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A SWOT ANALYSIS OF RENEWABLE ENERGY SECTOR IN BANGLADESH FOR SUSTAINABLE ENERGY TRANSITION

Abstract

The development of renewable energy (RE) sector is a key to sustainable energy transition. Despite various government initiatives including supportive policies and financial incentives, Bangladesh still lags behind in the development and expansion of RE. To achieve global goals of adopting clean energy sources under sustainable development goals (SDGs) and mitigation strategy of global climate change, it has become imperative to examine the potential challenges, risks and opportunity of this sector. This paper assesses the current state of RE sector in Bangladesh using the Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis. It finds that potential natural conditions, institutional arrangements, growing energy demand, recognition of RE in government policies, grid connection, human resources, and technology are the strength of renewable energy sector in Bangladesh. The weaknesses include variability in climatic condition, lack of awareness and social acceptance, lack of subsidy, higher unit cost, fragmented institutional arrangement, persistent supply and demand gap, higher initial cost, and policy inconsistency. This study also reveals that private capital and foreign direct investment, new job creation and economic development due to RE deployment, and availability of coastline and landmass are the opportunity for the renewable energy sector in Bangladesh. On the other hand, environmental risk, financial risk, renewable energy security and land acquisition are the threats for the development of RE in the country. This analysis provides strategic insights for policymakers and stakeholders to design targeted policies, mitigate structural weaknesses, leverage emerging opportunities, and accelerate a sustainable and just energy transition aligned with national development goals.

Keywords: Renewable Energy, Paris Agreement, SDGs, Energy Policy, SWOT Analysis

1. Introduction

Energy is essential for economic development. Globally, majority of the electricity is used to be produced primarily from various fossil fuels emitting huge greenhouse gasses.[1] Greenhouse gases are viewed as the primary factors

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[1] Solomon E Uhunamure and Karabo Shale, "A SWOT Analysis Approach for a Sustainable Transition to

contributing to climate change, prompting many countries to actively pursue energy diversification and clean energy transition [2]. More than 180 members of the United Nations Framework Convention on Climate Change (UNFCCC) have reached a consensus on the global shift to clean energy through the Paris Agreement. A key goal is to lower greenhouse gas emissions by promoting the adoption of low carbon energy sources to maintain the rise in average global temperatures below 2ºC compared to pre-industrial levels.

Bangladesh, a fast-developing South Asian nation, holds considerable promise in renewable energy production.[3] The Integrated Energy and Power Master Plan (IEPMP) envisions 40 per cent "clean energy" in the overall energy mix, of which 8.4 per cent is expected to come from renewable sources. The Climate Prosperity Plan (CPP) sets a more ambitious target of generating 40 per cent electricity from renewable energy.[4] More recently, the Renewable Energy Policy 2025 has established goals of 20 per cent renewable energy by 2030 and 30 per cent by 2040. Against the ambitious policy commitments, renewable energy sources account for only 5.4 per cent of installed capacity in Bangladesh.[5] The country faces multiple structural and institutional challenges in achieving its renewable energy targets. In this regard, it is imperative to identify the internal potentials and challenges as well as external risks and opportunities for the development of RE in Bangladesh.

A number of studies have explored the prospects and challenges of the renewable energy sector in Bangladesh.[6] One limitation of the existing studies is

Renewable Energy in South Africa," *Sustainability* 13, no. 7 (2021): 3933.

[2] Rawshan Ara Begum et al., "Impacts of Economic Growth, Energy Use, Population, Urbanisation, and Tourism on CO2 Emissions in Malaysia: An Empirical Analysis of ARDL Approach," *Environment, Development and Sustainability* (2025): 1–29.

[3] Madhushree Mitra, Nayan Ranjan Singha, and Pijush Kanti Chattopadhyay, "Review on Renewable Energy Potential and Capacities of South Asian Countries Influencing Sustainable Environment: A Comparative Assessment," *Sustainable Energy Technologies and Assessments* 57 (2023): 103295.

[4] Khondaker Golam Moazzem and Abrar Ahammed Bhuiyan, *Addressing Institutional Challenges in the Investment Cycle of the Renewable Energy: Case of Chinese Overseas Investment*, CPD Report (Dhaka: Centre for Policy Dialogue, 2025).

[5] Sustainable and Renewable Energy Development Authority (SREDA), "National Database of Renewable Energy," Ministry of Power, Energy and Mineral Resources, accessed March 08, 2026, http://www.renewableenergy.gov.bd/.

[6] Md. Mamun et al., "Renewable Energy in Bangladesh : Challenges, Sustainable Power Generation , and Future Prospects," in *8th International Conference on Mechanical, Industrial and Energy Engineering*, vol. 3, 2025, 485–492; Asif Raihan et al., "Renewable Energy Resources for Green Development in Bangladesh : Perspectives, Challenges, and Opportunities," *Innovation and Green Development* 4, no. 5 (2025): 100298, https://doi.org/10.1016/j.igd.2025.100298; Md Tanjil Sarker et al., "Analysis of the Power Sector in Bangladesh: Current Trends, Challenges, and Future Perspectives," *Bulletin of Electrical Engineering and Informatics* 13, no. 6 (2024): 3862–3879; Md Sadman Anjum Joarder et al., "Analysis of the Current Development of Renewable Energy Technologies in Bangladesh," *WSEAS Transactions on Environment and Development* 20 (2024): 883–894; Md. Yeamim Chowdhuri et al., "Current Challenges and Future Prospects of Renewable Energy : A Case Study in Bangladesh," *International Journal of Innovative Science and Research*

that they focus on the challenges related to foreign investment overlooking the issue of the energy transition. Against this backdrop, the aim of this study is to assess the potentials, internal weaknesses and external threats of the renewable energy sector for the sustainable energy transition in Bangladesh using the SWOT analysis.

2. Literature Review and Theoretical Framework

Many studies have explored the development of renewable energy sector in different regions using SWOT analysis method comprised of a set of indicators. For example, in their study on renewable energy sector of Poland, Igliński et al[7] used SWOT analysis which comprised of the following indicators: natural conditions; interest of investors/local authorities; current level of knowledge; investment costs and involvement of private investment; investment process; profit or subsidies of RE sector; price of renewable energy; the impact on environment; public opposition during the installation of RE project; laboratory and technical capacity; grid connection; security of RE; creation of new job; opportunity to develop mini-installations and micro-installations; progress towards economic growth; and impact of regulations on the development of the RE sector.

Indicators used by Kamran et al.[8] in their SWOT analysis of Pakistan's renewable energy sector include: ordinary conditions of the region; interests of investors, developers, and promoters; knowledge level of locals regarding RE sources; the subsidies and profits available in RE projects; grid parity, comparative cost of RE; level of cooperation between federal and provincial governments; win-win strategy among different institutions; level of coordination between energy and climate policies; impact of RE on the environment; demand for electricity; window facilitator in organising and licensing the projects; the level of knowledge of experts; returns rate and electricity theft; security for the availability of RE resources; creation of new jobs; opportunity for technology development at the mini and micro scale; economic growth opportunities for the development of RE-based projects; current

Technology 8, no. 4 (2023): 576-582; Md. Abdullah-Al-Mahbub and Abu Reza Md Towfiqul Islam, "Current Status of Running Renewable Energy in Bangladesh and Future Prospect : A Global Comparison," *Heliyon* 9, no. 3 (2023): e14308, https://doi.org/10.1016/j.heliyon.2023.e14308; Abdul Hasib Siddique et al., "Renewable Energy Sector in Bangladesh: The Current Scenario, Challenges and the Role of IoT in Building a Smart Distribution Grid," *Energies* 14, no. 16 (2021): 5083; Md. Alam Hossain Mondal, Linda M. Kamp, and Nevelina I. Pachova, "Drivers, Barriers, and Strategies for Implementation of Renewable Energy Technologies in Rural Areas in Bangladesh—An Innovation System Analysis," *Energy Policy* 38, no. 8 (2010): 4626–4634.

[7] Bartłomiej Igliński, Grzegorz Piechota, Anna Iglińska, Marcin Cichosz, and Roman Buczkowski, "The Study on the SWOT Analysis of Renewable Energy Sector on the Example of the Pomorskie Voivodeship (Poland)," *Clean Technologies and Environmental Policy* 18, no. 1 (2016): 45–61.

[8] Muhammad Kamran, Muhammad Rayyan Fazal, and Muhammad Mudassar, "Towards empowerment of the renewable energy sector in Pakistan for sustainable energy evolution: SWOT analysis," *Renewable Energy* 146 (2020): 543–558.

energy policy support for the promotion of the RE sources; local laboratory research to improve the efficiency; and the level of accuracy of the available metrological data.

