HOMER OPTIMIZED OFF-GRID ENERGY SYSTEM: A CASE STUDY ON DHAKA SOUTH CITY CORPORATION NAGAR BHABAN

Submitted By

Syed Md Mehedi Hasan	ME2003022267
Md Shahanur Rahman	ME2003022226
Kazi Asadur Rahman	ME2003022195
Md Saiful Islam	ME2003022203
Md.Enamul Hoq	BME1901017116

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CERTIFICATE OF RESEARCH

This is to certify that the work presented in this thesis was carried out by the author under the supervision of **Abrar Sobhan Chowdhury**, Lecturer, Department of Mechanical Engineering, Sonargaon University Dhaka, Bangladesh

……..……
Syed Md Mehedi Hasan

……..
Abrar Sobhan Chowdhury

……
Md Shahanur Rahman

...……
Kazi Asadur Rahman

…...……
Md Saiful Islam

……
Md.Enamul Hoq

CANDIDATES DECLARATION

We are student of Sonargaon University, solemnly declare that this academic thesis titled "Homer Optimized off-grid energy system: A Case study on Dhaka South City Corporation Nagar Bhaban" is our original work. All ideas, data, and analysis presented herein are the result of my independent research efforts. Any sources consulted for this thesis have been duly acknowledged and cited. I affirm that this thesis has not been submitted for any other degree or qualification at any other institution. We take full responsibility for the content and conclusions drawn in this thesis. Furthermore, we adhere to the academic integrity standards set forth by Sonargaon University, and any violations thereof would be subject to appropriate disciplinary action. We adhere to the academic integrity standards set forth by Sonargaon University, and any violations thereof would be subject to appropriate disciplinary action.

We hereby declare that this thesis is my original work and it has been written by me in its entirety. We properly credited every single information source that we used to create the thesis.

..……
Syed Md Mehedi Hasan

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Md. Shahanur Rahman

..……
Kazi Asadur Rahman

……
Md. Saiful Islam

..……
Md. Enamul Hoq

CERTIFICATION OF APPROVAL

This thesis title "Homer Optimized off-grid energy system: A Case study on Dhaka South City Corporation Nagar Bhaban" Submitted by Syed Md Mehedi Hasan (ME2003022267), Md Shahanur Rahman (ME2003022226), Kazi Asadur Rahman (ME2003022195), Md Saiful Islam (ME2003022203), Md. Enamul Hoq (BME1901017116)

Countersigned

……..

Abrar Sobhan Chowdhury

Lecturer

Department of Mechanical Engineering

Sonargaon University (SU), Dhaka-1205, Bangladesh

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[Authors]

Syed Md Mehedi Hasan

Md Shahanur Rahman

Kazi Asadur Rahman

Md Saiful Islam

Md Enamul Hoq

DEDICATION

This thesis is dedicated to my cherished parents and family, who have consistently provided me with motivation, support, and courage to pursue my further education and to confront life's unforeseen circumstances with fervor, thrills, and amazement of Allah.

ABSTRACT

Modernization and population growth are the two significant causes impacting in the contribution of carbon emission and global warming. The globe is shifting to renewable energy in order to reduce its reliance on traditional energy sources that are based on fossil fuels and protect the environment. The fundamental goal in this study is to perform feasibility analysis of a sustainable renewable energy system that can provide the required demand for power in a case study for a commercial building in Bangladesh. It is therefore crucial to choose the most reasonably priced hybrid system that can reduce energy costs and provide access to the required electrical energy. This investigation is conducted using HOMER Pro (Hybrid Optimization Model for Electric Renewable) Software to find the best outcome for a given scenario. The NASA Renewable Energy resource database, which has been imported into HOMER Pro, provided the solar and wind energy data for the simulation. Utilizing a variety of optimization and sensitivity analysis approaches, the combined solar, generator, and battery system displayed as the ideal system with $ 0.1086 as the levelized cost of energy (COE) per kWh, and $ 45,16,963 is the net present cost (NPC), with an operating cost of $95,387.58$ per year.

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NOMENCULTURE

DSCC	Dhaka South City Corporation (DSCC)
UNCCC	United Nations Climate Change Conference
GHG	Green House Gas
HRES	Hybrid Renewable Energy Systems
SWOT	Strength, Weaknesses, Opportunities and Threats
IEA	International Energy Agency
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
PSMP	Power System Master Plan
NCBD	National Committee Bangladesh
RE	Renewable Energy
TWh	Terawatt-hour
MW	MegaWatt
kWh	Kilowatt hour
MWh	MegaWatt hour
PV	Photovoltaic
GT	Giga Tons
CO2	Carbon Dioxide
kg	Kilogram
%	Percentage
$	Dollar Sign
DESCO	Dhaka Electric Supply Company
FR	Energy Friction
DSF	Demand Supply Friction
NPV	Net Present Value
NPC	Net Present Cost
LCOE	Levelized Cost of Energy
PHS	Pump Hydro Storage
HOMER	Hybrid Optimization of Multiple Energy Resources
HOMER	Hybrid Optimization Model for Electric Renewables
APS	Arizona Public Service
NZE	Net Zero Emission
CCUS	Carbon Capture, Use and Storage
RESs	Renewable energy sources
DERs	Various distributed energy resources
Renewable DERs	Renewable Distributed Energy Resources
NASA	National Aeronautics and Space Administration
HRES	Hybrid Renewable Energy Systems
RES	Renewable and Sustainable Energy
ESS	Energy Storage system
GRD	National Grid
ECD	Combined Dispatch
LOCE	Levelized cost of energy
COE	Cost Of Energy
HFO	Heavy Fuel Oil
MG	Micro Grid

CD	Combined Dispatch
LF	Load Following
CC	Cyclic Charging
EE	Excess Energy
Mtoe	Million barrels of oil equivalent
BT	Battery Technology
USA	United State of America
NASA	National Aeronautics and Space Administration

CHAPTER 1

INTODUCTION

Bangladesh's vibrant capital, Dhaka, is a booming city where urban life beats with unrelenting passion [1] Amidst the winding alleys and tall buildings, the pursuit of sustainability has become a pressing necessity [1]. Covering 5,200,000 square feet, this imposing building acts as the city's nerve core for administration. The South City Corporation in Dhaka, one of the administrative divisions in charge of overseeing the infrastructure and municipal services in the southern portion of the city, depends heavily on this organization [2]. Against the backdrop of rapid urbanization, burgeoning population growth, and mounting environmental challenges, the exploration of renewable energy integration within the boundaries of Dhaka South City Corporation (DSCC), "Nagar Bhaban" assumes paramount significance [3].

The integration of three powerful sources solar photovoltaics (PV), Generator, and wind turbines lays the foundation of this research. According to research by Zeyad M et al. [4], each of these elements is a potent instrument for achieving sustainable development. Colgan Jeff D. [5] argues that energy security is compromised by political conflicts, prompting the need for strategic energy planning. Dependency on external sources poses challenges, underscoring the importance of self-reliance. He highlights the advantages of renewable energy sources, noting their abundance, perpetual availability, and essentially infinite supply lifespan. As per the 2015 United Nations Climate Change Conference (COP21) accord in Paris, Das A et al [6] underscore that numerous nations have made the decision to restrict carbon emissions that are responsible for climate change and global warming. It has been determined that the decrease of GHG emissions is to be 40% by 2030 and 80% by 2050.

Conventional energy sources must be substituted by renewable ones to meet this goal. It is projected that thirty percent of energy will come from renewable sources, and by 2050, all energy will likely come from renewable sources. As a result, the importance of renewable energy is growing on a global scale. Governments, energy policy makers, and power producing firms in particular pay close attention to this issue. Fukutomi M [7] theorizes that amidst political instability leads to economic stability. It is necessary to have spare capacity and a variety of energy acquisition options. Last throughout the whole lifetime of the sun, or billions of years. Flexible in terms of both heat and electricity Saving money (including the initial investment made today) minimal maintenance, minimal noise, and very little pollution.

Islam Sharif S et al. [8]scrutinized Bangladesh's potential for renewable energy resources. To replace contemporary non-renewable energy resources, the government of Bangladesh is committed to investing in renewable energy projects in both the public and commercial sectors. Based on the production of electricity, the writers recommended that renewable energy contribute. Islam A et al. [9]investigated the correlation between energy and economic expansion and to provide potential solutions for Bangladesh's energy problems. Bangladesh's traditional energy sources are running out quite quickly. Technology that utilizes renewable energy might offer an alternate means of supplying Bangladesh's expanding energy needs. Bangladesh's improper utilization of renewable energy sources, despite their enormous potential, is caused by a lack of technical and informational understanding. The current study examined Bangladesh's economic growth in relation to the state of the energy sector today and the potential of sources of renewable

energy. Rahman M [10] Underscore that in developing nations like Bangladesh, Hybrid Renewable Energy Systems (HRES) that combine many power sources like solar, wind, hydro, and biomass have shown to be successful in tackling energy difficulties.

