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Solar Energy in Bangladesh: A Comprehensive Review of Current Status & Opportunities

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Abstract

Bangladesh, with its abundant sunlight and strategic geographic location, holds significant potential for solar energy to address its growing energy demands. This review explores the country's advancements in solar technologies, including solar parks, rooftop systems, solar home systems, solar-powered telecom BTS, solar streetlights, charging stations, mini-grids, and solar irrigation. Together, these systems contribute 988.59 MW of electricity, with 612.30 MW integrated into the national grid and 376.28 MW serving off-grid communities, enhancing rural electrification and socio-economic development. Despite these achievements, challenges such as inadequate infrastructure, financing constraints, and policy gaps limit broader adoption. This study offers a detailed review of Bangladesh's solar energy landscape, with a focus on major projects. It analyzes the current capacity, implementation challenges, and policy gaps to identify key barriers to expansion and provides targeted recommendations to facilitate Bangladesh's transition to a sustainable and energy-secure future.

Keywords: Renewable energy, Solar Energy, Solar Projects, Bangladesh.

1. Introduction

Bangladesh has great potential to use solar energy to satisfy its rising electrical needs. The government has established lofty objectives to produce solar electricity and is now executing many projects around the country. The country produces a significant amount of solar power which makes it the country's most prominent renewable energy source. Different types of projects are now running for harnessing solar power which is shown in Table 1. The Solar Home System (SHS) with 263.793 MWp are the main source [1]. Decentralized systems provide clean energy to isolated residences, especially those not linked to the national grid. SHS projects success shows their importance in rural electricity access and livelihoods. Another major source is net metering rooftop solar (101.466 MWp). With rooftop solar panels, commercial and residential buildings may produce their own power and sell excess to the grid. This minimizes dependency on conventional electricity and encourages rooftop solar investment. Solar irrigation projects produce 57.359 MWp of electricity from 3381 pumps. This novel method empowers farmers by supplying clean, consistent irrigation water. This switch from diesel-powered pumps reduces greenhouse gas emissions and farmer operating expenses, making agriculture more sustainable. Another testament to Bangladesh's clean energy ambition is solar street lighting which uses 17.104 MWp of electricity. They brighten streets, increase public safety, especially at night, and relieve the burden on the national grid by removing fossil fuel-powered street lighting. Large solar parks produce 461 MWp, but growth may be difficult because of high investment cost [2]. This study provides a detailed review of Bangladesh's solar energy landscape, focusing on major projects like solar parks, rooftop systems, and solar irrigation. By analyzing current capacity, implementation challenges, and policy gaps, it identifies key barriers to expansion and offers targeted recommendations. This paper contributes actionable insights to support Bangladesh's progress toward energy security and sustainability goals.

2. Solar Energy Potential in Bangladesh

Bangladesh has significant potential for solar energy due to its abundant sunshine. Bangladesh receives an average daily solar radiation of 4-6.08 $KWhm^{-2}day^{-1}$ [3]. The minimum amount of solar intensity is available from December to January, and the average intensity is available from June to November [3]. The maximum amount of solar intensity is available from March to May, shown in Fig. 1 (a) and Fig. 1 (b) represents the photovoltaic power potential of different regions in the country. The government aims to tap into this by generating a large portion of its electricity from solar [3].

Table 1. Technology wise solar power generation in Bangladesh [2].