Uhunamure and Shale[9] explored the sustainable transition to renewable energy in South Africa using the following indicators: accuracy level of the available renewable energy data; policy support for renewable energy promotion; interest of promoters, developers and investors in renewable energy projects; level of awareness regarding renewable energy sources; job creation by renewable energy; developmental opportunities of renewable energy at small, micro and medium scales; expertise in renewable energy technologies; developmental and economic opportunities for renewable energy; available grants and profits in renewable energy projects; impacts of renewable energy and fossil fuels on the environment; electricity demand of the country; grid equity; and level of coordination between climate guidelines and energy policies.

Based on the aforementioned literature review, this study has developed the following analytical framework as mentioned in Table 1 to assess the SWOT of the RE sector in Bangladesh.

Table 1: Indicators to assess the SWOT of renewable energy sector in Bangladesh

Serial	Proposed Indicator
1.	Natural conditions for the development of renewable energy sources (RES)[10]
2.	Interest of promoters, developers and investors in renewable energy projects[11]
3.	Level of awareness regarding renewable energy sources [12]
4.	Subsidies and profits available in RE projects[13]
5.	Comparative cost of renewable energy generation[14]
6.	Clear distribution of responsibilities among different institutions of the State[15]

[9] Solomon E. Uhunamure and Karabo Shale, "A SWOT Analysis Approach for a Sustainable Transition to Renewable Energy in South Africa," *Sustainability* 13, no. 7 (2021): 3933.
[10] Igliński et al., "SWOT Analysis of Renewable Energy Sector"; Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector"; Uhunamure and Shale, "SWOT Analysis Approach".
[11] Igliński et al., "SWOT Analysis of Renewable Energy Sector"; Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector"; Uhunamure and Shale, "SWOT Analysis Approach".
[12] Igliński et al., "SWOT Analysis of Renewable Energy Sector"; Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector"; Uhunamure and Shale, "SWOT Analysis Approach".
[13] Igliński et al., "SWOT Analysis of Renewable Energy Sector"; Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector"; Uhunamure and Shale, "SWOT Analysis Approach".
[14] Igliński et al., "SWOT Analysis of Renewable Energy Sector"; Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector"; Uhunamure and Shale, "SWOT Analysis Approach".
[15] Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector".

7.	Level of coordination between energy and climate policies[16]
8.	Impact of renewable energy on the environment[17]
9.	Electricity demand of the country[18]
10.	Length of investment process, requirement of documentation and bureaucratic complexity[19]
11.	RE leakage[20]
12.	Expertise in RE technologies[21]
13.	Connectivity of the installed project to the national power grid network[22]
14.	Availability of RE resources[23]
15.	Creation of new jobs in RE sector[24]
16.	Opportunity to develop mini-installations and micro-installations[25]
17.	Growth opportunities of RE-based projects[26]
18.	Policy support to RE promotion[27]
19.	Improvement of efficiency and reduction of cost of RE through local research[28]
20.	Accuracy level of the available renewable energy data[29]
21.	Public opposition to installation of RE projects[30]
22.	Investment costs and scope of private/international joint venture

[16] Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector"; Uhunamure and Shale, "SWOT Analysis Approach".
[17] Igliński et al., "SWOT Analysis of Renewable Energy Sector"; Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector"; Uhunamure and Shale, "SWOT Analysis Approach".
[18] Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector"; Uhunamure and Shale, "SWOT Analysis Approach".
[19] Igliński et al., "SWOT Analysis of Renewable Energy Sector"; Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector"; Uhunamure and Shale, "SWOT Analysis Approach".
[20] Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector".
[21] Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector".
[22] gliński et al., "SWOT Analysis of Renewable Energy Sector"; Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector".
[23] Igliński et al., "SWOT Analysis of Renewable Energy Sector"; Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector".
[24] Igliński et al., "SWOT Analysis of Renewable Energy Sector"; Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector"; Uhunamure and Shale, "SWOT Analysis Approach".
[25] Igliński et al., "SWOT Analysis of Renewable Energy Sector"; Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector"; Uhunamure and Shale, "SWOT Analysis Approach".
[26] Igliński et al., "SWOT Analysis of Renewable Energy Sector"; Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector"; Uhunamure and Shale, "SWOT Analysis Approach".
[27] Igliński et al., "SWOT Analysis of Renewable Energy Sector"; Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector"; Uhunamure and Shale, "SWOT Analysis Approach".
[28] Igliński et al., "SWOT Analysis of Renewable Energy Sector"; Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector".
[29] Kamran, Fazal, and Mudassar, "Empowerment of the renewable energy sector"; Uhunamure and Shale, "SWOT Analysis Approach".
[30] Igliński et al., "SWOT Analysis of Renewable Energy Sector".

3. Methodology

3.1 *Research Design*

This study adopts a qualitative research design. It uses SWOT analysis to systematically examine the strengths, weaknesses, opportunities, and threats of the renewable energy sector in Bangladesh in relation to the country's sustainable energy transition.

3.2 *Data Sources and Analysis*

The paper uses secondary data from a variety of sources including working papers, national energy reports and statistics, journals, research reports, and books. Based on 22 indicators developed for the renewable energy sector (as presented in Table 1), data were collected from multiple secondary sources. The extracted information was systematically compiled in MS Excel, with each indicator organised separately for clarity and comparison. Through repeated review and careful examination, the data were then categorised into four analytical dimensions, viz. strengths, weaknesses, opportunities, and threats within a separate worksheet to ensure structured classification. Finally, after conducting a detailed analysis of the evidences under each indicator, key themes were generated and synthesised to present the overall findings of the SWOT assessment.

3.3 *Data Analysis Tool*

The SWOT represents a strategic planning tool used to evaluate a project, sector or organisation. It is a well-organised analytical instrument that helps to identify internal factors (strengths/weaknesses) and external factors (opportunities/threats) to maximise potential and minimise risks.[31] For energy research, the SWOT is generally recognised as an effective analytical tool to understand the overall scenario of a country's energy sector.

[31] Zorica Srdjevic, Ratko Bajcetic, and Bojan Srdjevic, "Identifying the Criteria Set for Multicriteria Decision Making Based on SWOT/PESTLE Analysis: A Case Study of Reconstructing a Water Intake Structure," *Water Resources Management* 26, no. 12 (2012): 3379–3393.

Components of SWOT Analysis in an RE Project

Strengths: features of the business or project that provide it an edge over competitors,

Weaknesses: features that put the business or project in a less favorable position compared to others,

Opportunities: benefits that could be leveraged,

Threats: factors in the surroundings that may create difficulties for the business or project.

4. Results and Analyses

4.1 *Strengths of RE sector in Bangladesh*

4.1.1 *Potential Natural Conditions of the Country*

Bangladesh's geographical location and natural resource endowment constitute major strengths for renewable energy development. Among renewable sources, solar and wind energy hold particularly high potential due to their abundance, ease of installation, and deployment flexibility.[32] Located between 20.30–26.38° North latitude and 88.04–92.44° East longitude, Bangladesh is well positioned for solar energy utilisation and storage.[33] Intense solar radiation occurs from March to April, while minimal radiation is observed from December to January.[34] Solar power availability ranges from 4.0 to 6.5 kWh/m²/day, with 6–9 hours of sunny daylight for approximately 300 days per year, creating favorable conditions for large-scale solar deployment.[35]

Wind energy also presents significant opportunities. Bangladesh has a 200 km hilly coastline, a 724 km coastal belt, and more than 50 islands in the Bay of Bengal suitable for wind development. Regions such as Chattogram, Cox's Bazar, Jessore, Khepupara, Hatiya, Kuakata, Kutubdia, and Patenga demonstrate notable

[32] Abdulla Al Mamum et al., "Sustainable Renewable Energy Integration on Expressways in Bangladesh: A Techno-Economic, Environmental, and Sensitivity Analysis of a Grid-Connected Hybrid System," *Energy Conversion and Management: X* 26 (2025): 101020, https://doi.org/10.1016/j.ecmx.2025.101020.

[33] A. Z. A. Saifullah, Md Karim, and Md Karim, "Wind Energy Potential in Bangladesh," *American Journal of Engineering Research (AJER)* 5, no 7 (2016): 85–94.

[34] Abdullah-Al-Mahbub & Islam, "Current Status of Running Renewable Energy".

