OPTIMIZATION AND COST-BENEFIT ANALYSIS OF THE PHOTOVOLTAIC SYSTEM CONNECTED TO THE GRID AT DAFFODIL INTERNATIONAL UNIVERSITY

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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MAY, 2023

DECLARATION

I hereby declare that this project “**Optimization and cost-benefit analysis of the photovoltaic system connected to the grid at Daffodil International University**” 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.

Signature of the candidates

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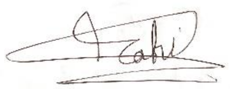

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APPROVAL

The project entitled **"Optimization and cost-benefit analysis of the photovoltaic system connected to the grid at Daffodil International University"** submitted by **Soumit Debnath (191-33-938) & M.A. Rafi (191-33-886)** 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 **May, 2023.**

Signed

3/5/23

Mr. Md. Dara Abdus Satter

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Daffodil International University

Dedicated

To

Our Parents

I Appreciate Everything You've Done for Me……..

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LIST OF ABBREVIATIONS

PLN	Personal Learning Network
PV	Photovoltaic
DC	Direct Current
AC	Alternating Current
KWh	Kilowatt hour
SREDA	Sustainable and Renewable Energy Development Authority
NPC	Net Present Cost
COE	Cost of Energy
NREL	National Renewable Energy Laboratory
YKSG	Younus Khan Scholar Garden
NASA	National Aeronautics and Space Administration
VFD	Variable Frequency Drive
UK	United Kingdom
NPE	Net Present Energy

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First of all, we want to give thanks to **GOD**. With his blessing we are able to complete our work with best effort.

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Author,

Soumit Debnath & M. A. Rafi

ABSTRACT

Growing energy consumption has made energy security a more pressing problem, necessitating the use of green resources. Solar is the one of the best resources that don't any kind of damage of environment. Using sunlight energy by solar panel we can use as replacement of our generated electricity that is produce by coal or liquid fuel. This kind of fuel is not sufficient for our human demand and also harmful for environment. In Daffodil International University we want to build up a solar based power plant. So, the investigation will be running on the rooftop of the Engineering Complex and YKSG-2 (hall) of Daffodil International University. The university located at Birulia, Savar, Dhaka. By Homer Pro software we get a result that is the Present worth is $ 86403 and our return on investment is 9%. A sensitivity analysis was also conducted to assess the impact of differences in radiation from the solar (4.35, 5.22, 6.10 kWh/m2/day), PV capacity (100 kW, 150kW, 200 kW), and grid prices ($0.10, $0.08, $0.11 per kWh) upon that optimum configuration. This study found COE is $ 0.0678. This research evaluates the system's effectiveness and demonstrates that, based on real net expenses and energy costs, the system is economically viable. So, we say, our concern is not only reducing our electricity cost also care of our environment.

An electrical inverter constantly connects a PV device to the grid. The performance and design of inverters enable many of the essential aspects of PV technology. As a result, there is a need for converter versions that are appropriate for researching PV systems. Several distributed generation (DG) modes are described in this article, including switching and averaging modes appropriate for various test scenarios and inverter-specific operation modes. Inverters' ability to locate undesirable islands rapidly and ultimately remove them in the case of a grid failure is a crucial function. This study examines various active anti-islanding methods with accurate voltage and frequency notes.

***Keywords:* Solar Panel, Inverter, Grid, Cost of Energy, Homer Pro.**

CHAPTER 1

INTRODUCTION

1.1 Introduction

The system is unable to supply all of the energy needs of the population because of Bangladesh's expanding industrial and commercial sectors and vast population. In some hilly areas, a grid cannot be established. We are switching to renewable energy sources like solar, biomass, wind, and others as a result. Since solar energy is a renewable resource, it is infinitely available. Solar energy doesn't cause pollution. It does not release any greenhouse gases that retain heat, such as carbon dioxide. It does not harm the environment in the same way as drilling or mining for fossil fuels does. Moreover, solar energy consumes little to no water compared to power plants that use steam turbines to produce electricity. Solar electricity can be produced with proven photovoltaic (PV) technology. Globally, it is used for a variety of purposes, including providing electricity to remote communities, reducing utility peak load, cathodic protection in pipelines, protecting distant oil fields and gas oil separation plants telecommunication towers, highway telephones and billboards, off-grid cottages, desert resorts, pumping water for irrigation and community use, lighting public parks, exterior home lighting, and many more.

Rooftop solar panels are SPV panels located above the house that produce electricity, lowering the demand for PLN electricity and completely removing the requirement for the PLN network. Rooftop solar panels can be utilized either independently or in conjunction with the PLN network. The PLN network now provides energy to almost all residential buildings. The electrical energy source used by PLN is made to use as little electricity as possible. Each home has a rooftop solar panel as one of the techniques used to try and reduce reliance on PLN energy sources.

Solar radiation is primarily used for practical purposes while discussing solar energy systems. Other than geothermal energy, all other renewable sources of energy rely on solar energy. [1]

Depending on how they capture, transform, and disperse sunlight, solar technologies can be roughly categorized as passive or active. In order to transform sunlight into useful outputs, active solar approaches use photovoltaic modules (also known as photovoltaic panels) and solar thermal collectors (with electrical or mechanical equipment). Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air. Passive solar technologies lessen the need for alternative resources and are typically thought of as demand side technologies, whereas active solar technologies enhance the energy supply and are classified as supply side technologies.

1.2 Renewable energy

Renewable energy sources include solar, wind, geothermal, water, and biogas because they renew themselves naturally and do not run out over time. These fuels are less harmful to the ecosystem than fossil fuels and are regarded as viable because they emit few to no carbon gases.

Using photovoltaic cells, which turn sunshine into power, solar energy is produced. Wind generators are used to create wind energy by converting the moving energy of the wind into electrical energy. Hydro energy is produced by using the force of water movement, whereas geothermal energy is produced by using heat from the earth's center.

Burning biological substance, like timber or agricultural residue, to produce heat or power is known as biomass energy. These green energy sources are crucial in the battle against climate change because they can all potentially substitute fossil fuels and cut carbon pollution.

1.2.1 Solar Energy

Solar energy is derived from the sun and is a sustainable energy source. It can be used to run houses, companies, and even entire towns because it is a pure, dependable, and renewable energy source. Solar panels are used to collect solar energy and transform it into electrical power that can be used to run buildings and houses.

Numerous advantages of solar energy include decreased carbon pollution, decreased reliance on natural fuels, and decreased energy expenses. It is a flexible energy source that can be used in isolated locations where it might be challenging or expensive to obtain conventional power sources.

Location, time of day, and temperature are just a few of the variables that affect how much solar energy can be captured. But as solar technology has developed, it has become more efficient and affordable, making it an attractive choice for many people and businesses seeking to cut their carbon impact and save money on energy expenses.

1.3 Calculate Load Current Analysis

The voltage given to the load and the resistance of the load itself must be known in order to compute load current. These variables can be calculated using a variety of techniques, such as measurements or calculations.

Using Ohm's Law, which states that the current through a conductor between two locations is directly proportional to the voltage between the two sites and inversely proportional to the resistance between them, you may calculate the load current once you have determined the voltage and resistance. Calculating load current uses the following formula:

$$I = V / R$$

Where I is the load current in amps, V is the load voltage in volts, and R is the load resistance in ohms. It is important to note that load current can vary over time depending on the characteristics of the load, such as whether it is a resistive, inductive, or capacitive load. Additionally, the calculation of load current may be affected by other factors such as the voltage drop across the wiring or other components in the circuit.

1.4 Types of solar Panels

Monocrystalline, polycrystalline, and thin-film solar panels are the three main types of solar panels used for harnessing solar energy. Each type has its own unique characteristics and benefits.

Monocrystalline solar panels:

Made from a single, high-quality silicon crystal, giving them a uniform appearance. Most efficient type of solar panel, with the ability to convert sunlight into electricity with an efficiency rate of up to 22%. Takes up less space than other types of solar panels and lasts for up to 25 years. Can be more expensive than other types of solar panels, due to the manufacturing process. [2]

Polycrystalline solar panels:

Made by melting multiple silicon crystals together, creating a less uniform appearance than monocrystalline panels. Slightly less efficient than monocrystalline panels, with an efficiency rate of up to 19%. More affordable than monocrystalline panels due to a simpler manufacturing process. Can take up more space than monocrystalline panels due to a lower power output. [2]

Thin-film solar panels:

Made from layers of photovoltaic material deposited onto a flexible substrate such as glass, metal or plastic. Less efficient than monocrystalline or polycrystalline panels, with an efficiency rate of up to 12%.Can be made in different colors and sizes, making them suitable for a range of applications. Can be produced more cost-effectively than other types of solar panels, but have a shorter lifespan of around 10-15 years. [2]

	Monocrystalline modules	Polycrystalline modules	Thin layer modules
Efficiency rate	16 - 20 %	14 - 18 %	6 - 14 %
Low-light behavior	Losses under diffuse lighting	Losses under diffuse lighting	Only low losses
Thermal behavior	Losses at high temperatures	Losses at high temperatures	Only low losses
Costs	More expensive than polycrystalline &Thin layer modules	cheaper than monocrystalline modules	cheaper than monocrystalline & polycrystalline modules
Long-term test	very high performance stable, high durability	High performance, stable high durability	average performance shorter durability
Weight per m^2	Higher	Higher	Lower
Susceptibility to failure	Very low	Very low	low

Figure 1.1: Difference Between of Three Types Solar Cell.

In summary, while monocrystalline panels are the most efficient and take up the least space, they are also the most expensive. Polycrystalline panels are slightly less efficient but more affordable, while thin-film panels are the most cost-effective but have the lowest efficiency rate and shortest lifespan. The choice of which type of solar panel to use will depend on various factors, including the available space, budget, and required efficiency.

1.5 Cost of Solar Cell

The cost of solar cells in Bangladesh can vary depending on several factors, such as the brand, type, and quality of the solar cell, as well as the installation and maintenance costs.

Generally, the price of a standard solar panel in Bangladesh can range from BDT 8,000 to BDT 20,000 (approximately USD 95 to USD 235) per unit. However, the cost can vary depending on the wattage, efficiency, and durability of the solar cell.

It's essential to note that the total cost of a solar power system also includes the cost of other components, such as batteries, charge controllers, inverters, and mounting structures, as well as installation and maintenance costs. **[3]**

Therefore, it's best to consult with a reputable solar energy provider in Bangladesh to get an accurate estimate of the cost of installing a solar power system for your specific needs and location.

1.5.1 Monocrystalline Solar Cells

Monocrystalline solar cells are photovoltaic cells made from a single, pure crystalline silicon ingot. They are also referred to as single-crystal solar cells because they are made from a single crystal of silicon. Monocrystalline solar cells are known for their high efficiency, durability, and long lifespan. Here are some key details about monocrystalline solar cells:

Efficiency: Monocrystalline solar cells are the most efficient solar cells on the market, with an efficiency rate of up to 22%. This means that they can convert up to 22% of the sunlight they receive into usable electricity.

Appearance: Monocrystalline solar cells are easily recognizable by their uniform black color, rounded edges, and octagonal shape.

Durability: Monocrystalline solar cells are highly durable and can last for up to 25-30 years with proper maintenance.

Cost: Monocrystalline solar cells are more expensive to produce than other types of solar cells, such as polycrystalline solar cells and thin-film solar cells. However, they are also more efficient, so they can produce more electricity in less space.

Installation: Monocrystalline solar cells are commonly used in rooftop solar panels and large-scale solar power plants. They can be installed in a variety of settings, including residential, commercial, and industrial.

Overall, monocrystalline solar cells are a highly efficient and durable technology for converting sunlight into usable electricity. While they are more expensive than other types of solar cells, they offer a high return on investment in terms of energy production and long-term durability. **[4]**

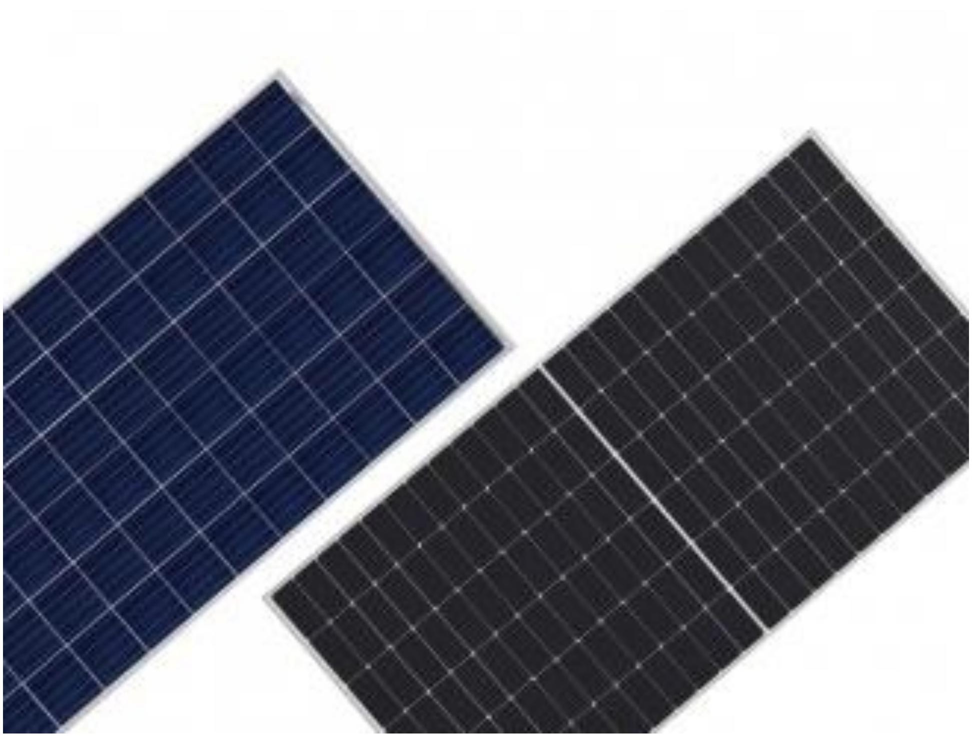

Figure 1.2: Monocrystalline Solar Cell

1.5.2 Polycrystalline Solar Cells

A form of photovoltaic cell used in solar panels to turn sunlight into energy is referred to as a polycrystalline solar cell, also known as a multi crystalline solar cell. These cells are created by melting together several small crystalline silicon cells to create a single big cell. Key information concerning polycrystalline solar cells is provided below:

Material: Silicon, which is readily available and reasonably priced, is used to make polycrystalline solar cells. After being melted and cast into ingots, the silicon is next thinly sliced into wafers.