Elavarasan R et al. [11] conducted a SWOT analysis to formulate a roadmap and suggest policies aimed at addressing the escalating energy demands of our nation in both the short- and long-term. Hazelton et al. [12] pointed out that the full potential benefits of hybrid renewable energy systems may not be realized without an effective dispatch strategy. The term "optimal dispatch strategy" describes the clever management and control of multiple sources of energy in a hybrid system to guarantee the most economical and effective distribution of energy. By optimizing energy generation, storage, and distribution, this strategy lowers operating costs, increases system dependability, and makes the most use of renewable resources.

International Energy Agency (IEA) in 2012 EIA (US) [13] provided insights into global energy demand projections, highlighting that energy demand is expected to grow by about one-third annually from 2010 to 2035. During this period, India and China are forecasted to necessitate the largest share of energy supply from external sources, accounting for approximately 50% of the global demand. This surge in energy demand, particularly in rapidly industrializing and economically expanding nations, raises concerns. However, advancements in domestic production and the adoption of fuel-efficient transportation systems are expected to lead the United States, previously the world's largest oil importer, to reduce its oil imports by 2035. Nevertheless, China is projected to surpass the United States as the world's leading oil importer by 2020. Additionally, in 2010, approximately 81.1% of all primary energy was generated.

M Hasanuzzaman et al.[14] unveil Bangladesh's average annual growth rate in energy demand is more than 10%, which can be attributed to the country's fast economic progress, industrialization, increased grid connectivity, and uptake of new appliances and technologies. By 2021, demand is predicted to be roughly 23,800 MW, with the industrial sector accounting for more than 40% of electricity use. Islam A et al. [9] embarked was initiated in 2009 with the goal of promoting mitigation and adaptation efforts to lower greenhouse gas emissions from all potential sources without compromising Bangladesh's capacity to feed its citizens or advance its development. The effects of current laws and activities on reducing greenhouse gas emissions and advancing environmental sustainability, however, are not well understood. This is particularly true for the power and agriculture sectors, which account for 44% and 39% of the nation's net emissions, respectively. Therefore, it is imperative to close this information gap by assessing how the nation's current policies and activities affect reducing greenhouse gas emissions and promoting environmental sustainability.

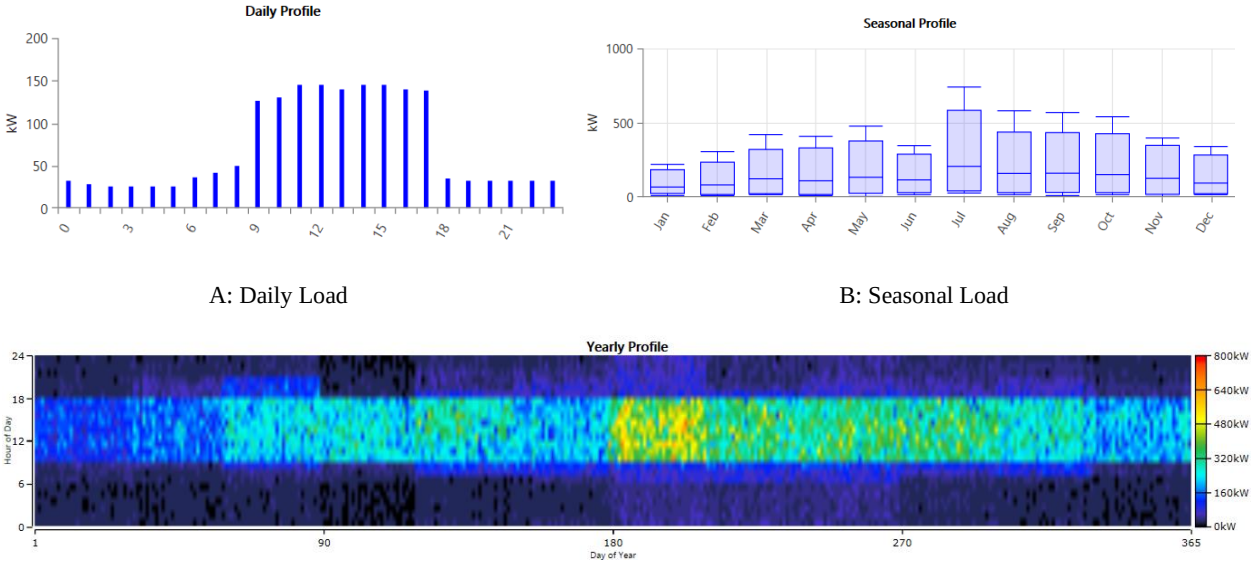
Das A et al. [6] reveals a diverse under Bangladesh Government’s Power System Master Plan (PSMP) The supply of electricity would come from nuclear (10%), coal (35%), gas (35%), oil (5%), and imports/renewables (15%), with a total demand for electricity of 335 TWh in 2041. The range of estimated electricity production expenses per megawatt-hour is 97–124 euros. Gulagi et al. [15] provided insight The estimated requirement for electricity by 2041 is 490 TWh, of which 55% will be generated from renewable energy, 37% from natural gas, and 8% through other sources. With a 78 TWh capacity, batteries would be used as storage technology. Das A. et al. [6] explored up until 2045, four possibilities were investigated the Power System Master Plan scenario, a scenario with a high-power import, a scenario with a higher use of renewable energy,

and a combined scenario with a high-power import and a high use of renewable energy. Selosse et al. [16] Utilize A TIMES model was used to optimize the results, which showed that a least-cost system is produced under the combination scenario of large imports and renewable energy. In the high-renewable energy scenario, installed PV and wind capacity is 10 GW and 4.6 GW, respectively, and total renewable energy generation in 2045 is estimated to be around 22.7 TWh. In the combined scenario, the maximum imports are approximately 100 TWh. Sharif et al. [8] highlighted that while the government aims to boost the share of renewable energy (RE) in the national grid, this growth can only materialize if the underlying issues surrounding RE projects are effectively addressed. Despite the implementation of comprehensive regulations and sustainability development strategies, renewable energy projects and green technologies still face financial, technical, and political obstacles.

Nonetheless, these efforts have acted as a catalyst for the integration of RE into the power generation industry. At present, there is currently no published research on large commercial buildings in Bangladesh. As a result, this study investigates alternative energy sources for one of the significant commercial buildings of Bangladesh, the Nagar Bhaban, their advancement, and their potential to fulfill future energy requirements and goals for sustainable economic development. By addressing the underlying issues hindering the adoption of renewable energy, it seeks to pave the way for a more resilient and energy-efficient future for Bangladesh. This research proposes a feasible hybrid energy system to be that can be implemented in other commercialized buildings in the country and assist in fulfilling the required energy generation from renewable sources and reduce pressure on the traditional sources of energy.

1.1 Problem Statement

In this paper we consider "Nagar Bhaban", the headquarters of Dhaka South City Corporation (DSCC). Its latitude and longitude are, respectively, 23.7104° N and 90.4074° E. It is a 12-storied building with 483,000 square meters of floor space (5,200,000 square feet). The entire city corporation's services for the citizen facilities are provided from this specific location. Here the demand is supplied by Dhaka Electric Supply Company (DESCO) from National Grid. The total amount of electricity used on DSCC for the 2023 fiscal year is 1,164,000 kWh. ***Figure 1*** A: Daily Load, B: Seasonal Load, C: Yearly Load Profile show the of Nagar Bhaban. This study will analysis the economic feasibility of using hybrid energy system for supplying the electrical load demand of Nagar Bhaban as a case study.



A: Daily Load

B: Seasonal Load

C: Yearly Load Profile

Figure 1. A: Daily Load, B: Seasonal Load, C: Yearly Load Profile

1.2 Objectives

The present case study on the investigation of feasibility of the utilization of renewable energy resources to meet the load requirements of Nagar Bhaban has a number of perspectives. The key objectives of this research are mentioned as follows.

- To find the minimum cost of energy
- To fulfill electric energy demand through the proposed off-grid system
- To reduce excess energy
- To find optimum number of solar PV and battery
- To minimize fuel usage
- To reduce generator sizing

1.3 Methodology

Analysis of hybrid renewable energy system to determine the optimum and feasible economic perspective for Nagar Bhaban. A comprehensive analysis of performance evaluation and optimization are also highlighted on the literature review. The following lists the key points from each section.

