# OPTIMIZATION OF COST AND DESIGN OF A HYBRID RENEWABLE SYSTEM

A Project report is 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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# DECLARATION

I hereby declare that this project "**OPTIMIZATION OF COST AND DESIGN OF A HYBRID RENEWABLE SYSTEM**" 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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# APPROVAL

The project entitled **"OPTIMIZATION OF COST AND DESIGN OF A HYBRID RENEWABLE SYSTEM"** submitted by **Md. Shahadat Hossain Mazumder (ID:191-33-894) & Moriom (ID:191-33-921)** 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 **June, 2023.**

Signed

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Dedicated

To

Our Parents

# TABLE OF CONTENTS

## LIST OF FIGURES

# LIST OF TABLES

# LIST OF ABBREVIATIONS

| | |
|---|---|
| COE | Cost of Energy |
| RE | Renewable Energy |
| HES | Hybrid Energy System |
| SHS | Solar Home System |
| RES | Renewable Energy Sources |
| NPC | Net Present Cost |
| O&M | Operation and Maintenance |
| BDG | Bio-Diesel Generator |
| SHP | Small Hydro Power |

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# ABSTRACT

One of the crucial initiatives that promotes sustainable development in Bangladesh is to create a compact energy system using solar, hydro, and wind power. The availability of electricity is very limited to rural areas. So, we are trying to design a hybrid renewable system for remote areas. For this purpose, we select a bio-diversity center which is located in the Chittagong Hilly Area. This area is full of plants and animals that have been extensively studied. The center is suitable for researchers and students to stay and study. The hybrid energy system will use solar panels, a wind turbine, and a hydropower generator to create electricity. To control the flow of electricity, the system includes different parts like inverters as well as switches. Solar panels will provide solar energy and Pico hydropower is collected from the Pico hydro power plant. Solar panels are used for converting the power from dc from to ac form. We use switches for getting our desired load.

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

At present, a lot of underprivileged and developing nations face the unusual difficulty insufficient power supply in remote and rural areas. Although these countries have abundant renewable energy (RE) resources that could be utilized to provide electricity to both rural and urban regions, the progress has been very minimal to adopt and implement them. Since Renewable energy (RE) is a cost effective, environment friendly and sustainable alternative to conventional energy-producing technologies, it is getting very much necessary for countries all over the world to adopt this **[1].**

In Bangladesh, there is a shortage of energy and power compared to the demand. 92% of urban households have access to electricity. On the contrary, only 67% of rural residents get access of electricity. Approximately 77.9% of the population has access to electricity, but approximately 34,000 megawatts of power is needed to ensure 7% economic growth by 2030. Government of Bangladesh is trying their best to supply electricity among all the people of Bangladesh. But several challenges like to much dependency on fossil fuels, dollar crisis and many more. The electric power industry in Bangladesh is plagued by several problems such as high system losses, slow construction of new plants, limited plant efficiency, unreliable power supply, energy theft, blackouts, and inadequate funds for power plant maintenance. Over the past decade, the power production units of the country have been unable to meet the demand of the system. [**2**].

## 1.2 Problem Statement and Proposed solution(s)

Presently the people of Bangladesh are suffering from acute energy crisis. In order to meet the increasing energy requirements, renewable energy itself is a viable option. With the current era's rapid technological advancements, renewable energy sources have gained significant attention as sources of electricity. Energy sources like wind, biomass, tidal/wave, micro-hydro, and PV are all infinite and can generate clean electricity. In rural areas where grid connection is unavailable or too costly, these renewable energy sources are the best alternative for power generation. Electrifying rural areas in the region is expected to bring about rapid changes in all aspects of life.

## 1.3 Objectives

- Construction of a hybrid solar-hydro-wind system which includes a photovoltaic module, a hydro turbine and a control system for fulfillment of the total load of biodiversity center.
- To develop the proposed system using HOMER.
- Selection of the proper cost-effective hybrid system.
- Calculation of capital cost, net present cost (NPC), cost of energy (COE).

