

Viability Assessment of New Domestic Solar Module Manufacturing Units

Can India Compete Against China in PV Production?

Executive Summary

India is one of the top 10 solar module producers in the world with an installed domestic photovoltaic (PV) module manufacturing capacity of about 15 gigawatts (GW). However, India is lagging behind its biggest competitor China, in not just module manufacturing capacity but also in production of other raw materials such as wafers, cells and poly silicon. In addition, the capacity utilisation of domestic production facilities is only 40-45% and estimated operational capacity is only about 7GW.¹ Current production capacity is only able to meet 35% of the total annual domestic demand. Even though domestic suppliers contribute only 30-35% share of all utility-scale solar installations, the situation is reversed in the commercial and industrial (C&I) and distributed segment of the market where domestic suppliers cater to nearly 60% of the market.

India is lagging behind its biggest competitor, China.

On the export-import front in India, Chinese suppliers account for 80% of the imported modules market with the rest of the imports coming from Thailand, Malaysia, Vietnam. Since 2015, India has on average imported solar cells and modules worth Rs176bn (US\$2.6bn) annually. Simultaneously, 80% of India's market share of exports is to the U.S. The exports of each of the top 4 players – Vikram Solar, Waaree, Adani Solar and Tata – constitute 25-30% of their total

¹ For leading domestic manufacturers only, Source: JMK Research.

trade volume. On the other hand, Chinese manufacturers, trade 66% of their production volume on average in the overseas market.

This report covers two distinct sets of policy framework and different industry incentive programmes prevailing in India and China. In India, in order to boost domestic manufacturing, several avenues were created under the Domestic Content Requirement (DCR) category, manufacturing linked tenders, incentives through Modified Special Incentive Package Scheme (M-SIPS), imposition of safeguard duties etc. to name a few. Whereas, the Chinese government offers cheap credit, free land, cheap loans, research funds, tax rebates, and sometimes even cash to support its manufacturing sector.

The report also analyses various components of PV module manufacturing cost, in which the Bill of Materials (BOM) has the highest share with more than 4/5ths of the total expenditure. BOM of solar modules include the cell, glass, ribbon, silicon, aluminium frame, etc, with the cell contributing the highest share in terms of component cost. For Indian manufacturers, the BOM is about 15% higher than the BOM for their Chinese counterparts for non-DCR modules (modules where imported cells are used) and about 20% higher for DCR modules. If India's capacity utilisation could be increased to 100%, then the per watt-peak (Wp) cost can be reduced by 7-8%.

In terms of profit margins, the Chinese module suppliers are able to absorb larger shares of profit (average 4.3%) of the operational revenues compared to that of Indian suppliers (excluding Adani), who earn an average profit income of less than 3%. This is because the Chinese module manufacturers have larger-scale production facilities, low dependence on imports, completely integrated facilities of modules, cells and wafers. This is also complemented by robust research & development (R&D) and favourable government support.

In terms of technology adoption trends, the more advanced mono-Si PV modules had almost a two-thirds share of the entire global PV production by 2019 in terms of GW volume. Whereas in India, considering the top 7 domestic module manufacturers in 2019, mono-Si PV modules constituted only 13% of PV production, while 87% comprised of multi-crystalline (or multi-Si) PV modules. According to JMK Research, in 2020, in India, the share of mono PERC modules is expected to increase to 25-30% of all utility-scale solar installations.

From having a virtually monopolistic presence in Chinese module exports prior to 2018, demand for M2 cell-based modules has been declining at a fast pace every quarter since 2019. Conversely, in the Indian market, the domestic manufacturers have only been catering to the M2 cell-based module market.

Furthermore, about 1-3% of the gross revenue has been utilised for R&D by the Chinese players every year. In India on other hand, there is not much investment in R&D, even by the leading players. Even the government has not promoted schemes or given grants to set up facilities to promote technological innovation, a key aspect of the solar sector. However, in a recent development, the Indian government gave the nod for the introduction of a Production-Linked Incentive (PLI) scheme in 10 key sectors, including the solar PV manufacturing sector, for which Rs45bn

(US\$603m) is allocated for investment by the Ministry of New and Renewable Energy (MNRE) in high efficiency solar PV modules.

With reformed national priorities following the COVID-19 pandemic and India-China border issues, the solar PV industry presents an opportunity for the nation to boost its self-reliance, albeit at a cost to downstream electricity users in the form of higher resulting tariffs. Henceforth, to assess the viability of new module PV manufacturing facilities in India, this report analysis and compares in detail various critical parameters, that are imperative to aid this segment.

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Overview

Until 2011, India was one of the largest exporters of best-in-class modules. Domestic manufacturers including Tata Solar, Moser Baer, BHEL, Indosolar and Lanco were industry pioneers. However, factors including lack of financing support, inconsistent government policy, lack of scale and competition from low priced Chinese imports led to undercutting of India's domestic module manufacturing growth.

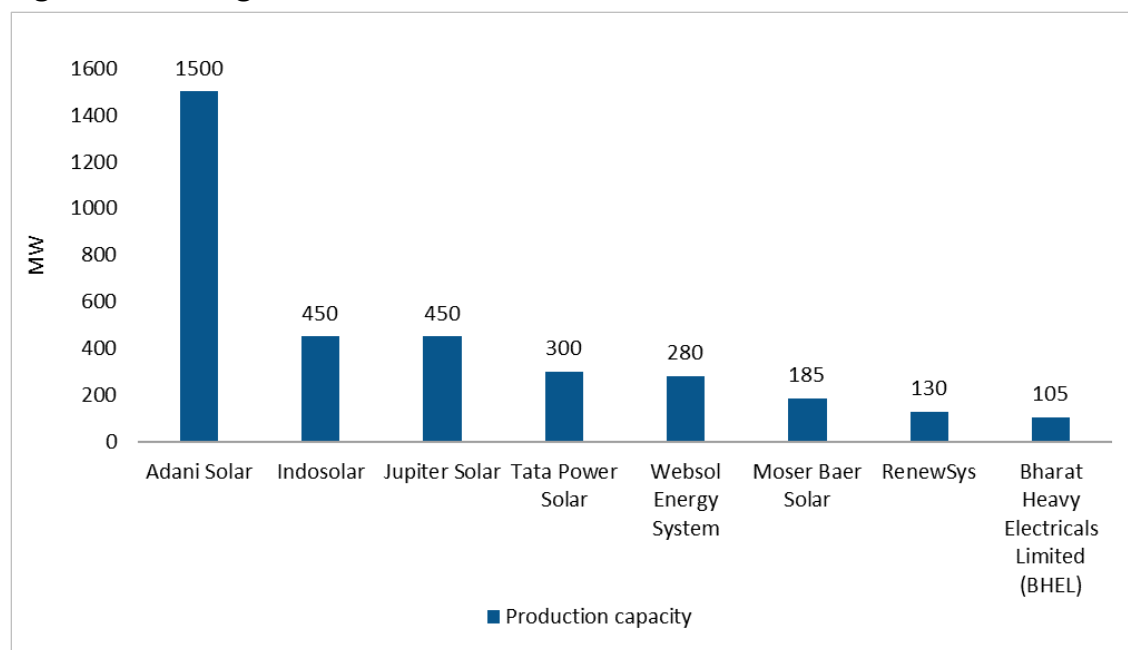
In India, domestic module manufacturing started picking up pace in 2010 with the announcement of the National Solar Mission. The mission required the bidders to use solar Photovoltaic (PV) modules manufactured domestically in the first ever solar tender of 150 megawatts (MW). The second tender of 350MW further strengthened the stipulation requiring bidders to use only solar cells and modules produced domestically instead of modules produced using imported solar cells. In 2012, the Modified Special Incentive Package Scheme (MSIPS) was launched to provide financial aid via subsidy grants for the local players. In the following years, to lend further assistance to the stressed sector, the Indian government introduced certain measures such as the Domestic Content Requirement (DCR) and the safeguard duty (SGD) to dampen the influx of cheap foreign imports. Later on, schemes were launched to reserve 50% of the tender capacity for solar cells and modules manufactured domestically while allowing the remaining 50% capacity to be set up using imported modules. But this was unhelpfully challenged in the World Trade Organization (WTO) by the U.S., which viewed it not as a government procurement but a commercial transaction. Due to this, the process of reserving capacities in the tenders for solar cells and modules manufactured domestically was stopped in January 2018.

Most of these central government initiatives did not catalyse a nation-wide move towards the indigenisation of the PV value chain in the desired manner. Apart from the policy and regulations concerning the industry, there are considerable techno-economic risks involved in the setting up and operation of module manufacturing facilities in India. But the challenges associated with these risks along with the rising annual demand for solar installation in the country signify the existence of enormous underlying potential for development of domestic module production. With reformed national priorities following the COVID-induced lockdown, the solar PV industry presents a critical opportunity for the nation to boost its self-reliance.

Domestic Cell Production Capacity

India has just over 3GW capacity of domestic cell manufacturing. With module production capacity in the country at around 5 times of that of solar cells, the huge dearth as well as the opportunity in the logistical support for Indian module manufacturing is quite evident. The demand for indigenously made solar cells is generally low because module suppliers demand cells of higher grade (in terms of wattage, efficiency, etc.). In addition to this, due to the narrow cell production scale for the majority of cell manufacturers, domestic cells are more expensive. Given these factors, domestic module suppliers prefer the superior imported cells.

Figure 1: Leading Domestic Solar Cell Manufacturers in India



Source: JMK Research.

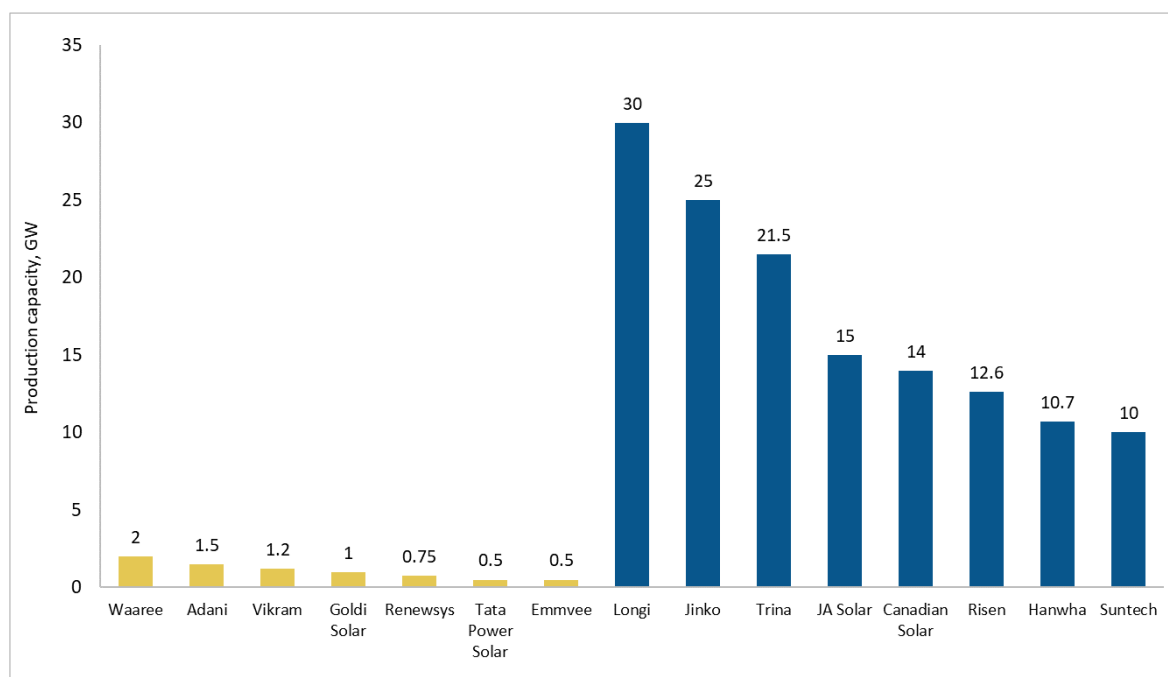
Module Manufacturing Capacity

According to MNRE, the current installed manufacturing capacity of domestic modules in India is about 15GW. Only a couple of GW-scale companies exist in India. The majority of the plants are of 50-200MW capacity and experience very high operating costs. The capacity utilisation of domestic production facilities is only 40-45% and estimated operational capacity is about 7GW.²

This low capacity utilisation has been attributed as the reason for the sub-scale production capacity with the average plant size 0.5-1GW in India vs. 3-5GW in China.

² JMK Research.