[35] Abdullah-Al-Mahbub & Islam, "Current Status of Running Renewable Energy"; Saifullah, Karim, and Karim, "Wind Energy Potential in Bangladesh".

wind potential.[36] Estimates from the National Renewable Energy Laboratory of the U.S. Department of Energy indicate a potential exceeding 30,000 MW of wind energy[37], with projections of generating 5000 MW by 2030 through onshore and offshore facilities.[38]

With an agro-based economy and substantial crop production including 34.36 million tons of rice in 2013-2014 and 61.09 million tons of total agricultural output in 2012-2013, Bangladesh has considerable scope for biomass-based energy also.[39]

4.1.2 *Institutional and Policy Framework for Renewable Energy Development*

The creation of the Sustainable and Renewable Energy Development Authority (SREDA) under the SREDA Act of 2012 is a major institutional milestone for Bangladesh's RE development.[40] Complementary institutions such as the Bangladesh Power Development Board (BPDB) and Infrastructure Development Company Limited (IDCOL) facilitate renewable projects including utility-scale solar, wind, and waste-to-energy initiatives under the IPP framework. The establishment of the Bangladesh Energy Regulatory Commission (BERC) in 2003 further strengthened tariff regulation, licensing, and investor confidence.

This institutional foundation is reinforced by a sustained policy commitment to renewable energy, reflected in successive policy instruments such as the Renewable Energy Policies of 2008 and 2025, the Energy Efficiency and Conservation Master Plan (2015) and the Power Sector Master Plans 2016. More recent strategic documents, including the Mujib Climate Prosperity Plan (MCPP) and the Bangladesh Delta Plan 2100, explicitly link renewable energy expansion with climate resilience, economic transformation, and reduced exposure to fossil fuel price volatility, alongside revised renewable energy targets of 20 per cent by 2030 and 30 per cent by 2040.

Institutional arrangements also emphasise stakeholder engagement and capacity building. Evidences from programmes implemented by Grameen Shakti and BRAC demonstrates that early involvement of local stakeholders, entrepreneurs,

[36] Raihan et al., "Renewable Energy Resources for Green Development in Bangladesh".
[37] Mamun et al., "Renewable Energy in Bangladesh".
[38] Hafez Ahmad et al., "Green Energy, Blue Economy: Integrating Renewable Energy and Sustainable Development for Bangladesh," *Marine Technology Society Journal* 57 (2023): 52–69, https://doi.org/10.4031/MTSJ.57.4.4.
[39] P. K. Halder et al., "Energy Scarcity and Potential of Renewable Energy in Bangladesh," *Renewable and Sustainable Energy Reviews* 51 (2015): 1636–1649, https://doi.org/10.1016/j.rser.2015.07.069.
[40] Hossain Mohammad, "Achieving Sustainable Energy Targets in Bangladesh," *UN Chronicle* 52, no. 3 (2013): 36–39.

and end-users enhances the sustainability of renewable energy projects.[41] Policy documents further stress coordination, awareness promotion, support for small and medium renewable enterprises, microcredit access, and private sector participation.[42] Collectively, this integrated institutional structure and consistent policy recognition provide a strong governance foundation for scaling up renewable energy in Bangladesh.

4.1.3 *Growing Electricity Demand*

Bangladesh's rapidly growing electricity demand is a key strength for renewable energy expansion. National consumption rose from 71,419 GWh in FY2020–21 to 85,607 GWh in FY2021–22, with peak demand increasing from 5,271 MW in 2009 to over 15,500 MW in 2019, and projections of 27,400–51,000 MW by 2030–2041[43]. Household, industrial, commercial, and agricultural sectors together provide a resilient demand base, while rising per capita consumption and industrial growth signal further latent demand.[44] Policy projections estimate up to 57,000 MW generation capacity needed by 2040–2041, creating structural opportunities for scaling up cost-competitive solar and wind energy as alternatives to imported fossil fuels.[45]

4.2 *Weaknesses of RE sector in Bangladesh*

4.2.1 *Variability in Climatic Conditions*

Bangladesh's geographical location and natural characteristics pose significant constraints to the large-scale development of renewable energy. Wind energy potential is limited due to the country's tropical climate and strong seasonal variability. Average wind speeds in coastal and island areas range between 3–5 m/s, which is below the threshold required for efficient electricity generation.[46] This limitation is further

[41] M. Rofiqul Islam, M Rabiul Islam, and M Rafiqul Alam Beg, "Renewable Energy Resources and Technologies Practice in Bangladesh," *Renewable and Sustainable Energy Reviews* 12, no. 2 (2008): 299–343, https://doi.org/https://doi.org/10.1016/j.rser.2006.07.003.

[42] Mohammad Ershadul Karim et al., "Renewable Energy for Sustainable Growth and Development: An Evaluation of Law and Policy of Bangladesh," *Sustainability* 11, no. 20 (2019): 5774.

[43] Abdullah-Al-Mahbub and Islam, "Current Status of Running Renewable Energy in Bangladesh and Future Prospect"; Khondaker Golam Moazzem and ASM Shamim Alam Shibly, Achieving the Target of Renewable Energy based Power Generation by 2041–Scopes and Way-forward, CPD Report 56 (Dhaka: Centre for Policy Dialogue, 2024).

[44] Abdullah-Al-Mahbub and Islam, "Current Status of Running Renewable Energy in Bangladesh and Future Prospect".

[45] Moazzem and Shibly, "Achieving the Target of Renewable Energy Based Power Generation by 2041"; Abdullah-Al-Mahbub and Islam, "Current Status of Running Renewable Energy in Bangladesh and Future Prospect".

[46] G M Joselin Herbert et al., "A Review of Wind Energy Technologies," *Renewable and Sustainable Energy Reviews* 11, no. 6 (2007): 1117–1145, https://doi.org/https://doi.org/10.1016/j.rser.2005.08.004.

compounded by insufficient wind-related data and a lack of wind energy expertise. Inadequate wind speed remains a major barrier to grid-scale wind power production.[47]

Solar energy development is also geographically constrained. Although solar power is widely adopted in rural areas, its applicability in urban zones remains limited. Variations in building height and dense construction patterns reduce uniform solar radiation exposure, making it difficult to maximise energy generation in urban settings.[48]

Hydropower potential in Bangladesh is restricted due to its predominantly flat terrain, with viable sites confined to a few hilly regions in the northeast and southeast.[49] Seasonal water flow variability further reduces hydropower potential.

4.2.2 *Limited Awareness and Social Acceptance*

Lack of awareness and low social acceptance remain key barriers to renewable energy development in Bangladesh. Industries, the public, utility companies, policymakers, and financial institutions often have limited knowledge regarding clean energy technologies.[50] Public understanding of renewable enegry is limited, with knowledge gaps about resource potential, appropriate technologies, and practical applications.[51]

Social acceptance issues compound these challenges, particularly for land-intensive projects in a densely populated country. While public attitudes are generally positive due to expectations of affordable electricity and employment, concerns over land acquisition, compensation, legal disputes, and competing land uses for agriculture and housing persist.[52] Strengthening awareness and engagement

[47] Hasan Mahmud and Joyashree Roy, "Barriers to Overcome in Accelerating Renewable Energy Penetration in Bangladesh," *Sustainability* 13 no 14 (2021): 1–28.

[48] Mohammad Didarul Islam, Khondaker A. Mamun, Redwan N. Sajjad, and M. Ryyan Khan, "Experimental study of effects of soiling on various solar panel tilts in a sub-tropical climate in South Asia," *Sustainable Energy Technologies and Assessments* 69 (2024): 103890.

[49] N. C. Mondal, S. Adike, and S. Ahmed, "Development of entropy-based model for pollution risk assessment of hydrogeological system," *Arabian Journal of Geosciences* 11, no. 14 (2018): 375.

[50] Md Washim Akram, Md Arman Arefin, and Afsana Nusrat, "Prospect of Green Power Generation as a Solution to Energy Crisis in Bangladesh," *Energy Systems* 13, no. 3 (2022): 749–787.

[51] Mahyar Kamali Saraji, Elahe Aliasgari, and Dalia Streimikiene, "Assessment of the Challenges to Renewable Energy Technologies Adoption in Rural Areas: A Fermatean CRITIC-VIKOR Approach," *Technological Forecasting and Social Change* 189 (2023): 122399; Mondal, Kamp, and Pachova, "Drivers, Barriers, and Strategies for Implementation of Renewable Energy Technologies in Rural Areas in Bangladesh—An Innovation System Analysis"; Akram, Arefin, and Nusrat, "Prospect of Green Power Generation as a Solution to Energy Crisis in Bangladesh".

