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Indian Solar PV Exports Surging

The country can potentially replace Southeast Asian countries as top exporter to the US

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Key Findings

The export of Indian photovoltaic (PV) modules has risen exponentially by more than 23 times between Fiscal Year (FY) 2022 and FY2024, primarily to the US, which accounted for more than 97% of India's exports in both FY2023 and FY2024.

With the expiration of the Free Trade Agreement and an ongoing antidumping and countervailing duty investigation, India can potentially replace Southeast Asian countries to become the leading PV exporting country to the US.

During periods of domestic supply shortage, certain distributed renewable energy segments, such as residential rooftop solar, will be affected due to their smaller order sizes.

After accounting for exports, the resultant supply by Indian PV manufacturers available for consumption in India in the next two years will only be 21 gigawatt (GW) and 25GW, which is less than the approximate requirement of 30GW per annum to meet India's 2030 renewable energy target.

Executive Summary

India's exports of solar photovoltaic (PV) products have surged by more than 23 times between Fiscal Year (FY) 2022 and FY2024, primarily to the US. Going forward, the country should continue to leverage its advantageous position in the US market to help its domestic manufacturers attain economies of scale, and improve their product quality and competitiveness. Domestic manufacturers, meanwhile, should focus on upstream backward integration to enable India to access untapped markets like Europe, Africa and Latin America. At the same time, balancing the demand of the export and domestic markets is also crucial. Ensuring domestic supply for smaller order sizes, such as for residential rooftop solar, is also important to ensure local energy transition initiatives are not affected.

India is making significant progress in transitioning from a net importer to a net exporter of photovoltaic (PV) products. In Fiscal Year (FY) 2024, Indian PV manufacturers exported approximately US$2 billion worth of PV modules. The export value of PV modules from India increased by more than 23 times in just two years between FY2022 and FY2024.[1]

Several factors have contributed to this rapid increase in PV exports from India FY 2022. These include reduced demand for domestic PV modules following the delayed implementation of the Approved List of Models and Manufacturers in April 2024, several countries considering India as a viable option for their "China Plus One" strategy, and an opportunity for domestic PV manufacturers to diversify their revenue base and sell their products at a higher premium abroad. Despite increased logistics expenses, domestic manufacturers can achieve approximately 40-60% higher profit margins on PV module sales in developed nations like the US than in India.

Indian PV manufacturers are increasingly focusing on the export market. Until FY2024, three of the largest domestic PV manufacturers – Waaree Energies, Adani Solar and Vikram Solar – accounted for most of India's PV exports. Each company exported more than half of its annual actual production in FY2024. Several other Indian PV manufacturers, like Grew Energy, ReNew Power, Navitas, Solex Energy and Saatvik Energy, are pursuing export markets and setting up supply chains abroad. Waaree Energies and Vikram Solar are also planning to set up PV manufacturing capacities in the US, taking advantage of the incentives offered under the Inflation Reduction Act (IRA).

[1] Export Import Data Bank. Ministry of Commerce and Industry

Most Indian PV exports are to the US, which accounted for 97% and 99% of India's PV exports in FY2023 and FY2024, respectively. India also exports PV products to South Africa, Somalia, Kenya, the UAE, Afghanistan, Nepal and Bangladesh.

The US has imposed steep tariffs on PV products from China to gradually phase out Chinese imports. The US government might extend these tariffs to imports from Southeast Asia (SEA), subject to the result of an ongoing antidumping and countervailing duty (AD/CVD) investigation by the US Department of Commerce. SEA countries, including Vietnam, Malaysia, Thailand and Cambodia, cater to more than three-fourths of the US' annual PV requirements. If found guilty under the AD/CVD investigation, the import duty on PV products from SEA countries will be the same as that on Chinese imports, enhancing India's prospects of establishing itself as a leader in PV exports to the US. The outlook for Indian exports further improves considering that PV manufacturing capacities set to come online in the US under IRA are experiencing delays and not all may come to fruition.[2]

India needs to adopt a multi-pronged export-oriented approach. First, it should continue to leverage its advantageous position in the US market, as it is one of the largest solar markets in the world in terms of both installations and technology adoption. This exposure will enable Indian PV manufacturers to attain economies of scale, ultimately enhancing their product quality and competitiveness. Second, to truly establish India as a global manufacturing hub in the long run, Indian PV manufacturers must focus on upstream backward integration. This will help India maintain its foothold in existing markets while unlocking untapped markets like Europe, Africa, Latin America, etc.

