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Bangladesh's Electricity Growth: Is Bangladesh Truly Advancing in Renewable Energy?

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Abstract

This study analyzes Bangladesh's electricity growth trends with a focus on renewable energy development over the past two decades. Descriptive statistical methods, including linear trends, were employed to assess growth rates, percentage contributions, and global rankings of renewable and non-renewable energy capacities. Data from International Renewable Energy Agency (IRENA) (2000–2023) were utilized. Key variables, such as installed capacities and energy source contributions, were categorized by type (solar, hydro, wind, bioenergy) and grid status (on-grid, off-grid). The results reveal an annual growth rate of 1,012.57 MW for non-renewable energy and 33.73 MW for renewable energy, highlighting the disparity in development. Renewable energy's share in total capacity declined from 5.23% in 2000 to 3.53% in 2023. Solar energy dominates Bangladesh's renewable capacity (76.32%), followed by hydropower (22.87%). However, the country ranks 39th globally in total electricity capacity but only 107th in renewable capacity, reflecting limited progress in diversifying renewable sources. The findings emphasize the need for strategic policy interventions to enhance renewable energy development in Bangladesh.

Keywords
Energy Sector Analysis, Renewable Energy, Bangladesh Energy Capacity, Electricity Growth Trends, Sustainability

1. Introduction
Globally, renewable energy is key to reducing carbon emissions, mitigating climate change, and achieving the Sustainable Development Goals (SDGs), particularly SDG 7, which promotes affordable and clean energy (Siraj et al. 2024). Unlike fossil fuels, renewable sources such as solar, wind, and hydropower produce minimal greenhouse gases, making them essential for limiting global warming and its associated impacts. For Bangladesh, the significance of renewable energy is even more pronounced due to the country's vulnerability to climate change and reliance on imported fossil fuels (Bari et al. 2022). Expanding renewable energy reduces dependency on energy imports, enhances energy security, and contributes to economic growth by creating jobs in emerging green sectors (Debnath et al. 2023). Furthermore, utilizing the country's ample solar and wind resources can address the growing energy demands while promoting sustainable development and reducing environmental degradation.However, Bangladesh struggles to succeed in renewable energy development due to inadequate infrastructure, limited financing, and policy implementation gaps (Siraj et al. 2022). Additionally, reliance on conventional energy sources and slow adaptation of advanced technologies hinders the full utilization of its abundant solar and wind resources.

From 2000 to 2023, Bangladesh's total installed electricity capacity increased from 4,396 MW to 28,460 MW, representing an impressive growth of approximately 550%. However, the picture is less encouraging when examining

the progress in renewable energy. By 2023, installed renewable energy capacity reached only 1,005 MW, up from 230 MW in 2000—making up a mere 3.5% of the total installed capacity. This figure underscores that Bangladesh has not achieved even the minimum level of renewable energy development expected for sustainable growth.In March 2022, Bangladesh announced that all citizens had access to electricity, although most of this energy was generated from fossil fuels (Majumder et al. 2023). Yet, recent reports from renowned Bangladeshi newspapers such as Prothom Alo, Dhaka Tribune, and The Business Standard have highlighted persistent load-shedding issues despite the numerous fossil fuel-based power plants across the country (Mohiuddin 2024, Rita 2024, Shishir 2024). These reports point to two primary challenges: disruptions in fossil fuel supply caused by natural disasters, geopolitical tensions, or local economic crises, as Bangladesh heavily relies on imported fossil fuels, and unequal distribution of load-shedding, with rural areas facing more significant difficulties compared to urban centers. This uneven distribution raises an important question: Is electricity in Bangladesh genuinely affordable and accessible for all?

Moreover, these challenges cast doubt on whether Bangladesh is on the right path to achieving SDG 7, which calls for affordable and clean energy—an outcome fossil fuels cannot deliver. In this context, this paper will explore the following research questions:
a. What is Bangladesh's position in the global landscape regarding electricity installed capacity from 2000 to 2023?
b. What are the actual trends in renewable energy growth in Bangladesh?