[52] Ridoan Karim et al., "Social, Economic and Political Implications of Nuclear Power Plant in Bangladesh," in *Social Sciences Postgraduate International Seminar (SSPIS)* (2017), 115; Mohammad Ershadul Karim, Ridoan Karim, Md. Toriqul Islam, Firdaus Muhammad-Sukki, Nurul Aini Bani, and Mohd Nabil Muhtazaruddin, "Renewable Energy for Sustainable Growth and Development: An Evaluation of Law and Policy of Bangladesh," Sustainability 11, no. 20 (2019): 577.

programs through media campaigns and community participation is essential to reduce informational barriers and enhance social acceptance.[53]

4.2.3 *Financial and Cost-Related Constraints in Renewable Energy Development*

Financial limitations, subsidy distortions, profitability uncertainties, and high unit costs collectively are the major structural weaknesses in Bangladesh's renewable energy sector. Government support through the national budget is constrained by limited fiscal space and competing priorities, such as health, education, and disaster management, restricting allocations for renewable energy subsidies. At the same time, indirect subsidies for conventional energy artificially lower fossil fuel prices, weakening the relative financial viability of renewable energy technologies (RETs).[54] Lack of competitive procurement mechanisms, reliance on imported components, currency depreciation, multiple duties, land acquisition challenges, administrative delays, and transmission connection costs, particularly in remote or riverbank locations, further inflate costs of RE.[55] Consequently, although fossil fuel-based electricity carries hidden system-wide costs, renewable electricity appears more expensive at the unit level due to financing, procurement, and structural constraints.[56]

4.2.4 *Fragmented Institutions and Policy Inconsistency in Renewable Energy Development*

Fragmented institutional arrangements and policy inconsistencies constitute a major governance weakness in Bangladesh's renewable energy sector. Although multiple institutions are involved, weak coordination and dispersed responsibilities across ministries, agencies, and departments undermine effective implementation and result in inefficient use of limited human and financial resources.[57] Poor coordination among government bodies and private sector actors

[53] Md Anisur Rahman, Henrik B Møller, and Md Monjurul Alam, "Assessing the Energy Potential of Agricultural Residues and an Approach to Meet the Rural Energy Demand: The Bangladesh Perspective," *Biomass Conversion and Biorefinery* 8, no. 4 (2018): 925–934; Mondal, Kamp, and Pachova, "Drivers, Barriers, and Strategies for Implementation of Renewable Energy Technologies in Rural Areas in Bangladesh—An Innovation System Analysis".

[54] Raihan et al., "Renewable Energy Resources for Green Development in Bangladesh"; Mahmud and Roy, "Barriers to Overcome in Accelerating Renewable Energy Penetration in Bangladesh

[55] Shah Mohazzem Hossain, Sagor Biswas, and Md Raihan Uddin, "Sustainable Energy Transition in Bangladesh: Challenges and Pathways for the Future," *Engineering Report*, no. 2022 (2023): 1–26, https://doi.org/10.1002/eng2.12752.

[56] Moazzem and Shibly, "Achieving the Target of Renewable Energy Based Power Generation by 2041".

[57] Islam, Islam, and Beg, "Renewable Energy Resources and Technologies Practice in Bangladesh".

has been repeatedly identified as a key barrier, particularly in licensing, permitting, and investment facilitation.[58]

Institutional capacity constraints further weaken governance effectiveness. BERC lacks sufficient institutional capacity, while SREDA and BPDB require targeted capacity-building and institutional audits to improve performance.[59] Although SREDA is mandated to lead renewable energy development, it lacks adequate regulatory authority, financial autonomy, and technical resources to coordinate effectively across agencies.[60] Similarly, BERC's limited capacity delays tariff approvals and regulatory decisions, increasing uncertainty for investors.[61] Limited stakeholder inclusiveness also constrains institutional effectiveness, as local entrepreneurs, investors, engineers, and end-users are inadequately involved in policy formulation, and consultations often remain symbolic with minimal influence on decision-making.[62] Heavy reliance on the national budget further creates uncertainty in financing allocation and delays implementation.[63]

Policy incoherence across national planning documents compounds these institutional weaknesses. While renewable energy policies and climate strategies set ambitious targets of 20–30 per cent renewable electricity by 2030–2040, core planning documents such as the Power System Master Plan (PSMP) 2016 and the Integrated Energy and Power Master Plan (IEPMP) 2023 allocate only a marginal share to renewable energy, prioritising fossil fuels and imported LNG instead. The IEPMP projects renewable energy contributing less than 10 per cent of long-term electricity generation and emphasises fossil fuel-based generation and speculative technologies, delaying large-scale deployment of proven options, such as solar and wind.[64]

Moreover, renewable energy targets remain largely aspirational, lacking binding timelines, sector-specific obligations, or penalties for non-compliance,

[58] R. K. Majumder, M. Khalil, and M. Rashi, "Uranium Exploration Status in Bangladesh: Conceptual Study," in *Proceedings of the IAEA Technical Meeting on Uranium from Unconventional Resources* (Vienna, Austria: IAEA, 2014), 1–26; Siddique et al., "Renewable Energy Sector in Bangladesh: The Current Scenario, Challenges and the Role of IoT in Building a Smart Distribution Grid".

[59] Khondaker Golam Moazzem and Abrar Ahammed Bhuiyan, "Addressing Institutional Challenges in the Investment Cycle of the Renewable Energy Case of Chinese Overseas Investment," 2025.

[60] Tareq Mahbub, "Energy in Bangladesh: From scarcity to universal access," *Energy Strategy Reviews* 54 (July 2024): 101490.

[61] Lin Chen et al., "Green Building Practices to Integrate Renewable Energy in the Construction Sector: A Review," *Environmental Chemistry Letters* 22, no. 2 (2024): 751–784.

[62] Mahmud and Roy, "Barriers to Overcome in Accelerating Renewable Energy Penetration in Bangladesh"; Karim et al., "Renewable Energy for Sustainable Growth and Development"

[63] Islam, Islam, and Beg, "Renewable Energy Resources and Technologies Practice in Bangladesh".

[64] Md. Tanjil Sarker et al., "Analysis of the power sector in Bangladesh: current trends, challenges, and future perspectives," Bulletin of Electrical Engineering and Informatics 13, no. 6 (2024): 3862–3879.

while feed-in tariffs and fiscal incentives are inconsistently applied.[65] Continued large-scale commitments to coal- and LNG-based power plants have generated excess capacity and financial strain, crowding out renewable energy investment and reinforcing fossil fuel dependency.[66]

4.2.5 *Persistent Supply-Demand Gap and Heavy Reliance on Fossil Fuels*

Bangladesh's power sector is characterised by a persistent mismatch between electricity demand and effective supply, despite a rapid increase in installed generation capacity. Although total installed capacity has exceeded 28,000 MW in recent years, actual peak generation has remained significantly lower due to fuel supply shortages, system constraints, and inefficient dispatch, resulting in continued load shedding during peak demand periods.[67] This discrepancy has created a paradox of surplus capacity alongside unmet demand, indicating structural weaknesses in demand forecasting and generation planning.

The situation is further exacerbated by the sector's heavy dependence on fossil fuels. More than 90 per cent of grid-based electricity generation in Bangladesh relies on natural gas, oil, and coal, with natural gas alone accounting for the largest share of power production.[68] Declining domestic gas reserves and increasing reliance on imported LNG, furnace oil, and coal have exposed the power sector to global fuel price volatility and foreign exchange constraints, significantly raising generation costs and fiscal pressure on the Bangladesh Power Development Board (BPDB).[69]

Despite repeated policy commitments, renewable energy has remained marginal in both planning and actual generation. Renewable sources have contributed less than 5 per cent of installed capacity and under 2 per cent of grid-based electricity generation over the past decade, reflecting weak institutional prioritisation and inadequate investment support. As a result, Bangladesh continues to rely on costly fossil fuel-based power plants, leading to rising electricity tariffs and increasing

[65] Siddique et al., "Renewable Energy Sector in Bangladesh".
[66] Karim et al., "Renewable Energy for Sustainable Growth and Development".
[67] Moazzem and Shibly, "Achieving the Target of Renewable Energy Based Power Generation by 2041"; Karim et al., "Renewable Energy for Sustainable Growth and Development".
[68] Khondaker Golam Moazzem et al., "Stakeholders' Perspectives on Key Challenges of the Power Sector Level of Stakeholders' Engagement in the Formulation of Master Plans" (Dhaka, Bangladesh, 2022); Halder et al., "Energy Scarcity and Potential of Renewable Energy in Bangladesh".
[69] Mehmet Akif Destek and Avik Sinha, "Renewable, Non-Renewable Energy Consumption, Economic Growth, Trade Openness and Ecological Footprint: Evidence from Organisation for Economic Co-Operation and Development Countries," *Journal of Cleaner Production* 242 (2020): 118537; Moazzem and Shibly, "Achieving the Target of Renewable Energy Based Power Generation by 2041".

subsidy burdens, while capacity payments to underutilised plants strain public finances.[70]

4.2.6 *High Initial Costs, Bureaucratic Procedure and Lengthy Process*

Renewable energy investment in Bangladesh is constrained by high upfront capital costs, lengthy return periods, and weak financial mechanisms. Utility-scale and distributed renewable energy technologies require substantial initial investment, which is difficult to bear within Bangladesh's current economic context.[71] Although renewable energy technologies are viable over their lifecycle, high installation costs, elevated market interest rates, and limited access to long-term finance reduce expected returns and discourage private investors.[72] Local banks and financial institutions remain reluctant to finance renewable projects due to risk perceptions, lack of technical understanding of green projects, bureaucratic paperwork, and inability to provide loans beyond short tenures.