As India establishes itself as a viable alternative to China, balancing the demands of the export and domestic markets is important. When there is a supply-demand gap, it is crucial to ensure adequate domestic supply, especially for market segments with smaller order sizes, such as distributed renewable energy, including residential rooftop solar. The supply-demand gap also affects solar module prices, a critical factor for the price-sensitive residential rooftop solar segment.

Introduction

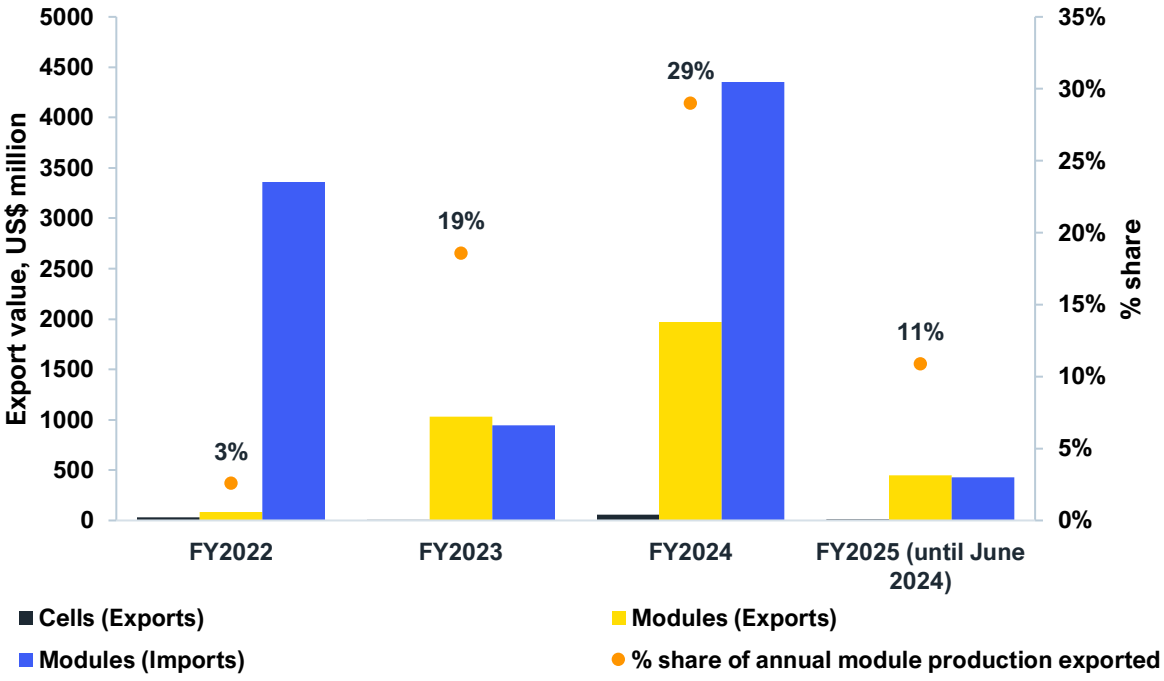
India has traditionally been among the largest consumers and importers of solar photovoltaic (PV) modules, but with the Indian government's push for domestic manufacturing, the volume of exports is also on the rise.

Indian PV manufacturers are increasingly focusing on export markets to access a larger global market, diversify revenue, avail higher profit margins, enable economies of scale and keep abreast of the latest technological developments.

[2] Wood Mackenzie. Is the IRA paying off for the US solar supply chain?. May 2024.

In Fiscal Year (FY) 2024, India imported a record US$6.2 billion worth of PV cells and modules from China-based manufacturers.[3] Interestingly, in the past few years, India has experienced a significant increase in PV exports, primarily high-efficiency PV modules to the US. The export value of PV modules has risen exponentially by more than 23 times in just two years between FY2022 and FY2024. In FY2024, India exported approximately a third of its PV modules to various countries.

