Boosting Module Efficiency:

Will Back Contact be the Next Big Leap?

While TOPCon dominates solar manufacturing globally, experts predict back-contact (BC) technology to be the next frontier in high-efficient solar modules and gain commercial traction in the Indian market in the next 2-3 years. Energetica India speaks with leading solar manufacturers in India to gauge market readiness.

India's solar manufacturing sector is on the cusp of a major technological leap. While all the leading manufacturers in India have already shifted to TOPCon technology, almost all the newer plants are adopting TOPCon. However, the industry is on the lookout for ways to enhance solar module efficiency further and globally, back contact solar modules are emerging as the next frontier in high-efficiency solar modules.

India's solar module manufacturing capacity has reached about 91.458 GW as per the latest Approved List Models and Manufacturers (ALMM) update published by the Ministry of New and Renewable Energy (MNRE) in June 2025. Further, a report by SolarPower Europe, with India-specific projections contributed by the National Solar Energy Federation of India (NSEFI), projects India's module manufacturing capacity to reach 160 GW by 2030.

As the solar manufacturing sector in India is growing fast, it becomes crucial for manufacturers to not only look at the currently dominating technologies but also look at upgradability to the next evolution in technology.

The Rise of TOPCon Modules

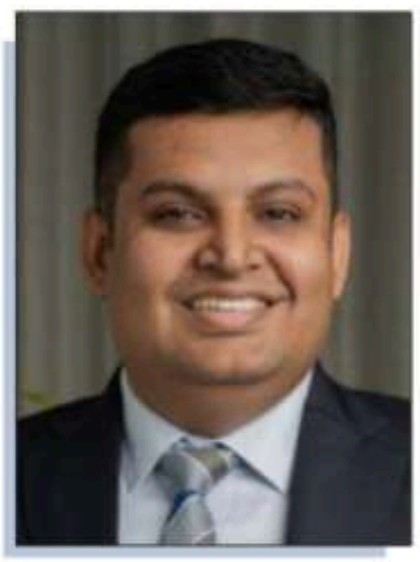
In India, TOPCon module manufacturing gained momentum in 2024 and is poised to overtake PERC module production soon. With superior efficiency, improved temperature coefficient, higher bifaciality, and reduced light-induced degradation (LID), TOPCon technology is well-positioned to lead India's solar manufacturing landscape for the next 3 to 5 years.

Dr. Balachander Krishnan, Chief Operating Officer, Indosol Solar, expects TOPCon technology to dominate solar manufacturing for the next 4-5 years. The current cell efficiency stands at 25.4 percent in the manufacturing scenario and has the potential to increase the cell efficiency up to 28.7 percent theoretically. "Recent innovations like Laser Enhanced Contact Optimisation (LECO) and Edge Passivation (EPD) have pushed it to current standards. With more innovations coming up – ultra-fine line metallisation, poly fingers, etc., can push it towards much higher efficiency in the near future. India, being a very cost-sensitive market, the yield and favourable costing will be the major driving factor which will primarily influence its future presence in the Indian market," opines Krishnan.

Gautam Mohanka, CEO, Gautam Solar, asserts that TOPCon technology is well-suited to boost utility-level projects in the Indian climate and is expected to lead the Indian solar manufacturing space for another 3 to 4 years. "However, their supremacy would depend on the cost-performance equation, since emerging technologies such as BC and HJT could pose tough competition in the future. The ability of domestic players to adapt TOPCon modules for evolving applications such as agrivoltaics and floating solar installations may further extend the relevance of TOPCon technology in the long run," he adds.

Avinash Hiranandani, Vice Chairman and Managing Director at RenewSys, states, "TOPCon technology will continue to lead solar manufacturing in India for at least the next four to five years. This is primarily driven by the scale of recent investments into cell manufacturing infrastructure. The momentum around TOPCon is strong, and while innovation is ongoing, the installed base and technical maturity of TOPCon will ensure its relevance in the coming years."

Gagan Chanana, Jt. Managing Director, Jakson Solar Modules & Cells Business feels that TOPCon technology is well-positioned to dominate the solar manufacturing industry in India for the next 3 to 5 years (up to 2028–2030). "TOPCon is distinguished by its enhanced efficiency, better temperature coefficient, higher bifacial performance, and lower LID, resulting in significantly higher power generation per Wp during the module life cycle. With Topcon Cells, PV Module power increases by 30-50Wp (6-8 percent) over PERC Module using 144HC cells combination. This will lead to a reduction in BOS cost and Levelized Cost of Electricity (LCOE) while saving space needed for a solar power plant," he says.