- ***Chapter 1*** highlights the importance of renewable energy in addressing global energy challenges and mitigating environmental degradation. It discusses research in Bangladesh, particularly in Dhaka, highlighting advancements in renewable energy technologies and policies. The chapter highlights the need for sustainable solutions in urban settings like Dhaka.
- ***Chapter 2*** Conduct a thorough search using appropriate keywords such as "optimal sizing," "PV module," "renewable energy hybrid system," "energy storage," "hybrid system optimization," and "energy cost minimization" in academic databases (e.g., IEEE Xplore, ScienceDirect, PubMed). Discover research on the best ways to integrate and size renewable energy sources especially photovoltaic (PV) modules with other renewable energy sources like wind, biomass, or hybrid systems.
- ***Chapter 3*** Hybrid system component modeling involves selecting and characterizing PV panels, diesel generators, and batteries to assess renewable energy systems' economic feasibility. It integrates data on capital, replacement cost, O&M cost, and expected lifetimes to create mathematical models. This approach ensures cost projections align with the system's operational lifespan, allowing informed decision-making and optimization strategies for hybrid system designs.
- ***Chapter 4*** An organized method was used in the design of the suggested hybrid energy system. Based on their capacity for integration, the key parts the generator, battery, PV panel, wind turbine, converter, and generator were determined. For system design, the HOMER program was utilized, which required input on unit counts, capital, replacement costs, operating costs, and system lifetime. A thorough cost analysis was carried out, which included annualized cost estimates for every component as well as Net Present Cost. This methodology made sure that the system's design and assessment were done in a methodical and accurate way.
- ***Chapter 5*** This study analyzes different hybrid energy system configurations and their economic feasibility. The base system, which used batteries and generators, initially cost $10.5 million USD. However, due to inefficient resource allocation and increased operating costs, its viability declined. Four case studies were conducted to compare different hybrid system configurations, including Solar/Generator/Battery, Solar/Wind/Generator/Battery, Wind/Generator/Battery, and Generator/Battery. Each case study evaluated the system's levelized cost of energy, net present cost, capital and operational costs, CO2 emissions, and renewable energy penetration. The results provide insights into the economic and environmental implications of different hybrid energy system configurations.

CHAPTER 2

LITERATURE REVIEW

Al-Ghussain et al. [17] studied the optimal sizing of a PV module with renewable sources like wind/biomass/hybrid system utilizing the Generalized Reduced Gradient algorithm. The research focused both energy storage system and without it emphasizing on enhancing the renewable energy fraction (FR) and demand–supply fraction (DSF) having a net present value larger than or equals to zero. They found that the incorporation of hybrid system provides approximately 100% autonomy. The outcome indicates the optimal system comprises of 2 MW wind, 0.92 MW biomass, and 1.79 MW PV systems along with 148.64 kWh battery bank and 24.39 MWh PHS. The study suggests an annual decrease of electricity bill by 1.37*10 6$ in the university. In a distant area of India, Kumaravel and Ashok [18] evaluated the viability of a standalone PV-biomass/pico-hydel hybrid system using the HOMER program. Their research, which centered on system optimization to reduce expenses, revealed that the suggested configuration, with an energy cost of 0.164 USD/kWh, presents a strong substitute for diesel/pico-hydel setups.

Chasapis D et al. [19] studied a hybrid integrated system for space heating that blends biomass and solar technologies in another study. Their findings demonstrated that, during the length of the operation, it was feasible to satisfy the needs of the household for hot water and space heating. IRENA [20] forecast that the total amount of electricity consumed would more than double. By 2050, the percentage of renewable energy in power generation is expected to increase from 25% to 86%. By 2050, variable renewables would account for about 60% of total power. International energy agency [13] note that in the APS, the share of electricity in total final consumption will increase from 20% to 41% by 2050, while in the NZE Scenario, it will surpass 60%. Electrification contributes significantly to lowering the demand for fossil fuels in addition to increasing the use of low-emission fuels and increasing efficiency.

Al-tabatabaie KF et al. [21] observe that at this juncture, fossil fuels like coal, heavy burner oil, imported diesel, natural gas, and so on are Bangladesh's main source of electricity. Rosa and Mazzotti [28] emphasize that Technology for carbon capture, use, and storage (CCUS) is an essential part of initiatives aimed at quickly lowering greenhouse gas emissions and achieving global carbon neutrality. CCUS is one of a number of promising decarbonization technologies that involves removing CO2 from the atmosphere or flue gas and transferring it for usage or long-term storage. For current industrial and electricity facilities that may otherwise produce about 600 Gt of CO2 over the next 50 years, CCUS is a carbon abatement a substitute.

Yamchi H et al. [22] assert that due to renewable energy sources (RESs) such as wind and solar (PV) are cost-effective and beneficial to the environment, they are the best option currently available for meeting global electricity demand while reducing greenhouse gas emissions. Traditional energy sources have lost ground in the competitive energy market because of their higher production costs, contribution to global warming, pollution, and climate depletion. To attain the necessary load, Youssef et al. [23] developed, simulated, and optimized eight different versions of hybrid systems incorporating renewable energy. They utilized the HOMER (Hybrid Optimization Model for Electric Renewables) software for this purpose. Input data for wind and

solar resources were provided by the National Aeronautics and Space Administration (NASA), while real-time field data for biomass resources at the selected study site was employed.

Akan A [24] Discover That The shift toward renewable energy sources continues to increase daily because of the decline of fossil fuel-based energy sources and the escalating environmental issues. The potential of renewable energy sources varies depending on the geographical area in which they are to be produced. Ali & Jang [25] accentuate that renewable energy technologies offer significant advantages beyond their role in reducing greenhouse gas (GHG) emissions. They emphasize the potential of these technologies to efficiently produce electricity in remote areas lacking access to other power sources. Adetoro S et al. [26] focus on ensuring optimal operation in hybrid renewable energy systems (HRES) integrated to an unstable national grid (GRD), this study evaluates dispatch options. In order to distribute energy efficiently, an improved combined dispatch (ECD) method that takes grid instability, load demands, and energy resource availability into consideration is given.

Amusan O et al. [27] research is consistent with a comparable study conducted in Qatar and the Springer report on Energy Democracy Evaluation for 100 percent Renewable Energy Policies and Projects, which indicates a rise in the use of reasonably priced, carbon-free renewable energy sources (RES) that will mitigate the consequences of climate change world. Aykut E et al. [28] utilize the HOMER software to simulate the system, which also determines the equipment's size and amount based on the campus's biomass capacity and weather. low Levelized cost of energy (LCOE), net present cost (NPC) and the cost of energy (COE)are used to find the best solution. Kapoor And Sharma et al. [29] Highlight that due to load shading, conventional energy sources are unable to provide the village's residential load with power for an extended period. From the perspective of low energy costs and efficiency, the above-proposed method is the best, regardless of an energy crisis or the availability of electricity from the grid for a set period.

Hossain M et al. [30] recommend enhancing the solar energy program is advised in terms of sustainability and commercial feasibility under the government's renewable energy initiative, which was facilitated by the private sector and microfinance institutions. The development of sustainable and renewable energies in Bangladesh will have a significant impact on these concerns. Karmaker et al. [31] stress the repercussions of Bangladesh's rapid development has resulted in an overall decrease in forest areas, an increase in sea level, and a rapid change in climate. Climate change and global warming are natural disasters that frequently cause affective problems in Bangladesh. Fossil fuel use has a major impact on the global climate. Fossil fuel supplies have been drastically decreasing. In Bangladesh, the promotion of sustainable and renewable energy resources can be achieved by reducing greenhouse gas emissions as well as improving energy security. Rahman and Rao et al. [32] shed light that Bangladesh faces significant obstacles to the growth of renewable and sustainable energy due to limitations in land availability and environmental circumstances. They suggest that considering renewable energy sources for power production in Bangladesh could alleviate concerns regarding environmental pollution and climate change. B. Das et al. [33] undertook a study in Bangladesh's Saint Martin. Their research compared the energy costs of various objective functions and found that the multi-objective approach outperformed the single-objective optimization system in terms of environmental benefits. They

also observed that, in terms of economic and environmental considerations, intelligent strategies were preferable to the hybrid optimization of different energy resources software tool. Furthermore, the suggested hybrid system configuration's unit electricity cost was found to be comparable to the grid's electricity supply, even with a likelihood of over 8% power supply loss, and had far lower life cycle emissions.

