Design and Optimization of Micro-Grid Hybrid Power System at Kutubdia in Bangladesh

A Project and Thesis submitted in partial fulfillment of the requirements for the Award of Degree of Bachelor of Science in Electrical and Electronic Engineering (EEE)

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June 2021

Certification

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ACKNOWLEDGEMENT

First and foremost, we would want to offer our heartfelt gratitude to Almighty Allah for his glorious grace, which has enabled us to successfully complete this study. We are grateful to Supervisor and want to express our deep gratitude **Dr. Md. Alam Hossain Mondal**, **Associate Professor**, Department of EEE Daffodil International University. Our supervisor's extensive experience and strong interest in the area of electrical power influenced us to complete this study. His unending persistence, scholarly instruction, consistent motivation, relentless and energetic supervision, constructive critique, and insightful advice at all stages enabled me to finish this study. This project cannot be completed without his valuable guidance and assistance. Again, thank you for giving us the chance to choose this projects for analysis.

We would also like to thank, **Prof. Dr. Md. Shahid Ullah, Professor and Head of the Department of EEE**, for his assistance, guidance, and continuous motivation.

We would like to extend our deep gratitude to the other faculty members and personnel in the EEE department of Daffodil International University.

We would like to convey our deep love and gratitude to our cherished family for their unfailing leadership, inspiration, and drive throughout our studies at this University.

ABSTRACT

Electricity is needed at all times for a country's long-term growth. The power shortage is a significant impediment to Bangladesh's economic growth. At the moment, the majority of electricity supply in the world is based on fossil-fuels, which are not environmentally sustainable and emit greenhouse gases that contribute to global warming. In Bangladesh, the amount of fossil-fuel reserved is insufficient. The abundance of renewable energy sources, such as, Solar energy, Wind energy, Battery, Diesel Generator and power Converter offers renewable options for renewable energy-based microgrid hybrid energy systems in Bangladesh's coastal regions. Renewable power generation systems combined with diesel engines can provide a reliable and integrated supply of energy in isolated or remote areas where grid access is difficult to achieve. This study presents a cost-effective micro-grid power system modeling of a Wind-Solar-Battery-Diesel Generators microgrid hybrid power system in a coastal region of Kutubdia, which is an Upazila in Cox's Bazar District in Bangladesh. The primary aim of this proposed integrated design is to meet the maximum load demand utilizing renewable energy sources at the lowest possible Cost of Energy (COE). Global warming is a serious issue in today's world. As a result, we see a decrease in both fossil-fuel consumption and carbon-dioxide emissions. This hybrid model was made with the help of a software program called Hybrid Optimization of Multiple Energy Resources (HOMER) PRO. In this scenario, HOMER determines the most cost-effective configurations from a collection of systems with an energy requirement of 812.23 kWh/day primary load and a peak load of 104 kW. The Cost of Energy (COE) is BDT 8.43/kWh.

Table of Contents **Page No.**

Chapter 3: The Condition of the power Sector in Bangladesh

Chapter 4: Analysis and Simulation

Chapter 5: Hybrid Power System Components Details

Chapter 6: Optimization and Simulation Result

Chapter 7: Conclusion

List of Figure

List of Tables

List of Abbreviation

DG	Diesel Generator
PV	Photovoltaic
WT	Wind Turbine
COE	Cost of Energy
NPC	Net Present Cost
UNFCC	United Nations Framework Convention on Climate Change
CDM	Clean Development Mechanism
SREDA	Sustainable & Renewable Energy Development Authority
JICA	Japan International Cooperation Agency
SHSs	Scale of solar home systems
TNPC	Total net present cost

CHAPTER 1
INTRODUCTION

1.1 Background of study

Bangladesh is a densely populated nation with a large population. This country is home to approximately 166 million people [1]. In 2015, 92% of the urban population and 67% of the rural population had access to electricity. In Bangladesh, an estimated 77.9 percent of the population had access to electricity [2]. Bangladesh would need an unprecedented 34000 MW of power by 2030 in order to support its economic growth of more than 7% [3]. As of September 2019 [4], Bangladesh's utility electricity market had one national grid with a total installed capacity of 21419 MW. Bangladesh's power system is heavily reliant on fossil fuels, as natural gas and coal are the country's primary sources of power production. Natural gas accounts for approximately 62.9 percent of electricity produced in Bangladesh, with diesel accounting for 10%, coal accounting for 5%, heavy oil accounts for 3%, and renewable energy accounting for 3.3% [5]. Since the electricity sources complement each other, a micro-grid hybrid power system combining green energy technologies increases load factors thereby lowering maintenance and repair costs. To construct a suitable micro-grid hybrid electric plant, the right type of property must be assessed. Solar, wind, diesel engine, and battery micro-grid hybrid power system cut costs and GHG emissions. As a result, this micro-grid hybrid system power generation station must be environmentally friendly. Kutubdia has an area of 36 square miles (93 km^2), 18 miles (29 km) in length and 2 miles (3.2 km) in breadth. The beach has an unobstructed view of both the sunrise and sunset over the Bay of Bengal. Kutubdia, had 58,463 households and a population of 125,000 people according to the 2011 Bangladesh census [6]. The current generation of power plants is inadequate to safety demand. This paper addresses various device components for micro-grid hybrid energy systems and develops a proposal for an off- grid solar, wind, diesel generator, and battery micro grid hybrid power system for Kutubdia, Bangladesh. A microgrid hybrid system is a more common way to use green energy. There are now many micro-grid systems in Bangladesh.

1.2 Introduction of Micro-grid Hybrid System

1.2.1 What is micro grid?

A microgrid is a small-scale of power grid that can function independently or in collaboration with other small power grids. The use of micro-grids is referred to as clustered, scattered, decentralized, city, or embedded energy generation. A micro-grid is any small-scale, decentralized power station with its own generation and storage capacity and definable boundaries. If the micro-grid can be connected to the city's main power grid, it is referred to as a hybrid micro-grid. Micro-grids are often powered by generators or renewable wind and solar energy sources, and they are often used as backup power or to supplement the main power grid at high demand hours. A micro-grid strategy that integrates local wind or solar power will provide redundancy for essential utilities while also reducing the vulnerability of the main grid to regional disasters.

1.2.2 What is a micro hybrid grid?

Microgrids are constructed from a single source. Solar panels are typically used to power a micro-grid. When two or more renewable energy sources are combined, a hybrid micro-grid system is formed. This is the most cost-effective method of electrifying rural areas with renewable energy sources. Infrastructure for micro-grids solar PV and hydro, solar PV and wind turbine, Solar PV and biomass and hydro, Solar PV and biomass and wind, solar PV and wind, and diesel generator as backup sources are all examples of hybrid microgrid systems.

1.3 Micro-grid hybrid Remote “off-grid” System

These micro-grids are never attached to the macro-grid and remain in island mode all of the time. Out-of-the-way region power grids with Alaska or on islands that typically have diesel or wind energy like Nome, Alaska-that can be interconnected and supply power to the local geography are examples of this kind of micro-grid. BC hydro is hard at work on a project in Bella Coola, British Columbia, where an off-grid microgrid is being built to reduce diesels fuel consumption by adding Solar photovoltaic (PV), distributed Wind, and run of the river hydropower. According to pike exploration, this group has the highest number of current installations off-grid, however, area power systems have a more affordable overall capability.

1.4 Statement of Problem

The most important feature of a microgrid hybrid system is to keep costs down. Using only micro grids, it can be difficult to serve or meet any of the demand for any rural energy needs. Perhaps the weather conditions aren't suitable for a single source off-grid operation. It may be difficult to charge the battery when the irradiation is insufficient, particularly on a rainy day or at night. As a consequence, a more effective method of solving the problem is needed. Solve the problem of a hybrid micro off-grid system is the best solution. The hybrid system consists of a solar, wind turbine, and diesel generator serves as backup systems and battery for storing energy. There are a number of other topics that must be discussed. The expense is the most serious concern. As a result, we've included a cost estimate of the hybrid micro off-grid infrastructure in our thesis report. In every renewable energy source, the most important factor is cost. Different system components for micro-grid hybrid energy systems are explored in this article, as well as a concept of an off-grid solar, wind, generator micro hybrid power system for Kutubdia, Bangladesh. A cost-benefit review of the new design could also be performed.

1.5 Objectives

The below are the objectives of this project and thesis:

i. To know about the present renewable condition for Bangladesh.

ii. To know about the HOMER.

iii. To design an effective hybrid micro off-grid system.

iv. To calculate or optimize the cost from the system.

v. To quantify a number of Carbon Dioxied gas emissions from different systems of the model.

vi. To analyze the economic and environmental feasibility of the proposed model

in different modes of operation.

1.6 Outline of the Study

The aim of our research is to reduce the expense of hybrid micro-off-grid systems. The construction of a proper hybrid micro off-grid system would also be a part of this study. Cost optimization is, in essence, the method of lowering costs. This is the most important part of any enterprise. All is predicated on it. The success of a project is often determined by its expense.

As a result, our research includes a complete hybrid system model created with HOMER software, as well as a cost analysis for this system.

Chapter 1 introduces the background of the microgrid hybrid power generation process, issue statement, and thesis objectives.

In chapter 2, describe Literature Reviews, Research Methodology and Micro-Grid of Hybrid power system.

In chapter 3 includes the Situation of the Bangladesh power sector and basic theory about solar energy and wind energy technology and the availability of renewable energy sources in Bangladesh.

In chapter 4 includes Analysis and Simulation

Chapter 5 Information of Hybrid Power system Components.

Chapter 6 Optimization result of proposed microgrid hybrid power system.

Chapter 7 Discussion and Conclusion.

CHAPTER 2
LITERATURE REVIEWS

2.1 Introduction

This paper looked at the creation of an off-grid micro-grid hybrid power system. A grid-connected hybrid includes solar PV and wind turbine system is more reliable and cost-effective than a conventional hybrid system. Oil is highly dependent on every portion of the globe, with fossil fuels and nuclear plants responsible for about 73.77 percent [7] of total energy, adding to global warming. The weight of the load is the same. As a result, the proposed model has a lower current cost than the off-grid model. Since the off-grid model necessitates a massive battery bank [8]. It is no longer possible to rely entirely on diesel to generate electricity. In this respect, a hybrid energy system (Solar PV, wind turbine, generator, and battery) can be a feasible and integrated solution [9]. Again, the velocity is heavily influenced by the site’s position. The findings of the ABC algorithm were similar to those of the HOMER software tool. In comparison to HOMER [10], the proposed algorithm-generated better results. If energy demands rise, so does the dependence on green energy sources. It would also relieve strain on the national power grid. Reduces gas emissions while maintaining a fair Cost of Energy (COE) [11]. The concept of a hybrid solar power system is focused on various forms of economic research, such as Net Present Cost (NPC) and Cost of Energy (COE), as well as calculating the greenhouse gas emission rate [12]. In terms of technological configuration and market analysis, a hybrid micro-grid solution for a remote non-electrified village is needed. Renewable electricity sources include solar panels, wind turbines and diesel generators. This essay identifies the right off-grid approach and compares it to conventional grid extension. At an off-grid location, a blended green energy mix can be cost- effective, long-term, technologically feasible, and environmentally sound [13]. Various optimization methods are used in PV-wind hybrid energy systems. Single optimization approaches are considered to be inferior to hybrid optimization strategies [14]. The majority of people live in rural areas of the country, and their lack of access to grid electricity seriously impedes their growth and the overall success of the country’s economy. In this regard, a hybrid micro-grid based on renewable energy sources may be a viable choice for ensuring universal electricity access. This paper looks at a case study of using a hybrid microgrid to provide electricity to Bangladesh's remote, unconnected regions, as well as the market creation, implementation, and related challenges. Modeling of three alternate power generation configurations using, various combinations of solar energy, wind energy, diesel generator, and battery storage tools is part of the analysis. The study revealed the optimal off-grid supply configuration's per-unit cost of energy is far higher than the controlled tariff for grid-connected residential customers, and that grid parity cannot be achieved even with the maximum capital subsidy [15]. For the first time, a hybrid micro-grid with combined Solar PV, Wind, Biomass and battery storage has been designed and applied functionally in this article. HOMER simulation [16] was used to determine the potential of various renewable sources for meeting daily energy demand, as well as their techno-commercial optimization. In Bangladesh, wind energy has a lot of promise and can be used in a number of ways. This energy supply would be the most cost-effective sources of electrical power in near future. Bangladesh is looking for alternative source of renewable energy to better satisfy the country's total electricity demand. In the Bay of Bengal, Bangladesh has a 574-kilometer coastline and several small islands, with a heavy south-westerly tread wind sea breeze in the summer and a mild north-easterly tread wind and land breeze in the winter [17].

2.2 Research Methodology

A micro-grid hybrid framework is suggested in this study for Kutubdia, Bangladesh. This proposed design can be implemented in Bangladesh's remote regions. Many energy supplies are studied to see which ones are the most effective. It is important to gather some key information, such as average daily load demand, available types of green energy for this area, monthly average solar radiation and clearness index from NASA surface meteorology, solar energy database, and average wind flow from Bangladesh's meteorological department. Following that, the best available energy options were used to build this micro-grid hybrid energy infrastructure. We used HOMER pro tools to create this pattern. HOMER model is used to measuring the energy balance for each unit configuration that can be considered. It is also possible to find out various kinds of costs using the program, such as Cost of Energy, Net Present Cost, Gross Annualized Cost, annual actual interest rate, capital recovery factor, replacement cost, service, repairs, gasoline, likely lowest cost, and greenhouse gas emission in tons/year. Based on the equation, the best mixture is determined in order to obtain the lowest cost. This software was also used to determine the viability of the device. The cost of and vital piece of equipment, as well as the availability of each piece of equipment, is all included in the design of this micro-grid hybrid scheme. The sensitivity for the planned hybrid system is also completed here. We first construct the model with HOMER tools, then simulate it to locate and measure the data and determine the model's viability. The HOMER platform is used for all architecture, estimation, simulation, optimization, and data collection.

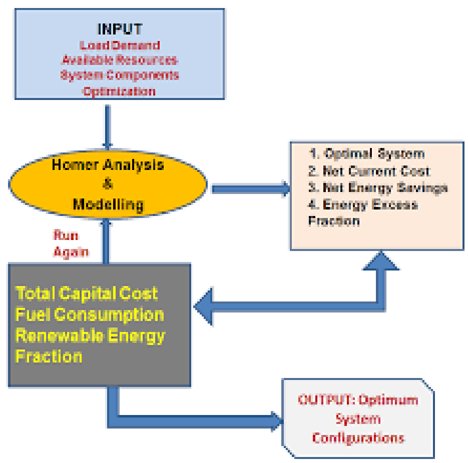


Figure 2.1: Optimization process of HOMER Software

2.3 Hybrid power infrastructure micro-grid

Micro-grid are electricity distribution networks designed to meet a power consumer's power and stability requirements. Micro-grid hybrid power is generated by integrating different technologies to produce electricity. Micro-grids are operated by a range of power generation forms and often mix organize and monitor renewable energy sources, based on particular targets and the availability of local resources [18]. It contributes a variety of energy sources, including Solar, Wind, a Diesel Generator, and a backup and Converter Battery pack. Alternatives to higher power prices include Solar PV, Wind, Diesel Generators, Batteries, and power Converter systems.

2.4 Summary

Bangladesh is a vast nation with a dense population. Our country's population is growing every day. The need for electricity, on the other hand, is rising every day. The amount of energy produce alone is insufficient for delivery. To production electricity, this needed to perform a quest for renewable energy sources. Hybrid power systems combine traditional and non-traditional energy sources. Where electricity transmission and delivery from a large centralized energy source is too remote and expensive to implement, micro-grid are better served by local energy sources. A micro-grid can effectively incorporate different sources of distributed generation, especially renewable energy sources, as a controllable entity. The technology we suggest is an off-grid model. An off-grid hybrid power system is intended for remote areas where grid connectivity is not possible. The number of renewable energy-based power plants in Bangladesh is steadily increasing. In the Bay of Bengal, Bangladesh has a 574-kilometer coastline and several small islands. We can get a lot of wind and solar energy in this place. Our research is primarily focused on developing an off-grid hybrid solution for remote areas. Our work is primarily focused on a small village in Cox's Bazar District called Kutubdia.

