



Resources Diversification in Bangladesh's Electricity Generation: A Study on the Role of Renewable Energy Sources

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The diversity of resources used to produce power in Bangladesh in 2010-2022 is examined in this research paper. The need for energy has increased dramatically as Bangladesh's economy expands quickly. Natural gas has historically been the primary fuel used in Bangladesh to generate power, although there has been a greater diversification towards renewable energy sources in recent years. The paper examines the country's electrical sector's present level of resource diversity and evaluates the possibility of even more diversification. The study takes a qualitative approach by reviewing secondary data sources. The findings show that the government has made significant strides toward diversifying the country's energy generation, even if natural gas remains the main fuel and electricity generated from natural gas in Bangladesh was 51.05% in the fiscal year 2020–2022. Renewable energy sources, such as solar, wind, and hydropower, have grown in

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popularity in recent years, and the government has set ambitious goals for their eventual implementation. However, a variety of difficulties, such as inadequate infrastructure, constrained financing, and legislative limitations are impeding the growth of renewable energy. The study report underlines the necessity to diversify Bangladesh's power-producing resources in order to guarantee energy security, reduce greenhouse gas emissions, and achieve sustainable development goals. According to our study, the government should improve infrastructure, offer suitable incentives, and resolve regulatory obstacles to foster investment in renewable energy. The results of this paper can direct stakeholders and policymakers in Bangladesh toward a more diverse, long-term, and robust electrical industry.

Keywords: Electricity resources; renewable energy; electrical power generation; herfindahl-hirschman index; diversification energy resources.

1. INTRODUCTION

For the economy of any country, including Bangladesh, the infrastructure and supply of energy must be secure. If Bangladesh wishes to enjoy economic growth, it must ensure that the supply of power is dependable and secure. However, due to the country's increasing need for electricity, Bangladesh's power sector has recently been struggling with a variety of problems.

Over 50% of Bangladesh's total electrical supply is produced by natural gas, making it the country's primary energy source [1]. Although Bangladesh has long relied on natural gas as a cheap and abundant energy source, concerns over the country's dependence on this fuel have grown in recent years.

First, because Bangladesh's natural gas reserves are finite, there have been concerns that they will run out. Because of the country's declining natural gas production over the previous few years, natural gas prices have risen. The Bangladeshi government raised natural gas prices by 30% in 2021, which had a significant impact on the nation's electricity sector as well as the economy as a whole. The excessive increase in natural gas prices with the Russia-Ukraine war in 2022 is also pushing the industry of European countries that focus on natural gas and electricity production [2].

Bangladesh's electricity supply is also vulnerable to shocks from outside sources due to the country's reliance on natural gas. The country has been importing liquefied natural gas (LNG) to meet its growing energy needs, but doing so has made it susceptible to shifts in the global LNG market. Any interruptions in the pipelines that deliver natural gas or rises in LNG prices could

have a negative impact on Bangladesh's economy.

Bangladesh must vary its methods of producing electricity in light of these challenges. Despite the fact that natural gas will continue to play a significant role in the country's energy mix, it is important to investigate alternate energy sources like hydroelectricity, wind, and solar power. Diversifying the sources of power generation can help to lessen dangers brought on by an overreliance on a single fuel in addition to enhancing the country's energy security.

One of Bangladesh's most promising energy sources is renewable energy, particularly solar electricity. Bangladesh is fortunate to have abundant sunshine throughout the year, which makes it the ideal location for producing solar power. According to a report by the International Renewable Energy Agency, Bangladesh has the capability to generate up to 32,000 megawatts of electricity from solar energy alone, which is more than twice the country's current electricity producing capacity [3].

In recent years, the Bangladeshi government has introduced a variety of initiatives to promote the use of renewable energy across the country. Additionally, a feed-in tariff system has been implemented to promote the construction of renewable energy facilities.

To diversify its energy mix, Bangladesh may look at employing coal and hydroelectricity in addition to renewable energy. The use of these energy sources must be environmentally friendly and sustainable, though.

