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TOWARDS SUSTAINABLE ENERGY TECHNOLOGIES AT A COVID-19 HOSPITAL IN DHAKA, BANGLADESH

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Abstract
The current energy demands in Bangladesh far supersedes the supply. The research provides an efficient way to account for the energy deficit by using a renewable hybrid model design. Solar, Wind, and Biogas were the focus of this paper for their abundance in the study region. The study explored the possibilities of implementing a hybrid energy system in a makeshift COVID-19 hospital in Purbachal, Bangladesh. The COVID-19 situation is getting worse, even after the first case detected in March 2020. It is tough to manage sufficient hospital beds with minimum facilities in the least developing country like Bangladesh. The hybrid model developed using HOMER software utilized solar, Wind, and Biogas in a configuration that achieved the best Cost of Energy (COE) and Net present cost (NPC) values. The model adjusted parameters such as fuel cost, wind speed, solar radiation, electricity price, and component cost for smooth and realistic simulation. From the simulations, it is observed that wind energy was not a feasible option for the region of study, and without Biogas, the PV-Wind or only PV system had a Cost of Energy (COE) of 0.492 and 0.517 USD, respectively. Good optimized results are found for PV-Bio as a generator-Battery system. The research found a Cost of Energy (COE) of around 0.176 USD with a considerable amount of initial capital, 82806.25 USD, even though the model was primarily fashioned for the healthcare sector in Purbachal, Bangladesh. The model can easily be modified for use in any region of the world and be re-purposed for use in other industries.

Keywords: COVID-19; HOMER; Healthcare; Renewable energy; Hybrid system

1. INTRODUCTION

In Bangladesh, the COVID-19 restrictions and general alertness have dwindled significantly over time. The country must remain vigilant for possible upcoming spikes in infection rates. Most researchers predict an up tic in infection rates in the coming winters. Thus, the general populous and the country must seek to implement more permanent measures to counteract the possible up tic and curb the rise of COVID-19 infection. In December 2019, Coronavirus was first detected in Wuhan, China (WHO, 2020b). A Public Health Emergency of International Concern (PHEIC) was declared in January 2020, and a pandemic in March 2020 following the outbreak. Finally, on March 18, 2020, the Government of Bangladesh ordained the National Preparedness and Response Plan (NPRP). for COVID-19 with a budget of USD 29,550,000 million (WHO, 2020a). In November 2020, the total number of cases found in Bangladesh was 417,475; among them, deaths were 6,036, and 335,027 were recovered (WHO, 2020a). With limited resources, expanding the healthcare capacity proves to be a challenge for Bangladesh. In 1980, there were only 28 ICU beds in Dhaka city. In 2017-18, the total number of hospital beds was 1,27,360. Out of these, 48,934 were in government hospitals, and 78426 were in private hospitals (Mostafa, 2018). According to ("The Daily Dhaka Tribune," March 21, 2020), In March 2020, the total medical capacity of Bangladesh is 141,903 hospital beds, or 0.84 beds per 1000 people ("The Daily DhakaTribune," 2020) (Khan et al., 2020). Fig.1 shows the distribution of isolation beds concerning division. On April 9, 2020, the Health Minister proposed setting up a 2,000-bed Isolation Centre at ICCB. On the other hand, 1,300 beds at the DNCC Market and 1,200 at Uttara Diabari were ready to serve. Barring these, 601 more institutions in districts and Upazilas, including the capital, were refurbished as coronavirus isolation centers (Standard, 2020). Health Minister Zahid Maleque inaugurated a 2,000-bed hospital at International Convention City Bashundhara on May 17, 2020 ("ICCB hospital for Covid-19 patients opens," 2020).

In Bangladesh, power sectors highly depend on conventional fossil fuels, including gas and coal. Thus, we have to find alternative solutions to meet our energy demands over time. Bangladesh has a high potential for renewable energy; this significantly increases the number of projects required to meet the country's electrical energy demands. But Sustainable energy initiatives account for a relatively small share of electricity generation (0.02 percent) (Das & Zaman, 2019). The most prevalent form of renewable energy currently in Bangladesh is PV-based off-grid systems,

including SHS, Nano-grid, and mini-grid, where biomass also has a high potential to be significantly integrated into the existing energy infrastructure.
According to the Power Department, in 1970, East Pakistan had a generating capacity of only 475 MW. The power generation capacity established in the country in 1972 was 500 MW (Masud, 2021). In the 50 years of independence, the generation capacity is now about 24,000 MW (Bangladesh, 2022). However, there are still some problems in the distribution of electricity. As a consequence, complaints of power disruptions continue to circulate. Although the capacity to generate electricity exceeds the demand, load shedding only increases in rural and district towns before the onset of summer. The improvement of production and supply lines and the country's geographical location is not conducive to fulfilling the promise of delivering electricity to households. Big rivers flow through the country. There are numerous islands and settlements in the estuary. It was also a challenge to take the grid power to those places. Submarine cable technology has been used to reach places like Char Atra in Shariatpur, Rangabali in Patuakhali, Charkukrimukri in Bhola, and Sandwip in Chittagong (Masud, 2021). There are 69 private sector power plants; Production is 9,384 MW. The number of centers in the public sector is 54; Production is 9 thousand 544 MW (Bangladesh, 2022). The electrical supply to health care centers in Upazila and rural areas is intermittent. Marginalized groups continue to rely on the capital Dhaka for treatment. For an extended period, Upazila health clinics lacked technology. As an outcome, renewable energy sources in healthcare facilities are vital.