Das T et al. [34] conducted extensive research employing various optimization and sensitivity analysis techniques, determining that the Solar/Biomass/Battery/Wind/Hydrokinetic system is the optimal choice for the site under consideration. With this setup, the energy cost per kWh is a mere $0.128. Additionally, the running costs are only $12,413 per year, but the net present cost (NPC) amounts to $3,033,006. Moreover, the suggested method is environmentally benign, as it produces far less CO2 (17.6 kg/year) and very minimal other emissions. Mondal S et al. [35] point out the prevalent reliance on fossil fuels as the primary energy source in developing nations, fossil fuels serve as the primary source of energy, satisfying around seventy-five percent of the world's energy demands. However, the consumption of fossil fuels, their depletion, and their contribution to global warming have rendered sustainable electricity production increasingly challenging. This situation underscores the growing need for sustainable energy technology, driven by concerns regarding greenhouse gas (GHG) emissions and the diminishing supply of fossil fuel resources.

T Chowdhury et al. [36] explored a hybrid system for the Rohingya refugees in Bangladesh's Kutupalong camp, Cox's Bazar. Their investigation led them to conclude that the Wind/PV Panel/Generator/Battery/Converter system was the most optimal among six options, primarily due to its lowest energy and emission costs. When compared to alternative systems such as kerosene, the grid, and diesel, the emissions discharged by the chosen hybrid system were less than 61%, 84%, and 65%, respectively. Wali et al. [37] propose an ideal system comprising an 8.67 kW photovoltaic system, a 7-kWh lithium-ion battery, a 6 kW electrolyzer, a 1.8 kW fuel cell, a 5 kg hydrogen tank, and a 1.67 kW converter. This configuration results in a net present cost of $25,099 and a levelized cost of energy of $0.34 per kWh. Their findings suggest that the hybrid system facilitates the achievement of sustainable development objectives by providing clean energy. Furthermore, they emphasize the necessity of government backing, funding, and expansion in distant developing nations. Islam M et al. [38] describe a rooftop PV system consisting of 400 Wp solar panels, a 25-kW bidirectional inverter, a 28-kW generator, connecting wires, a mounting system, and other necessary accessories. They utilized the latest PV design software, HOMER Powering Health Tool, in their assessment to estimate load requirements and evaluate the techno-economic and environmental aspects of the microgrid system.

Karim M et al. [39] address the primary issues associated with fossil fuels, namely their scarcity and slow depletion. They emphasize that the use of fossil fuels releases greenhouse gases into the atmosphere, resulting in detrimental effects on the environment. As a solution, they advocate for diverse political arguments to be presented to the world community, promoting the transition from fossil fuels to renewable energy sources. Sohail M et al. [40] highlight that among the most urgent issues facing developing Asia, the Middle East, and Sub-Saharan Africa are energy problems, increasing electricity costs, and lack of grid access. They suggest that the most effective approach to addressing these energy and financial challenges in developing nations is to construct hybrid

renewable energy systems capable of operating off the grid or being connected to it. However, they note that the creation of such systems is plagued by significant financial and technical difficulties.

Barua and Rahman et al. [41] underscore the significance of microgrid systems, both on and off the grid, in developing nations. These systems, which incorporate various distributed energy resources (DERs) such as solar, wind, biogas, micro hydro, diesel generators, and hybrid fuel oil (HFO), are essential for maintaining socioeconomic stability. Despite limited resources and a lack of technological assistance in the field of sustainable energy, Bangladesh is progressively advancing in the utilization of renewable distributed energy resources (renewable DERs) for hybrid distributed power generation. Anam K et al. [42] highlight the stark reality that in Bangladesh, where 70% of the population resides in rural areas, only 10% of countryside homes had access to electricity as of early 2015. They predict that within the next few decades, certain areas of Bangladesh may not even have access to the national grid for energy. Currently, public sector power plants generate 53% of Bangladesh's total electricity, while private sector power plants contribute 47% to the country's future generation. Rout and Kulkarni et al. [43] emphasize that all three primary energy sources traditionally employed for power generation are nuclear, hydro, and coal. Among these three sources, coal energy accounts for a notably larger portion of the electricity produced. Reza M et al. [44] devote significant attention to constructing a microgrid (MG) system aimed at reducing carbon emissions in the electrical sector and mitigating environmental impact by 2050.

Shaahid et al. [45] underscore the necessity of providing various input data to HOMER, including electrical load (primary energy consumption), renewable resources (solar radiation, wind speed data), technical specifications of individual components, cost, limitations, controls, etc. The software then employs thousands of hourly simulations to craft the best configuration possible to meet the required electric load requirements. Furthermore, HOMER conducts sensitivity analysis to scrutinize the effects of factors such as solar insolation, PV investment cost, wind speed, and diesel fuel price on the Cost of Energy (COE). It is stressed that conducting an economic study before implementing any power generation systems is imperative. Through this economic analysis, HOMER assigns a net present cost ranking to each system, facilitating decision-making processes. The optimal algorithm for the Energy Storage System (ESS) has been a focal point of their research. Their article presents background information and conducts a thorough examination of the ideal ESS method for MG applications. Additionally, they conducted a quick search using specific predetermined parameters through the Scopus database during the final week of January 2021 spanning 11 years to identify the most cited publications.

Das and Zaman [46] discover that the Combined Dispatch (CD) strategy exhibits slightly lower Cost of Energy compared to the Load Following (LF) and Cyclic Charging (CC) strategies. However, operational emissions for the Load Following Strategy are significantly lower than the other two strategies for both hybridized systems. Moreover, the Renewable Fraction is greater in Load Following than in the Combined Dispatch and Cyclic Charging strategies, albeit at the expense of Excess Energy (EE). Pilavachi P [47] asserts that energy plays a crucial role in sustainable development and forms the cornerstone of modern civilization. Worldwide, primary energy consumption is on the rise, driven by urbanization and population growth. The main energy

sources continue to be fossil fuels, encompassing coal, natural gas, and oil. It is anticipated that fossil fuels will continue to dominate the world's primary energy supply, accounting for 90% until 2020, barring any significant technological advancements. British Petroleum [48] note a significant surge in the use of fossil fuels over the past few decades. The amount of energy consumed for primary purposes has escalated from 8146 billion barrels of oil equivalent (Mtoe) in 1991 to 12,274.6 Mtoe in 2011.

CHAPTER 3

HYBRID SYSTEM COMPONENTS MODELING

Regarding HRES Design We are considering the suggested PV panel, diesel generator, battery, and converter in an effort to accomplish more effective outcomes. HOMER should be used to specify the number of units to be used, capital costs, cost of replacement, operation and maintenance expenses, and operating hours in order for simulating the system for the purpose of economic analysis.

3.1 Solar Photovoltic PV Model

The cost of PV module installation has been considered Trina Allmax M Plus. Lifetime module has been taken as 25 years. The parameters considered for the simulation solar PV are provide in ***Table 1***

Table 1. Solar PV array technical parameter and cost projection

Parameter	Unit	Value
Capital cost	USD/W	$400
Replacement cost	USD/W	$400
Derating factor	Percent	88%
Tracking system	No tracking system	-
Operation & Maintenance cost	USD/W/yr	$4
Lifetime	Years	25

3.2 Wind Turbine Model

For wind turbine in this HRES system we considered Generic 1 kW. Technical and economic parameters for selected wind turbine are provide in ***Table 2***

Table 2. Technical parameters and cost projection of wind turbine

Parameter	Unit	Value
Rated power	kW	1
Starting Wind speed	m/s	3
Rated wind speed	m/s	12
Cut-off wind speed	m/s	3.5
Capital cost	USD/kW	$5500
Replacement cost	USD/kW	$5200
Operation &maintenance cost	USD/year/turbine	5.2
Lifetime	Years	20

3.3 Generator Model

The CAT-250Kw-60hZ-PP model utilized in HOMER is a linear with slope and intercept at zero(no) load. with technical and economic parameters provide in ***Table 3***

Table 3. Technical parameters and cost projection for Biomass Diesel Generator

Parameter	Unit	Value
Capital cost	USD (Tk/kW)	$21839
Replacement cost	USD (Tk/kW)	$14194

Operation & Maintenance cost	USD/h	$0.03
Operational Lifetime	Hour/Year	60,000
Minimum load ratio	Precent	25%
Fuel curve intercept	l/h/kWrated	8.7
Fuel curve slope	l/h/kWoutput	0.228
Fuel price	USD	0.81

3.4 Battery

The EnerSys PowerSafe SBS XC 190F storage batteries are utilized in the hybrid system. The specification shows in ***Table 4***

Table 4. Technical parameter and cost projection for battery

Parameter	Unit	Value
Nominal Voltage	Volt	12
Nominal capacity	Ah(kWh)	2.51
Maximum current charge	A	190
Round-trip efficiency	Percent	97%
Maximum state of charge	Percent	N/A
Capital cost	USD/kWh	$300
Replacement cost	USD /kWh	$250
Operation & Maintenance cost	USD /kWh/yr	N/A
Lifetime	Years	12

3.5 Converter

To convert AC-DC or DC-AC, a converter is needed. The technical as well as economic specifications for the converter are displayed in ***Table 5***

Table 5. Technical parameters and cost projection for converter

Parameter	Unit	Value
Capital cost	USD /kWrated	$38
Replacement cost	USD /kWrated	$32
Efficiency	Precent	95
Rectifier capacity	Present	100
Rectifier efficiency	Present	95
Operation & Maintenance cost	USD /kWh/yr	N/A
Lifetime	Years	15

In the fiscal year 2023, monthly clearance index, daily solar radiation, temperature, and wind data were collected for Nagar Bhaban, DSCC.