In conclusion, Bangladesh's ability to generate power depends on the diversity of its resource base. The country's over reliance on natural gas makes its electrical infrastructure vulnerable to

external shocks and could eventually make it more difficult for it to prosper economically. By diversifying the sources of power generation, particularly through the use of renewable energy, the nation's energy security will increase and the risks associated with an excessive reliance on one fuel will be decreased.

This study looked into whether Bangladesh's sources of power production are sufficiently varied. First, a conceptual framework for the security of the power supply has been developed for this aim. In the following step, the Herfindahl-Hirschman and concentration indices were utilized to evaluate the development of the resource concentration used by Bangladesh to produce energy through time.

2. ENERGY AND SOURCES

No industry can grow without energy. A significant component of Bangladesh's economic activities is energy. The country's rapid industrialization and population growth have increased the demand for energy [4]. Individual needs like transportation, communication as well as the production activities of industries, heavily rely on energy sources. Bangladesh is a developing country with a high energy demand, and energy security is essential for its continued economic growth.

Two forms of energy are analyzed based on their convertibility. Natural gas, coal, petroleum, nuclear, solar, hydropower, wind, and biomass are some of the main energy sources. Primary energy sources are transformed into useful forms, like electricity, to create secondary energy sources [5]. In Bangladesh, natural gas is the most accessible primary energy source and is now the primary fuel utilized to produce power. To lessen reliance on a single source and ensure energy security, Bangladesh has to diversify its energy sources.

One of the biggest challenges facing Bangladesh in this regard is its limited energy resources. The country's reserves are limited, natural gas is 7.25TCF which will lead the country for the next few decades and also concerned about heavy relies on imported fossil fuels, which can cause significant financial strain on the country's economy. Due to the government's large investments in renewable energy projects, renewable energy sources have begun to take on greater significance in Bangladesh's energy sector. By 2021 and 2035, the government wants

to generate 10% and 20%, respectively, of the nation's total electricity from renewable sources [6]. To meet its energy needs, they start looking into alternatives like coal, nuclear power, and renewable energy sources like solar and wind to help decrease the nation's reliance on foreign oil and boost energy security.

Nuclear energy is not yet a significant source of energy in Bangladesh. But the government has set to become the 33rd nuclear power-producing country following the successful construction of the Rooppur Nuclear Power Plant in Pabna (RNPP). The plant is expected to generate 2400 MW of additional power by 2024, helping meet the country's growing electricity [7]. However, the use of nuclear energy in Bangladesh is still a matter of debate, and concerns over the safety of nuclear power plants and the potential for nuclear accidents.

The energy sector of Bangladesh recognizes the importance of using renewable energy sources to enhance energy supply security but acknowledges that it cannot solely rely on renewables in the short term. To diversify resources used in electricity production, different sources should be used as equally as possible, and imported from different countries. This will ensure that the country is not overly dependent on any one source of energy, which would pose a risk to energy security. In this paper, there are studies that detect causality both from growth to electricity production and from electricity production to growth [8].

3. BANGLADESH AND ELECTRIC GENERATION SOURCES

Due to a lack of domestic energy resources, Bangladesh has considerable difficulties in satisfying its rising electrical demand. The Bangladesh Power Development Board (BPDB) estimates that as of December 2022, the nation's total installed capacity was 22,482 MW, and its peak generation was 14,782 MW, with around 51.05% of that coming from gas-based power plants [1].

Due to rising demand from many industries, particularly electricity generation, Bangladesh's natural gas supplies are limited, and the nation has been experiencing a shortage in recent years. However, 75% of the primary commercial energy comes from natural gas. As a result, the nation has been largely reliant on imported LNG to satisfy its energy needs. Currently,

Bangladesh imports LNG from a number of nations, including Malaysia, Qatar, and Oman (Global Energy Monitor, 2022). Through the projected pipeline project connecting Russia, India, and Bangladesh, the nation is also considering the potential of importing natural gas from that nation (Reuters, 2021).