The COVID-19 outbreak has brought forward the ingrained vulnerabilities of health systems across the world. In health care services, a shortage of reliable power had eroded the standard of healthcare for millions of people, particularly in Sub-Saharan Africa, South Asia, and South-East Asia, long before the pandemic made regular headlines around the world (SEforALL, 2020a). The target here is to design renewable ICCB Covid medical facilities which satisfy sustainability.

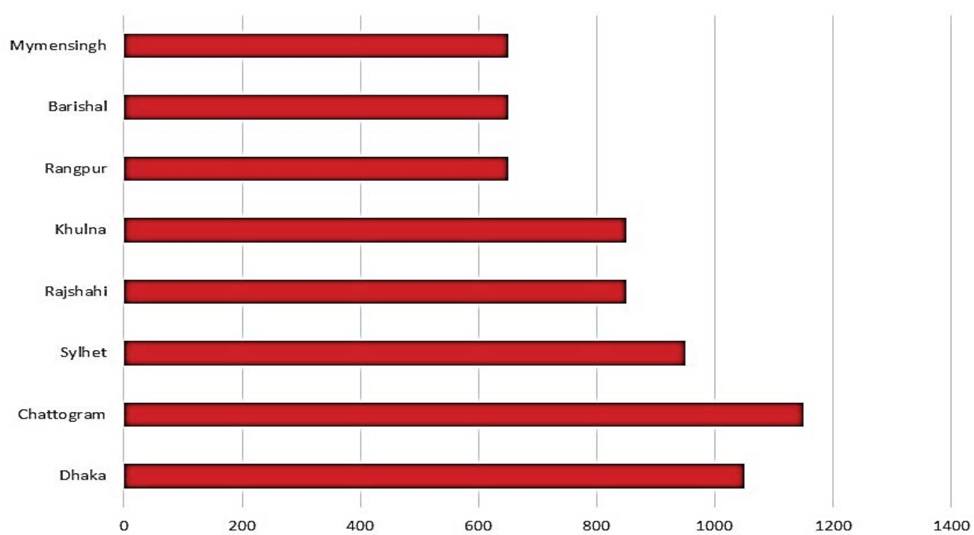

Fig.1 Division-wise number of isolation beds in April 2020 (Khan et al., 2020)

Fig.2 Renewable energy access in healthcare in Rural Sub-Saharan Africa (SEforALL, 2020)

The considerations of this paper are focused on Renewable energy sources (RESs) such as photovoltaic (PV), wind turbine (WT), biogas, biomass, and span over the integration of energy storage systems (ESSs) like batteries to the hybrid design, increasing the reliability of the system to a higher standard. The approach is designed using the hybrid optimization model (HOMER) and tested with different renewable sources.

Fig.3 A denim expo in ICCB

The most commonly used applications for hybrid systems designing such systems worldwide are HOMER, RET Screen, and IHOGA. NREL (National Renewable Energy Laboratory, USA) has developed a hybrid optimization model for electric renewables (HOMER) and model hybrid systems in more than 192 countries (Al-Falahi et al., 2017).
Numerous research has been undertaken over the last few decades to determine the optimal energy production systems with electricity storage. Khan and Javaid (Khan & Javaid, 2019) used HOMER as an energy management system for a hybrid PV-WT-FC-DG system. Rozario and Rehman (Mishra et al., 2016) used the bio-gas tool of HOMER software with solar energy to increase the system's reliability and provide a cost-effective solution. Mandal et al. (Mandal et al., 2017) designed Solar PV/Biogas/Diesel Generator Hybrid Energy System for a rural area locally named " CHAR" in Rajshahi. They found the best configuration at COE and NPC of USD 0.18 and USD 118007.39, respectively. Kamran et al. (Kamran et al., 2015) PV/Wind/diesel/battery Hybrid system for Energy Centre of UET Lahore. They have done techno-economical analysis using HOMER Pro. A similar approach is made by Khan et al. (Khan et al., 2018) for the Remote Area Electrification of Southern Punjab (Multan).