Appearance: Because to the numerous tiny crystals that make up polycrystalline solar cells, they have a blueish tint and a mottled or speckled look.

Efficiency: Compared to monocrystalline solar cells, which are constructed of silicon, polycrystalline solar cells have a lower efficiency. **[5]**

Cost: Polycrystalline solar cells are a popular option for home and commercial solar installations since they are less expensive to produce than monocrystalline solar cells.

Figure 1.3: Polycrystalline Solar Cell.

While having a little lower efficiency than monocrystalline cells, polycrystalline solar cells nonetheless provide a practical and long-lasting choice for the generation of solar energy.

1.5.3 Thin-Film Solar Cells

A type of photovoltaic (PV) technology known as thin-film solar cells uses incredibly thin layers of semiconducting materials to turn sunlight into power. Thin-film solar cells, as opposed to conventional silicon-based solar cells, can be manufactured from a number of substances, such as cadmium telluride, copper indium gallium selenide, and amorphous silicon. **[6]**

Compared to conventional solar cells, thin-film solar cells provide a number of benefits, such as cheaper production costs, smaller weight, and the capacity to bend and conform to various surfaces. Its employment is restricted in several applications due to the fact that their efficiency is often lower than that of conventional silicon-based solar cells.

Figure 1.4: Thin-Film Solar Cells

Large-scale solar power plants as well as smaller uses like portable electronics and photovoltaics built into buildings frequently employ thin-film solar cells.

CHAPTER 2

Cost Analysis & Hybrid Energy System Off-Grid Area

2.1 Introduction

Cost analysis is a vital component of designing and implementing a hybrid energy system for off-grid areas. A hybrid energy system combines two or more energy sources, such as solar, wind, and diesel generators, to provide a reliable and sustainable energy supply. Off-grid areas, which are not connected to the national grid, often rely on expensive and unreliable energy sources such as kerosene lamps and diesel generators.

A hybrid energy system can offer a cost-effective and environmentally friendly alternative. However, the design of such a system requires a thorough cost analysis, taking into account factors such as the cost of energy sources, maintenance costs, and the initial installation cost. The analysis must also consider the local weather conditions and energy demand patterns. By carefully analyzing these factors, a well-designed hybrid energy system can provide a reliable and sustainable energy supply to off-grid areas at a reasonable cost. [7]

2.2 Research Methodology

The research technique includes the following procedures for cost analysis and hybrid energy systems in off-grid areas:

A detailed study of prior research and reports on the cost analysis of off-grid hybrid energy systems will be conducted as part of the literature review.

Site Survey: To learn more about the energy needs, resource availability, and other important aspects that may affect the system's design and cost, a site survey is carried out.

System Design: A system design is created based on the site survey that will maximize energy production, storage, and delivery while lowering costs.

Cost Analysis: The proposed system's cost is examined, taking into consideration initial outlays, ongoing expenses, maintenance costs, and other pertinent elements.

Sensitivity Analysis: A sensitivity analysis is carried out to ascertain how modifications to the system's design or outside variables (such as fuel prices) would affect the cost and efficiency of the system.

Findings and Recommendations: The study's conclusions are given, and suggestions are provided for the off-grid hybrid energy system that will be the most affordable for the location in question. [7]

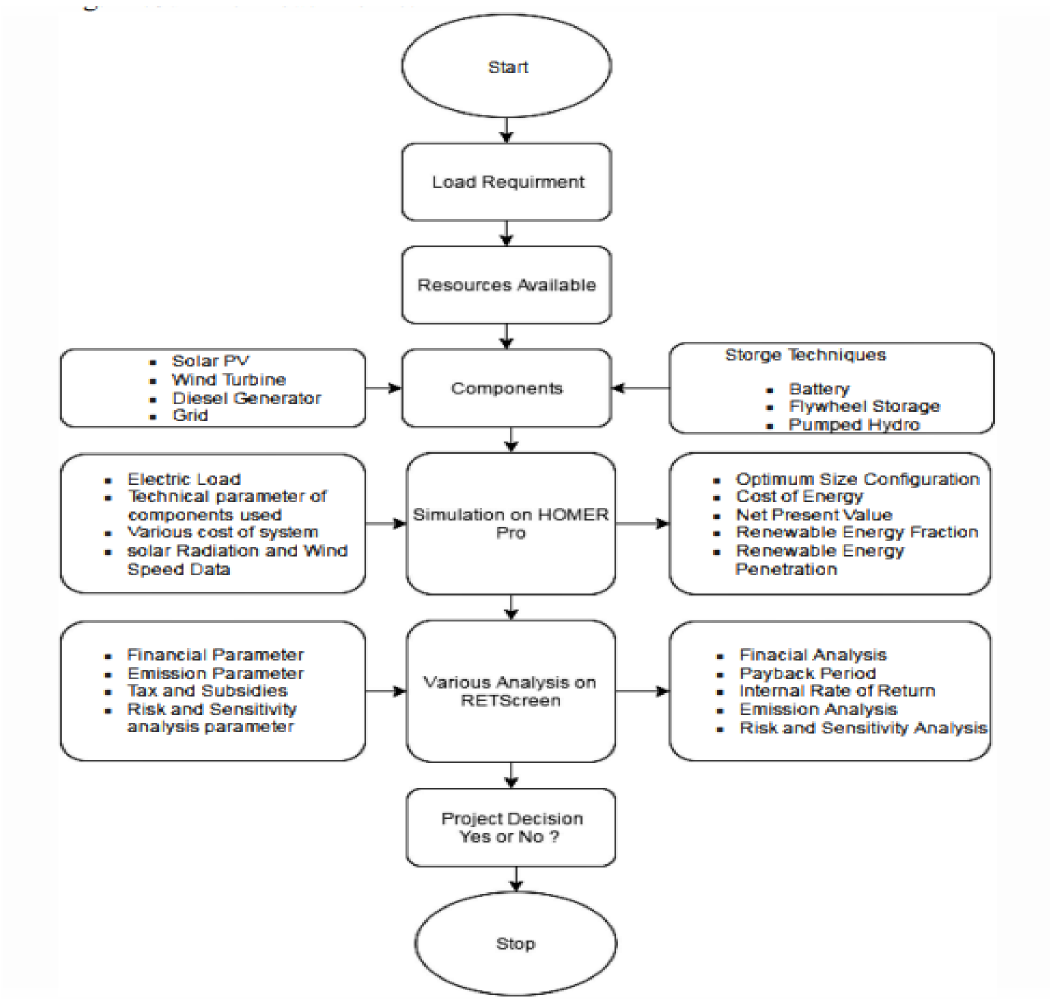

Figure 2.1: Research Methodology.

2.3 Off-Grid Solar PV System

Unconnected to the power grid, an off-grid solar PV system is a particular kind of solar energy system. It is intended to supply electricity to buildings such as residences, offices, or other establishments in rural locations where grid power is either unavailable or unreliable.

Systems for off-grid solar PV typically include batteries, charge controllers, inverters, and other parts. From the solar energy, the solar panels produce DC electricity, which is then stored in the batteries. To ensure that the batteries are charged safely and effectively, the charge controller controls the flow of electricity between the solar panels and the batteries. The inverter transforms the DC electricity generated by the batteries into AC electricity, which is then usable to run devices and appliances. [8]

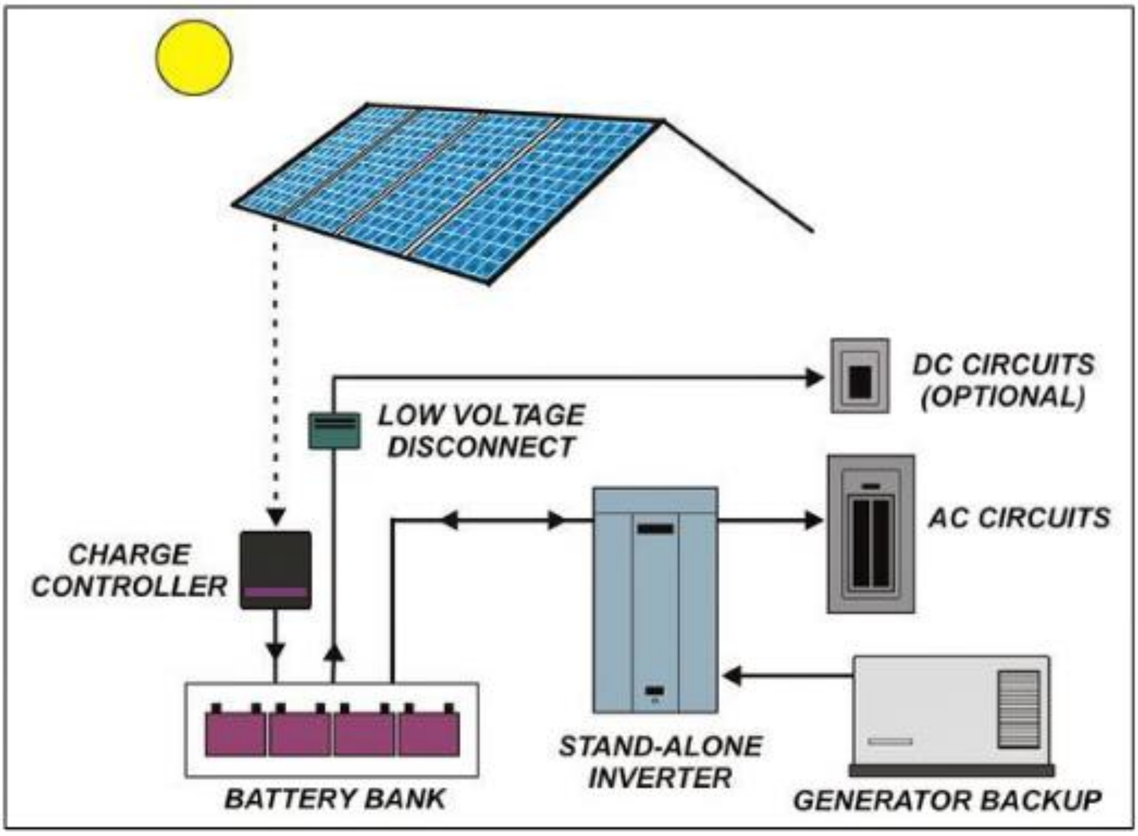

Figure 2.2: Off-grid PV System Schematic.

For distant areas, such as cottages, RVs, boats, and other transportable constructions, off-grid solar PV systems are the best option. **[9]** They can also be employed in underdeveloped nations without grid infrastructure or in places with unstable grids. Off-grid solar PV systems are often more expensive than grid-tied systems, but they offer energy independence and can be an affordable long-term solution, especially in places where grid power is scarce or expensive.

2.4 The Proposed PV-Biomass Hybrid System

A PV-biomass hybrid system combines photovoltaic (PV) and biomass, two renewable energy sources that may both provide power and lower carbon emissions. The system works by combining solar panels to harness solar energy and a biomass generator to create electricity from organic waste. By integrating the advantages of both technologies, the system has the potential to offer consistent and dependable electricity generation throughout the year. By lowering reliance on fossil fuels and fostering employment in the renewable energy industry, the PV-biomass hybrid system can also have a positive economic impact. This hybrid system has the potential to be a promising way to meet the rising demand for renewable energy while reducing global warming. **[10]**

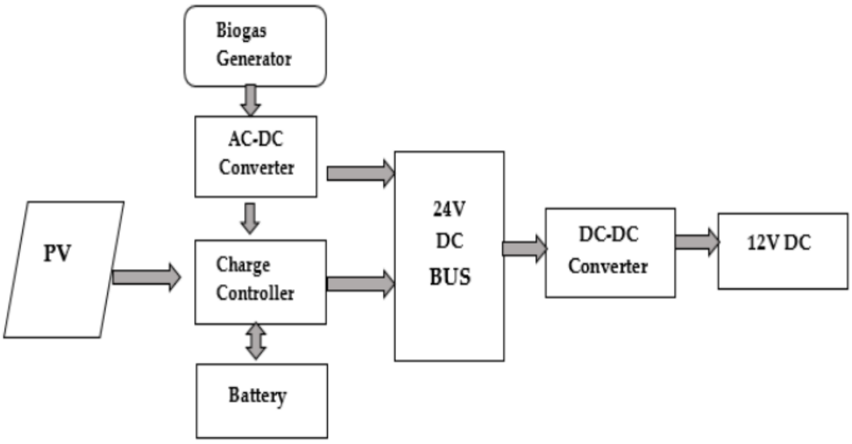

Figure 2.3: Block diagram of proposed photovoltaics (PV)-biomass hybrid energy system.

