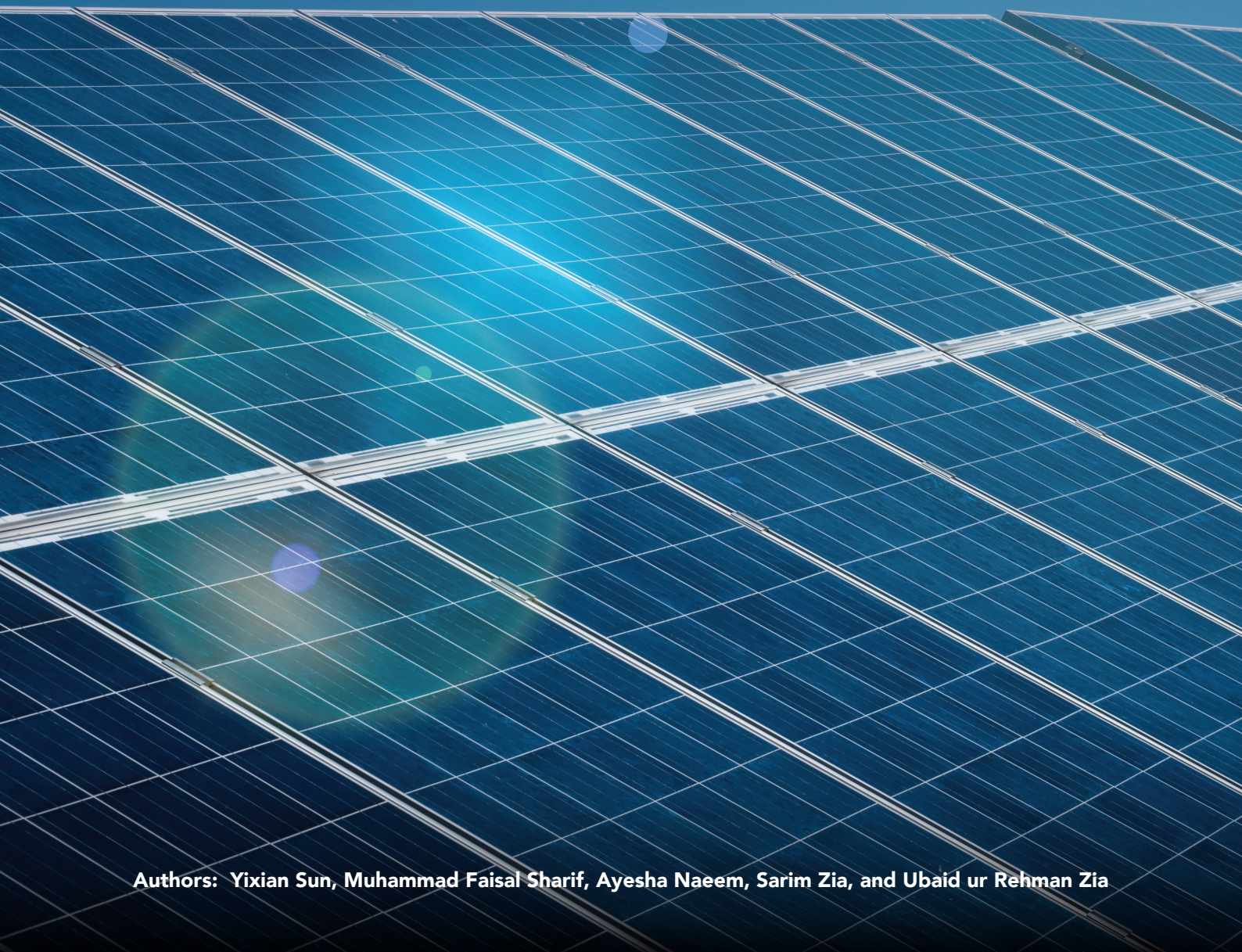
FROM **SOLAR BOOM** TO **GREEN INDUSTRIALIZATION:**

Policy Pathways to Localizing Solar Value Chains in Pakistan



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EXECUTIVE SUMMARY

Pakistan's energy landscape is undergoing a transformation driven by the rapid uptake of imported solar photovoltaic (PV) systems: as of mid-2025, solar is expected to contribute over 25% of Pakistan's power supply (including off-grid solar generation), surpassing the share of any single fossil fuel and becoming the second-largest source of generation after hydropower in Pakistan's energy mix. However, this solar boom has not benefitted all citizens equally. The installation of solar systems under net metering remains unaffordable for low-income families. The shift to rooftop solar has also reduced demand from the national grid, which has led to revenue losses for public-sector distribution companies, increased the financial burden on consumers who rely solely on grid supply, and posed challenges to overall grid stability. In recent years, the country has spent over USD 4 billion on imported solar equipment as it heavily relies on foreign manufacturers, particularly Chinese firms, without giving sufficient attention to developing local solar manufacturing capacity. This policy report advocates the localization of solar manufacturing to reduce import dependence, create jobs, and improve energy security. It explores key opportunities and challenges in developing a local solar PV value chain, including the use of special economic zones (SEZs), the provision of financial incentives, and the establishment of joint ventures with Chinese manufacturers under the China-Pakistan Economic Corridor. We propose a "5S" (Strategy, Subsidy, Standards, SEZs, Science & Knowledge) roadmap to foster a competitive solar industry in Pakistan.

Over

USD 4 bil.
spent in recent years on imported solar equipment

KEY POLICY RECOMMENDATIONS

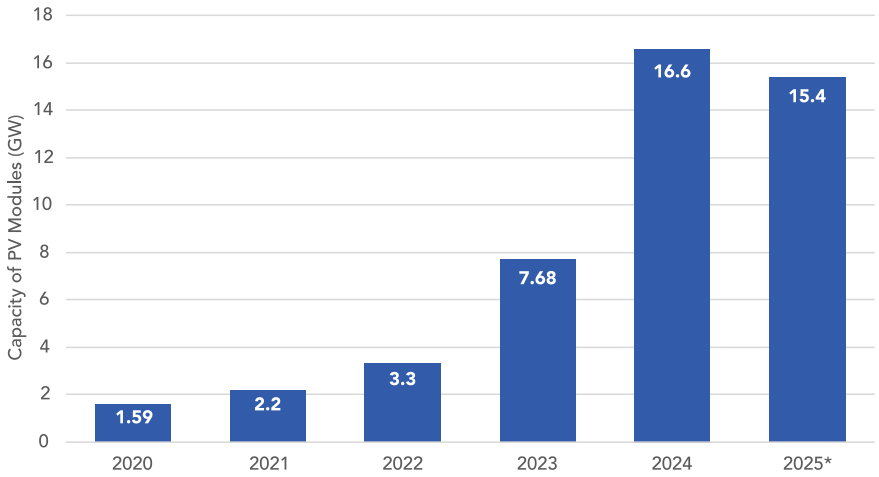
- Establish a National Solar Industrialization Task Force under the Ministry of Industries and Production to develop a long-term strategy, set milestones, and coordinate actions across key federal and provincial entities
- Develop a national policy framework that defines eligible technologies, tax incentives, land-access mechanisms, and investment protections to fast-track localization
- Reduce duties on key components of solar energy while gradually increasing duties on fully assembled imported panels
- Introduce local content and procurement targets for solar installations in public and utility-scale projects to create predictable demand for locally made products
- Set up an active national certification body for clean energy technologies to oversee conformity, inspection, and export licensing of solar products
- Build integrated solar clusters in special economic zones (SEZs) under the China-Pakistan Economic Corridor
- Strengthen academia-industry nexus to promote joint R&D with Chinese partners through innovation centres