This paper presents the renewable energy framework from the Healthcare Archives of Bangladesh. To the best of my perception, this study is the first to model a COVID-19 hospital on the outskirts of Dhaka city, Purbachal, with hybrid device facilities. This may be called a suburban environment with a number of open spaces. The fundamental objective of this work is to find the possibilities of sustainable energy access on this platform. As we know, COVID-19 is an emergency, but designing a hybrid system could supply energy even when this situation is over. Because this hospital area was used for many events [Fig.3], so this is not just a temporary solution.

The work encompasses: (i) The necessary load demands for a COVID-19 hospital (ii) Access to different renewable sources of the hybrid system. And (iii) Analyse the solutions of various hybrid configurations. The remainder of this article is summarized as follows: In Section 2, we discussed different resources like Solar energy, Bio-gas energy, and Wind energy. In Section 4, we have briefly talked about the HOMER input data for our design. Simulation and results are recorded in Section 5 and Section 6 of our proposed model, followed by conclusions in Section 7.

2. METHODS

Before developing the hybrid system, it is necessary to calculate demand. Then, based on the load demand, a further process will ensue. I used the power ratings of various types of healthcare equipment and an actual survey to calculate the load demand. After obtaining the entire energy demand, the next stage is centered on the renewable energy potential for that site. The hybrid model is created after collecting all data about load demand and resource availability.

2.1 ENERGY DEMAND ASSESSMENT OF ICCB COVID HOSPITAL

Table 1 shows the data of various equipment and calculated the total energy, which is 313.9 units per day. However, the peak load is 44.19 kW/day. The proposed Covid Hospital's monthly load profile is shown in Fig.5. In HOMER, we can select the load profile based on residential, community, industry, etc. Also, we can choose the peak months based on a country's geometrical position.

2.2 RESOURCE POTENTIAL ASSESSMENT

In the current situation, the nation is dependent mainly on non-renewable resources such as gas, oil, coal, etc., as shown in Table 2, which expresses Bangladesh's energy scenario. Therefore we need to progressively reduce non-renewable sources because of their environmental damage and rising rates.

2.2.1 Solar energy resources' potential

Advanced medical equipment technology allows devices to use the DC power supplied directly by PV modules. ICCB, located in north Dhaka, has a longitude and latitude of 23° 49.6'N and 90° 25.6'E, respectively. Fig.6 indicates that the scaled annual average of solar irradiance is 4.59 kWh/m^2/day over ICCB.

2.2.2 Producing biogas from animal manure

Many dairy farms are near the place we have selected for your design. Many families have 3-4 cows in the Purbachal express highway area; as this location is situated at the corner of the city, this place is still a suburban area with lots of open spaces. Several large agro-farms meet the city's daily demand for milk and meat, such as North Bengal dairy (Vatara), Dairysun (Bashundhara), Meghdubi agro, etc. We can easily obtain the available biogas resources for our design by applying good management.

One cow produces 15–16 kg of cow manure per day; 100 cows = 100 x 15 = 1500 kg per day. Total fuel produced per day by bio-gas = 1.65 tonnes. 0.036m3 of bio-gas is derived from one cow's manure (Mishra et al., 2016). In a report, the bio-gas needed for electricity generation of 1kw is 0.7 m^3/h (Hasan et al., 2014).

2.2.3 Wind energy resources' potential

Data on wind resources are collected by NREL (National Renewable Energy Laboratory) tools available in the Database with HOMER Pro. The data shown in Fig.7 implies that the annual average wind speed of the ICCB is 4.42 m/s.

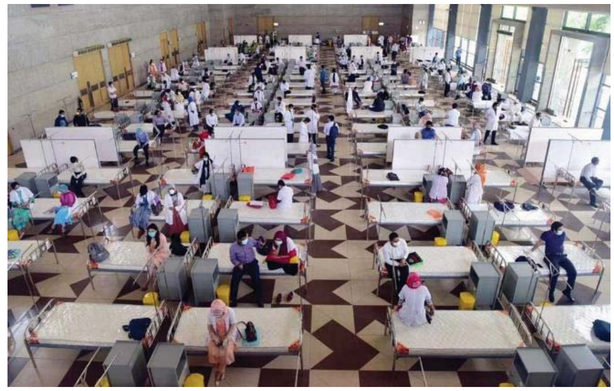

Fig.4 ICCB Covid-19 Hospital's load overview and expected demand (Tribune, 2020)

