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Scopes and Way-forward

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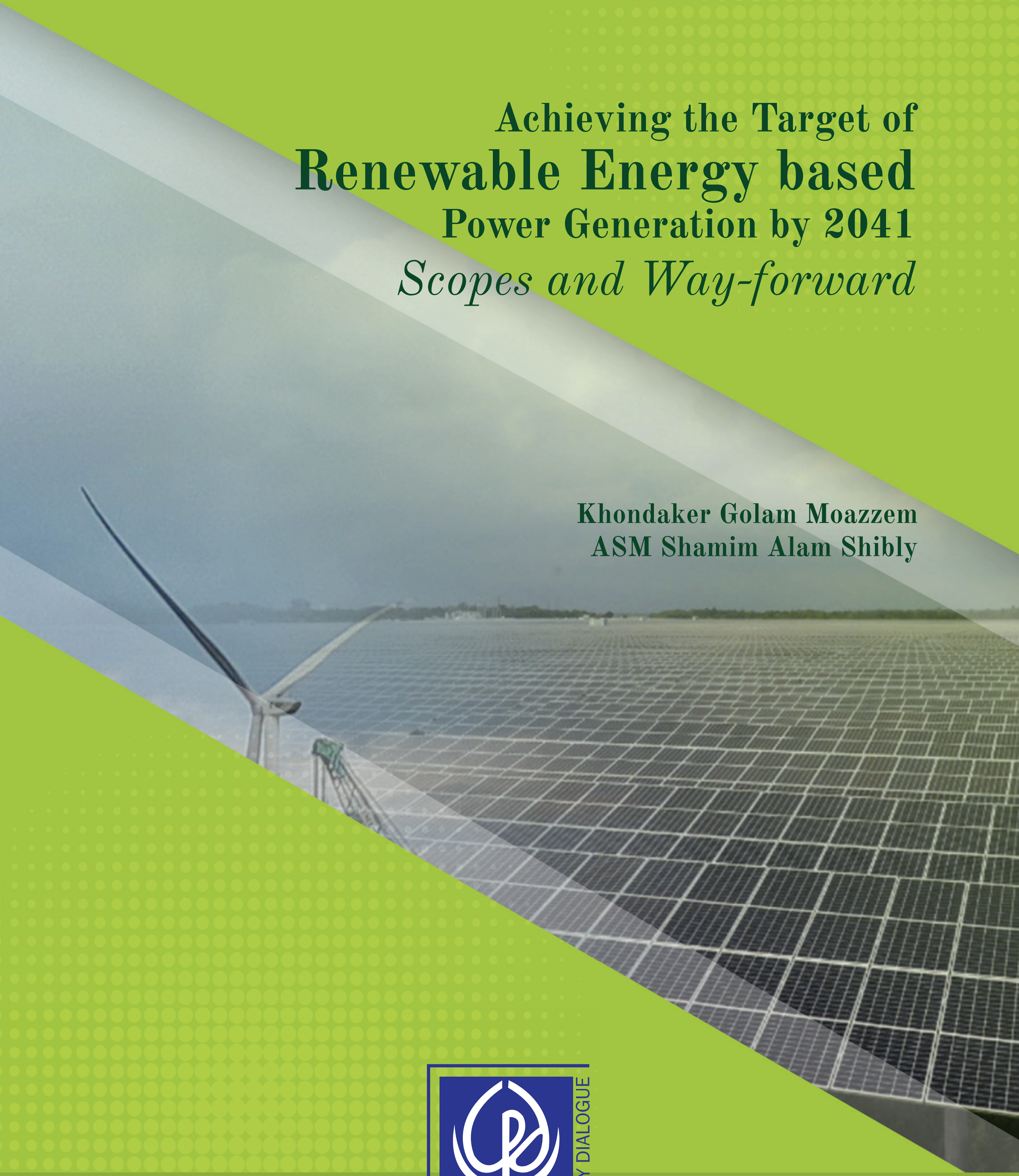

CENTRE FOR POLICY DIALOGUE

ACHIEVING THE TARGET OF RENEWABLE ENERGY BASED POWER GENERATION BY 2041

Scopes and Way-forward

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Abstract

Bangladesh, in alignment with national and international commitments, aims to significantly increase its reliance on renewable energy sources by 2041. The Mujib Climate Prosperity Plan (MCPP) outlines a strategic roadmap towards maximising renewable energy utilisation, emphasising energy efficiency and storage infrastructure to bolster resilience and energy independence. However, the recently formulated Integrated Energy and Power Master Plan (IEPMP) sets a considerably lower target for RE adoption, primarily by incorporating untested technologies under the umbrella of 'clean energy'. An index analysis methodology is applied to assess the performance of power plants and prioritise their gradual phase-out, facilitating the reallocation of resources towards RE projects. The analysis examines the cost dynamics of electricity sales by power plants in Bangladesh, focusing on the period from 2017 to 2022. The study underscores the urgency of transitioning from thermal to RE sources, detailing a phased approach for plant retirement based on index scores and contractual timelines. This strategy aims to achieve substantial savings and integrate RE into the energy mix, aligned with national targets. Additionally, policy recommendations advocate for transparent cost reporting, incentivising RE investment, and prioritising RE-based plants to actualise a cheaper, cleaner, and sustainable energy future in Bangladesh.

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Acronyms

CCS	Carbon Capture and Storage
CO_2	Carbon dioxide
CVF	Climate Vulnerable Forum
GCI	Global Competitiveness Index
GHG	Greenhouse Gas
GWh	Giga watt hour
HFO	Heavy fuel oil
IEPMP	Integrated Energy and Power Master Plan
IPPs	Independent Power Producers
kWh	kilowatt-hour
LCOE	Levelised Cost of Electricity
MCPP	The Mujib Climate Prosperity Plan
MoECC	Ministry of Environment and Climate Change
MoPEMR	Ministry of Power Energy and Mineral Resources
mtoe	Million or mega tonnes of oil equivalent
MW	Mega-watt
NoX	Nitrogen
QRPPs	Quick Rental Power Producers
RE	Renewable Energy
SO_2	Sulphur
VECM	Vector error correction model

1. INTRODUCTION

Bangladesh aims to gradually reduce its dependence on fossil fuels in all kinds of economic activities as part of its global and national commitments in connection with further decarbonisation for reducing climate vulnerabilities. Since the power sector is one of the most important carbon-emitters given its over-dependence on fossil-fuels as fuel-mix, it is important to strategise, plan and thereby implement gradual reduction of the share of fossil-fuel in power generation. A major step will be to increase the share of alternate energy - renewable energy (RE) in power generation and thereby develop the transmission and distribution related energy infrastructure. Though the share of renewable energy in power generation energy-mix is very low (4.5 per cent), the government has set a plan to enhance its share over the years and reach it to 40 per cent by 2041.

A number of issues concerned regarding the target of 40 per cent renewable energy as energy mix for power generation. These issues include non-alignment of major plans prepared by the Ministry of Power Energy and Mineral Resources (MoPEMR) and Ministry of Environment and Climate Change (MoECC) with regard to the target, a number of non-renewable energy-mix is considered terming those 'clean energy' along with renewable energy under the plan prepared by the MoPEMR, lack of clarity about disaggregated amount of 40 per cent renewable energy since projected demand for electricity by 2041 is questionable. Despite those concerns, one of CPD's recent study has conducted a detailed analysis of projection of power demand for 2030 and 2041 (Moazzem and Quaiyyum, 2024) which showed that a projection of 40 per cent renewable energy for power generation is feasible provided the power demand is carried out following the standard estimation technique.

While the share of 40 per cent of renewable energy in overall energy-mix is discussed, there is little clarity about gradual change in the overall share of fossil fuel and renewable energy is little discussed. These include sequencing of phasing out of fossil-fuel based power plants, setting the composition of energy-mix of different renewable energy sources including solar, wind, hydro and wastes and thereby raising share of those energy-mix towards reaching the target, etc. So far, no proper action plan has been developed regarding how the energy-mix in power generation will take place during the interim period, 2023-2041. Hence, there is a demand for a detailed analysis regarding how compositional change in the energy-mix in power generation should be ensured with a view to achieving 40 per cent of renewable energy by 2041.

In this backdrop, this study attempts to identify possible options for changing the composition of energy-mix during the interim period till 2041. The objective of the study is to review the current structure of power generation through different energy-mix, their possible timeline for ending of the contract and future plan inclusion of new power plants and based on the review, put forward a plan for changes in the energy-mix in power generation for the interim period (2023-2041) with a view to achieving 40 per cent renewable energy by 2041.

2. REVIEW OF NATIONAL PLANS ON FUTURE ENERGY-MIX IN POWER GENERATION

The energy-mix in power generation has been dynamically shifted both at global and national levels particularly considering its important role in the decarbonisation initiative. Following the global commitment, Honourable Prime Minister of Bangladesh has committed in the Climate Vulnerable Forum (CVF) to increase renewable energy-based electricity generation up to 30 per cent by 2030 and up to 40 per cent by 2041. Besides, different national plans have outlined long-term plans for improving the share of renewable energy. For example, the Integrated Power and Energy Master Plan (IEPMP) prepared by the Ministry of Power Energy and Mineral Resources (MoPEMR) mentions 40 per cent of 'clean energy' where the share of renewable energy is considered 8.4 per cent. On the other side, the Mujib Climate Prosperity Plan (MCPP) prepared by the Ministry of Environment and Climate Change mentions 40 per cent of renewable energy for power generation. Hence, it is important to review the national plans as well as global commitments on renewable energy use in power generation, and thereby try to get a clear understanding of future energy-mix for power generation.

