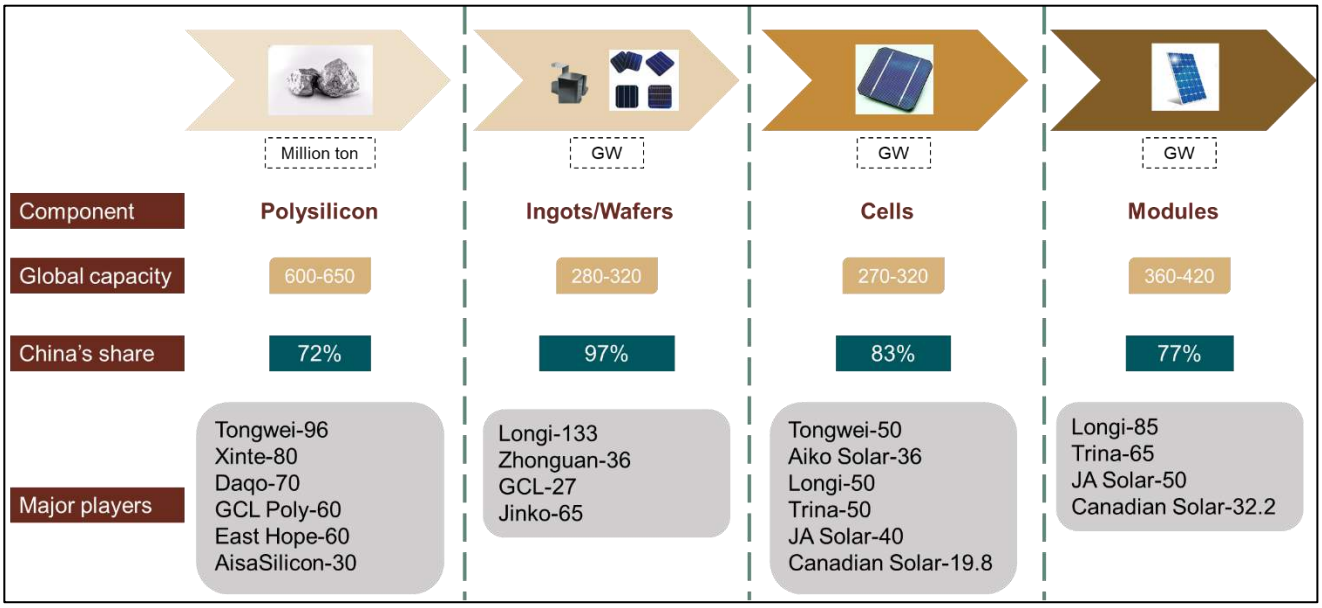
Germany maintains its status as a major supplier of polysilicon for the crystalline silicon (c-Si) PV module industry. In addition to Germany, the United States and Japan also possess significant polysilicon manufacturing capacity. However, these countries primarily focus their production on semiconductor-grade products, rather than specifically catering to the PV industry.

Module assembly in the solar PV industry has a relatively diversified geographic distribution. However, it is important to note that the majority of inputs required for module assembly, such as wafers, cells, and other components, are manufactured in China. Despite the diversified assembly locations, China remains the primary source for the manufacturing of essential PV components.

Having integrated solar PV manufacturing plants that produce wafers, cells, and modules all under one roof have certain advantages such as improved efficiency and cost reduction. With reduced transportation costs and economies

of scale, these plants can optimize their production flow and have better quality control. Integrated solar PV manufacturing plants also provide greater flexibility and supply chain security. The manufacturer can respond to changes in demand efficiently, dependence on external suppliers gets reduced and with access to advanced technologies, it can certainly gain competitive advantages in terms of quality as well as price.

Figure 76: China's share in solar value chain



Source: Company websites, CRISIL MI&A Consulting

First mover advantage combined with technological development under various incentive programs, has helped large scale integrated manufacturing base to be set up in China. Chinese dominance can be expected to continue as players such as Jinko are looking to expand their capacities more than 1.5 times, while polysilicon manufacturers such as Xinte have already booked orders for next 3-5 years for a facility yet to commission.

Over the past decade, China has emerged as the top destination for solar PV manufacture as a result of favourable government policies, continuous innovation and accelerated investments in the segment, surpassing Europe, Japan and the United States. Global PV shipments during 2022 crossed 300 GW, of which the top 10 players, including LONGi Solar, Trina Solar, Jinko Solar, accounted for a share of ~ 80% in shipments.

The global solar PV manufacturing capacity is projected to approach nearly 1000 GW by 2024 a capacity sufficient to cater to the expected annual demand of nearly ~650 GW by the year 2030 as projected by International Energy Agency (IEA). In 2022, global solar PV manufacturing capacity increased by over 70% to reach almost 450 GW, with China accounting for over 95% of new facilities throughout the supply chain. Governments in the US, Europe and India have already begun to prioritise solar PV supply chain diversification, implementing policies such as India's PLI scheme and the US IRA to provide direct financial incentives for domestic manufacturers to increase their competitiveness with Chinese counterparts. These country specific measures are expected to boost manufacturing capacities across the countries and would result in meeting the global demand by 2030.

Over the past decade, China has emerged as the top destination for solar PV manufacture as a result of favourable government policies, continuous innovation and accelerated investments in the segment, surpassing Europe, Japan and the United States. Global PV shipments during 2022 crossed 300 GW, of which the top 10 players, including LONGi Solar, Trina Solar, Jinko Solar, accounted for a share of ~ 80% in shipments.

Table 41: Comparative summary of global module manufacturers

Parameter	LONGi Solar	Trina Solar	Jinko Solar	JA Solar	Canadian Solar	Risen Energy
Number of manufacturing factories	8 in China	4 in China, 1 each in Thailand and Vietnam	14 in China, Vietnam, Malaysia and USA	12 in China and Vietnam	20 in Canada, China, Brazil, Thailand and Vietnam	4 in China, 1 in Malaysia
Experience in PV module manufacturing	23 years	26 years	17 years	18 years	22 years	21 years
Operational Capacity 2015	NA	5.1 GW Modules 3.7 GW Cells	4.7 GW Modules 3.0 GW Cells	4.0 GW Modules 4.0 GW Cells	4.3 GW Modules 2.7 GW Cells	NA
Operational capacity (As on Dec-23)	120 GW modules 80 GW cells 170 GW wafers	95 GW modules 75 GW cells 55 GW wafers 7 GW trackers	110 GW modules 90 GW cells 85 GW wafers	40 GW modules 56 GW cells 45 GW wafers	57 GW modules 19.8 GW cells 20 GW wafers	25.1 GW modules
Under-construction capacity	150 GW modules 100 GW cells 200 GW wafers	30 GW modules 25 GW cells 6.5 GW wafers	20 GW modules 40 GW cells 35 GW wafers	10 GW modules 30 GW cells 30 GW wafers	42.2 GW modules 40.2 GW cells 30 GW wafers 30 GW ingots	16 GW modules 19 GW cells
Product shipments (CY 23)	125.42 GW wafers 67.52 GW modules	65.21 GW modules	54 GW modules, 2.1 GW cells and wafers	57 GW modules and cells	30.7 GW modules	16 GW modules
Key Products and services	Solar PV modules, wafers, solutions for C&I, utility, and rooftop use	Solar PV modules, solar trackers, utility solutions, EPCM services	Solar PV modules, energy storage systems, C&I and rooftop solutions	Solar PV modules, energy storage systems for domestic and C&I use	Solar PV modules, energy storage, inverters, EPC	Solar PV modules, energy storage systems, EPC services

Parameter		LONGi Solar	Trina Solar	Jinko Solar	JA Solar	Canadian Solar	Risen Energy
Ky Technologies offered		TOPCon, Mono PERC, bi-facial module, half-cut cells	Bi-facial PERC, TOPCon, HJT, half-cut cells	Half-cell, bi-facial and tilling ribbon technologies, PERC and TOPCon	TOPCon, Mono PERC, bi-facial module, half-cut cells	TOPCon Bifacial and Monofacial, HJT modules, Dual Cell PERC,	Mono PERC, bi-facial PERC, bi-facial HJT modules, TOPCon
Key Financials (CY 23)	Revenue	$28.5 bn	$24.9 bn	$16 bn	$17.9 bn	$7.6 bn	$4.8 bn
	Net profit	$2.4 bn	$1.2 bn	$2.687 bn	$1.5 bn	$213 mn	$218 mn

Source: Company websites, CRISIL MI&A Consulting

While China dominates solar PV manufacturing, the United States and the European Union have also emerged as global PV hubs. The US imported ~75% of its cells and modules requirements from Southeast Asian countries namely, Malaysia, Thailand, Vietnam and Cambodia. In order to reduce dependence on imported products, the government announced several measures such as anti-dumping duty on shipments from China and Taiwan, 18% safeguard duty on cells and modules, as well as the passing of the Inflation Reduction Act (IRA) in 2022. US PV module production stood at ~34 GW in March 2024 and the Department of Energy has targeted an integrated manufacturing capacity of 50GW by 2030. In order to achieve this goal, several key players have announced their expansion plans as follows:

Table 42: Planned capacity additions for PV module manufacturing in US

US Market	PV Capacity Addition (GW)	Year of Commissioning
Q Cells	6.7	2024
SPI Energy	4.7	2024
First Solar	4.4	2025
3Sun	3.0	2024
Toledo Solar	2.8	2027
Mission Solar	0.7	2024
Meyer Burgur	0.4	2024
TOTAL	**22.7**	

Source: Company websites, CRISIL MI&A Consulting

The European Union is another key destination for module manufacture with a target to reach 30 GW solar module production by 2025, from its current capacity of 9.4 GW. As per announcements by key manufacturers, 15-20 GW of expansion is expected for modules, cells and wafers/ingots each, in addition to 30 GW of polysilicon manufacture by 2025. Expansion plans for cell and module manufacture by major players are given below:

Table 43: Planned capacity additions for PV module manufacturing in EU

EU Additions	Modules (GW)	Cells (GW)	Year of Commissioning
MCPV	6.0	6.0	2025
CARBON Solar	3.5	5.0	2025
Oxford PV	1.9	1.9	2024
Astrasun Solar	1.2	1.5	2024
Meyer Burgur	2.8	-	2024
Enel 3Sun	2.8	-	2024
FuturaSun	2.0	-	2024
SoliTek	0.6	-	2024
Voltec Solar	0.2	-	2023
TOTAL	**21.0**	**14.4**	

Source: Company websites, CRISIL MI&A Consulting

Global solar capacity additions will be largely policy driven across key markets:

China: NEA's "Guideline on Energy Work In 2023" targets to increase China's installed capacity of wind power and photovoltaic power by 160 GW over the year. Capacity additions will further be driven by $140,000 allocated to support feed-in-tariff (FiT) based projects, R&D programs & fiscal incentives.

USA: The extension of production tax credit (PTC) and investment tax credit (ITC) proposed by US government is envisaged to promote capacity additions. However, the planned phase out of tariffs on solar imports from China and full restrictions on imports from Xinjiang region, remain monitorable. The IRA aims to reduce domestic inflation and established an Advanced Manufacturing Production Credit to promote domestic manufacture of solar modules and its components offering solar tax credit of 30% till 2032.

Japan: Latest feed in tariffs unveiled in February 2022 were reduced from before and may cause capacity additions to slow down or even stagnate.

Germany: It is expected to record 4-5 GW of capacity additions annually, which may increase as the government is looking to move away from gas-based generation owing to geopolitical factors. Additionally, removal of cap on solar subsidies may also bolster capacity additions.

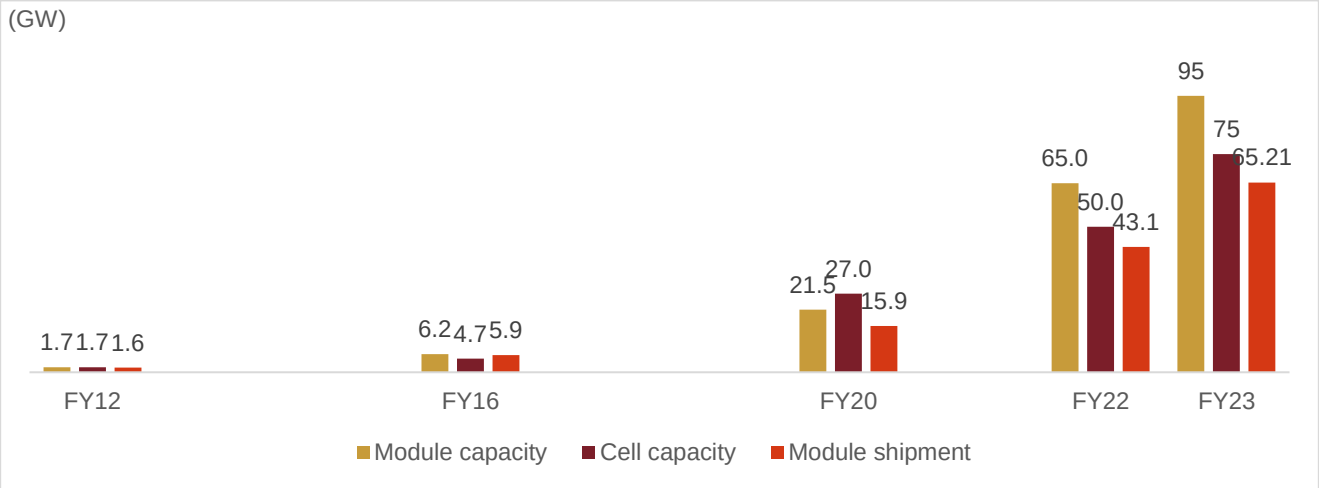
Spain: Spain has targeted to add ~81 GW of solar energy installed capacity by 2030. The Spanish PV market is predominantly focused on the utility sector, which holds 60% of the market share, followed by the commercial and industrial (C&I) sector at 27%, and the residential sector at 13%. Spain has been a leader in renewable energy adoption, and its ongoing investments in solar infrastructure are likely to continue driving rapid capacity additions.

