FEASIBILITY ANALYSIS OF SOLAR WIND HYBRID SYSTEM IN BANGLADESH

A thesis submitted in partial fulfillment of the requirements for the award of Degree of Bachelor of Science in Electrical and Electronic Engineering.

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MARCH, 2023

DECLARATION

I hereby declare that this thesis "**Feasibility Analysis of Solar Wind Hybrid System in Bangladesh**" represents my own work which has been done in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science In Electrical and Electronic Engineering, and has not been previously included in a thesis or dissertation submitted to this or any other institution for a degree, diploma or other qualifications. I have attempted to identify all the risks related to this research that may arise in conducting this research, obtained the relevant ethical and/or safety approval (where applicable), and acknowledged my obligations and the rights of the participants.

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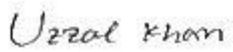

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APPROVAL

The thesis entitled **“Feasibility Analysis of Solar Wind Hybrid System in Bangladesh”** submitted by **Md. Nasim Kawsar (191-33-4903) & Uzzal Khan (191-33-4904)** has been done under my supervision and accepted as satisfactory in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical and Electronic Engineering** in **March, 2023.**

Signed

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Dedicated

To

Our

Beloved Parents

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COE	Cost of Energy
CNG	Compressed Natural Gas
DC	Direct Current
DAV	Data Access Viewer
HES	Hybrid Energy System
HRES	Hybrid Renewable Energy System
LCOE	Levelized Cost of Energy
NPC	Net Present Cost
PV	Photovoltaic Panel

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ABSTRACT

The most important and promising sector to explore for new energy sources to fulfill the expanding demand for electricity globally, particularly in a developing country like Bangladesh, has been the use of renewable energy sources. Due to their accessibility and ease of conversion into electricity, wind, and solar energy are the most often used renewable resources. Future power systems that rely on renewable energy sources like solar and wind won't need to burn fossil fuels to generate electricity. In the thesis, the feasibility study of a hybrid energy system—which makes use of both solar and wind energy—is highlighted. Performance is then evaluated using simulation. This study's primary objective is to design freestanding solar-wind hybrid systems for urban and coastal settings (three distinct places in Bangladesh, including Keraniganj, Barisal, and Cox's Bazar) and to assess their performance.

For system design and feasibility analysis, "HOMER" software was used. The HOMER application has been used to analyze the system's functionality. The program was used to measure the results of a number of performance evaluations, including feasibility, sensitivity, and economic comparisons using the Levelized Cost of Energy (LCOE), Net Present Cost (NPC), Capital Cost, and Operating Cost metrics.

The off-grid solar-wind hybrid system model that has been suggested is the most feasible, affordable, and ecologically friendly choice for the Bangladeshi areas under consideration, according to the simulation findings. Six lights, one refrigerator, four ceiling fans, and one LED TV are just a few examples of the home appliances we utilize.

Keywords: Off-grid solar wind hybrid system; Homer; Home appliances; Renewable resources; Economic comparisons.

CHAPTER 1
INTRODUCTION

1.1 Background

Renewable Energy is derived from resources that can be regenerated naturally over time and are therefore considered to be renewable energy. It is the cleanest most efficient way to generate electricity using natural sources that we'll never run out of, unlike non-renewable energy sources such as gas, coal, oil, etc. While fossil fuels are used to produce energy, including electricity and heat, a significant portion of the greenhouse gases that cover the Earth and trap solar heat is produced. With over 75% of all greenhouse gas emissions and almost 90% of all carbon dioxide emissions coming from fossil fuels like coal, oil, and gas, they are by far the biggest cause of climate change in the world. that we use mostly to generate electricity. Meanwhile, the most used renewable sources are solar radiation and wind forces. These sources are infinite and could be harnessed. The most abundant source of energy is solar energy, which may even be used under cloudy conditions. The pace at which the Earth absorbs solar energy is around 10,000 times higher than the rate at which people use energy. Solar technologies are capable of providing heat, cooling, natural lighting, electricity, and fuels for a variety of uses by converting sunlight into electrical energy through photovoltaic panels. Another Great renewable source is wind energy, Wind energy harnesses the kinetic energy of moving air by using large wind turbines located on land (onshore) or in sea or freshwater (offshore). Wind energy has been used for millennia, but onshore and offshore wind energy technologies have evolved over the last few years to maximize the electricity produced with taller turbines and larger rotor diameters. And for Bangladesh, these two could be a very good source of power generation.

Bangladesh is a heavily populated, mostly riverine nation with a total area of 147,570 sq kilometers with a 720 km (447 mi) long coastline along the northern littoral of the Bay of Bengal with a total coastal area of 47,201 km, or 32% of the country. Bangladesh is situated at a latitude of 23.6850° N and a longitude of 90.3563° E, Located at the Tropic of Cancer. The tropic of Cancer is a line in the earth's geography where the sun hits directly, meaning the most sunlight can be harnessed here. Bangladesh has a tropical monsoon climate with significant seasonal temperature, rainfall, and humidity fluctuations. Although there are some variations in the weather patterns of the northern and southern

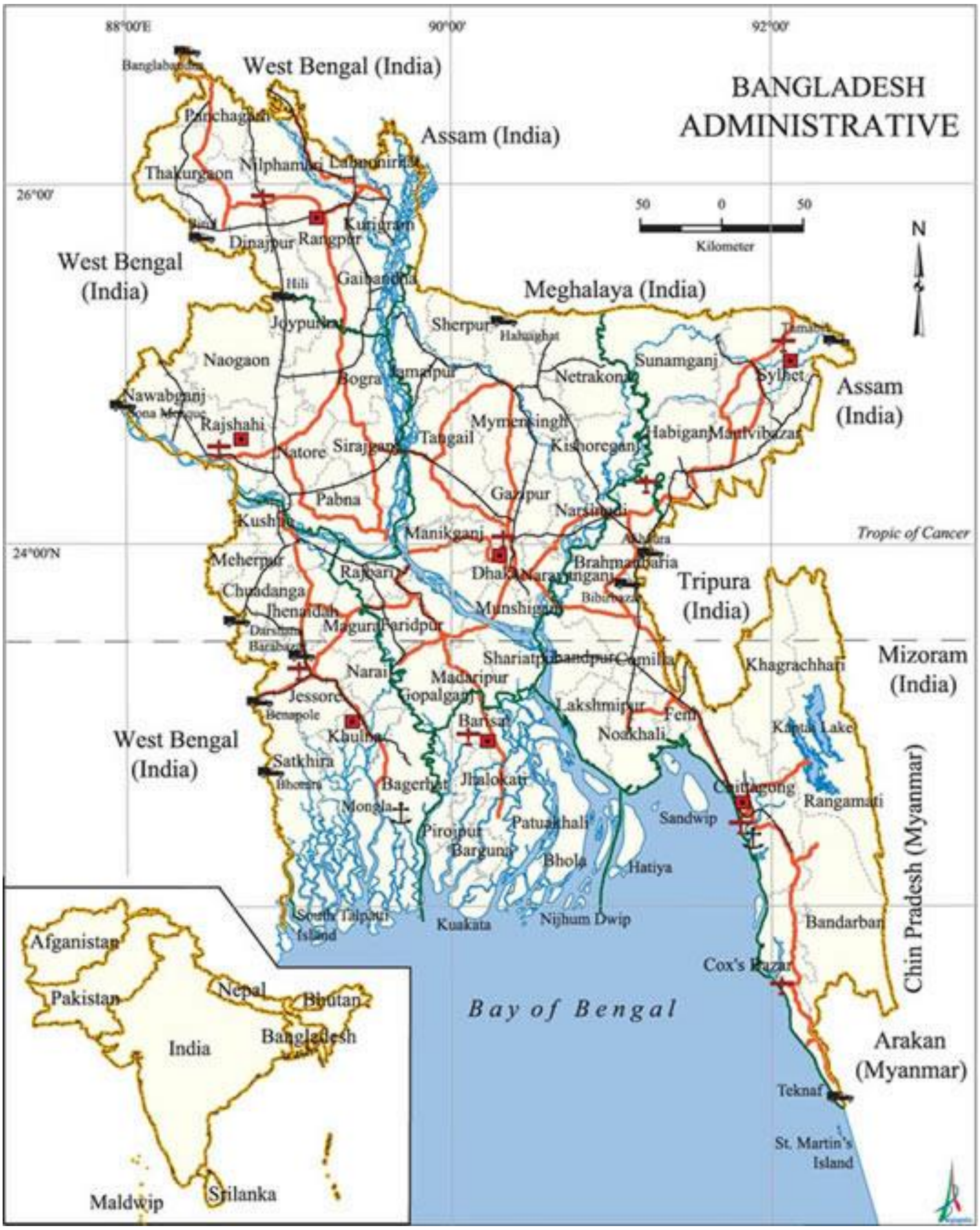

Fig 1.1 Bangladesh Map (WIKIPEDIA, 2023)

regions due to the piedmontal plains of the northern area having a Monsoon-influenced Humid subtropical climate, regional climatic variations in this flat region are modest. According to the Bangladesh Meteorological ointment, there are four seasons in Bangladesh based on temperature. The average maximum summer temperature is between 100.4 and 105.8 °F (38 to 41 °C). In the majority of the country, April is the warmest month. The coldest month is January when the average maximum and minimum temperatures are 16–20 °C (61–68 °F) during the day and 10–12 °C (50–50 °F) at night across most of the country. In the winter, winds are often out of the north and northwest, blowing at a gentle 1 to 3 kilometers per hour (0.6 to 1.9 mph) in northern and central areas, and 3 to 6 kilometers per hour (1.9 to 3.7 mph) near the coastline. Winds up to 60 km per hour are generated by strong thunderstorms from March to May. (37.3 mph). Early summer and late monsoon storms can produce powerful storms with southerly winds of more than 160 kph (99.4 mph) which makes the coastal area of Bangladesh a great place to harness wind energy at a stable rate throughout the whole year.

Bangladesh has the potential to generate a good amount of electricity from these renewable sources. Currently, Bangladesh generates 15 MW of solar energy through rural homes and 1.9 MW of wind energy in Kutubdia and Feni. The government of Bangladesh has approved 19 on-grid solar parks with a combined generation capacity of 1070 MW to be built by private entrepreneurs.

1.2 Problem Statement

In 2011, there were 79 natural gas wells in the 23 operating gas fields, which produced more than 2,000 million cubic feet (57 million cubic meters) of gas per day. It falls well short of the required 2,500 million cu ft (71 million m^3) per day, a figure that is increasing at a rate of roughly 7% per year. Natural gas, in fact, supplies more than three-quarters of the country's industrial energy demand. This key sector provides around 40% of the feedstock for power plants, 17% of industries, 15% for captive electricity, 11% for personal and household consumption, another 11% for fertilizers, 5% for compressed natural gas (CNG) operations, and 1% for commercial and agricultural applications.

Bangladesh generated a total of 22,608MW of electricity in 2022. More than half of this production comes from gas, 11,572MW or, 51.19% of the total generation. Following this,7.82% from coal, 27.77% from Heavy fuel oil power plants, 5.93% from High-speed diesel plants, 1.02% from Hydro, and 1.15% are generated from solar energy. However, 5.13% of the total capacity is imported, about 1160MW of energy. As the demand for electricity rises each year as more and more industrial power necessities are met, the import cost of oils and other finite sources rises as time goes by. Also, by generating power through fossil fuels, more and more greenhouse gasses are produced, Due to climate change in the world, we have seen many calamities happening all around, even in Bangladesh. Due to climate change, there are risks facing coastal land and territories bordering riverbanks subject to constant erosion and flooding since 2020 made a lot of people relocate their homes. If there's a way to keep climate change under control the way is to reduce the emission of greenhouse gases, by generating more power from the renewable sources available to us. Renewable sources have a much lower rate of carbon emission than fossil fuels, renewable energy is called Clean Energy for this reason. And the materials, components, and electronics used for renewable energy sources can last up to 25 years, has very low maintenance cost and the source is free and Infinite, if Bangladesh can even meet 10% of total generation through renewable energy sources, it will save millions of dollars worth of resources of our country helping Bangladesh prosper economically. Bangladesh has huge potential in solar and wind power generation. According to estimates, Bangladesh receives considerable amounts of solar radiation with 1,900 kWh/m^2 per year. Daily, this figure translates to 4 to 6.5 kWh/m^2. Also, Bangladesh has significantly more wind power potential than previously thought, especially at a hub height of 140 to 160 meters. The areas with the highest potential reach 724 km, like the coastline along the Bay of Bengal, Kuakata, Sandwip, and St. Martin.

1.3 Objectives

With the number of renewable resources available in our country, and the potential to utilize such resources to generate power, we can design a system for developing power generation through solar radiation and wind force.

The main goal of this study is to determine whether installing a solar wind hybrid system in Keraniganj, Barisal, and Cox's Bazar, Bangladesh, is feasible and will have a positive economic impact.

The objective can be segregated as:

1. Research various renewable energy sources.
2. Choosing a location for hybrid systems.
3. To create hybrid systems for the location.
4. To analyze and simulate hybrid systems.