Figure 1: PV Exports from India – Annual Trend



Source: Ministry of Commerce and Industry, JMK Research

A host of reasons fueled this meteoric rise of PV module exports from India:

- **Subdued domestic demand**: The government's decision to delay the implementation of the Approved List of Models and Manufacturers (ALMM) to April 2024 led to reduced demand for domestic modules in India. This compelled manufacturers to seek opportunities in international solar markets.
- **"China Plus One" strategy**: Many countries are adopting a "China Plus One" strategy to diversify their supply chains beyond China in order to minimise over-reliance on the country. India's rapidly growing PV manufacturing ecosystem positions it as a strong alternative for solar manufacturing.
- **Healthier profit margins**: Despite increased logistics expenses, domestic manufacturers can achieve approximately 40-60% higher profit margins on PV module sales in developed nations like the US compared with India. Based on industry interviews that JMK Research conducted

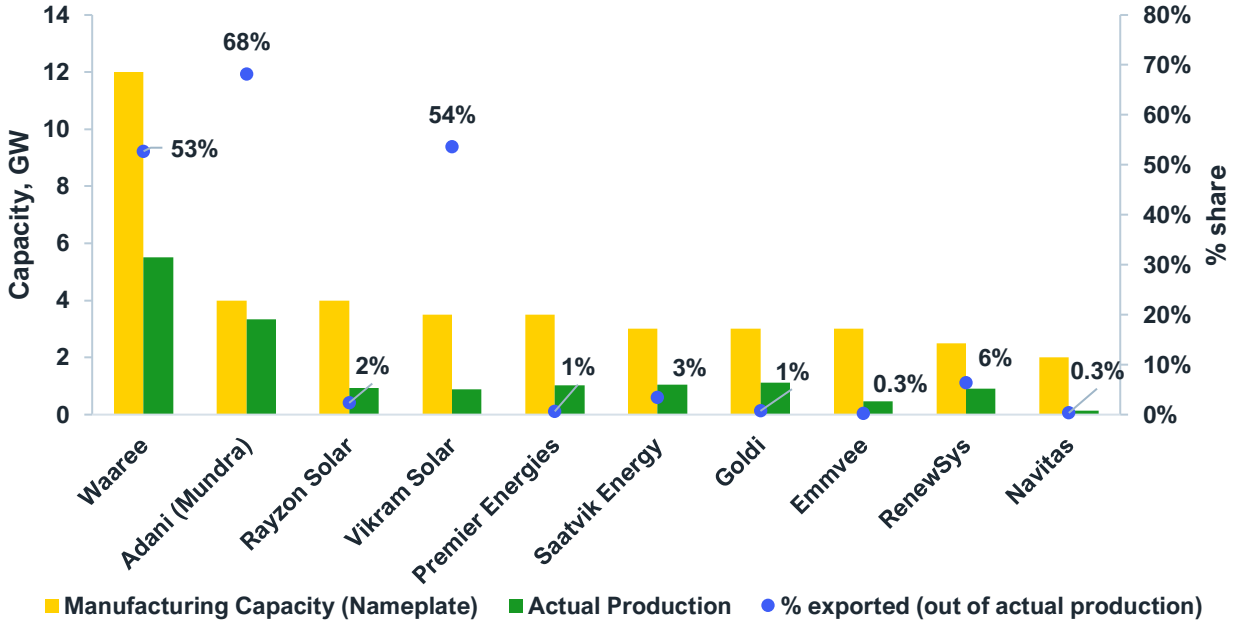
[3] Export Import Data Bank. Ministry of Commerce and Industry.

with manufacturers, the tunnel oxide passivated contact (TOPCon) module[4] price in the US is approximately US¢ 26-30 per Watt-peak (Wp) vis-à-vis approximately US¢ 15-18 per Wp in India.

Export Growth of Leading Domestic PV Manufacturers

In FY2024, India exported over 5.8 gigawatts (GW) of PV modules, which was at least three times higher compared with FY2023. Although India exported more than 29% of its PV module production in FY2024, the majority came from the three largest domestic PV manufacturers – Waaree Energies, Adani Solar and Vikram Solar – each of which exported more than half of its annual actual production in FY2024. Other leading players like ReNew and Tata Power utilised a significant portion of their output for captive consumption in FY2024.

Figure 2: Exports by Leading Domestic PV Manufacturers in FY2024



Source: JMK Research

With the increasing demand for Indian PV products abroad and the attractive incentive structure under the Inflation Reduction Act (IRA), many Indian manufacturers have announced plans to establish manufacturing facilities overseas, particularly in the US:

- **Waaree Energies** is setting up a 5GW per annum integrated PV cell and module manufacturing capacity in Texas, the US. The first phase of 3GW will be commissioned by the end of 2024.[5]

[4] A Tunnel Oxide Passivated Contact (TOPCon) module is a solar panel with excellent low-light performance that uses TOPCon technology to increase cell efficiency. It was introduced to the industry in 2013 by the Fraunhofer Institute for Solar Energy Systems.
[5] PV Magazine. Waaree Energies announces plans for a 5 GW solar cell module facility in the USA. December 2023.