7.2 Case study of Trina Solar

Trina Solar was founded in 1997 in China. The company initially started as a small manufacturer of solar PV modules and systems. During its early years, Trina Solar focused on research and development to improve the efficiency and cost-effectiveness of solar panels. Subsequently, the company got engaged in the production and sales of PV modules, power stations and system products, PV power generation, O&M services.

As of 2023, the Company has 10+ manufacturing bases spread across 5 countries and has 95 GW of module production capacity and 75 GW of cell production capacity cumulatively. The manufacturing capacity of solar cells and modules has increased at CAGR of 36% and 39%, respectively, over the past 11 years. The annual shipment has also increased to 35% CAGR over the same period. The total module shipment exceeded 205 GW as of December 2023.

Figure 77: Solar module and cell production capacity



Key Milestones and growth drivers for scaling up the manufacturing portfolio:

Technological Innovation: Trina Solar has consistently invested in research and development to enhance the efficiency of its solar panels. They were one of the first companies to mass-produce high-efficiency solar panels, which helped them gain a competitive edge in the market.

Global Expansion: In the mid-2000s, Trina Solar expanded its reach beyond China and started exporting its products to international markets. The company established a presence in Europe, the United States, and other parts of Asia. This global expansion strategy allowed them to tap into growing solar energy markets worldwide. It has set up regional headquarters in various parts of the world.

Vertical Integration: Trina Solar adopted a vertically integrated business model. The Company has announced 6.5 GW of silicon wafer facility in Vietnam This integration helped ensure quality control and cost-efficiency, making them competitive in the global solar market.

Technological Advancements and investments in R&D: The company continued to invest heavily in research and development, striving to produce higher efficiency solar panels and reduce the cost of solar energy. Trina Solar was an early adopter of advanced solar technologies, such as Mono PERC, Bifacial, HJT and TOPCon modules. These innovations improved the efficiency and performance of their solar panels which help them remain competitive in an evolving market.

Market Leadership: Through continuous innovation, a strong commitment to quality, and a competitive pricing strategy, Trina Solar gained a reputation as a leading solar PV manufacturer. The Company has a strong presence of 15-18% in global market share as of 2023 based on module shipments. This leadership position helped them secure partnerships with major solar project developers and utilities worldwide.

IPO and Global Recognition: In 2006, Trina Solar went public on the New York Stock Exchange (NYSE). This move not only provided capital for further expansion but also increased their global visibility.

Trina Solar's success story is a testament to the company's dedication to innovation, quality, and sustainability. Their journey from a small firm to a global leader in the solar industry demonstrates the potential for companies in the renewable energy sector to scale up and contribute to the global transition toward clean energy solutions.

7.3 Global technology trends

In 2020, COVID-19 and subsequent lockdowns posed considerable challenges globally. Despite the slowdown, PV deployment will continue to flourish due to its competitive cost. Solar technology is evolving every year and prices of modules are decreasing, both monofacial and bifacial modules. As a result, bifacial modules are preferred even in utility-scale projects. The global PV industry is moving towards monocrystalline cell technology from polycrystalline cells. The share of monocrystalline technology is now about 97%[2] (compared with 66% in 2019) of total crystalline silicon (c-Si) production. The performance ratio has also been improved in the 80-90% range. The c-Si segment is expected to grow substantially due to c-Si's long life and light weight. Monocrystalline solar PV panels possess high efficiency, and hence, preferred.

The future of PV modules is heavily reliant on technological innovations. Innovation plays a vital role in driving technological advancements throughout the clean energy supply chains. Within the solar PV sector, continuous technological innovation has led to notable improvements such as increased conversion efficiency of solar cells, reduced material usage, and enhanced energy efficiency per module.

Over the past decade, solar PV cells have become approximately 60% more efficient, while generation costs have seen a remarkable decline of almost 80%. These achievements have been made possible through the combination of public and private investments in research and development (R&D) efforts across the entire solar PV supply chain.

The affordability of solar PV as an electricity generation technology in various parts of the world can be attributed to these investments in R&D. Without such dedicated support, the cost reductions and advancements witnessed in the solar PV industry would not have been attainable. Hence, ongoing investments in R&D, both from the public and private sectors, continue to be essential to drive further innovation, cost reduction, and efficiency gains in the solar PV sector. Japan, Germany, United States and Switzerland, are considered pioneers in solar technology and have high-quality equipment in relation to solar.

Currently, the solar PV market is predominantly dominated by monocrystalline silicon technology. This is primarily due to its high efficiency levels and competitive pricing. However, ongoing technology innovation in manufacturing processes is crucial to reduce material intensity, especially for critical minerals like silver and copper. These efforts aim to minimize vulnerabilities in the supply chain.

In addition to process improvements, the development of new solar cell designs is essential for achieving further efficiency gains while simultaneously reducing material intensity and manufacturing costs. Multiple companies are

[2] Fraunhofer ISE: Photovoltaics Report, updated: 17 May 2024

actively working on tandem and perovskite technologies. These innovative designs hold the potential to enhance the performance of solar cells. However, additional investment in R&D will be required to bring these technologies to full commercialization.

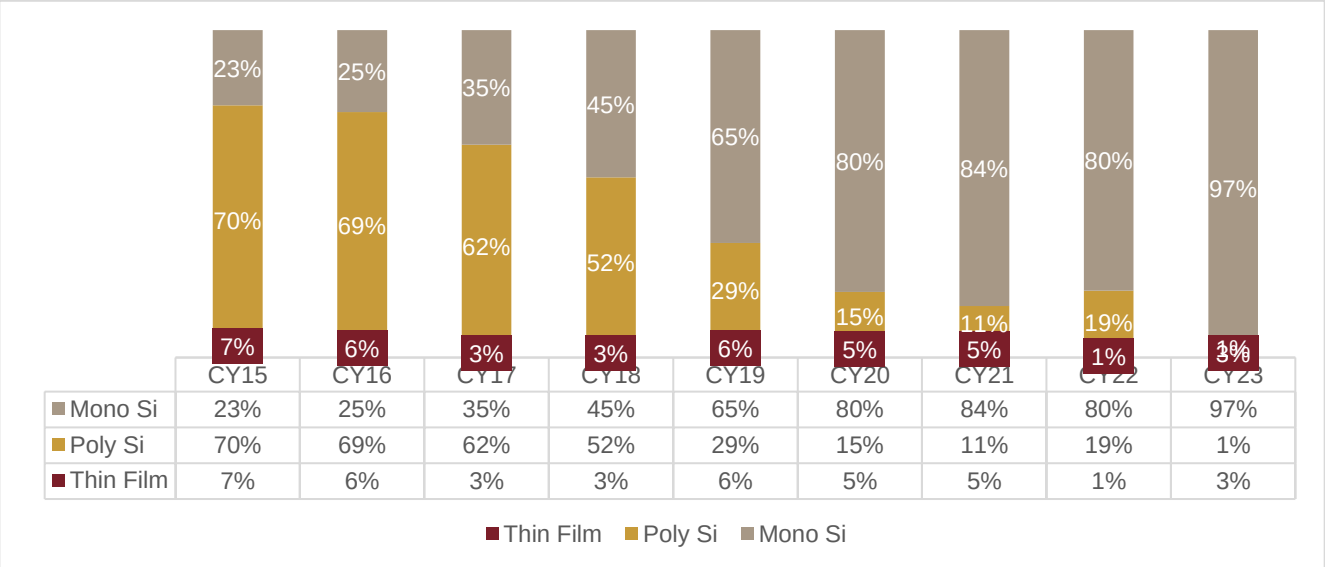
Figure 78: Existing vs upcoming technologies

Parameters	Mono PERC	TOPCon	HJT
Initial Capex	$ 31-38 mn./GW	$ 38-46 mn./GW	$ 69-75 mn./GW
Cell Efficiency	23.2% - 23.7%	24.5% - 25.2%	24.5% - 25.2%
Module Efficiency	20.0% – 21.5%	22.0% - 23.0%	22.0% - 23.0%
Bi-faciality	70% - 75%	80% - 85%	80% - 90%
Complexity	Moderately complex	Less than HJT	Most complex
Temperature Co-efficient of Power (Pmax Temperature Co-efficient)	• -0.35% / °C. • PERC cells experience a more noticeable power decline at elevated temperatures	• -0.29% / °C. • Offers a significant power improvement over PERC cell at elevated temperatures	• -0.24% to -0.26% / °C. • Lowest temperature coefficient - HJT cells experience minimal power loss even at high temperatures.
Losses and Damages	p-type Mono PERC cells are prone to LID and PID losses. Such losses are high compared to peers	PID and LID losses in TOPCon are lower compared to Mono PERC,	Not prone to PID and LID losses, since general cell construction is n-type

Note: Initial capex for module manufacturing lines pertains to Chinese set-ups.
Potential Induced Degradation (PID) and Light Induced Degradation (LID)
Source: Industry, CRISIL MI&A Consulting

In the coming years, it is expected that more advanced cell designs such as heterojunction (HJT), TOPCon, and back contact will gain greater market shares. These cell designs hold the potential for achieving additional efficiency gains in solar panels.

Figure 79: Module technology share



Source: Industry, CRISIL MI&A Consulting

More than 85-90% of Indian solar module manufacturers have shifted to Mono-PERC and Mono-PERC is expected to dominate the technology for the next 2-3 years. Most of the Indian manufacturers have set up or planning to set

up new facilities with an option of upgradation to newer technologies. Some of the Companies have existing manufacturing facilities which can be upgraded to TOPCon technology. Reliance New Energy Solar will leverage HJT for improved module efficiency. TOPCon technology is slowly getting prominence in Indian solar manufacturing Industries. Most of the leading players have already started offering TOPCon modules. Some of them are planning to switch to TOPCon from existing Mono-PERC or set up greenfield TOPCon manufacturing facilities. e.g. Adani, Emvee, Gautam Solar, TATA Power, Saatvik Green etc.

In addition, there are ongoing considerations for mass manufacturing of multilayer and tandem silicon-perovskite or silicon-CdTe hybrid solar panels. These innovative solutions have the potential to significantly increase cell efficiency, surpassing the 30% mark, while maintaining competitive production costs.

LONGi Solar: During 2022, LONGi effectively met customers' market demand for mono products. The sales of main products (i.e., mono wafers and modules) increased significantly over the same period last year, bringing steady growth of operating revenue and profit. In 2022, LONGi achieved wafer shipments of 85.06 GW, split between external sales of 42.52GW and 42.54 GW for internal use and shipped 46.76 GW of mono-crystalline modules, of which external sales accounted for 46.08 GW and internal use 0.68GW. Thus, almost entire sale of LONGi Solar was from mono type modules. During 2023, Jinko Solar shipped 78.5 GW modules. The following table summarises the sales volumes by solar module types.

Table 44: Sales volume solar technology wise

Sales volume	CY19		CY20		CY21		CY22		CY23	
	MW	%	MW	%	MW	%	MW	%	MW	%
Solar modules – Poly	3,554	25%	385	2%	40.8	0%	1.3	0%	0	0%
Solar modules – Mono	944	7%	115.2	1%	7.3	0%	13	0%	257	0%
Solar modules – N Type							10,684	24%	48,405	62%
Solar modules – Mono PERC	9,710	68%	18,270	97%	22,185	100%	33,636	76%	29,858	38%
Total	**14,208**	**100%**	**18,771**	**100%**	**22,233**	**100%**	**44,334**	**100%**	**78,520**	**100%**

Source: Annual Report 2022, CRISIL MI&A Consulting

From the above table, the mono PERC share for Jinko Solar increased from 25% in 2018 to ~100% in 2021. Thus, mono products have almost replaced poly products. However, recently there is a demand for N-type solar panels and Mono PERC panels are losing more and more ground compared to them. Share of n-type technology in China module manufacturing capacity stood at over 40% at end-2023 with TOPCon variant emerging as the frontrunner as Mono PERC lines can easily be upgraded to TOPCon at an additional investment of 10-15% of base capital expenditure. China TOPCon capacity at end-2023 stood at over 550 GW with another 180 GW in pipeline.

7.4 Overview of solar module manufacturing value chain in India

Crystalline silicon (c-Si) technology is largely deployed in solar PV globally as well as in India. The technology is also expected to comprise the largest pie in India's ambitious target of 280 GW solar capacity addition by 2030. However, currently, 80-85% of the solar modules need be imported as domestic capacity is inadequate to meet demand. India does not have a manufacturing base for polysilicon ingots and wafer; hence, players import these components, incurring high cost.

