

An Overview of Solar Power Growth in Bangladesh: Technologies, Policy Frameworks, and Market Trends

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Abstract

Bangladesh has witnessed a substantial transformation in its energy landscape over the past two decades, marked by a rapid rise in the deployment of solar power technologies. Falling photovoltaic (PV) costs, favorable solar irradiance, and targeted institutional support have facilitated the adoption of solar home systems (SHS), rooftop PV installations, solar irrigation pumps, mini-grids, and utility-scale solar parks. As of 2023, grid-connected solar PV capacity reached 459 MW, with a significant portion added in fiscal year 2022–2023. Meanwhile, off-grid solar — especially through SHS — has provided electricity access to millions in rural areas, elevating the role of decentralized energy in national electrification efforts. Yet, despite this growth, solar remains a minor fraction of total installed capacity, and challenges such as land scarcity, grid integration, financing bottlenecks, maintenance shortcomings, and underutilized installations hinder its full potential. Drawing on policy documents, empirical studies, and recent deployment data, this paper provides a comprehensive synthesis of solar technologies in Bangladesh, analyses recent market trends, discusses institutional and regulatory frameworks, identifies key challenges, and offers strategic recommendations to scale up sustainable solar adoption.

Keywords

Solar energy, photovoltaic (PV), rooftop solar, solar home systems, Bangladesh, renewable energy policy, grid-connected solar, off-grid solar, energy transition.

1. Introduction

Bangladesh stands at a critical juncture in its energy transition journey. Rapid urbanization, population growth, rising living standards, and expanding industrial and commercial activity have driven a steep increase in electricity demand over the last two decades. (Chowdhury, P., 2025; Debnath, K. B., 2022) Historically, the country has relied heavily on natural gas, furnace oil, coal, and imported electricity to meet its growing needs. However, concerns about energy security, fossil-fuel import dependence, environmental degradation, and climate vulnerability have prompted policymakers to explore renewable alternatives. (Mahbub, T., 2024; Shuvo, A. H., 2025) Among these, solar energy emerges as a promising and viable option, given Bangladesh's high solar insolation, expansive rural

population living beyond reliable grid access, and decreasing costs of PV technology globally. (Hoque, S. M. N, 2013; Hoq, E.,2025).

Solar energy offers multiple advantages: it is clean, modular, and can be deployed in both off-grid and grid-connected modalities. For a country like Bangladesh — densely populated, land-constrained, but with diverse settlement patterns (urban high-density, peri-urban, rural, coastal, and island regions) — solar presents a flexible solution that can be tailored to different socio-economic and geographic contexts. (Alam, M. S.,2025; IDCOL & World Bank, 2021).

Over the past two decades, Bangladesh has embarked on a multi-pronged solar strategy. At the household level, the solar home system (SHS) program has delivered electricity to rural households previously unserved by the national grid. In urban and peri-urban areas, rooftop PV and grid-tied installations are slowly gaining ground. On the utility scale, the establishment of solar parks marks a growing recognition of solar's role in the national energy mix. Complementing these are applications in agriculture (solar irrigation pumps), community electrification (mini-grids), and emerging sectors such as cold storage, agro-processing, and commercial rooftop systems. (Alamgir, M.,2024; Md. Hoque et al.,2023; Shirke, A. 2023).

Despite these advances, solar energy's share in total installed capacity remains modest. According to the latest official data, solar PV accounts for 459 MW out of a total power generation capacity of roughly 24,911 MW ($\approx 1.8\%$). (Bangladesh Power Development Board,2024). This underscores the significant potential for expansion — but also highlights persistent structural, institutional, financial, and technical barriers. Recognizing these, the government has laid out long-term renewable energy goals and integrated solar into broader energy transition pathways. (Hossain, M, 2025; A K M Alamgir, 2024).

This paper aims to provide a comprehensive overview of the solar energy landscape in Bangladesh, synthesizing technological deployment, policy and institutional frameworks, market trends, challenges, and future opportunities. By documenting progress and identifying bottlenecks, the analysis provides guidance for policymakers, investors, researchers, and development stakeholders interested in leveraging solar as a cornerstone of Bangladesh's sustainable energy future.

2. Solar Technologies in Bangladesh: Landscape and Deployment

Solar deployment in Bangladesh spans multiple technologies and application domains. This section reviews the main solar technologies currently in use, their scale, deployment models, and relevance to energy access, commercial application, and grid-scale power.

2.1 Solar Home Systems (SHS)

The SHS program is arguably the most transformative solar initiative in Bangladesh's energy history. Through concerted institutional effort and financing support, the country rolled out millions of SHS units — making it among the largest off-grid solar electrification efforts globally. According to empirical estimates, the country has installed over 6 million SHS units, providing basic electricity services (lighting, mobile charging, small appliance power) to rural households previously unserved or underserved by the national grid. (Cabraal, A., 2021; Khan, T, 2017).

