DESIGN A HYBRID MINI-GRID POWER SYSTEM FOR OFF-GRID AREAS OF BANGLADESH

This 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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CERTIFICATION

This is to certify that this project and thesis entitled "**Design a Hybrid Mini-Grid Power System For Off-Grid Areas Of Bangladesh**" is done by the following student under my direct supervision and this work has been carried out by them 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. The presentation of the work was held on January, 2020.

Signature of the candidate

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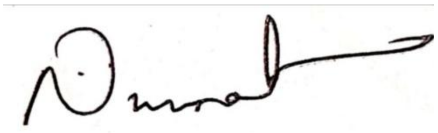
The project and thesis entitled "**Design a Hybrid Mini-Grid Power System for Off-Grid Areas of Bangladesh**" submitted by **Ibnal Moin Ahmed**, ID No: 161-33-3240, Session: Spring 2020 has been accepted as satisfactory in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical and Electronic Engineering** on January 2020.

Signature of the supervisor



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Dedicated to

My parents

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LIST OF FIGURES

LIST OF ABBREVIATION

COE	Cost of Electricity
PV	Photovoltaic
NPC	Net Present Cost

ACKNOWLEDGEMENT

First we express my heartiest thanks and gratefulness to Almighty for his divine blessing makes us possible to complete this thesis successfully. I feel grateful to and wish my profound my indebtedness to Supervisor, Department of EEE Daffodil International University, Dhaka. Deep knowledge & keen interest of my supervisor in the field of Electric power influenced me to carry out this thesis. Her endless patience, scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism, valuable advice at all stage made it possible to complete this thesis.

To my beloved family, I want to give them my deepest love and gratitude for being very supportive and also for their inspiration and encouragement during my studies in this University.

ABSTRACT

As a developing country, renewable energy is now the focus of attention. Wind energy in particular, because it offers a large potential energy source in the electricity sector. Renewable energy generation system coupled with diesel engines can be a reliable and optimized source of energy for decentralized and remote areas, where grid connection is virtually impossible. The increasing demand for electricity has to be addressed in Bangladesh. Reduce costs of renewable energy technology and improved efficiency and reliability. HOMER software uses techno-economic analysis of optimum off-grid system modelling. Energy resources are considered, primarily wind power alongside solar energy and diesel fuel. In this research, a cost-effective mini-grid power station modelling of Wind-Solar-Diesel hybrid power system in a coastal area is considered. The main focus of this proposed integrated design is to provide a minimum cost of energy (COE) with the maximum load demand using renewable energy sources. In today's world, global warming is an alarming issue. So, we see reducing fuel burning and also reducing carbon dioxide emissions. Here, HOMER is used to examine the most cost-effective configurations among a set of (104)KWh / day primary load, (18.67)KW peak load electricity requirement system.

CHAPTER 01

INTRODUCTION

1.1 Background of study

Bangladesh is a country with a vast population. There are 161,376,708 (2016 est.) People live in this country. An enormous amount of energy is needed to fill the vast number of people. Energy is one of the most important basic ingredients needed to reduce poverty and bring about the socio-economic development of a country. Fossil fuel, sunlight, air, water and nuclear power plants are all sources of energy in the world. The largest source of energy is still fossil fuel, but the supply is declining. Fossil fuel is used when it emits greenhouse gasses for global warming, which is a danger to climate change and sustainable development. In Bangladesh –

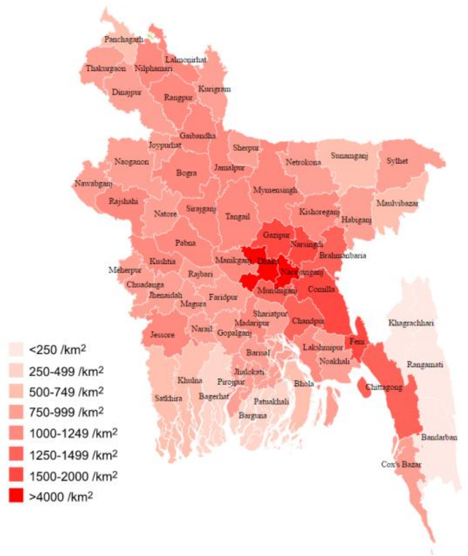


Fig 1.1: Population density in Bangladesh.

- 75.92 % of its 161 million people have access to electricity.

-Across rural areas only 40% have access to electricity.

-People in this rural areas base on kerosene lamps for lighting.

It can happen due to decreased exposure to fossil fuel, reduced global emissions related to climate change mitigation along with energy security. Under the changed perspective of renewable energy, particularly solar panel technology becomes correctly common in contributing to global climate change along with the prospect of carbon trading. The United Nations Framework Convention on Climate Change (UNFCC) has taken the initiative of a Clean Development Mechanism (CDM). In this specific context, solar energy is becoming a common source of energy throughout the world. In order to meet the growing demand for power within industries, some developed countries utilize transportation and household use solar energy while using renewable sources. This not only meets the larger energy demand area, but also provides significant socio-economic benefits and strives to maintain a clean environment. With the exception of individual renewable sources, it will never be reliable for continuous power. The grid-connected hybrid system will be more feasible to deliver on-going power. The two renewable sources relating to the hybrid system are wind and solar. If an example may not be in operation, different others may contribute. Renewable energy supplies are infinite, and they will never be concluded. So we need to make maximum use of these huge amounts of one's.

Hybrid mini grid power systems are more common in using renewable energies exactly. There are several mini-grid networks already in operation in Bangladesh. But only the solar energy determines this grid. Sometimes it's less cost-effective. Our study is primarily for the hybrid sun wind system of mini-grid.

1.2 Introduction to Energy

Energy in physics the ability to do the work. . There may be various forms of potential, kinetic, thermal, electrical, chemical, nuclear or otherwise. In the process of transferring energy from one body to another, there is also heat and work. The nature of energy is always identified after it is transferred. Thus, the transmitted heat can be converted into thermal energy while the work can be made mechanical energy

"Energy can be neither created nor destroyed but only changed from one form to another'' this is the law of conservation of energy. Energy can be transformed from one form to another in several different ways. A number of different types of devices such as fuel heaters, generators, batteries, fuel cell and magneto hydrodynamic systems generate usable mechanical or electrical energies. .

1.2.1 Types of energy

Energy comes in various forms:

-Thermal energy

-Motion (kinetic) energy

-Radiant energy

-Nuclear energy

-Gravitational energy

- Electrical energy

-Chemical energy

Whenever people use electricity in their homes, energy is likely to be produced by burning coal or natural gas, a nuclear reaction, or a river-side hydroelectric plant, to name only a few. As people fill the gasoline tank of a vehicle, the source of energy is oil (gasoline) derived from crude oil and may include fuel ethanol provided by growing and processing maize. Coal, natural gas, nuclear, hydropower, petroleum, and ethanol are referred to as sources of energy.

There are two groups of energy sources:

(i) Renewable.

(ii) Non-renewable.

1.3 Renewable energy

Renewable energy is energy that is obtained from renewable resources that are replenished naturally on a human scale. Renewable energy also referred to as clean energy, comes from continually replenishing natural sources or processes.

Types of renewable energy are:

-Solar energy

-Wind energy

-Hydro-electric energy

-Biomass energy

-Tidal and wave energy

1.3.1 Solar energy

Solar or photovoltaic (PV) cells are made of silicon or other materials which directly convert sunlight into electricity. Solar power is the cleanest and most plentiful source of renewable energy. Solar technology can harness this energy for a variety of uses, including electricity generation, light or comfortable interiors, and heating water for residential, commercial, or industrial use.

Fig 1.2: Teknaf Solar Power plant of Bangladesh

1.3.1.a Solar Technologies

Solar energy can be used in three main ways: photovoltaics, solar heating & cooling, and solar power concentration. Photovoltaic produces electricity directly from the sun through electronic processing and is able to supply anything, including calculation systems and road signs, from small electronics to homes and large businesses. . Solar Heating & Cooling (SHC) and Concentrating Solar Power (CSP) technologies both use sun-generated heat to provide room or water heating for SHC systems or, for CSP power plants, to operate conventional electricity generating turbines.

1.3.2 Wind energy

A wind turbine is a device that converts wind energy into electricity. A wind turbines blades spin at a constant or variable velocity between 13 and 20 revolutions per minute, depending on their technology, where the velocity of the rotor varies with respect to the velocity of the wind in order to achieve greater efficiency. Wind turbines have an average life span of more than 25 years, although the most common accounting standard is set for 20-year spans. Rapid development of wind technology has resulted in an increase in wind turbine efficiency.

Fig 1.3: Kutubdia wind power plant of Bangladesh

1.3.2.a Wind Turbine Technologies

Most wind turbines are made up of three blades mounted on a tubular steel tower. There are less common variations of two blades or towers made of concrete or steel. The turbine helps the turbine to take advantage of greater wind speeds encountered at higher altitudes at 100 feet or more above the ground. With their propeller-like blades, which work much like an aircraft wing, turbines capture the energy of the wind. When the wind blows, on one side of the blade there is a pocket of low-pressure air. Then the low-pressure air pocket draws the blade towards it, spinning the rotor. This is known as the lift. The raise force is much greater than the force of the wind against the blade's front leg, called drag. The lift and drag combination makes the rotor rotate like a propeller. The rotation of the rotor from approximately 18 revolutions a minute to approximately 1800 revolutions a minute is increased by a number of gears, which helps the rotor generator to generate AC electricity.

A sealed structure called a nacelle is located inside a housing called a nacelle and includes the main turbine components-usually including gears, rotor and generator. Many nacelles located at the top of the turbine turbines are wide enough to land on a helicopter.

The controller of the turbine is another important component which maintains rotor speeds of 55 mph to avoid wind damage. A wind speed measuring anemometer constantly sends data to the controller. During emergencies, a brake, often located in the nacelle, mechanically, electrically or hydraulically stops the rotor. Use the above interactive graph to learn more about wind turbine dynamics.

1.3.3 Hydro electric power

Energy derived from water movement is hydroelectric energy. Water has mass. Water has mass, because of gravity it sinks downwards. It has kinetic energy to be harnessed when it runs. The force of motion is kinetic energy. Hydro-power is Bangladesh's main renewable power source, while wind energy is likely to take the lead soon. Hydro-power usually uses water that moves quickly or quickly from a high point on a large river and converts the strength of the water into electricity by turning turbine blades of a generator.

Big hydropower plants or mega-damps are often viewed nationally and internationally as non-renewable energy. Mega dams divert and reduce flows, limiting access to river-based animal and human populations. The carefully managed small hydro plants (a capacity less than 40 megawatts installed) do not tend to damage the environment as much because only a fraction of the flow is distracted.