## 1.4 Brief Methodology

For the fulfillment of our simulation process, we have used HOMER software. It is a widely used software all over the world in order to figure out the configuration of decentralized systems. Here is the brief explanation of the whole process of our project:

- Firstly, we have selected the appropriate location of our project.
- After that we downloaded the solar, wind, temperature and hydro resources from National Renewable Energy Lab (NREL).
- Then we calculated the peak and average loads for microgrid project.
- Lastly, we selected converter, PV module, wind turbine, pico-hydro turbine, generator and storage according to our need and simulate the design.

## 1.5 Implementation Schedule

- Week 1: Selection of topic
- Week 2: Data collection from secondary sources.
- Week 3: Literature review
- Week 4: Research methodology plan
- Week 5&6: Simulation and designing
- Week 7: Final research project

## 1.6 Structure of the Report

Chapter 1 contains brief discussion about present scenario of power sector, why we choose the topic and implementation schedule of our project. In chapter 2, we have discussed about literature review. Brief discussion about how we implement our project, the materials and their costs is discussed in chapter 3. After the simulation of our project in Homer software, optimized result is discussed in chapter 4. Furthermore, the overall economical, societal and global impact of this project is explained in chapter 5. Lastly there is an overall conclusion and future recommendation about how to improve the system is elaborate in chapter 6.

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 Introduction

The presented literature review has a couple of objectives. Firstly, it identifies a gap in knowledge that validates the necessity of this research. Secondly, it consolidates the methodology employed in the study and provides a pool of resources for comparison, triangulation, and referencing. The literature is utilized to highlight the constraints of previous research, with a particular emphasis on studies that utilized HOMER as an analytical instrument.

## 2.2 Related Research

Khan and Iqbal have delved into the possibility of a hybrid system that utilizes hydrogen as an energy carrier in Newfoundland, exemplifying this line of research [8]. While there is an abundance of research available on developing countries, a comprehensive evaluation of this literature is beyond the purview of this work. Instead, we concentrate on a select few for our objectives. In a compelling case study of Sri Lanka, Givler and Lilienthal have ascertained the point at which a PV/diesel hybrid surpasses standalone small solar residential systems (50 W PV with battery) in terms of cost-effectiveness [9]. The study presumes a daily load average of 305 watthours, with a base load of 5 watts and a peak load of 40 watts. Through a vast number of simulations, the study finds that as demand escalates, the PV/diesel hybrid becomes increasingly cost-effective. However, this study solely focuses on fundamental necessities while excluding energy utilized for productive purposes. In their research, Munuswamy et al. utilized HOMER simulations to compare the cost of power generated from fuel cells against that of grid supply for a rural health center in India [10]. The results indicate that the off-grid source is less expensive beyond a distance of 44 kilometers from the grid. This project exclusively focused on fulfilling the requirements of a rural health center and was not a component of any standard rural electrification initiative. In another study, Hafez and Bhattacharya investigate the optimal design and planning of a microgrid system based on renewable energy for a hypothetical rural village with a daily energy demand of 5000 KWh/day and a base load of 600 KW, as well as a peak load of 1183 KW [11]. Solar, wind, hydro, and diesel are included as energy sources in the research. Despite the study addressing the 24-hour electricity demand, it may not be feasible for several off-grid areas in impoverished countries owing to the entirely theoretical nature of assumptions. Lau et al. studied the economic feasibility of a hybrid system in a rural residential region in Malaysia using HOMER [12]. The study employed a hypothetical scenario of 40 households with a peak demand of 2 KW, a base demand of roughly 30 KW, and a peak demand of 80 KW. While such high rural demand may be typical of Malaysian settings, this is not always the case in other countries, and the analysis fails to incorporate any advantageous utilization of electricity.