Figure 2: Production Capacity of Leading Domestic vs. Chinese Module Manufacturers – 2020

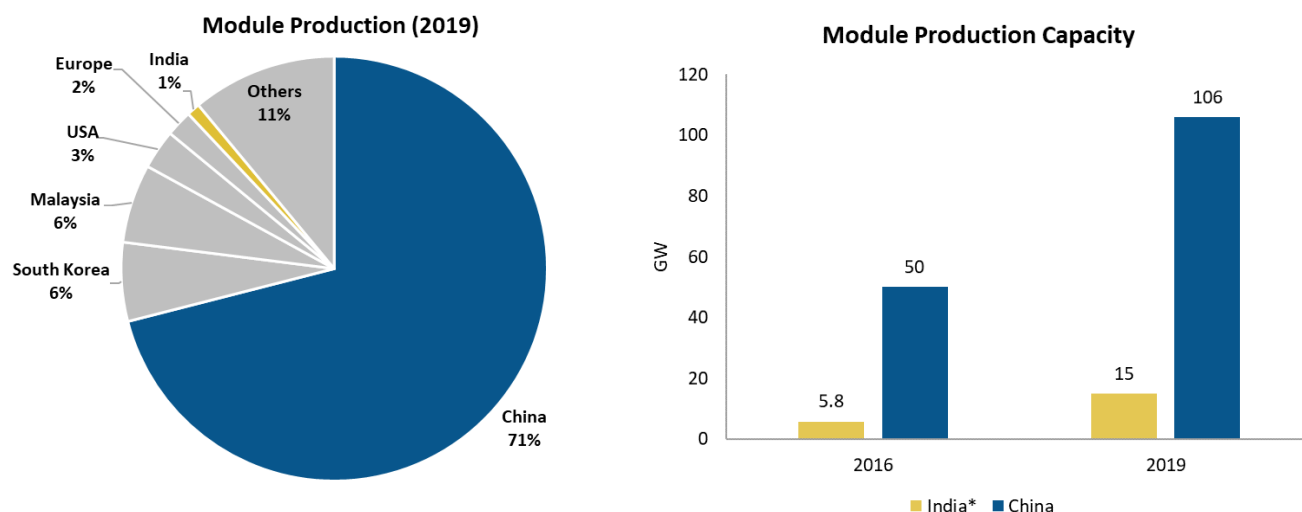


Source: JMK Research.

China accounts for ~71% of the total solar module manufacturing capacity globally. It has witnessed growth in solar manufacturing capacity from 10GW in 2010 to 106GW in 2019. In addition to modules, China is also a leading producer of silicon wafer with a 97.4% share of the global market, PV cells with a 79% share and poly silicon with a 67% share.³ India is lagging behind its biggest competitor not only in module manufacturing capacity but in other raw material production such as wafers, cells, poly silicon as well. With rapid solar technology innovation, Indian firms also struggle to keep pace with China's constant manufacturing capacity upgrades.

³ IEA. IEA PVPS Annual Report 2019, China. May 2020.

Figure 3: Global Module Production Trends vs. India



Source: IEA PVPS Annual Report, JMK Research.
*Installed Capacity.

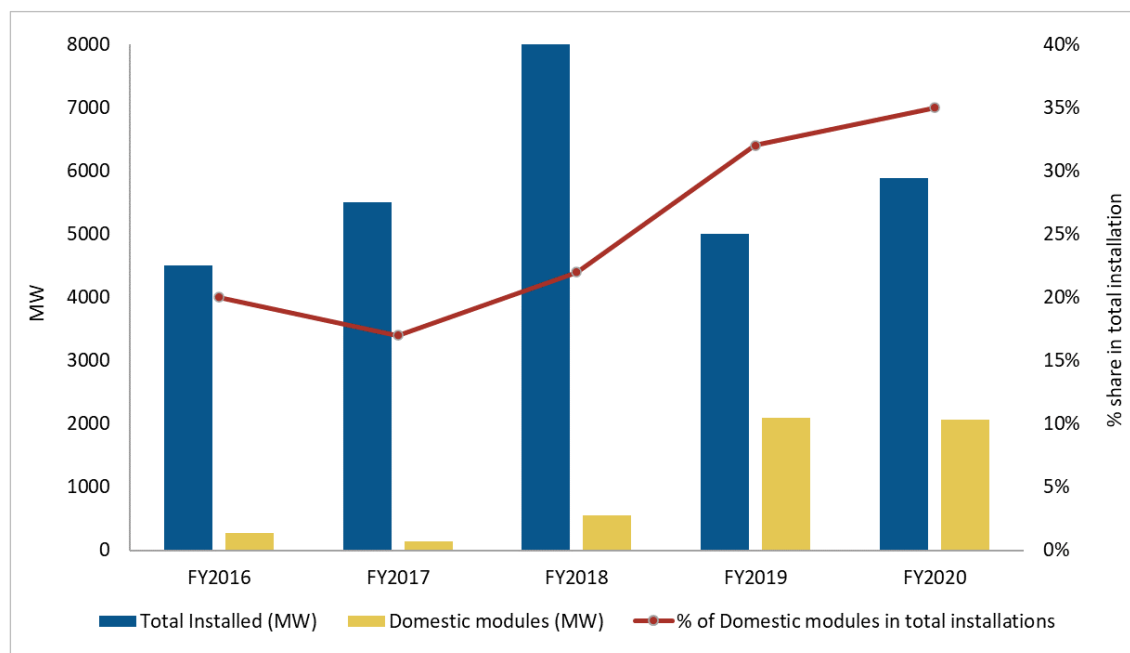
Domestic production of modules is yet to attain critical mass in India. Current production capacity is only able to meet 35% of the total annual domestic demand.⁴ The share of Indian PV module sales compared to overall global sales so far is insignificant. But major expansion plans by some of the biggest domestic players such as Waaree and Adani are expected to spur the growth of domestic module sales in the next few years.

However, in the near term, the prospect of manufacturing capacity addition/expansion looks to be uncertain. Though the import of solar modules has reduced since the beginning of COVID-induced lockdown, it has also affected the domestic manufacturing industry. The Indian manufacturers have been dealing with raw material import restrictions and a surge in the prices of these inputs.

Due to insufficient domestic module manufacturing capacity and quality, over the years India has relied mainly on imported modules. The domestic module manufacturing industry has a long way to go to fulfil the 10GW annual domestic demand for solar installations. As shown by the chart below, the share of domestic modules installed in total in India has increased from 15% to 35% in the last three years. Despite this, the industry is heavily reliant on imported modules from China only.

⁴ JMK Research. Annual Solar Report Card FY2020. June 2020.

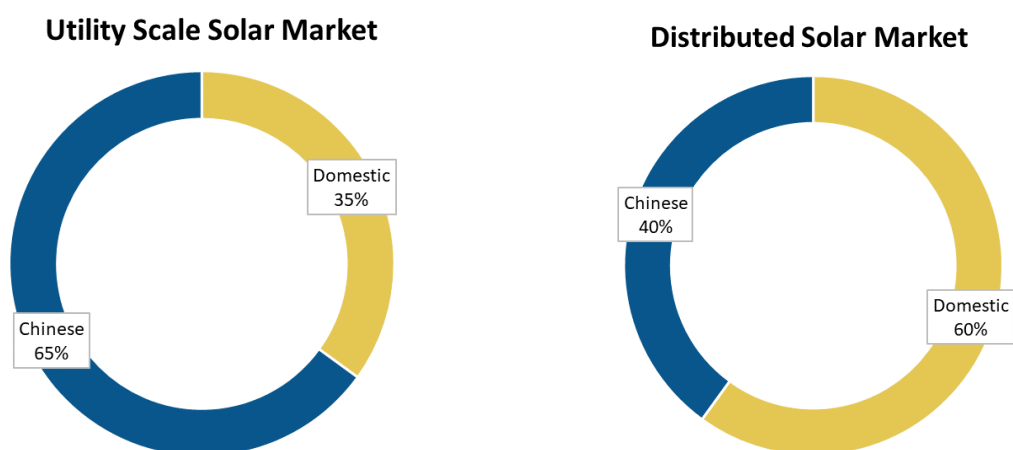
Figure 4: Domestic Supplier Share in Indian Utility Scale Solar Installations



Source: JMK Research.

Even though domestic suppliers contribute only about a 30-35% share of all utility-scale solar installations, the situation is reversed in the commercial and industrial (C&I) and distributed segment of the market where domestic suppliers cater for nearly 60% of the market.

Figure 5: Estimated Customer Segmentation of Module Suppliers in FY2020

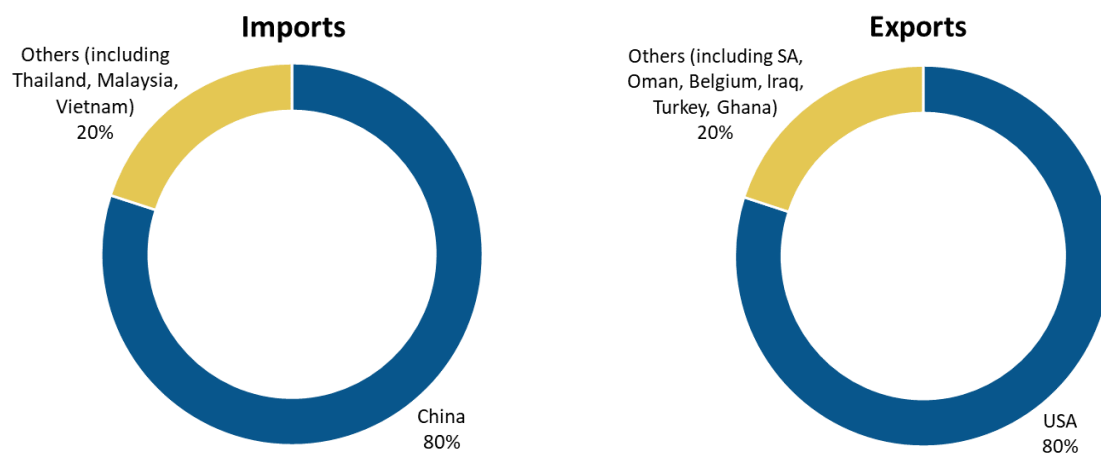


Source: JMK Research Annual Solar Report Card.

Import-Export Trends

Chinese suppliers still account for 80% of India's solar import market. Imports also come from other countries including Thailand, Malaysia and Vietnam. India's 80% market share of exports is to the U.S. Other export countries are South Africa, Oman, Belgium, Iraq, Turkey and Ghana. Since 2015, India has on average imported solar cells and modules worth Rs176bn (US\$2.6bn) annually.⁵

Figure 6: Import Export Trends of Modules in India



Source: JMK Research.

Domestic Regulatory Compliances

Approved List of Models and Manufacturers (ALMM)

In January 2019, MNRE issued the Approved Models and Manufacturers of Solar Photovoltaic Modules (Requirements for Compulsory Registration) Order, 2019, with the objective of ensuring reliability of solar PV manufacturers and to protect consumer interests. The order sets out enlisted eligible models and manufacturers of solar PV cells and modules complying with the Bureau of Indian Standards (BIS). It is also published in the "Approved List of Models and Manufacturers" (ALMM). List I consists of models and manufacturers of solar PV modules and List II includes models and manufacturers of solar PV cells. All ALMM-enlisted module manufacturers must only purchase their solar cells from ALMM List II-enlisted solar cell makers.

The application fee for one model of module or cell is Rs5,000/MW of the total installed manufacturing capacity for solar PV modules or cells. However, for PV module manufacturers with a total installed manufacturing capacity of modules less than or equal to 50MW, the application fee for one module is Rs2,500/MW of the

⁵ CEEW. *Solar PV Manufacturing: Reassessing Priorities in the Post-COVID-19 Era*. May 2020.

total installed manufacturing capacity of solar modules or cells.

Now solar PV manufacturers exempt from BIS registration are eligible to enlist their solar PV modules in ALMM. However, the validity of their enlistment in ALMM must be in line with the validity of the exemption from BIS certification. If the solar PV manufacturer has enlisted products under ALMM without BIS certification, the manufacturer must obtain BIS registration and submit the documents to MNRE at least one month before the date of the expiry of the ALMM enlistment. Only ALMM-enlisted solar module manufacturers are eligible to participate in government tenders.

The final date for enlistment for the two ALMM Lists was 31 March 2020. But on account of the challenges due to the COVID-induced lockdown, the date was extended to 30 September 2020.

BIS Certification

MNRE under the BIS Act notified the Solar Photovoltaics Systems, Devices and Components Goods (Requirements for Compulsory Registration) Order 2017 on 5.09.2017 for quality assurance in SPV Power Projects. It includes SPV modules, inverters and battery storage for SPV applications. As per the order, no person shall manufacture or store for sale, import, sell or distribute goods, which do not conform to Indian Standards specified in the order.