SHS units in Bangladesh typically comprise modest PV panels (often 50–100 Wp), a battery storage system, a charge controller, and basic appliances — LED lights, mobile chargers, small fans, or radios. The financing model has been central to the success: households make a small down payment, and the remainder is paid via microfinance institutions (MFIs) or concessional credit, often facilitated by a state-backed financier (e.g., Infrastructure Development Company Limited, IDCOL).

The social impact of the SHS program is significant. Access to electricity has improved livelihoods through easier lighting (enabling children to study), mobile charging (communication), and small-scale productive uses (e.g., powering sewing machines, small shops, or cold-storage for small vendors). Job creation has also been notable — installation, maintenance, and supply-chain roles have created thousands of employment opportunities. (Cabraal, A. 2021; Khan, T.,2017)

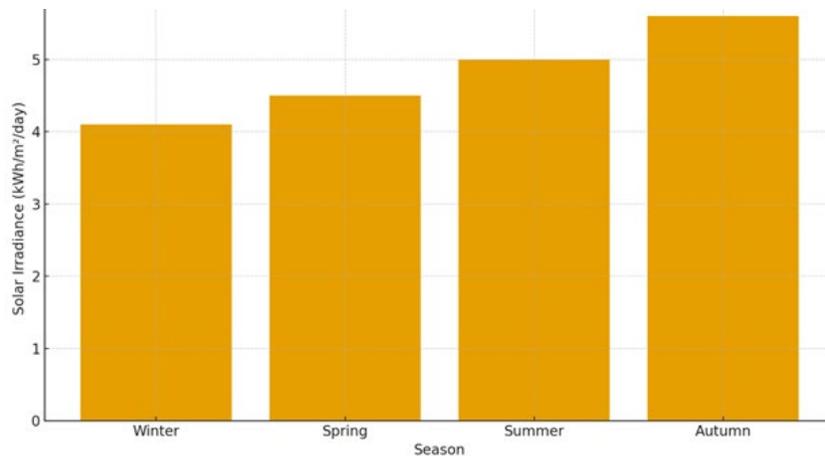


Figure 1. Seasonal Solar Irradiance in Bangladesh

However, the SHS program now faces new challenges. As the national grid expands, many rural areas previously off-grid are being electrified through grid extension. Consequently, demand for SHS has declined, leading to underutilization of existing systems (Figure 1). A recent analysis reports that only about 2 million out of the six million installed SHS systems remain actively used. Also, issues of maintenance, battery degradation, lack of after-sales service, and inadequate technical support have been cited as reasons for poor system reliability or abandonment. Given these dynamics, while SHS remains a landmark achievement for rural electrification, its role in the future energy mix may shift — from primary electrification source toward supplementary, backup, or hybrid (solar + grid) applications. This transition will require new policies, financing models, and service mechanisms to repurpose or integrate existing SHS assets efficiently. (Hossain, I., 2024; Parvez, S., 2024; Islam, M. R., 2020).

2.2 Rooftop Solar Photovoltaic (PV)

Rooftop PV offers a promising route for distributed solar generation in urban and peri-urban areas, especially for commercial, industrial, and large residential buildings. As of December 2023, the combined rooftop solar capacity under net-metered and non-net-metered systems reached approximately 162.7 MW — a modest share but signaling growing interest.

The policy and regulatory framework have played a role in this uptake. A rooftop-installation mandate for new buildings — especially industrial and commercial — along with the introduction of net-metering guidelines in 2018, provide incentives for building owners to invest in rooftop PV. Rooftop solar allows consumers to generate electricity during daylight, reduce their dependence on grid supply (or diesel backup), and, under net-metering, export excess electricity to the grid — enabling potential cost savings and income generation.

Rooftop PV's attractiveness is particularly high for energy-intensive commercial and industrial consumers facing frequent load-shedding or high daytime tariffs. As argued by recent analysis, rooftop solar can help stabilize electricity costs for such users and reduce pressure on the national utility. (Rahman, M., 2025).

Nevertheless, the rooftop solar market remains underdeveloped compared to its potential. Reasons include:

- **Underutilization:** Some building owners reportedly installed panels solely to satisfy regulatory or grid-connection requirements. Many of these systems are now inactive.
- **Quality and maintenance issues:** Low-quality panels, substandard installations, and lack of after-sales service contribute to poor performance and early system degradation.
- **Financing constraints:** While tariffs and financing options have improved, upfront costs remain significant. SMEs and smaller commercial users often lack access to affordable credit, limiting adoption.
- **Regulatory and administrative bottlenecks:** Although net-metering is allowed, lack of awareness, slow permitting, and insufficient technical support hinder rapid expansion.



(a) (b)
Figure 2. (a), (b) Solar Rooftop Project

Thus, while rooftop PV holds considerable promise, realizing this potential will require stronger enforcement of policies (Figure 2), improved financing mechanisms, quality assurance frameworks, and support for maintenance and after-sales services. (The Daily Star,2025).