## 2.3 Compare and Contrast

In the current era of energy crisis, renewable energy sources (RESs) are an obvious sustainable alternative. Although Bangladesh, being a low-income country, may not prioritize environmental factors, utilizing renewable energy can help reduce its dependence on rapidly declining natural resources. A hybrid energy system combines two or more energy sources to improve system efficiency and maximize overall benefits. Hybrid renewable systems have numerous advantages, including low maintenance costs and reduced costs for high-availability renewable energy systems. However, the high initial capital cost of the hybrid system is a major barrier to its adoption, and there is a need for long-lasting, reliable, and cost-effective systems. Hybrid energy systems can reduce the size of diesel engines and battery storage systems, leading to fuel savings and reduced pollution. Additionally, hybrid renewable energy systems improve load factors and reduce maintenance and replacement costs. However, battery replacement is expensive, and there are challenges with battery disposal and recycling. There are also issues with hydrogen fuel cells. Furthermore, renewable energy often requires more land than fossil fuel production, which can result in habitat fragmentation or even the eradication of high-quality wildlife habitats. Renewable energy can also have negative consequences for wildlife, such as behavioral changes and direct mortality.

## 2.4 Summary

With the increasing population over the years, the shortage of energy becomes a matter of headache for the govt of Bangladesh. In order to meet up the increasing demand of electricity, renewable energy can be a best option. In this chapter we give brief discussion about previous research related to our project. Microgrids are becoming popular day by day for its reliability, cost-effectiveness and sustainability. Microgrids can provide energy independence to communities or businesses, reducing their dependency on larger grid and potentially reducing energy cost. In some cases, installing a microgrid can be cost effective especially in areas with high energy costs or unreliable grid infrastructure.

# CHAPTER 3
# MATERIALS AND METHODS

## 3.1 Introduction

This objective of this project is to development of a hybrid renewable energy system with the combination of solar, wind, and hydro resources for a biodiversity center. To achieve that desired goal, we have used HOMER PRO application for a simulation-based investigation. National Renewable Energy Laboratory in the United States is behind the development of this software which is now widely used to design of a remote, stand-alone, and distributed off-grid and grid-connected power systems [13]. It performs three primary tasks, including simulation, optimization, and sensitivity analysis to determine a technical feasibility and life cycle of a system. In this investigation, various mix scenarios will be tested and predicted to establish the ideal renewable energy penetration levels. To accomplish this, load curve and load duration curve were generated, and annual solar, wind, hydro, and temperature data were obtained from the internet [14]. The peak and average loads were then calculated, and a schematic sketch of the model was created. The proposed model consists of a PV system, wind turbine, pico-hydro turbine, and storage [15].

## 3.2 System Design and Components

### 3.2.1 Selection of site and loads

The first and foremost job of the project is to choose of a proper site for installing hybrid systems. Naturally this kind of project can be very much beneficial for rural areas where electricity is not always available.

The location of our project is given below:

Figure 3.1 Location map (From HOMER software)

**Table 3.1: Calculation of loads:**

| Time duration | Capacity and run time of loads | Total load |
|---|---|---|
| 12am - 6am | Dream light (3;0.5 watt each), LED outdoor light (3;50 watt each),Fans (5;50 watt each), Refrigerator(1; 250 watt) | 0.5*6*3+50*6*3+50*6*5+250*6*1w/h= 3909w/h=3.909kw/h |
| 6am-8am | Refrigerator 1, AC(1;1500 watt) | 250*2*1+1500*2*1 w/h=3.5 kw/h |
| 8am-10am | Refrigerator 1,Energy bulbs(3;15 watt each),Computer(2;150 watt each),AC 1 | 250*2*1+15*2*3+150*2*2+1500*2*1 w/h=4.19 kw/h |
| 10am - 12pm | 3 computers, refrigerator, water pump(1 hour), AC (10 am-11am) | 150*2*3+250*2*1+750*2*1+1500*1*1 =4400 w/h=4.4 kw/h |
| 12 pm-3pm | air condition (12pm-2pm), | 1500*2*1+250*3*1+50*3*5+150*3*1= 4950=4.95 kw/h |

