A Case Study of Bangladesh Power Generation and Sustainable Solution

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***Abstract*—** Currently, the plants under construction are more organized and well-planned, while most of the existing power plants in Bangladesh are located here and there without proper manner. Therefore, feeding fuels have to be transported from long distances to the site, which adds to production costs. Moreover, Bangladesh is trying to switch to a coal-based power system (approximately 50% of total generation) that will create a non-sustainable growth of electricity with coal dependency from other counties. As a result, this system will release a vast amount of carbon into the environment, and light residue causes air pollution. In addition, a bulk amount of land is required for the storage of imported coal, which can be used for sustainable development sectors such as agriculture. After all, dependence on foreign fuels can lead to fuel crises for unexpected occurrences and turn to power shortages. At this hurdle, switching the entire power system will also be impossible in another system of generation. However, Bangladesh can produce electricity from renewable sources, and newfangled ideas can ensure the proper use of land and resources. Furthermore, it also has a huge opportunity to generate a sufficient amount of electricity from the ocean and rivers. This paper aims to highlight those problems and find a solution.

***Keywords*—** Bangladesh, power scenario, sustainable power, power plant, Bangladesh power.

I. INTRODUCTION

Bangladesh has almost succeeded in reducing load shedding to zero, and the current power plant construction scenario is declaring that they are ready for the future. The country is undertaking long-term projects to support economic growth of the country. Bangladesh is also introducing highly electricity-dependent developments such as the Metrorail system. So, at a glance, Bangladesh is doing a great job in developing the power sector.

But problems are found more frequently when one dives deeper into the development of the power system. Gas, coal, and oil are the three pillars behind this development [17], although Bangladesh has small gas and coal reserves that can hardly sustain this wave of progress. Moreover, it has no oil reserves compared to gas or coal, so the country has to import all kinds of power plant-feeding oil, which stabs progress.

As a result, Bangladesh has decided to build coal-based power plants near ports and import coal from other countries. It is difficult to sustain a system if the system is highly dependable. If Bangladesh can buy coal for a long time, it will need to build huge coal storage facilities to store large quantities of coal.

So, the country will need double or triple the land for power generation in 2040 than now, and coal contains carbon residue and ash, which is very harmful and causes global warming. As a result, the electricity sector of Bangladesh will collapse soon. Besides, the country has the opportunity to generate almost all of its electricity needs from renewable sources because it is a tropical country and has the world's largest beaches [13]. Therefore, Bangladesh needs to plan better for appropriate and sustainable solutions.

This paper addresses that issue and provides some steps to start making the electricity production system sustainable. First, it will show the resources that Bangladesh is using to generate electricity.

Then some lists of power plants to understand the system dependency, and finally, what the system will look like in the future and its sustainability of the system

II. RESOURCES OF ENERGY OF BANGLADESH

Bangladesh has three kinds of resources to produce electricity, and they are natural gas, coal, and crude oil.

A. Natural Gas

Below ground, Bangladesh has 7.25 trillion cubic feet (Tcf) [1] of natural gas, and beneath the Bay of Bengal, Bangladesh has about 103 Tcf [2] of methane. So Bangladesh is rich in gas. But daily consumption is also high, about 2,280 mmcf per day in 2021 [3].

Table I: *Location of gas resources are given division wise*

Gas fields in Dhaka Division [19]		
Si. No	Place	Year
1.	Gazipur	1981
2.	Narsingdi (Meghna)	1990
3.	Narsingdi	1990
Gas fields in Chittagong Division [19]		
Si. No	Place	Year
1.	Brahmanbaria	1962
2.	Brahmanbaria	1996
3.	Khagrachhari	1969
4.	Comilla	1969
5.	Lalmai	2005
6.	Gangura	2005
7.	Cox's bazar	1977
8.	Begumganj	1977
9.	Feni	1981
10.	Chittagong	1996
11.	Noakhali	2011
12.	Comilla	2012
Gas fields in Mymensigh Division [19]		
Si. No	Place	Year
1.	Netrokona	2011
Gas fields in Sylhet Division [19]		
Si. No	Place	Year
1.	Haripur	1955
2.	Sunamganj	1959
3.	Habiganj	1960
4.	Habiganj	1963
5.	Habiganj	1998
6.	Kailashtila	1962
7.	Beyanibazar	1981
8.	Jalalabad	1989
9.	Moulvibazar	1989
10.	Moulvibazar	1997
Gas fields in barishal Division [19]		
Si. No	Place	Year
1.	Shahbazpur	1995
2.	Shahbazpur	2017

B. Coal

Bangladesh has about 400,000,000 tons of coal reserves, and daily production is roughly 1,000,000 tons [4]. As a result, Bangladesh will be able to use its reservoir for a long time. But recent coal-fired power plants could deplete that reservoir faster than current production rates.