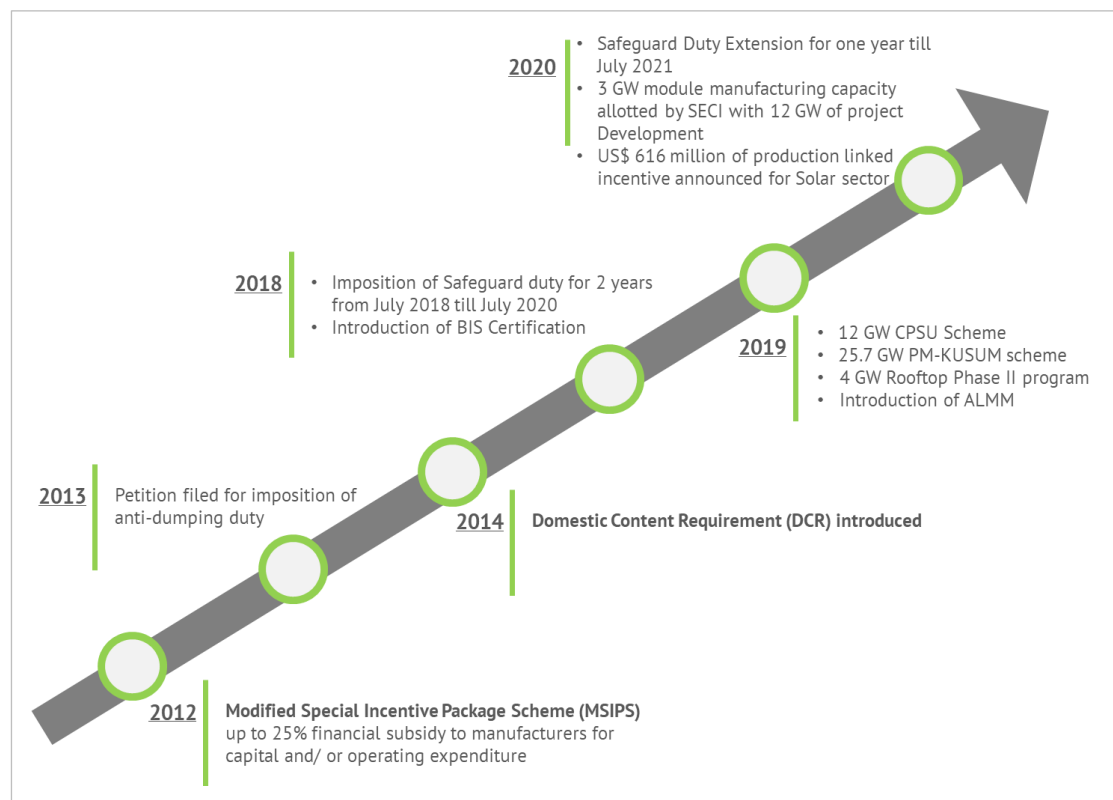
The aforementioned order came into force in 2018 and, among other measures, required PV modules to be mandatorily tested in accordance with IS 14286:2010, IS 61730(Part-I) and IS 61730(Part-II) by local BIS-approved laboratories in India. Only the certified modules are allowed to enter the Indian domestic market. The BIS certificate is valid for 2 years from the date of issuance.

Module manufacturers who have less than 50MW annual capacity were exempt from BIS certification up to 4 September 2020, provided they had a valid IEC certificate. Around Rs0.24 crore/series of module is required for BIS registration.

Government Subsidies and Incentives for Domestic Players

The Government has introduced a slew of measures in an attempt to provide a level playing field for domestic module manufacturers. Several avenues were created under the domestic content requirement (DCR) category, manufacturing linked tenders, incentives through the Modified Special Incentive Package Scheme (M-SIPS) and imposition of safeguard duties, to name a few. However, manufacturers were not able to get substantial benefit from most of these measures.

Figure 7: Government Initiatives for Domestic Module Manufacturers in India



Source: JMK Research.

Incentives for Domestic Manufacturers

Modified Special Incentive Package Scheme (M-SIPS)

The scheme, launched in 2012, offered a financial subsidy of 20% to manufacturers for capital and operating expenditure in Special Economic Zones (SEZs) and 25% in non-SEZs. However, the majority of incentives under this scheme could not be disbursed, so many companies did not benefit from it. Further, the scheme was applicable to all electronics manufacturing, and did not have separate allocation for solar manufacturing. The government stopped accepting fresh applications under M-SIPS as of the end of 2019. However, by February 2020, 252 proposals worth Rs7,205m were approved. Further, incentives of Rs89.7m had already been disbursed to 71 applicants.⁶

Adani Solar, under the same scheme, has set up a vertically integrated 1.2GW solar photovoltaic manufacturing facility along with research and development (R&D) facilities within an Electronic Manufacturing Cluster (EMC) facility in Mundra SEZ. The PV facility, touted to be the largest vertically integrated producer of solar cells

⁶ Economic Times. [Manufacturing incentives scheme created 1,20,000 jobs so far: R S Prasad](#). February 2020.

as well as modules in India, is also the first facility to be located in an SEZ under the M-SIPs scheme. The scheme approved the investment made by Mundra Solar PV Ltd (MSPVL) and released a major portion of the capex subsidy of Rs3.42bn⁷ during FY2019/20.

Export Incentive

Under Remission of Duties and Taxes on Exported Products (RoDTEP), government has approved exporter incentives @2%. The industry however wants the incentive to be increased from the existing 2% to 8-10%.

Customs Duty Exemption Under EPCG Licence for Import of Capital Equipment for Manufacturing

Export Promotion Capital Goods (EPCG) Licence, as the name suggests, is intended to act as a stimulus for exports. It allows exemption of customs duty on import of capital goods subject to the condition that an export obligation of eight times the duty saved is to be fulfilled within 8 years of authorisation issue date.

Government Schemes to Support Domestic Players

Domestic Content Requirement (DCR)

Mandatory domestic content requirements were imposed on solar power developers that participated in the initial batches of Jawaharlal Nehru National Solar Mission (JNNSM) energy scheme. The DCR came under the lens of the WTO in 2014 when the U.S. complained that this scheme was more of a commercial transaction than a procurement strategy. In view of the WTO ruling, as of January 2018 the DCR provision was stopped for future tenders that were not for government/public sector undertaking (PSU) manufacture. MNRE directed all states/central PSUs not to take any new projects with DCR under the developer mode. In order to be WTO-compliant, the government now needs to be a procurer wherever domestic content is given priority, while a private domestic developer can be an engineering, procurement and construction (EPC) contractor or bag projects that get state subsidies. The following schemes were introduced as part of this:

Central Public Sector Undertaking (CPSU) scheme: The CPSU scheme was introduced in January 2015 to promote domestic solar manufacturing in India by setting up 1,000MW of grid-connected solar PV power projects by CPSUs and government organisations with Viability Gap Funding (VGF). Power procured from projects under this scheme are only to be consumed by government organisations, which is in line with the General Agreement on Tariffs and Trade (GATT), 1994, that permits governments to purchase domestic products preferentially without violating WTO norms. The scheme's target was extended from an initial 1,000MW to 12,000MW in 2019, to be achieved by 2023. VGF support of Rs85,800m has already been sanctioned for the scheme, capping the total amount to Rs7m/MW. Till date,

⁷ India Ratings & Research. [India Ratings Revises Mundra Solar PV's Outlook to Stable; Arms 'IND BBB+'](#). May 2019.

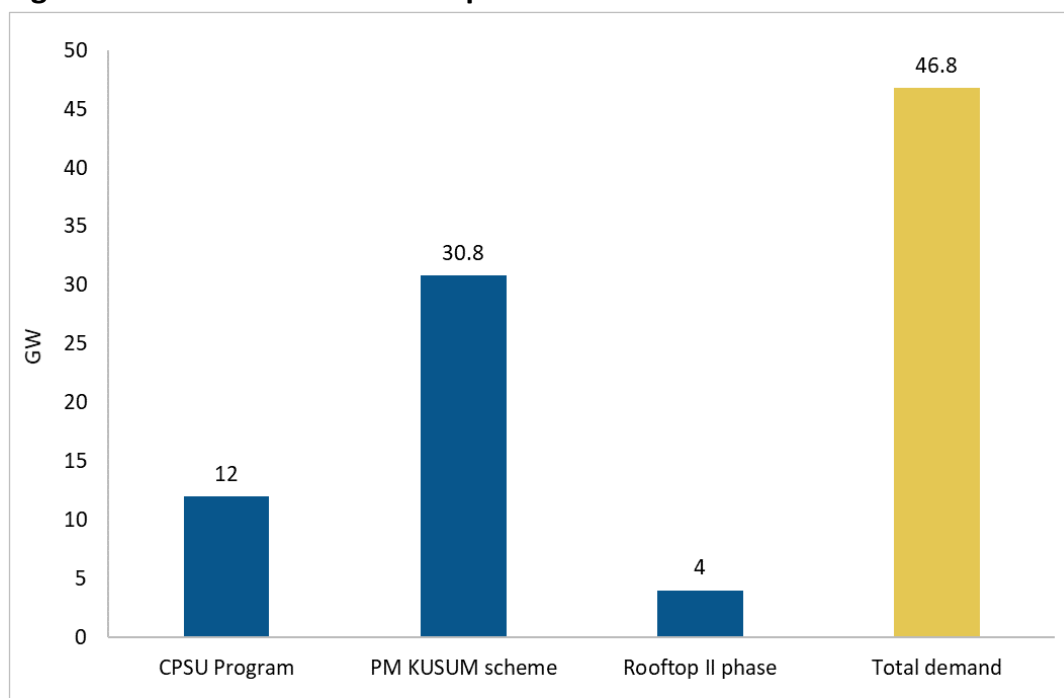
Solar Energy Corporation of India (SECI) has been able to conduct just two auctions under the scheme, out of which only 2,027MW could be awarded. NTPC alone accounts for ~85% of this capacity allotted.

Rooftop programs: MNRE implemented the Grid Connected Rooftop and Small Solar Power Plants Programme (Phase I) in 2015 for which a subsidy of up to 30% of the benchmark cost was provided for general category states, and up to 70% of the benchmark cost for special category states for installation across the residential, institutional and social sectors. In addition, for government installations, achievement-linked incentives of up to 25% of the benchmark cost in general category states / union territories (UTs) and up to 60% of the benchmark cost for special category states / UTs were provided. Despite setting a target of 40GW of rooftop solar capacity to be achieved by 2022, the total rooftop solar capacity stood at only 5.9GW as of June 2020. To give a fillip to the solar rooftop market, the government introduced the Rooftop Phase II Programme in August 2019 to achieve the target. Under the program, additional rooftop solar capacity of 4GW was targeted for the residential segment and 18GW was targeted through incentives for distribution companies (discoms). To achieve the residential target of 4GW, central financial assistance (CFA) of 40% of project cost for a system size of up to 3kW was also sanctioned. To be eligible to benefit from CFA and government incentives, the projects are required to install only domestically produced modules.

PM-KUSUM scheme: The Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) scheme was launched in July 2019. The scheme initially targeted to set up decentralised solar power capacity of 25,750MW by 2022. However, the MNRE with its notification dated 13 November 2020 has increased the aggregate target to 30.8GW from 25.7GW by FY2023. The scheme has the following three components: setting up of 10,000MW of decentralised ground/stilt-mounted grid-connected solar or other renewable energy-based power plants; installation of 1.75 million standalone solar agriculture pumps; and solarisation of 1 million grid-connected solar agriculture pumps.

In November 2020, the scope of the scheme was further expanded to allow solar projects smaller than 500 kW as well. For solar pumps to be set up, the CFA will be allowed for higher than 7.5 HP of capacity. Eligibility conditions for participation have also been relaxed, allowing joint ventures (JV) between manufacturers of solar panels/ solar pumps/ solar pump controllers and integrators. Previously only solar pump and solar panel manufacturers were eligible.