Daily horizontal solar radiation values and wind potential of the region were obtained from the NASA Meteorological database [49] integrated into HOMER Pro software. Took a close look on ***Table 6***

Table 6. Solar and wind energy data of The Nagar Vaban

MONTH	CLEARANCE INDEX	DAILY RADIATION (kWh/m²d)	TEMPRATURE (°C)	WIND SPEED (M/S)
January	0.613	4.92	23	2.66
February	0.595	5.59	24	2.83
March	0.55	5.76	29	3.19
April	0.481	5.3	30	3.2
May	0.405	4.53	30	3.07
Jun	0.383	4.23	31	2.74
July	0.405	4.29	30	2.41
August	0.417	4.02	27.01	2.17
September	0.519	4.32	25.48	1.85
October	0.602	4.28	22.5	2.08
November	0.642	4.21	20.2	2.2
December	0.613	4.92	23	2.66
Average	0.537	4.826 kWh/m²	25.536°C	2.588 m/s

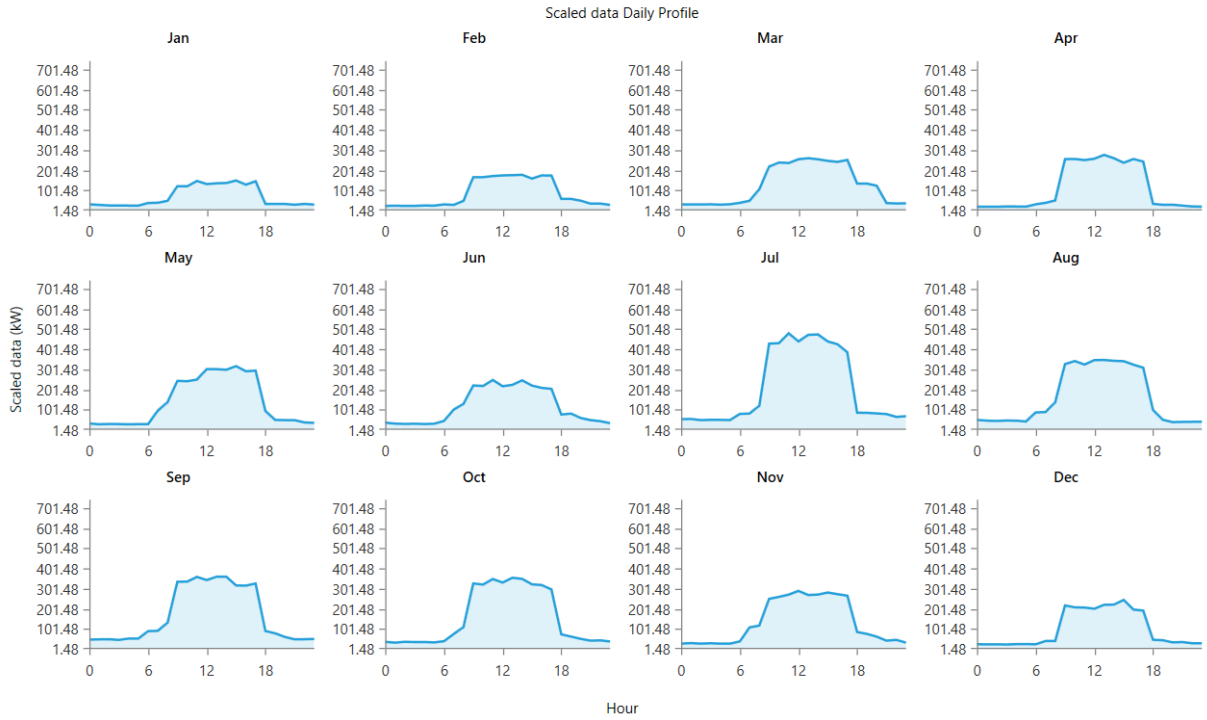


Figure 2. Load data Plot

The daily data profile for the last 12 months, as represented in ***Figure 2***, is given individually, as specified.

CHAPTER 4

COMPONENT

4.1 Component of The Hybrid System

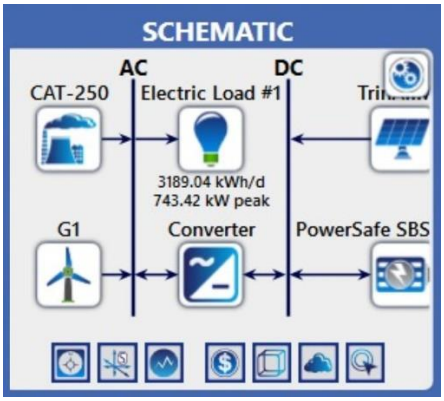


Figure 3. The components used in the proposed system.

Main components of this hybrid energy system are the wind turbine, PV panel, generator, converter, and battery as shown in ***Figure 3***. To design the system, HOMER needs different parameters such as the number of units used, capital cost, replacement cost, operation, and maintenance (O&M) cost of the system, lifetime, and other parameters. The hybrid system is designed in HOMER by selecting "do not model grid" option which represents a typical stand-alone system.

4.2 Cost Summary Net Present cost

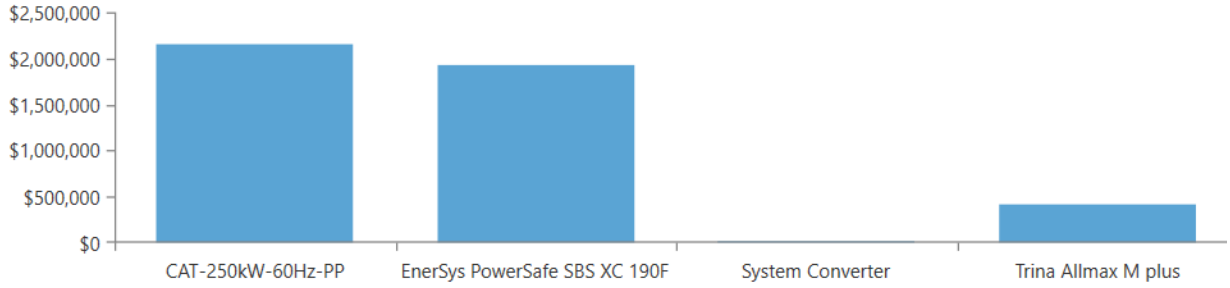


Figure 4. Cost Summary of Net Present Cost

According to the Net Present Cost (NPC) for each component, this is the project's overall cost breakdown. A thorough breakdown of the costs related to each component, including capital, replacement, operation, and maintenance (O&M), fuel, salvage, and overall expenditures, is included in the ***Table 7*** below. The entire cost of the CAT-250Kw-60hZ-PP is $2,161,066.43, with fuel and capital investment accounting for a large portion of the costs. Comparably, the EnerSys PowerSafe SBS XC 190F has high costs of $1,926,913.09, which are mostly attributable to capital and replacement charges. Though not as much, the System converter and Trina Allmax M Plus also add to the project's expenses. To view the cost breakdown graphically, please refer to the ***Figure 4*** that is attached. This thorough cost summary offers insightful information on the financial aspects of our project, enabling educated decision-making.