1.4 Brief Methodology

In order to generate power, a solar-wind hybrid system in Bangladesh would combine solar panels and wind turbines. Here is a general description of the methods that could be used to put such a system into place:

1. Selection of Study Area: The population needs to obtain electricity at a reasonable cost by utilizing the area's natural resources, such as sources of solar and wind energy and the city in Bangladesh is Keraniganj, Barisal, and Cox's Bazar.
2. Access Potentials for PV and Wind Turbines: After choosing the location, we need to know the source's potential, or how many kW to use, such as PV or wind.
3. Data gathering and estimation: We will use the HOMER Pro software and Nasa Access viewer – NASA POWER to collect data.
4. Component selection: We select elements from non-renewable energy sources, such as battery storage, as well as renewable energy sources, such as solar and wind.
5. Specify the Technical Parameters: The term "Specification" also refers to the requirement that a material, design, product, or service meet certain criteria, such as lifetime, minimum load, power rating, purchase cost, replacement cost, operational management, etc.
6. Data Simulation Using HOMER: The important step is to obtain the measure once the input has been provided, and we will notice two boxes labeled Sensitivity and Optimization.
7. Construct a hybrid system: We will construct a single hybrid system with identical components for three distinct situations.
8. Determine the best HRES in terms of COE: We'll look at the COE, or cost of energy, after constructing the various examples by stating the three possible scenarios.
9. Data Validation Through Comparison: Based on our research, we plan to compare energy prices with the goal of bringing the lowest price.

1.5 Structure of the Report

Chapter 1: The problem statement, objectives, and scope of the research study are all described in this overview. The case study will serve as the foundation for the research project.

Chapter 2: represents the literature review and the fundamental research on the modeling's constituent parts.

Chapter 3: discussed the analysis and modeling requirements for the various renewable energy sources as well as the technical input parameters.

Chapter 4: Several case studies of planned power systems were discussed.

Chapter 5: Discussed impact assessment of solar wind hybrid systems such as economic, societal, and global impact, Environmental and ethical issues, Utilization of Existing Standards, and other concerns.

Chapter 6: This is covered in the summary result analysis, and we provide strong support for our proposed power system, allowing Bangladesh to explore the potential of solar PV and wind energy

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

A solar wind hybrid power production system produces electricity by combining the usage of wind turbines with solar panels. The system is intended to maximize the benefits of wind and solar energy while minimizing each source's weaknesses. In a solar wind hybrid system, solar panels provide energy while the sun is shining during the day, while wind turbines produce energy while the wind is blowing at night or on cloudy days. Batteries are used to store the electrical energy generated by the wind and solar turbines for later use. The ability to continuously produce electricity, even when the weather is unsuitable for either solar or wind energy, is one of the main advantages of solar-wind hybrid systems. As a result, they are a desirable option in areas where the weather is erratic or where there are long stretches of darkness or wind. The Solar-Wind hybrid system, which uses a techno-economic analysis methodology, the most popular method for hybrid system optimization, increases load factors and reduces maintenance and replacement costs since the components from renewable sources complement one another. For both the short- and long-term quality of people's lives, access to a reliable, secure power supply is essential. Increasing household output and maybe generating income helps break the cycle of poverty. In order to satisfy the demands of communal loads, it is also necessary to use energy resources through the combination of solar and wind energy conversion systems; these systems are known as hybrid energy systems (HES).

2.2 Related Research/ Works

In recent years, there has been a substantial amount of study and development in the solar wind hybrid power generation field. Among the major examples of study and works in this field are:

"Feasibility analysis of a solar-wind hybrid power system for a distant community in Bangladesh" by M. M. Rahman et al. (2017) This research assessed the viability of setting up a solar-wind hybrid power system in a rural Bangladeshi community. The

authors discovered that the hybrid system may offer the town a dependable and affordable supply of power.
"Performance analysis of a hybrid solar-wind energy system for rural electrification in Bangladesh" by M. M. Rahman et al. (2017) - The effectiveness of a hybrid solar-wind energy system used to electrify rural Bangladesh was examined in this study. According to the authors, the system can produce a sizable quantity of power and would be a good choice for bringing electricity to rural sections of the nation.

The feasibility of a solar-wind hybrid system for rural electricity in Bangladesh was examined in a 2012 study by M. A. Rashid et al. Based on technological, financial, and environmental factors, this study looked at whether it would be feasible to use a solar-wind hybrid system to electrify rural Bangladesh. According to scientists, a system like this may be a dependable and affordable choice for bringing power to rural regions.

For rural places in Bangladesh, a feasibility assessment of hybrid renewable energy systems has been conducted (Md. Farid Uddin et al., Renewable Energy, 2017): The viability of supplying power to rural parts of Bangladesh utilizing hybrid renewable energy systems, such as solar-wind hybrid systems, was investigated in this study. The study discovered that such systems may be a dependable and efficient way to supply power in these regions.

Renewable and Sustainable Energy Reviews, 2015, "Evaluation of a Solar-Wind Hybrid System for Rural Electrification in Bangladesh," by Md. Rashedul Islam et al. In a Bangladeshi hamlet in a rural area, the performance of a hybrid solar-wind system was examined. The wind turbine and solar panels worked together to produce more energy than each one alone, proving that the system was successful in supplying electricity to the community.
A study on the viability of employing a solar-wind hybrid system to power a rural Bangladeshi hamlet was released in 2016 by academics from the Bangladesh University of Engineering and Technology. According to the research, such a system may give the hamlet a dependable supply of power and enhance the standard of living for its inhabitants.

A small-scale solar-wind hybrid system was installed in a rural village in Bangladesh as part of a pilot project that was finished in 2018 by the International Centre for Renewable Energy and Development (ICRED). The United Nations Development

Programme (UNDP) provided funding for the initiative, which had as its goal to prove the viability and advantages of using renewable energy in Bangladesh's rural areas.

A solar-wind hybrid system was put in place in a Bangladeshi school in 2019 by the Grameen Shakti group. The technology gives the school power while minimizing its dependency on fossil fuels.

2.3 Compare and Contrast

Occasionally, these studies were carried out in Bangladesh. Some of this, however, neglects to include the fact that there are huge places that are abundant in solar radiation or have strong winds that might be utilized for increased power generation and storage. Given that this renewable energy may be purchased in greater quantities,

A solar-wind hybrid system in Bangladesh has the benefit of being able to utilize the nation's strong solar radiation as well as its high wind speeds. While wind turbines may capture wind power, solar panels can produce electricity from the sun's beams. A hybrid system can generate more power than each of these two energy sources could on its own.

Bangladesh has developed significantly in the production of renewable energy, particularly in the area of solar power. Due to its high levels of solar radiation and expanding need for electricity, the country has a large solar energy potential.

Bangladesh's government has lately made attempts to promote the expansion of solar energy through a variety of regulatory measures and initiatives. The development of hybrid solar-wind power systems is one such endeavor. In order to produce electricity, these systems combine the use of solar panels with wind turbines, providing a stable source of power in areas where there may not be enough wind or sunlight to do so.

Many companies and organizations in Bangladesh have already implemented hybrid solar-wind systems or have plans to do so. Think of this:

Grameen Shakti, a nonprofit organization, has been engaged in promoting the use of renewable energy sources in Bangladesh's rural areas. More than 200 hybrid solar-wind-producing producing stations have been installed by businesses around the country.

Since then, this technology has been used by several other local, regional, and foreign companies around the country.

According to plans made public by the Bangladeshi government, a 100 MW hybrid solar-wind power plant would be constructed in Cox's Bazar.

Even though Bangladesh's renewable energy industry is still in its early stages of development, the use of hybrid solar-wind power systems has the potential to considerably help meet the country's energy needs and lessen dependency on fossil fuels.

Globally, there is a growing trend toward the usage of solar and wind hybrid systems, which produce energy by combining the technologies of solar power and wind power. These systems may be advantageous because they lessen reliance on fossil fuels and can employ many sources of energy to provide a more dependable source of electricity.

Many nations are making investments in renewable energy sources, such as solar and wind energy, in order to lower their carbon emissions and sustainably satisfy their energy demands.

In Denmark, a hybrid power plant is one example of such a system, where solar and wind energy is mixed. Even when there is no wind or sunlight, the two technologies working together provide a constant supply of power.

Wind and solar power facilities are combined to create hybrid systems in India. The country can have a regular and dependable source of power throughout the year by integrating seasonal sources of energy like wind and solar.

In the US, solar and wind hybrid systems are also becoming increasingly popular, especially in isolated and off-grid areas where connecting to the conventional power grid can be challenging.

Overall, it is anticipated that the worldwide market for solar and wind hybrid systems would expand in the upcoming years as more nations seek to employ more renewable energy sources and lessen their reliance on fossil fuels.

2.4 Summary

The ability of solar wind hybrid systems to generate electricity continuously both during the day and at night, as well as their potential to reduce dependency on fossil fuels and greenhouse gas emissions, are some of its most important features. The need for reliable energy storage technologies, the challenges of integrating hybrid systems into existing electrical grids, and the high upfront costs of adopting hybrid systems are a few examples of barriers that might be examined in a literature review. The size and direction of the home, the amount of sunshine and wind at the site, and the size of the system needed to meet the home's electrical needs are all factors to take into account when choosing a solar wind hybrid power-producing system for a home.

The initial costs of setting up a hybrid system must also be considered, as well as any ongoing maintenance and repair expenditures. Finally, solar wind hybrid power systems can be a cost-effective solution to create energy for homes, offering a constant supply of electricity as well as the potential for lessening dependency on fossil fuels. However, these systems could demand a substantial upfront investment, so it's important to carefully consider the particular needs and expenses of a certain location and system size. Additionally, obtaining licenses and clearances and connecting the system to the electrical grid may be necessary (if desired). Despite these challenges, solar wind hybrid systems have the potential to offer a clean and renewable source of power, lowering environmental impact and promoting a more sustainable energy future.

CHAPTER 3
MATERIALS AND METHODS

3.1 Introduction

This chapter starts off by outlining the suggested approach for determining the ideal solar-wind hybrid system architecture. The best design for a solar-wind hybrid system has been identified using a technique. For the assistance of renewable energy, building energy efficiency, and agricultural demands, various relevant data have been gathered from the data access viewer-NASA POWER, which offers solar meteorological data sets from NASA research. An appropriate algorithm has been created through the collection and examination of the input parameters. The focus of the following section is on a feasibility study for solar-wind hybrid systems that would deliver power to three distinct locations in Bangladesh.

Keraniganj, Barisal, and Cox's Bazar are the three different areas of Bangladesh that are being examined. On the Buriganga River's bank, the settlement of Keraniganj is located at (23.7012° N, 90.3976° E) on the southwest side of Dhaka City. Located on the banks of the Kirtankhola river in south-central Bangladesh, the important city of Barisal is located at 22.7010° N and 90.3535° E. Cox's Bazar, on the other hand, is the most popular beach and tourist destination in Bangladesh. It is located at (21.4272° N, 92.0058° E) next to the Bay of Bengal beach and the Indian Ocean, and it has an uninterrupted 120-kilometer stretch of golden sand. It can be reached by car along the choppy water. This town is located next to Myanmar in the Chittagong Division of southern Bangladesh (Burma).

The optimal hybrid system that is both energy-efficient and renewable has been investigated using the Homer program. Electrical load (primary energy consumption), renewable resources (solar radiation, wind speed data), technical specifics of the components, pricing, restrictions, controls, etc. are some of the input data that must be provided to HOMER. The software creates the ideal arrangement to support the required electrical loads. In order to develop the best strategy, HOMER runs many simulations every hour. Prior to installing the power-producing system, economic research is crucial. This economic study is carried out by HOMER, which ranks the buildings based on their current net expense.

3.2 System Design and Components

As renewable energy technologies progress and the cost of 24 petroleum products rises, hybrid renewable energy systems (HRES) are becoming more and more common for distant region power production applications. These technologies' economic benefits make it worthwhile to incorporate them in efforts to increase the capacity of developing nations' power plants. In order to improve their performance, develop methods for precisely estimating their production, and successfully integrate them with other conventional producing sources, research and development activities in solar, wind and other renewable energy technologies must continue.

An off-grid hybrid system, which is especially helpful in distant locations, is shown in block diagram form in figure 3.1. Wind and solar power generators have been employed in the off-grid system. In order to regulate the load, batteries, and inverter and enable both DC and AC loads, a load controller is also included in the planned system.

