

India's Bid to Become the Next Solar Manufacturing Hub

The Ministry of New and Renewable Energy (MNRE) has reimposed the Approved List of Models and Manufacturers (ALMM) order for solar photovoltaic (PV) modules with effect from April 1, 2024.

This decision of the government is expected to provide much-needed relief to the domestic manufacturers, boosting domestic solar equipment manufacturing and India's pursuit to achieve self-sufficiency in the sector.

The ALMM order was put on hold for financial year 2023-24 due to insufficient domestic module manufacturing capacity. Now that the government has decided to reinstate ALMM order on solar PV modules, is India ready to become the next solar manufacturing hub?

Energetica India talks to the key players in the PV module manufacturing industry to explore the opportunities and challenges in the Indian solar market.

India's solar module manufacturing capacity is witnessing substantial growth. The Indian government's ambitious target of 450 GW of solar capacity by 2030 ensures a steady demand for solar products.

According to a report released by the All India Solar Manufacturers Association (AISMA) last year, India has achieved a milestone of 60 GW of installed solar module manufacturing capacity which is a phenomenal achievement for

the Indian solar manufacturing sector. Meanwhile, the Approved List of Models and Manufacturers (ALMM) has come into effect kick-starting the much-awaited support for India's solar manufacturing industry.



and net-zero goals. Indigenously manufactured Solar PV cells and modules will be at the forefront of this green revolution, thereby providing the three-pronged benefits of supply chain resiliency, boost in local manufacturing and employment creation in India. To reach a USD 5 trillion economy by 2026-27, manufacturing must rise to account for 25 percent of India's GDP from the current 17 percent. Therefore, the domestic solar manufacturing industry has a vital role to play in India's infrastructure development."

The country's push for being 'Aatmanirbhar' has come in the form of Production Linked Incentive (PLI) scheme. Touted to be a game-changer for India's manufacturing sector, PLI Scheme is playing a crucial role in making India globally competitive.

Furthermore, the increasing adoption of solar energy across various sectors, including agriculture, commercial, and residential, presents a vast market for PV cell and module manufacturers to cater to, thus positioning India as a promising destination for solar manufacturing investments."

The Ministry of New & Renewable Energy (MNRE) has been consistently bringing out policies to increase the manufacturing of indigenous solar photovoltaic modules. Some of the other initiatives are Domestic Content Requirement (DCR), preference to 'Make in India' in public procurement, imposition of basic customs duty on import of solar PV cells & modules and discontinuation of customs duty concessions.



Talking about the prospects, **Gautam Mohanka, Managing Director, Gautam Solar** says, "In India's burgeoning solar market, PV cell and module manufacturers have a vast growth opportunity. Solar photovoltaic energy is pivotal in achieving ambitious renewable energy



Ishver Dholakiya, Founder & Managing Director of Goldi Solar Pvt. Ltd. adds, "Initiatives like the PLI scheme offer financial incentives and support to domestic manufacturers, fostering a conducive business environment. With the growing emphasis on sustainability and clean energy, both domestically and globally, manufacturers can leverage India's favourable geographical location and skilled labour pool to establish cost-effective production facilities.



Highlighting the advantages of PLI scheme for the solar sector, **Gyanesh Chaudhary, Chairman and Managing Director of Vikram Solar** says, "The Production Linked Incentive (PLI) Scheme for High Efficiency Solar PV Modules (Tranche-II) allocated a total capacity of 39,600 megawatts (MW) to 11 companies, with an outlay of INR 14,007 crore. The manufacturing capacity is expected to become operational in phases by 2026. India's commitment

to solar manufacturing aligns with its vision of self-reliance in renewable energy. Additionally, the nation's solar cell manufacturing capacity stands at approximately 4.7 GW as of September 2022. India's solar module exports have surged, reaching INR 8,440 crore in FY2023, driven by demand from the USA. By 2025, India is projected to become the second-largest producer of solar modules, focusing on catering to US demand."



