MODERN VILLAGE-NEOTERIC GRID AND SUSTAINABLE ENERGY WITH DYNAMIC BANGLADESH

This thesis has been submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirement for the degree of Bachelor of Science in Electrical and Electronic Engineering.

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July, 2023

DECLARATION

We hereby declare this thesis "**MODERN VILLAGE-NEOTERIC GRID AND SUSTAINABLE ENERGY WITH DYNAMIC BANGLADESH**" represents my own work which has been done in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering, and has not been previously included in a thesis or dissertation submitted to this or any other institution for a degree, diploma or other qualifications. I have attempted to identify all the risks related to this research that may arise in conducting this research, obtained the relevant ethical and/or safety approval (where applicable), and acknowledged my obligations and the rights of the participants.

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APPROVAL

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DEDICATED TO

OUR PARENTS
AND
RESPECTED TEACHERS

ACKNOWLEDGEMENT

We will always be grateful to Daffodil International University's Department of Electrical and Electronic Engineering for allowing us to do this thesis. Our warmest thanks go out to **Professor Dr. Md. Shahid Ullah (**Professor & Head) Department of Electrical and Electronic Engineering **Jahedul Islam** (Lecturer) Department of Electrical and Electronic Engineering at Daffodil International University, who served as our thesis supervisor and co-supervisor. Without question, their leadership and constant inspiration throughout the course were key factors in our ability to move forward with that thesis. We also appreciate the professors from the Department of Electrical and Electronic Engineering for lending a helping hand when we are working on our thesis.

Finally, we would want to thank our parents, relatives, and friends for their support.

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LIST OF ABBREVIATIONS

PV = Photovoltaic

MW= Mega Watt

Kwh= Kilo watt hour

AC = Alternating Current

DC = Direct current

HOMER = Hybrid Optimization of Multiple Energy Resources

SPIS = Solar Powered Irrigation System

HRES = Hybrid Renewable Energy Systems

REN = Renewable Energy Policy Network

CPD = Centre for Policy Dialogue

GDP = Gross domestic product.

USD = U.S. Dollar

SDG = Sustainable Development Goal

IDCOL = Infrastructure Development Company Limited

SHS = Solar Home System

LDR = Light Dependent Resistor

MPPT = Maximum Power Point Tracking

BPDB = Bangladesh Power Development Board

BWDB = Bangladesh Water Development Board

LGED = The Local Government Engineering Department

RESCO = Renewable Energy Service Company

GHI = Global Horizontal Irradiance

DIF = Diffuse Horizontal Irradiance

DNI = Direct Normal Irradiance

HAWT = Horizontal-axis wind turbine

VAWT = Vertical axis wind turbine

GWEC = Global Wind Energy Council

NEA = National Energy Administration

NREL = National Renewable Energy Laboratory

IRENA = International Renewable Energy Agency

CF = Capacity Factor

TVM = Time Value of Money

BCR = Benefit to Cost Ratio

COE = Cost of electricity

NPV = Net Present Value

ABSTRACT

Bangladesh is a nation in development. The lack of energy is the main issue preventing Bangladesh from developing. The majority of this happens in the nation's rural areas. The majority of our country's nooks and crannies are still without electricity. Load darkening is much to blame for how miserable public life is. Sustainable energy is currently the subject of interest because this nation is developing. Particularly since it presents a significant potential energy source for the power sector. A stable and efficient energy source for decentralized and distant locations, where grid connection is almost impossible, can be a renewable energy generation system linked with diesel engines. In Bangladesh, the rising demand for power needs to be handled. Technology for renewable energy will cost less, and efficiency and dependability will improve. Another of green energy sources of sun, wind, hydro etc most valuable power in present time in the whole world. Khalisha Chapani is located in Dimla Upazila, Bangladesh, this area of a solar power plant. Chilmari is another location with a wind turbine. Both sites provide hydropower. Daily Load power in 50000 PV Panel is power generated 136MW Generated by Electricity. This is total Approximately 31.56 Acre in solar Panel Area Size. And the total area of 49 wind turbine is power production 118.58MWh per day. The Teesta and Dharla Hydro Power Plant's two flood-prone locations produced 97.99 MW of power continuously for six consecutive months from May to September each year with full assistance. Homer Pro software and other tools will be used for all technical analysis, economic comparisons, and design simulations so that our government can provide consumers with the needed electricity at a reduced cost. Therefore, the cost lowers as the load does. Therefore, a system that has less load is considerably more practical. In today's world, global warming is an alarming issue. So, we see reducing fuel burning and also reducing carbon dioxide emissions. Human life is developing in this plan of the modern village and neoteric grid system in clean energy.

Keywords: Global Solar Atlas, Global wind Atlas, CFD Support & GoLab and Homer Pro

CHAPTER 1

INTRODUCTION

1.1 Introduction:

Solar power is the process of converting solar energy directly into electricity via the use of photovoltaics (PV) or indirectly through the use of concentrated solar power. The photovoltaic effect is used by photovoltaic cells to convert light into an electric current. The Solar System is the only system in which a habitable planet has been observed, the only star we can observe up close, and the only planets we can explore with spacecraft. Understanding the creation and evolution of planets as well as the conditions required for life requires extensive investigation into the solar system. Bangladesh has high ambitions for solar and renewable energy. By 2030, the nation aims to produce 4,100 MW of sustainable energy, of which 2,277 MW will come from solar, 1,000 MW from hydropower, and 597 MW from wind. Wind power is the conversion of wind electricity to useful energy through the use of turbines that rotate to produce electrically. The power and wind speed are directly proportional. Fossil fuel supplies are diminishing daily. Due to a lack of electricity supply, Bangladesh's rate of industrial development has showed down. Without significantly harming the environment, wind energy offers a big potential to lessen our dependency on conventional energy sources like as coal, gas, and oil. With an increase in GDP of about 7% in 2015, Bangladesh's economy is among those that are growing the quickest globally. About 51% of people in Bangladesh, especially in the disconnected areas, lacked a connection to power. Given the nearing exhaustibility of fossil fuels and the rapidly increasing need for electricity, the nation's lawmakers have shifted their emphasis to renewable energy sources like wind power in different organizational arrangements.

Renewable energy from sources like solar, biogas, wind, and hydropower has grown in popularity in Bangladesh. The only electrical station in the country having a 230 MW electricity collection capacity is the hydroelectric project at Karnaphuli. The Kaptai Dam is located 65 kilometers above sea level in Kaptai, Bangladesh's Rangamati District, on the bank of the Karnaphuli River. It is a construction dam with a water storage capacity of 6,477 million cubic meters. The primary purpose of the reservoirs and dams was to generate hydropower electricity. It has been used for more than 20 years to efficiently create power using current wind turbines. China, United States, Germany, Spain, India 91424MW, 61091MW, 22959MW, 20150MW and the top five nations that use windmills to harvest electricity from the wind in 2013. The first wind power facility in Bangladesh began operations in 2005. Two projects in Bangladesh that produce wind energy are those at the Muhuri Dam and the one on Kutubdia Island. The initial grid-connected wind turbine in Bangladesh will be the Muhuri dam construction. Bangladesh can be found from 20.30- and 26.38-degrees northern latitude and 88.04- and 92.44-degrees eastern longitude. It has a 700-kilometer-long coast.

Bangladesh ranks as one of the countries with the smallest per-person energy consumption. Every day, there is a greater and greater demand for electricity. Natural gas, a fuel which is primarily utilized in the electricity sector, may be found in Bangladesh's eastern region. The possibility for wind is the highest of any green power resource.

1.2 General Overview on Electricity and National Infrastructure

Electricity facilities refers to the devices and amenities needed to deliver electrical energy—whether it comes from petroleum or coal, nuclear, solar, wind, geothermal energies or biomass power stations, dams, or energy storage systems—to end users in the residential, business, and industrial sectors. Infrastructure for charging electric cars and associated grid administration technologies, including distributed renewable energy management systems (DERMS), advanced distribution management systems (ADMS), and virtual nuclear plants, constitutes a part of today's electricity system. Power converters, volt regulators, breaks, switchgear, capacitors, fuses, controllers, arresters, and conductors are just a few examples of the transmission- and distribution-level technology that is also incorporated. In addition to finances, financing projects, and engineering, purchasing, and contracting (EPC), electricity infrastructure testing and certification, as well as other associated services, are all examples of research and development.

A crucial industry on a worldwide scale is electricity infrastructure. Health and welfare are at risk if there isn't a reliable source of electricity. Almost all economic activity requires dependable electricity to run. Authorities and utility throughout the globe are increasingly concentrating on the need to maintain a reinforced grid that will be resistant to the impact of natural catastrophes, notably those spurred on by warming temperatures, as well as the synthetic hazards of hacking or terrorist. Smart grid solutions that enable wider adoption of variable sources of renewable electricity and improve load economy will be crucial if nations and businesses are to meet the worldwide sustainability commitments.

Bangladesh's services electricity sector had a single national grid having a current capacity of 27,361 MW as of May 2023. The energy sector in Bangladesh falling short of forecasts. However, it's believed that Bangladesh uses more electricity per person than it produces. Electricity arrived on December 7, 1901, while the nation was still governed by the British. Electricity is primarily used to power the majority of the nation's fiscal activities. The largest energy consumers in Bangladesh are the household and manufacturing industries, next to the business and farming industries. To sustain its over 7% growth by 2030, the GDP of Bangladesh will require 34,000 MW of power. Blackouts, stolen electricity, significant losses to the system, delays in construction conclusion, low plant efficiency, erratic electricity supply, and a lack of financing for power are all problems. Some of the challenges Bangladesh's electricity industry faces have to do to upkeep of facilities. Power is a major source of electricity utilized by industries and farms in Bangladesh. These two industries together account for 50,3 percentage points of Bangladesh's GDP. To ensure that electricity can be utilized successfully, effective planning is necessary. For the energy system as a whole—a system of infrastructure that includes generation, transmission, distribution, wiring, and metering—collaboration is crucial.

1.3 Summary of Thesis

We are study on some places in Bangladesh. Our project we started Bangladesh, Rangpur District, around Teesta Barage coastal region some place. We are studying this place. In order to provide water to around 6.32 lac hectares of land in the district of Niphamari, Ragpur, Dinajpur, Jaipurhat, Gaibandha and bogra Bangladesh built the Teesta barrage in 1990. The Teesta barrage is Bangladesh largest irrigation project. Tista barrage is located in Duani Union on the Teesta River in the Hatibandha subdistrict of the Lalmonirhat district. It will be started 1979 and was completed in 1997-98. The barrage is a type of lower head, diversions barrier that consists of numerous big gates which may be raised or closed to control the amount of water passing across. As a result, to be utilized alongside other systems, the structure may control and upkeep the elevation of the river ahead.

According to Bangladesh's Power System Master Plan 2016, the country has the ability to generate 3.6 GW of total energy utilizing sources of clean energy. The potential for the use of wind power alone is 20 GW, claims a further study. Bangladesh has 15 MW of sunlight potential through rural households and 1.9 MW of wind energy potential at Kutubdia and Feni. Private enterprises are constructing 19 on-grid solar parks with a total combined generating of approximately 1070 MW has been permitted by the government of Bangladesh. Our research was initiated in Bangladesh's Rangpur District, maybe in the Teesta Barage coastal region. When taking this into account, the country's entire demand for electricity is exceeded by a certain percentage.

By 2023, Bangladesh plans to generate a total of 1169.73 MW energy using sources that are sustainable including the sun, wind, water, and trash. The country wants to increase the proportion of green power to 17% by 2041 in order to reach its Intentional Nationally Determined Contribution (INDC) commitment to reduce the release of greenhouse gases by 5% through 2030.

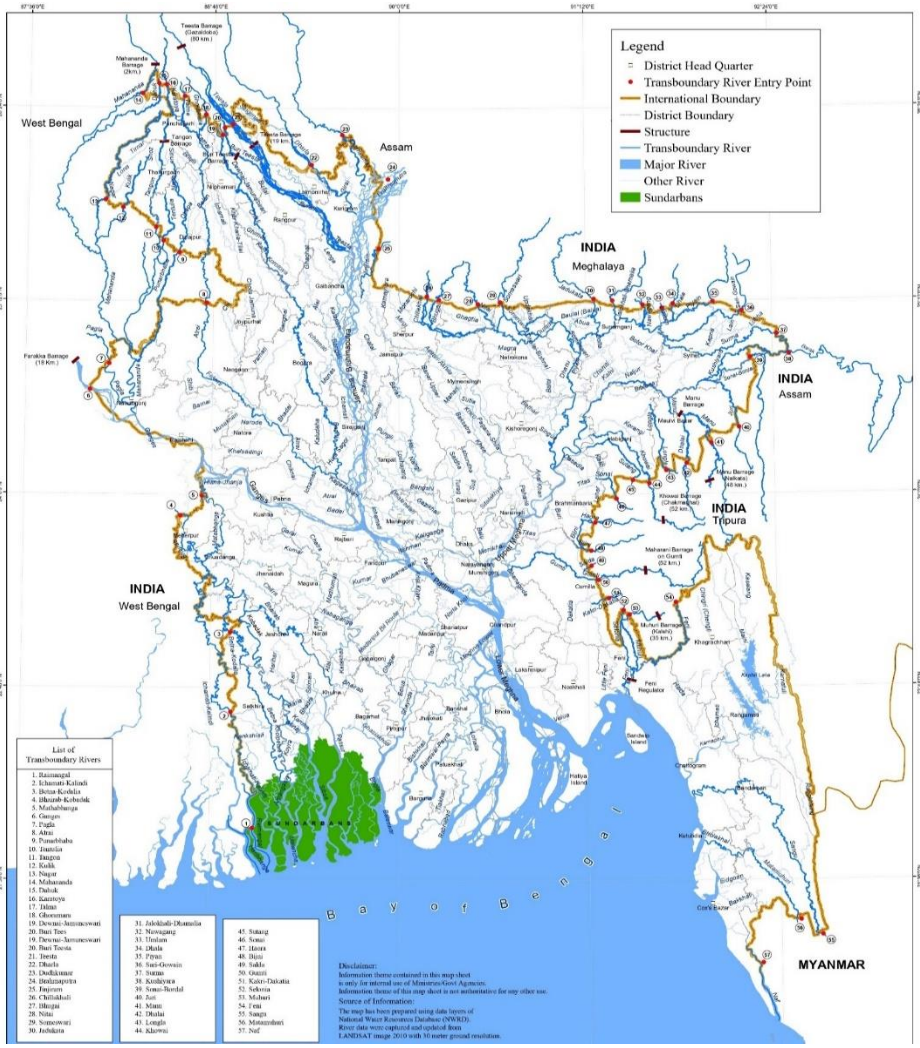


Figure 1.1: Bangladesh Major River [1]

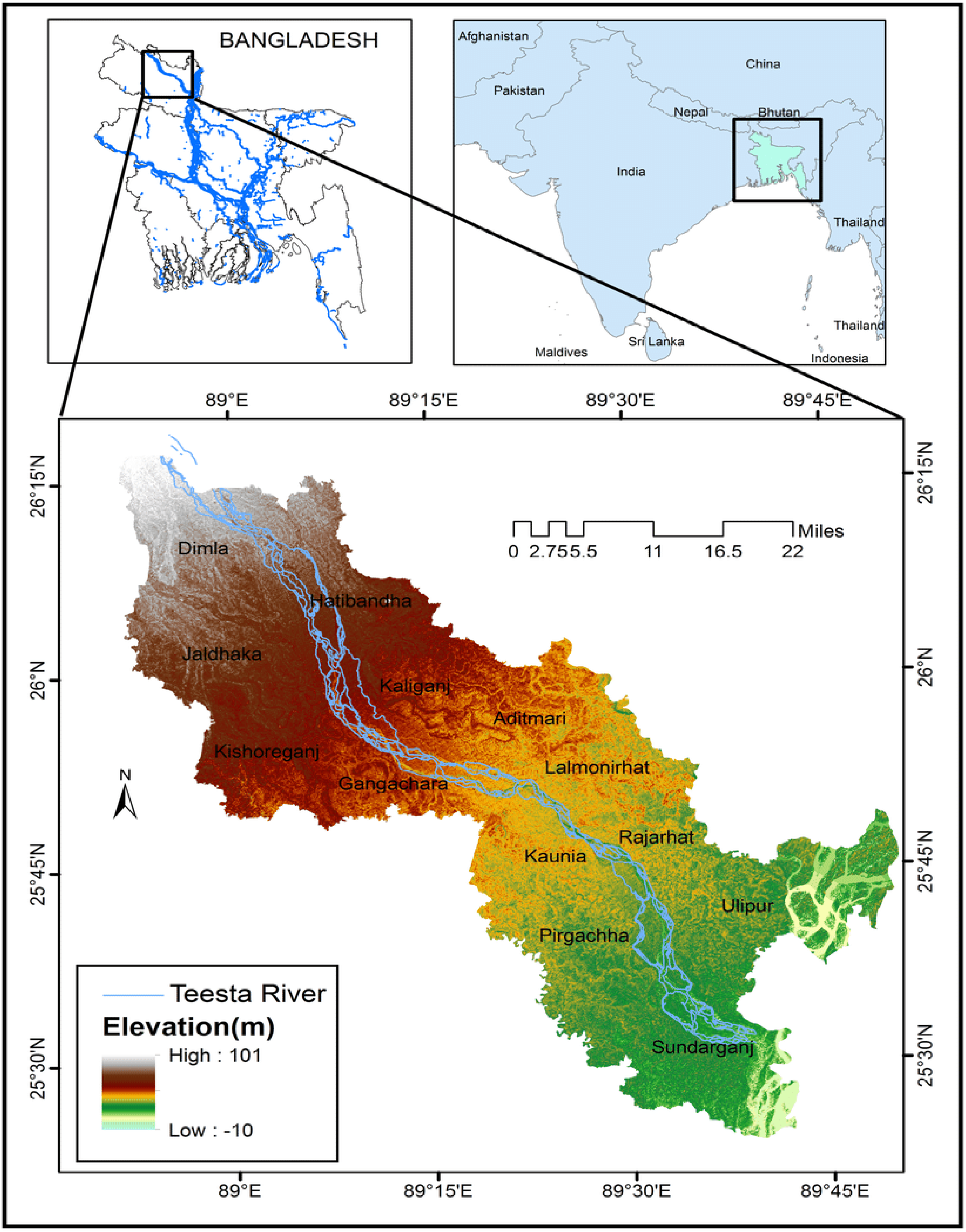


Figure 1.2: Teesta River Map [2]

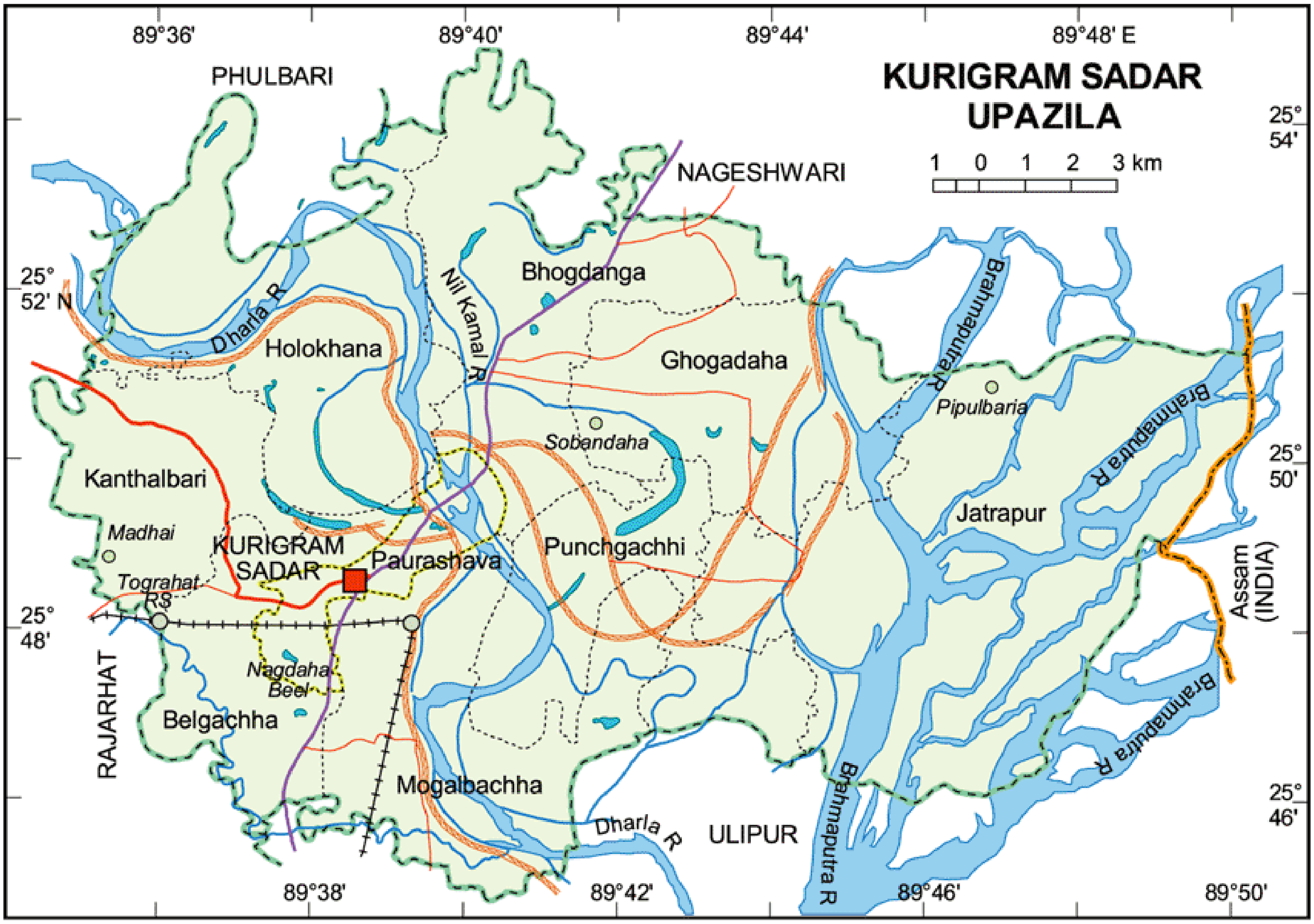


Figure 1.3: Dharla and Brahmaputra River Map [3]

1.4 The Plan of This Thesis

1. River rescue and river navigability enhancement.
2. Construction of dams on both sides of on the river.
3. Installation of wind turbines on both sides of the river.
4. Recovery of arable land.
5. Increasing harvesting of food for the growing of HYV-Boro and T-Aman.
6. Development flood prevention system.
7. Provision of adequate water for agriculture during dry season.
8. Setting up of solar power plants on uncultivated land.
9. More fruit-bearing plants and a communal forest planting.
10. More readily available drinking water.
11. Reduce incidence of waterborne diseases.
12. Reducing pressure on non-renewable energy and encouraging people to use renewable energy.
13. Contribution of renewable energy to meet Bangladesh's electricity deficit.
14. Increase the locals' income and quality of life.
15. Impact of Bangladesh Economic development.

CHAPTER 2

DURABLE ENERGY GENERATION SCENARIO.

2.1 In Bangladesh.

There are concerns about Bangladesh's energy stability in the years to come as the country recovers from its energy constraints in 2023. Despite the nation's goal of generating 40% by using sources of clean energy for at least ten percent, the present administration is now discussing long-term LNG contracts. Bangladesh's electricity grid will continue to be susceptible to energy disruptions and the ensuing economic upheaval if a conversion to renewable energy is not made. The term "renewable energy" in Bangladesh refers to the country's usage of the production of electricity using natural power resources. Biogas, that is created by biomass, solar power, hydroelectricity, and wind power, as currently a clean energy supply. solar energy the number of hours with bright sunshine each day in Bangladesh's coastlines vary from 3 to 11, depending on long-term mean sunlight data. In Bangladesh, each day's sunlight averages 5 kWh/m2/day and ranges from 3.8 to 6.4 kWh/m2/day. These demonstrate that the integration of solar thermal and renewable utilization in the nation have bright futures. wind energy the long-term history of wind flow, especially in the barrier islands and southern coastline of Bangladesh, indicates that the mean wind speed continues to range around 3 and 4.5 m/s from March to September while ranging from 1.7 and 2.3 m/s for the remainder of the year. The usage of turbines that spin for electric and industrial purposes. In island and coastal areas is a good possibility. But from March through October, the summer and monsoon seasons, severe low-pressure zones, and storm winds of 200 to 300 km/h are possible. To resist these high wind speeds, wind turbines must be sturdy. Biogas in Bangladesh, floating dome and fixed dome biogas plants are the two main types used. In the nation, bag-type plants are also employed, albeit infrequently. Bangladesh's advantages of renewable energy It is possible to develop capacity in the field of electricity effectively by using renewable energy sources (renewables and energy utilization), that not only reduce the release of greenhouse gases but also promote jobs and improve the well-being of people by reducing pollution in the air. As to research by the Low Emissions Strategies for Development International Partnership and based on to-depth modeling examination, the advantages of increasing renewable resources in Bangladesh's electrical energy mix in compared to "business as usual" might be reflected in the following accumulated consequences by 2030.

Bangladesh's energy situation will affect how the Asian country's economy performs in 2023 as it struggles with the energy crisis. Due to dwindling domestic fossil fuel reserves and a growing dependency on imported natural gas, Bangladesh is experiencing load shedding and has a power supply shortage. After reaching nearly 100% electrification, its energy grid has a high baseline power demand. This electricity is crucial for Bangladesh's ready-to-wear apparel industry, which accounts for roughly 10% of the country's GDP and 80% of all exports. Bangladesh's economic development is currently in danger due to a lack of diversity in its energy portfolio. So, the durable Energy Generation Scenario in Bangladesh day by day increased.

2.2 In the World.

The renewable energy sector is anticipated to continue growing and reach the necessary numbers in 2023, with capital flow, technological advancements, and government backing in the form of forward-thinking policies serving as the main drivers of growth. According to London-based think tank Ember, releases of atmospheric greenhouse gases caused by the electrical industry which account for the majority of global emissions, are predicted to decline for the first time. The demand for electricity around the world is continuously increasing, despite this. Because the rise of Wind and solar power are outperforming conventional sources of electricity in terms of growth in demand, emissions are expected to decline. The future’s Earth’s biggest supply of energy Because they are currently the most established, wind, nuclear fission, and hydropower are expected to be our strongest energy sources in the coming years. But new technology will appear. For instance, nuclear fusion has enormous promise and may someday be the best energy source available. Energy scenarios for the world. The innovative method used by the World Energy Council to create energy futures through 2050. The WEC's strategy. In order to study the ramifications of various determine the level of stability of projected future growth under various sets of hypotheses. scenarios are alternate visions of the future. In the past, renewables were simply the more expensive but more environmentally friendly choice. They'll actually make financial sense by 2023. We provide our predictions for how the industry will rethink themselves by taking use of this adaptable green surge in 2023: The Near Futures of Renewables. These predictions depend on study results and comments submitted by BDO's world resources employees. Each among the nine practicing leaders—Australia, Canada, France, Malaysia, New Zealand, Portugal, South Africa, the United Kingdom, and the United States—has a standout forecast that is also emphasized.

The ability of solar energy production is anticipated to rise by 600 gigawatts (GW) by 2024, nearly tripling Japan's current all-electricity production. By 2024, 1200 GW more renewable power is anticipated to be produced globally, which is equivalent to the total power plant of every state in the US. Recent years have seen a number of good tipping points for renewable energy, and a significant one is expected to be reached in 2023. Renewable energy is expected to reach a crucial tipping point this year. The aforementioned three nations all dominate the world in energy sources that are renewable. They came in first, second, and third location, accordingly, depending to the standings. In addition to any other country in the globe, Norwegian uses hydroelectricity, which accounts for 45% of its overall supply. We might reduce energy costs, reduce emissions, and limit the risks of global warming in the future, notably how it would affect agriculture, if we could transition from petroleum and natural gas to an abundant clean power source.

CHAPTER 3

SOLAR POWER SYSTEM

3.1 Introduction

3.1.1 Problem Statement

Bangladesh is a small nation with a sizable populace. There are currently 169.4 million residents, and that number is rising every. As a result, to satisfy her need, enormous amounts of electricity are required. The government is currently concentrating on renewable energy. They are making efforts to encourage the use of sustainable Power. Sun energy of the more widely used and comfortable renewable resource. Bangladesh, a developing nation with a sizable population and high energy demand, is well known. People here are experiencing a severe power crisis, which is considered to be a major roadblock to economic growth, especially in the electrical industry due to the country's limited resources. The fact that we lack the necessary resources and manpower to create a vast electric power generating system is a cruel twist of fate. As a result, we must choose the renewable energy option. because it is regarded as the ideal solution for supplying clean energy. [4]

As a result, we frequently choose solar energy plant generation. It was definitely chosen because of the cost and the moreover the favorable geography and right surroundings.

Goddimari in the district of Rangpur is the location that was chosen for this PV facility. Therefore, to build a star plant, we would initially need a substantial sum of money. This power plant can help us reduce CO_2 emissions and benefit the environment. Production of electricity is one of the biggest contributors to CO_2 emissions. To minimize greenhouse gas emissions, more attention should be paid to the broad use of sustainable power sources.

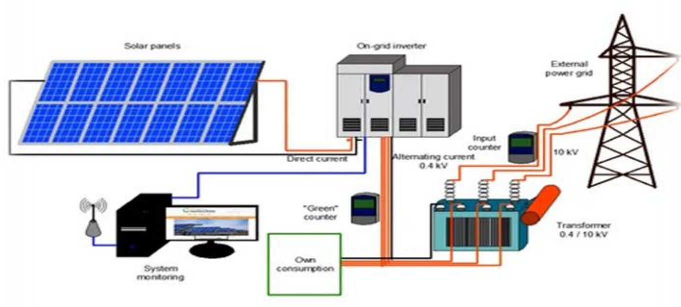


Figure 3.1: On Grid Solar Power System [5]

3.1.2 Literature Reviews

Building a solar project at the Solar Park at Goddimari in the Rangpur District serves as the foundation for the entire thesis effort. We consulted a variety of informational sources and conducted extensive study to properly prepare this thesis. Through an inspection of the location, we have gathered some experimental data. Additionally, we have employed calculations that account for both present values and situations. Additionally, we used Global Solar Atlas to design the solar project. Here, HOMER serves as the simulation tool. The most practical technique to carry out the job at any other various loads was determined using HOMER. We have drawn a distinction towards the article's conclusion. We have made an effort to recommend the most ideal and practical method of constructing the project.

3.1.3 Solar Energy in Bangladesh

Bangladesh's management of the biggest off-grid solar energy initiative in the world offers lessons to be learned for other countries seeking to expand access to affordable, clean electricity. The scheme gave 20 million Bangladeshis access to energy by utilizing solar power. Bangladesh is renowned for its creative methods to development. Through a public-private cooperation, the government has effectively implemented cost-effective off-grid renewable energy solutions in rural and difficult-to-reach places. Mercy Tembon, the Country Director for Bangladesh and Bhutan at the World Bank, claims that clean energy translates into improved living and medical situations for households and increased time to learn for children. "Our partnership with the government for this program spans nearly two decades, and now our support has been expanded to include other renewable energy options." Thanks to aggressive attempts by the government and the private sector, Bangladesh has seen a rise in solar energy since 1996, beginning with the installation of tiny units of the solar home system (SHS) around the nation. The astounding 6,037,601 SHS units have now been recorded.

3.1.4 Solar Energy's Importance

Atomic power plants and petroleum derivatives (coal, oil, and gas) are the principal resources of the modern energy age. The use of non-renewable power resources causes greenhouse gases (CFC, CH_4, O_3, but primarily CO_2) to diffuse into the atmosphere. Carbon is delivered in a small quantity (90 grams of carbon dioxide equivalent per kilowatt hour) from the thermal energy station. However, the radioactive waste that is still present has been dynamic for more than a thousand years, which is a typical source of natural contamination. Energy age is the source of the more carbon dioxide emission[6]. Therefore, the development of this ideal energy has the highest impact on global warming. The greatest natural threat to us now comes from global warming and natural pollution. Alternatively, there is a worrying energy crisis occurring globally as the availability of petroleum derivatives decreases and power facilities that are getting older may soon have to shut down.

Finally, we may state the following on the use of solar energy:

1. There are Fewer Sources of Conventional Energy.

2. CO emissions result from the creation of force using conventional energy.

3. Easy to use and introduce.

4. No commotion

5. Less maintenance.

6. The source is endless.

7. Because it has no moving parts, it has a long lifespan.

3.1.5 Bangladesh's Current Renewable Energy Situation

The showcase for renewable energy in Bangladesh has enormous potential. This generally holds true with the most recent data from the World Bank, which lists Bangladesh as one of the 20 economies with the fastest GDP growth. This expansion brings with it the requirement to satisfy growing energy use demands. The primary energy sources for Bangladesh as of 2022 are natural gas, other fossil fuels, and biofuels. In 1980, only 0.016 percent of Bangladeshis were in positions of power. The percentage has surged to 92%

after 40 years. Bangladesh was one of many countries, along with Mongolia, that had jolt rates under 90% a while back.

The official begins of Bangladesh's arrangement move toward renewable vitality came with the 2008 distribution of its approach rules by the Service of Control, Vitality, and Mineral Assets. Up to 2022, Bangladesh has made direct but unfaltering advance. In spite of Bangladesh's display vitality blend as it were counting 3% of renewable vitality, the nation has as of now affirmed an ace arrange within the field.

3.1.6 Objectives of The Thesis

This study focuses on the simultaneous usage of grid power and solar power to power loads at the Goddimari location. The following are its goals:

i. To research Bangladesh's current renewable energy situation.

ii. To calculate the area of the Home Solar and Solar Park.

iii. To determine the loads throughout various hours of the day in both the summer and the winter.

iv. Using PVSYST to determine the system power.

v. To evaluate the system's techno-economic viability using the HOMER model.

3.2 Literature Reviews

3.2.1 Renewable Energy

Renewable vitality comes from characteristic sources that supplant themselves more rapidly than they are utilized up. Cases of such sources that are ceaselessly recharged are the sun and the wind. There are numerous distinctive sorts of renewable vitality accessible to us.

On the other hand, non-renewable fossil fills like coal, oil, and gas require hundreds of millions of a long time to form. When fossil fills are utilized to make vitality, they transmit perilous nursery gasses like carbon dioxide. More outflows are created by burning fossil fills than by creating power from renewable sources. The key to tackling the climate catastrophe is exchanging from fossil fills, which presently create the lion's share of outflows, to renewable vitality. In most countries, renewables are presently more reasonable and create three times as much vitality.

The term "renewable vitality" alludes to vitality sources like wind and sun powered vitality that are ceaselessly and naturally reestablished. Economic vitality is another title for renewable vitality. The direct opposite of fossil fills, such as coal and gas, which are a limited vitality source, are renewable vitality sources. Renewable vitality is made from actually renewing and unending sources, such as the sun and wind. Transportation, space and water warming and cooling, and power era are all conceivable with renewable vitality.

3.2.2 Crisis in Global Energy

A global energy crisis of unusual depth and complexity is currently centered on the planet. Despite being in the midst of an emergency, Europe has significant recommendations for global markets, agreements, and economies. The poorest and most defenseless people are likely to suffer the most, as is frequently the case. Even if Russia's invasion of Ukraine did not cause the tensions, it has significantly worsened them. Extremely high costs have prompted a reevaluation of energy strategies and requirements. The energy link between Europe and Russia is deteriorating, raising questions about the validity of business decisions based on decades-old fossil fuel foundations. The global energy sector is currently undergoing a massive reorientation, which is posing new market risks because it addresses persistent weaknesses[7].

A number of economic variables contributed to the current crisis, particularly the quick after the pandemic economic recovery that exceeded the availability of energy, which then worsened after Russia invaded Ukraine. Natural gas prices hit record levels, which had an impact on electricity prices in several markets. The cost of oil reached its highest rate since 2008. More costly power made it troublesome for people making closes meet, provoked certain fabricating offices to decrease yield or near off inside and out, and hampered development within the economy.

The way to secure the move to a zero-emissions control framework while minimizing perils and compromises among diverse arrangement goals is a vital center within the World Energies the Viewpoint 2022.

3.2.3 Resources for Energy

The essential vitality source on Planet is daylight. Vitality from coal, warm vitality, the wind, the biomass, petroleum, atomic vitality, among a parcel more are illustrations of other sources of vitality. Based on maintainability, vitality is partitioned into two categories: vitality from renewable sources and fossil fills[8]. Natural resources for green power are abundant and durable. These energy sources are environmentally friendly and may be renewed organically.

Our primary energy source is nonrenewable.

1.Petroleum.
2. liquid hydrocarbon gas.
3.Gas, natural.
4. Coal.
5. Atomic energy.

Anything that can produce heat, move objects, or produce electricity is considered an energy resource. A fuel is any substance that transforms chemically to release energy. Typical examples include fossil fuels.

3.2.4 Solar Energy

Solar electricity is sunlight that has been transformed into energy that is either electrical or thermal. The United States contains among of the globe's most prolific and purest solar resource bases. sunlight is the most abundant and environmentally friendly green power source currently available. Solar technology can capture this renewable resource for a range of purposes, such as electricity generation, interior lighting, and water heating for household, business reasons, and industrial purposes. Solar electricity is a potent source of electricity that may be utilized for heating, chill, and illuminate buildings. The solar system emits more electricity into the atmosphere in a single day than the entire planet does in a year. Sunlight is converted into useful energy for structures using a variety of ways[9]. Solar photovoltaics for electricity, passive sunshine architecture for air conditioning and heating of spaces, and rooftop solar water heaters are the most widely used renewable energy sources for residences and businesses.

Solar technology helps businesses and industries vary their power sources, increase productivity, and cut costs. Solar cell and concentrating solar power technologies are used by utilities and energy producers to generate electricity on a large scale that powers cities and towns of any size. Solar power refers to the Sun's irradiation which has the ability to create heat, trigger chemical reactions, or create power. The quantity of sunlight received by Earth exceeds both current and future energy needs by a wide margin. The sun's energy has the ability to meet all future requirements for power if properly utilized.

3.2.5 Solar Energy Types

The following solar technologies are described in further detail:

Photovoltaic solar technology. directly transforms sunlight into electricity to run homes and businesses. Solar water heating, solar process heat, passive solar technology, etc focusing solar energy. Solar energy systems, which transform the light right away into electrical power, concentrated solar power (CSP), that utilizes the thermal energy from the sun to generate electricity for massive electrical turbines, and sunlight cooling and heating (SHC) systems, which capture warmth from the sun, are the three main ways to use the power of the sun.

3.2.6 Solar Energy is Both Active and Passive

sun cells utilize active sun power. Its design makes it suitable for residential heaters and supplying towns and entire homes with energy. Flat-plate photovoltaic cells that may be installed or left fixed can be used for solar energy production to capture the power from the sun. Dynamic energy from the sun works by absorbing the sun's heat through liquid or air. After that, the substance is transferred to a storage space till it is turned into energy. Solar cells are one example of an external item that must be used by active renewable energy sources to gather, store, and transform solar energy from the sun into electricity that can be used.

As it acts as a stronger transmitter of energy as well as heat, fluid is frequently used. Air, nevertheless, offers an advantage. In order that it remains cold. A structure or house can be heated or cooled using either fluid. Although airborne systems are commonly referred to as air enthusiasts, liquid catchers are known as hydrological catchers.

In contrast to active solar power, passive sunshine doesn't need any additional hardware to capture or retain heat from the sun. It uses only economics and itself to capture sunlight and convert it into electrical energy. The most effective heating and cooling systems for passive solar energy sources are those in tiny dwellings. However, this technique might not perform as effectively in areas with particularly overcast or wet conditions.

The fundamentals of passive solar energy are something you already know if you've ever parked your car in the sun on a chilly winter day. The glass of your automobile traps the heat as it is parked in the sun. This is referred to as "the climate effect" as well. The heat continues to increase, just to way a growing facility operates. Once you Upon entering, visitors slip toward a comfortable automobile rather than the brisk wintry atmosphere.

Concentrated solar power (CSP) differs from various other sunlight sources in that it may run inside of a utility-scale power station. CSP concentrates solar energy into fluid-filled tunnels that react to generate heat with mirrored beams. The elevated conditions stimulate the water to such an extent that it powers an engine or turbine, which in turn powers an electric generator. Without storage facilities, CSP systems may be able to supply energy for approximately eleven hours on a bright, bright summertime day across the Southwestern.

3.2.7 Photovoltaic Cells

Sunlight is transformed into energy at the level of an atomic using solar photovoltaic technologies. Many semiconductor substances absorb sunlight's photons or protons and release electrons as a result of the phenomenon known as photoelectric effect. A cell made from photovoltaic material uses visible light to generate electrical; a solar panel uses the entire spectrum of light frequencies-not just visible light-to capture ultraviolet (UV) rays and turn it into usable energy. Polycarbonate and solar cell systems are utilized for network or standalone generation of electricity in many different sorts of equipment, from electric-powered cars (EVs) and solar roofs to drinking-water pumping highly desalination apparatus. They are a safe, environmentally friendly, and effective source of vitality [10].

To transform light energy, which is present in the shape of photons, into an electric current, which is present in the form of electrons, solar energy cells use stacked semiconductor substances known as a junction of semiconductors (PN). A donor electron substance, a semiconductor of the n- type, and a p-type semiconductor are connected by the junction called the PN. A single electron becomes detached when a beam of light enters an n-type semiconductor technology, creating a free electron and electrons-hole pair. The so-called p-type material is drawn to the inversely charged electron, while the material of the n kind is drawn to the strongly charged hole. The unattached electron will move through a circuit if it is attached to the electrodes, producing current and voltage until it reassembles with an atom-hole again within a p-type material.

The effectiveness of photovoltaic panels varies depending on the kind of semiconductor material and solar cell technology employed. Inorganic polycrystalline and single-crystalline materials made up the earliest solar cells. Exceptional developments in organic circuitry and materials have led to notable breakthroughs in solar power.

Several advantages for solar power systems include:

A solar energy system is made up of a number of layers of electronic components, one of which is lined up adjacently with an electrical charge and the other with an antagonistic charge.

Sunlight, which is made up of tiny energy packets called photons, enters the cell and is either thought about, transferred, or retained.

The kinetic energy of the photon passes to an electron in the atomic structure of the photovoltaic cell whenever photons are absorbed by the negative layer of the cell.