INTRODUCTION

1.1 Pakistan's solar boom

Since mid-2023, Pakistan has witnessed an unprecedented transformation in solar PV adoption – a transition led by its people due to escalating energy prices (over 155% increase in the last three years), rapidly declining costs of solar PVs, and growing instability of the national grid (Profit by Pakistan Today, 2024). This bottom-up solar boom contrasts sharply with the country's historical reliance on large-scale, centralized generation projects under a single-buyer power market. Pakistan has an installed capacity exceeding 45 gigawatts (GW) with heavy reliance on thermal energy sources, particularly imported fossil fuels, which has exposed the country's energy system to the volatility of fuel prices in international markets. The turning of people towards distributed solar power marks a pivotal moment in the country's energy transition and opens a policy window for green industrialization and local value-chain development.

Figure 1: China Solar Panel Exports to Pakistan (2017-2025*) (Source: Ember)



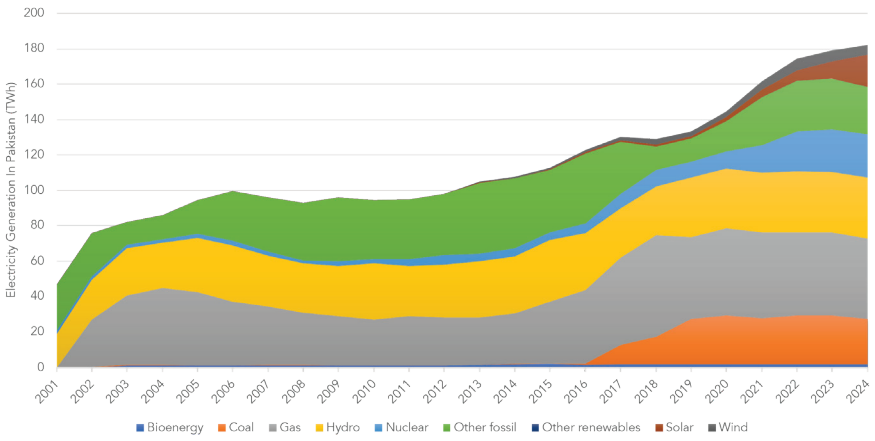
(Note: the year of 2025 depicts the data from January through August in 2025)

In the period of eighteen months from July 2023 to January 2025, various sources reported that the country had imported 22 GW of solar panels, making it the largest Chinese solar export market in Asia and the second largest globally after Europe (Arab News Pakistan, 2025; Profit by Pakistan Today, 2024; The Nation, 2024). Until the second half of 2025, this uptake is still sustained and increasing at a rapid pace. In the first four months of 2025, Pakistan imported over 10 GW of solar panels from China, an increase of nearly 18% from the previous year, driving the share of solar energy to over 25% of the national power generation (including off-grid solar generation) and making solar a major source of electricity for Pakistan, which was at fifth place just two years ago (Maguire, 2025). A similar trend, though smaller in scale, is observed on the net-metered scale, with capacity reaching 5.8 GW as of July 2025 (PPIB, 2025).

Pakistan imported
22 GW
of Chinese solar panels (2023–25), 2nd largest globally.

Solar contributed
25%+
of Pakistan's power by mid-2025, **surpassing the share** of any single fossil fuel

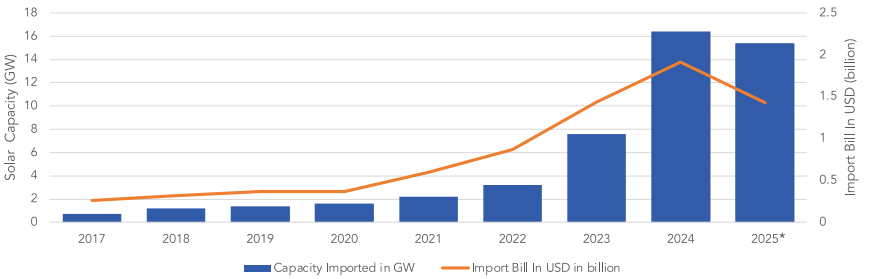
Figure 2: Pakistan Electricity Generation (TWh) (Source: Ember)



Although this solar rush has enabled a shift towards cleaner and more affordable energy in Pakistan, it has also created an array of challenges for the existing system that demands course correction if this growth is to be sustained. Several assessments have been made on the potential impact of this people-led solar boom on the revenue streams of distribution companies (DISCOs) and other economic indicators of the energy sector. But less attention has been given to the prospects of unleashing the potential of green industrialization based on this boom by building a local solar PV industry. In other words, the question of how to move from the reliance on imports to self-reliance through localization of Pakistan's solar PV industry for long-term sustainable development is worth considering.

For the past four years, Pakistan has spent over roughly USD 4.1 billion on imports of solar equipment, while local industrial development remains nascent, restricting local value addition and technological development (Renewables First & Herald Analytics, 2024). Hence sustaining this solar uptake requires a critical analysis of the possibility to localize solar PV value chains in the country, ranging beyond simply assembly to manufacturing of core components including panels, batteries and services for system integration. This also demands a deeper analysis on the enabling role of China, as the dominant player in the global cleantech supply chains, and what policies can support this momentum without disrupting the economic and market dynamics.

Figure 3: Pakistan Solar Import Bill (Source: Ember)



(Note: the year of 2025 depicts the data from January through August in 2025)

1.2 Economic and social implications of solar localization for Pakistan

The rapid uptake of solar energy since 2023 by individual consumers has been unable to bring significant benefits to the local economy. Foreign manufacturers, especially Chinese companies, have become the main beneficiaries of Pakistan's solar boom by flushing products to the Pakistani market. With unparalleled production capacity and economies of scale, Chinese firms can produce solar modules at costs far below what most countries can match. This raises the question regarding economic costs and benefits of Pakistan's solar boom.

Until now, Pakistan's solar industry has created very limited jobs, primarily in installation and maintenance. Local technicians and small-scale entrepreneurs have formed informal supply chains and gained technical skills through on-the-job learning and digital platforms, but these gains remain peripheral to the benefits for foreign manufactures. The country still has no capacity to assemble, nor produce, solar PVs or batteries. According to our consultations with key business stakeholders in the country, manufacturing solar PVs locally would be significantly more costly than importing from China, as the country lacks an industrial base to produce key parts of solar PVs. Hence, without additional interventions, Chinese manufacturers have little incentive to localize production in Pakistan.