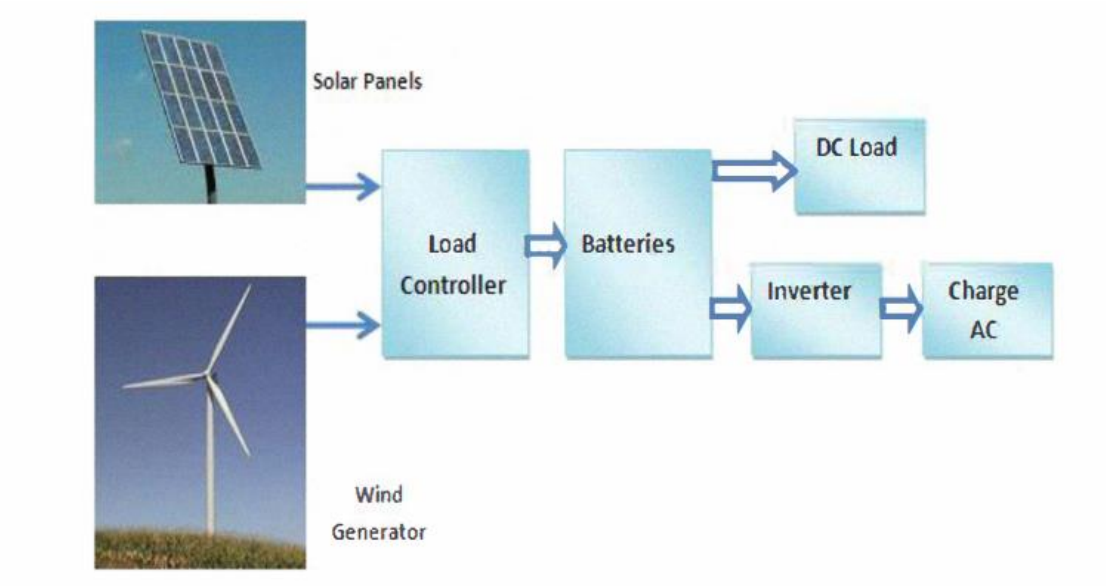

Fig 3.1 Off-grid solar wind hybrid system

Small wind turbines and photovoltaic solar panels are dependent on the environment and weather. As a result, using only solar or wind power is insufficient. If solar and wind energy is combined in one body, according to certain renewable energy experts, we will have a reliable hybrid energy source.

Wind velocity is generally low during the summer when the sun is shining brightly enough. Wind velocity is high in contrast during the winter when bright days are relatively shorter. The effectiveness of various renewable energy sources varies throughout the year. To maintain the consistency of the system's energy generation, these two systems must be supported in conjunction with one another.

A standalone solar-wind hybrid system is what is being shown. Below is a list of the parts that were utilized, each with a description:

3.2.1 Solar/ photovoltaic panel

The system's essential component is the PV module. Other names for the photovoltaic cell are photocell and solar cell. The typical photocell, also known as a solar cell or photocell, is constructed of silicon. Since silicon is a key component of sand, it is one of the most prevalent elements on Earth and is used to make most photocells. Solar energy is converted into direct current (DC) power by photovoltaic (PV) modules. The modules may be connected to each other to create a PV array, which increases both the available voltage and current by connecting the modules in series and parallel, respectively.

The needed energy consumption must be assessed in order to decide the size of PV modules. As a result, the PV module size in KWp is determined as follows:

Size of a PV module = Daily Energy Use/Insolation*Efficiency

Whereas energy consumption is measured in watts or kilowatts and insolation is measured in KWh/m2/day.

The most widely used solar technology is silicon crystalline. There are two types of panels available on the market: monocrystalline silicon panels and polycrystalline silicon panels.

a. **Monocrystalline Silicon panels:** The crystal structure of the whole sample is continuous in monocrystalline silicon panels. The use of monocrystalline silicon panels is advised when a greater voltage is desired. This would happen if DC electricity had to travel a considerable distance before being used or stored in a battery bank. Averaging 14% to 17% efficiency, these panels are also the most effective PV technology.
b. **Polycrystalline Silicon panels**: Polycrystalline Crystallites of various sizes and orientations make up silicon panels in large numbers. Monocrystalline silicon panels are more expensive per watt than polycrystalline silicon panels, which typically have efficiencies of 12% to 14%. Polar applications employ this sort of panel the most frequently.

PV: Peimar SG310MBF

The Peimar Inc. PV system has a nominal capacity of 1.52 kW. The annual production is 2,065 kWh/yr.

Rated Capacity	1.52 kW	Total Production	2,065 kW
Capital Cost	$988.69	Maintenance Cost	30.4 $/yr
Specific Yield	1,357 kWh/kW	LCOE	0.0503 $/kWh
PV Penetration	94.0 %		

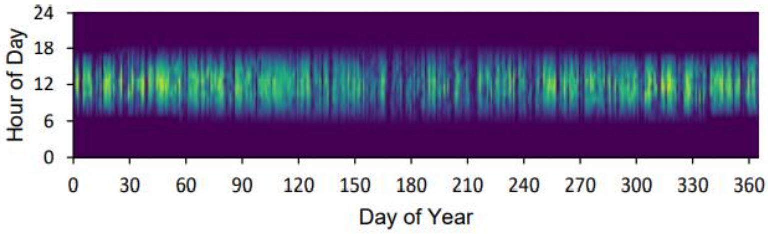

Fig 3.2 Solar output day of the year

Peimar SG310MBF has been employed in this project; its PV penetration is 94.0% and its annual maintenance cost is 30.4 $/yr.

3.2.2 Wind Turbine

Electricity is produced by wind turbines using the force of the wind. Without any emissions or greenhouse gases during operation, wind power generates energy. Numerous separate wind turbines connected to electrical transmission cables make up wind farms. The majority of wind turbines have three blades and are mounted on a tubular tower, which frequently has the ability to spin toward the direction of the wind. Onshore or offshore wind farms are also possible. In order to be competitive with electricity generation that burns fossil fuels, onshore wind farms need a lot of turbines, which are typically between 80 and 300 feet tall. They also need a lot of land and space. Many former farmers lease their property to corporations so that they may build wind turbines on it. Turbines are a part of offshore wind farms.

For this project, an AWS HC 1.5kW wind turbine with a hub height of 35 m and a 20-year lifespan was chosen.

Wind Turbine: AWS HC 1.5kW Wind Turbine

Power output from the AWS wind turbine system, rated at 1.50 kW, is 2,334 kWh/yr.

Quantity	1
Wind Turbine Total Production	2,334 kWh/yr
Capital Cost	$3,000
Wind Turbine Lifetime	20.0 years

Rated Capacity	1.50 kW
Hours of Operation	7,206 hrs/yr
Maintenance Cost	100 $/yr

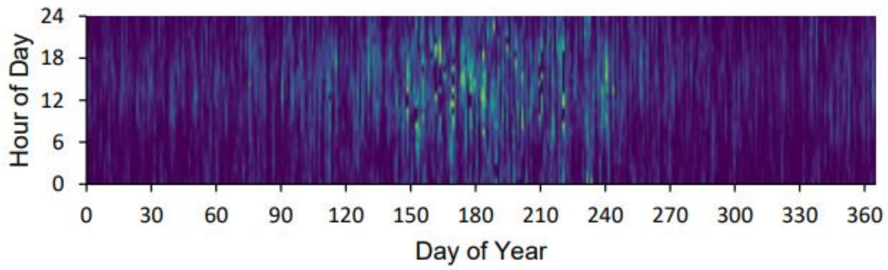

Fig 3.3 Wind turbine output of day of the year

3.2.3 Battery

Because of their affordability and simplicity, lead acid batteries are the most used kind of energy storage in PV systems. Based on the chemical reactions of lead sulphuric acid, they are. They have developed into two sets of 6V and 12V batteries in durable plastic containers with capacities of up to 200Ah and bigger sizes of 2V battery bank cells, ranging from around 100 Ah to several thousand Ah.

Storage: Trojan SSIG 12 145

The Trojan Battery Company storage system's nominal capacity is 10.5 kWh. The annual throughput is 719 kWh/yr.

Rated Capacity	10.5 kWh
Annual Throughput	719 kWh/yr
Maintenance Cost	120 $/yr
Autonomy	33.5 hr

Expected Life	4.05 yr
Capital Costs	$1,500
Losses	161 kWh/yr

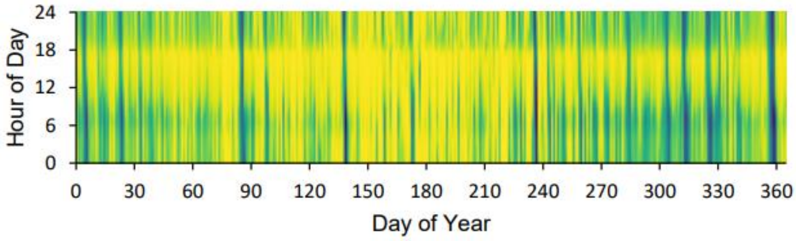

Fig 3.4 Battery output day of the year

3.2.4 Converter

A device known as an inverter transforms DC electricity from the battery bank into AC power for various loads. It could be feasible to do away with this component entirely in smaller PV systems. An inverter must be used in bigger systems with components that require AC power. Additionally, an inverter enables an effective method of delivering electricity to the point of use if the instrument site is some distance from the power generating site. Alternating current, which is now the accepted modern electrical standard since it is easier to carry across vast distances.

Inverters may be divided into two basic groups: synchronous and static or standalone. Synchronous inverters can be connected to utility electricity or the electrical grid. Static inverters are the kind that is most frequently utilized for remote PV applications since they are made for autonomous, utility-free power systems.

Converter: Studer AJ 700-48

Capacity	1.11 kW	Hours of Operation	8,760 hrs/yr
Mean Output	0.251 kW	Energy Out	2,197 kWh/yr
Minimum Output	0.00995 kW	Energy In	2,337 kWh/yr
Maximum Output	1.11 kW	Losses	140 kWh/yr
Capacity Factor	22.6 %		

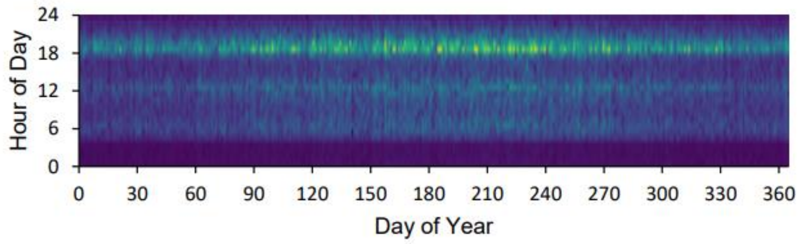

Fig 3.5 Converter output day of the year

In this project, Studer AJ 700-48 was used; its Capacity Factor is 22.6% and its Minimum and Maximum output are 0.00995 kW and 1.11 kW.

3.3 Modeling of solar wind hybrid system

Combinations of several technologies are used to create power using hybrid systems. A solar array and a wind turbine are two types of hybrid energy systems. As a result, the wind turbine would produce higher output during the winter, while the solar panels would provide their maximum production during the summer. In comparison to stand-alone wind, solar, geothermal, or trigeneration systems, hybrid energy systems frequently produce superior economic and environmental benefits. Such a hybrid system's power generation is more stable and less variable than either of its two component subsystems. In order to improve their performance, develop methods for precisely forecasting their production, and successfully integrate them with other conventional producing sources, research and development activities in solar, wind and other renewable energy technologies must continue.

3.3.1 Block diagram of solar wind hybrid system

The schematic block diagram of a full solar-wind hybrid energy system is based on Figure 3.6. The components of a hybrid energy system include a wind turbine, solar (PV) panels, load demand, batteries, and a converter to convert dc to ac electricity.

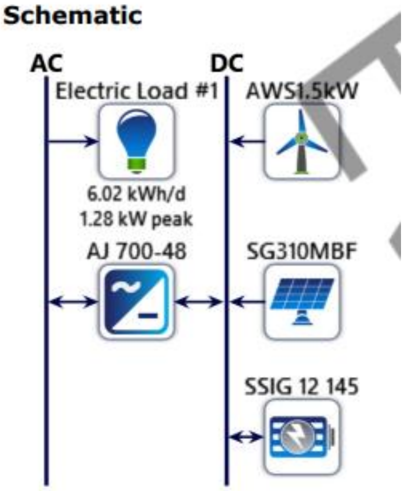

Fig 3.6 Schematic block diagram of a solar wind hybrid system

3.3.2 Load Profile

The best hybrid combination of all renewable energy systems combines a standalone wind system with a solar photovoltaic system, which can handle seasonal variations and is suited for the majority of applications. In this study, we assume that lower-class and higher-class families make up the same portion of the residential load for single-family homes in the Keraniganj, Barisal, and Cox's Bazar areas. We use this load for home appliances like lights, refrigerators, ceiling fans, and LED TVs, and the rate at which such equipment is lit up. For one LED TV, one refrigerator, four ceiling fans, and six lights, the power requirements are 180W, 50W, 320W, and 100W, respectively.

Table 3.1 Electrical consumption of popular electronic consumer products in a typical house.

Name of appliances	Watts(W)	No	Total Watts	No of Hours	Energy(Total Watts*No of hours)
Light	30	6	180	6	1080 Wh
Ceiling fan	80	4	320	12	3840 Wh
refrigerator	100	1	100	8	800 Wh
LED TV	50	1	50	5	300 Wh

The daily consumption of a single house is 6.02 kWh.