2.4.1 Solar to Grid Connection

Solar to grid connection is the process of generating and distributing electricity by tying solar panels to the electrical grid. Due to its advantages for the environment and falling cost, solar energy is a renewable energy source that is gaining popularity. The homeowner or company owner may obtain credit for the extra energy produced by solar panels when they produce more energy than is required and feed it back into the grid. This method is called net metering. In order to transform the direct current (DC) generated by solar panels into alternating current (AC) that can be used by homes and businesses, solar panels must be connected to the grid using specialized equipment, such as a solar inverter.

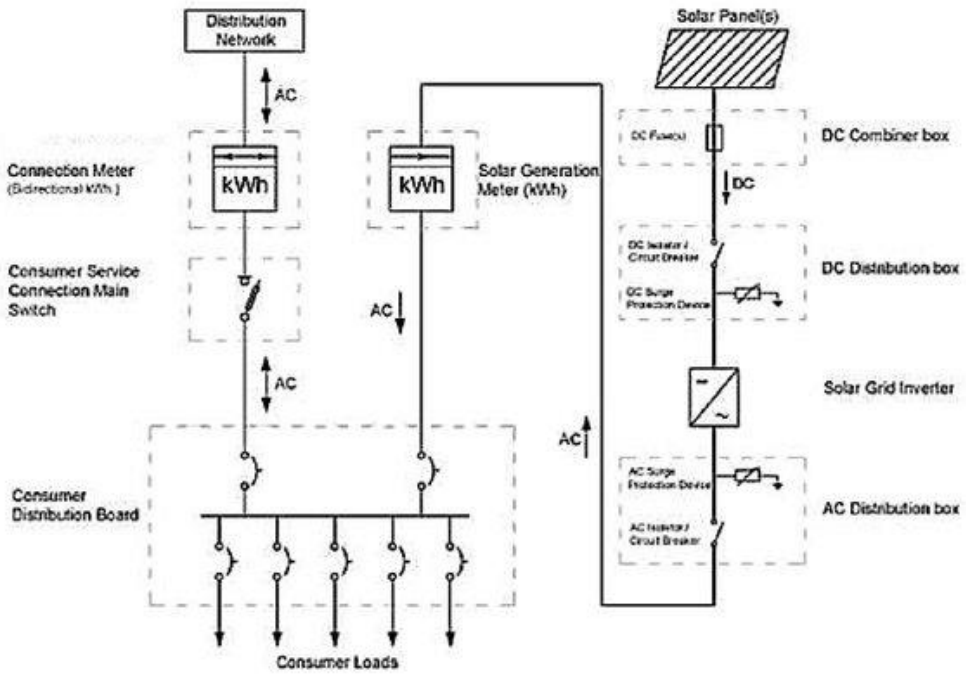

Figure 2.4: Wiring Diagram for Grid-Connected Solar System.

2.4.2 Reactive Power Cost Analysis

In alternating current (AC) systems, reactive power is needed to maintain the electromagnetic fields. Reactive power is sometimes referred to as "non-active" or "wasted" power since, despite being necessary for the system's correct operation, it does not contribute to beneficial work.

Because installing equipment like capacitors, inductors, and transformers can be expensive, the cost of reactive power is a crucial factor for utilities. Through the use of power factor adjustment procedures, such as the addition of capacitors to the system, the cost of reactive power can be kept to a minimum, improving system efficiency and lowering overall energy expenditures. Reactive power cost analysis is crucial for utilities to make informed decisions.

Figure 2.5: Reactive Power Cost Analysis.

2.4.3 Cost model of synchronous generator

One of the key elements that affects a synchronous generator's price is its capacity.

Generators with higher capacities cost more than those with lesser capacities.

The cost is also impacted by the generator type.

For instance, wrapped rotor generators are more expensive than permanent magnet generators.

The cost of the generator is significantly influenced by its design.

In general, harsh environment generators, like those used in offshore wind turbines, are more expensive than those used indoors. The synchronous generator's price is influenced by the materials used in its production. Copper and high-grade steel are examples of high-quality materials that are more expensive than inferior resources.

In conclusion, a synchronous generator's price is affected by its capacity, kind, design, and building materials.

2.5 Methodology & Load Assessment

The systematic approach or collection of techniques used to conduct research, collect data, and analyze findings is known as methodology. In order to respond to research questions or test hypotheses, it entails choosing the suitable research design, data collection techniques, and statistical analyses. Methodology guarantees the objectivity, validity, and dependability of the research.

The practice of calculating a system's or an organization's workload in order to spot potential inefficiencies or overloads is known as load assessment. It entails assessing the quantity, diversity, and pace of effort and resources required to finish tasks. Organizations can optimize their procedures and available resources with the use of load assessments in order to boost productivity, cut expenses, and increase efficiency.

HOMER Pro (Hybrid optimization model for electric renewables) is a powerful tool used for building wind/solar/biomass hybrid systems developed by NREL (National Renewable Energy Laboratory, USA). HOMER Pro was used to do a techno-economic analysis for electrifying a selected rural area utilizing a hybrid system. HOMER Pro is the most recent version of the HOMER software, including more advanced capabilities. It may be used to create off-grid and on-grid power systems. HOMER combines inputs such as solar or wind resource potential with the load profile provided. It then runs simulations by equating the input resources' hourly power generation (wind, solar, biomass, etc.) with the required output power (hourly load). [7]

HOMER Pro simulates all possible combinations and provides us with the best possible hybrid combination based on NPC (Net Present Cost). For the chosen community, an hourly load profile has been created. Hourly data on solar and wind resources has been collected from an MHP unit deployed in Bahawalpur. Biomass potential data was obtained from the World Bank and ESMAP's biomass mapping project. HOMER works in three stages: simulations, sensitive analysis, and optimization. Load, components, and the grid are all critical components in a hybrid system. Load can be classified as electric or thermal, with electric being the most common. HOMER Pro has a variety of components, including a PV, wind turbine, biomass generator, converter, and batteries, which were utilised in our study. [7]

2.6 Chapter Summary

A cost analysis of a hybrid energy system for off-grid locations looks at the practicality and economic sustainability of mixing renewable energy sources like solar, wind, and hydro with traditional fossil fuels like diesel. When conducting a cost analysis, it's important to take the initial investment cost, maintenance and operation costs, and the entire payback period into account. A well-designed hybrid energy system can lower the overall cost of energy while supplying a dependable and sustainable power source.

In conclusion, using hybrid energy systems provides a dependable and affordable solution to supply power to remote locations. Designing a successful hybrid energy system requires careful consideration of all the variables, and cost analysis is a crucial component.

In conclusion, using hybrid energy systems is a good approach to supplying off-grid locations with dependable and affordable power. A successful hybrid energy system must take into account costs, and thorough study of all the variables can help guarantee that the system is efficient and sustainable over the long term.

CHAPTER 3

MATERIALS & METHODS

3.1 Introduction

Our need for electricity is growing every day, yet we are unable to meet that need. Hence, we need to adopt a different action, similar to how every industry or tall structure built its own solar power plant. In this study try to introduce the optimization result of energy production by employing commercial building rooftop solar power plant as fulfilling the energy demand and also sold to the grid as a financial aspect. [11]The software HOMER, which can conduct both on-grid and off-grid analysis, is used to conduct techno-economic feasibility studies.

At Daffodil International University, an on-grid PV system is recommended in this thesis. Data on monthly average temperatures and solar radiation are gathered from the National Solar Radiation Database. Homer Software is utilized to create this study. For each possible system configuration, HOMER is utilized to calculate the energy balance. Various costs, including those for energy, net present costs, total annualized costs, annual real interest rates, capital recovery factors, replacement costs, operations and maintenance costs, fuel costs, potentially lowest costs, and greenhouse gas emissions in tons per year, can be discovered by using the software. The best combination of the cost of energy production and the financial gain from PV energy export to the grid is found through computation.

3.2.1 Study Design

For the study's design to adequately respond to the aforementioned research questions, additional information is required. There are two groups for the various information types.

1. Information and data that can be acquired by visiting our substation
2. Knowledge accessible from a variety of secondary sources

Data from the following case studies will be reviewed in order to determine the financial viability of rooftop solar PV for various applications:
1) Installed rooftop solar panels rather than other generations.
2) Implemented a net metering policy for rooftop solar PV that is connected to the grid.

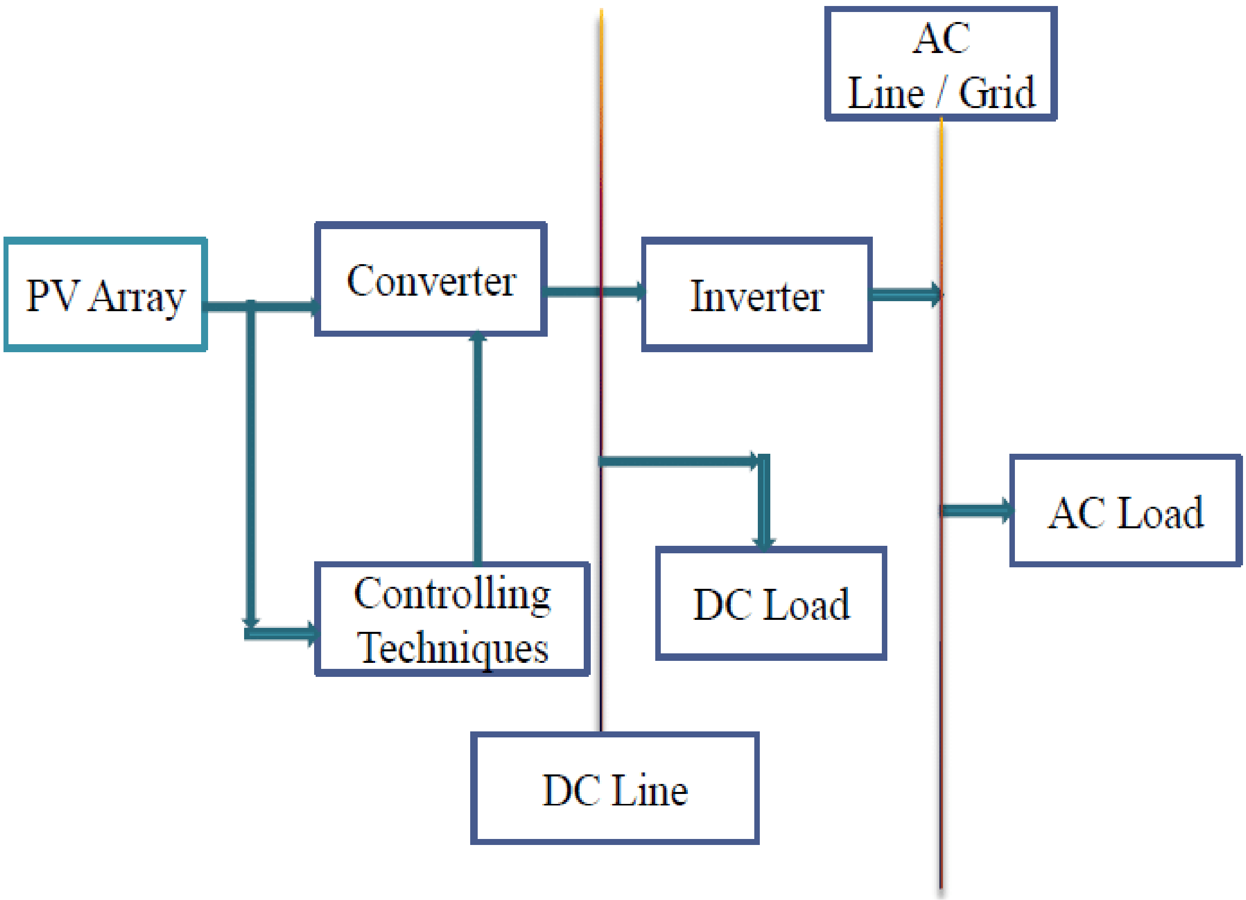

Figure 3.1: Block diagram of PV solar system

In the block diagram, we see firstly has attracted a PV panel with an inverter and then has a line that is connected with the national grid and also supplies in AC load. By the block diagram, we understand our full system that how the solar does works. Then if we want we can store our electricity by battery as a DC it will be converted into AC.

3.2.2 Study Area

This investigation will be placed on the roof of the Engineering complex and YKSG-2 (Hall) at Daffodil International University. For this analysis, a particular portion of Daffodil International University's rooftop area is taken into account. For this study, a rooftop area measuring 2793 square meters with an installed capacity of........KW is used. A total of 80% of the chosen area can be utilized PV installation. [11]

Figure 3.2: Rooftop of Engineering Complex

Our other selected place is the rooftop of YKSG-2. The total area is 1473.58 square meters. This is our hall building where we can install our solar panel and also keep our inverter and necessary equipment. The building height approximately 52 m. So, we get a good amount of sunlight to receive the solar panel as a result we get our output best.