"The government's support for technological advancement, particularly in PV cell innovations tailored to Indian climatic conditions, underscores a commitment to sustainable energy development," concludes **Vikas Arya, VP – Product Development & Design, Jakson Solar.**

Trends in Domestic PV Manufacturing

Over the last few years, the PV manufacturing industry has moved to adopt advanced manufacturing technologies. Mono PERC technology predominantly forms the basis of new PV manufacturing lines. According to industry estimates, about 90 percent of the Indian solar market has transitioned to

using mono PERC technology. Meanwhile, TOPCon and HJT are the latest high-efficiency technologies in PV

	PERC	TOPCon	HJT
Efficiency	Maximum efficiency approximately 22-24%	Maximum efficiency approximately 27-28%	Conversion efficiency approximately 25-26%
Temperature Coefficiency	Perform exceptionally well in low-light and high-heat environments	The temperature coefficient of TOPCon solar panels is lower than that of PERC solar panels.	Similar to TOPCon, HJT Exhibits a low temperature coefficient
Bifaciality Rate	Bifacial rate of 75%	Bifacial rate of 85%	Bifacial rate of 95%

"The solar energy industry is on the brink of a revolution. As we look forward, advancements in PV technology are setting the stage for a transformative era in renewable energy. Solar energy technology continues to evolve and improve, driven by advancements in materials, manufacturing processes, and innovative approaches," says Gyanesh Chaudhary of Vikram Solar.

Elaborating more on next-gen solar cells and technological advancements, he adds, "Today, nearly all solar panels are made from silicon, which boast an efficiency of 22 percent. This means silicon panels can only convert about one-fifth of the sun's energy into electricity. Here enters perovskite cell technology -the synthetic semiconducting material has the potential to convert substantially more solar power than silicon at a lower production cost, Tandem cell stack multiple layers, each absorbing different sunlight wavelengths, maximising energy generation from a single panel. These clever cells stack multiple layers, each absorbing different sunlight wavelengths, maximising energy generation from a single panel.

Tungsten diamond wire has 1.2-1.3 times bigger breaking load, 60 percent bigger tensile strength and 10 times bigger torsional rigidity than carbon steel wire with same specs. Researchers at Stanford University have developed

manufacturing that are gaining prominence.

pyramidal lenses that promise to concentrate the amount of light that hits a solar cell, getting the same amount of light to hit an area a third of the size. This breakthrough could make solar panels more efficient in indirect light conditions, which is especially important in areas with less sunlight. Sun Tracking Panels adjust their position throughout the day to face the sun directly, capturing the most sunlight possible. The Internet of Things allows solar systems to be monitored remotely. Real-time data helps optimise performance and predict maintenance needs. While all the technologies (TOPCon, PERC, HJT) are promising, in the context of India's solar future, a strong contender is likely to be Mono PERC (Passivated Emitter Rear Cell). PERC is a mature technology with a well-established manufacturing base in India. This translates to readily available expertise and lower production costs compared to newer options like HJT. PERC cells boast impressive efficiency rates, reaching up to 22 percent and potentially even higher in the future. This translates to more electricity generation per square meter of panel area, a crucial factor for land-constrained regions. While not the absolute cheapest, PERC offers a good balance between efficiency and affordability, making it a practical choice for a cost-sensitive market like

India. HJT cells boast even higher efficiencies than PERC, potentially reaching 25 percent. However, HJT technology is still relatively new, and large-scale, cost-effective manufacturing is yet to be fully established in India. As pro-

duction ramps up and costs become more competitive, HJT may become a future game-changer. Overall, PERC's established presence, high efficiency, and cost-effectiveness make it a strong candidate to shape India's solar future.

However, the solar industry is dynamic, and other technologies like HJT should not be discounted. Advancements can rapidly change the landscape, so staying updated on these exciting developments is key."