2.1 IEPMP

According to the Integrated Power and Energy Master Plan (IEPMP), Bangladesh strives for net-zero carbon emissions through using 'cleaner' energy in power generation. 'Cleaner energy', according to the IEPMP, means including non-tested technologies such as ammonia, hydrogen, and critical and super-critical carbon capture units. The IEPMP states that to achieve the goal of 40 per cent of electricity generated from clean energy sources, it will be necessary to introduce H2 at 6 per cent and NH3 at 2 per cent. It also plans to introduce gas-fired power plants with 20 per cent hydrogen co-firing starting in 2037, 100 per cent hydrogen firing starting in 2040, and coal-fired power plants with 20 per cent NH3 co-firing starting in 2035, upgraded to 50 per cent in 2040. After 2037, the introduction of carbon capture and storage (CCS) should also be considered to further reduce CO_2 emissions. The IEPMP shows that only 8.8 per cent of total electricity (5280MW) is to be generated from RE sources.

2.2 Mujib Climate Prosperity Plan (MCPP)

The MCPP outlines that by building on the targets of up to 40 per cent RE by 2041 and 100 per cent RE by 2050, as set by the Climate Vulnerable Forum, Bangladesh aims to become a net exporter of energy and a global player in the green economy through technological innovation. It acknowledges that advances in renewable energy and storage technologies will reduce the competitiveness and returns of fossil fuel investments, making it prudent to design the power system to leverage modern technologies for better pricing, reliability, and reduced exposure to inflation and international market fluctuations. The MCPP emphasises achieving domestic energy security through investments in solar power, including rooftop, ground-mounted, and floating installations on reclaimed land as part of the Bangladesh Delta Plan 2100 (Annex 1). Solar power is expected to generate 2000MW for government buildings, supplemented by offshore wind and domestic storage capacity. Additionally, the plan includes utilising alternative power generation in the Bay of Bengal, such as tidal power and ocean thermal energy conversion, and proposes a 4000MW wind generation array network linked to a mangrove green belt along the coastline.

To enhance resilience and energy security, fossil fuel-based power plants need to be phased out. This transition can be implemented in two ways: (a) replacing existing thermal plants with RE; and (b) generating electricity by establishing new RE plants from different areas and sources.

2.3 Centre for Policy Dialogue (CPD) Estimates

The Centre for Policy Dialogue (CPD) has undertaken an estimate of demand for electricity in Bangladesh by 2041 (Table 1). Using a vector error correction model (VECM) with data spanning from 1985 to 2022 (the COVID-19 incident is addressed), the study forecast illustrates a much lower electricity forecast estimation every year compared to that mentioned in the IEPMP.

The scenario considered in CPD analysis from the IEPMP is the 'ATS In-Between', which is deemed to be feasible, and demonstrates the minimum energy consumption. The CPD forecast shows that the electricity demand in 2041 will be 27,345 MW compared to the estimate of the IEPMP, 58,410 MW. Considering the 25 per cent reserve margin (as proposed in the IEPMP), the projected capacity would be 34,181 MW. Forty (40) per cent of this capacity will be 13,672 MW which could be generated from renewable energy.

Table 1: Comparison of VECM Forecast of Energy Demand with that of IEPMP

Year	Primary energy consumption (mtoe)		Changes in Forecasted energy consumption (times)	
	IEPMP	CPD estimates	IEPMP forecast of energy demand	CPD forecast of energy demand
2019	41.25	41.25	–	–
2030	67.65	56.10	1.64 times	1.36 times
2041	98.59	72.60	2.39 times	1.76 times
2050	129.53	84.98	3.14 times	2.06 times

Source: Moazzem, et.al., (2024).

2.4 Overall Observations

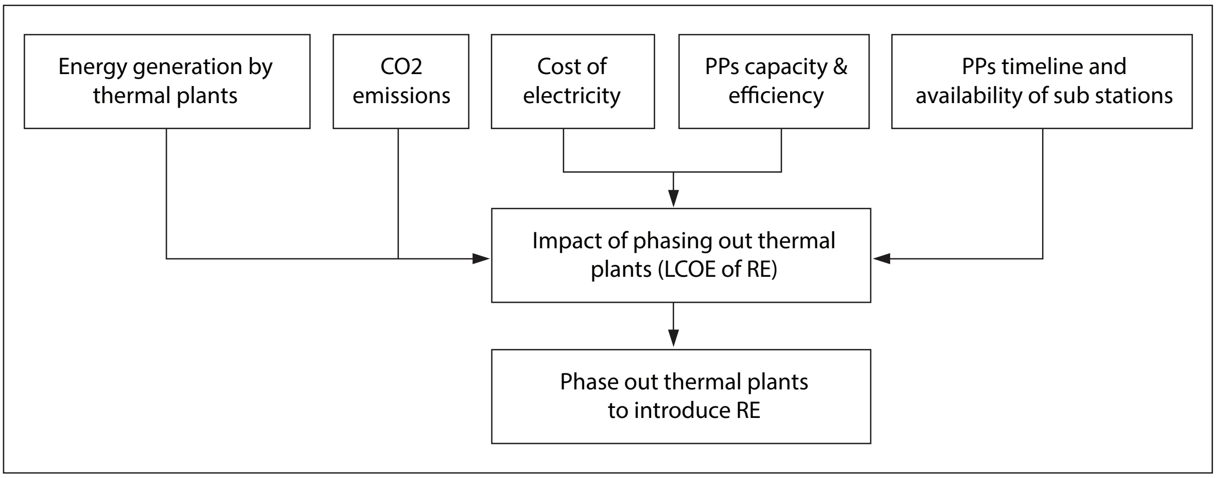
The MCPP aims to achieve a 40 per cent RE target by 2041, whereas the IEPMP sets a lower target of 8.8 per cent RE by the same year. A notable distinction exists in the IEPMP's inclusion of 'clean energy', often referred to as renewable energy, which considers expensive sources like LNG, ammonia, and CCS. Despite being the directive guidelines, the target of the IEPMP and MCPP differs. Notably, the MCPP predates the IEPMP, reflecting the political commitment of the government. However, the IEPMP was developed without taking into consideration the energy-mix suggested in the MCPP. Considering the estimates made by the CPD (2024), a 40 per cent of power generation through renewable energy which is equivalent to 13672 MW is a feasible target. This study therefore considers the 40 per cent of renewable energy or 13,672 or 14000MW as the share of energy-mix from renewable energy.

3. ANALYTICAL FRAMEWORK AND METHODOLOGY

3.1 Analytical Frame

The study considers two primary approaches for changes in the energy-mix in Bangladesh. These two approaches are:

Figure 1: Framework of the Renewable Energy Transition



Source: Authors' illustration.

a. Gradually phasing out existing fossil fuel plants and substituting them with renewable energy plants; and
b. Identifying new locations suitable for establishing renewable energy plants, considering the specific renewable energy resources available in those specific locations.

Before the gradual phase-out of fossil fuel-based power plants, an index analysis will be undertaken. This analysis computes an index score based on various factors – (a) power plants' performance, (b) net energy generation, (c) carbon emissions, (d) price of the electricity, (f) total sales of electricity, (g) carbon emissions, (h) operational timeline, (i) plant efficiency, and (j) geographical location, etc.

The ranking derived from this score-based analysis informs decisions regarding whether certain plants should be prioritised immediately or gradually. From Figure 1, indicators in the first line boxes are assessed for a gradual phase-out of fossil fuel-based plants and to calculate financial savings from phasing out those plants and subsequently investing that money for renewable energy-based plants.

3.2 Methodology

3.2.1 Formula for Index Analysis

An index analysis was undertaken to assess and rank the performance of these plants. The purpose was to identify the least efficient power plants for gradual phase-out between 2025 and 2041. To calculate the performance score, the study employed a formula shown below. A condensed version of this formula was derived specifically for quantitative data analysis, enabling the computation of performance scores for individual power plants. The formula is outlined as follows:

$$\text{Score of the PP} = \frac{\text{Value of a respective variable of a PP} - \text{Minimum value of a particular variable from all PP}}{\text{Maximum value of a particular variable from all PP} - \text{Minimum value of a particular variable from all PP}} \times 100$$

3.2.2 Computing Score for Power Plants

Utilising the provided formula, a score was computed for each variable associated with an individual power plant. The score ranged from 0 to 100, where lower values indicated better performance, encompassing factors such as environmental friendliness, cost-effectiveness, plant utilisation over time, and efficiency in electricity generation. Conversely, higher values, nearing 100, signified poorer performance by a power plant across these criteria. Subsequently, an overall index score was determined by averaging the scores of all variables, leading to the assignment of ranks to identify the power plants with the least satisfactory performance.

3.2.3 Phase-Out of Power Plants

In order to phase out existing thermal power plants to create space for renewable energy-based power generation, the rank of the power plants based on the index score was analysed to phase out the power plants in three stages: (a) top priority (within 2025); (b) medium priority (within 2030); and (c) low priority (after 2030). Addition to the score-based ranking, the timeline of the quick rental, rental, and IPPs were reviewed to phase those out immediately after their expired timeline.

3.3 Data and Variables

The study followed quantitative analysis based on secondary data sources. The data were collated from the BPDB Annual Report from 2016-17 to 2021-22 of each power plant-related information. The data points include net generation of electricity (kWh), net emission of carbon dioxide (CO_2), sulphur (SO_2), and nitrogen (NoX), total energy sales (in BDT), generation cost (BDT/kwh), annual plant factor, plant efficiency, plant timeline, location of the power plant, and availability of sub-station in the nearest power plant location.