Figure 80: Schematic of c-Si PV module supply chain

Source: CRISIL MI&A Consulting

Only few GW-scale companies are present in India. Many of the smaller companies have capacities in the 100-500 MW range, with very high operational costs.

Table 45: Key domestic solar module manufacturers with capacity

Sr. no.	Name	Installed capacity (MW)
1.	Waaree Energies	12,000
2.	Adani Mundra PV	4,000
3.	ReNew Power	4,000
4.	Saatvik	3,800
5.	Vikram Solar	3,500
6.	Renewsys	2,750
7.	Goldi Solar	2,500
8.	Premier Energies	2,400
9.	Rayzon	1,500
10.	Emmvee Photovoltaic	3,500
11.	Solex	1,200
12.	Grew Energy	1,200
13.	Pixon Green Energy	1,000

As on June, 2024

Source: Company websites, CRISIL MI&A Consulting.

In contrast, global manufacturers such as LONGi Solar, Trina Solar, JA Solar, Jinko Solar, etc are present across the PV value chain, and operate on a larger scale; hence, enjoy significant cost advantages.

The development of the Solar PV industry in India is at a critical point. Following COVID-19, it underwent an expedited change that was largely made possible by a supportive policy initiative. As a result, the sector is preparing to meet the growing demand for solar energy on both domestic and global markets.

India and other net PV importers, like the U.S., have implemented several policies throughout time to reduce their reliance on China for PV products. The use of tariff barriers, such as safeguard duties (SGD) in India and anti-dumping taxes in the US, is one of them.

India's cumulative module manufacturing nameplate capacity has reached ~63 GW in fiscal 2024 and the cumulative cell manufacturing capacity is about ~13 GW. The difference in the manufacturing capacities of solar cell and module is partly due to the lack of vertical integration of domestic solar fabs. However, the operational capacity could be less than 50% of the nameplate capacity.

Further, regarding ingots/wafer manufacturing, Adani Solar in December 2022 introduced a large-sized monocrystalline silicon ingot in its Mundra (Gujarat) facility. This development led the company to become India's first manufacturer of monocrystalline silicon ingots, capable of producing M10 (182mm) and M12 (210mm) size wafers. Lastly, Polysilicon, the first stage in the PV manufacturing chain involves the most complex manufacturing process. Currently there are no manufacturers for domestic polysilicon manufacturing, but it is expected that under the PLI scheme the winners would setup the first of the future polysilicon production capacities within the next two-three years through integrated factories.

While moving up the value chain, from solar modules and cells to ingots/wafers and polysilicon, India's PV manufacturing skills substantially decline. Proceeding upstream in the PV supply chain, the complexity and manufacturing capex requirements increase. Polysilicon and ingots/wafers have historically played a negligible role in India's overall PV commodities/products trade. For these components, the domestic industry has solely depended on imported products from international marketplaces.

It is also noteworthy that the majority of solar module production is centred on a small number of states. Manufacturing of solar modules is concentrated in these states for a number of reasons, including easy access to ports (for international trade), affordable land, and readily available power close to special economic zones (SEZ). Gujarat will still house most of the manufacturing capacity.

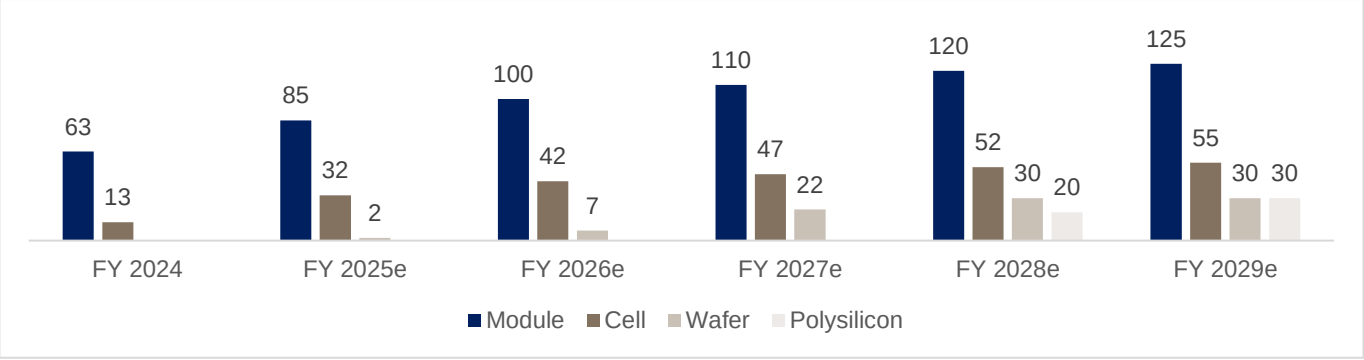
7.5 Outlook for solar module manufacturing

India aims to build its presence across all stages of PV manufacturing over the next two to three years. In November 2020, the GoI introduced the PLI scheme for manufacturing high-efficiency solar PV modules with a financial outlay of Rs 45 billion. It later enhanced the outlay by Rs 195 billion under the Union Budget for fiscal 2023.

In May 2021, the IREDA issued a tender to set up 10 GW of high-efficiency solar module manufacturing capacities. The total PLI granted across the three final awardees (Reliance, Shirdi Sai Electricals and Adani) was Rs 44.55 billion, which would lead to the setting up of 8,737 MW of PLI-linked capacity. The second bid conducted by SECI under PLI scheme concluded in February 2023. A total capacity of 39.6 GW of domestic Solar PV module manufacturing capacity has been awarded to 11 companies, with a total outlay of Rs 140 billion. As per the government estimates, manufacturing capacity totaling 7.4 GW is expected to become operational by October 2024, 16.8 GW by April 2025 and the balance 15.4 GW by April 2026. Considering the two tranches together, the total domestic solar PV module manufacturing capacity allocated under the PLI Scheme is 48,337 MW, with a cumulative support of more than Rs. 185 billion by the Government.

CRISIL MI&A Consulting expects solar PV manufacturing Capacity to reach 125 GW by fiscal 2029, with full integration from polysilicon to modules expected to account for ~25% of capacities, largely driven by PLIs. Achieving this is expected to require an investment of Rs 1.17 trillion by fiscal 2029. CRISIL MI&A Consulting expects module manufacturing capacity to grow twice by fiscal 2029 with ~25% of the capacity to be fully integrated and integrated units to come only post fiscal 2025. Gujarat will be at the epicenter of additions with ~55-60% additions in the next 5 fiscals.

Figure 81: Current and projected manufacturing capacity, GW



Source: Industry, CRISIL MI&A Consulting

India is expected to add around 175-180 GW of solar capacity over fiscals 2025-2030. Considering the average module price of USD 0.22/Wp, this capacity addition provides a total opportunity of USD ~38-40 Bn over fiscals 2025-2030.

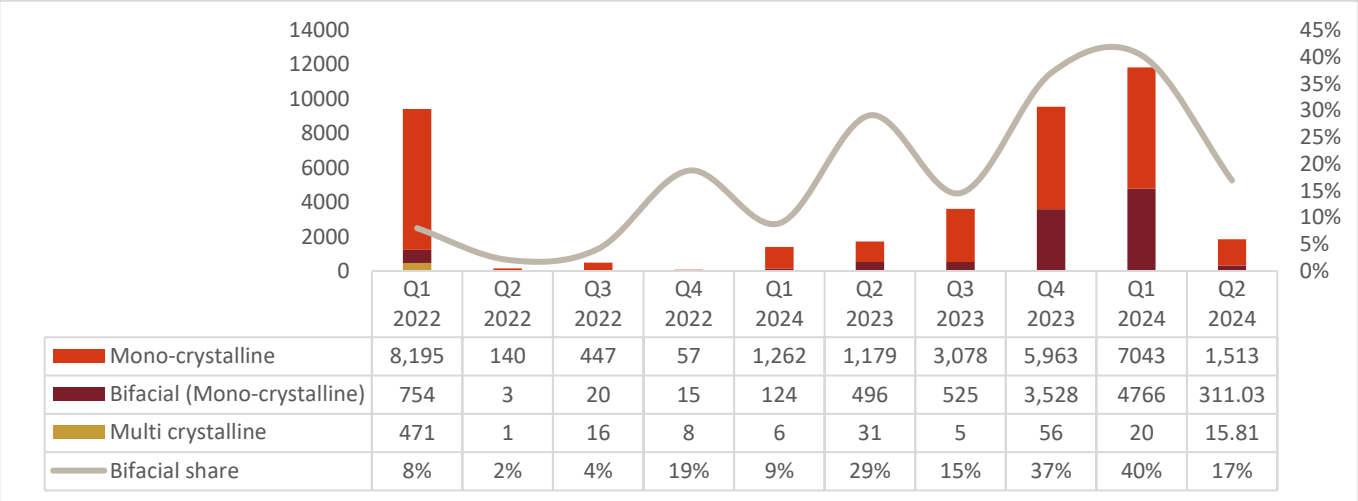
More than 85-90% of Indian solar module manufacturers have shifted to Mono-PERC and Mono-PERC is expected to dominate the technology for the next 2-3 years. Most of the Indian manufacturers have set up or planning to set up new facilities with an option of upgradation to newer technologies. Some of the Companies have existing manufacturing facilities which can be upgraded to TOPCon technology. TOPCon technology is slowly getting prominence in Indian solar manufacturing Industries. Most of the leading players have already started offering TOPCon modules. Some of them are planning to switch to TOPCon from existing Mono-PERC or set up greenfield TOPCon manufacturing facilities. e.g., Adani, Emvee, Gautam Solar, TATA Power, Saatvik Green etc.

In addition, there are ongoing considerations for mass manufacturing of multilayer and tandem silicon-perovskite or silicon-CdTe hybrid solar panels. These innovative solutions have the potential to significantly increase cell efficiency, surpassing the 30% mark, while maintaining competitive production costs. Solar power is becoming increasingly attractive due falling module prices and improving efficiency resulting from excess manufacturing capacity in China and technology advancements, respectively.

On the project development front, developers are exhibiting heightened preference for bifacial modules that typically have higher efficiency relative to mono-facial modules and are compatible with tracker technology. In 2023, the share of bifacial variant in module imports increased from 8% in Q1 2022 to 37% in Q4 2023. On the other hand, multi-crystalline modules are being phased out due to lower efficiency and higher degradation rate – share of import volume was negligible in 2023.

The share of monocrystalline technology is now about 84% (compared with 66% in 2019) of total crystalline silicon (c-Si) production. The performance ratio has also been improved in the 80-90% range. The c-Si segment is expected to grow substantially due to c-Si's long life and light weight.

Figure 82 : Historic module imports, MW



	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2024	Q2 2023	Q3 2023	Q4 2023	Q1 2024	Q2 2024
Mono-crystalline	8,195	140	447	57	1,262	1,179	3,078	5,963	7043	1,513
Bifacial (Mono-crystalline)	754	3	20	15	124	496	525	3,528	4766	311.03
Multi crystalline	471	1	16	8	6	31	5	56	20	15.81
Bifacial share	8%	2%	4%	19%	9%	29%	15%	37%	40%	17%

Source: Ministry of Commerce, Industry, CRISIL MI&A Consulting

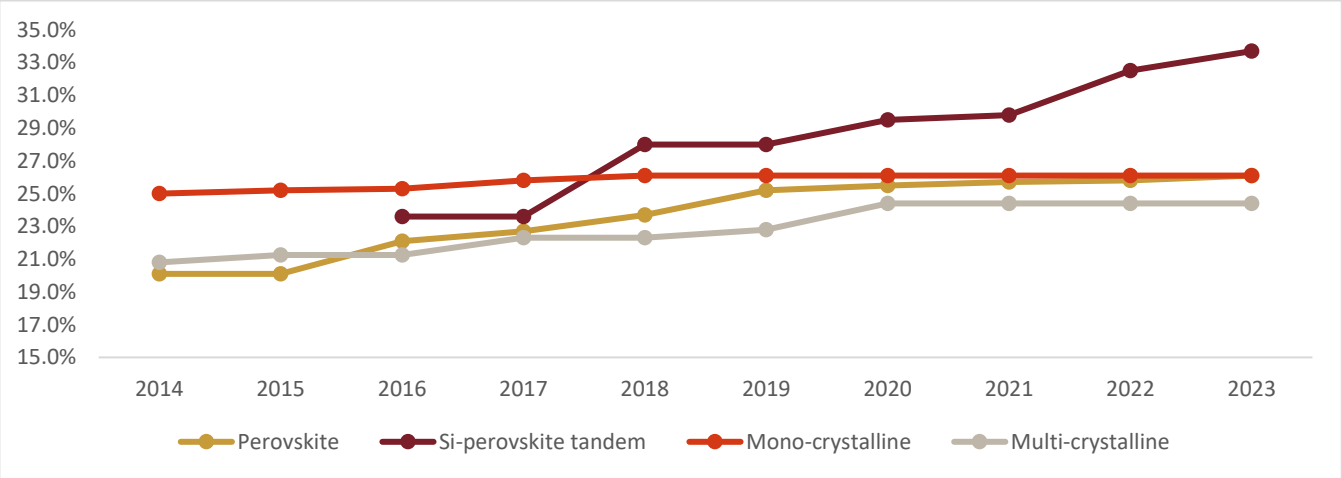
Currently, the solar PV market is dominated by monocrystalline silicon technology. Within monocrystalline technology, Mono PERC is an advanced version that employs dielectric passivation film on the rear surface of the cells which increases the efficiency levels. These cells are currently leading the market due to higher efficiency, cover less space, higher output in low light conditions and are available at competitive pricing. However, ongoing technology innovation in manufacturing processes is crucial to reduce material intensity, especially for critical minerals like silver and copper. These efforts aim to minimize vulnerabilities in the supply chain.