Table 7. Cost Summary of Net Present Cost

Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
CAT-250Kw-60hZ-PP	$21,839	$0.00	$1,519.96	$2,141,345.97	$3,638.50	$2,161,066.43
EnerSys PowerSafe SBS XC 190F	$750,000	$1,358,890	$0.00	$0.00	$181,977.40	$1,926,913.09
System converter	$16,905	$0.00	$0.00	$0.00	$962.25	$15,943.21
Trina Allmax M Plus	$320,000	$0.00	$114,336.68	$0.00	$21,296.56	$412,040.13
System	$1,108,744	$1,358,890.49	$115,856.64	$2,141,345.97	$207,874.70	$4,516,962.86

4.3 Cost Summary Annualized

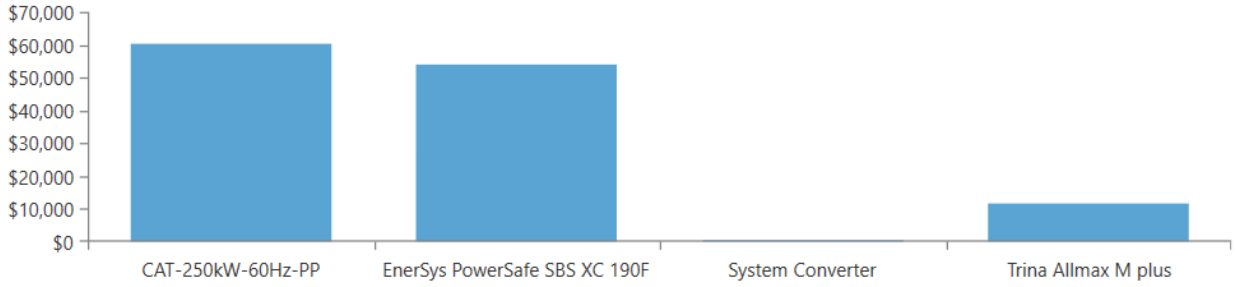


Figure 4. Cost Summary of Annualized

Based on the annualized cost by component, this is the project's overall cost breakdown. A thorough breakdown of the capital, replacement, operation, and maintenance (O&M), fuel, salvage, and overall costs related to each component may be found in the ***Table 8*** below. At $60,482.89, the CAT-250Kw-60hZ-PP has a total cost that is mostly related to fuel and capital expenditure. Comparably, the EnerSys PowerSafe SBS XC 190F has high costs of $53,929.52, which are mostly attributable to capital and replacement charges. Though not as much, the System converter and Trina Allmax M Plus also add to the project's expenses. To view the cost breakdown graphically, please refer to the ***Figure 4*** that is attached. This thorough cost summary offers insightful information on the financial aspects of our project, enabling educated decision-making.

Table8. Cost Summary of Annualized

Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
CAT-250Kw-60hZ-PP	$611	$0.00	$42.54	$59,930.96	$101.83	$60,482.89
EnerSys PowerSafe SBS XC 190F	$20,991	$38,032	$0.00	$0.00	$5,093.10	$53,929.52
System converter	$473	$0.00	$0.00	$0.00	$26.93	$446.21
Trina Allmax M Plus	$8,956	$0.00	$3,200.00	$0.00	$596.04	$11,559.97

System	$31,031	$38,032.00	$3,242.54	$59,930.96	$5,817.90	$126,418.58

4.4 Electrical

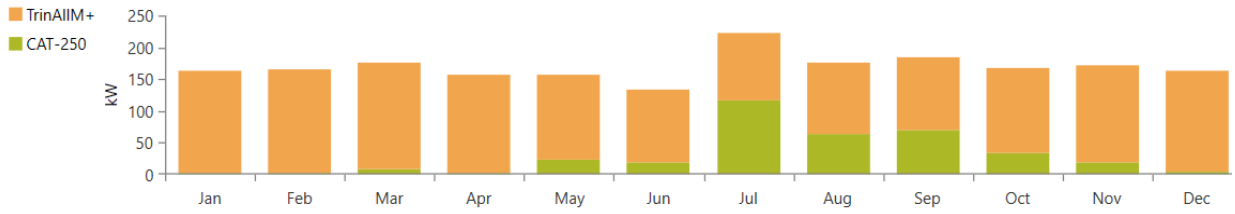


Figure 6. Monthly average electrical power produced by the proposed system for the model.

Trina Allmax M Plus has produced 1,216,839 kWh/yr, which is 81.8% of the total electricity produced using renewable energy sources. However, the CAT-250Kw-60hZ-PP generates 270,998 kWh/yr, which is 18.2% of the total amount of electricity produced. Utilization of fuel is the source of this electricity. Excess energy 253,425 kWh/yr which is 17% of total electricity. For graphical view is shown in ***Figure 6.***

4.5 Fuel Summary

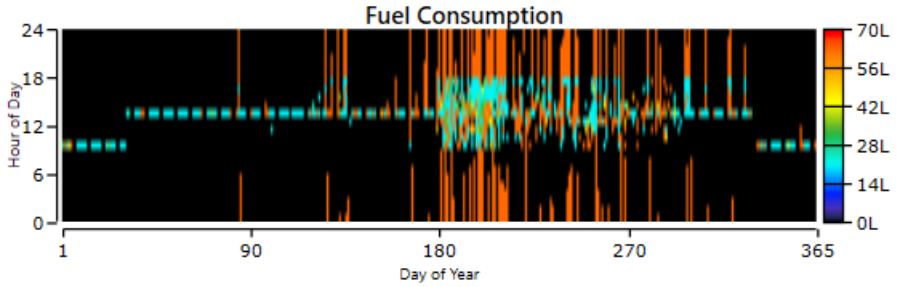


Figure 7. Fuel Consumption

In this analysis result shows that Total fuel consumed stand 73,989L Per year, Averaging 20L fuel per day and 8.45L per hour. This information illustrates how much fuel the system needs on a daily and hourly basis. Watch the ***Figure 7*** to observe how it has changed over time.

4.6 Generator

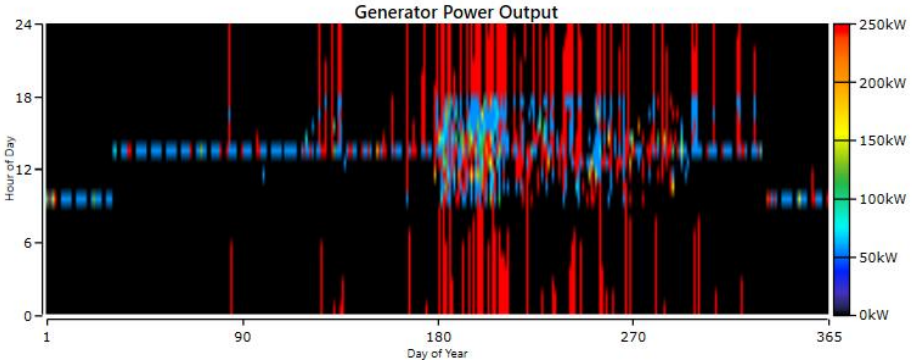


Figure 8. Generator Output

According to our simulation analysis, The CAT-250Kw-60hZ-PP generator, with a capacity factor of 12.4%, operates for 1418 hours annually with 326 starts, maintaining a 42.3-year operational life. It produces 270,998 kWh of electricity annually, with a fixed generation cost of $7.31 per hour and a marginal generation cost of $0.184 per kWh. Pay attention of the generator's output in the ***Figure 8*** And examine the ***Table 9*** for different Value.

Table 09. Output of Generator

Quantity	Value	Unit
Hours of operation	1418	hrs./yr
Number of starts	326	starts/yr
Operational Life	42.3	yr
Capacity factor	12.4	%
Fixed Generation Cost	7.31	$/hrs.
Marginal generation Cost	0.184	$/kWh
Electricity production	270998	kWh/yr
Fuel energy input	728050	kWh/yr

4.7 Battery

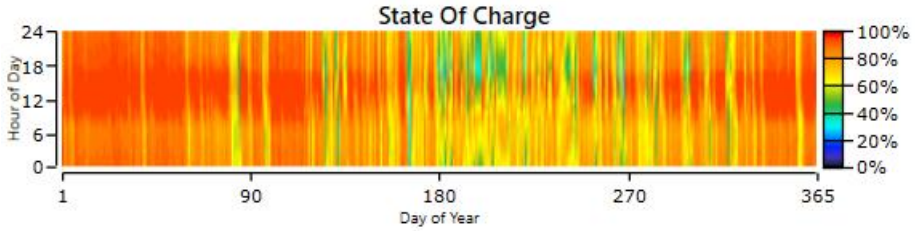


Figure 9. Battery State of Charge

EnerSys PowerSafe SBS XC 190F batteries used for energy storage in the system have a nominal voltage of 12V. Changing the charge status of batteries over time is shown in ***Figure 9*** And other detailed parameters shown on the ***Table 10.***

Table 10. Battery

Quantity	Value	Unit
Batteries	2500	qty.
String Size	2	batteries
String in Parallel	1250	strings
Bas Voltage	24	V
Nominal capacity	6267	kWh
Average Energy cost	0.0407	$/kWh
Energy In	410738	kWh/yr
Energy Out	398942	kWh/yr
Annual Throughput	405064	kWh/yr
Expected Life	12	yr