4 REVIEW OF DIFFERENT INDICATORS FOR ESTIMATING THE INDEX VALUE

4.1 Energy-mix for Power Generation

The primary source of electricity generation is thermal power plants, with a large number of heavy fuel oil (HFO) based (64) and gas-based power plants (56), as indicated in Table 1. Independent Power Producers (IPPs) and Quick Rental Power Producers (QRPPs) – both are privately owned, predominantly operated HFO-based plants. Nevertheless, public plants, highlighted in Table 2, significantly contribute to energy generation owing to their higher installed capacity.

Table 2: Power plant by ownership and fuel types (in number)

Ownership	Coal	Gas	HFO	HSD	Total
BPDB	2	19	10	2	33
IPP	1	15	44	7	67
Public Plant	0	13	1	0	14
QRPP	0	9	9	0	18
Total	**3**	**56**	**64**	**9**	**132**

Source: Authors' analysis based on BPDB (2022).
Note: Payra coal-based plant is a Joint Venture initiative which is portrayed as IPP here.

Over the years, there has been a steady increase in average energy generation by BPDB (from 380 GWh in 2017 to 481 GWh in 2022) and IPP (from 543 GWh in 2017 to 632 GWh in 2022) plants (Table 3). In contrast, energy generation by public plants has decreased (from 1180 GWh in 2017 to 1050 GWh in 2022), along with a decline in QRPP plants (from 281 GWh in 2017 to 158 GWh in 2022). The diminishing trends in public plants are attributed to maintenance requirements, while rental plants show a decreasing trend, indicating limited requirements of power during peak hours owing to over-generation capacity. However, this idle status of QRR plants indicates increased payment of capacity charges by the BPDB.

On the other hand, over the years, the difference in utilisation of IPPs and public plants is somewhat worrisome. The maximum generation of electricity by the IPPs is higher than the BPDB and public plants. The utilisation of IPPs over public plants is influenced by a combination of factors related to increased level of efficiency, better management practices, and higher financial incentives. IPPs often

Table 3: Summary statistics of energy generation by types of plants

Ownership	Year	Observation	Average generation (in GWh)	Minimum generation (in GWh)	Maximum generation (in GWh)
BPDB	2017	31	380.0	0.4	2540.0
	2018	33	413.0	0.4	2880.0
	2019	38	421.0	0.5	2160.0
	2020	34	466.0	0.0	2420.0
	2021	30	486.0	1.4	1840.0
	2022	33	461.0	1.2	2520.0
IPP	2017	30	543.0	28.2	2600.0
	2018	39	467.0	8.9	3220.0
	2019	51	416.0	20.2	2940.0
	2020	58	430.0	3.4	3050.0
	2021	63	547.0	21.0	3810.0
	2022	67	632.0	13.9	4000.0
Public Plant	2017	10	1180.0	198.0	3210.0
	2018	13	1130.0	74.3	3010.0
	2019	15	1190.0	157.0	2710.0
	2020	15	1150.0	6.8	2780.0
	2021	15	1070.0	11.6	2710.0
	2022	14	1050.0	98.0	2140.0
QRPP	2017	29	281.0	29.9	997.0
	2018	28	256.0	45.8	591.0
	2019	27	221.0	10.9	634.0
	2020	22	175.0	7.5	446.0
	2021	19	235.0	21.3	605.0
	2022	18	158.0	20.8	620.0

Source: Author's analysis based on BPDB (2017 to 2022).

operate based on contractual agreements with guaranteed power purchase agreements, providing them with a steady revenue stream. Public plants, on the other hand, may face uncertainties related to government budget allocations and its (hidden) policy position regarding using sources for power supply. There is a consistent emphasis on prioritising power plants operating under IPPs and QRPPs although public plants incur zero capacity charges and minimal operational costs. At the same time, the government bears the financial burden for meeting huge capacity charges of IPPs and QRPPs due to less use of private power plants.

To shift from fossil-fuel based power generation to renewable energy-based power generation, the above-mentioned power plants both under public and private sector need to be phased out. These power plants are increasingly causing fiscal and financial pressure to the government apart from their structural problem of adverse environmental consequences such as emission of CO_2, sulphur, nitrogen, and other particles. The following sections further scrutinise the CO_2 emissions associated with thermal energy generation.

4.2 CO_2 and Other Greenhouse Gas (GHG) Emissions by Power Plants

CO_2 emissions have been computed based on the total electricity generated by power plants within a single year, implying that greater electricity generation by a single plant causes higher CO_2 emissions. The level of emission is contingent on the fuel type and carbon capture technology employed by the power plants. Table 4 displays average CO_2 emissions from various power plants, with public power plants exhibiting the highest recorded emissions. It is crucial to acknowledge that public plants surpass others in terms of generation, as previously mentioned.

For calculating emissions, it was assumed that all plants utilise cutting-edge technology to mitigate CO_2 emissions. Therefore, the lowest emission figure for each fuel type was employed to determine the emission values presented in Table 4. These figures represent the minimum average CO_2 emissions in tonnes per total energy generation by a plant. The emissions are directly proportional to the generation levels of the plants—higher generation corresponds to increased CO_2 emissions, and vice versa.

In 2022, thermal plants contributed to a total of at least 5 crore tonnes of CO_2 emissions, constituting nearly 70 per cent of Bangladesh's overall carbon emissions. These CO_2 emissions are also linked with emission of sulphur, nitrogen, and other particulate matter. Such high carbon intensity in power generation leads to air pollution and adverse impacts of climate change. Although Bangladesh is globally ranked 48th (out of 215 countries) in terms of CO_2 emissions which is mainly accounted for by the emissions of thermal-based power plants. The proportion of pollution attributed to thermal plants surpasses that of comparable countries (Global Carbon Budget, 2023). The following sub-section examines a detailed analysis of the electricity prices of various power plants.

Table 4: Summary statistics of CO_2 emission by types of plants

Ownership	Year	Observation	Average CO_2 emission (in tonne)	Std. dev. (in tonne)	Minimum emission (in tonne)	Maximum emission (in tonne)
BPDB	2017	30	227278.00	302924.60	305.10	1308765.00
	2018	32	265138.40	417157.90	341.00	1728488.00
	2019	37	248787.30	324050.30	366.20	1149765.00
	2020	33	282851.40	403000.70	34.40	1796591.00
	2021	30	276242.80	319353.60	1063.90	1121435.00
	2022	33	264665.30	351106.00	603.70	1299946.00
IPP	2017	30	322999.80	348549.90	14521.40	1339282.00
	2018	39	279368.10	360504.40	6781.40	1656684.00
	2019	50	258712.30	309591.60	15307.00	1513084.00
	2020	58	261757.70	375397.20	2617.50	1570417.00
	2021	63	375367.40	571240.70	15961.00	3892125.00
	2022	67	445443.00	574027.20	10586.00	4082619.00
Public Plant	2017	10	610281.80	580008.30	101775.20	1656458.00
	2018	13	579754.30	471484.80	38293.80	1550254.00
	2019	15	623017.30	424618.00	119079.90	1394458.00
	2020	15	599494.40	477982.10	3480.80	1434249.00
	2021	15	559786.30	420317.90	8811.10	1394496.00
	2022	14	544508.60	410290.30	59823.40	1100202.00
QRPP	2017	29	213536.80	156078.40	22729.80	756541.60
	2018	28	194123.40	108366.70	34780.60	448369.50
	2019	27	167726.40	105430.10	8293.40	481217.00
	2020	22	133015.20	89306.38	5693.20	338196.20
	2021	19	153835.20	120172.90	14365.70	424410.10
	2022	18	96098.57	74899.67	15818.90	319445.70

Source: Authors' analysis based on BPDB (2017 to 2022).

4.3 Cost of Electricity Sales by Power Plants

The reliance on fossil fuel-based power generation has resulted in higher electricity costs, particularly evident since the energy price volatility started in 2021 due to global conflicts. Hence, it is important to take into account the cost and return of power generation.

The sales of electricity from various power plants to BPDB experienced an almost threefold increase between 2017 and 2022, excluding BPDB's own plant. Despite a rise in electricity generation for BPDB plants (from BDT 1.6 billion in 2017 to BDT 1.7 billion in 2022, as per Table 5), their energy sales value has remained constant. This is noteworthy, especially given the surge in fuel prices, as the data do not elucidate why BPDB's costs have not escalated despite the expansion of its power plant portfolio and increased energy production. The possibility of zero capacity charges might account for the observed low cost.

Table 5: Summary statistics of energy sales (in billion BDT) by types of plants

Ownership	Year	Number of PPs	Energy sales (in billion BDT)	Std. dev. (in billion BDT)	Minimum sales (in billion BDT)	Maximum sales (in billion BDT)
BPDB	2017	37	1.60	1.80	0.01	8.30
	2018	39	2.40	3.30	0.02	15.20
	2019	42	1.80	1.80	0.03	8.70
	2020	45	1.60	2.20	0.00	11.60
	2021	41	1.60	1.90	0.03	9.70
	2022	44	1.70	1.90	0.00	8.90
IPP	2017	30	2.90	3.60	0.10	20.20
	2018	39	2.70	2.90	0.14	16.50
	2019	51	3.10	2.10	0.38	9.60
	2020	58	3.00	2.20	0.09	10.10
	2021	63	4.40	4.70	0.28	32.80
	2022	67	8.80	14.70	0.31	109.00
Public Plant	2017	10	2.60	2.20	0.39	5.60
	2018	13	3.50	2.90	0.36	9.30
	2019	16	4.30	2.60	0.49	8.90
	2020	16	4.20	2.20	0.28	8.70
	2021	16	4.30	2.40	0.25	7.80
	2022	14	5.00	2.90	0.42	11.10
QRPP	2017	29	2.10	1.50	0.17	5.20
	2018	28	2.20	1.70	0.16	5.80
	2019	27	1.90	1.40	0.18	4.80
	2020	22	1.50	1.00	0.12	3.90
	2021	19	1.80	1.60	0.10	5.00
	2022	18	1.60	1.20	0.12	4.10

Source: Authors' analysis based on BPDB (2017 to 2022).