In addition to process improvements, the development of new solar cell designs is essential for achieving further efficiency gains while simultaneously reducing material intensity and manufacturing costs. The p-type to n-type migration is currently underway and paving the way for new technologies – by end of 2023, n-type technologies including TOPCon, heterojunction (HJT) and back contact represented 42% of China's total module manufacturing

capacity (7% in 2022). These designs hold the potential for achieving additional efficiency gains in solar panels. Based on pilot tests conducted by leading global manufacturers, it is estimated that the TOPCon cell could provide an additional efficiency gain of upto 2-2.5% gain over mono PERC modules. While TOPCon is expected to be the dominant n-type technology over next couple of years due to its lower cost over other new technologies, higher efficiency, and lower temperature sensitivity of HJT modules make it a better alternative to TOPCon modules in select locations. Additionally, China market share of HJT modules is expected to increase from an estimated 2% in 2023 to around 16% in 2027 due to decreasing production cost differential with TOPCon technology.

In addition, there are ongoing considerations for mass manufacturing of multilayer and tandem silicon-perovskite or silicon-CdTe hybrid solar panels. These innovative solutions have the potential to significantly increase cell efficiency, surpassing the 30% mark, while maintaining competitive production costs and promise to make solar power an even more compelling and sustainable energy solution in the years to come.

Figure 83 : Cell efficiency comparison



Source: NREL, CRISIL MI&A Consulting

7.6 Scheme and incentives supporting solar module manufacturing in India

The Indian government has taken several policy initiatives to promote solar module manufacturing in India. These initiatives include DCR mandate for use of domestically manufactured solar cell and modules, PLI Scheme, imposition of BCD on import of solar PV cells & modules, mandated registration of solar cell and module under the ALMM for complying with BIS standards, incentives for research and development, and support for training and skill development. Some of the key government initiatives to support a domestic PV manufacturing industry are as follows:

a) *Domestic content requirement* - The DCR mandates the use of solar cells and modules manufactured domestically as per specifications and testing requirements fixed by MNRE. There are various schemes announced by the government to promote the use of domestically manufactured modules such as CPSU scheme, PM-KUSUM scheme, grid connected rooftop solar programmes. All these schemes have a Central Financia Assistance (CFA)/VGF component to cover the cost difference between imported and domestic solar cells and modules It is mandatory to use DCR cells and modules to avail the financial aid provided by the central/state government. Phase – II of the Grid Connected Rooftop Solar Programme was launched to encourage grid connected rooftop solar systems in various consumer segments. A target of adding 38 GW of rooftop solar capacity by March 2026, which comprising 4 GW in residential segment with CFA and 34 GW in commercial and industrial sector through suitable incentives by DISCOMs, wherein government subsidy is given, it has been mandated domestic manufacturing of solar cells and modules to support the growth of the RTS sector.

b) *Performance linked incentive scheme* – The National Program on High-Efficiency Solar PV Modules is a government-backed initiative to promote domestic manufacturing of Solar PV modules and cells in India. The PLI

scheme offers incentives to eligible manufacturers based on their annual production of high-efficiency solar PV modules and cells. The incentive amount is calculated as a percentage of the manufacturing cost of the modules or cells and is capped at Rs 400 per watt for modules and Rs 150 per watt for cells. The scheme is being implemented in two tranches. Tranche-I, with an outlay of Rs 4,500 crore, was launched in February 2022. Tranche-II, with an outlay of Rs 19,500 crore, was launched in September 2022. The scheme is expected to reduce India's dependence on imported solar modules, and to make solar power more affordable for Indian consumers.

c) *Safeguard duty* - The government imposed a safeguard duty on solar cells and modules imported from China, Malaysia, Thailand, and Vietnam in July 2018. The duty was initially set at 25% for the first year, followed by a phased down approach for the second year, with the rate reduced by 5% every six months until it ended in July 2020. The purpose of the duty was to protect the domestic solar manufacturing industry from cheap imports from China. In July 2020, the government extended the safeguard duty for another year, with the rate set at 14.90% from July 30, 2020, to January 29, 2021, and 14.50% from January 30, 2021, to July 29, 2021.

d) *Basic customs duty* - The government imposed a basic customs duty of 40% on solar modules and 25% on solar cells on April 1, 2022. This was done in an effort to boost domestic manufacturing of solar components and reduce India's reliance on imports. The BCD applies to all imports of solar modules and cells, regardless of the country of origin.

e) *Approved list of models and manufacturers* - The ALMM was introduced in 2019 to ensure the quality and performance of solar modules used in India. It is a list of solar cell and module types and manufacturers in India that have been certified by the Bureau of Indian Standards. Only modules that are listed on the ALMM are eligible for use in government sponsored solar projects.

f) *Solar manufacturing linked tender:* SECI had floated an EOI with the proposition of linking solar project tendering to setting up of module manufacturing capacities. The initial proposal had been floated for 5 GW of manufacturing-linked capacities linked to 10 GW of solar projects, which was then reduced to 3 GW of manufacturing capacities but linked to 10 GW of projects. Under this initiative, developers would have to comply with a 1:3 ratio between manufacturing capacities and projects and adhere to the timelines, otherwise strict penalties were stipulated. Additionally, developers could only import polysilicon while the remaining manufacturing chain from silicon wafers to modules would have to be set up. However, the above tenders failed to attract bidder response except for a single bid from Azure Power for 600 MW of manufacturing capacity and 2,000 MW of solar projects. This bid was, however, cancelled due to disagreement over the final bid price (no auction conducted as only one bidder). After few extensions and revised tenders, In October 2019, the tender was scaled up to 7 GW of power generation capacity linked to 2 GW of photovoltaic manufacturing capacity. This also included a greenshoe option if the developers wished to avail of it. The tender finally got allocated in January 2020, with even a 1 GW over subscription (several clauses were amended and tariff ceiling raised). The bid was won by Adani Green Energy (6W of power generation) and Azure Power (2 GW). They also availed 2 GW each under the greenshoe option. Both recently signed PPAs with SECI for ~4.67 GW and 2.3 GW respectively. The capacities for manufacturing-linked tenders are expected to be commissioned from fiscal 2025 onwards in phases. Additionally, in September 2021, SECI revised the tariff to INR 2.54/unit from INR 2.92/unit. This led to pick-up in PSA signing activity for manufacturing-linked tender with 1 GW of PSA signed by TANGEDCO, 0.5 GW by GRIDCO and 5.5 GW by AP discom

g) *Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan (PM-KUSUM) Scheme* – It aims to reduce diesel use in agriculture and boost farmers' income. It offers central government subsidies of up to 30-50% for installing standalone solar pumps and solarizing existing grid-connected pumps. Additionally, farmers can install grid-connected solar power plants up to 2 MW on barren land and sell electricity to DISCOMs. The scheme, implemented by state departments, targets adding 34,800 MW of solar capacity by March 2026 with a total central financial support of INR 344.22 billion

h) The CPSU Scheme Phase-II 12 GW - Government Producer Scheme, is a significant initiative from the Indian government to promote domestic solar power generation and enhance energy security. Key features of the scheme are:

- Financial Assistance: The scheme offers Viability Gap Funding (VGF) of up to INR 7 million per MW to incentivize participation and address project cost viability concerns.
- Capacity Target: The scheme initially aimed to develop a total of 12,000 MW of grid-connected solar power capacity through plants set up by the eligible entities. While the deadline for the project commissioning has already passed, the scheme continues to be operational for unallocated projects.
- Implementation: The scheme is implemented through a competitive bidding process managed by the Solar Energy Corporation of India (SECI). Eligible entities can submit proposals for setting up solar power plants, and SECI selects the most competitive proposals based on pre-defined criteria. With government initiatives like the PM-KUSUM, PM-Surya Ghar Muft Bijli Yojana, and the CPSU scheme in play, there is an emphasis on the utilization of DCR solar modules within the domestic solar market.

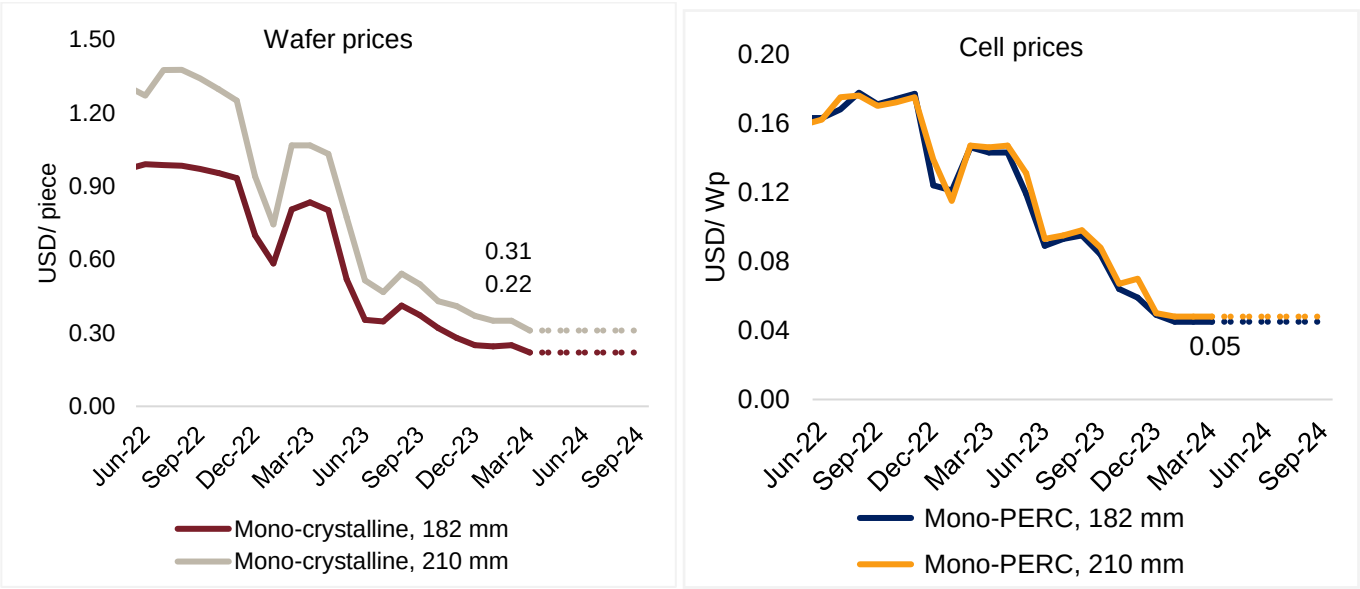
7.7 Price trend of solar PV cells and modules

Low prices to prevail across the value chain

On a global scale, the polysilicon base expanded by 68% year-on-year by the end of December 2022, reaching a range of 1000-1100 metric tons from the previous 600-650 metric tons. Weakened demand and lower consumption coupled with oversupply, resulted in a dramatic price drop of 71% to $8 per kg in March 2024, down from $28 per kg in December 2022. Consequently, downstream components also witnessed significant price reductions, with wafer prices plummeting by 50-55% to $0.31/piece.

The oversupply of polysilicon also prompted the world's largest monocrystalline solar wafer supplier to cut the prices of its photovoltaic wafers twice between April and May 2023, reducing prices by 33% as cell manufacturers sought to fulfill their order requirements. Cell prices were also down 58%over December 2022 levels, reaching $0.05 per Wp in March 2024. Module prices fell by 52% to $0.11 per Wp during the same period. Module prices are expected to remain stable or decline marginally due to the supply glut in China coupled with subdued demand in international markets like the US and EU.

Figure 84: Wafer and cell prices



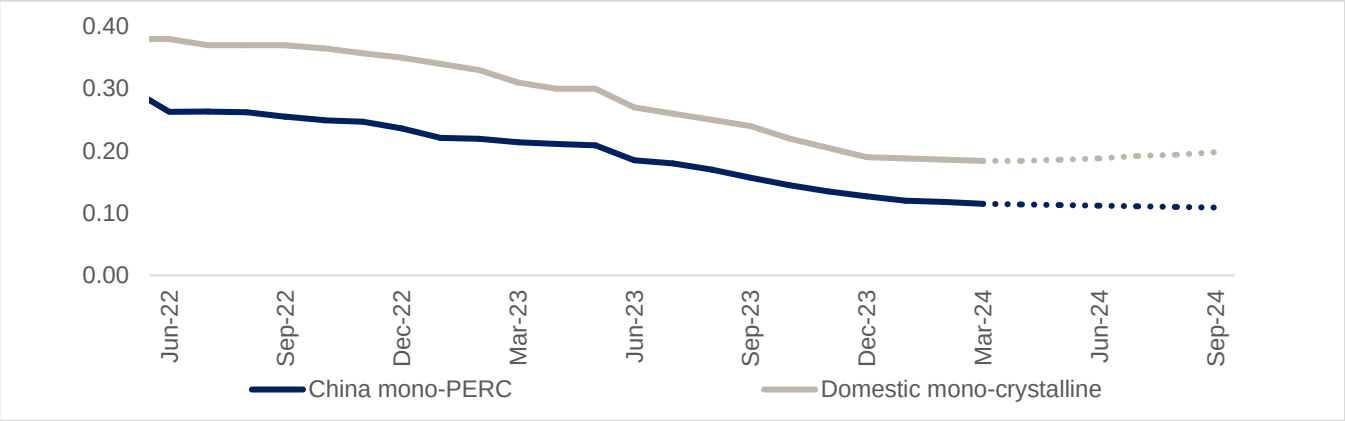
Source: CRISIL MI&A Consulting

Declining module prices

Module prices experienced a remarkable surge of 22% in fiscal 2022 and a subsequent 7% increase in fiscal 2023. However, in fiscal 2024, module prices underwent a significant decline, standing at $0.11 per Wp in March 2024,

down 43% YoY. The sharp decline can be attributed mainly to the supply glut in China and low upstream components including polysilicon. Domestic module prices declined in line with China prices to $0.18 per Wp in March 2024 but maintained a sizeable premium over China prices. As of March 2024, India had approximately 63 GW module capacity, in contrast to only around 13 GW of cell capacity.