To address these research questions, this paper aims to analyze secondary data from the International Renewable Energy Agency (IRENA) using descriptive statistics to gain insights that can help determine Bangladesh's actual position in the global renewable energy landscape, assess its growth trends, and fill the existing gaps in the literature.

1.1 Objectives

This research aims to achieve the following objectives to contribute to the literature on renewable energy in Bangladesh:

1. Examine trends in Bangladesh's electricity capacity growth.
2. Assess Bangladesh's global renewable energy ranking.
3. Analyze the composition of Bangladesh's renewable energy.

2. Literature Review

Renewable energy adoption has become a global imperative to address challenges associated with fossil fuel dependency, environmental degradation, and energy sustainability. Numerous studies have explored various aspects of renewable energy implementation, barriers, and growth trends, providing valuable insights for developing countries like Bangladesh in shaping their energy policies and strategies. This section reviews the key findings from relevant studies and positions the current research within the existing body of literature.Mohazzem Hossain et al. (2024) highlights Bangladesh's energy challenges, including resource scarcity, high fuel costs, and the instability of gas-based electricity generation. The study advocates for renewable energy adoption to ensure a sustainable energy future. It emphasizes the need for policy reforms, infrastructure development, research, and community engagement to overcome barriers such as limited infrastructure and high investment requirements. While this study provides a broad analysis of challenges and solutions, it does not examine historical growth trends or compare Bangladesh's renewable energy status to global benchmarks, as the current research addresses.

Saeed and Siraj (2024) investigate global renewable energy capacity distribution, revealing that 15 countries, including China, the USA, and Brazil, account for over 80% of global capacity, with solar, hydropower, and wind as the dominant contributors. The study highlights significant disparities in renewable energy adoption and the need for region-specific policies to ensure equitable development, aligning with SDG 7. However, this research focuses on global trends and policy implications, contrasting with the current study's localized evaluation of Bangladesh's electricity growth, its global renewable ranking, and the composition of its renewable energy sources.Payel et al. (2023) identifies barriers to solar energy implementation in emerging economies, using the DEMATEL method to analyze 13 key challenges. The findings highlight 'High upfront costs' and 'Limited access to land and resources for large-scale projects' as critical barriers, with 'Limited access to financing' as the least significant. While the study provides actionable insights for overcoming these barriers, it focuses solely on solar energy and lacks the broader,

multi-source perspective provided in this research, which examines Bangladesh's renewable energy trends and composition across various sources.

Debnath et al. (2023) employs an integrated MCDM approach combining IVT2IF theory and DEMATEL to identify factors influencing wind energy adoption in Bangladesh. The study finds 'Fossil fuel supply disruption,' 'Stable financial investment,' and 'Geographical region' as the most significant factors, offering long-term grid sustainability and carbon neutrality strategies. However, this research focuses exclusively on wind energy, whereas the current study examines Bangladesh's overall renewable energy landscape, including trends, rankings, and source compositions. Finally, Siraj et al. (2022) uses the DEMATEL method to analyze challenges to renewable energy adoption in developing countries. The study identifies 'Large land requirement,' 'Uncertain supply,' and 'End-of-life management difficulties' as prominent barriers, with 'Long economic recovery periods' as the most causative factor. While it provides valuable insights for policymakers, its generalized focus on barriers across developing nations contrasts with the current research's focus on Bangladesh's electricity capacity growth and renewable energy progress.

While existing studies address global renewable energy trends, barriers, and specific energy sources like solar and wind, none have comprehensively examined Bangladesh's electricity growth trends, global ranking, and renewable energy composition. The current research fills this gap, offering a localized and data-driven perspective on Bangladesh's renewable energy progress within the global landscape.