Along the same lines, Gautam Mohanka added, "There are numerous technological advancements happening in the solar industry. Commercial solar panels now boast higher efficiencies, converting more sunlight into electricity, increasing power output per unit area. Polycrystalline Panels, widely prevalent 5 years back, are being phased out in new projects. Bifacial Solar Panels are gaining popularity due to their ability of generating power from both sides. Additionally, advancements in Solar Trackers and Battery Storage systems are enhancing overall efficiency and reliability in solar energy systems.

In recent years, PERC technology has been dominating India's solar panel market, but due to efficiency limitations in mass production, a gradual shift is happening towards advanced technologies like TOPCon and HJT. However, HJT manufacturing is complex with resulting higher production costs, which could potentially hinder its adoption in a cost-sensitive market like India."

Talking about the strengths of TOPCon, Capt. Ishver Dholakiya says, "Its advantages lie in superior passivation quality, reducing energy losses, and enabling higher cell efficiencies. Moreover, TOPCon's compatibility with existing production lines makes it an attractive option for manufacturers seeking to upgrade their facilities. As India aims to

bolster its solar manufacturing capabilities, technologies like TOPCon offer the promise of increased competitiveness, improved energy yields, and accelerated progress towards sustainable energy goals."

"Upgradation of MonoPerc to TOPCon is compatible for Cell & Module manufacturing, hence TOPCon is expected to be major contributor in N Type for next 2-3 years. HJT technology has higher capital investment with new lines but operate at lower temperature," adds Vikas Arya.



Nikunj Patel, CEO, Australian Premium Solar (India) Ltd. also agrees that PERC technology has been widely adopted in the Indian solar market due to its proven performance, cost-effectiveness, and compatibility with existing manufacturing processes.

"However, as the market matures and efficiency becomes increasingly important, technologies like HJT and TOPCon could gain traction, offering higher efficiency and better performance in hot and humid climates like those found in India. Bifacial modules also hold promise, particularly in utility-scale projects where land availability and cost-effectiveness are critical factors. Ultimately, the choice of module technology will depend on various factors such as project requirements, cost considerations, and technological advancements. Manufacturers that can offer a balance of efficiency, reliability, and cost-effectiveness will be well-positioned to shape the future of solar power in India and beyond," he concluded.

Production Capabilities

With the improvement in access to raw materials, supportive government policies, technological advancements and financing schemes, India has made substantial efforts in enhancing its production capabilities for solar components. "Access to raw materials has improved, and the Government has implemented policies to support domestic manufacturing and reduce reliance on imports. Technologies are being transferred and developed locally through partnerships and collaborations with international players," says Gyanesh Chaudhary. "Financing schemes such as subsidies, tax incentives, and concessional loans

have been introduced to stimulate investment in the solar sector. The PM Surya Ghar: Muft Bujli Yojana directly targets residential solar power generation. Subsidies, concessional loans (around 7 percent), and the removal of collateral requirements make rooftop solar more affordable for a wider range of households. Incentivizing urban and rural local bodies to promote rooftop solar can lead to faster adoption through local outreach and initiatives. This combined approach (manufacturing + rooftop installations) can propel India's solar sector to new heights, achieving energy security and environmental benefits," he added.

Mitigating the Challenges

While solar manufacturers in the industry are keeping up with global markets with respect to tech advancements, financing and availability of skilled workforce by establishing skill development courses, they still face various challenges that impact their operations, profitability, and competitiveness in the global market.

Some of these challenges are price volatility of raw materials, trade disputes and tariffs, supply chain disruptions, policy and regulatory uncertainty, access to financing and capital market demand and price competitiveness.