Figure 85: Module prices, USD/ Wp



Source: Industry, CRISIL MI&A Consulting

CRISIL MI&A Consulting anticipates China module prices to remain stable or decline marginally over fiscal 2025 due to the supply glut. Domestic module prices are expected to increase to $0.19-0.20 per Wp due to ALMM implementation before softening in the medium-term as domestic manufacturing becomes sufficient to meet local demand.

7.8 Share of domestic and imported modules

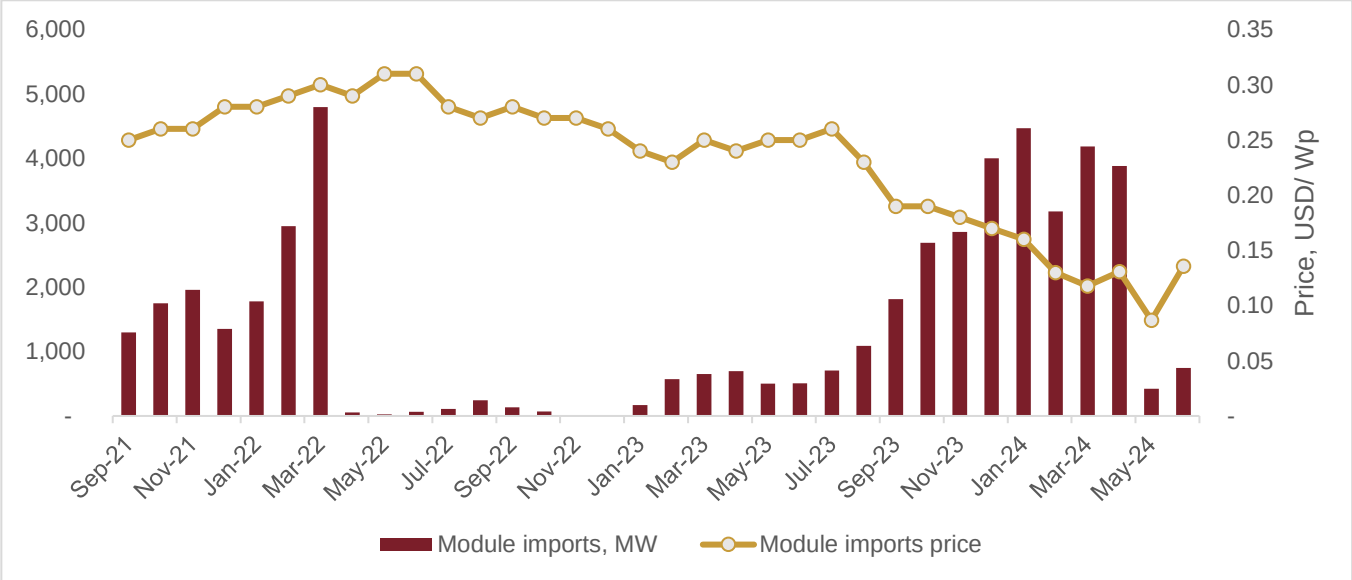
During 2000-2010, the Indian cell and module manufactures were as competitive as their global counterparts. They exported majority of their production due to robust overseas demand. Players such as Moser Baer, Tata BP Solar (now Tata Power Solar), Jupiter Solar Power, and Indosolar made substantial investments in solar cells and modules manufacturing. However, the Indian market still relied heavily on imported modules that were cheaper and more efficient than domestic modules.

As of March 2024, India has ~13 GW installed capacity of solar cells and ~63 GW of modules. Even though India is one of the top ten solar module producers, it is far behind its biggest competitor China. Considering this, 80-85% of solar modules need to be imported due to inadequate capacity as well as technology. In fiscal 2024, imports increased by a staggering 11x on-year to 26,690 MW (from 2,098 MW in previous fiscal). The sudden and sharp surge in import was mainly due to ALMM waiver coupled with expiration of time extensions provided to projects under COVID-19 relief.

Despite price surge across the value chain for solar components, imports have been robust as seller and developers availed duty free period after July 2021 and imported modules for commissioning planned even in fiscals 2022 and 2023 in advance.

However, during fiscal 2023, the module import declined due to imposition of BCD on imported solar module, DCR and increased domestic production capacity.

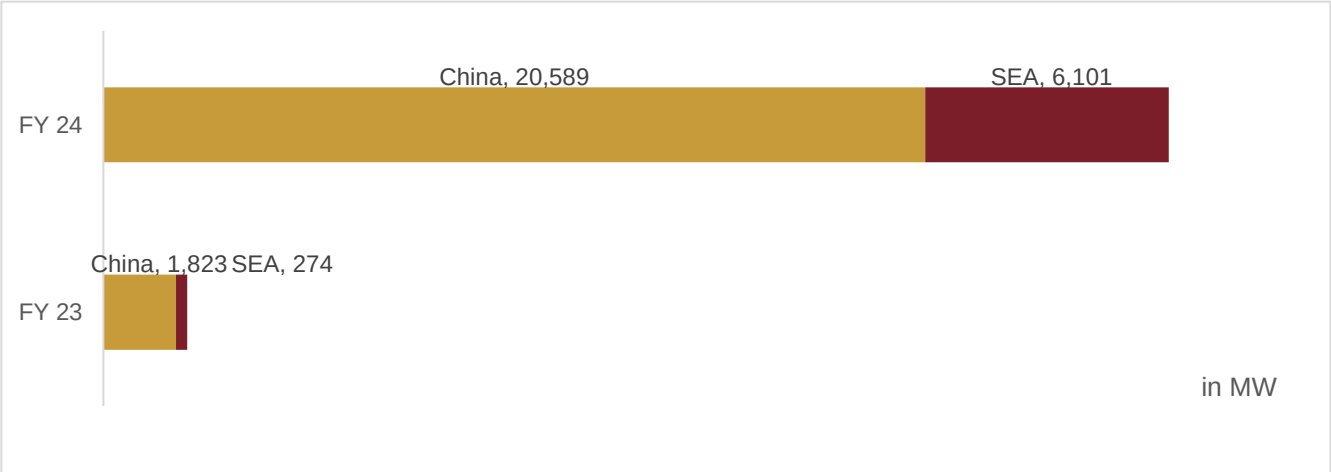
Figure 86: Solar module imports, GW



Source: CRISIL MI&A Consulting

China continues to be the largest module exporter to India, followed by Southeast Asia (SEA). BCD along with the PLI scheme is expected to improve the demand for domestic modules. However, till that time imports will continue to form majority portion of domestic demand due to lower price and better technology.

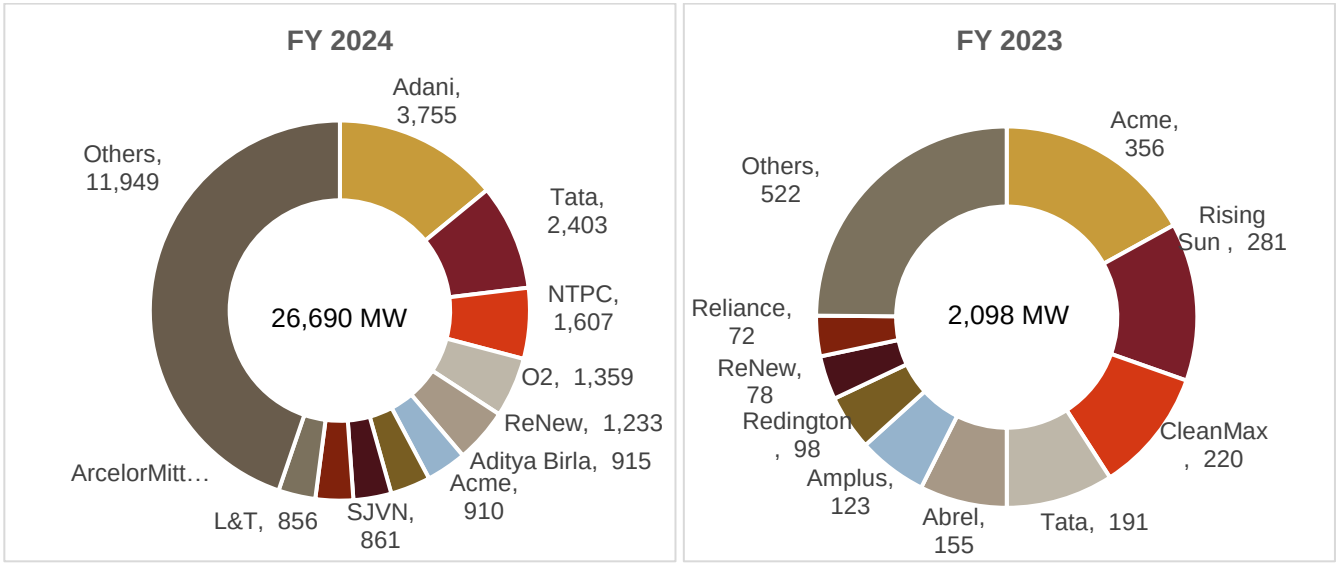
Figure 87: Country-wise module imports, MW



Source: CRISIL MI&A Consulting

Imports have been the primary source of modules installed in the country over the past 7-8 years, with China's share reaching 77% in fiscal 2024. While China has historically maintained the majority share in imports, SEA imports, eligible for zero custom duty under the Free Trade Agreement (FTA) are gaining strong traction. Module imports from countries other than China and SEA have been negligible. Going forward, reliance on module imports is expected to decrease after fiscal 2024 due to reimposition of ALMM coupled with rapid growth of domestic manufacturing capacity. CRISIL MI&A Consulting anticipates that import dependency for modules will decline to 8-10% by fiscal 2028. Nevertheless, India will continue to depend on imports for upstream components such as polysilicon, wafers, and cells.

Figure 88: Leading module importers, MW



Source: Industry, CRISIL MI&A Consulting

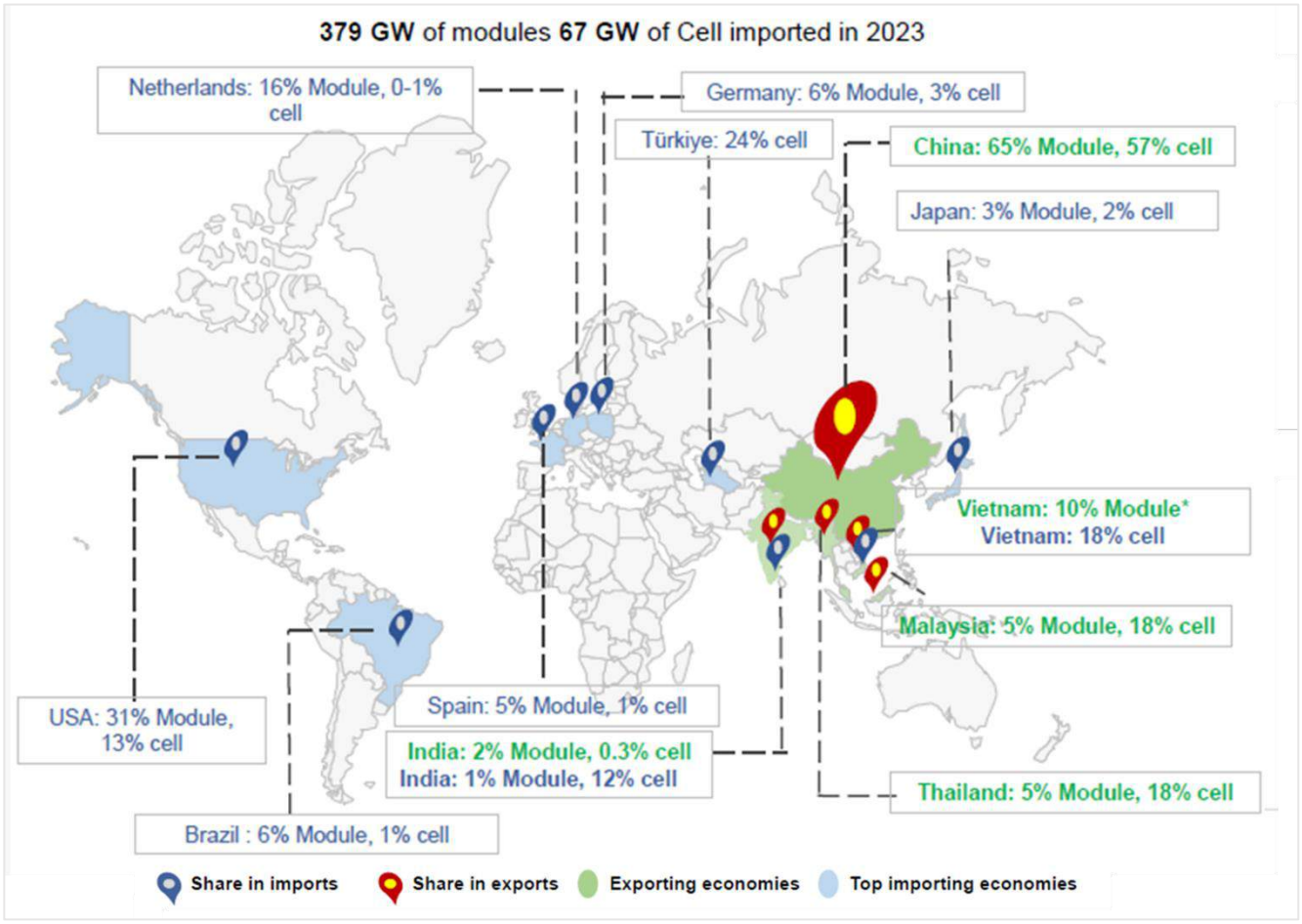
7.9 Domestic versus export demand potential