Fig 1.4: Kaptai Hydro-electric power plant of Bangladesh

1.3.4 Biomass energy

Biomass is renewable, plant and animal material which contains plants, waste wood and trees. When biomass is consumed it is discharged as heat and electricity can be produced with a steam turbine. Often biomass is mistakenly described for electricity production as cleaner, renewable fuel and a greener alternative to coal and other fossil fuels. Recent science has however shown that many types of biomass particularly forests produce higher emissions of carbon than fossil fuels. Biodiversity is also adversely affected. However, under the right circumstances some forms of energy from biomass could be a low carbon option.

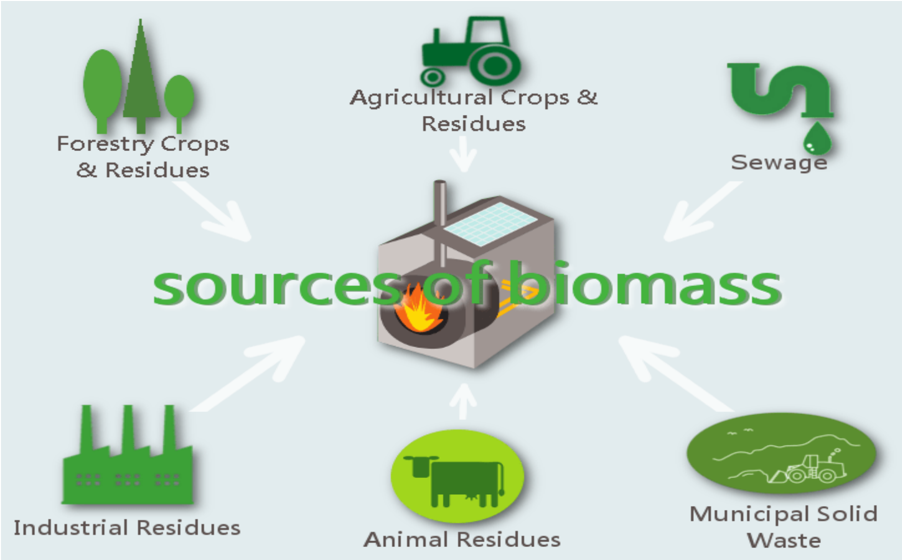


Fig 1.5: Biomass energy

1.3.5 Tidal and wave energy

Tidal and wave energy are still in a phase of development, but the ocean will always be governed by the gravity of the moon, which makes it an attractive option to harness its power. Some approaches to tidal energy can harm wildlife, such as hydrology dams in a sea or lagoon which work very much like barrages. Wave power, like tidal power, relies on dam-like structures or on anchored devices on or under the surface of the water.

Fig 1.6: Tidal and Wave energy in Europe

1.4 Non-renewable energy

A natural resource like coal, gas, or oil that cannot be replaced after consumed. Most of the energy resources currently in use are non-renewable while those that are renewable (such as wind and solar power) are not well established.

Types of Non-renewable energy is,

- Coal
- Oil
- Natural Gas
- Nuclear energy

1.4.1 Coal

Coal has a high carbon and hydrocarbon content as a combusting black or brownish-black sedimentary rock. The fact that coal takes millions of years to shape is known as a source of non-renewable energy. Coal includes the resources that plants have accumulated that existed in swampy forests hundreds of millions of years ago.

Fig 1.7: Coal

1.4.2 Oil

Oil is a natural substance, but it is an hydrophobic material at room temperature but can be dissolved in a number of organic solvents. Oil is a natural substance. This natural resource has many uses and is available in many parts of the world. The vast use of oil in industry and automobiles is becoming scarce for this natural resource. The world is therefore finding alternative sources of energy to replace oil. This is an efficient source of energy and fuel that no alternative fuel can match its properties. Fuel has a high content of carbon and hydrogen. Oil is a source of energy that is not renewable.

Fig 1.8: Oil

1.4.3 Natural Gas

Natural gas is also called fossil gas. It's a hydrocarbon gas mix that mainly consists of methane, but usually includes various amounts of higher carbon dioxide, nitrogen, hydrogen sulfide, or helium. It's a natural mixture. This occurs when the layers of plants and animals that decompose the Earth over millions of years have been exposed to extreme heat and pressure. The energy initially derived from the sun by the plants is contained in the gas in the form of chemical bonds.

Fig 1.9: Gas based Power plant in Bangladesh

1.4.4 Nuclear energy

Nuclear energy comes from splitting atoms into a reactor, turning a turbine and generating electricity into a steam. All of it without emissions of carbon because uranium is used by the reactors and not fossil fuels. Such plants also run well to prevent interruptions and are built to withstand extreme weather conditions, to sustain the grid 24/7.

Fig 1.10: Rooppur Nuclear power plant in Bangladesh

1.5 Introduction of Hybrid Mini-grid System

As demand increases, the energy crisis is concerned that global demand for the limited natural resources used to power industrial society will decrease. The supply is limited for these natural resources. It may take hundreds of thousands of years to fill up the shops while they happen naturally. That's why we need some renewable source. Mini-grid hybrid system is one kind of renewable system.

1.5.1 Mini-grid

A mini grid, also referred to as a ' micro grid or isolated grid, ' can be defined as a collection of electricity generators and possibly energy storage systems interconnected to a distribution network supplying electricity to a localized group of customers. This includes small-scale electricity generation (10 kW to 10 MW) serving a limited number of consumers through a distribution grid. This power supply model can be contrasted with a single customer network like a solar home system (SHS). Where no consumer interconnecting distribution network exists, it can be connected to a regional grid system if electrical energy is distributed over large distances from large central generators where local generators are typically unable to meet local demand.

1.5.2 Hybrid mini grid

A hybrid mini-grid puts together at least two different types of power generation systems and distributes energy through an autonomous grid to several customers. Therefore, the mini grid comes with a mixture of renewable energy sources (RES) and a diesel generator generally used as a backup. It is a mature and cost-effective solution of technology that offers, among other things, high quality and reliable electricity for lighting, communications, water supply, or motive power. An autonomous hybrid system can provide the same standard and services as the national grid. In addition, the technology allows a mini-grid to be connected to the national grid with proper arrangements. Countries where the national grid provides customers with power just a few hours a day and often suffer from blackouts could be more beneficial to the rural populations served by the hybrid mini grid than their fellow urban consumers.

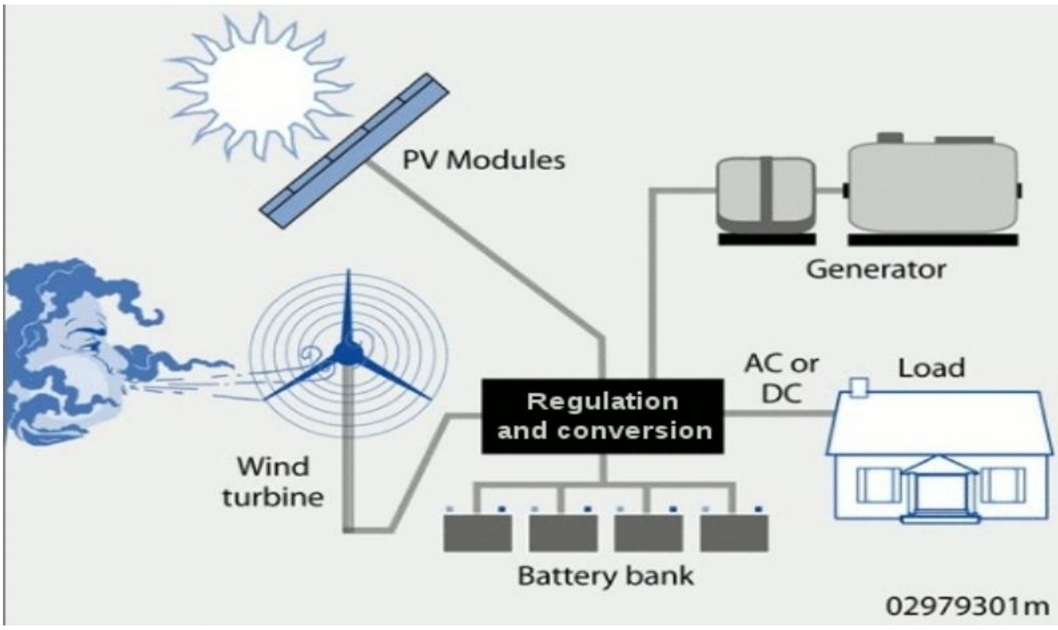


Fig 1.11: Hybrid mini-grid system model.

Compared to a single technology, combining various technologies with different energy sources offers competitive advantages. Combining renewable and genset sources has proved to be the least expensive solution for rural communities as the advantages and benefits of each technology are mutually complementary. Since the renewable energy

industry operates "fuel free," fuel prices or volatility are not subject to them. Renewable systems are however not dispatchable, meaning that they are dependent upon resource availability at a specified time. In contrast, diesel gensets may be dispatched and electricity can be delivered as planned. A variety of shifting load profiles can be covered by combining these two sources. In addition, in many scenarios the combination of different renewable energy sources is just useful. A mix of energy sources can accommodate fluctuations in seasonal resources, for example, by complementing solar PV collectors with wind in the months or catching on if the hydropower is produced in the dry season. With regard to daily energy variations, the production of solar power peaks around midday, whereas wind power plants can operate whenever the wind blows. If input from renewable energy is inadequate, batteries add stability to the system by storing energy for high consumption.

1.6 Statement of Problem

The most important aspect is for a hybrid mini grid system that minimizes costs. It is sometimes difficult to support or satisfy any demand for rural power for only a limited grid system. For solar mini grid, weather conditions are sometimes not very suitable for an off-grid system based on only one source. Occasionally, if radiation is too weak, or when rainy day and night, it is difficult for batteries to charge properly. So, to solve the problem, we need an efficient way. Hybrid mini grid system is the best way to resolve the problem. The solar, wind and generator for hybrid systems are included as backup systems.There is also a problem which needs to be minimized. High costs are the biggest problem. Our research also shows the hybrid system mini-off grid costs study.

1.7 Objective of Research

-. To introduce renewable energy (RE) as an alternative solution for generating electricity.

- To ensure continuous supply of power.

- To design an efficient hybrid mini grid system.

- To optimize the cost form the system.

1.8 Scopes

Bangladesh is not one hundred percent satisfied with electricity. There are number of village in district of Chandpur.. We have chosen a village (Shilarchar) of Chandpur that has no electricity. The village's benefit in supplying sunlight and wind for hybrid mini-grid power plants. And this village stays between two river Padma and Meghna. This village is good for transport system. Because of river transportation cost is very low. There are a number of fisherman are live here. It will be beneficial for the country if they can reserve their fish in refrigerator.