On the other hand, while the costs of BPDB's own plants have stayed unchanged, costs for other public plants rose from BDT 2.6 billion in 2017 to BDT 5 billion in 2022, and for IPPs from BDT 2.9 billion in 2017 to BDT 8.8 billion in 2022, almost tripling in both cases. Although there is an uptick in electricity generation for both IPPs and BPDBs, the substantial increase in electricity sale values for IPPs suggests a notable surge in capacity charges. Conversely, with regard to public plants, the growth in sales values requires scrutiny, especially considering the declining trend in electricity generation.

The electricity cost per kilowatt-hour (KWh) is noted to be higher in BPDB's plants (BDT 41.3/kWh in 2022) compared to IPPs (BDT 16.1/kWh in 2022), public plants (BDT 8.5/kWh in 2022), and rental (BDT13.1/kWh in 2022) sources. Despite earlier tables (3-5) indicating a lower amount of energy generation, CO_2 emission and total energy sales from BPDB's own plants, the per unit price of electricity (table 6) from BPDB's plant exceeds that of other plants (IPP, public and QRPP).

It is crucial to highlight the apparent discrepancy in the average electricity price presented in BPDB's annual report, which claims only BDT 5 per KWh, a figure that needs to be investigated further.

Table 6: Summary statistics of energy price (BDT/KWh) by types of plants

Ownership	Year	Number of PPs	Average price (BDT/KWh)	Std. dev. (BDT/KWh)	Minimum price (BDT/KWh)	Maximum price (BDT/KWh)
BPDB	2017	31	14.2	11.5	1.5	39.1
	2018	35	15.9	13.8	0.0	51.3
	2019	38	16.7	17.9	0.9	84.3
	2020	34	60.0	138.6	1.6	755.7
	2021	30	26.3	48.7	1.9	218.8
	2022	33	41.3	120.4	1.3	681.9
IPP	2017	30	7.4	5.0	1.5	19.7
	2018	39	9.8	7.1	1.5	31.1
	2019	51	16.3	20.2	1.3	82.5
	2020	58	77.5	253.8	1.6	1579.6
	2021	63	18.6	28.5	1.7	180.7
	2022	67	16.1	10.6	1.7	55.4
Public Plant	2017	10	2.3	0.7	1.5	3.5
	2018	13	3.7	3.2	1.1	13.3
	2019	15	5.9	6.2	2.0	23.1
	2020	15	41.2	136.3	2.2	533.4
	2021	15	14.7	32.1	2.4	128.0
	2022	14	8.5	8.5	2.1	28.5
QRPP	2017	29	9.0	7.7	2.6	28.9
	2018	28	9.2	7.4	2.0	31.7
	2019	27	10.5	7.1	2.9	23.8
	2020	21	10.8	8.7	3.3	36.7
	2021	18	7.9	4.5	3.1	16.5
	2022	17	13.1	8.8	3.0	27.4

Source: Authors' analysis based on BPDB (2017 to 2022).

The discrepancy in the electricity price of BPDB's plant indicates encouraging thermal plants over renewable energy-based plants. The perception that thermal plants have lower costs compared to RE-based power plants may have been true in the past, but the landscape is changing rapidly. In recent years, the cost of renewable energy technologies has significantly decreased, making them increasingly competitive with traditional thermal power plants.

The following section highlights the capacity and efficiency of the thermal power plants in detail.

4.4 Power Plant Capacity and Their Efficiency

Coal-fired power plants typically have large capacities and provide a stable base load, but they often operate at lower efficiencies due to losses in combustion and heat conversion (Clarke, 2012). Natural gas-fired plants, while offering higher efficiency and lower emissions compared to coal, may have slightly lower capacities. Combined cycle gas turbine plants, utilising both gas and steam turbines, exhibit higher efficiency levels than conventional gas plants, making them more energy efficient. Meanwhile, oil-fired power plants, although less common, can have moderate capacities and efficiencies.

Tables 6 and 7 provide insights into the capacity, plant factor index score, and efficiency index score for various thermal plants managed by BPDB, IPP, public plants, and QRPPs. Notably, the available data indicates that QRPPs are utilized for the least amount of time each year, averaging nine months of idle time in 2022. This marks a gradual decreases from the utilisation observed in 2017 when QRPPs were operational for around six months annually. This declining trend in QRPP utilisation poses a financial challenge for the government due to the accumulation of larger capacity charges. In contrast, despite possessing higher capacity, public plants are in operation only half of the year, and their efficiency levels are somewhat poor.

Table 7: Summary statistics of plant capacity in 2022 by types of plants

Ownership	Fuel Types	Number of PPs	Average Installed Capacity (in MW)	Std. dev. (in MW)	Minimum installed capacity (in MW)	Maximum installed capacity (in MW)
BPDB	**BPDB Average**	**43**	**151**	**111**	**2**	**400**
	Coal	2	247	38	220	274
	Gas	24	194	115	20	400
	HFO	12	83	50	50	225
	HSD	5	71	93	2	212
IPP	**IPP Average**	**74**	**150**	**167**	**11**	**1320**
	Coal	1	1320	–	1320	1320
	Gas	17	181	148	11	450
	HFO	50	114	65	22	300
	HSD	6	167	82	100	300
Public Plant	**Public Plant Average**	**14**	**277**	**139**	**50**	**450**
	Coal	–	–	–	–	–
	Gas	13	291	135	50	450
	HFO	1	100	–	100	100
	HSD	–	–	–	–	–
QRPP	**QRPP Average**	**34**	**68**	**29**	**10**	**115**
	Coal	–	–	–	–	–
	Gas	17	55	26	10	95
	HFO	12	85	27	40	115
	HSD	5	71	27	50	100

Source: Authors' analysis based on BPDB (2017 to 2022).

Table 8 indicates the index score of annual plant factor and plant efficiency. The higher value from zero (0) indicates worse for both the indicators. Plant-level efficiency data are available till 2020. The table shows that, the higher the plant factor and efficiency level score are, the lower the level of utilisation of power plants and the less efficiency. Over the years, utilisation of BPDB, rental, and public plants decreased, however, utilisation of IPPs and QRPPs increased as the index score is lower compared to others. Nonetheless, the efficiency level of IPPs and QRPPs increased.

In the case of QRPPs, the quick and temporary nature of these plants is designed for rapid deployment during peak demand, contributing to higher generation during specific periods. Besides, IPPs and QRPPs are likely to adopt better technologies, making their power plants more efficient and productive. Public plants which include dated plants, are lagged in adopting cutting-edge technologies.

Table 8: Summary statistics of plant factor, and efficiency index by types of plants

Ownership	Year	Average Annual Plant Factor Index	Average Plant Efficiency Index
BPDB	2017	63.7	55.0
	2018	69.3	61.0
	2019	72.8	56.0
	2020	71.0	53.0
	2021	57.6	–
	2022	64.7	–
IPP	2017	41.0	33.0
	2018	51.9	37.0
	2019	51.0	33.0
	2020	66.0	45.0
	2021	53.1	–
	2022	44.1	–
Public Plant	2017	46.4	46.0
	2018	48.8	40.0
	2019	41.4	39.0
	2020	33.8	36.0
	2021	38.7	–
	2022	51.3	–
QRPP	2017	53.2	41.0
	2018	48.4	41.0
	2019	48.4	44.0
	2020	58.2	53.0
	2021	51.8	–
	2022	73.4	–

Source: Authors' analysis based on BPDB (2017 to 2022).

Thermal power plants have traditionally been associated with higher capacity factors due to their ability to provide a consistent and reliable output. However, they often operate at lower overall efficiency levels, as a significant portion of electricity is lost during the conversion process (Clarke, 2012).

While thermal plants offer a stable base load, renewable plants contribute to a cleaner energy mix with lower environmental impact. The transition towards renewable energy can balance capacity and efficiency to achieve a sustainable and resilient energy infrastructure. Therefore, the current thermal plants need to be phased out after their stipulated timeline. The following sections discuss in detail the timeline of the power plants and grid availability in their surrounding regions.

4.5 Power Plants Period of Operation and Grid Availability

As per BPDB's annual reports, there is a lack of available data regarding the timelines for most public and BPDB plants, excluding IPPs and QRPPs. The analysis maintains uniformity and omits the timeline details in Table 8, yet it utilises this information to calculate power plant index scores in a subsequent section.

Table 9 illustrates the presence of substations at power plant locations, determined by dividing the number of power plants in a specific location by the total number of substations in that area. A higher ratio indicates more power plants, and vice versa. The decision to phase out additional plants could be made for locations with higher power plants, while those with fewer plants could be phased out later.

Regardless of fuel types, public plants, QRPPs, and IPPs tend to be situated in regions with an existing high number of power plants. The BPDB's plants, on the other part, are positioned in areas with a lower concentration of power plants. Diesel-based QRPPs are notably concentrated in power plant-dense areas, whereas HFO-based QRPPs and BPDB's plants are more prevalent in these regions as well. This observation suggests that the distribution of plants is influenced by regional factors, such as gas-based plants being more common in Sylhet due to abundant natural gas, and oil-based plants being located near Chattogram for easier port-based fuel transportation.