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Figure 3.3: Rooftop of YKSG-2 (Hall)

3.2.3 Data Collection

The Daffodil International University in Ashulia, Dhaka, Bangladesh, is where the primary data was gathered. Daily, monthly, and annual electricity load are noteworthy among the major data. Also, there is the high expense of BREB's power transmission using 33KV. Our typical load requires 845 KW, or around 1 MW, of power.

The majority of secondary data was gathered through SREDA and NASA reports and recommendations. NASA is used to gather information on air temperature and sun radiation. Also, data was gathered from books, conference papers, journals, and other publications.

Weekdays | Weekends

Hour	January	February	March	April	May	June	July	August	September	October	November	December
0	92.000	101.000	106.000	340.000	350.000	421.000	380.000	90.000	308.000	223.000	197.000	49.000
1	99.000	100.000	391.000	333.000	340.000	450.000	402.000	320.000	389.000	256.000	259.000	57.000
2	117.000	110.000	316.000	345.000	355.000	438.000	420.000	395.000	417.000	289.000	321.000	67.000
3	148.000	140.000	375.000	365.000	370.000	467.000	432.000	350.000	408.000	276.000	348.000	49.000
4	179.000	160.000	416.000	360.000	375.000	425.000	445.000	305.000	422.000	256.000	338.000	57.000
5	168.000	150.000	380.000	391.000	400.000	486.000	456.000	295.000	358.000	298.000	344.000	65.000
6	148.000	165.000	325.000	401.000	420.000	500.000	467.000	340.000	376.000	333.000	370.000	69.000
7	140.000	138.000	335.000	445.000	450.000	502.000	472.000	385.000	417.000	307.000	348.000	76.000
8	103.000	107.000	310.000	406.000	410.000	487.000	484.000	270.000	358.000	289.000	289.000	53.000
9	131.000	106.000	280.000	395.000	385.000	510.000	495.000	223.000	337.000	223.000	216.000	77.000
10	130.000	125.000	290.000	390.000	419.000	512.000	510.000	195.000	386.000	274.000	319.000	105.000
11	120.000	131.000	235.000	370.000	390.000	514.000	522.000	205.000	375.000	245.000	238.000	164.000
12	125.000	117.000	215.000	381.000	395.000	520.000	534.000	260.000	358.000	289.000	346.000	159.000
13	156.000	120.000	175.000	391.000	400.000	525.000	525.000	120.000	396.000	256.000	339.000	179.000
14	160.000	156.000	390.000	396.000	409.000	534.000	540.000	305.000	384.000	238.000	320.000	151.000
15	140.000	161.000	395.000	401.000	421.000	535.000	530.000	385.000	326.000	274.000	228.000	126.000
16	130.000	148.000	385.000	406.000	430.000	566.000	512.000	318.000	356.000	268.000	246.000	107.000
17	100.000	130.000	315.000	410.000	425.000	487.000	487.000	370.000	337.000	258.000	212.000	86.000
18	110.000	106.000	375.000	420.000	433.000	470.000	476.000	356.000	323.000	233.000	222.000	92.000
19	120.000	100.000	390.000	397.000	401.000	460.000	455.000	395.000	389.000	279.000	207.000	79.000
20	121.000	129.000	360.000	415.000	399.000	456.000	442.000	346.000	419.000	289.000	223.000	59.000
21	145.000	123.000	399.000	398.000	406.000	465.000	421.000	320.000	406.000	265.000	246.000	61.000
22	136.000	146.000	260.000	425.000	402.000	470.000	391.000	223.000	399.000	305.000	233.000	84.000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 3.1: Data of hours and months

Here, all data are collected from Daffodil International University's substation which is a 33/11 KV substation. There are 12 months of load that are used by the university. Also, all data are represented with KW. Now we are analyzing the data. To answer stated research questions, test theories, and assess results, data collection is the process of collecting and quantifying information on factors of interest in a systematic and established manner.

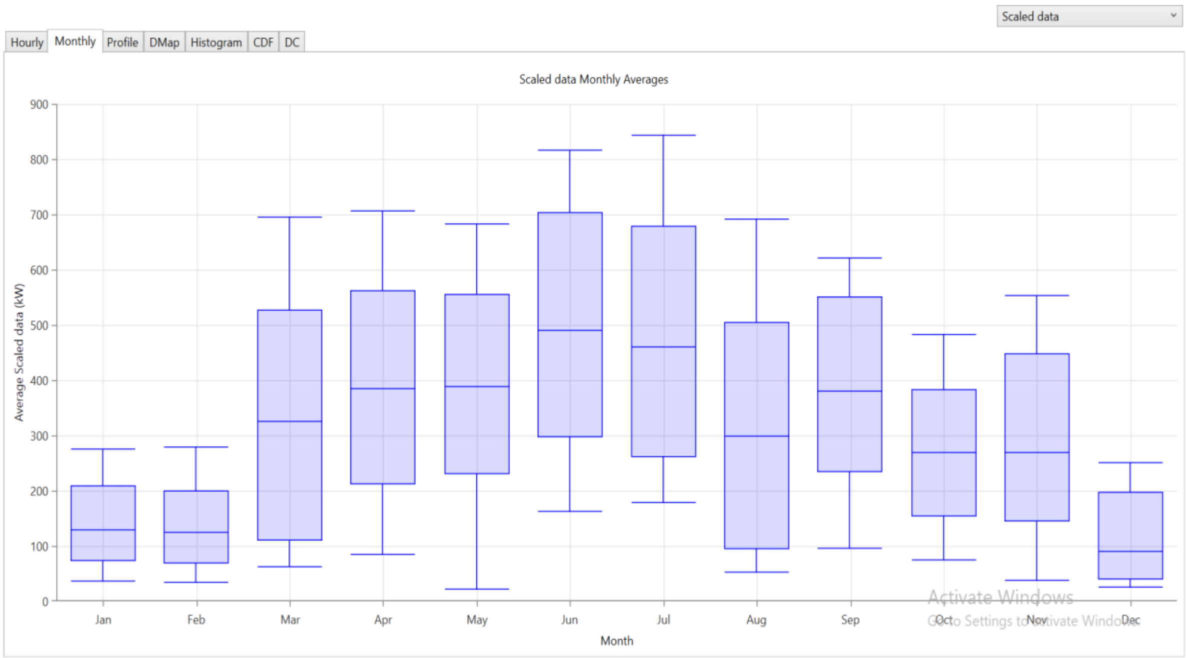

Figure 3.4: Data analysis of all months

After analyzing the data we can see our result from fig 3.4. So, here are peak month is July because according to our country temperature this month is carry high temperate so ‘the use of electricity demand also increased. We also see the winter times (Dec-Jan) when demand is low due to winter season.

The load and consumption of electricity at a plant are quantified by a load inventory. They have a significant impact on the selection and sizing of suitable energy storage devices, such as batteries and photovoltaic (PV) panels. They can also be used to compare facility energy use to industry norms or other comparable facilities as benchmarks. Administrators can measure and compare energy use by other performance factors, including the number of patients serviced, by creating energy indices.

Monthly Data Profile:

This is the scaled data of a year. Here we see the first month of January our load is about 120 whereas second-month load is almost same around 122 KW. Now the third month march the started high load around 421 KW and it is continuing to July. From August to December the load again decreasing due to winter season. In July our peak month and the highest load is around 845 KW. It is the hottest month in our country so this time our demand is also high. [12]

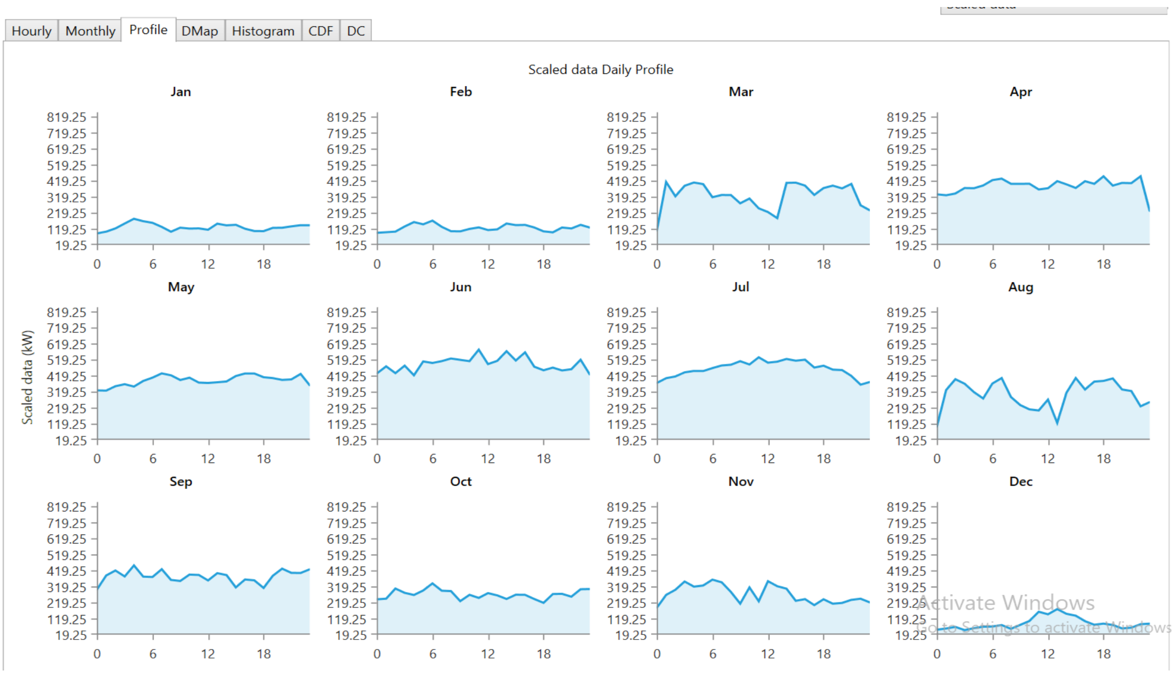

Figure 3.5: Monthly Data Profile in a year

3.3 Solar Radiation and Temperature

The National Solar Radiation is the source of all data. Radiation is at its highest in April and at its lowest in September. Solar radiation increases in December and diminishes in April. The warmth of the sun also rises in March and falls in October. The output of solar PV energy is negatively impacted by temperature increase **[13]**

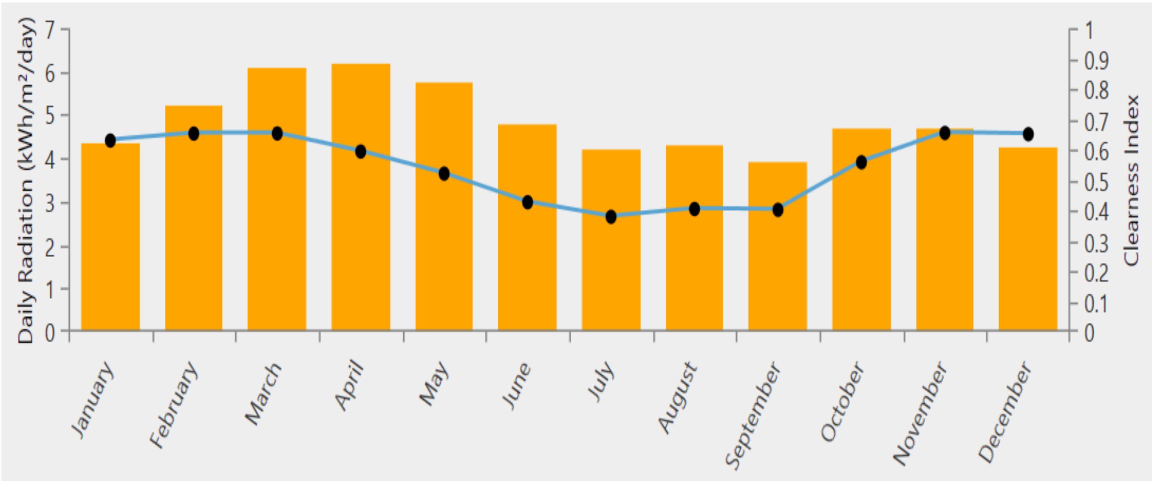

Figure 3.6: Solar radiation and temperature.

3.4 Schematic Designing

The National Renewable Energy Laboratory developed HOMER, a piece of software for developing micro-electrical systems. It performs optimization and calculates the life cycle costs and technical viability of a certain system configuration for each hour of the year. In order to evaluate the effects of changes in input variables, it also executes several optimizations under a variety of input assumptions.