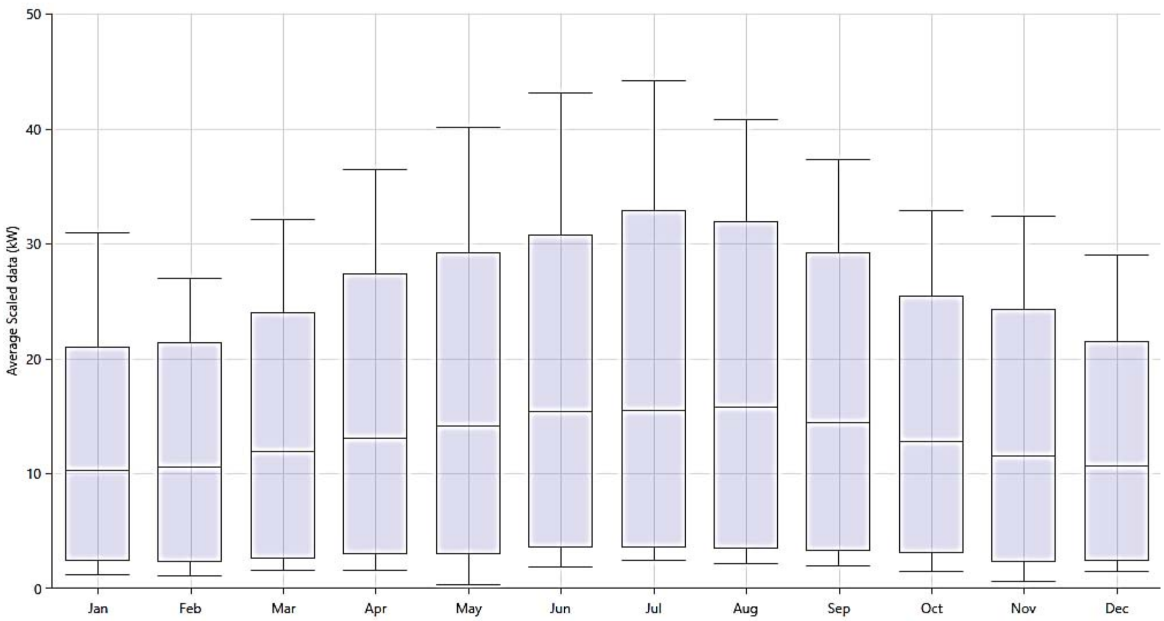

Fig.5 Seasonal profile of the load

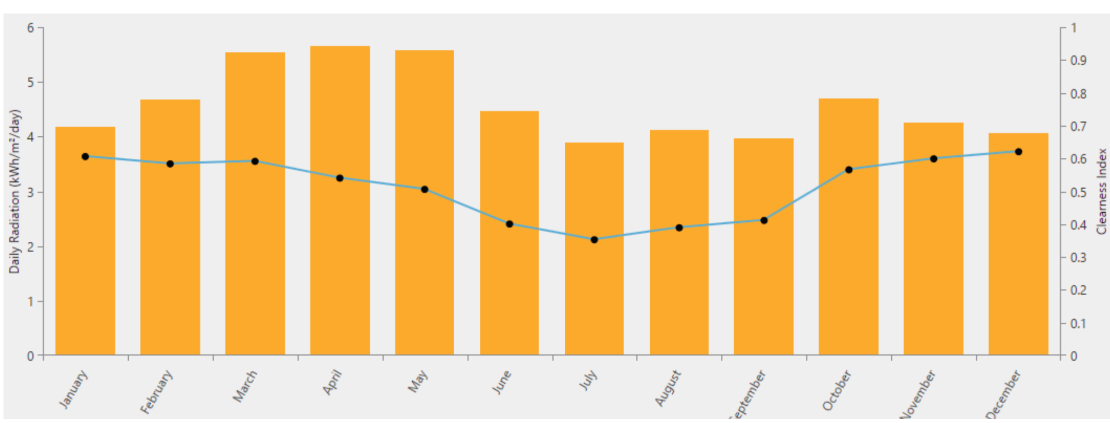

Fig.6 Solar irradiance for our project location

Table 1: The load description and estimated demand of ICCB Covid Hospital (Olatomiwa et al., 2018).

Load Description	Quantity	Rated Power (W)	Total Power (W)	Daytime hour (h/d)	Night hours (h/d)	Total on time (h/d)	Total Energy (kWh/d)
Lighting- CFL (indoor)	350	15	5250	2	6	8	42
Lighting-CFL (outdoor)	20	40	800		12	12	9.6
Fan (Ceiling/wall)	50	60	3000	6	6	12	36
Blood bank refrigerator	5	70	350	12	6	18	6.3
Vaccine refrigerator	20	60	1200	12	6	18	21.6
Small refrigerator	20	300	6000	5	5	10	60
Patient Ventilator	75	200	5400	10	-	10	54
Nasal Cannula	50	90	4500	10	-	10	45
Lab Autoclave (40-60L)	5	3000	15000	1	-	1	15
Blood Gas analyzer	20	50	1000	0.5	-	0.5	0.5
Electrocardiograph	20	80	1600	0.5	-	0.5	0.8
Suction Pump	20	24	480	10	-	10	4.8
Desktop Computer	10	150	1500	5	-	5	7.5
TV set	10	80	800	4	2	6	4.8
Mobile charger	50	20	1000	2	4	6	6
Total			47880			127	313.9

Fig.7 Average wind speed for ICCB

Table 2: Energy perspective in Bangladesh (Arefin & Hossan, 2014)

Energy sources	Target period 2010	2021	2030
Gas	88%	30%	28 %
Oil	6%	3%	5 %
Coal	3.70%	53%	38 %
Hydro	2.70%	1%	4 %
Nuclear	0%	10%	19 %
Renewable	0%	3%	6 %

3. HYBRID SYSTEM DESIGN

The input power diagram is presented in Fig. 8. This paper uses DC and AC buses. The bus from DC combines the battery and PV panel output, as displayed in Fig.8. The AC bus mixes the output/input of the Biogas generator, AC load from the wind turbine, and hospital. To perform the conversion from DC to AC, the inverters are used.