Technology	Quantity	On-grid (MWp)	Off-grid (MWp)	Total (MWp)
Solar Home System	6037689	0	263.793	263.793
Solar Street Light	297691	0	17.104	17.104
Solar Irrigation	3381	2.742	54.616	57.359
Net Metering Rooftop Solar	2243	101.466	0	101.466
Solar Powered Telecom BTS	1933	0	8.06	8.06
Rooftop Solar Except NEM	234	49.708	27.766	77.474
Solar Drinking Water System	82	0	0.095	0.095
Solar Mini grid	28	0	5.805	5.805
Solar Charging Station	15	0.016	0.275	0.291
Solar Park	10	461	0	461
Solar Nano grid	2	0	0.001	0.001
Total	6343308	614.932	377.515	992.448

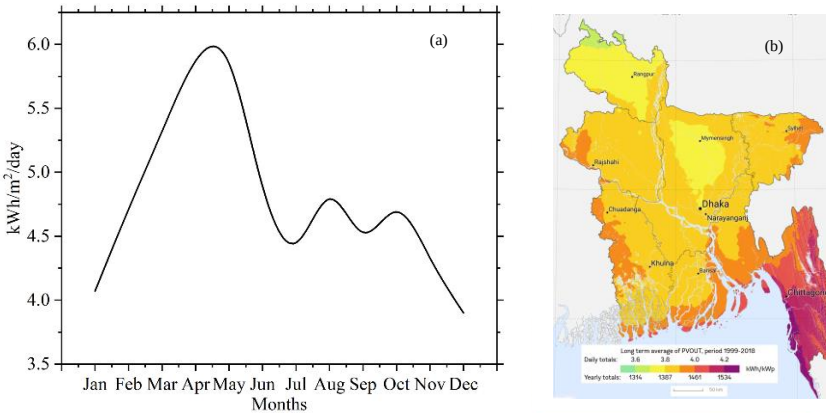


Fig. 1. (a) Average solar radiation [4] and (b) PV power potential of Bangladesh [5].

3. Solar PV Projects in Bangladesh

Bangladesh has advanced in solar photovoltaic (PV) technology to meet energy demands and boost rural electrification. Projects like solar parks, rooftop systems, and solar irrigation are transforming the renewable energy landscape. Despite challenges, these initiatives drive clean energy adoption and socio-economic growth. The following sections provide brief descriptions of various solar PV projects currently being implemented.

3.1 Solar Park

A photovoltaic power station or solar park is a large-scale grid-connected installation designed to produce commercial electricity. The schematic diagram of solar park is shown in Fig. 2. Unlike building-mounted and decentralized solar power systems, utility-scale solar power systems offer electricity at the utility level rather than to local customers or consumers. Modules are organized together to produce a substantial quantity of power, creating an array. These are strategically placed over an open field to maximize solar power collection. Teesta solar park with a capacity of 200 MWp is the largest solar power project situated in Gaibandha Sundarganj. Over 500,000 solar modules cover 600 acres of land in the project. The facility is expected to neutralize 375 billion tons of CO_2 throughout its lifespan. Bangladesh has established 67 solar installations. Ten projects are complete, eight are being executed, 42 are under planning. All the running solar park projects are shown in Fig. 3 [6].

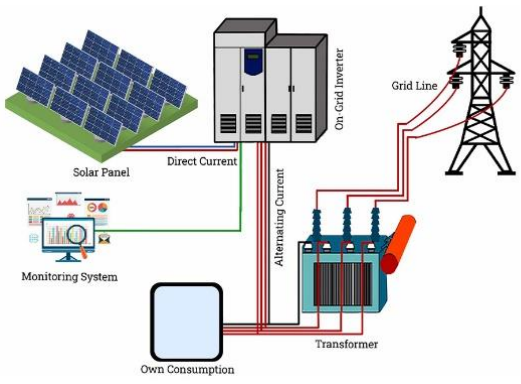


Fig. 2. Schematic diagram of solar park

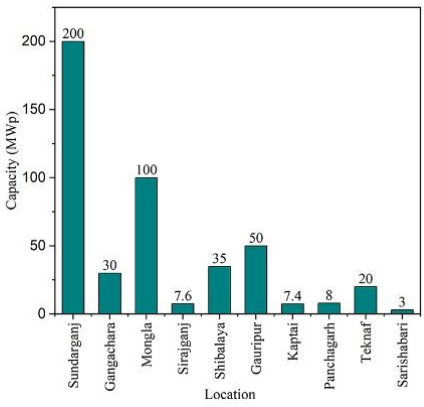


Fig. 3. Solar Park projects in Bangladesh.