2.3 Solar Irrigation Pumps and Agricultural Applications

Solar-powered irrigation pumps represent an interesting intersection of renewable energy deployment with agricultural modernization — a critical sector for Bangladesh’s economy. By enabling daytime water pumping directly from solar energy, these systems can replace diesel-powered pumps, cut fuel import costs, reduce greenhouse gas emissions, and lower irrigation expenses for farmers.

Several pilot and scaled-up implementations have been reported. According to governmental sources, the ambition includes installing thousands of solar irrigation pumps in the coming years as part of sustainable agriculture and renewable energy initiatives. (Alam, M. R. ,2022; Alam, M. R. 2024).

The benefits of solar irrigation are manifold: fewer diesel expenses, reduced operating costs, lower emissions, and an alignment of irrigation demand with peak solar generation (since irrigation often occurs during daylight). This makes solar pumps an economically and environmentally sensible choice.

Yet, challenges remain:

- **High upfront costs:** Even with subsidies or concessional financing, the initial investment can be prohibitive for smallholder farmers.
- **Land and water-resource constraints:** Larger solar arrays or ground-mounted panels may require land that is otherwise used for cultivation. In flood-prone or small-holding areas, this becomes a notable trade-off.
- **Maintenance and technical capacity:** Solar pump systems are more complex than simple SHS units; they demand periodic maintenance, technical know-how, and spare parts. In rural or remote areas, lack of after-sales services can impede reliable operation over time.
- **Institutional and financing barriers:** Large-scale rollouts require coordination between agriculture, energy, and financing sectors — a non-trivial institutional challenge.

Thus, while solar irrigation holds strong potential, realizing that potential at scale will require careful policy design, targeted subsidies or financing, capacity-building initiatives, and stakeholder coordination. (Limu, M. I. et al.,2025; Mitra, A. et al. 2023; Hossain, M. A., 2024).

2.4 Solar Mini-grids and Off-grid Community Systems

Solar mini-grids offer a practical solution for remote, geographically isolated, or sparsely populated regions — including islands, riverine chars, coastal zones, and remote rural areas — where grid extension is economically or logistically challenging. Mini-grids typically combine PV arrays, battery storage, a local distribution network, and often hybrid backup (diesel or generator) to ensure reliability.

Although publicly available data on the number and capacity of mini-grids in Bangladesh is limited, some studies and reports note several dozen mini-grid installations with cumulative capacities of a few megawatts. These community-level systems enable electrification of households, schools, community centers, and small businesses, offering improved livelihoods, education, health services, and economic activities in underserved areas.

The importance of mini-grids lies not only in electrification but also in resilience: in flood-prone, disaster-sensitive zones, decentralized energy systems can provide reliable power when the main grid is disrupted. Given Bangladesh's vulnerability to climatic events, such as cyclones and floods, solar mini-grids can play an important role in disaster-resilient infrastructure planning.

However, challenges include the high per-unit cost of small-scale systems, difficulty in financing, operation and maintenance burdens, tariff-setting complexities, and the need for community-level management. Without supportive institutional frameworks, capacity-building, subsidy mechanisms, or assistance, many mini-grid projects risk being unsustainable in the long run. (Mojumder, M. R. H et al., 2022; Aziz, S. et al., 2021; Akter, F., et al. 2023).

2.5 Utility-Scale Solar Parks

Utility-scale solar parks represent the most visible expression of solar's potential to contribute significantly to Bangladesh's national power supply. Recent years have seen major strides in this direction.

Most prominently, a 200 MW (AC) solar park built by Teesta Solar Limited in Sundarganj (Gaibandha district) was commissioned in early 2023 — currently the largest solar project in the country. This project, spread over roughly 243 hectares (600 acres), uses hundreds of thousands of solar panels and feeds electricity into the national grid. (Islam, M. R., 2024; Ali, M. F. 2023).

According to the latest annual report, total grid-connected solar PV capacity stands at 459 MW, of which 230 MW was added during the 2022–2023 fiscal year — signaling a sharp recent acceleration in utility-scale solar deployment. (Babu, R. M., 2024).

The growth in utility-scale solar underscores increasing investor confidence, falling PV costs, and stronger governmental commitment. In some recent tender rounds, the national utility has floated projects amounting to several gigawatts, reflecting ambitions to scale up solar contribution to national supply.

However, realizing large-scale solar's full potential requires overcoming substantial challenges:

- **Land scarcity:** Bangladesh is one of the most densely populated countries worldwide; acquiring hundreds of hectares for solar parks is both difficult and potentially contentious, due to competing agricultural, residential, or ecological land uses.
- **Grid integration constraints:** Many potential sites are distant from existing high-voltage substations — requiring new transmission infrastructure, which increases project cost and complexity.
- **Seasonal and diurnal variability:** Solar generation peaks during daytime and can be mismatched with demand. Without storage or complementary generation, solar parks might not always deliver useful power.
- **Financing and risk exposure:** Large upfront investments, currency risk, long-term PPA (power purchase agreement) negotiations, and concerns over returns can deter investors.
- **Operation & Maintenance (O&M):** Maintaining large-scale solar parks — cleaning panels, replacing inverters, ensuring grid-synchronization — demands technical capacity, ongoing investment, and institutional coordination.