PV arrays can be any size and are easily erected.

Building-mounted PV systems have negligible environmental impact.

3.2.8 Photovoltaic Technology Types

1. Silica Monocrystalline Cells

2. Silica Polycrystalline Cells

3. Tissue-Sealed Cells

4. High Performance Cells

Solar cells made of monocrystalline silicon at a fifteen percent efficiency, silicon monocrystalline is the greatest efficient solar PV unit and hence the priciest choice. Essentially since they create more energy and can generate as much as fourfold the power as thin-film solar panels, they take up a smaller area than other cell. Additionally, these outperform conventional panels in darkness and have a longer lifespan. The main drawback is the price, which frequently prevents residents from selecting it as their primary option. The production method is sometimes viewed as inefficient because the cells must be cut to wafers that are and it can also be affected by dirt or shadow, which can disrupt the circuit that allow it to malfunction.

Solar cells that are polycrystalline Polycrystalline solar cells are frequently viewed as a more cost-effective option, especially for individuals, because to its 13% performance. These are created by melting several of smaller quartz crystals collectively followed by recrystallizing them [11]. They can be produced more quickly and with less waste than monocrystalline panels. In general, they operate exactly like the more priced equivalent, albeit they do suffer more under extreme temps that may shorten their lives. Due to their lower power conversion effectiveness, polycrystalline photovoltaic panels' main drawback is the fact that you require a greater number of those.

solar cell thin-film arrays the most inexpensive alternative is lightweight solar cells, which are amongst the most inefficient ones on the marketplace at 7%. That are constructed of non-crystalline silica that may be applied in a thin layer onto another substance such as glass, and they function well in low light, even moonlight. The key benefit is that it can be mass produced for a lot less money but is better suited for circumstances where space is not a major concern. The primary drawback of thin film solar panels is that they are typically not used for residential applications and degrade more quickly than polycrystalline systems.

High Performance Cells Combination solar energy systems, which have an effectiveness of 18%, are created by combining unstructured and monocrystalline cells. Hybrid cells come in a wide range of varieties, and as they remain still in the early phases of development, these are right now priced higher than other options.

3.2.9 The Way Solar Panels Work

Electrons are particles are dislodged from their nuclei whenever photons strike a solar cell. A system of electricity is created by connecting wires to a cell's both sides. Electricity is produced when electrons go through such a circuit. A solar panel is made up of several cells, while a solar power system is made up of many panels (or units). The ability to deploy more panels will increase the amount of energy you are able to produce. The sunlight is absorbed when it contacts a solar panel's surface. To blend the qualities of insulating and metals, a semiconductor substance is used in every solar cell [12]. Therefore, it makes sense to transform sunlight into electrical. When sunlight strikes a solar panel, a semiconductor's surface absorbs the energy and converts photons into electrons, allowing the charged particles to flow throughout the material's surface like a flow of electricity. Solar cells use a variety of semiconductor components, including silicon and photovoltaics such as thin-film, organic, and concentrator photovoltaics.

An anti-reflective glass cover is part of the cell's main layer. Semiconductor components are shielded from radiation by this transparent material. Under the transparent surface of this cell, there are tiny grid patterns and thin metallic strips. Glass, aluminum segments, and a coating that prevents reflections will be used to create the cells top covering.

Utilizing sunlight, photovoltaic cells produce useful electricity. At an elevated level, solar cells use the "photovoltaic principle" to convert sunlight that comes into them into an electrical current. Through means of plates and cables, this current of electricity is harnessed and transformed into a useful energy current that is then transmitted to your residence and gadgets. We'll explain in detail how solar panels generate energy from the sun for your home in the next section.

3.2.10 Global Solar Technology Development

A number of the more important environmentally conscious power sources, sunlight is a technology that is kind to the natural world as well as a reliable source of electricity. It contributes significantly to finding energy solutions for sustainable development. As a result, the enormous amount of sunlight that may be produced each day renders it a particularly appealing resource for producing power. To meet our energy needs, both technologies—solar photovoltaics as well as uses of concentrating solar power—are constantly being improved. Therefore, in the same context, a high installed capacity of solar energy applications promotes the renewable energy sector and meets the employment market to acquire enough development. This essay highlights the employment possibilities of renewable energy and discusses how solar energy applications contribute to equitable growth. As a result, it offers perspectives and reflections on the power of the sun. Ecological responsibility, which includes financial and sustainable development. Additionally, it has been noted how solar power projects contribute to environmentally friendly development by meeting energy needs, generating employment possibilities, and improving the safeguarding of the environment. Finally, the application of solar power technology is developed in the electrical energy market and provides a view of its potential future growth.

Expanded solar power potential:

Solar panels are used in PV systems that transform sunshine into electrical power. Due to their widespread installation, these solar power plants in the swiftly emerged as the least expensive choice for fresh electrical power generation in many parts of the globe [13]. For instance, the price of producing power from solar PV plants reduced by 77% between 2010 and 2018. Yet, from 2005 and 2018, the installed capacity of solar PV increased 100-fold. In order to provide individuals with secure and affordable power, a sustainable energy network is necessary. As a result, solar PV has become a crucial part of this system, helping to satisfy the Paris Climate Agreement and reach the 2030 goals of the Sustainable Development Goals.

The use of solar power:
Solar energy is a type of power that can be directly received through the sun's rays. Opportunities for the sunlight have increased internationally since it is able to produce electric power, heat, and eliminate water, among other things. Conventional semiconductor components are used to create a PV solar energy device, which transforms sunlight directly into power. The particles with a total of four electrons inside their outermost orbit or envelope serve as the basis for the properties of these substances. The process of reverse osmosis is another water-treatment method that relies on sun-thermal energy and solar concentrated electricity via the parabolic funnel technology. It uses CSP technology, allowing for perpetual operation and is an affordable option. CSP technology uses hybrid integrating and heat storage. The use of solar thermal in the home is possible, even in dryers. The referred to as dehydrated food method has historically been employed in some cultures or communities to preserve particular kinds of food like meat, vegetables, and fruits.

3.2.11 House of Solar Service
Solar Home System (SHS) offers dependable energy for running tiny electric fans, radios, and other low-power equipment. A SHS's electricity can also be used to power Direct Current (DC)-driven devices as DC shouldering irons, drilling machines, etc. and to recharge mobile phones' batteries. Larger systems can power appliances like pumps, computers, and refrigerators. People who reside in off-grid locations are receiving Solar Home Systems (SHS) from IDCOL and BREB. roughly 55 lakh SHS (installed capacity: 250 MW) have previously been delivered by IDCOL through various partner organizations, and BREB distributed roughly 30 thousand SHS across the nation. Solar home systems are stand-alone solar energy systems that offer remote off-grid residences a cost-effective option to supply power for amenities like lighting and devices. SHS can be used to satisfy a household's demand for energy in remote areas that are not connected to the grid, supplying their basic power requirements. Many thousands of remote residences throughout the world receive power from SHS since network electrification is unfeasible.

SHS normally provide power for minimally powered DC items such lights, radios, and small TVs for three to five hours each day at their 12 V direct current (DC) rated voltage. They also use cables, switches, mounts, and building parts, as well as energy conditioners/inverters, which change 12/24 V power into 240 VAC power for bigger equipment [14]. Since it minimizes the array size, SHS are most efficient when used with energy-efficient devices. A SHS typically includes a charge that controls power distribution and protects the storage devices and devices from harm, at least one battery to store energy for use when the sunlight is not shining, one or more photovoltaic panels consisting of photovoltaic cells, and at least one battery.

A home built to capture and hold solar heat. also known as a solar house. On-Grid (should have the grid for this arrangement), Off-Grid (where there is no power grid present), and Hybrid (will connect GRID, Battery, Diesel Generator—DG) are the three main types of solar plant installation. The largest national off-grid electrification scheme in the world is the Bangladesh Solar Home Systems (SHS) scheme. SHS installations under the Program, which began in 2003, came to an end in 2018. The world's longest-running off-grid electrification scheme, it has been in operation since the beginning. Grid-tied, off-grid, and backup solar power systems are the three most common varieties. She and her coworkers constructed Solar One in 1971, the first home to harness solar energy for both heating and lighting, helping to spark a national solar boom. The dynamic heating systems created by Telkes, Hottel, and many others had largely disappeared by the time photovoltaic solar panels hit the market. Numerous of them concentrated on the creation of the solar house as a distinct type. They all have linear east-west floor designs with huge south-facing windows and roof overhangs to protect against the intense summer sun.

The biggest solar project in Bangladesh Infrared Rays Power:

Sundarganj in the Gaibandha district of Rangpur division is home to what the Indian solar EPC company Rays Power Infra refers to as the "single largest" solar power plant in Bangladesh, with a 275 MW DC capacity and more than 500,000 PV modules.

The largest solar village:

A solar power facility called the Bhadla Solar Park is situated in Rajasthan, India's Thar Desert. As of 2023, it will be the largest solar park in the world with a total installed capacity of 2,245 megawatts (MW) and a footprint of 56 square kilometers. Thanks to aggressive attempts by the government and the private sector, Bangladesh has seen a rise in solar energy since 1996, beginning with the installation of tiny units of the solar home system (SHS) around the nation. The astounding 6,037,601 SHS units have now been recorded.

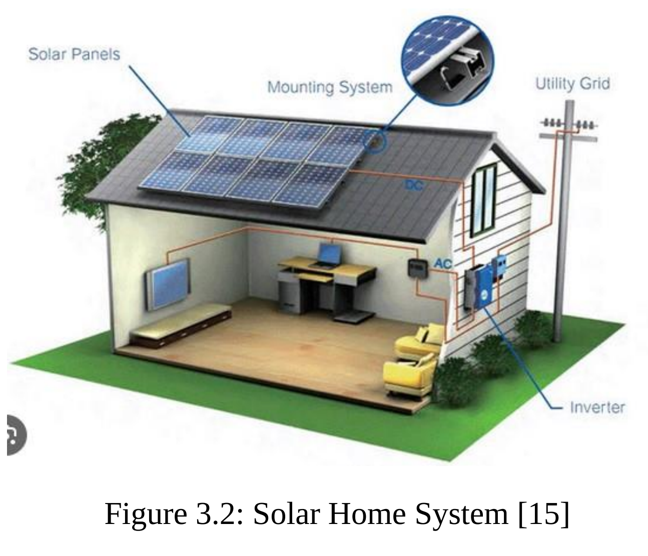


Figure 3.2: Solar Home System [15]

Bangladesh has high ambitions for solar and renewable energy. By 2030, the nation aims to produce 4,100 MW of sustainable energy, of which 2,277 MW will come from solar, 1,000 MW from hydropower, and 597 MW from wind[16]. How much electricity is generated by a solar panel each day? The typical daily output of solar energy from a single panel in a solar panel system is 2 kWh. Bangladesh aspires to reach 4.1 GW of sustainable capacity by 2030 under its updated Nationally Determined Contribution (NDC) (August 2021), including almost 2.3 GW of solar capacity.

3.2.12 Govt/ Non Govt Running or Previous Project in Solar power

1. A solar farm called Rangpur (Intraco) solar farm is being built in Rangpur district, Rangpur Division, Bangladesh.

2. A solar farm called Rangpur (Beximco) solar farm is currently in the planning stages at Sandarganj, Gaibandha, Rangpur, Bangladesh.

SREDA Data:

Govt Project agency of Bangladesh Power Development Board (BPDB) in Location Gangachara, Rangpur District in Bangladesh Project name of the 30MW (AC) Solar Park by Intraco CNG Ltd & Juli New Energy Co. Ltd. Capacity is 30 MWp in Solar Park system in sustainable energy. It is Expected Energy Generation and CO2 Emission reduction during System Life is the 654 GWh, 309 k tCO2 System of On Grid Power Processing system.

Another Govt Project agency of Bangladesh Power Development Board (BPDB) in Location Patgram, Lalmonirhat District in Bangladesh Project name of the 5 MW (AC) Solar Park by PV Power Patgram Ltd. Capacity is 5 MWp in Solar Park system in sustainable energy. It is the Expected Energy Generation and CO2 Emission reduction during System Life is the 109 GWh, 52 k tCO2 and On Grid System Energy processing.

3.3 Solar System

3.3.1 Introduction of Solar Instrument

The sun, the eight planets, and the satellites make up the solar system. In addition to these, there are comets, dust, small planets, gas, and asteroids. The inner solar system is made up of the Sun, Mercury, Venus, Earth, and Mars, while the asteroid belt is located between Mars and Jupiter's orbit. Due to the sharp decrease in polysilicon costs and subsequent normal sun PV expenses, the quarter saw significant investment. In reality, the market's oversupply grew to such an extent that several major players in the sector were forced to shut down their polysilicon manufacturing facilities as a result of shrinking profit margins and difficulties in competing on price with Chinese output. A comprehensive solar PV system is a united collection of many parts. A very large supply chain made up of several large components, such as a solar module and system balance (BOS) - inverters, mounting frameworks, electrical infrastructure, and (in some cases) some energy savings, is used to separate and integrate these components. Additionally, it is crucial to consider the present growth in cellular efficiencies Due to the sharp decrease in polysilicon costs and subsequent normal sun PV expenses, the quarter saw significant investment. These has also played a major role in designating solar power as a vital source of electricity. In order to protect humans, animals, and ecological systems, it is imperative to reduce the emissions of greenhouse gases and avoid climate change. Solar energy is an environmentally friendly resource that significantly contributes to these goals. Solar energy may also improve air quality and use less water in energy production. A collection of a star plus everything in its orbit, such as planets, moons, asteroids, comets, and other things. Solar wind is the sun's continuous outpouring of particles and energy. The atmospheric conditions in space that may have an impact on satellites, Earth, and space flight. The Sun keeps the solar system in place by maintaining its orbit around everything, even the smallest pieces of junk. It has been around for 4.5 billion years.

Jupiter has enough room to fit all the other planets in the solar system. The Solar System predates time. To put that in perspective, if the Solar System's age were equal to one year, then humanity would have arrived on Earth right before the New Year's Eve countdown.

3.3.2 Sun System

The solar system's purpose is to use sunshine to produce power. There are typically two types of this approach.

1.Initial Solar System

2.Solar-powered Off-Grid System

The gravitationally bound Solar System is made up of the Sun and the asteroids that circle it. In order of distance from the solar system, the eight planets—four terrestrial planets, Mercury, Venus, Earth, and Mars; two gas giants, Jupiter and Saturn; and two ice giants, Uranus and Neptune—are the biggest of these bodies. The terrestrial planets have well defined surfaces and are mostly made of rock and metal. While 'volatile' substances like water, ammonia, and methane make up almost all of the content of ice giants, both helium and hydrogen are the main parts of gas giants. In some literature, these huge and terrestrial planets are referred to as the planets of the inner and outer solar systems, respectively.

A massive interstellar molecular cloud was gravitationally collapsed into the Sun System, creating it 4.6 billion years ago. The Solar and a protoplanetary disk, which eventually condensed to form the planet and all of the other objects, were created throughout time by the cloud. This explains why the orbits of all eight planets are nearly in the same plane. Currently, the Sun has 99.86% of the Solar System's mass, with Jupiter holding the most of the remaining mass[17]. Natural satellites or moons orbit around several other bodies, including six planets, the six biggest dwarf planets, and more others. Planetary rings, which are made of ice, dust, and occasionally moonlets, surround every big planet and a few other smaller things.

3.3.3 Solar On-Grid System in Bangladesh

Solar photovoltaic systems that are on-grid only generate electricity when a utility power grid is accessible. They require a connection to the grid in order to operate. When you produce surplus energy, they can send it to the grid so you can store it for later use.

These are the cheapest to install and the simplest technique. In three to four years, the systems will pay for themselves through reducing utility costs. These are cost-effective in the long run and provide enough savings to cover their costs. It is a fantastic option because it can lower its own electronic costs and carbon impact.

Price in Bangladesh for a 1.5 kilowatt on-grid solar power system is 120,000 Taka. Solar panels, a grid-type inverter, a structure, an energy meter, distribution boards, and wiring wire are all components of a 1.5 KW on-grid solar power system[18]. German heritage. sort of powerful solar panel is the most efficient panels now available use pricey IBC cells because of the high purity N-type semiconductor substrates and lack of busbar shade loss (21-23%).

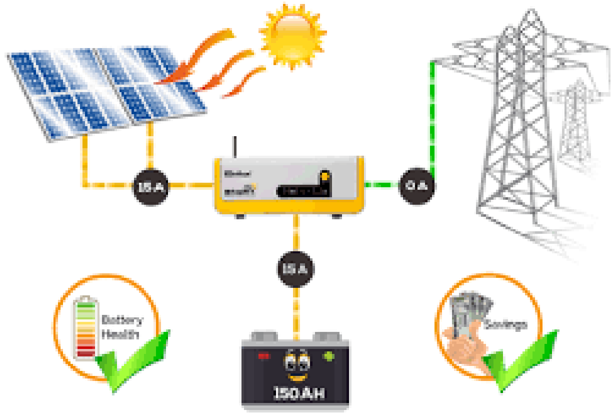


Figure 3.3: Grid Solar System [19]

3.3.4 Solar Off-Grid System in Bangladesh

The technique of turning the sunlight directly into power using solar energy (PV), indirect via focused sunlight, or both is known as solar panel power. In concentrating solar energy organisms, monitoring mechanisms, glasses, or mirrors are utilized to focus a wide area of sunlight into a tiny beam. Photovoltaic panels turn light into an electric current using the effect known as photovoltaic. The earliest large-scale photovoltaic uses were the calculator powered by a single solar cell and rural homes powered by an off-grid rooftop PV system. The first industrial facilities for concentrating sunlight were built in the 1980s. The 392 MW Ivanpah project, the largest concentrating solar power facility in the world, is located in California's Western Sands. Bangladesh's Off Grid Solar System Dhaka[20].

Off-grid refers to the process of storing solar energy in batteries for usage at night or during load shedding. These devices enable the storage of solar energy in batteries for usage when the electrical grid is down or not available. When the sun shines, hybrid systems supply the energy to balance the grid's electricity and send any excess back to the grid for later use. The following tools are needed for off-grid solar systems:

a) Solar panels

b) Charge controller

c) Inverter and

d) Battery system

The Off Grid Solar Power System in Bangladesh Dhaka. The solar cell turns sun in direct current (DC) electricity to charge the power source. This DC electricity is sent to the battery by a solar controller, which ensures that it is fully charged and undamaged. DC uses can run directly off batteries, while AC appliances require the conversion of the direct current (DC) to a 240-volt source of AC power, which requires a device called an inverter.

Featuring the price of green electricity falling, utility-scale photovoltaic power plants with numerous megawatts are being built, and the total quantity of grid-connected solar PV systems has surpassed the million marks. Solar photovoltaic (PV) technology is quickly becoming a low-cost, low-carbon way to harness solar energy. The biggest solar farm is the 850 MW Tonganoxie Dam Photovoltaic Farm in Qinghai, China. present-day solar power station. Off Grid Solar System in Bangladesh Dhaka.

3.3.5 Solar Cells

Semiconductor solar panels use radiation from the sun to generate power. They go through the same manufacturing and processing steps as storage chips. The main component of solar cells is silicon, which collects the radiation that the sun's beams emit. The method was first identified in 1839. For communication between each of the solar cells to the next, waffles of silicon are doped, and power lines are installed. The final silicon discs are coated with an anti-reflective material. Light transmission is prevented by this covering. After that, solar panels are enclosed and mounted in an aluminum frame. To achieve consistency in quality throughout time, this procedure needs to be continuously monitored. They go through a final test after the production process is finished to determine their effectiveness under typical situations.

Solar panels have the added benefits that they're compact and affordable while offering greater power production than other traditional sources. The development of less expensive solar cell substitutes like silicon amorphous and poly crystalline quartz is also underway. According to recent research, prismatic lenses and layers of various materials are also potential ways to focus and enhance the amount of daylight that is efficiently used. A device which transforms the power that light emits in electrical power using the photovoltaic effect is referred to as a solar cell, which is also sometimes known as a photovoltaic cell[21]. A great deal of solar-powered devices is made of silicon, which is available in a variety of forms, from undefined through polycrystalline to crystal, with improving effectiveness and decreasing cost. Solar cells don't use chemical processes or require gasoline to generate electricity, unlike battery or fuel cells. Also, and they also don't have any moving parts as generating do.

Large clusters of photovoltaic cells known as arrays can be created. Those arrays, which are made up of thousands of separate cells, can serve centralized electric power plants by using solar radiation to produce electricity that can then be distributed to customers in commercial, residential, and industrial settings. On their rooftops, householders have put in solar cells in much smaller designs, often known as solar cell panels or just solar panels, to supplement or replace their traditional energy supply. In numerous distant terrestrial regions where traditional electric power suppliers either are inaccessible or excessively expensive to build, solar-powered panels are additionally used to produce electricity.

A solar energy system is an instrument that converts sunshine into power using photovoltaic (PV) cells. Whenever subjected to light, materials employed to make PV cells discharge ions. When electron pass through an electronic device, direct current, or DC, energy emerges; it is capable of being employed to power a number of electronics or stored as batteries. Additional names for solar power systems include PV modules, solar electric panels, it's and rooftop solar panels.

3.3.6 Charging Control

The photovoltaic panel is operated by the solar controller, which also provides load control voltage for voltage-sensitive devices. The major control component of the entire photovoltaic power supply, it regulates the battery's charging and discharging circumstances as well as the power output of the load's solar cell module and battery. The battery's charge is managed by it. When the battery is fully charged, it will no longer charge and will cut the load off from the battery. thereby defending the battery. Most "12 volts" panels cut between 16 and 20 volts, therefore if Control is not used, the battery will suffer additional charge damage. The majority of batteries need between 14 and 14.5 volts to completely charge. Typically, trickle charge or low maintenance panels with 1 to 5 watts of power don't require a charge controller. The general rule is that we don't need a panel if it can hold 2 watts or less for every 50-amp battery.

A charge controller for solar panels stops the power source from charging excessively by regulating the voltage and power that flow from the sun's rays to the battery[22]. It is configured at 15-A/200-W unit and employs MPPT (maximum power point tracking) to accelerate solar battery usage by up to 30% per day. Equipment called a solar charge controller. It regulates how much electricity is sent from the solar panels to the battery bank. The deep cycle battery is not overburdened during the day and electricity is not returned to the photovoltaic cell’s nighttime. While some charge controller has other capabilities like controlling load and illumination, managing power is their primary purpose.

The two available techniques for solar power controllers are PWM and MPPT. Since a charge controller using MPPT is more costly and substantially more efficient than a PWM charge the controller, it is usually desirable to spend greater sums on it.

3.3.7 Parallel and Series Controller

Multiple solar controllers can be connected in parallel to a battery bank in order to fulfill high power charging requirements, with each controller being connected to a different PV subarray. Due to the reduced impact of voltage mismatches, MPPT tracking of each subarray is recommended for MPPT controllers.

Shunt or parallel controller: The charge controller, battery, and load are all connected in parallel in this setup. The controller shortens the solar panel after the battery is fully charged. A blocking diode is required for this arrangement. Therefore, the reverse current panel battery is not that. This block diode gets hot when the battery is being charged through it. A shunt controller has some drawbacks, including power loss, a high quantity of short circuit current (ISC) switches (FETs) flowing when the panel is summed up, and it runs warmer than a series controller.

Controlling a series:

The solar panel and battery are connected to the charge controller in this setup. To stop the flow of power to the batteries, the series controlled have to must be disconnected from it. Although it is not necessary in this system, the diode is employed to stop the discharge mechanism for a number of reasons. It must maintain the least amount of resistance in order to reduce power loss. Benefits of a series controller include the absence of a blocking diode.

Low switching sound; series controller switch operated at lower voltage than shunt controller.

This is made possible by the PWM technology and the accurate battery charge. Solar cells lined up in series perform best under lighting conditions. If every single panel of sequential arrays is shaded, the power output will be decreased. Each of the panels is crucial in a series interconnection. If you require a system with low amps, solar panels in series are also the best option

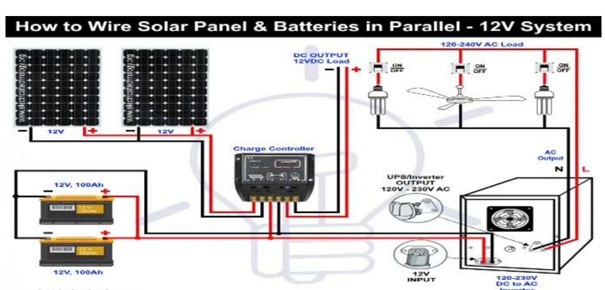


Figure 3.4: Automatic UPS System with Parallel Connection of Solar Panels and Batteries - 12V Installation [23]

This 12V connector is among the most common type of solar cell connection for battery. Frequently, battery and solar power systems are linked in parallel to create a 12VDC to 120/230VAC system. For powering a battery, an electrical demand, or a DC powered device, let's look at how to join more than two solar power systems and batteries together with a charger for the sun and an automated inverter/ups to provide a 120-230V electrical load.

The majority of battery and solar energy systems, for instance, come in voltages of 2/24/36V. To improve the system's capacity, it needs to be connected in a parallel manner. Imagine if a single battery can power a ceiling fan over six hours. The same fan might be operated. 12 (almost double) hrs. of electrical power from two pair battery with the same size. Additionally, two separate solar cells that are linked in parallel will quickly recharge the battery packs while providing extra load. Parallel connection is necessary for operating a 12V structure, such as a voltage converter and battery controllers. This leads to the combination of a few batteries and solar cells (each of which with a 12VDC result).

3.3.8 Inverter

A number of the more crucial components of an array of solar panels is an inverter. It refers to an appliance that transforms solar panels produced direct current (DC) energy into alternating current, or AC, energy needed by the electrical system.

According to the following, solar inverter's function:

1) A transformer is used to transport DC electricity.

2) The electrical energy is converted to AC by the transformers, which also reduces it.

3) For the processing of the DC, at least three devices are employed.

4) To feed the two separate sides of the transformer, they are quickly turned on and off.

The electrical current (DC) produced the sun's rays is transformed into a current known as alternating current (AC), what is utilized by home and professional equipment, via an inverter for solar power. It frequently gets referred to as the neural network of a solar panel it constitutes one of the greatest important parts of the system, since it transforms electricity from the sunlight into reusable energy. Because solar energy cannot be utilized to drive electrical devices directly, inverters that convert sunlight into electricity are an essential component of a photovoltaic system. Solar inverters used to be simple devices that converted DC into AC, but they have since developed into far more intelligent devices capable of monitoring data, operating sophisticated utility oversight, and other tasks.

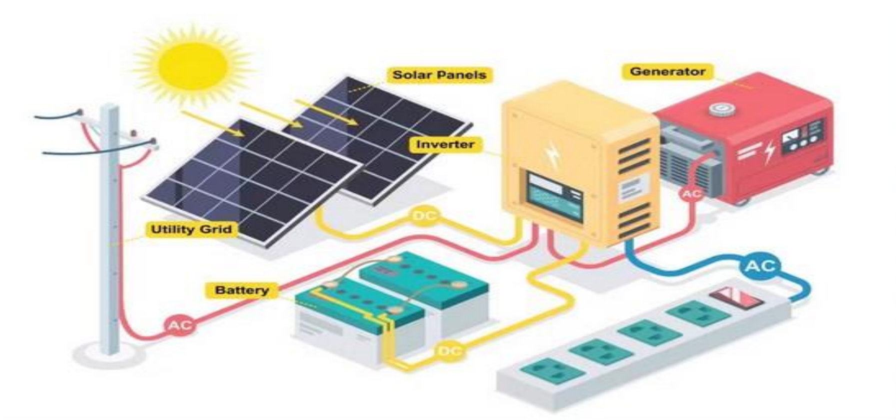


Figure 3.5: Solar Inverter [24]

Four major categories can be used to classify solar inverters:

1. Independent inverters are used in freestanding electrical systems and receive their direct current (DC) power from battery recharged by solar panels. When a source of electrical power is accessible, several independent inverters have integrated chargers for batteries to replenish the battery. These are most often not in any manner connected to the electrical grid, consequently they are exempted from the need for anti-is landing security.

2. Grid-tie inverter devices, that match phase to a sine wave that's supplied by the utilities. Grid-tie transformers are designed to turn off instantly if the power feed is shut off out of security concerns. When electricity and water are cut off, they don't provide backup electricity.

3. Battery backups converters are specialist converters that manage the batteries level with an incorporated charge and are able to send extra electricity to the grid for distribution while taking power via the battery's charge. These converters must have anti-is landing safety and have the ability to provide AC power to particular applications in the event of a power interruption.

4. The power electricity, storage for batteries, and solar arrays are each directly linked to the gadget, and sophisticated hybridization inverters regulate each of these systems. The primary function of these modern a one-stop systems is consumption by oneself using storage, while they are typically extremely versatile and may be utilized in backup purposes, standalone, or grid-tie purposes.

3.3.9 Battery

Simply said, a solar battery is a battery that has been powered by solar energy. There are many different kinds, from microscopic to utility-scale. Visit our sections on Portable Solar Panels & Chargers if you're looking for more compact solar power options. Generators run on solar energy. There are numerous variations of solar batteries. The Amp-Hour, also known as Ah, is the most typical way to measure battery storage capacity. Solar batteries might be less than 100 Ah or larger than 1,000 Ah in a single battery. Without a way to convey the power that the solar cells generate, sunlight could prove rather ineffective; alternatively, devices would operate only while the sun's rays are out and the photovoltaic cells create energy. Without use, the electrical power could be wasted and not be available for consumption at night. Now on the photovoltaic batteries and more which are used to store the electricity generated by these solar cells so that it may be used whenever it is truly needed. As a substitute for (or addition to) supplying energy back into the grid, batteries made from sunlight can let a house or business totally shut off from the electrical system or even partly protect it from unexpected blackouts.

Types of Solar Batteries

Lead-acid, lithium-ion batteries nickel-cadmium, and flow-cell batteries are four of the main kinds of batteries used in sunlight.

1. Lead-Acid Batteries made with lead acid have become the many widely used kinds of batteries in businesses and factories because they have been lying around for a very long time. They are reliable and inexpensive despite having a low power density, meaning that these can only hold a little amount of electricity per kg of weigh. For this reason, they are widely employed in home solar panels.

Batteries made of lead acid come in inundated and vented variants and can be either shallow cyclic or deep cycle based on the intended purpose and safe depth of depletion (DOD). Recent technological advancements are now more durable.

2. Lithium-ion: Considering the far longer history of lead-acid batteries, we can refer to this type as "the new kid on the block." It has been enhanced concurrently with advancements made in the battery technology needed for electric vehicles in recent years. Residential home owners are fond of lithium-ion solar batteries. Three factors account for this:

- They have a longer life span.
- Fewer repairs are necessary.
- Compared to lead-acid batteries, they are smaller and lighter.
- These kinds of batteries also have a greater useful size and can easily withstand deep decreases of at least 80 percent in along with these features.

3. Flow batteries: The flow battery is yet another up-and-comer in the field of solar battery technology. Despite being a relatively new storage technology that still has to be improved, flow batteries are a popular choice for a few reasons. It discharges at 100% depth. You can therefore utilize all of the energy that has been stored. Flow batteries are non-toxic, in contrast to nickel cadmium batteries, which we will examine in the following section. They are water-based, which is the cause.

4. Nickel cadmium: Known as "nickel batteries" and "Ni-Cd" interchangeably, nickel cadmium batteries are another tried-and-true option. They are renowned for their capacity to function at high temperatures devoid of sophisticated battery management technologies. They are more common among commercial-scale initiatives because of this.

A component with one or more electrochemical cells and a connecting mechanism on the exterior is referred to as an electron, or electric cell. When coupled, electrons can produce the electrical energy required to run a number of electrical appliances, including flashlights, cell phones, and even electric vehicles. An electron's electrically negative end is referred to as an anode electron and its electrically positive end is known as a cathode electron when it generates electrical power. Battery can be connected in both directions when using a lot of them. Increasing the amount of voltage requires connecting the power sources in series, whereas increasing the current requires connecting the cells in parallel.

3.3.10 Rooftop Photovoltaic System

A photovoltaic, or PV, system consisting of electricity-generating solar cells positioned on the highest point of a residential or commercial facility or structure is known as a rooftop solar energy system, sometimes known as a rooftop PV system. Sunroof modules, installation structures, wires, sun inverters, as well as additional wiring components are some of the method's many parts. A rooftop photovoltaic energy location, also referred to as a rooftop solar energy system, is a system made up of photovoltaic cells with its electricity-producing solar cells positioned on the highest point of a home or other building. PV modules, installation systems, cables, sun inverters, and various other electronic components are some of the system's many parts. Rooftop mounted installations are a type of dispersed production since they are modest in comparison to photovoltaic plants on earth with capacity in the megawatt scale. In advanced economies, grid-dependent solar energy sources make up the majority of rooftop PV stations. Residential rooftop PV systems normally have an output of 5 to 20 kW, whereas those installed on commercial buildings frequently have a capacity of 100 kW to 1 MW[25]. Industrial-scale buildings can fit under very huge roofs. Industrial-scale photovoltaic panels with a power range of 1 to 10 Megawatts can be installed on very big rooftops. The study focused on a middle-class house in Amman, which is the Jordanian capital. The limitations imposed on PV use by building rooftops were also examined in this study, and the findings support the importance of providing environment leadership, the building industry, and the general public with crucial instructions on the use of renewable energy to provide heating and cooling for buildings. This study therefore increases understanding of a building's general power necessities, which is critical for the eventual rise of environmentally friendly structures.

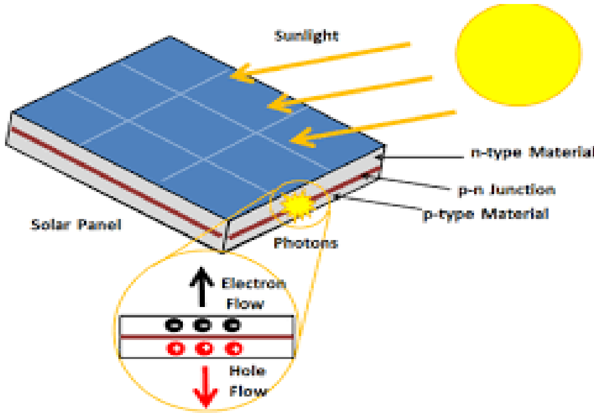


Figure 3.6: Photovoltaic Solar Power [10]

For solar energy generation, upright roofing materials are the best form of roof. Drilling holes in the roof is not necessary with freestanding seam build, simplifying and lowering the cost of setup. The greatest roofing materials for rooftop solar panels are basalt or wood rooftops. Photovoltaic cells transform warmth into electricity, while rooftop solar panels transform ultraviolet rays into heating. These answers don't contradict with each other as a result. They may do better as a team.

Monocrystalline Sun Cells: The most prevalent and efficient type of solar energy generation, monocrystalline solar panels are preferred by both homeowners and businesses. They have an electrical rating of 300 to 400 watts, occasionally even more, and consist of unique, entirely silicon nanocrystals.

3.3.11 Sun Tracking and MPPT

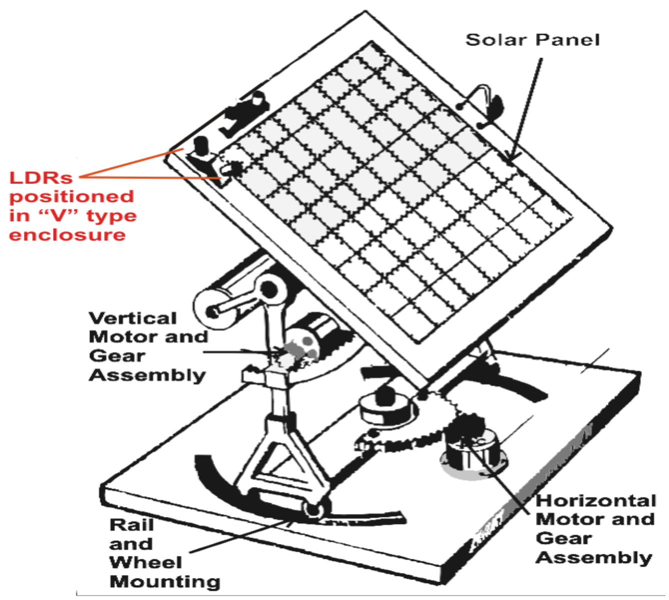


Figure 3.7: Sun Tracking Solar Panel Circuit Diagram [26]

Sun Tracking: For rooftop solar panels, upright metal roofs constitute the best form of roof. Solar trackers, a mechanism that puts a thing at an angle with respect to the Sun, and sitting seam building are not required with sitting seam architecture. Placing PV cells (solar cells) to ensure they stay orthogonal to the Sun's beams and placing telescopes in orbit so that scientists can identify the Sun's orientation are two of the most frequent uses for solar tracking devices. Solar tracking devices are employed to keep solar power plants and solar panels pointed directly at the sun during the course of each day[27]. The solar power collector receives additional sunlight when Solar Tracking devices are used, which boosts the electrical production of the heat/electricity produced. Ron Corio, the chief executive officer of Array, established the company in Albuquerque around 1989 to take advantage of the chances given by the solar energy sector at the time. At the outset, Corio and his colleagues created a novel concentrate solar panel technology that reduced the need for pricey semiconductor.

The Elements of the Circuit:

Light Dependent Resistor (LDR) x 2 10K x 3 Actuator Push-button Breadboards Paper Joining Wires Solar Panels ATmega328 Microchip Computer 16MHz engine, 22pF ceramic capacitors twice, etc.

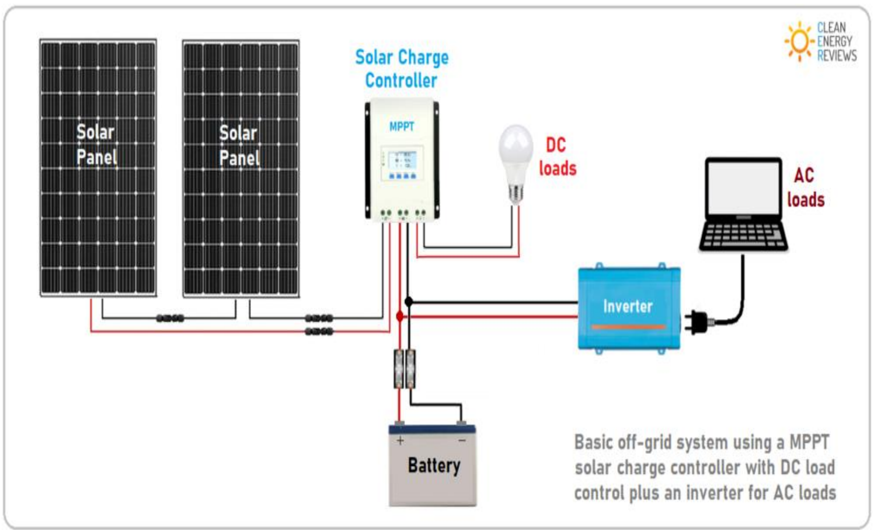


Figure 3.8: MPPT [28]

MPPT: To precisely pair the photovoltaic panel to the batteries, MPPT is a DC-to-DC transformer that works by receiving the DC signal coming from the PV module, turning it to AC, and then transferring it again to a matching DC voltage and power. Power converters known as "boost converters" have lower DC input voltages than DC final voltages. The fundamental advantage of MPPT chargers is the fact that devices can boost the sun's electric power and recharge effectiveness, particularly in dimly lit or chilly environments when the photovoltaic cells generate a greater voltage what the energy bank could manage. Utilizing solar energy is amazing. Unfortunately, animals don't have much intelligence. Battery is not; in reality, they are downright foolish. The majority of PV panels are built to produce 12 volts at optimum power. The only problem is the "nominal". The bulk of so-called "12-volt" solar cells are actually constructed to generate between 16 and 18 volts. The problem is that, based on how full the battery's state, a nominal 12-volt batteries is actually only 10.5 to 12.7 volts distant from a true 12-volt battery. While under charge, batteries typically require between 13.2 and 14.4 volts to completely charge, that's far more than the voltage a great deal of cells are designed to deliver.