Figure 8: Schemes With DCR Requirement

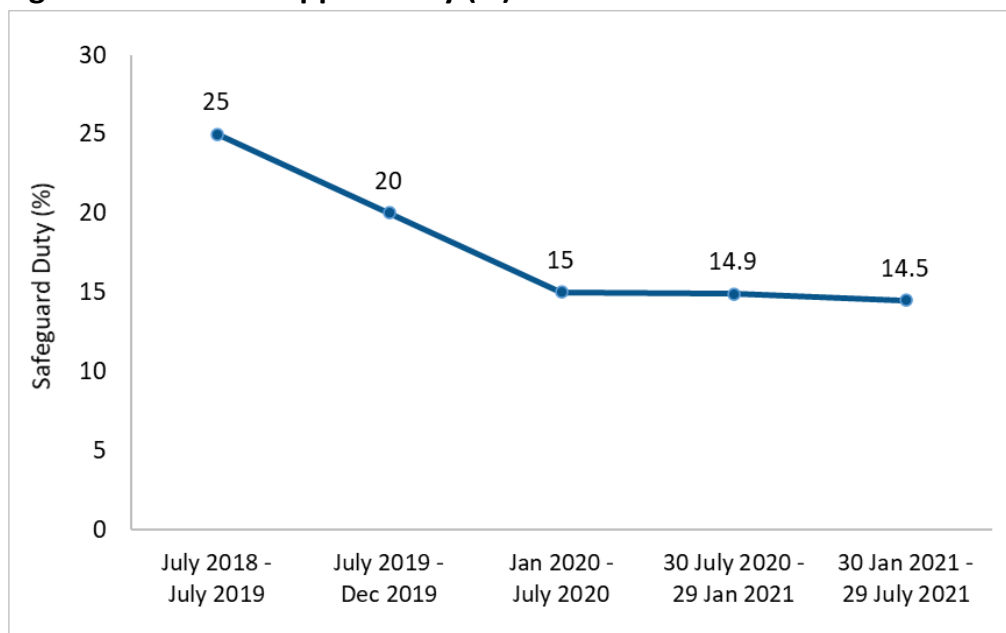


Source: MNRE, JMK Research.

Imposition of Safeguard Duty (SGD) on Imports of PV Cells and Modules

SGD was introduced in July 2018 till July 2020 to promote domestic manufacturing and curb imports from China, Taiwan and Malaysia. 25% duty was imposed on solar cells and modules starting July 2018. SGD was reduced to 20% post July 2019 for 6 months and then to 15% for the next 6 months. Domestic manufacturers were not able to benefit from the imposition of these additional duties as the duration was too short (2 years). Most projects got a tariff pass through under a “change in law” condition of tenders under which projects were won. The Ministry extended SGD duty for one more year. 14.9% SGD is applicable from 30 July 2020 to 29 January 2021 and 14.5% from 30 January 2021 to 29 July 2021 for all solar cells and modules imported from China, Thailand and Vietnam.

Figure 9: SGD Rate Applicability (%)

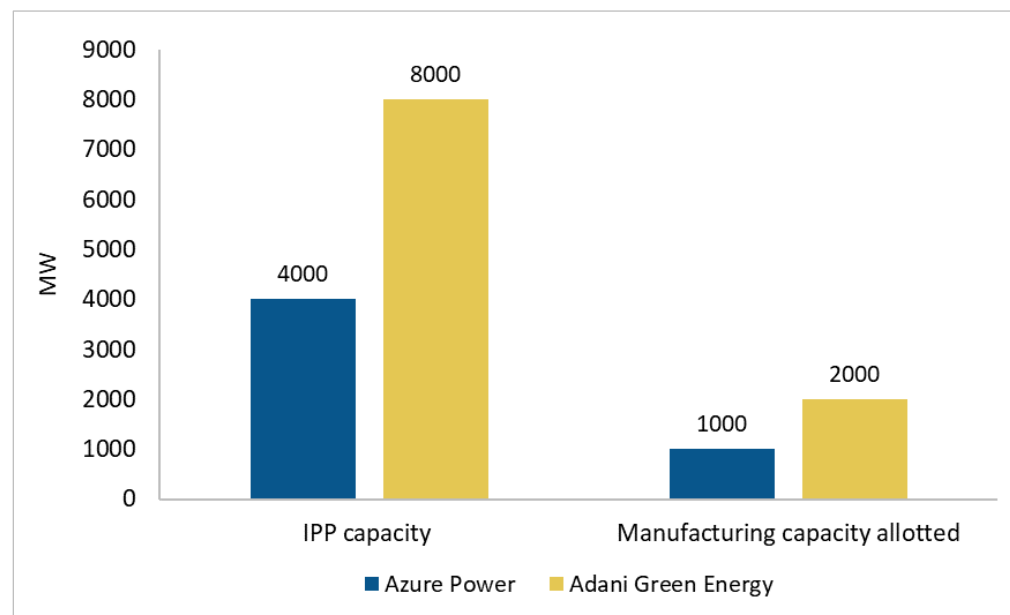


Source: MNE, DGTR, Ministry of Finance.

First Ever Project Development Tender With Manufacturing

Adani Green Energy won a bid for solar panel manufacturing capacity of 2GW of solar and the associated generation capacity of 8GW in SECI's first manufacturing-linked solar tender. In addition, Azure Power won a bid for 1GW solar panel manufacturing and 4GW generation capacity. The tariff has been fixed at Rs2.92/kWh which the discoms now consider too high, particularly in light of the Covid-19 demand disruption over 2020.

Figure 10: Details of Solar Project Development Tender With Module Manufacturing



Source: SECI, JMK Research.

Even though auction was completed in late 2019, Letter of Award (LoA) was issued by SECI for these 12 GW of new project development about six months ago only. Since then, SECI has struggled to sign power supply agreements (PSAs) with discoms. Until the PSAs are signed between SECI and the discoms, SECI, the intermediary procurer, is unable to sign PPAs with Azure/ Adani. SECI has now decided to bundle 12GW of solar in batches of 3GWs. The 3GW of solar projects with the tariff of Rs2.92/kWh (~US\$0.04/kWh) are to be bundled with 1.2GW (Tranche VIII) auctioned in February 2020 and 2GW (Tranche IX) of ISTS-connected solar projects auctioned in June 2020. The winning tariffs in the 1.2GW auction ranged between Rs2.50/kWh (US\$0.0348/kWh) and Rs2.51/kWh (US\$0.035/kWh), while the tariffs for the 2GW auction were between Rs2.36/kWh (~US\$0.0313/kWh) and Rs2.38/kWh (~US\$0.0316/kWh).

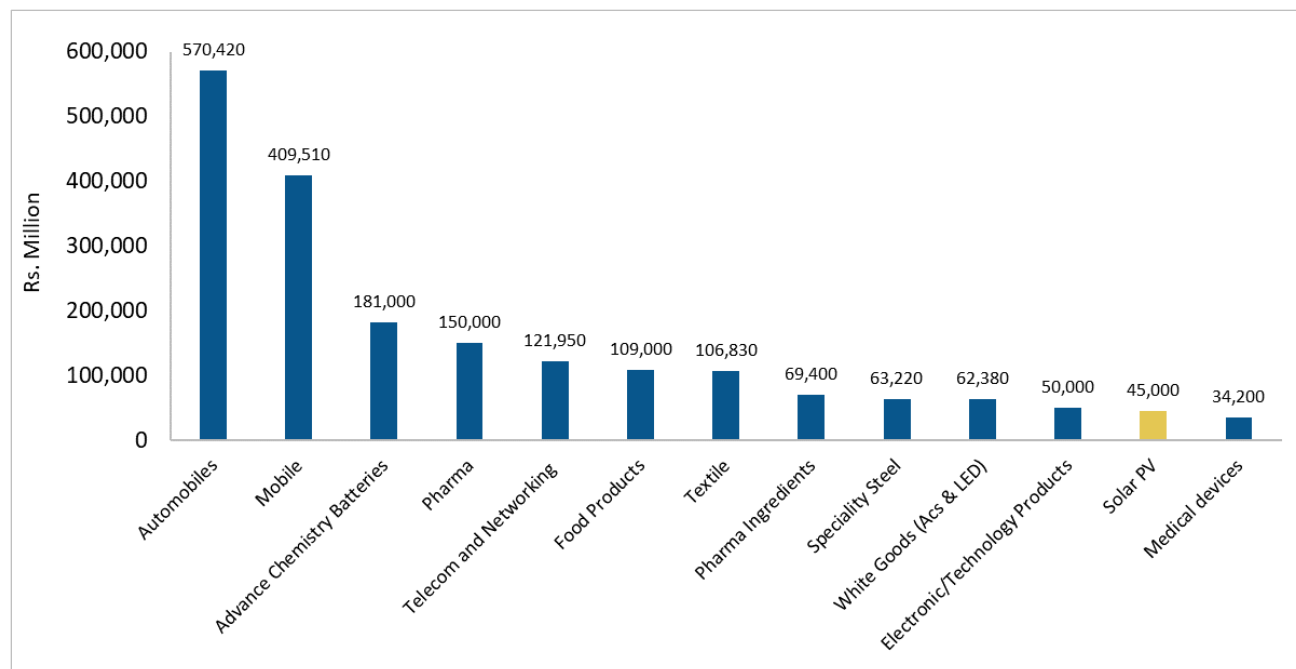
Furthermore, with new record low tariffs reaching to Rs 1.99/ kWh in recent solar auctions, there is a likely chance of further delay and reluctance from DISCOMs. In a recent update, Azure acknowledges tariff markdown from Rs2.92/kWh (~US\$0.04/kWh) due to various factors such as exchange rates, interest rates and improved capex. Therefore, as a best-case scenario, a downward repricing is likely which may stimulate signing of PSAs between SECI and discoms.

Production Linked Incentive (PLI) Scheme

The Cabinet on 11 November 2020, approved a Rs1.46 lakh crore (US\$20bn) production-linked incentive (PLI) scheme for 10 sectors to attract investments and boost domestic manufacturing. As part of this, Rs45bn (US\$616m) is allocated for the solar PV sector. Expenses incurred on plant, machinery, equipment, R&D and

technology transfer would be eligible for the incentive scheme. The scheme shall also extend an incentive of 4-6% on incremental sales (over the base year) of products manufactured in domestic facilities and covered under target segments, to eligible companies, for a period of 5 years subsequent to the base year.

Figure 11: Details of Allocation Under Production Linked Incentive (PLI) Scheme



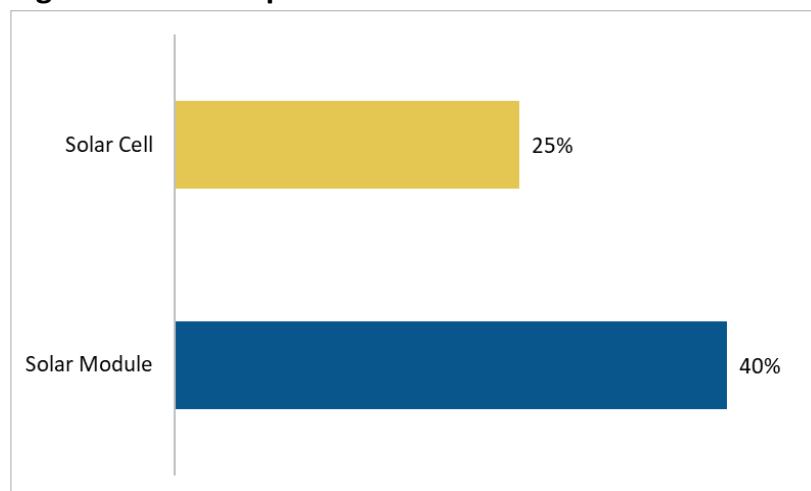
Source: Ministry of Electronics and Information Technology (MEITY).

New Initiatives Under Planning

Basic Custom Duties (BCD) To Be Introduced

In order to make imported cells and modules more expensive, the government had proposed the implementation of a new tariff scheme, the Basic Custom Duties, on solar cells, modules and inverters, starting from 2021. But, recently, in supersession to the previous announcements, now, the finance ministry will be issuing an order for imposing 40% and 25% BCD on the import of solar modules and solar cells respectively. The new tariffs shall be imposed from 1st April 2022. It would replace the current SGD regime on the concerned solar equipments.

Figure 12: BCD Imposition Details



Source: Industry news articles, JMK Research.

Exemption of Custom Duties on Raw Material for Domestic Manufacturers

In February 2020, MNRE requested that solar PV manufacturers provide a list of machinery/capital goods (required for setting up of units for the manufacture of solar PV modules, cells, polysilicon, wafers and ingots) that the manufacturers deem fit to be included in the BCD exemption list. The last date for submission was extended to 9 October 2020 owing to the outbreak of the COVID-19 pandemic. This inclusion was proposed to help manufacturers by not imposing any duty on equipment used in manufacturing.