Moreover, the existing solar boom may have unintended consequences on society by reinforcing inequality and undermining energy justice. Despite decreasing prices over the last few years, installation costs remain far beyond the reach of most Pakistanis, around 45 percent of whom live below the poverty line. More energy generated from rooftop solar also means a continuous decrease in the demand from the national grid, which may lead to higher electricity bills for poor people who cannot afford to have their own solar PVs.

As affluent households and large commercial users increasingly switch to rooftop and captive solar systems, national grid demand has weakened, shrinking the pool of paying customers. Electricity sales fell by 2.8 percent in mid-2024, a second consecutive year of decline (Dawn, 2025). As a result, roughly PKR 200 billion in fixed grid costs were shifted to non-solar users during FY2023–2024, resulting in a PKR 2 per unit tariff increase. Considering the massive import of solar panels, grid demand is expected to decline further by 15%, potentially resulting in a 17% increase in the base tariff, which would worsen affordability for lower-income consumers already struggling with doubled electricity prices between 2021 and 2024 (Dawn, 2025).

Considering such intended consequences of the recent solar boom in Pakistan, the localization of solar manufacturing seems a necessary strategy for the country to better harvest benefits of clean energy transition. It will not only be economically beneficial for Pakistan's development, but will also help its government reduce energy inequality and provide affordable energy to all. Despite this potential, little effort has been made so far to localize parts of solar supply chain in the country.

1.3 Our objectives

In the backdrop of Pakistan's rapid uptake of solar energy and its socioeconomic impact, this policy report aims to produce evidence-based analysis on opportunities and challenges to localize solar value chains in Pakistan. We combine desk research of existing market and policy data with primary data collected through key informant interviews and focus group discussions. By situating Pakistan in China's growing global investments in cleantech manufacturing, we evaluate policy landscape and market readiness for the localization of solar PV value chains in Pakistan. Our analysis shows that despite several economic and institutional challenges that Pakistan has faced recently, many opportunities still exist for Chinese manufacturers to design strategies to localize parts of their value chains in the country, in the context of greening China-Pakistan Economic Corridor (CPEC). If this can happen, the country can harvest economic, social and environmental co-benefits of a rapid clean energy transition. To achieve that goal, we propose a policy roadmap with five enablers (5S) - Strategy, Subsidy, Standards, SEZs, Science & Knowledge – to promote green industrialization in Pakistan through the development of a local solar value chain.

2. CPEC 2.0 AND PAKISTAN'S GREEN INDUSTRIALIZATION AGENDA

2.1 China's cleantech dominance and its Green BRI strategy

Over the last decade, China has quickly risen to become a cleantech superpower by dominating manufacturing of almost all clean technologies including solar, wind, batteries and electric vehicles (IEA, 2024). In the global solar value chain, the country manufactures over 80% of solar PVs worldwide and leading Chinese companies in the sector control key technologies. For countries like Pakistan, this dominance means that building a domestic solar manufacturing base will require strategic engagement with Chinese partners. Considering the long-term strategic partnerships between China and Pakistan and the existence of the CPEC as a flagship project in China's overseas engagement strategy, leveraging China's support through investments and technology transfer seems a viable route.

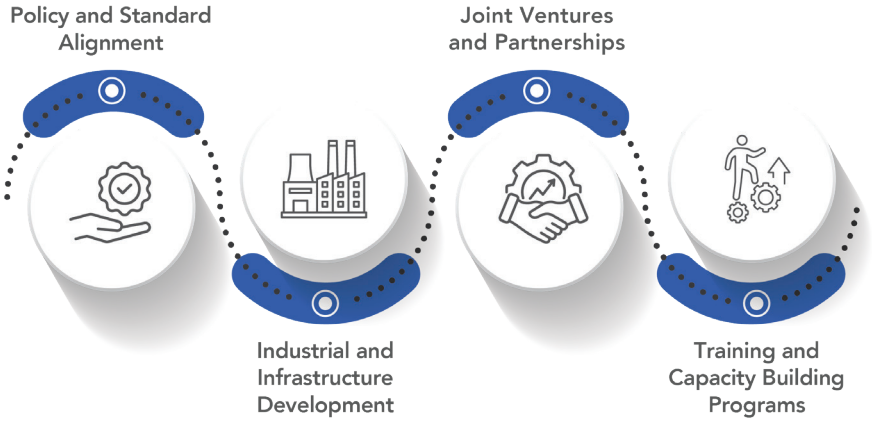
In fact, as the Belt and Road Initiative (BRI) enters its second decade, China's overseas development strategy has evolved toward a low-carbon transformation, industrial upgrading, and inclusive, people-centered growth. The term "Green BRI" was coined in 2017 in the joint publication "Guidance on Promoting Green Belt and Road" by four Chinese ministries, including the Ministry of Ecology and Environment, which promotes the integration of ecological protection across all phases of BRI projects. Initiatives like the Belt and Road Initiative International Green Development Coalition (BRIGC), Green Investment Principles for the BRI, and other guidance documents developed by different ministries together constitute a new governance ecosystem to promote the management of environmental and social risks of Chinese companies' overseas activities, and encourage preferential financing for clean industries while deterring high-emission investments (Sun & Yu, 2023). Overall, these developments suggest a new policy direction reflecting China's ambition to lead global climate action (Sun 2025).

China's overseas investments are increasingly aligned with its green industrial priorities. Since 2023, China's international investments in clean energy have exceeded USD 100 billion, more than double those of the US or EU, with a particular focus on solar modules, lithium batteries, and electric vehicles (Slaymaker, 2024). In 2024 alone, green energy projects (solar, wind, waste-to-energy) under the BRI reached USD 11.8 billion, a 60 percent-on-year increase, comprising nearly a third of total energy-related activity. A corresponding surge in green technology and manufacturing investments, particularly in EVs, batteries, and renewable energy (referred to as "The New Three"), pushed total tech-related Chinese BRI engagements above USD 30 billion (Nedopil, 2025).

China's approach to supporting localization of cleantech manufacturing in the Global South usually includes several mechanisms as highlighted in Figure 4. Over the years, China's overseas development has observed a growing focus on solar PVs, with over USD 57 billion (25.2% of total Chinese

green manufacturing overseas investment) committed to 135 overseas solar manufacturing projects (Xue & Larson, 2025). These projects span from Southeast Asia and Middle East to Africa and Europe.