CHAPTER 3

THE CONDITION OF THE POWER SECTOR IN BANGLADESH

3.1 Condition of Bangladesh power sector

Bangladesh was listed as a developing country both economically and socially in March of 2018. Bangladesh has fulfilled all three requirements to be listed as a developing country. Bangladesh is the world's most densely populated region, with 166 million people residing on a landmass of 148,460 square kilometers. If the world's population increases, so do the demand for electricity. Bangladesh's utility power sector had one national grid with a gross installed capacity of 21,419 MW as of September 2019. The gross installed capacity is 20,000 MW-(combining solar power). Bangladesh's energy industry is thieving. Bangladesh recently began work on the 2.4 gigawatts (GW) Rooppur Nuclear Power Plant, which is scheduled to being operations in 2023. In July 2018, the Bangladesh Power Development Board stated that 90% of the country's population had access to electricity. Bangladesh, on the other hand, has a low per capita electricity intake. Electricity is the primary source of energy for the majority of the country's economic activities. As of January 2017, Bangladesh's total installed electricity generation capacity was 15,351 MW with a goal of 20,000 MW in 2018, and it is successful. Industries and the residential sector use the most electricity in Bangladesh, followed by the commercial and agricultural sectors. Electricity was available to 92 percent of the urban population and 67 percent of the rural population in 2015. In Bangladesh, an average of 77.9% of the population had access to electricity. By 2030, Bangladesh will need a projected 34,000 MW of power to maintain its economic growth of over 7% [19]. High grid losses, delays in the construction of new plants, poor plant productivity, intermittent power supply, energy theft, blackouts, and a lack of funds for power plant maintenance are all issues in Bangladesh's electric power market. Over the last decade, the country's generation plants have been unable to satisfy machine demand.

3.2 Present Structure of Power Sector

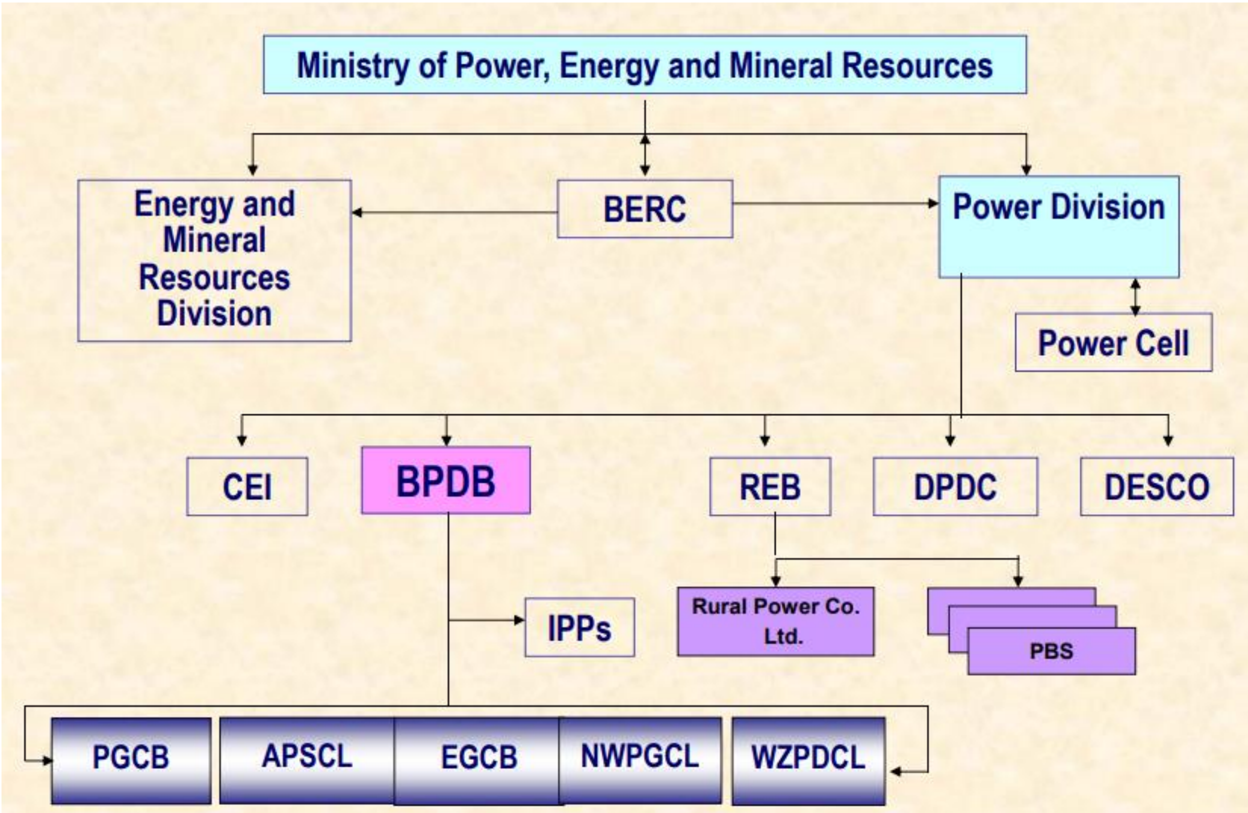


Figure 3.1: Present Structure of Power Sector

□ Apex Institution

Power Division, Ministry of Power, Energy & Mineral Resources (MPEMR)

□ Regulator

Bangladesh Energy Regulatory Commission (BERC)

□ Generation

- □ Bangladesh Power Development Board (BPDB)
- □ Ashuganj Power Station Company Ltd. (APSCL)
- □ Electricity Generation Company of Bangladesh (EGCB)
- □ North West Power Generation Company Ltd. (NWPGCL).

- Independent Power Producers (IPPs).

- **Transmission**
  - Power Grid Company of Bangladesh Ltd (PGCB).
- **Distribution**
  - Bangladesh Power Development Board (BPDB).
  - Dhaka Power Distribution Company (DPDC).
  - Dhaka Electric Supply Company Ltd (DESCO).
  - West Zone Power Distribution Company (WZPDC).
  - Rural Electrification Board (REB) through Rural Co-operatives.

3.3 Renewable Energy Prospects in Bangladesh

In the last few years, there has been notable success in the clean energy market. Currently, 404 MW is produced from renewable energy sources. Solar home systems are a success story in Bangladesh, and their popularity is growing in rural areas, especially in off-grid areas.

The Table below shows the progression complied so far in the renewable energy sector in Bangladesh [20].

Table 3.1

Progression complied so far in the renewable energy sector in Bangladesh.

Methods	MW
Installation of Solar Home System (3.5 million)	150.00
Installation of Rooftop Photovoltaic (PV) at Government/Semi-Government offices	3.00
Installation of PVs on commercial buildings and shopping centers	1.00
Installation of PVs by consumer during new electricity connections	11.00
Installation of Wind-based power plants	2.00
Installation of Biomass-based power plants	1.00
Installation of Biogas- based power plants	5.00
Solar Irrigation	1.00
Hydro Electric power generation	230.00
Total	404.00

3.4 Renewable Energy Sources in Bangladesh

The future of renewable energy in Bangladesh looks bright, especially in the case of solar energy. However, renewable energy will remain annexed to the current energy genesis through non-renewable traditional means for the foreseeable future. Nonetheless, solar technology can play an important role in saving customers who live outside of the national grid or where grid access is delayed. Major sources of renewable energy in Bangladesh are as follows:

3.4.1 Solar

Bangladesh is a country in South Asia that is situated between latitude 20°34' and 26°39' North and longitudes 80°00' and 90°41' East. As a result, it is an excellent area for using solar energy. Furthermore, since it is a subtropical region, sunlight is abundant for 70% of the year [21]. As a result, solar panels are very useful in Bangladesh. The average daily solar radiation is 4-6.5 KWh/m2, with the highest levels in March-April and the lowest in December-January. As a result, solar energy could be a feasible response to Bangladesh’s power crisis [22]. Solar energy also has certain important characteristics, such as producing no waste or emission, having no negative environmental impacts, and being well-suited for distributed power applications [23]. Recently, the government has taken a several of measures to resolve this problem. Around the same time, several non-governmental organizations are trying to provide customers with solar panels, which are already very cheap.

3.4.2 Wind Energy

Wind power is the transfer of wind energy by wind turbines into a functional medium, such as electrical or mechanical energy. The strength is equal to the wind velocity. The Wind is used to generate electricity by harnessing the kinetic energy generated by moving air. Wind turbine or wind energy conversion devices are used to convert this into electrical energy. Wind first strikes a turbine’s blades, allowing them to spin and then turning the turbine to which they are attached. Bangladesh has two wind turbines power generation sectors. Wind power of 1.9 MW in Kutubdia and Feni. Annual energy outputs for Kutubdia and Kuakata are projected to be 133 MWh and 160 MWh for a 150 KW wind turbine, respectively, while outputs from a 250 KW station at these locations are approximately 200 MWh and 230 MWh [24].

3.4.3 Biomass Energy

The Energy created or provided by living or once-living organisms is referred to are, biomass energy. Plants, such as corn and soy, are the most popular biomass materials used for energy. This species energy may be burned to generate heat or transformed into electricity [25]. Biomass can be used as an energy source directly by burning it to produce heat or indirectly by converting it into various forms of biofuel. Biomass conversion to biofuel can be performed in a number of ways, which are broadly classified as arctic, nuclear, biological, and biochemical processes. Today, the most common biomass energy source is forest debris such as dead trees, leaves, and tree stumps as well as property clipping, wood chips, and in some cases municipal solid waste. Biomass is described as plant or animal matter that can be converted into fabrics or other synthetic chemicals, as well as biofuels.

3.4.4 Biogas Energy

Biogas is a gas mixture that is formed by the biological breakdown of organic matter in the absence of oxygen. Organic wastes include dead plants and animals, furthermore, animal waste and kitchen waste can be converted into biogas, a gaseous fuel.

3.5 Energy Sector

For the majority of the country's economic operations, electricity is the primary source of energy. Bangladesh's overall installed electricity generation capacity (include capacitive power) was 15,351 MW in January 2017, increasing to 20,000 MW in 2018 [26]. Bangladesh's power sector has enormous potential in terms of producing electricity. 95% of the people have access to this industry. The private sector producing a significant amount of electricity using a combination of conventional and non-conventional sources.

3.5.1 Natural Gas

Natural gas is a naturally occurring hydrocarbon gas mixture mainly composed of methane, but also containing variable quantities of other higher alkanes and, on occasion, a trace of carbon dioxide, nitrogen, hydrogen sulfide, or helium [27]. Natural gas is the primary energy in the majority of Bangladesh's new power plants. Gas-fired power stations currently account for 88%

of total electricity generation. Aside from petroleum, other fuels such as furnace oil and coal are used to produce a small amount of electricity.

3.5.2 Coal

Coal is a flammable black or brownish-black sedimentary rock that is found in the form of coal seams. Coal is mostly made up of carbon, with varying concentrations of other elements such as hydrogen, sulfur, oxygen, and nitrogen. Natural gas is the most common fuel to generate electricity. It would, though, wear out day by day. So take a different path. Future green energy alternatives such as solar, wind, tidal, and others are included, but deployment is slow. Matarbari, Cox’s Bazar, and Chittagong both have coal-fired power plants. It is a proposed coal-fired power plant with a capacity of 1200 MW. Rampal power plant now proposing a coal-fired power station. It has a capacity of 1320 MW [28].

3.5.3 Oil

Oil is the second phase in the energy production process. Bangladesh has a limited oil reserve. Bangladesh has found oil in two old gas fields in the country’s northeastern district, with 5.5 billion USD recoverable reserve, according to the chairman of state-owned Petrobangla [29].

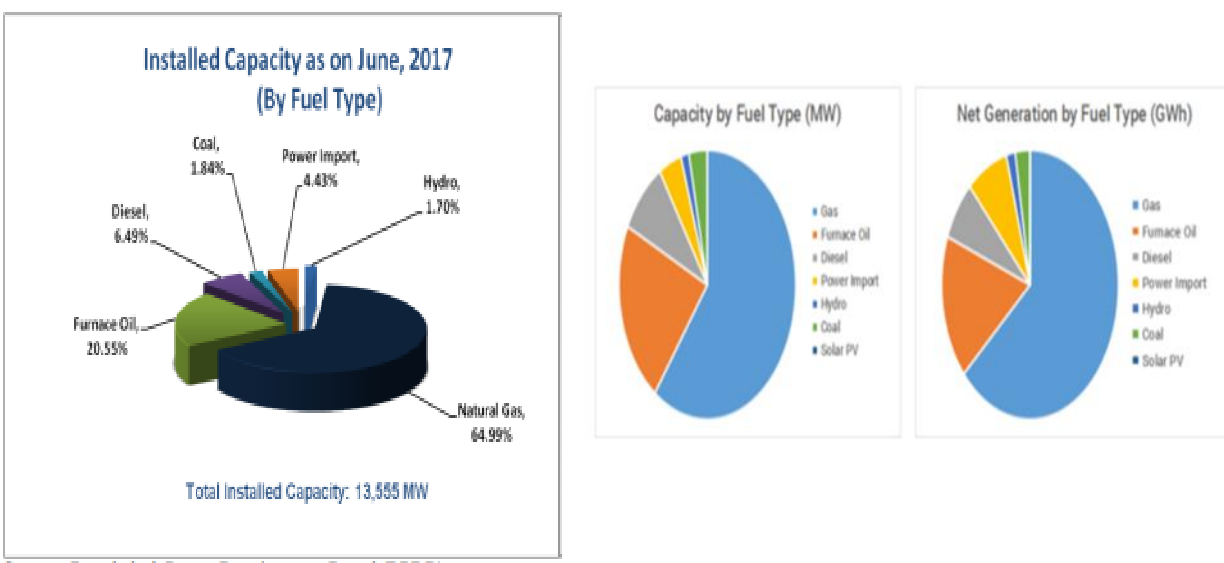


Figure 3.2: Energy generation by Fuel (%)

3.6 Bangladesh's Power Sector Master Plan

The growing disparity between the country's total electricity generation capability and demand has compelled the government to update the power system master plan, or PSMP, two years after its implementation. According to a senior power division official at the Ministry of power, energy, and Mineral resources, or MPEMR, work has begun on developing a revised master plan for 2021. The previous proposal was started in 2016, but it was implemented after it was completed in 2018. Over the current season, the country's power demand is less than half of its overall generating capacity of about 9,600 megawatts or MWs during day peak hours and about 59% at about 12,229 MWs out of a total generation capacity of 20,383 MWs, according to BPDB statistics as of September 12 [30]. The government is drafting the Power System Master Plan (PSMP)-2016 with the year 2041 in mind when power demands are expected to rise to more than 57,000 MW. According to the initiative, gas and coal would account for around 35% of overall capacity, with the remaining 30% coming from regional electricity, renewable energy, and nuclear power. According to the PSMPs, a large portion of primary energy will be provided by coal and renewable (with estimated coal production of about 38,500 MW by 2030), with less use of gas and petroleum. Since then, the estimated consumption of different energy sources has changed. Natural gas continues to be the most important source of electricity, followed by heavy fuel oil and high-speed diesel. Among emerging markets, Bangladesh has one of the most gas-dependent power sectors. Up to 58% of domestic gas output is set aside for power generation. Because of rising environmental issues, as well as an increase in the price of imported coal to Bangladesh and a delay in building the required infrastructure for import, the government has recently changed its mind about using coal. In the future, the emphasis has changed to using imported natural gas as the primary fuel source for electricity production. Renewable electricity, on the other hand, has continued to play a significant yet developing role [31]. In FY 2019, the total net energy produced and supplied to the national grid in public and private sector power plants was classified by the fuel used in the following graph.

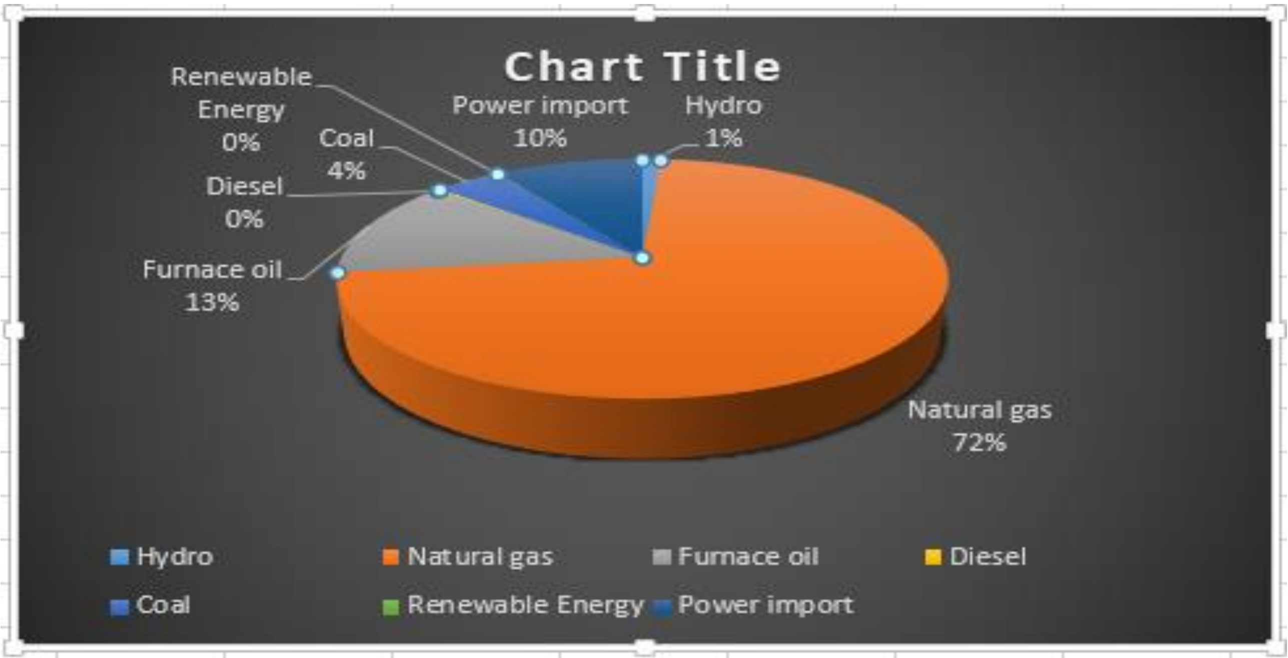


Figure 3.3: total net energy generated and supplied to the national grid in public and private sector power plants was classified by the fuel used

3.7 Summary

Every day, Bangladesh needs a large amount of fossil fuel to produce electricity. Renewable energy is more necessary for power generation because it is less expensive. Bangladesh provides a wide range of fuels including renewable sources of oil. Green energy becomes more dependent as a result of electricity. As a part of the eventual loss of nuclear energy. Several megaprojects are also in the planning stages. Among them are the Ruppur Nuclear Power station, Matarbari Coal Power Plant and Rampal Coal Power Plant. This means that tremendous amount of energy will be produce. Our suggestion is that this projects be finished with a large amount of electricity. Bangladesh is progressing at a rapid pace. In the other hand, the potential of electricity production and installation is growing. Bangladesh has reached a new high power generation milestone, with a power plant producing a record- breaking 13,018 megawatts of electricity.