Plans to Set Up Solar Equipment Manufacturing Plants Near Ports

MNRE is in talks with the Ministry of Ports and Shipping to offer land near ports to companies for setting up solar equipment factories. The decision will not only facilitate exports but will also make manufacturing more cost competitive. The plan follows the government's decision to impose tariff and non-tariff barriers to put a check on imported solar cells and modules – a move that will increase the cost of sourcing them from China.

Chinese Government Initiatives

If we compare the initiatives taken by India vs. China, it is apparent that China is much more aggressive and effective in providing a complete ecosystem to boost its PV manufacturing sector at world-leading scale. The Chinese government has offered cheap credit, free land, cheap loans, research funds, tax rebates, and sometimes even cash to support this sector. The incentives and exemptions provided by the Chinese government over the years led to China becoming a global hub for PV manufacturing and export. Some of the biggest initiatives are:

- **Cheaper debt for longer tenure:** Cheaper loans are provided at interest rates of 0-0.5% for setting up manufacturing facilities for a longer time frame for PV manufacturers.
- **New lines of credit:** Post 2008 global financial crisis, the China Development Bank (CDB) opened a line of credit worth US\$30bn for solar cell and module manufacturers in China.
- **Free landbanks:** Local governments already have abundant landbanks as a result of confiscating land from urban residents and villagers, or from other factories. The Guangdong provincial government, for instance, persuaded enterprises in an existing industrial park in Heyuan City, Guangdong Province to accept land reallocation without compensation for the incoming players. In addition, the government shortened the approval process to only five working days.
- **Cheaper electricity costs:** Government offers highly subsidised electricity to PV manufacturing facilities.
- **Bailing out manufacturers from time to time:** Government has bailed out major solar panel manufacturers including Shanghai Chaori and Wuxi Suntech from time to time. The Wuxi municipal government, for instance, gave directives to Bank of China's local subsidiary to disregard the risk of default of Wuxi Suntech and grant emergency loans of CNY 200 million. The government also established national key laboratories at several leading firms.
- **Cash grants:** Cash grants up to CNY 1 million are available for large "demonstration projects" by manufacturers.
- **Export credits:** Export-Import Bank of China offers export assistance in the form of export seller's credit and export contingent loans at preferential rates. The companies can opt for export seller's credit which is a form of export-contingent loan provided by the Export-Import Bank of China. Also, more than 70% foreign-backed export-oriented firms in China are eligible to pay only half the income tax rate.
- **Value-added tax (VAT) exemptions:** The renewable energy law allows "qualified" solar-component manufacturers to apply for an exemption from half of the VAT they owe to the central government.

In addition to the above initiatives, several Chinese provinces from time to time announce refunds for interest on loans and electricity costs, loan guarantees, 10-year tax holidays, refunds of value-added taxes, assistance in building road infrastructure, subsidised leases and property tax breaks for solar manufacturers.

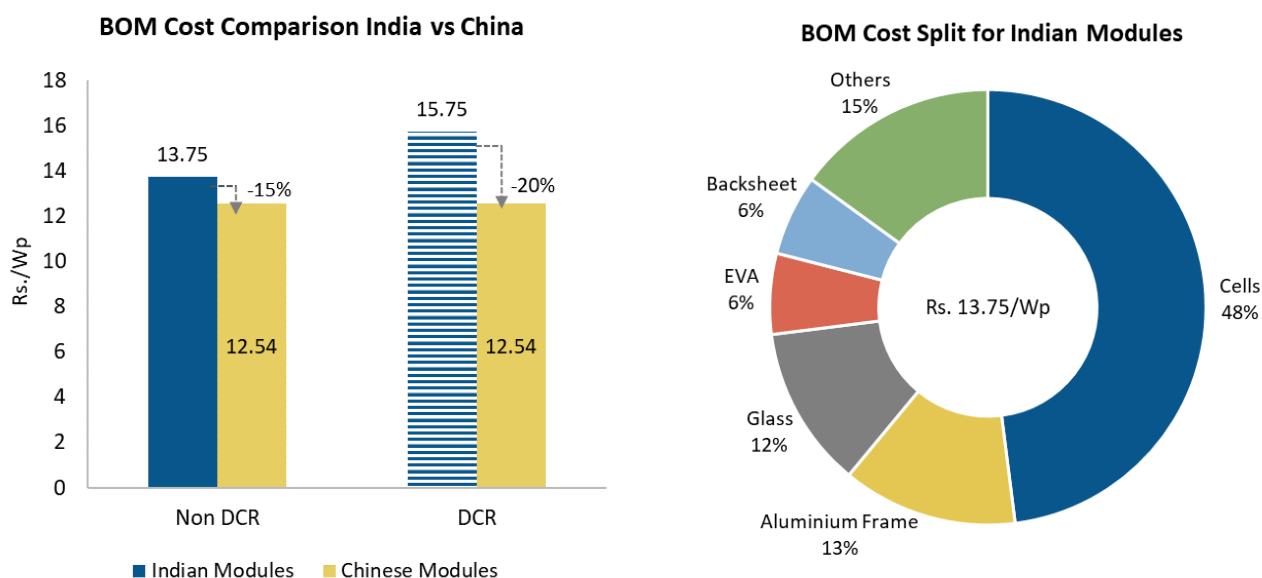
Key Challenges for Indian Manufacturers in Relation to Chinese Suppliers

In order to understand the overall viability of operating domestic module manufacturing plants, it is necessary to assess the various challenges, technological capabilities and economic costs of the sector in detail. The market competitiveness of various aspects of domestic modules in relation to aggressively priced imported modules is an indicator of the potential prospects for setting up new production facilities in India. However, limited scale manufacturing capacity, capacity under-utilisation (due to fluctuating demand for domestic modules) and sluggish technological development are some of the major reasons for India lagging behind China in the PV manufacturing industry.

Higher Costs

Among the various components of PV module manufacturing cost, the Bill of Materials (BOM) has the highest share with more than 4/5ths of the total expenditure. The BOM of solar modules includes cell, glass, ribbon, silicon, aluminium frame, etc, with cell contributing the highest share in terms of component cost. Indian manufacturers' BOM is about 15% higher than that of their Chinese counterparts for Non DCR modules (modules that use imported cells) and about 20% higher for DCR modules. This is because Indian manufacturers have to import many of the raw material inputs, unlike Chinese players who can rely on their end-to-end domestic PV value chain. Raw material costs are huge in India as the majority are imported. The value chain of solar PV manufacturing, for instance, involves polysilicon, wafer, cell and module assembly. Most Indian companies are however engaged in later processes of module assembly only.

Figure 13: Comparison of BOM Cost for India vs China



Source: Industry Interviews, JMK Research.

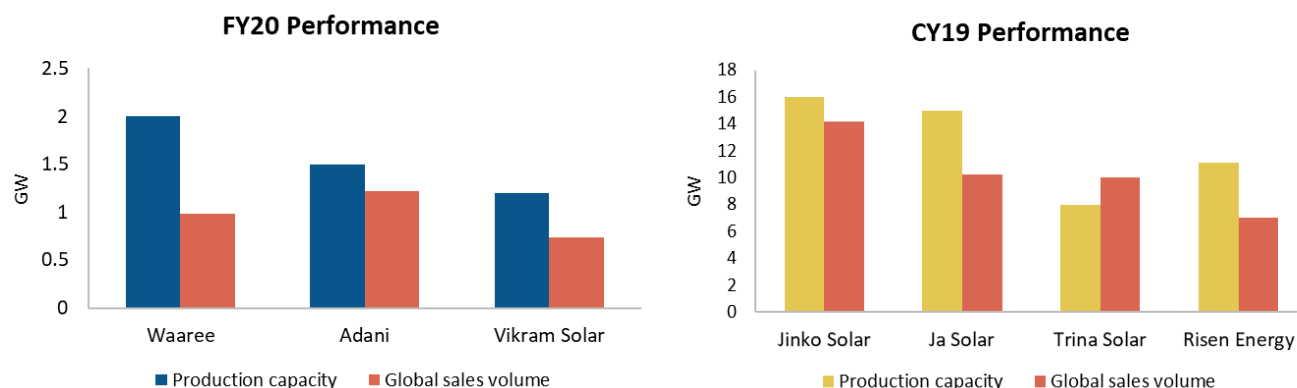
Note: BOM cost for a module capacity 330 Wp, 72 cell module of 4.7 Wp.

Lack of scale is another reason why BOM costs are higher in India. The low 40-45%⁸ utilisation of production facilities in India leads to a significant cost difference between Indian and Chinese players. If the capacity utilisation were to be increased to 100%, then the per Wp cost differential could be further reduced by 7-8%.⁹ The comparative trend between production volume and total sales of leading Indian and Chinese suppliers is shown in the following chart.

⁸ For leading domestic manufacturers, Source: JMK Research.

⁹ Source: CEEW. *Scaling up Solar Manufacturing to Enhance India Energy Security*. August 2020.

Figure 14: Operational Performance Comparison Between Indian and Chinese Companies (noting scale differences)



Source: JMK Research.

In comparison, apart from the raw material procurement angle, Indian PV manufacturing players also end up paying higher costs for fulfilling the project capex (land, machinery, etc.) and for availing themselves of financing (debt or equity) options as well as higher utility charges including electricity. In China, free land parcels are allotted by various state provinces, even financing is available at negligible interest rates and cheaper electricity is provided to PV manufacturing facilities at very subsidised rates.

Smaller Profit Margins

With a monopolistic presence in the solar PV manufacturing market and strategic priority awarded by the government to this industry, China enjoys the lion's share of revenue and profit generated by the industry worldwide. China's massive-scale manufacturing capacity and advanced technological capabilities put it ahead of other nations.

Even though operational revenue earned by the Indian players has generally been on an upward trend in recent years, it is still far behind that of their Chinese counterparts. Except in 2018, when revenue of Chinese players trended downward and in FY2019 where Indian players have observed a minor dip.

The reason for this dip was that China imposed an installation cap at 10GW on ground-mounted power plants and distributed generation projects and reduced its feed-in tariff (FiT) for projects, which at the time were more than double the ruling solar tariffs evident in India. This weakened domestic demand in China for Chinese solar modules affected the module sales in that year, but had the clear strategic intent of lowering the required solar tariffs to accelerate the move to grid parity (achieved in China in 2020, well behind India's 2017 delivery).

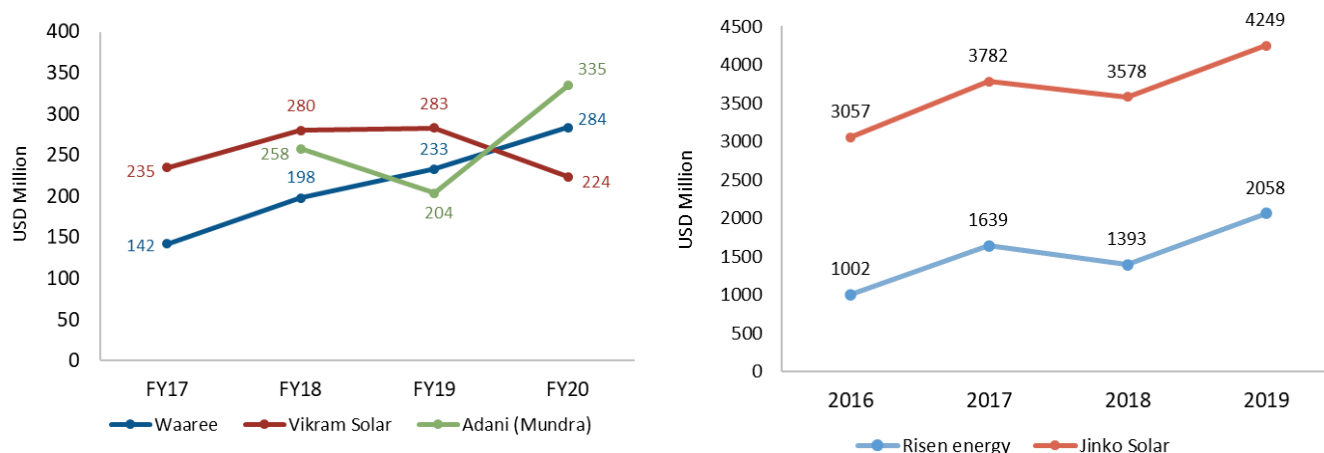
The revenue trend among India's leading manufacturers has not been consistent during the last four years of their operations. Adani (Mundra Solar PV) has shown a significant dip in revenue in FY2019 on account of various one-off, industry-wide

issues such as lack of clarity on the implementation of safeguard duty and deferment of purchases by the developers due to a considerable fall in solar module/wafer prices globally.

Waaree, another leading player, showed an increase in profits till FY2019 and then a sudden dip in FY2020, mainly due to expansion of its facility from 1.5GW to 2GW in that period and unit price declines.