3.2 Solar Irrigation

Solar irrigation employs solar energy to power water pumps for agricultural irrigation. It's cost-effective, energy-efficient, and eco-friendly, particularly beneficial in rural areas with limited electricity access, enhancing agricultural productivity and sustainability [7]. Fig. 4 shows the schematic diagram of the solar irrigation pump. The solar irrigation business in Bangladesh is expected to see substantial expansion, as the Infrastructure Development Company Limited (IDCOL) has set ambitious goals to deploy 50,000 solar irrigation pumps (SIPs) by 2027. This growth has the potential to transform agriculture, reducing dependence on costly and environmentally harmful diesel pumps. Solar irrigation is a financially efficient option that reduces operating expenses for farmers while limiting the release of greenhouse gases. The existing presence of more than 1,900 SIPs serves as evidence for the feasibility and future prosperity of this technology. Fig. 8 shows the total capacity (MWp) and the quantity of pumps installed by different organizations in Bangladesh [2] [8].

3.3 Solar Powered Telecom BTS

A Solar-Powered Telecom BTS (Base Transceiver Station) is a telecommunications infrastructure that utilizes solar energy to power its operations, reducing reliance on traditional grid electricity and minimizing environmental impact [9]. Fig. 5 shows the schematic diagram of a typical BTS tower. In contemporary times, the mobile technology network has become an essential need for us. Furthermore, its use has seen a significant surge in the field of communication and network technology. In 2022, the International Telecommunication Union (ITU) reported a global total of over 8.58 billion active mobile subscribers. As of February 2024, the total number of mobile phone users has reached 191.38 million in Bangladesh [10]. To accommodate a large number of users, the network provider must establish a Base Transceiver Station (BTS) as a core component of the cellular network. Approximately 45,674 BTS towers in Bangladesh required a substantial quantity of power [10]. By implementing solar energy in these regions, it is feasible to save power and provide high-quality communications services in distant places where the absence of electricity hinders the availability of mobile networks. In approximately 1933, solar-powered BTS towers in Bangladesh are conserving 8.06 MW of energy. Fig 10 shows the running solar powered telecom BTS projects in Bangladesh till now 2024 [2] [10].

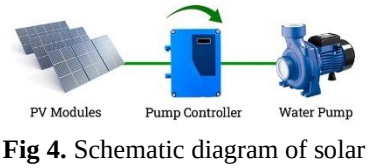


Fig 4. Schematic diagram of solar irrigation pump

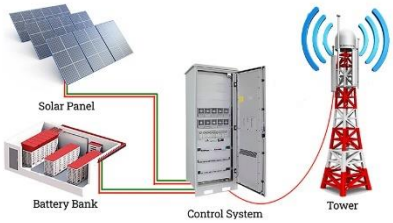


Fig. 5. Schematic diagram of typical solar-powered telecom BTS.