CHAPTER 4
ANALYSIS AND SIMULATION

4.1 HOMER Software

4.1.1 About HOMER

HOMER Energy LLC, based in Boulder, Colorado, was founded in 2009 to commercialize the HOMER hybrid optimization of multiple energy resource models established by the US department of energy's national renewable energy lab. DOE stands for the department of energy of the United States of America. The primary goal of HOMER energy is to ensure that HOMER continues to thrive, spread, and be sponsored. The HOMER energy concepts include economics as well as physics. Micro-grid optimization has been on the drawing board for more than two decades. The economist and programmer who founded the HOMER program at NREL, as well as seasoned managers, analysis, and industry experts, make up the HOMER energy team. Corporate project experience, clean energy sources, and electric car network toughness. Our shared purpose is to provide tools, services, and data to people all over the world in order in order to accelerate the use of renewable and distributed energy systems as energy sources.

4.1.2 Optimization Process

We create the proposed model, then enter all of our information and determine the venue. Numerous organizational and physical structures on the site that are feasibly designed with respect to economy, reliability, and environmental controls and the focus of numerous organization and physical construction on the site. Typically, the primary aim is to find a micro-grid configuration with a low TNPC (total net present cost). For this, various system structures and operating constraints are simulated. As a consequence, the engineer has a wide range of product component variations from which to select. Finally, the list of configurations is sorted and compared.

4.2 Load Profile

In this thesis, we considered a remote rural Village. When opposed to urban areas, the need for power in a very small rural village is just not as strong. Electricity is needed for domestic purposes such as lighting, refrigerator, fans, and televisions.

During the night, the power demand of the Community unit increases, with only simple electro-mechanical equipment using electricity. During the morning hours, as everyone is leaving for training, service, or food preparation, the load demand decreases. Since nearly half of the family members are outside during the noon hour, the load demand volumes are at their lowest. Again, during the evening hours, when everybody in the family is home, energy demand increases when everybody switches on different Weight appliances. The average energy utilization of electrical appliances of the community unit is presumed (812.23 kWh/day). The Peak Load is 104.00 kW. For this thesis Purpose, we have taken a village of Kutubdia. Here maximum people work all day long. So this region is Electricity Consume a Small Amount. A total of 120 households have been considered in this area. This load is made up of 5(23 W each) energy-efficient lights, 3(75 W each) fans, 1(150 W) refrigerator, 1(40 W) TV, 3(18 W each) mobile charger, and 1(746 W) water pump. Winter season energy consumption is lower than summer season because low use of ceiling fans. In this season people use 1 fan for the emergency purpose for each family. Annual Peak load of 104 kW and Primary load to 812.23 kWh/day.

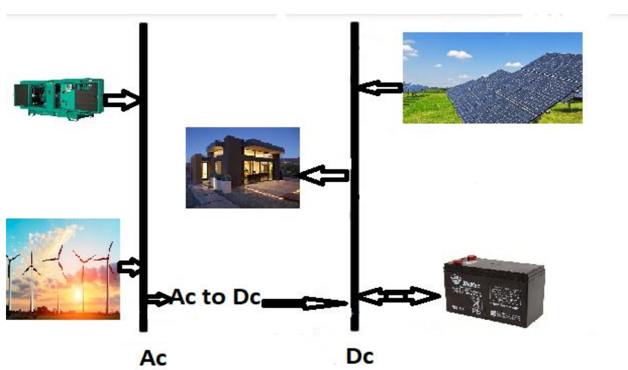


Figure 4.1: Load profile

4.3 Hybrid Energy System

A hybrid energy system is a mixture of various types of energy generating devices, such as electrical energy turbines means wind turbines, electrical energy storage battery facilities, and green energy sources, energy technologies that have become commonplace in today's world. In a hybrid energy system, renewable energy sources are used. This system has the greatest effect on the energy market because it is both grid and off-grid-related. This computer has nothing to do with the grid. In this study solar and wind energy is combined with a diesel engine as renewable energy sources. The term "DC load" refers to a form of energy demand. The maximum output connected to a DC bus is DC, as is the load. A hybrid generation system consists of an electrical load, renewable energy sources, and other system components such as PV, wind turbines, and batteries, diesel generators, and converter. Fig.4.2 shows the hybrid energy system.

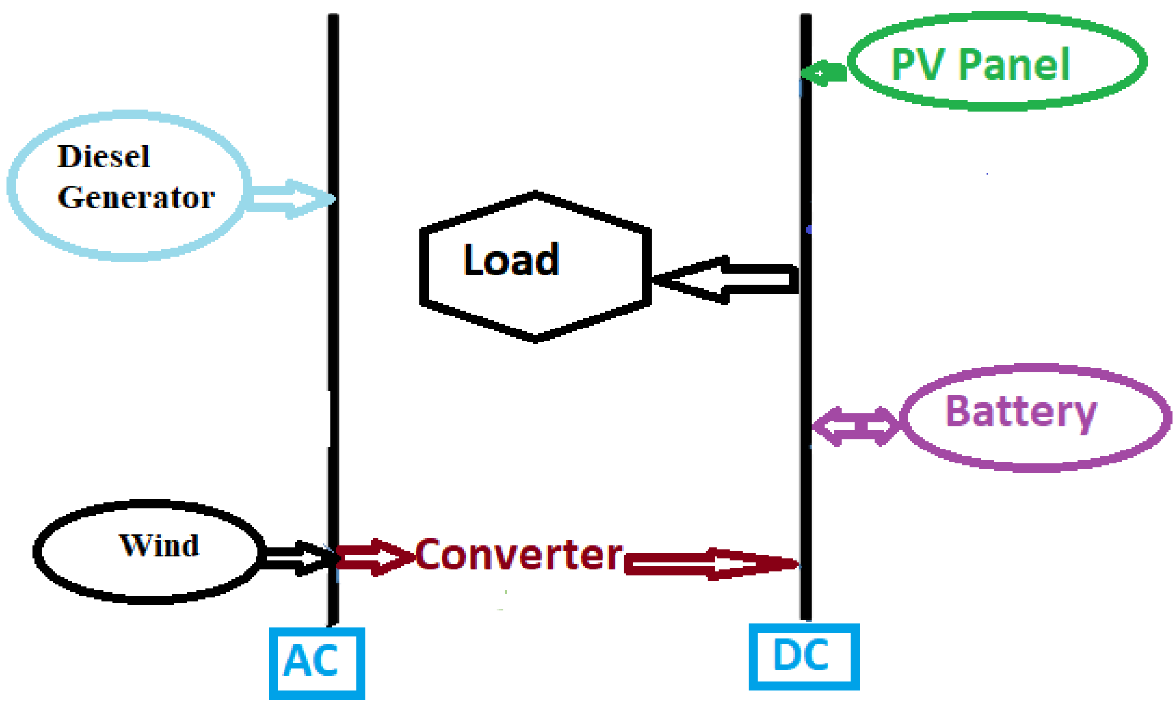


Figure 4.2: Hybrid Energy System

4.4 Economic Input Analysis

A micro-grid infrastructure is an important part of the system's fixed capital, as well as its operation and maintenance costs. This figure is input into the HOMER software. In a micro-grid system, fixed capital costs include land, and associated structures, as well as storage centers and manufacturing costs. And the fixed operating and repair costs of the system are wages. For this micro-grid hybrid power system, a 2-kilometer area is considered. To produce electricity, a micro-grid system is used. This electricity distribution considers an area in 120 households. Electricity distribution included materials are wire, poles, circuit breakers, energy meter, multiple breaker, and labor salary. So, the total system fixed capital cost is $6000, (BDT 508,320) considered in this Location, and systems fixed O&M cost is $250, (BDT 21180) for salary.

4.5 Summary

Traditional and non-traditional energy sources and technologies are combined in a hybrid power systems. Micro-grids and have hybrid power networks. The importance of hybrid systems in the power sector cannot be overstated. That this technology can produce a significant amount of electricity. As a developing country with a sizable electricity industry. Electricity-based industry, vehicles, and megaprojects are all growing in popularity. As a result, the energy demand is changing. Optimize a hybrid power system for cost and environmental analysis using HOMER. It's just about the apps. This is a technological contribution to the energy sector.

CHAPTER 5

HYBRID POWER SYSTEM COMPONENTS DETAILS

5.1 Hybrid Power System Components Details

PV panels, Wind Turbines, Diesel Generators, Batteries, and Converter are all part of the hybrid generation scheme.

5.1.1 PV (Solar Photovoltaic)

The cost of a PV module, including capital, replacement, and operation and maintenance costs, must be entered into the program for simulation and modeling purposes. The construction and replacement costs for a 1 kW solar energy are considered to be BDT 85,829.37, and BDT 80,551.61 respectively. This PV module has a 25-year life expectancy. Here 335 W PV modules are Considered, [32]. 1$ (USD) = 84.79 Taka (BDT) [33].

Table 5.1

Technical and economic parameters of Solar Photovoltaic.

Parameter	Unit	Value
Capital cost	BDT/kW	85,829.37
Replacement cost	BDT/kW	80,551.61
O&M cost	BDT/kW/yr	150
Tracking System	No tracking system	0.05
Life time	Years	25

5.1.2 Wind Turbine

The cost of a wind turbine is determined by the height of the wind. 100 KW price is about $ 48,000 [41]. Wind turbine energy availability is highly dependent on wind variation. In this analysis we considered Northern Power NPS100C-21, 100 kW Wind Turbine with hub height 29m can be used for the hybrid design the wind turbine capital cost considered about $45,000, (BDT 3,812,400), and the replacement cost about $35,000, (BDT 2,965,200). It provide AC voltage as an output Northern Power NPS100C-21 Wind Turbine starting wind speed is 3.5m/s in this study. Rated Wind Speed 15m/s. [34]

Table 5.2

Technical and economic parameters of wind turbine.

Parameter	Unit	Value
Rated Power	kW	100
Starting Wind Speed	m/s	3.5
Rated Wind Speed	m/s	15
Security wind Speed	m/s	59.5
Capital cost	BDT/kW	3,812,400.00
Replacement cost	BDT/kW	2,965,200.00
O&M cost	BDT/kW	27000.00
Life time	Years	20

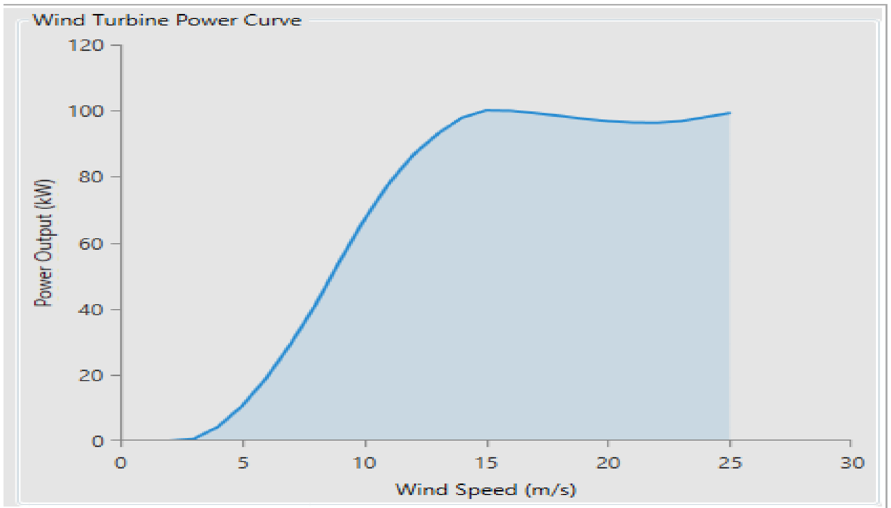


Figure 5.1: Power curve of 100 kW Wind Turbine

5.1.3 Diesel Generators

Diesel generator cost depends on its Size. Here has been 25 kW used in diesel generator. For this system a slope and the intercept are 0.273 L/hr/kW and 0.825 L/hr/kW respectively [35].

Table 5.3

Technical parameters and cost assumptions for diesel generators.

Parameter	Unit	Value
Capital cost	BDT/kW	420,000
Replacement cost	BDT/kW	420,000
Operational Life time	Hours	15,000
Minimum load ratio	Percent	25
Fuel curve intercept	1/h/kW rated	0.825
Fuel curve slope	1/h/kW rated	0.273
Fuel price	BDT	65

Diesel fuel price = BDT 65.0 [36]

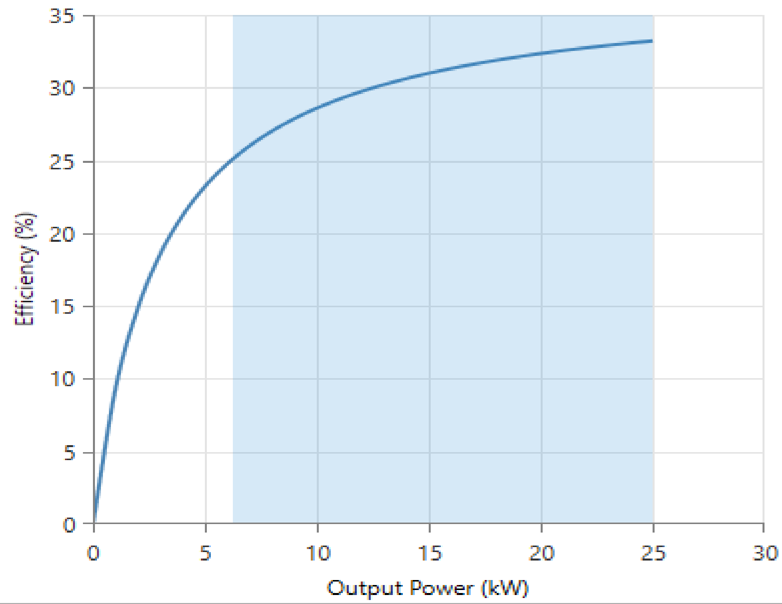


Figure 5.2: Efficiency curve of 25 kW diesel generator

5.1.4 Battery

The Hybrid system are considered in The Discover 12VRE-3000TF-L storage batteries. Batteries System connected in hybrid power system for backup system. Considered batteries are nominal voltage 12V and nominal Capacity 3.11 kWh [37].

Table 5.4

Technical parameters and cost assumptions for battery.

Parameter	Unit	Value
Nominal Voltage	Volt	12
Nominal Capacity	kWh	3.11
Maximum Charge Current	A	43
Round Trip Efficiency	Percent	80
Minimum state of charge	Percent	20
Capital cost	BDT/kWh	46172.40
Replacement cost	BDT/kWh	35670.00
O&M cost	BDT/kWh/yr	20

5.1.5 Converter

The energy transfer between the AC and DC components is maintained by a power converter. Since the electricity generated by the PV or Wind Turbine is DC. Inverter is a device that converts DC current into AC current. .Considered Converter Range 1 kW to 15 kW [38]. Shown Table 5.5 the technical and Economical parameters of the Converter.

Table 5.5

Technical parameters and cost assumptions for converter.

