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A STUDY ON FEASIBILITY OF RENEWABLE HYBRID POWER GENERATION PLANT IN MANPURA ISLAND

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Abstract: *With the increasing demand, developing country like Bangladesh is facing major problem of providing electricity to some of the remote areas that contribute considerably to the fishing sector. In order to sustain the economic growth it is imperative to rely on the renewable energy sources. Moreover it is viable to use renewable energy because the distribution and transmission of electricity from the National Grid to those remote areas is economically infeasible. This paper exclusively portrays the feasibility of using Hybrid Power Generation System utilizing Wind, Solar Energy and Biogas in Manpura Island, Bhola, one of the significant remote areas of Bangladesh. The analysis, design and simulation of the Hybrid Renewable Power Generation System have been performed using HOMER simulation software. The software depicts the usage of electricity in variation with load, wind speed, solar energy and biogas supply. The simulation also predicts the effective utilization of the natural resources and the cost of electricity is 20.96 Taka/kWh ($.262/kWh) with a net present cost of 1,303,669,360 Taka ($16,295,867.48).*

Key words: Renewable Energy, Hybrid Power Generation Plant, HOMER.

1. INTRODUCTION

Bangladesh, being a developed country, is facing a major problem in power sector as it is substantially struggling to meet its energy demand. The maximum power demand served so far is about 9212MW but there is still shortage of about 2000-2500 MW [5]. As a matter of fact with the increasing demand in the urban areas the rural areas are being faced with the maximal power outrage.

The solution to this power shortage can be compensated by Renewable energy since 5% of the total power generation of Bangladesh comes from renewable energy sources. Distributing power from National Grid to those rural and urban areas specifically islands and chars are economically not feasible. Moreover, the high initial cost for the distribution of power to the area of lower load density is not viable. Plausible solution of this problem can be acquired by employing Standalone Hybrid System, which will contribute to the Global Greenhouse Gas (GHG) emission reduction initiative. The government is also emphasizing on renewable energy by taking projects like 7.5 MW off-grid PV-Wind Hybrid system with diesel generator in Hatiya Island [6].Some studies have already been conducted to check the feasibility of off-grid hybrid renewable power plant in Bangladesh. Places like Adorsho Char [1] which is off-grid area or islands like Sandwip [2], Saint Martin’s Island [3] and Nijhum Dwip [4] were founded to be feasible for hybrid renewable power plant. Whereas the feasibility study for an Island like Manpura is yet to be conducted.

The study of practicality and viability of a Hybrid Energy System for a remote Island of Manpura has been depicted in this paper. The simulation of the proposed Hybrid Energy System has been performed by HOMER [7]. The proposed Hybrid Energy System incorporates Wind turbine, Solar PV and Biogas generator with additional battery storage.

2. OVERVIEW: MANPURA ISLAND

Manpura Island (22°17'60.00"N,90°57'59.99"E) is an island in the northern Bay of Bengal, Bangladesh, at the mouth of the Meghna River[8].

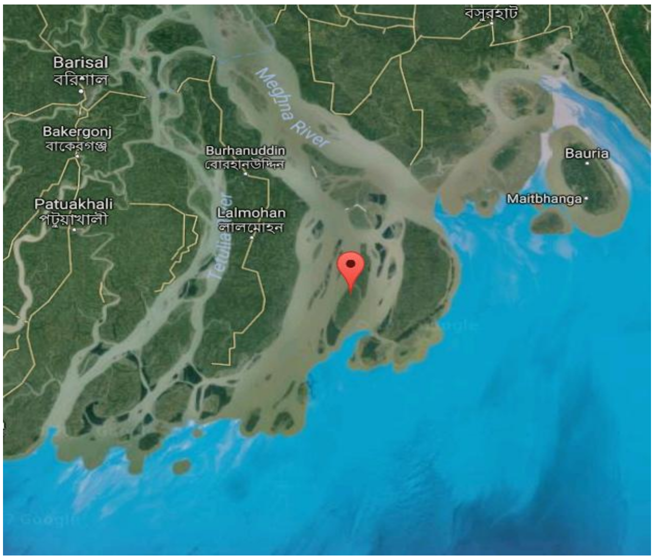

Fig. 1: Satellite Image of Manpura Island

It is a part of Manpura Upazila, Bhola District. The island has an area of 373 km^2. The population of the Island is approximately 80000 with household of approximately 15000. The Island also consists of 8 secondary schools, 38 primary schools and 2 colleges. Moreover, it has 20 bazars, 110 religious institutes and about 10 administrative buildings. Majority of the population depends on fishing. There are also plenty of livestock including 10000 cows and bulls approximately. All the unions of the upazila are under electrification network. However, 4.71% (urban 22.49% and rural 4.10 %) of the dwelling households have access to electricity [9].