Despite these challenges, utility-scale solar parks appear increasingly central to Bangladesh's energy transition strategy. If deployment continues at the recent pace, solar could emerge as a meaningful contributor to national supply, particularly during peak daytime demand and as part of diversified energy portfolios. (Chowdhury, P. et al. 2025; Hussain, M. N. et al. 2025)

3. Institutional & Policy Frameworks Supporting Solar Growth

The expansion of solar energy in Bangladesh has been shaped not solely by market forces or technological suitability, but significantly by institutional frameworks, policy incentives, and regulatory instruments. This section reviews the core policies, key institutions, and financing mechanisms enabling solar deployment.

3.1 National Renewable Energy Targets and Strategic Plans

The government of Bangladesh has articulated long-term ambitions for renewable energy integration. Under the recently adopted long-term energy planning frameworks (e.g., the revised master plan of 2023), solar and wind have been identified as priority sources, with aggressive capacity targets envisaged under a “net-zero” scenario pathway (Figure 3).

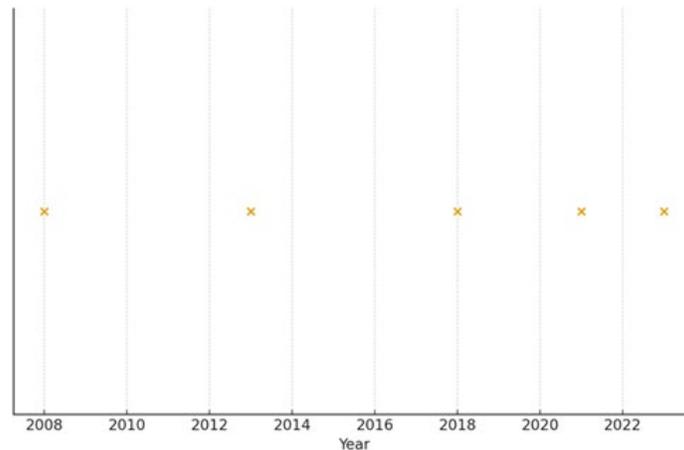


Figure 3. Major Solar policy Milestone in Bangladesh

According to the projections, solar and wind capacities are expected to expand by tens of gigawatts by mid-century, reflecting a commitment to shift away from fossil fuel dependence toward clean energy. These strategic plans signal a favorable long-term policy environment — crucial for attracting private investment, guiding infrastructure planning, and generating stakeholder confidence. (Akash, F. A. et al. 2024; Paul, P. K. et al. 2022; Sustainable and Renewable Energy Development Authority, 2025).

Furthermore, the ministry and relevant authorities have issued incentive frameworks — including tax/duty exemptions for solar equipment, concessional financing schemes, and streamlined approval processes — designed to lower entry barriers for developers and end-users.

3.2 Regulatory Instruments: Net-Metering and Rooftop Mandates

To encourage distributed solar adoption, especially rooftop PV, regulatory instruments have been introduced. A mandatory rooftop solar requirement for new industrial, commercial, and large residential buildings has been in place for several years. More importantly, the reintroduction of net-metering guidelines in 2018 has enabled rooftop solar owners to export surplus electricity to the national grid and potentially offset their electricity bills.

These measures reflect an institutional recognition of the value of distributed generation: reducing daytime demand on the grid, lowering peak-load stress, and offering cost savings to consumers. They also serve to expand the customer base for solar beyond rural or off-grid areas — to urban commercial, industrial, and institutional users.

However, implementation has been inconsistent. Reports highlight slow issuance of net-metering approvals, lack of awareness among building owners, insufficient dissemination of technical standards, and inadequate after-sales support infrastructure. Without robust regulatory enforcement and supportive infrastructure, the promise of rooftop solar remains only partially realized. (Sustainable and Renewable Energy Development Authority (SREDA), Power Division, Bangladesh, 2018; Sultana, M. 2023; Abdullah-Al-Mahub, M. 2023).

3.3 Role of Key Institutions and Financing Bodies

A few key institutions have played outsized roles in Bangladesh’s solar sector:

- **IDCOL (Infrastructure Development Company Limited):** As a non-banking financial institution, IDCOL has been pivotal in financing off-grid solar (SHS), solar irrigation, rooftop solar, and mini-grid

initiatives. Through concessional credit, microfinance linkages, and targeted programs, IDCOL has lowered financial barriers for households, small businesses, and rural users.

- **Bangladesh Power Development Board (BPDB):** As the primary national utility and off-taker for grid-connected solar, BPDB's role includes tendering solar parks, entering PPAs (power purchase agreements), and integrating solar generation into the broader grid. The 2023 commissioning of the 200 MW solar park was managed under BPDB's grid infrastructure and regulatory system.
- **Sustainable and Renewable Energy Development Authority (SREDA):** SREDA is mandated to formulate renewable energy policies, issue guidelines (including net-metering), and coordinate across governmental agencies to promote renewables. Its role is central to regulatory coherence, standards-setting, and long-term planning.
- **Financial institutions / banks:** Under national "green financing" frameworks, several banks provide concessional loans for solar projects (rooftop, irrigation, commercial), thereby reducing upfront cost barriers.