3.4 Solar Irrigation System

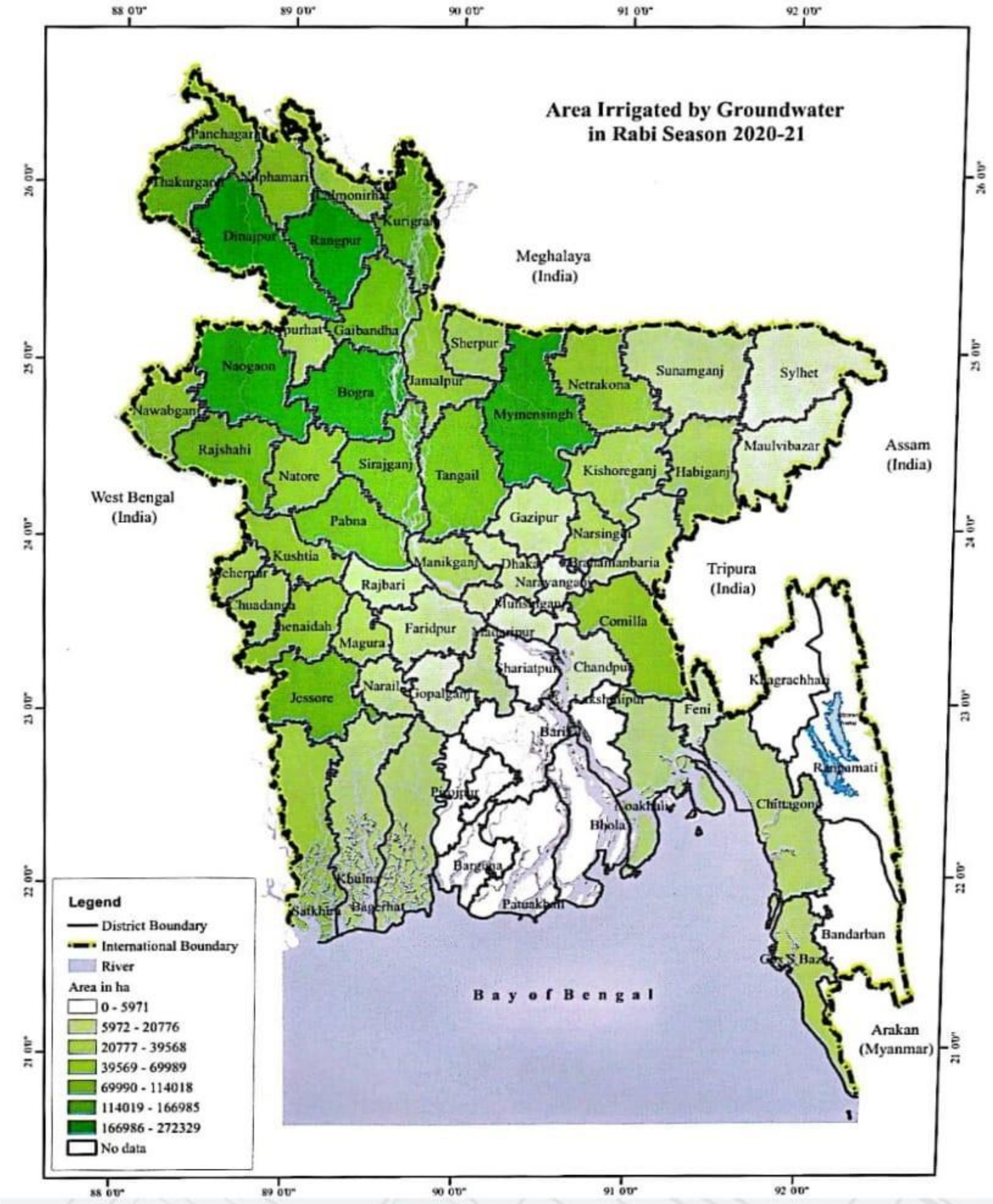


Figure 3.9: Area Irrigated by Groundwater [29]

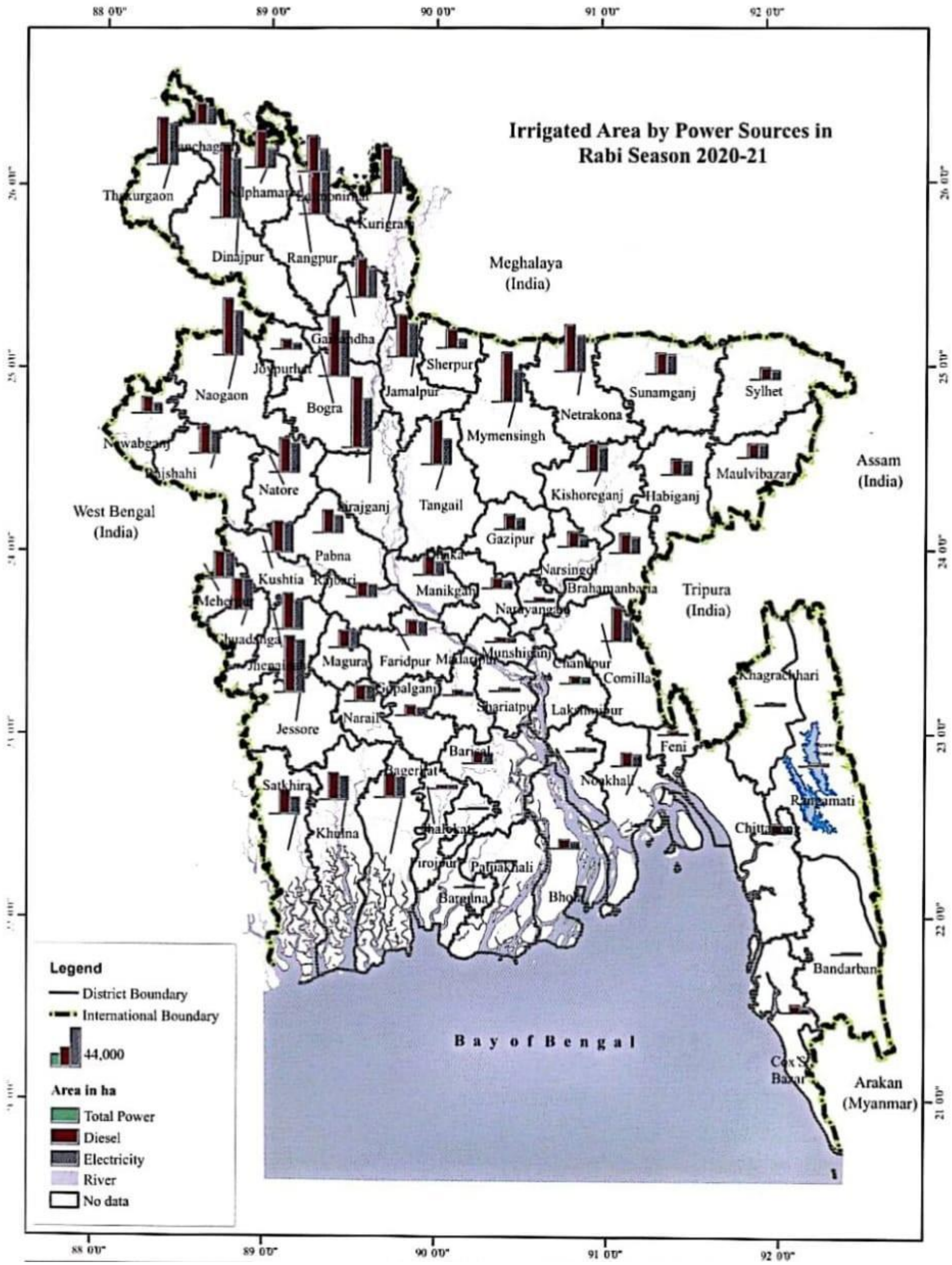


Figure 3.10: Irrigated Area by Power Source [29]

3.4.1 The Irrigation System of Bangladesh

Bangladesh's agricultural production is severely constrained by the abundance of water during the monsoon and the paucity of it during the rabi season. Therefore, one of the more valuable factors for growing the area under cultivated and enhancing long-term production and employment is believed to be the planned exploitation and efficient management of water resources, notably through irrigation. Since irrigation creates dry season crops and boosts rainy season yields by creating a more favorable water regime for crops, irrigation is regarded as the primary input for increasing agricultural productivity. It also encourages people to invest in other by lowering the likelihood that investments in high-yielding seeds, fertilizer, and extra labor will be lost due to drought. Overall, irrigation provides the foundation upon which all other yield-increasing inputs function. One of the key measures is the application of water to the cultivated ground.

The utilization of ground water for the DTW and STW installation created a revolution in the agricultural sector, rescuing the nation from a persistent food shortage. The primary and most accessible resource for irrigation is ground water. Bangladesh extracts 86% of the water it needs for irrigation from subterranean sources, with the remaining 14% going to home and industrial consumption. As water demand in agriculture rises, it is now crucial to exploit and utilize ground water throughout the nation. In many regions of the world, water is becoming more and more limited, just like other natural resources. Lack of water could have negative effects that are far-reaching if handled improperly.

Although Bangladesh has a lot of water resources, they are not spread equitably throughout the year or the area. However, the majority of the country's potential for groundwater irrigation is found in the west and north, and the majority of the remaining potential for regional rivers is found in the south-central region[30]. However, the drying of wells during the dry season in some parts of the Northern region demonstrated the need for careful usage of ground water supplies. It is believed that the practice of farming began on the Indian subcontinent nine thousand years ago when people mastered the art of cultivating crops and taming wild animals. Many years later, they learned that crop productivity is greatly boosted if river water can be channeled to cultivated areas. This is how the irrigation system was created. The 'Kallanai Dam' was the first irrigation system in the world and is still in use. It was constructed on the Kaveri River in Tamil Nadu, India, in the first or second century. Along with Mohenjo-Daro and Harappa, the construction of such an old water reservoir demonstrates that Indian civilization is among the oldest in the world.

Figure 3.11: Teesta barrage Area Irrigation Land

Figure 3.12: Teesta Barrage Area Water Distribution System

Table 3.1: Total Area (ha) covered by Different irrigation Mode during Rabi Season 2020-21

Different Mode of Irrigation	Irrigation Year 2020-21 Irrigated Area (ha)	% of Total Area
Deep Tube Well	1085431	19.19%
Shallow Tube Well	3006074	53.16%
Low Lift Pump	1287013	22.76%
Gravity Flow	245136	4.34%
Solar Pump	16524	0.29%
Manual & Artesian well	6752	0.125
Traditional Method	6124	0.11%
Dug Well	1735	0.03%
Total	5654789	100%

Table 3.2: Division wise distribution of irrigation equipment's (DTW, STW, LLP) used during Rabi Season 2020-21

Name of Division	Nos..of Irrigation equipment's in the Year 2020-21 DTW	STW	LLP	Solar	Dug well
Dhaka	2570	172778	25727	345	35
Mymensingh	4292	154506	12326	140	42
Rajshahi	17053	302263	12054	389	342
Rangpur	**8133**	**393273**	**2206**	**765**	**89**
Chittagong	2054	75826	46245	461	13
khulna	2640	282805	35970	611	16
Sylhet	212	28079	43607	172	10
Barisal	1	159	26256	1640	8
Total	36955	1406989	204391	4523	555

Table 3.3: Division wise distribution of Total Irrigated Area (ha) during Rabi Season 2020-21

Name of Division	Irrigation Year 2020-21 Irrigated Area (ha)	% of Total Area
Dhaka	696697	12.32%
Mymensingh	609570	10.78%
Rajshahi	1233277	21.82%
Rangpur	**1067345**	**18.88%**
Chittagong	645100	11.41%
Khulna	790412	13.98%
Sylhet	425203	7.52%
Barisal	185460	3.28%
Total	5653054	100%

Table 3.4: Area lrrigated by DTWs and STWs in eight divisions of Bangladesh in Rabi season 2020-2021.

Name of Division	lrrigation Year 2020-2021 Area Irrigated (ha) by DTW	Area Irrigated (ha) by STW	Total irrigated Area (ha)
Dhaka	64619	396321	460940
Mymensingh	148861	333590	482451
Rajshahi	509482	650195	1159677
Rangpur	**239160**	**789196**	**1028356**
Chittagong	54309	206642	260951
Khulna	62155	537584	599739
Sylhet	6825	92142	98967
Barisal	20	404	424
Total	1085431	1409689	2495120

Table 3.4: Area lrrigated by DTWs and STWs in eight divisions of Bangladesh in Rabi season 2020-2021.

Division	Irrigated Area (ha)	% of Total
Dhaka	1119	14.255
Mymensingh	305	3.88%
Rajshahi	230	2.93%
Rangpur	**200**	**2.55%**
Chittagong	810	10.32%
Khulna	770	9.81%
Sylhet	2570	32.73%
Barisal	748	9.53%
Total	6752	100%

Table 3.6: Area irrigated by Surface water in eight divisions of Bangladesh in Rabi season 2020-21.

Name of Division	Irrigated Area (ha) by LLP	Irrigated area (ha) Traditional Method	irrigated Area (ha) by Gravity Flow	Irrigated Area (ha) by Solar	Total irrigated Area (ha)
Dhaka	215601	16289	1595	1153	234638
Mymensingh	105870	19782	580	572	126804
Rajshahi	69742	2047	80	1501	733770
Rangpur	**20975**	**14770**	**270**	**2774**	**38789**
Chittagong	313172	67132	1672	1423	383399
Khulna	137787	49256	757	2130	189930
Sylhet	248682	73585	820	579	323666
Barisal	175184	2275	410	6419	184288
Total	1287013	245136	6124	16524	1554797

Table 3.7: Comparative study of area coverage per equipment (DTW, STW & LLP).

Irrigation season	Irrigated Area ('000 ha) DTW	STW	LLP	Operational Equipment ('000 No.) DTW	STW	LLP	Area Coverage per Equipment DTW	STW	LLP
1982-83	234	371	337	13.8	93.1	35.5	16.96	3.98	9.49
1983-84	263	480	342	15.5	120.3	36	16.97	3.99	9.5
1984-85	287	586	351	16.9	147	37	16.98	3.99	9.49
1985-86	304	586	356	17.9	146.9	37.5	16.98	3.99	9.49
1986-87	318	639	386	18.7	160.3	40.6	17.01	3.99	9.51
1987-88	345	753	402	20.3	188.7	42.3	17	3.99	9.5
1988-89	380	941	482	22.4	235.9	50.8	16.96	3.99	9.49
1989-90	384	1037	484	22.6	260	51	16.99	3.99	9.49
1990-91	365	1078	513	21.5	270.3	51.6	16.98	3.99	9.94
1991-92	434	1234	500	25.5	309.3	50.3	17.02	3.99	9.94
1992-93	437	1392	496	25.7	348.9	52.2	17	3.99	9.5
1994-95	502	1638	538	26.7	488.9	57.1	18.8	3.35	9.42
1995-96	540	2004	568	27.3	571.2	60.6	19.78	3.51	9.37
1996-97	475	2159	570	25.2	629.8	62.9	18.85	3.43	9.06
1997-98	465	2182	622	25.3	664.7	66.3	18.38	3.28	9.38
1998-99	507	2522	628	26.7	736.1	72.9	18.99	3.43	8.61
1999-00	529.64	2122.51	581.8	23.53	707.57	58.05	22.51	3	10.02
2000-01	538.26	2295.66	603.28	23.18	865.21	71.31	23.22	2.65	8.46
2001-02	530.29	2355.03	628.75	23	893.36	77	23.06	2.64	8.17
2002-03	587.93	2409.41	664.02	23.43	924.02	79.87	25.09	2.61	8.31
2003-04	589.49	2429.13	630.67	24.72	925.15	77.79	23.85	2.63	8.11

2004-05	654.19	3159.9	838.38	27.18	1128.99	99.25	24.07	2.8	8.45
2005-06	700.66	3120.61	803.17	28.28	1182.52	119.13	24.78	2.64	6.74
2006-07	725.26	3196.12	810.02	29.17	1202.72	107.29	24.86	2.66	7.55
2007-08	785.68	3197.18	903.87	31.3	1304.97	138.63	25.1	2.45	6.52
2008-09	790.12	3245.14	957.04	32.17	1374.55	146.79	24.56	2.36	6.52
2009-10	773.323	3336.65	964.9	32.91	1425.14	150.61	23.5	2.34	6.41
2010-11	719.206	3505.287	1009.981	336.7	15491.49	1736.69	21.36	2.26	5.82
2011-12	758.963	3418.147	1084.594	340.45	14983.86	1772.16	22.23	2.28	6.12
2012-13	934.342	3242.44	1035.736	353.22	15236.09	1705.69	26.45	2.13	6.07
2013-14	876.803	3278.838	1083.535	360.34	15367.91	1710.41	24.33	2.1	6.33
2014-15	962.039	3235.184	1106.705	365.66	15497.11	1671.75	26.3	2.08	6.62
2015-16	1194.177	2954.949	1164.603	369.79	14170.08	1731.79	32.29	2.08	6.72
2016-17	1063.486	3079.001	1187.823	371.75	13989.6	1764.78	28.6	2.2	6.73
2017-18	1072.539	2981.646	1220.879	375.38	13558.52	1814.69	28.57	2.19	6.72
2018-19	1076.141	2994.466	1248.616	376.34	13575.32	1871.88	28.59	2.21	6.67
2019-20	1084.245	3001.12	1269.661	370.07	13987.06	1999.14	29.3	2.15	6.35
2020-21	1085.431	3006.076	1287.013	369.55	14096.49	2043.91	29.37	2.13	6.29

Table 3.8: Division Wise Distribution of lrrigation Equipment on the basis of Power Source

Division	Electric Number	Area (ha)	Diesel Number	Area(ha)	Total Number	Area (ha)
Dhaka	72486	306604	128589	369937	201075	676541
Mymensingh	58507	311835	112617	276488	171124	588321
Rajshahi	100842	754117	230528	475302	331370	1229419
Rangpur	**106668**	**463183**	**296944**	**586148**	**403612**	**1049331**
Chittagong	40977	256244	83148	317879	124125	574123
Khulna	41511	187960	279904	549566	321415	737526
Sylhet	10865	60275	61033	287374	71898	347649
Barisal	1390	18752	25026	156856	26416	175608
Total	433246	2358970	1217789	3019550	1651035	5378520

Table 3.9: Groundwater Table Hydrographs

Year	Upazila/district	No.of DTW	No.of STW	lrrigated Area (ha) for Rabi crop	Maximum Depletion Groundwater Level (m) (Jan-March)
2005-06	Mithapukur Rangpur	168	8200	24360	3.37
2006-07	Mithapukur Rangpur	134	10456	25850	3.3
2007-08	Mithapukur Rangpur	148	10836	34603	3.82

2008-09	Mithapukur Rangpur	149	11720	28803	3.91
2009-10	Mithapukur Rangpur	140	12800	30925	3.29
2010-11	Mithapukur Rangpur	120	18014	45043	3.13
2011-12	Mithapukur Rangpur	224	24271	45113	3.67
2012-13	Mithapukur Rangpur	209	19041	36842	3.84
2013-14	Mithapukur Rangpur	235	7398	20255	3.95
2014-15	Mithapukur Rangpur	256	15859	41846	4.01
2015-16	Mithapukur Rangpur	267	14690	44287	4.25
2016-17	Mithapukur Rangpur	263	14316	30849	3.5
2017-18	Mithapukur Rangpur	268	14320	34218	4.1
2018-19	Mithapukur Rangpur	318	29146	44202	4.44
2019-20	Mithapukur Rangpur	333	25255	45550	4.14
2020-21	Mithapukur Rangpur	333	25255	45570	3.17

3.4.2 Solar Pumping

A mechanical system that gets its power from the sun is a solar water pumping operating system, as was previously stated. It harnesses the power from the sun to power mechanical parts that transport water from a source, such as a river, storage container, or underground well, to a predetermined location. This location can be a farmland or a storage container for domestic usage. This video explains how it functions. Water pumping using natural energy has been a concept for more than a thousand years. Dutch engineers had been using windmills to pump water for over 1000 years before the solar water-powered pump was created. Pumping water using the wind turned out to be a surprisingly dependable method. Simply by employing the wind's energy to push water out to sea, the Dutch were able to restore more than half of their nation from the sea.

In the 1970s, solar water pumping was developed. The system at the time consisted of a DC/AC water pump and solar panels, and it was pretty simple. It has since evolved and become more refined. The solar-powered water pump of today Water pumping using natural energy has been a concept for more than a thousand years[31]. Dutch engineers used windmills in a variety of businesses, including the agricultural sector, the industrial sector, and home settings, before the solar water-powered pump was created.

Figure 3.13: Solar Pumping Irrigation in Village [32]

Solar water-powered pumps are now widely used in the agriculture sector. This is due, in part, to the fact that the majority of agricultural lands are frequently expensive and remote from the grid. Grid power is frequently too expensive to be brought to the fields of agriculture. Additionally, the cost calculation of consuming coal-based fuels is frequently high during to the rising prices around the Anywhere in the world with sufficient solar insolation can use solar water pumps. They are best suited for rural, off-grid locations where installing the grid would be too expensive. They are therefore the ideal choice for the majority of South America, South Asia, Southeast Asia, and Africa. All of these areas have strong solar insolation and poor grid connectivity. However, practically everywhere on Earth that is habitable can have a solar water pump system built.

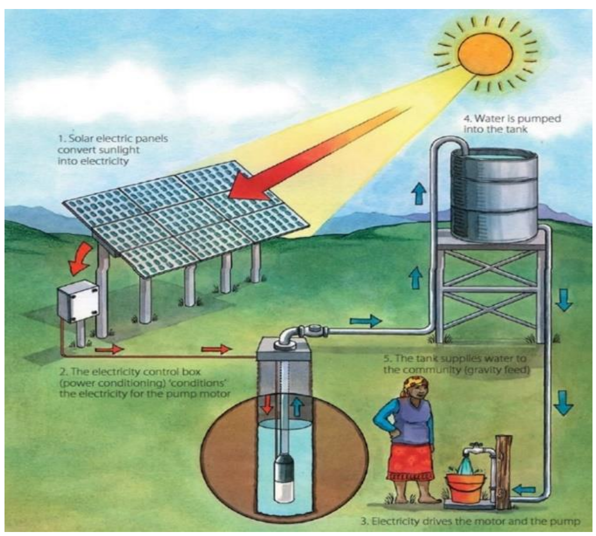


Figure 3.14: Solar Pumping System [33, p. 101]

3.4.3 Work of Solar Pump

When the sunshine strikes PV panels, the photovoltaic cell converts the solar energy into electrical energy using Si wafers installed inside the PV panels. The cable-based pumps are then run using an electrical motor that is fueled by the sunlight. The rotor that is attached to the pump begins rotating when the pump is turned on, drawing water from the soil and supplying it to the fields. varieties of solar pumps: Surface sun pumps, submersible solar pumps, DC pumps, and AC pumps are the four various types of solar pumps used in Bangladesh's Rangpur District homes as part of a supply chain solution to address the water problem. This area's irrigation system has a water problem.

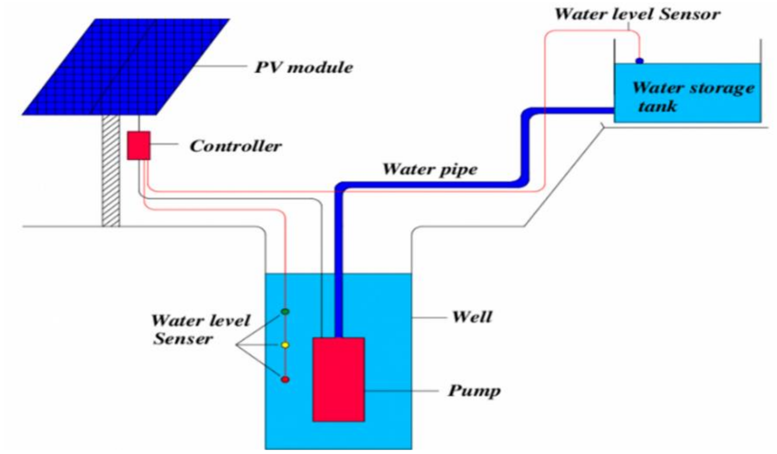


Figure 3.15: Solar Pump Work [34]

3.4.4 Solar-Powered Irrigation System/ Submersible Pump

Systems for solar-powered water pumping can be used for irrigation, livestock watering, and town water delivery. The usage of a sun-powered water pump systems in gardens and paddy fields for irrigation purposes is known as solar-powered irrigation. Fig. depicts a typical illustration of a solar-powered irrigation system.

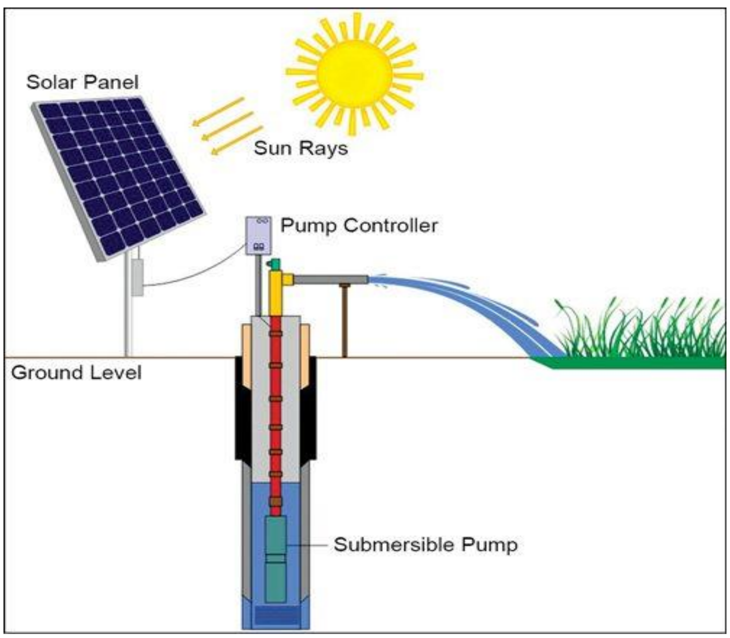


Figure 3.16: A typical irrigation system powered by solar [35]

Essentially, this pumping is a hermetically enclosed motor. The entire submersible pump unit is submerging in the liquid being pumps. It is made to fit inside the drilled bore and is typically used to pump water from tiny borewells. The depth of the well could range from a few meters to 550 meters. However, the system would be more potent and costlier the deeper the hole. Water can be raised higher with the use of submersible pumps. In order to convey water from a canal to ability of tanks or from an underground storage tank to an overhead tank, these pumps are also employed in those applications.

3.4.5 Control of The Pump and Stands for Solar Tracking

Control of the pump: There are two types of pumps controllers' inverters or variable-speed drive (VFD). If an alternating current solar pump is used, an inverter is needed to convert the DC from the solar panels into AC. Larger irrigation systems require inverters with greater power levels, which are not supported by a basic inverter, which supports power levels from 0.15 kW to 55 kW. In order to accommodate the rush characteristic of an AC motor, the photovoltaic panel and inverter must be of the appropriate size. The inverter to be ability of manage that additional starting loading because the AC pump takes a lot of power at first. To make sure that the pump motor receives the correct voltage and current, a VFD controller may occasionally be employed. Solar DC pumps usually require a specific controller if they're going to be supplied exclusively by photovoltaic cells (without batteries). The control unit or continuous current booster (maximum power point tracker) enables the water pump to get started and run in low light conditions on overcast days, in the early mornings, and in the late evenings. A controller may not even be required for a battery-operated DC pump.

Stands for solar tracking: The collecting surface of photovoltaic solar panels operates most efficiently when it is perpendicular to the sun's rays. The only period the panels will catch the sun perpendicularly if they are fixed, with the ideal orientation and tilt angle, is between noon and two in the spring (March) and fall (September).

Solar panels will not produce to their full capacity outside of this window (time of day and year), when the sun's beams are not parallel to the panel's surface. It is feasible to install panel supports that can adjust their orientation and/or tilt depend to the season time of the day in order to maximize the performance of the panel. Both human and automated processes are available for this.

completely automated systems in all nations (even French-speaking ones), solar tracking systems (see illustration below) are referred to as such. Because of the potential for failure and the limited availability of repair options, they are not advised for installations at rural or distant sites. On the other hand, we shouldn't discount the benefits that can result from setting up a straightforward system, such as manually tilting and/or rotating the panels.

3.4.6 Backup Power Source

Although solar pumping is often intended to operate completely on its own, it is necessary to provide a connection for an external energy source, typically a generator, once the water supply is important for agriculture or vital for the population.

This backup energy source can be used either in lieu of solar energy during particular seasons or weather conditions, such as when there is a lot of rain, cloud cover, or snow that covers the panels, or it can be used in addition to solar energy during repairs, maintenance, or breakdowns. While the connection to this energy source need not be permanent, it must be possible. For grid power outages, solar-powered battery backup systems are a fantastic substitute for fossil fuel generators. Battery-backed solar PV systems function similarly to standard generators, with the extra benefit of supplying your home with green, renewable energy throughout the day. The meter spins backwards as the extra solar energy is either immediately put on the grid or stored in batteries.

solar PV system then provides with energy independence from both batteries and the sun in the event that the utility grid goes down. This is due to the solar inverter's automatic switching to be just solar and batteries energies to be run essential loaded like the refrigerator, TV, internet, lights, and energy outlets, day or night. The solar inverter is the gear that converting the DC power output from PV panels to AC so for this home can use it a great replacement for adding a battery to a new or existing solar PV system is buying a generator with fossil fuels. Generators are noisy, generate fumes, and use fuel, but batteries are silent and clean. Additionally, a generator prevents current solar customers from using their inactive solar panels when there is a power outage. The battery system is eligible for the federal tax incentive.

Lithium-ion batteries are dependable, safe, and maintenance-free.

The solar inverter employs pure, cost-free solar energy to charge the battery before, during, and after power outages.

An easy-to-use software gives access to a cloud-based energy monitoring platform that permits tracking of a home's energy usage and solar production. This app works on any personal electronic device or home computer.

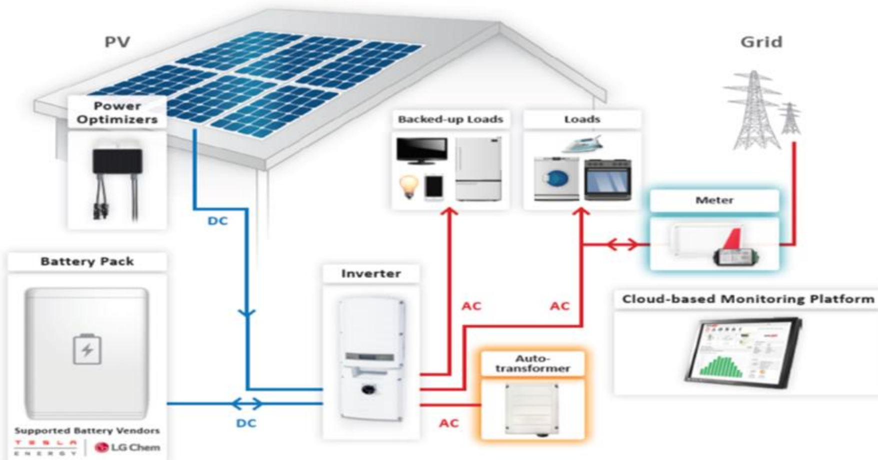


Figure 3.17: Solar-powered battery back-up systems [36]

3.4.7 Solar Park in Remote Area of Teesta River

People's lives in the Teesta basin are improved by the solar power plant:

The development of a solar power plant in the Showlmari-Vhotmari union under Kaligonj upazilla of Lalmonirhat district has improved the lot and socioeconomic life of thousands of disadvantaged people living in remote char areas of the Teesta River basin.In the unions' charred regions, which are mostly affected by erosion, approximately 15,000 people reside. They lost their land, leaving them helpless. Their lives were made more difficult by the lack of minimally necessary amenities like healthcare and educational institutions. It appeared as though people were residing on a remote island. Due to poor road connectivity, villagers were cut off from the upazilla and district headquarters. Villagers must travel across the extensive char regions and cross the river in order to get to Upazilla and the district center. Due to a lack of employment opportunities in the communities, district hub. People in the settlements depend on cultivating the char lands seasonally, fishing the river, and raising cattle for a living because there aren't many jobs available. For their survival, they must use nature to defend themselves through draughts, winters, and floods.

Intraco Solar Power Ltd. started construction of a 30-megawatt power facility in the char areas last year as part of the government's goal to expanded accessing to power. Due to the absence of a direct road connection, the company first encountered difficulties bringing the necessary supplies and equipment to the site. In order to prevent river erosion, they built a four-kilometer-long embankment, two bailey bridges, and 18 culverts to smooth out the roads. The construction activity is moving quickly to install electric poles from three to four kilometers out and put the isolated settlements under power supply. Many of the residents of the char have been working in construction and earning money to maintain their families.

3.4.8 Govt/ Non Govt Running or Previous Project in Solar Irrigation

Solar Photvoltaic pumping for Agricultural Irrigation Expected Energy Generation and CO2 Emission reduction during System Life 237 MWh, 112 tCO2. Given its cost-effectiveness, the government is now aiming to employ solar electricity extensively for irrigation after having good success with solar household systems in off-grid areas.

Farmers may find that the environmentally friendly solar-powered pumps can offer a long-term answer to the irrigation dilemma they experience each dry season. A significant portion of the cost of farming goes on irrigation. Farmers can irrigate their crops with solar pumps at a low cost over an extended period of time without harming the environment. The nation currently uses 1.34 million diesel-powered pumps, which use 2.9 million tonnes of diesel yearly, costing $1 billion. These pumps handle the majority of the nation's irrigation needs. Additionally, the government must spend a significant sum of money on gasoline subsidies in order to make it affordable for farmers.

Additionally, the nation has 240,000 electricity-powered pumps, which add an additional 1,500 megawatts of daily demand to the power grid during the dry season when irrigation is necessary. In this context, the solar irrigation system is creating new opportunities for fuel-free, low-cost crop cultivation, particularly for the Boro paddy. According to electricity division representatives, they are currently concentrating on installing solar pumps to cut farming costs as well as to cut carbon dioxide emissions. In an effort to cut carbon emissions, a number of organizations and authorities are also promoting the usage of solar-powered irrigation pumps around the nation. Currently, the nation is home to 1,446 solar irrigation pumps with a total hourly generation capacity of 31 megawatts.

The Infrastructure Development Company Ltd. (IDCOL), a state-owned non-bank financial institution, has funded the construction of 1,270 solar irrigation pumps out of the total number of solar pumps. These solar irrigation pumps have a combined capability of producing roughly 28.78 megawatts per hour. By 2025, IDCOL wants to have installed 50,000 solar irrigation pumps. To that end, the government has provided the corporation with low-interest financing. The Department of Agricultural Extension, Bangladesh, has also started a program. Solar-powered pumps will be installed by the Agricultural Development Corporation and other ministries and departments. According to a senior official at Bangladesh's Sustainable and Renewable Energy Development Authority (SREDA), the government plans to replace diesel-powered pumps with solar-powered ones that can generate 150 megawatts of electricity.

3.4.9 The Potential for Solar Irrigation

The solar cell receives sunlight, which triggers it to produce electrical power. That electrical power drives a spinning flywheel and engine, and that in turn drives the piston in order that draws water in and throw it out. In Bangladesh that solar irrigation methods have tremendous promise. A solar water pump with an average capacity of 18.5 Kw may water 130 bighas of land. In conditions of local solar irradiation, a pump of 18.5 kW size is capable of lifting 25–30 Lac gallons of water each day. Irrigation's major objective is to give crops with the appropriate amount of nutrients at the right time. The setup of the seedbed, germination, root development, nutrient uptake, plant growth and regeneration, yield, and quality are all impacted by sufficient soil moisture. Giving plants the proper dosage of fertilizer at the correct moment is irrigation's main goal.

A suitable amount of water in the soil affects the preparation for the seedbed, germination, growing roots, nutrient uptake, development of plants and regrowth, yield, and beauty. Bangladesh is a tiny nation. In an island nation that is situated in a tropical river delta, watering is essential to agriculture. Therefore, solar irrigation methods in Bangladesh have tremendous potential.

Solar powered pumps can minimize carbon emissions, offer fuel-free sustainable solutions, and save hundreds of millions of dollars in foreign exchange.

There are various benefits to SPIS, including the creation of environmentally friendly agricultural practices and the provision of a clean substitute for petroleum and coal. They aid in the electrification of rural communities and lower the price of energy for agriculture in places where there is no or sporadic access to energy. This increases many farmers' accessibility to water and may have a positive ripple impact on their earnings and efficiency.

Solar power, sunlight for water being heated, heated by the sun, sun breathing, and sunlight are five primary applications of solar power. There are many more applications for solar electricity, but two are most common: residential solar installations and commercial solar power.

3.4.10 Plan for Proposed Irrigation

Bangladesh is an agricultural country that produces enough rice to be almost self-sufficient. nearly the past 20 years, the nation's output of rice has climbed by nearly 15 million tons. Groundwater accessibility is continuously growing as a result of the expansion of deep and shallow tube wells, which is necessary for achieving this self-sufficiency. The evidence that is currently available implies that policy has focused more on "resource development" than "resource management" thus far. This has led to significant issues, most notably an excessive amount of drawdown in heavily watered areas and a decline in groundwater quality. A key hot spot identified in "Delta Plan 2100" is the country's northern region, which is also prone to drought. As a result, a thorough field survey was carried out in the Rangpur division during the year. 2018 to monitor the state of the rice fields' ground water table depletion and establish some of the best ways for permanently resolving these issues. It is concerning that the ground water table in this area has decreased to 6.5 to 8 m over the past 20 years. To lessen the strain on groundwater, it can be argued that surface water resources need to be developed and managed carefully. In addition, attention should be paid to maximizing crop water demand by improving water use efficiency through the adoption of water-conserving management strategies and practices. According to the authors' recommendations, the management of ground water in the Rangpur division may be sustained over the long-term using six fundamental principles. The techniques are: 1) Start with the right rice choice dry period Boorish rice farming is probably not Bangladesh's best long-term alternative. Therefore, it is necessary to explain both the selection of rice varieties and cropping patterns. Considering water availability and the sustainability of aquifers, it is necessary to promote drought-tolerant rice varieties throughout the rabi season, beginning with the promotion of T. Aman rice and practical substitutes for boor, such as the introduction of wheat. Evaluation of strategic choices and monitoring the implementation of national policies for the people water sector will be continued to be difficult in the absence of appropriate institutional mechanisms. It can be argued that these six techniques will help to manage the ground if they are implemented in the research field by creating strong connections and better communications between various organizations and the government Using our SDG (Sustainable Development Goal) of "Zero Hunger" requires a sustainable use of our water resources.

3.4.11 Financial Analysis

In Bangladesh, the solar powered irrigation system (SPIS) has become a viable technology. Finding SPIS's financial and environmental significance was the goal of this investigation. In the Rangpur District's Teesta barrage, this study also examines the factor demand and elasticity of a substitute for SPIS irrigation. Despite intense population pressure, a lack of available land, and a propensity for natural disasters, Bangladesh has achieved significant success in raising agricultural production over the past few decades. Solar power is frequently used for house warming and hot water from the sun. Solar ponds heat may be used to create a variety of products, including foods, chemicals, fabrics, warm greenhouses as well as swimming pools, and cow barns. In addition to being a source of electricity for electronic devices, solar energy may be utilized for cooking.