3. LOAD PROFILE

Bulbs, Fans, TVs and Pumps are considered as basic loads, which will be supplied by Hybrid system. The loads have been divided into two Categories-Residential Loads and Non-residential Loads. Residential Loads are divided into two sub-categories; solvent household; non-solvent households. Table 1 shows the load description of different household types. Non-residential loads are further divided into six sub-divisions as shown in Table 2.

Table 1: Load description for different household types

Household Type	Load Description
Solvent	2 CFL (2*20 Watts) 1Fan(40Watts)
Non-solvent	1CFL (20 Watts) 1Fan(40Watts)

Table 2: Load Description for different Non-residential loads

Household Type	Load Description
Primary Schools	2FAN 2CFL
Administrative Buildings	4CFL 2Fan
College and Secondary Schools	4CFL 4Fan
Hat/Bazars(Per Shop)	1CFL
Religious Institutions	3CFL 2Fan
Clubs/Cultural Organizations	2CFL

For summer time irrigation pumps have been also considered. The rating of pumps has been considered 2kW. Load consumptions are mainly divided into two different time periods. Summer loads are considered from February to October and winter loads are considered from November to January. Fig.-2 and Fig.-3 depict the picture of hourly load demand during winter season and summer season respectively. Fig.-4 depicts that the load demand is higher during summer than that of winter.

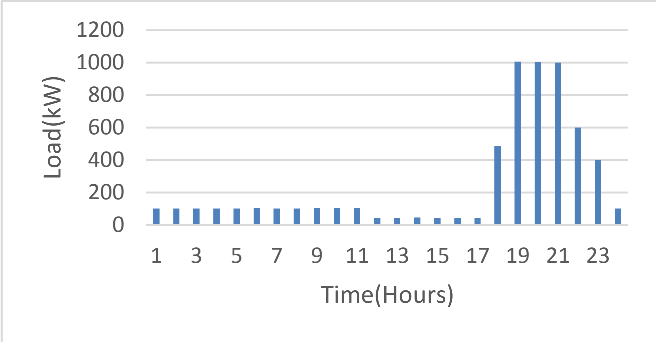

Fig.2: Winter Load (November-January)

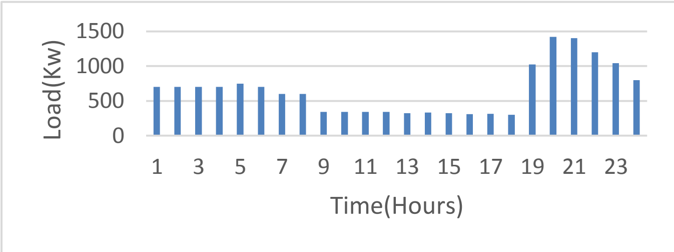

Fig. 3: Summer Load (February-October)

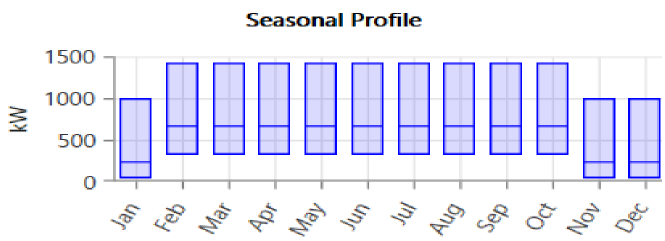

Fig. 4: Yearly load profile

4. RENEWABLERE SOURCES

Different renewable resources are used for simulation. The data of these resources were collected from different sources and will be described in detail in the following subsections.

4.1 Solar Resources

The monthly average solar irradiation and clearness index have been collected from Surface meteorology and Solar Energy by NASA [10] and are shown in Fig.-5.

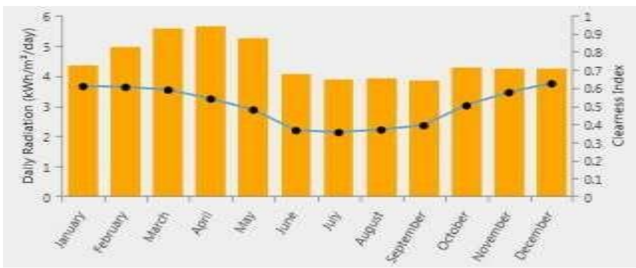

Fig. 5: Daily Solar Radiation and Clearness Index

4.2 Wind Resources

The average wind speed data has been obtained from NASA Surface meteorology and Solar Energy [10]. Fig.-6 shows the Average wind speed of Manpura Island.