| | | |
|---|---|---|
| | refrigerator, 5 fans, 1 computers | |
| 3pm-5pm | air condition, 3 fans, refrigerator, 2 computers, water pump | 1500*2+50*2*3+250*3+150*2*2+750*1*1=5400 w/h=5.4 kw/h |
| 5pm-9pm | Refrigerator, 2 LED bulb, 4 fans, television (7pm-9pm), 6 energy bulbs , 5 computers, (5pm-6pm) – AC | 250*4+50*4*2+50*4*4+50*2+15*4*6+150*4*5+<br>1500*1*1=7160w/h=7.16 kw/h |
| 9pm-12am | 2LED outdoor bulb, 3 energy bulb, refrigerator, television, 6 fans, AC (10pm-12am) | 50*3*2+15*3*3+250*3+50*1+<br>50*3*6+1500*2*1=5135=5.135 kw/h |
| | | Total load=38.644 kw/h |

### 3.2.2 Annual data of various resources:

**i. Solar resource:**

We can estimate solar resource through the utilization of either satellite-based solar models or ground-based sensors. Reliable and high-frequency data is offered by Ground-based sensors. On the contrary, lower frequency with an extensive historical record data is provided by satellite-based models. An annual irradiation level ranging between 4.0-4.5 kWh/m$^2$/day will result in outstanding annual energy photovoltaic outputs. While the annual average can be a vital parameter for assessing resource quality, significant seasonal variations exist. In particular, the impact of ideal design is substantial in regions far from the equator with extended rainy seasons. Global Horizon Irradiation (GHI) is the most vital parameter to consider at the time of constructing a PV power system. We have used the database of National Renewable Energy Laboratory in HOMER Pro to retrieve GHI data for this modeling, revealing an annual average GHI of 4.86 kWh/m$^2$/day [16].

Figure 3.2: Annual solar resource graph

### ii. Wind resource:

The assessment of wind resources presents greater challenges than the evaluation of solar resources. While wind speed statistics are widely available, it is important to note that the average wind speed can exhibit significant spatial variation over a small area, unlike solar radiation. The magnitude of this variation can be influenced by a range of factors, including surface roughness, interruptions (such as buildings and trees), and height. Ascertaining the wind speed data used in research studies is contingent upon the latitude and longitude of the site. In this study, wind speed data was sourced from NASA Surface Meteorology, and the average annual wind speed at the site in question was recorded as 3.2 meters/second.

Figure 3.3: Annual wind resource graph

### iii. Hydro resource:

The graph of hydro resource is given below. It shows that the annual average of steam flow is 5.31 L/s.


Figure 3.4: Annual hydro resource data

### iv. Temperature resource:

Annual average temperature in that location is **24.87** degrees Celsius.


Figure 3.5: Annual temperature resource data

### v. Assumption of peak and average load:

As the weather of that area is moderate, so we select July as peak load assumption month.


Figure 3.6: Load assumption data

| Metric | Baseline | Scaled |
|---|---|---|
| Average (kWh/day) | 11.27 | 38.68 |
| Average(kW) | .47 | 1.61 |
| Peak (kW) | 2.39 | 8.22 |
| Load factor | .2 | .2 |

Load Type: AC DC

## 3.3 Design Specifications

### 3.3.1 Schematic diagram of project:

We have combined a variety of energy sources to construct a miniature grid for the generation of electricity at the Biodiversity Centre which includes solar panels, wind turbines, hydro, batteries, generators, and converters. We integrate the battery and PV model to the DC bus in the project's schematic design. We have connected the opposite end of the AC bus to the generator, wind turbine, and hydro.