The cost of system dependability was examined using a sensitivity analysis for the greatest yearly capacity deficit. Normally, sensitivity assessments are performed to evaluate the significance and impact of a certain system parameter.

The goal was to demonstrate how the cost of power fluctuates for various degrees of the permitted capacity shortfall. It seems to reason that if 100% of the load needs to be met, the energy system will cost more. The system must be oversized to accommodate more capacity than is typically needed in order to prevent any capacity shortages throughout the year. How much users must pay can be determined by performing a sensitivity analysis of the capacity shortage of the system.

3.4 System Analysis

Due to the country's abundance of both solar and wind resources, solar-wind hybrid systems may be a viable option for Bangladesh in terms of power production. In rural locations with sporadic or nonexistent access to the electrical grid, these devices may be very well suited.

A system analysis of a solar-wind hybrid system in Bangladesh would need to take into account a number of variables, such as the quantity and quality of solar and wind resources at the proposed site, the kind and size of the equipment that will be used, and the intended use of the electricity produced. The price of buying and installing the equipment, the accessibility of competent labor for maintenance and repair, and the legal and policy framework for renewable energy in Bangladesh are additional variables that may need to be taken into account.

The environmental effects of the solar-wind hybrid system, including any potential effects on land use, wildlife, and water resources, would also need to be taken into account. It might also be required to evaluate the system's social and economic effects, including any potential advantages for nearby towns.

To establish the practicality and feasibility of a solar-wind hybrid system in Bangladesh, a full system analysis is required. Order to examine the costs, advantages, and risks related to the system, would entail collecting and evaluating a variety of data and information as well as employing tools and techniques including financial modeling and lifecycle assessment.

3.4.1 Solar energy resources in Keraniganj

The information in table 3.2 was gathered from the NASA POWER Data Access Viewer (DAV). As Keraniganj is situated in the Dhaka district, solar radiation should most likely be in the range of 3-6 kWh/m2/day. This indicates that it has the capacity to produce a substantial amount of electricity using solar energy. Additionally, the government and commercial sectors have been concentrating on creating solar energy systems in Keraniganj and other locations in Bangladesh due to the growing population and energy demand.

Table 3.2 Solar resources in Keraniganj

Month	Clearness Index	Daily Radiation (kwh/m2 /day)
January	0.47	3.26
February	0.55	4.51
march	0.54	5.11
April	0.56	5.87
May	0.49	5.38
June	0.34	3.78
July	0.38	4.25
August	0.41	4.27
September	0.47	4.59
October	0.52	4.34
November	0.56	4.04
December	0.52	3.41

The annual average solar radiation (for inclined panels) is 4.4 kWh/m2/day.

Bangladesh has intense sunshine all year round (3.8-6.42 Kw-hr/m 2), and it has been determined that the average sunshine hours in the winter, summer, and monsoon seasons are 6.69, 6.16, and 4.81, respectively.

We utilized Data Access Viewer-NASA POWER and Solar Energy to obtain monthly average global radiation data for Fig. 3.7. The average monthly amount of worldwide horizontal radiation has been measured for a year. The table provides a monthly summary of the solar statistics (for tilted PV panels) and the clarity index.

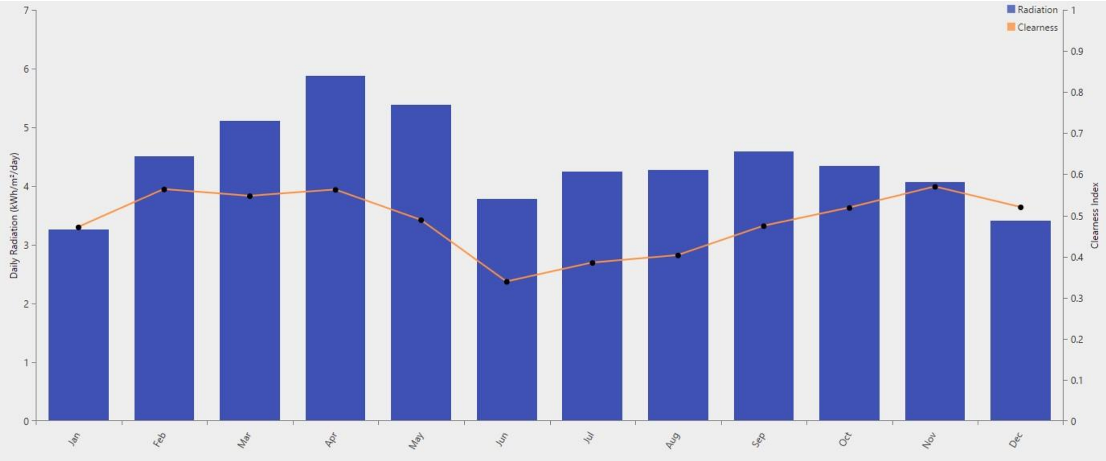

Fig 3.7 Solar Radiation Data Throughout the year

3.4.2 Temperature data in Keraniganj

Table 3.3 Monthly average temperature data for Keraniganj

Month	Daily average temperature (°C)
January	17.06
February	20.35
March	28.23
April	31.68
May	29.9
June	28.3
July	28.62
August	28.44
September	27.85
October	26.6

November	20.86
December	18.12
Annual Average (°C)	25.52

The data table 3.3 were collected from the Data Access Viewer – NASA POWER, which shows the monthly average temperature data in Keraniganj, Dhaka.

As we can see in fig 3.8, In Keraniganj has an annual average temperature of 25.52. The months of May and April is the highest temperature for the whole year. January, February, and December is the lowest temperature. On the other hand June, July, August, and September is the lowest temperature in Keraniganj.

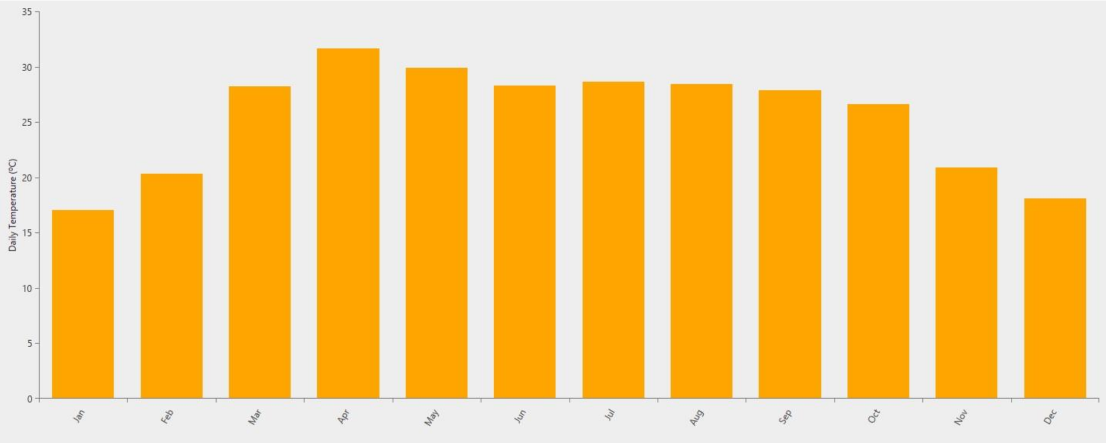

Fig 3.8: Monthly average temperature data for Keraniganj

3.4.3 Wind Energy Resources in Keraniganj

In Keraniganj, the maximum wind speed is around 8 m/s, while the average wind speed is 2.5 m/s. The average ambient temperature, which can vary from 7.3°C to 34.2°C, is 24.3°C. With a range of 25.7% to 99.8% and an average of about 80.6%, the relative humidity is variable. The average station pressure is 1020 hPa, with a pressure range of 1008 to 991 hPa. According to Keraniganj's wind rose, 14.56% of all wind directions are in the SSE. Although wind speeds in the Dhaka region vary seasonally, they are generally strong enough to provide wind-generated electricity, according to a NASA data study.

Table 3.4: Monthly Average wind speed data in Keraniganj

Month	Average wind speed(m/s)

January	3.22
February	3.4
March	3.7
April	4.41
May	4.8
June	6.15
July	5.76
August	5.43
September	3.98
October	3.22
November	2.88
December	3.55
Annual Average(m/s)	4.21

In table 3.3, According to the data from Data access viewer-NASA POWER and Solar Energy, the yearly average wind speed at Keraniganj is 4.21 m/s with a maximum speed of 6.15 m/s in June and a minimum speed of 2.88 m/s at November.

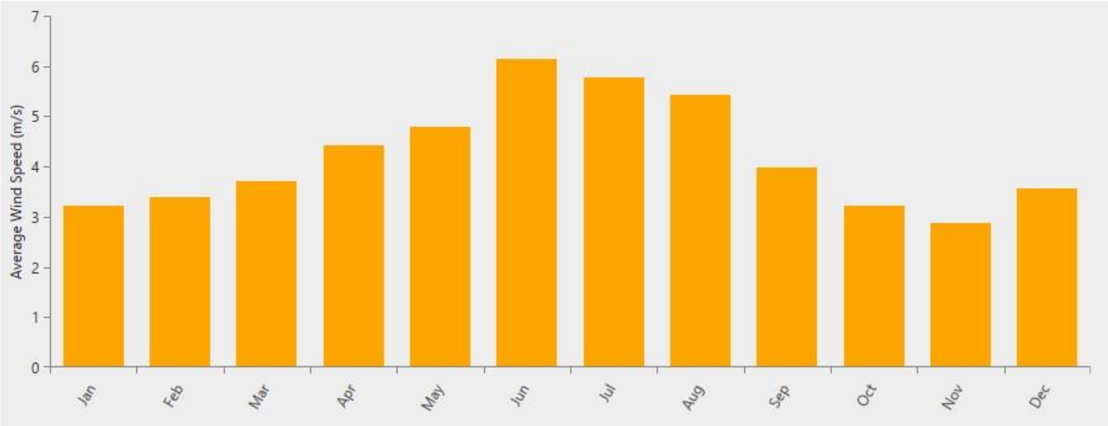

Fig 3.9 Average wind speed at Keraniganj throughout the year

In fig 3.9, we have the monthly average wind speed in Keraniganj, according to the figure, we can see the months of June, July, and August are very high speeds.

3.4.4 Solar Energy Resources in Barisal

Bangladesh is ideally situated for solar energy harvesting, being between 20.30 and 26.38 North latitude and 88.04 and 92.44 East longitude. According to the radiation statistics, Bangladesh experiences daily solar radiation that ranges from 4 to 6.5 kWh/m2 [41]. This high solar potential suggests that Bangladesh can electrify the majority of its territory, especially in the north, by deploying solar power systems**.**

Table 3.5 Solar resources in Barisal

Month	Clearness Index	Daily Radiation (kWh/m2 /day)
January	0.51	3.62
February	0.57	4.70
March	0.53	5.06
April	0.58	6.04
May	0.5	5.47
June	0.31	3.47
July	0.38	4.14
August	0.38	3.99
September	0.43	4.19
October	0.52	4.42
November	0.59	4.32
December	0.53	3.56

The resource data were extracted from the Data Access Viewer-NASA POWER and Solar Energy as for the case of Barisal. The clearness index and daily radiation in Barisal are displayed in Figure 3.10.

Locations within the Barisal area may experience different levels of solar radiation, and other variables like air pollution, height, cloud cover, and climatic conditions may also have an impact. Barisal is situated in the south-central region of the nation, where solar radiation is often greater, therefore it should have quite high levels of solar radiation there.

Fig 3.10 Solar Radiation Data Throughout the year

3.4.5 Temperature data in Barisal

The average temperature in Barisal is shown for all months of the year in Figure 3.11

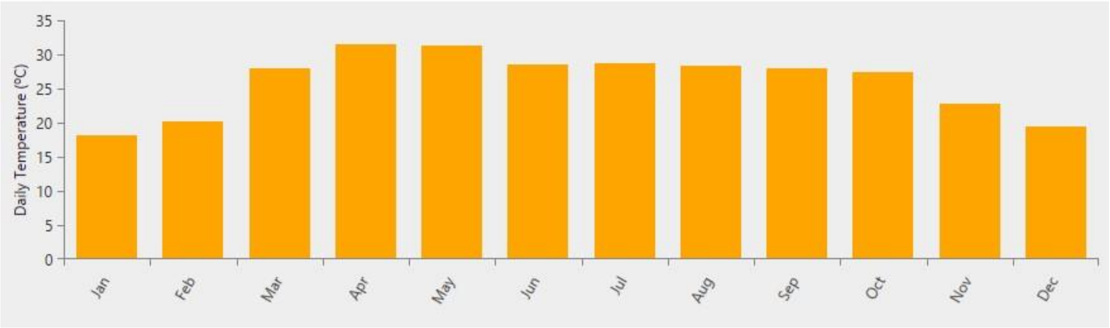

Fig 3.11: Monthly average temperature data for Barisal

As we can see in fig 3.11, In Barisal has an annual average temperature of 26.03. The months of March and April is the highest temperature for the whole year. January, February, and December have the lowest temperatures. On the other hand, July August, and June is the medium temperature in Barisal.