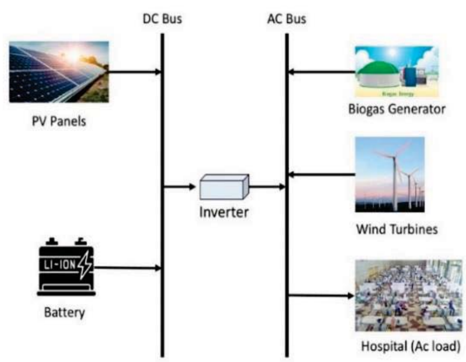

Fig.8 System model of the hybrid system

4. HOMER INPUT DATA

In software analysis, HOMER simulates different systems' configurations according to defined technical constraints and gives results based on the system's Net Present Cost (NPC). The NPC is calculated by (Iqbal & Siddiqui, 2017) :

$$C_{NPC} = \frac{C_{ann,tot}}{CRF_{(i,R_{Proj})}}$$

Where, Cann,tot : Total annualized cost, i: discount rate, RProj: Project lifetime, CRF(i,RProj): Capital Recovery factor.

4.1. HYBRID SYSTEM COMPONENT DATA

1) PV Modules

The per-unit cost of solar energy production in Bangladesh began at USD 0.17-0.19 (Situ, 2018). This research uses standardized 1 kW capacity flat-plate PV modules. In local manufacturing, investment costs for 1 kW in Bangladesh range from BDT 80000-1000000 (BDStall, 2022), which is equivalent to we took 1000 dollars/kW cost. At the same time, the replacement cost is 800 dollars / kW. And its life span is 25 years.

2) Wind turbine

Because of its low cutting speed, i.e., 2.5 m/s (5 mph), we have selected Bergey Excel 10 here. The BWC Excel 10 is a modern 10 kW wind turbine with a diameter of 7 meters (23 ft). It is designed for low maintenance, reliability, and automatic service in extreme weather conditions (*Excel 10*). The wind turbine's power is 10 kW with 20 years of lifespan. Production and replacement costs are USD 380, USD 235, respectively.

3) Bio-gas generator

This study takes 1.65 tonnes/day of scaled annual average biogas fuel. This can be done with 100 cow manure, which is already mentioned in section 2.2.2. In Bangladesh, digesters cost around USD 538 for 3.2m3 (Karmaker et al., 2020). USD 1156 was taken as capital expense in another research to generate 3 kW electricity (Mandal et al., 2017). So we took out the initial capital of USD 350 in our report With 15,000 hours of lifespan. Again, Muhammad Umer Khan, Muhammad Hassan, and M. Haseeb Nawaz assumed 53 dollars per ton of fuel cost (Khan & Javaid, 2019).

4) Power Converter

The converter is used for the transfer of electrical power from AC-DC and DC-AC, respectively. As the performance from PV panels is in the form of DC, which is used to transform DC to AC to feed the electrical load of AC. the capital, replacement, and operation The cost of repair and maintenance for 1 kW, which is respectively considered 900 USD, 900 USD, and 90 USD (Mishra et al., 2016). The output of the converter is 90 percent and with a 15-year lifespan.

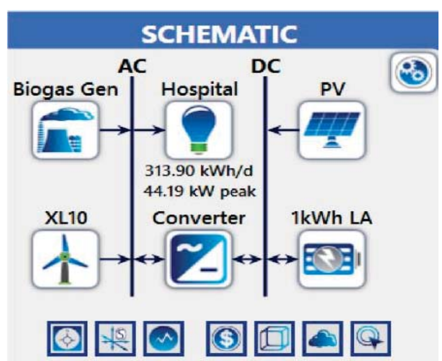

Fig.9 Schematic diagram of a hybrid system in HOMER

5) Batteries

A 6 V Li-ion battery with a nominal capacity of 1 kW and a lifetime of 15 years is used in our paper, with an initial capital ranging from around 300 dollars.

4.2 SENSITIVITY ANALYSIS

In the optimal sizing procedure of Hybrid renewable energy, parameters such as fuel cost, wind speed, solar radiation, electricity price, and components cost do not have deterministic values. So, the uncertainty of these parameters has an effect on the simulation and optimization stages. These parameters are adjusted into HOMER with different values for a smoother simulation.