Institutional fragmentation and regulatory inconsistency further weaken the investment environment. Renewable energy governance in Bangladesh involves multiple institutions with overlapping mandates, leading to duplication, coordination failures, and the absence of a single authority responsible for monitoring policy implementation.[73] Regulatory expertise is often insufficient, and implementation is widely viewed as an isolated exercise rather than an integrated strategy.[74] These weaknesses are compounded by the lack of a coherent business model and market-oriented framework for commercial-scale renewable energy, which limits grid-connected solar expansion and discourages private participation.[75]

The administrative process for renewable energy projects is particularly complex and time-consuming. Developers must navigate extensive documentation

[70] Moazzem et al., "Stakeholders' Perspectives on Key Challenges of the Power Sector Level of Stakeholders' Engagement in the Formulation of Master Plans".
[71] Siddique et al., "Renewable Energy Sector in Bangladesh: The Current Scenario, Challenges and the Role of IoT in Building a Smart Distribution Grid"; Faysal Ahamed Akash et al., "Greening the grid: A comprehensive review of renewable energy in Bangladesh," Heliyon 10, no. 5 (2024): e26233.
[72] Islam, Islam, and Beg, "Renewable Energy Resources and Technologies Practice in Bangladesh"; Akram, Arefin, and Nusrat, "Prospect of Green Power Generation as a Solution to Energy Crisis in Bangladesh".
[73] Karim et al., "Renewable Energy for Sustainable Growth and Development: An Evaluation of Law and Policy of Bangladesh"; Mahmud and Roy, "Barriers to Overcome in Accelerating Renewable Energy Penetration in Bangladesh
[74] Lamia Lazmi Khandker, Sakib B. Amin, and Farhan Khan, "Renewable Energy Consumption and Foreign Direct Investment: Reports from Bangladesh," *Journal of Accounting* 8, no. 3 (2018): 72–87.
[75] Tasbirul Islam et al., "Current Energy Scenario and Future Prospect of Renewable Energy in Bangladesh," *Renewable and Sustainable Energy Reviews* 39 (2014): 1074–1088, https://doi.org/10.1016/j.rser.2014.07.149; Dipal C. Barua, "Strategy for Promotions and Development of Renewable Technologies in Bangladesh: Experience from Grameen Shakti," *Renewable Energy* 22, no. 1–3 (2001): 205–210.

requirements, overlapping licensing systems, and a mixture of online and offline procedures involving multiple agencies.[76] In practice, developers may require up to forty permits, clearances, and authorisations before commencing operations, resulting in significant delays and, in some cases, project abandonment even after Letters of Intent and PPAs are issued.[77] Delays in issuing Statutory Regulatory Orders, customs clearances, property registration, and land acquisition substantially increase project costs and uncertainty, discouraging foreign direct investment.[78]

4.2.7 *Grid and Technical Capacity Constraints in Renewable Energy Development*

Grid limitations and capacity gaps in technology and human resources represent critical structural weaknesses in Bangladesh's renewable energy sector. The existing transmission and distribution network is primarily designed for conventional fossil-fuel-based generation and has not been adequately upgraded to integrate distributed renewable energy systems.[79] Key constraints include the absence of smart distribution networks capable of handling bi-directional power flow, lack of grid capacity assessments for additional renewable integration, and the absence of standardised technical interconnection guidelines.[80] Large-scale projects face further challenges due to land scarcity, unsuitable project locations, and weak synchronisation between generation planning and transmission expansion, particularly in coastal and island regions.[81] Developers also struggle to access national grid data for feasibility studies, increasing project uncertainty.[82] Persistent transmission and distribution losses projected to remain above 10 per cent, along with rising production costs, further undermine efficient renewable integration.

From an investment and operational perspective, renewable projects encounter unequal grid access, additional connection costs, limited institutional capacity, and a financial sector unfamiliar with renewable technologies, weakening investor confidence.[83] Technological challenges such as intermittency, voltage and frequency stability issues, lack of large-scale storage deployment, and unresolved

[76] Moazzem and Bhuiyan, "Addressing Institutional Challenges in the Investment Cycle of the Renewable Energy Case of Chinese Overseas Investment".
[77] S. Aziz, S. A. Chowdhury, and M. Alauddin, "Investment risks and policy solutions for renewable electricity in Bangladesh," *Energy for Sustainable Development* 85 (2025): 101605.
[78] Karim et al., "Renewable Energy for Sustainable Growth and Development".
[79] Siddique et al., "Renewable Energy Sector in Bangladesh".
[80] Siddique et al., "Renewable Energy Sector in Bangladesh".
[81] Shahriar Ahmed Chowdhury, "Indicative Tariff for Utility-Scale Solar IPP in Bangladesh," *United Nations Development Programme (UNDP)* (Dhaka, 2018).
[82] Khondaker Golam Moazzem and Mashfiq Ahasan Hridoy, "Overseas Investment in Bangladesh's Renewable Energy Sector Case of Chinese Investment".
[83] Aziz, Chowdhury, and Alauddin, "Investment risks and policy solutions".

concerns regarding reactive power support, spinning reserves, and protection systems highlight limited preparedness for high renewable penetration.[84]

These grid challenges are compounded by broader capacity deficits in research, technology, and skilled human resources. Insufficient past research and fragmented, underfunded R&D activities have constrained technical support for the development, operation, and maintenance of renewable energy technologies.[85] The absence of domestic manufacturing for PV cells, converters, generators, storage systems, and related components has increased reliance on imported technologies.[86] Weak quality control, limited durability, inadequate storage infrastructure, and the absence of battery handling and disposal systems further undermine technological reliability.[87] Additionally, shortages of specialised engineers, project managers, R&D professionals, and quality assurance experts, along with limited training infrastructure and empirical knowledge, constrain innovation and effective renewable energy expansion[88].

4.2.8 *Land acquisition constraints for the Renewable Energy Sector of Bangladesh*

Land-related challenges pose a structural and persistent weakness to the growth of renewable energy in Bangladesh. Experts consistently identify land availability and acquisition as the single most critical constraint, characterising the process as costly, risky, legally complex, and excessively time-consuming. The prevalence of multiple ownership titles exposes investors to prolonged litigation, making large-scale solar and wind projects particularly vulnerable and discouraging foreign direct investment.

[84] Chowdhuri et al., "Current Challenges and Future Prospects of Renewable Energy"; Moazzem and Hridoy, "Overseas Investment in Bangladesh's Renewable Energy Sector Case".

[85] Pranjal Barman et al., "Renewable Energy Integration with Electric Vehicle Technology: A Review of the Existing Smart Charging Approaches," *Renewable and Sustainable Energy Reviews* 183 (2023): 113518; Mahmud and Roy, "Barriers to Overcome in Accelerating Renewable Energy Penetration in Bangladesh"; Akash et al., "Greening the Grid

[86] Siddique et al., "Renewable Energy Sector in Bangladesh: The Current Scenario, Challenges and the Role of IoT in Building a Smart Distribution Grid"; Islam, Islam, and Beg, "Renewable Energy Resources and Technologies Practice in Bangladesh".