These institutional and regulatory architectures have been instrumental in enabling solar deployment. Nonetheless, gaps remain: enforcement is weak, after-sales service and quality assurance are limited, and long-term maintenance remains uncertain. For solar to scale sustainably, institutional strengthening — particularly in O&M, monitoring, and regulatory enforcement — is essential. (Ahmed, J. U. et al. 2020; Hossain, K. et al. 2025; World Bank & Government of Bangladesh, 2019).

4. Market Trends, Capacity Growth and Demand Dynamics

To assess solar's current role and future potential in Bangladesh's energy sector, it is essential to examine market trends, demand drivers, capacity growth trajectories, and evolving patterns of adoption. This section presents an integrated analysis of these elements, supported by recent data, studies, and observed developments.

4.1 Installed Capacity Trends

Available official data and industry reports indicate a steady increase in solar capacity over the last decade, with a major uptick in the last few years:

- As of fiscal year 2022–2023, grid-connected solar PV capacity reached 459 MW, including a 200 MW solar park commissioned at Sunamganj (Gaibandha) in early 2023.
- Rooftop solar, combining net-metered and non-net-metered systems, reached around 162.7 MW by late 2023.
- Off-grid solar systems — primarily SHS — number in the millions. Over 6 million SHS units have been installed over the past two decades, providing basic electricity services to large rural populations.
- Emerging off-grid solutions — such as mini-grids, solar irrigation pumps, and community-scale solar — are also being deployed, albeit at smaller aggregate capacities compared to SHS or grid-connected PV.

These capacity deployments reflect both the widespread uptake of distributed solar (SHS, rooftop) and growing momentum for utility-scale solar. However, solar still represents a small share of total generation capacity ($\approx 1.8\%$) under the national grid, indicating substantial headroom for future expansion. (Hussain, M. N. 2024, Hussain, M. N. et al. 2025, Ali, M. F. 2023)

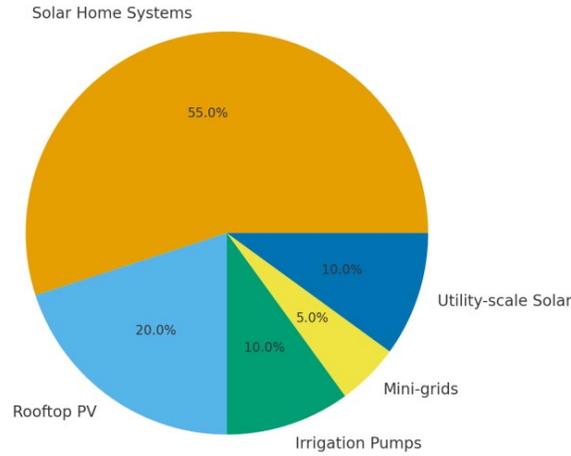


Figure 4. Distribution of Solar Technology in Bangladesh

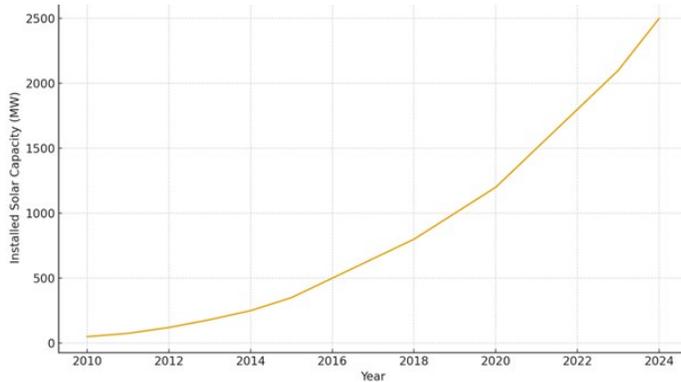


Figure 5. Solar Power Capacity Growth in Bangladesh

The cumulative capacity trend shows slow growth until roughly 2003–2025, followed by accelerating deployment — particularly after policy stabilization, financing expansion, and utility-scale projects.