Vikram Solar has seen a significant dip in FY2020 revenues. It laid off about 320 employees at one of its two manufacturing facilities in West Bengal. According to the company's official statement, this move was due to the slowing economy, inconsistent policy implementations, unfavourable trade policies and liquidity crises resulting in various organisational level changes.

Figure 15: Revenue Comparison Between Indian and Chinese Companies

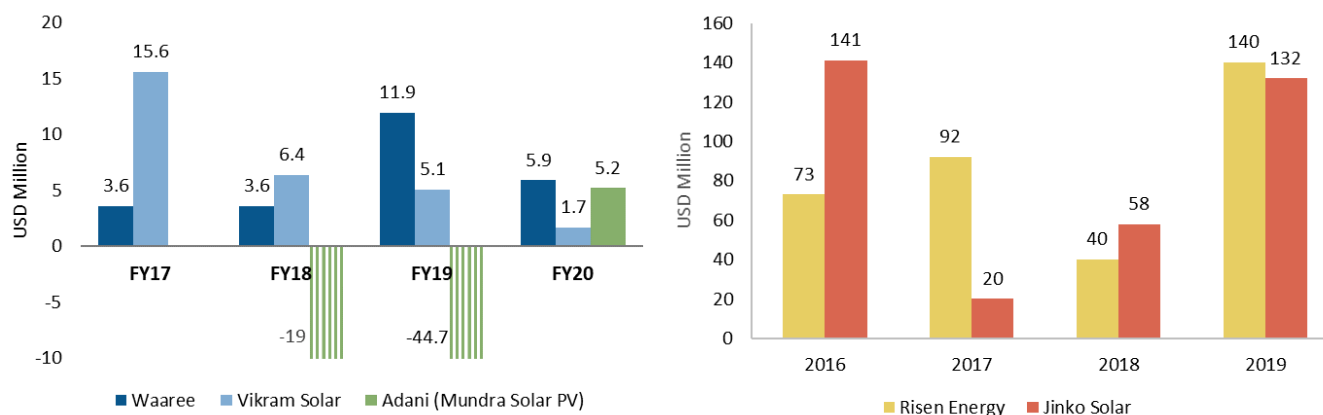


Source: Company's Financial Reports, JMK Research.

In terms of profit comparison, Chinese module suppliers are able to absorb larger shares of profit (average 4.3%) of the operational revenues than Indian suppliers (excluding Adani), who earn an average profit income of less than 3%. This is because Chinese module manufacturers have larger scale production facilities, low dependence on imports and completely integrated facilities of modules, cells and wafers. This is also complemented by robust R&D and favourable government support.

Adani (Mundra Solar PV) only started its integrated 1.2GW cell and module manufacturing facility in 2018. During the third year of its operations Adani (Mundra Solar PV) was able to flip the course of its performance around to mark its first profitable fiscal year. During FY2020, the company received a capex subsidy of Rs3.42bn under M-SIPS scheme.

Figure 16: Profit Comparison Between Indian and Chinese Companies



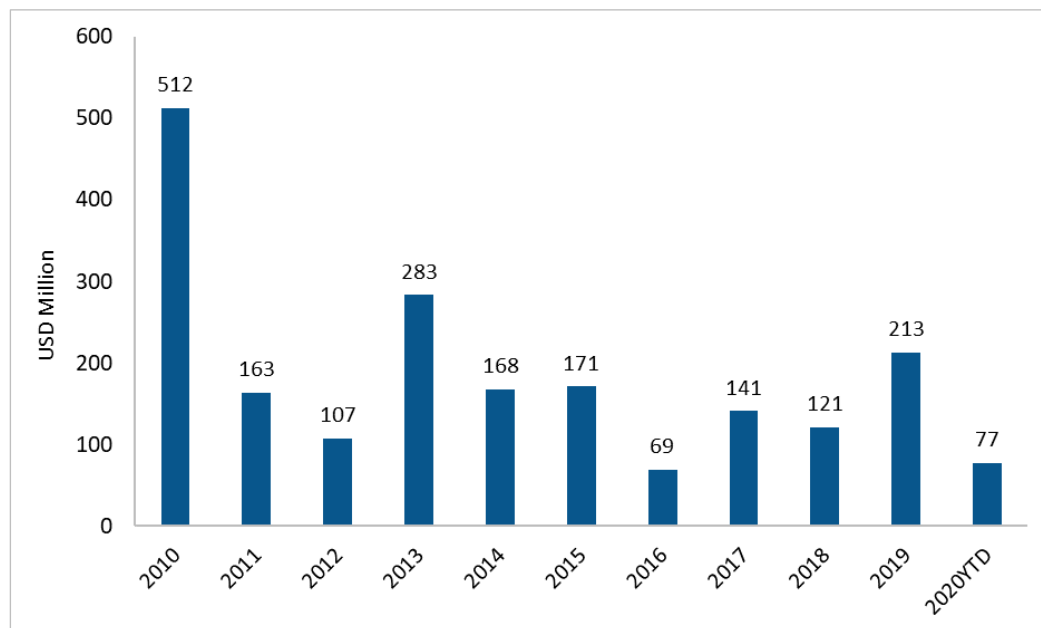
Source: Company's Financial Reports, JMK Research.

Apart from the bigger players, in a rather exceptional case, with just 280MW of cell line and 250MW of module line capacity, Websol Energy Systems reported a PAT (profit-after-tax) of Rs6.6 crore during the year FY2019-20 compared to Rs29 crore loss in FY2018-19. This surge in profit is attributed to its business transformation in response to some major challenges including US safeguard duty on PV module imports from India. Websol had chosen to enter into conversion agreements for customers who provided the raw material for the company to convert in exchange for a tolling remuneration paid to the company.

Lesser Volume of Exports

India used to export significantly more (in value terms) in the previous decade. The quality of solar cells and modules produced in India is on a par with those produced in other major solar PV manufacturing countries. Around 2010, with the supply of cheaper Chinese modules in the global market, the share of Indian exports began to dwindle.

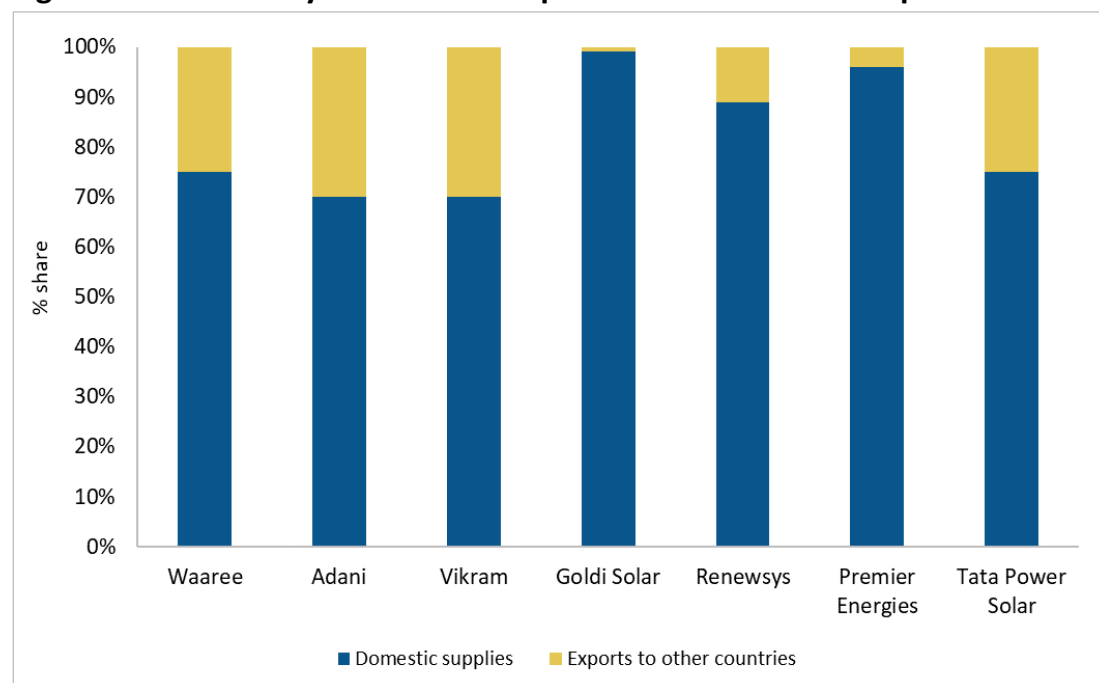
Figure 17: Solar Cells and Modules Export in India



Source: Ministry of Commerce.

Even though the Indian-made solar PV products have found buyers in the international market, the volume of exports of cells and modules is much lower than that of their Chinese counterparts. The exports of each of the top 4 players – Vikram Solar, Waaree, Adani and Tata – constitute about 25-30% of their total trade volume. The rest of the players have a very minor share of exports, at less than 15%.

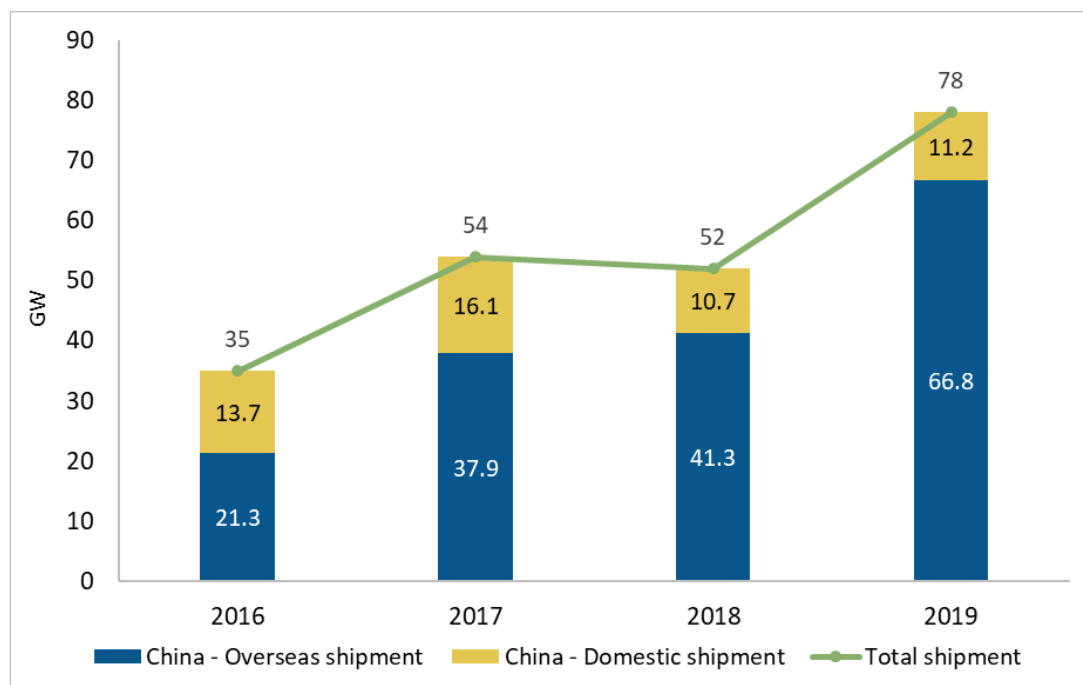
Figure 18: Indian Players' Share of Exports in 2019 Module Shipments



Source: JMK Research.

Chinese manufacturers, on average, trade 66% of their production volume in the overseas market. Clearly the export trend of Indian players is the reverse of Chinese players. Chinese players have been able to develop and expand their overseas solar market with strategic export-oriented policy interventions under China's "Going Global" strategic orientation. The companies can opt for export seller's credit which is a form of export-contingent loan provided by the Export-Import Bank of China. Also, other (>70%) foreign-backed, export-oriented firms in China are eligible to pay only half the income tax rate. This government-backed export stimulus comes along with other grants and incentives with the intention of promoting global marketing and sales of Chinese-branded products. Introducing such policy initiatives and incentives in India is necessary to boost the capacity expansion to make India an export hub for solar goods.