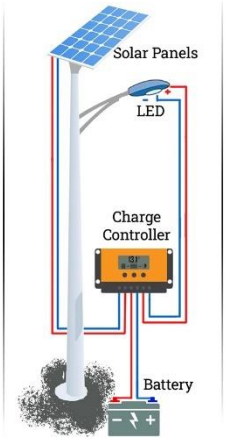


Fig. 6. Schematic diagram of solar Streetlight

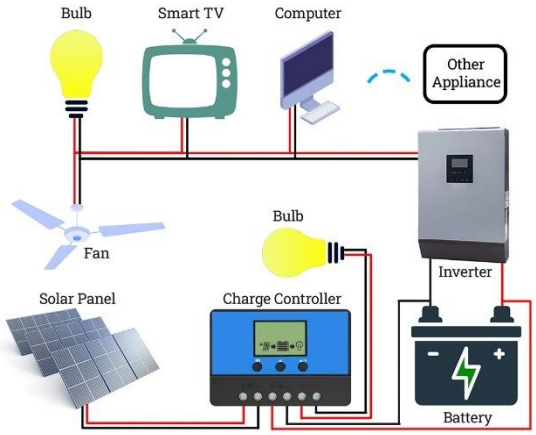


Fig. 7. Schematic diagram of solar home system

3.4 Solar Streetlight

Solar streetlights are lighting systems powered by solar panels, storing energy in batteries for illumination during the night. They are cost-effective, eco-friendly, and ideal for areas with limited access to electricity [11]. Fig. 6 shows the schematic diagram solar streetlight. An uninterrupted power supply must be maintained on the busy roads, especially at night in the city. These require a lot of electricity. It is possible to save a lot of electricity from the country's national grid by lighting streetlights using solar energy. At the same time, the roads in remote areas where grid electricity has not yet been reached can be illuminated through street lighting. This will reduce the suffering of the people as well as reduce the pressure on the national grid. For this purpose, the Bangladesh government is working on a street lighting project. Under this, streetlights have been installed across the country through various agencies. A significant number of streetlights have been installed through BPDB, NESCO, MoCHTA, and MoDMR agencies, which is shown in Fig. 9. It is possible to save a total of 17.065 MW of electricity from the national grid [2]. According to the growing demand of the country, more investment in this infrastructure is required.

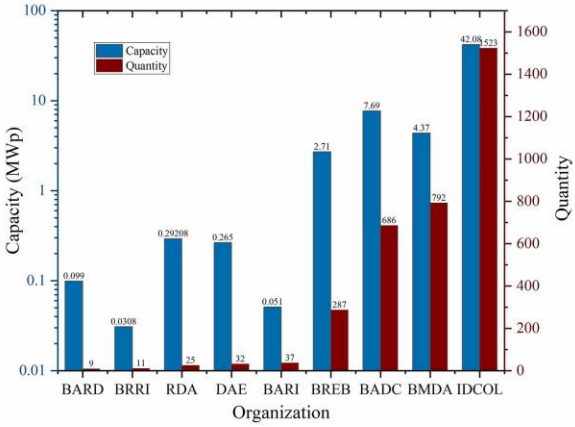


Fig. 8. Statistics of solar irrigation projects developed by different organization.

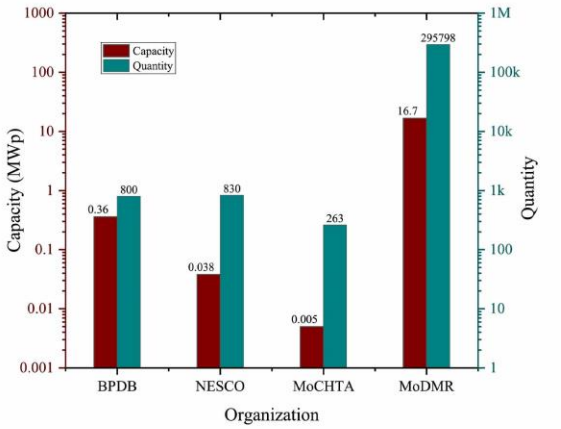


Fig. 9. Statistics of installed solar streetlight by different organization

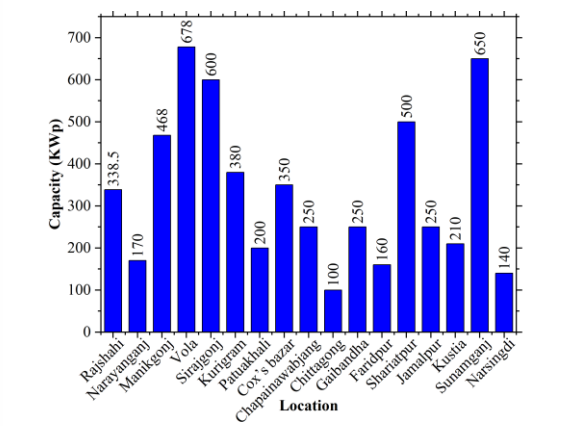


Fig. 10. Statistics of solar powered telecom BTS projects in Bangladesh.