- **Vikram Solar** announced a 4GW PV module manufacturing facility in Colorado, the US, which will be commissioned by the end of 2024. By 2025, Vikram Solar will invest US$1.25 billion to set up a facility to integrate the upstream components of ingots, wafers and cells.[6]
- **Saatvik Energy,**[7] **Navitas Solar**[8] and **Premier Energies**[9] have announced that they will set up three units of 1.5GW, 1.2GW and 1GW of PV module manufacturing capacity in the US.

Indian PV Market Export Destinations

The US

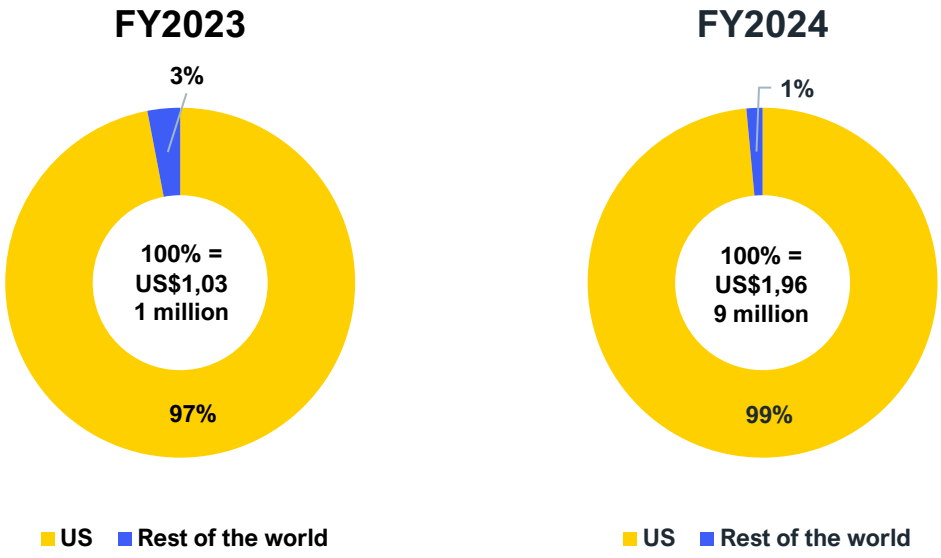
An overwhelming majority of PV module exports from India are to the US, with the share of total exports (by value) to the US being more than 97% in FY2023 and FY2024. Apart from the overall contributing factors for the rise in exports mentioned in the "Introduction", the US administration's imposition of high tariffs on Chinese-origin products and strong trade relations with India have accelerated the demand for Indian PV products.

- Section 301 of the US Trade Act of 1974 regulates the tariffs on goods imported from China. These tariffs on solar modules, including antidumping and countervailing duty (AD/CVD), can rise to as much as 120% in certain US states.
- Since June 2022, Chinese PV products tracing their origins to China's Xinjiang region have been banned under the Uyghur Forced Labor Prevention Act (UFLPA).[10]

Another trend has been the rise of solar cell imports by Indian players from Chinese manufacturers' facilities in Southeast Asian (SEA) nations such as Malaysia, Thailand, Vietnam, etc., and the export of finished PV modules to the US.

[6] PV Magazine. Vikram Solar announces $1.5 billion vertically integrated factory in the U.S. June 2023.
[7] PV Magazine. Navitas Solar sets up a US manufacturing unit. August 2023.
[8] Saatvik Group. Indian panel manufacturer Saatvik has plans for a 1.5-GW factory in the USA. 2023.
[9] PV Magazine. Heliene and Premier Energies announce the US solar cell factory. July 2024.
[10] CSIS. The Uyghur Forced Labor Prevention Act Goes into Effect. June 2022.

Figure 3: Indian PV Exports to the US vis-à-vis Rest of the World



Source: Ministry of Commerce and Industry, JMK Research

The US is the world's second-largest solar consumer after China and is at the forefront of adopting advanced solar technologies. Indian solar manufacturers provide the US with high-quality, high-efficiency PV modules. Until March 2024, this primarily consisted of monocrystalline passivated emitter and rear cell (Mono PERC) bi-facial modules. However, since the beginning of the current financial year, preference and supply have shifted towards TOPCon bi-facial modules.