Figure 4: Key Mechanisms of China's technology transfer to its Global South partners



In the Middle East, the Chinese private sector is actively engaged in promoting localization. Jinko Solar in 2024 announced the development of a 10 GW high-efficiency cell project in Saudi Arabia (Global Times, 2024). Similarly, joint venture in Oman's free trade zones aims to construct 8 GW advanced PV module and 2 GW PV cell production bases (H.A. Hassan, 2024). Similar efforts by various Chinese players are being made in Africa to support both assembly and complete manufacturing. Even Italy's Bee solar and Huasun have signed agreements for the development of a PV production hub using China's technology (Reuters, 2024). For the BRI countries, a few notable projects include:

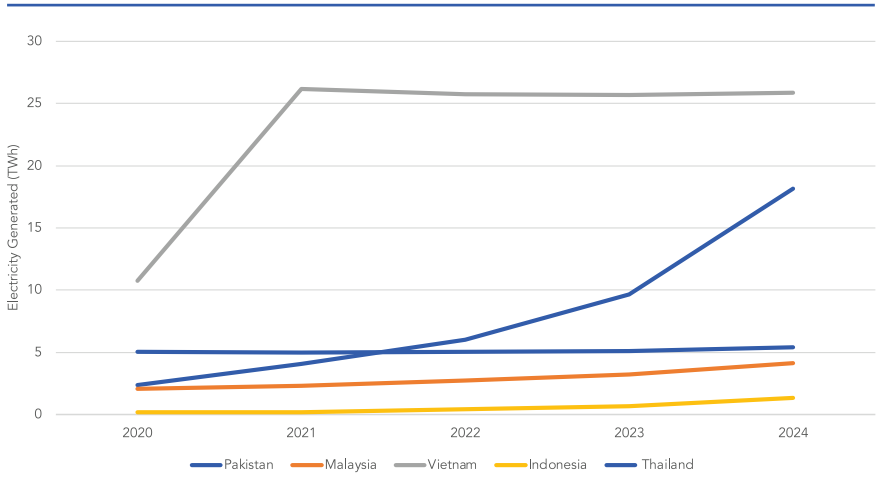
- **Malaysia:** USD 380 million PV module manufacturing facility in Selangor invested by LONGi
- **Indonesia:**
  - 1 GW integrated solar cell and module manufacturing facility in the Kendal Industrial Park, invested by PT Trina Mas Agra Indonesia, a joint venture between Trina Solar and local partners
  - 1.6 GW solar panel manufacturing facility invested by a joint venture between LONGi and Pertamina NRE
- **Turkey:** 5 GW solar cell manufacturing facility invested by Chinese company JTPV and Turkish company Schmid Pekintaş under the HIT-30 High Technology Incentive Program
- **Kazakhstan:** Solar PV plant in Kapchagay by Universal Energy. The plan followed the principal of "100% made in China, and 100% construction in Kazakhstan

According to the China Low Carbon Technology FDI Database, the ASEAN region remains the primary destination for Chinese green manufacturing investments, accounting for nearly half of all such investments before 2024,

with Indonesia ranking at the top of the list, followed by Vietnam, Malaysia, and Thailand (Xue & Larsen, 2025). Overall, over 75 percent of China's overseas green technology manufacturing projects are in the Global South, showing China's continued focus on emerging markets through the BRI. This represents a substantial opportunity for Global South countries to host green FDI and enhance their participation in the global green technology market in collaboration with China. For Pakistan, which hosts CPEC, the flagship of the BRI, this opportunity carries particular significance.

Interestingly, Pakistan's solar demand outpaces that of most ASEAN countries that have attracted massive Chinese investments in solar manufacturing. However, until now, no Chinese FDI in solar industry has been materialized in the country. As shown in Figure 5, except for Vietnam, all top ASEAN recipients of Chinese solar projects generate less solar electricity than Pakistan, showing a clear disconnect between market potential and investment flows. This imbalance highlights Pakistan's untapped opportunity to position itself as the next major destination for Chinese green manufacturing capital, particularly under the framework of CPEC 2.0, where clean energy and low-carbon development are central themes.

Figure 5: Electricity Generation from Solar (2020-2024) (Source: Ember)



2.2 Local Solar Manufacturing: A win-win opportunity for China and Pakistan

Building on a decade of large-scale infrastructure and energy investments, Pakistan has now entered the second phase CPEC, termed as a "people-centric" era with more focus on green development. Meanwhile, the government of Pakistan aims to develop and improve its industrial growth under the 5-E framework (Exports, E-Pakistan, Environment & Climate Change, Energy & Infrastructure, and Equity & Empowerment) in which energy and environment hold promising development trajectories. In this context, localization of a solar value chain within Pakistan holds significant

Localization Gains

Localization to **cut imports, create jobs, and lower solar costs.**

opportunities for Pakistan and China. As our analysis shows below, there are economic as well as political opportunities for both sides.

Opportunities for Pakistan

- **Support climate action and clean energy transition:** Pakistan's push for developing a local solar value chain aligns closely with its ambitious climate targets. Under its NDC 3.0, submitted in September 2025, Pakistan has pledged a 50% reduction in projected 2035 greenhouse gas emissions (17% unconditionally and 33% conditional on international support), while earlier NDCs set goals to achieve 62% renewable energy, alongside a ban on coal imports. The Ministry of Climate Change is also finalizing a Green Industrialization Policy Framework to promote cleaner production and reduce GHG emissions (MoCC&EC, 2025). Parallel efforts, such as State Bank's Green Taxonomy and carbon market frameworks, reinforce a national priority for decarbonization and green industrialization.

- **Reduce import dependency and make solar energy more affordable:** Pakistan currently imports nearly all solar panels, inverters, and upstream materials such as wafers and cells, contributing to a growing trade deficit. Localizing production can reduce such costs and retain a substantial share of value within the domestic economy. More importantly, with appropriate policy support to attract foreign investors and incentivize technology transfer, localizing solar manufacturing holds the potential to reduce costs of end products, and therefore, make solar energy more affordable for middle- and low-income families in the country.

- **Create jobs and skilled workforce:** The transition to solar manufacturing offers Pakistan an entry point into the global cleantech value chains. Establishing assembly and component manufacturing lines can support industrial upgrading, strengthen technical skills, and create thousands of direct and indirect jobs. With institutions such as the National Vocational and Technical Training Commission (NAVTTC) and provincial TEVTAs, Pakistan can align skill development programs with the needs of Chinese partners, ensuring a trained workforce for renewable industries.

- **Build a competitive green industry:** In addition to supplying the domestic market, a competitive solar industry Pakistan has also the promise to target regional markets especially in Central and South Asia. This can be realized by better utilizing special economic zones. Under CPEC, nine SEZs are being developed to enhance industrial cooperation. Three of these SEZs (Rashakai, Allama Iqbal, and Bostan) have been prioritized due to their strategic locations and incentives such as tax exemptions, land access, and infrastructure support. However, these SEZs have not yet attracted significant investments. If they can be designated to develop solar manufacturing clusters with duty-free equipment import and dedicated transport infrastructure, there is a huge potential to develop a competitive industry in the region.

Opportunities for China

At the same time, supporting the development of a local solar value chain may also bring several benefits for Chinese businesses due to the changing market and political contexts.