3.5 Analysis of Data from Global Solar Atlas

3.5.1 Overview of the Study Area

Preliminary assessment of the photovoltaic electricity production

Project	Rangpur Division
Geographical coordinates	26.160060°, 89.052644° (26°09'36", 089°03'10")
Report generated	12 Jun 2023
Generated by	Global Solar Atlas
Map link	https://globalsolaratlas.info/map?s=26.16006,89.052644,10&pv=ground,180,27,1000

Project	Rangpur Division
Location	Khalisha Chapani, Dimla Upazila, -, Bangladesh
Geographical coordinates	26.160060°, 89.052644° (26°09'36", 089°03'10")
Time zone	UTC+06
Elevation	54 m

Figure 3.18: Rangpur, Khalisha Chapani Satellite View

3.5.2 Irradiance

Map data			Per year
Direct normal irradiation	DNI	1098.7	kWh/m²
Global horizontal irradiation	GHI	1628.3	kWh/m²
Diffuse horizontal irradiation	DIF	887.7	kWh/m²
Global tilted irradiation at optimum angle	GTI opta	1772.6	kWh/m²
Optimum tilt of PV modules	OPTA	27 / 180	°
Air temperature	TEMP	24.9	°C
Terrain elevation	ELE	54	m

Map data			Per day
Direct normal irradiation	DNI	3.010	kWh/m² per day
Global horizontal irradiation	GHI	4.461	kWh/m² per day
Diffuse horizontal irradiation	DIF	2.432	kWh/m² per day
Global tilted irradiation at optimum angle	GTI opta	4.857	kWh/m² per day
Optimum tilt of PV modules	OPTA	27 / 180	°
Air temperature	TEMP	24.9	°C
Terrain elevation	ELE	54	m

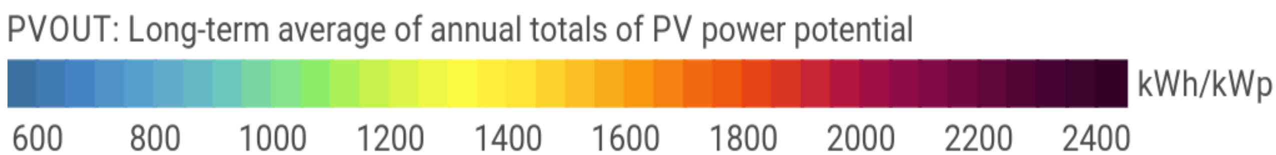


Figure 3.19: Global Solar Atlas Irradiance

3.5.3 Irradiation and Temperature Sensor

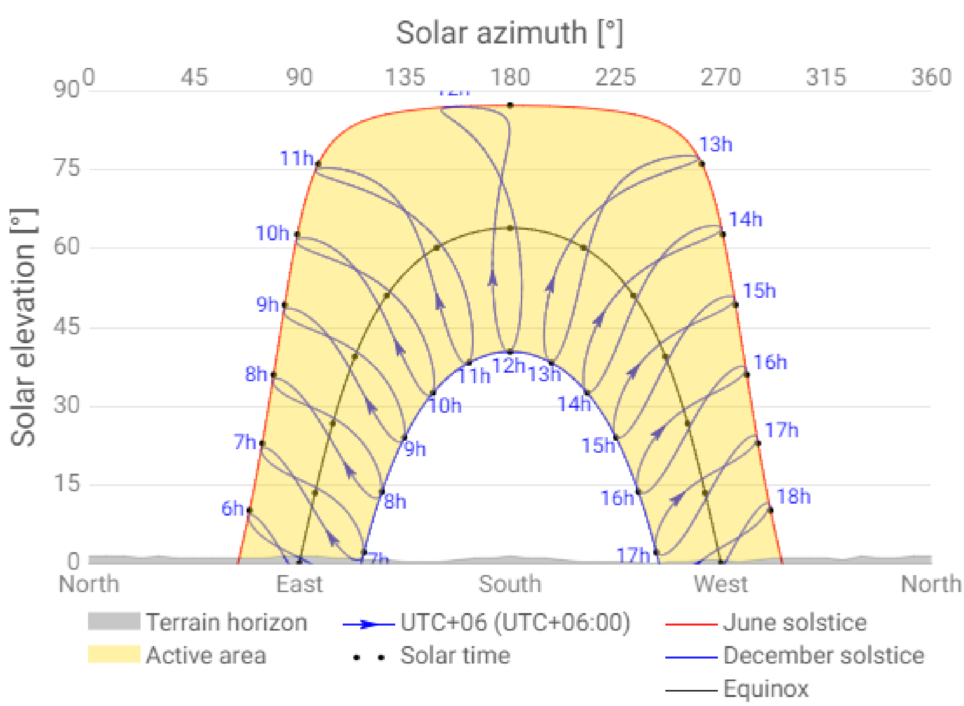


Figure 3.20: Irradiation and Temperature Sensor

3.5.4 Solar Module

PV system configuration		
Ground-mounted large scale	Large-scale commercial photovoltaic system mounted on leveled ground. Azimuth and tilt of PV modules are homogeneous, usually facing towards the Equator and inclined at the optimum tilt to maximize yearly energy yield. The modules are fix-mounted on tilted structures aligned in rows.	
System size	1000	kWp
Tilt of PV panels	27	°
Azimuth of PV panels	180	°

Map data

Direct normal irradiation	DNI	1098.7	kWh/m²
Global horizontal irradiation	GHI	1628.3	kWh/m²
Diffuse horizontal irradiation	DIF	887.7	kWh/m²
Global tilted irradiation at optimum angle	GTI_opta	1772.6	kWh/m²
Air temperature	TEMP	24.9	°C
Optimum tilt of PV modules	OPTA	27	°
Terrain elevation	ELE	54	m

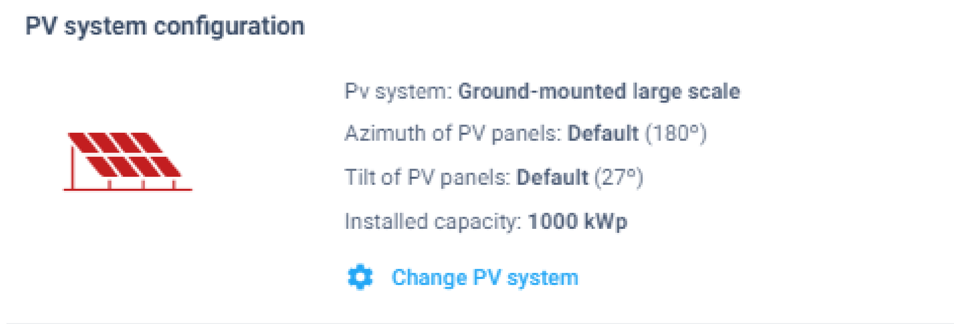


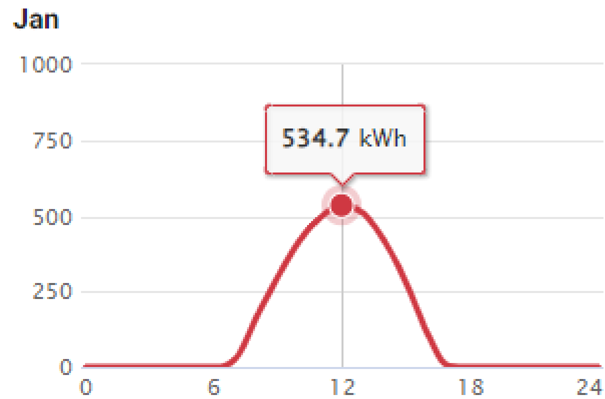
Figure 3.21: PV System Configuration

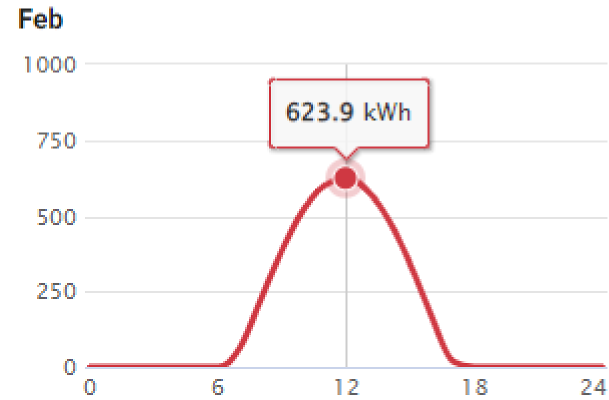
3.5.5 Measurement Power

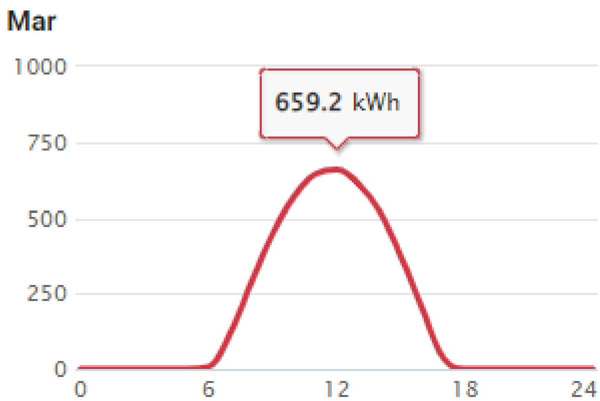
Average Hourly Profiles

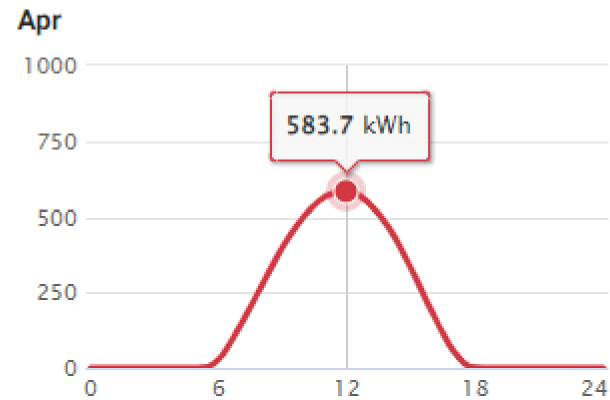
Total Photovoltaic Power Output [KWh]

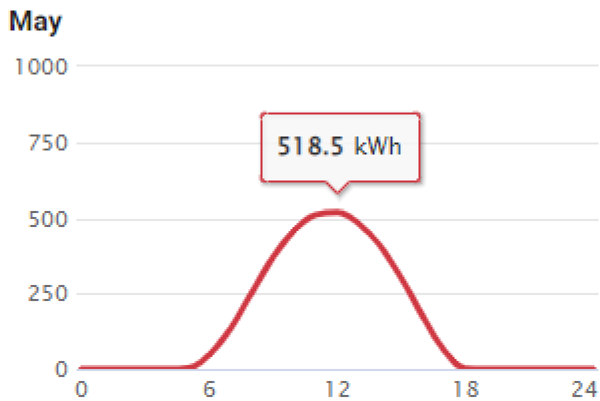
The Total Photovoltaic Power Output a daily load curve profile is created using the standard load curve. A periodic profile is created using the whole daily load profile, taking into account the maximum load 659.2kwh month of March, minimum load kwh, daily high and July month continually daily lowest load 434.5 kw consumption for each month.

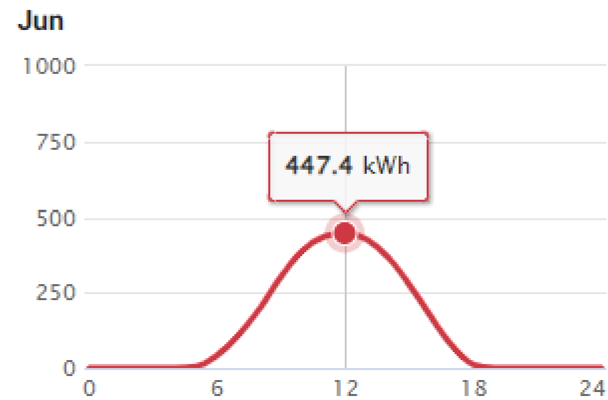

Jan
1000
750
500
250
0
534.7 kWh
0
6
12
18
24

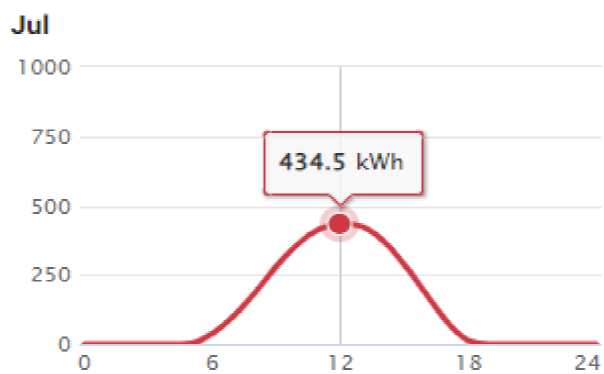

Feb
1000
750
500
250
0
623.9 kWh
0
6
12
18
24

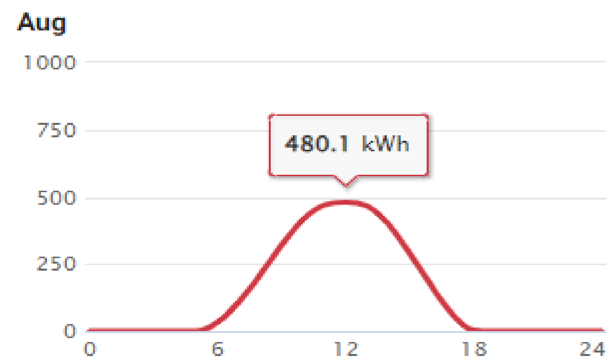

Mar
1000
750
500
250
0
659.2 kWh
0
6
12
18
24


Apr
1000
750
500
250
0
583.7 kWh
0
6
12
18
24


May
1000
750
500
250
0
518.5 kWh
0
6
12
18
24


Jun
1000
750
500
250
0
447.4 kWh
0
6
12
18
24


Jul
1000
750
500
250
0
434.5 kWh
0
6
12
18
24


Aug
1000
750
500
250
0
480.1 kWh
0
6
12
18
24

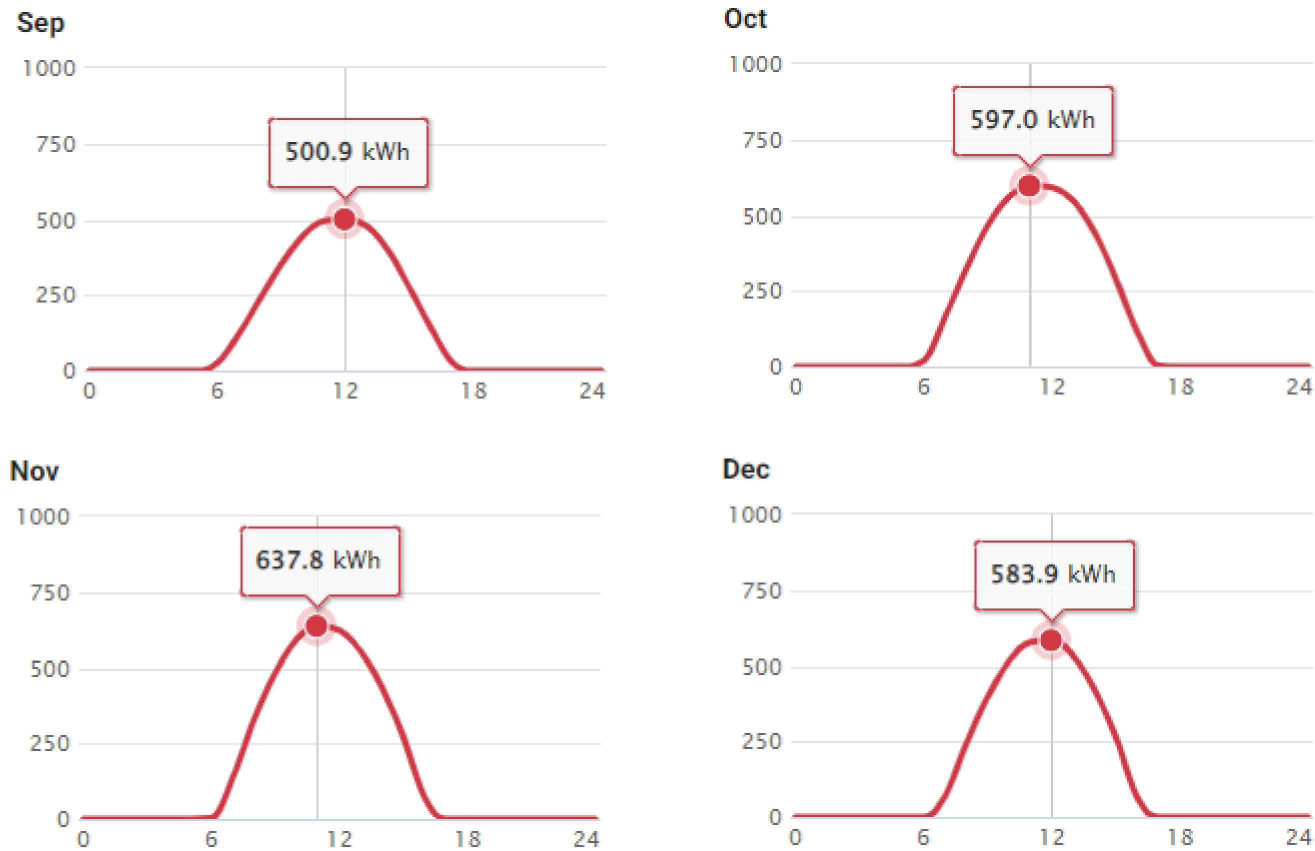


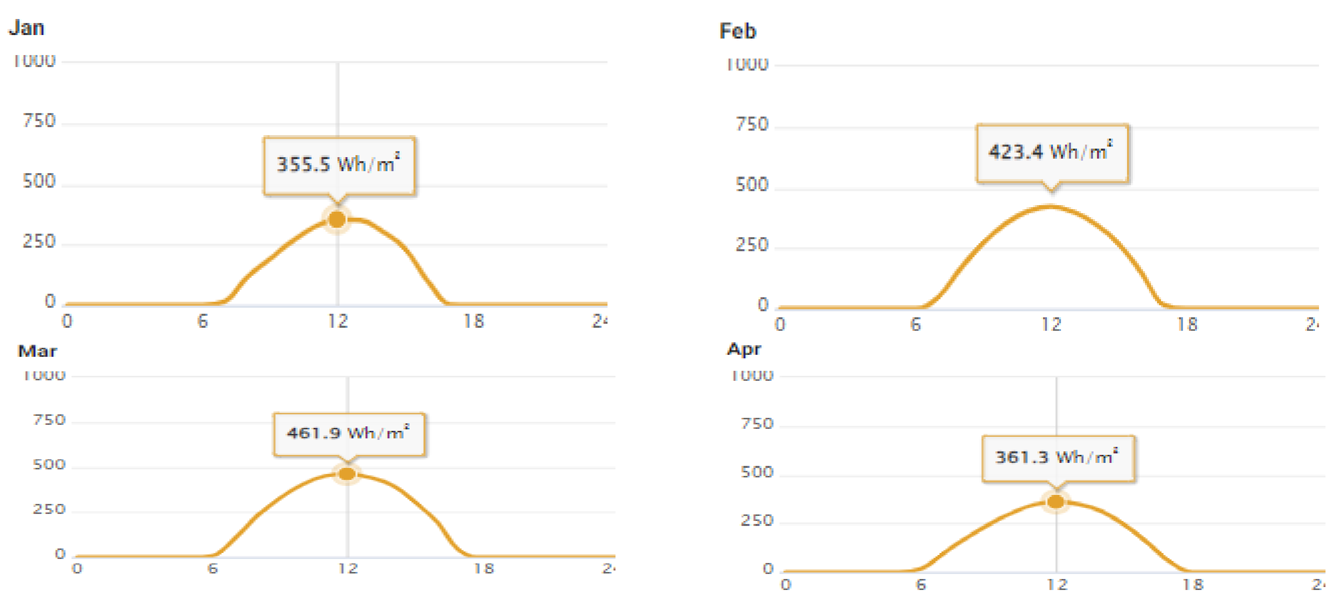
Figure 3.22: Photovoltaic Average Hourly Profiles

3.5.6 Main Power

Average Hourly Profiles

Direct Normal Irradiation [Wh/m^2]

A daily load curves profiles is created using the average load curve. A seasonality profile is created using the whole daily load profile, taking into account the monthly maximum load 537.2 Wh/m² in November, monthly minimum load 265.1 Wh/m²in July month, and daily highest and lowest load Wh/m²consumption.



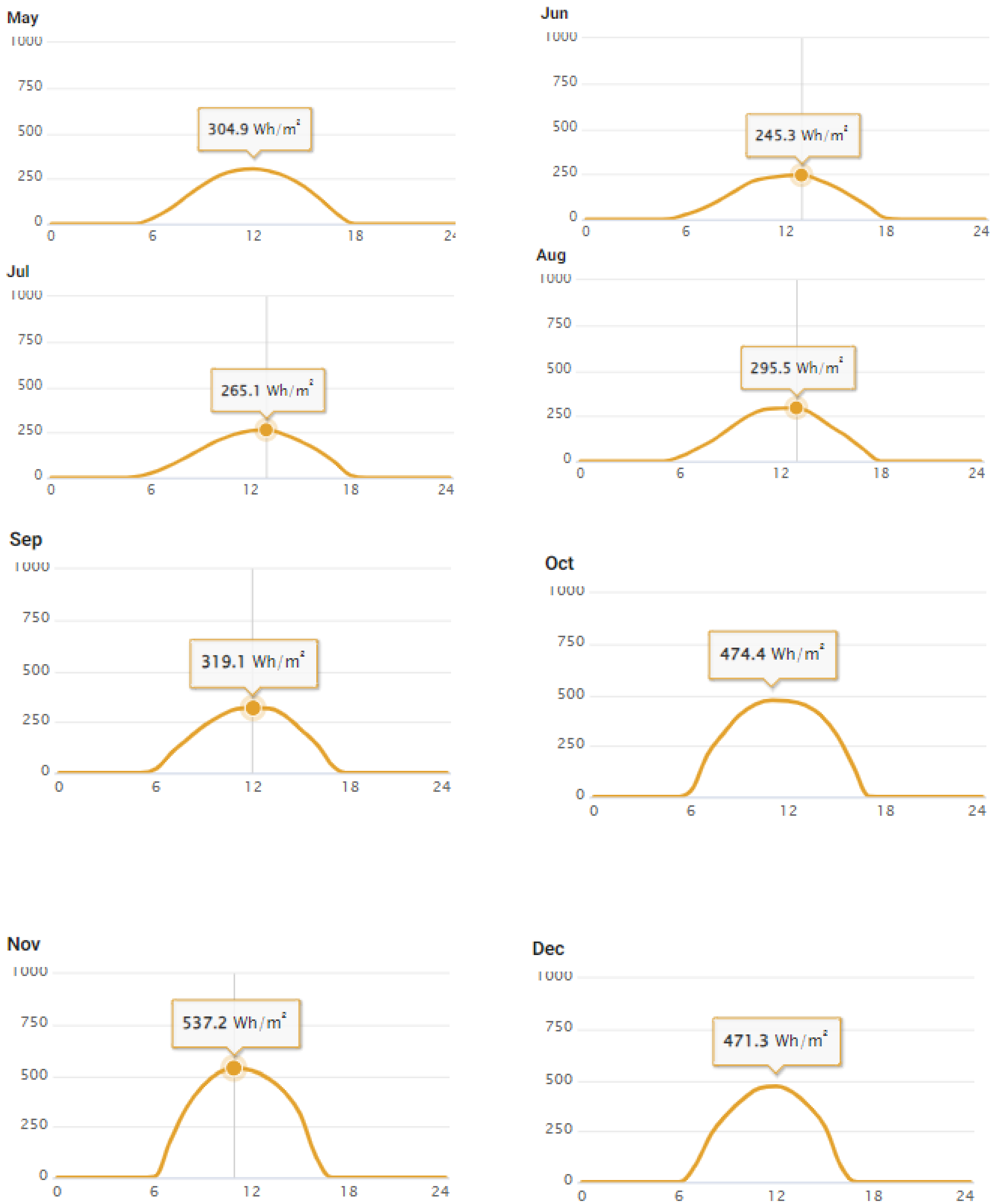


Figure 3.23: DNI Average Hourly Profiles

3.5.7 Efficiency

Average Hourly Profile

Total Photovoltaic Power Output [KWh]

Table 3.10: Photovoltaic Power Output

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 - 1												
1 - 2												
2 - 3												
3 - 4												
4 - 5												
5 - 6					3	4	3	0				
6 - 7		0	8	30	48	43	39	34	25	20	3	
7 - 8	27	61	117	140	136	109	101	109	121	166	138	68
8 - 9	167	223	287	272	255	199	186	211	238	327	331	243
9 - 10	300	387	448	402	373	303	281	322	354	468	485	396
10 - 11	418	520	571	503	462	390	361	415	445	562	595	514
11 - 12	498	600	644	567	511	436	415	470	496	597	638	577
12 - 13	535	624	659	584	519	447	434	480	501	591	624	584
13 - 14	507	581	613	546	481	425	424	466	479	546	554	532
14 - 15	414	484	523	461	408	366	373	399	399	441	434	420
15 - 16	278	339	373	329	300	275	286	290	274	285	271	263
16 - 17	109	167	201	184	175	170	182	171	142	111	70	65
17 - 18	3	19	36	55	62	73	80	63	27	3		
18 - 19				1	2	11	13	3				
19 - 20												
20 - 21												
21 - 22												
22 - 23												
23 - 24												
Sum	3,255	4,006	4,479	4,073	3,732	3,252	3,180	3,434	3,501	4,117	4,142	3,662

Monthly Averages:

Averages of The Total Photovoltaic Power Output a monthly load curve profile is created using the average load curve. A periodic profile is created using the whole monthly load profile, taking into account the maximum of 138.9 MWh and lowest load in 65.5 MWh consumption for each month as well as the daily high and low load in MWh consumption.

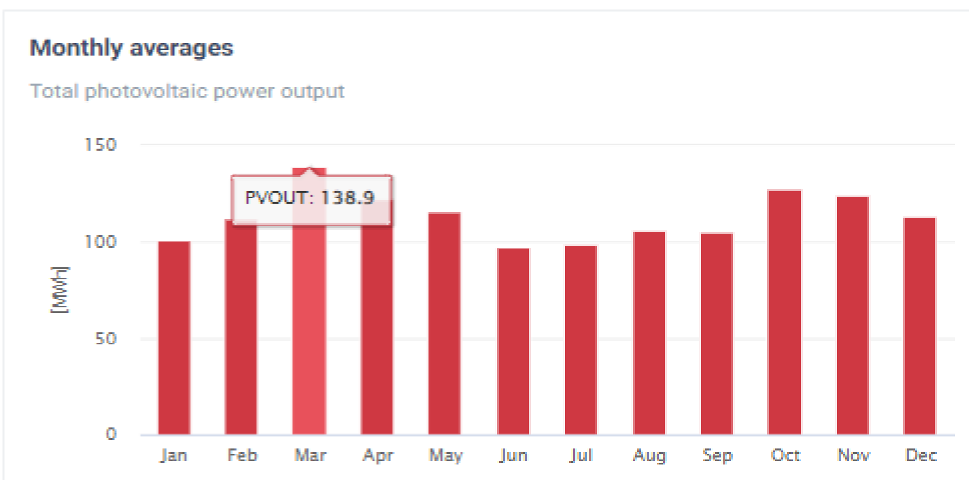


Figure 3.24: Photovoltaic Monthly Averages Power

Total photovoltaic power output and Global tilted irradiation

1.363

GWh per year

1713.6

kWh/m^2 per year

Average Hourly Profile

Direct Normal Irradiation [Wh/m²]

Table 3.11: DNI Average Hourly Power

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 - 1												
1 - 2												
2 - 3												
3 - 4												
4 - 5												
5 - 6					1	2	4					
6 - 7			7	17	31	27	25	26	20	30	4	
7 - 8	17	48	104	97	80	59	61	69	102	205	181	82
8 - 9	118	166	230	176	150	105	107	119	170	311	344	238
9 - 10	192	272	328	245	216	159	157	184	233	403	450	337
10 - 11	266	351	404	303	269	210	205	247	282	456	515	410
11 - 12	325	405	451	347	297	231	240	286	314	474	537	462
12 - 13	355	423	462	361	305	243	260	293	319	470	526	471
13 - 14	353	401	441	348	290	245	265	296	317	452	489	442
14 - 15	305	349	398	312	259	217	240	257	280	402	424	373
15 - 16	233	269	306	243	207	179	202	194	210	304	313	273
16 - 17	100	150	189	153	134	126	154	135	135	153	100	77
17 - 18	3	15	32	53	53	69	92	64	28	3		
18 - 19						8	14	2				
19 - 20												
20 - 21												
21 - 22												
22 - 23												
23 - 24												
Sum	2266	2849	3353	2655	2291	1880	2027	2171	2411	3662	3882	3165

Monthly Averages:

The Direct Normal Irradiation is a monthly load curve profile is created using the average load curve. A periodic profile is created using the whole monthly load profile, taking into account the maximum 122 kWh/m² and lowest load in 56 kWh/m² consumption for each month as well as the daily high and low load in kWh/m² consumption.

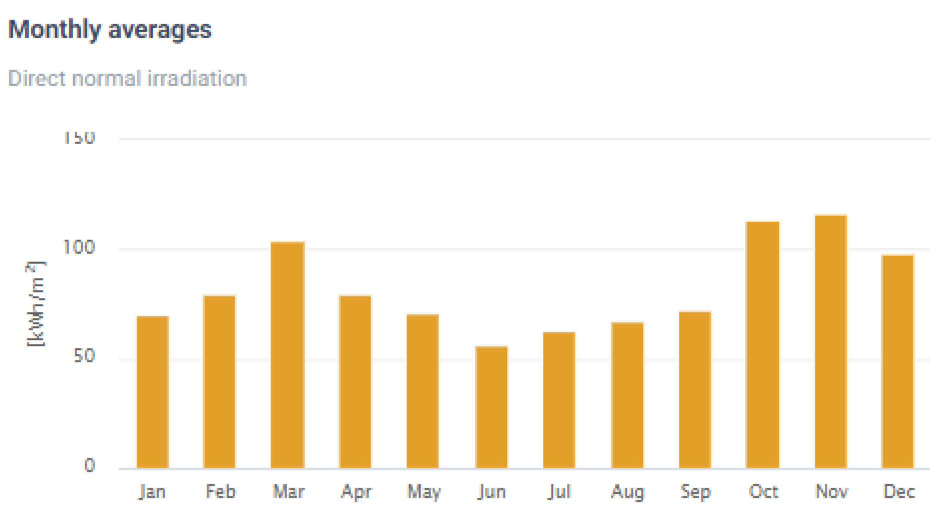


Figure 3.25: DNI Monthly Averages Power

Annual Averages
Direct Normal Irradiation

Annual Averages Direct Normal Irradiation is 991.6 kWh/m^2 per annually efficiency in PV module this panel electricity of production.

So, The Efficiency is demonstrative table of monthly and yearly averages power

Table 3.12: Efficiency of Monthly and Yearly Averages

Monthly & Yearly Averages			
	PV OUT specific	**PV OUTtotal**	**DNI**
	kWh/kWp	kWh	kWh/m^2
Jan	100.9	100920.4	70.3
Feb	112.2	112173.4	79.8
Mar	138.9	138857.2	104
Apr	122.2	122199.6	79.7
May	115.7	115697.5	71
Jun	97.6	97559.5	56.4
Jul	98.6	98584.8	62.8
Aug	106.4	106441.1	67.3
Sep	105	105038.3	72.3
Oct	127.6	127631.2	113.5
Nov	124.3	124258.6	116.5
Dec	113.5	113531.3	98.1
Yearly	1362.9	1362893.1	991.6

Finally, Daily Load power in 50000 PV Panel is power generated 136000 kWh/m^2 its 136 MW Generated by Electricity.
Yearly Total PV Panels are generated is (136*365) =49640 MW Generated by Electricity.
Sunway solar panel 500-watt is the model of panel name and
One 500W solar panel is about 27.5 square feet in size.
50000 Solar PV Panel 500W panel is about (27.5*50000) =1375000 square feet in size.
This is total 31.56 Acre in solar Panel Area Size. Approximately Sunway solar panel 500-watt total Panel, Inverter, batteries and others equipment Cost 112million dollar Or,12118691200 Taka (Minimum) and Yearly Loaded in 49640 MW

3.6 Simulation and Homer Software /Methodology

3.6.1 CAPEX and OPEX

CAPEX: Capital expenditures are referred to as CAPEX. The entire cost of the photovoltaic system must be paid in advance if we choose to go photovoltaic using the CAPEX approach. This enables us to acquire the solar system and qualifies us for the advantages of rapid depreciation. While operating expenses are an organization's ongoing costs, investments are its substantial, long-term costs. Real estate like as structures, equipment, machinery, and transportation are examples of capex. Employee salary, rent, utilities, and taxes on real estate are a few examples of operational expenses.

OPEX: The developer owns the solar power plant under the OPEX or operating expenses model, while consumers just pay for the electricity that is produced. The Renewable Energy Service Company (RESCO) concept is another name for this one. OPEX (operational expenditure) refers to the funds that an entity or company spends continuously and regularly to operate. These costs could be only once or ongoing. These costs might include anything between the ink needed to print papers to the salaries paid to personnel, according to the sector. High operational costs can boost productivity, attracting more clients and fostering business expansion.

Figure 3.26: OPEX Solar Model [37]

Financial viability, yet, is directly impacted by operational costs. If operational costs are increased excessively, the profit margins will decrease. A third-party energy service company (ESCO) investments the CAPEX in the OPEX model, and the electricity provider pays the ESCO monthly for the electrical power used. ESCO is in charge of overseeing site management, servicing, and refueling in addition to providing 24x7 Electricity available.

Step 1: Track and categories expenses

Make a list of every expense your business or organization incurred within the selected time.

Step 2: Add all operating expenses

This will provide a comprehensive view of running expenses.

Operating Expense= Salaries + Promotional and Advertising Cost + Supplies + Furniture + Supplies + Sales Commission + Property taxes + Insurance…

Formula for operating expenses

The operational revenues and the costs of products sold can also be subtracted with the total earnings in order to compute operating expenses.

Operating Expense= Revenue – Operating Income – COGS

CAPEX cost calculated

Operating Expense= Salaries + Promotional and Advertising Cost + Supplies + Furniture + Supplies + Sales Commission + Property taxes + Insurance…

The difference between CAPEX and OPEX renewable energy:
The fundamental distinction is that whereas OPEX is what the project needs to run, CAPEX is the cost of starting from scratch. In order to calculate the project's time to payback, it is crucial to calculate the project's original capital along with operational costs.

Table 3.13: Distribution of the investment cost CAPEX and the operational OPEX for the three LCOE

Item	LCOE		
	Minimum	Average	Maximum
CAPEX			
CSP Plant	61.2%	62.9%	61.8%
Recurring CAPEX	2.2%	2.3%	2.2%
Substation	1.7%	1.7%	1.7%
Transmission Line	0.4%	0.4%	0.9%
Road	0.0%	0.0%	0.0%
Total CAPEX	65.5%	67.3%	66.6%
OPEX			
Fixed costs CSP Plant	18.2%	18.7%	18.4%
Human Resources	6.6%	6.8%	6.6%
Variable costs CSP Plant	6.0%	3.3%	2.3%
Waterpower block & cleaning	3.3%	3.5%	5.6%
Substation	0.4%	0.5%	0.4%
Transmission Line	0.0%	0.0%	0.1%
Transport service	0.0%	0.0%	0.0%
Total OPEX	34.5%	32.7%	33.4%
Total (CAPEX + OPEX)	100.0%	100.0%	100.0%

We are infrastructure our solar project in Teesta area in Dimla upazilla, Rangpur District Solar power plant model system is the OPEX System. Overall, we are choosing the system of OPEX in our project of solar power.

3.6.2 Using Of Solar Energy

After given the desire input in Homer pro, the software will show several butputs. We choose most efficient and minimum costly system. After choose we will see the details about each component. Solar radiation knowledge was collected from HOMER software package for location Dimla Upazilla, Rangpur, Bangladesh. Information shows that the potential for radiation of this location is nice and might manufacture huge quantity electricity by using electrical phenomenon panels.

3.6.3 System Analysis and Design

Four key components make up this off-grid and on-grid power generation system: solar panels, a converter, a battery, and a grid. We will use almost identical components—PV panels, converters, and batteries—to present an economic comparison between off-grid and on-grid systems. We will let the Homer optimization choose the infrastructure settings for PV panels and conversions during on-grid association. Grid is used in the Homer program for inducing the outcomes. Additionally, some strings were carefully chosen for the battery packs, and Homer is able to indicate the number of batteries.

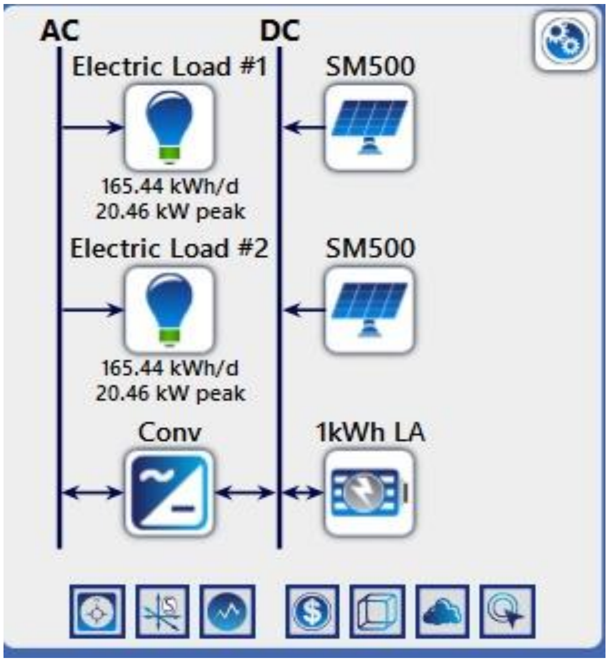


Figure 3.27: Schematic of the grid plant

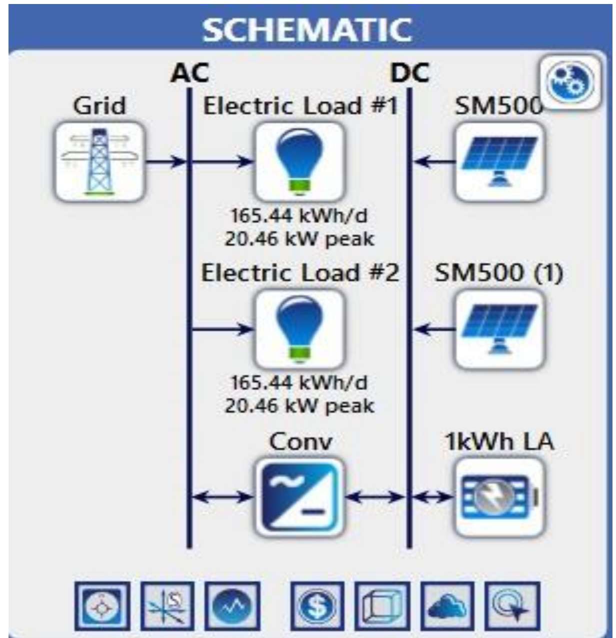


Figure 3.28: Schematic of the grid connected plant

Daily Load Profile:

The Remote Residential Unit is straightforward and uses a small amount of power for lighting and electricity. The recommended load profile took into account the widespread use of hourly loads. At midnight, just the most basic electrical appliances are still using energy in the residential unit. The demand for load increases in the morning as everyone gets ready to head to work or school. Due to the fact that most refrigerators use electricity at this time, there is a significant demand for loads. When the majority of family members return home in the evening, traffic is also very heavy.

From Bangladesh's perspective, numerous climate changes are happening.

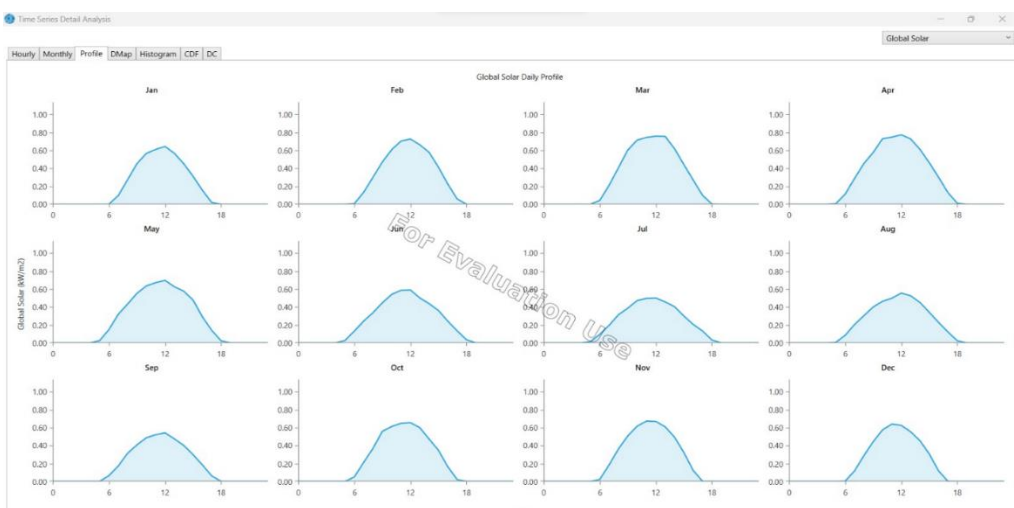


Figure 3.29: Daily Load profile

Monthly Load Profile:

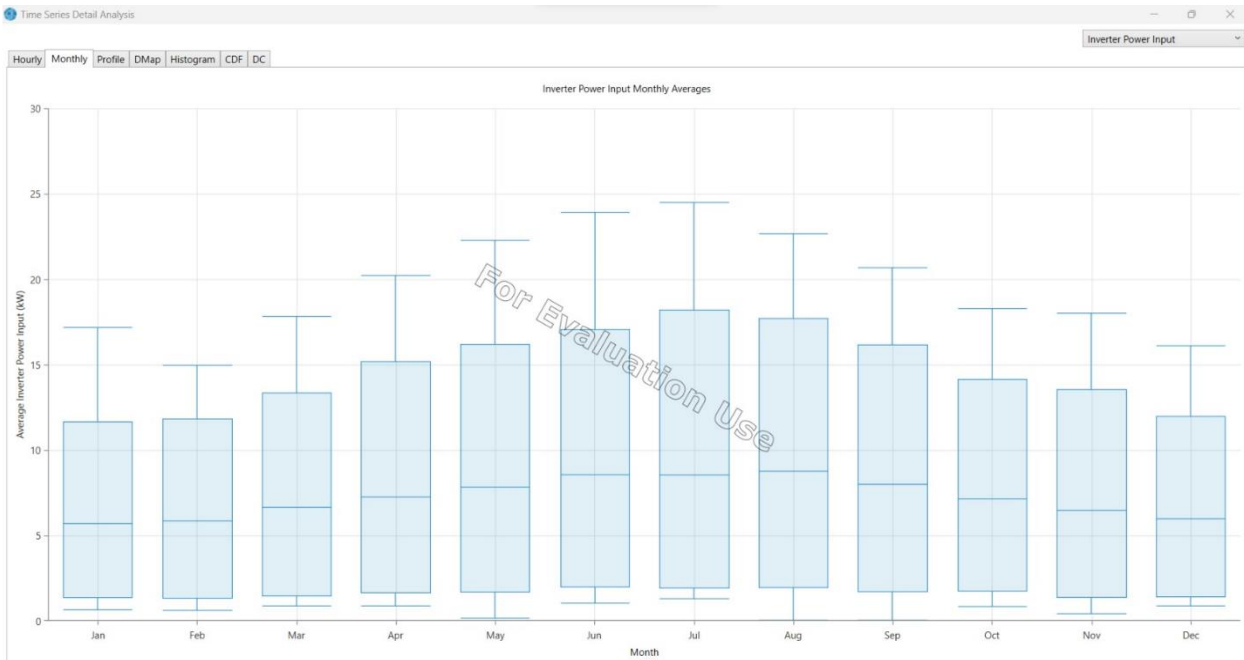


Figure 3.30: Monthly Load Profile

3.6.4 Battery Storage

The batteries' initial costs, replacement expenses, and annual operating and maintenance (O&M) costs are all included in the batteries' cost area.

272 strings of Battery are needed for the system. Bus voltages are 24v. Total energy consume the battery is 36,368 KWh/year. And total energy supply is 29,163 KWh/year. Losses are 7,282 KWh/year.

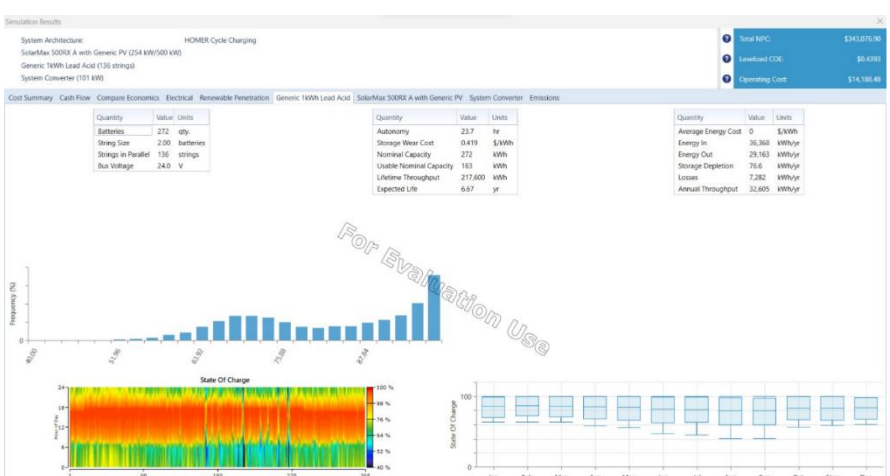


Figure 3.31: Batteries Costs

Photovoltaic

In this system we needed 254 KW of PV plate. Mean output is 19.2 KWh/day. PV penetration is 70.7%. Operational hour in a year is 4377 hours.

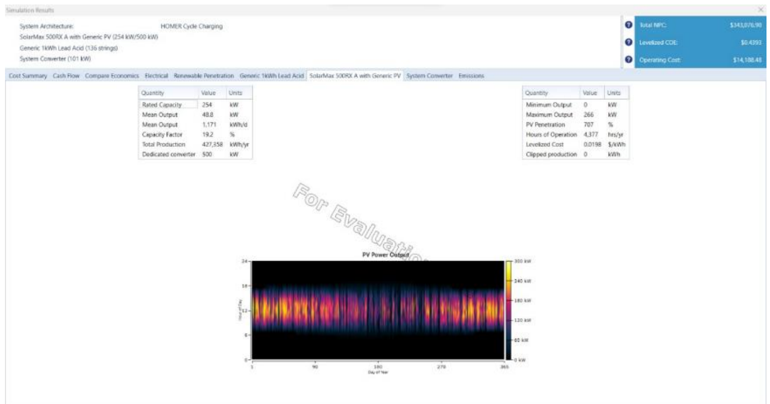


Figure 3.32: Photovoltaic for the system.

System converter

In this system we need 101 KW of system converter. Capacity factor is 6.82%. Total operational time in a year is 8,760 hours. Energy consumes 63,587 KWh and energy out 60,408 KWh through a year.