1.9 Research Methodology

For the research, the remote rural area was Shilarchar district of Chandpur in Bangladesh. The Chandpur district has many villages and consists of a major hot and fertile area, alongside the river with scattered households. For the present study, this community is un-electrified village, which was considered the best candidate to electrify hybrid systems consisting of solar, wind and diesel generators. The village is accessible only by boat. There are river between main land and this island. There are 197 households with about 1500people. The houses are close together and most households use early morning and evening candles and kerosene lamps to illuminate. People are faced with the most important requirements, such as good food facilities, electricity. In this village there are two schools and a clinic. Most of the people are fisherman. In this stage they need to store their fish. But they are not able to store their fish for no electricity.

The study area has ample sunshine and wind speeds from moderate to high. Energy requirements in different sectors are calculated on the basis of the data collected from the survey. Specifies the load in individual sectors in the non-electrified research villages with the total load of 104 kwh / day, include lighting, other home loads, such as television, fans and refrigerators.

1.10 Thesis Outlines

Chapter 1: Introduction

Chapter 2: Literature review

Chapter 3: Configuration of solar system

Chapter 4: System design

Chapter 5: Result and discussion

Chapter 6: Conclusion and recommendation

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Bangladesh is situated on the eastern and northern hemispheres of South-Central Asia, on the Indian subcontinent. Bangladesh is bordered by the Bay of Bengal, India and Burma (Myanmar) nations. On this land an average of 5 kWh / m2 of solar radiation occur over 300 days a year. Maximal radiation in March-April is available and minimal radiation available in December-January. A 2012 study found that the average hours of sunshine in Bangladesh ranged from 10 to 7 hours, but this was further decreased by 54% (to 4.6 hours) to compensate for drought, cloud and fog. Therefore, in various sectors of Bangladesh this abundant solar power has great potential to decrease traditional power consumption dependent on fossil fuels and ensure a green environment for future generations.

2.2 Review the Literature

This paper presented a comparative analysis of a hybrid power system connected to an off grid and a grid. Compared to the traditional hybrid system, the grid connection hybrid (PV / Wind) system is more efficient and economical. At the same load. As a result, the new model's current cost is less than off grid. Even though the model off grid needs an extra large battery reserves [1]. In this context, a hybrid energy system can be workable and configured (PV-Diesel-Wind-Battery hybrid) It is not feasible to use diesel alone as a source of energy production today [2]. The maximum wind power is highly dependent on the wind speed. Again, the velocity is highly dependent on the location of the site [3]. The ABC algorithm deducted results were compared with the HOMER and PSO software tool tests. In comparison to HOMER and PSO, the proposed algorithm has shown better results [4]. Variable PV array scale, wind turbine number and AC-DC converter. Minimized design, small reservoir and all environmental considerations are important [5]. The productive effort to preserve the efficiency of energy supplies from the renewable energy sources in conjunction with the combination of several power plants in various energy sources is a hybrid power system [6]. The rising demand for energy is increasing dependence on renewable sources of energy. It will also reduce the national grid's pressure. Reduce gas emissions and also COE emissions [7]. A hybrid mini grid network for a remote non-electrifier village is considered for the technological set up and business analysis [8]. The paper describes the best off-grid alternative and compares this to traditional grid extension with renewable resources hydropower, solar PV, wind, bio-diesel generator. A hybrid renewable energy mix off grid can be economical and affordable, technically feasible and environmentally friendly [9]. Multiple optimization techniques used in hybrid energy systems focused on Photovoltaic-Windegree are best found than single optimization approaches hybrid optimization techniques [10]. PV, wind turbine, Diesel generator with battery system and inverter system also represents a very good alternative solution with little electrical costs and a net present expense [11]. Renewable energy is a greater source of energy to reduce costs [12]. Focus mainly on grid and micro grid service by independent mode. In order to keep the fully reliable and stable device under constant loads, the model generates a number of loads connected with the grid using bidirectional converters [13]. This article discusses conventional and non-conventional power supplies for off-grid systems: the production of electricity due to the favourable daily average sunlight varies but the price of diesel is almost the same [14]. In different locations Bangladesh has a great opportunity for wind power. In the near future this source of energy will be the most economical source of electricity. In order to add total energy demand in the region, Bangladesh looks for renewable energy sources. Huge amount of wind power in Bangladesh's 574 km coastline. In 2020, renewable energy sources will be able to generate more than 10 percent of the total power demand [15].

2.3 Bangladesh's energy sector

In Bangladesh, the power sector has a national grid of 21.419 MW installed as of September 2019. The total capacity installed is 20,000 MW (the combination of solar power). The energy sector in Bangladesh is on the rise. Bangladesh recently began to build a 2.4-gigawatt (GW) Rooppur Nuclear Power Plant scheduled to be commissioned in 2023. In July 2018, 90 percent of the population was able to access electricity, according to the Bangladesh Power Development Council. Yet Bangladesh considers low energy consumption by population. For most of the country's economic operations, electricity is the primary source of power. The total installed capacity for generating electricity in Bangladesh (including captive) as early as January 2017 was 15,351 MW, and in 2018 it amounted to 20,000 Megawatts. Bangladesh's biggest energy users are the residential and manufacturing sectors, followed by trade and farming.

As of 2015, electricity was available to 92 percent of the urban population and 67 percent of the rural population. In 2030 Bangladesh will need about 34,000 MW of power to maintain economic growth by over 7 per cent, an estimated 77.9 per cent of the population had access to energy.

Problems in Bangladesh's electricity sector include high losses in the grid, delayed construction of new power stations, low power production, intermittent energy supply, and theft of electricity, blackouts and shortages of funding for the maintenance of power stations. Overall, system demand in the last decade has not been met in the country's production plants.

CHAPTER 03

CONFIGURATION OF HYBRID MINI-GRID SYSTEM

3.1 Information of Hybrid mini-grid system components

The system of hybrid generation combines PV panels, wind turbines, diesel generators, batteries etc.

3.1.1 Solar Photovoltaic panel

Photovoltaic modules use Sun-based light energy (photons) to produce power with the photovoltaic effect. Some modules use crystalline silicon cells or thin-film cells mounted on wafers. A module's structural (load carrying) component can be either the top or the back layer. Cells must be secured against moisture and mechanical damage. Most modules are rigid, but there are also semi-flexible modules based on thin film cells. The cells are electrically connected in series, with the desired voltage each other, and then raise amperage in parallel. Unit wattage is the empirical voltage product and unit amplification.

Most of the currently available solar panels fit into one of three types:

-Monocrystalline

-Polycrystalline

-Thin-film.

3.1.1.a Monocrystalline

A solar panel consisting of monocrystalline solar cells is a solar panel. These cells consist of the cylindrical silicon ingot produced in the same way as a semiconductor from a single high purity silicon crystal. The cylindrical ingot is divided into cell wafers. The circular wafers are cut into octagonal wafers to optimize the usefulness of the cells. The octagonal form of these cells gives a unique look. The cells are also uniform in color.

Fig 3.1: monocrystalline solar panel

3.1.1. b Polycrystalline

Poly-critical solar panels are usually less efficient than monocrystalline, but have lower cost advantages. Moreover, polycrystalline solar panels tend to show a blue color rather than the black color of monocrystalline panels. Even made of silicon are polycrystalline solar panels. However, the manufacturers melt many fragments of Silicone together to form the wafers to the panel instead of using one single silicone crystal. PCS are also called "multi-crystalline" or "multicrystalline" silicon. Because every cell contains many crystals, electrons are less free to move.

Fig 3.2: polycrystalline solar panel

3.1.1.c Thin-film

A thin-film solar cell is a Second. generation solar cell that uses a thin layer or thin film of photovoltaic material, including glass, plastic or metal, to deposition one or more of the material on a substratum. Thin Filmed solar cells, including cadmium telluride (CdTe), Copper Indium gallium dieseline (CIGS) and Amorphous Thin Film silicone (a-Si, TF-Si) are widely used for many technologies. Film thicknesses range from a few nanometers to decades of micrometers (µm), which is significantly thinner than rival thin-film technology, traditional crystalline solar silicone cell of the first generation (c-SI), which is wafer-thickness up to 200 µm.

Fig3.3: Thin Film Solar Panel

3.1.2 Wind turbine

A wind turbine or a wind energy converter is a device that transforms the kinetic energy of the wind into electricity. Wind turbines can rotate either a vertical or horizontal axis.

3.1.2.a Vertical axis wind turbine

The principal rotor shafts are arranged upright with wind turbines of vertical axis and the main advantages of this type of connection are that it is not necessary to point the turbine towards the wind to be effective. This is to the advantage of locations that have a very uneven wind direction, such as when incorporated in commercial and industrial buildings. The main constraints of this type of wind turbine include the low rotating speed of the wind, which means the higher cost of drive train, the lower power factor, the Aeroflot's 360-degree rotating movement in wind flow during each cycle and therefore the very dynamic load on the blade, the vibrant torque generated by some rotor systems in the drive train.

Fig 3.4: Vertical axis wind turbine

3.1.2.2 Horizontal axis wind turbine

The wind turbines in the horizontal axis are a rotor shaft and a generator at the top of a tower and have to be directed to wind. In small HAWT turbines, a simple wind valve is used for connecting large turbines with a wind sensor that is usually fitted with an AC or DC servo motor. The turbine usually stands upwind from its supporting tower when turbulence is generated behind it. Turbine blades are rigidly constructed to put the blades off by high winds into the tower. In addition, the blades lie a considerable distance from the tower and are sometimes tilted to the wind.

Fig 3.5: Horizontal axis wind turbine

3.1.3 Diesel generator

A diesel generator is a combination of a diesel engine and an electrical generator for electrical energy generation. The engine generator is a particular case. A diesel compression allergy engine is usually designed to be fuel for diesel fuel, but certain types are suited for other liquid or natural gas fuels.

3.1.3. a Prime Rating: Should not be used for applications for Construction Power. Output available for an unlimited time with varying load. Typical peak demand is 100 percent of prime-rated kW with 10 percent of emergency use overloads capability for up to 1 hour in 12. For a limited time, a 10% overload capability is available. This rating does not apply to all models set to the generator**.**

3.1.3.b Base Load Rating: For continuous delivery of energy to a constant load for limitless hours up to the maximum production rate. For this ranking there is no sustainable overload capability. Consult the authorized rating distributor. Such test does not extend to all models set by generators.

3.1.4 Battery

BAE Secura BLOCK SOLAR batteries are the optimal solution in extremely extreme industrial conditions for reliable and robust storage of regenerative energy. The BAE Secura PVS BLOCK SOLAR batteries are characterized by their special electrode design, which provides high safety, reliability and cycle life.