[87] Mohammad Ziaur Rahman, "Multitude of progress and unmediated problems of solar PV in Bangladesh," *Renewable and Sustainable Energy Reviews* 16, no. 1 (2012): 466–473; Rafia Zaman and Thomas Brudermann, "Energy governance in resource-poor settings: The case of Bangladesh," *Energy Procedia* 142 (2017): 2384–2390,

[88] Alam Hossain Mondal and Manfred Denich, "Assessment of Renewable Energy Resources Potential for Electricity Generation in Bangladesh," *Renewable and Sustainable Energy Reviews* 14, no. 8 (2010): 2401–2413, https://doi.org/10.1016/j.rser.2010.05.006; Mahmud and Roy, "Barriers to Overcome in Accelerating Renewable Energy Penetration in Bangladesh"; Karim et al., "Renewable Energy for Sustainable Growth and Development"; Raihan et al., "Renewable Energy Resources for Green Development in Bangladesh

The situation is exacerbated by high population density, extensive dependence on agriculture, and the policy-driven protection of arable land. Most available land is designated for agricultural use, and the absence of clear guidelines distinguishing agricultural and non-agricultural land makes it difficult for investors to identify suitable sites.[89] The National Agriculture Policy 2018 further restricts the conversion of agricultural land for non-agricultural purposes, intensifying competition for limited non-cropped land and prolonging project approval timelines.

Large-scale renewable projects face additional threats due to their high land intensity, particularly solar farms requiring extensive contiguous land areas. Developers are often forced to acquire land in remote, flood-prone coastal or riverside regions with limited infrastructure and grid access, increasing both project costs and technical risks.[90] Moreover, land acquisition in these regions is complicated by social resistance, reluctance of landowners to sell or lease land, and climate-related vulnerabilities such as seasonal flooding and erosion.

Collectively, these factors, including complex land administration, restrictive land-use policies, social contestation, and geographic vulnerability, constitute a major threat to timely project implementation, cost efficiency, and long-term scalability of renewable energy development in Bangladesh.[91]

4.3 *Opportunity of RE sector in Bangladesh*

4.3.1 *Renewable Energy as a Pathway for Climate Action and Environmental Sustainability*

Renewable energy development offers Bangladesh a strategic opportunity to mitigate climate change and promote environmental sustainability by reducing greenhouse gas emissions and diversifying the national energy mix.[92] Deployment of solar, wind, biomass, and small-scale hydropower can lower emissions intensity,

[89] Siddique et al., "Renewable Energy Sector in Bangladesh".

[90] Hossain, Biswas, and Uddin, "Sustainable Energy Transition in Bangladesh".

[91] Siddique et al., "Renewable Energy Sector in Bangladesh"; Mahmud and Roy, "Barriers to Overcome in Accelerating Renewable Energy Penetration in Bangladesh"being a developing country, needs an uninterrupted electricity supply to sustain and expand economic growth. The government's strategic vision of 2021 and the international commitment under the Paris Agreement has meant to attract new capital investments for renewable electricity generation by diversifying energy blends, ranging from natural gas to more reliable coal technologies and renewable energy. To understand the practical implementation of such policies, this paper explores the key factors of the renewable energy (RE.

[92] Md Monirul Islam Chowdhury et al., "A review of policies and initiatives for climate change mitigation and environmental sustainability in Bangladesh," *Environment, Development and Sustainability* 23, no. 2 (2021): 1133–1161

support the country's Nationally Determined Contribution (NDC) targets, and enhance energy access in rural and off-grid areas.[93]

Favorable natural endowments including high solar irradiation, extensive river networks, and abundant biomass create strong potential for decentralised and community-based renewable systems such as rooftop solar PV, solar irrigation pumps, biogas digesters, and run-of-river micro-hydro, which provide sustainable energy solutions with minimal ecological disruption.[94] Integration of renewable energy into national energy and climate strategies, supported by policies like net metering, fiscal incentives, and institutions, such as SREDA and BERC, strengthens governance, policy coherence, and institutional coordination.[95]

Technological advancements, declining costs of solar PV, energy storage, and smart grids, combined with international climate finance and development partner support, present opportunities to overcome intermittency, integrate higher renewable shares into the grid, and reduce fiscal pressure from fossil fuel imports while supporting a just and environmentally sustainable energy transition.[96]

4.3.2 *Private Capital Mobilization and Foreign Investment*

Renewable energy development in Bangladesh presents strong opportunities through private sector participation, international investment, and supportive policy instruments. With limited government fiscal capacity to finance large-scale power expansion estimated at US$ 24 billion for generation alone, the mobilisation of Independent Power Producers (IPPs) and private capital has been central to national power planning. The adoption of the Private Sector Power Generation Policy has significantly increased the share of private power generation, demonstrating the sector's capacity to attract investment when enabling conditions exist.[97]

International investment and development cooperation further expand renewable energy prospects. Bangladesh has received interest and commitments from foreign investors and development partners, including China, Norway, Sweden,

[93] Ratan Kumar Das et al., "Feasibility of Micro-Hydro Power for Rural Electrification in Bangladesh: A Case Study from the Chittagong Hill Tracts," *Energy Engineering* 122, no. 12 (2025), https://doi.org/10.32604/ee.2025.071727; Islam, Islam, and Beg, "Renewable Energy Resources and Technologies Practice in Bangladesh".

[94] Islam, Islam, and Beg, "Renewable Energy Resources and Technologies Practice in Bangladesh"; Das et al., "Feasibility of Micro-Hydro Power for Rural Electrification in Bangladesh".

[95] Das et al., "Feasibility of Micro-Hydro Power for Rural Electrification in Bangladesh".

[96] Chowdhury et al., "A Review of Policies and Initiatives for Climate Change Mitigation and Environmental Sustainability in Bangladesh".

[97] T. Mahbub, "Energy in Bangladesh: From Scarcity to Universal Access," *ScienceDirect* 54 (2024): 1–24.

Denmark, Finland, France, the United States, and multilateral institutions, across solar, wind, rooftop solar, offshore wind, and grid infrastructure. Large pledges such as Norfund's US$ 1 billion renewable initiative and Denmark-led offshore wind projects create opportunities for technology transfer, risk-sharing, and long-term capital mobilisation.

Policy reforms can enhance investment attractiveness by withdrawing fiscal benefits for fossil-fuel power, rationalising subsidies, and providing consistent incentives such as value added tax (VAT) exemptions, tax holidays, microcredit support, and incentive tariffs. Emerging instruments like competitive procurement, merchant power plants, public-private partnerships, risk mitigation facilities, and dedicated renewable energy funds offer additional pathways to reduce costs, mobilise private capital, and overcome land and grid constraints.[98]

4.3.3 *Job Creation Driven by Renewable Energy*

The expansion of renewable energy in Bangladesh presents significant employment opportunities, particularly through solar energy deployment. The SHS programme, the largest globally, has installed around 5.8–6 million systems and generated over 100,000 jobs in installation, maintenance, sales, customer support, and after-sales services, directly benefiting more than 30 million people.[99] The initiative has also promoted rural employment by training local technicians, including women, while improving welfare, education, and agricultural productivity through enhanced access to electricity.[100]

Renewable energy development further offers inclusive and diversified employment opportunities, with increasing participation of women and youth. At least 20,000 green jobs have been created through SHS programs, including training

[98] Joshua Pearce et al., "A New Model for Enabling Innovation in Appropriate Technology for Sustainable Development ARTICLE for Sustainable Development," *Sustainability: Science, Practice and Policy ISSN:* 7733, no. December (2017), https://doi.org/10.1080/15487733.2012.11908095; Aziz, Chowdhury, and Alauddin, "Investment risks and policy solutions"; Mondal, Kamp, and Pachova, "Drivers, Barriers, and Strategies for Implementation of Renewable Energy Technologies in Rural Areas in Bangladesh—An Innovation System Analysis".

[99] Abdul K Hossain and Ossama Badr, "Prospects of Renewable Energy Utilisation for Electricity Generation in Bangladesh," *Renewable and Sustainable Energy Reviews* 11, no. 8 (2007): 1617–49; Md Nazmus Sakib and M A Matin, "Design of Mini-Grid for Solar Home Systems with NPV in Bangladesh," in *2023 International Conference on Electrical, Computer and Communication Engineering (ECCE)* (IEEE, 2023), 1–6.

[100] M K Bahauddin and T K SalahUddin, "Impact of Utilization of Solar PV Technology among Marginalized Poor People in Rural Area of Bangladesh," in *Proceedings of International Conference on Environmental Aspects of Bangladesh (ICEAB'10)*, 2010; Hossain, Hossain, and Uddin, "Renewable Energy: Prospects and Trends in Bangladesh".

of approximately 5,000 women as solar technicians.[101] Employment in renewable energy shows better gender balance compared to fossil fuel sectors, and women's participation in technical and engineering roles is gradually increasing.