Table 9: Summary statistics of plant factor and, efficiency index by types of plants

Ownership	Fuel Types	Number of PPs	Availability of sub-station Index	Std. dev.	Maximum PP Availability	Minimum PP Availability
BPDB	**BPDB Average**	**50**	**29**	**19**	**0**	**61**
	Coal	2	13	0	13	13
	Gas	24	29	16	0	61
	HFO	13	38	22	3	61
	HSD	11	21	17	3	61
IPP	**IPP Average**	**78**	**32**	**31**	**3**	**100**
	Coal	1	5	–	5	5
	Gas	20	40	34	3	100
	HFO	50	29	30	5	100
	HSD	7	28	33	3	100
Public Plant	**Public Plant Average**	**15**	**43**	**29**	**0**	**100**
	Coal	–	–	–	–	–
	Gas	14	46	27	22	100

(Table 9 contd.)

(Table 9 contd.)

Ownership	Fuel Types	Number of PPs	Availability of sub-station Index	Std. dev.	Maximum PP Availability	Minimum PP Availability
	HFO	1	0	–	0	0
	HSD	–	–	–	–	–
QRPP	**QRPP Average**	**27**	**39**	**27**	**3**	**100**
	Coal	–	–	–	–	–
	Gas	16	36	16	13	61
	HFO	9	38	38	3	100
	HSD	2	71	41	42	100

Source: Authors' analysis based on BPDB (2017 to 2022).

A higher number of power plants with lower sub-stations need to be phased out as those are set up due to the natural resource endowment in those regions. Phasing out those plants is important to make space for renewable energy. Older power plants may be less efficient and technologically outdated - replacing them with modern, renewable energy-based plants can improve overall efficiency and contribute to the modernisation of the energy infrastructure.

5. STRATEGY 1: PHASING-OUT OF THE THERMAL PLANTS

5.1 Gradual Phase-out of Thermal Plants Over Time

A comprehensive phase-out plan needs to consider the above-mentioned issues. The phased-out plants are determined based on an index score derived from seven key pillars: (a) CO_2 emission; (b) energy sales in billion BDT; (c) energy price per kWh; (d) annual plant factor; (e) plant efficiency; (f) plant timeline; and (g) availability of substations.

Considering the index score, the phase-out plan is designed for three distinct phases. These three phases are: (a) the first phase targets the top-priority power plants (PPs) for phasing out by 2025; (b) the second phase focuses on medium-priority PPs slated for phasing out by 2030; and (c) the third phase involves low-priority PPs, which are earmarked for phasing out during the post-2030. The prioritisation of phasing out of plants is determined through an index calculation outlined in section 3.

The index scores range from 20.3 to 64.7 (out of 100). The higher the index value is, the worse the plant. The ranges were divided into three stages. Plants receiving a score between 45 to 64.7 are designated as 'top priority' PPs. Those scoring above 30 to <45 were identified as 'medium priority', and plants scoring below 30 were categorised as 'low priority'. Notably, certain PPs are placed on the top and medium-priority lists, even if their scores fall below the specified thresholds, owing to their contractual terms ending by 2025 or 2030.

An important caveat is that, in cases where a plant on the medium-priority list has a timeline equal to or earlier than 2025, it is elevated to the top-priority list, and vice versa. This adaptive approach ensures that plants are appropriately classified based on both their index scores and contractual timelines, optimising the efficacy of the phase-out strategy. Therefore, the government need not pay additional financial incentives for retiring the IPPs or QRPPs as those will be phased out within the stipulated timeline.

The imperative is to phase out top-priority plants by 2025, a measure expected to yield savings of approximately BDT 86 billion (highlighted in Annex 2). This strategic move creates ample space for the integration of nearly 4GW of RE electricity generation within the existing power plant regions. The top-priority list encompasses 18 Quick Rental Power Plants (QRPPs) and 8 Independent Power Producers (IPPs), all facing expiration of their timelines by 2025.

A medium-priority list outlines the phased-out retirement of two IPPs and additional thermal plants (Annex 3). This action is anticipated to facilitate the establishment of 1900 MW of RE power plants. Finally, lower-priority plants were earmarked for phase-out after 2030, with a significant energy-saving potential of almost 14GW (Annex-4).

Table 10: Timeline wise Phasing Out of Fossi-fuel Based Power Plants

	2023	2025	2030
No of plants to be phased out	30	16	94
IPP	8	2	57
QRPP	16	–	–
Public Plant	2	3	9
BPDB	–	11	3

Source: Authors' analysis based on BPDB.

This comprehensive approach ensures a well-informed and balanced strategy for phased retirement of power plants, considering multiple factors crucial to the sustainability and efficiency of the energy landscape. Phasing out existing thermal power plants creates space for renewable energy-based electricity generation. From Table 10, by 2025, existing renewable energy-based electricity generation will increase to 19.5 per cent from 2.7 per cent in 2023 if the government phases out its existing thermal power plants. Phasing out those plants will also save BDT 86.7 billion which the government provides to the thermal power plants for capacity charges and energy prices (Table 11). The amount of BDT 86.7 billion is currently being provided to various power plants by BPDB for selling their energy to the government. By phasing out, the government can nearly fulfil (34.4 per cent by 2041) its target to generate 40 per cent (20130 MW) by 2041 from renewable energy sources. According to the IEPMP forecast of generating 58597 MW of electricity, 40 per cent RE accounts for 23438 MW, of which 34.4 per cent (20130 MW) RE can be generated by phasing out existing thermal-based power plants. However, according to the CPD forecast of much lower demand for electricity by 2041, the total RE will need almost 14000 MW which can be simply achieved by phasing out the existing power plants.

Table 11: Summary table of Renewable Energy share in 2025, 2030 and 2041

Year	Thermal Capacity (in MW)	Renewable Electricity Capacity (in MW)	Share of Renewable Electricity (%)	Financially Saves (in billion BDT)
2023	25929.0	689.0	2.7	–
2025	22274.0	4344.0	19.5	86.7
2030 IEPMP	29257.0	17579.0	30.0	–
2030 Calculated	20434.0	6184.0	30.3	41.8
2041 IEPMP	58597.0	24000.0	40.0	–
2041 Calculated	58597.0	20130.0	34.4	630.0
Total	**58597.0**	**31347.0**	–	**758.5**

Source: Author's estimation based on the IEPMP and BPDB annual report of 2017-22.

The total thermal capacity value indicates the IEPMP forecast, with 31,347 MW representing the total RE to be generated by phasing out existing power plants. If the government builds power plants according to the IEPMP forecast and phases out the existing thermal power plants, it could save a total of BDT 758.5 billion on electricity purchases (excluding purchases from India) that were spent in the fiscal year 2021-22. In the fiscal year 2022-23, the government spent BDT 868.6 billion (excluding purchases from India) on electricity, which is 2.1 per cent of the GDP for 2022-23.

It is important to note that the financial savings mentioned are not accrued over time but rather represent savings phased out for specific plants within a defined timeframe. This is because the government procures electricity from various plants at varying prices and the phase-out priority suggests a varied number of plants in different timeframes. Hence, the savings amounts for 2025, 2030, and 2041 differ due to the amount of energy sales as well as the total number of plants that are going to be phased out in that given timeframe.

To facilitate the transition to renewable energy by replacing current thermal plants, it is crucial to determine the levelised cost of electricity (LCOE) associated with renewable sources. LCOE is a metric used to evaluate the average cost per unit of electricity generated by a specific energy-generating asset or technology throughout its operational lifespan. Existing literature reveals the calculation of LCOE costs for various countries over the past decade. From 2010 to 2021, solar energy costs plummeted by 88 per cent, with onshore and offshore wind costs dropping by 68 per cent and 60 per cent, respectively (IRENA, 2022). In 2020, the fossil fuel industry received USD 5.9 trillion in subsidies, including explicit subsidies, tax exemptions, and unaccounted health and environmental losses (Yale Environment, 2021). Achieving net-zero carbon emissions by 2030 requires an annual investment of about USD 4 trillion in renewable energy for technology and infrastructure (International Energy Agency, 2021). While initial costs may challenge nations with limited resources, financial and technical assistance is crucial for a successful transition. Renewable energy investments show profitability, with potential savings of up to USD 4.2 trillion annually by 2030 through reduced pollution and climate impacts (United Nations, 2020). Efficient and reliable renewable technologies can enhance energy resilience and security by diversifying power supply options.

Those studies include the average global weighted LCOE cost (Table 12) of different RE power plants.

Table 12: Renewable energy installed prices and levelised cost of electricity

Renewable source	Levelised cost of electricity (USD/kilowatt-hour)		
	2010	2021	Change %
Bioenergy	0.08	0.07	-14
Geothermal	0.05	0.07	34
Hydropower	0.04	0.05	24
Solar photovoltaics	0.42	0.05	-88
Concentrated solar power	0.36	0.11	-68
Onshore wind	0.10	0.03	-68
Offshore wind	0.19	0.08	-60

Source: Osman, et.al., (2023).

The decreasing trend in the LCOE for renewable energy plants holds the potential to attract investors in the renewable energy sector. This trend not only makes renewable energy more economically viable but also aligns with environmental objectives. As the LCOE continues to decline, it becomes increasingly appealing for investors, fostering the broader transition of the power sector from thermal sources to renewable energy, thereby promoting sustainability both economically and environmentally.