- Diversifying Production Bases: With growing concerns of many countries over China's dominance in clean technologies, Chinese solar exports have been facing unprecedented trade restrictions, especially U.S. tariffs introduced by the second Trump administration, which are planned to reach as high as 3,521 percent on panels routed through some of Southeast Asian countries (Da Silva, 2025). In response, Chinese companies began to diversify production lines to alternative destinations such as Indonesia and Laos (Recessary, 2024). Pakistan can serve as another strategic alternative especially given the highly friendly investment environment for Chinese companies.
- Lower production costs and expand to new markets: As shown in Figure 6, an important incentive for Chinese investors to support the development of a local solar value chain in Pakistan is the size of the country's market, which continues to grow. Moreover, the country's strategic location also means Chinese manufacturers can use Pakistan as a new production base for the regional market. By shifting some production to Pakistan, Chinese solar manufacturers can benefit from reduce labor and transportation costs for their export to central Asia, and Middle East, and Europe.
- Align with the Green BRI and CPEC 2.0: In addition to economic costs, investing in the development of a solar value chain in Pakistan would align strongly with China's evolving overseas investment strategy under the Green BRI. Accordingly, Chinese businesses and financial institutions may receive government support for such investments in green industries. In Pakistan, China has already supported flagship clean energy projects, such as the 1,000 MW Quaid-e-Azam Solar Park, 100 MW UEP Wind Farm, and 50 MW Sachal Wind Farm. Under CPEC 2.0, both governments have reaffirmed their commitments to green development. In this context, cooperation for localization of solar value chains in Pakistan is likely to be prioritized by both states and receive strong policy support.

In fact, the momentum for localizing solar manufacturing in Pakistan is already building. Over the past two years, multiple memorandums of understanding have been signed to plan the development of solar PV manufacturing plants in Pakistan. With mutual interests from both Pakistan and China, negotiations are taking place between the Government of Pakistan, local firms, and various Chinese private companies including LONGi Solar, AIKO Solar, Ningbo Green Light Energy (NGLE), and C&D clean energy.

In 2024, AIKO (China) signed an agreement to establish a solar panel assembly plant in Punjab (Arab News Pakistan, 2024). Around the same time, Ningbo Green Light Energy (China) committed USD 200 million to convert an existing thermal power plant in Muzaffargarh into a 300 MW solar power facility (Haider,

$ 4.2 billion

MoUs signed in 2025 for Chinese investments in Pakistan

2024). These developments followed a visit by a 12-member delegation of leading Chinese firms to the Dhabeji SEZ, where proposals were also made to set up manufacturing units for solar panels, inverters, and batteries (Profit by Pakistan Today, 2024). With the provision of a conducive policy environment, these initiatives may lead to strong and long-term industrial partnerships.

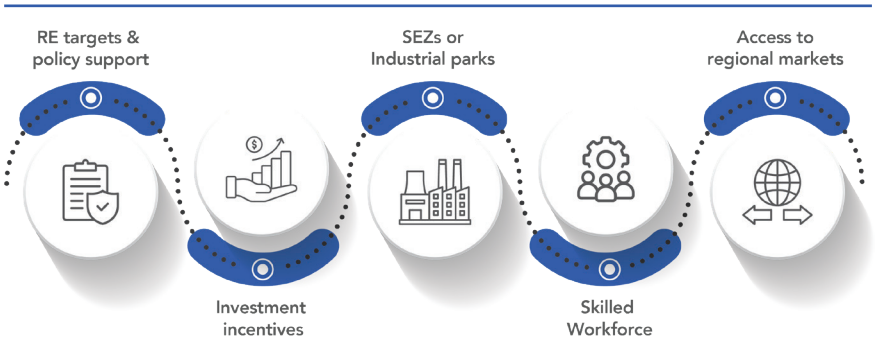
Moreover, the government of Pakistan has also invited Chinese companies to invest heavily in its renewable energy sector, particularly solar (Associated Press of Pakistan, 2024). At the second Pakistan–China Business-to-Business (B2B) Investment Conference taking place in Beijing in September 2025, the Pakistani government reaffirmed its readiness to host Chinese industries in SEZs under CPEC 2.0, ensuring full protection to investors. The conference led to the signing of 21 MoUs worth USD 4.2 billion across sectors including solar energy and electric vehicles (The Nation, 2025).

In summary, these opportunities suggest that localizing solar value chains in Pakistan can create a win-win situation for both countries. As CPEC 2.0 prioritizes business-to-business partnerships, technology cooperation and value chain integration can advance rapidly and the solar sector is likely to become a key area of cooperation given Pakistan's solar boom. However, realizing this potential requires targeted policy reforms in Pakistan. Below we identify key bottlenecks in the existing policy framework.

2.3 Bottlenecks in Pakistan

China's overseas investments in solar value chains have been shaped by a combination of "Push and Pull" factors, namely China's outward investment strategies on one hand, and host countries' enabling environment on the other. Figure 6 summarizes several key pull factors in host countries for Chinese investment in the solar sector.

Figure 6: Host Country Pull Factors Enabling Chinese PV Localization



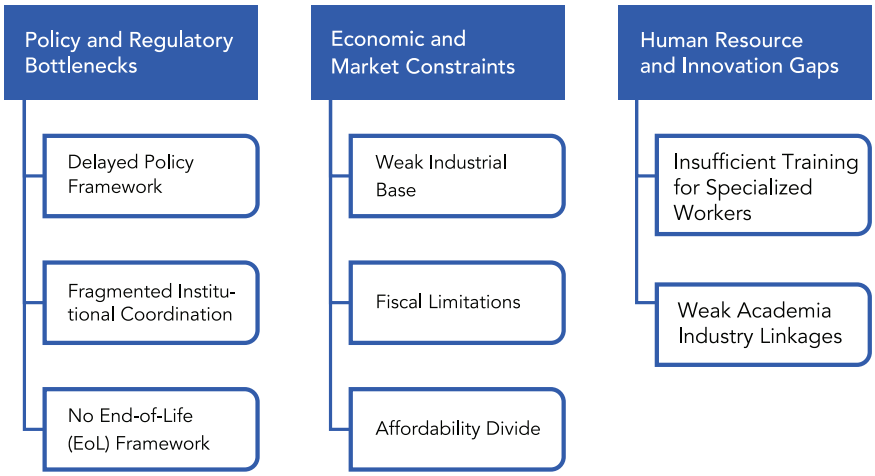
Among various factors, a primary condition for host countries to attract cleantech investments is clear and supportive policy frameworks for clean energy and industrial development. Indonesia provides an important example of structuring Chinese engagement through a combination of industrial pragmatism and policy leverage. The country has deliberately used its resource endowments, large domestic market, and proactive industrial policy to shape foreign participation and bargain for jobs, skills, and knowledge transfer. Policies such as local content requirements, downstream industrial policies, and the integration of renewable energy targets (23% by 2025) have created a clear long-term signal for investors (Li, 2025).

Malaysia, too, offers an instructive case of policy coherence and regulatory clarity. Based on its National Energy Transition Roadmap (NETR), Malaysia targets a 70% renewable energy share by 2050. The government's approach balances openness to foreign capital with protective mechanisms to ensure local participation and technology absorption, as shown by strategic programs like the Large-Scale Solar Ministry of Energy Transition and Water Transformation (Malaysia) (PETRA) initiative, which mandating joint ventures with Malaysian partners (D&P Law, 2025). Moreover, specific incentives such as the Green Investment Tax Allowance and Green Income Tax Exemption have made Malaysia an attractive manufacturing base for major global solar companies. A well-defined licensing regime, environmental review process, and transparent industrial zoning have provided further assurance to foreign investors.