"Limited availability of raw materials such as silicon, silver, and aluminium affects production costs and supply chains resulting in excessive Chinese dependency. The domestic market remains underdeveloped, accounting for less than 35 percent of overall sales. Insufficient manufacturing capacity, currently operational 2 GW of cell factories and 12

GW of module factories, poses a challenge as India aims to achieve 50 GW in the next 5 years. High manufacturing expenses and a shortage of skilled manpower further compound the industry's struggles. Land acquisition costs and adherence to quality control standards are critical considerations for sustainable growth in the solar sector," says Gyanesh Chaudhary

"The solar industry has experienced periods of overcapacity, leading to intense competition and downward pressure on prices. Overcapacity can result from factors such as rapid expansion of manufacturing capacity, changes in government policies, and shifts in market demand. Moreover, rapid technological advancements in solar cell and module technologies require manufacturers to continually invest in research and development to remain competitive. Failure to innovate and adopt new technologies can result in product obsolescence and loss of market share," added Nikunj Patel.

Commenting on the same, Gautam Mohanka said, "A number of challenges are faced by India's solar manufacturers, which still rely heavily on Chinese suppliers for raw materials. Among 12 PLI scheme winners, 11 listed Chinese supply chain vendors and service providers (while one has not submitted any names) to the government to facilitate visa process for foreign experts. Other challenges remain high investment required for solar module manufacturing and the rapid changes in solar panel technology, which tends to make older technologies obsolete and investors hesitant like the shift from Polycrystalline to Mono PERC to TOPCon. Addressing the challenges related to supply chain dependency, financing costs and com-

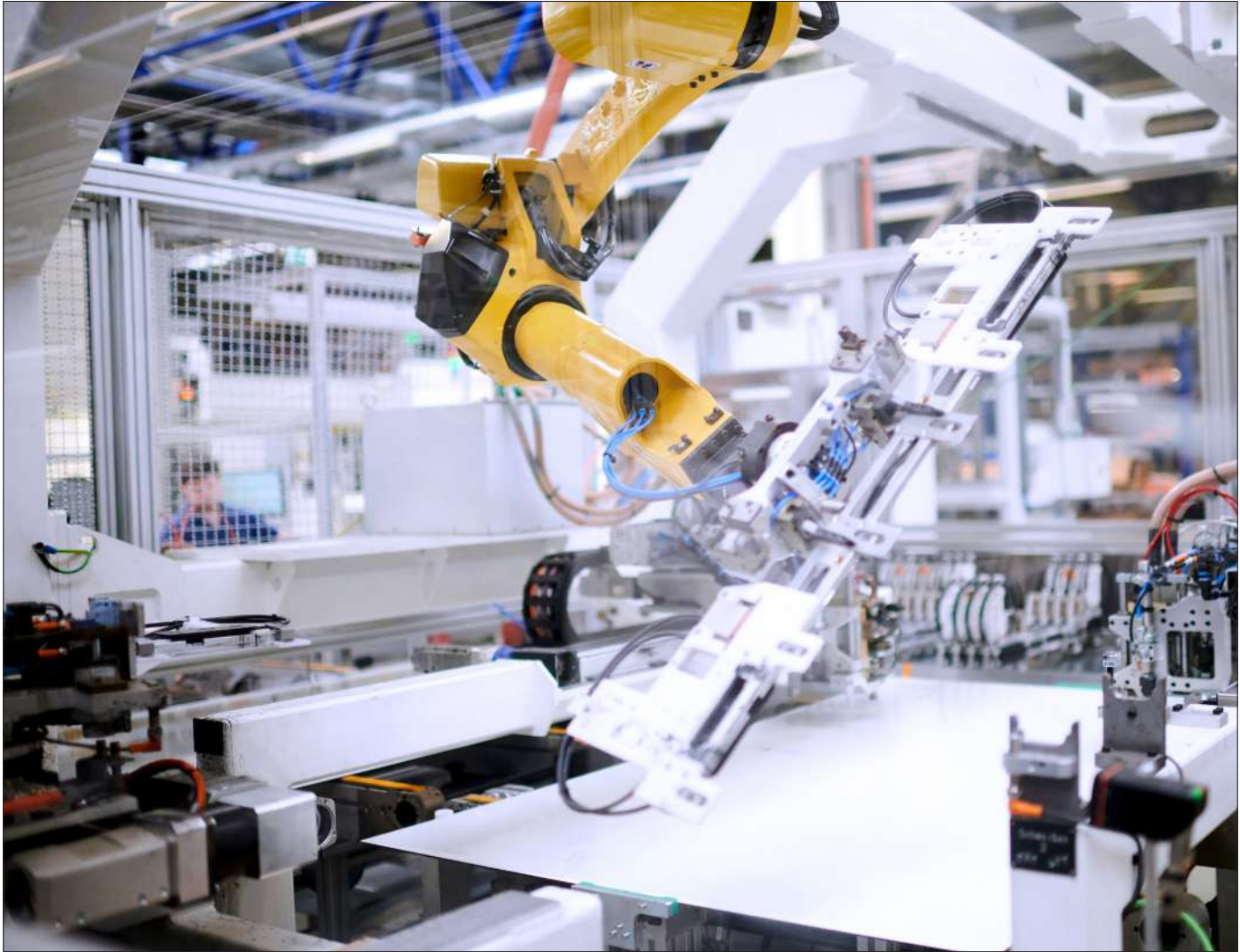
patibility of new technology with older machines will be crucial for further growth of domestic solar manufacturing."