Table II: *Location of coal resources are given division wise*

Coal Fields in Rangpur Division [18]		
Si. No	Place	Year
1.	Barapukuria	1985
2.	Khalashpur	1989
3.	Dighipara	1995
4.	Phulbari	1997
Coal fields in Sylhet Division [18]		
Si. No	Place	Year
1.	Jamalganj	1962

C. Crude oil

Bangladesh has recently discovered some blocks of crude oil under the Bay of Bengal [2], and earlier in

2012, 153 million barrels [5] of crude oil were found in Sylhet, although Bangladesh meets its oil demand through imported oil.

Table III: *Location of crude oil resources are given division wise*

Oil fields in Sylhet Division [5]		
Si. No	Place	Year
1.	Jamalganj	2012

III. BANGLADESH POWER PLANTS

If broadly classified there are mainly nine types of fuel-based power plants in Bangladesh and they are Natural Gas, HFO, Furnace or Fuel Oil, HSD, Diesel, Coal, Hydro, SKO and LDO. Most of the power plants are natural gas based, about 71.15% [6,7] of the total electricity comes from those plants. While the second highest power generation is from HFO-based plants, about 14.21% [6] of total electricity and other contributions are F. Oil 4.99%, HSD 4.19%, Coal 3.11%, Diesel 2.79%, Hydro 1.4%, SKO 1.37% and LDO 0.18%.

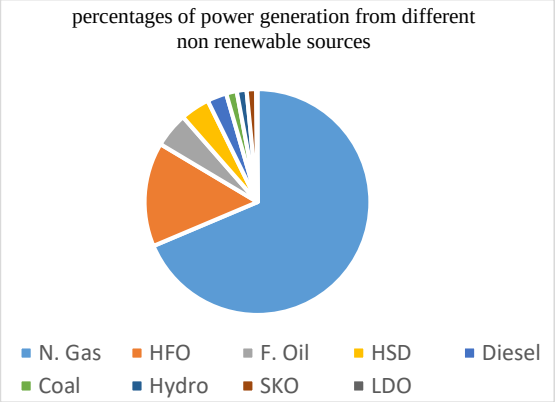

Figure I: *percentages of power generation from different non-renewable sources*

Table IV: *Location of running plants are also given division wise*

Power Plants in Dhaka Division [6]			
Si. No	Place	type	Capacity MW
1.	siddhirganj	Gas (combine)	260
2.	ghorashal	Gas	955
3.	Tongi	Gas	105
4.	Megnaghat	Gas	450
5.	Siddirgani	Gas	105
6.	Ghorashal	Diesel	145
7.	Narayaganj	Diesel	50
8.	Siddhirganj	Gas	105
9.	Faridpur	HFO	54
10.	Gopalganj	HFO	109
11.	Siddhirganj	Diesel	100
12.	Narayanganj	HFO	102
13.	Megnagjhat	HFO	100
14.	Ghorashal	Gas	78
15.	Gazipur	Gas/HFO	52
16.	Keraniganj	HFO	100
17.	Megnaghat	Gas/HFO	203
18.	Ghorashal	Gas	108
19.	kodda	Gas/HFO	149
20.	Kathpotti	HFO	51
21.	Megnaghat	Gas/HSD	102
22.	Madanganj	HFO	55
23.	Nababganj	HFO	55
24.	Manikganj	HFO	55
25.	Megnaghat	Gas	450
26.	Narsingdi	Gas	90
27.	Megnaghat	Gas	450
28.	Megnaghat (2nd phase)	Gas	450
29.	Narsingdi	Gas	24
30.	Dhaka PBS - 1	Gas	25