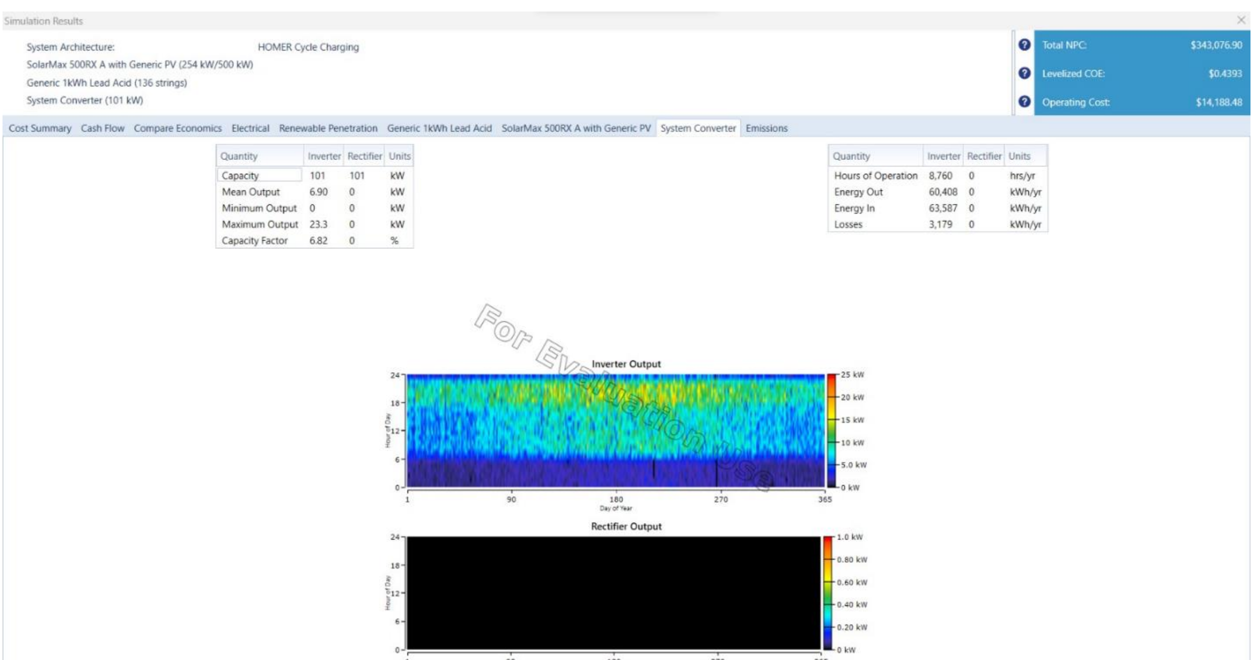


Figure 3.33: Converter in the System

Renewable penetration

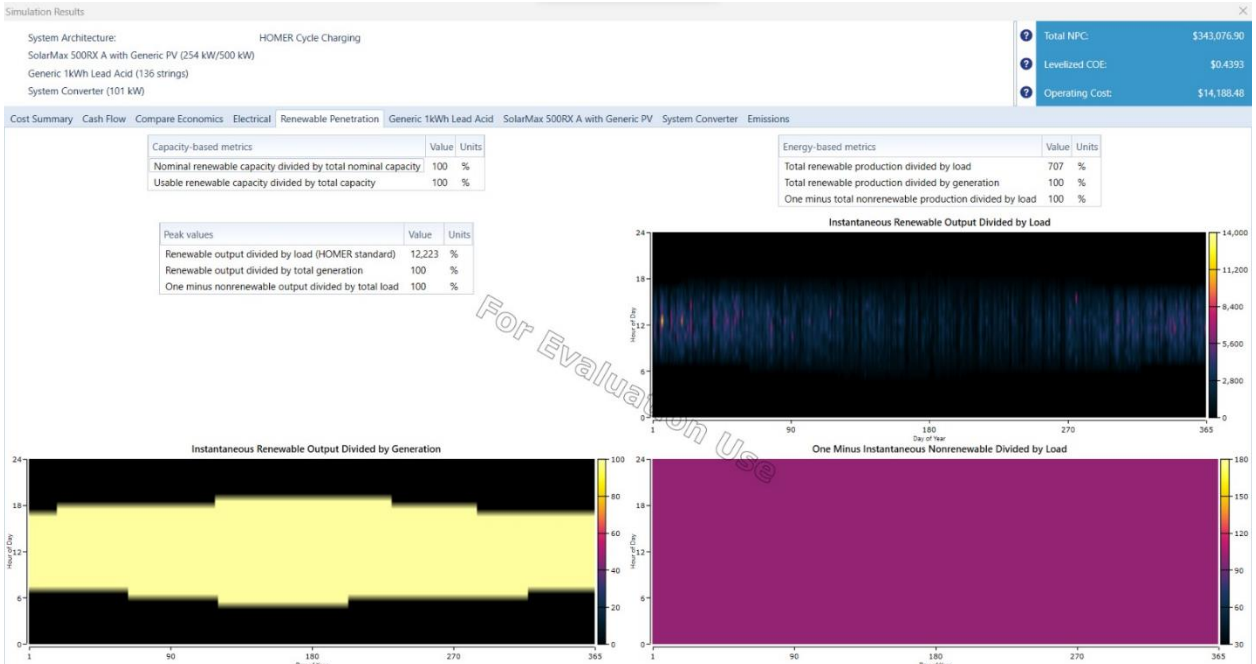


Figure 3.34: Renewable penetration

Emission

In this system there will be some emissions.

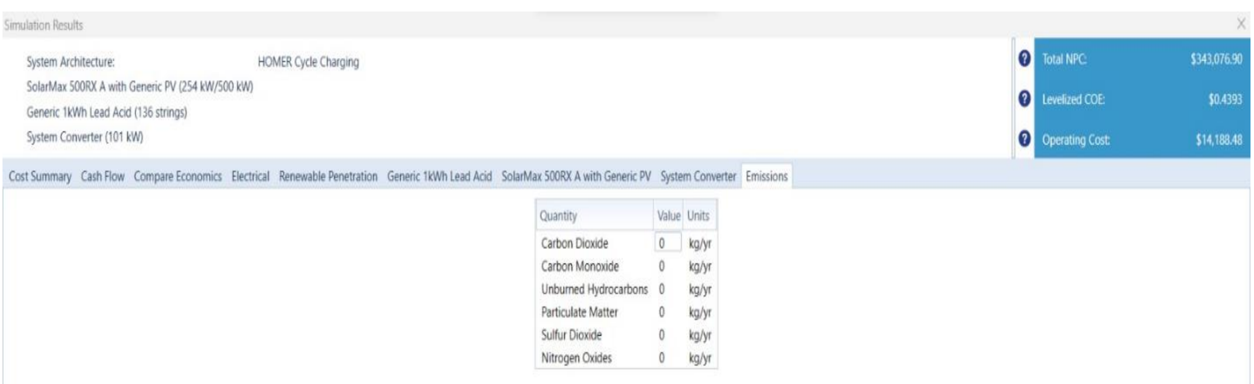


Figure 3.35: Emissions for this system

3.6.5 Cost Summary

After the simulation total Net present cost is $343076.95, Levelized COE is $0.4393 and Operating cost is $14188.48. Most of the money spends in Battery which is some money this system cost. But it can produce carbon free energy.

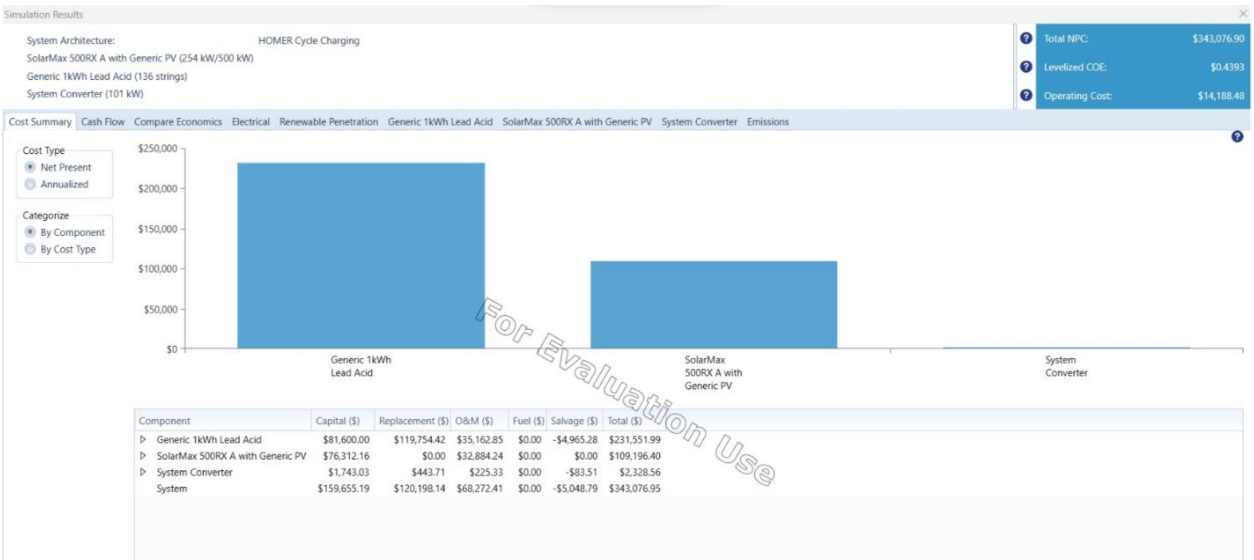


Figure 3.36: Cost summary

Cash flow

In this system capital is almost $150000, after several times salvage value is almost $25000.

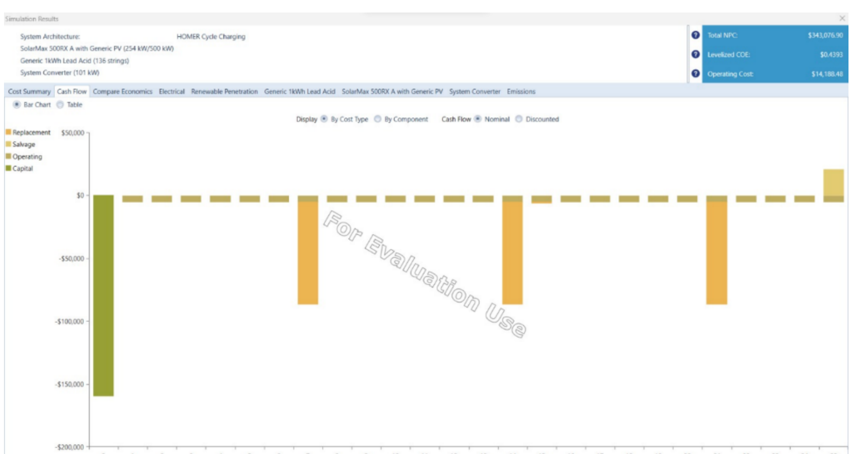


Figure 3.37: Cash flow

3.6.6 Compare Economics

For the current system we can compare with base system. In our current system which consists PV

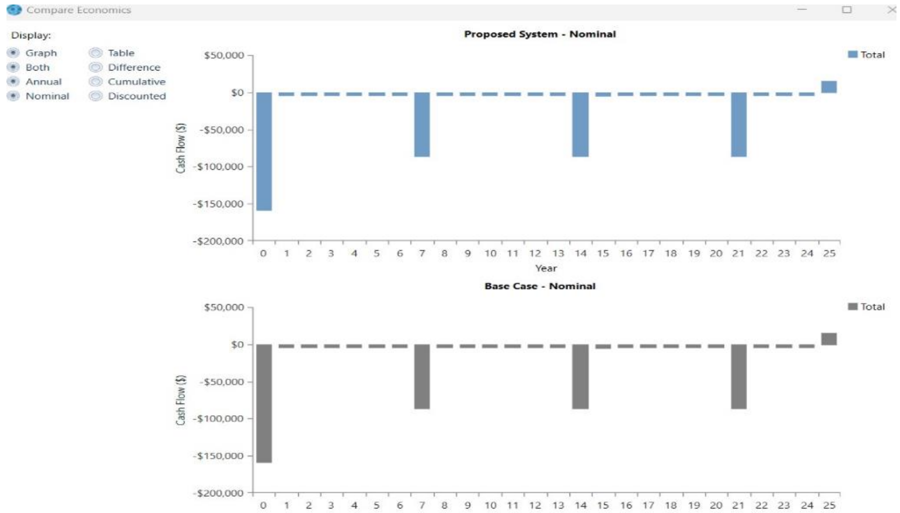


Figure 3.38: Proposed System and Base Case Nominal Compare

Table 3.14: Compare Economics

Compare Economics

Display: Graph, Both, Annual, Nominal, Table, Difference, Cumulative, Discounted

	Nominal Cash Flows						Discounted Cash Flows					
	Proposed System		Base System		Difference		Proposed System		Base System		Difference	
Year	Annual	Cumulati	Annual	Cumulati	Annual	Cumulati	Annual	Cumulati	Annual	Cumulati	Annual	Cumulati
0	-$159,655	-$159,655	-$159,655	-$159,655	$0	$0	-$159,655	-$159,655	-$159,655	-$159,655	$0	$0
1	-$5,281.1	-$164,936	-$5,281.1	-$164,936	$0	$0	-$4,987.7	-$164,642	-$4,987.7	-$164,642	$0	$0
2	-$5,281.1	-$170,217	-$5,281.1	-$170,217	$0	$0	-$4,710.6	-$169,353	-$4,710.6	-$169,353	$0	$0
3	-$5,281.1	-$175,498	-$5,281.1	-$175,498	$0	$0	-$4,448.9	-$173,802	-$4,448.9	-$173,802	$0	$0
4	-$5,281.1	-$180,779	-$5,281.1	-$180,779	$0	$0	-$4,201.8	-$178,004	-$4,201.8	-$178,004	$0	$0
5	-$5,281.1	-$186,061	-$5,281.1	-$186,061	$0	$0	-$3,968.3	-$181,972	-$3,968.3	-$181,972	$0	$0
6	-$5,281.1	-$191,342	-$5,281.1	-$191,342	$0	$0	-$3,747.9	-$185,720	-$3,747.9	-$185,720	$0	$0
7	-$86,881.	-$278,223	-$86,881.	-$278,223	$0	$0	-$59,261.	-$244,981	-$59,261.	-$244,981	$0	$0
8	-$5,281.1	-$283,504	-$5,281.1	-$283,504	$0	$0	-$3,343.0	-$248,324	-$3,343.0	-$248,324	$0	$0
9	-$5,281.1	-$288,785	-$5,281.1	-$288,785	$0	$0	-$3,157.3	-$251,482	-$3,157.3	-$251,482	$0	$0
10	-$5,281.1	-$294,066	-$5,281.1	-$294,066	$0	$0	-$2,981.9	-$254,464	-$2,981.9	-$254,464	$0	$0
11	-$5,281.1	-$299,348	-$5,281.1	-$299,348	$0	$0	-$2,816.2	-$257,280	-$2,816.2	-$257,280	$0	$0
12	-$5,281.1	-$304,629	-$5,281.1	-$304,629	$0	$0	-$2,659.7	-$259,940	-$2,659.7	-$259,940	$0	$0
13	-$5,281.1	-$309,910	-$5,281.1	-$309,910	$0	$0	-$2,512.0	-$262,452	-$2,512.0	-$262,452	$0	$0
14	-$86,881.	-$396,791	-$86,881.	-$396,791	$0	$0	-$40,422.	-$302,874	-$40,422.	-$302,874	$0	$0
15	-$6,326.9	-$403,118	-$6,326.9	-$403,118	$0	$0	-$2,684.3	-$305,559	-$2,684.3	-$305,559	$0	$0
16	-$5,281.1	-$408,399	-$5,281.1	-$408,399	$0	$0	-$2,116.1	-$307,675	-$2,116.1	-$307,675	$0	$0
17	-$5,281.1	-$413,680	-$5,281.1	-$413,680	$0	$0	-$1,998.6	-$309,673	-$1,998.6	-$309,673	$0	$0
18	-$5,281.1	-$418,962	-$5,281.1	-$418,962	$0	$0	-$1,887.5	-$311,561	-$1,887.5	-$311,561	$0	$0
19	-$5,281.1	-$424,243	-$5,281.1	-$424,243	$0	$0	-$1,782.7	-$313,344	-$1,782.7	-$313,344	$0	$0
20	-$5,281.1	-$429,524	-$5,281.1	-$429,524	$0	$0	-$1,683.6	-$315,027	-$1,683.6	-$315,027	$0	$0
21	-$86,881.	-$516,405	-$86,881.	-$516,405	$0	$0	-$27,573.	-$342,600	-$27,573.	-$342,600	$0	$0
22	-$5,281.1	-$521,686	-$5,281.1	-$521,686	$0	$0	-$1,501.8	-$344,102	-$1,501.8	-$344,102	$0	$0
23	-$5,281.1	-$526,967	-$5,281.1	-$526,967	$0	$0	-$1,418.3	-$345,521	-$1,418.3	-$345,521	$0	$0

Total Electric production in a year most productions in March which is 45 MWh. And lowest production in July which is 25 MWh. PV energy productions are 427358KWh in a year which is approximately 100% of the total production.

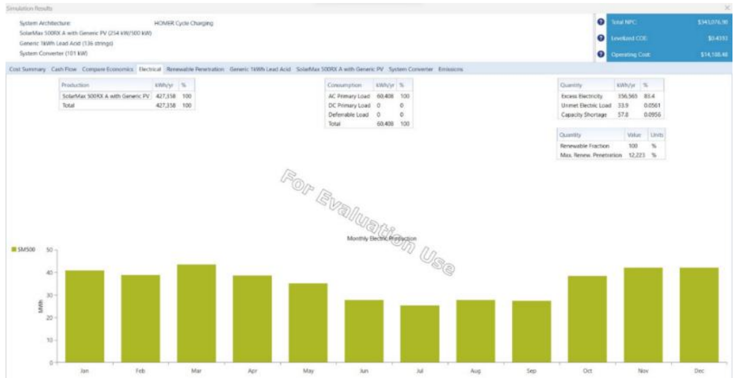


Figure 3.39: Electric production

3.6.7 Conclusions

Bangladesh is a small nation with the world's greatest population. The country with the densest population is Bangladesh, where 79% of people reside in rural areas. The growth of the electricity crises is the key issue. In general, nations are affected by the availability of unmet electrical demands. Fossil fuels are dependent on both privately owned and government-run power plants. There is not enough natural gas supply to satisfy demand. More significantly, the gas and oil reserves will be depleted once every day. We must therefore consider alternate sources of energy. An alternate energy source is solar energy. Rural and remote regions lack adequate power supplies, which usually handle issues wherever power has yet to be reached, particularly in some locations. The new power plant's components continue to spark attention. Hiring a sun-based energy can be a terrific opportunity and aid in determining the sun's liveliness over Bangladesh while taking care of the overall demand for energy. However, Sunflowers Home Framework is well known in Bangladesh. By constructing sun-based home structures, one can establish sturdy, dependable, environmentally friendly, and naturally life-sustaining systems. This has an influence on people's lives in Bangladesh's Matrix region by giving them access to extremely quick and unintended money. Electricity and irrigation problem solution in Rangpur Division area people in way of Solar Power Structure char area beside the Teesta barrage. Intraco Solar Power Ltd. started construction of a 30-megawatt power facility in the char areas last year as part of the government's goal to expanded accessing to power. Among the Beximco Group's subsidiaries is Teesta Solar Limited. When fully operational, the 200 MW facility in Gaibandha would surpass the 134.3 MW plant of Energon Renewables Ltd, a company of the industrial giant Orion Group, in Mongla as the largest solar-based power station in the nation. Intraco and Teesta Solar Limited Compare of this paper project daily solar power is one hundred thirty-six MW Generated by Electricity. The paper of project is more benefit of cost, area, human resource, electricity etc compare of the Intraco and Teesta Solar Limited power. For the project to be implemented, a cost study is crucial. For the industry of electricity generating, cost management is a crucial factor. Bangladesh needs to place more emphasis on the implementation of power plant costs. Government decision-making will be aided by cost analyses of electricity projects. So, hopefully problem solution of water in irrigation system, land development, electricity crisis and human life.

CHAPTER 4

WIND ENERGY

4.1 Introduction

4.1.1 Introduction:

As of my knowledge cutoff in September 2021, Bangladesh has been making efforts to develop its wind energy sector, although wind power currently represents a relatively small portion of its renewable energy mix. The country has been primarily focusing on harnessing its abundant solar energy resources, but there have been some initiatives to explore wind energy as well. Bangladesh has identified several potential wind energy sites, particularly in coastal areas and offshore locations. The coastal regions of Cox's Bazar, Feni, and Kuakata, as well as the offshore islands of Saint Martin's and Moheshkhali, have been identified as areas with favorable wind conditions for potential wind power projects. The government of Bangladesh has set a target to generate 10% of its total electricity from renewable energy sources by 2021, and wind energy is expected to contribute to this target. The Bangladesh Power Development Board (BPDB) has been working on identifying suitable locations and conducting feasibility studies for wind power projects. It's important to note that the development of wind energy in Bangladesh is still in its early stages compared to other forms of renewable energy, such as solar power. Factors such as the relatively low wind speeds in certain regions, limited experience in wind energy projects, and the need for appropriate infrastructure and investment have posed challenges to the rapid growth of wind power in the country.

Since my knowledge is not up-to-date, I recommend checking the latest developments and initiatives from reliable sources or government agencies for the most recent information on the wind energy scenario in Bangladesh. The Teesta River area in Bangladesh has the potential for wind energy development, but the viability of wind power projects depends on various factors, including wind resources, topography, infrastructure, and economic considerations[38]. To determine if wind energy will work effectively in the Teesta River area, a detailed assessment of the wind resources is necessary. Wind speed, direction, and consistency are critical factors for successful wind power generation. Wind resource assessments involve collecting data over an extended period to understand the wind patterns and identify optimal locations for wind turbines. Additionally, the topography of the area plays a role in wind energy feasibility. Obstacles such as hills, buildings, or dense vegetation can impact wind flow and potentially reduce the effectiveness of wind turbines. Conducting thorough site surveys and wind modeling studies can provide insights into the local topography and its impact on wind energy generation. Infrastructure is another important consideration. Wind power projects require an appropriate electrical grid infrastructure to transmit the generated electricity. The proximity of transmission lines and substations to the Teesta River area would be a crucial factor in determining the feasibility and cost-effectiveness of wind energy projects in the region.

Lastly, economic factors, including the cost of wind turbine installation and maintenance, the availability of financing options, and the potential return on investment, need to be carefully evaluated to assess the viability of wind energy in the Teesta River area. The Teesta River area in Bangladesh holds potential for wind energy development, offering an opportunity to harness clean and renewable power resources. Wind energy refers to the conversion of wind's kinetic energy into electrical energy through the use of wind turbines. By strategically placing wind turbines in areas with favorable wind conditions, such as along the Teesta River, the kinetic energy of the wind can be captured and converted into electricity. Wind turbines consist of large blades mounted on a tower, which spin as the wind blows. The rotational motion of the blades drives a generator, producing electricity. Introducing wind energy in the Teesta River area would involve conducting detailed assessments to evaluate the wind resources, which include factors like wind speed, direction, and consistency. These assessments help identify optimal locations for installing wind turbines to maximize energy production. Once the wind resource assessment is complete and suitable locations are identified, wind turbines can be installed along the Teesta River. These turbines would be connected to the electrical grid, allowing the generated electricity to be transmitted and distributed to consumers.

The benefits of wind energy in the Teesta River area include:

1. Renewable Power: Wind energy is clean and renewable, contributing to reducing greenhouse gas emissions and environmental impact compared to fossil fuel-based power generation.
2. Energy Diversity: Introducing wind energy adds to the energy mix, diversifying the sources of electricity generation and reducing dependence on conventional power sources.
3. Local Economic Development: Wind energy projects can create job opportunities during construction, operation, and maintenance phases. Additionally, the development of wind energy infrastructure can stimulate local industries and services.
4. Energy Security: Harnessing wind resources can enhance energy security by reducing reliance on imported fossil fuels and providing a domestic source of power generation.
5. Sustainable Development: Wind energy aligns with sustainable development goals, promoting a transition towards cleaner and more sustainable energy systems.

It's important to note that the successful implementation of wind energy in the Teesta River area requires comprehensive planning, including feasibility studies, environmental assessments, and engagement with relevant stakeholders. Additionally, addressing challenges such as wind intermittency, grid integration, and infrastructure requirements is crucial for the effective integration of wind power into the energy system.

4.1.2 Background

Our working place:

1. Teesta River both sides.
2. Dharla River both Side.

Wind energy is an environmentally friendly energy source that uses the power of the winds to produce electrical. It involves the use of wind turbine, which are tall structure that have large blades attached to them. The turbine's rotors rotate when the breeze strikes while it is via that rotary motion that energy is produced. Since wind power does not generate any pollution in the atmosphere or greenhouse gases, it is an environmentally conscious form of energy. Additionally, given the most dramatic decline in the price of producing power from windmills, it is a very cost-effective means of generating power.

Throughout the globe, wind energy is being employed more frequently to power buildings, businesses, and sometimes whole towns. It could play a big part in lowering our dependency on petroleum and coal and combating worldwide warming.

4.1.3 History of Wind Energy

Since ancient times, people have mostly employed wind power for tasks like chopping wheat, producing water, and navigating boats. The earliest known use of wind power dates back to around 5000 BCE, when ancient Egyptians used sails to move boats along the Nile River. Windmills were also developed in Persia around 500-900 CE, and were used to pumps waters and crush grains.

James Blyth created the initial wind turbine that could generate power in Scotland in 1887. The 33-foot-diameter blade of the first turbine produced sufficient electricity to run his family's house. In the following decades, wind turbines were developed and used primarily in rural areas to generate electricity for farms and ranches.

The shortage of oil in the 1970s raised curiosity in sources of alternative energy, such as wind power. Due to this, bigger wind turbines that could produce enormous quantities of energy were developed, and the initial industrial windmills emerged in California in the 1980s. Since then, wind energy has continued to grow in popularity and technological advancement, with many countries now generating a they use a considerable amount of wind energy to generate utility.

With turbines built all over the globe, wind energy is currently a fast-growing sector. It has grown into a significant component of the entire global energy mix that is anticipated to expand as an alternative form of green power in the upcoming years.

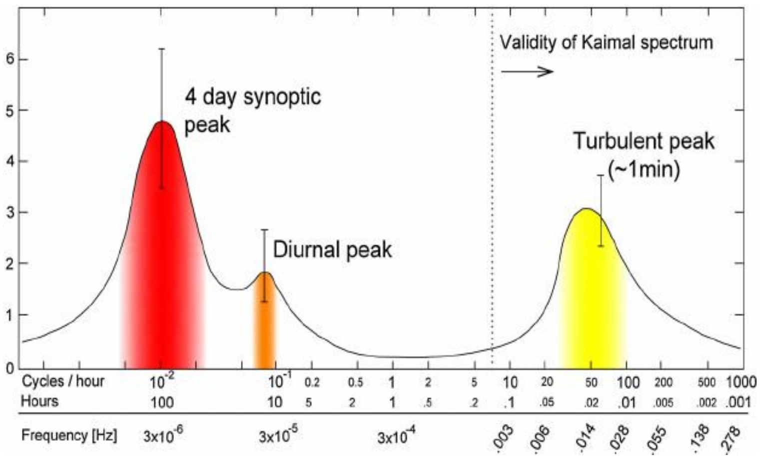


Figure 4.1: Wind Peak Load Carve [39]

Van der Hoven (1957) created a wind-speed spectrum from both permanent and immediate Brookhaven, New York recordings. The resulting spectrum clearly showed peaks that corresponded with the synoptic, nocturnal, and turbulence influences stated previously. It is clear due to the "spectral gap" that exists between daily and tumultuous peaks why these modifications can be treated quite distinct from atmospheric higher-frequency rhythms of the instability.

4.2 Analysis

Types of Wind Turbine

The two primary categories of turbines for wind power are: horizontal axis wind turbines (HAWTs) and vertical axis wind turbines (VAWTs).

1. Horizontal axis wind turbines (HAWTs).
   The most popular kind of windmill. They're composed of wings which revolve along a horizontal axis and a horizontally rotors spindle. HAWTs can be further categorized based on the number of blades, such as two-bladed, three-bladed, or more. Most commercial wind turbines used in large-scale wind farms are HAWTs.
2. Vertical axis wind turbines (VAWTs)
   They're composed of blades that revolve along a vertical axis and a vertical rotor spindle. Depending on how they shape, VAWTs may also be further classified into Savories, Darrius, or helical categories. In smaller-scale usage like homeowners related to agriculture, or disconnected structures, VAWTs are frequently utilized.

4.2.1 Vertical Axis Wind Turbines (VAWTs)

The nominal rating or electrical output of windmills can also be used to categorize them, with capacities that span just a few kilowatts to many megawatts.

There are benefits and drawbacks for both horizontally oriented wind turbines (HAWTs) and vertical axis wind turbines (VAWTs), including the best option depends on the specific application and location. HAWTs have higher efficiency and power output compared to VAWTs and are therefore more commonly used in large-scale commercial wind farms. They are able to be made with greater rotor dimensions, which will enable them to harness greater amounts of wind power [40]. HAWTs are also more versatile and can be designed to adapt to varying wind speeds and directions.

VAWTs, on the other hand, have some advantages in certain applications. They can operate effectively in turbulent wind conditions, and their vertical design makes them easier to install and maintain, especially in urban or residential areas where space is limited. VAWTs can also be designed to operate at lower wind speeds, which can be useful in some locations.

Overall, the best option depends on the specific application and location. For large-scale commercial wind farms, HAWTs are generally the preferred option, while VAWTs may be more suitable for smaller-scale or urban installations.

Advantage and Disadvantage of Vertical axis wind turbines (VAWTs).
The following are some of the advantages and disadvantages of vertical axis wind turbines (VAWTs):

Advantages:

- Low wind speed operation: VAWTs are suited for locations that have below average gusts of wind since they perform as well in smaller gusts than HAWTs.
- Operate in turbulence: VAWTs are capable of operating efficiently in turbulence, which might be prevalent in metropolitan or coastline settings.
- Easy maintenance: VAWTs are often easier to maintain and repair than HAWTs because the components are located closer to the ground.
- Small scale: VAWTs are frequently lower than HAWTs, which makes them appropriate for household or lower-scale uses.
- Visual impact: In comparison to HAWTs, VAWTs might have a smaller visual effect on the landscape around them, which renders them more appropriate for locations were aesthetically are valued.

Disadvantages:

- Lower efficiency: VAWTs have lower efficiency and power output compared to HAWTs, which can limit their use in large-scale wind farms.
- Limited scalability: VAWTs may be more difficult to scale up for large-scale applications.
- Higher maintenance costs: While maintenance may be easier for VAWTs, the frequency of maintenance required can be higher, which can lead to higher overall maintenance costs.
- Noise pollution: VAWTs can still produce noise that may be considered disruptive to nearby communities.
- Bird and bat mortality: VAWTs can pose a risk to birds and bats, particularly during migration seasons.

Overall, the advantages and disadvantages of VAWTs make them a suitable option for certain applications, such as smaller-scale or urban installations. However, their lower efficiency and power output compared to HAWTs limit their use in large-scale commercial wind farms. Careful consideration of potential impacts and suitability for the specific application and location is necessary when deciding whether to use a VAWT or HAWT.

VAWTs of several types

Persian Windmill:

- The first windmill to be installed was in Persia. Between the seventh and thirteenth centuries
- A.D. in Persia, Afghanistan, and China.
- It has a vertical axis and is a windmill.
- Grain was ground in this windmill to manufacture flour.

The Rotor VAWT:

- It was first patented in 1929 by S.J.
- Wind current is measured using it.
- 31% efficiency.
- Because the structure is omnidirectional, it is advantageous in areas wherein the wind frequently shifts angles.

Rotor VAWT:

- It has a cross-section like an airfoil and has two or three convex blades.
- A vertical shaft has the blades positioned symmetrically.
- Mechanical brakes are installed to restrict rotation speed.

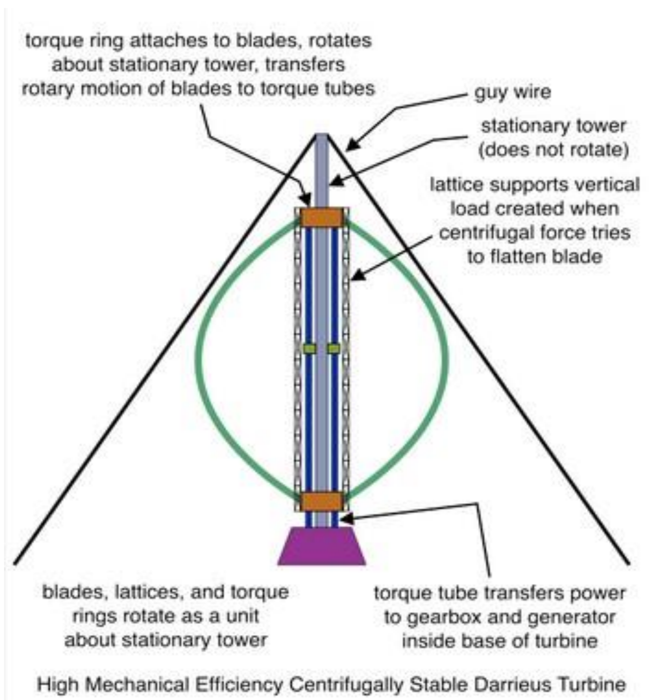


Figure 4.2: VAWT Rotor Design [41]

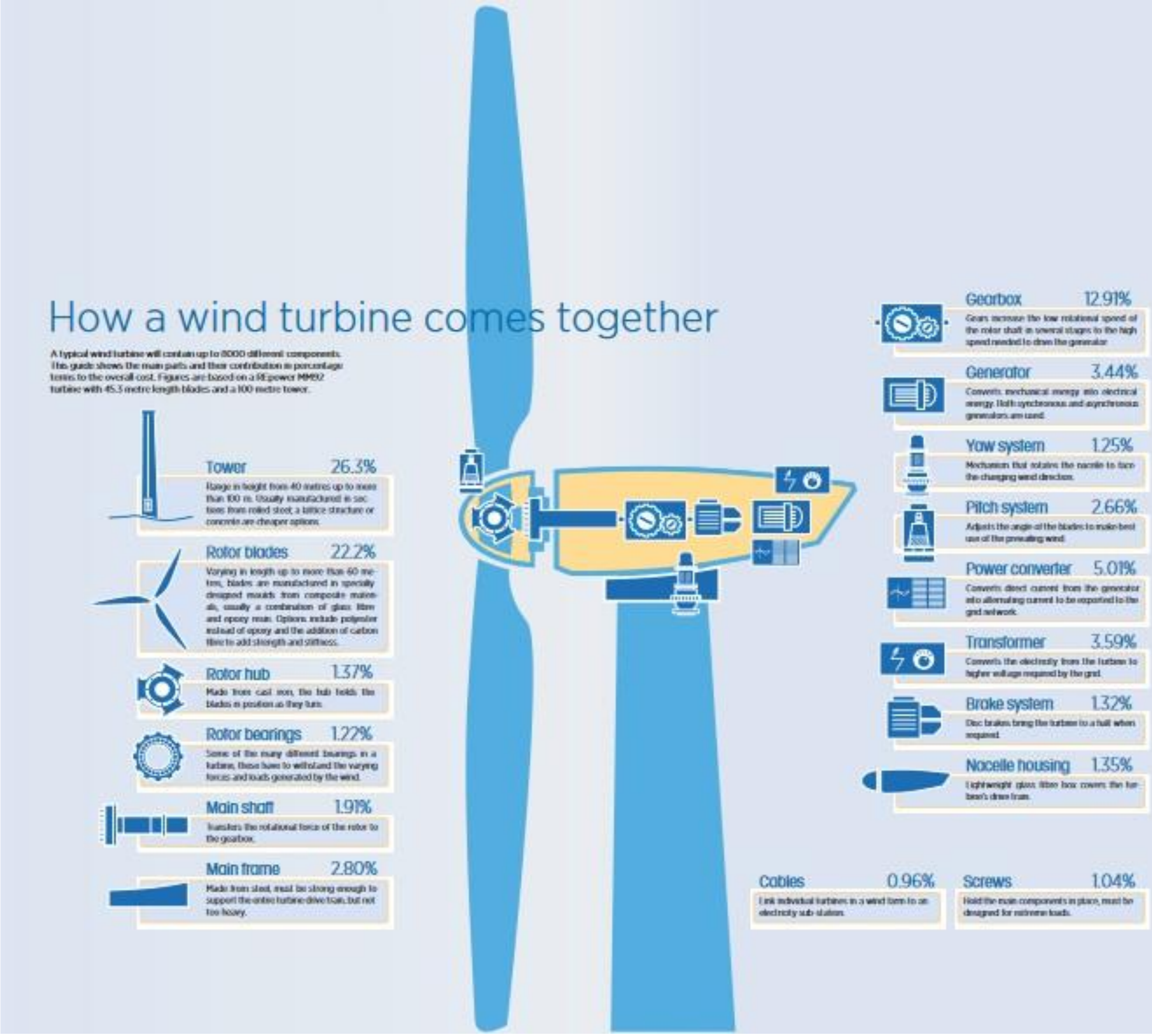


Figure 4.3: Wind Mechanism System [42]

4.2.2 The Horizontal Axis Wind Turbine

A wind turbine known as a horizontal axis wind turbine (HAWT) has its main rotational gear and generator of electricity oriented directly with the gusts of the wind. Its rotor's wings revolve about an axis that is horizontal and connect by a hub in the center.

The most popular kind of wind turbine utilized to generate electrical power for business is a HAWT. These are intended to use the lift to catch the power of the wind force generated by the blades as they rotate. The blades are usually made of fiberglass or carbon fiber and are designed to be aerodynamically efficient to maximize energy capture.

The rotation of the rotor is typically controlled by a pitch control system, it modifies the blades' angles of tilt to improve the generator's efficiency under various winds. The rotor's spin is then transferred to a gearing and power source, which transforms the whirling blades' energy from motion into electrical power[43].

HAWTs are available in a variety of dimensions, from tiny turbines for home or agricultural use to enormous rotors for use in wind power plants for commercial electricity generation. They have several advantages, including high efficiency and versatility, but also have some disadvantages, including noise pollution and visual impact on the surrounding landscape. Careful planning and consideration of potential impacts are necessary to ensure that HAWTs are created in a manner that is environmentally friendly and sustainable.

Advantage and Disadvantage of Horizontal axis wind turbines (HAWTs).

Here are some advantages and disadvantages of horizontal axis wind turbines (HAWTs):

Advantages:

- High efficiency: HAWTs can achieve higher efficiency and power output compared to vertical axis wind turbines (VAWTs).
- Versatility: HAWTs May be made to adjust to different wind speeds and directions, making them more versatile and effective in a wide range of locations.
- Established technology: HAWTs are a well-established technology with a long history of use, making them a reliable option for large-scale wind farms.
- Large-scale energy production: HAWTs are capable of producing significant amounts of energy, making them suitable for large-scale commercial wind farms.
- Lower maintenance costs: HAWTs are generally easier to maintain and repair than VAWTs, which can lead to lower maintenance costs over the lifetime of the turbine.

Disadvantages:

- Noise pollution: HAWTs can produce noise that may be considered disruptive to nearby communities.
- Visual impact: HAWTs can produce a striking visual effect. on the surrounding landscape, which can be considered unattractive by some people.
- Bird and bat mortality: HAWTs can pose a risk to birds and bats, particularly during migration seasons.
- High upfront costs: Installing a HAWT might come at a hefty upfront capital cost, making it more difficult for smaller-scale projects to get off the ground.
- Intermittent energy production: HAWTs are dependent on wind speed and direction, which can be variable and unpredictable, leading to intermittent energy production.

Overall, the advantages of HAWTs, such as high efficiency, versatility, and large-scale energy production, outweigh the disadvantages. However, careful planning and consideration of potential impacts are necessary to ensure that HAWTs are created in a manner that is ethical and environmentally friendly.

Types of HAWTs

- **Mono-Blade**

Features:

- They cost less and feature a lighter rotor.
- The blades are 15 to 25 meters long and constructed of metal, composite carbon fiber/fiberglass, laminated wood, and glass reinforced plastic.
- The plant has a service life of 30 years and produces power between 15 and 50 kW.

Advantages:

- Simple and lightweight design.

- Competitive price 3. Simple to set up and manage.

Disadvantages:

- For heavier loads, anchoring control is required.
- Unfit for ratings of power of greater wattages.

Applications:

- Irrigation of fields.
- Plants for desalinating seawater.
- The provision of electricity to remote loads and farms.

Twin-Blade HAWT

- These high-power units feed directly into the supply system; they are huge in size with an output of electricity in a variety of 1 MW, 2 MW, and 3 MW.
- These powerful devices are connected right away to the supply system.

3-Blade HAWT

- Both overseas and in India, wind farms with blade propellers have already been erected.
- Triple blades are fastened to the center on the rotating part. For regulating shaft velocity, blade tips include a pitch adjustment range of 0 to 30[44].
- Bearings are used for supporting the drive shaft.
- The rate of the generating shaft is changed via a gear ring.

4.2.3 The component of the HAWTs

A horizontal axis wind turbine (HAWT) has numerous major parts, including:

- **Rotor blades:** These blades are made to collect wind power and transform it to rotating power that is then sent to the engine. Three blades are what is considered a typical variety of scissors, while other numbers are possible.
- **Rotor hub:** The center part, that connects to the primary shaft, is where the edges of the rotor blades are fastened.
- **Main shaft:** The primary shaft, which is the centerpiece of a wind turbines, is responsible for transferring the rotational power from the rotating part to the generators.
- **Gearbox:** The gearboxes is in charge of accelerating the rotational blade to the generator's necessary velocity.
- **Generator:** Propeller motion is transformed into electricity by the engine. Usually, the power source is an asynchronous three separate phases motor.
- **Nacelle:** The gearbox, power source, and other parts of the breeze turbine are housed within the nacelle. Normally positioned on top of a tower with the nacelle can turn toward the wind.
- **Tower:** The tower, which may be constructed of concrete or steel, accommodates the wind turbine. Depending upon the size with the rotating the turbine, the rise of the tower may change.
- **Control system:** The blades of the wind turbine's efficiency is tracked by the management system, which additionally performs modifications to maximize effectiveness. Safety elements that guard against harm to the blades of wind turbines in high-wind situations can also be incorporated into the control system [45].