Figure 19: Domestic and Overseas PV Module Shipment by Chinese Manufacturers



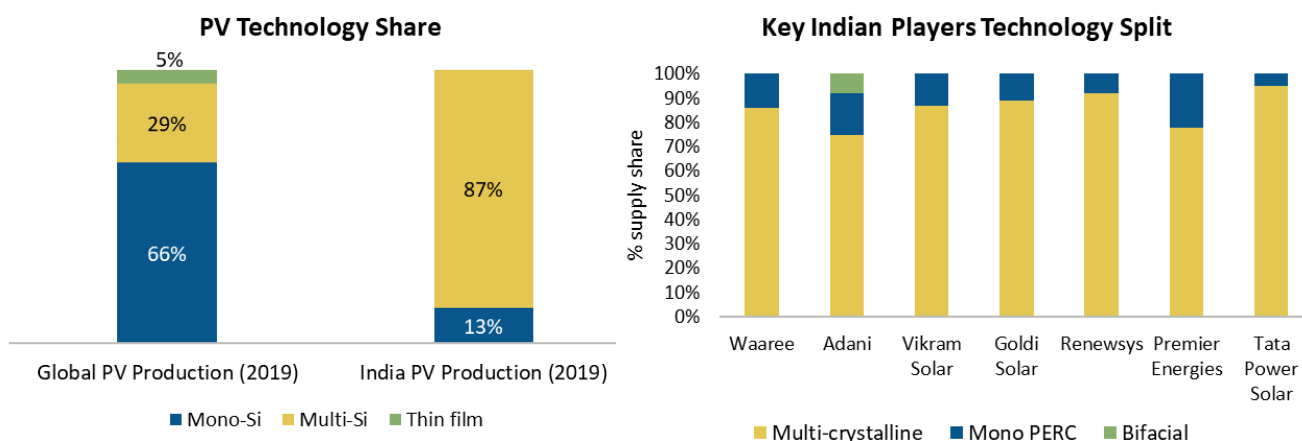
Source: IEA, JMK Research.

Slow Rate of Technology Adoption in India

As the world shifts towards mono-crystalline (mono-Si) based PV technology, there is a greater focus on enhancing technological prowess in this segment by the major players across the world. From a global perspective, the more advanced mono-Si PV modules have almost a 2/3rd share of the entire PV production by 2019 in terms of GW volume. Whereas PV production in India, considering the top 7 domestic module manufacturers in 2019, constituted only 13% of mono-Si PV modules and 87% of the multi-crystalline (or multi-Si) PV modules.¹⁰ The current technology split of production of leading Indian domestic manufacturers is shown in the chart below.

¹⁰ JMK Research. Solar Project Database.

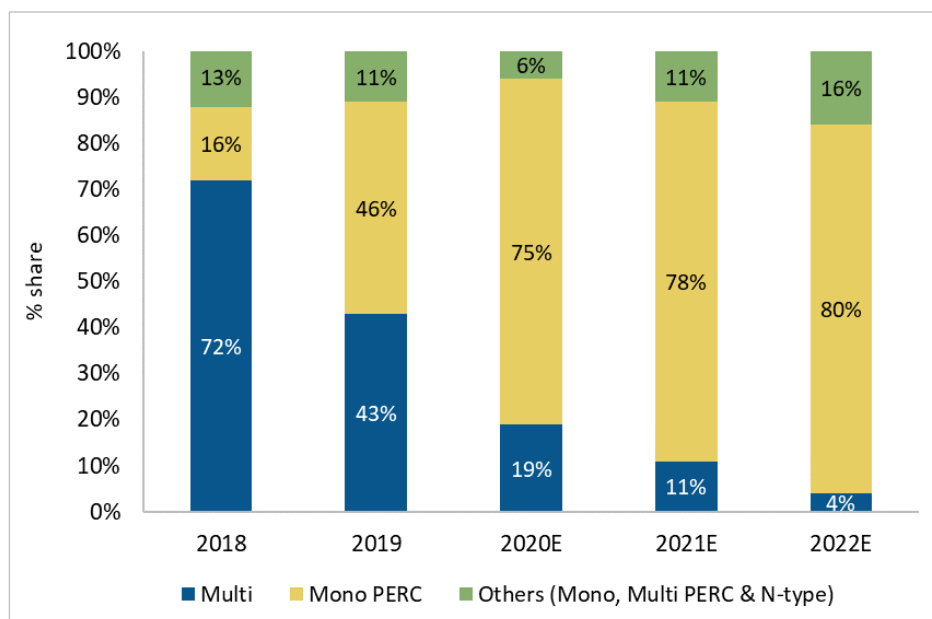
Figure 20: Breakup by Technology for Indian Module Suppliers in 2019



Source: Fraunhofer Institute for Solar Energy Systems, JMK Research.

Since the advent of mono-modules in 2018, the share of this module type has increased significantly in the global shipments. Share of export of mono PERC modules from China has increased substantially from a mere 16% in 2018 to 75% in 2020 as most leading manufacturers have completely shifted to, or are planning to shift to, higher efficiency mono PERC modules only. India is way behind in new technology innovation as well as adoption and hence there will be a slow transition. According to JMK Research, in 2020 the share of mono PERC modules is expected to increase to about 25-30% of all utility scale solar installations in India.

Figure 21: Share (in terms of GW) of Mono and Multi-modules in the Chinese Modules Export Market



Source: PV InfoLink.

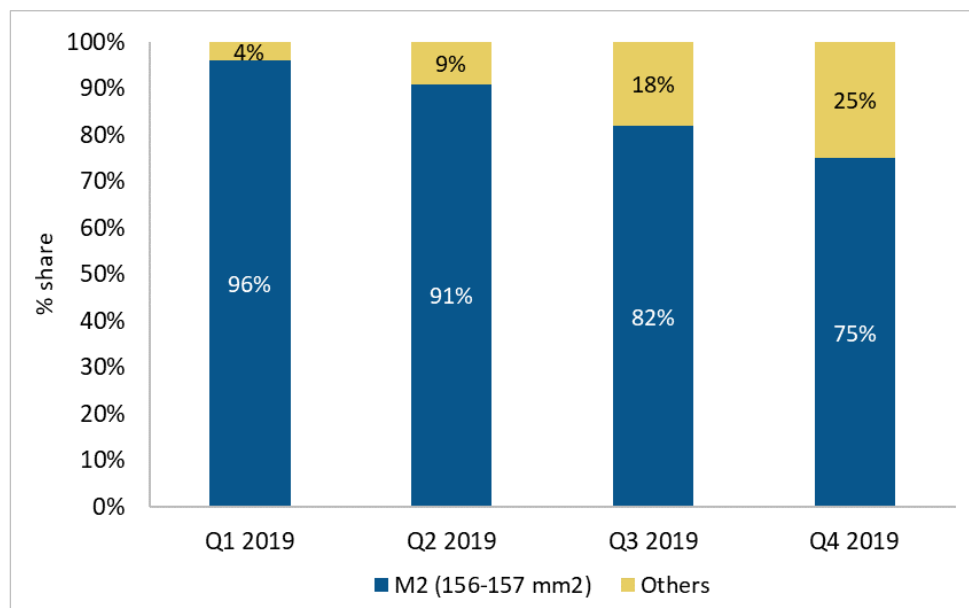
Also, there is a strong impetus in the global solar industry for advancement in emerging technologies such as bifacial cells, half cells, etc., which are expected to further increase cell efficiency over the coming years.

Larger Cells

Globally, there is a rising demand for larger cell-based modules due to their higher efficiency and wattage output range. In the past two years, with the ground-breaking developments by Chinese module manufacturers in the PV technology space, there have been numerous novel cell types that have been introduced including the larger sized cells. The PV module market is seeing a steady shift in global shipment from the older generation cell type, M2 (156-157 mm²), to larger cells, such as G1, M4, M6, M10, M12 etc. (158-210 mm²), in the last 1-2 years. From having a virtually monopolistic presence in the Chinese module exports prior till 2018, the demand for M2 cell-based modules has declined at a fast pace during every quarter since 2019.

Conversely, in the Indian market the domestic manufacturers have only been catering for the M2 cell-based module market. India has been a laggard in transitioning towards development of the latest cell technology, primarily due to the lack of R&D support and enormous financial drain associated with the continuous technology upgradation.

Figure 22: Share (in terms of GW) of Cell Types in Chinese Module Exports in 2019



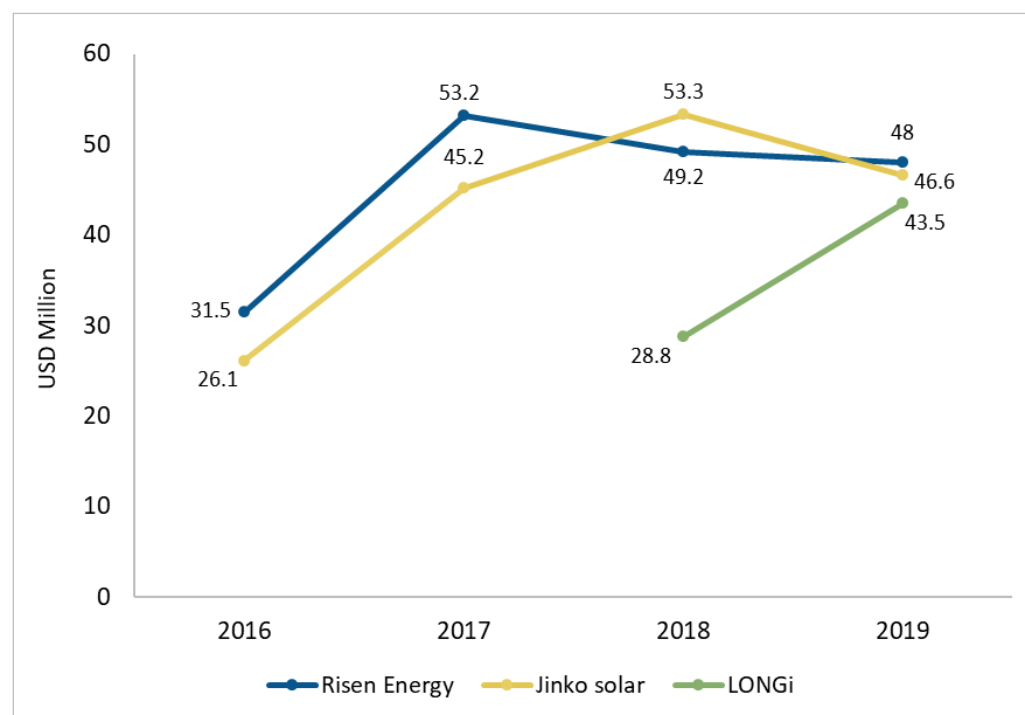
Source: PV InfoLink.

Lack of Focus on R&D Expenditure in India

It is crucial to incentivise the Indian solar manufacturing industry to continually invest along the PV value chain in light of the ongoing rapid technology improvements. This must be encouraged along with financial and technological reinforcement of solar PV tech R&D facilities in India.

The shift towards higher efficiency technologies and cell types in China is fuelled by substantial investment in R&D activities by the leading manufacturers. The top Chinese module manufacturing firms have been investing a substantial share of their annual revenue for product R&D. Typically, Chinese players have utilised about 1-3% of gross revenue for R&D every year.

Figure 23: R&D Expenditure of Leading Chinese Companies



Source: PV Tech, JMK Research.

In India, on other hand, there is limited investment in R&D by the leading players. Even the government has not promoted schemes or given grants to set up facilities to promote technological innovation. However, in a recent development, the Indian government, gave the nod for the introduction of Production-Linked Incentive (PLI) scheme in 10 key sectors, including the solar PV manufacturing sector, to enhance domestic manufacturing in the country. The total financial outlay for the 10 sectors is about Rs1.46 lakh crores (US\$20bn) over the next 5 years. Out of which, the central government has allocated Rs45bn (\$616m) for investment by the MNRE in high efficiency solar PV modules.

Higher Selling Prices

Prior to imposition of SGD, Chinese modules were cheaper than domestic modules by at least 15%.¹¹ Post the SGD imposition in July 2018, the landed cost, i.e. module cost + SGD, of the Chinese modules was higher than that of the Indian modules, giving the latter the competitive edge over the imported modules. But, with the progressive decline of SGD in every six months since its imposition along with the ongoing reductions of Chinese module cost, the price difference between the Chinese and Indian modules has narrowed.