Vinay Thadani, Executive Director and CEO at GREW Solar, opines that TOPCon is a preferred choice in the market because of the good balance it holds between performance and cost for utility-scale and rooftop solar projects in India. "It is expected to remain in power for the coming 3- 5 years, supported by a projected 19-22 percent CAGR and policy backing. However, the longevity of the technology depends mainly on a few key factors, including the pace at which technologies like HJT or perovskite come to the existing markets, cost competitiveness and speed of innovation in module efficiency," he remarks.

Enhancing TOPCon Module Efficiency

The TOPCon technology itself is maturing with newer innovations and techniques being adopted by manufacturers to further enhance its capacity to reach closer to the theoretical limit.

Chirag Nakrani, Managing Director, Rayzon Solar, asserts that while Rayzon remains committed to adapting early to technological advancements, the company aims to maximise the potential of TOPCon for the present. "Our advanced cell architecture, combined with high-transparency glass and optimised (UV-transparent) encapsulant materials, significantly boosts rear-side light capture and overall energy yield. We have optimised the gridline size on the back glass to allow maximum exposure area on the backside and are also exploring the possibility of optimisation of the frame flange length to reduce shading on the cell backside due to the frame," he shares.

Krishnan adds, "At the cell level, to improve bifaciality factor and rear-side performance in TOPCon solar cells, we focus on optimising the rear-side passivation layer, especially tuning the a-Si layer is crucial to achieve maximising light reflection. At module level, ensuring proper installation practices, ensuring adequate ground clearance, and utilising surfaces with high reflectivity like white gravel or specialised reflective membranes will be the major focus points."

Hiranandani emphasises that while bifaciality is inherent to TOPCon cells—typically ranging between 75-80 percent—true performance gains for utility-scale installations also depend heavily on system design and maintenance. "Efficiency gains are not just about the cell; they are about the entire module ecosystem. We are actively developing glass and encapsulant materials with higher transmittance to maximise rear-side energy capture."

Gautam Solar is enhancing bifacial performance in its TOPCon modules by optimising glass-to-glass designs and improving rear-side light capture through advanced encapsulant materials and transparent backsheets, en-

abling better albedo utilisation in high-reflectivity environments such as deserts, shares Mohanka.

He further adds, "We have also undertaken several other efficiency-boosting initiatives, including the establishment of a state-of-the-art R&D lab in collaboration with Hototech China. The implementation of AI-powered electroluminescence (EL) testing for defect-free production and the development of dual-power generation modules under the G-2X Series can deliver up to 30 percent more energy."

Thadani divulges, "We enhance bifaciality using high-transparency glass, optimised encapsulants, and a design that minimises rear shading to better capture reflected sunlight. We also deploy high-reflectivity surfaces under panels and fine-tune cell spacing to boost rear-side power gain. Built with high-efficiency M10 (182mm) cells, our modules deliver more power without raising system costs. Superior ribbons reduce resistance, and smart heat-dissipating materials improve efficiency."

He further adds, "GREW's forward plan is installing smart monitoring systems and material upgrades to ensure the modules stay ahead in performance and efficiency. We are also keeping a close watch on next-gen technologies like HJT, perovskite tandem, along with improving the current TOPCon lineup."

Jakson were among the few leading module manufacturers in India who started commercial production of TOPCon Glass-Glass Modules from the 2nd quarter of 2024 using M10 16BB TOPCon cells. "From April 2025, we switched to the latest M10R cells with module power increasing up to 585/590 Wp in the same module size. To further enhance module power from the front and rear sides, we have successfully done trial testing using Front Glass with a special higher transmittance coating and back glass with white Mesh. These would be adopting this change from next quarter, which would lead to a further increase in module power and efficiency," shares Chanana.

Will Manufacturers Go the Back Contact Route?

Back-Contact (BC) and Interdigitated Back Contact (IBC) technologies, with all contacts placed on the rear side of the cell, offer clear efficiency and aesthetic advantages. These technologies are already being adopted in markets like the US, Germany, Japan, and China.

"In India, while TOPCon currently leads due to its balance of performance and cost, we see IBC gaining ground within the next 3–4 years. At Grew, we are strategically preparing for this transition. Our current infrastructure is adaptable, allowing us to upgrade to IBC with minimal changes. We're closely tracking global trends and aligning our R&D and manufacturing capabilities to be IBC-ready as the market evolves," says Thadani.

Talking about the probable transition to IBC technology, **Prashant Mathur, CEO, Saatvik Green Energy,** states, "Looking ahead, technologies like Interdigitated Back Contact (IBC) and hybrid models such as IBC-TOPCon represent the next frontier in module efficiency. While large-scale commercial adoption may take 3–5 years, manufacturing lines are being designed with the flexibility to accommodate these emerging technologies."

Mohanka expects BC and IBC to reach the commercial stage within the next 2-3 years in India, considering a decline in global prices and concerted R&D efforts by indigenous manufacturers. "Meanwhile, Gautam Solar is prepared to develop hybrid solutions such as IBC-TOPCon that provide a suitable trade-off between high efficiency and economies of scale. The company has also taken up technology feasibility studies in its R&D centre. Modular line planning for future flexibility of BC and IBC technologies, without affecting major infrastructure changes, is part of growth strategies," he says.