❖ These parts work together to transform the momentum of the breeze into generators of electricity that may be utilized to run buildings such as houses and companies.

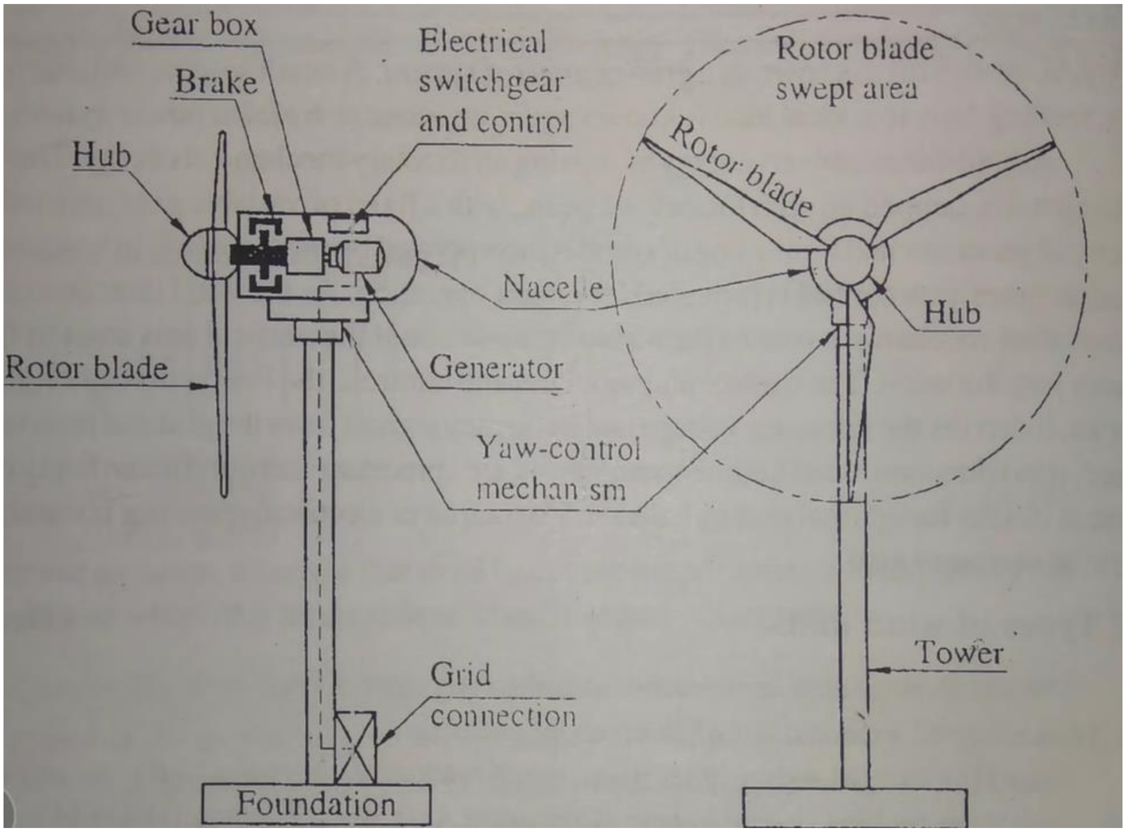


Figure 4.4: HAWTs Model

Calculation

Dynamism of a wind flow The overall power of a windy stream is given by Pt = m. (K.E.w) = 0.5m.Vi2.
Where,
m = mass flow rate of air, kg/s
Vi = incoming wind velocity, m/s
Air mass flow rate is given by
m = ρ^2**A**
Vi Where, ρ^2 = Density of incoming wind, kg/m^2 = 1.226 kg/m^2 at 1 atm, 15^o C
A = Cross-sectional area of wind stream, m^2

When we substitute the information above and take the variables into consideration, we get the subsequent result:

$$\boldsymbol{PW = 0.5\rho\pi R3\, Vw3\, CP(\lambda, \beta)}$$

Were,
Pw = extracted power from the wind,
ρ= air density, (approximately 1.2 kg/m3 at 20^0 C at sea level)
R = blade radius (in m), (it varies between 40-60 m)
V_w = wind velocity (m/s) (velocity can be controlled between 3 to 30 m/s)
Cp = the power coefficient which is a function of both tip speed ratio (λ), and blade pitch angle, (β) (deg.)

The ratio of the electricity compared to the energy accessible from the wind is known as the power coefficient (Cp).

Betz Limit

The potential cap placed on a wind turbine's performance is known to be the Betz limit. No windmill can transform more than 59.3% of the wind's energy that moves into shafts mechanical power, according to this statement. The permitted amount of Cp is thus constrained by the Betz limit. The effectiveness of an efficient rotor is between 35 and 45 percent.

Diameter of the Rotor:

The power produced is a helpful indicator because it is directly related to the cube of the rotor's size. Fundamentally, it depends on the relationship among the maximum amount of electricity that must be produced and the local average wind speed [46].

Power generated,

$P = \eta_e \eta_m C_p P_0$

$= 1/2 \eta_e \eta_m C_p A \rho V_\infty^3$ here, η_e= efficiency of electrical generation

$= 1/8 \eta_e \eta_m C_p \pi \rho V_\infty^3 D^2$ η_m= efficiency of mechanical transmission

In the absence of concrete data, the following empirical formulae can be used:

$P = 0.15 V_\infty^3 D^2$, for slow rotors

$= 0.20 V_\infty^3 D^2$, for faster rotors

The Number of Blades

Both the building and the functioning of a wind rotors depend on the quantity of propellers chosen. Smaller rotors might not be possible to catch as much wind power, and more blades are known to cause instability in the overall system. Therefore, each of these limitations ought to be used to estimate the total amount of blades, along with a thorough examination of its TSR dependency. So, for an n-bladed rotor spinning with an angular acceleration, we get the relationship that follows: Let ta represent the time it takes one of the blades to advance into the location that the previous sword formerly held relation:

$$t_a = 2\pi / n\omega$$

Once more, let tb represent the amount of time needed for the disturbed wind, caused through the blade' disruption, to dissipate and for normal airflow to once again prevail. Now, depending on how quickly or slowly the wind is moving, this will have a significant impact upon the wind speed. As a result, it is dependent on the velocity of the wind V and the total length of a significantly disturbed wind the road, say d. There it is:

$$t_b = d/V$$

ta and tb ought to be equivalent for optimal power the extraction process, therefore

$$t_a = t_b$$

- ✓ $2\pi / n\omega = d/V$
- ✓ $d = 2\pi V / n\omega$

d has to be determined empirically.

The pitch angle:

Pitch angle is determined by

α=I-i, where I denotes the relationship among the direction of the wind stream's and the rotors' speeds.

Power Speed Characteristics

$$P=0.5C_p A\rho V_\infty^3$$

As is common knowledge, Cp depends on both the TSR and the slope angle. The formula mentioned previously can be stated as follows for a turbine that generates electricity with radius R:

$$P=0.5C_p \pi R^2 \rho V\infty^3$$

Now as the TSR, $\lambda= \omega R/V_\infty$

For each wind velocity, the highest shaft generated electricity can be represented as:

$$Pm=0.5C_p\pi(R^5/\lambda^3)\ \omega^3\rho$$

- ✓ $P_m\ \alpha\ \omega^3$

Torque Speed Characteristics

We now understand the following relationship between the torque value and output curves:

$$Tm= Pm/\omega$$

Using the above value for $P_m=0.5C_p\pi(R^5/\lambda^3)\ \omega^3\rho$

We have, $T_m= P_m/\omega$

- ✓ $T_m=0.5C_p\ \pi(R^5/\lambda^3)\ \omega^2\rho$

It can be shown that the tension and velocity of rotation are exponentially connected to the Cp- curve's optimal functioning position.

4.2.4 Cost Analysis of HAWTs

A horizontal axis wind turbine's (HAWT) price can change according to a number of variables, including the turbine's dimensions, location, and costs for labor and supplies. These, however, constitute certain general price factors:

Equipment costs: The price of the components plays a significant role in the windmill's overall cost. That covers the price of the hub, a gearbox, the generator, nacelle, tower, and other parts. Given the dimensions of the generator, the machine's price may differ significantly.

Installation costs: The wind turbine's building expenses can be high as well. This includes the cost of site preparation, foundation, transportation, and assembly. The installation costs can vary depending on the location and site-specific conditions.

Operations and maintenance costs: Once a wind turbine is installed, there are ongoing costs associated with its operation and maintenance. These costs can include regular maintenance, repairs, replacement parts, and labor costs.

Financing costs: Financing costs, such as interest rates and loan origination fees, can also contribute to the total price of a windmill [47].

Government incentives: In some countries, government incentives such as tax credits, grants, or feed-in tariffs can cut the price of a wind turbine greatly.

Even though erecting a windmill is expensive in the beginning, it has a comparatively low cost of operation and can be a long-term provider of green power. Because of recent technological developments, the price of wind energy has been declining, and in years to come, it is anticipated to become even more economically-competitive with conventional energy sources that use fossil fuels.

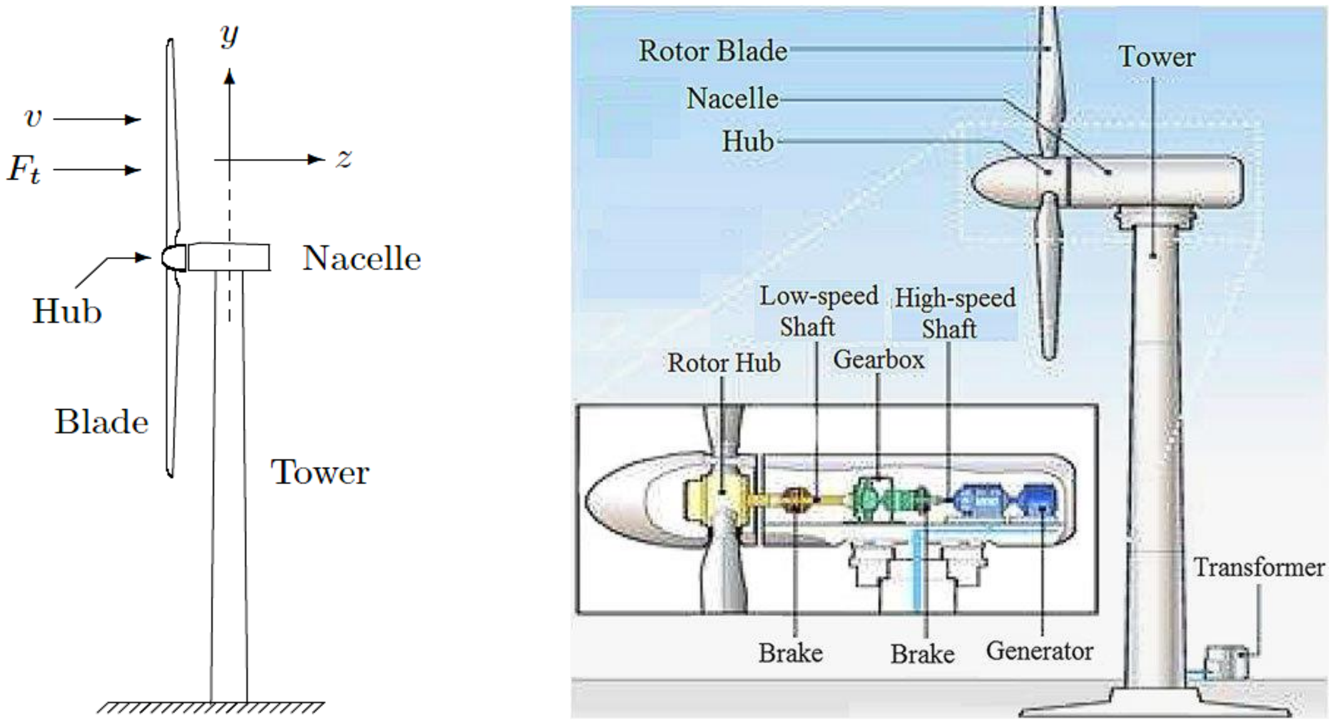


Figure 4.5 HAWTs Components

Some Cost Name:

- Installed cost
- Operating Cost
- The levelized cost of electricity
- There is an excellent chance for further savings in costs.
- In the medium-to long-term

The formula that follows is utilized to calculate the LCOE of renewable energy technologies:

Equation 1 LCOE Formula

$$\frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

I_t = Investment expenditures in year t (including financing)

M_t = Operations and maintenance expenditures in year t

F_t = Fuel expenditures in year t

E_t = Electricity generation in year t

r = Discount rate

n = Life of the system

Table 4.1: Impact of turbine size, rotor diameter, and hub height on yearly output

Generator Size, MW	Rotor, m	Hub Hight, m	Annual production, MWh
3.0	**90**	**80**	**7089**
3.0	**90**	**90**	**7497**
3.0	**112**	**94**	**10384**
1.8	**80**	**80**	**6047**

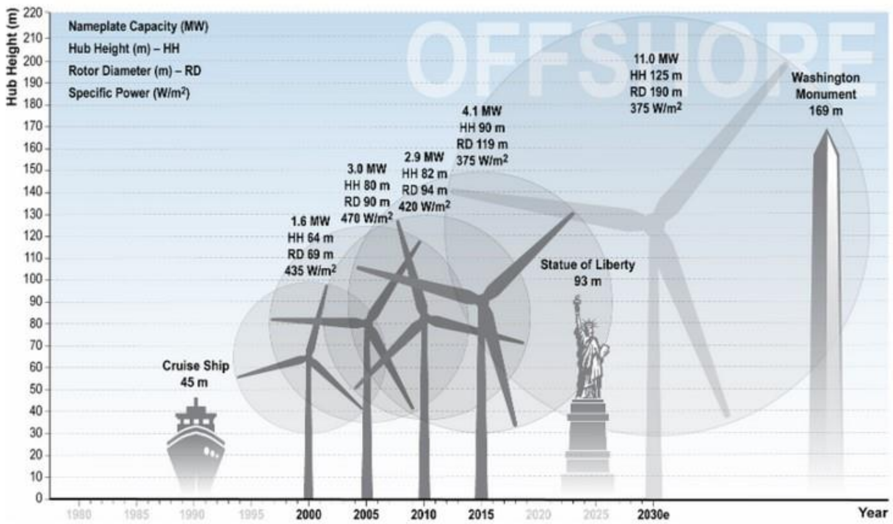


Figure 4.6 Wind Hub Hight

Table 4.2: Offshore Wind Power Systems' Capital Structure

Name	Share of total cost (%)	Cost (USD/KW)	Sub-Component	Cost Share of Sub-components (%)
Wind Turbine	**44**		**Nacelle Blades Gearbox Controller Rotor hub Transformer Tower Other**	**2 20 15 4 10 5 4 25 15**
Foundation	**16**			**-**
Electrical Infrastructure	**17**		**Small array cable Large array cable Substation Export cable**	**4 11 50 36**
Installation	**13**		**Turbine installation**	**20 50**

			Foundation installation Electrical installation	**30**
Planning and Development	**10**		**-**	
Total	**100%**		**-**	

Table 4.3: An offshore 3MW geared turbine's cost breakdown

Tower	15%
Marinization	12%
Blades	12%
Hub	3%
Pitch mechanism and bearings	3%
Spinner, Nose Cone	0%
Low speed Shaft	2%
Main bearing	1%
Gearbox	15%
Mechanical brake, HS coupling	0%
Generator	8%
Variable-Speed Electronics	10%
Yaw drive and bearings	2%
Main frame	6%
Electronic Connections	6%
Hydraulic, Cooling System	2%
Nacelle Cover	1%
Control safety System, Condition Monitoring	2%

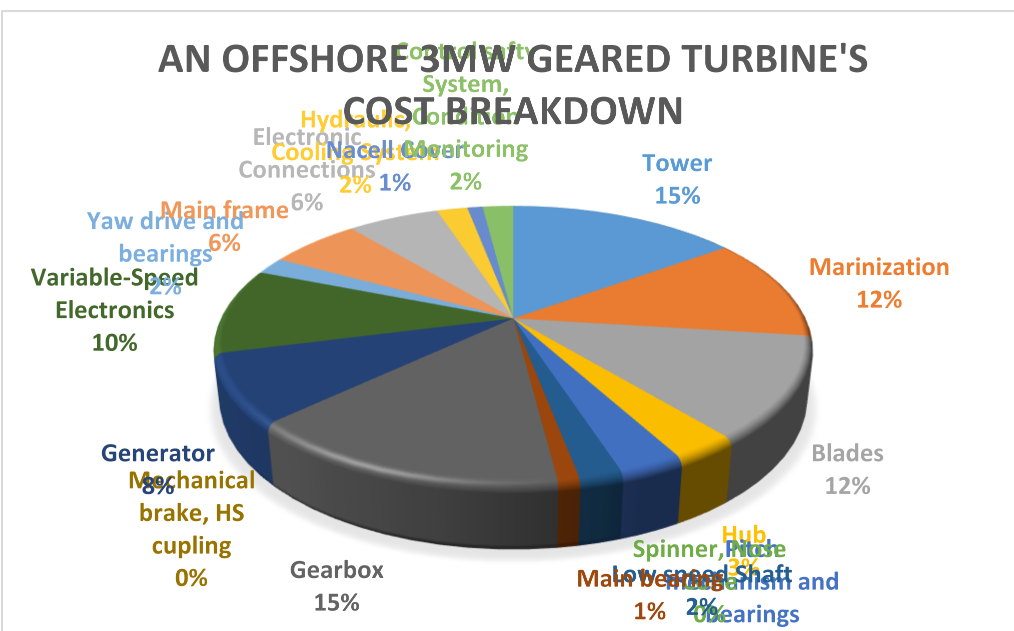


Figure 4.7: An offshore 3MW geared turbine's cost breakdown

4.2.5 Energy Security

In order to satisfy social requirements, there must be an ongoing and dependable source of power. It is crucial to both environmentally friendly growth and politics, economy, and safety. A broad and healthy economic mix, less reliance on international energy supplies, encouraging energy utilization and preservation, and expanding the use of clean energy sources are all ways to attain energy independence.

Energy security is important for several reasons:

Economic stability: Energy is a critical input to many economic activities, and interruptions in energy supply can lead to disruptions in economic activities and negatively impact economic growth.

National security: A reliable and secure energy supply is essential for the functioning of essential services such as healthcare, emergency services, and national defense.

Environmental sustainability: Dependence on fossil fuels can lead to environmental degradation and climate change. A diversified energy mix with an increased Utilizing sources of sustainable energy can lessen the emission of greenhouse gases and slow down global warming.

Energy access: Energy security also includes ensuring access to energy for all members of society, including those in rural or remote areas, and low-income households.[48]

To achieve energy security, governments and private organizations can take several actions, such as power promotion, energy utilization enhancement, creation of technologies for storing electricity, and investment in green resources conservation. Energy security can also be enhanced through international cooperation and collaboration, including sharing best practices and technologies and increasing energy trade and cooperation among nations.

Effect of Energy security in wind Energy

Wind energy plays a crucial role in enhancing energy security by providing a clean, renewable, and domestic source of energy. Here are some of the effects of energy security on wind energy:

Diversification of energy sources: By offering a substitute for conventional fossil fuels like coal, oil, and natural gas, wind energy contributes to the electrical power mix's diversification. Wind power can improve energy security and lessen the susceptibility of power systems regarding supply interruptions by lowering reliance on these foreign and import commodities.

Reduced price volatility: The price swings of petroleum and natural gas, which are influenced by shifts in demand as well as supply, international disputes, and other variables, do not apply to wind energy. Security of supply and price volatility can both be improved by using wind energy as a dependable and predictable source of electricity.

Domestic resource: One home alternative that can lessen reliance on power from abroad is wind energy. Utilizing wind energy allows nations to become less reliant on foreign energy imports, improving energy security and lowering geopolitics risks.

Reduced environmental impact: Wind energy has a lower environmental impact compared to traditional fossil fuels. Wind turbines release no greenhouse emissions or air pollution, and the land use requirements for wind farms are relatively low compared to other forms of energy production. By reducing environmental risks and enhancing sustainability, wind energy can enhance energy security in the long term.

By varying the power mix, lowering fluctuations in prices, and encouraging domestic generation of energy, wind power can significantly contribute to improving security of energy. As a result, policies and expenditures that encourage the creation and widespread acceptance of wind power technology can contribute to improving the availability of energy and lowering the risks related to interruptions in the supply of power.

4.2.6 Energy Safety

In order to protect individuals, property, and the surroundings, energy must be produced, distributed, and used in a safe manner. It encompasses the safe operation power facilities and infrastructure, including power plants, refineries, pipelines, and storage facilities, as well as the safe use of energy in homes, businesses, and transportation.

Energy safety is essential for several reasons:

Protection of human life and health: Energy-related accidents can have serious consequences for human life and health. Ensuring the safe production, distribution, and use of energy can help prevent accidents and minimize their impact on people.

Protection of property and the environment: Energy-related accidents can also damage property and the environment. By ensuring energy safety, the risk of such incidents can be reduced, and the impact of any accidents can be minimized.

Economic stability: Energy-related accidents can disrupt economic activities and negatively impact economic growth. Ensuring energy safety can help prevent disruptions and maintain economic stability.

Public confidence: Energy safety is essential for maintaining public confidence in the energy sector. When people are confident that energy is being produced, distributed, and used safely, they are more likely to aid in the growth and growth of energy technology and infrastructures.

Governments and private organizations may undertake a number of steps toward achieving power security, including enforcing security regulations and norms, carrying out safety examinations and audits, funding the creation of innovative safety methods, and offering training and information on power safety. It is feasible to provide a reliable and secure supply of electrical power while safeguarding individuals, possessions, and ecosystems by placing a high priority on energy protection.

Wind Energy Role of Energy Safety

In numerous ways, wind power may significantly improve energy security:

Reduced risk of accidents: Wind power lacks the delivery or storage of dangerous fuels or substances, in contrast to conventional energy sources that depend on fossil fuels. This reduces the risk of accidents related to transportation or storage of fuels, such as spills or explosions.

Lower risk of catastrophic events: Wind energy does not involve the risk of catastrophic events such as oil spills or nuclear accidents, which can have severe consequences for human life, property, and the environment.

Minimal impact on the environment: Wind energy has a minimal impact on the environment compared to traditional energy sources. When opposed to other generation methods, wind energy facilities use comparatively less land because they don't produce any carbon dioxide or air pollution. This lessens the chance that energy production may harm the environment.

Reliability and stability of supply: Wind energy can enhance energy safety by providing a reliable and stable source of energy. Wind turbines can operate for long periods without interruption, reducing the risk of power outages or disruptions to the energy supply.

Improved resilience: Wind energy can enhance the resilience of energy systems by providing distributed sources of power which are less susceptible to interruptions in circulation or natural calamities.

Wind energy can play an important role in enhancing energy safety by reducing the risk of accidents, minimizing the impact on the environment, and providing a reliable and stable source of energy. As such, policies and investments that promote the development and deployment of wind energy technologies can help enhance energy safety and reduce the risks associated with traditional energy sources.

4.3 Statistics

4.3.1 National incentive programs in wind power

China has put in place a number of nationwide incentives to encourage the growth of wind energy. These are a few instances:

Feed-in Tariff (FIT) program: The Chinese government has implemented a FIT program that provides subsidies for wind power generation. Under this program, wind power projects that meet certain eligibility criteria are guaranteed a set value for the electrical energy they produce, aiding in the growth of fresh wind power initiatives. Renewable Portfolio Standard (RPS): A nationwide RPS system has been put in place in China, requiring utilities to produce a specific amount of their output from environmentally friendly sources such as wind turbines. This initiative contributes to the growth of the market for wind energy along with additional sources of green energy. Governments financing: The Chinese government has contributed significantly to the advancement of wind power, particularly through incentives for wind turbine construction. and support for research and development of new wind power technologies. Tax incentives: The Chinese government has also implemented tax incentives to encourage investment in wind power, including tax exemptions for wind power equipment and reductions in corporate income tax for wind power companies. Renewable Energy Development Fund (RED): The Chinese government has established the RED Fund, which provides financial support for renewable energy development projects, including wind power. These incentive programs have helped to create a favorable environment for wind energy advancements in China, and they have assisted with the country's wind energy sector increase significantly throughout the previous ten years.

4.3.2 Increased Expansion Rate in China

China has been increasing its wind power expansion rate in recent years. In fact, China is currently the greatest wind energy generator in the world. China constructed 52 GW of offshore wind energy production in 2020, making up more than 50% of all deployments worldwide, reported to the International Wind Energy Association.

By 2030, the Chinese government hopes to have built 1,200 GW of energy generated from renewable sources, out of which 26% is anticipated to be sunlight. wind power. In order to achieve this target, China is actively promoting wind power development through a variety of measures, including policy support, investment incentives, and technology innovation.

The intermittent nature of wind energy, as well as the requirement for better integration into the grid with battery backup capacities, are obstacles that must be overcome in order for wind energy to be developed in China. To get around these obstacles and support the ongoing development of wind electricity in the People's Republic the Chinese government as well as private sector stakeholders are constantly cooperating.

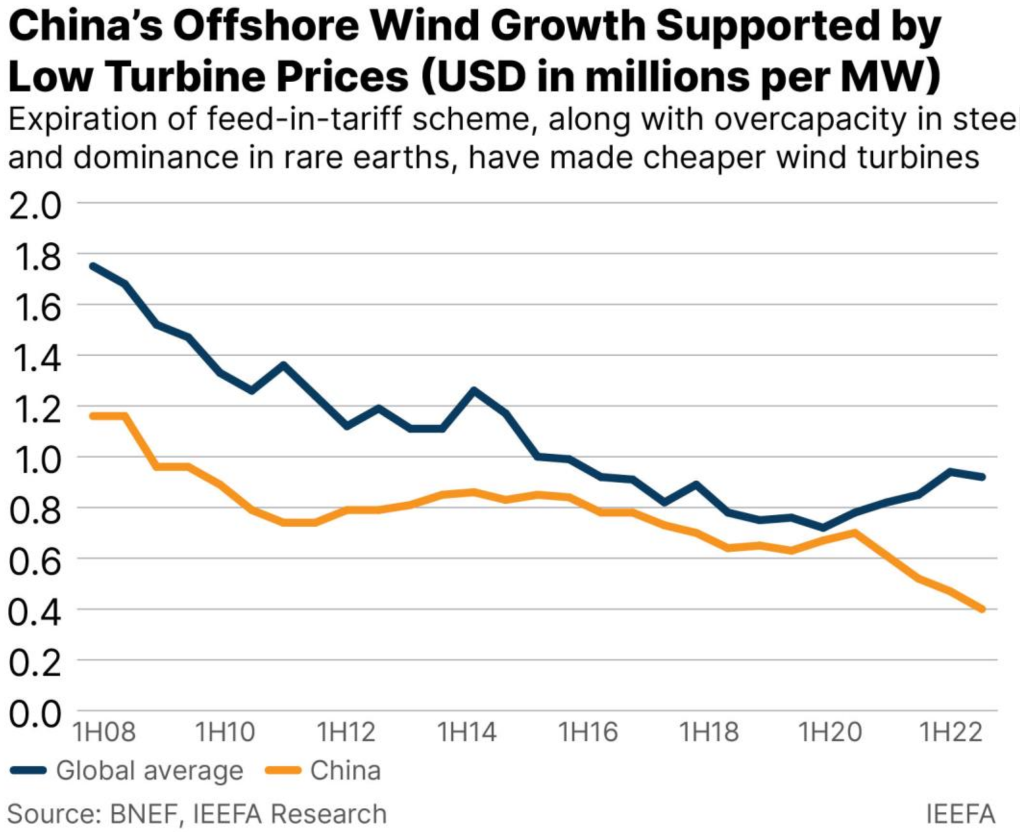


Figure 4.8 China Wind Growth Carve [49]

The following represent a few significant figures regarding China's increase in wind energy from 2010 to 2020:

China had a 42 GW operational wind energy potential in 2010. China's total solar energy capacity increased to 281 GW by the end of 2020. Between 2010 and 2020, China increased its capacity for wind energy by a typical of 22 GW year. In 2010, 2.5% of China's electrical power was produced by wind energy. By 2020, 10% or so of China's total generated electricity came from wind energy. In 2020, China alone erected 52 GW of wind energy capacity, making up over fifty percent of all deployments worldwide. In terms of wind generating capacity, Mongolia's innermost region, Gansu, Xinjiang, and Hebei became among the best four regions in 2010, and they maintained the position of leaders. Shandong completes the top five in 2020, with. Over the past ten years, wind energy's cost in China has drastically fallen, enhancing its ability to compete with other energy sources. The levelized cost of wind energy in China fell from $121 per megawatt-hour in 2010 to $77 per megawatt-hour in 2020, according to the National Renewable Energy Laboratory. In recent years, China has also made investments in offshore wind energy with the aim of installing 10 GW of offshore wind energy by 2025.

Over the last ten years, China has been quickly increasing its renewable energy capability, and it now has the largest installed wind power capacity in the world. These are a few figures on the development of wind turbines in China: China had 281 GW of built wind turbines as of 2020, which is over one third of the amount of developed capacity for wind power worldwide. China increased its renewable energy production by 52 GW in 2020, a greater increase than every other nation on earth. 10% of all the electrical power produced in China in 2020 came from wind energy. By 2025 and 400 GW by 2030, respectively, are the wind power capacity goals stated by China. China's five windiest regions are the Inner Mongolia, Gansu, the Xinjiang, Hebei, and Jiangxi. plus, Shandong. During the past ten years, China's windy power sector has expanded quickly. Numerous significant domestic corporations, including Goldwind, Envision, and MingYang, are engaged in the creation and production of wind energy. With a goal of installing 10 GW of wind power on the seafloor by 2025, China is additionally making investments in marine wind energy recently.

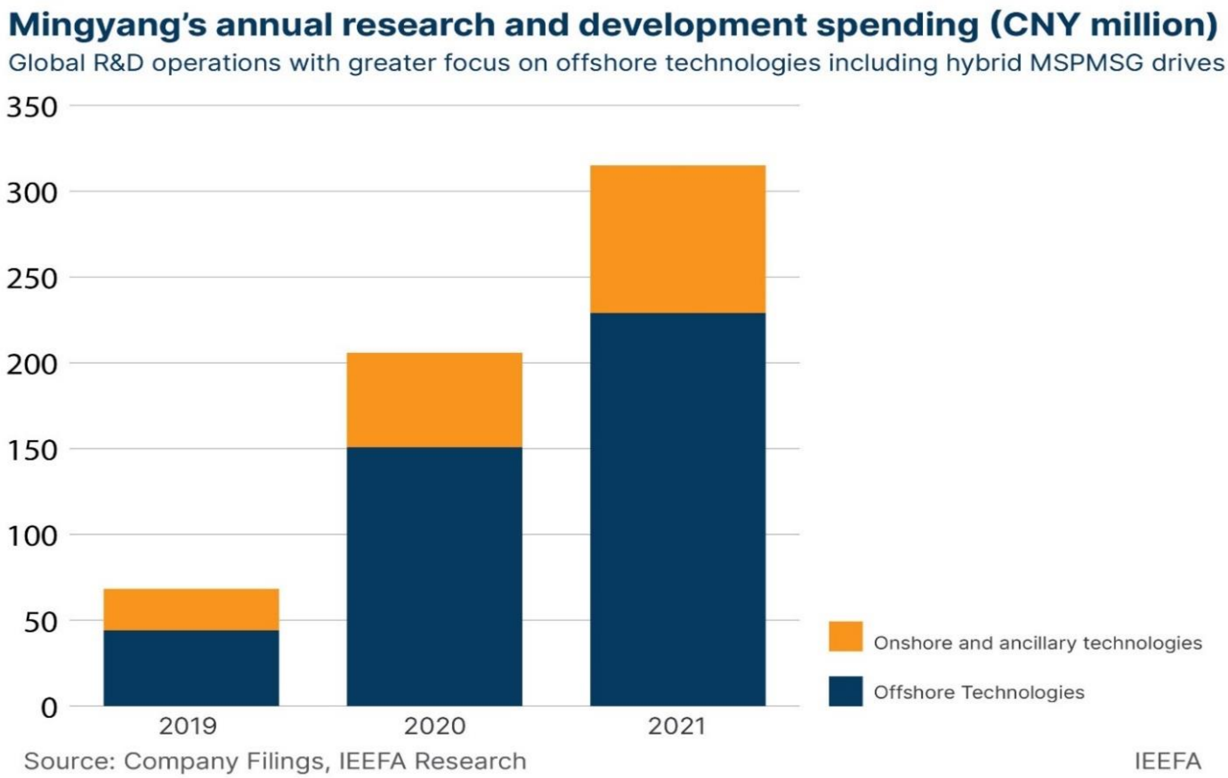


Figure 4.9: CNY IEEFA Research Score [50]

The well-funded international development of Mingyang might increase the availability of offshore wind energy globally.

IEEFA Asia, September 5: China said in 2019 that the offshore wind feed-in tariff program will terminate in 2021 and switch to an auction. China added about 17 gigawatts (GW) on its own in 2021 as a result of this policy move, which was the most the world has ever added in a single year. The greatest offshore wind industry in the world is now found in China. The country's increase in offshore wind capacity from 2010 to 2020 accounted for 32% of the overall worldwide expansion. One out of every five offshore wind turbines constructed between 2020 and 2022 will be a Mingyang type, made by China's largest private wind turbine producer. The fast rise of Mingyang and China is examined in a new paper by Energy Finance Analyst Norman Waite of the IEEFA. "Mingyang's overseas expansion could drive turbine sizes higher, wind farm development prices lower, and benefit the supply of offshore wind power in many markets around the world," claims Waite.

4.3.3 GWEC (Global Wind Energy Council)

The National Energy Administration (NEA), which revealed China's 2020 new wind power capacity numbers yesterday, is genuinely impressive. According to the NEA, a startling 71.7 GW of new wind capacity was added last year, considerably exceeding GWEC's Q3 2020 projections and surpassing China's previous annual growth record.

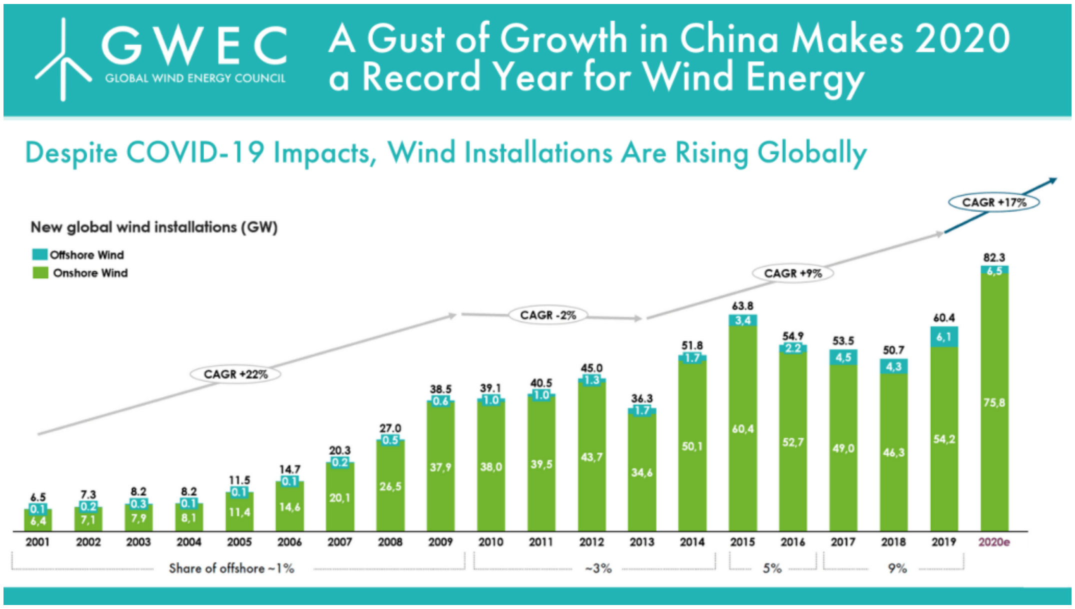


Figure 4.10: GWEC New Global Wind Installations [51]

Wind firms and industry observers have been responding to these findings with a mix of astonishment and wonder, said Ben Blackwell, CEO of GWEC. When annual global wind installations in 2010 totaled barely 39 GW, it would have been inconceivable ten years ago for one market to supply this much power. The results for China's wind installations, however, provide as yet another example of the wind energy sector's resilience in the face of COVID-19 and the potential for development that can be achieved when size and governmental commitment are combined. It should be noted that the 71.7 GW statistic does not necessarily refer to the year that wind turbines were erected, but rather the overall grid-connected capacity in China in 2020. A GWEC member from China, the Chinese Wind Energy Association (CWEA), predicts that by the conclusion of 2019, 26.3 GW of wind power that had been generated had already been connected to the grid. This capability was therefore considered in the NEA's 2020 forecasts. In China, the new grid-connected wind power capacity for 2020 would be 45.4 GW if this latent volume were excluded. The installation of 45.5 GW is still a tremendous accomplishment and would still constitute a record year for the Chinese wind business. Nearly as much energy was installed internationally in 2018 as this quantity. 2020 is predicted to be an all-time high for winds development featuring a predicted 82.3 GW of new wind producing capability worldwide, which marks a 36% increase in installments over the company's Q3 2020 forecast for China, based on early estimates by GWEC. increase in installations year over year. The worldwide wind sector is now on pace to grow, and we anticipate seeing similar installation levels in 2021, according to GWEC Market Intelligence.

4.3.4 IRENA (International Renewable Energy Agency)

The International Organization for clean energy is known as IRENA. It is a non-profit organization whose mission is to encourage the global uptake and responsible application of alternative power sources. With its headquarters in Abu Dhabi, United Arab Emirates, IRENA was established in 2009. As of 2021, the organization had 166 member nations, including the European Union. . IRENA serves as a platform for international cooperation and information exchange on renewable energy, and provides technical and financial support to countries seeking to expand their use of renewable energy.

Some of the key activities of IRENA include:

Providing policy advice and technical assistance to member countries on renewable energy policy and planning.

Conducting research and analysis on renewable energy technologies and markets, and producing reports and statistics on renewable energy deployment.
Facilitating partnerships between governments, private sector entities, and other stakeholders to promote renewable energy investment and development.
Supporting the development of renewable energy infrastructure, including the deployment of off-grid renewable energy systems in rural and remote areas.
Hosting international events and workshops to promote awareness of renewable energy and share best practices and lessons learned.
IRENA is widely regarded as a pioneering international body in the area of green energy, and it has a significant impact on the direction of international clean energy investments and regulation.

4.3.5 Support for technical development in wind power

There are a variety of institutions and programs that support technical development in wind power. Here are a few examples:
Wind turbines is one of the green energy technologies that the National Renewable Energy Laboratory (NREL), a U.S. federal research lab, is studying and developing. The Wind Energy technology Office at NREL promotes studies regarding cutting-edge turbine technology, as well as work on evaluating wind resources, integrating wind power systems, and developing and evaluating winds.

The International Energy Agency (IEA) Wind Innovation Cooperation Project is a worldwide academic partnership with the objective of accelerating the growth of wind power systems. The program undertakes research on many different aspects of wind electricity, such as the layout of wind turbines, the evaluation of wind resources, and the incorporation of wind electrical systems.

EWEA, the European Wind Energy Association: The EWEA is a trade group for companies and associations working in the wind power sector in Europe. The organization promotes initiatives and policies that increase the use of wind power throughout Europe and supports studies and developments on wind energy technology.

Wind Energy Research Center (WERC): The WERC is a research center based in China that focuses on wind energy technology development. The center conducts research on advanced wind turbine designs, wind resource assessment, and wind power system integration.

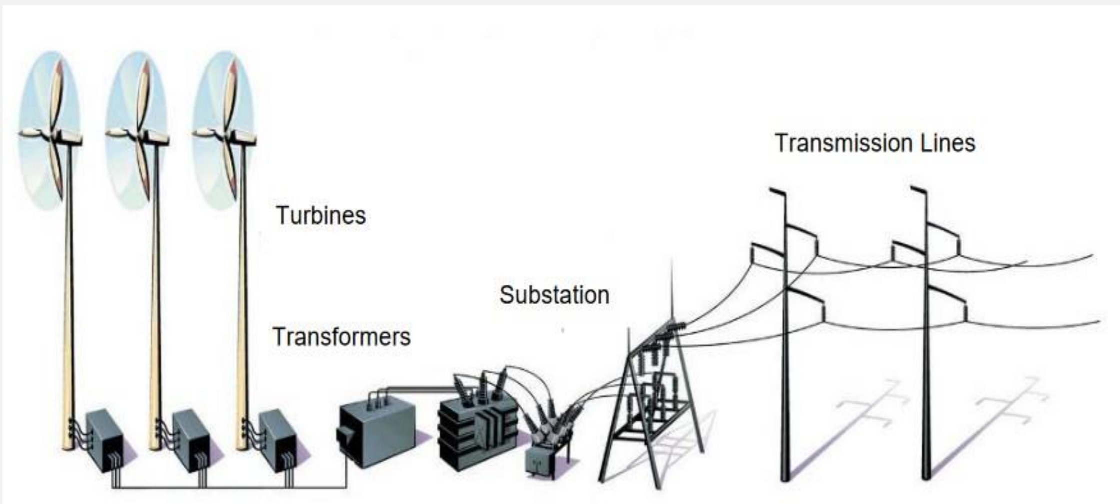
Wind Energy Institute of Canada (WEICan): WEIC and is a research organization based in Canada that carries out research and development work on wind power solutions. The company runs a wind energy evaluation and study center that offers various accreditation and testing solutions for windmills and other renewable energy technology.

These organizations and initiatives have a significant impact on the advancement of wind energy technology development and global wind energy implementation.

4.4 Power Component

Alternating Current (AC)	A cycle or periodic reversal in the direction of an electrical current. The American standard is 60 cycles per second, or 120 reversals. Most of the world's electrical networks utilize alternating current (AC) power because it is very simple to manage the voltage, enabling electricity to High voltage signals are sent across great distances before being lowered for usage in households.
Direct Current (DC)	**A** particular kind of electricity that flows through a circuit exclusively in one direction, frequently at a high flow and low power. To be used for typical 120- or 220-volt appliances, DC must be transformed to AC, which is the reverse. For

	transfer and use in households and businesses, a great deal of batteries, solar cells, and turbines first produce direct current (DC), which is then changed to alternating current (AC).
Efficiency	Shows the ratio of the amount of wind-generated electricity that the turbine collects to the amount of electrical power that is currently being generated.
Grid-Connected System	A working from home power system, including photovoltaic cells or wind turbines, that serves as a central producing station and supplies electricity to the industrial grid.
Inverter	A device that converts electricity from direct current (DC) into alternating current (AC), either for use in independent applications or for running a grid of electricity.