3.4.6 Wind Energy Resources in Barisal

The coastal region of Bangladesh is best suited for the generation of green energy since the climate there is ideal for gathering green energy. Here, there is a strong wind flow that originates from the Indian Ocean during the majority of each month of the year. Bangladesh is affected by this wind from March to September. The average monthly wind speed in Bangladesh, according to the meteorological bureau, ranges from 3 m/s to 8.3 m/s. From April to September, the wind blows strongly, and from October to February, the wind blows very little. The months of June and July experience the highest wind speeds. Figure 3.12 displays the annual average wind speed for each month at Barisal.

Fig 3.12 Average wind speed at Barisal

3.4.7 Solar energy resources in Cox's Bazar

Cox's Bazar is a seaside city close to the Myanmar border in southeast Bangladesh. Cox's Bazar's solar resources will be influenced by a variety of elements, including its location, seasonal weather, and regional terrain.

Cox's Bazar often receives a lot of solar radiation because of its proximity to the equator. The city experiences a tropical monsoon environment with high temperatures and humidity throughout the year, and typical solar radiation levels range from 4-6 kWh/m2/day. However, due to monsoon clouds and heavy rains, which can restrict the quantity of solar radiation reaching the ground, solar radiation levels might change depending on the season and weather.

These numbers were taken from NASA's Surface Meteorology and Solar Energy database. From January 2021 through December 2021, monthly averaged values were used to estimate the solar GHI data from this source. Figure 3.13 shows the clearness index and daily radiation for the Cox's Bazar location in kWh/m2/day**.**

Fig 3.13 Solar Radiation Data Throughout the year

3.4.8 Temperature data in Cox's Bazar

The average temperature in Barisal is shown for all months of the year in Figure 3.14

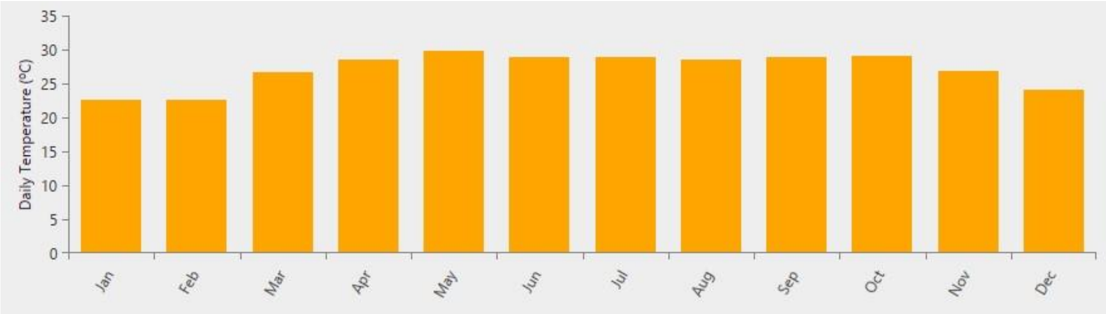

Fig 3.14 Temperature data in Cox's Bazar

As we can see in fig 3.14, In Cox's Bazar has an annual average temperature of 27.14. The months of May and April is the highest temperature for the whole year. January, February, and December have the lowest temperature. On the other hand, June to October is the medium temperature in Cox's Bazar.

3.4.9 Wind Energy Resources in Cox's Bazar

Since wind resource data, particularly wind speed data at a given height, are not easily accessible, it is extremely difficult to estimate the wind data that is closest to real data. The Bangladesh Meteorological Department set up 20 monitoring stations to gather information on the availability of wind resources. According to the previous study, Bangladesh's wind speed statistics are only sparsely available outside of the coastal region. The Bangladeshi meteorological agency estimates that Cox's Bazar has an average monthly wind speed of between 4 and 8.5 m/s. In contrast to the other months of the year, when wind speed is sometimes quite low, wind speed is at its maximum from June through September. The months of July and August have the highest wind speeds. Figure 3.15 shows the monthly average wind speed around the year at Cox's Bazar.

Since wind speeds are often higher at higher elevations, a wind turbine erected on a hill or mountain would likely be able to produce more power than one put at sea level. Additionally, because Cox's Bazar's shore is located in the Bay of Bengal, typhoons and storm surges can affect it during the monsoon season. High winds may result from these circumstances, which may be used to generate wind energy.

Fig 3.15 Average wind speed at Cox’s Bazar

3.5 Simulation Results by using Homer Pro Software

The lowest cost of energy was what we were aiming for.

In this project, the COE for Keraniganj, Barisal, and Cox's Bazar is 0.493, 0.469, and 0.476, respectively, which is excellent. The project is also practical because the NPC for each location is $14,008, $13,309, and $13,514, respectively.

The COE is just the typical price per kWh of electricity.

NPC: Represent the system life-cycle cost.

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

Architecture					Cost				System		SG310MBF		AWS1.5kW			SSIG 12 145			
SG310MBF (kW)	AWS1.5kW	SSIG 12 145	AJ 700-48 (kW)	Dispatch	NPC ($)	COE ($)	Operating cost ($/yr)	Initial capital ($)	Ren Frac (%)	Total Fuel (L/yr)	Capital Cost ($)	Production (kWh/yr)	Capital Cost ($)	Production (kWh/yr)	O&M Cost ($)	Autonomy (hr)	Annual Throughput (kWh/yr)	Nominal Capacity (kWh)	Usable Nominal C (kWh)
1.52	1	6	1.11	CC	$14,008	$0.493	$633.18	$5,822	100	0	989	2,065	3,000	2,334	100	33.5	719	10.5	8.40
5.58		11	1.26	CC	$18,814	$0.663	$933.09	$6,751	100	0	3,625	7,570				61.4	1,307	19.3	15.4
	3	20	1.33	CC	$26,802	$0.944	$959.34	$14,400	100	0			9,000	7,002	300	112	601	35.0	28.0

Fig 3.16 Optimization results for Keraniganj

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

Architecture					Cost				System		SG310MBF		AWS1.5kW	
SG310MBF (kW)	AWS1.5kW	SSIG 12 145	AJ 700-48 (kW)	Dispatch	NPC ($)	COE ($)	Operating cost ($/yr)	Initial capital ($)	Ren Frac (%)	Total Fuel (L/yr)	Capital Cost ($)	Production (kWh/yr)	Capital Cost ($)	Product (kWh/
1.08	1	6	1.22	CC	$13,309	$0.469	$598.79	$5,569	100	0	704	1,471	3,000	2,773
	2	10	1.16	CC	$18,408	$0.648	$739.59	$8,847	100	0			6,000	5,547
5.48		12	1.29	CC	$19,174	$0.675	$945.65	$6,949	100	0	3,562	7,446		

Fig 3.17 Optimization results for Barisal

Export...

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

Categorized Overall

Architecture					Cost				System		SG310MBF		AWS1.5kW	
SG310MBF (kW)	AWS1.5kW	SSIG 12 145	AJ 700-48 (kW)	Dispatch	NPC ($)	COE ($)	Operating cost ($/yr)	Initial capital ($)	Ren Frac (%)	Total Fuel (L/yr)	Capital Cost ($)	Production (kWh/yr)	Capital Cost ($)	Product (kWh/
1.50	1	6	1.20	CC	$13,514	$0.476	$593.90	$5,836	100	0	976	2,233	3,000	2,735
5.90		11	1.21	CC	$18,969	$0.668	$929.99	$6,946	100	0	3,833	8,771		
	2	15	1.38	CC	$20,654	$0.728	$811.47	$10,164	100	0			6,000	5,469

Fig 3.18 Optimization results for Cox’s Bazar

3.6 Summary

A flowchart of the suggested technique is shown in this chapter. The processes for obtaining a cost-effective solution are presented. The load demand is computed once a comparative examination of three distinct RE sources is completed. It can be seen that solar energy and wind energy both predominate in Keraniganj, Barisal, and Cos’s Bazar. The suggested model's equipment requirements and price are detailed. Finally, a software program called HOMER was used to create the suggested model.

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 Introduction

Results of the suggested solar-wind hybrid system for Keraniganj, Barisal, and Cox's Bazar are provided in this chapter. This chapter displays the detailed simulation findings for three regions. The analysis's results have been compiled and graphically displayed. Finally, a quick comparison of the tabulated data has been done for the suggested model based on COE, NPC, the proportion of a renewable fraction, the total contribution of RE on a grid system, total annualized cost, and greenhouse gas emission. The investigations' findings are presented in the manner that follows.

4.2 Optimum Results for Keraniganj

Analyses have been carried out by adjusting the number of wind turbines and PV modules for off-grid mode in order to choose the ideal combination of solar and wind components. Here is the first solar and wind hybrid model ever created. PV (1.52 kW), wind (1.50 kW), battery storage (10.5 KWh), and inverter (1.1 kW) model part specifications are shown in Fig. 4.1.

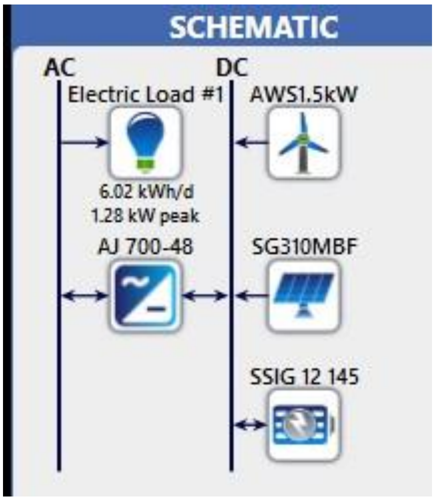

Fig 4.1 Hybrid model using solar and wind for Keraniganj

4.2.1 Electrical production

The average electricity generation from the PV and wind systems is shown in Fig. 4.2. PV accounts for 46.9% (2065 kWh/year) and wind turbines for 53.1% (2334 kWh/year) of the contribution. For the production of electricity over a 12-month period

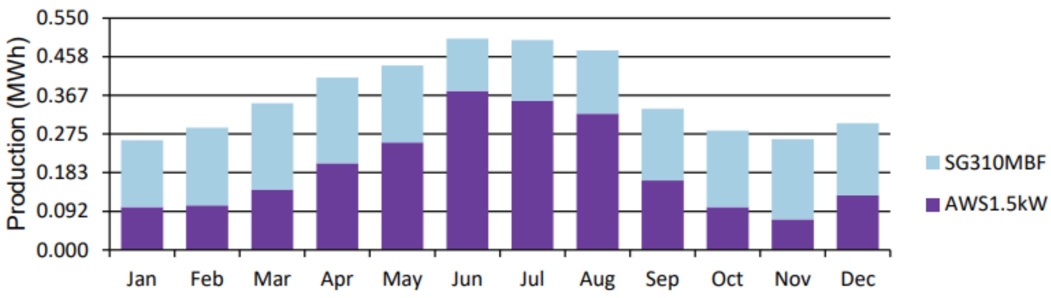

Fig 4.2 Electrical production from Homer for Keraniganj

4.2.2 Total electricity production by PV and Wind

Table 4.1 illustrates how each source component's output is defined as contributing to the production of electricity. PV makes up 46.9% (2065 kWh/year) and wind turbines make up 53.1% (2334 kWh/year) of the contribution to the generation of energy in a year.

Table 4.1 The sum of the annual contribution of electricity generation

Production	Kwh/yr	%
Peimar SG310MBF	2065	46.9
Wind turbine	2334	53.1
Total	4399	100

4.2.3 Capacity shortage

This section of table 4.2 displays According to the table, the system runs out of power at 2.09 kWh per year, while the surplus electricity from the other hands is used up at 1,903 kWh per year, resulting in a 0.491 kWh unmet electrical load.

Table 4.2: Amount of Unserved Load

Quantity Electricity	kWh/yr	%
Excess Electricity	1,903	43.3

Unmet Electric Load	0.491	0.0224
Capacity Shortage	2.09	0.0953

4.2.4 Cash Flow

This fig. 4.3, both a and b, demonstrate that the highest cost of cash flow was the initial cost of capital, which was estimated to be about $6000 under the framework. Establishment requires an initial cost higher than the cost of operation, salvage, in this case, the replacement of the hybrid system configuration.