3.2 About Homer Pro Software

HOMER has been a US National Renewable Energy Laboratory free software program. The framework is used to technologically and financially develop and analyze solutions for off-grid and on-grid electricity systems for remote, autonomous and distributed generation applications. It allows a large number of technological options to take into account the availability of energy resources and other variables.

HOMER was initially developed to understand tradeoffs between different configurations of output of energies for the internal DOE (Department of Energy) use in 1993. Some years after the initial design, the NREL released a free version to the growing community of renewable energy systems designers. Since then, HOMER has remained an application with free software which has become a very solid tool for modeling both conventional and renewable.

HOMER is one of GSMA's methods for designing base stations for green energy. This manual explores the complexity of the soft-application and instructs telecom operators how to build renewable energy stations with HOMER and interpret the results in detail across HOMER and various components within the network.

HOMER calculates and simulates the power system based on the various permutations of possible designs. We can compare our standard diesel generator configurations with renewable hybrids (wind and solar), pure wind and pure solar models according the design that we have dimensioned. The existing solution (or standard operator solution for a new facility) should be compared to the preferred renewable alternative in the context of a consistent business case for an off-grid site. In addition, we are able to evaluate the financial and sustainable indicators of the various models under multiple scenarios by incorporating the sensitivity analysis on the diesel price and primary load.

CHAPTER 04

SYSTEM DESIGN

4.1 Introduction

As of 2018, the estimate for Bangladesh's rural population was 102,248,100. This indicator has in the last 58 years reached 102,715,900 in 2013, with 455,480,010 in 1960. This indicator has not been met. The rural population is described by national statistical offices as people who are living in rural areas. The disparity between total population and urban population is estimated. Aggregation of urban and rural populations due to different coverage of the country cannot add up to the total population.

Day by day, demand for electricity is growing; there is an unprecedented decrease in fossil fuels sources. Therefore, renewable energies such as the solar energy, wind, biomass, microhidro, geothermal and ocean have to be looked for in various modern times in order to meet their every day requirements in electrical energy. In the developed countries, photovoltaic modules are now commonly used for electricity production, where the use of traditional supplies may be inconvenient or costly. In these regions, the solar power system can be employed to generate electricity. Photovoltaic is an independent, green-friendly and silent source of power and also wind power is eco friendly.

4.2 Explanation of design

At first consider a certain number of photovoltaic module (PV) that’s connected in series, which are connected to a charge controller (CC). The CC monitors the voltage and current coming from the solar panel into the DC bus bar and battery. The solar power is not available at night, therefore it needs to be stored. There are a number of connecting batteries in series that store energy for the night. After that there is a AC bus also, Converter are here to changes AC to DC. A wind turbine is added, which is connected to AC bus. A generator is connected also to AC bus, it works when there is no sun and no wind. The batteries are not enough to back up, so we need extra power.

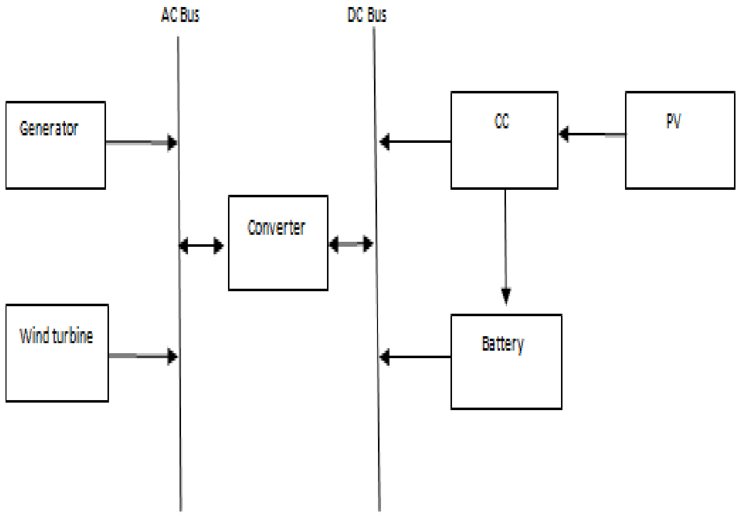


Fig 4.1: Block diagram of system design.

4.3 System design by Homer

Homer Pro Software designs the most economical program with thousands of systems being analyzed in minutes. Firstly it take some input value then it is analyzed the value and give a best system design which is cost effective.

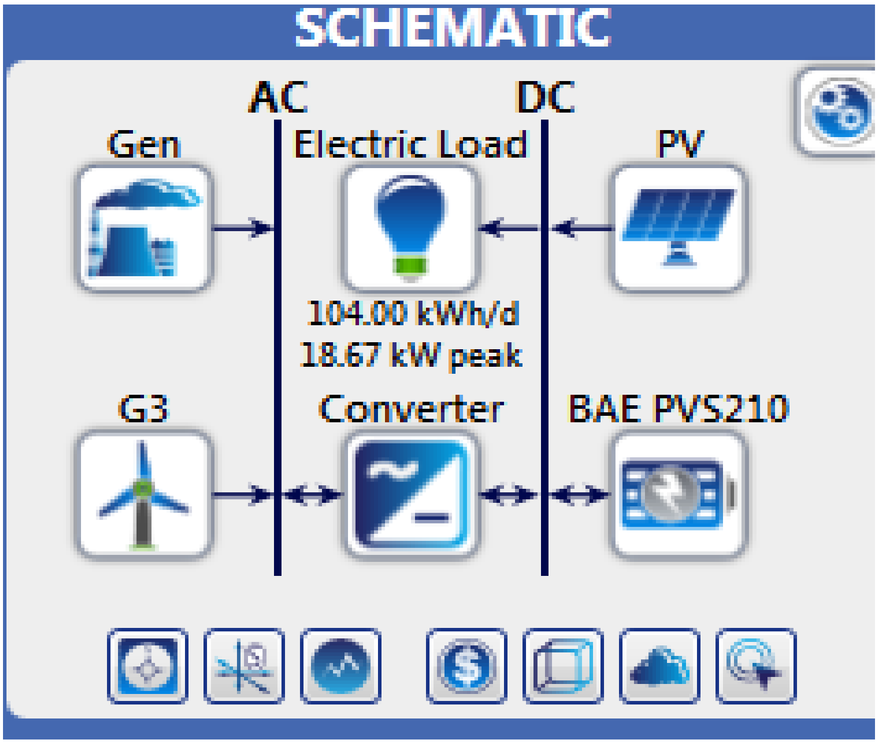


Fig 4.2: Hybrid mini-grid system design by homer software.

4.4 Daily Load profile

The Remote Residential Unit is simple and does not require large amounts of power for electricity and lighting. The load profile was proposed considering the general use of hourly loads. At midnight, the power consumption for the residential unit is reduced where only basic electrical appliances consume power. In the morning, load demand rises when everyone is prepared either to go to school or fields. The demand for loads is high all noon, as most refrigerators consume electricity this time. In the evening hours also loads high, when most of the family members are come home. From Bangladesh's perspective, the number of changes of climate takes place. Consider this therefore, everyday load split three sectors like,

-July to October

-November to February

-March to June

4.4.1 Loads daily profile July to October

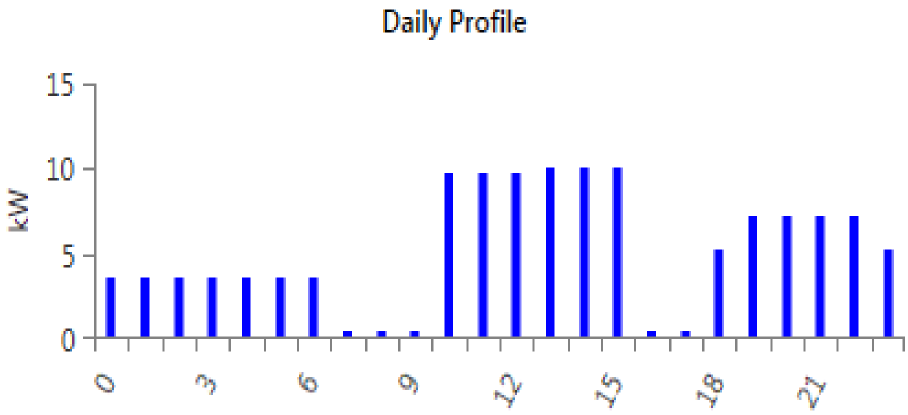


Fig 4.3: Load profile July to October

4.4.2 Loads daily profile November to February

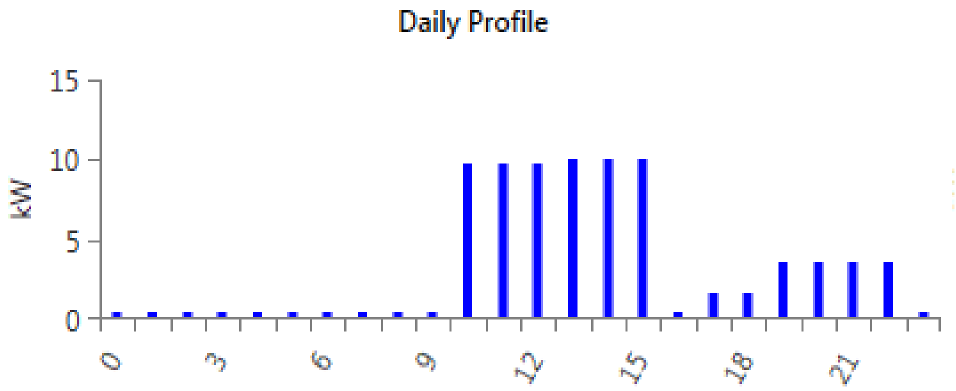


Fig 4.4: Load profile November to February

4.4.3 Loads daily profile March to June

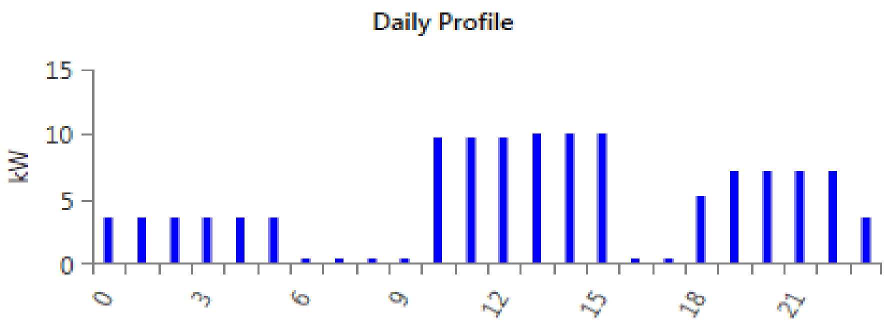


Fig 4.5: Load profile March to June

4.5 Seasonal load profile

The average load curve is used to construct a monthly load curve profile.The entire m onthly load profile is used to build a seasonal profile that considers every month maximum load (kw), minimum load(kw) consume and daily high and daily low load(kw) consume.