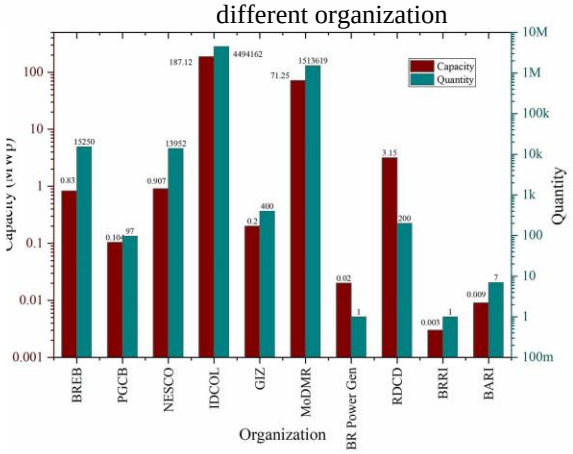


Fig. 11. Statistics of solar home systems projects in Bangladesh

3.5 Solar Home Systems

Solar home systems (SHS) are independent photovoltaic systems that provide isolated off-grid homes with an affordable way to provide electricity for lights and appliances [12]. The schematic diagram of SHS is shown in Fig. 7. SHS can meet a household's energy demand while also meeting basic power demands in rural locations that are not grid-connected. IDCOL started promoting Solar Home Systems (SHSs) in 2003 with the support of the World Bank. Under the project of IDCOL, 6 million solar home systems have already been set up in the rural areas of Bangladesh [13]. Through this, about 13 million people can fulfill their electricity demand. Every year, more than 65000 new SHS are being established. About 70000 people are involved in this project in many ways. SHS produces 263.793 MW of total electricity, which is off grid [2]. Fig. 11 shows the quantity and capacity of SHS by different organization in Bangladesh.

3.6 Rooftop Solar

Rooftop solar is a photovoltaic (PV) system that has its solar panels installed on the roof of a building, whether it be residential or commercial. These systems are made to capture sunlight and transform it into electrical energy, giving the building a renewable and sustainable source of energy. Solar rooftops are divided into two categories: "Net metering rooftop solar" shown in Fig. 12 (a)" and rooftop solar (excluding net metering)" shown in Fig. 12 (b). In a "net metering rooftop solar" system, the prosumer, who generates and consumes electricity, initially uses the generated electricity for personal use. Any surplus electricity is then fed into the grid and sold to nearby customers or utility providers. Net energy metering (NEM) uses a bidirectional meter to measure power flow in two directions: from the grid to the customer (import) and from the customer to the grid (export) [14]. Fig. 13 shows the statistics of installed net metering systems by different organization in Bangladesh. Almost 101.466 MW and 77.474 MW of power are produced by Rooftop solar with NEM and without NEM respectively [2].

3.7 Solar mini grid

A mini grid refers to a collection of tiny electricity producers and perhaps energy storage devices that are linked to a distribution network. This network delivers power to a small, localized group of consumers and functions independently from the national transmission grid. Their sizes vary from a few kilowatts to 10 megawatts. Smaller

mini-grids are sometimes called micro grids or nano-grids. Fig. 14 shows the schematic diagram of solar mini grid system.

Table 2. System capacity differences in between mini grid, micro grid, nano grid and pico grid [15].