Focusing on the US market can have several benefits for the Indian PV manufacturing ecosystem:

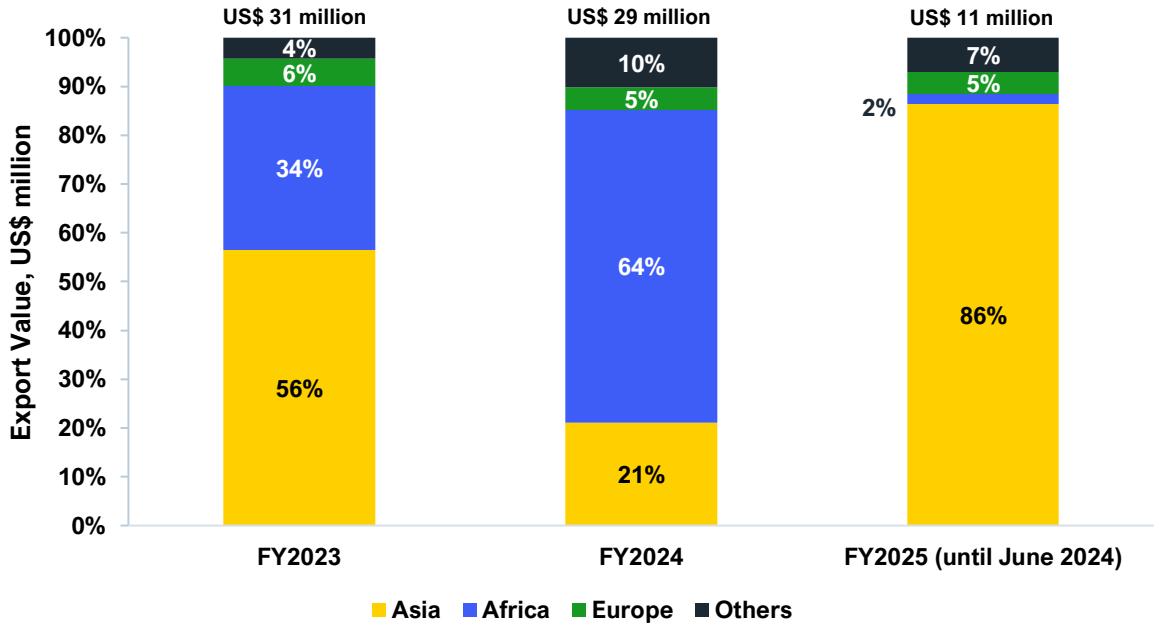
- **Domestic manufacturers attaining economy of scale**: The Solar Energy Industries Association (SEIA) forecasts that the US annual solar demand can reach 140GW by 2030.[11] Thus, domestic manufacturers who leverage India's advantageous position in the US solar market can achieve economies of scale, a critical factor in ensuring price competitiveness on the global stage.
- **Enhanced support for upstream manufacturing integration:** Because of the US embargo on Chinese PV products, Indian manufacturers aiming to sell in the US market will need to start producing the necessary components themselves. This will help Indian PV manufacturing by integrating the upstream processes more effectively. Currently, there is a significant nameplate capacity difference between modules and upstream components like cells, wafers and ingots.

[11] SEIA. Solar Industry Research Data. 2024.

Rest of the World

Apart from the US, much of the demand for Indian PV products comes from African countries like South Africa, Somalia and Kenya, as well as Asian countries like the UAE, Afghanistan, Nepal and Bangladesh. Due to lower transportation costs and strong trade relations, neighbouring countries like Bangladesh, Nepal and Afghanistan will continue to import a significant quantity of Indian-manufactured PV modules. Moving forward, India must explore bilateral tie-ups and cooperation agreements with other countries for production offtake and PV manufacturing, especially in the upstream components of cells, ingots, wafers and polysilicon.