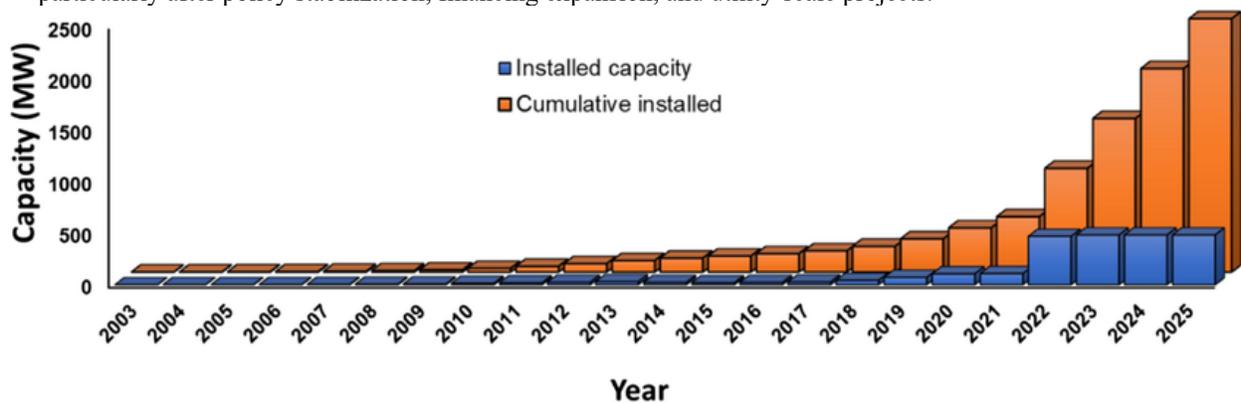


Figure 6. Cumulative Installed Solar Capacity (2005–2025)

The figure illustrates the growth of solar power capacity from 2005 to 2025, showing both annual installed capacity and cumulative installed capacity (Figure 4- Figure 6). From 2005 to around 2015, solar development remained minimal with very small increases each year. After 2016, installations began to rise gradually, indicating growing interest and investment in solar energy. A significant acceleration is observed from 2020 onward, where both yearly

installations and the cumulative total increase sharply. By 2023–2025, the expansion becomes rapid, reflecting large-scale solar projects and a strong shift toward renewable energy adoption. Overall, the graph highlights a slow early phase followed by a steep growth trajectory in solar capacity in recent years.

4.2 Drivers of Demand and Adoption

Multiple factors underpin the growing demand for solar energy in Bangladesh:

- **Rising electricity demand:** Urbanization, industrial growth, and increasing household consumption drive a steady rise in demand, especially for reliable electricity.
- **High and volatile fuel costs:** With fossil-fuel-based generation and diesel backup being costly and dependent on global price fluctuations, solar offers a stable, fuel-free alternative.
- **Import-substitution and foreign exchange conservation:** By reducing fuel imports, solar helps ease foreign exchange pressures and enhances national energy security.
- **Improved finance and incentives:** Concessional loans, tax/duty exemptions, and net-metering incentives lower financial barriers, making solar economically more attractive.
- **Environmental and climate considerations:** Growing awareness of climate change, air pollution, and long-term sustainability makes solar a socially and environmentally desirable option.
- **Institutional push and policy signals:** Government targets, regulatory mandates, and institutional backing signal long-term commitment — encouraging private investment and consumer confidence.

As a result of these factors, both distributed and utility-scale solar have become more viable and appealing across diverse user segments — rural households, commercial/industrial customers, farmers, and investors. (Institute for Energy Economics and Financial Analysis (IEEFA). 2023; The Business Standard. 2023)

4.3 Emerging Market Trends & Innovations

Recent years have seen several notable trends and innovations shaping the trajectory of solar adoption in Bangladesh (Figure 7):

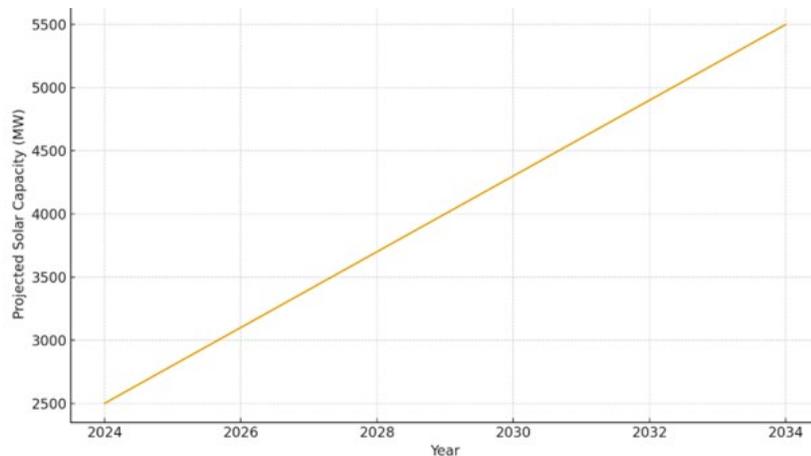


Figure 7. Solar Market Projection for Bangladesh (2024-2034)

- **Rapid acceleration of utility-scale deployment:** The commissioning of the 200 MW solar park and rounding up of multiple large-scale tenders signal a shift in emphasis toward grid-connected solar at scale.