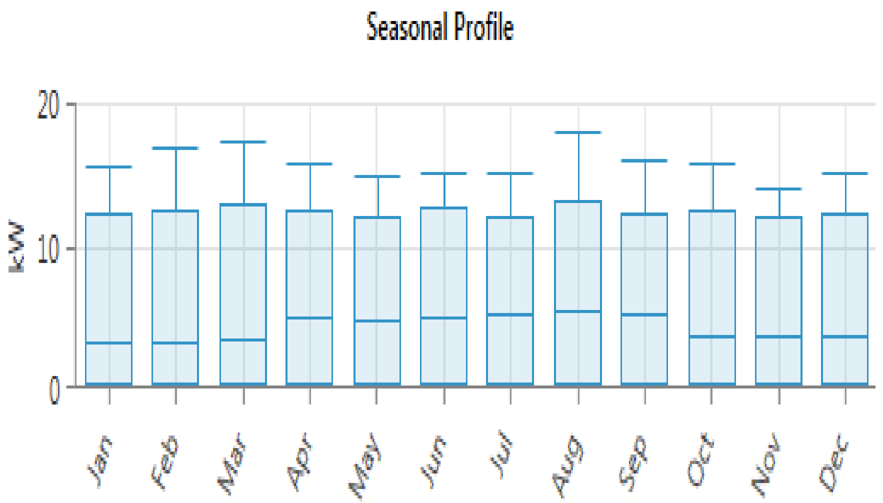


Fig 4.6: Seasonal load profile

4.6 HOMER input value

Basically Homer software is uses for mini grid system design. On this way need to give some data for run the software. Such as PV, Diesel generator, Wind turbine, Battery etc. This elements price/KW is the given input.

4.6.1 Photovoltaic Array (PV)

The lifetime of Photovoltaic Array (PV) is 25 years. In this system uses 24.7KW photovoltaic Array.

4.6.1.a Costs of Photovoltaic Array

The Costs table shows the initial cost of capital and replacement of the PV system per kilowatt, as well as the cost of ongoing operation and maintenance (O&M) per kilowatt.

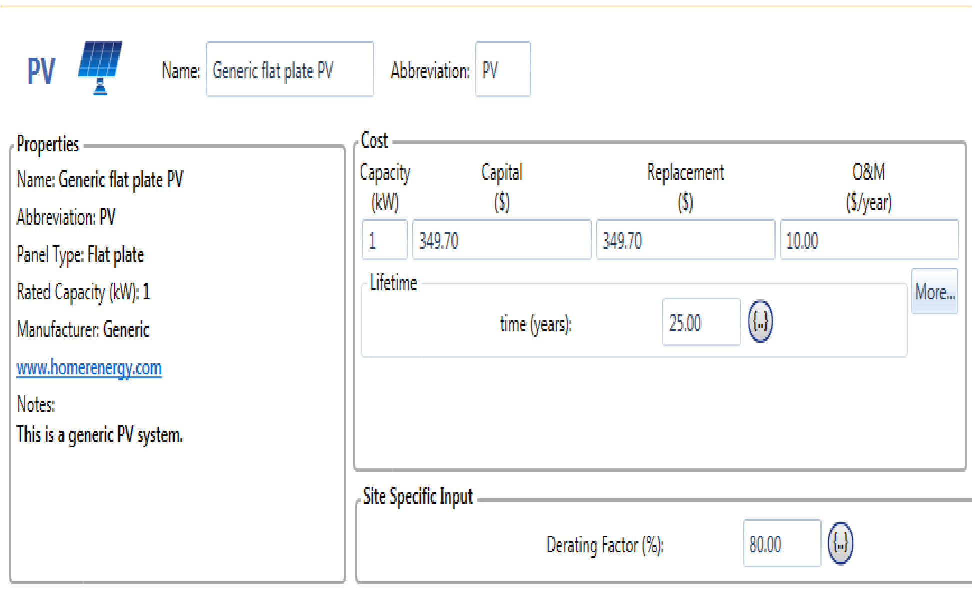


Fig 4.7: Generic flat plate PV costs.

4.6.2 Diesel Generator

The lifetime of generator is also 25 years. In this system uses 22kw diesel generator. The fuel of this generator is diesel.

4.6.2.a Cost of Diesel generator

The Generator Cost area includes the generator's initial cost of production and replacement costs, as well as annual cost of operation and maintenance (O&M).

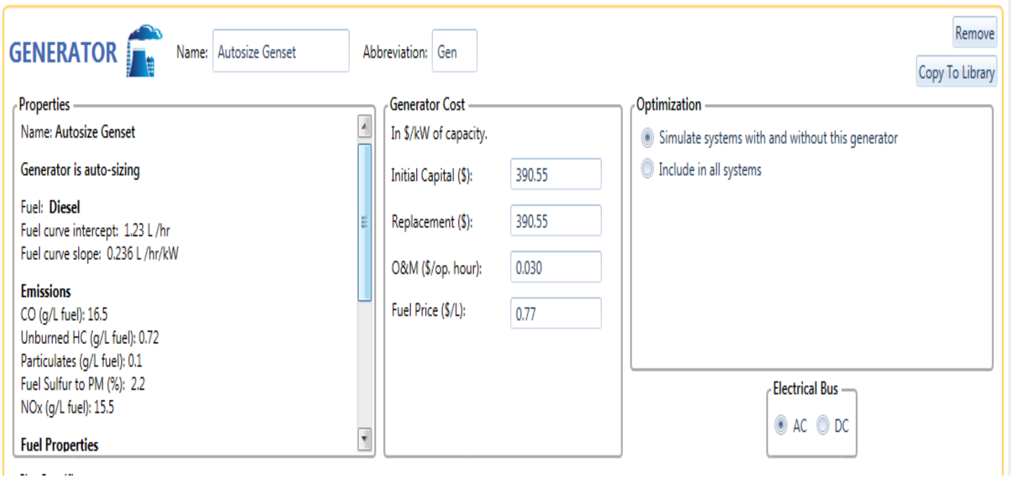


Fig 4.8: Generator and Fuel costs

4.6.3 Wind Turbine

The lifetime of a wind turbine is 25 years. In this system we uses 3kw wind turbine.

Minimum required wind speed for run the turbine is 8 m/s.

4.6.3.a Costs of Wind turbine:

The capital cost is the initial purchase value for a turbine, the replacement cost is the cost of replacing the wind turbine at the end of 20 years and the operation and maintenance cost is the annual cost of operating and maintaining the wind turbine. Generally operation and maintenance cost is 2% of the capital cost.

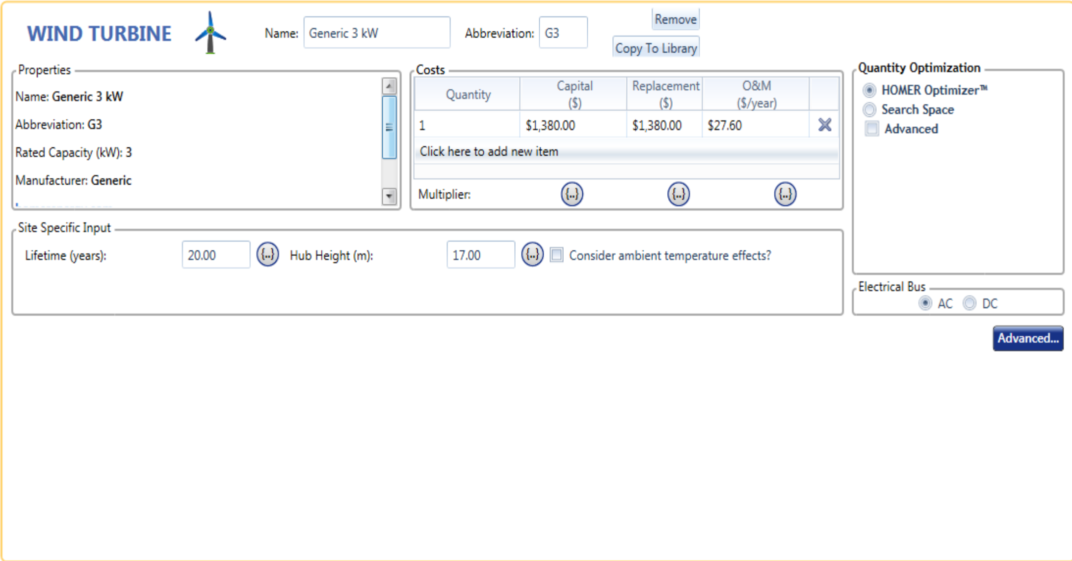


Fig 4.9: Wind turbine costs.

4.6.4 Battery

The lifetime of the BAE PVS block 12v 210 is about 18 years. In this system we uses 12 volts battery.

4.6.4.a Cost of Battery

The Batteries Cost area includes the Batteries initial costs and replacement costs, as well as annual cost of operation and maintenance (O&M).

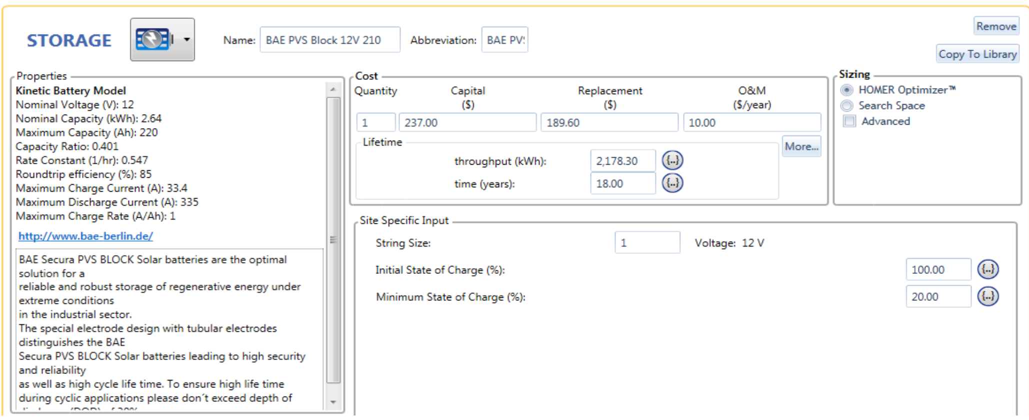


Fig 4.10: Kinetic batteries costs.

4.6.5 Converter

The lifetime of the converter is about 15 years. Its main purpose is converting the power through AC to DC bus.

4.6.5.a Cost of system converter

The capital cost is the initial purchase value for a converter; the replacement cost is the cost of replacing the converter at the end of 15 years.

