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Feasibility Study of Hybrid Renewable Energy System for Electrification of Kutubdia

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ABSTRACT
Bangladesh has been experiencing several problems over the past few decades**.** Day by day, the no of population is increasing significantly. Sufficient amount of power generation in a sustainable way is an important issue for this rapidly increasing population and economic development As a result, the country has been struggling. Hybrid system can play a vital role in the electrification of rural development. In this study, a renewable hybrid system has been proposed for Kutubdia island. The simulation was designed by Homer software and planned to apply in Kutubdia city to meet the electricity demand. The optimum system consists of PV array, diesel generator, biogas generator, wind turbine for power generation and battery for surplus energy storage Economical analysis was also carried out and it was found that COE is $0.221/kW which is 17.68 taka in BDT (1 US=80 taka).

Keywords***:*** Hybrid System , Homer software, Kutubdia**.**

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1. Introduction

Approximately 80% of the people of Bangladesh live in rural area and 40% of people have access to electricity [1]. The biggest portion of her energy demand is met up by fossil fuels such as natural gas, coal etc. As the population is increasing, the demand for electricity is increasing continuously. As a result, fossil fuels consumption is also increasing. According to the World Bank, fossil fuel energy consumption (% of total) in Bangladesh was reported at 73.77% in 2014. Various dangerous gases emit from the combustion of fossil fuels. These gases are harmful for the environment. The only solution for this problem is to utilize renewable energy as they are environment -friendly. It is estimated that about 44% of the world population does not have access to grid electricity because of the higher cost grid connection, dispersed population [1]. Due to generation capacity shortage, it is quite difficult to provide power the places that are connected to the grid. Furthermore, for various places like islands grid connection becomes difficult and costly. So efficient use of local resources is the most useful solution in this case. It will help the government to reach its vision which is to provide most of the power from renewable energy sources. Hybrid system can play an effective role in this regard. For several off grid places Monpura island[2] Adorsho Char [3] ,Sandwip[4] , Saint Martin's Island [5] and Nijhum Dip [6] feasibility of hybrid system have been checked . But for an Island like Kutubdia, it is yet to be conducted.

2. Overview

Kutubdia lies between 21°49′N to 91°51.5′E. It is in the Cox's Bazar district which is in the division of Chittagong, Bangladesh. It is generally an island [7]**.** It covers an area of 215.79 sq. km. About 125279 population live on the island. Approximately 9 secondary schools, 32 primary schools, 7 madrasah and 1 college can also be found here. Moreover, it has 8 bazaars and 190 religious institutes. No of cows and buffalos in Kutubdia are approximately 13236. Number of electrification in villages of Kutubdia is none according to [8].
Here figure 1 shows the satellite image of Kutubdia.

Fig. 1: Satellite Image of Kutubdia Island.

The government has set up a wind battery hybrid power plant in Kutubdia. But it does not provide power all the time. People only get power only 3 hours a day and 3 to 4 hours during night time. Only 50% of people get benefitted for that project [9]. So this study is an attempt to check the feasibility of solar wind biomass integrated hybrid system in Kutubdia.

3. Load Profile

In this simulation the load is supplied by the Hybrid system and basic loads like-bulbs, fans and pumps are considered. The load has been divided into two divisions-residential load and non-residential Load.

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Table 1: Load description for residential load

Type	Load Description
Household	1 CFL(20 watts) 1 Fan (40 watts)

Table 2: Load Description for different Non-residential Load

Type	Load description
Religious Institutions	3 CFL(20 watts) 2 Fan (40 watts)
College & Secondary School	4 CFL(20 watts) 4 Fan (40 watts)
Primary School	2 CFL(20 watts) 2 Fan (40 watts)
Bazaars(considering 10 shop in a bazaar)	1 CFL(20 watts) 1 Fan (40 watts)
Madrasah	3CFL(20 watts) 2 Fan (40 watts)

During summer, irrigation pumps are used for agricultural purposes. Here in this simulation, a 2 KW irrigation pump is considered. Here summer load is considered from January - October and winter load is from November – February.
Figure (2-4) shows winter, summer &annual load of Kutubdia.