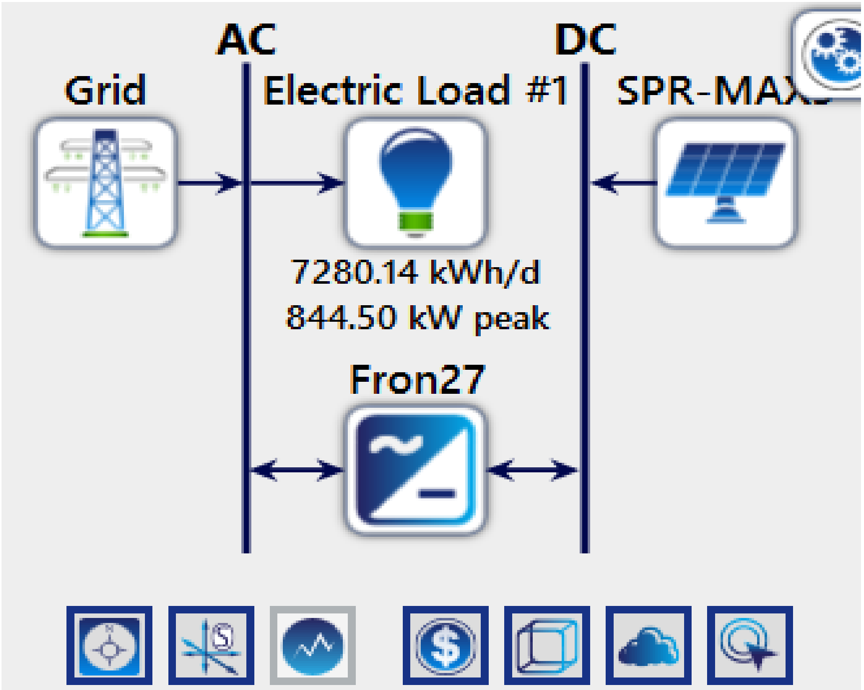

Figure 3.7: Schematic diagram of the solar system

By specifying an average daily demand profile with a 10% daily, 15% hourly random variability, the examined load profile is altered in the HOMER model. As a result, the starting demand grew by 7253 KWh per day, and the annual peak load increased to 844.31 kilowatts. The suggested system setup that connects to the grid through net metering is shown in Figure.

3.4.1 Solar Panel

A solar cell panel, solar electric panel, or solar panel is an assembly of photovoltaic solar cells installed in a (often rectangular) frame. It is sometimes referred to as a photovoltaic (PV) module or PV panel. Sunlight is used by solar panels to collect radiant energy, which is then transformed into direct current (DC) power.

The selected panel is SunPower X-Series Residential Solar Panels and the model is **SPR-MAX3-390**

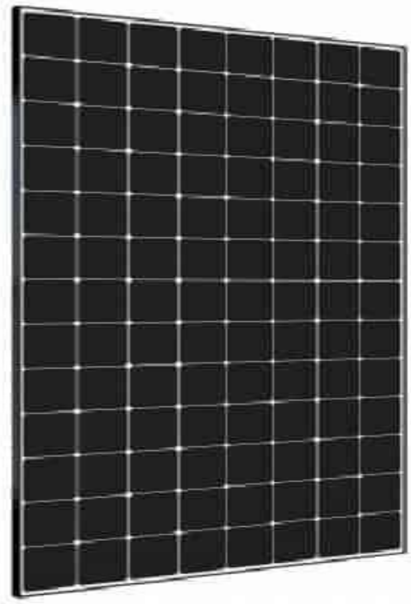

Figure 3.8: SunPower-SPR-MAX3-390

Efficiency- More than 21% Efficiency, Suitable for rooftops where space is at a premium or where future expansion could be needed. [14]

PV modules employ the photovoltaic effect to produce electricity by converting light energy (photons) from the Sun into a huge number of solar cells. Thin-film or wafer-based crystalline silicon cells are used in the majority of modules. The top layer or the back layer of a module may serve as the structural (load-bearing) member. Cells need to be shielded from moisture and mechanical harm. Although thin-film cell-based semi-flexible modules are also available, most modules are stiff. Electrical connections between the cells are often made in series to achieve the necessary voltage and then in parallel to boost current. The module's power is measured in watts and is dependent on both the amount of light and the electrical load that is connected to the module. Watts are calculated as the mathematical product of voltage and current. The production requirements for solar panels are obtained under normal settings, which are typically not representative of the actual operating circumstances to which the solar panels are subjected during installation.

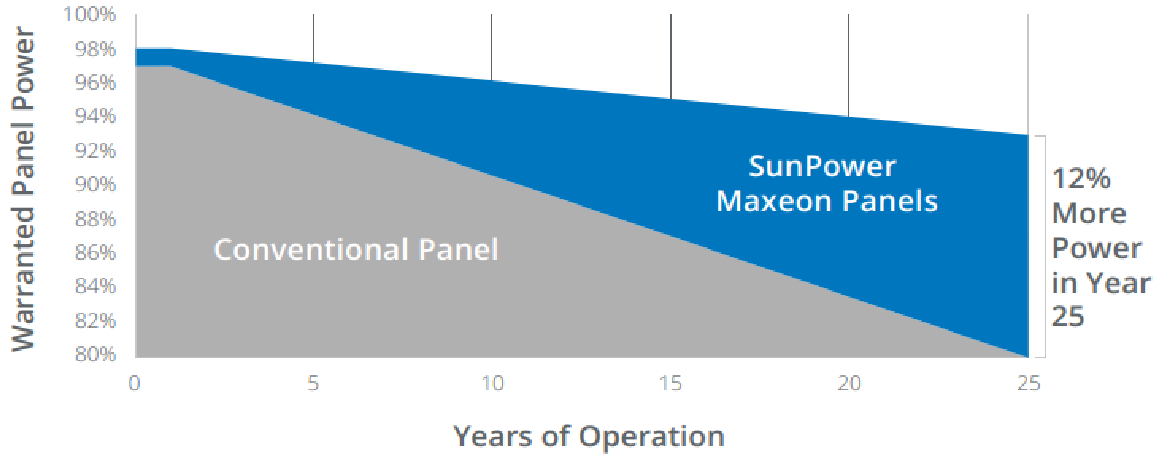

Figure 3.9: Comparison warranty with Sun power panels

more power to run your house. Residential X-Series systems generate 45% more energy in the first year, converting more sunshine into electricity. Throughout the first 25 years, this advantage produces 60% extra energy to meet your needs.

Performance- Created to deliver the maximum energy in challenging real-world circumstances, including hot rooftop temperatures and partial shadow.

The Product warranty sheet link-

https://d2fp8gxcp7iq0s.cloudfront.net/documents/by25e24887g5HeCNBtaG3gBu4Sw5lpEGaPDfBs9V.pdf

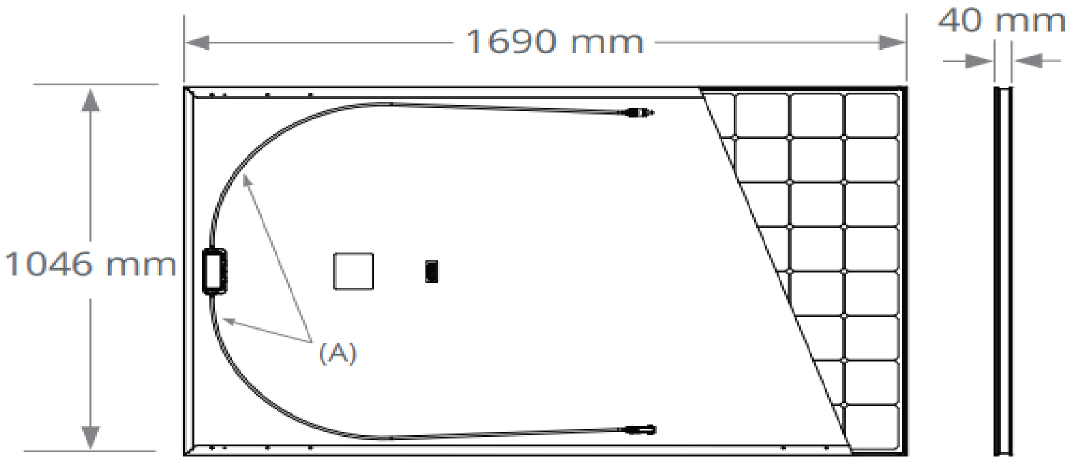

Figure 3.10: Panel Frame Profile

A. Cable Length: 1200 mm +/-10 mm

B. LONG SIDE: 32 mm SHORT SIDE: 24 m

Electrical Data			
	SPR-MAX3-400	SPR-MAX3-390	SPR-MAX3-370
Nominal Power (Pnom) [7]	400 W	390 W	370 W
Power Tolerance	+5/0%	+5/0%	+5/0%
Panel Efficiency	22.6%	22.1%	20.9%
Rated Voltage (Vmpp)	65.8 V	64.5 V	61.8 V
Rated Current (Impp)	6.08 A	6.05 A	5.99 A
Open-Circuit Voltage (Voc)	75.6 V	75.3 V	74.7 V
Short-Circuit Current (Isc)	6.58 A	6.55 A	6.52 A
Max. System Voltage	1000 V IEC		
Maximum Series Fuse	20 A		
Power Temp Coef.	−0.29% / °C		
Voltage Temp Coef.	−176.8 mV / °C		
Current Temp Coef.	2.9 mA / °C		

Table 3.2: Electrical data of solar panel

Operating Condition And Mechanical Data	
Temperature	−40° C to +85° C
Impact Resistance	25 mm diameter hail at 23 m/s
Solar Cells	104 Monocrystalline Maxeon Gen III
Tempered Glass	High-transmission tempered anti-reflective
Junction Box	IP-65, Stäubli (MC4), 3 bypass diodes
Weight	19 kg
Max. Load [10]	Wind: 4000 Pa, 408 kg/m² front & back Snow: 6000 Pa, 611 kg/m² front
Frame	Class 1 black anodised (highest AAMA rating)

Table 3.3: Operation condition and Mechanical Data

Never put anything on the modules, not even briefly, since the ensuing residue might scratch or taint the glass. Contact with any module if the front glass is cracked or the back sheet is ripped. Electrifying surfaces or module frames is possible.

Broken connections or J-boxes present electrical risks in addition to laceration risks. Any such module should be taken out of the array by the installers, who should then get in touch with SunPower for disposal advice.

Never touch or install the modules when they are wet or when there is a lot of wind. Avoid obstructing drain holes and allowing water to collect in or close to module frames.

3.4.2 Inverter

Known as AC Drives or VFDs, inverters (variable frequency drive). These are electronic devices that convert direct current (DC) to alternating current (AC) (Alternating Current). It is also in charge of regulating the torque and speed of electric motors.

- Max output power is 27 KW
- Max PV generation output is 37.8 KW
- AC output current is 40.9 A
- DC Input voltage range is 580-1000 V
- Wight – 35.7 Kg

Figure 3.11: Fronius Eco 27.0-3-S Inverter

For more details click on the link-

https://www.europe-solarstore.com/download/fronius/Fronius_ECO_Datasheet_2020.pdf

MPPT- Maximum Power Point Tracking is algorithm that included in charge controllers used for extracting maximum available power from PV module under certain conditions. The voltage at which PV module can produce maximum power is called maximum power point.

3.4.3 Grid

An electrical grid is a network of connected structures used to transport power from generators to consumers. Electrical networks come in a variety of sizes and can span entire continents or nations.

Grids typically function with synchronized three-phase alternating current (AC) frequencies, which means that all distribution areas (so that voltage swings occur at almost the same time). This makes it possible for AC power to be transmitted throughout the region, linking a large number of electricity generators and consumers and possibly enabling redundancy generation and more efficient electricity markets.

Figure 3.12: Kamrangirchar (132/33/11) KV Grid

After completing the setup we are collecting the system with the national grid. By the grid, we can transmit our extra load which is getting from our solar system and also we can take from the grid if needed.

If you need to arrange for a new electricity supply, it's a good idea to get a better understanding of how the UK electricity network operates. Getting to know the difference between a DNO and a supplier will ensure you know exactly who to call to get your property connected as soon as possible.

Electricity is connected to domestic homes via a series of underground and overhead power cables. Electricity travels from energy generations sites – like power plants, solar farms and wind turbines – via this infrastructure to local substations.

When it arrives at local substations, the electricity's voltage is stepped down in order to make it suitable for domestic use. It's then fed into our homes via a local distribution network.

At the point the electricity enters your property, you'll see an energy meter. This measures the amount of electricity your household uses and allows energy companies to calculate your bills.

3.5 Mathematical Model

Every piece of software's calculation relies on its underlying mathematical model. To anticipate power generation, radiation, battery charging and discharging, clearness index, optimization, and sensitivity analysis, Homer Pro software employs some specific mathematical analysis.

3.5.1 Modeling of solar PV energy in mathematics

Output from PV arrays mostly depends on array size, derating factor, solar radiation, and
temperature. To compute that output, HOMER uses this equation below

$$P_{pv}=C_{pv} f_{pv} (I_T / I_{T,STC})[1+ \beta_p (t_c - t_{C,STC})]$$

here, C_{pv} is PV array capability (kW), f_{pv} is a derating factor of the PV panel [%], I_T is in the current time step, solar energy strikes the array in kW per m^2, $I_{T, STC}$ is in conventional test conditions, incident radiation kW/m2, β_p is the heat coefficient of energy in %/o C, t_c is current time step's cell the temperature in degrees Celsius, and $t_{C, STC}$ is the temperature of cells under typical circumstances for testing. [12]

HOMER's cost analysis procedure

The sum of the ??? and converter costs C_{CONV} is the system cost.

$$C_{System} = C_{PV} + C_{CONV}$$

A. Net present cost: Total installation and operation costs over its lifetime, are determined as

$$NPC = \frac{ÆC}{R_F}(i, P_L)$$

where, A_C , R_F ,i, and P_L represent total annualized cost, capital recovery factor, interest rate in
percentage, and system lifetime in years, respectively.