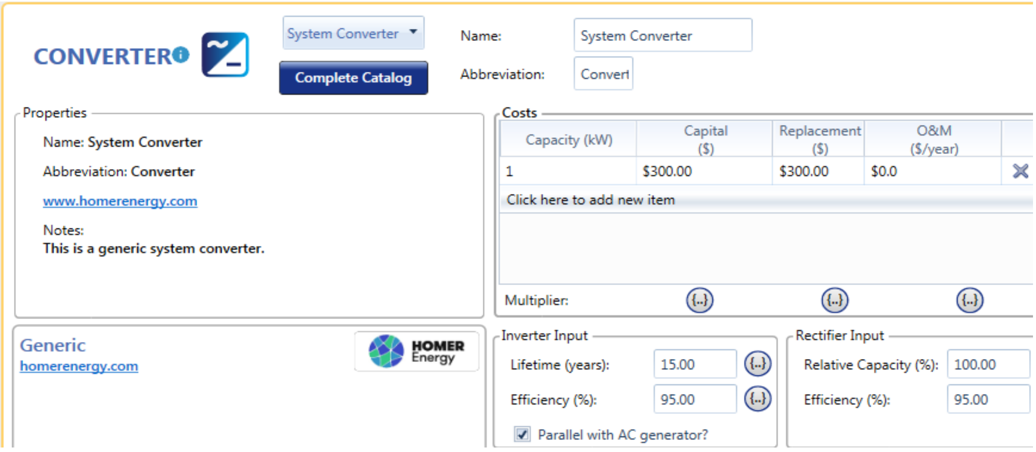


Fig 4.11: System converter costs

4.6.6 Solar resources

Solar radiation is maximums in April to May. On the other hand lowest radiations in September, October, November, December and January.

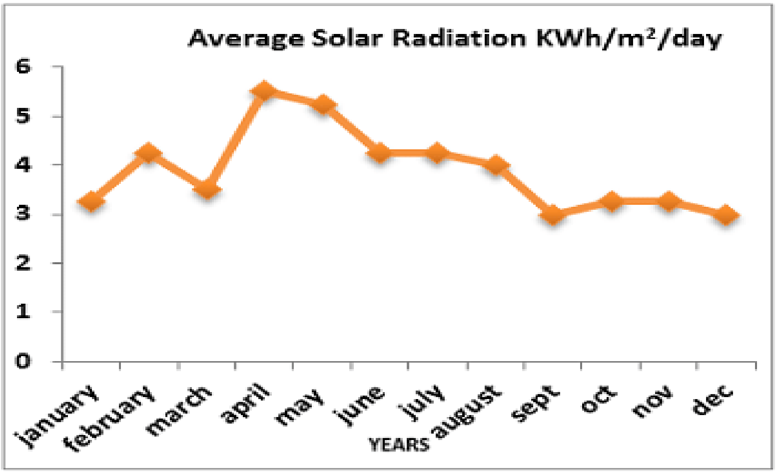


Fig 4.12: Solar radiation graph.

4.6.7 Wind resources

In our chosen site most of the time of a year average wind speed is greater than 8 m/s. But in November to February wind speed below 8m/s. In such time we must depend on other sources.

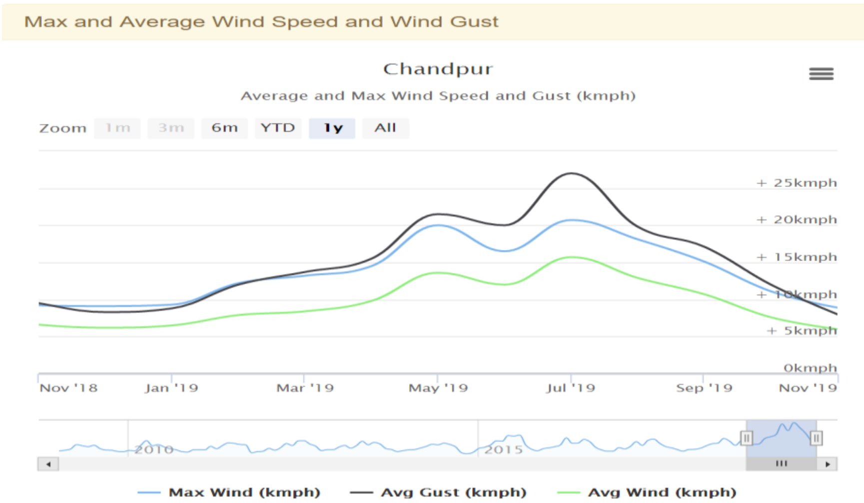
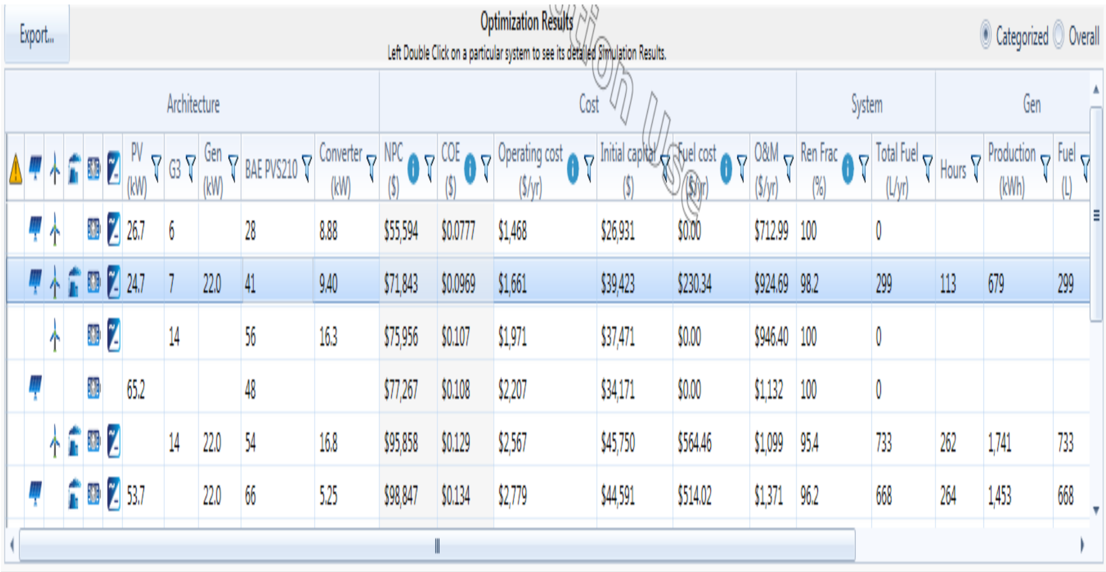


Fig 4.13: Wind speeds graph of Chandpur.

4.7 Simulation

Each component's input data and variables defined for controlling and optimizing the system allow HOMER to develop the most economical and efficient system. The optimization takes into account the flexibility in the selection of the source. The optimal configurations are found after several simulations taking into account 47293 kWh / m2/day of solar radiation with a clearness index of 0.508, wind speed of 8 m / s and diesel price of 0.77$/L. HOMER suggested many different configuration systems from which the PV / Wind / Battery / Generator system is the most efficient system, taking into account initial capital, operating costs, TNPC and COE.



Architecture					Cost						System		Gen		
PV (kW)	G3	Gen (kW)	BAE PVS210	Converter (kW)	NPC ($)	COE ($)	Operating cost ($/yr)	Initial capital ($)	Fuel cost ($/yr)	O&M ($/yr)	Ren Frac (%)	Total Fuel (L/yr)	Hours	Production (kWh)	Fuel (L)
26.7	6		28	8.88	$55,594	$0.0777	$1,468	$26,931	$0.00	$712.99	100	0			
24.7	7	22.0	41	9.40	$71,843	$0.0969	$1,661	$39,423	$230.34	$924.69	98.2	299	113	679	299
	14		56	16.3	$75,956	$0.107	$1,971	$37,471	$0.00	$946.40	100	0			
65.2			48		$77,267	$0.108	$2,207	$34,171	$0.00	$1,132	100	0			
	14	22.0	54	16.8	$95,858	$0.129	$2,567	$45,750	$564.46	$1,099	95.4	733	262	1,741	733
53.7		22.0	66	5.25	$98,847	$0.134	$2,779	$44,591	$514.02	$1,371	96.2	668	264	1,453	668

Fig 4.14: Simulation for PV/wind/battery/generator system

CHAPTER 05

RESULT AND DISCUSSION

5.1 Introduction

Greenhouse gas emissions are reduced substantially as minigrids are considerably mor e environmental friendly than other types of grids.Because they reduce the demand fo r diesel generators, air and noise pollution are also improved in mini-network areas. In addition, mini grids deliver other financial advantages, aside from reduced fuel costs. Mini grids can be run through a variety of energy sources, ensuring that power costs are lower. In addition to off-grid or indoor solar systems, mini-grid systems can dispense electrical storage to many users, which reduces the cost of electrical storage in one area. Mini-networks are also richer than other electricity grid types. When their electricity services have improved and malfunction such as blackouts have decreased, consumers are more generally satisfied and thus ready to pay for mini grids services which lead to increased revenues. Mini-grids benefit the people and communities they serve, as well as their technical and economical advantages. Many companies and organizations need workable and efficient electricity to function. In order to succeed in developing areas, mini grids provide the services needed for companies. This creates more jobs and increases the community's revenues. Improving electricity can also benefit healthcare and institutions within the regions and lead to higher living standards. The electricity mini networks can also provide additional opportunities for social events and community-building events.

5.2 Simulation results

After given the desire input in Homer pro, the software will show several output. We choose most efficient and minimum costly system. After choose we will see the details about each component.

5.2.1 Cost summary

After the simulation total Net present cost is $71842, Levelized COE is $0.096 and Operating cost is $1660. Most of the money spends in Battery which is almost $29000. But it can produce carbon free energy.