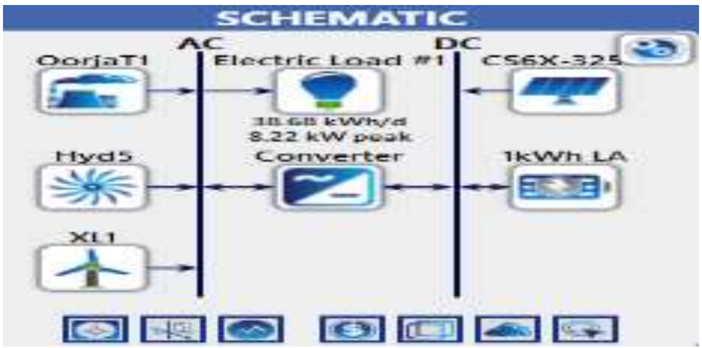


Figure 3.7: Schematic diagram

### 3.3.2 Selection of components

i. **Converter:**

We have employed a standard system converter. With a 15-year lifespan and a 95% efficiency, this converter is highly efficient. We must utilize a converter with a capacity that is 25% greater than our peak load because our average load is 8 kw. So we use a converter with a 10 kW capacity.

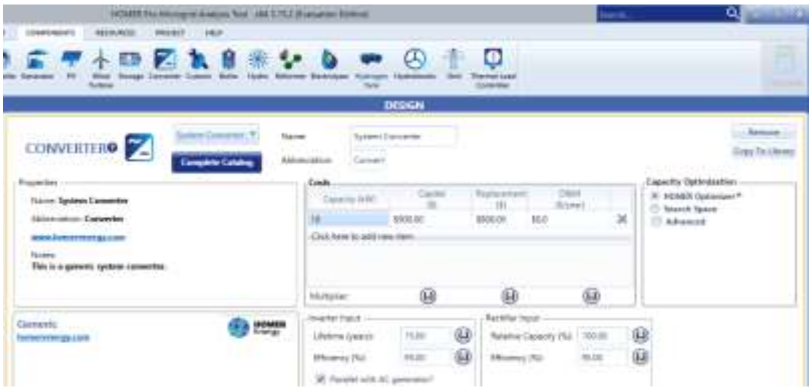


Figure 3.8: Converter design

### ii. PV model design:

The size of the PV array is determined using the Homer Optimizer TM approach. We make use of the Max Power CS6X-325P from Canadian Solar. Flat plates are used to create panels. This model's rated output power is 0.325 kW. The model has a 25-year lifespan and a 16.94% efficiency. The temperature of operation is 45 degrees, and the temperature coefficient is -0.41. Canadian Solar is the brand that makes the item.

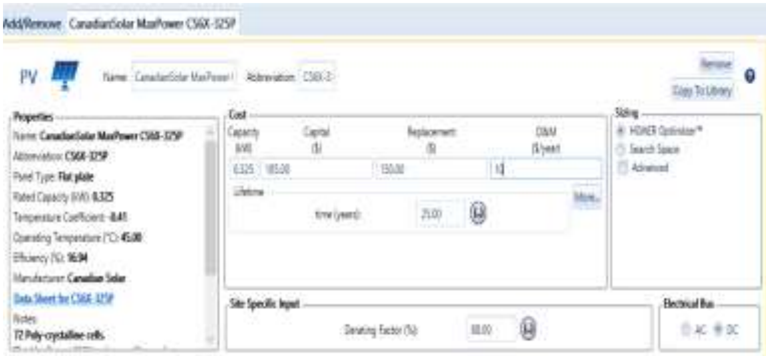


Figure 3.9: PV module design

### iii. Wind turbine design:

An excellent and affordable renewable energy source is the wind. Our microgrid system utilizes wind turbines as a result of it. Bergey BWC XL is the brand we prefer to use. The brand name of the producer is Bergey Windpower [18]. One kilowatt of electricity is the maximum output. The wind turbine's anticipated lifespan is 20 years. Ten meters is the height of the center hub.