Bangladesh also produces electricity from coal, oil, and renewable energy sources in addition to natural gas. The country has a tiny amount of coal deposits, and the coal is of poor grade. In order to meet its energy needs, the nation has been importing coal from nations like Indonesia, Australia, and South Africa. The country's installed capacity is made up of around 7.86% coal-based power plants, according to the BPDB [1]

The installed capacity of Bangladesh's oil-based power plants is quite limited, and they are mostly used as backup sources of electricity during times of high demand. To diversify its energy mix and lessen its reliance on fossil fuels, Bangladesh has been encouraging renewable energy sources like solar, wind, and hydropower. With regard to off-grid capacity, renewable energy sources make up roughly 2.87% of the nation's total installed capacity [9].

For its small internal reserves and reliance on imports, Bangladesh faces a severe issue as a result of its heavy reliance on natural gas to produce power. In order to diversify its energy mix and lessen its reliance on fossil fuels for the purpose of maintaining a stable and secure energy supply in the future, the nation is looking into the possibilities of importing natural gas from Russia and encouraging renewable energy sources.

4. METHODS

As the paper is about "Resources Diversification in Bangladesh's electricity Generation" that's why we have discussed generation sources of Bangladesh in the last 11 years. And we have used "HHI" and "CR" (Concentration Ratio) methods to show the impact of the first four resources compared to others [10].

The HHI which refers to the 'Herfindahl-Hirschman Index' is a measure of concentration. Though the term is mainly related to economics or marketplace competitiveness, we have used it here to measure the concentration of main

resources. The value of HHI starts from 0 to 10000. The formula is: -

$$HHI = \sum_{i=1}^N P_i^2$$

where, N= Number of Sources

P=% of the sources in total generations

If $HHI < 1000$, Low Concentration

$1001 < HHI < 1800$, moderate level

$1801 < HHI < 10000$, High Concentration

$HHI = 10000$, Full Concentration

The main advantage of this method is it isn't complex to understand. Though CR (Concentration ratio) isn't affected by a small number of percentages, HHI avoids this problem.

CR or Concentration Ratio is nothing but simply the summation of all percentages of four sources of generations [11]. The mathematical formula is:

$$CR = \sum \% \text{ of 1st four sources of generations}$$

If (0-30), Low Concentration

(31-50), Moderate Level

(51-70), High Concentration

Above70, Ultimately High Concentration

CR clearly shows us the dominance of the first four sources in case of electricity generations over the years. And how they hold up the total generations of Bangladesh.

5. FINDINGS AND DISCUSSION

From the following "Electricity Production Bangladesh" table we got to know that there are seven unique resources (Steam Turbine, Reciprocating Engine, Gas Turbine, Hydro, Power Import & Solar) used in electricity generation of Bangladesh in the past 12 years. Though we were trying to cover up our electricity demand from the steam turbine, Reciprocating Engine, Gas Turbine & Hydro, we had to import power from outside after 2014 to cover up our load shedding and continuously increasing power demand. Solar PV was introduced in 2017. In 5 years between 2014-15 and 2019-20, electricity generation has almost doubled. Reciprocating Engine and Combined Cycle played a massive role in this growth [12,13].

Table 1. Electricity production Bangladesh (Unit in MW)

Years	Steam turbine	Reciprocating engine	Combined cycle	Gas turbine	Hydro	Power import	Solar PV	General total
2010-11	2211	2100	1166	932	230			6,639
2011-12	2193	3250	1292	1145	220			8,100
2012-13	2193	3374	1455	1295	220			8,537
2013-14	2115	3603	1757	1616	230			9,821
2014-15	2217	3992	2162	1838	230	500		10,939
2015-16	2578	4471	3293	1193	230	600		12,365
2016-17	2404	4591	4625	1105	230	600		13,555
2017-18	2404	5604	5730	1322	230	660	3	15,953
2018-19	2344	7226	6364	1607	230	1160	30	18,961
2019-20	2966	7808	7330	851	230	1160	38	20,383
2020-21	3268	8100	7933	1211	230	1160	129	22,031
2021-22	2968	8430	7963	1502	230	1160	229	22,482