Parameter	Unit	Value
Capital Cost	BDT/kWh	14,388.80
Replacement Cost	BDT/kWh	14,388.80
Life time	Years	15
Efficiency	Percent	95
Rectifier Capacity	Percent	100
Rectifier Efficiency	Percent	95

5.2 Summary

This chapter we discuss and information about system components of micro-grid hybrid power system. Hybrid power systems are used to meet the needs of different types of equipment. The equipment's costs are being debated. My preferred method of browsing different websites is to use my preferred attribute .Acceptable value as used in this case. Solar Panel, Wind Turbines, Diesel Generators, Batteries and power Converters are among the specifications under consideration.

CHAPTER 6

OPTIMIZATION AND SIMULATION RESULTS

6.1 Area and population of Kutubdia

Kutubdia is an upazila in Bangladesh's Cox's Bazar District, in the division of Chittagong. The upazila consists of an island off the coast of Chakaria in the Bay of Bangle, known as Cox's Bazar. Kutubdia is 36 square miles about 93 km in size, with a length of 18 miles about 29 km and a width of 2 miles about 3.2 km. It is known for having Bangladesh's only lighthouse, which was establish by the British under their reign 21.816 degree N91.8583 degree E is the latitude and longitude of Kutubdia. It covers a total area of 215.8 square kilometers and has 58,463 households. Kutubdia had a population of 125,000 people according to the 2011 Bangladesh census. Males made-up 51% of the population while females made-up 49%. There were 41,755 people over the age of 18 in the city. The average literacy rate in Kutubdia was 24.1% while the national average was 32.4%. Ali Akbar Dale is the most densely populated city. Thousands of people visit this island every day as a result of travel and other business related activities [39].

Figure 6.1: Kutubdia islands google map

6.2 Profile of Load Assessment

6.2.1 Summer load profile (March-October)

For this thesis we have taken a village of Kutubdia upazila. This region 120 households has been considered. For summer season we calculate the energy demand for 120 households. Summer is the time with highest energy consumption because three celling fan, five light, one TV, one refrigerator, three mobile charger and one water pump is used at that time. Using the refrigerator full energy consumption the refrigerator service hours are 24 hours the power rating is 150 W. Celling fan service hours are 14.30 hours and the power rating is 75 W each fan. Light service hours are 5.45 hours and the power rating is 23 W each light, while TV operates 5.15 hours and the power rating is 40 W, people charge their mobile several time a day about 2.30 hours the power rating is 18 W each charger and lastly water pump service 0.40 hour a day the power rating is 746 W.

The household load demand variation considered as 10% day to day random variation.

This load calculation is based on mainly 5 energy efficient light, 3 fans, 1 refrigerator, 1 TV, 3 mobile charger and 1 water pump.

Table 6.1: Summer Season Appliance Details

SL NO.	Name of appliance	Number of appliance	Watt
01	Light	5	23(each)×5=115
02	Fan	3	75(each)×3=225
03	Refrigerator	1	150×1=150
04	TV	1	40×1=40
05	Mobile charger	3	18(each) ×3=54
06	Water pump	1	746×1=746

Table 6.2: **Summer Load (March-October)**

Duration	Light (23W)×5	Fan (75W) ×3	Refrigerator (150W) ×1	TV (40W) ×1	Mobile Charger (18W) ×3	Water Pump (746W) ×1	(Watt) Wh	(Watt×120)÷1000 kWh
0-1	0 hr	1 hr	1 hr	0 hr	0 hr	0 hr	375	45
1-2	0 hr	1 hr	1 hr	0 hr	0 hr	0 hr	375	45
2-3	0 hr	1 hr	1 hr	0 hr	0 hr	0 hr	375	45
3-4	0 hr	1 hr	1 hr	0 hr	0 hr	0 hr	375	45
4-5	0 hr	1 hr	1 hr	0 hr	0 hr	0 hr	375	45
5-6	0.45hr	0.30hr	1 hr	0 hr	0 hr	0.20 hr	429.7	51.56
6-7	0 hr	0.30 hr	1 hr	0.30hr	0 hr	0 hr	229.5	27.54
7-8	0 hr	0.40 hr	1 hr	0 hr	0 hr	0 hr	240	28.8
8-9	0 hr	0 hr	1 hr	0 hr	1 hr	0 hr	204	24.5
9-10	0 hr	0.20 hr	1 hr	0.40hr	0.30 hr	0 hr	222.2	26.67
10-11	0 hr	0 hr	1 hr	0 hr	0 hr	0 hr	150	18
11-12	0 hr	0 hr	1 hr	0.30hr	0 hr	0 hr	162	19.44

12-13	0 hr	0.40hr	1hr	0.20hr	0 hr	0 hr	248	29.76
13-14	0 hr	0.30hr	1 hr	0 hr	0 hr	0 hr	217.5	26.1
14-15	0 hr	0 hr	1 hr	0 hr	0 hr	0 hr	150	18
15-16	0 hr	0.20hr	1 hr	0 hr	0 hr	0 hr	195	23.4
16-17	0.25hr	0 hr	1 hr	0 hr	0 hr	0 hr	178.75	21.25
17-18	0.35hr	0.35hr	1 hr	0 hr	0 hr	0.20 hr	418.2	50.18
18-19	1 hr	0.25 hr	1 hr	1 hr	0 hr	0 hr	361.25	43.35
19-20	1 hr	1 hr	1 hr	1 hr	0 hr	0 hr	530	63.6
20-21	1 hr	1 hr	1hr	0.45hr	0 hr	0 hr	508	60.96
21-22	1 hr	1 hr	1 hr	0.30hr	1 hr	0 hr	502	60.24
22-23	0 hr	1 hr	1 hr	0 hr	0 hr	0 hr	375	45
23-24	0 hr	1 hr	1 hr	0 hr	0 hr	0 hr	375	45
Total=	5.45hr	14.30hr	24hr	5.15hr	2.30hr	0.40hr	7571.1Wh	908.55 kWh

So, Summer season Maximum power consumption for 120 households is= 908.55 kWh/day

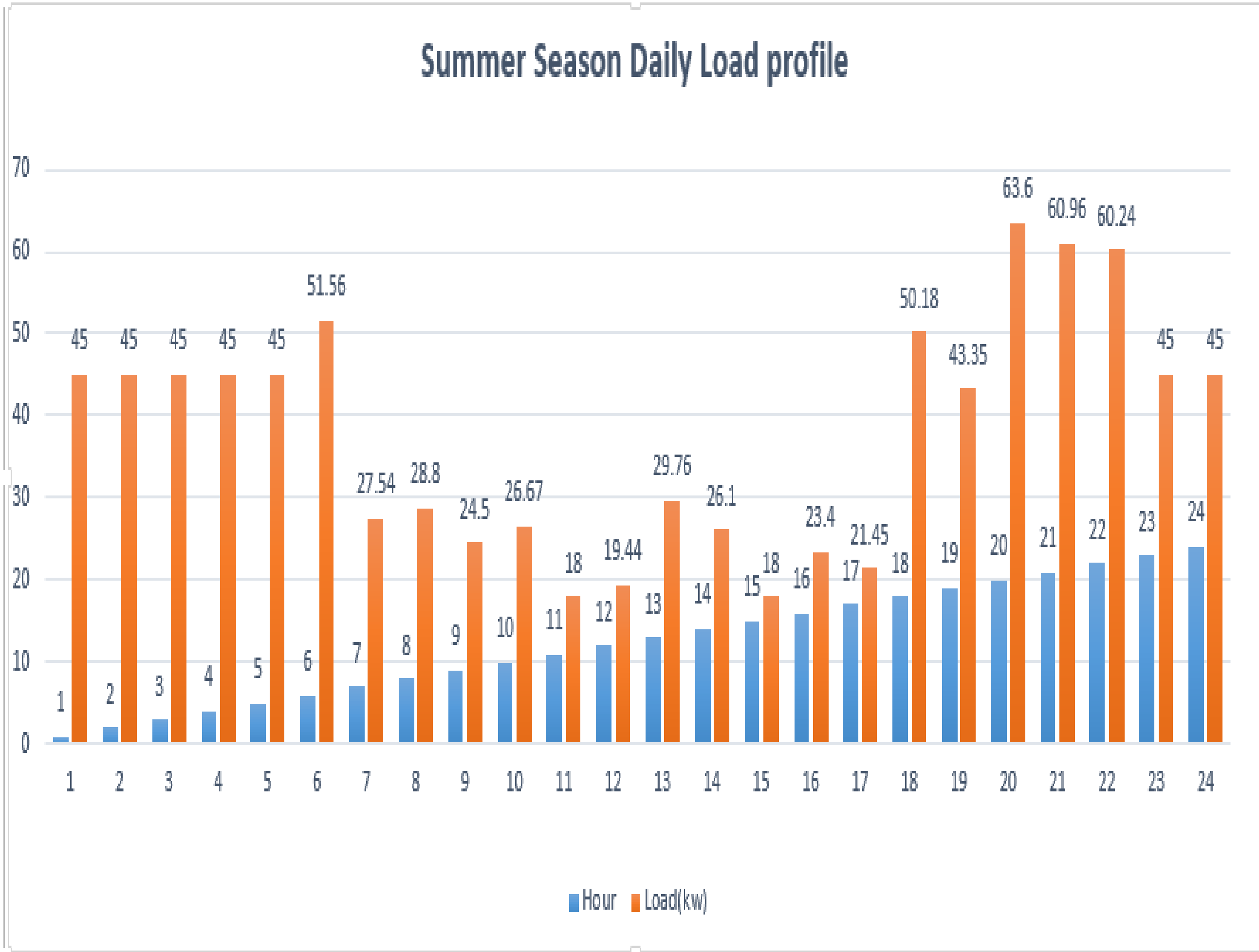


Figure 6.2: Summer season daily load profile

6.2.2 Winter Season Load Profile (November-February)

The winter season energy consumption is lower than summer season because low use of celling fan. In this season people use 1 fan for emergency purpose.

Using the refrigerator full energy consumption the refrigerator service hours are 24 hours the power rating is 150 W. Celling fan service hours are 1.25 hours because of winter season and the power rating is 75 W each fan. Light service hours are 6.20 hours and the power rating is 23 W each light, while TV operates 7.30 hours and the power rating is 40 W, people charge their mobile several time a day about 2.25 hours the power rating is 18 W each charger and lastly water pump service 0.55 hour a day the power rating is 746 W.

Table 6.3: Winter Season Appliance Details

SL NO.	Name of appliance	Number of appliance	Watt
01	Light	5	23(each)×5=115
02	Fan	1	75×1=75
03	Refrigerator	1	150×1=150
04	TV	1	40×1=40
05	Mobile charger	3	18(each) ×3=54
05	Water pump	1	746×1=746

Table 6.4: Winter Load (November-February)

Duration	Light	Fan	Refrigerator (150W) ×1	TV	Mobile Charger	Water pump	(Watt) Wh	(Watt×120)÷1000 kWh

	(23W) ×5	(75W) ×1		(40W) ×1	(18W) ×3	(746W) ×1		
0-1	0 hr	0 hr	1 hr	0 hr	0 hr	0 hr	150	18
1-2	0 hr	0 hr	1 hr	0 hr	0 hr	0 hr	150	18
2-3	0 hr	0 hr	1 hr	0 hr	0 hr	0 hr	150	18
3-4	0 hr	0 hr	1 hr	0 hr	0 hr	0 hr	150	18
4-5	0 hr	0 hr	1 hr	0 hr	0 hr	0 hr	150	18
5-6	0.45hr	0 hr	1 hr	0 hr	0 hr	0.30hr	425.55	51.06
6-7	0.35	0 hr	1 hr	0 hr	0 hr	0 hr	190.25	22.83
7-8	0 hr	0 hr	1 hr	1 hr	0 hr	0 hr	190	22.8
8-9	0 hr	0 hr	1 hr	0.30hr	1 hr	0 hr	216	25.92
9-10	0 hr	0 hr	1 hr	0 hr	0.25hr	0 hr	163.5	19.62
10-11	0 hr	0 hr	1 hr	0 hr	0 hr	0 hr	150	18
11-12	0 hr	0 hr	1 hr	1 hr	0 hr	0 hr	190	22.8
12-13	0 hr	0 hr	1 hr	0 hr	0 hr	0 hr	150	150
13-14	0 hr	0.40hr	1 hr	0 hr	0 hr	0 hr	180	21.6
14-15	0 hr	0 hr	1 hr	0 hr	0 hr	0 hr	150	18
15-16	0 hr	0.45hr	1 hr	1 hr	0 hr	0 hr	223.75	26.85
16-17	0.25hr	0 hr	1 hr	0 hr	0 hr	0 hr	178.75	21.45
17-18	0.35hr	0 hr	1 hr	0 hr	0 hr	0.25hr	376.75	45.21
18-19	1 hr	0 hr	1 hr	1 hr	1 hr	0 hr	359	43.08
19-20	1 hr	0 hr	1 hr	1 hr	0 hr	0 hr	305	36.6
20-21	1 hr	0 hr	1 hr	1 hr	0 hr	0 hr	305	36.6
21-22	1 hr	0 hr	1 hr	1 hr	0 hr	0 hr	305	36.6
22-23	0 hr	0 hr	1 hr	0 hr	0 hr	0 hr	150	18
23-24	0 hr	0 hr	1 hr	0 hr	0 hr	0 hr	150	18
Total=	6.20hr	1.25hr	24hr	7.30hr	2.25hr	0.55hr	4749.5Wh	613 kWh

So, Winter season Maximum power consumption demand for 120 households= 613 kWh/day

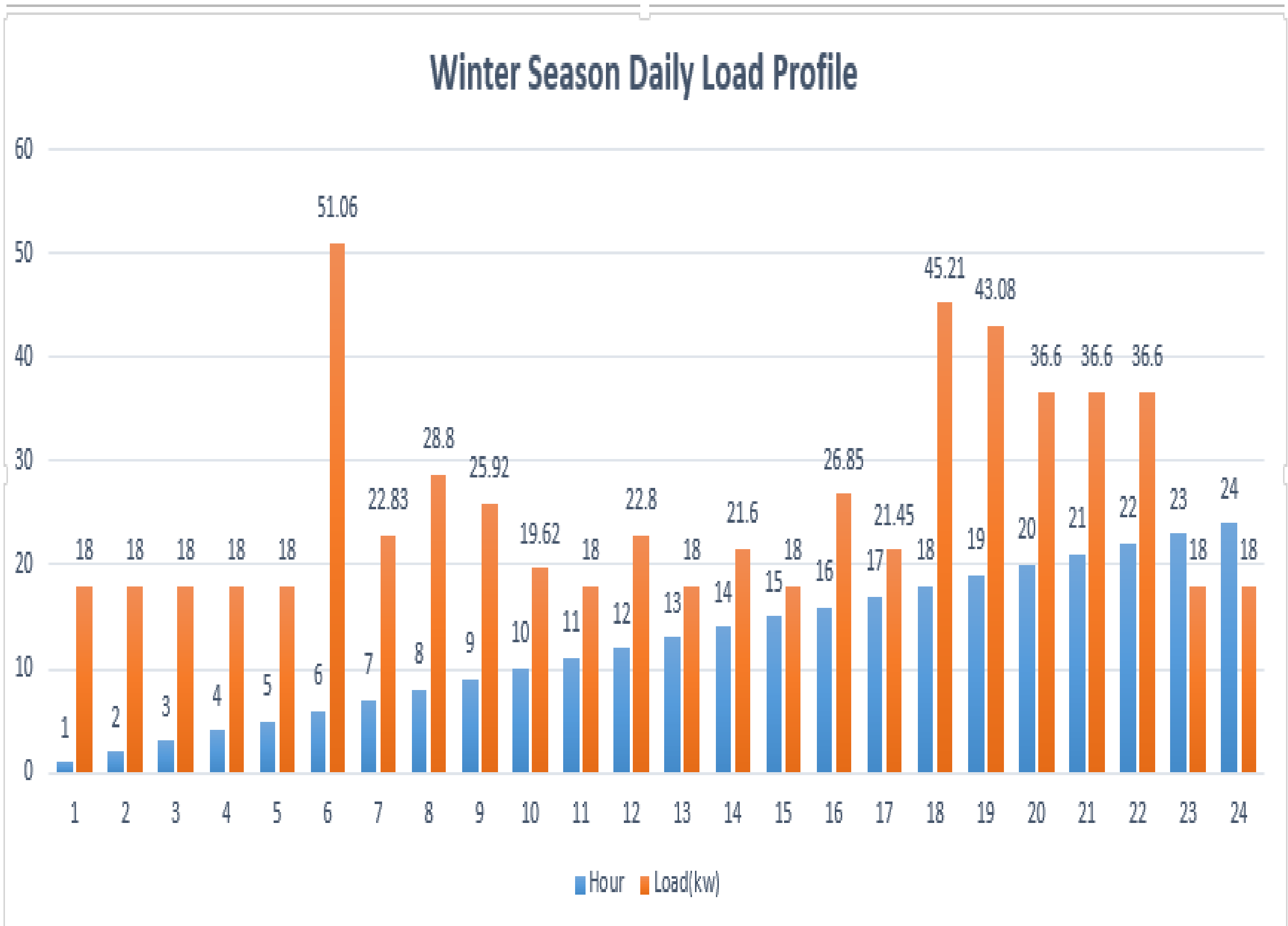


Figure 6.3: Winter season daily load profile

6.3 For DC Load Several Types of "Off-Grid" Model Optimization and Result

i. Wind Turbine + Battery + Converter

ii. Solar PV + Diesel Generator + Battery + Converter

And our proposed micro-grid hybrid power system

iii. Solar PV + Wind Turbine + Diesel Generator + Battery + Converter

For electricity generation technologies are seen here. The HOMER program was used to simulate this system. By using the HOMER tools we can discover a variety of optimization results. And we see the optimization result and we will choose the correct results.