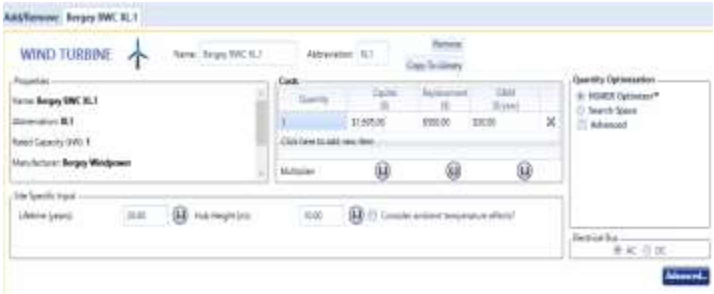


Figure 3.10: Wind turbine design

**iv. Pico hydro turbine design:**

The capacity of pico-hydro power plant is under 0.005 MW. A turbine in a hydroelectric facility transforms the kinetic energy of moving water into mechanical energy. After that, an electric generator which generates electricity is driven by the turbine. Thousands of years ago, people first employed hydropower for mechanical activity, especially for agriculture. It was the original way of producing electricity from renewable resources. 20% of the world's energy requirements are currently satisfied by hydroelectric power plants. In order to evaluate the potential of the location for power generation, the available head and, consequently, the overall flow rate were assessed. The cost per unit of the proposed hybrid system was then calculated using Homer software. A model for Pico Hydro Plant was developed. The flow rate was measured utilizing the bucket method. The bucket volume was divided by the average time for figuring out the flow rate.

Flow rate=Volume of bucket/Time for filling the bucket=150/6 L/s=25L/s.

If we consider 3% losses the available head become 9.70 meter.

**v. Generator:**

Diesel generators can play a significant role as a non-renewable source to meet the energy requirements at the availability of lower solar radiation. Batteries can also be charged by using generator on rainy or cloudy days. Without a backup generator, continuous deep draining and inadequate charging on wet and foggy days might lead the battery bank to malfunction and eventually fail. The generator will be stopped automatically when batteries are fully charge. We select Oorja 1.5kw Model T-1 as our generator. Generators will take over to supply energy when our solar, wind, and water resources run out.


Figure 3.11: Generator

**vi. Storage design:**

One of the elements for a microgrid is storage. Energy storage system can eliminate the variations in the output of renewable energy sources and assists in maintaining voltage stability. Since batteries use a reversible chemical process for storing and converting chemical energy into electrical energy, it is used as an energy storage element in microgrids. Battery bank is connected with the DC bus. Batteries have a longer response time than supercapacitors, but they have a larger energy storage capacity, which is essential for mini-grid development. Deep discharge may cause battery damage. We should keep the charge state within acceptable limit. We utilize a standard 1 kW lead-acid battery. The nominal voltage of our battery is 12 volts. We connect battery to the dc bus since it can take charge and supply power to the load. Output voltage remains same as both battery and PV cell are connected to the identical bus.


Figure 3.12: Storage design

# CHAPTER 4
# RESULTS AND DISCUSSIONS

## 4.1 Results

### 4.1.1 Optimization result

In order to ensure the systems' long-term viability and lowering cost, technical design for the hybrid system including simulation and optimization techniques can play a significant role. The system was designed and optimized by researchers.

Various software applications are implemented when creating hybrid systems. HOMER can be used for clean energy management. Resource data, such as meteorological data, is one type of input data for the HOMER algorithm. Components, load profiles, technical and financial details, statistics about wind, hydro, and solar resources, and technical and financial data standards. As a consequence, data is produced that includes the appropriate unit size and cost of energy. The HOMER software simulates each possible system configuration and ranks them according to their overall Net Present Cost (NPC). This software can process each configuration on the basis of the ascending order of cost-effectiveness. According to figure 4.1, it is economical. The most effective choices are a 8.94 kilowatt converter and 31.7 kilowatt solar array. The current Net Present Cost (NPC) of the system is \$54,672, with an energy cost of \$0.3/kWh.