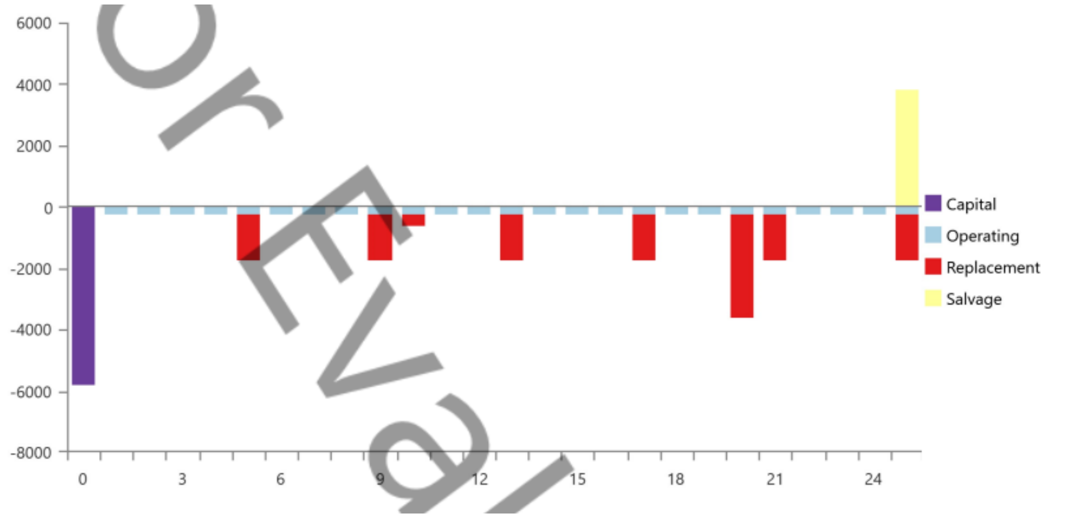

Fig 4.3 Cash flow from Homer for Keraniganj(a)

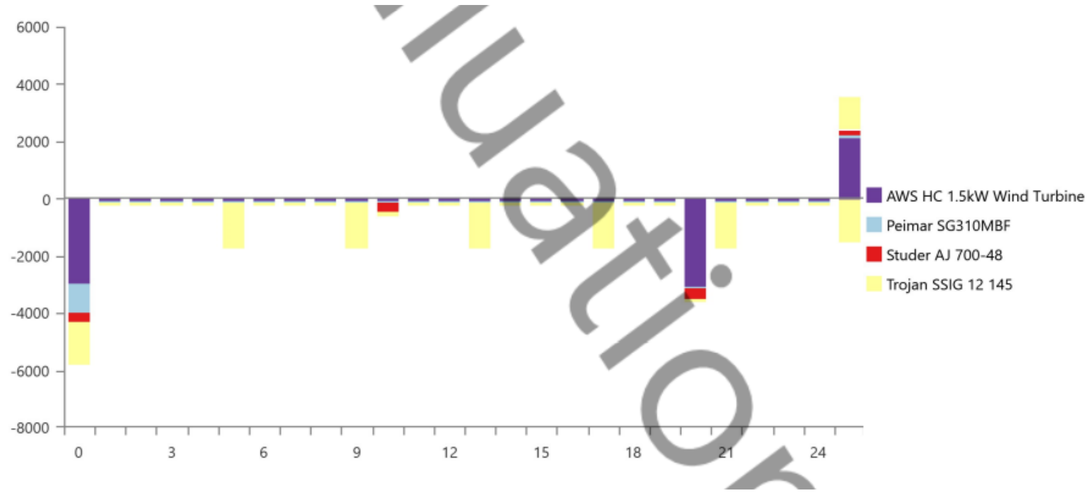

Fig 4.3 Cash flow from Homer for Keraniganj(b)

4.2.5 Cost summary

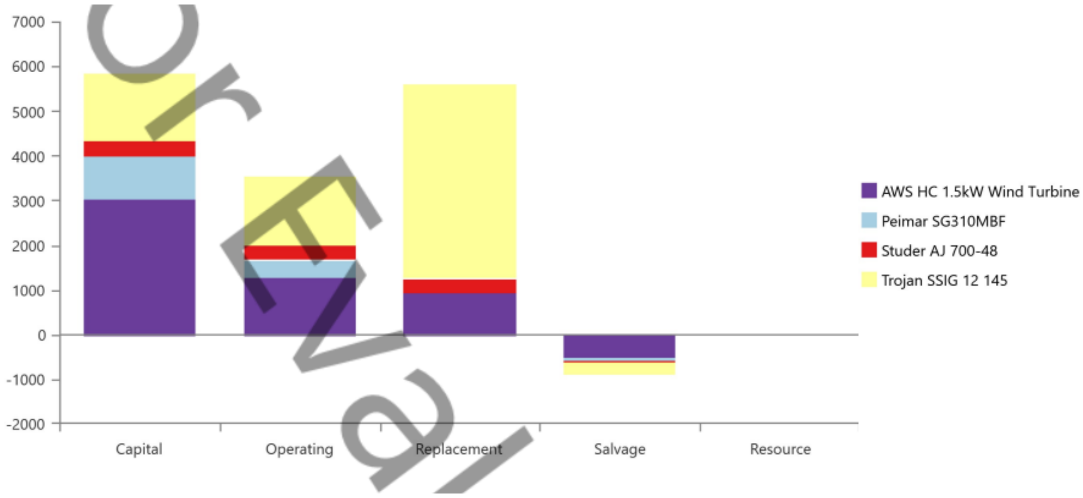

Fig 4.4 Cost Summary of Keraniganj

The cost overview of the complete system is shown in Fig. 4.4. To calculate the included cost of each component, the Net Present Cost (NPC), which depicts the system's life cycle, is used. The total NPC consolidates all expenses and revenues that arise during the course of the project.

The capital expenses, replacement costs, operational and maintenance costs, and salvage are all covered in this cost overview. The price of the generator is primarily made up of the capital cost, which is effectively the running cost. It is clear from the aforementioned statistic that our custom-built technology accounts for the majority of installation costs.

4.2.6 Cost of energy of Keraniganj

We obtained the results required by Homer Output from fig. 4.5.

Net current cost: $14,007.52

Operating Cost: $633.18

Price per unit: $0.4932

Fig 4.5 Cost of the energy of Keraniganj

4.3 Optimum Results for Barisal

In order to select the best mix of solar and wind components, analyses have been done by altering the number of wind turbines and PV modules for off-grid mode. Here is the first hybrid model of solar and wind energy ever made. The model part parameters for the PV (1.08 kW), wind (1.50 kW), battery storage (10.5 KWh), and inverter (1.22 kW) are displayed in Fig. 4.6

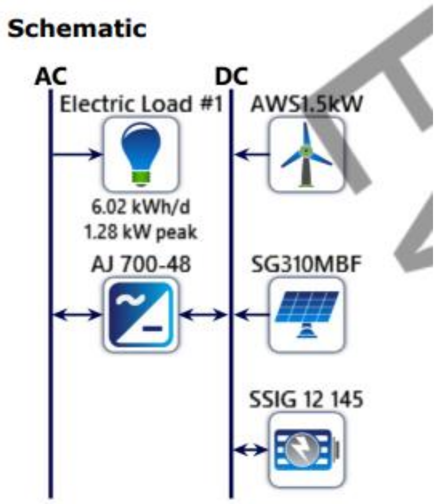

Fig 4.6 Hybrid model using solar and wind for Barisal

4.3.1 Electrical production

Figure 4.7 displays the average monthly contribution from the PV and wind systems. PV accounts for 34.7% (1,471 kWh/year) of the wind turbine's 65.3%. (2773 kWh/year) of the contribution. (Renewable fraction) for the production of electricity over a 12-month period

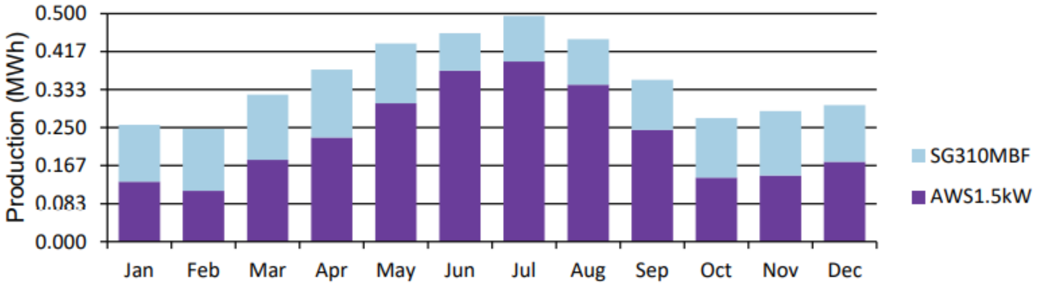

Fig 4.7 Electrical production from Homer for Barisal

4.3.2 Total electricity production by PV and Wind

Table 4.3 displays the output of each source component as it relates to their contribution to the production of electricity. The contribution (Renewable fraction) for the generation of energy in a year was made up of 34.7% (1471 kWh/yr) from PV, and 65.3% (2773 kWh/yr) from the wind.

Table 4.3 The sum of the annual contribution of electricity generation

Production	Kwh/yr	%
Peimar SG310MBF	1471	34.7
Wind turbine	2773	65.3
Total	4244	100

4.3.3 Capacity shortage

In this section Table 4.4, it is shown. The table shows that the system runs out of power at a rate of 2.19 kWh per year, but the extra electricity generated by the other hands is only used up at a rate of 1761 kWh per year, leaving a 0.737 kWh per year unmet electrical load.

Table 4.4: Amount of Unserved Load

Quantity Electricity	kWh/yr	%
Excess Electricity	1761	41.5
Unmet Electric Load	0.737	0.0335
Capacity Shortage	2.19	0.0998

4.3.4 Cash Flow

This fig. 4.8, both parts a and b, demonstrate that the biggest cost of cash flow was the initial cost of capital, which was expected to be around $6000 according to the framework. Compared to the cost of operation, salvage, and maintenance, establishment requires a greater initial outlay. In this instance, the hybrid system configuration was changed

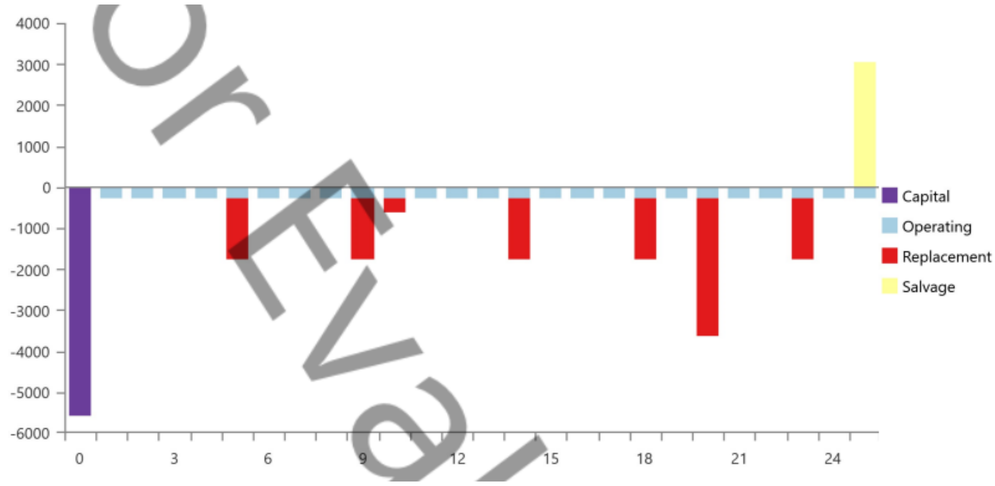

Fig 4.8 Cash flow from homer for Barisal(a)

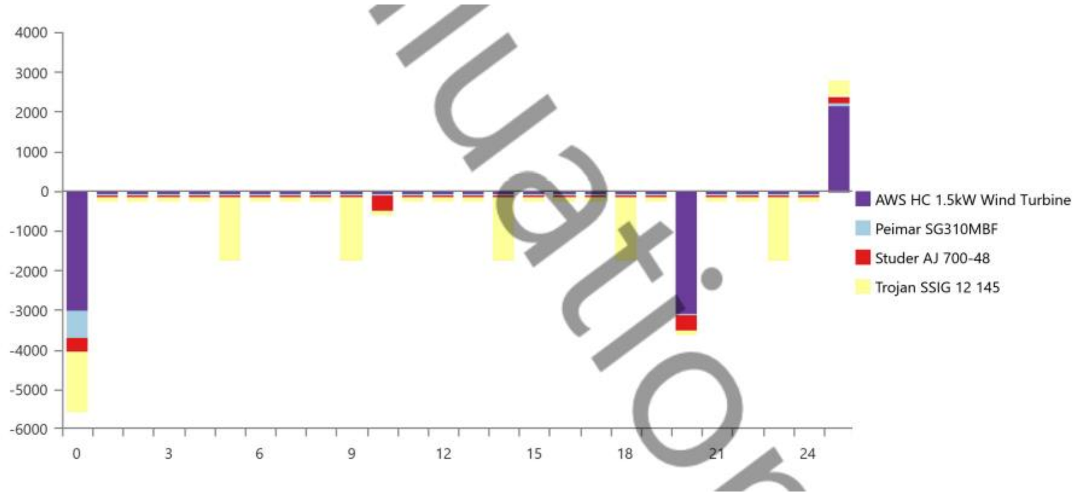

Fig 4.8 Cash flow from homer for Barisal(b)

4.3.5 Cost summary

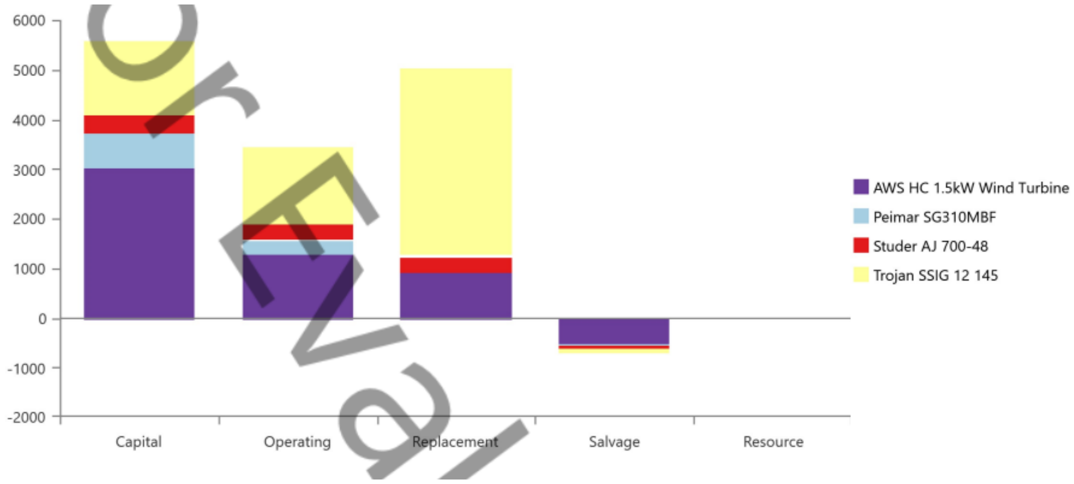

Fig 4.9 Cost summary of Barisal

According to Fig. 4.9, the price of solar energy is $703.50, while the price of wind energy is $3000. The second-highest price is roughly $1500 for battery storage made of Li-loan

4.3.6 Cost of the energy of Barisal

We obtained the results required by Homer Output from fig. 4.10.