At utility and commercial scales, growth in rooftop and grid-connected solar projects has created demand for skilled labour, including engineers, technicians, project managers, and analysts. Employment coefficients suggest that expanding renewable energy capacity will generate substantial jobs across residential, commercial, and utility-scale installations. Projections indicate that renewable energy-based power plants could create approximately 13,778 jobs by 2030, while increasing the renewable energy share to around 30 per cent of the energy mix could generate up to 37,000 new positions, provided adequate training and skill development.[102]

Bangladesh's ranking as the third in renewable energy employment in South Asia, coupled with national policies such as the Bangladesh Delta Plan 2100, IEPMP 2023, and the National Solar Energy Roadmap, underscores the potential for renewable energy to serve as a significant job creation frontier.

4.3.4 *Renewable Energy and Economic Growth*

Renewable energy development offers substantial economic growth opportunities for Bangladesh by improving energy access, productivity, and macroeconomic outcomes. Enhanced electricity availability from renewable sources supports micro- and small-scale enterprises such as rice mills, sewing workshops, and cold storage facilities, stimulating local economic activity and income generation.[103] Projects also generate employment across construction, operation, monitoring, and maintenance phases, contributing to both short- and long-term economic activity.[104]

Empirical studies indicate a positive relationship between renewable energy consumption and economic growth. Econometric analyses reveal long-run causal linkages from GDP to renewable energy consumption and vice versa, highlighting that increased adoption of renewable energy fosters sustained economic expansion.[105]

[101] Bahauddin and SalahUddin, "Impact of Utilization of Solar PV Technology among Marginalized Poor People in Rural Area of Bangladesh".
[102] Moazzem et al., "Stakeholders' Perspectives on Key Challenges of the Power Sector Level of Stakeholders' Engagement in the Formulation of Master Plans".
[103] Das et al., "Feasibility of Micro-Hydro Power for Rural Electrification in Bangladesh".
[104] Das et al., "Feasibility of Micro-Hydro Power for Rural Electrification in Bangladesh".
[105] Md. Safiullah Kayesh and Ashma Siddiqa, "The Impact of Renewable Energy Consumption on Economic Growth in Bangladesh : Evidence from ARDL and VECM Analyses," *International Journal of Energy Production and Management* 8, no. 3 (2023): 149–160.

Renewable energy also reduces environmental externalities linked to growth. While economic growth tends to increase carbon emissions, greater renewable energy use significantly lowers CO_2 emissions, promoting environmentally sustainable development.[106] Sectoral benefits include cost savings and efficiency gains from rooftop solar, reduced reliance on imported fossil fuels, and fiscal savings for the government and private sector, enhancing industrial competitiveness and freeing resources for productive investment.

Inclusive economic opportunities arise in rural areas and for women, as access to electricity reduces time spent on biomass collection and enables engagement in education, skills development, and income-generating activities.[107] Additionally, renewable energy investment can address structural inefficiencies in the power sector, reduce fiscal strain from fossil fuel dependency, and enhance energy security, positioning renewable energy as a key driver of Bangladesh's sustainable economic transition.[108]

4.4 *Threats of RE sector in Bangladesh*

4.4.1 *Environmental Risks and Climate Vulnerability to Renewable Energy Expansion*

Despite its potential, renewable energy development in Bangladesh faces several external threats that may undermine its effectiveness and social acceptance. Climate change poses a significant threat to renewable energy reliability. Solar, wind, hydro, and biomass energy production are highly sensitive to climatic variables such as solar irradiation, rainfall, wind speed, and temperature. Increasing climate variability manifested through droughts, floods, cyclones, and extreme heat can disrupt renewable energy generation, damage infrastructure, and reduce system stability, particularly in Bangladesh's climate-vulnerable coastal and riverine regions.[109]

Social and political opposition to renewable energy projects represents another critical threat. Evidence from large-scale solar power installations indicates

[106] Raihan et al., "Renewable Energy Resources for Green Development in Bangladesh".
[107] Islam, Islam, and Beg, "Renewable Energy Resources and Technologies Practice in Bangladesh".
[108] Govinda R Timilsina and Sheoli Pargal, "Economics of Energy Subsidy Reforms in Bangladesh," *Energy Policy* 142 (2020): 111539, https://doi.org/10.1016/j.enpol.2020.111539.
[109] Md. Riyda Hasan Mojumder, M. Hasanuzzaman, and Erdem Cuce, "Prospects and Challenges of Renewable Energy-based Microgrid System in Bangladesh: A Comprehensive Review," *Clean Technologies and Environmental Policy* 22 (2022): 1987–2009; Chowdhury et al., "A Review of Policies and Initiatives for Climate Change Mitigation and Environmental Sustainability in Bangladesh".

rising resistance from local communities and environmental groups due to land acquisition disputes, loss of agricultural land, displacement, and inadequate compensation mechanisms. Allegations of forced land acquisition, governance failures, and environmental damage have the potential to delay projects, increase transaction costs, and erode public trust in renewable energy initiatives, threatening long-term sustainability and scalability.

Finally, weak institutional capacity and fragmented policy implementation continue to threaten renewable energy expansion. Although policies and targets exist, inconsistent enforcement, limited technical expertise, and insufficient coordination among key institutions constrain effective governance of the renewable energy climate nexus.[110] Without addressing these governance and social challenges, renewable energy development risks reproducing the same environmental and political conflicts historically associated with conventional energy projects.

4.4.2 *Financial Risk Exposure and Declining Investor Confidence*

Renewable energy investment in Bangladesh faces serious external threats arising from policy volatility, sovereign and currency risks, and weakening investor confidence. Abrupt policy reversals such as the cancellation of 31 renewable energy projects initiated under the repealed Quick Enhancement of Electricity and Energy Supply Act have heightened perceptions of regulatory unpredictability and contractual risk. The removal of implementation agreements, previously treated as de facto sovereign guarantees, has made project developers reluctant to participate in new tenders due to difficulties in securing debt finance.

Macroeconomic and financial risks further threaten investment flows. Bangladesh's sovereign credit rating downgrade from B1 to B2 has increased borrowing costs and reduced access to affordable foreign capital for renewable energy projects. Currency volatility poses an additional risk, as sharp depreciation of the Bangladeshi Taka increases the cost of servicing foreign-denominated debt while project revenues remain in local currency.[111] These risks are compounded by BPDB's financial distress, rising subsidy burdens, and counterparty risk, which undermine investor confidence in long-term power purchase agreements.

Structural constraints particularly land scarcity, fragmented ownership, and high acquisition costs represent persistent threats to utility-scale renewable energy development in a densely populated, agriculture-dependent country. Capex-heavy

[110] Anutosh Das et al., "Navigating the Energy Policy Landscape of Bangladesh : A Stern Review And," *Energy Strategy Reviews* 52, no. March (2024): 101336, https://doi.org/10.1016/j.esr.2024.101336.
[111] Aziz, Chowdhury, and Alauddin, "Investment risks and policy solutions".

projects with long payback periods are poorly matched with Bangladesh's short-term lending structure and underdeveloped capital market, limiting the participation of institutional investors such as pension funds and insurance companies. Declining competition in renewable energy tenders, cancellations of approved projects, and persistent bureaucratic inefficiencies risk further discouraging foreign and domestic investors at a time when large-scale private investment is essential to meet national renewable energy targets.