4.8 Solar PV

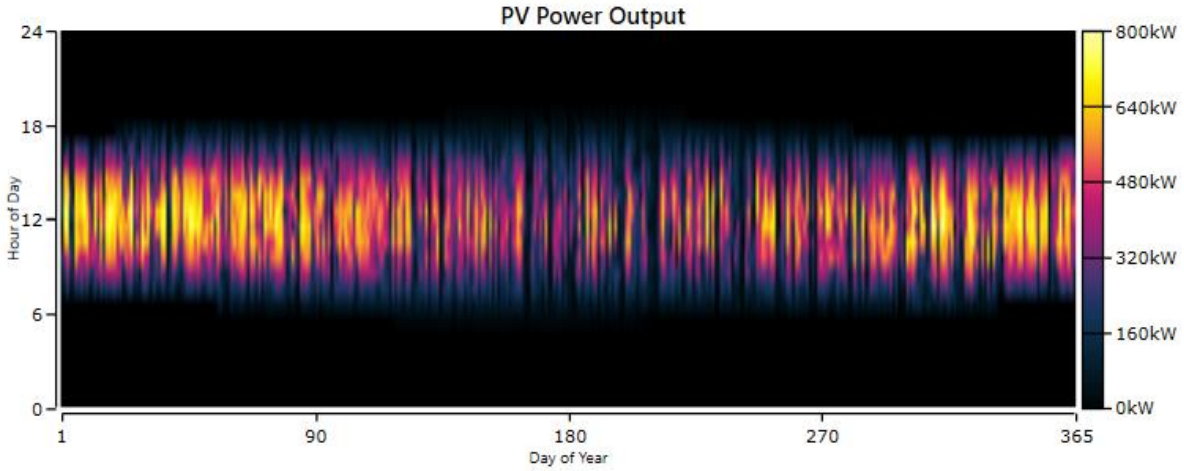


Figure 10. Solar Output

Trina Allmax M Plus flat photovoltaic panels are used in the reviews. 95% of the PV panels are efficient. Figure 10 shows a graph of the PV panels' output power, while Table 11 offers more information. A maximum power point tracking system with a 1 kW capacity has also been incorporated into the system.

Table 11. Solar PV Output

Quantity	Value	Unit
Rated capacity	800	kW
Mean Output	139	kW
Mean Output	3334	kWh/d
Capacity Factor	17.4	%
Total Production	1216839	kWh/yr
PV Penetration	105	%
Hours of Operation	4373	hrs./yr

4.9 Converter

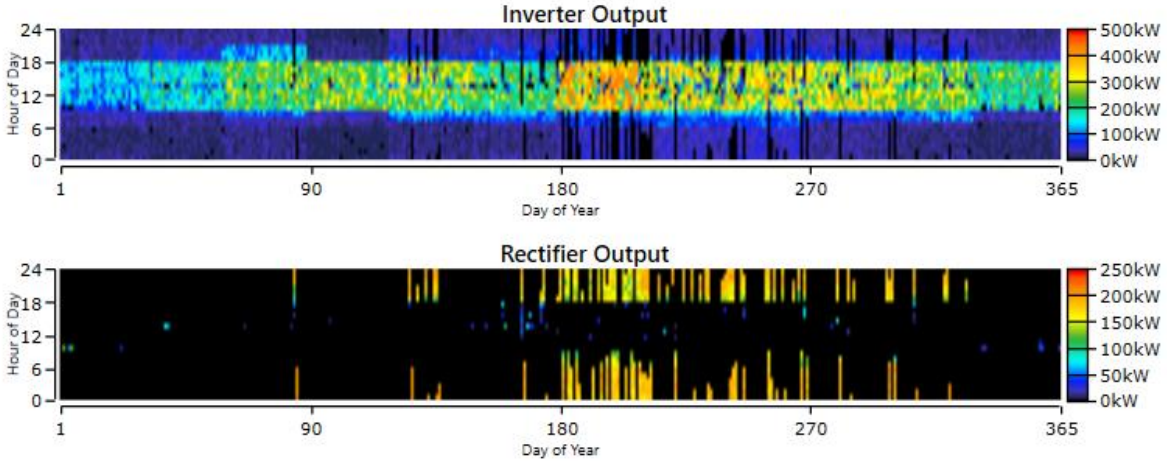


Figure 11. Converter Input and Output

A general-purpose converter system is the System Converter. This flexible converter translates across multiple systems, facilitating seamless integration and communication. ***Table 12*** presents additional data in addition to the outcomes of the simulation analysis shown in ***Figure 11***.

Table 12. Converter

Quantity	**Inverter**	**Rectifier**	**Units**
Capacity	445	445	kW
Mean Output	115	12.7	kW
Minimum Output	0	0	kW
Maximum Output	445	226	kW
Capacity Factor	25.9	2.85	%
Hours of operation	8087	673	hrs./yr
Energy In	1009711	111236	kWh/yr
Energy Out	1062854	117091	kWh/yr
Losses	53143	5855	kWh/yr

4.10 Emission

Table 13. Gas Emissions of grid and the hybrid renewable system.

Quantity	Only from Grid	From Renewable Energy	Difference in Emission
Carbon Dioxide (CO2)	1059240kg/yr	195408kg/yr	863832kg/yr
Sulfur Dioxide (SO2)	5820 kg/yr	485kg/yr	5335kg/yr
Nitrogen Oxides (NOx)	3492kg/yr	1407kg/yr	2085kg/yr

When compared to the grid, the hybrid renewable system drastically lowers emissions. It emits 863,832 kg/yr. less CO2 than the grid, with only 195,408 kg/yr. Nitrogen oxide emissions also drop by 2,085 kg/yr and sulfur dioxide emissions by 5,335 kg/yr. This significant emission decrease emphasizes how environmentally benign the suggested system is, making it a viable option for energy production. Demonstrate inspection at the ***Table 13*** to notice the variations.

CHAPTER 5

SIMULATION RESULT

5.1 Result Analysis

This paper performed a number of simulations for determining the feasible system for the mentioned commercial building. 3,589 number of simulations were conducted out of which 647 numbers were discarded and 2,942 number showed results.

5.1.1Base system

	Architecture											Cost	
							TrinAllM+ (kW)	G1	CAT-250 (kW)	PowerSafe SBS XC 190F	Converter (kW)	NPC ($)	Initial capital ($)
Base system									250	1,614	619	$10.5M	$529,548
Current system							800		250	2,500	445	$4.52M	$1.11M

Figure 12. Compare Economics

The initial expenditures of the base system, which only uses batteries and generators, jump to $10.5 million USD. Even with this large expenditure, it is not as economically feasible as its equivalent. As a result of inefficient resource allocation and increased operating costs, the base system eventually loses its viability and manipulated. ***Figure 12*** displays the compare economics of the analyzed systems.

5.1.2 Case Study

Case 1: Solar/Generator/Battery Hybrid System

The 800 kW PV module, the 250 kW diesel generators, the 2,500 battery packs with a nominal capacity of 6,267 kWh, and the 445 kW inverters make up the hybrid system in this scenario. This system has a COE of $0.109/kWh ***Figure 11*** The system's running cost is $95,388, and the total NPC is $4.52M. The system will cost $1.11 million in capital and $59,931 in fuel per year. Due to the greater cost of PV modules, the system has a comparable COE but a larger initial capital cost than the other scenarios. It is clear from that the CO2 emission is 195,408 kg/yr, which is rather low in comparison to the other situations. This is due to the increased usage of renewable energy, which accounts for 100% of all energy delivered.

Case 2: Solar/Wind/Generator/Battery Hybrid System

The system's components consist of 2,494 battery units with a nominal capacity of 6,252 kWh, 1 wind turbine, 250 kW diesel generators, 800 kW photovoltaic modules, and 438 kW inverters. This system's COE $0.110/kWh is marginally higher than Case A's $0.109/kWh. Additionally, compared to the prior arrangement, the NPC is higher $4.56M. With a renewable component of 76.2%, this hybrid system emits CO2 196,068 kg/yr, which has a lower environmental impact than the Case A system, which had a capital cost of $1.11 million. Although the system has a marginally higher penetration of renewable energy and lowers pollutants emissions, the configuration is not

as favorable as Case A due to the higher capital cost and lower share of wind energy. The total power generation from a wind turbine, however, only contributes 39.6 kWh/yr of total energy produced, while the energy generation from PV is $1,216,839 kWh/yr.