Compared to the abovementioned cases, a policy framework supporting localization of solar value chains remains underdeveloped and inconsistent in Pakistan, despite the country's close relationship with China and growing interest in green industrialization. China has been Pakistan's largest energy investor, committing nearly USD 68 billion between 2005 and 2024, with 74% of these investments under CPEC (Isaad and Sayed, 2025). However, due to regulatory instability, policy incoherence and inconsistency and financial in Pakistan, Chinese investments in Pakistan have witnessed a significant decline in recent years – 40% in 2024, following a 74% drop in 2023 (Nedopil, 2025). Through our consultations with Chinese businesses and financial institutions, regulatory instability, policy incoherence and inconsistency, and high credit risks have been identified as key factors discouraging Chinese investments in Pakistan.

Besides its policy framework, economic conditions in Pakistan seems also not ready to develop a local solar industry. To date, the country still lacks some basic capacity to manufacture solar PVs. Local firms such as Tesla PV, MaxPower, and Sunlife Solar operate low-capacity assembly lines dependent on fully imported materials. The country's fiscal limitations further constrain the possibility for the state to support the development of a domestic clean energy industry. In other words, local industrial base for potentially developing manufacturing capacity remains very weak. This issue is also linked to the lack of skilled workforce for a prospective cleantech sector. In the absence of integrated value chain development, the sector has yet to achieve meaningful scale, cost-efficiency, or technological depth.

Figure 7: Key Bottlenecks to Solar Localization in Pakistan

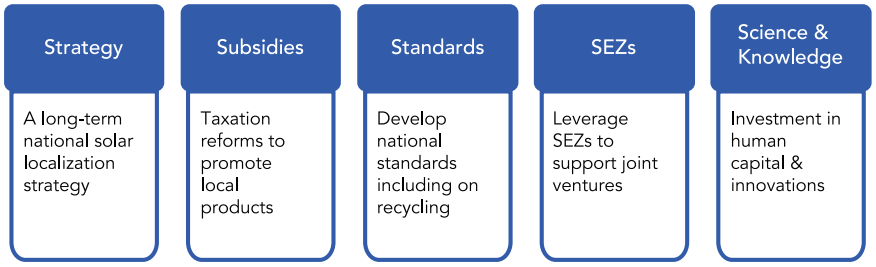


Based on the analysis of policy and economic conditions in the country, we have identified in Figure 7 key challenges to localization of solar value chains in Pakistan. Annex 2 provides more detailed analysis on these challenges and Annex 3 summarizes the case of a Chinese company's plan to localize solar manufacturing in Pakistan and related challenges.

3. A ROADMAP TO A LOCAL SOLAR INDUSTRY IN PAKISTAN

Our analysis shows that Pakistan's rapid solarization has provided the country with a unique opportunity of green industrialization, which would further accelerate sustainable and just energy transition. Supporting Pakistan's development of a local solar value chain can be also beneficial for major solar manufacturers from China. However, to realize the potential of localizing solar value chains, Pakistan must develop a coherent plan to guide the transition. Considering the country's political economy context, we propose a roadmap with five enablers as shown in Figure 8: Strategy, Subsidies, Standards, SEZs, Science and Knowledge ("5S"). This roadmap presents a holistic approach connecting national planning and systemic reforms to specific policies and actions. Below we identify possible actions under each enabler and related pathways to localizing solar value chains in Pakistan.

Figure 8: Five "S" Roadmap for Solar Localization in Pakistan



3.1 Strategy: Developing a national macro policy framework

First, a strong institutional coordination mechanism is critical for driving solar localization efforts in Pakistan. At present, overlapping mandates and fragmented responsibilities across ministries and agencies often delay policy implementation and discourage investor confidence. To ensure coherence between industrial, energy, and fiscal policies, there is an urgent need to establish a **Solar Industrialization Task Force** under the leadership of the Ministry of Industries and Production. The Task Force should coordinate actions across key federal and provincial entities including Ministry of Energy (Power Division), Engineering Development Board (EDO), Board of Investment (BOI), Federal Board of Revenue (FBR), Ministry of Climate Change and Environmental Coordination, and Ministry of Science and Technology, as well as provincial departments to streamline decision-making, monitor progress on localization targets, and align reforms across industrial, trade, and energy sectors.

Given the current economic situation in Pakistan, especially the upcoming IMF support package, the foremost action should be to align the efforts with a macro-fiscal policy environment. This means aligning the industrial and trade policies with reform measures that can enable the correct incentives, while

de-risking the overall investments. Enabling this direction necessitates the following specific steps:

The country needs have a long-term (e.g., 10-year) national policy framework to fast track solar manufacturing. This framework must clearly define eligible technologies, tax incentives, land access mechanisms, and investment protections. This must accompany its institutional arrangement under a well-coordinated approach between EDB, Special Investment Facilitation Council (SIFC), BOI, and also industry associations (e.g., Pakistan Solar Association), think tanks, and academia to ensure cross-sectoral alignment.

From a strategical point of view, the Task Force will need to define a phased localization model to maintain price competitiveness while supporting gradual capacity building. Any protective duties, if introduced, should be short-term, conditional, and time-bound, aimed at facilitating technology transfer and scaling rather than indefinite protection. This approach would avoid inefficiency that have occurred in other localization efforts, such as in the automobile industry, and ensure that localization enhances, rather than undermines, solar affordability and adoption.

More specifically, the country can first target Balance of System (BoS) components to build domestic capacity and competitiveness. With BoS elements, such as racking systems, inverters, and installation, now comprising up to 70% of total project costs, and demand growing by ~300 MW per month, localizing these segments can generate immediate industrial value and jobs, while laying the groundwork for deeper localization through development of skills, supply chains, and standards.

To generate viable demand for locally manufactured solar products, the Task Force can also develop tailored solar solutions that address Pakistan's specific energy challenges, such as solar-powered tube wells in Balochistan and rooftop systems for the 54% of protected consumers using less than 200 units/month. By enabling locally relevant, niche solutions, Pakistan can create new domestic markets and reduce its overreliance on competing directly with China's scale-driven manufacturing.

In the long-term, the localization strategy should be export-oriented to target small-scale, cost-competitive products demanded in developing markets across Asia and Africa, rather than replicating high-end global models. Accordingly, the Task Force should develop the plan to focus on producing small-scale and hybrid systems (200–250W panels, 2–6 kW inverters, 12–48 V batteries). Existing OEM arrangements by Pakistani brands in China can be gradually shifted to local facilities to build competence step by step.

3.2 Subsidies: Making trade and taxation reforms

Second, reforms are needed to develop financial support for localization of solar value chains in Pakistan. Draw on various policy instruments, the national government can rationalize the duties and taxes across the whole value chain, earmark funding from carbon taxes or climate finance to support its localization strategy, while aligning with international trade norms to ensure competitiveness. Achieving this balance can use the following targeted policy measures:

The Pakistan government can strategically reform tariffs of related products by reducing duties on key components while gradually increasing duties on fully assembled imported panels. Meanwhile, harmonizing sales tax across imported and domestic products will eliminate artificial price disparities and incentivize local assembly lines. A phased approach that aligns with industrial development milestones could be used. To preserve equity in solar energy access, the government can adopt tiered deployment mechanisms, for example, permitting imported panels for low-income or rural users while requiring locally manufactured panels for urban and industrial installations.