In this paper, the calculation is done with regard to solar radiation, wind speed, and per-price tonne biogas fuel price for the simulation. For realistic simulation, the actual values may fluctuate.

4.3 SIMULATIONS

HOMER Pro simulates all available and potential hybrid system configurations to achieve the best cost-effective and feasible system configuration. HOMER Pro optimizes various combinations of NPC-based hybrid systems with the lowest-cost system on top. Table 5 shows the simulation for the sensitivity cases we have already mentioned, and Table 4 shows the most optimal cases. In Table 4, there are 10 rows, each row showing a different configuration, and the other related cost values are also shown there. In section 6, the cases are pointed out one by one. The PV-Biogas generator - Battery system is considered the most optimal case because having a low COE of USD 0.176 with an NPC of USD 260022. Then again, sensitivity analysis gives more practical ideas about any design. It makes the system more reliable. The sensitivity scenarios for the optimal solution are listed in table 5. Where average solar radiation is taken as 4.65 kWh/m^2/day, the average wind speed is 4.42 m/s, and the biomass price (dollar per tonne = 53), which carries COE USD 0.176 with an NPC of USD 260022. Though in our optimal case, wind energy is not a feasible solution, so the effect of wind speed doesn't matter in that particular case.

5. RESULTS AND DISCUSSION

From Table 4, different hybrid configurations can be observed, and it is visible that the COE for these cases is between USD 0.176 to USD 0.517. Let's discuss Table 4, where the best-case scenarios are explored. The ten rows each represent a unique hybrid system setup that will be addressed separately. The first case is PV, a Biogas generator, Battery bank (1kWh) system. In this case, wind energy is not considered. In this case, the COE, NPC, and OC are USD 0.176, USD 260021.6, and USD 13708.38, respectively. Then in the second case, all renewable sources are taken, and the situation is observed, where PV, a Biogas generator, a Wind generator, and the Battery bank (1kWh) are considered for the design. In this case, the COE, NPC, and OC are USD 0.185, USD 274322.7, and USD 12179.51, respectively. PV and Wind energy systems are eliminated in the third case. For this case, the COE, NPC, and OC are USD 0.192, USD 283987.5, and USD 17923.5, respectively. In comparison to the previous two examples, the COE seen here is relatively high, and it can be seen that it is steadily growing throughout the following several cases. The fourth case is a Bio-gas, Wind energy, and battery bank (1kWh) design. And the COE, NPC, and OC received USD 0.202, USD 298680.8, and USD 17022.4, correspondingly. In the fifth case, the Bio-gas generator is the only single source for meeting the load requirement. But from Table 4, it can be observed that the initial capital is the lowest for this case. In this case, the COE, NPC, and OC are USD 0.244, USD 361589.2, and USD 26643.88, respectively. In this instance, the dependence is predominantly on animal waste. However, in the case of hybrid architecture, it is impractical to rely on a single power source. The sixth case is PV and Biogas generator-based design. The initial capital cost is also less for this particular case. Here the COE, NPC, and OC values are USD 0.246, USD 364076.1, and USD 26685.45, respectively. The seventh case is a Bio-gas generator and Wind energy system. In this case, the COE, NPC, and OC are USD 0.266, USD 393980.7, and USD 26674.17, respectively. In the eighth case, we consider PV, Bio-gas generators, and Wind energy as sources. The COE, NPC, and OC, in this case, are USD 0.268, USD 396520, and USD 26719.79, respectively. The ninth and tenth are worse cases. We need a very high initial capital value, USD 529415.7 and USD 509405.2, respectively. A large COE of USD 0.492 and USD 0.517 can not be considered good optimal cases. However, wind energy is not deemed a feasible option in the located area. Yet, we try to test our hybrid design with wind facilities as our location is suburban, and there are many open spaces. From the study of different cases as mentioned above, it is clear that a mix of solar PV-Biogas generator-Battery system appears to be the most optimal in terms of both economic and environmental aspects because compared to other cases, all the values obtained here are the most beneficial. Then in Table 5, we have done the sensitivity analysis for the PV-Biogas-Battery system. If we look closely at the figure, average solar radiation is taken as 4.65 kWh/m^2/day, average wind speed 4.42 m/s, and the biomass price (dollar per tonne = 53), which carries COE USD 0.176 with an NPC of USD 260021.6. The initial capital is low for this particular case which is USD 82806.25.