31.	Tangail	Gas	22
Total =			5259
power Plants in Chittagong Division [6]			
Si. No	Place	type	Capacity MW
1.	ashuganj	Gas	724
2.	Raozan	Gas	420
3.	Shikalbaha	Gas	116
4.	Shikalbaha	Gas	150
5.	Shikalbaha	HFO	55
6.	Ashuganj	Gas	55
7.	Ashuganj	Gas	53
8.	Doudkandi	HFO	52
9.	Dohazari	HFO	102
10.	Hathazari	HFO	98
11.	Bragmanbaria	Gas	70
12.	Ashuganj	Gas	80
13.	Ashuganj	Gas	53
14.	Siddirganj	HFO	100
15.	Chadpur	Gas	163
16.	Julda	HFO	100
17.	Raozan	Gas/HFO	25
18.	Ashuganj	Gas	76
19.	patenga	HFO	50
20.	Comila	HFO	52
21.	Ashuganj	Gas	142
22.	Ashuganj	Gas	75
23.	Potiya	HFO	108
24.	Ashuganj	Gas	195
25.	Ashuganj	Gas	373
26.	Comila	Gas	90
27.	Comila	Gas	13
Total			3490
Power Plants in Rajshahi Division [6]			
Si. No	Place	type	Capacity MW
1.	Baghabari	Gas	100
2.	Baghabari	Gas	90
3.	Baghabari	HFO	52
4.	Pabna	HFO	71
5.	bogura	Gas	20
6.	Sirajganj	Gas/HSD	150
7.	Santahar	HFO	50
8.	Katakhali	HFO	50
9.	Chapai	HFO	50
10.	Katakhali	HFO	50
11.	Sirajganj	Gas/HSD	68
12.	Natore	HFO	52
13.	Baghabari	Gas	90
14.	Baghabari	Gas	40
Total			933
Power Plants in Rangpur Division [6]			
Si. No	Place	type	Capacity MW
1.	Saidpur	HSD	23

2.	Thakurgaon	LDO	6
3.	Rangpur	HSD	20
4.	Barapukuria	Coal	250
5.	Haripur	Gas	110
6.	Haripur	Gas	360
7.	Thakurgaon	HFO	50
8.	Haripur	Gas	421
9.	Haripur	Gas	110
10.	Haripur	Gas	360
11.	Haripur	Gas	120
Total			1830
power plants in Mymensigh Division [6]			
Si. No	Place	type	Capacity MW
1.	Mymensingh	Gas	140
2.	Jamalpur	Gas/HFO	95
3.	Mymensingh	Gas	140
4.	Mymensingh	Gas	70
Total			445
Power Plants in Sylhet Division [17], [27]			
Si. No	Place	type	Capacity MW
1.	Shahjibajar	Gas	166
2.	Fenchuganj	Gas	90
3.	sylhet	Gas	20
4.	Fenchuganj	Gas	104
5.	sylhet	Gas	142
6.	Fenchuganj	Gas	44
7.	Bibiyana	Gas	222
8.	Bibiyana	Gas	119
9.	Shajibazar	Gas	330
10.	sylhet	Gas	28
Total			1265
Power Plants in Khulna Division [17]			
Si. No	Place	type	Capacity MW
1.	Khulna	F. oil/SKD	226
2.	Bheramara	HSD	60
3.	Noapara	F. oil	110
4.	Khulna	Diesel	55
5.	Bheramara	Diesel	110
6.	Noapara	HFO	40
7.	Khulna	HFO	115
8.	Noapara	HFO	105
9.	Khulna	Gas/HSD	150
10.	Khunla	Gas/HSD	72
11.	Khulna	F. oil	110
			Total = 1153
Power Plants in barishal Division [17]			
Si. No	Place	type	Capacity MW
1.	Barishal	HSD	42
2.	Bhola	Gas	194
3.	Barishal	HFO	110
Total			346

Table V: Under construction Power plants

Under construction Power plants in Dhaka Division [25], [26]			
Si. No	Place	Type	Capacity MW
1.	Bhairab	Gas	55
2.	Manikganj	Gas	162
Under construction power plants in Chittagong Division [23], [24], [27]			
Si. No	Place	Type	Capacity MW
1.	Matarbari	Coal	1320
2.	Feni	Gas	114
3.	Anwata	HFO	300
Under construction power plants in Rajshahi Division [22]			
Si. No	Place	Type	Capacity MW
1.	Rooppur	Nuclear	2400
Under Construction power plants in Mymensigh Division [27]			
Si. No	Place	Type	Capacity MW
1.	Jamalpur	HFO	115
2.	Mymensigh	HFO	200
Under construction power plants in Khulna Division [21], [20]			
Si. No	Place	Type	Capacity MW
1.	Rampal	Coal	1320
2.	Rupsa	Gas	880
Under construction power plants in barishal Division [20]			
Si. No	Place	Type	Capacity MW
1.	Payra	Coal	1320
2.	Payra	Coal	1320
3.	Payra	Gas	3600

IV. STUDY ANALYSIS AND OVERVIEW

A. Positivity of Under Construction Plants

The power plants currently under construction are well thought out and organized, such as Payra Coal-based Power Plant. It will run on coal imported from abroad. Consequently, they are located near the port. Payra gas based power plant will run on gas brought from Shahbazpur which is next to it so production cost will be lower.