Nakrani anticipates BC and IBC's commercial viability in India within the next 2–3 years, driven by increasing demand for ultra-high efficiency modules in space-constrained and premium segments. "To stay ahead of the curve, we are evaluating pilot-scale feasibility and aligning our manufacturing infrastructure to adapt swiftly when the market matures."

Hiranandani agrees, "We expect back-contact module

technology to start gaining commercial traction in small volumes in India over the next 24 months. At RenewSys, we are closely evaluating the technology, cell availability, and required ecosystem readiness. Our roadmap includes provisions for this shift, and our equipment is being aligned to accommodate back-contact module production with relative ease."

Chanana shares that Topcon Back Contact (TBC) is likely to be the next efficiency enhancement technology for TOPCon manufacturers. "Presently, this is under development/trial production and has a higher cost of production. Our upcoming green field solar module and solar cell plants would be capable of this upgradation as and when BC technology assumes commercial production on a bigger scale."

Krishnan, however, feels that its current cost doesn't justify the incremental gains. The complex manufacturing process still needs time – likely another five years – for standardisation and cost parity. "Additionally, its bifaciality is limited (60–70 percent) due to rear-side metallization, making it more suited for rooftop or BIPV applications initially. As a technology-driven company, we're tracking its potential for niche and premium markets but will act once the technology matures."

Challenges for BC Modules Adoption in India

The BC modules' adoption is expected to face technical as well as commercial challenges for widespread adoption. "IBC requires precise alignment of rear-side contacts and advanced passivation layers—demanding high precision manufacturing and tighter process control. Laser patterning and fine-line screen printing for back-contact grids are not standard in current Indian production lines. Use of high-purity silicon and advanced coatings increases cost and requires strict contamination control," shares Chanana.

He further adds, "IBC modules are 10–15 percent more expensive today; difficult to justify in India's highly cost-sensitive market with higher LCOE, unless targeting niche premium segments. Further, the Indian ecosystem lacks a mature supply of IBC-specific materials, e.g., rear-passivation films, conductive pastes, precision lasers."

Talking about the technical challenges, Krishnan shares, "The major technological challenge is to achieve both diffusion and metallization steps on the rear side, where very precise process control and complex equipment are required to achieve the right set of yields and to achieve high efficiencies. In the manufacturing scenario and with the current available technologies for cell manufacturing, this seems to be slightly lagging, which causes huge loss in yield (~75 percent running in Chinese factories), which makes the entire costing too high."

He further adds, "Once this technological barrier is surpassed, it can definitely be combined with TOPCon to achieve much higher efficiencies, but effectively this is likely to happen in the next 4-5 years. Once this is completed at the cell level, achieving it in the module level will be a much easier phenomenon."

Technically, BC modules require advanced manufacturing setups, precise cell interconnections, and compliance with demanding standards like 3× IEC testing, which takes 7–8 months. "The larger challenge is the availability of BC cells, as most of the cell manufacturers are still ramping up and will certainly take 3-4 years before streamlining their manufacturing process to offer consistent volumes," asserts Thadani.

Hiranandani believes that the primary challenge lies in economics—costs are currently higher due to limited manufacturing capacity. "That said, as the industry transitions to N-type technologies, we believe TOPCon-based back-contact architectures offer an excellent balance between performance and scalability."

Mohanka adds, "Adopting BC modules in India faces technical hurdles like precision manufacturing, microcrack sensitivity, and lack of a local ecosystem, along with commercial barriers such as high CAPEX, limited installer awareness, and no strong LCOE case. Hybrid solutions like IBC-TOPCon offer a smoother transition by adapting existing TOPCon lines with minimal changes while retaining efficiency benefits."

Talking in favour of a hybrid solution, Nakrani comments, "Hybrid solutions like IBC-TOPCon offer a promising bridge—combining the high efficiency of in-

terdigitated back contact (IBC) with the proven manufacturability and cost-effectiveness of TOPCon. This approach could ease the transition by leveraging existing capabilities while moving towards the superior aesthetics and performance of full BC modules."

Are the Manufacturers Ready for the Transition?

Although IBC has immense efficiency potential, its adoption in India will hinge on cost reduction, ecosystem readiness, and demand maturity. Hybrid pathways like IBC-TOPCon can serve as stepping stones, especially for manufacturers already invested in N-type technologies.