5.2 Strategy 2: Different Renewable Energy-based Power Plants as Part of Reaching Target of 40% of Renewable Energy

Table 13 represents the total electricity that needs to be generated from different renewable energy sources. To fulfil the 40 per cent renewable energy-based electricity generation, the government needs to install new solar and wind-based power plants in different locations subject to the potential of energy generation. In this regard, several studies have been conducted to assess the availability and potential of renewable energy from various sources, in accordance with the targets outlined in the MCPP and the IEPMP (SREDA, n.d.). The MCPP mentions specific targets, such as generating 4,000 MW of wind-based electricity from the mangrove green belt and 2,000 MW of solar power from government buildings. Additionally, the government aims to explore offshore wind energy and enhance domestic storage capacity, capitalising on the Bay of Bengal for tidal power-based energy generation. The detailed breakdown presented in Table 13 is derived from the SREDA database, encompassing existing renewable energy-based power generation sources, and modified based on the phase out calculation. This breakdown considers various targeted measures spanning the period from 2025 to 2041, aligning with the government's renewable energy objectives.

The gradual phase-out of existing thermal power plants holds the potential to generate financial savings for the government. This financial space can be strategically utilised to advance the promotion of electricity generation from renewable energy sources. Moreover, the funds can be allocated to compensate power producers for the early retirement of their plants (if any). This dual-purpose approach not only supports the transition towards cleaner and sustainable energy but also acknowledges the economic implications for power producers affected by the phased-out plants. It reflects a balanced strategy that aligns fiscal responsibility with the promotion of environmentally friendly and economically viable energy alternatives.

Table 13: New electricity to be generated by RE in different time period

RE Source	Technology	2025 Total MWp	2030 Total MWp	2041 Total MWp
Solar	Solar Park	1683.8	1964.7	2029.9
	Rooftop Solar Except NEM	273.4	928.4	959.2
	Net Metering Rooftop Solar	309.7	361.3	373.3
	Solar Irrigation	190.3	222.1	229.5
	Solar Home System	963.5	1124.2	1161.5
	Solar Minigrid	21.2	24.7	25.6
	Solar Microgrid	0.0	0.0	0.0
	Solar Nanogrid	0.0	0.0	0.0
	Solar Charging Station	1.0	1.2	1.2
	Solar Street Light	62.5	72.9	75.3
	Solar Powered Telecom BTS	29.4	34.3	35.5
	Solar Drinking Water System	0.3	0.4	0.4
Wind	All Wind Projects	2523.4	3743.9	3868.2
Hydro	All Hydro Projects	840.1	980.2	1012.7
Biogas	Biogas to Electricity	2.5	2.9	3.0
	Biogas Plant	0.0	0.0	0.0
Biomass	Biomass to Electricity	1.5	1.7	1.8
	Total	**10139.0**	**13720.2**	**14175.8**

Source: Authors' analysis based on BPDB (n.d.) and SREDA (n.d.).

6. POLICY RECOMMENDATIONS FOR INTRODUCING RENEWABLE ENERGY

Recognising the transformative potential of RE in mitigating environmental impacts, enhancing energy security, and fostering economic growth, the following policy recommendations aim to chart a course towards a cleaner and more sustainable energy landscape. A detailed exploration of strategic measures can empower governments, industries, and communities to embrace and integrate RE solutions.

a. Gradual phasing out of thermal plants: Phasing out thermal plants gradually can be a critical strategy to augment the share of renewable energy in the energy mix of power generation, guided by the prioritised list outlined in Annexes 2 to 4. The financial benefits of retrofitting these plants underscore the viability of this approach.
b. Incentivising renewable energy-based plants to promote renewable energy investment over fossil fuel-based plants: Incentivising renewable energy-based plants becomes imperative to stimulate investments in renewable energy, necessitating a restructuring of incentive frameworks with financial incentives surpassing those for fossil fuel-based plants.
c. Publishing accurate cost data of the thermal power plants: Transparency in disclosing accurate cost data for thermal power plants is needed to prevent distorted RE investment decisions.
d. Replacing higher PP areas with RE-based plants: The government needs to identify regions burdened by excessive power plants and strategically replace thermal-based facilities with RE-based plants.

e. Aligning the targets of MCPP and IEPMP: Both the MCPP and IEPMP are government plans, however, the IEPMP is amended later with a high-cost energy plan where renewable energy-based power generation target is still limited to 10 per cent. The government should consider revising its commitment to the IEPMP and implementing 40 per cent renewable energy by 2041 as mentioned.

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Annexes

Annex 1: Targets to be achieved by the MoPEMR set by MCPP

Year	Target	Lead Ministry
2023	Bongoposagor Independence Giga Array begins installing 500MW of offshore wind per year up to 2030	MoPEMR
2023	To set up 2,000 MW of renewable energy procurement on a modular basis completed by 2025	MoPEMR
2024	To set up storage procurement to be completed in phases through 2030	MoPEMR
2025	All railway platforms to include solar power and other public spaces to maximize use of solar power	MoPEMR
2026	To set up 5,000 MW of renewable energy procurement on a modular basis to be completed by 2030	MoPEMR
2029	phase out all imported fossil fuel subsidies and redirect them to lower cost options, loss and damage, adaptation, renewable energy, and storage technology	MoPEMR
2030	Bongoposagor Independence Giga Array completes installation of 4 GW of offshore wind generation and parallel planting of mangrove greenbelt	MoPEMR
2030	To set the trajectory for 40% renewable energy by 2041 and 100% by 2050	MoPEMR
2041	40% renewable energy with support from international resources	MoPEMR
2050	100% renewable energy with support from international resources	MoPEMR

Source: Authors complation from MoPEMR Report 2022.

Annex 2: Power plants to be phased out as top priority by 2025

Generating Plant under Power Station	Capacity in 2022 in MW	Types of Plant	Ownership	Net Generation (kWh) 2022	CO_2 Emission 2022 (in ton)	Total Generation Cost (BDT) 2022	Gen. Cost BDT/ kWh 2022	Overall Index Score
EGCB Ltd. (412) MW	412.00	GAS	Public Plant	1981733402.00	1021167.40	4954975092.00	2.5	64.2
Dutch Bangla Power & Associates Ltd.	100.00	HFO	QRPP	161,026,042.00	122233.30	3,250,631,030.00	20.2	57.7
Paramount BTrac Energy Ltd. - Sirajganj	200.00	HSD	IPP	104571634.00	79379.30	5791953269.00	55.4	57.3
Ashuganj Power Co. Ltd (APSCL) (450 MW) North	450.00	GAS	Public Plant	2017615091.00	1039656.90	5960985814.00	2.95	57.0
Summit Power Co. Ltd Madanganj (100 MW)	102.00	HFO	QRPP	109,319,891.00	82983.60	2,100,228,103.00	19.20	55.70
APR Energy 300MW	300.00	HSD	IPP	259472196.00	196962.70	10835439637.00	41.80	54.20
Summit Meghnaghat Power Ltd.	337.00	HSD	IPP	1524542505.00	1157265.00	6428574957.00	4.20	52.00
Aggreko Energy Solution Ltd. - Bhahmangoan (100MW)	100.00	HSD	IPP	120485001.00	91459.00	4245841612.00	35.20	51.20
Shahjibazar Power Co. Ltd. 86 MW RPP (15 yrs)	86.00	GAS	QRPP	619,933,776.00	319445.70	2,194,442,394.00	3.50	50.00
Khulna (KPCL-U-2) 115 MW	115.00	HFO	QRPP	107,420,657.00	81541.90	2,138,624,001.00	19.90	49.80
Bhola 32 MW (Venture Energy Resources Ltd.)	33.00	GAS	QRPP	189,564,498.00	97680.70	672,491,504.00	3.60	43.00
Power Pac Mutiara Keraniganj	100.00	HFO	QRPP	91,903,200.00	69762.80	2,515,217,918.00	27.40	40.70
Acron Infrastructure Services Ltd (Julda)	100.00	HFO	QRPP	222,839,580.00	169155.30	4,110,168,523.00	18.44	39.60
Ashuganj 55 MW 3Yrs Rental (Precision Energy)	55.00	GAS	QRPP	276,586,308.00	142522.20	1,257,886,706.00	4.60	38.60
Aggreko, International Ltd.- Ashuganj (95 MW)	95.00	GAS	QRPP	103,561,853.00	53364.40	1,327,286,944.00	12.80	38.20
Energyprima Limited, Fenchuganj	44.00	GAS	QRPP	48,318,547.00	24898.10	146,415,205.00	3.00	35.60
Energyprima Limited, Kumargaon	54.00	GAS	QRPP	41,095,560.00	21176.10	119,125,405.00		35.40

(Annex Table 2 contd.)

(Annex Table 2 contd.)

Generating Plant under Power Station	Capacity in 2022 in MW	Types of Plant	Ownership	Net Generation (kWh) 2022	CO_2 Emission 2022 (in ton)	Total Generation Cost (BDT) 2022	Gen. Cost BDT/ kWh 2022	Overall Index Score
Khanjahan Ali Power Ltd.	40.00	HFO	QRPP	29,896,435.00	22694.10	586,325,265.00	19.60	34.90
Amnura (Sinha Power Generation)	50.00	HFO	QRPP	20,839,351.00	15818.90	274,117,988.00	13.20	29.20
Baraka power co. Ltd.		GAS	QRPP	349,663,734.00	180178.20	1,120,522,242.00	3.20	27.40
GBB Power Ltd. Bogra RPP (24MW) 15 yrs	22.00	GAS	QRPP	167,469,576.00	86295.40	685,508,842.00	4.10	23.50
Desh Cambridge Kumargaon Power Co. Ltd.	10.00	GAS	QRPP	75,345,178.00	38824.60	273,009,147.00	3.60	17.90
Northern Power Solution Ltd.		HFO	QRPP	66,336,489.00	50355.40	1,696,707,045.00	25.60	
Orion Power Meghnaghat Ltd.		HFO	QRPP	165,454,808.00	125595.10	3,425,588,809.00	20.70	
Aggreko Energy Solution Ltd. - Aorahati (100MW)	100.00	HSD	IPP	131526563.00	99840.50	4417000846.00	33.60	47.90
Bangla Track Power Company Ltd.	200.00	HSD	IPP	159163968.00	120819.80	6736713233.00	42.30	46.00
Bangla Track Power Company Ltd. (Unit-2)	100.00	HSD	IPP	102068064.00	77478.80	3703225481.00	36.30	43.20
Meghnaghat Power Ltd.	450. 00	GAS	IPP	2140792000.00	1103128.70	5709336569.00	2.70	42.70
Total	**3655. 00**			**11388545907.00**	**6691683.845.00**	**86678343581.00**		

Source: Authors annalysis from BPDB annual report 2017-22.