Net current cost: $13,309.42

Operating Cost: $598.79

Price per unit: $0.4687

Fig 4.10 Cost of the energy of Barisal

4.4 **Optimum Results for Cox's Bazar**

In order to select the best mix of solar and wind components, analyses have been performed by altering the number of wind turbines and PV modules for off-grid mode. The first hybrid model of solar and wind energy is shown here. The specs for the PV (1.50 kW), wind (1.50 kW), battery storage (10.50 KWh), and inverter (1.20 kW) model parts are displayed in Fig. 4.11

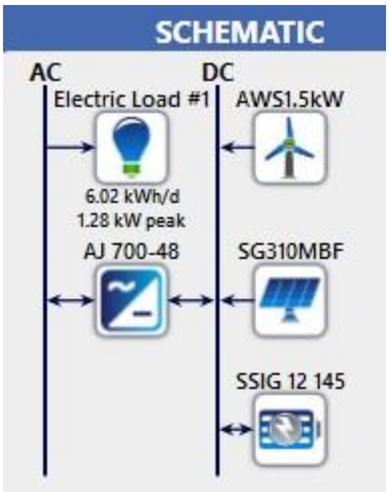

Fig 4.11 Hybrid model using solar and wind for Cox's Bazar

4.4.1 Electrical production

Fig. 4.12 displays the typical PV and wind systems electricity. In terms of contribution, PV contributes for 44.9% (2233 kWh/year) and wind turbines 55.1% (2735 kWh/year). for the generation of electricity over a year

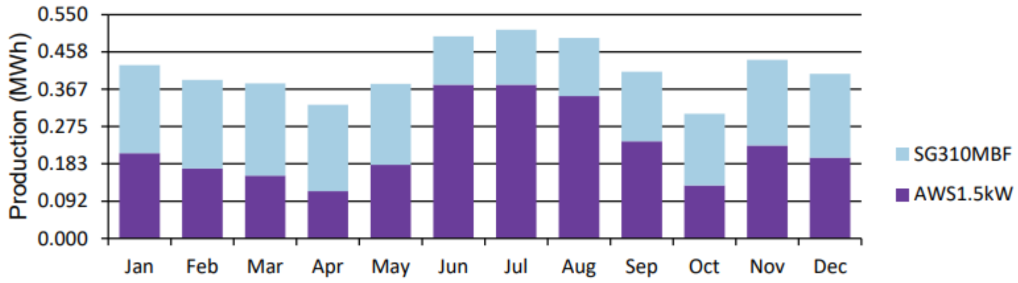

Fig 4.12 Electrical production from Homer for Cox's Bazar

4.4.2 Total electricity production by PV and Wind

Table 4.5 displays the output of each source component as it relates to their contribution to the production of electricity. The contribution (Renewable fraction) for the generation of energy in a year was made up of 44.9% (2233 kWh/yr) from PV, and 55.1% (2735 kWh/yr) from the wind.

Table 4.5 The sum of the annual contribution of electricity generation

Production	Kwh/yr	%
Peimar SG310MBF	2233	44.9
Wind turbine	2735	55.1
Total	4968	100

4.4.3 Capacity shortage

In this specific area, Table 4.6 shows The table shows that the system's insufficient power is achieved at 2.19 kWh per year, while the extra electricity produced by the other hands is used up at 2490 kWh per year, leaving a 0.877 kWh per year unmet electrical load.

Table 4.6: Amount of Unserved Load

Quantity Electricity	kWh/yr	%

Excess Electricity	2490	50.1
Unmet Electric Load	0.877	0.0399
Capacity Shortage	2.19	0.0995

4.4.4 Cash Flow

This fig. 4.13, both parts a and b, demonstrate that the biggest cost of cash flow was the initial cost of capital, which was expected to be around $6000 according to the framework. Compared to the cost of operation, salvage, and maintenance, establishment requires a greater initial outlay. In this instance, the hybrid system configuration was changed.

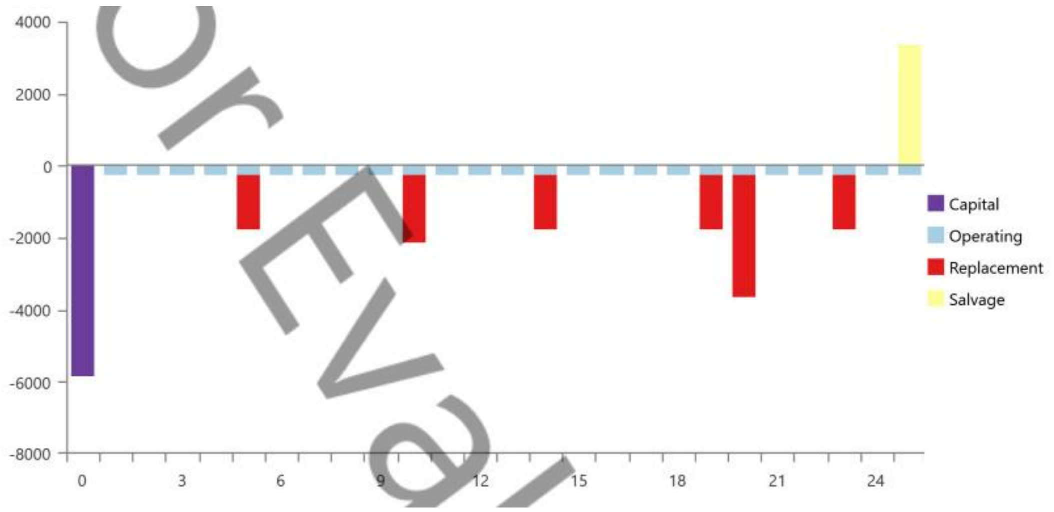

Fig 4.13 Cash flow from homer for Cox's Bazar(a)

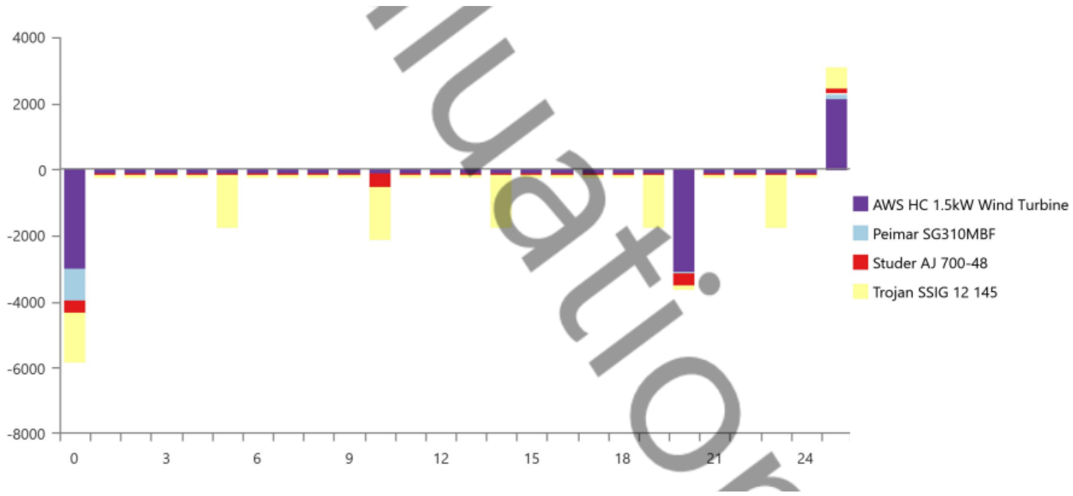

Fig 4.13 Cash flow from homer for Cox's Bazar(b)

4.4.5 Cost summary

The Net Present Cost (NPC), which represents the life cycle of the system and the total NPC, condenses all expenses and revenues that arise throughout the course of the project, is shown in Fig. 4.14 as a cost overview of the entire system.

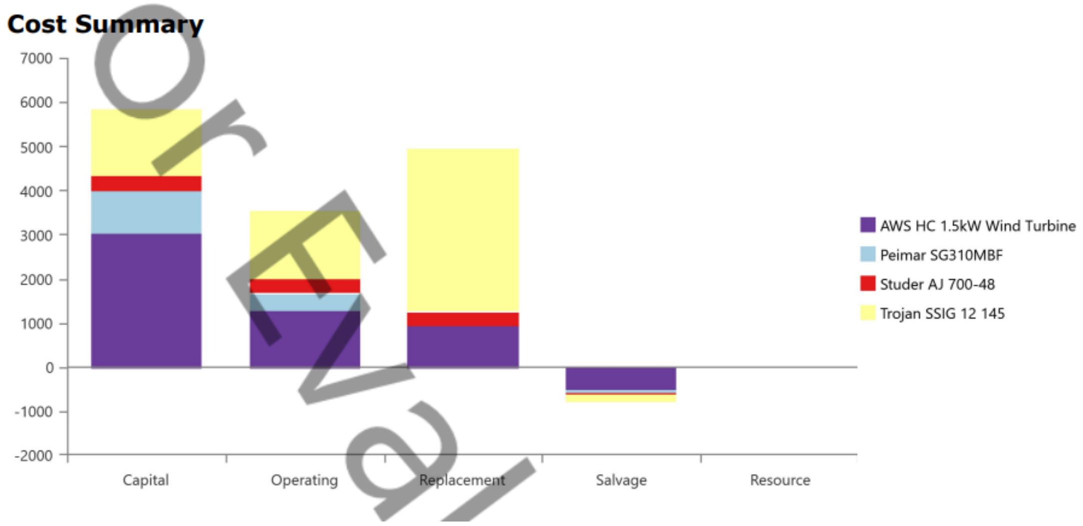

Fig 4.14 Cost summary of Cox's Bazar

4.4.6 Cost of the energy of Cox's Bazar

We obtained the results required by Homer Output from fig. 4.15.

Net current cost: $13,513.81

Operating Cost: $593.90

Price per unit: $0.4759

Fig 4.15 Cost of the energy of Cox's Bazar

4.5 Result Analysis

This chapter covers a comparison study for a highly unique model developed as part of our HOMER Simulation program. We've shown that one is more successful with viability, optimization, and cost analysis in these three situations of comparative analysis. Each time, we made sure to incorporate the scale requirements for modeling a given renewable resource system. The best low-cost energy design system for Keraniganj, Barisal, and Cox's Bazar is the chapter's main focus.

4.5.1 Summary of three case studies

The overview of the four case studies presented here is shown in Table 4.7. Cost of energy in all circumstances, capital cost, operating cost, and net present cost.

Table 4.7 Summary of a three Cases

Area	PV	Wind Turbine	Battery storage	Converter	Capital cost	Operating cost	NPC	COE
Keraniganj	1.52 kW	1.50 kW	10.5 kWh	1.1 kW	$5,822	$633.18	$14,008	$0.493
Barisal	1.08 kW	1.50 kW	10.5 kWh	1.22 kW	$5,569	$598.79	$13,309	$0.469
Cox's Bazar	1.50 kW	1.50 kW	10.5 kWh	1.20 kW	$5,836	$593.90	$13,514	$0.476

4.5.2 Comparison of Electricity Production Generation for three places

The comparison of all situations for electrical production, electrical consumption, and excess electricity is shown in Table 4.8.