Figure 4: Indian PV Exports' Annual Trend, Destination Region/Country Share (except the US)



Source: Ministry of Commerce and Industry, JMK Research

Exports to the EU are Yet to Pick Up

Even with market conditions similar to the US, such as high demand and the phasing out of Chinese-origin PV products, Europe's share in Indian exports is abysmal. Although Europe aims to reduce dependence on China like the US, its trade laws and import restrictions on Chinese-origin products are not as stringent. In contrast, in the US, the import duty on Chinese-manufactured PV products is almost 8-10x vis-à-vis Indian-manufactured PV products. In May this year, the import tariff on solar cells from China went up from 25% to 50% under Section 301.[12] However, to avail of lower import

[12] White House. FACT SHEET: President Biden Takes Action to Protect American Workers and Businesses from China's Unfair Trade Practices. May 2024.

duty benefits, Indian manufacturers must demonstrate vertical integration and ensure that the raw materials used in the modules are not sourced from China, especially Xinjiang.

Analysis of US Solar Module Imports

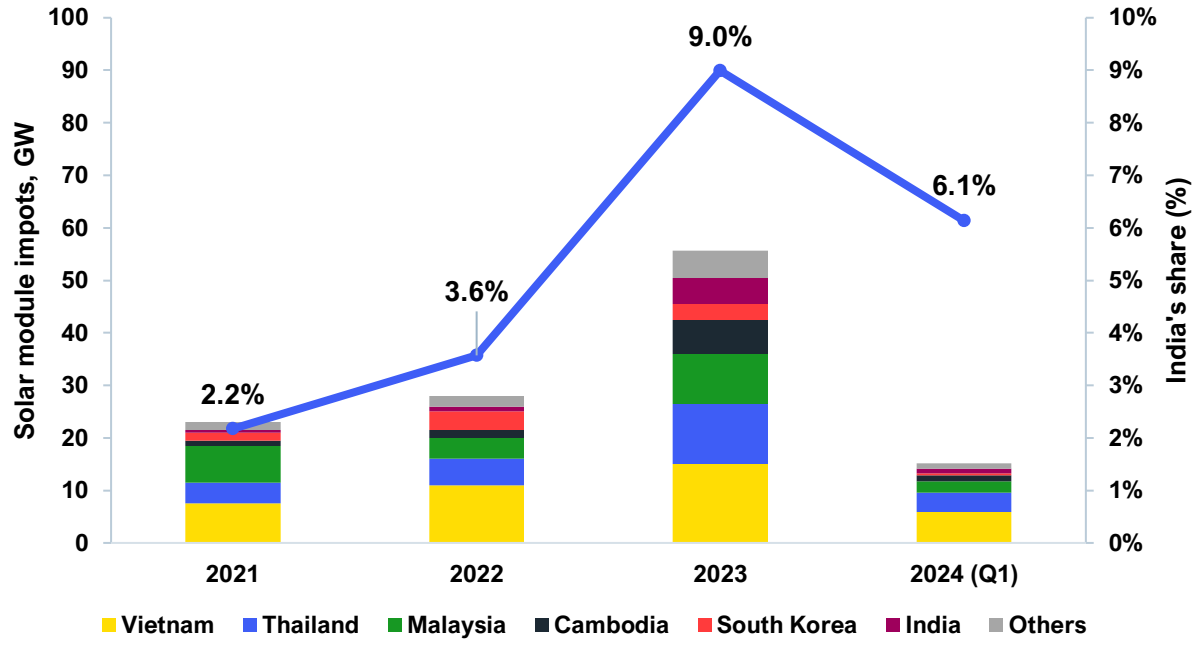
The US imports most of its solar PV components from Vietnam, Thailand, Malaysia and Cambodia. Since 2021, these countries have consistently made up over 75% of the US' annual solar PV imports.[13] Many of the manufacturing units in these SEA countries are owned by Chinese corporations and serve as their offshore hubs to bypass import restrictions in countries that prohibit products made in mainland China.

India's share in US solar PV imports has been increasing over the past few years. Between 2021 and 2023, this share grew more than fourfold, from 2.2% to 9%. In 2023, India surpassed South Korea to become the fifth-largest exporter of solar PV components to the US. However, Indian exports to the US stalled in 2024 owing to the US presidential election and the delayed implementation of ALMM in India.[14] Indian manufacturers expect imports to pick up after the election and with quantitative easing measures like a reduction in interest rates.

Former President Donald Trump's return to power presents unique opportunities and challenges for Indian solar PV manufacturing. His tough stance on Chinese products is likely to lead to even stricter tariff barriers for imports from China and Southeast Asia (which often serve as indirect entry points into the US for Chinese PV manufacturers). This development makes the export outlook for Indian PV products with domestically made cells even brighter, especially since the US lags significantly behind India in PV manufacturing capacity. However, if incentives for domestic manufacturing under the IRA are reduced, it may deter some Indian manufacturers who were considering setting up facilities in the US.