6.4 Wind Turbine

A Wind Turbine is a machine that transforms the kinetic energy of the wind into electricity. Wind Turbines comes in a variety of vertical and horizontal axis configuration. The blade, rotor, tower, and hub are the key components of a Wind Turbine. We'll use horizontal in this situation. Wind turbine with an axis. The operating theory of Wind Turbine is that when wind is present, the turbine blades begin to spin, and we obtain electrical power from kinetic energy. The turbines are used for a variety of purpose, including battery charging for vessels and caravans, as well as powering traffic warning signals. Turbines that are somewhat bigger can be used to generate electricity. Contributions to a domestic electricity source by the sale of surplus power at the energy provider through the use of the electrical grid. Arrays of massive Turbine, known as Wind farms, are becoming an increasingly valuable source of intermittent renewable energy, and many countries are using them as a part of plan to reduce their dependence on fossil fuels. The temperature rises. The configuration of a Wind Turbine is shown in the diagram below [40].

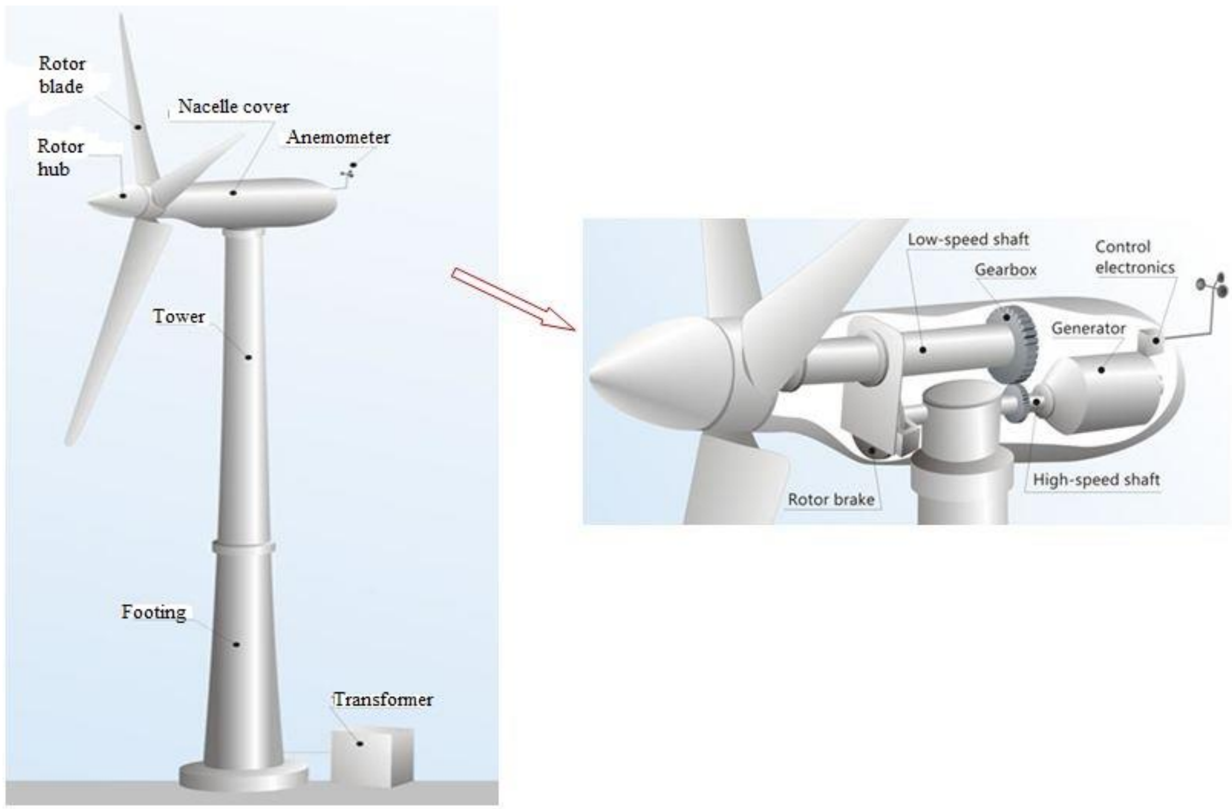


Figure 6.4: Wind turbine configuration

6.5 Battery

A battery is a device that stores electricity. PV, wind turbines, and diesel generator are all part of a micro-grid hybrid power plant. PV and wind are examples of renewable energy sources. Seasonal and environmental factors influence how much energy is generated. As a result, this electricity required to be saved. In this system we use Discover 12VER-3000TF-L storage batteries. There are two kinds of battery designs. As an example, consider parallel and series architecture. The capital cost about BDT 46,172.40 and replacement cost is about BDT 35,670 and the maintenance cost is 20 taka/year. Batteries System connected in hybrid power system for backup system. Considered batteries are nominal voltage 12V and nominal Capacity 3.11 kWh [37]. We used a 12V 3.11 kWh Battery for this project, string 4 batteries, Bus 48v.

6.6 Converter

The energy transfer between the AC and DC components is maintained by a power converter. Since the electricity generated by the PV or wind turbine is DC. Inverter is a device that converts DC current into AC current. .Considered Converter Range 1 kW to 15 kW [38].

6.7 Solar PV(Photovoltaic)

The term "Photovoltaic" refers to the convension of light into electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon studied in physics, photochemistry, and electrochemestry. A tradional photovoltaic system employs solar panels, each of which contains a number of solar cells that produce electricity. Photovoltaic installations maybe mounted on the ground, on the roof, or on the wall. The mount can be mounted or solar tracker can be used to trace the sun through the sky. As an energy source, photovoltaic has many advantages, it produces no carbon and emits no greenhouse gases after installation, it has straightforward scalability based on power requirements, and silicon is abundant in the Earth's crust. PV the only drawback of these devices is that the energy generation is dependent on sunshine. As a result, approximately 10-25 persent is missing, if the monitoring device is not used, since the cell is not necessary directly facing the sun. Dust, clouds, and other atmospheric pursuits also reduce the production of electricity another big problem would be the concentration of activity within hours corrosponding to significant insolation, and do not normally corrospond to the peaks often used in human activity menstrual cycle unless existing societal usage patterns and electrical networks jointly tolerate this situation, energy must also be suppemented by numerous other power sources, most commonly hydrocarbon [42]

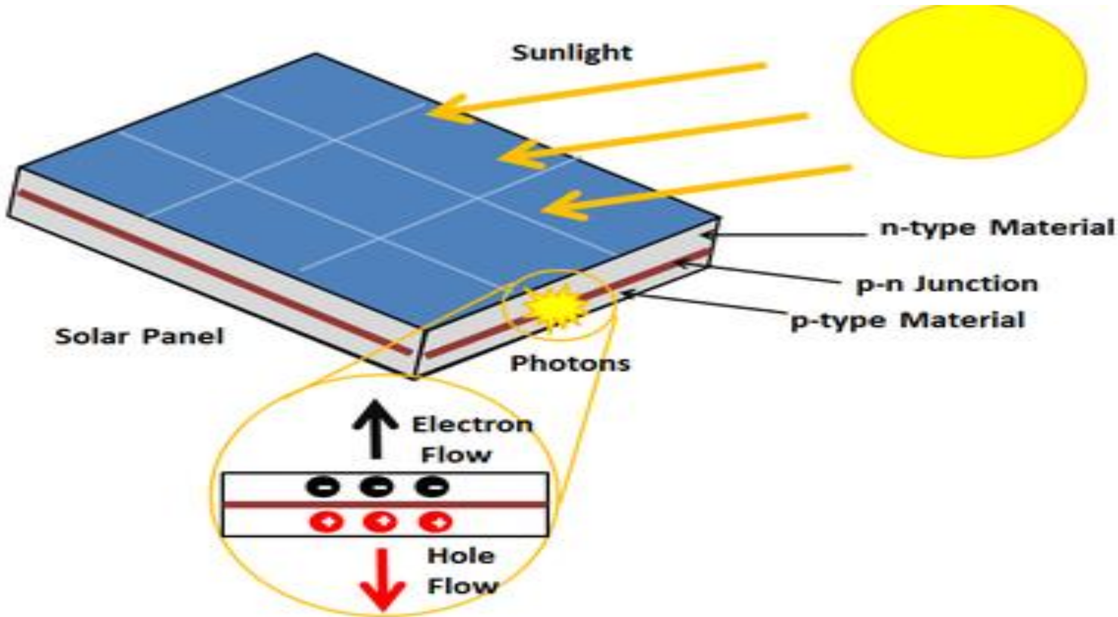


Figure 6.5: A diagram showing the Photovoltaic effect

6.8 Diesel Generator

A Diesel Generator is a device that combined a Diesel Engine and an electric Generator to produce electricity. This is an example of an engine-generator. A diesel compression-ignition engine is typically designed to run on fuel oil, but some models are modified to run on gasoline for alternative liquid fuels or natural gas. Diesel Generator sets are used in areas where is no power grid connectivity, as an emergency power source if the grid fails, and for more complicated uses such as peak-lopping, grid support, and export to the power grid.

6.9 Wind Turbine Information

Wind turbine energy availability is highly dependet on wind variation. In this analysis we considerd Northern Power NPS100C-21, 100 kW Wind Turbine with hub height 29m can be used for the hybrid design the wind turbine capital cost considered about $45,000, (BDT 3,812,400), and the replacement cost about $35,000, (BDT 2,965,200). It provied AC voltage as an output Northern Power NPS100C-21 Wind Turbine starting wind speed is 3.5m/s in this study. Rated Wind Speed 15m/s. [34]

The below table shows wind speed data of Kutubdia,

Table 6.5

Wind speed data of Kutubdia

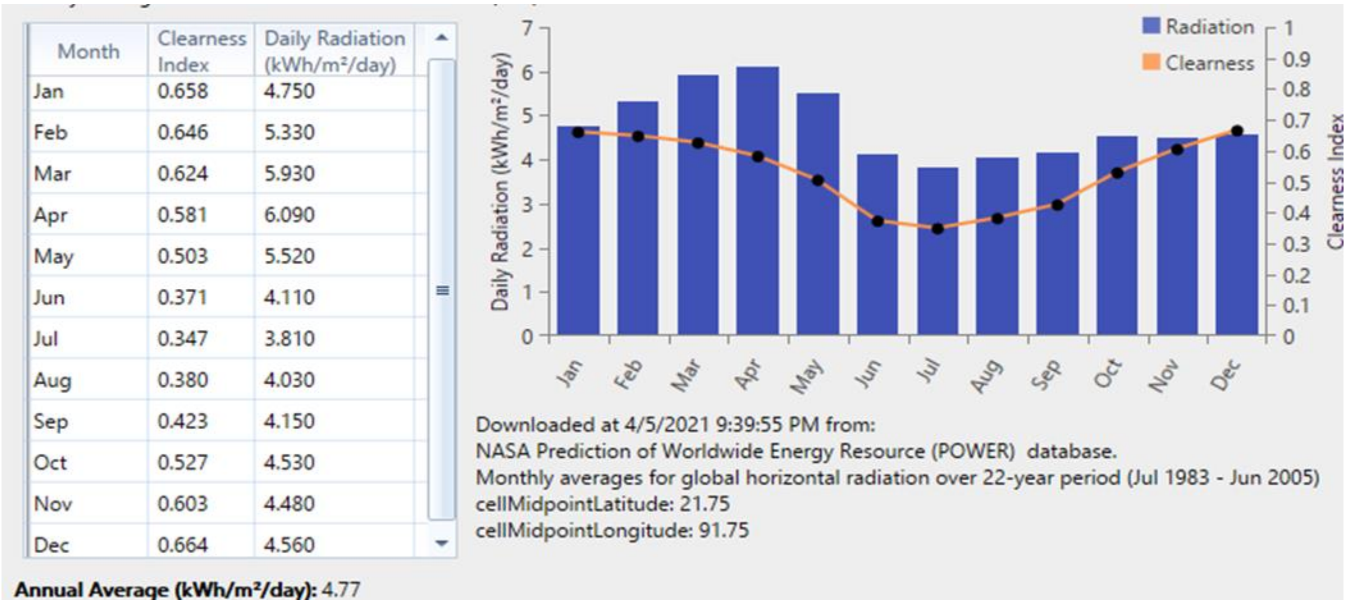
Month	Average (m/s)
Jan	4.380
Feb	3.920
Mar	3.950
Apr	4.250
May	4.980
Jun	6.380
Jul	6.620
Aug	5.940
Sep	4.630
Oct	3.930
Nov	4.130
Dec	4.130

Annual Average (m/s): 4.77

We can see from the table above that there are different Wind speed for each month of the year. 4.77 m/s is the estimated annual Wind speed.

6.10 Solar PV Information

The cost of installing solar panels is BDT 85.83/W. In this scenario, a 335 W solar energy system was considered. The construction and replacement costs for a 1 kW solar energy are considered to be BDT 85,829.37,and BDT 80,551.61 respectively. The life time of this PV array is 25 years [32].



Month	Clearness Index	Daily Radiation (kWh/m²/day)
Jan	0.658	4.750
Feb	0.646	5.330
Mar	0.624	5.930
Apr	0.581	6.090
May	0.503	5.520
Jun	0.371	4.110
Jul	0.347	3.810
Aug	0.380	4.030
Sep	0.423	4.150
Oct	0.527	4.530
Nov	0.603	4.480
Dec	0.664	4.560

Figure 6.6: Solar Radiation Data of Kutubdia

6.11 Diesel Generator Model

The Diesel Generator is connected to the AC bus. Diesel Generators are widely used for remote electrification. Since it is a low-cost, simple-to-install, and electric-powered machine. There is a wide range of Diesel Generators available, choose a suitable model for this location. The power used in this situation 25 kW fixed the cost of a Diesel Generator is estimated to be BDT 420,000. The minimum load ratio is 25%, and the lifetime ranking is about 15000 hours. The diesel price per liter is BDT 65 taka [35, 36].

6.12 Battery Model

The Hybrid system are considered in The Discover 12VRE-3000TF-L storage batteries. Batteries System connected in hybrid power system for backup system. Considered batteries are nominal voltage 12V and nominal Capacity 3.11 kWh [37]. The cost of one is BDT 46,172.40, and replacement cost is BDT 35,670. The battery to be considered in this simulation is 1 to 40 units.

6.13 (Wind turbine + Battery + Converter) System of Energy Production

6.13.1 Evaluation of System Components

The part of the energy grid are the wind turbine, battery and converter. For and piece of equipment, the expense, number of units to be used, operational hours, and so on must be defined in HOMER tools. This segment goes into the specifics of the previous section.

The key feature of this system is the dean energy component, which is a wind turbine. Since the wind turbine generates AC and is connected to an AC networks, the current is transferred to DC, Since the load is AC. In addition, the batteries system serves as a backup system.

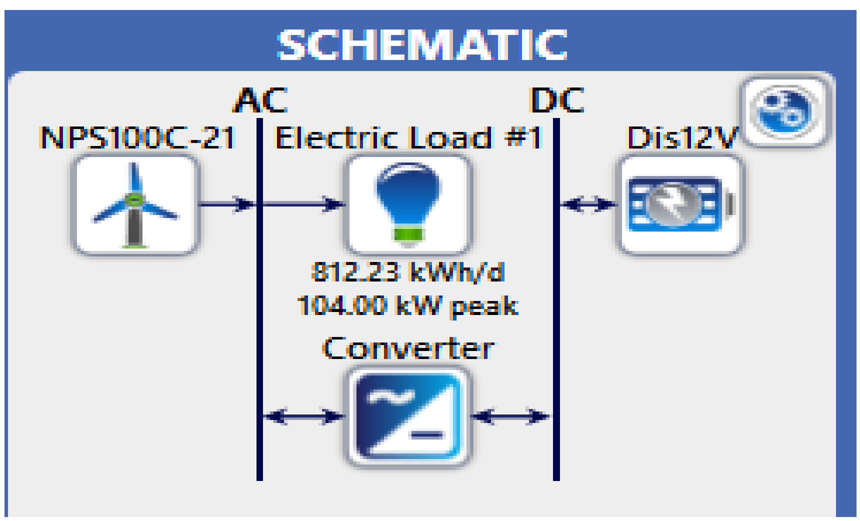


Figure 6.7: (Wind turbine+Battery+Coverter) energy generation system

6.13.2 Simulation Results

The project's life expectancy is estimated to be 25 years. This device could primarily consist of a 500 kW Wind Turbine and 322 strings of Batteries and 152 kW of power Converter, is the best mix of power system components for our case study. For such a device, the Total Net Present Cost (TNPC), Capital cost and Cost of Energy(COE) are BDT 44,373,860, BDT 37,952,396.86, BDT 11.59/kWh.