Table 4.8 Comparison of three cases the electrical production

Area	Electrical production (kWh/year)	The electrical consumption (kW)	Excess Electricity (%)

Keraniganj	4,399	2,197	43.3%
Barisal	4,244	2,197	41.5%
Cox’s Bazar	4,968	2,196	50.1%

4.6 Summary

The output data for the same models for three different situations are provided in this chapter, along with a comparison of the results. By examining the results, several comparisons are made. The proposed model is found to effectively minimize costs. We can observe that PV and wind hybrid power systems are more efficient from the aforementioned study, statistics, and comparative analysis for Cox's Bazar, Barisal, and Keraniganj. Again, the system includes a solid backup to meet demand throughout the period of abnormal environmental circumstances.

CHAPTER 5
IMPACT ASSESSMENT OF SOLAR WIND HYBRID SYSTEM

5.1 Economical, Societal and Global Impact

The environment, society, and economy of Bangladesh may all benefit from the use of solar and wind energy systems.

Economical Impact:

In order to diminish their reliance on fossil fuels, families and businesses may cut their energy costs by using solar and wind energy systems.

These technologies have the potential to boost employment and create new jobs in the field of renewable energy.

By diversifying the country's energy mix, solar and wind energy systems can increase energy security and decrease the likelihood of fuel price volatility.

Societal Impact:

Solar and wind energy systems can improve public health by reducing air pollution, a major problem in Bangladesh.

These systems can improve living conditions and provide access to power in rural regions as a steady and reliable source of energy.

Global Impact:

Utilizing solar and wind energy systems helps reduce greenhouse gas emissions that contribute to climate change. Switching to renewable energy sources can help Bangladesh prepare for and mitigate the consequences of climate change because the country is particularly vulnerable to these effects.

The adoption of solar and wind energy systems in Bangladesh can act as a paradigm for other countries to follow, promoting a shift away from fossil fuels and toward renewable energy.

Generally speaking, solar and wind energy technologies may greatly enhance Bangladesh's economy, society, and environment.

5.2 Environmental and Ethical Issues

The installation of a solar-wind hybrid system in Bangladesh may lead to a number of ethical and environmental problems.

One issue is the possible influence on the local environment. Land clearing may be required to install solar and wind turbines, which might have an impact on the environment and habitat in the area. If there are nearby vulnerable or endangered species, this might be quite dangerous.

Another issue is the possible impact on the community. Large solar-wind hybrid systems, for instance, may cause traffic, noise, and light pollution that would interfere with locals' everyday activities. The neighborhood's needs and wishes should be taken into consideration while planning the implementation of such a system.

There may be ethical issues with purchasing the resources required to construct the solar-wind hybrid system. The responsible supply of all supplies and upholding of workers' rights are essential throughout the construction process.

It is necessary to carefully examine and resolve any environmental and ethical concerns that may arise during the construction of a solar-wind hybrid system in Bangladesh toup during the construction of a solar-wind hybrid system in Bangladesh in order to ensure that the benefits exceed any negative impacts.

5.3 Utilization of Existing Standards

For the planning, setting up, and running of solar-wind hybrid systems in Bangladesh, a number of standards and recommendations already exist. These consist of both regional and global standards and industry best practices. The following are some of the main norms and directives that solar-wind hybrid systems in Bangladesh may need to follow:

• The Bangladesh Renewable Energy Policy 2008 (BREP 2008): This policy establishes the foundation for the growth of renewable energy in Bangladesh and establishes goals for the deployment of various renewable energy technologies.

• The Bangladesh Energy Efficiency and Conservation Act of 2009: This law encourages energy efficiency and conservation in Bangladesh, in part by utilizing renewable energy sources like solar-wind hybrid systems.

• The Bangladesh National Constructing Code 2010: This code establishes requirements for the planning, building, and upkeep of structures in Bangladesh and contains clauses for the incorporation of renewable energy sources, such as solar-wind hybrid systems.

• International standards for electrical, electronic, and related technologies are created and published by the International Electrotechnical Commission (IEC), a global organization. Many IEC standards, such as IEC 61400 (Wind turbine generators) and IEC 61215 (Solar-Wind Hybrid Systems), are pertinent to the design, installation, and operation of solar-wind hybrid systems (Photovoltaic modules).

5.4 Other concerns

There are a number of possible issues that might be related to Bangladesh's adoption of solar-wind hybrid systems. These worries might include, among others:

• Price: Compared to other energy generation systems, installing and maintaining solar-wind hybrid systems can be rather expensive. If they lack access to funding or other incentives, this can be a worry for people or companies wanting to deploy these systems.

• Reliability: In regions with low amounts of wind or sunshine, solar-wind hybrid systems would not be able to supply a steady and dependable source of power. Users that depend on these systems as their main source of energy may find this to be concerning.

• Intermittency: Due to their reliance on the availability of sunshine and wind, solar-wind hybrid systems may not always be able to provide power. For customers who require a consistent power supply, this can be a problem.

• Environmental effects: Solar-wind hybrid systems might have an adverse effect on the environment if huge wind turbines are built or if hazardous chemicals are used in the solar panel manufacturing process. When adopting these systems, it is crucial to take these effects into account carefully and take preventative measures.

When assessing the utilization of solar-wind hybrid systems in Bangladesh, it is critical to take these and other possible issues into serious consideration.

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This thesis performs a feasibility analysis to investigate the possibility of a solar wind hybrid system at three different locations in Bangladesh. The goal of the thesis was to investigate whether the Solar Wind Hybrid System's costs were comparable to those of the conventional system, which is more practical given recent increases in fuel prices. In addition, the Solar wind Hybrid system, which transfers power from renewable energy sources utilizing the PV and Wind Turbine, has been considered an off-grid Solar wind Hybrid system that is more efficient and promising than the grid-connected system, both urban and rural. The off-grid hybrid system uses just renewable energy, but it still requires a sizable battery bank to store electricity. The Bangladeshi cities of Keraniganj, Barisal, and Cox's Bazar are situated in an area with a range of renewable energy sources, including extremely windy and bright areas, and offer great potential for wind and solar power.

The optimization results demonstrate that, when compared to PV/Battery systems, hybrid wind, and PV power systems offer the best performance and most cost-effective combination of NPC and COE. Maximum sources have been integrated into it so that peak load can be readily mitigated. In Keraniganj, Barisal, Cox's Bazar, and other areas of Bangladesh, the Hybrid Power System might be the only effective way to resolve the current power problem.

6.2 New Skills and Experiences Learned

An off-grid solar-wind hybrid system in Bangladesh can offer opportunities to develop a variety of skills, knowledge, and experiences, such as:

Understanding the technical underpinnings of solar and wind energy production, such as the physics guiding these systems and the engineering ideas guiding their design and construction.

finding out about the rules and regulations regulating renewable energy, especially as they apply to the development and use of off-grid renewable energy systems in Bangladesh and other countries.

acquiring project management skills and participating in interdisciplinary teams, since the creation and use of off-grid renewable energy systems typically call for collaboration between engineers, technicians, decision-makers, and other experts.
In order to evaluate the effectiveness of off-grid renewable energy systems and identify areas for improvement, it is vital to learn data collection, analysis, and monitoring methodologies.
examining the impacts of off-grid renewable energy systems on society, the economy, and the environment as well as how they may promote sustainable development and provide stable electricity in off-the-grid or underserved areas.
gaining expertise in the planning and execution of hybrid renewable energy systems, which combine a number of renewable energy sources to provide off-grid communities with a stable and cost-effective supply of power.

6.3 Future Recommendations

As clean, renewable, and generally accessible energy sources, solar and wind energy systems are anticipated to play a large part in the future of power generation. In particular, hybrid solar wind systems—which combine solar and wind energy generation—are promising because they may offer a steady and affordable supply of electricity, especially in off-grid or isolated areas. Future research on solar-wind hybrid systems may focus on a number of topics, including:

• Creating and enhancing hybrid solar-wind systems that are more dependable and efficient.

• Creating new technologies and methods for combining the production of solar and wind energy, such as sophisticated control systems and hybrid storage options.

• Lowering the price of solar and wind energy systems, particularly by utilizing cutting-edge manufacturing processes and materials.

• Increasing the use of solar and wind energy systems in a range of locales, such as distant areas, developing nations, and urban and rural areas.

• Researching the social, economic, and environmental effects of solar and wind power systems and creating policies and plans to encourage their broad use

• Developing cutting-edge power management systems and utilizing smart grids to improve the integration of renewable energy technologies into the electrical grid.

In general, as we move toward a more sustainable and dependable energy system, the future of solar wind hybrid systems is expected to entail the continuous development and implementation of these technologies in a number of scenarios.

REFERENCES

1. M.M. Atiqur Rahmana and Md. Atiq Zaowadb, 2020, ‘Feasibility Analysis of Renewable Energy Based Hybrid Power System for Rural Area of Bangladesh’, International Journal of Electronic and Communication Research, vol. 11, pp. 1-11.
2. Mir Nahidul Ambial, Md. Kafiul Islam, Md. Asaduzzaman Shoeb, Md. Nasimul Islam MaruF, and A. S. M. Mohsin, 2010, ‘An Analysis & Design on Micro Generation of A Domestic Solar-Wind Hybrid Energy System for Rural & Remote Areas - Perspective Bangladesh’, 2nd International Conference on Mechanical and Electronics Engineering, vol. 2, pp. 107-110.
3. Shahidul I, Khan,Mohammad Upal Mahfuz, Tareq Aziz and N. M. Zobair, 2002,’ Prospect of Hybrid Wind System in Bangladesh’, Second International Conference on Electrical and Computer Engineering, pp. 212-215.
4. G.M. Sharif Ullah Al-Mamun, Md. Rokib Hasan, Md. Imran Hossain, Al Jubair Hossain, Ashfaqur Rahman, Sokhorio Margon D'Costa, and A.S.M. Shakil Imam, 2013, ‘Design and Analysis of a Solar-Wind Hybrid System’, STM Journals, pp.1-10.
5. Prosenjit Barua and Bikram Ghosh, 2020, ‘Feasibility Analysis of Renewable Energy Based Hybrid Power System in a Coastal Area, Bangladesh’, Emerging Technology in Computing, Communication, and Electronics.
6. Jeffy Johnson, Surajit Mondal, Amit Kumar Mondal, Sravendra Rana, and Jitendra Kumar Pandey, 2018, ‘Feasibility Study of a 200 kW Solar Wind Hybrid System’, Applied Solar Energy, Vol. 54, pp. 376–383.
7. Sunanda Sinha and S.S. Chandel, 2013, ‘Pre-feasibility analysis of solar-wind hybrid system potential in a complex hilly terrain’, International Journal of Emerging Technology and Advanced Engineering, vol. 3, pp. 277-282.
8. M. M. Rahman, 2017, Feasibility study of a solar-wind hybrid power system for a remote village in Bangladesh.
9. M. M. Rahman, 2017, "Performance analysis of a hybrid solar-wind energy system for rural electrification in Bangladesh".
10. M. A. Rashid, 2012, "Feasibility of solar-wind hybrid system for rural electrification in Bangladesh".
11. Md. Farid Uddin, 2017, "Feasibility study of hybrid renewable energy systems for remote areas in Bangladesh".
12. Md. Rashedul Islam, Renewable and Sustainable Energy Reviews, 2015, "Evaluation of a solar-wind hybrid system for rural electrification in Bangladesh".
13. Data Access Viewer-NASA POWER. https://power.larc.nasa.gov/data-access-viewer/
14. Parita Dalwadi, V. Shrine, C R Mehta, and Pankit Shah, 2011, ‘Optimization of Solar-Wind Hybrid System for Distributed Generation’.
15. Bangladesh Power Development Board. https://www.bpdb.gov.bd/

16. Power and Energy 19_BER_22_En_Chap10.pdf

17. Ugur FESL, Raif BAYIR and Mahmut bZER, "Design and Implementation of a Domestic Solar-Wind Hybrid Energy System".

18. Himadry Shekhar Das, “Feasibility analysis of standalone PV/wind/battery hybrid energy system for rural Bangladesh” International Journal of Renewable Energy Research, Vol. 6, No. 2, 2016, pp. 1-11.

19. Bangladesh Meteorological Department. https://live.bmd.gov.bd/

20. National Energy Policy, M.o. Power, Editor. 2022, Government of Bangladesh: Energy and Mineral Resources.

21. T. Ali, H. Ma, and A. J. Nahian, “Techno-Economic Analysis of a Hybrid Mini-grid in Rural Areas: A Case Study of Bangladesh,” J. Energy Res. Rev., vol. 4, no. 1, pp. 10–29, 2020.

22. M. Nurunnabi, N. K. Roy, E. Hossain, and H. R. Pota, “Size Optimization and Sensitivity Analysis of Hybrid Wind/PV MicroGrids- A Case Study for Bangladesh,” IEEE Access, vol. 7, pp. 150120–150140, 2019.

23. “HOMER - Hybrid Renewable and Distributed Generation System Design Software.”, 2020, Available: https://www.homerenergy.com/

24. M. S. H. Lipu, M. Shazib Uddin, and M. A. R. Miah, “A feasibility study of the solar-wind-diesel hybrid system in rural and remote areas of Bangladesh,” Int. J. Renew. Energy Res., vol. 3, no. 4, pp. 892–900, 2013.