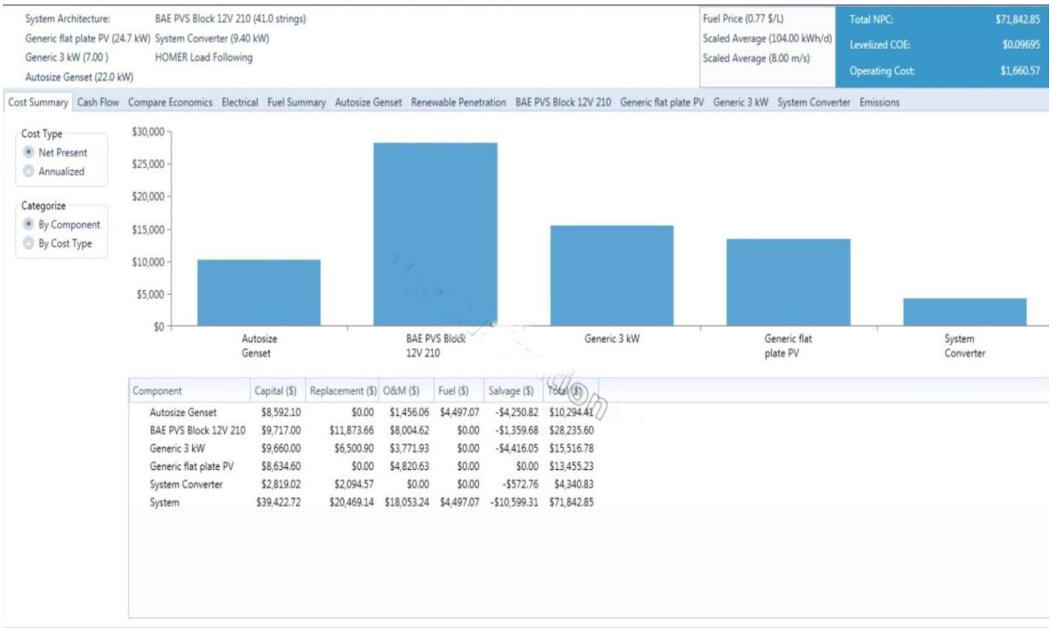


Fig 5.1: Cost summary

5.2.2 Cash flow

In this system capital is almost $40000, after several times salvage value is almost $20000.

Fig 5.2: Cash flow

5.2.3 Compare economics

For the current system we can compare with base system. In our current system which consists PV, wind, genset, battery and converter total net present cost is $71843 and initial cost is $39423. But in base system which consists only genset and converter net present cost is $403027. This is almost 6 times costly comparing with our current system.

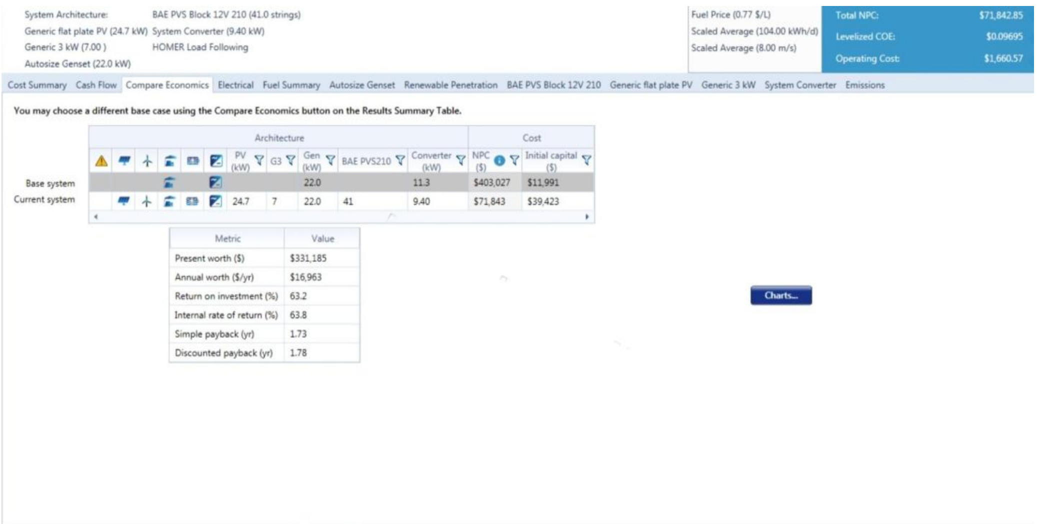


Fig 5.3: Compare economics

5.2.4 Electric production

Total Electric production in a year most productions in April and May which is 10 MWh. And lowest production in October which is 5.5 MWh. PV energy productions are 36393KWh in a year which is 39.2% of the total production. Genset production is 679 KWh in a year. And wind energy productions are 55658 KWh in a year which is 60% of the total energy production.

Fig 5.4: Electric production

5.2.5 Fuel summary

Most of the time generators are not running. But in July to November generator are needed. That’s why it consumed fuel. Total fuel consumed in a year is 299 Litre. Average fuel consumed per day is 0.820 Litre. Average fuel consumed per hour is 0.0341 Litre

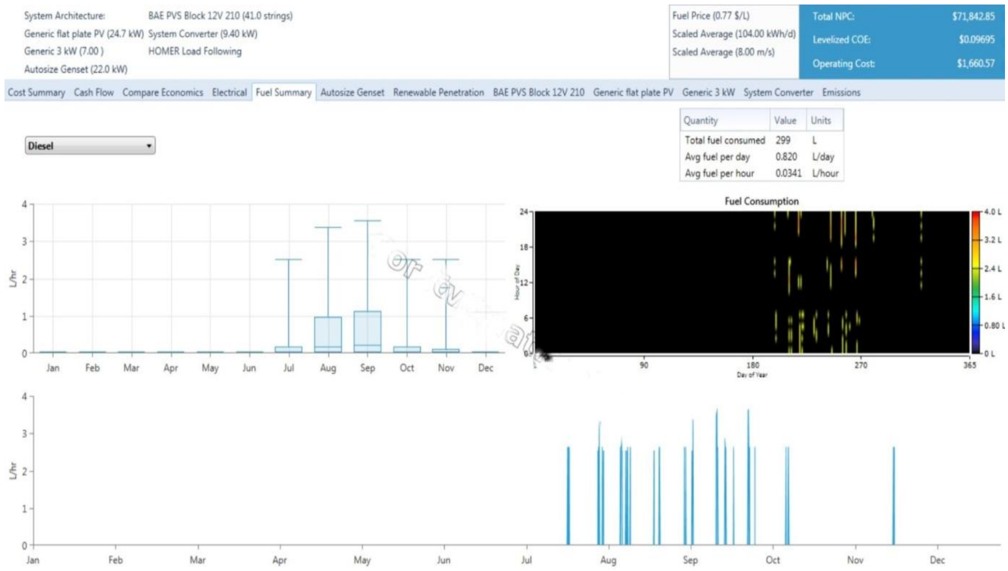


Fig 5.5: Fuel summery

5.2.6 Generator

22 KW Genset are needed for the system. Generator is mostly needed in summer seasons. Generator are run through a year is 113 hour. Total electricity production is 679 KWh in a year. Total fuel consumption is 299 litres.

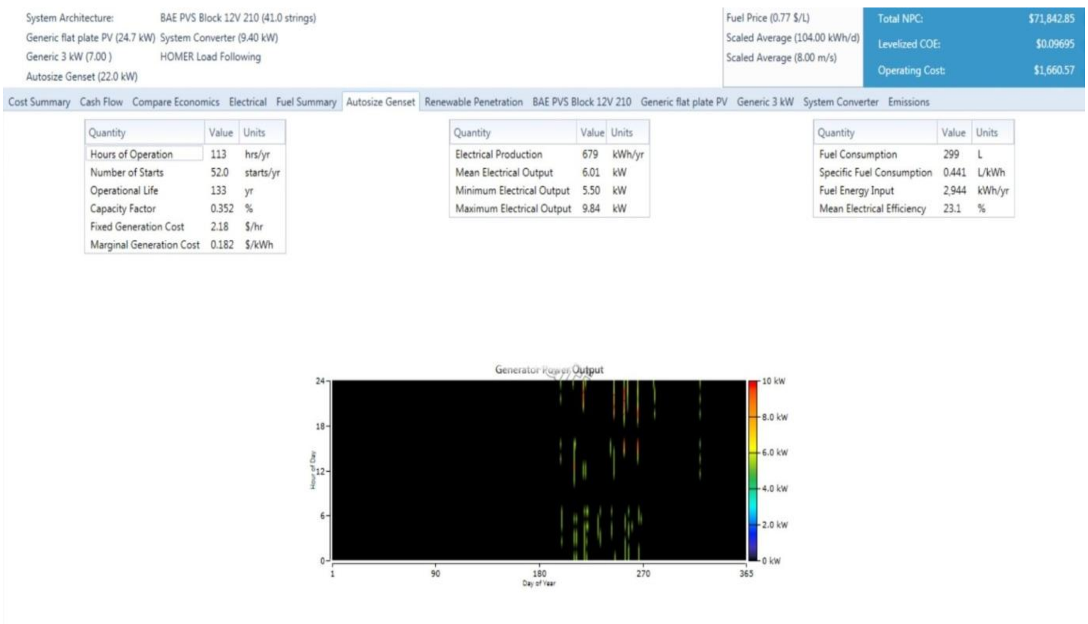


Fig 5.6: Generator

5.2.7 Battery

41 strings of Battery are needed for the system. Bus voltages are 12v. Total energy consume the battery is 10498 KWh/year. And total energy supply is 8936 KWh/year. Losses are 1576 KWh/year.

Fig 5.7: Battery

5.2.8 Photovoltaic

In this system we needed 24.7 KW of PV plate. Mean output is 99.7 KWh/day. PV penetration is 95.9%. Operational hour in a year is 4374 hours.

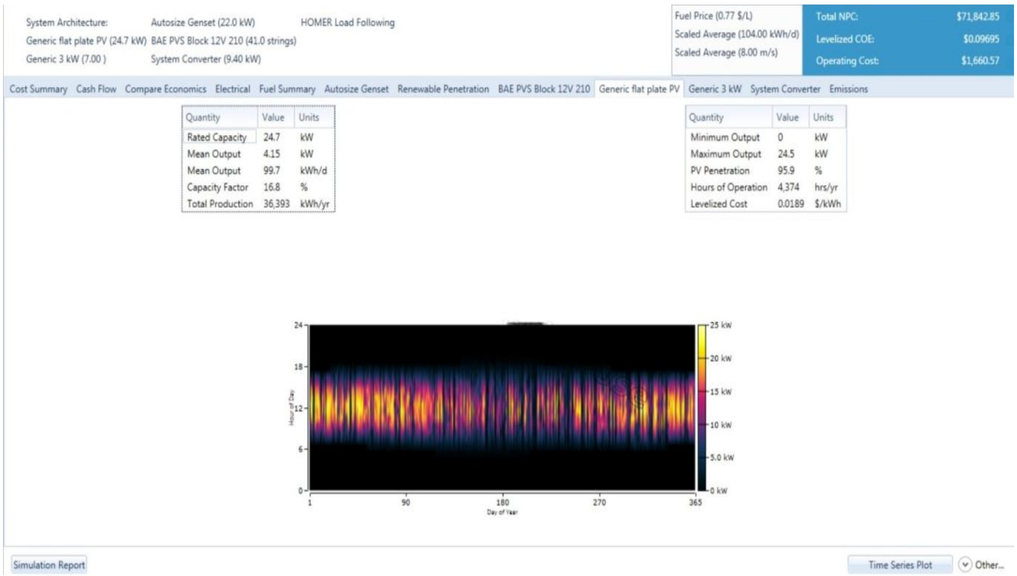


Fig 5.8: Photovoltaic for the system.