[13] NREL. Spring 2024 Solar Industry Update. May 2024.
[14] Financial Express. Solar panel exports stagnate in Q1 after post-FY22 surge. September 2024.

Figure 5: US Solar Module Import Trend by Country of Origin



Source: NREL, JMK Research

Trends Favouring the Shift from SEA Countries to India

In June 2022, under the Presidential Proclamation 10414, the US president enacted a Free Trade Agreement (FTA) to provide duty-free access to solar imports from Cambodia, Malaysia, Thailand and Vietnam for two years. In June 2024, the US government clarified that solar imports from Southeast Asian countries would be subject to import tariffs, just like imports from all other nations.[15]

Additionally, the US Department of Commerce is investigating solar cell and module imports from SEA under AD/CVD tariffs.[16] The investigation is based on a petition by the American Alliance for Solar Manufacturing Trade Committee, which claims that SEA countries follow potentially illegal trade practices and tariff circumvention strategies. The final ruling under this investigation will be issued by early 2025. If found guilty, solar PV imports from SEA will potentially face import restrictions and duty similar to what is levied on Chinese products, which could make Indian PV products more attractive to the US.

The outlook for India improves further if we consider the delay in the 45% module capacity, 25% cell capacity and 5% wafer capacity set to come online in the US under the Inflation Reduction Act

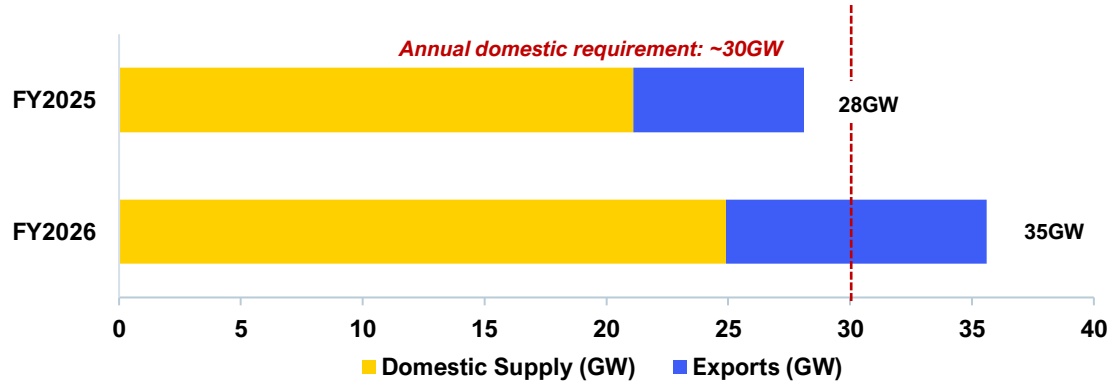
[15] International Trade Administration. Expiration of Presidential Proclamation 10414 on Solar Cells from Cambodia, Malaysia, Thailand, and Vietnam. June 2024.
[16] Bloomberg. Asian solar imports are subject to a new US commerce probe. May 2024.

(IRA).[17] Stringent labour laws, a shortage of skilled labour for integrated PV manufacturing, delays in obtaining environmental clearances and high industrial electricity prices are major hurdles for PV manufacturers setting up capacity in the US.

PV Exports can Impact Domestic Supply-Demand Gap

Based on industry stakeholder discussions and our analysis, annual module production by Indian PV manufacturers in FY2025 and FY2026 will likely be 28GW and 35GW, respectively. After accounting for exports, the resultant supply by Indian PV manufacturers in the next two years will be only 21GW and 25GW, respectively, which is less than the requirement of approximately 30GW per annum to meet India's 2030 renewable energy target.

Figure 6: Forecast of Actual Supply of PV Modules by Indian Players to the Domestic Market



Source: JMK Research

It is important for PV manufacturers in India to balance the needs of the growing export market with domestic availability. During periods of domestic supply shortage, certain distributed renewable energy segments, such as residential rooftop solar, could be affected due to their smaller order sizes. This can make it difficult for players to secure enough supplies to execute their projects. The supply-demand gap also affects solar module prices, which is a critical factor for the price-sensitive residential rooftop solar segment.