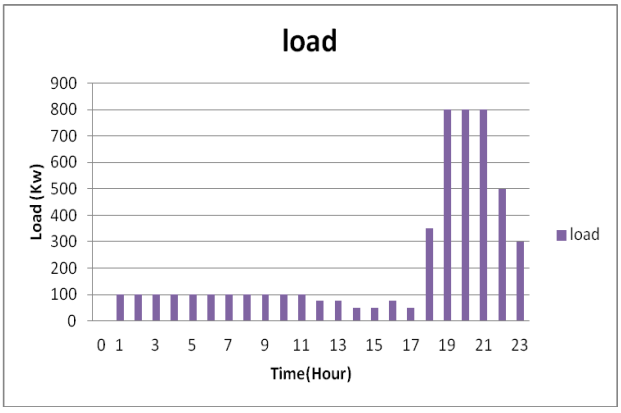


Fig. 2: Winter load (November to February)

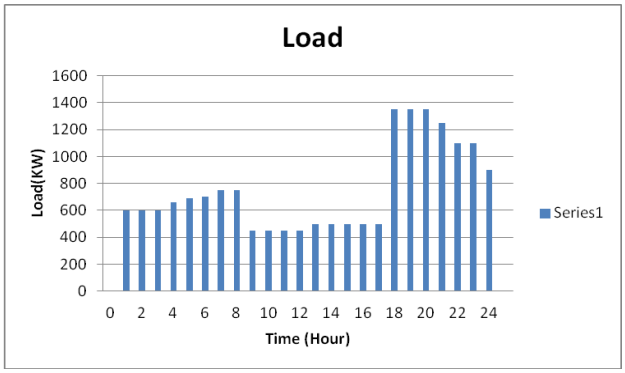


Fig. 3: Summer Load (January to October)

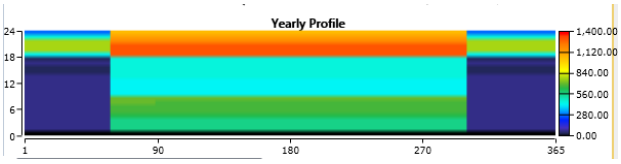


Fig. 4: Yearly load profile.

4. Renewable Resources

In this simulation different renewable energy sources have been used.

Wind Resources

Figure 5 shows the average wind speed data of different months of Kutubdia [10].

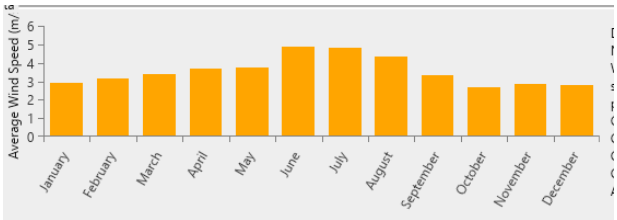


Fig. 5: Average Wind Speed

Solar Resources

Figure 6 shows the average solar radiation data and clearness index data of different months of Kutubdia [10].

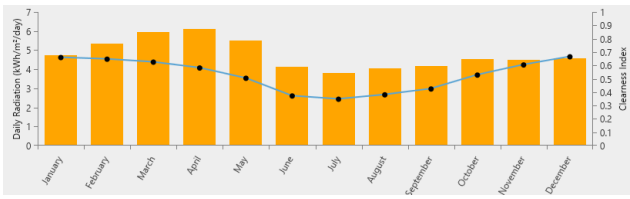


Fig. 6: Daily Solar Radiation and Clearness Index

Biomass Resources

Kutubdia has 13236 no cows and buffaloes [8].In South Asian perspective, each cattle gives 8-10 Kg fresh manure per day [11]. So, the total manure production of

Kutubdia is 120 tons. By considering a 20% collection rate, it is found that 24 tons of manure are produced daily.