3. Methods

This research applies descriptive statistical methods to analyze the trends and comparative metrics of Bangladesh's renewable and non-renewable energy capacities over the past two decades. The study focuses on identifying growth patterns, global rankings, and contributions of different renewable energy sources to assess Bangladesh's renewable energy development in the global context. The linear growth trend of renewable and non-renewable capacities was analyzed using the slope formula from linear regression (Equation 1). The calculated slope identifies the rate of change for renewable and non-renewable capacities in Bangladesh.

$$Slope = \frac{C_{end} - C_{start}}{n} \quad (1)$$

Where,

C_{start} and C_{end} are capacities at the beginning and end of the period.
n is the number of years in the study period.

The percent contribution of renewable energy in total installed capacity was calculated for each year using Equation 2. This method tracks the share of renewable energy in Bangladesh's energy mix over time.

$$P_{REN} = \frac{C_{REN}}{C_{REN} + C_{NONREN}} \times 100 \quad (2)$$

Where,

P_{REN} is the percentage contribution of renewable energy in the total capacity.
C_{REN} is the total installed capacity of renewable energy.
C_{NONREN} is the total installed capacity of non-renewable energy.

Equation 3 evaluated the contributions of various renewable energy sources (e.g., solar, hydro) to Bangladesh's renewable capacity.

$$P_j = \frac{C_j}{\sum_{j=1}^{n} C_j} \times 100 \quad (3)$$

Where,

C_j is the is the capacity of source j.
$\sum_{j=1}^{n} C_j$ is the total capacity of all renewable sources.

Bangladesh's global position in renewable energy was determined by ranking its total renewable capacity and individual source capacities (solar, hydro). Rankings were compared with global totals to provide context.

Specific energy types (e.g., on-grid vs. off-grid solar and mixed hydro plants) were analyzed to identify unique trends in Bangladesh. For example:

$$P_{ON} = \frac{C_{ON}}{C_{SOLAR}} \times 100 \quad (4)$$

Where,

C_{ON} is the on-grid solar capacity.
C_{SOLAR} is the total solar capacity.

Similarly, the share of renewable hydro was determined to highlight Bangladesh's focus on fully renewable hydro plants.The analysis results were visualized using line charts to show growth trends of renewable and non-renewable capacities, and bar and pie charts to illustrate the contributions of different renewable sources and their comparisons.

4. Data Collection

The research utilized secondary data from the IRENA, encompassing annual statistics on renewable and non-renewable energy capacities, energy source contributions, and global energy rankings (IRENA, 2024). The data were cleaned to ensure consistency and completeness, with missing values addressed through interpolation or exclusion based on relevance. Key variables, including installed capacities, growth rates, and percentage contributions of renewable sources, were extracted and categorized by energy type (e.g., solar, hydro, wind, bioenergy) and grid status (on-grid and off-grid). The data were organized into structured datasets for trend analysis, percentage calculations, and comparative global assessments. The data prepared for analyzing electricity installed capacity in Bangladesh from 2000 to 2023 is presented in Table 1.

Table 1. Electricity installed capacity in Bangladesh

Year	Non-Renewable (MW)	Renewable (MW)	Total (MW)
2000	4166	230.007	4396.007
2001	4543	230.01	4773.01
2002	5103	230.048	5333.048
2003	5249	230.621	5479.621
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2021	23247	743.967	23990.967
2022	24633	762.253	25395.253
2023	27455	1005.693	28460.693

In 2023, country-wise data on electricity installed capacity from renewable energy and total energy, prepared to determine Bangladesh's position in the global sphere, is presented in Table 2 and Table 3. The IRENA report includes some entities labelled as countries, although they are not independent nations according to the United Nations (UN). The report reflects sovereign states, territories, regions, and entities with distinct energy reporting. These entities are often included because they maintain separate energy policies or statistics, contributing to a more comprehensive and granular global energy analysis. For example, territories such as Hong Kong or Puerto Rico are listed alongside countries to provide detailed insights into energy capacities at all administrative levels.