The below figure shows the simulation result.

Export...

Optimization Results

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

Categorized Overall

Architecture						Cost				System		Gen25			
SPR-X21 (kW)	NPS100C-21	Gen25 (kW)	Dis12V	Converter (kW)	Dispatch	NPC (৳)	COE (৳)	Operating cost (৳/yr)	Initial capital (৳)	Ren Frac (%)	Total Fuel (L/yr)	Hours	Production (kWh)	Fuel (L)	O&M Cost (৳/yr)
121	2	25.0	608	113	LF	৳32.3M	৳8.43	৳312,357	৳28.3M	99.8	175	35.0	535	175	700
127	2		704	106	CC	৳32.8M	৳8.57	৳265,913	৳29.4M	100	0				
	5	25.0	836	80.8	CC	৳40.3M	৳10.53	৳669,273	৳31.7M	96.5	3,380	693	10,286	3,380	13,860
	5		1,288	152	CC	৳44.4M	৳11.59	৳496,729	৳38.0M	100	0				
301		25.0	1,420	87.8	CC	৳56.5M	৳14.75	৳816,304	৳45.9M	92.2	7,614	1,557	23,183	7,614	31,140
418			1,676	204	CC	৳64.5M	৳16.85	৳319,498	৳60.4M	100	0				

Figure 6.8: Simulation Results

6.13.3 Cost Summary

When a Wind Turbine is constructed, the cost of maintenance and operation falls dramatically. The project's fixed Capital cost is BDT 37,952,396.86. The cost of Operation and Maintenance is expected to be BDT 2,209,225.92 a year. The cost of repair or Replacement is BDT 9,651,454.80. Various civil construction, manpower, logistics salaries, necessary permits, administration, and government approvals, and other miscellaneous co-financing are included in the system's fixed capital cost.

The below figure shows the Cost Summary

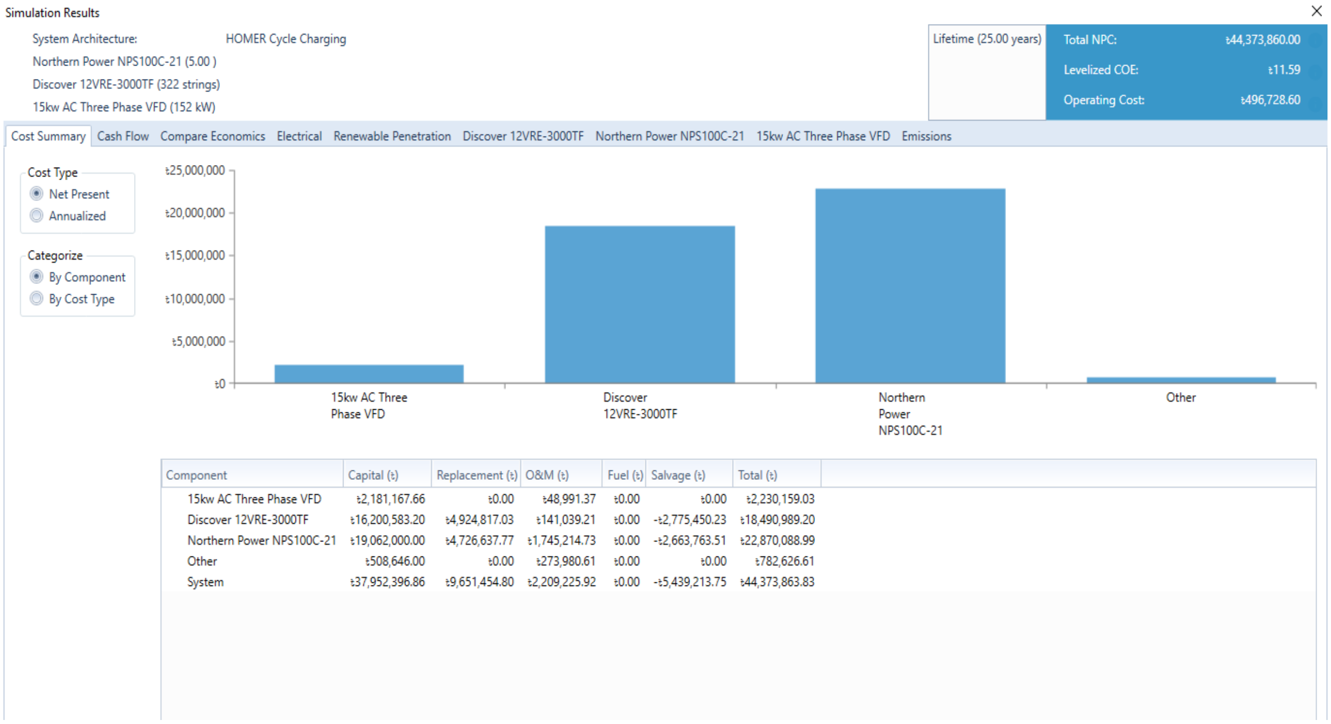


Figure 6.9: Cost Summary

6.13.4 Cash Flow

The figure shows the cash flows graph. The total NPC is BDT 44,373,860. The levelized COE is BDT 11.59/kWh. And the operating cost is BDT 496,728.60.

Figure 6.10: Cash Flow

6.13.5 Monthly Average Electric Production

The graph below depicts the monthly distribution of electricity produed by the wind turbine in MW. The wind turbine is mainly seen from April to September. Battery store energy, which is used to generate electricity for lack of wind speed in various month.

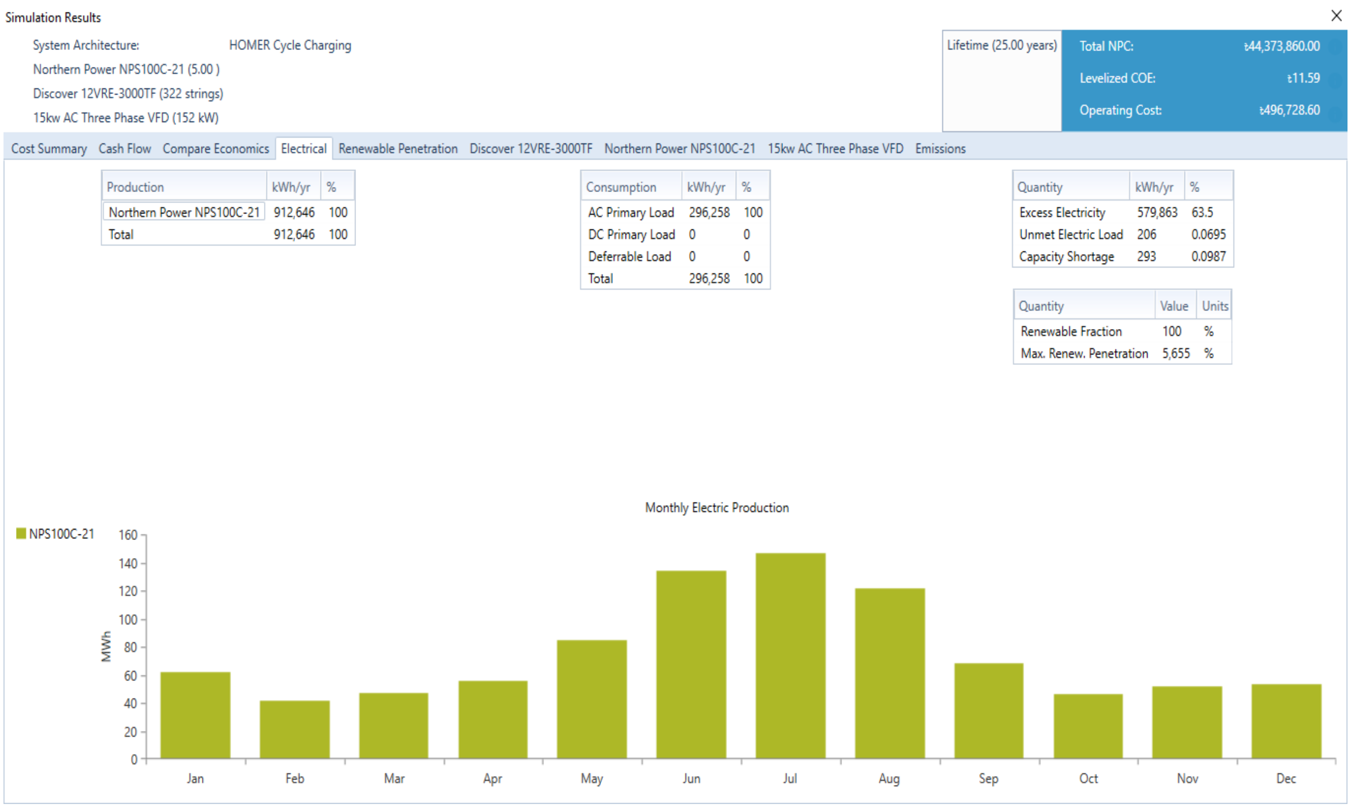


Figure 6.11: Monthly average electric production

Table 6.6

Electricity production of the system components

Production	kWh/yr	%
Wind Turbine	912,646	100

6.13.6 Sensitivity and Optimization Results

In this case, susceptibility variables such as (wind turbine capacity, Battery size) are taken into account. When an area load of 812.23 kWh/day and a peak load of 104 kW, this device could primarily consist of a 500 kW Wind Turbine and 322 strings of Batteries and 152 kW of power Converter. And HOMER software simulate those scenarios. Original money, gross Net Present Cost (NPC), Cost of Energy (COE), green fraction. This system of COE BDT 11.59/kWh .The gross expense of the Net Present Cost was BDT 44,373,860. Excess energy generates 579,863 kWh/yr, a 63.5% increase, and a 206 kWh/yr, Unmet electric load of 0.0695%. Also, there is a 293 kWh/yr capacity shortage of 0.0987%. 100 is the magnitude of the renewable fraction.

As result of the sensitivity result in this situation, the (Wind turbine, Batteries and power Converter) based hybrid system is not suitable due to huge cost.

6.14 (Solar PV + Diesel Generator + Battery + Converter) System of Energy production

6.14.1 Evaluation of System Components

PV modules, a Diesel Generator, a Battery, and a power Converter are the elements of the energy grid. For any of these pieces of equipment, the expense, number of units to be used, operationl hours, and so on must be defined in HOMER software. This material contains specifics of past events subsection. The key feature of this system is the green energy components, which is a PV panel. Another source of renewable energy is the diesel generator. Since the generator is AC current but the load is DC current. There is a lot to use here. The PV panel to be generated DC, and the PV panel is attached to a DC bus but the generator is attached to a AC bus so this current is converted because the load is DC. Batteries are used as a recovery mechanism.

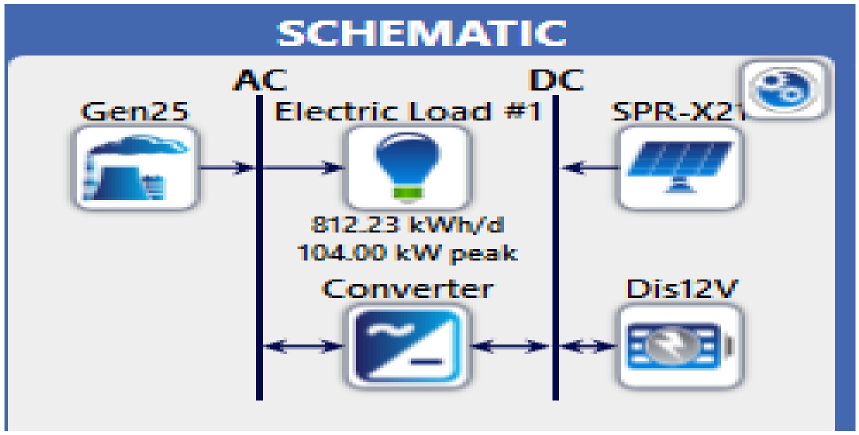


Figure 6.12: (Solar PV+Diesel generator+Battery+Converter) Energy generation system

6.14.2 Simulation Results

The project's life expectancy is estimated to be 25 years. This system might majority consists of 301 kW PV array, arrange 25 kW fixed generator, 355 strings of Batteries and 87.8 kW of power converter, is the best mix of power system components for our case study. This system considered at BDT 65/L of diesel cost. For each device, the Total Net Present Cost (NPC), Capital cost and Cost of Energy (COE) are BDT 56,471,500, BDT 45,918,715.19, and BDT 14.75/kWh.

The below figure shows the simulation result

Export... | **Optimization Results** — Left Double Click on a particular system to see its detailed Simulation Results. | Categorized | Overall

Architecture						Cost				System		Gen25			
SPR-X21 (kW)	NPS100C-21	Gen25 (kW)	Dis12V	Converter (kW)	Dispatch	NPC (৳)	COE (৳)	Operating cost (৳/yr)	Initial capital (৳)	Ren Frac (%)	Total Fuel (L/yr)	Hours	Production (kWh)	Fuel (L)	O&M Cost (৳/yr)
121	2	25.0	608	113	LF	৳32.3M	৳8.43	৳312,357	৳28.3M	99.8	175	35.0	535	175	700
127	2		704	106	CC	৳32.8M	৳8.57	৳265,913	৳29.4M	100	0				
	5	25.0	836	80.8	CC	৳40.3M	৳10.53	৳669,273	৳31.7M	96.5	3,380	693	10,286	3,380	13,860
	5		1,288	152	CC	৳44.4M	৳11.59	৳496,729	৳38.0M	100	0				
301		25.0	1,420	87.8	CC	৳56.5M	৳14.75	৳816,304	৳45.9M	92.2	7,614	1,557	23,183	7,614	31,140
418			1,676	204	CC	৳64.5M	৳16.85	৳319,498	৳60.4M	100	0				

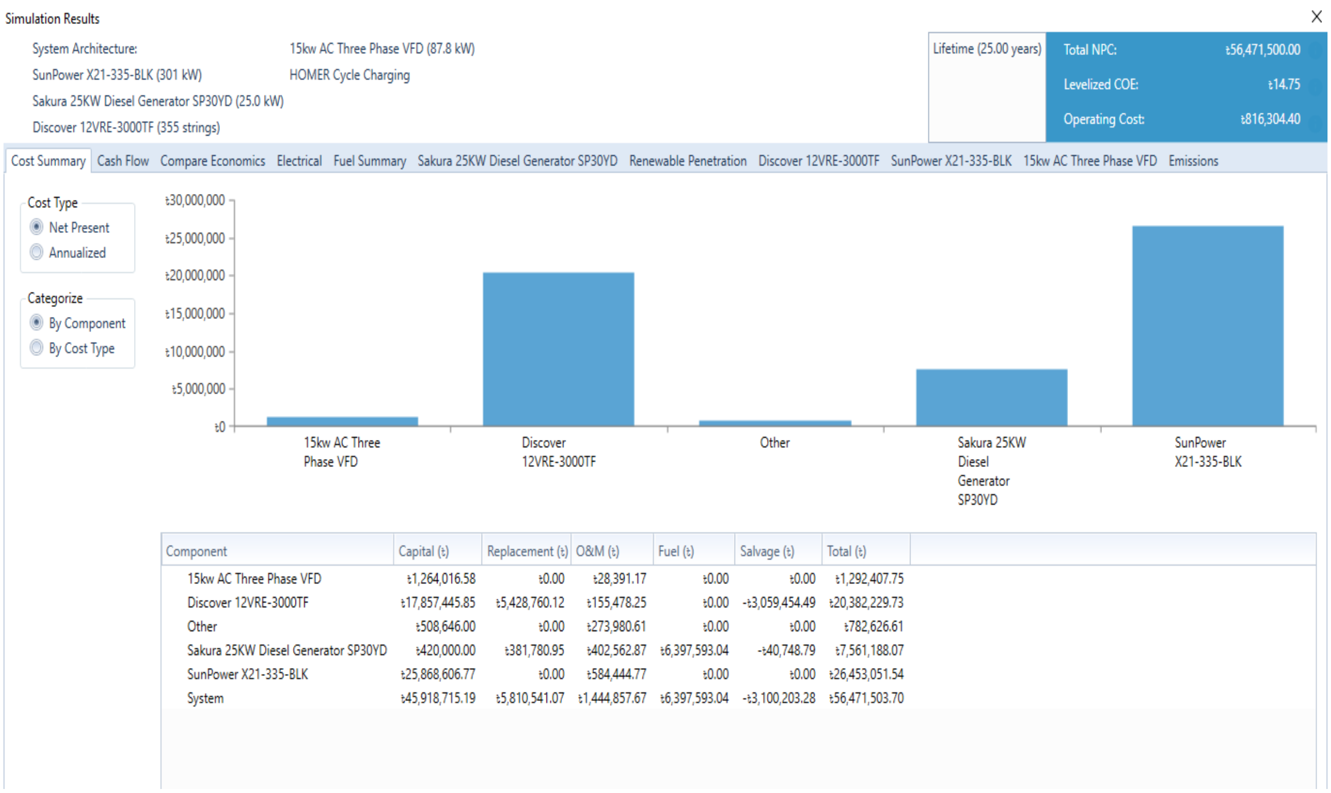
Figure 6.13: Simulation Results

6.14.3 Cost Summary

When a solar PV is constructed, the cost of maintenance and operation falls dramatically. The project's fixed Capital cost is BDT 45,918,715.19 .The cost of Operation and Maintenance is expected to be BDT 1,444,857.67 a year. The cost of repair or Replacement is BDT

5,810,541.07.Various civil construction , manpower, logistics salaries, necessary permits, administration and government approvals and other miscellaneous co-financing are include in the system's fixed capital cost.