Figure 7 shows the monthly manure production of Kutubdia.

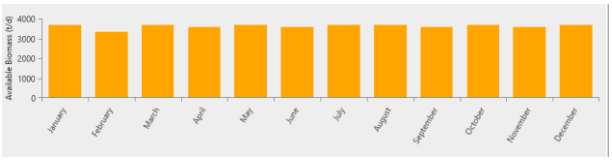


Fig. 7: Monthly manure production of Kutubdia

5. Hybrid System Modeling

Homer software [12] is used for simulating the following system.

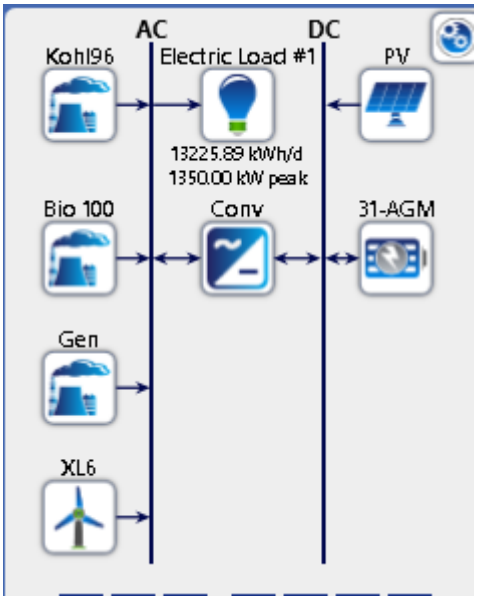


Fig. 8: System model

Diesel Generator

For the simulation purpose the, diesel generator considered here Kohler 96kW. The capital & replacement cost of the generator considered here is $35000.00 and $30000 respectively. The operation and maintenance cost is considered $2.00 per hour for the generator. The lifetime is considered 15000 hours in this simulation for the diesel generator.

PV Array

The capacity of PV panels has been considered 3KW in this simulation. The capital and replacement cost is of each panel is considered $5000.00 $4000.00 respectively with operating and maintenance cost of $10.00 per year. The life time of PV panel is assumed to be 25 years.

Energy Storage

For the purpose of storing the generated energy batteries are required. The battery used here is Trojan 31-AGM . The nominal voltage of battery considered here is 12V and its throughput is 673.20kWh. The capital and replacement cost of battery considered here to be is $450 and $350 respectively. The O&M cost is considered $11.000 per year.

Converter

A converter is required for the purpose of conversion of DC into AC power. The capacity of the converter is considered 100kW in the simulation. With O&M cost of $100 per year, the capital and replacement cost of the converter is assumed to be $6500 and $100 respectively. The life time of the converter is assumed as 10 years. The efficiency of the converter considered here is 96.30%.

Wind Turbine

For simulation purpose, the model considered here is Bergey Excel 6. The capacity of the turbine is considered as 6 kW. The hub height of the turbine is 30 m. The capital and replacement cost of battery considered here to be is $20000.00 and $12000.00. The O&M cost is considered $40.00 per year. The lifetime of the turbine considered to be is 20 years.

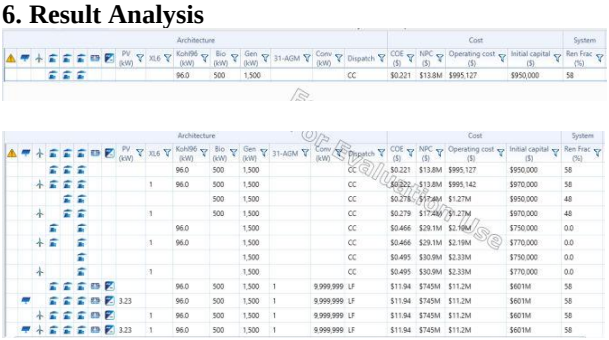
Biogas Generator

For simulation purpose, the rating of the Biogas Generator considered here is 100kW. The capital and replacement cost of biogas generator considered here is $40000.00 and $ 30000.00. Biomass Resources will be used as fuel and $0.1 per hour is considered the O&M cost of the biogas generator. The lifetime is considered 15000 hours in this simulation for the biogas generator.