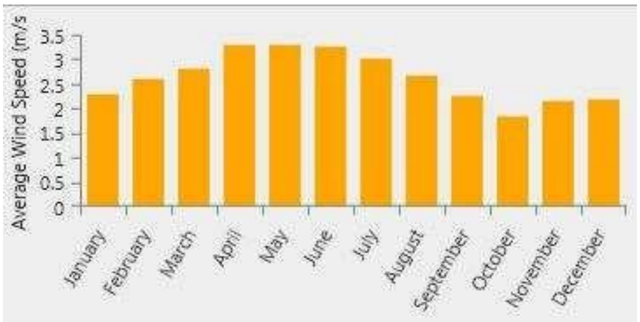

Fig. 6: Average Wind Speed

4.3 Biomass Resources

Manpura has about 22819 cows and buffalos [11]. We considered 20000 cows and buffalos for this analysis. Each livestock providing 7.5kg of manure per day. Considering 15% collection factor, total 30 tons of manure can be procured daily.

5. HYBRID SYSTEM MODELING

The proposed Hybrid System consisting of PV Array, Wind Turbine, Batteries, Inverter, Biogas Generator, Diesel Generator and electrical load. This proposed system is considered as an exemplary model for fulfilling the energy demand for Manpura Island. The system is modeled in HOMER Software where capital cost, replacement cost and O&M cost for each component have been considered as input parameters in HOMER. The schematic of the system modeled in HOMER has been shown in Fig.-7.

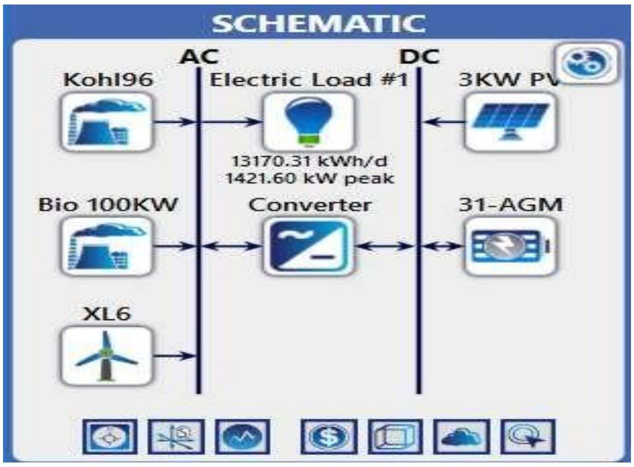

Fig. 7:System Architecture

5.1 PV Array

3 kW PV panels with continuous tracking have been considered. The capital cost of each panel is considered to be $5000.00 and replacement cost is $4000.00 with operation and maintenance cost of $10.00 per year. The lifetime of each panel has been considered 25 years with derating factor of 80%.

5.2 Wind Turbine

The Wind Turbine Model used for this Simulation is Bergey Excel 6 having a rated capacity of 6 kW. Its Hub height is 30m.The capital cost of the turbine is considered to be $20000.00 and the replacement cost is $12000.00. The Operation and maintenance cost is considered $50.00 per year. The Life time of the turbine is considered to be 20years.

5.3 Biogas Generator

The rating of the considered Biogas Generator is100kW. Its capital cost and replacement cost are considered to be $40000.00 and $30000.00 respectively. The operating and maintenance cost is considered $0.1 per hour. The Fuel to be used is Biomass Resources. The lifetime of this biogas generator is considered to be 20years.

5.4 Diesel Generator

Kohler 96kW Prime diesel generator has been used in the simulation. Its capital cost and replacement cost are considered to be $35000.00 and $30000.00 respectively. The operation and maintenance cost of the generator are considered to be $2.00 per hour.

5.5 Energy Storage

Batteries have been considered in the simulation for the energy storage. The Model used is Trojan 31-AGM with nominal voltage of 12V and string size of 1. Its throughput is considered to be 673.20kWh.The capital and replacement cost are considered to be $450 and $350 respectively. The O&M cost is considered $10.000 per year.