A blended finance vehicle, combining public funds with support from development partners, can be established to de-risk early-stage investments in solar ventures. However, this alone is not sufficient for long-term, large-scale projects, which require mobilizing private capital and market-driven investment by addressing structural barriers, ensuring contract enforcement, reducing input costs such as energy, streamlining land and tax regulations, and simplifying permitting and approval processes.

The government can also introduce local content requirements and public procurement targets for solar installations in government and utility-scale projects to create predictable demand for locally manufactured products. Such measures will stabilize the market and incentivize foreign investments, especially from Chinese solar manufacturers, in upstream manufacturing.

3.3 Standards: Standardizing industrial development

Moving beyond the existing model of low-value assembly operations would require a robust system enabling technology transfer in Pakistan and standardization is a key step to develop this system. Therefore, developing related standards for a local solar industry should be part of the country's solar industrialization roadmap, which can contain following actions:

Pakistan needs to establish an active national certification body for clean energy technologies under the EDB or Ministry of Science and Technology, aligned with international best practices. This agency should oversee conformity, inspection, and export licensing, creating confidence for both domestic consumers and international buyers. Developing national standards on clean energy will also facilitate the country's access to voluntary carbon markets.

In addition to technical standards on production, Pakistan should also take a life-cycle approach to incorporate end-of-life planning, including take-back obligations, e-waste collection logistics, and recycling plants. Developing regulatory frameworks on life-cycle management of solar energy components are thus necessary, and related policies should be codified in the National Electric Power Regulatory Authority's licensing and environmental review processes. Drawing lessons from the Sui Southern Gas Company's (SSGC) recycling of retired gas meters, where 1.5 million kg of aluminum was recovered, Pakistan can also establish a solar panel recycling industry to reclaim materials such as aluminum, glass, and silicon. This would require setting standards for collection, refurbishment, and recycling to create a circular economy in the solar sector.

The government needs to develop an ecosystem to support and monitor the implementation of solar-related standards. This ecosystem includes testing labs, certification bodies, and auditing firms. Public-private partnerships and joint ventures can be viable mechanisms to support the establishment of relevant entities.

3.4 Special economic zones (SEZs): Leveraging SEZs for green industrialization

To realize the potential of green industrialization, Pakistan needs a strategy to gradually scale up its production of related products. SEZs, which currently remain underutilized, provide unique opportunities to attract large-scale investments and develop strong base for a prospective solar industry in Pakistan. Specific opportunities include:

The Pakistani government can use existing SEZs, especially those under CPEC, to support joint ventures with Chinese solar manufacturing companies. Pakistan's solar localization strategy can target CPEC 2.0 to develop integrated solar clusters in related SEZs. Strategic use of land provision, equity-sharing, and utility concessions can further attract Chinese investors.

The government can use SEZs to promote entrepreneurship in the country's broader solar ecosystem, by supporting startups and SMEs working on solar software, inverters, storage, and tailored off-grid systems. Through a dedicated innovation and venture capital strategy, SEZs can provide crucial support to local businesses, which can play a key role in the localization of solar value chains.

3.5 Science & knowledge: Enabling human resource development for technology transfer

Given that Pakistan currently lacks local expertise in advancing solar manufacturing, technology transfer and domestic skill development must go hand-in-hand with investment promotion. Through CPEC 2.0's Innovation Corridor and the framework of the Belt and Road Science, Technology and Innovation Cooperation Action Plan, Pakistan and China have been deepening bilateral cooperation scientific and technological innovation. To support localization of solar value chains in Pakistan, several actions can be taken to develop a competent workforce over a medium to long-term:

Pakistan needs to invest in solar-focused education to support long-term industrial development. Curriculum reforms and new degree programs in clean energy and energy storage can be introduced. Meanwhile, research partnerships with Chinese manufacturers can be embedded under new and existing initiatives. University programs can also promote innovation clusters focusing on applied solar system design and efficiency improvements.

Multi-stakeholder initiatives can be developed to establish and strengthen joint research and development (R&D) such as through innovation labs or centres. Drawing on academia-industry nexus involving Chinese companies and research institutions, these initiatives can embed skill development in real industry settings.

To support the development of a strong local industry, the Pakistani government can also integrate the training of skills related to the manufacturing of solar PVs and related technologies into the curricula of national vocational training institutes (e.g., TEVTA and NAVTTC).

Finally, to track progress on localization, the proposed Task Force should develop time-bound key performance indicators, such as local production capacity, number of jobs created, technology transfer partnerships, and R&D spending. Annual progress reviews can help align fiscal and industrial policies with evolving market dynamics. In summary, localization of solar value chains requires a transition towards green industrialization with incremental steps based on long-term planning. With a dedicated task force to coordinate key stakeholders, the government of Pakistan can start this process with specific points of action. Our proposed roadmap can guide this transition, trigger path dependencies, and potentially accelerate industrial development.

4. CONCLUSION

Pakistan's growing solar uptake, paired with China's shifting overseas investment priorities, offers a timely win-win opportunity to localize solar manufacturing and strengthen clean energy resilience in Pakistan and also bring economic benefits to Chinese solar manufacturers and support Green BRI. To seize this opportunity, Pakistan needs a clear and coordinated strategy, as shown in our proposed 5S roadmap, to addresse current market imbalances, develop technical standards, support industrial relocation, and invest in human capital. With the right policy direction, solar localization can reduce import dependency, create skilled jobs, and improve Pakistan's position in regional clean energy supply chains. By analyzing the prospect of this green industrialization process, our goal is to identify possible policy interventions and trigger further reforms to support this transition.

Moving forward, Pakistan's solar industrialization should be guided by a shared vision that aligns national priorities with global sustainability agendas. Strengthening cooperation with China under CPEC 2.0, supported by development partners and the private sector, can translate this opportunity into tangible socio-economic, industrial and climate benefits. Ultimately, localizing the solar value chain is not only an industrial goal but also a pathway towards a clean and affordable energy system, economic resilience, and a climate-friendly future.

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Annex 1 Chinese solar companies operating in Pakistan			
Company name	**Localization Efforts**	**Partners**	**Latest engagement**
AIKO Solar	Local manufacturing and assembly plant in Punjab	Government of Punjab	Arrangements confirmed in 2024
LONGi Solar	JV for exploring opportunities and synergies in solar energy projects and capacity-building initiatives	Nimir Energy	MoU signed in 2023
C&D Clean Energy	Signed strategic cooperation agreements with prominent Pakistani partners to expand footprint in Pakistan	Multiple partners such as LONGi, Bahum, and Pantera Energy	Agreements signed in February 2025
NGLE	Committed $200 million to convert an existing thermal power plant in Muzaffargarh into a 300 MW solar power facility		Commitment made in 2024
JA Solar	Signed memoranda of understanding with three Pakistani companies to supply 600MW of n-type PV modules	Garibsons, SM Solar, Wasiq Traders	MOUs signed during Solar Pakistan 2024 to supply PV modules
Sinotec Solar	Proposed JV for local solar panel production	Ghani Glass	Commerce Ministry proposed JV in March 2024 to accelerate solar panel production in Pakistan.
ReneSola	Setting up a solar panel assembly facility at Port Qasim in Karachi	ACT Group	In advanced stages as of August 2024; plans include 750 MW production in Phase 1, with expansion to 2 GW.
Hanersun Technolo-gies	Partnered with local firm for 500 MW solar projects	My Energy	Collaboration announced in March 2024 with a $700 million investment for solar projects in Pakistan.