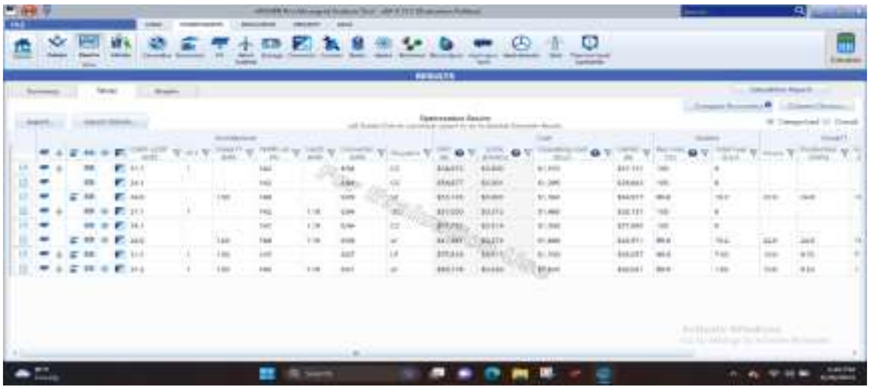

Figure 4.1: Optimization result

### 4.1.2 Cost of different component

Figure 4.2**:** Cost summary

### 4.1.3 Monthly electricity generation

Figure 4.3: Monthly electricity generation graph

### 4.1.4 Renewable penetration analysis

Percentage of renewable energy in the total energy mix of a country in known as renewable penetration. It is a measurement of how much energy we get from renewable sources like solar, wind, hydro, geothermal and biomass. We can calculate renewable penetration by dividing the total amount of renewable energy generated by the total amount of energy generated in the same area. For example, if a country generates 100 MW of electricity and 20 MW of it comes from renewable sources, the renewable penetration rate would be 20%. Renewable penetration is a vital indicator to assess the progress of a region or country wanted to transition to a low-carbon economy and to minimize the emissions of greenhouse gases.

Figure 4.4: Renewable penetration

### 4.1.5 Battery state

Lead-acid batteries need to be kept indoors and away from extreme heat and dirt, and they require frequent maintenance. The battery is connected to the DC bus and will draw power from it when its charge is low and provide power to the load when needed. In hybrid mini-grids two kinds of lead-acid batteries are used. Wet cell flooded batteries that need regular electrolyte level monitoring and sealed or gel cell batteries that have no access to the electrolyte but have a regulated valve. It is important to perform maintenance and testing recommended by the manufacturer, such as checking the electrolytes, retightening terminals, monitoring cell voltages, and checking specific gravity. The battery's cost and nominal capacity should be in accordance with the specifications given in Figure (4.5) based on using a 12V battery and a 24V bus voltage. A loss of 1,881 Kwh/year can be expected.

Figure 4.5: Battery state graph

### 4.1.6 Power output from PV module

The ultimate goal of solar technology is to implement the power of sunlight to originate electricity using photovoltaic (PV) panels. In order to fulfill the world's energy demands for an entire year, only one and a half hour of sunlight is enough. Solar PV systems is a combination of multiple solar panels and various equipment, including inverters that allow electricity to flow through the panels. Depending on the type of system, several components such as string inverters, microinverters, or power optimizers can be used to convert energy. Nevertheless, the core components of most PV systems are the same.

The annual production of a PV system is determined by the amount of irradiation received by the PV panels, as shown in Figure 4.6. According to Homer optimization, a 31.7 KW PV panel is required, and the total energy production is estimated to be 49,833 KWh per year.