B. Annualized cost: The sum of all equipment's annualized costs, including capital, operation, and maintenance, including replacement and gasoline costs.

$$C_{Ænnual} = (CCR_F + CO)$$

C. Capital recovery factor: It is a ratio that calculates the present value of equal annual cash flows

$$R_F = (i \times (1 + i)^n / ((1 + i)^{n-1})$$

where n denotes the length of time and i the denotes yearly real interest rate.

D. Cost of energy: It is the average cost per kilowatt-hour of usable electricity produced by system.

$$COE = A_C / (D_{Pr,(ÆC)} + D_{Pr,(DC)})$$

here, $D_{Pr,(ÆC)}$ denotes primary load of AC and $D_{Pr,(DC)}$ is DC primary [12] load.

3.5.2 On-Grid Model

The simplest system model is the on-grid model. No load is mentioned, and no recommended array size is offered. Instead, the user suggests the latter. Simply said, the suggested inverter has the same output as the nominal array power. The energy generated by the array, less inverter losses, is what is made available to the grid:

E grid = EAηinv……………………………………………………………………

where η inv is the inverter efficiency.

Depending on the grid configuration not all this energy may be absorbed by the grid. The energy actually delivered is:

E dlvd = E grid *η abs ………………………………….…………………………..……

where η abs is the PV energy absorption rate.

Operating cost

Operation cost is important parameter for cost analysis to determine operating cost following equation is used by homer :

$C_{OC} = C_{TAC} - C_{TACC}$……………………………………(3.5)

Where ,

C_{TAC} = Total annualized cost.

C_{TACC} = Total annualized capital cost

A solar power production system that is linked to the utility infrastructure is called a "on-grid" system. The grid receives the energy the system generates and uses it to power the different appliances. Additionally, it is hassle-free and simple to keep the implementation.

The configuration of solar panels captures sunlight and turns it into energy. Direct Current is being produced here. (DC). [15]The solar converter then changes the DC to AC, enabling it to charge the electrical devices. Following that, this energy is sent to the grid, where it is provided for daily use. A net meter is an essential component. It is a gadget that keeps track of the energy used and the energy provided to the grid. Each month's remaining balance is noted, and a statement is sent to the customer.

Chapter 4

Result & Discussion

4.1 Introduction

The findings of the planned grid-connected solar PV power generation system for the Daffodil International University are provided in this chapter. All results are displayed graphically and in tabular format. Also, the suggested model's economic performance has been compared in terms of NPE, energy production costs, renewable energy percentages, the total contribution of solar PV to grid systems, total annualized costs, and greenhouse gas emissions. The output of these calculations is provided below.

4.2 Financial conditions

Financial condition refers to the available funds to carry out the contract. The ability to secure all necessary payment bonds, performance bonds, and liability insurance are the very minimum requirements for evaluating a bidder's financial standing.

	Architecture							Cost	
					SPR-MAX3 (kW)	Grid (kW)	Fron27 (kW)	NPC ($)	Initial capital ($)
Base system					100	999,999	80.0	$2.99M	$149,160
Current system					200	999,999	160	$2.90M	$229,020

Metric	Value
Present worth ($)	$86,403
Annual worth ($/yr)	$5,399
Return on investment (%)	9.0
Internal rate of return (%)	12.3
Simple payback (yr)	7.56
Discounted payback (yr)	9.09

Table 4.1: Total net worth

From the table we see the present value is $86,403. This is our capital amount for the project. The annual worth is $5,399. Per year have an expense including any maintenance.

After 9 years we get our profit. The row mention is Return on investment is 9 years because our every material well branded and expensive. So, we need some more time to get returns. Also, the internal rate of returns is 12.3%. After overall analysis we come to a final and satisfy result that is the project is profitable for us.

4.3 Monthly Grid and Solar Energy Output

Fig. 4.1 shows that the import of grid electricity for usage by the company is shown in a different hue from the yellow color that reflects the power generated by the PV system. The effect of temperature on electricity output varies. Also, depend on seasonal factors like the winter, rainy season, and summer. The skies turn overcast and dreary throughout the winter and rainy seasons. Production of electricity fluctuates at such time.

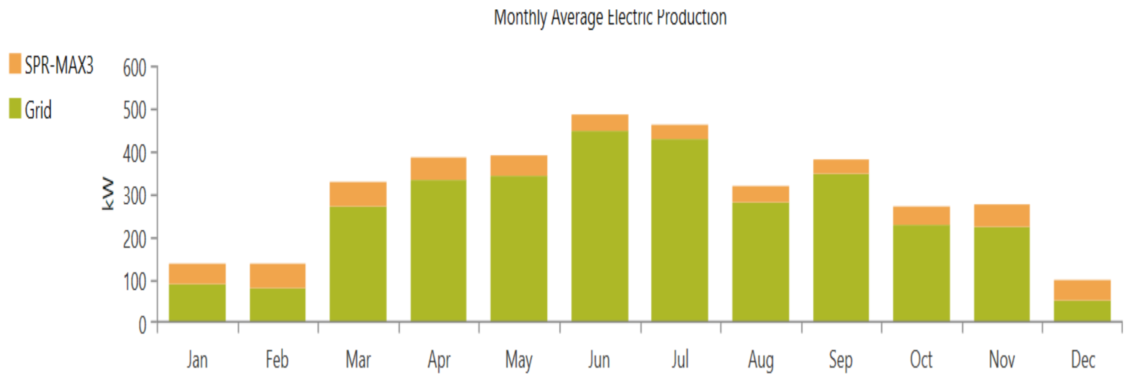

Figure 4.1: Monthly Electricity Production

The graph shows in two colors one is orange and other is olive. The colors are indicated different two things. Olive color are represented how much electricity purchase from the grid and the orange color represented solar panel (Sun 345). There we see in July month the peak month. In time about 500kw energy used with two types of sources.

4.4 Cost Summery

The Cost Summary shows the overall standard and actual cost of labor, materials, and subcontracts as well as the amount and percentage of fluctuation between standard and actual costs.

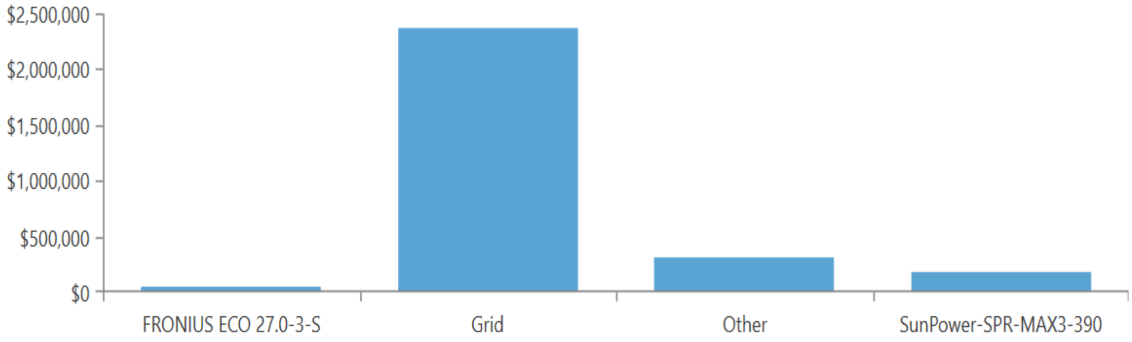

Figure 4.2: Cost Summery of the project

In this project we are using three most components like solar panel, Inverter and grid. Grid has no cost for our project due to its public property. But the solar panel that model is Sun power MAX3-390, the capital cost is $ 145000. It's replacement cost is very low but it has O&M cost that is $ 38406.

The cost of Inverter is $ 14720 and the model is Fronious Eco 27.0. It's replacement cost is $ 6909. It has O&M cost that is $25604. It has no fuel cost.

Though grid has no installation cost but have some Operation and maintenance cost. The amount is $ 2361744.31 that is include in our project.

4.5 PV Power Output

Because of the cold temperatures and intense radiation, February to April sees the highest PV output. PV power absorption time increases from April to October as a result of longer sunlight hours, but it drops during times of low radiation, precipitation, and high temperatures. Due to the short sunlight hours and gloomy weather, PV production increased after October but not sufficiently. The temperature of a solar PV cell is lowest from December to January, then it rises after January. The temperature of solar PV cells is at its highest from May to September.

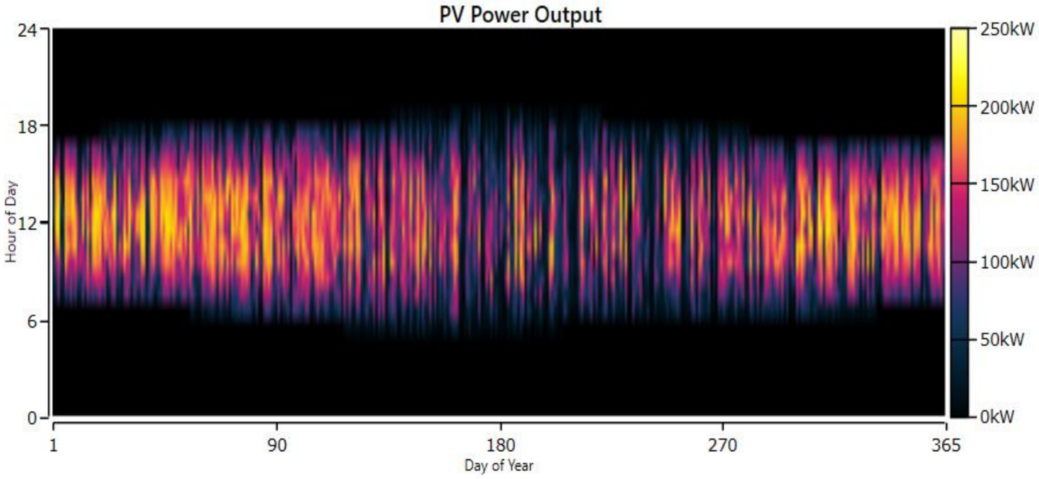

Figure 4.3: PV Power Output

The total output of the PV. Sunpower-345SPR-X21-345 chosen for the project that is readily available on the global market and is beneficial for use by business to get superior results. It is evident that the capacity factor is 12.7% because the rated capacity is 243 KW and the output is 30.8 KW. The average amount of PV energy produced each day is 739 kWh/d, the annual production is 269769 kWh, and the total number of hours of operation per year is 4374. Here, the levelized cost of producing power with the suggested technology is $0.043/KWh.

The next graph is shown the temperature of the solar panel of whole year. The graph result is after January month the temperature increase and the second month also increase because of our climate change and the end of the year we see the temperature decrease and this time we get low energy from our solar system.

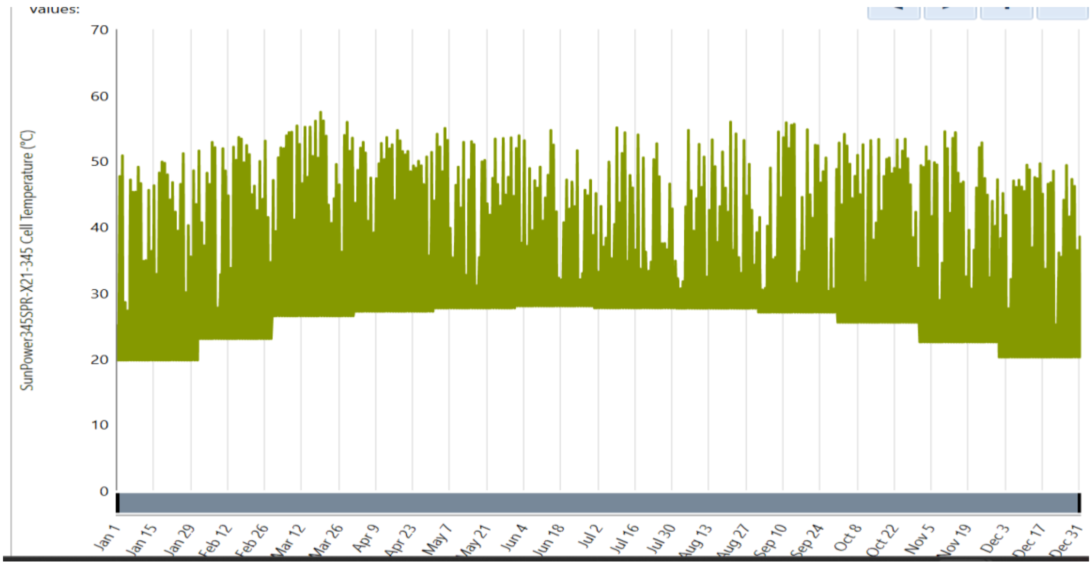

Figure 4.4: Temperature of the solar panel

4.6 Energy Purchase and sold to grid

Monthly Grid purchase and sales are shown in table. from January to May net energy is sold to grid, that time electricity production is high but load become lower compare with whole year. but from June to September net energy is purchased from the grid and from October to December net energy is sold to the grid. Peak demand is in April. Annual energy purchase 2393232 kWh and Sales is 2251 kWh. So, after a year net energy is sold to the grid. The industry purchases maximum electricity the month of May, June, and July respectively 265704KWh, 334153 KWh and 325298 KWh that time load is maximum for storage product on there. Here we see that, energy sold maximum to the grid due to off session and also that time electricity production maximum using propose project. The following month are January, February and March which are respectively 75117KWh, 63784KWh, and 217540KWh.