4.4.3 *Renewable Energy Security in Bangladesh*

Renewable energy security in Bangladesh is threatened by persistent energy leakage within the power system, despite improvements in transmission and distribution (T&D) efficiency. Although T&D losses declined from 32 per cent in 1999–2000 to 14 per cent by 2014, technical losses continue due to inefficient distribution systems, ageing infrastructure, resistance in equipment and power lines, and limited grid modernisation investments.[112] Commercial losses linked to electricity theft, inefficient billing, and non-payment further undermine system reliability and financial sustainability, posing risks to the integration of renewable energy into the grid.[113]

The security of renewable energy availability is also under threat due to weaknesses in the power network and governance instability. The power network in Bangladesh remains insecure, with energy theft still occurring at relatively high levels.[114] Emerging risks associated with the increasing penetration of IoT devices, including hacking and denial-of-service (DoS/DDoS) attacks, present additional threats to the reliable operation of renewable energy systems.[115] Furthermore, policy uncertainty following the High Court's cancellation of key provisions of the Quick Enhancement of Electricity and Energy Supply Act in November 2024, and the subsequent decision by the Power Development Board to halt power purchases from solar companies, has created uncertainty regarding the continuity and security of renewable energy projects.[116]

Renewable energy security is further threatened by the limited accuracy, accessibility, and validation of renewable energy resource data. Information on renewable energy potential remains fragmented, with limited region-wise and

[112] Mahbub, "Energy in Bangladesh: From Scarcity to Universal Access"; Sarker et al., "Analysis of the Power Sector in Bangladesh.
[113] Karim et al., "Renewable Energy for Sustainable Growth and Development".
[114] Siddique et al., "Renewable Energy Sector in Bangladesh".
[115] Siddique et al., "Renewable Energy Sector in Bangladesh".
[116] Moazzem and Bhuiyan, "Addressing Institutional Challenges in the Investment Cycle of the Renewable Energy Case".

seasonal variation data available to developers and policymakers.[117] The absence of a centralised and nationally validated database of resource assessments constrains informed investment and planning decisions[118]. Although feasibility studies and satellite-based assessments exist, the lack of government validation and detailed seasonal data particularly in disaster-prone coastal areas poses a continuing threat to the secure deployment of renewable energy projects.[119]

Table-2: SWOT Table Based on the Findings

Strengths	Weaknesses
Favorable natural conditions (high solar irradiation 4.0–6.5 kWh/m²/day, ~300 sunny days/year)	Variability in climatic conditions limiting wind and solar reliability
Significant wind energy potential (>30,000 MW) along 724 km coastline and 50+ islands	Average wind speed (3–5 m/s) below threshold for efficient electricity generation
Hydropower contribution via Kaptai Plant (230 MW, 24% of RE generation)	Hydropower constrained by flat terrain and seasonal water flow variability
Biomass as second-largest energy source (~70% of energy consumption)	Limited awareness and low social acceptance among public, industries and policymakers
Established institutional framework (SREDA, BPDB, IDCOL, BERC)	Fragmented institutional arrangements and weak inter-agency coordination
Successive supportive policy instruments (RE Policy 2008 & 2025, MCPP, Delta Plan 2100)	Policy inconsistency between ambitious RE targets and core planning documents (PSMP, IEPMP)
Rapidly growing electricity demand (peak demand projected 27,400–51,000 MW by 2030–2041)	Persistent supply-demand gap despite installed capacity exceeding 28,000 MW

[117] Siddique et al., "Renewable Energy Sector in Bangladesh"; Homeyra Akter, Harun Or Rashid Howlader, Akito Nakadomari, Md. Rashedul Islam, Ahmed Y. Saber, and Tomonobu Senjyu, "A Short Assessment of Renewable Energy for Optimal Sizing of 100% Renewable Energy Based Microgrids in Remote Islands of Developing Countries: A Case Study in Bangladesh," *Energies* 15, no. 3 (2022): 1084.

[118] Mozaharul Alam, Atiq Rahman, and Muhammed Eusuf, "Diffusion Potential of Renewable Energy Technology for Sustainable Development: Bangladeshi Experience," *Energy for Sustainable Development* 7, no. 2 (2003): 88–96; Syed Masiur Rahman and A N Khondaker, "Mitigation Measures to Reduce Greenhouse Gas Emissions and Enhance Carbon Capture and Storage in Saudi Arabia," *Renewable and Sustainable Energy Reviews* 16, no. 5 (2012): 2446–2460; Islam et al., "Current Energy Scenario and Future Prospect of Renewable Energy in Bangladesh".

[119] Hossain, Biswas, and Uddin, "Sustainable Energy Transition in Bangladesh".

Strengths	Weaknesses
Favorable natural conditions (high solar irradiation 4.0–6.5 kWh/m²/day, ~300 sunny days/year)	Variability in climatic conditions limiting wind and solar reliability
Stakeholder engagement through Grameen Shakti and BRAC programmes	Heavy fossil fuel dependency (>90% of grid electricity from gas, oil, and coal)
Grid connectivity and expanding RE capacity	High initial capital costs and limited access to long-term finance
Growing technical and expert capacity in RE sector	Bureaucratic complexity requiring up to 40 permits for project approval
	Lethargic grid connection and absence of smart distribution networks
	Land acquisition constraints in a densely populated, agriculture-dependent country
Opportunities	**Threats**
Renewable energy as pathway for climate action and NDC target achievement	Environmental risks from life-cycle impacts of RE technologies (habitat loss, pollution)
Declining global costs of solar PV, energy storage, and smart grid technologies	Climate vulnerability (cyclones, floods, droughts) disrupting RE infrastructure
Strong potential for private capital mobilisation and Foreign Direct Investment (FDI)	Social and political opposition due to land acquisition disputes and displacement
Interest from international development partners (China, Norway, Denmark, USA, multilaterals)	Financial risks from policy volatility and cancellation of 31 RE projects
Large pledges including Norfund's US$1 billion renewable initiative	Sovereign credit rating downgrade (B1 to B2) increasing borrowing costs
Significant job creation potential (up to 37,000 jobs at 30% RE share)	Currency depreciation increasing cost of foreign-denominated debt servicing
SHS programme generating 100,000+ jobs and benefiting 30 million people	Persistent energy leakage and T&D losses undermining grid reliability

Strengths	Weaknesses
Favorable natural conditions (high solar irradiation 4.0–6.5 kWh/m²/day, ~300 sunny days/year)	Variability in climatic conditions limiting wind and solar reliability
Positive relationship between RE consumption and GDP growth	Cybersecurity threats (hacking, DoS/DDoS attacks) to IoT-integrated RE systems
Inclusive economic growth opportunities for rural communities and women	Limited accuracy and fragmented RE resource data constraining investment planning
Availability of long coastline (724 km) and landmass for large-scale RE deployment	Weak institutional capacity and inconsistent policy enforcement
International climate finance and development partner support	BPDB financial distress and rising subsidy burdens undermining investor confidence

5. Concluding Remarks

Bangladesh's renewable energy sector is strengthened by favorable natural resource conditions, established institutional arrangements, rising energy demand, supportive policy recognition, expanding grid connectivity, and increasing technical and expert capacity. The weaknesses include variability in climatic conditions, lack of awareness and social acceptance among the community, lack of subsidy in the RE, higher unit cost, fragmented institutional arrangement, gap between supply and demand, high initial cost, policy inconsistency, capacity constraints and lethargic grid connection. The renewable energy sector presents significant opportunities, including positive contributions to climate change mitigation, job creation, and overall economic growth. The sector also has strong potential to attract foreign investment. Key threats to the sector include environmental risks and climate vulnerability, exposure to financial risks and declining investor confidence, challenges to renewable energy security, and conflicts related to land acquisition.

The present study has some limitations. First, it relies primarily on secondary data sources. Second, SWOT analysis by its nature captures a snapshot of the renewable energy sector at a particular point in time. Third, the analysis treats Bangladesh as a broadly uniform context without sufficiently accounting for regional variations in renewable energy potential, infrastructure availability,

and socioeconomic conditions across different divisions and districts of the country. Finally, while the study covers the principal renewable energy sources including solar, wind, hydropower, and biomass, emerging technologies such as offshore wind, tidal energy, and green hydrogen, are not fully explored within the scope of this analysis. Based on the findings of the study, the following recommendations can be made:

1. Develop a RE policy managing the utilization of the potential strengths of the RE sources integrated with the GHG mitigation policy.

2. Define the priority based future power project policy for clean and green energy sources.

3. In the land acquisition process, especially for private land, the Sustainable and Renewable Energy Development Authority (SREDA) should play monitoring role in coordination with local land offices to safeguard the rights of both project developers and landowners. Additionally, existing legal constraints such as restrictions on individuals acquiring large tracts of land (e.g., 100 bighas) should be revisited and reviewed to facilitate project implementation while maintaining regulatory balance.

4. Strengthen the one window facility for the private investors in the RE sector. Policy related to investment in renewable energy sector should be made stable and coherent across the regimes to boost up the confidence of investors.

5. Introduce some lucrative subsidies and incentives for the off-grid and on-grid power projects.

6. The government need to simplify the legislation and licensing policy for renewable energy projects.

7. Strengthen coordination between SREDA and major agencies such as the Ministry of Power, Energy and Mineral Resources, Bangladesh Power Development Board, and Bangladesh Energy Regulatory Commission. In this regard, an inter-agency renewable energy coordination platform should be created to reduce overlapping mandates and policy fragmentation.

8. Strengthen the SREDA's capacity in terms of technical, financial, and human resource to design, implement, and monitor renewable energy programmes and also to increase its administrative autonomy so that SREDA can make timely regulatory and project decisions.

9. Take initiatives to build public awareness and consumers' confidence in renewable technologies. Local governments and civil society can play the leading role in this regard.