Systems Capacity (SC)	System Type
5 MW > SC ≥ 100 kW	Mini Grid
100 kW > SC ≥ 10 kW	Micro Grid
10 kW > SC ≥ 3 kW	Nano Grid
3 kW > SC ≥ 500 W	Pico Grid

The country has 28 solar mini grids with a total capacity of 5.805 MW. Within these, IDCOL has established 26 mini grids using the commercial model, Bangladesh Power Development Board has erected one using Climate Change Trust Fund funding, and NESCO has funded another. IDCOL has financed 26 mini-grids, 19 of which are for Bangladesh Rural Electrification Board (BREB), three for Bangladesh Power Development Board (BPDB), three for West Zone Power Distribution Company (WZPDCL), and one for Northern Electricity Supply Company [2].

3.8 Solar charging station

A solar charging station harnesses solar energy to charge electronic devices like smartphones or electric vehicles, providing eco-friendly and renewable power for sustainable energy consumption. The schematic diagram of solar charging stations is shown in Fig. 15. Approximately 47% of the country's overall petroleum products are allocated for use in the transportation industry. Furthermore, the country's overall population is steadily growing, which poses a costly challenge in satisfying the transportation needs of this expanding population. The transportation industry in Bangladesh is a significant contributor to greenhouse gas (GHG) emissions. Electric vehicles (EVs) are crucial in this scenario. Consequently, the prevalence of electric rickshaws in Bangladesh has significantly increased in recent years which is shown in Fig. 16 [16]. According to Bangladesh Road Transport Authority (BRTA), the aggregate count of auto-rickshaws as of June 2022 was at 322,371 [16]. The abundance of electric rickshaws requires a substantial quantity of power. Therefore, solar charging stations may serve as an alternate means in such a situation. Currently, a significant number of solar charging stations are operating in Bangladesh, generating 0.291 MW of power from both on-grid and off-grid sources, as shown in Fig. 17 [2].