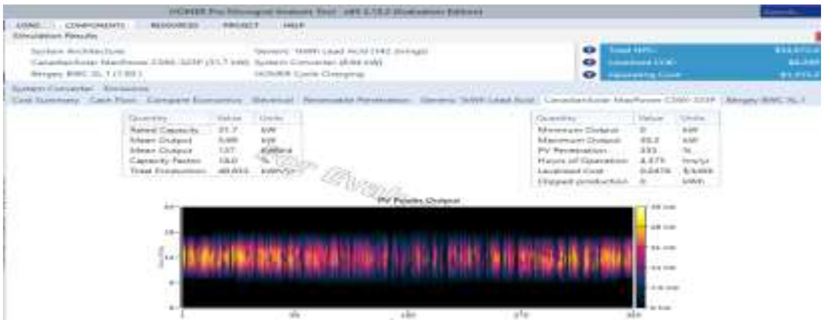

Figure 4.6: PV power output analysis

### 4.1.7 Output from system converter

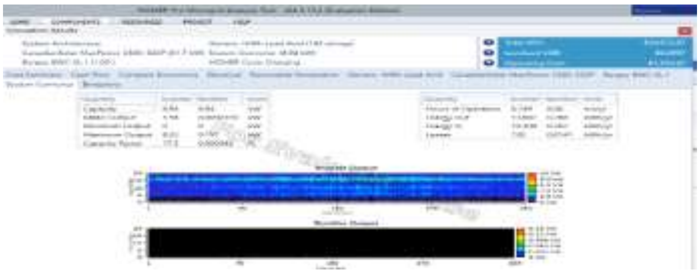

Figure 4.7: System inverter output

## 4.2 Discussions

From this chapter it can be easily determine the best possible design for our microgrid project. We can also estimate the cost and size of different components according to our load. Thus, the simulation result from homer pro can provide valuable information for making informed decisions about the design and implementation of renewable energy systems.

# CHAPTER 5
# IMPACT ASSESSMENT OF THE PROJECT

## 5.1 Economical, Societal and Global Impact

There are some significant economical, societal and global impact of our project. Such impacts are discussed below:

- **Economic impact:** The project implemented by HOMER can play a significant role by creating jobs in the renewable energy sector and reduce the cost of energy for the consumers. It also reduces the capital and operational cost of an project which makes the projects financially more viable and attractive to the investors.
- **Societal impact:** The role of HOMER based models is very vital to those countries where access of electricity is limited or unreliable. Limited access of electricity negatively makes an impact on education, healthcare and economic development. We can design and implement renewable energy for this kind of locality and improve the life of people.
- **Global impact:** A HOMER based models can mitigate climate change by reducing greenhouse gas emissions and other pollutants associated with fossil fuels. So, it can reduce the impact of climate change significantly on a global scale.

## 5.2 Environmental and Ethical Issues

Homer usually use machine learning algorithms to generate realistic text based on a given prompt which can rise several environmental and ethical issues. Some of these are stated below:

- **Environmental issues:** A lot of hardware is needed for implementing such type of project. After a specific period of time these components eventually become electronic waste, which can be a serious threat for environment if not disposed properly. On the contrary, an ideal hybrid renewable system can reduce the emission of 31.2 kg of $CO_2$ per year.
- **Ethical issues:** Sometimes the data provided by Homer can be not exact than the real one. So, difficulty can be raised at the time of implement these projects.

# CHAPTER 6
# CONCLUSIONS AND RECOMMENDATIONS

## 6.1 Conclusions

In this project, we have tried to design a hybrid system for a remote area including various components like PV module, wind turbine, generator, converter and storage in order to ensure uninterruptable power supply to that community. From Homer software we can determine Net Present Cost (NPC), Cost of Energy (COE) and payback period of the system.

## 6.2 New Skills and Experiences Learned

This project provides us a vast knowledge about how to construct a hybrid system using Homer software. We also learned about how to estimate the cost of any hybrid system.

## 6.3 Future Recommendations

The crisis of fossil fuels like coal and oil is getting bigger on recent times. It is very vital to emphasize on renewable sources instead of the non-renewable ones. In future more efficient PV module, wind turbine and generator will come. We can implement these systems to stay up-to-date. We have to integrate smart grid technologies into the system to optimize energy management, reduce energy waste and improve the overall efficiency of the system.

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# APPENDIX A

# TURNITIN REPORT

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