- **Diversification beyond lighting and basic load:** Solar is increasingly applied in productive uses — irrigation, agro-processing, cold storage, small enterprises — broadening its socioeconomic impact.
- **Rooftop and distributed solar interest among commercial/industrial users:** Firms, particularly energy-intensive industries, are exploring rooftop PV to reduce electricity costs and avoid dependence on diesel backup.
- **Emerging policy and financing models — e.g., third-party OPEX models, green financing:** Rather than requiring end-users to own systems, built-operate-transfer (BOT) or lease-based models are starting to take shape, lowering upfront costs for adopters and attracting investors.
- **Technical and GIS-based planning for optimal deployment:** Recent studies use high-resolution GIS data to assess rooftop potential, floating PV options, and land-use constraints, indicating large latent capacity (e.g., tens of GW) if properly harnessed. These trends suggest that solar adoption in Bangladesh is gradually shifting from small-scale, off-grid electrification toward integrated, large-scale, grid-connected, and diversified solar ecosystems — bridging energy access, industrial demand, agricultural needs, and national energy supply. (Riad Mollik Babu et al. 2025; Bogotá, P. 2023;

5. Challenges, Constraints, and Risks

Despite encouraging trends, the expansion of solar energy in Bangladesh faces several structural, technical, institutional, and economic challenges that can hinder long-term sustainability and growth. Recognizing and addressing these is crucial for effective solar policy and investment.

5.1 Technical and Operational Challenges

- **Intermittency and variability:** Solar generation is inherently variable — diurnal and seasonal — which can complicate integration into the grid without storage or complementary generation.
- **Grid integration and transmission infrastructure constraints:** Many potential solar park sites are distant from high-voltage substations; integrating large solar capacities will require substantial grid upgrades and investments in transmission, substations, and distribution networks.
- **Quality assurance and maintenance:** There have been widespread reports of poor-quality panels, substandard installation, and lack of after-sales service — particularly in rooftop and off-grid systems. Over time, this reduces system performance, undermines investor and user confidence, and leads to early abandonment.
- **Operation & Maintenance (O&M) capacity gap:** A limited pool of trained technicians, spare-part shortages, and lack of institutionalised maintenance systems threaten long-term viability — especially for mini-grids and utility-scale parks. (Siddique, A. H. 2021; “Solar PV based power generation in Bangladesh: Prospect and Challenges. 2025; Afridi, Y. S. 2021)

5.2 Land Use, Environmental & Social Constraints

- **Land scarcity and land-use competition:** Bangladesh is one of the most densely populated countries globally. Acquiring large contiguous tracts of land for solar parks often competes with agriculture, habitation, ecological zones (wetlands, floodplains), or other land uses — creating social, environmental, and legal complexity.
- **Ecological impact and displacement risk:** Large-scale solar parks may disrupt existing ecosystems (wetlands, flood-prone areas, forests), affect biodiversity, or require resettlement.
- **Water-land conflict for solar irrigation / agro-applications:** Solar irrigation systems require land (for panels) and water for pumps; in small landholding and flood-prone contexts, balancing agricultural production, water access, and solar infrastructure becomes challenging.(Mitra, A., Alam. 2022; Sunny, F. A. 2022).

5.3 Financial, Institutional and Regulatory Barriers

- **Upfront capital costs and financing risk:** Even with concessional financing, many potential adopters (especially small businesses, farmers, rural households) face difficulty mobilizing initial capital. Long

payback periods, currency risk, uncertain revenues (for utility-scale), and return-on-investment concerns deter many investors.

- **Policy inconsistency and regulatory uncertainty:** While policies like net-metering and rooftop mandates exist, enforcement is weak, administrative delays are common, and regulatory procedures (permits, approvals, PPAs) are often cumbersome — discouraging potential adopters and investors.
- **Under-utilization of existing installations:** Reports show that a significant proportion of rooftop solar systems installed earlier (sometimes to fulfill regulatory requirements) are now idle; this suggests inefficient resource use and potential public funds wastage.
- **Lack of local manufacturing and value-chain development:** Bangladesh remains largely dependent on imported PV modules, inverters, batteries, and other components — making the sector vulnerable to global supply chain disruptions, currency fluctuations, and import restrictions. Create limited domestic economic value addition. (Islam, M. S. 2022; Alamgir, A. K. M. 2024).

5.4 Data, Monitoring, and Institutional Capacity Gaps

- **Inadequate monitoring and performance tracking:** There is no comprehensive, publicly accessible registry tracking solar installations (rooftop, off-grid, mini-grid) by status, performance, maintenance history, or utilization. This impedes evaluation, policy planning, maintenance, and decision-making.
- **Limited technical and human capacity for O&M:** The pool of trained solar technicians, certified installers, and maintenance service providers is inadequate to support large-scale deployment, especially in rural or remote regions.
- **Coordination challenges among stakeholders:** Effective solar deployment (especially utility-scale or irrigation-based) requires coordination among multiple agencies — energy, agriculture, water, land administration, finance, local government. Institutional siloing often impedes smooth implementation.

Taken together, these challenges highlight that while solar in Bangladesh has made commendable progress, scaling it sustainably and equitably will require systemic reforms — in policy, regulatory enforcement, financing, technical capacity, land-use planning, and institutional coordination. (IDCOL. 2022; Islam, M. R., Rahman. 2021).

6. Opportunities & Strategic Recommendations

Despite the challenges outlined, the potential for solar energy to play a transformative role in Bangladesh remains significant — if guided by strategic, integrated, and inclusive policies and actions. Below are key opportunities and recommendations.