Generator

For the generation of electricity generator is required. The rating of the generator considered here is 1500kW. Diesel is to be used as fuel and the capital & replacement cost considered here is $500. The operation and maintenance cost is considered $0.03 per hour for the generator.

6. Result Analysis



Architecture										Cost				System
PV (kW)	XL6	Kohl96 (kW)	Bio (kW)	Gen (kW)	31-AGM	Conv (kW)	Dispatch	COE ($)	NPC ($)	Operating cost ($)	Initial capital ($)	Ren Frac (%)
		96.0	500	1,500			CC	$0.221	$13.8M	$995,127	$950,000	58
	1	96.0	500	1,500			CC	$0.222	$13.8M	$995,142	$970,000	58
			500	1,500			CC	$0.278	$17.4M	$1.27M	$950,000	48
	1		500	1,500			CC	$0.279	$17.4M	$1.27M	$970,000	48
		96.0		1,500			CC	$0.466	$29.1M	$2.19M	$750,000	0.0
	1	96.0		1,500			CC	$0.466	$29.1M	$2.19M	$770,000	0.0
				1,500			CC	$0.495	$30.9M	$2.33M	$750,000	0.0
	1			1,500			CC	$0.495	$30.9M	$2.33M	$770,000	0.0
		96.0	500	1,500	1	9,999,999	LF	$11.94	$745M	$11.2M	$601M	58
3.23		96.0	500	1,500	1	9,999,999	LF	$11.94	$745M	$11.2M	$601M	58
	1	96.0	500	1,500	1	9,999,999	LF	$11.94	$745M	$11.2M	$601M	58
3.23	1	96.0	500	1,500	1	9,999,999	LF	$11.94	$745M	$11.2M	$601M	58

Fig. 9: Comparison between different simulated systems

Different size for PV systems, wind turbines and generators have been considered in this simulation. From this Homer software has calculated the optimum system which is shown in figure 9.The result is explained below.

Cost Analysis

From simulation the cost of electricity is found $0.221which is 17.68 taka in BDT. The Capital cost found in this simulation is $950000 & the Net Present Cost of this hybrid system is$13,800,000. As Kutubdia is an off-grid place, it has not blessed with modern technological equipments. So an extra cost is needed to transport these equipments. Hence the cost of energy is high.

Emission Analysis

Emission analyses have also done in this study. It can be seen from table 3 that the emission of green house gases is quite low as the system is 100% renewable. The environmental analysis represented that the hybrid system emits zero SO_2 and negligible CO_2 and CO emission.

Table 3: Emissions Due to Hybrid Power Plant

Quantity	Value(kg/yr)
Carbon dioxide	600.26
Carbon mono oxide	16.5
Unburned Hydrocarbon	0.72(g/fuel)
Particulate matter	0.1(g/fuel)
Sulphur dioxide	0
Nitrogen dioxide	15.5

7. Conclusion

Day by day people need for energy is increasing. It is quite difficult to meet up this demand. Proper utilization of renewable sources can help in meeting up this demand. As the grid connection is very expensive, the hybrid system proposed here will be effective for meeting up the electricity demand of rural Kutubdia. At present, the government has set up wind power plant at Kutubdia. Beside this people also rely on the diesel generator for electricity. The use of diesel generator results in the emission of harmful gases. The hybrid system proposed here reduces the emission of greenhouse gases. Besides the proposed system can provide electricity for the proposed place. So it can be stated that this proposed hybrid plant is feasible for providing power to Kutubdia Island.

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