Module exports experienced a significant uptick in fiscal 2024 reaching a record high of 6,077 MW, up 87% YOY due to higher prices in the international market – export price of domestic modules ranged from USD 0.29-0.37 per Wp, a significant premium over domestic prices. International aversion to Chinese imports following implementation of Uyghur Forced Labour Prevention Act in 2022 has been a key catalyst. The recently initiated antidumping investigation in the US against SEA imports is expected to be another key catalyst for Indian module manufacturers. Exports are expected to remain high between fiscal 2024 and 2028, reaching 25 GW, driven by domestic capacity additions of 60-65 GW. Export demand will also be supported by other key renewable energy markets, such as the Middle East, the European Union, and Latin American nations.

Ban on modules linked to Xinjiang due to notification of the UFLP Act in June 2022 by US could ideally provide Indian manufacturers with an opportunity to increase market share in US, however, withdrawal of tariffs on non-Xinjiang Chinese modules in February 2022 could prove to be roadblock and this continues to remain a monitorable. USA continues to be top consumer of Indian made modules 60% of FY 23 exports to US already achieved in Q1 FY 24 owing to ban on Chinese module imports The European Union is also expected to contribute to future demand. Post BCD levy, domestic project developers may tie up with domestic module manufacturer to import cell at 25% duty for local assembly of modules to avoid 40% duty levied on panels and, rather face 25% duty levied on imported cells. Also, on February 4, 2022, the Biden administration extended the Section 201 tariffs imposed on the import of solar modules from China for four years. This is a growth driver for domestic module exports. Ban on Chinese region and ALMM abeyance to surge Indian exports in fiscal 2024 and domestic usage to be largely preferred till 2028.

With the ban on imports from Xinjiang region and PV grade polysilicon being designated “high priority” item to enforce ban, ~ 45% of global PV grade polysilicon facilities could come under scrutiny. USA imported 54 GW of modules in 2024, with SEA representing around 84% share. Module manufacturers like Longi, Jinko, JA and their ties with Xinjiang based polysilicon providers have come under special scrutiny for use of forced labour and could look for an alternative market like India to off load surplus panels. However, off late module shipments worth 600 MW of Trina was cleared. Indian manufacturers on other hand could be looking to capitalise on this and increase their market share in USA by exporting more and supplying less locally.

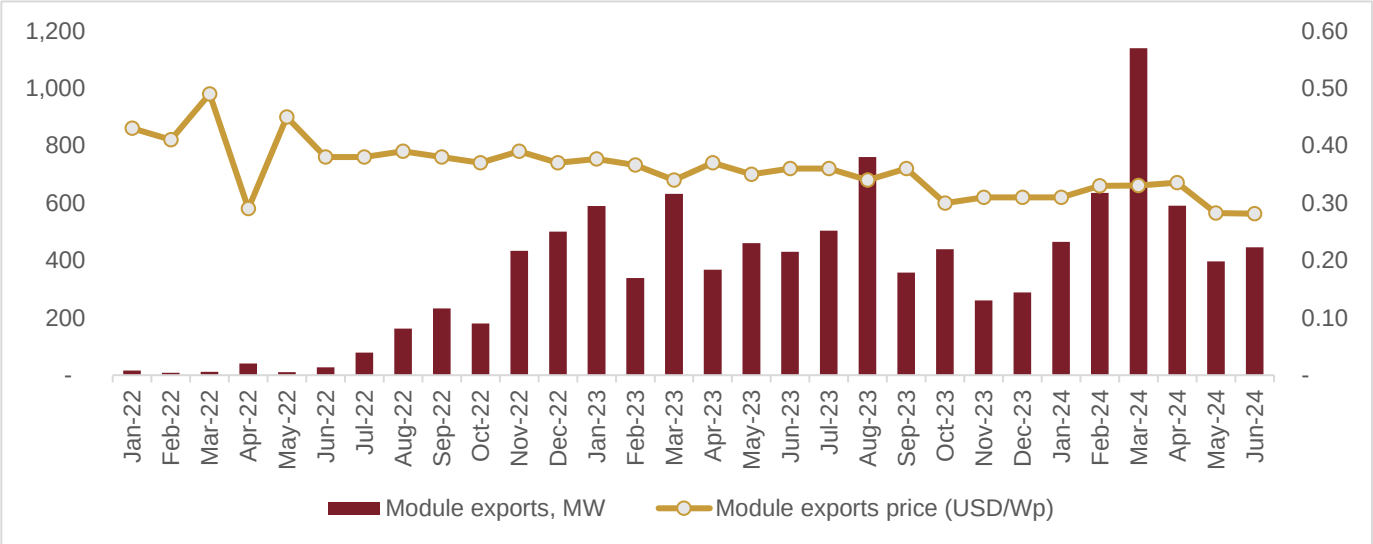
Figure 89: India's exports face tough ASEAN competition, limiting market share



**Vietnam data is for 2022; Source: ITC Trade map, CRISIL MI&A Consulting*

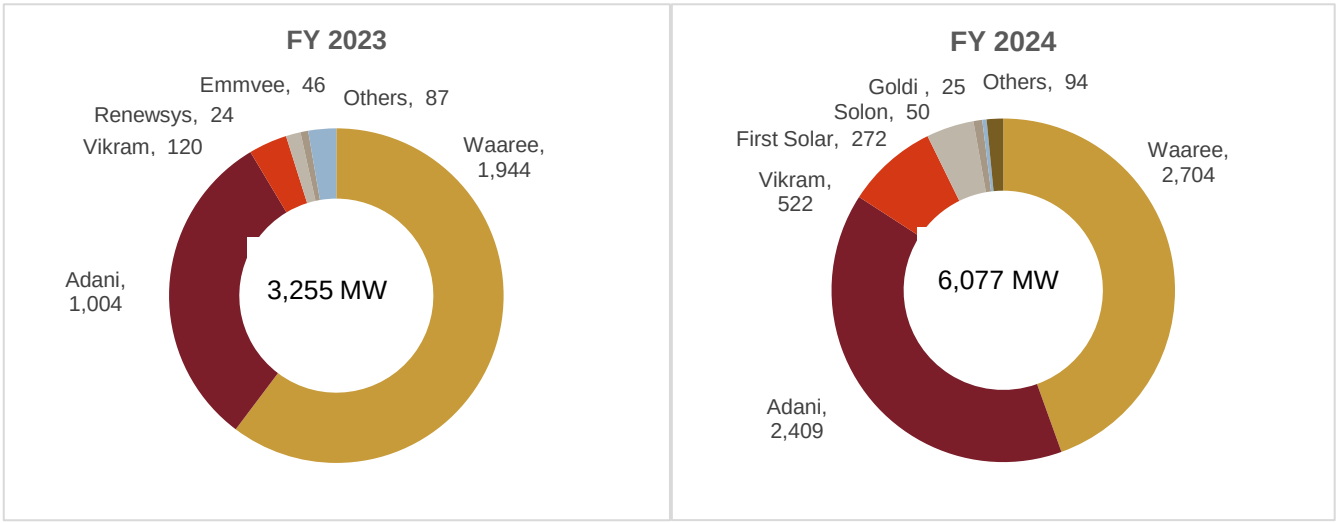
In the export market, Waaree has historically been the market leader, accounting for 44% market share in fiscal 2024, followed by Adani (39%) and Vikram (9%).

Figure 90: Module exports and prices



Source: CRISIL MI&A Consulting

Figure 91: Leading module exporters, MW



Source: Industry, CRISIL MI&A Consulting

7.10 Distribution Channels for PV Modules

To reach out to the end users such as residential, commercial, and industrial consumers, various module manufacturers have their distributor network or have appointed franchisee. Retail consumers are relatively price-sensitive when it comes to solar installations due to smaller project sizes, expected shorter payback period and more competition.

Availability of local contact is very important for these consumers while accepting the solar products. With increased awareness, more and more consumers are showing interest in solar installations. The distribution channel partner help in reaching out to consumers as well as for informing them about the new technology. Due to diverse geographical presence, local support and to build customer relationship, a strong distribution network become essential.

Further, the end user generally does not have technical knowledge of complex products such as modules and hence have very little say in selection. However, through a known partner, the consumers can be convinced to a large extent and such network can be utilized for enhancing the consumer reach. By addressing price sensitivity and leveraging their distribution networks, module suppliers can increase their market share in the retail segment.

Waaree Energies has 388 unique franchisee networks across India. This model provides different opportunity than just dealership or distributorship of products. These are exclusively tied up traders which help in end-to-end product plus service. They help in reaching the last mile connectivity and help in increasing consumer awareness about various offerings in residential and C&I consumers specially in tier-1 and tier-2 cities. Vikram Solar has distribution network connecting more than 40 cities, ensuring the availability of solar products and solutions across 600+ locations Pan-India. Similarly, Adani solar with Roofsol Energy has retail distribution of its solar panels to more than 2,500 towns in India.

7.11 Competitive mapping of solar module manufacturers in India

Competitive mapping covers the details of companies, their products and services within a given market to understand competitive intensity. The top 5 players namely, Waaree Energies, TATA Power Solar (incl. TP Solar), Adani Solar (Mundra Solar PV), ReNew Photovoltaic and FS India (First Solar) account for about ~ 51% of the total domestic ALMM enlisted module manufacturing capacity of ~56.52 GW (excl. co-branding).

Table 46: Comparative summary of domestic module manufacturers

Parameter	Waaree Energies	Vikram Solar	Adani Mundra Solar PV	Premier Energies	Websol Energy Systems	RenewSys India	Emmvee Photovoltaic	Alpex Solar
Number of manufacturing factories	4 in Gujarat	1 each in West Bengal and Tamil Nadu	1 in Gujarat	2 in Telangana	1 in West Bengal	1 each in Karnataka, Telangana and Maharashtra	2 in Karnataka	1 each in HP and UP
Experience in PV module manufacturing	16 years	17 years	8 years	26 years	~30 year	12 years	16 years	18 Years
Operational capacity (as on June-24)	12 GW modules	3.5 GW modules	4 GW cells and modules	4.1 GW modules, 2 GW Cells	550 MW Module 1.8 GW Cells	2.75 GW modules, ~0.1 GW cells	3.5 GW modules	848 MW modules
Under-construction capacity	6 GW Modules 5.4 GW Cells **Proposed-** 6 GW modules, 6 GW cells, 6 GW Ingot-Wafer capacity	Proposed 7 GW Module and 3 GW integrated cells & modules	10 GW cell and module	1 GW modules, 1 GW cells	1.2 GW Cells	2 GW Modules ~1.9 GW	1.75 GW including 1.5 GW wafer-to-module capacity	300 MW
NABL Accredited Lab	For modules	For modules	-	-	-	For encapsulants and backsheets	-	-

Parameter	Waaree Energies	Vikram Solar	Adani Mundra Solar PV	Premier Energies	Websol Energy Systems	RenewSys India	Emmvee Photovoltaic	Alpex Solar
Enlisted Capacity as ALMM List Sep 24	11,919 MW	2,250 MW	4,067 MW	2,561 MW	NA	1,636 MW	2,692 MW	248 MW
Market share as a % of total enlisted capacity as per ALMM List Sep 24	21.09%	7.20%	6.74%	4.53%	NA	2.897%	4.76%	0.44%
Key Products and services	Solar PV modules, Inverters, Batteries, EPC services, rooftop solutions, O&M Services, and solar water pumps	Solar PV modules, EPC services, solar O&M services, and water pumps	Solar PV cells and modules, EPC services, O&M services,	Solar PV cells and modules, EPC services, O&M services, and water pumps	Solar PV cells and modules	Solar PV modules and cells	Modules, EPC, rooftop solutions, and solar water heater solutions	Solar modules, EPC services, Water Pumps
Cumulative Installed capacity in EPC	1000+ MW	1,420 MW	NA	650+ MW	NA	NA	NA	NA
Key Technologies offered	TOPCon, Mono and poly crystalline PV modules, Mono PERC, Bifacial, Flexible modules, BIPV	TOPCon, Mono PERC, mono-facial & bifacial, poly-Si modules	TOPCon, Multi crystalline, Mono PERC and Bifacial modules	TOPCon, Polycrystalline Si cells, mono PERC, poly Si modules	Monofacial Mono PERC, Bifacial PERC Modules	TOPCon, Mono/Multi PERC, Bi-facial	TOPCon, Mono PERC, polycrystalline modules, bi-facial module	TOPCon, Monocrystalline, polycrystalline Modules