Annex 3: Power plants to be phased out as medium priority by 2030

Generating Plant under Power Station	Capacity in 2022 in MW	Types of Plant	Ownership	Net Generation (kWh) 2022	CO_2 Emission 2022 (in tonne)	Total Generation Cost (BDT) 2022	Gen. Cost BDT/ kWh 2022
Rangpur Gas Turbine Power Station	20.00	HSD	BPDB	2082840.00	1581.10	237280611.00	113.92
North West Power Gen (NWPGCL)-Bheramara	410.00	GAS	Public Plant	1966292933.00	1013211.10	6934357044.00	3.53
Ghorashal Power Station (Unit 1&2)	110.00	Gas	BPDB			448226236.00	
Baghabari Power Station	171.00	Gas	BPDB	51,893,680.00	26740.30	857449266.00	16.52
North West Power Gen (NWPGCL)-Sirajganj (Unit - 3)	225.00	GAS	Public Plant	1220422550.00	628871.50	4748113291.00	3.89
Digital Power & Associates Ltd.	102.00	HFO	IPP	440988642.00	334750.10	7478876342.00	17.00
SBU Haripur	20.00	Gas	BPDB	-347975.00	-179.30	241227585.00	
Siddhirganj power station	115.00	Gas	BPDB	-1053008.00		985270541.00	
Barapukuria Power Station	220.00	Coal	BPDB	248793827.00	254028.40	3420149816.00	13.75
Sandip Diesel Generator		HSD	BPDB	—	—	12736.00	
Khulna Power Station		HFO	BPDB	—	—	292223354.00	
Bera Peacking Power Plant	71.00	HFO	BPDB	60148245.00	45657.90	1358463204.00	22.59
North West Power Gen (NWPGCL)-Khulna	225.00	GAS	Public Plant	437277714.00	225324.80	11138939273.00	25.47
Shantahar 50MW Power Plant	50.00	HFO	BPDB	68351477.00	51884.90	1337579690.00	19.57
Katakhali 50MW Power Plant	50.00	HFO	BPDB	67786253.00	51455.90	1310986927.00	19.34
Midland Power Company Ltd.	51.00	GAS	IPP	370760585.00	191049.20	1021219011.00	2.80
Total	1840.00	—	—	4933397763.00	2824376.00	41810374927.00	—

Source: Authors annalysis based on BPDB annual report 2017-22.

Annex 4: Power plants to be phased out as long-term by 2041

Generating Plant under Power Station	Capacity in 2022 in MW	Types of Plant	Ownership	Net Generation (kWh) 2022	CO_2 Emission 2022 (in tonne)	Total Generation Cost (BDT) 2022	Gen. Cost BDT/ kWh 2022	Overall Index Score
Baghabari 50 Peaking Power Plant	50.00	HFO	BPDB	106132634.00	80564.20	2044545547.00	19.26	39.50
Gopalganj peaking power plant	100.00	HFO	BPDB	18612822.00	14128.80	958418759.00	51.49	38.80
Chattogram power station, Rawzan	360.00	Gas	BPDB	560551576.00	288846.60	2708419702.00	4.83	38.00
Chapainawabganj Peaking pp 100 MW Amnura	100.00	HFO	BPDB	251354160.00	190800.40	5788344434.00	23.03	37.90
Summit Bibiyana II Power Company Ltd.	341.00	GAS	IPP	2310625924.00	1190642.40	5996723144.00	2.6	37.20
Barapukuria Power Station	274.00	Coal	BPDB	1094796315.00	1117830.80	8896769673.00	8.13	36.50
Summit Purbachal Power Ltd.-Jangalia		GAS	IPP	232729909.00	119923.40	945539654.00	4.1	36.50
Bibiyana - South	383.00	Gas	BPDB	2522746430.00	1299946.00	4679258795.00	1.85	36.30
Faridpur Peacking Power Plant	50.00	HFO	BPDB	42848640.00	32526.00	896785197.00	20.93	36.20
Tongi Power Station	105.00	Gas	BPDB	-74765.00		390026306.00		36.00
Fenchuganj 2x 90 MW CCPP (1st & 2nd unit)	201.00	Gas	BPDB	540062078.00	278288.60	1686677007.00	3.12	35.70
North West Power Gen (NWPGCL)-Sirajganj		GAS	Public Plant	224720935.00	115796.50	2148277482.00	9.56	35.20
Shahjibazar 100 P/S	100.00	Gas	BPDB	59677856.00	30751.40	535795204.00	8.98	35.20
North West Power Gen (NWPGCL)- Sirajganj (Unit - 2)		GAS	Public Plant	1008745563.00	519796.50	7522171723.00	7.46	34.90
United Payra PP Patuakhali Imp 115MW	150.00	HFO	IPP	76919436.00	58388.80	2502197530.00	32.5	34.90
EGCB Ltd. (360MW) Simple Cycle	360.00	GAS	Public Plant	1419204804.00	731302.00	5958406989.00	4.2	34.80
Lanka Power Limited - Feni	114.00	HFO	IPP	329452681.00	250084.20	5721652913.00	17.4	34.80

(Annex Table 4 contd.)

(Annex Table 4 contd.)

Generating Plant under Power Station	Capacity in 2022 in MW	Types of Plant	Ownership	Net Generation (kWh) 2022	CO_2 Emission 2022 (in tonne)	Total Generation Cost (BDT) 2022	Gen. Cost BDT/ kWh 2022	Overall Index Score
Haripur Power Ltd.	360.00	GAS	IPP	1919174000.00	988931.20	3267873587.00	1.7	34.70
Ghorashal Power Station (Unit 5&6)	190.00	Gas	BPDB	477730490.00	246169.70	1395279150.00	2.92	34.20
Kumergoan Gt Power Sylhet	20.00	Gas	BPDB	65637000.00	33822.10	236431800.00	3.6	34.00
Ashuganj Power Co. Ltd (APSCL) (450 MW) South	450.00	GAS	Public Plant	2135112449.00	1100202.10	8036514579.00	3.76	34.00
EPV Thakurgaon Limited (115 MW)	115.00	HFO	IPP	191362182.00	145261.10	3406841241.00	17.8	33.80
Shahjibazar 330 CCPP	330.00	Gas	BPDB	1079194056.00	556097.90	5220392173.00	4.84	33.20
Orion Power Rupsha Ltd. - Khulna (105MW)	105.00	HFO	IPP	540193296.00	410055.30	9038681251.00	16.7	32.90
Hathazari Peacking Power Plant	98.00	HFO	BPDB	28044085.00	21288.00	888274206.00	31.67	32.60
Ghorashal Power Station (Unit 3)	260.00	Gas	BPDB	4491600.00	2314.50	3062796623.00	681.89	32.10
Sinha People Energy Ltd.	51.00	HFO	IPP	25438560.00	19310.20	497991030.00	19.6	31.60
Payra Bangladsh -China Power Company (Pvt.) Ltd. 1320MW	1320.00	Coal	IPP	3998490350.00	4082618.60	55395607066.00	13.9	31.50
United Ashuganj Energy Ltd.	195.00	GAS	IPP	259236429.00	133581.90	2895092642.00	11.2	31.40
Lakdhanvi Bangla Power Ltd.	52.00	HFO	IPP	217114112.00	164809.20	3654069728.00	16.8	31.10
Ashuganj Power Co. Ltd (APSCL) (Except New 570 MW)		GAS	Public Plant	347574918.00	179101.90	2516021467.00	7.24	30.90
United - Anawara (300MW)	300.00	HFO	IPP	1677406561.00	1273302.50	27943395632.00	16.7	30.70
Sayedpur Gas Turbine Power Station	20.00	Gas	BPDB	1171640.00	603.70	214378695.00	182.97	30.70
Titas 50 MW Peacking Power Plant	52.00	HFO	BPDB	102724595.00	77977.20	1909193576.00	18.59	29.80

(Annex Table 4 contd.)

(Annex Table 4 contd.)