In the Table 2, we can see specific statistics of “First Four Sources in Electricity Generation in Bangladesh” in the past 12 years. Natural Gas and Furnace Oil are respectively dominating 1st and 2nd place in those years. Diesel ensuring 3rd place before 2020-21, then coal has become our 3rd key resource for the last 2 years. The 4th place has been shared for 4 years, 6 years and 2 years respectively between Hydro, Power Import and Diesel. We can also see the Concentration Ratio and Herfindahl-Hirschman Index on the right side of the table. Their respective bar graph is also shown here. The Concentration Ratio (CR) reached its highest point in 2012–2013 (97.66%) then, shockingly, fell to its lowest point in 2013–2014 (92.87%). In the interim years (2014–15, 2015–16, 2016–17), it ranged between 96% and 97%, but in the most recent years (2019–20, 2020–21, 2022–23), it was between 92% and 93%. HHI, on the other hand, reached its peak in 2010–11 (5577.2) and its trough in 2021–22. The same thing happened in both 2011–12 and 2012–13. The HHI for 2016–17 (96.46%) was the highest in the preceding nine years. Though it wasn’t a linear graph, it is gradually decreasing in the last 6 years.

We can clearly see that the domination of the First four resources is decreasing day by day.

Bangladesh is a lower-middle-income country. It is now one of the fastest developing nations. It has a strategic plan named “Vision 41” to develop socio-economic standing [14]. To make this goal a reality, ensuring minimum load shedding is mandatory. Even a few years ago, reducing load shedding in Bangladesh was a dream. Because there were a lot of issues

hampering the development of this sector. There was corruption, a lack of capacity, and a lack of skilled people. But things and the scenario have started to change during the last few years.

From the electricity production table, we observed that electricity generation has increased almost 3.5x in the last 12 years. We also see that new production sources have been introduced in the last few years. In the Table 2, the concentration ratio and Herfindahl-Hirschman Index also talk about the current situation or contribution of the first four sources in our electricity generation. Between 2010-11 and 2021-22, the resources have changed. In 2010-11, Natural gas held 73.25% shares of total generation. On the other hand, the percentage has reduced to 51.05% in 2021-22. These single stats show and remind us that Natural Gas is not renewable energy. And depending only on non-renewable energy doesn’t bring any progress. In the last 12 years, Authorities have tried to introduce new sources of electricity generation so that the dependency on non-renewable energy sources could be reduced. We can clearly see the results in statistics. Power generation has increased, and the domination of the first four sources has decreased which is clearly visible on the bar graph of the concentration ratio. The HHI bar graph also tells the same thing that the concentration of the first four resources has been decreasing over the years which is really a positive sign for our “Vision 41” (Vision 2041). This everything tells one thing that in the last 12 years there is really huge diversity of resources in the Electricity Generation in Bangladesh.