Annex 2 Key Bottlenecks to Solar Localization in Pakistan		
Category	**Sub-category**	**Description**
Policy & Regulatory Challenges	Absence of policy for solar PV localization	Although the Engineering Development Board under the Ministry of Industries and Production is in the process of developing the solar PV localization policy, it's been long overdue. Further concerns raised by the World Bank and IMF regarding fiscal impacts have further slowed progress, providing an uncertain environment for investors. Notably, firms such as ReneSola, which entered advanced discussions on local manufacturing, have expressed concern over these delays (see Annex 3 for details).
	Lack of unified coordination among key institutions	Lack of unified coordination among BOI, SEC, EDB, SIFC, PSA, and research institutions has led to disjointed efforts, deterring investors and slowing down solar manufacturing localization.
	Lack of standards	Pakistan lacks internationally recognized standards for solar modules, inverters, and batteries, impeding both domestic quality assurance and export competitiveness. In the absence of IEC/TUV-equivalent certification protocols, local products will remain barred from regulated foreign markets.
	Lifecycle Management	First-generation panels deployed over a decade ago are now reaching end-of-life, and many users are upgrading from older modules to newer, more efficient panels. Pakistan currently has no formal policy, institutional capacity, or commercial infrastructure for solar panel or battery recycling. The absence of end-of-life regulations, reverse logistics, and material recovery facilities poses environmental risks and regulatory exposure.
Economic & Market	Uncompetitive Local Manufacturing	Pakistan's fledgling solar manufacturing sector struggles to compete with low-cost Chinese imports. High component duties in earlier years raised production costs, pushing many local firms out of business. Even after levy removal, local production remains commercially unviable as seen in countries like Nigeria and India. Countries like the U.S. and India show that high tariffs and protectionism have not built globally competitive industries, burdening consumers with higher costs or making domestic products viable only in export markets.
	Market Alignment	Global trends focus on high-capacity panels (585W–700W) and large hybrid inverters, while Pakistan's demand is largely for smaller-scale systems, 200–250W panels, 2–6kW inverters, and 12–48V batteries for UPS-driven markets. Competing directly with global brands like Jinko, Trina, Huawei, or Sungrow in high-capacity products is impractical for Pakistan's nascent industry.
	Tax and Duties	High import duties on inverters and batteries increase the cost of off-grid solar systems, despite their higher return on investment compared to net metering setups.

	Affordability Divide	Solar adoption, like most new technologies, initially benefits higher-income users. Local manufacturing may further raise prices during its early phase, widening the affordability gap. Without targeted subsidies or financing support, localization could unintentionally limit access for lower-income or rural households.
	Fiscal Space	Under IMF program and conditions, fiscal considerations restrict public spending on industrial incentives and transition reforms supporting decentralized energy growth.
Human Resource	Advanced Skills Gap	Pakistan's workforce lacks sufficient specialized training in advanced solar technologies, which can limit the country's ability to move beyond basic assembly toward more complex, value-added manufacturing processes.
	Weak Academia-Industry Linkages	The solar sector suffers from limited collaboration between industry, academia, and government, which restricts the development of locally relevant innovations and the transfer of advanced solar production knowledge to the domestic industry. Despite emerging interest from global players to invest in R&D, such as Huawei's intent to establish a lab, there is no formalized mechanism to facilitate such partnerships or embed them within local universities.

Annex 3 The case of ReneSola's Localization Plans

ReneSola's Localization Plans

In 2024, ReneSola, a Tier-1 Chinese solar panel manufacturer, in collaboration with the ACT Group, entered advanced stages of setting up a solar panel assembly facility at Port Qasim, Karachi. The planned facility is structured in three phases: 750 MW of solar panel production in Phase 1, an additional 750 MW in Phase 2, and 2 GW of solar cell production in Phase 3, with a minimum of 50% output targeted for exports.

During high-level meetings with the Special Investment Facilitation Council (SIFC), Ministry of Industries, AEDB, Power Division, and other relevant agencies in May 2024, the company was assured that a comprehensive solar manufacturing policy would be introduced to support domestic solar manufacturing. Based on these assurances, the company accelerated its investment and project planning (Ghumman, 2024).

Although the company had anticipated the solar manufacturing policy's inclusion in the FY25 budget, it remains unannounced, even as the FY26 budget approaches, raising concerns over policy delays and lack of parity in incentives for local manufacturers.

ReneSola's CEO formally requested the elimination of sales tax and duties on solar panel components and manufacturing equipment. The company highlighted a structural disadvantage: imported solar panels are tax-exempt (0% customs duty and 0% sales tax), while local manufacturers face an 18% sales tax on most components, with no provision for input adjustment, making local production commercially unviable. Furthermore, imported manufacturing equipment incurs 18% sales tax, which becomes a non-adjustable cost given the exemption on finished goods.

The company proposed a clear long-term solar manufacturing policy, including:

- Rationalizing the sales tax and customs duty structure for components and equipment;
- Eliminating all taxes on the import of machinery used for assembling solar panels and manufacturing components; and
- Promoting the localization of solar components with a defined timeframe for establishing domestic manufacturing facilities.

According to company estimates, these reforms could reduce Pakistan's solar-related import bill by $300–500 million within five years and generate up to $300 million annually through domestic production and exports (Ghumman, 2024).

SGAIN

Sustainability Governance of China's Global Infrastructure Investments (SGAIN) is a long-term research initiative at the University of Bath, supported by the UKRI Future Leaders Fellowship. The project explores how China promotes green development through its overseas infrastructure investments and examines the environmental and social impacts of key projects across the Global South. By combining innovative research methods and international collaboration, SGAIN contributes to advancing global understanding of sustainable development and governance. The University of Bath is a leading UK institution recognized for excellence in research and teaching, with a strong focus on sustainability, policy, and international development.

SDPI

The Sustainable Development Policy Institute (SDPI) is an independent non-profit research organization based in Islamabad, Pakistan, established in 1992 following the recommendations of the Pakistan National Conservation Strategy. SDPI serves as a center of excellence for policy research, advocacy, and dialogue on sustainable development. Its work focuses on providing evidence-based policy advice, promoting the implementation of sustainable development practices, and strengthening civil society engagement. Through interdisciplinary research, capacity building, and collaboration with national and international partners, SDPI aims to advance peace, social justice, and environmental sustainability in Pakistan and beyond.

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