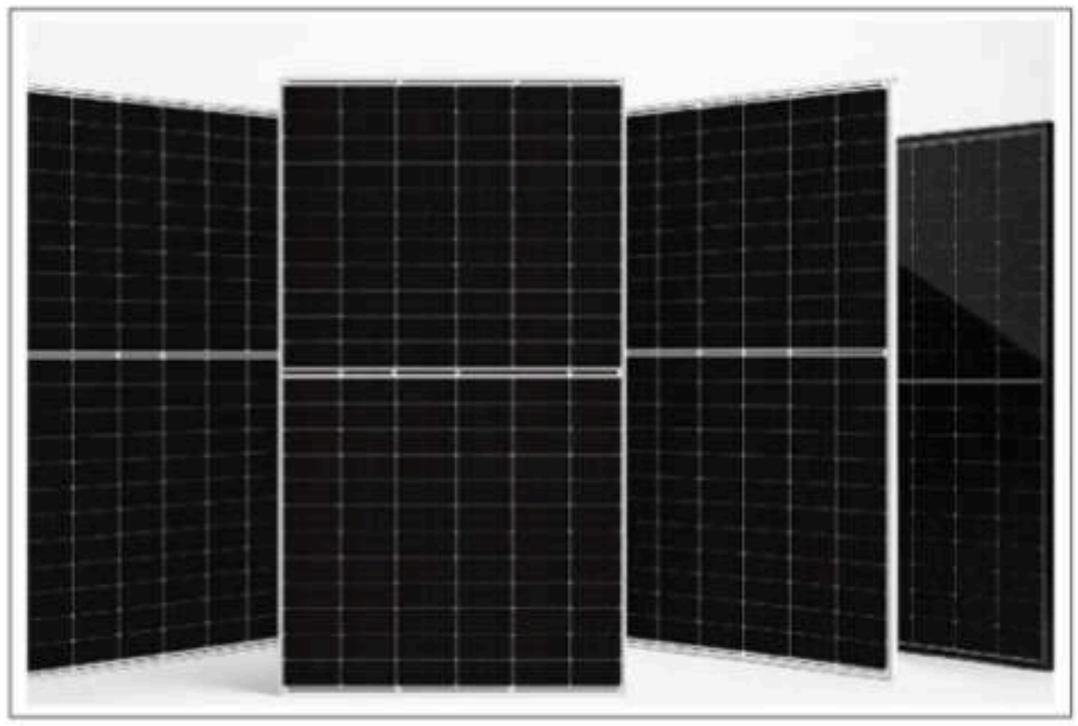
"We expect commercial production of BC modules in India by 2026, with wider adoption likely by 2027–2028 as costs fall and demand rises. In the meantime, hybrid configurations will play a critical role in easing the transition," anticipates Thadani, further adding that Grew Solar's lines are capable of accommodating futuristic technologies with a few minor changes.

The main challenge is the high CAPEX of back-contact modules in India's cost-sensitive market, but falling LCOE and rising demand for high-output modules are likely to speed up adoption. "A vertically integrated approach, from ingot to module, will be vital not only for competitiveness but also for driving the shift toward next-gen solar manufacturing," shares Mathur.

Hiranandani asserts that RenewSys' current and planned TOPCon lines are designed with flexibility in mind. "With minimal upgrades, these lines can be adapted to support back-contact technologies, including IBC-TOPCon variants."

Gautam Solar has existing and upcoming manufacturing assemblies adaptable enough to future upgrades like BC and IBC-TOPCon, with automation and modularity at the centre of this vision. "Gautam Solar advocates for R&D-linked policy support in collaboration with government bodies and leveraging its high-efficiency product portfolio to boost India's export competitiveness, particularly in the high-demand markets of Europe and the US," remarks Mohanka.

Rayzon Solar, too, is prepared for the probable transition. "Our current and proposed TOPCon manufacturing lines are designed with future-ready flexibility, allowing us to seamlessly adapt to emerging technologies such as back-contact (BC) and hybrid architectures like IBC-TOPCon. We understand that innovation is key to maintaining competitiveness in the evolving solar landscape, and we are proactively investing in R&D and process adaptability to support the transition to next-generation, high-efficiency modules."



Chanana emphasises that Jakson's upcoming TOPCon manufacturing lines for solar modules and solar cells are being designed with future flexibility in mind, enabling potential transition toward back-contact (BC) and hybrid architectures like TBC.

Krishnan highlights that the existing TOPCon manufacturing line will have to undergo major upgradation in both stringer, bussing and EL inspection level to accommodate back contact or IBC-TOPCon. This will involve major CAPEX investment and will be primarily driven by market conditions. "We primarily want to bring this change at the cell level in the next few years initially, as availability of BC cells is still at a niche and subsequently to our module line to ensure that we support high efficiency products in our lines. Currently, our major focus is on improving the existing TOPCon module efficiency."

Many Indian manufacturers have already set up cell-agnostic lines and are incorporating BC-readiness into their long-term expansion strategies. Here, India has the opportunity to not only match global trends but to shape them, driven by strategic investments and forward-looking technology decisions.