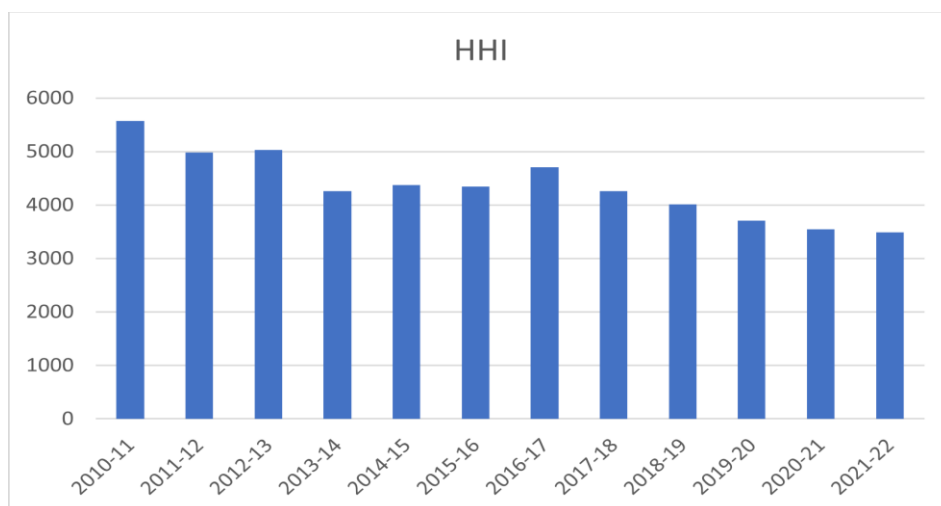


Fig. 1. Herfindahl-hirschman index

Table 2. The first four sources in electricity generation and their shares

Years	First	P(MW)	%	Second	P(MW)	%	Third	P(MW)	%	Fourth	P(MW)	%	Total(MW)	C	HHI
2010-11	N.Gas	4863	73.25	F.Oil	671	10.11	Diesel	655	9.87	Hydro	230	3.46	6,639	96.69	5577.2
2011-12	N.Gas	5417	66.88	F.Oil	1752	21.63	Diesel	511	6.31	Hydro	220	2.72	8,100	97.54	4988.0
2012-13	N.Gas	5730	67.12	F.Oil	1876	21.97	Diesel	511	5.99	Hydro	220	2.58	8,537	97.66	5030.3
2013-14	N.Gas	6016	61.26	F.Oil	2050	20.87	Diesel	825	8.40	Hydro	230	2.34	9,821	92.87	4264.4
2014-15	N.Gas	6781	61.99	F.Oil	2301	21.03	Diesel	927	8.47	P.Import	500	4.57	10,939	96.06	4377.6
2015-16	N.Gas	7628	61.69	F.Oil	2629	21.26	Diesel	1028	8.31	P.Import	600	4.85	12,365	96.11	4350.2
2016-17	N.Gas	8810	64.99	F.Oil	2785	20.55	Diesel	880	6.49	P.Import	600	4.43	13,555	96.46	4707.7
2017-18	N.Gas	9413	61	F.Oil	3443	22	Diesel	1380	6.49	P.Import	660	4	15,953	93.49	4263.2
2018-19	N.Gas	10877	57.37	F.Oil	4770	25.16	Diesel	1370	7.23	P.Import	1160	6.12	18,961	95.88	4014.1
2019-20	N.Gas	10979	53.86	F.Oil	5540	27.18	Diesel	1290	6.33	P.Import	1160	5.69	20,383	93.06	3712.1
2020-21	N.Gas	11450	51.97	F.Oil	6004	27.25	Coal	1768	8.03	Diesel	1290	5.86	22,031	93.11	3546.7
2021-22	N.Gas	11476	51.05	F.Oil	6329	28.15	Coal	1768	7.86	Diesel	1290	5.74	22,482	92.8	3493.2