The below figure shows the Cost Summary



Component	Capital (৳)	Replacement (৳)	O&M (৳)	Fuel (৳)	Salvage (৳)	Total (৳)
15kw AC Three Phase VFD	৳1,264,016.58	৳0.00	৳28,391.17	৳0.00	৳0.00	৳1,292,407.75
Discover 12VRE-3000TF	৳17,857,445.85	৳5,428,760.12	৳155,478.25	৳0.00	-৳3,059,454.49	৳20,382,229.73
Other	৳508,646.00	৳0.00	৳273,980.61	৳0.00	৳0.00	৳782,626.61
Sakura 25KW Diesel Generator SP30YD	৳420,000.00	৳381,780.95	৳402,562.87	৳6,397,593.04	-৳40,748.79	৳7,561,188.07
SunPower X21-335-BLK	৳25,868,606.77	৳0.00	৳584,444.77	৳0.00	৳0.00	৳26,453,051.54
System	৳45,918,715.19	৳5,810,541.07	৳1,444,857.67	৳6,397,593.04	-৳3,100,203.28	৳56,471,503.70

Figure 6.14: Cost Summary

6.14.4 Cash Flow

The below figure shows the cash flow graph. The total NPC is BDT 56,471,500. The levelized COE is BDT 14.75/kWh. And the Operating Cost is BDT 816,304.40.

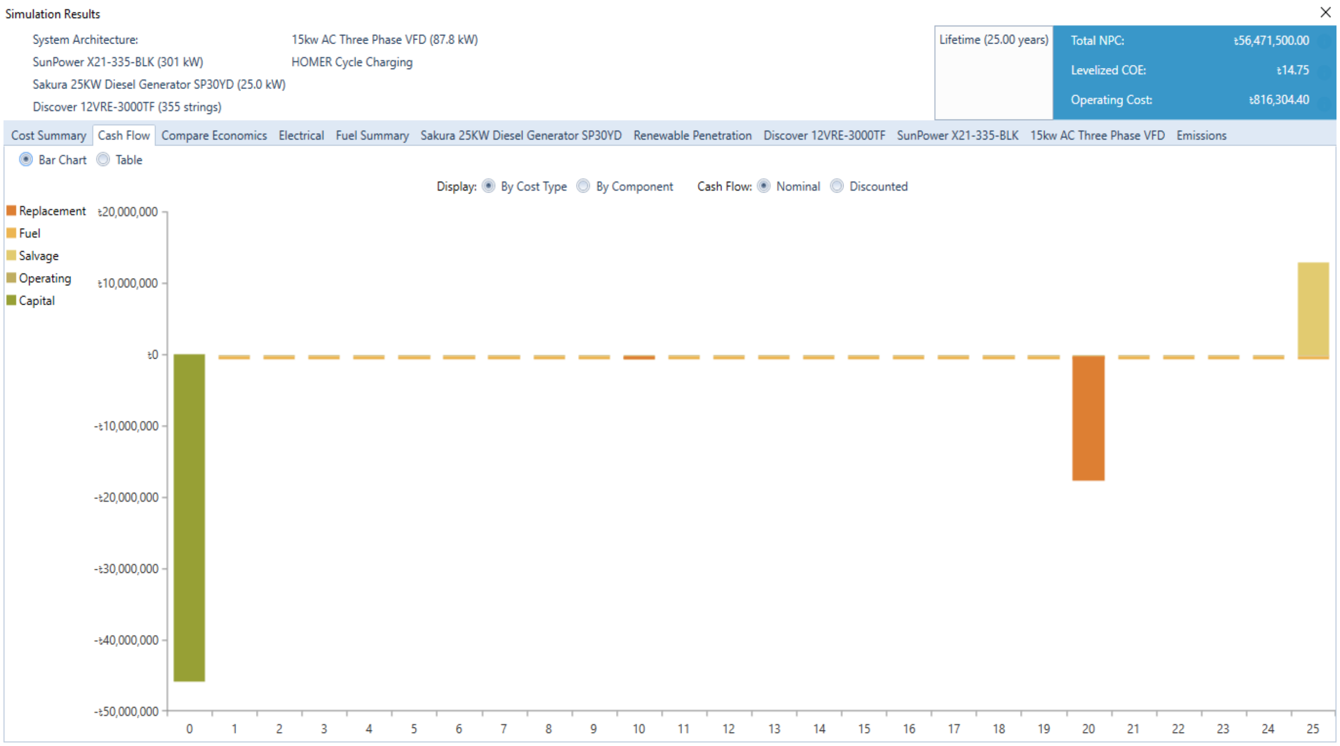


Figure 6.15: Cash Flow

6.14.5 Monthly Average Electric Production

The graph below shows the monthly average distribution of electricity produce by the Solar PV and Diesel generator in MW. From October to March the solar PV is mostly combined with Diesel Generator . Lack of solar radiation during rainy day, and some of winter days, we get some power from diesel generator.

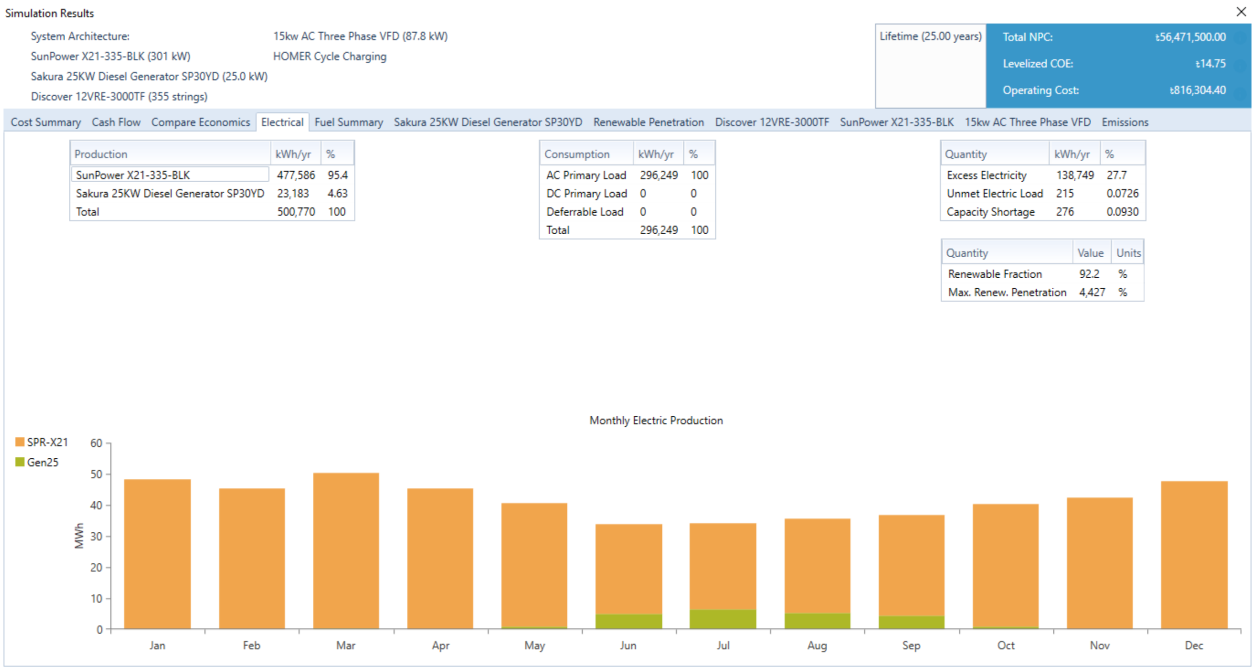


Figure 6.16: Monthly average electric production

Table 6.7

Electricity production of the system components

Production	kWh/year	%
Solar PV	477,586	95.4
Diesel generator	23,183	4.63
Total	500,770	100

6.14.6 Sensitivity and Optimization Results

This case consist of three sensitivity variables like (solar PV, Battery and power converter) are considered in this analysis. The area load at 812.23 kWh/day and peak load is 104 kW, this system might majority consists of 301 kW PV array, arrange 25 kW fixed generator, 355 strings of Batteries and 87.8 kW of power converter. And HOMER software simutate this things. Capital cost, Total Net Present Cost (NPC), Cost of Energy (COE), green fraction. The system of COE BDT 14.75/kWh . The gross expense of the Total Net Present Cos (TNPC) was BDT 56,471,500. Excess of energy generates 138,749 kWh/yr, a 27.7% increase, and a 215 kWh/yr, Unmet electric load of 0.0726%. Also, there is a 276 kWh/yr capacity shortage of 0.0930%. 92.2 is the magnitude of the renewable fraction.

As a result of the sensitivity result in this situation (Solar PV, Diesel Generator, Battery and power Converter) based hybrid microgrid are not suitable due to huge cost. The cost is very large.

6.14.7 Emission

We can see the below figure the major emission comes from Carbon Dioxied.

Quantity	Value	Units
Carbon Dioxide	19,931	kg/yr
Carbon Monoxide	124	kg/yr
Unburned Hydrocarbons	5.48	kg/yr
Particulate Matter	0.746	kg/yr
Sulfur Dioxide	48.8	kg/yr
Nitrogen Oxides	117	kg/yr

Figure 6.17: Emission

6.15 Micro-Grid Hybrid Power System

A microgrid hybrid power system made up of variable components such as, Solar PV, Wind Turbine, Diesel Generator, Battery, and power Converter. The below figure shows the microgrid hybrid power system.

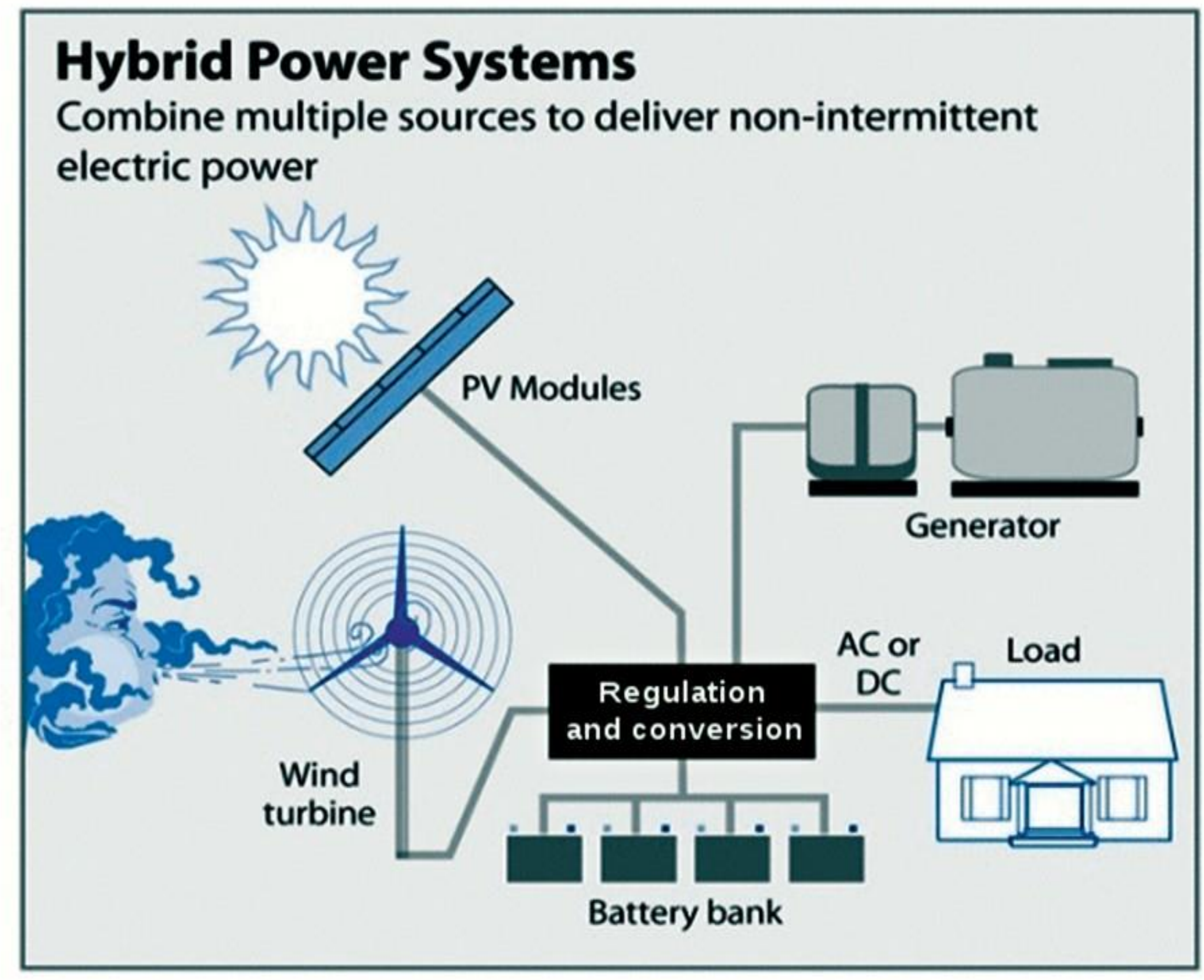


Figure 6.18: Micro-Grid Hybrid Power System

6.16 The Proposed Micro-Grid Hybrid Power System

(Solar Pv + Wind Turbine + Diesel Generator + Battery + Converter)

6.16.1 Proposed Hybrid System Modeling

We proposed combining the following technologies: A solar PV system, a wind turbine, Batteries, Diesel generator (DG), and power converter.

The demand from the region is DC coupled in the hybrid system, the diesel generator (DG) and the wind turbine are linked to the AC side of the network, and the solar PV system and batteries are connected to its DC side. Typically, a traditional backup diesel generator (DG) is used to complement the hybrid power system at high loads and when renewable resources are unavailable.