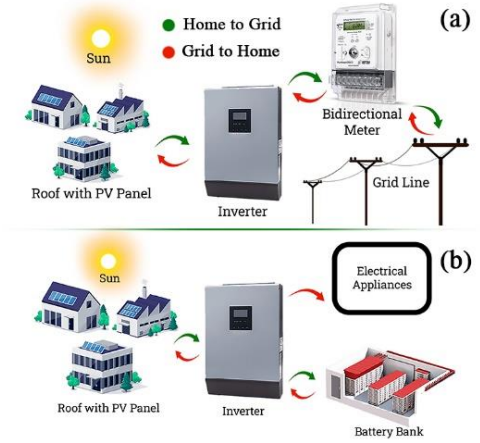


Fig. 12. Rooftop solar with NEM & without NEM

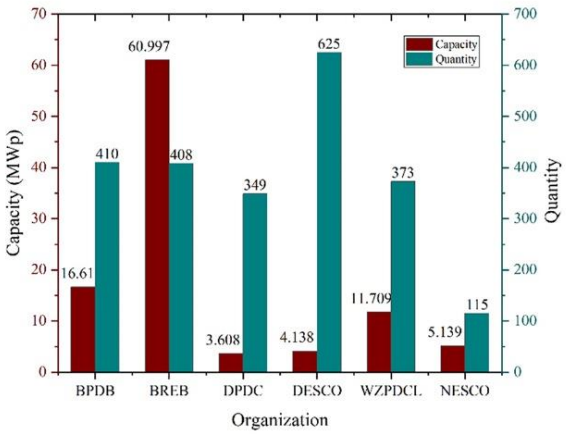


Fig. 13. Statistics of installed net metering systems by different organization

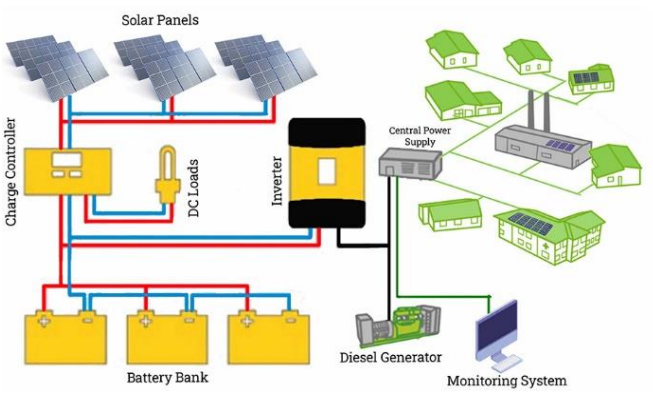


Fig. 14. Schematic diagram of solar mini grid

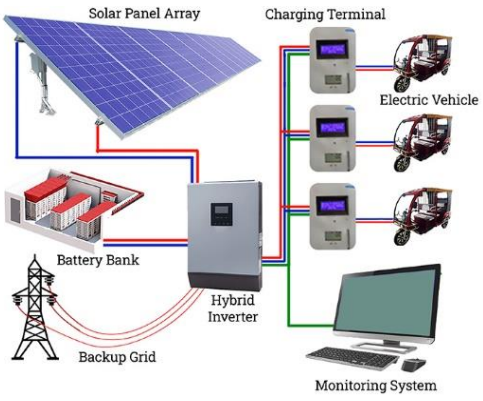


Fig. 15. Schematic diagram of Solar charging station

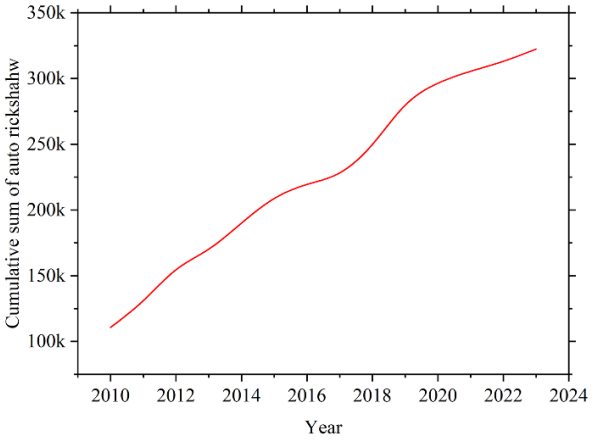


Fig. 16. Increasing trend of auto-rickshaws in Bangladesh.

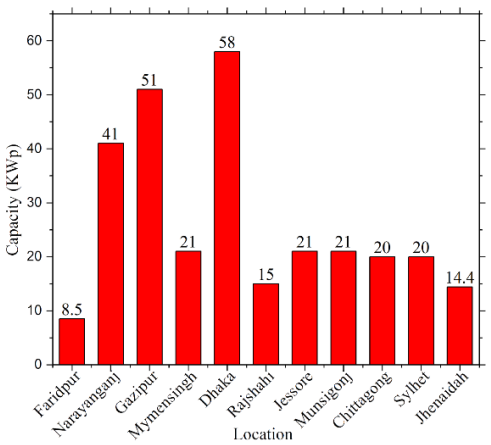


Fig. 17. Solar charging station projects in Bangladesh.

4. Conclusion

Solar energy has significantly advanced, especially in rural and off-grid areas of Bangladesh. Solar Home Systems (SHS) and solar irrigation provide clean, affordable energy for households and agriculture, supporting socio-economic growth. Beyond rural electrification, solar-powered streetlights, telecom BTS, and rooftop systems enhance public infrastructure, safety, and reduce pressure on the national grid. Key outcomes and recommendations from this review are as follows:

- SHS and solar irrigation projects have improved energy access and supported rural livelihoods, making solar a vital component of Bangladesh's renewable energy mix.
- Solar-powered streetlights, telecom base transceiver stations (BTS), and rooftop systems enhance public safety, strengthen communication networks, and improve energy efficiency, highlighting the essential role of solar energy in building sustainable infrastructure.
- With limited land for large-scale solar parks, partnerships are essential to maximize land use, including access to idle public land and investment in rooftop and vertical solar installations.
- To enable greater adoption, policy reforms should include financial incentives, subsidies, and simplified regulatory processes to encourage innovative solar solutions across various sectors.

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