5.2.9 Wind turbine

In this system we needs 7 wind turbine. Total capacity is 21 KW, mean output is 6.35KW. Total production in a year is 55658 KWh/year. Wind penetration is 147%. Its operational time is 7590 hours in a year. Levelized cost is 0.0143 $/Kwh.

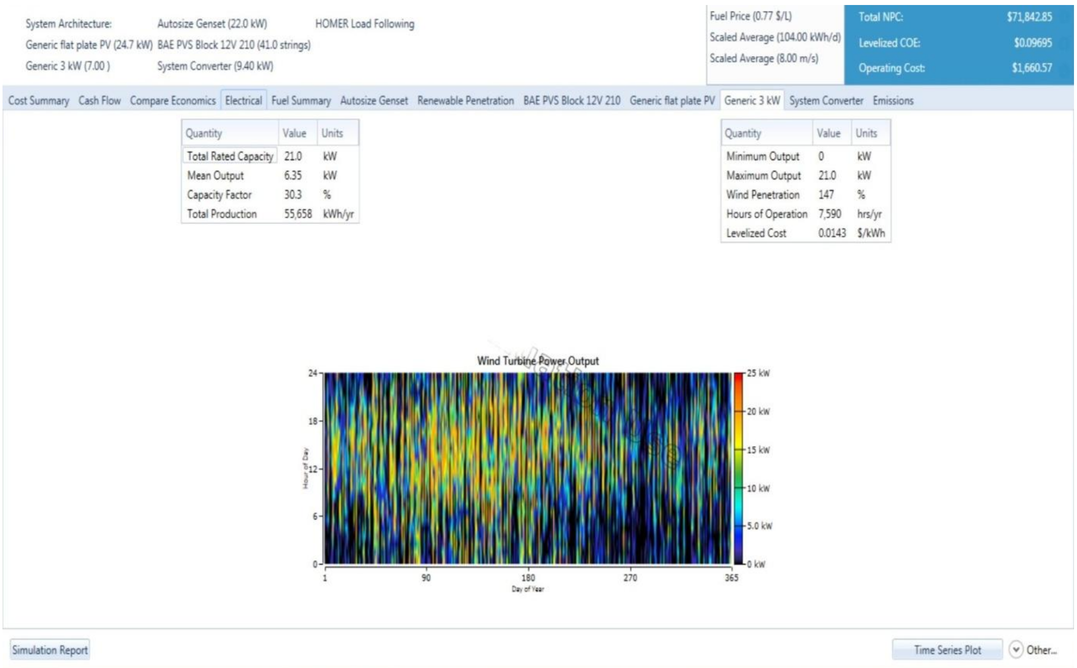


Fig 5.9 Wind turbine

5.2.10 System converter

In this system we need 9.40 KW of system converter. Capacity factor is 19.5%. Total operational time in a year is 5493 hours. Energy consumes 16907 KWh and energy out 16061 KWh through a year.

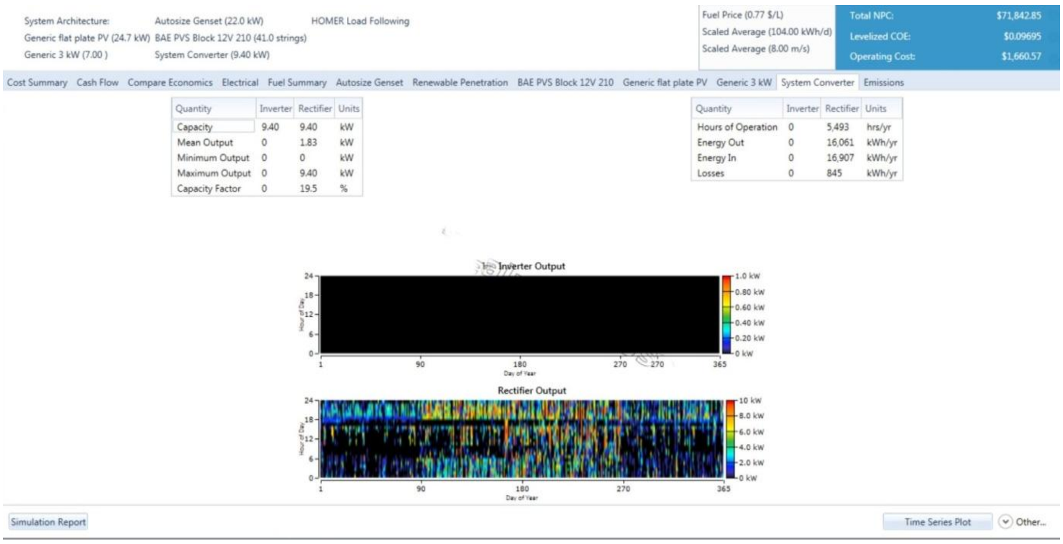


Fig 5.10: converter in the system

5.2.11 Renewable penetration

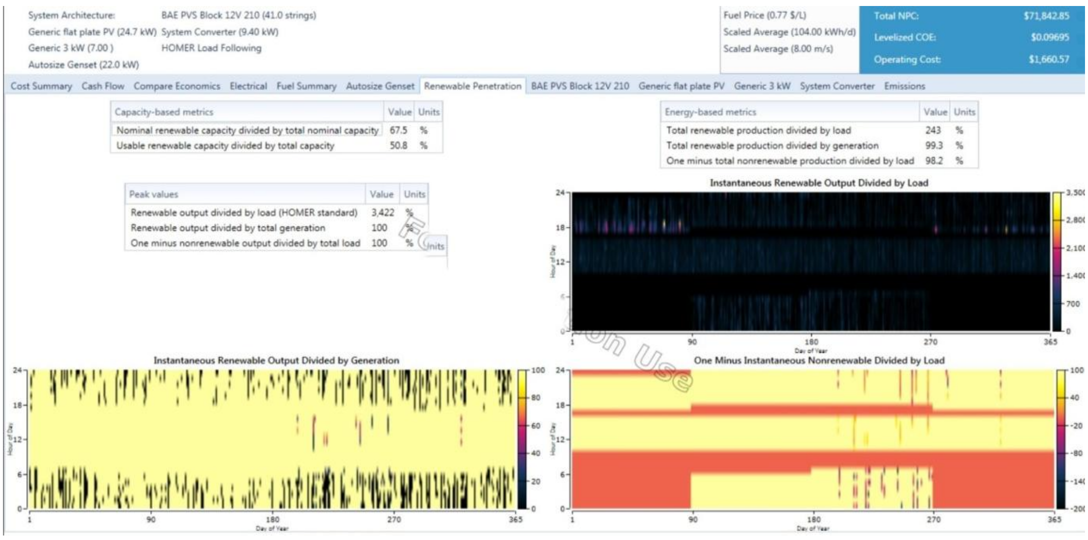


Fig 5.11: Renewable penetration

5.2.12 Emission

In this system there will be some emissions. Because this systems are not fully renewable system. Total carbon emission is 787.94 Kg through a year. And there are also some other emissions.

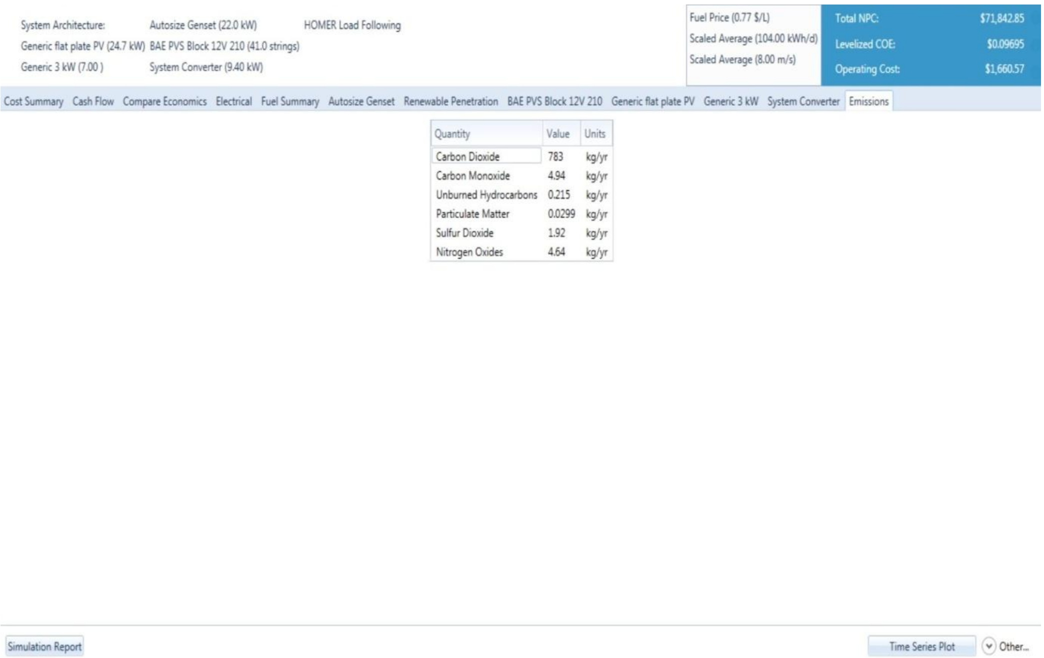


Fig 5.12: Emissions for this system

CHAPTER 06

CONCLUSION

6.1 Conclusion

This paper focused on the design of an independent hybrid mini-grid system intended for community. The loads were analyzed and suitable load curves were designed for a Twelve months period to ensure a highly precise solution. The main objective was to minimize the overall NPC of the system while a few other technical restrictions did not allow for load shedding. The optimization method analyzed thousands of design choices ranging from different capacities of chosen energy resources and converters as well as batteries combining different technical features and capital costs. The analysis arrive at a judgement that, the given loads, the finest system design is the one consist of a PV array with a capacity of 24.7 kW, a 22 kW diesel generator, 98.4 kWh of batteries, wind turbine with a capacity of 21 kW, and a converter with a power rating of 9.4 kW; the total NPC of this system is $71.857.

6.2 Limitations

- Solar radiations are not same always. Homer does not calculate it.
- In rainy days there was a severe thunderstorm, it can damage the system.
- There is a chance in such poor areas; the government may not pay the money.
- There is no road in that village, can cause an inconvenience.
- Sometimes the wind may stop blowing.

6.3 Opportunities for future work

- Carbon emission can be further reduced.
- Solar panels can be used with more advanced technologies.

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