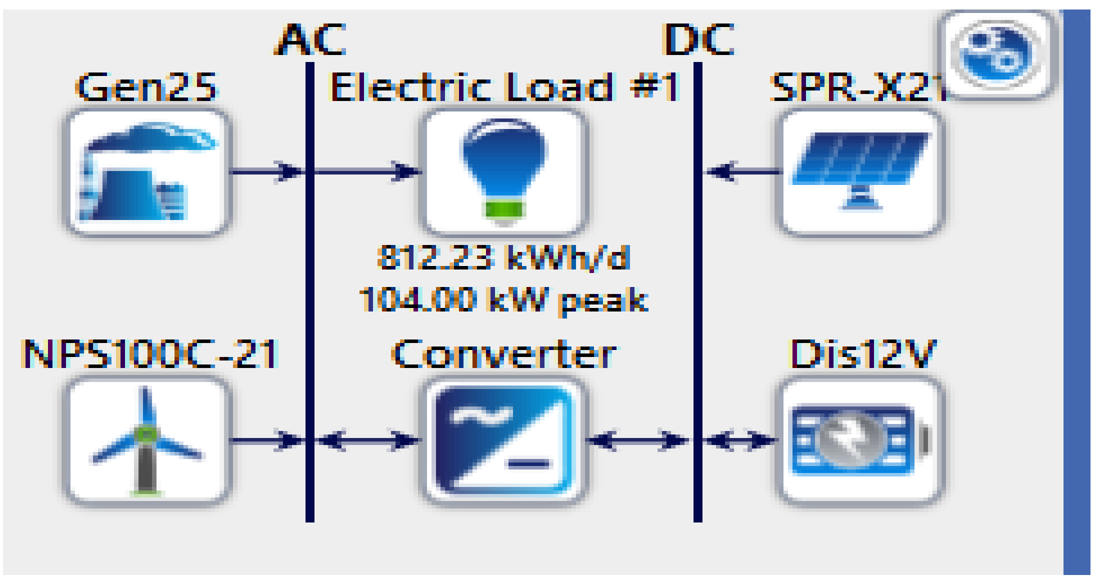


Figure 6.19: Proposed Hybrid System

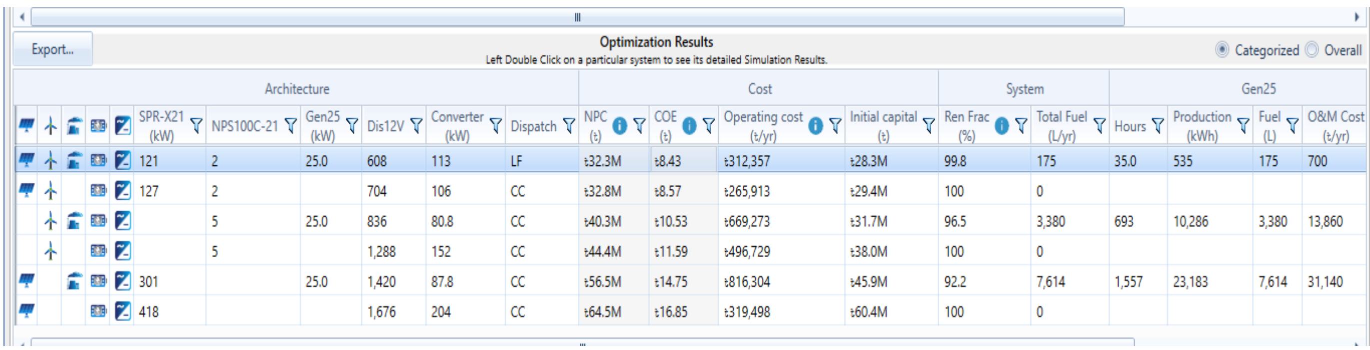
6.16.2 Evaluation Of System Components

PV modules, Wind Turbines, Batteries, and power Converter are the elements of the energy grid. For any of these pieces of equipments, the expense, number of units to be used, operational hours, and so on must be defined in HOMER software. This material pertains to the preceding part. The key part of this system is green energy, which includes a PV panel and a Wind Turbine. The load is DC, and the backup source is a diesel generator and batteries. PV panels and Batteries are manufactured in direct current (DC), other hand Wind Turbine, and Generator is connected to the AC bus. As a result, since the load is DC, this current is converted.

6.16.3 Simulation Results

The project's life expectancy is estimated to be 25 years. A 121 kW Solar PV, 200 kW Wind Turbine, 25 kW Generator, 152 strings of Batteries, and 113 kW of power converter is the best mix of power system components for our case study. For such a device, the Total Net Present Cost (TNPC), Capital cost and Cost of Energy (COE) are BDT 32,300,890, BDT 28,262,899.93, BDT 8.43/kWh.

The below figure shows the simulation result


Export...
Optimization Results
Left Double Click on a particular system to see its detailed Simulation Results.
Categorized Overall

Architecture						Cost				System		Gen25			
SPR-X21 (kW)	NPS100C-21	Gen25 (kW)	Dis12V	Converter (kW)	Dispatch	NPC (৳)	COE (৳)	Operating cost (৳/yr)	Initial capital (৳)	Ren Frac (%)	Total Fuel (L/yr)	Hours	Production (kWh)	Fuel (L)	O&M Cost (৳/yr)
121	2	25.0	608	113	LF	৳32.3M	৳8.43	৳312,357	৳28.3M	99.8	175	35.0	535	175	700
127	2		704	106	CC	৳32.8M	৳8.57	৳265,913	৳29.4M	100	0				
	5	25.0	836	80.8	CC	৳40.3M	৳10.53	৳669,273	৳31.7M	96.5	3,380	693	10,286	3,380	13,860
	5		1,288	152	CC	৳44.4M	৳11.59	৳496,729	৳38.0M	100	0				
301		25.0	1,420	87.8	CC	৳56.5M	৳14.75	৳816,304	৳45.9M	92.2	7,614	1,557	23,183	7,614	31,140
418			1,676	204	CC	৳64.5M	৳16.85	৳319,498	৳60.4M	100	0				

Figure 6.20: Simulation Results

6.16.4 Cost Summary

When a Solar PV, wind turbine, diesel generator is constructed, the cost of maintenance and operation dramatically. The project's fixed Capital cost is BDT 28,262,899.93. The cost of Operation and Maintenance is expected to be BDT 1,319,669.98 a year. The cost of repair of Replacement is BDT 4,656,566.99. Various civil construction, manpower, logistics salaries, necessary permits, administration and government approvals and other miscellaneous co-financing are included in the system's fixed capital cost.

The below figure shows the Cost Summary

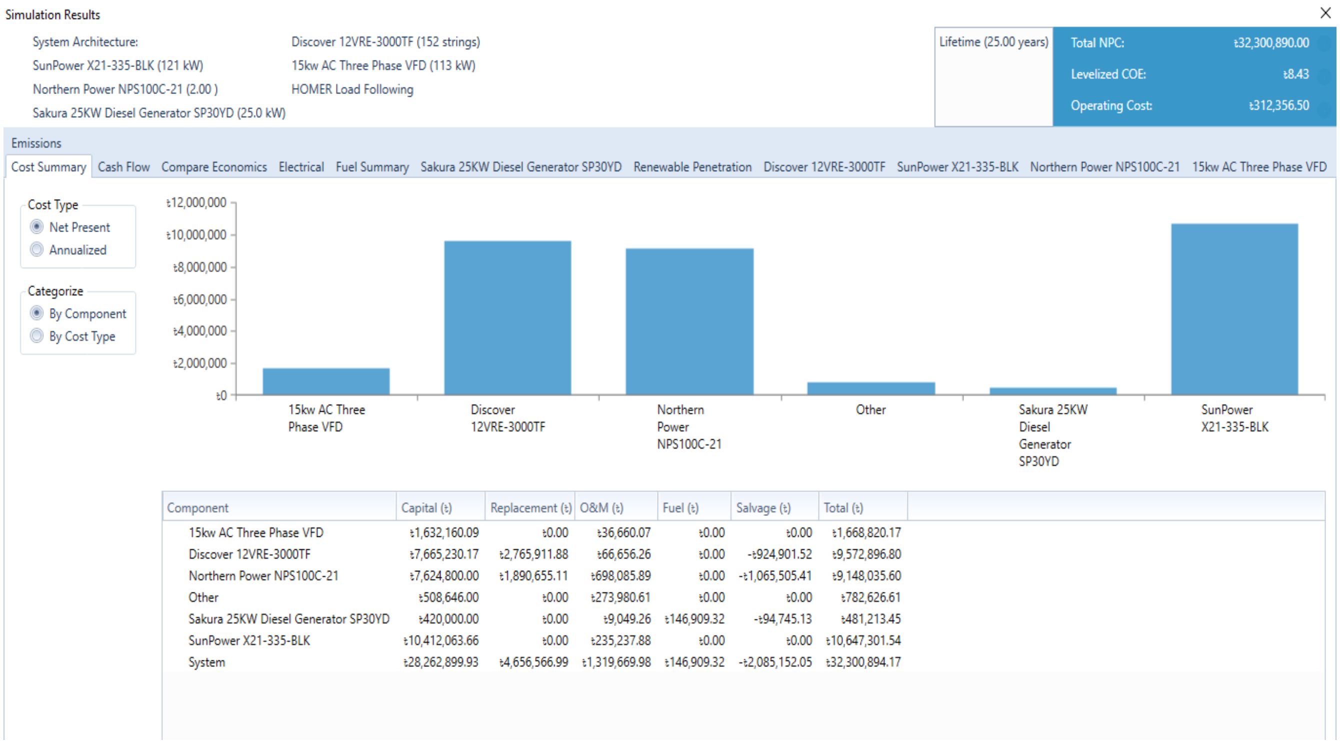


Figure 6.21: Cost Summary

6.16.5 Cash Flow

The below figure shows the cash flow. The total NPC is BDT 32,300,890. The Levelized COE is BDT 8.43/kWh. And the Operating cost is BDT 312,356.50.

Figure 6.22: Cash Flow

6.16.6 Monthly Average Electric Production

The graph below depicts the monthly average distribution of electricity produce by the Wind Turbine, Solar PV, and Generator in MW. The wind turbine is mainly seen from May to September. The Wind Turbine operates at full load along the year and produces (365,059 kWh/yr), achieving a capacity factor of 65.4%. In various month when solar radiation are inadequate and wind are unavailable, Diesel generator becomes the dominant producer. For the selected system the Generator produces (535 kWh/yr) and consumes 175 liter of fuel. The Solar PV produces (192,228 kWh/yr), achieving a capacity factor of 34.5% and Generator capacity factor of 0.0958%.

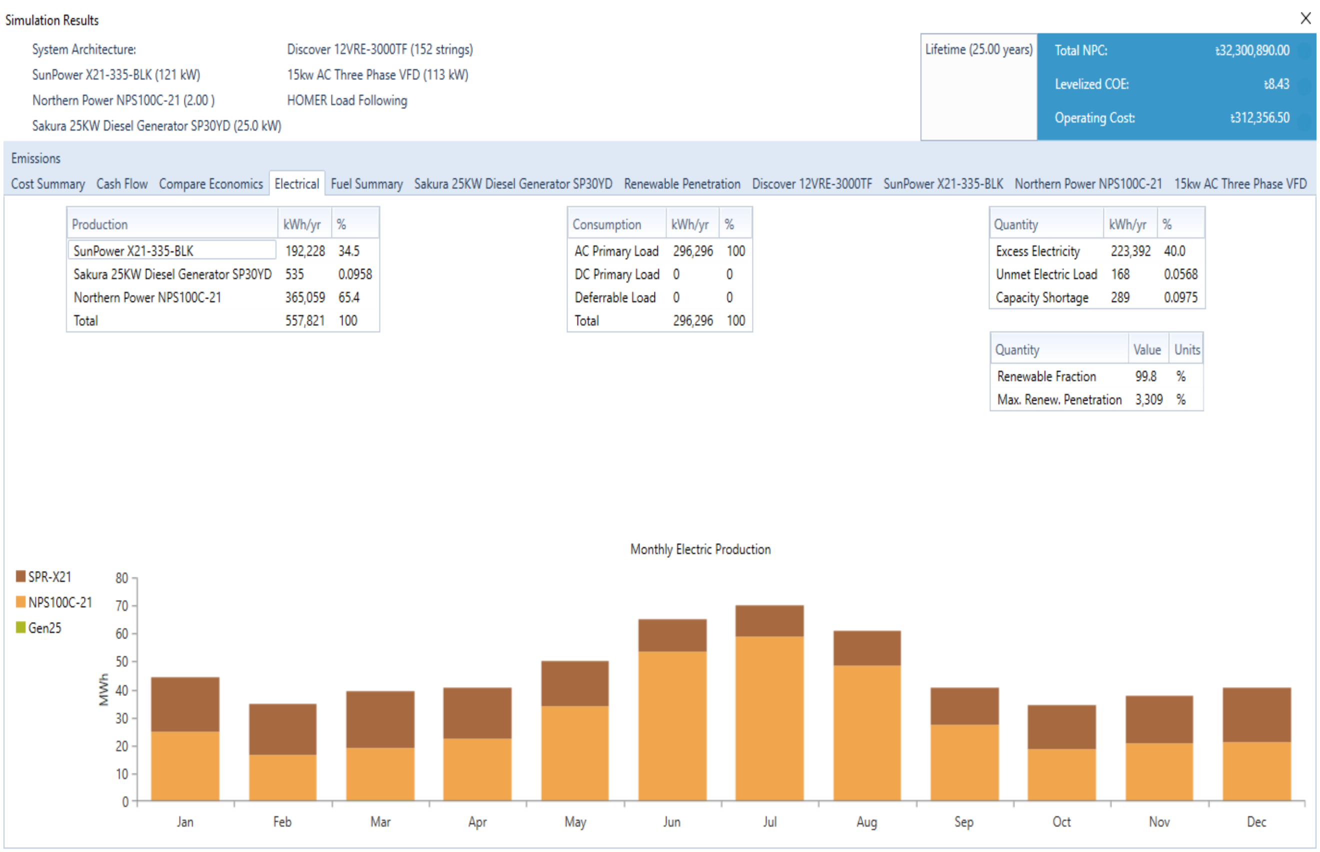


Figure 6.23: Monthly average electric production

Table 6.8

Electricity production of the system components

Production	kWh/yr	%
Solar PV	192,228	34.5
Diesel Generator	535	0.0958
Wind Turbine	365,059	65.4
Total	557,821	100

6.16.7 Sensitivity and Optimization Results

This case includes sensitivity variables such as (Wind Turbine, Solar PV, Diesel Generator, Battery, and power Converter size) that are taken into account in this study. With an area load 812.23 kWh/day and peak load of 104 kW, this device could primarily consist of an 121 kW solar panel, an 200 kW Wind Turbine, 152 strings of Batteries, 25 kW fixed Generator, and 113 kW power Converter. And those cases are simulations of, HOMER software. For this case optimization result are consist of initial capital, Total Net Present Cost (TNPC), Cost of Energy (COE), renewable fraction, Diesel in liter and Generator in hourly working in this system. This system of COE BDT 8.43/kWh. The Total Net Present Cost BDT 32,300,890. Excess electricity produce 223,392 kWh/yr of 40%. And, Unmet electric load 168 kWh/yr of 0.0568%. Also capacity shortage 289 kWh/yr of 0.0975%. Further renewable fraction value 99.8%.

As a result of the sensitivity result in this situation (Solar PV, Wind Turbine, Diesel Generator, Battery, and power Converter) based hybrid microgrid are suitable for stand alone. Because we have an alternative source of electricity, such as a Diesel Generator, we will guarantee that we will be able to supply electrical energy to customers 100% of the time.

6.16.8 Emission

We can see the below figure the major emission comes from Carbon Dioxide.

Quantity	Value	Units
Carbon Dioxide	458	kg/yr
Carbon Monoxide	2.86	kg/yr
Unburned Hydrocarbons	0.126	kg/yr
Particulate Matter	0.0171	kg/yr
Sulfur Dioxide	1.12	kg/yr
Nitrogen Oxides	2.69	kg/yr

Figure 6.24: Emission

CHAPTER 7

CONCLUSION

7.1 Conclusion

In this work, a feasibility study was carried out to investigate renewable energy at Kutubdia in Bangladesh. The load profile in one small community is determined in this thesis. The estimations are not reliable in terms of power generation since both the irradiation and wind speed of wind change from year to year. The optimization of microgrids is beneficial in understanding the penetration of renewable resources in the electricity sector. The HOMER simulation gives the required flexibility in carrying out time-consuming simulations using efficient tools. This aids in understanding the system and building various models. The hybrid system may significantly reduce reliance on fossil-fuels while also supplying individual power to AC or DC systems as needed. The hybrid optimized system is capable of efficiently supplying energy between their respective busses. Based on the simulations, it is possible to meet the load requirement effectively utilizing an optimal hybrid model. Using this technology, adequate energy may be given to a specific region while incurring the least amount of running expense. This hybrid technology significantly minimizes carbon emissions and aids in the long-term reduction of environmental concerns. The model generates practical findings that may be used to minimize fuel usage and enhance the efficiency of renewable resources. This thesis presents the optimization of a wind turbine, Solar PV, Diesel Generator, Battery, and power Converter hybrid power system. In this system Solar PV and batteries are connected to the DC bus and Wind Turbine, Diesel Generators are connected to the AC bus. So the Converter converted the AC power to DC. A Solar PV, Diesel Generator, Wind Turbine, Battery, and Converter hybrid microgrid generation system was found to be the most viable and configured in this analysis. In term of Cost of Energy (COE), environmental requirements, and renewable fraction, our proposed model 121 kW Solar PV panels, 200 kW Wind Turbine, 25 kW fixed Diesel Generator, 152 strings of Batteries, and 113 kW converter are considered to be the best design. BDT 8.43/kWh is the Cost of Energy (COE). This system's renewable fraction is 99.8%. This project lifetime 25 years.

7.2 Limitations

1. We are unable to have an exact diagram

2. Solar radiation is not exactly the same, but HOMER does not account for this.

3. It operates on a set diesel price, but the price of fuel is not fixed at all.

4. Wind speed does not always remain constant, but HOMER program does not account for this.

5. While no GHG (Greenhouse gas) analysis is possible, Carbon emissions can be collected.

6. The obtained result is obtained using the HOMER program. The final calculated outcome can differ.

7.3 Future Work Scope

1. Diesel, gasoline, methanol, and propen will all be applied to the proposed hybrid energy generation system.

2. In addition to the planned hybrid electricity generation, hydro energy may be used.

3. Biogas energy will be used in conjunction with the planned hybrid energy generation.

4. Liquefied natural gas will be used to supplement the planned hybrid electricity production.

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