Load	When discussing wind energy initiatives, the expression "load" relates to the demands for energy placed on a power plant in addition to the electricity used by an array of consumers or a group of devices. frequently expressed in amps or watts.
Megawatt (MW)	A typical unit of measuring for the capacity to produce energy is one million watts (W) or one million kilowatts (kW). Big utilities size turbines for wind power typically have an output ranging from 900 kW to 2 MW.
Megawatt-Hour (MWh)	Energy consumed if labor is done for an hour at a typical rate of 1 million watts.
Renewable Portfolio Standards (RPS)	legislation that mandates that a specific amount of the energy used by electrical providers come from natural sources. An RPS about was approved in 2008 mandates that 10% of Michigan’s electricity be derived through sources that are clean by the year 2015.
Storage Battery	Also known as a battery with a charger. may convert power into an electrical signal to a biochemical form, while the other way around. When output is at its highest, power may be temporarily stored in chemical form and released, using a connection to turbines.
Substation	A structure that adjusts the voltage of utility power lines. Where power is transmitted across great distances, the voltage is raised. Where the electricity enters local distribution lines, it is stepped down.
Transformer	Wire coiled on a laminate core in several separate coils. uses magnetic induction to move electricity from one circuit to another, commonly to step up or decrease voltage. only functions with AC.

4.4.1 Wind Turbine Generators

Generators called wind turbines use the motion energy of wind energy to produce electricity. They are an essential part of wind power installations and are frequently mounted on top of windmills to collect wind energy. A rotor with two or three blades is used by wind turbine generators to catch the wind. A shaft that is attached to a generator rotates as a result of the wind blowing across the blades. The electricity is produced by the shaft's rotation and either sent to the power grid or stored in battery. Synchronous and asynchronously generators are the two primary kinds of wind turbine generators. In large-scale renewable energy systems, synchronous power plants are commonly working, and they are created to must run at a constant speed that is coordinated with the current grid's frequency. One the other hand, asynchronously generators, which are built to operate at varying speeds, are often employed in small-scale wind generating systems. Small windmills that can power just one home are available, as are gigantic wind turbines that can produce many megawatts of electricity. A number of variables, such as the speed of the wind and the amount of space, affect the dimension and capacity of a wind power generator. Wind turbine generators are an essential part of wind power plants and are crucial to the development and evolution of wind generation as an alternative source of electricity.

There is no single "better" type of wind turbine generator that is suitable for all applications. The choice of wind turbine generator depends on a range of factors, including the wind resource, the available space for installation, and the intended use of the electricity generated. Here are some of the factors that may influence the choice of wind turbine generator: Wind speed: The wind speed at a particular site is a critical factor in determining the size and type of wind turbine generator that is appropriate. High wind speed sites typically require larger, more powerful turbines, while low wind speed sites may be better suited for smaller turbines.

Available space: The available space for installation is another important factor in determining the size and type of wind turbine generator that is appropriate. Larger turbines require more space for installation, so smaller turbines may be better suited for sites with limited space. Grid connection: The intended use of the electricity generated is another important factor. If the electricity is intended for connection to the grid, synchronous generators may be more appropriate, as They are made to run at a set pace that is coordinated with the electrical grid's frequency. A synchronous generating may be more suitable if the electricity is going to be used off the grid since they can run at different speeds.

Cost: Another crucial aspect to think about is the wind turbine generator's price. The type of turbine may rely on the available budget because larger turbines are typically more expensive than smaller turbines. There is no one-size-fits-all option when it comes to selecting a wind turbine generator; it all relies on the particular needs and specifications of the project. Determine the most suitable type and size by carefully examining the site characteristics, the anticipated use of the electricity generated, and the available budget.

4.4.2 DC GENERATOR

Permanent Magnet Synchronous Generators.

A generator with a synchronous function which utilizes permanent magnets is known as a permanent magnet synchronous generator (PMSG). magnets to generate a magnetic field. PMSGs are commonly used in wind turbines, as they are efficient, reliable, and well-suited to the variable speed operation required in wind power systems.

PMSGs work by using a rotor with permanent magnets to generate a magnetic field. The rotor is typically mounted on the same shaft as the wind turbine blades, so that it rotates as the blades turn. As the rotor rotates, the magnetic field generated by the permanent magnets induces an electrical current in the stator windings, which are stationary and surround the rotor. The electrical current generated by the stator windings is then transmitted to the electrical grid or stored in batteries.

Compared to other types of generators, PMSGs have several advantages. One key advantage is their high efficiency, as they are able to convert a large proportion of the wind energy into electrical energy. PMSGs also have a high-power density, meaning that they can generate a large amount of power from a relatively small generator. Additionally, PMSGs are well-suited to the variable speed operation required in wind power systems, and can operate over a wide range of wind speeds.

Overall, PMSGs are an important component of many wind power systems, and their efficiency, reliability, and suitability for variable speed operation make them a popular choice for wind turbine.

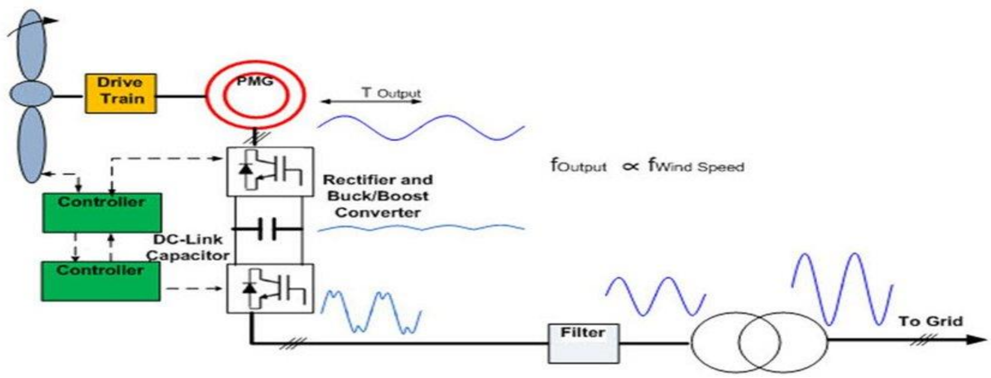


Figure 4.11: DC Generator

4.4.3 AC Synchronous Generator

Utilizing a synchronized generator as a wind generator:

According to Faraday's rule of electromagnetism, synchronous generators operate similarly to an automotive alternator, just like the DC generator in the previous tutorial. This time around, the synchronous power plant stands out from the DC generator in that the former generates a single DC or direct current output, while the latter generates a single-phase AC voltage output from its stator windings. Single-phase synchronous generators are another choice for low power residential wind turbine asynchronous generator systems. A synchronization generator's fundamental components consist of a spinning magnetic field on the rotor, which acts as the generator, and a stationary stator with several winds, which is the source of the generated power. either through direct contact on the rotor mounted permanent magnets or with an outside DC current flowing the magnetic resonance system (excitation) within the rotor is created through the electromagnetic field windings. This DC field electricity is transferred to the synchronized machine's rotor using slip rings, carbon or graphite brushes, and other elements. Simultaneous power plants as opposed to the prior DC generator concept, do not need complicated commutation, enabling a more straightforward construction. The synchronous generator then has the two components listed below in common, and it functions similarly to an automobile alternator.

The Synchronous Generator's Primary Components

- The Stator: Three different (3-phase) armature windings which are both physically as well as electrically separate are held in the stator. 120 degrees apart, resulting in an output of AC voltage.
- The Rotor: Through the use of slip rings, carbon brushes, and wrapped field coils coupled to an external DC power supply, the rotor transmits the magnetic field.

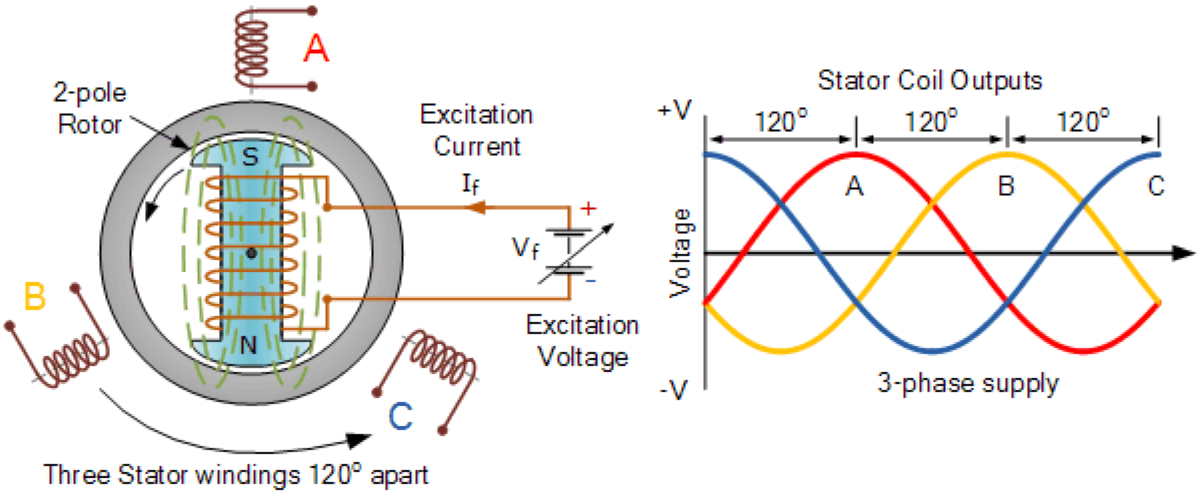


Figure 4.12: AC Synchronous Generator

Equation 2 The Synchronous Speed of the Generators

$$\text{Frequency}, (f) = \frac{P}{2} \times \frac{N}{60} = \frac{PN}{120}\,\text{Hz}$$

Circuit for a synchronous generator:

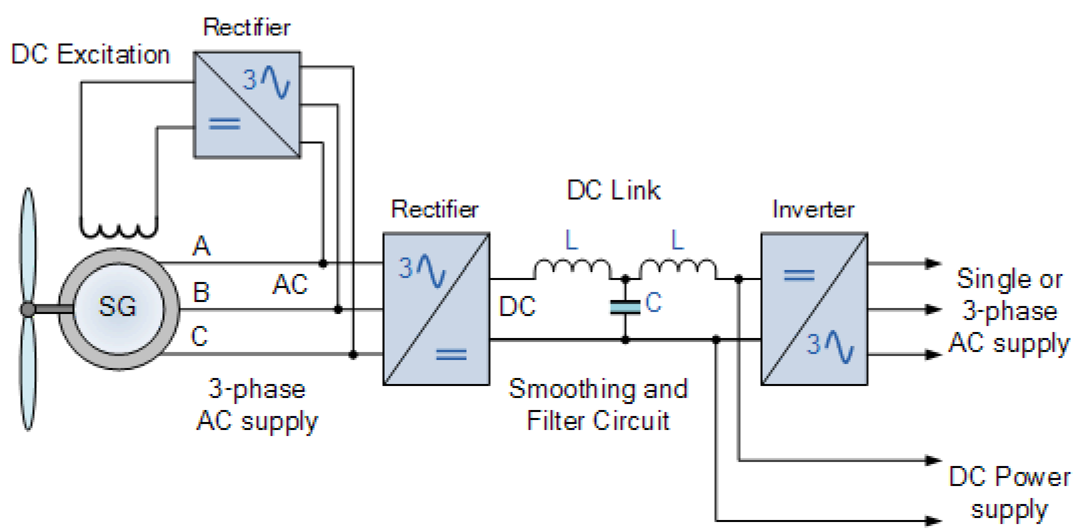


Figure 4.13: synchronous generator

Synchro synchronized with the speed of the blade. Slip rings and brushes must be utilized to stimulate the rotor winding from an external DC source in grid-tied engines in order to properly align them with the utility grid frequency.

4.4.4 AC Asynchronous Generator:

Rotating electrical machines are often used in wind power systems. Most of these electrical devices can function as either a motor or a source of power, depending on their purpose. Induction In addition to the Synchronous Generator that we looked at in the previous lesson, generators are a more popular variation of the three-phase spinning machine that we may use as a wind turbine generator. Both synchronized and induction generators use fixed stator coil configurations to produce a three-phase (or single phase) voltage output when driven by a revolving magnetic field. Induction generator rotors often have either a "squirrel cage" or a "wound rotor" design, which distinguishes them from the blades of the other two devices. induction because they Squirrel-cage induction engine type engines are the foundation of most generator design because they are reasonably priced, dependable, and easily accessed in an array of electrical sizes, from fractions horse generators to multi-megawatt capacity. They are therefore ideal for use in both residential and industrial wind energy operations.

Construction of an Induction Generator

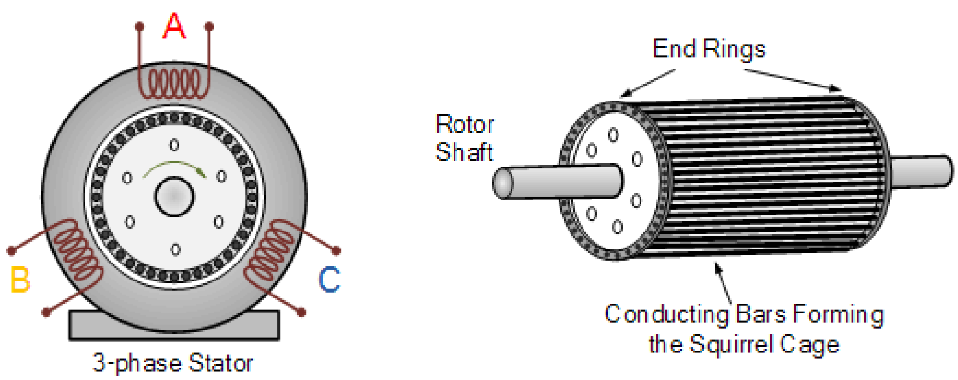


Figure 4.14: Induction Generator

One of the sequential machine's many advantages is that, when connected to a three-phase power source, it may be used as a generator without the use of additional electronics like an exciter or power controller. When an idle asynchronous generator is connected to an alternating current grid, the frequency associated with the induced the voltage, that's equal to the cycle of the voltage being used, flows into its rotor winding [52].

Characteristics of an Induction Machine's Torque and Speed:

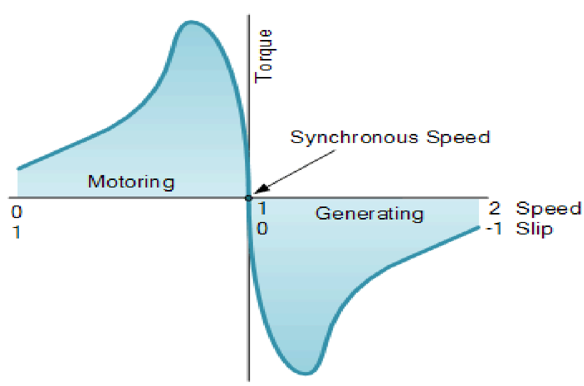


Figure 4.15: Characteristics Torque and Speed

4.4.5 Wind Gear Box

The fundamental principle of how a windmill works is that, in contrast to a fan, which generates wind by using power, a wind turbine generates electricity without using wind. To generate power, the blades of a

turbine, which mimic propellers, revolve around a rotor. When all three of the following occur simultaneously, solar energy manifests as wind.
The sun's uneven climatic warming; faults on the earth's crust; and the rotation of the planet.
There are many various types of geography, vegetation, and water bodies in the United States of America, and each has an impact on the direction and speed of the wind. Sailing, kite flying, and even the creation of electricity is just a few of the activities that humans engage in using the wind's flow, or motion energy. "Wind energy" as well as the term "wind power" describes the process of generating mechanical or electrical energy by utilizing the wind. The kinetic energy can be converted into power using a generator or employed for specific tasks (like pumping water or milling grain)'
In order to get the windmills to spin at the faster rate required by the generator, which converts their motion to electricity, wind-powered gearboxes augment the sluggish, high torque rotating of the wind turbines. The operating environment for gearboxes is challenging, and lengthy lifespan expectations are typical. Wind energy production at high costs is problematic[53].

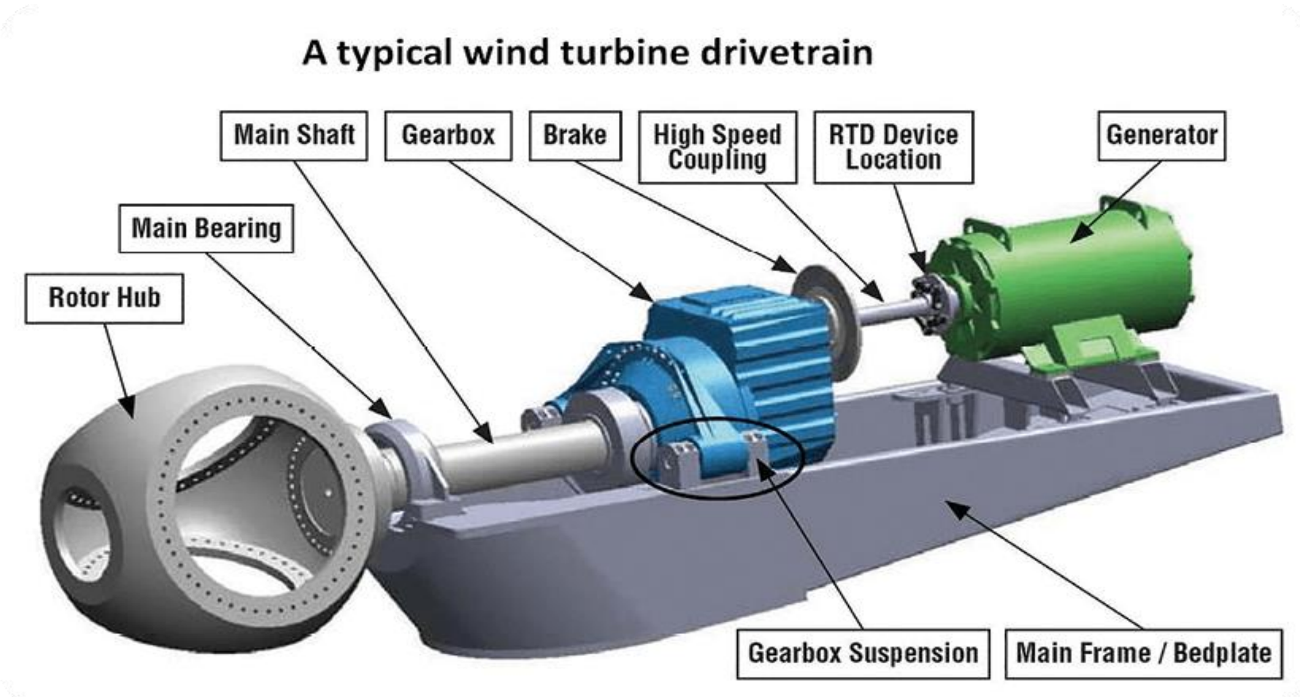


Figure 4.16: Wind Gear Box

4.5 Transmission

4.5.1 Power Of Electric Transmission

In the proposed wind energy transportation structure, the slow rotation of a large wind turbines rotor's shaft is immediately transformed to electricity by a generator that is synchronous through the movement of a gas with a high pressure working in a closed loop. Land-based wind power plants can be as large as multiple megawatts or as small as 100 kilowatts. A significant amount of power is supplied to the electrical grid via wind plants, which are constructed from larger wind farms because they are cheaper to build when grouped together. Wind power generation is the process of converting the wind's energy into spinning blade energy and then converting that rotating energy into electrical energy. Since wind power grows as a square of wind speed, WTGs should be located in places with higher wind speeds.

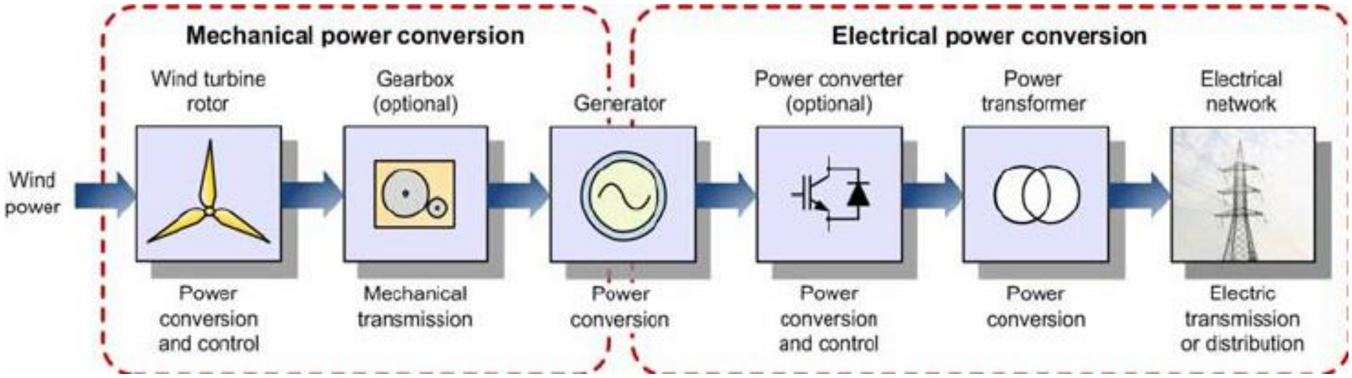


Figure 4.17: Power of electric transmission

4.5.2 Power System component:

The components of the powertrain include the rotor, major carrying main shaft, gear box, and generators. The drivetrain transforms the high-torque, low-speed rotation of the turbine's rotor into electrical power. With asynchronous and induction-powered ones being frequently employed in bigger wind turbine generating systems, electrical equipment operating as generating are the type of electrical equipment most frequently used for wind turbine purposes. A simple principle underlies how wind turbines operate. The energy of the wind powers the rotation of two or three blades that imitate propellers surrounding a rotor. The primary shaft is connected to the rotor and spins a generator to generate electricity.

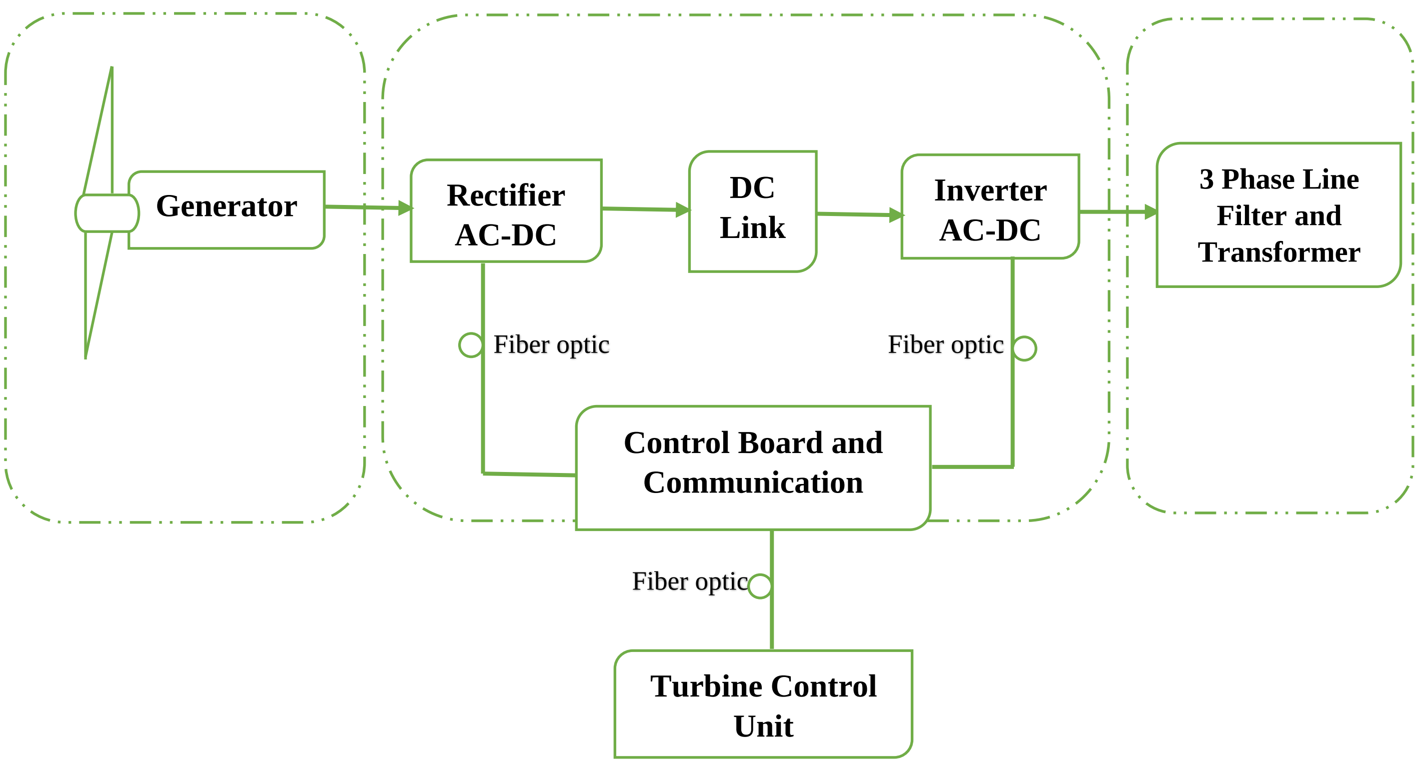


Figure 4.18: Power System component

4.5.3 Underground Power Transmission

Underground power transmission refers to the method of transmitting electrical energy through cables installed beneath the surface of the ground, instead of using overhead power lines. This approach offers several advantages, such as reduced visual impact, lower susceptibility to extreme weather conditions, and improved reliability by minimizing outages caused by storms or falling objects.

When it comes to wind energy, underground power transmission can be used to connect offshore wind farms to the mainland electrical grid. Wind farms that are offshore are situated within water bodies, usually near the shore or at sea, where powerful, dependable winds can be used to produce power. Transmitting this energy from the offshore wind farms to onshore locations requires an efficient and reliable method, and underground power transmission is one viable option.

The transmission of wind energy from offshore wind farms to the shore can be achieved using subsea cables buried beneath the seabed. These cables are specially designed to withstand the marine environment, including water pressure, corrosion, and possible disturbances caused by marine activities.

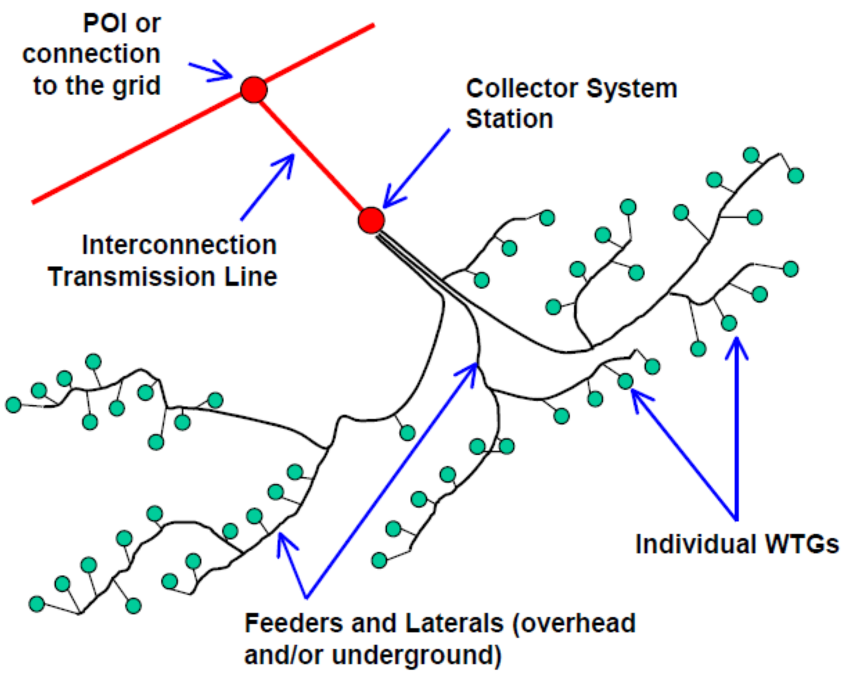


Figure 4.19: Underground Power transmission

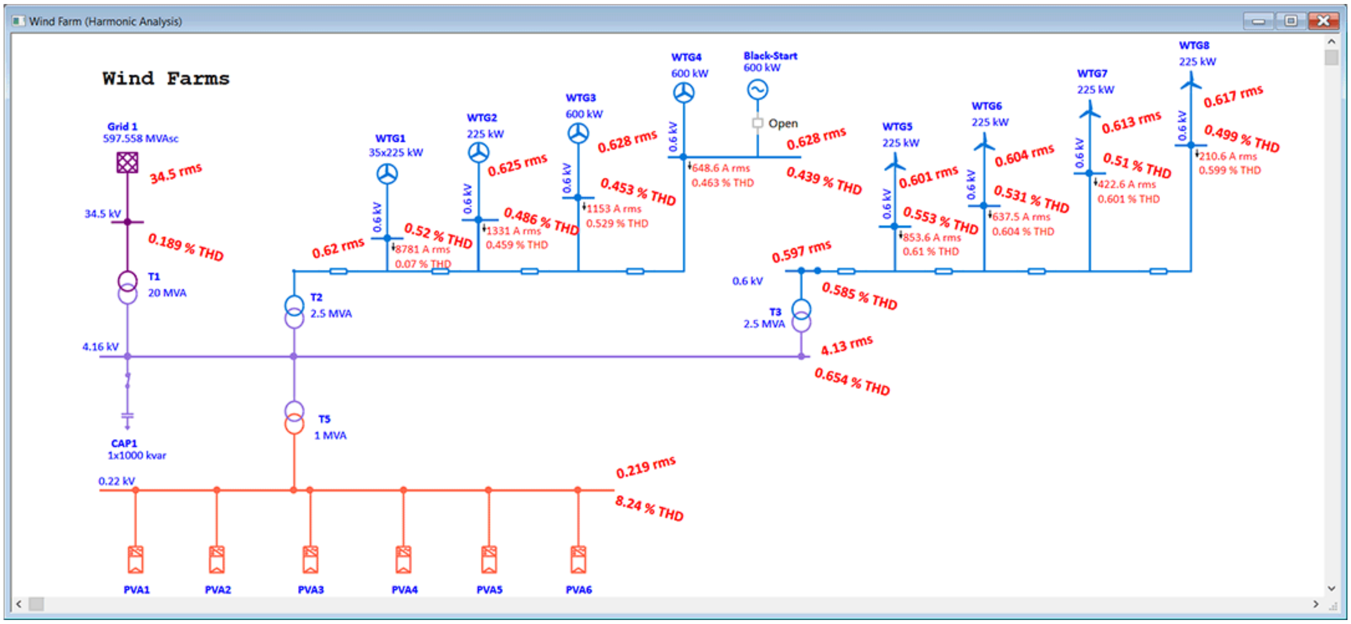


Figure 4.20: Wind Farms

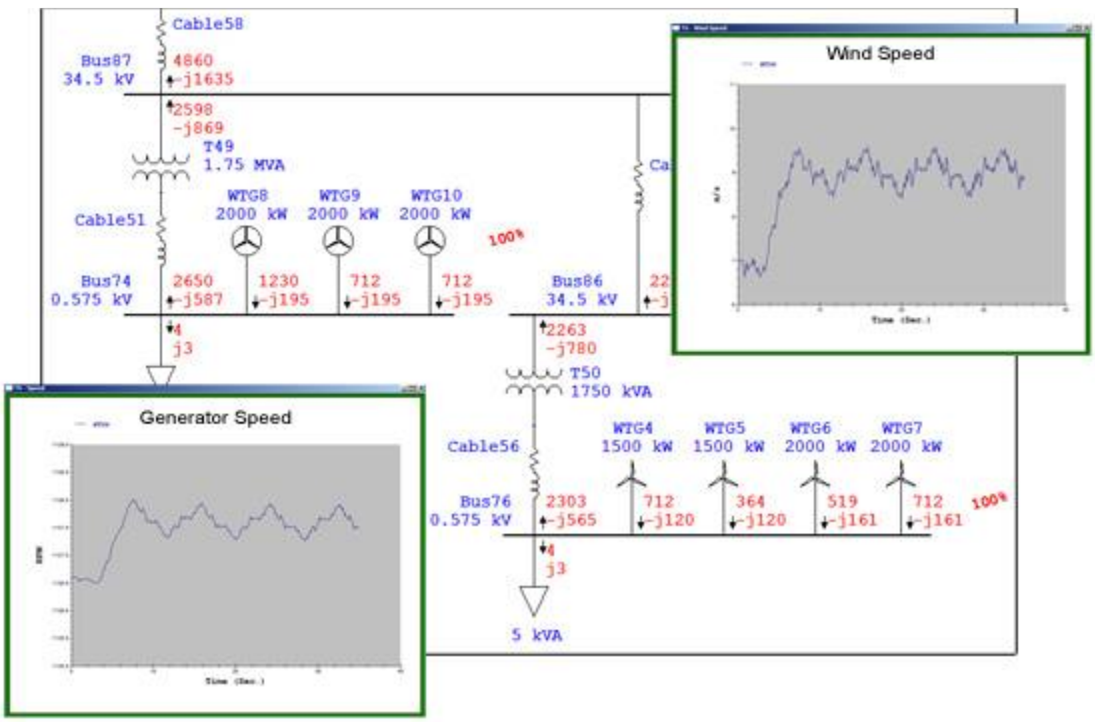


Figure 4.21: Wind Speed and Generator Speed

Benefits of underground power transmission for offshore wind energy include:
Aesthetics: Underground cables eliminate the need for extensive overhead power lines, which can be visually intrusive, especially in scenic coastal areas.
Reliability: Underground cables are less vulnerable to extreme weather events, such as strong winds, ice storms, or lightning strikes, reducing the risk of power outages.
Efficiency: Underground transmission can minimize energy losses during long-distance power transport, resulting in improved overall system efficiency.
Environmental impact: Underground power transmission reduces the potential negative environmental impacts associated with overhead lines, such as bird collisions or visual clutter.

However, it's worth noting that underground power transmission can be more expensive to install and maintain compared to overhead lines. The excavation and installation of subsea cables can be technically challenging and costly, especially for long-distance transmission projects.
Nonetheless, as technology advances and costs decrease, underground power transmission for wind energy is becoming more prevalent, especially in areas with sensitive landscapes or where the use of overhead lines is impractical or undesirable.
It's important to consider various factors, including the specific geographical and environmental conditions, project requirements, and cost-effectiveness, when deciding on the most suitable transmission method for wind energy projects.

4.5.4 Overhead Power lines

Overhead power transmission refers to the traditional method of transmitting electrical energy using overhead power lines. When it pertains to wind energy, ashore wind farms are frequently connected to the electrical grid using overhead power transmission.

The electrical power produced by the rotating turbines at onshore wind turbines is collected and transported through a network of overhead power lines to substations and ultimately to consumers. These power lines consist of tall towers or poles with conductors strung between them, typically made of materials such as aluminum or steel.

Here are some key points regarding overhead power transmission for wind energy:
Cost-effectiveness: Overhead power transmission is generally more cost-effective compared to underground power transmission. The installation and maintenance of overhead power lines are typically less expensive, making it the preferred choice for onshore wind farms, where land availability and cost considerations are significant factors.
Ease of installation and maintenance: Overhead power lines are relatively easier to install and maintain compared to underground cables. The accessibility of the power lines makes it simpler to inspect, repair, or replace components if necessary.
Flexibility and scalability: Overhead power transmission systems can be easily expanded or modified to accommodate the growth of wind farms. Additional power lines can be added or upgraded to meet the increasing electricity demand.
Visual impact: One of the potential drawbacks of overhead power transmission is its visual impact. The presence of tall towers and lines across the landscape can be considered visually intrusive, especially in areas with scenic or environmentally sensitive surroundings. However, efforts can be made to minimize visual impact through careful route planning and design considerations.
Susceptibility to weather conditions: Overhead power lines are more vulnerable to extreme weather conditions, such as strong winds, ice storms, or lightning strikes. Severe weather events can cause damage to the power lines, leading to power outages and disruptions. However, modern designs and materials are employed to enhance the resilience of the transmission infrastructure.
Overall, overhead power transmission remains the most common method for connecting wind power of the electric power is cost-effectiveness, ease of installation, and scalability. However, the choice between overhead and underground transmission depends on various factors, including geographical conditions, project requirements, environmental considerations, and cost-benefit analysis.

4.5.5 Substation

A wind energy substation, also known as a wind farm substation or a collector substation, is a key component of a wind power project. It serves as the central point where electricity generated by multiple wind turbines within a wind farm is collected, transformed, and transmitted to the main electrical grid for distribution.
Here are some important aspects of a wind energy substation:

Collection and Interconnection: A wind farm consists of multiple wind turbines spread across a designated area. Each turbine generates electricity, and the substation collects this electricity from individual turbines through underground or overhead cables. The substation acts as a collection point, gathering the power generated by each turbine.
Voltage Transformation: The electricity generated by wind turbines is typically at a relatively low voltage level. The substation transforms this low-voltage electricity into a higher voltage level suitable for long-distance transmission. This voltage transformation reduces transmission losses and improves efficiency.
Switching and Protection: The substation incorporates various switching equipment and protective devices to ensure the safe and reliable operation of the wind farm. This includes circuit breakers, disconnect switches, and surge protection devices. These components enable the substation to isolate any faulty turbines or sections of the wind farm from the grid during maintenance or in the event of an electrical fault.
Control and Monitoring: The substation may have control and monitoring systems to manage and monitor the operation of the wind farm. This can include supervisory control and data acquisition (SCADA) systems, which allow operators to remotely monitor and control various parameters such as power output, voltage levels, and turbine performance.
Grid Connection: One of the primary functions of the wind energy substation is to connect the wind farm to the main electrical grid. The substation integrates the wind farm's electricity with the existing transmission or distribution infrastructure. This enables the wind power to be transmitted to consumers and contributes to the overall energy supply.
Wind energy substations are typically designed and engineered based on the specific requirements and characteristics of each wind farm. They play a crucial role in efficiently collecting, transforming, and integrating the electricity generated by wind turbines, facilitating the integration of wind power into the broader electrical grid.