5.6 Converter

DC to AC converter of 100kW has been considered in the simulation. The capital and replacement cost are considered to be $6000 and $100 respectively with O&M cost of $100 per year. The lifetime is considered 15 years with 95% efficiency.

6. RESULTS AND DISCUSSIONS

6.1 Optimized System

The optimized system consists of PV array, wind turbine, biogas generator, batteries and converter. The system is 100% renewable. The electricity share of this system is PV array 81.77%, Biogas Generator 10.91% and Wind turbine 7.32%. Fig.-8 shows the production of the individual system in kWh per hour.

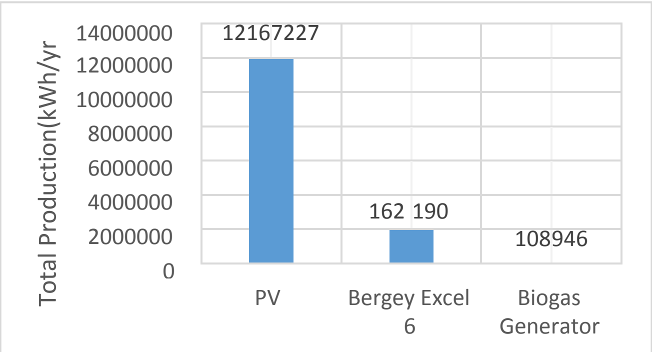

Fig. 8: Total Electricity Production by Different Components of the system

Table 3: Comparison among different simulated systems

PV (kW)	XL6	Kohl96 (kW)	Bio	31-AGM	Converter	COE ($)	NPC ($)	Operating Cost ($)	Initial Cost ($)	Ren. Frac.(%)
8,112	834	0	500	9,704	1,064	$0.26	$16.3M	$144,488	$14.4M	100
8,117	829	0	500	9,713	1,064	$0.26	$16.3M	$144,586	$14.4M	100
8,146	832	0	500	9,711	1,068	$0.26	$16.3M	$144,315	$14.5M	100
8,144	831	0	500	9,693	1,065	$0.26	$16.3M	$144,608	$14.5M	100

6.2 Cost Analysis

The Net Present Cost of this hybrid system is $16,295,867.48 with Capital costof $14,428,000.05. The cost of electricity is $0.262. These costs are portrayed in Fig.-9. The cost comparison among different simulated systems is depicted in Table 3.

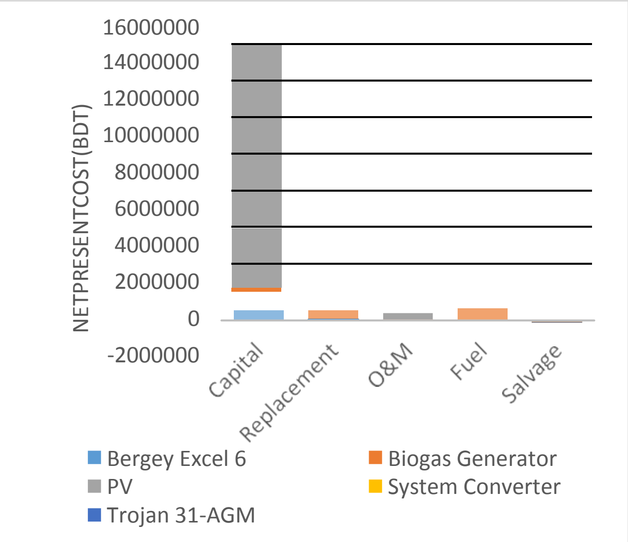

Fig. 9: Cost analysis for hybrid power plant

6.3 Emission Analysis

The renewable fraction of the optimized hybrid system is 100%. The emissions of pollutant gases and particulates as simulated by HOMER are depicted in Table 4.

Table 4: Emissions Due to Hybrid Power Plant

Quantity	Value(kg/yr)
Carbon Dioxide	900.15
Carbon Monoxide	9.99
Unburned Hydrocarbons	0.00
Particulate matter	000
Sulfur dioxide	0.00
Nitrogen dioxides	6.24

7. CONCLUSION

With the increasing demand of power, Remote Island like Manpura is in a dire need of uninterruptible electricity. However, connection from the national grid is not feasible and using fossil fuel to generate electricity is costly and inefficient. As a result, Renewable Energy is a solitary solution. The paper successfully depicts that a Hybrid Renewable power plant is feasible in providing power to Manpura Island. Moreover, this Hybrid System also diminishes carbon emissions exceptionally.

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