NA: Not available

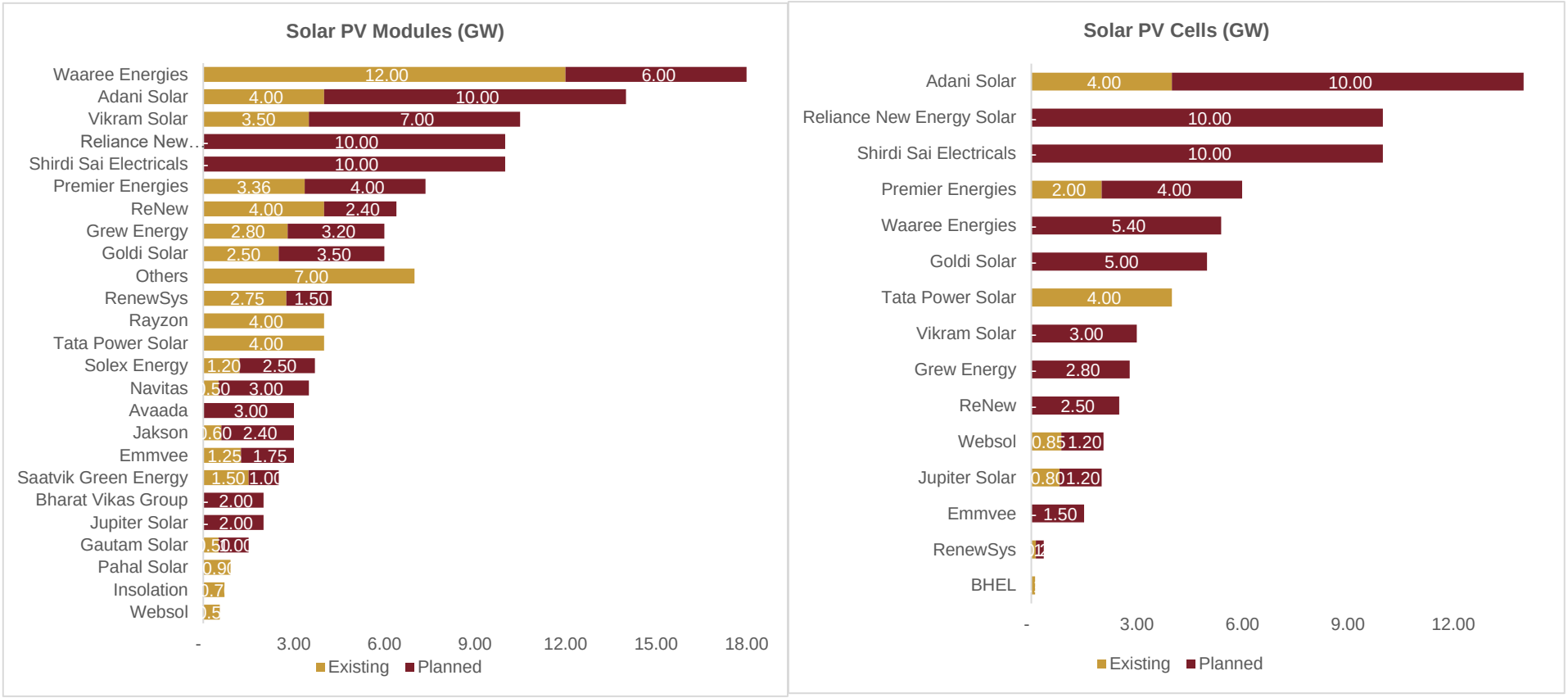
Source: Company websites, SEBI Filings; MNRE ALMM 27-Sep-2024, CRISIL MI&A Consulting

Capacity addition plan of Indian solar PV manufacturers

In order to boost domestic production and reduce imports, the central government initiated the first tranche of the PLI scheme in April 2021 with a target of 8,737 MW module manufacturing capacity as well as introduced basic customs duty on imports. The second tranche of the scheme targets a capacity addition of 39,600 MW by April 2026. Considering the favourable environment, various Indian solar PV manufacturers have planned for capacity expansion. As of

December 2022, 70-75 GW module and 50-55 GW cell capacity expansion plans have been announced by various players. Also, with the announcement in Union Budget 2023 on the enhancement of the outlay of Rs 19,500 crore under the PLI scheme for high efficiency modules under the second tranche of the scheme, the segments could see a further boost. Moreover, the ALMM order issued by MNRE acts as a trade barrier by encouraging domestic manufacture of solar modules, thus making it one of the key drivers for the development of domestic PV manufacture.

Figure 92: Existing and planned capacity additions



Source: Company websites, Industry, Waaree from Company (Additionally, it has planned 2 GW capacity in USA); PLI Scheme results, CRISIL MI&A Consulting*

To analyse competitiveness, productivity and efficiency, it is imperative to run a financial analysis of the company's books and then compare the performance standards with that of industry peers. Five major players have been analysed and benchmarked.

Table 47: Financial summary of domestic module manufacturers

Company	FY	Operating income (Rs. Mn)	Revenue Growth (%)	OPM (%)	NPM (%)	ROCE (%)	ROE (%)	Debt:Equity Ratio (Times)	Gearing (times)	Interest coverage
Waaree Energies Ltd.	FY24	113,980	69%	14%	11%	26%	30%	0.09	0.48	13.4
Vikram Solar Ltd.	FY24	25,110	21%	10%	3%	23%	18%	1.8	0.64	2.58
Tata Power Solar Systems Ltd.	FY24	117,260	71%	6%	3%	39%	27%	NM	NM	4.97
Websol Energy Systems Ltd.	FY24	259*	50%	-572%	-468%	-16%	-112%	1.7	0.63	-1.59
Mundra Solar PV Ltd.	FY23	15,640	-38%	3%	-22%	-2%	-70%	2.4	0.7	NA
Premier Energies Ltd.	FY24	31,438	120%	15%	7%	25%	36%	2.3	0.7	3.39

**Websol had discontinued operations following the decision to graduate to a superior technology (TOPCON); NM: Not measurable*

Source: Annual accounts, filings; CRISIL MI&A Consulting

Most of the companies reported significant revenue growth in fiscal 2024. Operating profits are also sufficient to cover interest and finance costs. Waaree Energies Limited recorded a revenue growth of 69% with a healthy ROCE of 26% in fiscal 2024 The interest coverage ratio remained above 1 for most players, suggesting these companies' capability to pay the interest due on outstanding debt.

Following table summarises the competitive analysis of Waaree Energies with publicly listed Indian module manufacture companies.

Table 48: Competitive analysis with a publicly listed Indian module manufacturers

Parameters	Waaree Energies Ltd.					Websol Energy Systems Ltd.					Premier Energies Ltd.				
	FY22 (A)	FY23 (A)	FY24 (A)	Q1 FY24 (A)	Q1 FY25 (A)	FY22 (A)	FY23 (A)	FY24 (A)	Q1 FY24 (UA)	Q1 FY25 (UA)	FY22 (A)	FY23 (A)	FY24 (A)	Q1 FY24 (A)	Q1 FY25 (A)
Revenue from operations (₹ million)	28,543	67,509	113,976	33,283	34,089	2,132	172	259	2	1,116	7,429	14,285	31,438	6,110	16,574
Domestic Sales	21,965	21,344	48,285	8,871	20,564	2,132	153	259	2	NA	7,361	14,210	27,041	5,728	16,557
Export Sales[3]	6,578	46,165	65,691	24,412	13,525	NA	20	0	NA	NA	68	75	4,397	383	17
Other Income	916	1,095	2,352	867	875	46	30	10	1	2	242	347	275	52	114
Total Income	29,459	68,604	116,328	34,150	34,964	2,178	202	268	3	1,118	7,670	14,632	31,713	6,162	16,688
Profit for the Year (₹ million)	797	5,003	12,744	3,383	4,011	97	-237	(1,210)	-50	229	(144)	(133)	2,314	313	1,982
EBITDA[5] (₹ million)	2,025	9,441	18,096	5,543	6,400	310	-99	-66	-12	442	537	1,129	5,053	767	3,697
EBITDA Margin[6] (%)	6.88%	13.76%	15.6%	16.23%	18.30%	14.24%	-48.77%	-24.5%	-410.00%	39.5%	7.0%	7.7%	15.9%	12.4%	22.2%
Total Debt to Equity Ratio[7]	0.85	0.17	0.09	0.08	0.06	0.19	0.14	1.70	NA	NA	1.23	1.96	2.29	1.98	1.52
Total Debt to EBITDA Ratio[8]	1.79	0.34	0.19	0.42	0.41	1.18	-2.79	(27.91)	NA	NA	9.01	7.13	2.93	11.44	3.48
Return on Average Capital Employed[9] (%)	23.49%	48.83%	36.95%	17.75%	12.39%	7.21%	-11.67%	-17.69%	-4.05%	NA	3.83%	6.35%	30.14%	5.59%	16.51%
PAT Margin[10]	2.70%	7.29%	10.96%	9.91%	11.47%	4.44%	-117.06%	-451.10%	-1666.67%	20.46%	-1.88%	-0.91%	7.30%	5.08%	11.87%
ROE[11]	17.69%	26.26%	30.26%	12.36%	8.79%	5.05%	-12.38%	-112.29%	-12.89%	NA	-3.64%	-3.11%	35.77%	7.07%	23.41%

Parameters	Waaree Energies Ltd.					Websol Energy Systems Ltd.					Premier Energies Ltd.				
	FY22 (A)	FY23 (A)	FY24 (A)	Q1 FY24 (A)	Q1 FY25 (A)	FY22 (A)	FY23 (A)	FY24 (A)	Q1 FY24 (UA)	Q1 FY25 (UA)	FY22 (A)	FY23 (A)	FY24 (A)	Q1 FY24 (A)	Q1 FY25 (A)
ROCE[12]	21.89%	31.61%	26.29%	15.86%	9.45%	7.03%	-12.05%	-15.64%	-12.96%	NA	3.19%	5.63%	24.72%	5.42%	15.60%
Capacity in MW	4,000	9,000	12,000	12,000	12,000	250	250	550	250	550	1,220	1,370	3,360	1,660	4,130
Order Book (MW)	3,280	18,060	19,926	17,190	16,661	NA	NA	NA	NA	NA	3,170*	9,860	54,332	10,781	57,790

UA: Unaudited,

*Source: Company, Company websites, Audited Annual Reports, *Premier Energies Order book in Rs. Mn from RHP Filing dated August 20, 2024, CRISIL MI&A Consulting*

Notes: NA-Not available

1. *Direct Sales to Utilities and Enterprises refers to our sales to utilities and enterprise customers.*
2. *Franchisee Sales includes module sales through our franchisee network focused on rooftop and MSME customer segments as well as franchisee EPC revenue*
3. *Export Sales includes module sales to international customers as well as international EPC revenue*
4. *Other Revenue from Operations includes EPC services for domestic utilities and enterprise customers, O&M services, trading in ancillary products, export incentives, generation of electricity from renewable resources and scrap sale.*
5. *EBITDA has been calculated as profit for the year before exceptional items and taxes plus finance cost, depreciation and amortization*
6. *EBITDA margin has been calculated as EBITDA divided by total income.*
7. *Total Debt to equity ratio has been calculated as total borrowings (including current maturities of long-term debt) divided by total equity (excluding non-controlling interest) (less)/add (deferred tax assets)/deferred tax liability (net).*
8. *Total Debt to EBITDA ratio has been calculated as total borrowings (including current maturities of long-term debt) divided by EBITDA for the relevant fiscal year/ period.*
9. *Return on average capital employed has been calculated as profit before exceptional item and tax plus finance costs divided by average of opening and closing capital employed calculated as total equity (excluding non-controlling interest) add non-current liability.*
10. *PAT Margin has been calculated as profit for the year/ period divided by total income*
11. *Return on equity has been calculated as net income (owners share) divided by total equity (excluding non-controlling interest)*
12. *Return on capital employed has been calculated as profit before exceptional item and tax plus finance cost divided by total equity (excluding non-controlling interest) add non-current liability*

7.12 India opportunity-Energy security and manufacturing renaissance

7.12.1 MNRE Tendering trajectory-50 GW annual RE capacity to be tendered

The Government has decided to invite bids for 50 GW of renewable energy capacity annually for the next five years i.e., from Financial Year 2023-24 till Financial Year 2027-28. Considering the fact that RE projects take around 18-24 months for commissioning, the bid plan will add 250 GW of renewable energy and ensure 500 GW of installed capacity by 2030. The Ministry of Power is already working on upgrading and adding the transmission system capacity for evacuating 500 GW of electricity from non-fossil fuel.