Generating Plant under Power Station	Capacity in 2022 in MW	Types of Plant	Ownership	Net Generation (kWh) 2022	CO_2 Emission 2022 (in tonne)	Total Generation Cost (BDT) 2022	Gen. Cost BDT/ kWh 2022	Overall Index Score
Summit Barishal Power Ltd.	110.00	HFO	IPP	62791776.00	47664.60	2313583188.00	36.9	29.80
Shahjibazar Power Station	70.00	Gas	BPDB	416665550.00	214703.60	1267460786.00	3.04	29.70
Ghorashal Power Station (Unit 7)	365.00	Gas	BPDB	1514663501.00	780491.00	4812460804.00	3.18	29.60
Shikalbaha Power Station (Duel Fuel)	150.00	Gas	BPDB	91759968.00	47283.00	792042727.00	8.63	29.60
Chandpur Power Generation Ltd. (115 MW)	115.00	HFO	IPP	205345603.00	155875.80	3713184400.00	18.1	29.50
Bibiyana-3 400mw	400.00	Gas	BPDB	2139346500.00	1102383.90	2840470994.00	1.33	29.30
Hatiya Diesel Generator	2.00	Diesel	BPDB	4204217.00	3191.40	129907929.00	30.9	29.00
Chandpur cc power plant	163.00	Gas	BPDB	726768536.00	374496.60	2057993424.00	2.83	28.50
Sylhet 150 MG Peaking Power Plant	231.00	Gas	BPDB	1294125009.00	666849.70	2884828271.00	2.23	27.90
Power Pac Motiara – Jamalpur	95.00	HFO	IPP	13945632.00	10586.00	307097193.00	22.0	27.60
Ghorashal Power Station (Unit 4)	240.00	Gas	BPDB	432377000.00	222799.50	1464560571.00	3.39	26.70
Nutan Bidyut (Bangladesh) Ltd. (220MW)	220.00	HFO	IPP	1653494918.00	1255151.50	4973733765.00	3.01	26.40
Desh Energy Chandpur Power Company Ltd.	200.00	HFO	IPP	752048193.00	570872.30	12934344889.00	17.2	26.10
Baraka Shikalbaha Power Ltd. (105MW)	105.00	HFO	IPP	610898228.00	463726.70	9816459440.00	16.1	26.10
Karnaphuli Power Ltd. Shikalbaha 110 MW PP	110.00	HFO	IPP	693947514.00	526768.60	10738505984.00	15.5	26.00
Shikalbaha 225 MW Shamipur (Duel Fuel)	225.00	Gas	BPDB	371948514.00	191661.30	371948514.00	8.52	25.90
ECPV Power Ltd.	108.00	HFO	IPP	407101368.00	309026.60	7158148504.00	17.6	25.80
Dohazari Peacking Power Plant (Sangu, Dohazari-kaliaish 100 MW PPP)	102.00	HFO	BPDB	131892360.00	100118.20	2616812217.00	19.84	25.40

(Annex Table 4 contd.)

(Annex Table 4 contd.)

Generating Plant under Power Station	Capacity in 2022 in MW	Types of Plant	Ownership	Net Generation (kWh) 2022	CO_2 Emission 2022 (in tonne)	Total Generation Cost (BDT) 2022	Gen. Cost BDT/ kWh 2022	Overall Index Score
Kushiara Power Company Ltd.	163.00	GAS	IPP	1038532925.00	535145.60	3185653217.00	3.1	25.10
HF Power Company Limited	113.00	HFO	IPP	577999758.00	438753.80	8906890033.00	15.4	24.30
ACE Alliance Power Ltd. (149MW) (Summit Gazipur)	149.00	HFO	IPP	809133408.00	614205.10	13339615719.00	16.5	24.00
Bhairab Power Limited (54.50MW)	54.00	HFO	IPP	198278640.00	150511.30	3361477855.00	17.0	23.90
Acron Infrastructure Services Ltd. Unit-2	100.00	HFO	IPP	512083584.00	388717.50	8055322054.00	15.7	23.70
Ashuganj Power Co. Ltd (APSCL) (225 MW)	225.00	GAS	Public Plant	1579703499.00	814005.40	5245040830.00	3.32	23.60
Confidence Power Ltd. – Rangpur	113.00	HFO	IPP	623970029.00	473649.40	10001094642.00	16.0	23.60
Raj Lanka Power Limited	52.00	HFO	IPP	234706041.00	178163.00	3656794613.00	15.6	23.50
Regent Energy & Power Ltd.	108.00	GAS	IPP	360724103.00	185877.50	1472507201.00	4.1	23.40
Confidence Power Ltd. (Unit-2) - Bogra	113.00	HFO	IPP	655152288.00	497319.60	108551170802.00	16.6	23.30
United Jamalpur 200MW	115.00	HFO	IPP	627954216.00	476673.80	10830596553.00	17.3	23.00
Acron Infrastructure Service Ltd. (Unit-3)	100.00	HFO	IPP	586327094.00	445075.00	8847932285.00	15.1	22.60
M/S Banco Energy Generation Ltd.	54.00	HFO	IPP	376975008.00	286158.00	5969027473.00	15.8	22.40
Confidence Power Ltd. (Unit-1)	113.00	HFO	IPP	613355712.00	465592.20	10097178928.00	16.5	22.30
North West Power Gen (NWPGCL)-Madhumati		HFO	Public Plant	98005392.00	74394.90	2787875557.00	28.45	21.80
BPDB RPCL Power Gen Ltd		HFO	IPP	480557237.00	364786.20	9535028277.00	19.8	21.40
Baraka Patenga Power Limited	50.00	HFO	IPP	232871760.00	176770.60	3620246651.00	15.6	21.20
Zodiac Power Ctg. Ltd.	54.00	HFO	IPP	320369811.00	243189.50	5029347420.00	15.7	21.20

(Annex Table 4 contd.)

(Annex Table 4 contd.)

Generating Plant under Power Station	Capacity in 2022 in MW	Types of Plant	Ownership	Net Generation (kWh) 2022	CO_2 Emission 2022 (in tonne)	Total Generation Cost (BDT) 2022	Gen. Cost BDT/ kWh 2022	Overall Index Score
Anlima Energy Limited (116MW)	116.00	HFO	IPP	755550326.00	573530.70	11468258410.00	15.2	21.10
Tangail Palli Power Generation Ltd. (22MW)	22.00	HFO	IPP	149421480.00	113424.40	2365086053.00	15.8	21.00
RPCL 52MW Gazipur	220.00	HFO	IPP	209417122.00	158966.40	3793092964.00	18.1	20.70
Manikganj Power Generations Limited (162MW)	162.00	HFO	IPP	1041083049.00	790275.70	16458006350.00	15.8	20.00
Bhola 225 MW CCPP	195.00	Gas	BPDB	633957607.00	326672.00	3411238694.00	5.38	18.90
Midland East Power Company Ltd.		HFO	IPP	858896611.00	651979.80	13304285799.00	15.5	18.20
Sembcorp NWPC Ltd. - Sirajganj (282MW)	414.00	GAS	IPP	2817383745.00	1451769.70	9132705810.00	3.2	16.00
Summit Gazipur II Power Ltd. - Kodda (300MW)	300.00	HFO	IPP	1421077329.00	1078725.60	24417833567.00	17.2	15.80
Doreen Northern Power Limited		GAS	IPP	297602757.00	153351.70	4903100529.00	16.5	15.30
United Mymensingh Power Ltd. (200MW)	200.00	HFO	IPP	1052002800.00	798564.80	17447304343.00	16.6	15.20
Doreen Southern Power Limited		GAS	IPP	311143774.00	160329.30	5040225092.00	16.2	14.30
Ashuganj Power Co. Ltd (APSCL) (New 50 MW)	50.00	GAS	Public Plant	194969682.00	100465.90	417729941.00	2.14	14.20
Doreen Power Generation & System Ltd.-Feni		HFO	IPP	161137538.00	122317.90	467524474.00	2.9	14.20
Doreen Power Generation & System Ltd.- Tangail		HFO	IPP	156351263.00	118684.70	462019663.00	3.0	14.10
EGCB Ltd.(210X2) MW	420.00	GAS	Public Plant	116096664.00	59823.40	1631192273.00	14.05	13.50
RPCL 25MW Rawjan	25.00	HFO	IPP	80466131.00	61081.00	1502164876.00	18.7	13.00

(Annex Table 4 contd.)

(Annex Table 4 contd.)

Generating Plant under Power Station	Capacity in 2022 in MW	Types of Plant	Ownership	Net Generation (kWh) 2022	CO_2 Emission 2022 (in tonne)	Total Generation Cost (BDT) 2022	Gen. Cost BDT/ kWh 2022	Overall Index Score
Shahjanullah Power Generation Co. Ltd.		GAS	IPP	119664201.00	61661.80	413061164.00	3.5	12.50
RPC LTD. Mymensingh (210 MW)	210.00	Gas	IPP	1106935572.00	570392.80	4130993792.00	3.7	12.50
RPCL - Gazipur (105MW)	105.00	HFO	IPP	535752588.00	406684.40	8934646402.00	16.7	9.70
Regent Power Ltd.		GAS	IPP	147081880.00	75789.80	453755759.00	3.1	7.00
United Power Generation & Distribution		GAS	IPP	193143360.00	99524.80	642881762.00	3.3	6.10
Kanchan Purbachal Power Generation Limited (55MW)	55.00	HFO	IPP	190009188.00	144234.10	3183850656.00	16.8	46.80
Orion Power Sonargaon Ltd.	104.00	HFO	IPP	638940480.00	485013.30	8427320532.00	13.2	42.00
Summit Narayangonj Power Unit II Ltd.	55.00	HFO	IPP	288604038.00	219076.40	4990935236.00	17.3	40.40
Total	**13946.00**			**58795917398.00**	**383900430**			

Source: Authors annalysis from BPDB annual report 2017-22.

Bangladesh aims to gradually reduce its dependence on fossil fuels in all kinds of economic activities as part of its global and national commitments. Since the power sector is one of the most important carbon-emitters given its over-dependence on fossil-fuels as fuel-mix, it is important to strategise, plan and thereby implement gradual reduction of the share of fossil-fuel in power generation. A major step will be to increase the share of alternate energy - renewable energy (RE) in power generation and thereby develop the transmission and distribution related energy infrastructure. Though the share of renewable energy in power generation energy-mix is very low (4.5 per cent), the government's plan to reach 40 per cent RE by 2041 through gradual phase out of existing fossil fuel-based power plants and establishing new RE-based power plants.

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