Table 4: Optimization Cases

PV(Kw)	XL 10	Biogas Gen (kW)	1 kWh LI	Converter(kW)	Dispatch	Cost/NPC ($)	Cost/COE($)	Cost/Operating cost ($/yr)	Cost/Initial capital ($)
31.28		49	66	23.53	CC	260021.6	0.176	13708.38	82806.25
28.08	1	49	99	22.05	CC	274322.7	0.185	12179.51	116871.9
		49	94	18.15	CC	283987.5	0.192	17923.5	52281.25
	1	49	61	19.19	CC	298680.8	0.202	17022.4	78623.44
		49			CC	361589.2	0.244	26643.88	17150
1.64		49		0.35	CC	364076.1	0.246	26685.45	19099.48
	1	49			CC	393980.7	0.266	26674.17	49150
1.64	1	49		0.35	CC	396520	0.268	26719.79	51099.48
374.11	1		420	43.68	CC	728143.3	0.492	15372.46	529415.7
320.65			738	45.73	CC	764479.9	0.517	18731.15	509405.2

Table 5: Sensitivity cases (Solar radiation, Wind speed, Biogas fuel price)

Sensitivity/Solar Scaled Average (kWh/m^2/day)	Sensitivity/Solar Scaled Average (kWh/m^2/day)	Sensitivity/Solar Scaled Average (kWh/m^2/day)	PV (kW)	XL10	Biogas Gen (kW)	1kWh LI	Converter (kW)	Dispatch	Cost/NPC	Cost/COE	Cost/ Operating cost ($/yr.)	Cost/ Initial capital ($)
4.2	3.5	45	31.74		49	67	23.41	CC	259969.3	0.176	13661.74	83356.91
4.2	4.42	45	31.74		49	67	23.41	CC	259969.3	0.176	13661.74	83356.91
4.65	3.5	45	32.72		49	65	24.02	CC	256317	0.173	13291.94	84485.18
4.65	4.42	45	32.72		49	65	24.02	CC	256317	0.173	13291.94	84485.18
4.2	3.5	53	32.33		49	67	23.47	CC	264180	0.178	13937.59	84001.65
4.2	4.42	53	32.33		49	67	23.47	CC	264180	0.178	13937.59	84001.65
4.65	3.5	53	31.28		49	66	23.53	CC	260021.6	0.176	13708.38	82806.25
4.65	4.42	53	31.28		49	66	23.53	CC	260021.6	0.176	13708.38	82806.25
5	3.5	53	32.36		49	103	23.23	CC	258112.7	0.174	12924.98	91024.82
5	4.42	53	32.36		49	103	23.23	CC	258112.7	0.174	12924.98	91024.82
4.2	3.5	60	33.19		49	66	23.33	CC	267670.7	0.181	14165.92	84540.46
4.2	4.42	60	33.19		49	66	23.33	CC	267670.7	0.181	14165.92	84540.46
4.65	3.5	60	30.28		49	64	23.87	CC	263575.5	0.178	14068.01	81711.08
4.65	4.42	60	30.28		49	64	23.87	CC	263575.5	0.178	14068.01	81711.08
5	3.5	60	32.52		49	72	24.15	CC	260941	0.176	13547.76	85802.15

Though there are sensitivity cases for wind speed, but as our optimal system doesn't consider wind energy, there is no effect of wind energy on our pricing. Fig.10 shows that the graph of renewable power output and PV power output is quite identical. The Bio-gas generator operates at its rated capacity of about 7 PM. Table 6 shows the cost summary scenario, which provides information about the cost for a different system and the cost of capital, replacement, operation and maintenance, fuel, etc. The auto-set generators have the greatest overall cost, according to Table 6. Obviously, there will be no fuel price for other systems that accept the generator. Again there is a high replacement cost for the battery. The cost of capital in cash flow exists only during the project's erection, i.e., in year zero. As shown in Fig.11, there are constantly operating and fuel costs for each year from the beginning of the project until the end of the project.

Replacement costs are repeated nine times throughout the whole project. All these costs discussed above are cash outflows, while the project's salvage value is considered the cash inflow at the end of the project. Fig.11 displays the cash flow review for the 25 years of the project. For a given period, cash flow graphs physically reflect revenue and expenditure. Here it is observed that for the 1st year, the system needs to invest capital, so the expenses are the highest.

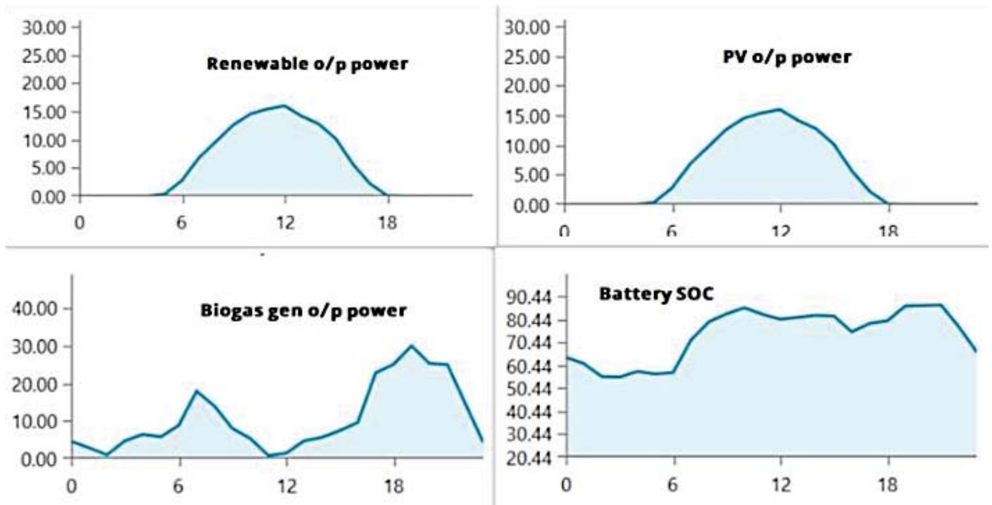

Fig.10 Daily profile for May.