Impact on Government Projects

The central government mandates the use of domestic content requirement (DCR) modules in its schemes, including PMSGY and PM-KUSUM. For a solar module to be classified as DCR, both the PV cells and modules must be domestically manufactured. However, India's PV cell manufacturing capacity is just over 8GW, far less than the annual solar demand. With a large share of modules manufactured using Indian cells earmarked for exports, there might be a shortage of DCR modules in

[17] Wood Mackenzie. Is the IRA paying off for the US solar supply chain? May 2024.

India for government projects. According to industry stakeholders, the prices of DCR modules in India are already approximately 30% higher than those of their non-DCR counterparts.

PMSGY envisages approximately 30GW of residential rooftop solar installations by March 2027, translating to an annual target of roughly 8-10GW.[18] Adding demand from other segments, the annual target for DCR installations under government schemes can go up to 15GW, which is much higher than what India can produce.

Impact on Utility-scale Solar Projects

After the reinstatement of ALMM in April 2024, the availability and affordability of solar modules for utility-scale solar projects (including open access) is turning out to be a roadblock. There are concerns among suppliers and developers regarding availability shortages and delays in meeting order deliveries. With ALMM, developers are forced to choose from whatever is available domestically.

According to developers, due to a surge in demand post ALMM reinstatement, they are unable to source orders of more than 20-25MW of modules at a time. For larger utility-scale projects of more than 200MW, developers are forced to source from three to four different suppliers and endure long wait times, escalating project costs and hindering timelines.

In addition to availability, the price and quality of domestic modules remain a concern. Despite Indian module manufacturers meeting internationally recognised standards such as those prescribed by the International Electrotechnical Commission, some developers have cited domestic modules failing the I-V test[19] when deployed in projects. Developers also highlight that the exported modules are of superior quality and have a different bill of materials than the ones sold domestically.

Conclusion

India's solar PV industry is transforming – it is evolving from a major importer to an exporter of PV modules. Indian PV exports (by value) have risen 23x in just two years between FY2022 and FY2024. Three manufacturers – Waaree Energies, Adani Solar and Vikram Solar – have driven the exponential rise in Indian PV exports to the US. Other manufacturers, including Grew Energy, Navitas Solar and ReNew Power, will also contribute significantly to the Indian PV export market with their comprehensive understanding of global markets.

This paradigm shift from a major importer to an exporter presents both opportunities and challenges for India's renewable energy ambitions. By tapping into the vast US market, Indian PV manufacturers

[18] PIB. Cabinet approves PM-Surya Ghar: Muft Bijli Yojana for installing rooftop solar in One Crore households. February 2024.
[19] An I-V test, or I-V curve test, measures the current and voltage output of a solar module under different loads to create an I-V curve. This curve shows the relationship between the current (I) and voltage (V) produced by the module.

can generate higher profit margins vis-à-vis India. This exposure also enables them to attain economies of scale, ultimately enhancing product quality and competitiveness. Furthermore, with a pressing need to diversify their supply chains away from China, the export growth adds to Indian manufacturers' upstream backward integration efforts in manufacturing PV components domestically.

However, this rapid expansion in exports also raises important considerations. With India's increasing PV module production being directed towards foreign markets, there are concerns about meeting domestic demand and achieving the country's ambitious 2030 renewable energy target. As Indian manufacturers continue to strengthen their foothold in global markets, particularly in the US, they must strike a balance between meeting international and domestic demand.

Going ahead, India should adopt a multi-pronged export-oriented approach. First, it should continue to leverage its advantageous position in the US market, as it is one of the largest solar markets in the world in terms of both installations and technology adoption. Simultaneously, India should keep exploring opportunities in other regions with a strong "China Plus One" sentiment, such as Europe, where China currently exports more than 100GW of solar modules annually. The Indian government can facilitate this by establishing trade agreements with certain countries to ensure the long-term offtake of PV products.

Second, to truly establish the country as a global manufacturing hub in the long run, Indian PV manufacturers must focus on upstream backward integration. The government can facilitate this by increasing the incentives for manufacturing upstream PV components, such as cells, wafers, ingots and polysilicon. Rather than a combined production-linked incentive for integrated PV production, it should be delinked and disbursed separately for stage-wise production output.

India is on the cusp of an energy transition revolution, with solar technology being a critical enabler. The Indian PV manufacturing industry is gearing up to meet India's domestic demand and simultaneously establish itself as a viable alternative to Chinese-origin PV products. This approach will contribute significantly to achieving India's renewable energy goals while emerging as a reliable partner in the global transition to cleaner energy sources.

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The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

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