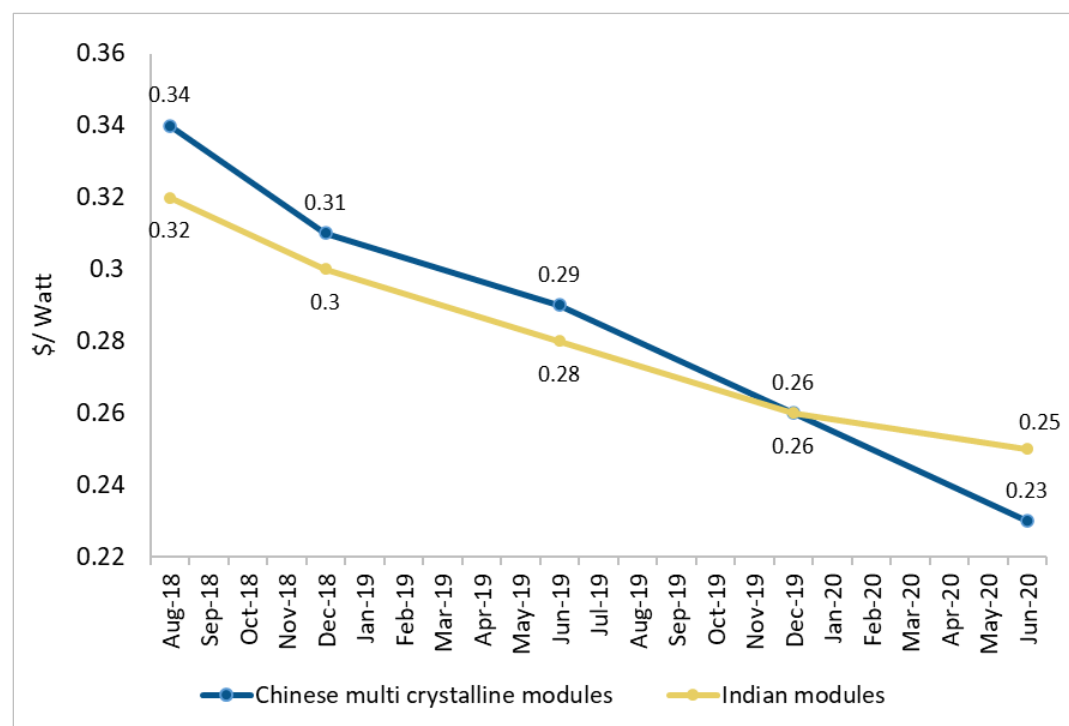
The current influx of cheaper and more reliable overseas modules marginalises the demand in India for the domestic products. This has eroded Indian manufacturers ability to compete with the major foreign players. This same experience has been evident over the last decade in Germany, Japan, the U.S. and Taiwan, with the ongoing growing dominance in global market share held by China.

Analysis of the module market trend past Q2 2020 shows that there is a significant uptake in the demand for solar modules. This sudden surge can be attributed to stronger sentiment towards clean-tech initiatives during the COVID-19 pandemic. The sharp increase in demand has led to a rise in overseas module prices of about 20% or more.¹² However, the supply side of the market is still facing certain hurdles on the path to post-COVID recovery. Exacerbated by logistical constraints such as delay in BIS certification of new and existing solar panel models, the manufacturers are now demanding renegotiation of contracts with Indian EPC players, which were agreed at much lower module prices. These ongoing developments are causing a shift in the procurement interests of the EPC players towards Indian manufacturers.

¹¹ Economic Times. [OPINION: How India can become "Atmanirbhar" in Solar PV Manufacturing](#). September 2020.

¹² Financial Express. [BIS norm: Delay in panel supplies from China seen to hit 500MW solar rooftop projects](#). October 2020.

Figure 24: Price Trends of Chinese and Indian Multi-Crystalline Modules



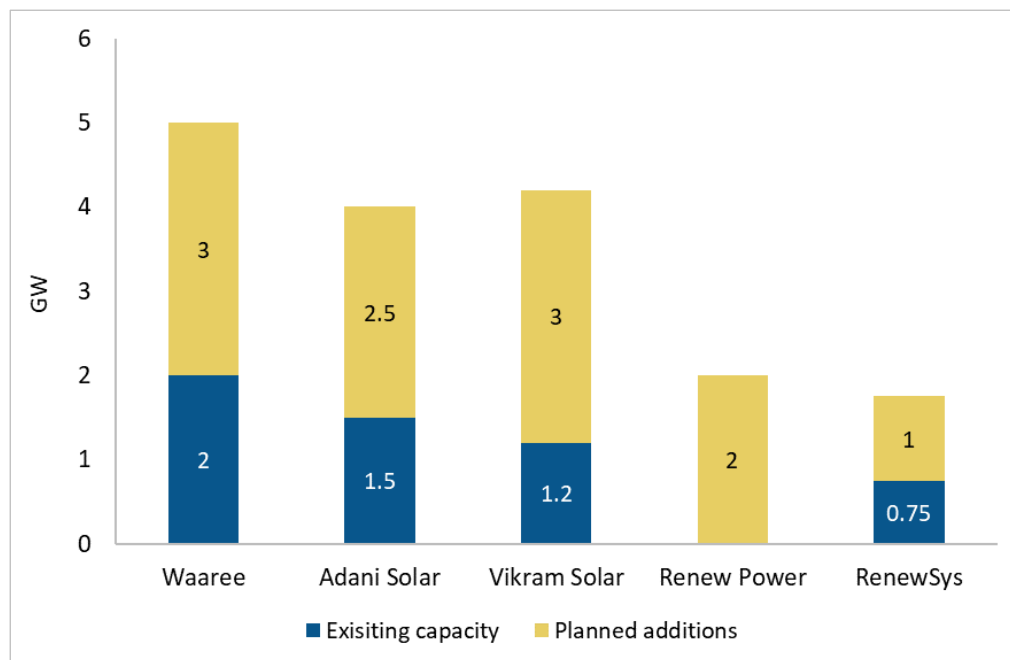
Source: JMK Research.

Domestic Expansion Plans and Opportunities

Amidst the ramp up phase of various Indian industries following the COVID-induced lockdown, a good number of domestic solar manufacturing companies have been announcing production expansion as well as backward integration plans. The associated commitments have been made in expectation of more robust domestic solar demand and increased government support for manufacturing self-reliance.

Adani Solar's 2-2.5GW cell and module manufacturing expansion project is underway and is expected to go online in 2021. With this capacity addition, the total cell and module manufacturing capacity of the company would increase to 3.5 - 4GW. In July 2020, Vikram Solar signed an MoU with the Tamil Nadu government to build a new facility with 3GW wafer, cell and module production capacity, and is willing to invest up to Rs. 54bn (US\$726m). Waaree Energies is undergoing module manufacturing capacity expansion of 3GW. Also, Azure Power has partnered with Waaree for 500MW module capacity addition as part of a manufacturing-linked solar scheme tender. In the same month, ReNew Power announced setting up of a 2GW cell and module manufacturing capacity plant initially by investing up to Rs15-20bn (US\$200-267m). RenewSys intends to add 420MW and 1GW of cell and module capacity respectively. With its new cell manufacturing expansion project to be commissioned by the end of 2020, Jupiter Solar intends to add 200MW capacity to its existing facility.

Figure 25: Existing Module Production Capacity & Planned Capacity Additions by Leading Players to Provide Improved Scale



Source: JMK Research.

In an effort to encourage local manufacturing, some of the state-owned organisations such as Rajasthan Electronics and Instruments Limited (REIL), Central Electronics Limited (CEL) and Bharat Heavy Electricals Limited (BHEL) have been issuing tenders for supply of domestic multi-crystalline or mono-crystalline solar cells since 2019. Between CEL and BHEL, about 12 tenders have been issued in total for a combined quantity of more than 30 million cells during the January to November 2020 period alone. Additionally, state-run public sector entity Coal India Limited (CIL) is planning to develop a Rs45,500 crore integrated solar wafer manufacturing facility under a new SPV (Special Purpose Vehicle).

The aggressive manufacturing scale-up and vertical expansion plans of the Indian manufacturers and rise in government interest to promote the indigenous PV value chain signifies the vast opportunities that this sector can offer in terms of employment growth. The jury is still out as to the viability of sustained investment returns to new potential investors, but long-dated import duty protection will help.

Summary of Key Differentiating Factors: India vs. China

Parameter	India	China
Capital cost	Expenses towards land, infrastructure and utility must be covered by the manufacturing companies. Plant equipment and machinery needs to be imported. These factors raise the capital expenditure for the manufacturing players by at least 15-20%.	Local government meets the company capital requirements such as land and buildings at concessional rates and also provides electricity, water and other utilities. Plant machinery is procured domestically owing to the well-established backward-integrated value chain network.
Operational cost	Raw material cost adds heavily to the total project cost due to heavy dependence on imported inputs. Semi-automation setups also demand higher labour costs. The majority (low scale) 50-200MW capacity plants are facing huge OPEX costs.	Locally sourced production inputs ensure minimal raw material expenses. Higher automation plants improve productivity and also greatly reduce labour costs.
Financing cost	Term loan and working capital loan options have shorter tenure and are very expensive at interest rates of 11% or more. Depreciation costs are higher due to use of relatively obsolete equipment.	Availability of loans for solar industry at rates cheaper than commercial rates and for prolonged tenures.
Profit Margins	Lower productivity, in addition to very low capacity utilisation rates of 40-45%, make it very difficult for domestic players to achieve a sustainable return on investment.	Occupying the highest market share, notably with higher scale of manufacturing and productivity, Chinese players earn a steady and substantial return on investment.
R&D expertise	High insufficiency of R&D in terms of investment and policy support. No technological expertise in capital intensive processes of silicon and ingot production.	There is a greater degree of government support and collaboration between industries and academia. Investment of US\$30-50m is spent each year, making up nearly 1-3% of the gross annual revenue by leading players.
Product price	Domestic modules are priced 2-3 cents/Wp higher than those of Chinese counterparts. With imposition of BCD on the imports, the price differential is expected to shrink even further.	The Chinese players' dominant supply-side power enables them to have strong control over global market prices, often undercutting their global competitors.
Technology competitiveness	Indian manufacturers produce only M2 cell-based modules and largely (about 85%) caters to the multi-crystalline module segment. The domestic industry is lagging by at least 2 years in terms of technology adoption.	In a state of constant technology upgradation, Chinese module makers are steadily transitioning to (200+ mm ²) larger cell-based modules with greater efficiencies. The Mono-PERC type has taken up the majority share in Chinese module production volume since 2019.

Global Competitiveness	Lack of manufacturing scale and technical innovation means India's global competitiveness is very low, with a contribution of just 1% to global module production in 2019.	China has the lion's share of more than 70% of 2019 global module production.
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Source: JMK Research.

Conclusion

Over the past few years the Indian government has introduced various initiatives and schemes to support the domestic PV manufacturing industry, given the trade balance, employment and localisation of supply chain benefits. However, most of them have been unable to provide the necessary support to the sector. With a renewed emphasis on the "Make In India" initiative, the government is now focussing on building a complete ecosystem to boost the domestic PV manufacturing industry. As part of this, the Indian government is planning to provide capital subsidy, tax breaks, custom duty exemption on imported capital goods and the machinery needed for manufacturing, along with cheaper land parcels near port areas to be developed as manufacturing hubs.

In the wake of all these factors, many Indian players including Adani, Renew, Azure, Vikram Solar have announced plans to expand their existing facilities or set up completely new integrated facilities. Even government entities like CIL are looking to setup integrated wafer manufacturing facility.

However, these players will face stiff competition from the leading global players. Chinese firms' aggressive ongoing capacity expansion and growing thrust towards technology advancement are yielding development of superior efficiency yet cost-effective PV cells and modules.

The government now needs to provide a balanced framework and should focus on a long term strategy. Imposition of safeguard duties and basic custom duties can help the domestic players remain competitive with imported modules. However, this is only a partial solution that will only create demand in the local market. The planned initiatives should not be limited to boosting the domestic market. The focus should also be on helping players expand their horizons to be globally competitive.

Government should formulate plans to support backward integration now and plan initiatives to set up cell, wafer and ingot manufacturing facilities as well as module manufacturing. State governments can intervene at these junctures by providing land, utilities, etc. at concessional rates and various regulatory approvals and permissions in a more timely and efficient manner if competition vs China is to be successful over the long term.

Further, sustained innovation should be the core of all the government's new plans. Government should focus on setting up new R&D facilities and institutes to support this high growth sector. The market is experiencing a huge shift to higher efficiency products and with global technological advancements in the PV manufacturing

sector, India should also focus on spending more on R&D to build a long term, sustainable segment.

Government has set a target to achieve 450GW of renewable capacity by 2030. To achieve this, about \$18bn worth of products annually will be imported. Instead, if a small proportion of this amount, about US\$3-3.5bn, were to be spent on building the domestic segment it would give long term results and make India's solar sector completely 'AtmaNirbhar'. A self-reliant solar sector would not only cater to domestic demand but could also open new avenues of exports, especially after the COVID-19 supply chain shock that forced nations to start looking at alternatives to China. Clear political intent along with a long-term vision is what is now needed for this sector to take off.

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JMK Research provides research and advisory services to Indian and international clients across renewables, electric mobility, and the battery storage market. www.jmkresearch.com

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