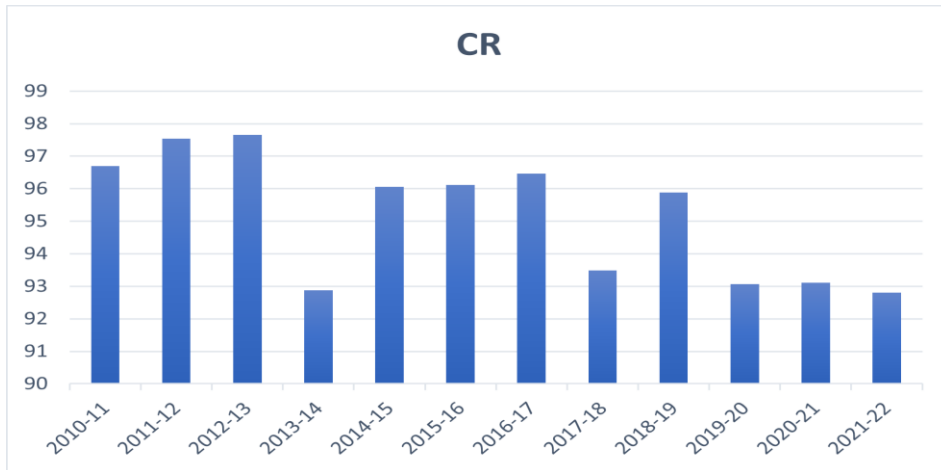


Fig. 2. Concentration ratios

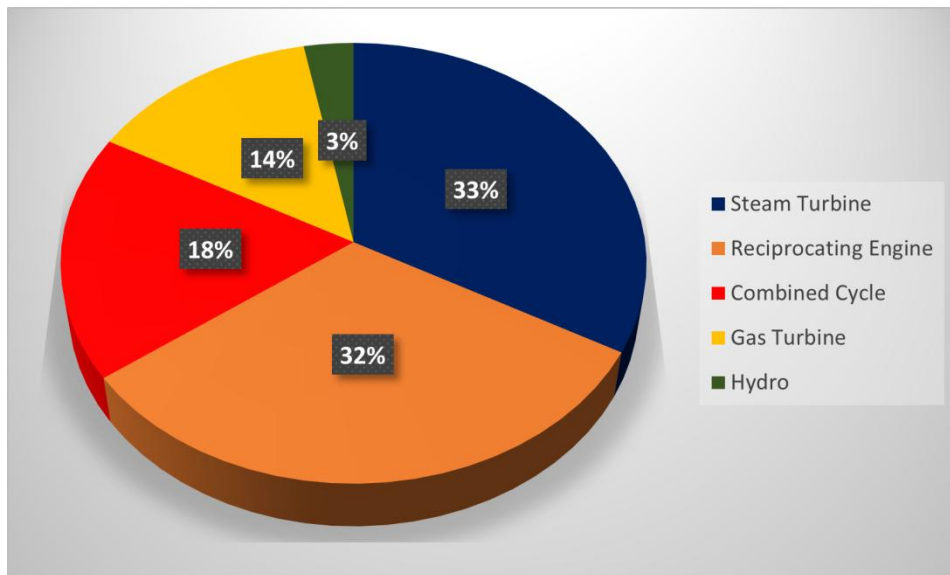


Fig. 3. Electricity generation in 2010-11

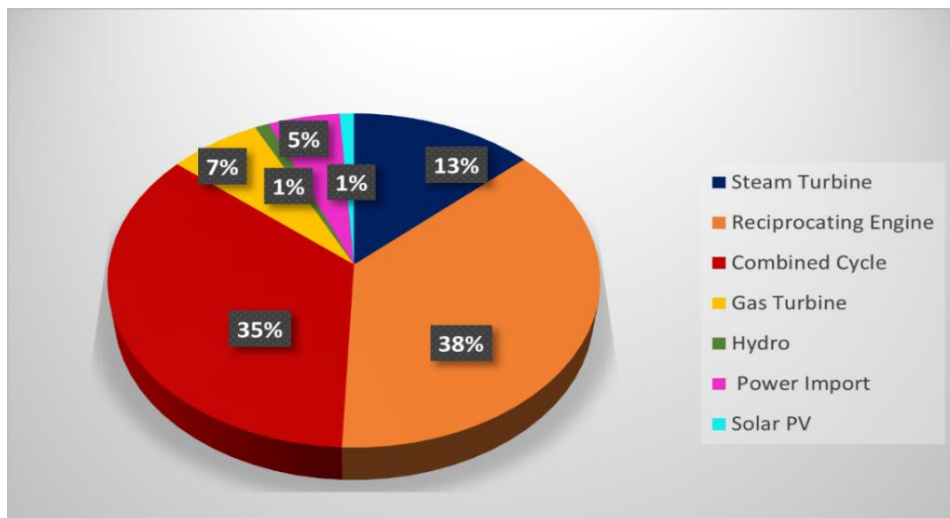


Fig. 4. Electricity generation in 2021-22

The two pie charts of electricity production in 2010-11 and 2021-22 also support this statement [15,1] Clearly, we can see the diversification in those years. Non-renewable energy will surely end one day. So, creating alternatives is the best way to be prepared for future generations. Because of these diversifications, load shedding has decreased. It opens a lot of opportunities for the development of Bangladesh. It impacts our whole economical, educational and social progress. If this diversification continues, then it will surely make Bangladesh one of the biggest names in the world in many sectors.

6. CONCLUSION

The developments in Bangladesh's energy resources over the previous 12 years are discussed and analyzed in this paper. Something encouraging may be seen in the roughly three-fold rise in energy production over the previous 12 years due to a substantial reliance on natural gas and innovation in new methods of power generation. In the era of nuclear energy, the dependency on mineral resources are pretty much unsuitable. Though the government and engineers are doing their best to reduce it and the improvements are visible in the analysis. It will be interesting to observe how much renewable energy production keeps up with this change and eliminates reliance on mineral resources.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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