Month	Energy Purchased (kwh)	Energy Sold (kwh)	Net Energy Purchased (kwh)	Peak Demand (kwh)	Energy Charge ($)	Demand Charge ($)
January	75,117	525	74,592	275	$7,635.68	$0
February	63,784	389	63,395	279	$6,486.53	$0
March	217,540	12	217,527	696	$22,188.41	$0
April	253,664	0	253,664	708	$25,873.74	$0
May	265,704	0	265,704	643	$27,101.79	$0
June	334,153	0	334,153	813	$34,083.57	$0
July	325,398	0	325,398	831	$33,190.57	$0
August	205,737	30	205,707	679	$20,983.69	$0
September	256,679	0	256,679	611	$26,181.23	$0
October	177,125	21	177,104	457	$18,065.69	$0
November	173,228	0	173,228	553	$17669.21	$0
December	45,105	1,273	43,832	203	$4,537.07	$0
Annual	2,393,232	2,251	2,390,982	831	$243,997.1	$0

Table 4.2: Energy purchase and sold in a year

Figures and depict the energy that was bought and sold from the grid. This graph shows that during the first three months of the year, the system only purchases energy at night or during periods when sunshine is not present. Energy should be purchased day and night from April to September because demand is highest then. Then it was mostly energy

Occasionally, it also buys electricity from the utility during the day when insufficient energy is produced from the grid in the absence of sunlight.

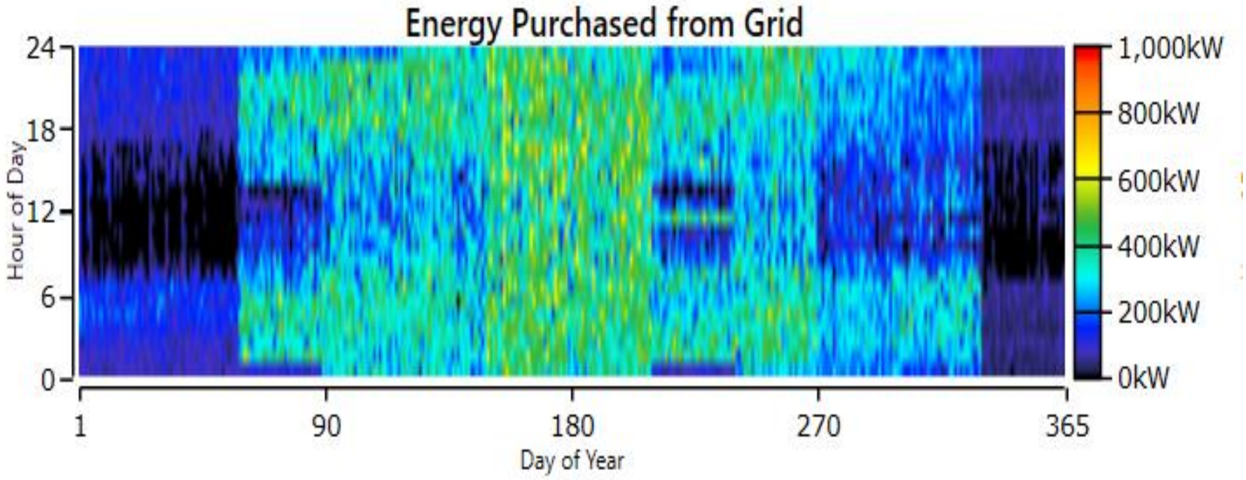

Figure 4.5: Energy Purchase from Grid

In this Fig showing the graph which indicates how much energy sold to grid. Here the amount of sold part is very low as a result the graph shows almost black

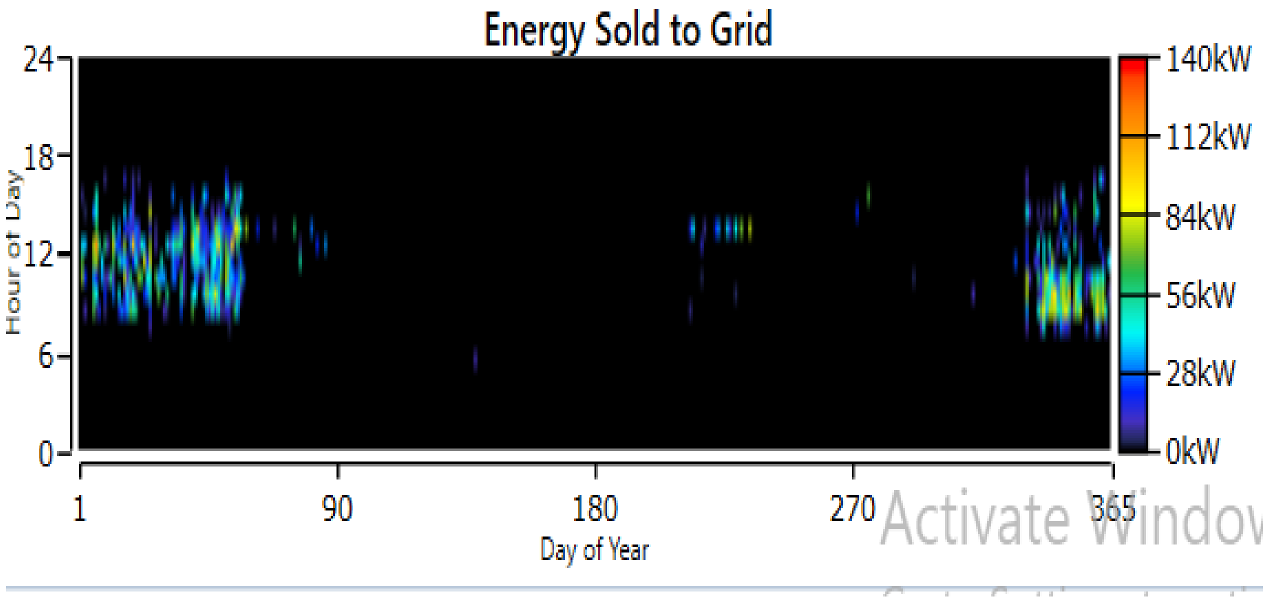

Figure 4.6: Energy sold from Grid

4.7 Inverter Output

The Inverter used is Fronius Eco 27.0-3-S. It is a powerful on grid inverter. The maximum power is 27 KW. After analysis by HOMER Pro software we get a result how the inverter works. The fig of inverter output shows the result here, given the hole year data. The total capacity is 160 KW and it's efficiency is almost 100%. The capacity factor is 27.6% for this project.

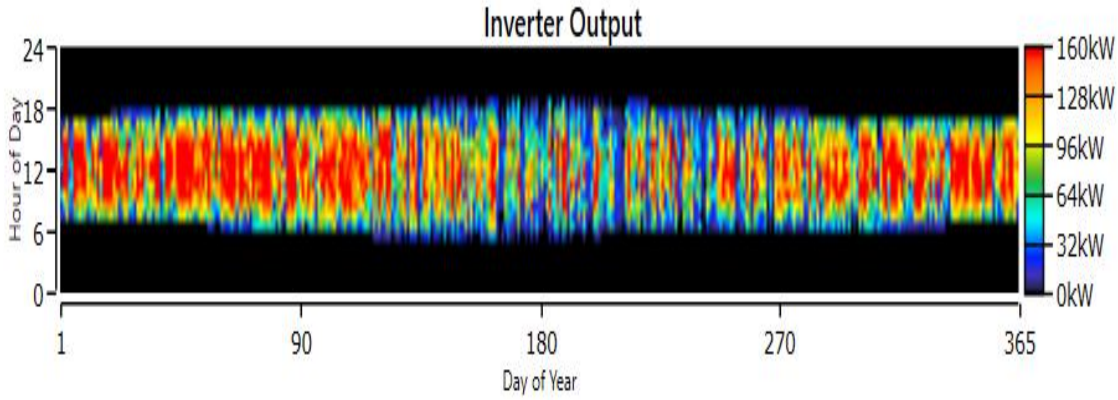

Figure 4.7: Inverter Output for a Year

Frounious inverter operation time is 4374 hour per year. The energy in by the inverter is 394628 KWh per year and the energy out is 386735 KWh per year. It has also some losses that is 7893 KWh per year. Finish all data analysis we see that the inverter converted our required energy as a result we can use the inverter for our project.

4.8 Summary

From this chapter, we get out output from this we understand our system condition here, we see some major points like cash flow, every month electricity production, How much energy purchases or sold to grid etc. The points are play a vital role for the system because after the analysis by the points we get our required output. For established a system at first take some mathematical steps and also software base calculation then we represent our plan or system in front our client. Also know that how much effective the system is for us.

Chapter 5

Project Management

5.1 Introduction

The process of controlling a team's work to fulfill all project goals within the given constraints is known as project management. Typically, descriptions of this data are included in the project documentation that is created at the beginning of the development process. The project involves using the solar system to produce energy. We obtain our necessary energy from the project at a reasonable cost, and on occasion, when it produced more energy than we needed, we also sold it to the national grid.

5.2 Resource and Cost Management

To complete our project we are using HOMER Pro software. The software resource is shown by the fig below.

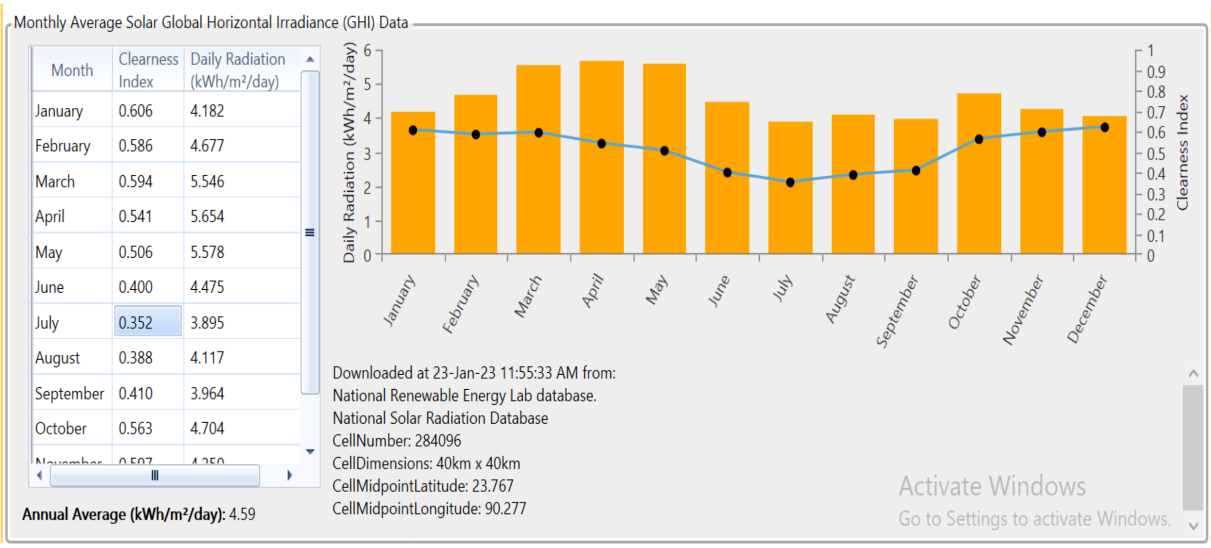

Figure 5.1: Daily Radiation of a year (month wise)

Here we see a graph which is indicate our solar system resources. On the right side there has a orange color graph which show our monthly radiation and it download from National Solar Radiation Database. In January month the radiation is high and it continue to march and then it decreased. In July the radiation is low then it also increased month by month and finally stop in December.

On the right side has every month's clearness Index and Daily Radiation.

From the table, the average daily radiation is 4.59 ($kWh/m^2/day$). In December has highest clearness Index that is 0.621. In April the daily radiation is high the rate is 5.65 $kWh/m^2/day$. This time is our summer season because the sun provided the highest sun light so the radiation also high.

Month	Clearness Index	Daily Radiation ($kWh/m^2/day$)
January	0.606	4.182
February	0.586	4.677
March	0.594	5.546
April	0.541	5.654
May	0.506	5.578
June	0.400	4.475
July	0.352	3.895
August	0.388	4.117
September	0.410	3.964
October	0.563	4.704
November	0.597	4.250
December	0.621	4.058

Table 5.1: Monthly Clearness Index

5.2.1 Cash Flow

The movement of money into and out of a business is known as cash flow. Cash spent indicates outflows, whereas cash received indicates inflows. The cash flow statement is a financial report that details the sources and uses of a company's cash over some time.

The formula of cash flow is,

Operation cash flow = Operating income + non-cash express-taxes + changes in working capital.