Table 2. Country-wise electricity installed capacity in 2023

Country	Total (MW)
China	2920666.250
United States of America (the)	1222036.491
India	504608.956
Japan	360694.000
Russian Federation (the)	273408.070
Germany	263828.000
Brazil	226446.578
Canada	156976.975
Republic of Korea (the)	156083.538
France	151545.737
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Bangladesh	28460.693
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Tuvalu	6.964
Niue	3.025
Tokelau	1.200
South Georgia and the South Sandwich Islands	0.316

Table 3. Country-wise electricity installed capacity in 2023 from renewable sources

Country	Renewable (MW)
China	1453701.250
United States of America (the)	387548.591
Brazil	194084.662
India	175928.991
Germany	166939.000
Japan	127327.500
Canada	108763.705
Spain	80136.157
France	69301.346
Italy	65157.068
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Bangladesh	1005.693
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Niue	0.941
Timor-Leste	0.766
South Georgia and the South Sandwich Islands	0.186
Saint Barthélemy	0.062

Data on electricity installed capacity from various renewable sources in Bangladesh for 2023 has also been compiled and is presented in Table 4. In this table, on-grid and off-grid electricity data are also separated.

Table 4. Renewable source-wise electricity installed capacity (MW) in Bangladesh

Renewable Sources	Off-grid electricity	On-grid electricity	Total
Solar energy	173.225	594.218	767.443
Hydropower	0	230	230
Bioenergy	5.35	0	5.35
Wind energy	2	0.9	2.9
Total	**180.575**	**825.118**	**1005.693**

Since all of Bangladesh's electricity installed capacity from renewable sources comes from Solar, Hydro, Bio, and Wind, global data for electricity installed capacity from these sources has also been compiled to analyze Bangladesh's position in each category.

5. Results and Discussion

5.1 Numerical Results

Using Equation 1 and 2, after analyzing the data from Table 1, this research found that the annual growth rate for non-renewable energy is approximately 1,012.57 MW per year over the analyzed period, while the annual growth rate for renewable energy is approximately 33.73 MW per year, indicating a much slower increase compared to non-renewable energy. Between 2000 and 2023, Bangladesh's total renewable installed capacity increased from 230 MW to 1,005.693 MW (with a linear upward trend starting from 2005). In contrast, non-renewable capacity grew from 4,166 MW to 27,455 MW. Consequently, the percentage of renewable energy in the total installed capacity declined from 5.23% in 2000 to 3.53% in 2023.

Analyzing Tables 2 and 3, the results show that in 2023, Bangladesh's total electricity installed capacity is 28,460.693 MW, ranking 39th globally out of a total of 8,963,243.916 MW. However, Bangladesh ranks 107th in renewable energy with a capacity of 1,005.693 MW, compared to the global total renewable electricity capacity of 3,869,704.713 MW. This disparity highlights a lack of continuous improvement in Bangladesh's renewable energy sector.

Using Equations 3 and 4, the analysis of Table 4 reveals that solar energy dominates Bangladesh's renewable capacity, contributing over three-quarters (76.32%) of the total renewable capacity. Hydropower is the second-largest contributor (22.87%) and is entirely on-grid. Bioenergy and wind energy have negligible contributions (0.53% and 0.29%, respectively) to the total renewable capacity. On-grid electricity constitutes the majority (82.04%) of the renewable capacity, while off-grid electricity accounts for only 17.96%.

Further analysis reveals that Bangladesh ranks 56th globally in solar energy, 106th in hydropower, and 107th in overall renewable energy. This indicates that only solar energy has shown growth over time, while other renewable sources have not received adequate attention from the country's policymakers and energy sector.

5.2 Graphical Results

Figure 1 shows the growth of electricity installed capacity in Bangladesh over the years. It illustrates that the increase in installed capacity from renewable energy sources is significantly lower than that from non-renewable sources.