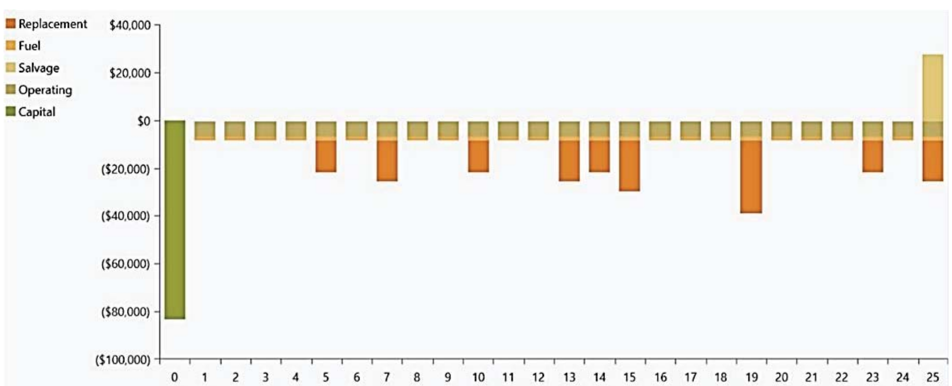

Fig.11 Cash Flow.

Table 6: Cost Summary

Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
Autoset Genset	$17,150.00	$31,270.15	$47,470.62	$22,715.56	$3,437.38	$115,168.95
Generic 1kWh Li-Ion	$13,400.00	$32,895.15	$8,661.44	$0.00	$1,563.40	$53,393.19
Generic flat plate PV	$31,735.47	$0.00	$4,102.61	$0.00	$0.00	$35,838.08
System Converter	$21,071.44	$8,940.06	$27,240.14	$0.00	$1,682.61	$55,569.03
System	$83,356.91	$73,105.36	$87,474.80	$22,715.56	$6,683.39	$259,969.25

6. CONCLUSION

This study has created a homogenized system that is not localized and can be optimized for many other cases and geographic locations. However, the optimized model (Biogas generator, PV, Battery) in the paper has been fashioned to be best suitable for Bangladesh regarding parameters such as COE, NPC, and initial capital. As COVID-19 is a temporary emergency and the mentioned hospital is a makeshift hospital, the hybrid design can be used as a power source even after the pandemic. Although the covid condition becomes normal with time, hospitalized people continue to die and exhibit covid signs daily. Moreover, this venue was previously used for numerous business activities, so the hybrid concept will not go in vain. This study shows the HOMER optimization system to analyze all the possible outcomes and setups. A hybrid solar PV, Biogas generator, and battery-based system are found to be the most optimal case for the defined load, based on the large number of simulation results obtained from HOMER. In this case, the price of COE, NPC, OC, and initial capital is less concerning the other implementations considered. Then in section 6, sensitivity cases are discussed. So, the ambiguity of some parameters (like fuel cost and solar radiation) affects the stages of simulation and optimization. These parameters are modified in HOMER for a smoother simulation using different values. Although there are multiple theories of the various hybrid systems in our country, this paper provides new insight into the optimized integration of a hybrid system geared towards the healthcare sector. In addition, biogas energy can be an excellent power source in Bangladesh.; However, the government and NGOs are working for bio-gas-based management; most of the projects are based in rural areas where the ultimate goal is to power a small house or community. But the implementation can be done in a commercial case too. The anaerobic digestion process creates smell and needs maintenance for the digester. Because the proposed location is in the out strikes of the city, implementation and operations will be easy. As of April 2022, Dhaka faces an intense gas crisis (Correspondent, 2022). Meanwhile, the Titas Gas (Natural gas distribution company) authorities have no idea when the gas crisis will end (Khan, 2022). Increasing the use of biogas may be the solution for city dwellers. Lastly, if we talk about Bangladesh's healthcare facilities, bed availability in public hospitals is very acute. Although our government provides intensives, things don't function appropriately compared to the large population of Bangladesh. So, for any emergency scenario, we need contingency plans. And at this specific stage, our planned hospital is a milestone. Future tasks include undertaking techno-economic evaluations of additional renewable energy systems at the small rural clinic and coastal shelter center in Bangladesh. Furthermore, the viability of integrating wind energy and solar systems on floating platforms will be assessed.

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