While commenting on how to address such challenges, Ishver Dholakiya further said, "Solutions include strategic partnerships, domestic production ramp-up, R&D focus, and government incentives. By upskilling the workforce, optimizing processes, and adopting high-efficiency technologies, India can compete globally. Initiatives like the PLI offer financial support, while access to various financing options aids capacity expansion. Leveraging economies of scale, technological innovations, and competitive pricing strategies, Indian firms are gaining traction in global markets. Adherence to stringent quality standards enhances product credibility, boosting competitiveness internationally."

Strengthening Export Opportunities for Domestic Manufacturers

Exports of solar modules from India are gradually increasing, gaining from the China Plus-One strategy which opened opportunities for Indian players. Industry experts are hopeful that the trend will continue to be a part of the policy for most manufacturers. As per the data, India exported solar modules valued at USD 1031.36 million in 2022-23. The total export value for the US alone remained at USD 1000 million, which was almost 97 percent of the total exports of solar modules from India.

"The growth in manufacturing will create a thriving ancillary market for components and services needed to support the entire PV ecosystem. With major importers looking to diversify



their sourcing beyond China ('China + 1' strategy), India is well positioned to attract new business due to its growing capacity and expansion plans. India is already the second largest module manufacturer globally, and the PLI scheme is expected to solidify this position in the coming years," said Gyanesh Chaudhary of Vikram Solar.

Gautam Mohanka of Gautam Solar added, "India remains competitive in the global market due to the large domestic market, fueled by a burgeoning demand for solar energy, presenting opportunity for achieving economies of scale and cost reduction. Apart from this, a potential shift from Chinese solar panels in regions like the US and Europe presents an opportunity for In-

dia to emerge as an alternative, thereby boosting domestic manufacturing. Yet challenges persist due to China's dominance in the global market."

Nikunj Patel of APS added that domestic manufacturers must focus on factors such as cost-effectiveness, product quality, efficiency, and reliability to remain competitive. Building strong supply chain networks, optimizing manufacturing processes, and adopting sustainable practices can enhance competitiveness in global markets.

Way Forward

While various financial incentives and subsidies have been implemented to encourage investment in solar projects,

including tax benefits, accelerated depreciation, and concessional financing, the introduction of competitive bidding processes for solar projects has helped drive down the cost of solar power generation and increase transparency in project allocation.

Furthermore, policies such as net metering and renewable purchase obligations (RPOs) mandate utilities to procure a certain percentage of their energy from renewable sources, thereby creating a stable market for solar energy. Hence, India seems to sail in the right boat when it comes to becoming self-reliant in solar panel manufacturing!