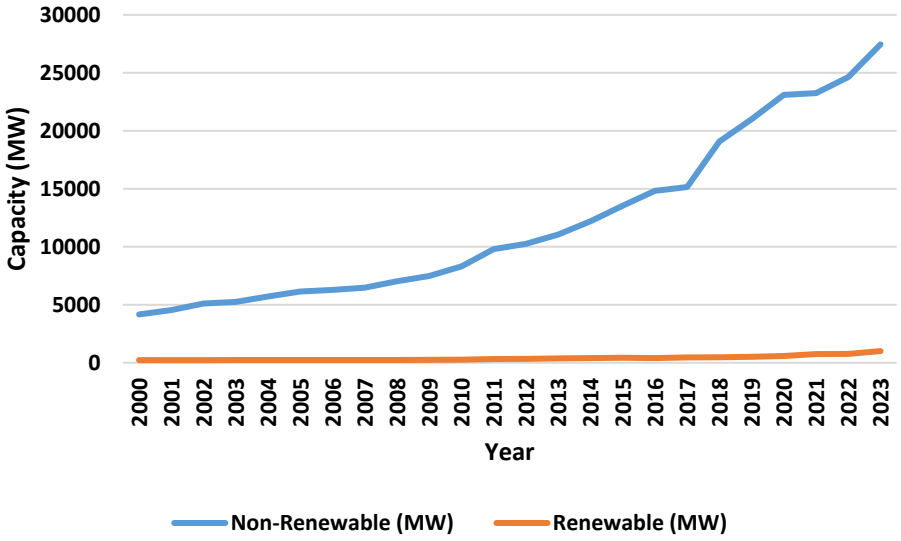

Figure 1. Electricity installed capacity growth in Bangladesh over the years

Figure 2 highlights the significant dominance of a single energy source in terms of installed capacity, with solar energy making the largest contribution.

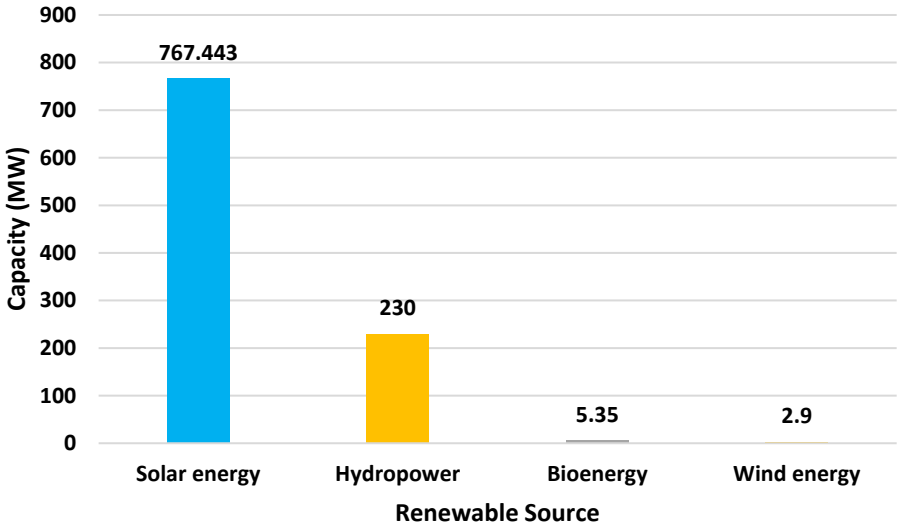

Figure 2. Installed capacity of renewable energy sources in Bangladesh, 2023

Figure 3 highlights the distribution of total renewable capacity into off-grid and on-grid systems, with on-grid capacity forming the majority.