In addition to this, the Ministry has declared a quarterly plan of the bids for fiscal 2024, which comprises of bids for at least 15 GW of renewable energy capacity in each of the first and second quarters of the financial year (April-June 2023 and July-September 2023 respectively), and at least 10 GW in each of the third and fourth quarters of the financial year (Oct-December 2023 and January-March 2024 respectively).

Among the four PSUs designated as Renewable Energy Implementing Agencies (REIAs), the SECI and NTPC will float bids of 15 GW each of solar, wind, hybrid and round-the-clock projects during the current financial year. Similarly, hydro power generators NHPC and SJVN will float RE projects bids of 10 GW each in FY24.

Table 49: Renewable Energy Implementing Agency wise bidding calendar for fiscal 2024

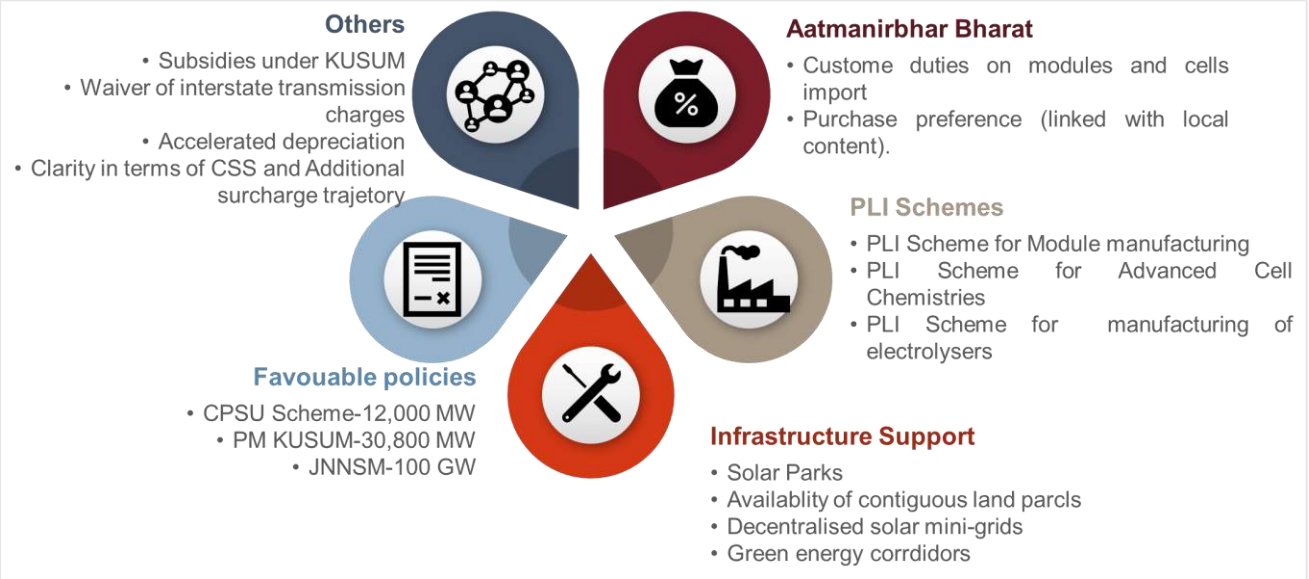
Bidding Agency	Type	Q1FY24	Q2FY24	Q3FY24	Q4FY24	Total
SECI	Solar, Hybrid, RTC etc.	3.5	6	2	1	**12.5**
	Wind	2.5				**2.5**
NTPC	Solar, Hybrid, RTC etc.	3	3	3	3.5	**12.5**
	Wind		2.5			**2.5**
NHPC	Solar, Hybrid, RTC etc.	3	1.5	1.5	1.5	**7.5**
	Wind			2.5		**2.5**
SJVN	Solar, Hybrid, RTC etc.	3	2	1	1.5	**7.5**
	Wind				2.5	**2.5**
Total		**15**	**15**	**10**	**10**	**50**

Source: MNRE, CRISIL MI&A Consulting

7.12.2 Government provides various incentives for promotion of renewable energy

Several incentives are being provided for growth of the renewable energy sector in the country. In order to promote local manufacturing of solar panels, the Government has taken a number of steps. Government of India has been consistently bringing out policies for developing and facilitating domestic renewable energy equipment manufacturing in the country. Some of the recent initiatives undertaken to promote solar energy domestic equipment manufacturing in the country are summarised in following figure:

Figure 93: Government incentives are aligned for manufacturing renaissance



Source: MoP, MNRE, Various ministries, CRISIL MI&A Consulting

7.12.3 Manufacturing capacity additions

As discussed earlier, CRISIL MI&A Consulting expects solar PV manufacturing Capacity to reach ~125 GW by fiscal 2029, with full integration from polysilicon to modules expected to account for 25% of capacities, largely driven by PLIs (Production-Linked Incentives).

India is the world's third-largest energy consumer, and its energy demand is expected to grow rapidly in the coming years. To meet this demand, India will need to diversify its energy mix and reduce its reliance on fossil fuels. Solar energy is a clean and abundant resource that can help India achieve its energy security goals.

7.12.4 Export opportunity

China is the world's largest manufacturer of solar modules, but it is also facing several challenges, including trade tensions with the US and EU, rising labor costs and environmental concerns. These challenges are making it more difficult for Chinese solar module manufacturers to compete in the global market. This is creating an opportunity for Indian solar module manufacturers to gain market share. The US and EU are implementing several regulations to promote the use of renewable energy, including solar energy. These regulations are creating a large market for solar modules in the US and EU.

India has the potential to become a global leader in the manufacturing of solar modules. The country has a large pool of skilled labor, a growing manufacturing ecosystem, and abundant access to raw materials. Additionally, the Indian government has introduced several policies to support the domestic solar industry. India's solar module manufacturing capacity is expected to reach ~125 GW by fiscal 2029. Domestic demand for solar modules is estimated to be around 38-42 GW in the same year. This means that India will have a surplus of solar modules that can be exported to other countries.

The global solar market is expected to grow rapidly in the coming years, driven by increasing demand for renewable energy and government policies to support solar deployment. This presents a significant export opportunity for Indian solar module manufacturers.

7.12.5 Increased ESG Awareness

Increased ESG awareness is leading to increased demand for solar modules, as solar energy is a clean and renewable energy source that can help companies and governments reduce their carbon footprint. With increased focus on climate change, Companies and governments are looking for ways to reduce their environmental impact. Meeting international energy and climate goals requires the global deployment of solar PV to grow on an unprecedented scale. In addition to the environmental benefits, solar energy can also provide social and economic benefits. For example, solar energy can create jobs in the solar industry and can help to reduce energy poverty.

7.12.6 India as Global supplier

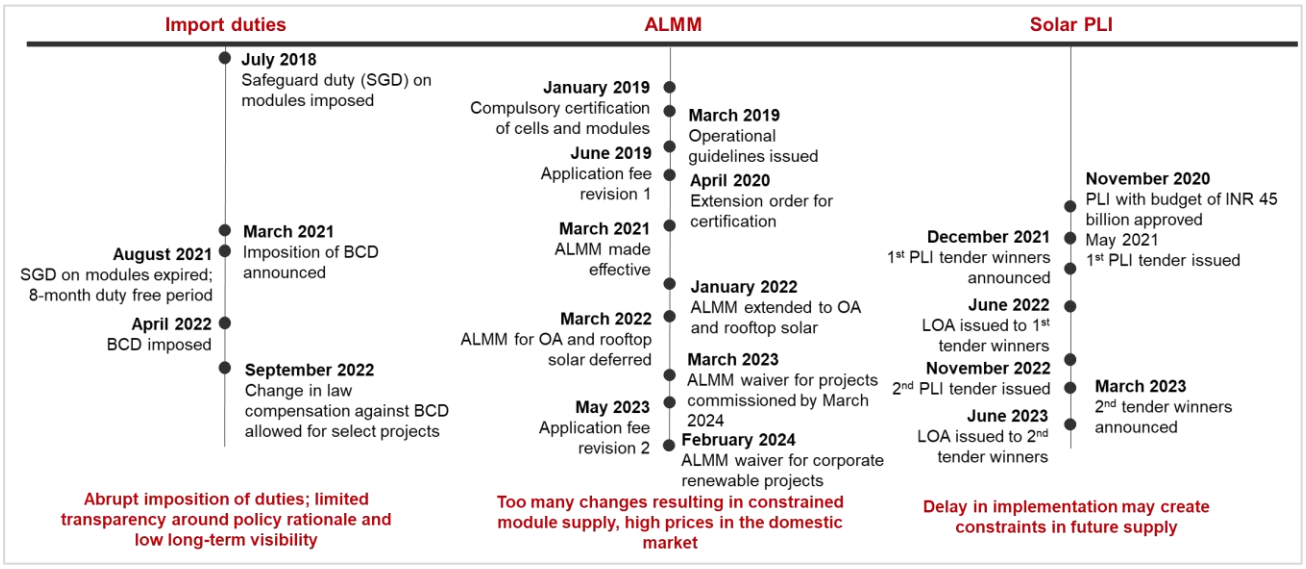
Developing countries are increasingly investing in solar energy to meet their growing energy demand. This presents a significant export opportunity for Indian solar module manufacturers. The Indian government is providing several incentives to support the export of solar modules. Indian solar module manufacturers can diversify their markets by exporting to countries where there is high demand for solar modules and low import duties.

India has an immense opportunity to export solar modules. This can help the country achieve its energy security goals and usher in a manufacturing renaissance. Indian solar module manufacturers need to overcome a few challenges, such as competition from China and high import duties in some countries. However, there are several opportunities for Indian solar module manufacturers to export their products, such as growing demand in developing countries, government support, and diversification of markets. Overall, the export demand for Indian solar modules is potentially on the rise due to anti-China sentiment and government support.

8 Risks and challenges

8.1 Policy and regulatory uncertainty

The solar energy segment is largely dependent on government policies. Government policies play a crucial role in shaping the solar module manufacturing landscape in India. Key policy measures include applicability of ALMM, safeguard duty, BCD and solar module manufacturing PLI scheme. Despite a very supportive government, the policy framework has been in flux with several amendments and reversals. Policy formulation and implementation is often hampered by shifting and conflicting priorities, poor design, disjointedness between different arms of the government and disregard for practical considerations. A representative example of policy flux in the PV module market is given below.



8.2 Market demand variability

Market demand fluctuations is influenced by changes in government policies, incentives for solar projects, changes in solar tendering capacity, shifts in export markets. The government tenders play a crucial role in driving demand for solar modules in India. Inconsistent tendering schedules can create uncertainty for manufacturers, making it difficult to plan production and manage inventory. Indian Solar PV manufacturers still operate their plants at ~50% of its capacity due to lack of demand from private IPPs. Sudden spikes in demand can strain production capacity, while dips can lead to underutilisation of resources. Similarly, an economic downturn or growth spurts in export markets can lead to fluctuating demand for solar modules.

8.3 Technological challenges

Solar PV manufacturing advancing towards more efficient and cheaper modules. Any changes in solar technology can shift demand towards newer products, rendering existing inventory less desirable. All technology know-how and even manufacturing lines and installation personnel for new PV cell and module lines, being set up currently, are coming mostly from Chinese suppliers. Therefore, maintaining high quality standards and keeping up with rapid technological advancements can be challenging for this industry. Solar cell manufacturing plant face significant technological risk of obsolescence as compared to solar panel manufacturing due to rapid advancements in solar cell technology.

8.4 Project development risks

Developing a solar cell manufacturing plant involves high capital expenditure for infrastructure, machinery and technology. The complexity of setting up production lines requires precision and stabilisation period of 6-12 months for achieving high cell efficiency and yield. On the contrary, solar module manufacturing process is comparatively requires lesser capex with limited complexities in setting up the assembly line. It typically takes upto 2 months to stabilise the process. Stringent quality check is critical for both the manufacturing process to avoid product recall or reputational damage.

8.5 Supply chain disruptions

India heavily relies on imports for critical components like solar cell, wafers, EVA sheet, glass, etc. India has limited solar cell capacities and no ongoing production for polysilicon, ingots and wafer. This dependence makes the industry vulnerable to global supply chain disruptions, price volatility and trade policies. An unreliable supply chain can lead to production delays and inconsistencies affecting the ability to meet demand.

8.6 Competitive pressure

There are multiple players in this sector who have announced their plans to setup manufacturing facilities in India. The domestic manufacturer may face competition not only in the domestic market but also with the global players with established manufacturing base like China and Southeast Asia. Hence domestic manufacturers face stiff competition from cheaper and better-quality modules imported from China. Domestic manufacturers do not enjoy economies of scale like leading Chinese suppliers. Huge supply glut in China has led to prices falling sharply across the value chain threatening competitiveness of local manufacturers despite high import duties.

8.7 Environmental factor

The manufacturing process involves the use of materials that can generate hazardous waste. The production process involved in solar PV manufacturing, such as etching, doping, and coating, can generate greenhouse gases, volatile organic compounds, and acid gases, which can contribute to air pollution. Some of the materials used to make solar cells, such as cadmium, lead, arsenic, and selenium, are toxic and can pose health and environmental risks if not handled properly. The water consumption is also significant, especially for the production of silicon wafers, which need to be purified, cut, and polished with large amounts of water. These challenges can impact costs, operational efficiency and the overall feasibility of the project.

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