Case 3: Wind//Generator/Battery Hybrid System

The 250 kW generators powered by diesel with 1,614 batteries and the 619-kW converter make up the diesel-only system. This system has the second-highest COE of all the systems, at $0.253/kWh. The battery/diesel system is more expensive than other systems due to its higher operational cost of $279,339/year, replacement cost of $30,858.88, and fuel cost of $257,212/year, even though its original capital cost of $529,548 is cheaper. Since the community's peak load is more than the diesel-only system's capacity, converters and batteries are utilized to store electricity in order to supply additional load during peak hour.

Case 4: Generator/Battery Hybrid System

There are 1618 battery units with a nominal capacity of 4,056 kWh, one 1 kW wind turbine, six 19 kW inverters, and two 250 kW diesel generators. Compared to Case A $0.109/kWh, the COE of this system is greater at $0.254/kWh. Additionally, the NPC $10.6M is more than it was in the prior setup. The capital cost of this system is $536,259. However, this hybrid system emits more CO2 838,620 kg/yr. than other systems, which has a greater environmental impact. The total electricity generated by a wind turbine, however, only makes up 39.6 kWh of the 1,204,408 kWh of energy generated annually by the generator. The system emits more pollutants and has a somewhat lower penetration of renewable energy, while the fraction of wind energy is smaller.

Export...

Optimization Results

Left Double Click on a particular system to see its detailed Simulation Results.

Architecture											Cost			
						TrinAIIM+ (kW)	G1	CAT-250 (kW)	PowerSafe SBS XC 190F	Converter (kW)	Dispatch	COE ($)	NPC ($)	Operating cost ($/yr)	Initial capital ($)
						800		250	2,500	445	CC	$0.109	$4.52M	$95,388	$1.11M
						800	1	250	2,494	438	CC	$0.110	$4.56M	$96,619	$1.11M
								250	1,614	619	CC	$0.253	$10.5M	$279,339	$529,548
							1	250	1,618	619	CC	$0.254	$10.6M	$280,485	$536,259

Figure 13. Optimal Result's

The study ***Figure 13*** examines four different hybrid energy systems, focusing on cost, environmental impact, and integration of renewable energy sources. The first case, a hybrid system with 800 kW photovoltaic modules, 250 kW diesel generators, and 2,500 battery packs, has higher running costs but lower CO2 emissions. It provides a comparable Cost of Energy (COE) to Case 2, which has a higher COE but better environmental benefits. The second case, a generator/battery hybrid, shows lower penetration of renewable energy sources and higher CO2 emissions, indicating less beneficial environmental results. The analysis provides valuable insights for future energy planning initiatives, highlighting the complex interactions between cost, environmental impact, and renewable energy integration in hybrid energy systems.

CHAPTER 6

RECOMENDATION

To ensure the effective implementation of hybrid microgrid systems, the Bangladeshi government needs to give them top priority and provide subsidies. Government initiatives should stimulate local technological development, attract private sector investment in renewable energy projects, and foster innovation via teamwork and research. In order to improve the capabilities of the local labor force, the government should also prioritize capacity building and technological advancement in the production of electricity from renewable sources. Public awareness campaigns and the thoughtful location of wind and solar facilities can boost the uptake of renewable energy by consumers. With careful planning for the use of solar and wind power in the right places, incentives should be in place to support the growth in the generation of alternative energy. Involving local people in renewable energy projects promotes support and ownership. To promote private sector participation, governments should pass legislation and provide incentives like tax breaks, subsidies, and regulatory frameworks.

- The utilization of energy resources in Bangladesh demands careful consideration from the government. Government priority and subsidy play a pivotal role in implementing hybrid microgrid systems, as highlighted by Ahmed et al. and Hossain et al., making it the single greatest factor in shaping their successful deployment.
- Government policies should encourage private sector investment in renewable energy projects, promoting local technology development for sustainability and self-reliance. Investments in research and collaboration with academia and industry can drive innovation. The government should prioritize capacity building and technological advancement in renewable energy electricity generation, enhancing local workforce skills. Strategic placement of wind and solar facilities and widespread.
- For more consumer adoption of renewable energy and increase understanding of its advantages, public awareness and education initiatives should be launched. This entails advocating for energy-saving practices and advancing the use of renewable energy sources in both commercial and residential settings.
- To meet energy demands, wind and solar energy utilization should be deliberately built in appropriate regions. Policies and activities aimed at providing incentives should facilitate the increase in the share of alternative energy in the production of electricity.
- Engaging communities in renewable energy initiatives fosters ownership and support, addressing their needs and concerns. This can be achieved through outreach programs, consultation processes, and decision-making. Community involvement also helps identify local resources and opportunities for sustainable outcomes.
- Renewable energy initiatives can benefit greatly from cooperation with foreign organizations and partners, which can offer resources and essential help. To speed up the switch to renewable energy, this entails obtaining financial opportunities, exchanging best practices, and utilizing the knowledge of international partners.
- Renewable energy sources like solar and wind power significantly reduce fuel consumption, offering a sustainable solution and mitigating environmental impacts. This transition minimizes reliance on finite fossil fuels and reduces greenhouse gas emissions, promoting a cleaner, more sustainable energy future.

CHAPTER 7

LIMITATION AND FEATURE SCOPE

Dependency on the availability of sun and wind as a result these systems mainly depend on solar and wind energy, their output is highly weather-dependent, which can cause irregularities in energy production and even shortages during times when renewable energy resources are scarce.

Presented Capacity for Energy Storage These systems' battery storage capacity might not be enough to meet energy demands during protracted low-renewable resource input times, which would increase fuel consumption and the need for backup generators. Intricacy and upkeep System complexity increases with the integration of renewable energy sources, generators, and batteries, necessitating specialist knowledge. Greater outlay at first Implementation is hampered financially by the upfront expenditures associated with incorporating solar panels and wind turbines, especially in locations with limited resources. Impact on the Environment Off-grid energy systems are designed to lessen carbon emissions and harm to the environment, but in certain designs, their reliance on fossil fuel-powered backup generators might raise greenhouse gas emissions and exacerbate climate change.

One of the cutting-edge developments in energy that will help ensure the security of electricity in the future is hybrid microgrid power generation. Our optimum outcome has extra energy of 17%. We can sell electricity to the National Grid when we do not need as much of it. As opposed to using a diesel engine, we can use low pressure biogas. Alternatively, we may construct a biogas plant and produce biogas there to generate our utilities. By means of detailed surveying and analysis, it is possible to strategically deploy wind turbines in order to attain feasible results. In a similar vein, using hydrogen fuel cells has the potential for achieving successful outcomes. The solar panel will produce more energy than a comparable traditional solar if the swing type is utilized, which moves the panel in the direction of the sun. Off-grid energy systems rely heavily on solar and wind energy, making their output weather-dependent. This can cause irregularities in energy production and shortages during periods of limited renewable resource availability. Battery storage capacity may not always meet energy demands, leading to increased fuel consumption and reliance on backup generators. Integrating renewable energy sources adds complexity and requires specialized knowledge for installation, operation, and maintenance. Implementing these systems can be challenging in regions with limited resources. Relying on fossil fuel-powered backup generators may contribute to climate change.

CHATER 8

CONCLUSION

One of the leading-edge renewable energy technologies that will help ensure the security of electricity in the future is hybrid microgrid power generation. The research being conducted uses a range of models of hybrid energy systems with a range of components, such as solar, wind, generator, and battery systems, to determine which hybrid energy system is optimal for the selected site. In this study, we are providing a simulation-based analysis by Homer cycle charging for the Dhaka South City Corporation (DSCC). The significant parameters obtained from this investigation includes the followings.

- The net present cost (NPC) is $45,16,963, the levelized cost per kWh is $0.1086 and the yearly operating cost is $95,387.58. Furthermore, an 87% capacity factor for the system is predicted.
- The best hybrid power system (PV/Wind/generator with batteries) is shown to have the lowest operating cost among the four models evaluated in this study. The efficiency of solar photovoltaic systems declines with temperature, underscoring the necessity of effective temperature control and heat management methods to improve energy production and performance.
- The proposed methodology is environmentally friendly & has potential to satisfy the load requirement. This hybrid energy system reduces the emission of CO2 significantly which reduces global warming which is a matter of headache all over the world. Fuel consumption is substantially decreased by renewable energy sources, such as solar and wind power, providing a sustainable alternative and reducing environmental effects. This shift promotes a cleaner, more sustainable energy future by lowering greenhouse gas emissions and minimizing reliance on finite fossil resources.

Similar studies of hybrid system can be undertaken for other large building that require lot of electricity to mitigate electricity problem on summer and also to find alternative clean energy.

8.1 Declaration of Competing Interest

The authors declare that none of the work reported in this study could have been influenced by any known competing financial interests or personal relationships.

8.2 Funding

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