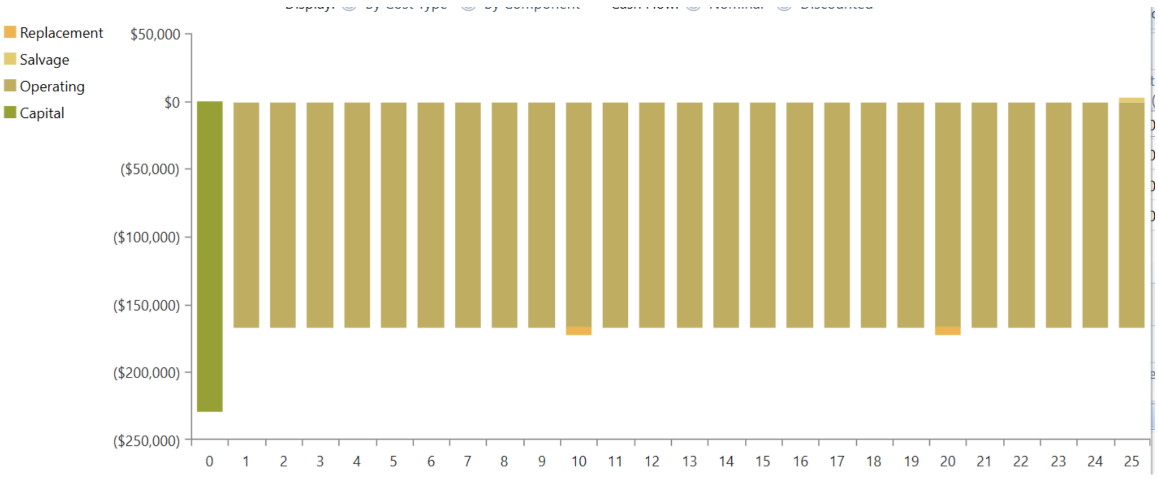

Figure 5.2: Cash flow

5.2.2 Compare Economics

There are two graphs one is the current system of nominal and the other is the base system of nominal. The graph's left side has dollar section and the bottom has tima e section. So, [11]
we see the average current system nominal between ($ 220000-$ 240000). Sometimes it increased by about $ 270000.

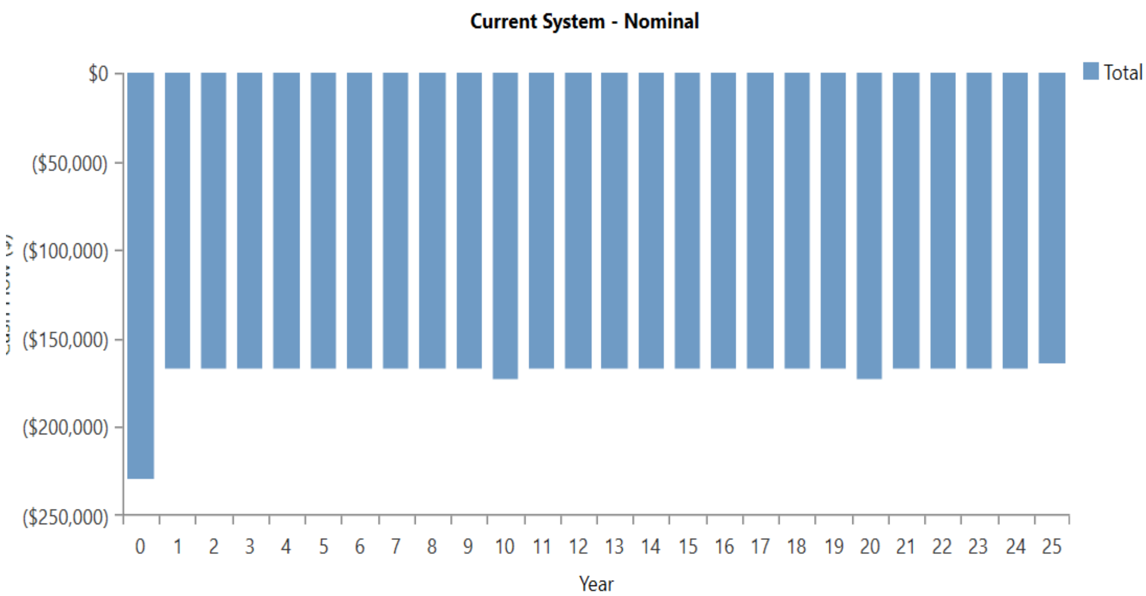

Figure 5.3: Nominal Current System

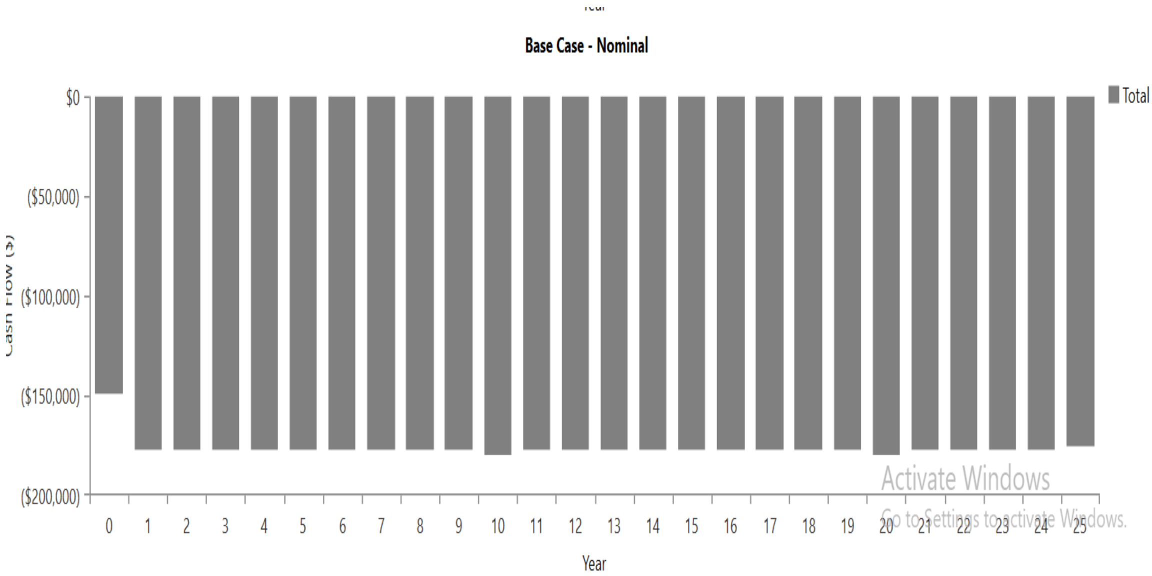

Figure 5.4: Nominal Base Case

In Base case-nominal shows all are the same. It means all time its costs are the same without first year.

5.3 The economic benefit of PV system

The difference between total revenues and total opportunity costs, including all of their explicit and implicit components, is known as economic profit. From an economic standpoint, money is not necessary Prior to incurring a cost, money must exchange hands. Expense implies sacrifices, yet alternatives and scarifications can be made without exchanging any cash. The financial gain (benefit) of employing a PV solar system to generate electricity can be examined in this context. Each unit of electricity generated by a PV system will substitute for a unit generated by a fossil fuel. Oil-related energy resource savings can either be sold on the world energy market for higher profits or put aside for future generations.

The opportunity cost of generating electricity from fossil fuels should be taken into consideration while calculating the PV solar systems' economic profit. The opportunity cost should also be considered.

Take into account the hidden cost of environmental contamination. The following assumption can be used to determine the true economic advantage of installing a PV solar system in Kuwait based on the discussion above:

- In Bangladesh, the price per kWh to produce power from fossil fuels is roughly $0.17. The cost of energy, or 0.078 dollars per kWh, accounts for 66.6% of the overall cost of production.
- For each kWh produced using PV solar system, Bangladesh will lower its CO2 emissions cost by the amount of ……….$/KWh

5.4 Emission

A general term for the electromagnetic radiation that the sun emits is solar radiation. Sunlight alone or the solar resource are other names for it. Solar radiation can be captured by a wide range of equipment and converted into usable energy types including heat and electricity.

Quantity	Value	Units
Carbon Dioxide	1,512,523	kg/yr
Carbon Monoxide	0	kg/yr
Unburned Hydrocarbons	0	kg/yr
Particulate Matter	0	kg/yr
Sulfur Dioxide	6,557	kg/yr
Nitrogen Oxides	3,207	kg/yr

Table 5.2: Environmental

From the table we get some value like carbon dioxide which is 1512523 kg/year. There is no carbon monoxide and Unburned Hydrocarbons but have sulfur dioxide of 6557 kg/year and also have nitrogen oxides 3207 kg/yr.

5.5 Environmental and Ethical Issues

In order to protect humans, animals, and ecosystems, it is imperative to reduce greenhouse gas emissions and prevent climate change. Solar energy is a sustainable resource that significantly contributes to these goals. Also, using solar energy can reduce water usage and improve air quality. Since ground-mounted photovoltaics (PV) and concentrating solar-thermal power plants need the use of land, sites must be selected, designed, and managed to minimize impacts to adjacent wildlife, animal habitat, soil resources, and water supplies. The U.S. Department of Energy's (DOE) Solar Energy Technologies Office (SETO) supports research to better understand the connections between solar energy facilities, wildlife, and ecosystems and to create strategies that will enhance the local environment as much as feasible.

Negative Impact for environment of solar:

1.Solar energy production requires a significant amount of starting energy. Mining, manufacturing, and transportation are all energy-intensive sectors that are involved. Quartz must be prepared, cleaned, and produced along with other components that may originate from other sources to make a single solar module (aluminum, copper, etc.). At the processing stage, quartz must be heated using high heat. [16] Manufacturing requires the highly exact blending of multiple elements to produce high-efficiency panels. There is a lot of initial work involved in all of this. Before being used in a single location, traditional fuels like gas or coal are often mined, cleaned, and processed on a large scale.

2.Hazardous chemicals are frequently used in the manufacturing of semiconductors to provide silicon that is suitable for solar energy. Depending on the country of origin and manufacturer of the solar panel.

Some ethical issues are:

- Solar energy development should not be at the expense of people's essential rights.
- Solar energy should be environmentally sustainable.
- Solar energy should not contribute to net reduction of total greenhouse gas emissions and not exacerbate global climate change

5.6 Overview

The project is become a good example for our next generation. For this they don’t suffer any problem of electricity because by the project we generate our required energy using renewable energy. In our world we are using two types of energy and renewable is one of them. According to many researchers, renewable energy is the energy that is used at the end day of the world. So, the Solar system is a renewable energy because here we get our energy from the sun which is universal. Every people should use the system for generating electricity, as a result, we reduce our oil-based power plants and also reduce carbon dioxide from the air. Then the air will be fresh and people take a fresh breath. It is a helpful project for general people. All people should create a solar plant on the rooftop of their building. The project helps us to protect our environment and also gives us a good society. Finally, we are all will be benefited.

CHAPTER 6

CONCLUSIONS & RECOMMENDATIONS

6.1 Conclusion

These include anything from promoting plant photosynthesis to using photovoltaic (PV) cells to generate electricity to heating food and water. Solar technologies concentrate solar radiation using photovoltaic (PV) panels or mirrors to turn sunlight into electrical energy. This energy can be used to create electricity, or it can be stored thermally or in batteries. solar-powered water heaters. One of the best uses of solar energy is to heat water because we practically always need it. Outside solar lighting is available. Solar cells convert sunlight into electricity and are used in outdoor energy-saving lights (like solar floodlights or solar security lights). The ecosystem is protected by solar energy. It doesn't release any carbon or other "greenhouse" gases, which trap heat. It reverses the environmental harm brought on by mining or exploration for fossil fuels. Solar energy also uses little to no water compared to power facilities that use steam turbines to produce electricity.

The analysis also demonstrates that due to Bangladesh's excellent solar radiation, practically every location would be a good candidate for the installation of one of the grid-tied solar photovoltaic systems. According to this analysis, future adoption of the suggested system or comparable ones would relieve grid congestion and boost renewable energy generation, which would minimize the need for fossil fuels and enhance energy security while lowering greenhouse gas emissions.

Grid-connected solar PV systems have high up-front expenses, but over time they are very profitable and environmentally friendly. Grid-connected solar photovoltaic systems provide greater service quality and dependability, which can significantly contribute to global and Bangladeshi electrification.

6.2 New Skills & Experiences Learned

We should learn about raising or lowering the amount of sunlight absorbed by the Earth's surface is one of these methods. This can have an impact on the average temperature of the Planet. Temperature changes, which can affect the distribution of snow and ice cover. Solar panels produce direct current electricity. This is then fed through an inverter, which converts it to alternating current, which is either fed into the grid or used by houses and businesses with solar panels. The YKSG-2 roofing is another possibility. 1473.58 square meters is the entire area. This is our hall building, where we will store our inverter, other critical equipment, and solar panels. The structure measures 52 meters in height. As a result, we receive sufficient sunlight to operate the solar panel, and our output is excellent. The primary reason for the growing popularity of renewable energy supplies is rising energy demand combined with dwindling natural resources. As a result, a power system model for sustainable and efficient power must be developed.

6.3 Future Recommendation

The research team identified a number of potential areas for future research to advance cost-estimated techniques as it went along.

The investigation found that different agencies did not use the same wording. Information could be easily shared amongst DOTs by looking at the adoption of a uniform procedure to gather and use cost data. Then, the lesson might be used to enhance the procedures of all agencies. The creation of an industry-standard coding scheme for project factors is another application of this idea.

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