Bangladesh's first nuclear power plant is also well-planned; the Same goes for Rampal. But more planning should have been done before starting the construction of the Rupsa gas-fired power plant as additional money would be needed to transport the gas, increasing production costs.

But the overall signs of progress are good but not environmentally friendly as coal and gas will increase carbon levels.

B. Drawback of Running Power System

Dhaka Division generates one-third of the total production using fossil fuels. Then Chittagong, Rangpur, Sylhet, Khulna, Rajshahi, Mymensingh, and Barisal. Most of the electricity is produced by gas. So one might think that in the number of gas fields Dhaka will at first and Barisal will at last just like power plants. However, Chittagong and Sylhet are two dominant divisions in gas production. Therefore, the gas has to travel by pipeline or transport.

The life span of an iron pipe is less than that of an electric line. To extend its life, skilled people and anti-corrosion materials are required. Therefore, additional cost will be added as running cost, and fixed cost will also increase by 1/6th, as for piping, pump costs. So a plant in Dhaka, which uses gas from Chittagong is more expensive than a plant in Chittagong, which takes gas from Chittagong and supplies power to Dhaka. It saves both fixed and running costs. Below is the comparison between them,

Table VI: *Comparison between near and far located power station from fuel source*

Plant near fuel station with far load point	**Plant near load point with far fuel station**

The size of the plant is small because a fuel purifier, and a fuel pressure regulator are capable of supplying pure pressurized fuel to all power plants.	The size of the plant will be large because the pipes may be damaged in various ways, or the fuel pressure may need to be adjusted, thereby requiring fuel purification and pressure regulator, which will increase the cost of power generation.
Fewer employees are needed to work at the plant.	As the number of machines will increase so will the number of employees
Electricity is the most efficient form of energy to transmit	Transporting fuel to produce electricity is not an efficient method.
Less land is required because the same fuel-based power plant will be in the same location, using a common purifier and regulation. Hence less land will be required for additional facilities.	More land will be required as the same type of additional facilities have to build for each power plant
Production costs will be lower	Production costs will be higher

Here is just an example to understand the problem. The same phenomenon applies to coal-fired power plants. All coal fired plants should be in Rangpur and Sylhet. But coal based plants are here and there without any pattern. Other power plant types such as HFO, and HSD need to be built closer to the load as most HFO or HSD are small private power plants in Bangladesh. Therefore, gas and coal-fired plants need to be sited properly.

C. Drawback of Overall Power System

Bangladesh is trying to cope with the increasing electricity demand, in 2018–2019, the installed capacity of Bangladesh was 18961 MW, but the peak generation was 12893 MW [7], while the total electricity demand was about 13100 MW. In 2019-2020 the demand was 13300 MW while the total generation was 12738 MW [28]. And finally, in 2020-2021, demand was 14500 MW, and generation was 13792 MW [28]. So Bangladesh is doing well there. However, the Ministry of Power thought that the demand would be 20000 MW in 2021 [8]. Although the demand is not as high as expected by the Ministry, it will increase rapidly in the near future. Int. Trade Administration estimates that it will be 40,000 MW in 2030 [9], and that expected demand will help boost growth in export-oriented economies and increase total investment by $70 billion over the next 15 years [9]. Hence, the government is implementing power projects with a target of creating a 60,000 MW power generation capacity by 2041 [10].

Let's dive into the sources of production. Gas, HFO, coal, and HSD are the primary sources of electricity generation in Bangladesh contributing 71.15%, 14.21%, 3.11%, and 4.19% respectively [7]. Now focus on gas as it has the largest share. Gas consumption in December 2019 was reported at 3.324 cubic feet/day. Whereas in the previous year, the figure was 2.654 cubic feet/day [11]. It is estimated that the country will be able to meet the growing demand for natural gas for the next 10-12 years with remaining gas reserves [12]. As a solution, there are 26 blocks in the Bay of Bengal, including 11 shallow blocks and 15 deep sea blocks [9].