6.1 Leverage Declining Technology Costs and High Solar Potential

Global PV module and inverter prices continue to decline, making solar increasingly cost-competitive with conventional generation — especially when environmental and external cost savings are considered. Given Bangladesh's high solar insolation (averaging around 5 kWh/m²/day) and favorable irradiance across much of the country, solar power generation becomes an economically sensible and scalable option.

Policymakers should capitalize on this by setting ambitious but realistic solar capacity targets (both distributed and utility-scale), backed by clear roadmaps, supportive financing, and enabling regulations. (International Renewable Energy Agency (IRENA). 2023; World Bank. 2020).

6.2 Expand Rooftop & Distributed Solar via Innovative Business Models

To overcome upfront cost and financing barriers, the government and private sector can promote third-party financing models: lease-based or build–operate–transfer (BOT) arrangements, where a developer installs and maintains the system, and consumers pay for electricity via long-term contracts. This reduces the burden on end-users and spreads investment risks. Green financing instruments and subsidized loans should be expanded, especially targeting SMEs, small businesses, and commercial users.

Policies should also enforce quality assurance, warranty/guarantee requirements, and after-sales service obligations — to avoid repeat errors of underperforming or abandoned rooftop systems. (IRENA. 2020; Narayan, P. K. 2022).

6.3 Strategic Utility-Scale Solar Deployment and Land Use Planning

Given land scarcity, solar parks should prioritize non-agricultural, underutilized lands: degraded lands, wastelands, government-owned lands (e.g., water authority, railways, flood-protected zones), or industrial zones — to avoid

competition with agriculture or habitation. Utility-scale parks should be planned in conjunction with grid-expansion plans: locate them near existing or planned high-voltage substations to minimize transmission costs and grid-integration complexity.

Environmental impact assessments, community consultation, and land-use planning should be mandatory to ensure sustainable and socially acceptable deployment. (Sunny, F. A., et al. 2022).

6.4 Strengthen Institutional Capacity, O&M Systems, and Local Value Chains

- Establish a national registry/database for all solar installations (rooftop, off-grid, grid-connected, mini-grids) including their status, performance data, maintenance history, and owner information — supporting monitoring, evaluation, and planning.
- Develop accredited training and certification programs for solar installers, technicians, and maintenance providers — elevating technical capacity and ensuring long-term reliability.
- Promote domestic manufacturing or assembly of solar components, inverters, battery systems — to reduce import dependency, foster local job creation, and build supply chain resilience.
- Implement mandatory quality standards and periodic inspections for installations, combined with warranty enforcement and after-sales maintenance obligations.

6.5 Integrate Solar with Social and Economic Development Policies

Solar deployment should not be limited to electrification and industrial uses — it should be aligned with agricultural modernization (solar irrigation, cold storage), rural livelihoods (small enterprises, agro-processing), disaster resilience (mini-grids in disaster-prone zones), and climate adaptation strategies.

By embedding solar in broader development and resilience planning, Bangladesh can maximize socio-economic returns, generate green jobs, reduce emissions, and strengthen energy security — contributing to sustainable development goals.

7. Conclusion

Over the past two decades, Bangladesh has made notable strides in adopting solar energy — from grassroots electrification via solar home systems to large-scale solar parks feeding the national grid. The country's solar journey offers a valuable model of how distributed solar, institutional support, financing innovations, and policy incentives can expand energy access and contribute to national energy transition goals. At present, solar in Bangladesh remains a small fraction of total generation capacity. But recent acceleration — particularly in utility-scale deployment — suggests that solar could emerge as a significant component of the national energy mix, especially if supported by robust policy, financing, technical capacity, and institutional frameworks.

Nevertheless, obstacles remain land scarcity, grid integration challenges, financial and institutional bottlenecks, maintenance capacity gaps, and underutilisation of installations. To realize the full potential of solar, Bangladesh needs a strategic, integrated approach: combining ambitious targets, enabling policies, financing innovation, quality assurance, and linkages with socio-economic development.

If these measures are implemented effectively, solar energy can evolve from a niche solution for rural electrification to a core pillar of Bangladesh's sustainable, resilient, and low-carbon energy future.

8. Recommendations

Bangladesh can accelerate sustainable solar energy growth by strengthening policy enforcement, improving regulatory consistency, and expanding financing mechanisms such as third-party ownership and concessional green loans to reduce upfront costs for rooftop and distributed systems. Ensuring quality installation, establishing a national registry, and enhancing technical capacity for maintenance are essential to prevent system underperformance and abandonment. Utility-scale solar development should focus on non-agricultural or underutilized lands and be coordinated with grid-expansion plans to ease integration challenges. Off-grid solutions — including solar irrigation pumps and mini-grids — require stronger maintenance frameworks and context-appropriate deployment models to remain effective. Finally, promoting local manufacturing and integrating solar deployment with agricultural modernization, rural livelihoods, and climate-resilience strategies will help maximize socio-economic benefits and support Bangladesh's broader energy-transition goals.

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