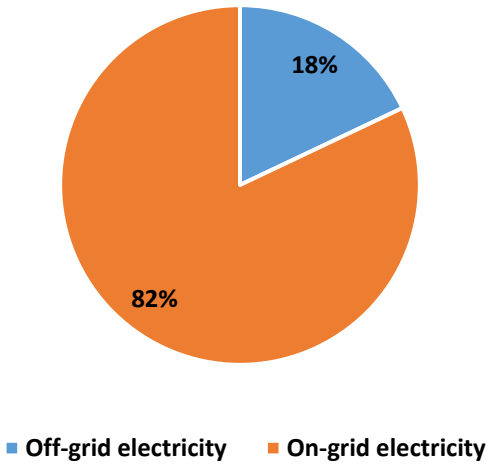

Figure 3. Comparison of On-Grid and Off-Grid Electricity Installed Capacity from Renewable Sources

5.3 Proposed Improvements

Several improvements are essential to accelerate renewable energy growth in Bangladesh. The study reveals that solar energy dominates the country's renewable capacity, contributing over three-quarters of the total, while bioenergy and wind energy collectively account for less than 1%. This underscores the urgent need to diversify into other renewable sources to enhance energy security and reduce reliance on solar energy alone. Policy reforms, such as targeted subsidies and tax incentives, are crucial to promote private sector investment and encourage the adoption of underutilized sources like wind and bioenergy. Infrastructure development is equally important, with on-grid capacity

forming over 82% of the total renewable capacity. Strengthening both on-grid and off-grid systems, alongside investments in smart grid technologies, would ensure better integration and management of renewable energy. Furthermore, promoting floating solar plants and rooftop systems can help mitigate land constraints while maximizing solar energy generation. Access to affordable financing options, such as green loans, will also be vital to support the large-scale adoption of renewable technologies. These measures can help reverse the current trend, where the renewable share in total installed capacity has declined from 5.23% in 2000 to 3.53% in 2023, despite an increase in absolute capacity.

While comprehensive, this study's reliance on secondary data limits its ability to capture specific local conditions or the latest technological advancements. Although effective in identifying trends, descriptive statistical methods do not support predictive modeling or scenario analysis for future energy development. Incorporating primary data collection and advanced forecasting techniques could offer a deeper understanding of Bangladesh's potential growth trajectories in renewable energy. Moreover, the study focuses on growth trends and contributions but does not assess socio-economic or environmental impacts, which are critical for understanding the broader implications of renewable energy adoption. Future research could integrate multi-criteria decision-making frameworks to evaluate these impacts and guide more comprehensive policy and investment strategies. Addressing these methodological limitations would improve the study's applicability and contribute to more robust decision-making for Bangladesh's renewable energy sector.

6. Conclusion

The findings of this study address the research gap identified at the outset, which highlights the lack of a comprehensive understanding of Bangladesh's renewable energy growth trends and its global standing in electricity capacity. The results reveal that while Bangladesh has made significant strides in increasing its overall electricity installed capacity, the progress in renewable energy development remains disproportionately low. The decline in the percentage contribution of renewables, from 5.23% in 2000 to 3.53% in 2023, underscores the persistent challenges in achieving sustainable energy growth.The study's objectives of examining electricity capacity growth, assessing global rankings, and analyzing the composition of renewable energy sources have been systematically addressed. The analysis demonstrates that solar energy dominates Bangladesh's renewable portfolio, contributing over three-quarters of the total renewable capacity, with negligible bioenergy and wind energy contributions. Furthermore, the country's global ranking in renewable energy capacity (107^{th}) is significantly lower compared to its total electricity capacity ranking (39^{th}), indicating a stark disparity in its renewable energy advancement.

These insights align with the study's aim of highlighting Bangladesh's inadequate focus on renewable energy development. The findings emphasize the need for policymakers to prioritize renewable energy expansion to bridge the gap between Bangladesh's overall electricity growth and its renewable energy contributions. Closing this gap is essential for achieving the objectives of SDG 7 and promoting long-term energy sustainability.This study lays a foundation for future research and policy interventions by highlighting the dominant reliance on solar energy and the limited growth of other renewable sources. To achieve a balanced and sustainable energy mix, targeted efforts to diversify renewable energy investments and enhance off-grid systems are essential. These strategies will enable Bangladesh to improve its global renewable energy standing, mitigate the impacts of climate change, and promote energy equity.

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