The government is having second thoughts to protect the Bay of Bengal as it aims to produce 50 percent of the total electricity using coal-based power plants by 2030 [9]. However, in 2016, coal reserves were 323 million tons which is equal to 153.8 times its annual consumption. This means Bangladesh has about 154 years of coal left [4] and wants 33200 MW from coal-fired power plants in 2041 [14]. So a little calculation {(41848*3.11)/100=1301.4728 [7]; (33200 [14]/1301.4728) =25.51} one can say that coal consumption will be 25.51 times higher than in 2020. So the country can't even depend on their coal. As a result, Bangladesh will import coal for large power plants like Rampal. But large coal reservoirs will be required to ensure long-term production. So Bangladesh has to increase storage several times more than now. Where gas requires less storage and no residual but requires gas piping with sufficient flow rates.

If the storage area between gas and coal is compared, then 1 kg of gas is equivalent to 1.845 kg of coal [15] {0.813 kg LNG = 1 kg oil = 1.5 kg coal [15]}, plus18.86% ash [16], approximately 2.193 times more area of storage required for same production if we consider coal in place of gas.

As a result, in 2041, 5 times more land will need storage coal to meet that demand. So roughly the land for electric generations would triple from now just to add

coal-based plants, and there are other sources of energy to add. Therefore, Bangladesh does not have adequate gas or coal reserves for future power generation, and importing coal is not a good decision because it requires more storage area, and it also has residue.

V. PROBABLE SOLUTION FOR SUSTAINABLE DEVELOPMENT

In one sentence, Bangladesh's electricity development is neither environmentally friendly nor sustainable. It should use more green sources of energy, although not all green sources are entirely reliable. So they have to plan long-term to build the power sector more accurately.

During that time, it gradually increased its renewable sources and reduced its dependence on gas or coal. Therefore, Bangladesh should generate more electricity from renewable sources like solar, tidal, wind, OTEC, thermal, etc. The following discussion is intended to indicate where the focus needs to be for developing more sustainable electricity.

A. Proper Land Use

Bangladesh is a tropical country, so it can use electrical energy from almost everywhere, they can install solar panels or build SWET or combine both on road dividers [29]. The country can use rooftops and rivers to get solar energy. Although not all places in Bangladesh are good for wind turbines, scientific calculations can help to use the wind properly [30].

B. Harnessing Energy from The Sea.

Bangladesh can meet almost all of its electricity needs using only the Bay of Bengal. They can get electrical energy by making OTEC, water turbines, solar panels, windmills etc. There are many opportunities to combine renewable energies, and get the best results.

C. Less Carbon Leaking into The Air

Not all renewable energy is exactly reliable, so Bangladesh may need non-renewable sources but those production methods need to be carbon-free, such as nuclear power plants or hydro.

D. More Production Without Residues

Non-renewable sources must also be residue-free or have very low residues per kilowatt. Therefore, Bangladesh should reduce the use of coal as fuel for power plants.

E. Building Power Plants Closer to The Source of Energy

Production costs must be low so Bangladesh should stop building large gas pipelines for power plants or transporting fuel from long distances to power plants. As a result, power plants have to be established near the source of energy

F. Construction of Large Power Plants

Large power plants require less land per kilowatt compared to small power plants. Therefore, large power plants close to the source can significantly reduce generation costs.

G. Recycle-Based Combined Power Plants

People will depend on oil for a long time because airplanes, rockets, large construction machines or ships cannot change instantly. So Bangladesh can set up a pyrolysis-based power plant that serves both recycler and power plant at the same time [31].

Bangladesh may need to do more to produce more electricity from environmentally friendly sources, but these ideas are sufficient to build a sustainable electricity generation system.

VI. DISCUSSION

This paper aims to create awareness against fossil fuels, improvident power plant installation, and less productive land use and tries to demonstrate suitable power harnessing possibilities from sustainable and pollution-free sources. It is necessary and obvious to take a view to generate electricity from naturally available sources including the bay of bangle which contains a gigantic amount of varieties form of energy, for instance, wave energy, tidal and, ocean thermal energy. If the proper action is taken by the government and industrialists in this sector, the upcoming power demand can be mitigated easily for long-term goals in a convenient way without any hassle. It only covers a tiny portion of the problem, but that portion is enough to understand the problem and what needs to do to get rid of that situation.

VII. CONCLUSION

From the structure of the power generation system, it is clear that Bangladesh is following an old, traditional method of power generation. But this is the 21st century where people are so conscious about their environment and are investing a lot of money to make the world more liveable and stable. There has been a lot of research in the renewable sector. Therefore, even winter major

countries are able to generate good amount of electricity using renewable sources. Therefore, Bangladesh should use this modern technology to increase the production of electricity from good and clean sources.

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