4.6 Simulation

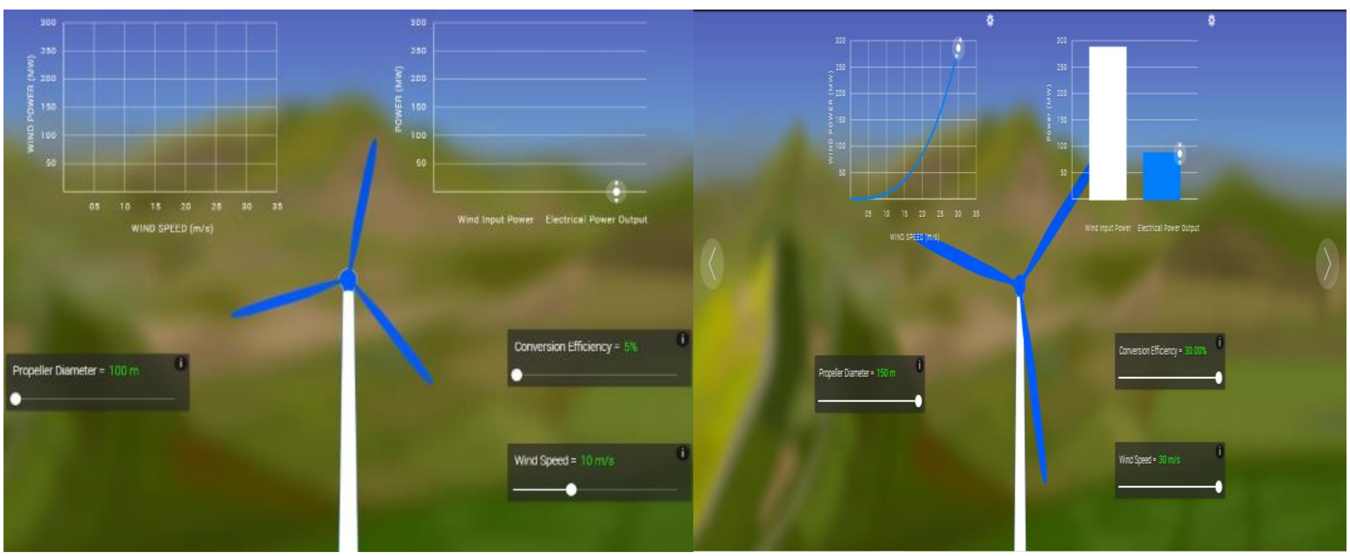


Figure 4.22: Wind Simulation

Figure 4.23: Wind Speed Carve

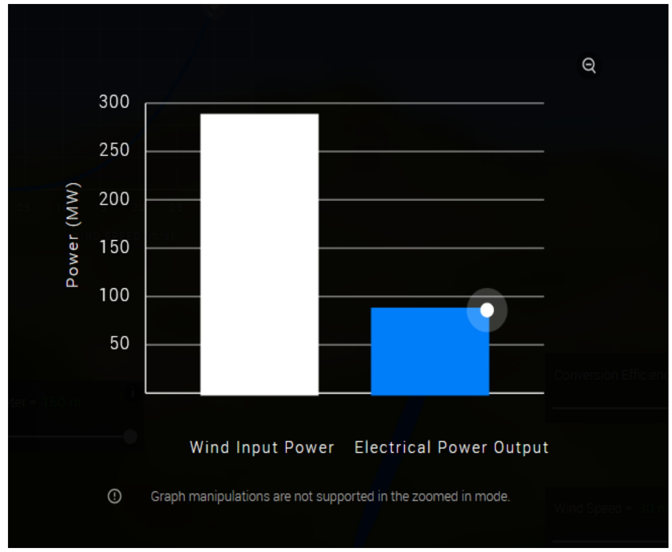


Figure 4.24: Wind Power Curve

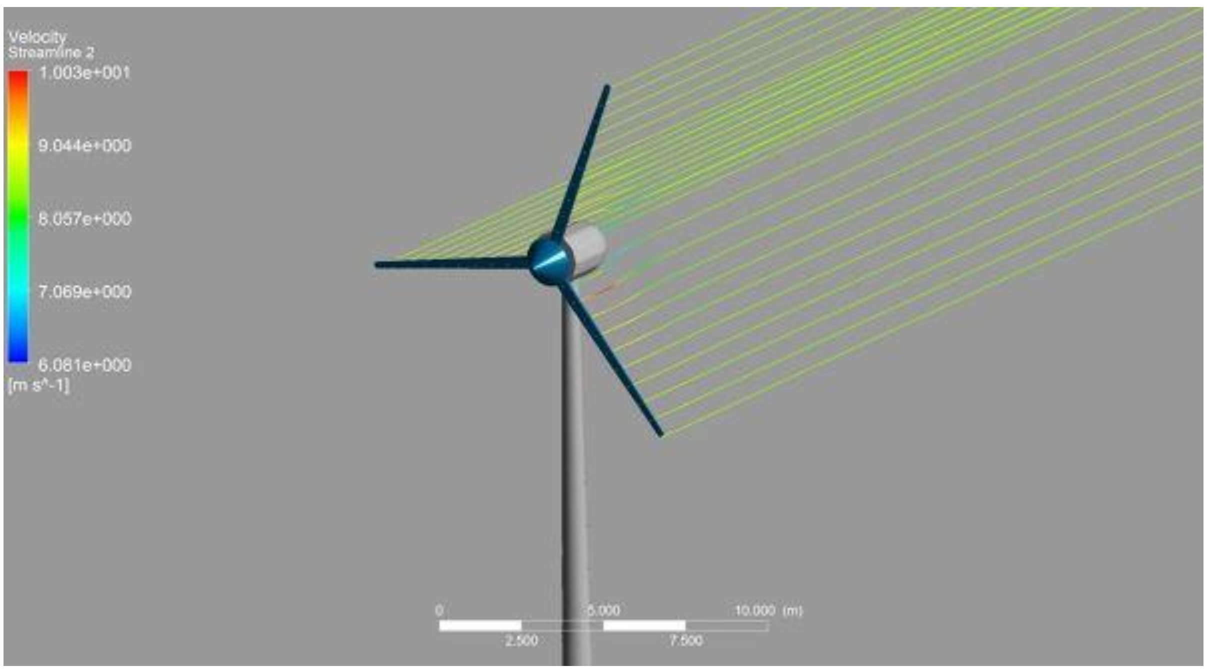


Figure 4.25: Wind Velocity

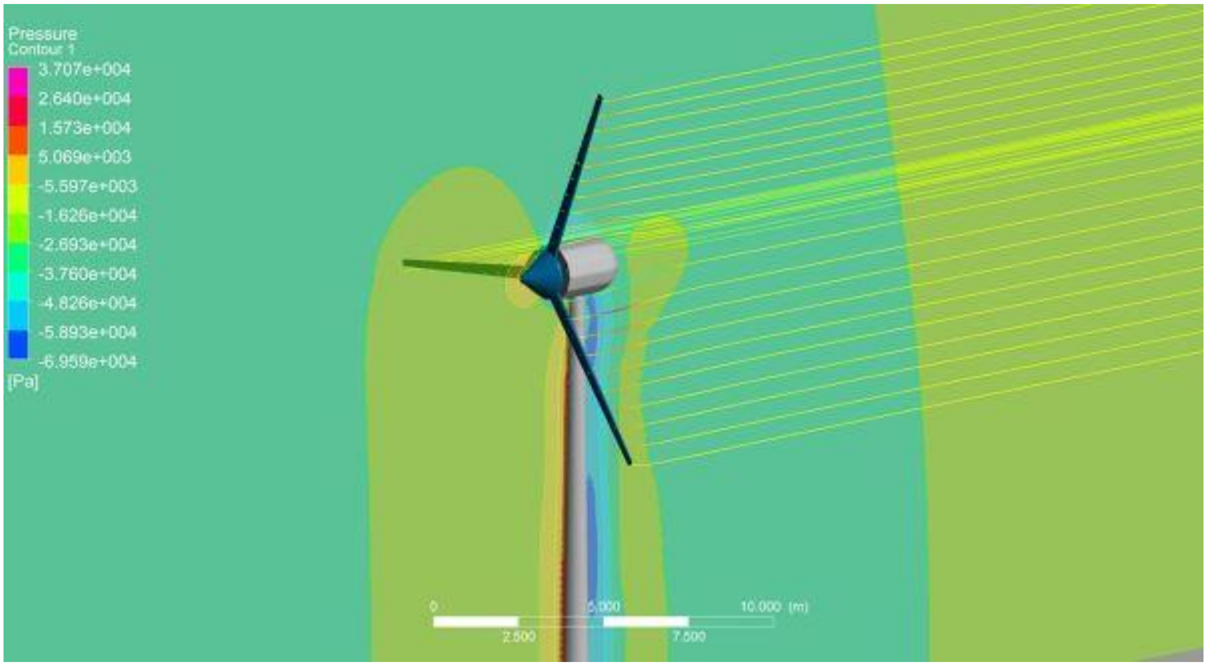


Figure 4.26 Wind Pressure

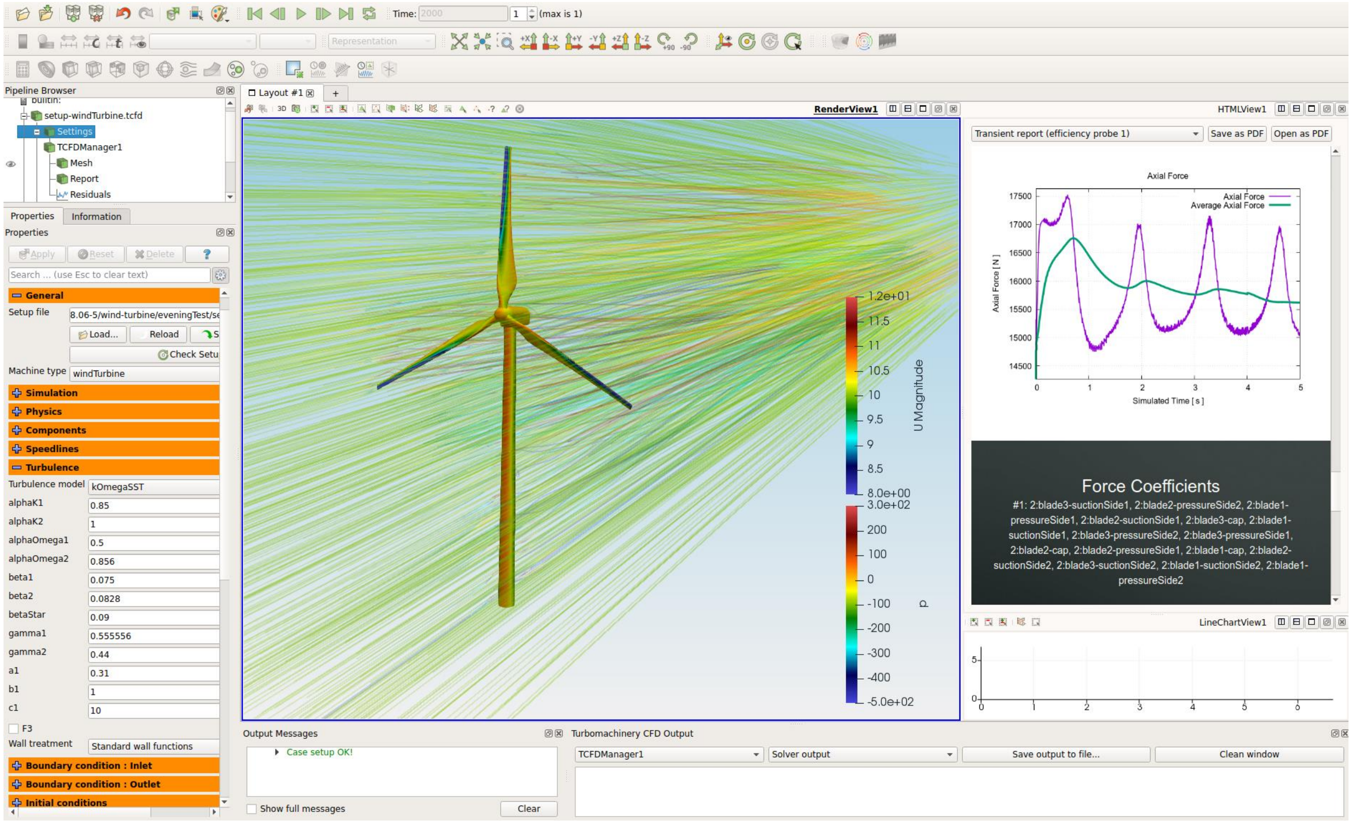


Figure 4.27: Wind Simulation

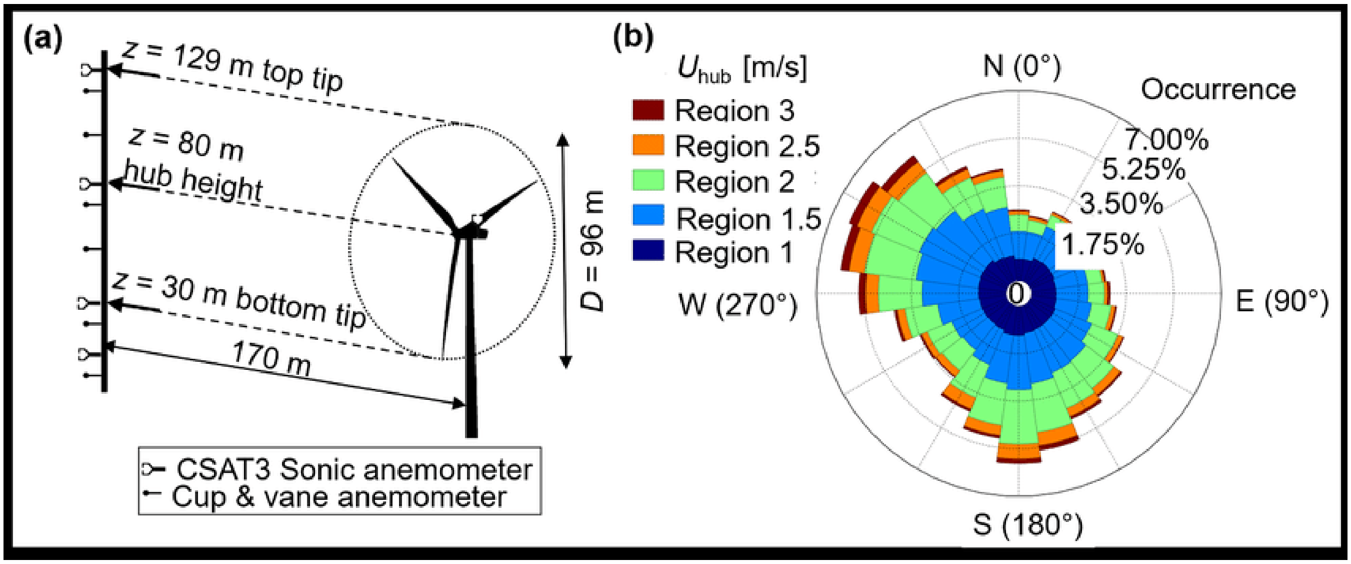


Figure 4.28: Wind Simulation Data

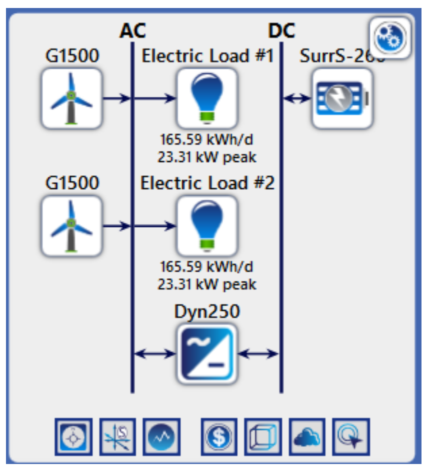


Figure 4.29 HomerPro G1 Simulation

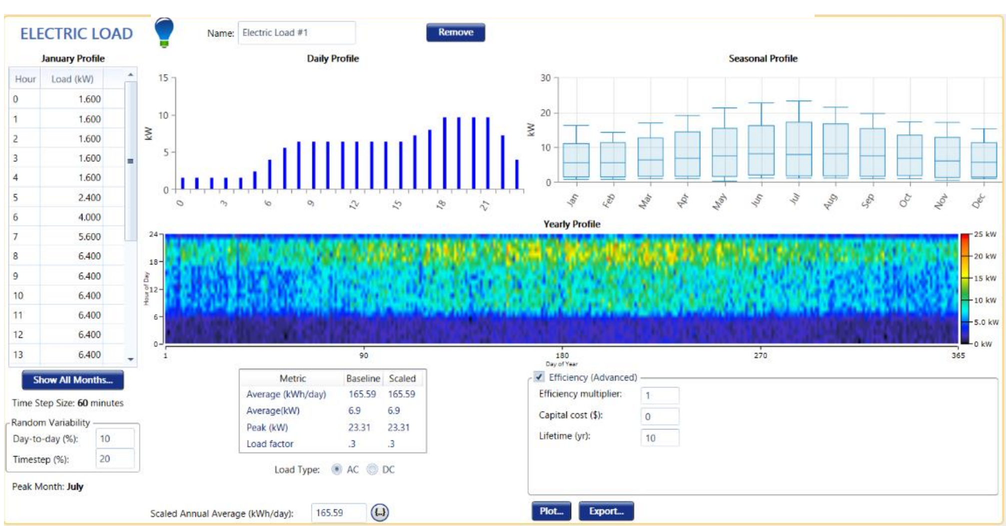


Figure 4.30 Electric Load Calculation

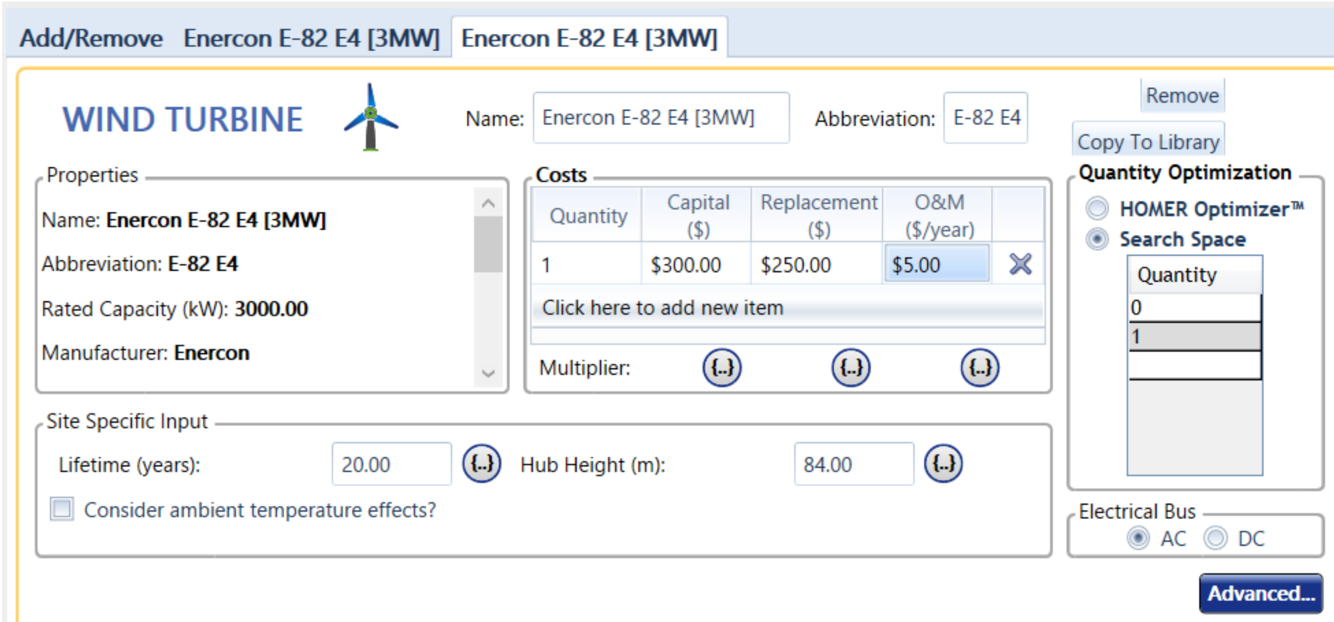


Figure 4.32: Enercon E-82 E4 3MW

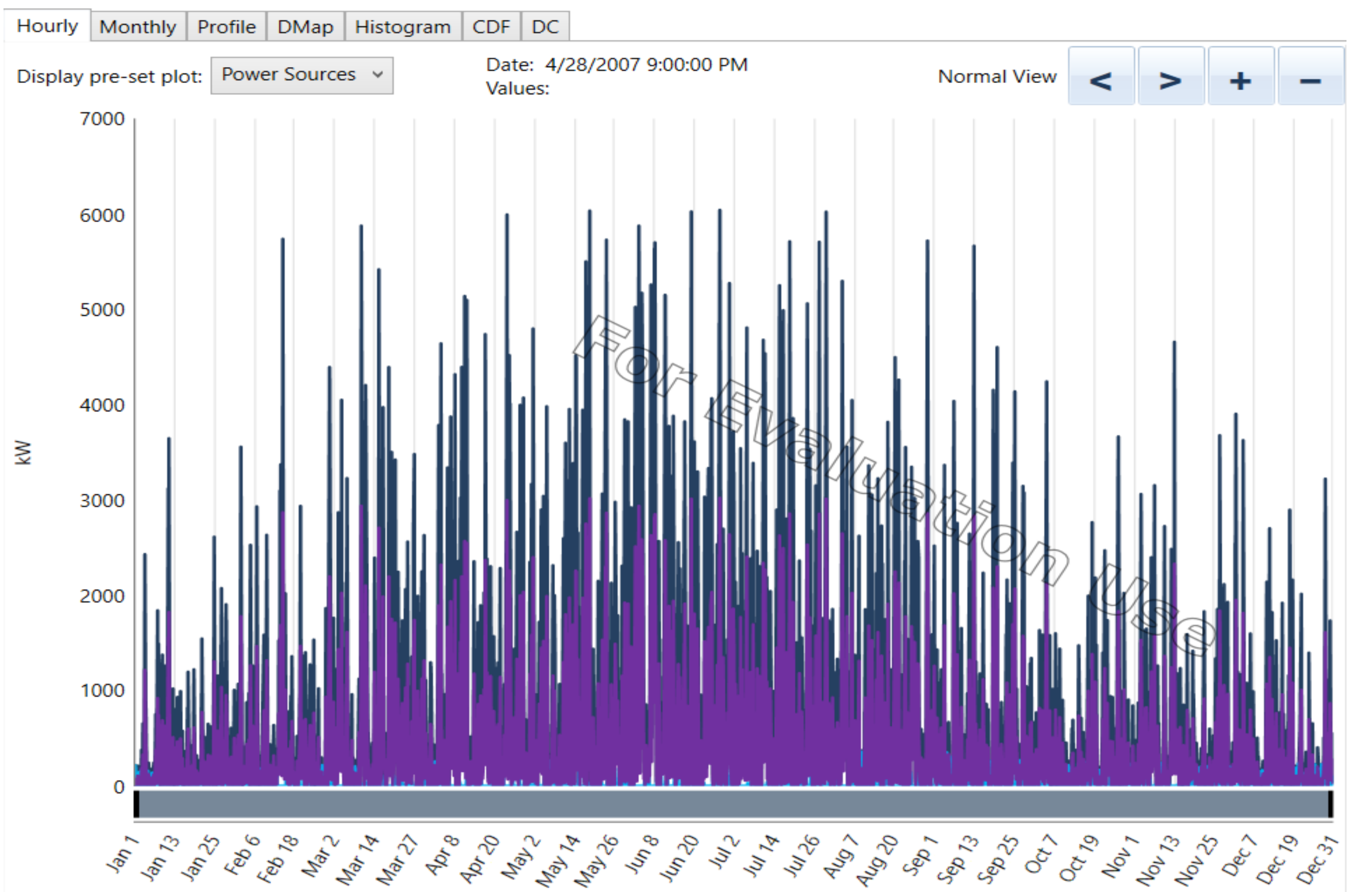


Figure 4.33: Hourly load Profile

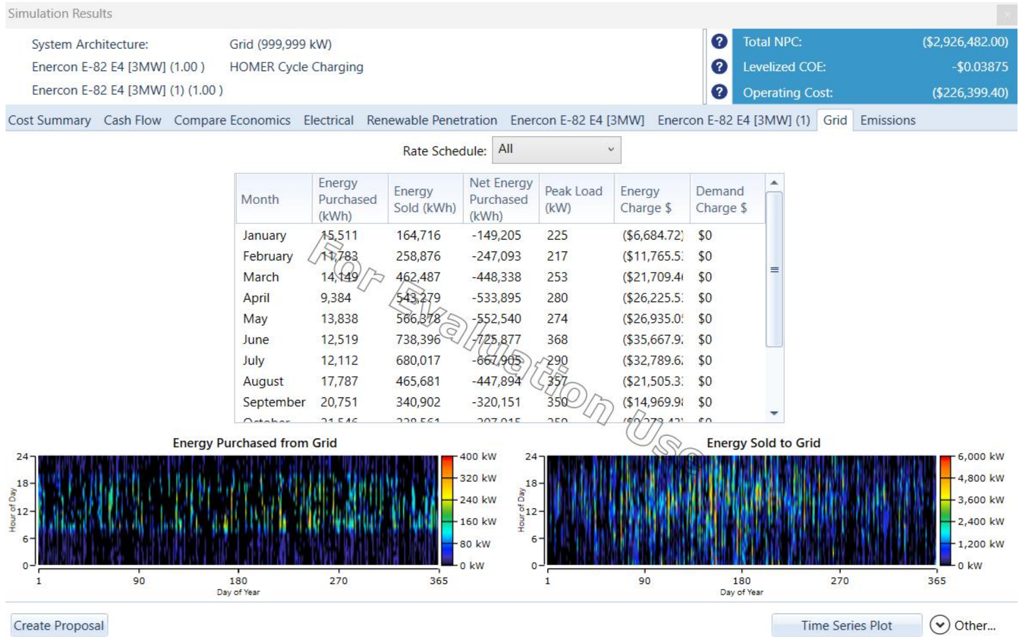


Figure 4.34: Monthly Cost

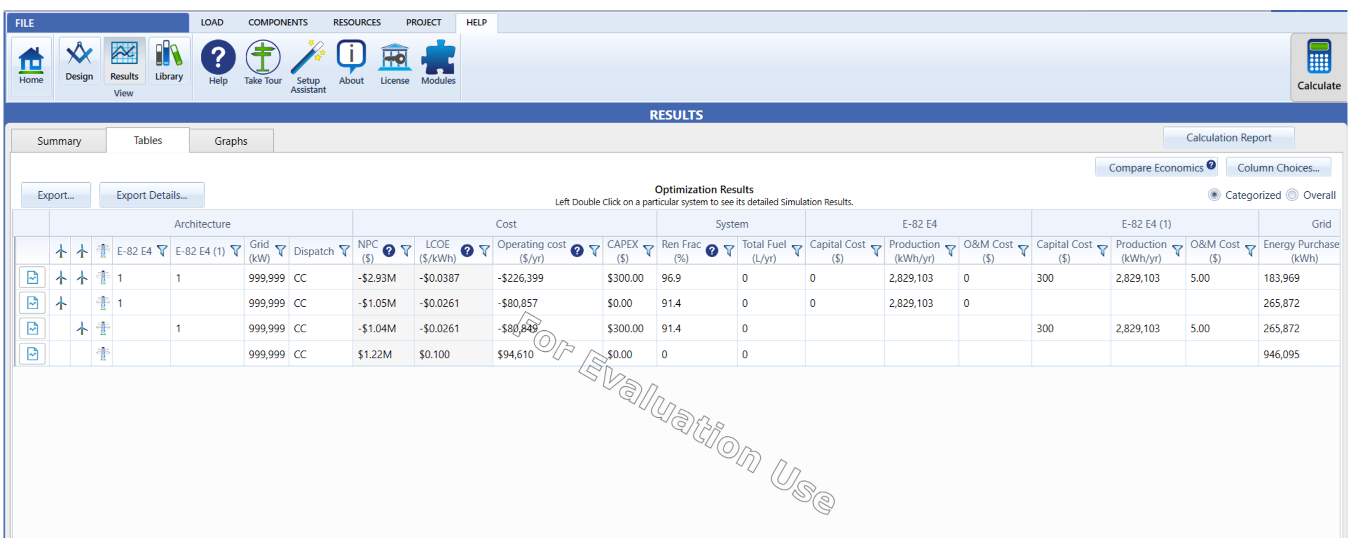


Figure 4.35: 3Mw Two Turbine Cost

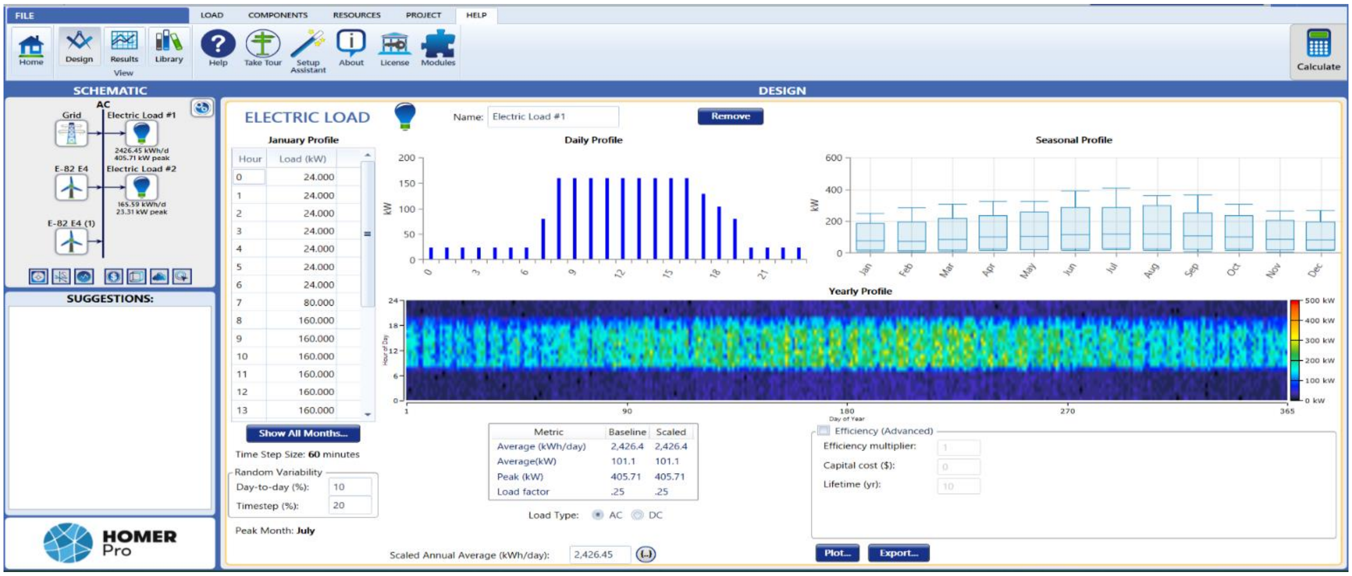


Figure 4.36: HomerPro Total simulation

4.6.1 Small Wind Parks

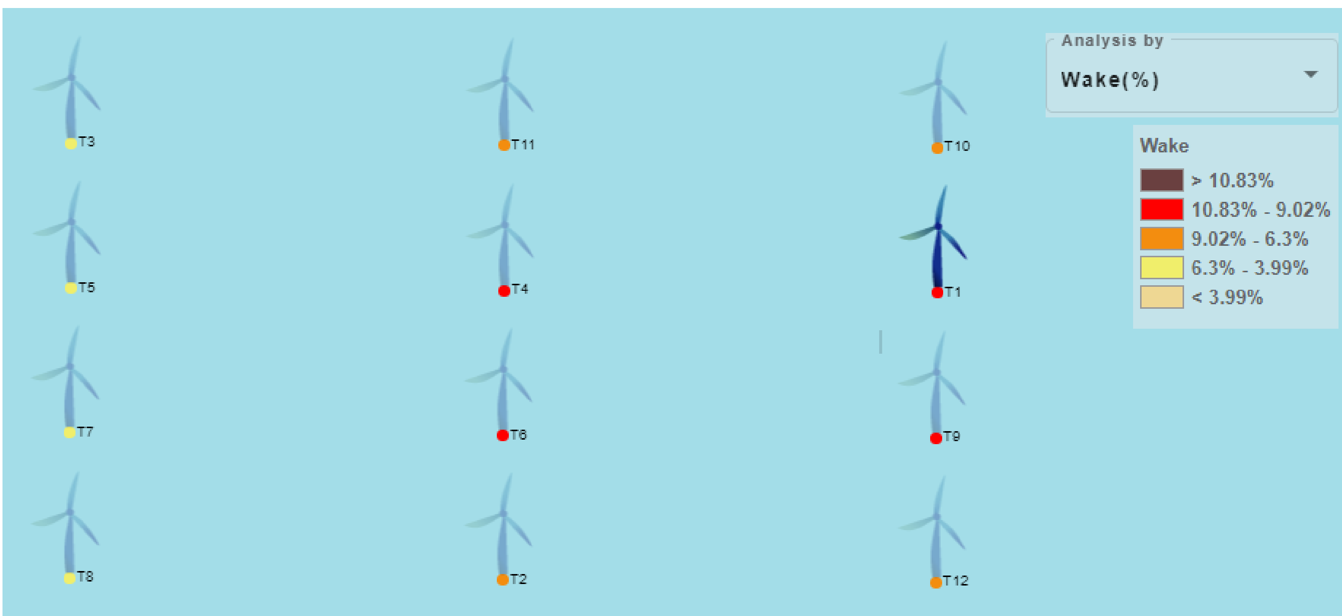


Figure 4.37 Small Wind Park Design

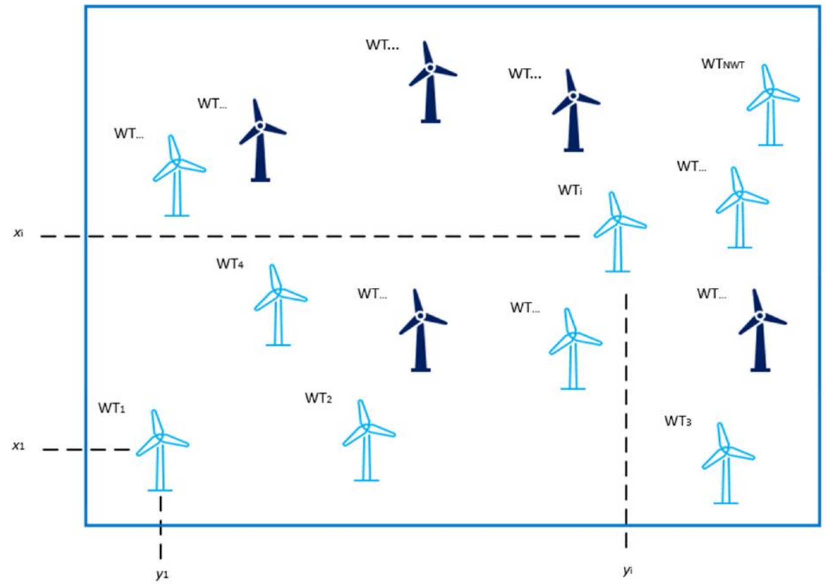


Figure 4.38: Air flow Wind Park Design

Figure 4.39: River Wind Park

4.6.2 The Wind Park and The Number of Turbines Rated power

Recommended Model Name: 3.45MW-IFC Class 2
Rated Power: 3450
Rotor Diameter: 100m
Using Model Name: 3.00MW-IFC Class 2
Rated Power: 10384
Rotor Diameter: 112m
Hub Hight: 96/102m
Design Average Wind Speed: 8.7m/s
Air density: 1.225k/m^3
Number of wind turbine: 49
The Map data finally
Annual Averages is the 1 Wind Turbine production the power 10384MWh, some losses so, approximately power is 912.5MWh in year
Daily Load
1 wind turbine is power production 2.42MWh 49 wind turbine is power production 118.58MWh
Yearly Load
Yearly Total wind turbine are production is (11858*365) =43281.7 MW Generated by Electricity.
Total Aera Size
One 3.00MW wind turbine is about 9864m in size.
Wind turbine total 49 Inverter, batteries and others equipment Cost 144 million dollars.

4.6.3 The Wind Turbine Distance & Hight

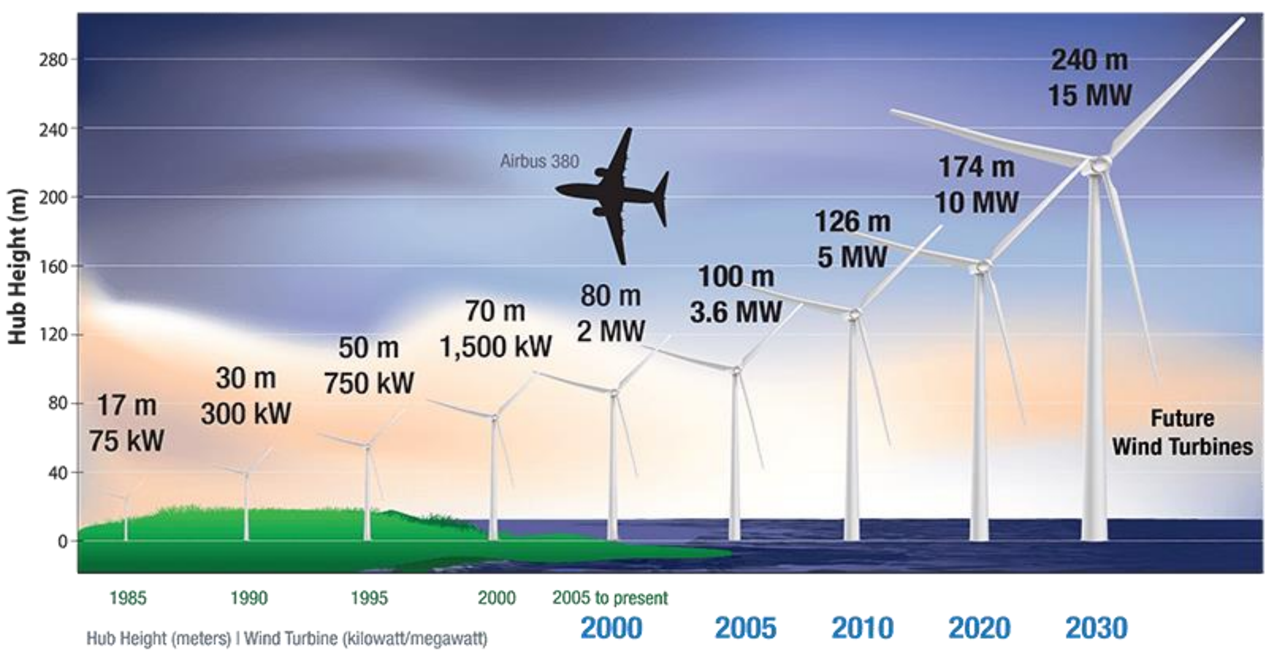


Figure 4.40: Wind Turbine Distance & Hight

4.6.4 The Reasons Behind Blackouts

While wind energy is a clean and renewable source of power, blackouts can still occur in wind energy systems due to various factors. Here are some reasons behind blackouts in wind energy:
Wind Variability: Wind is inherently variable, and its strength and direction can change rapidly. If the wind speed falls below a certain threshold or exceeds the turbine's operational limits, the wind turbines may automatically shut down for safety reasons. When multiple turbines experience low wind speeds simultaneously, it can result in a significant reduction in power generation or even a complete shutdown, leading to a blackout.
Grid Integration Challenges: Integrating a large amount of wind energy into the existing power grid can pose challenges. Wind farms are typically connected to the grid through transmission lines, and if the capacity of these lines is insufficient to handle the power generated, it can lead to transmission congestion and blackouts.
Grid Faults and Instability: Wind farms are connected to the electrical grid, which can experience faults or instability due to various reasons, such as equipment failures, grid maintenance, or grid-wide disturbances. When the grid experiences a fault or instability, wind turbines may disconnect from the grid to protect their own systems, resulting in a temporary blackout.
Electrical Grid Limitations: The electrical grid has specific technical limits on factors such as voltage, frequency, and power quality. In some cases, when wind energy generation exceeds the grid's capacity to handle it, grid operators may curtail or reduce the output of wind turbines to maintain grid stability. This curtailment can result in a temporary reduction in power generation or localized blackouts.
Maintenance and Repair: Wind turbines, like any mechanical systems, require regular maintenance and occasional repairs. During scheduled maintenance or unexpected equipment failures, wind turbines may be temporarily taken offline, reducing the overall power generation from wind farms and potentially contributing to blackouts.
Efforts are being made to mitigate these issues through advanced wind forecasting techniques, improved grid integration technologies, and better coordination between wind farm operators and grid operators. Additionally, energy storage systems, such as batteries, are being deployed to store excess wind energy and release it during periods of low wind, helping to stabilize the grid and minimize the risk of blackouts.

Blackouts, or power outages, can occur for various reasons, ranging from technical failures to natural disasters. Here are some common causes of blackouts:
Equipment Failure: Blackouts can happen due to failures in electrical infrastructure, such as transformers, power lines, or distribution systems. Aging infrastructure or inadequate maintenance can contribute to these failures.
Grid Overload: When the demand for electricity exceeds the supply capacity of the power grid, it can result in blackouts. This situation often occurs during periods of high energy usage, such as heatwaves or severe cold spells, when air conditioning or heating systems are heavily utilized.
Natural Disasters: Severe weather events, including hurricanes, tornadoes, earthquakes, floods, or ice storms, can damage power infrastructure and cause widespread blackouts. Falling trees, high winds, flooding, or other destructive forces can disrupt power transmission and distribution.
Human Error: Mistakes made by workers during maintenance or repair work can lead to blackouts. Accidental damage to power lines or equipment, incorrect settings, or errors in judgment can trigger power outages.
Cyber Attacks: In our increasingly interconnected world, cyber-attacks on power grids are a growing concern. Hackers targeting utility companies or critical infrastructure can infiltrate systems, disrupt operations, and cause blackouts as a result of deliberate actions.

Scheduled Outages: Sometimes, utility companies need to conduct planned maintenance or upgrades on power systems. To ensure the safety of workers and the integrity of the electrical infrastructure, they may schedule temporary blackouts in specific areas.
Voltage or Frequency Instability: Sudden fluctuations in voltage or frequency beyond acceptable limits can lead to automatic shutdowns as a protective measure. This can happen due to equipment malfunctions, lightning strikes, or other unforeseen circumstances.
It's important to note that the causes and durations of blackouts can vary significantly depending on the specific circumstances and the region affected. Local utility companies and power authorities are responsible for managing and restoring power during blackouts.

Bangladesh has been experiencing challenges in its power sector, leading to frequent blackouts. Some of the main reasons behind blackouts in Bangladesh are:
Insufficient Power Generation Capacity: Bangladesh has been struggling to keep up with the increasing demand for electricity due to its rapid population growth and economic development. The existing power generation capacity is often insufficient to meet the rising demand, resulting in blackouts.
Inadequate Fuel Supply: Bangladesh heavily relies on natural gas and oil for power generation. Fluctuations in fuel supply, including shortages or delays in fuel delivery, can lead to power plant shutdowns and subsequent blackouts.
Transmission and Distribution Losses: Inefficient transmission and distribution systems contribute to power losses. Aging infrastructure, technical faults, and illegal connections can lead to significant electricity losses during transmission and distribution, resulting in blackouts.
Technical Failures: Equipment failures, such as transformers, generators, or other components of the power system, can result in blackouts. Inadequate maintenance, lack of investment in infrastructure, and outdated equipment contribute to technical failures.
Natural Disasters: Bangladesh is prone to natural disasters such as cyclones, floods, and storms. These events can cause damage to power infrastructure, including power lines, substations, and power plants, leading to blackouts.
Seasonal Variations in Power Demand: Bangladesh experiences a significant increase in electricity demand during the hot summer months due to the extensive use of air conditioning. The power generation and distribution systems may struggle to cope with this peak demand, resulting in blackouts.
Load Shedding: To manage the demand and supply gap, utility companies in Bangladesh often resort to load shedding, where electricity supply is intentionally interrupted in certain areas for a specific period. Load shedding is a temporary measure to balance the demand and avoid widespread blackouts.
Efforts are being made to address these issues in Bangladesh's power sector, including investments in new power plants, infrastructure upgrades, renewable energy initiatives, and improvement in transmission and distribution systems.

4.7 Data Analysis

Area Overview:

Project	**Rangpur Division**
Geographical coordinates	*Chilmari, Kurigram District, Rangpur Division, 5630, Bangladesh* 26.160060°, 89.052644° (26°09'36'', 089°03'10'')
Report generated	12 April 2023
Generated by	Global Wind Atlas
Map link	https://globalwindatlas.info/map?s=26.16006,89.052644,10=ground,180,27,1000

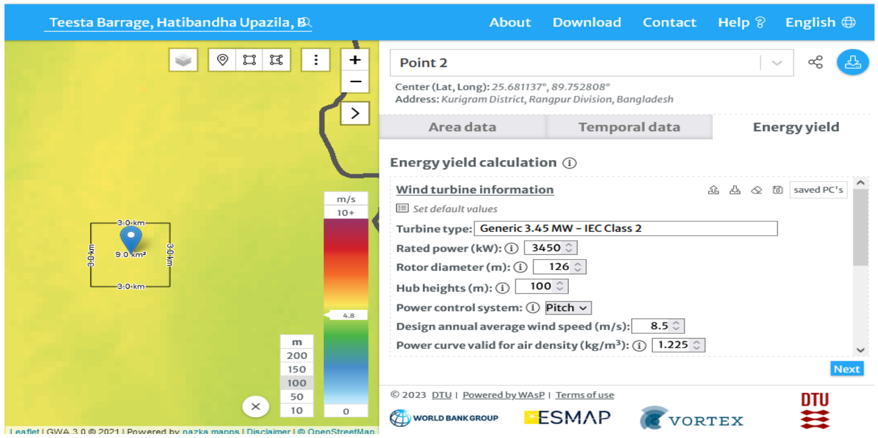


Figure 4.41: Global Wind Atlas Map Data View

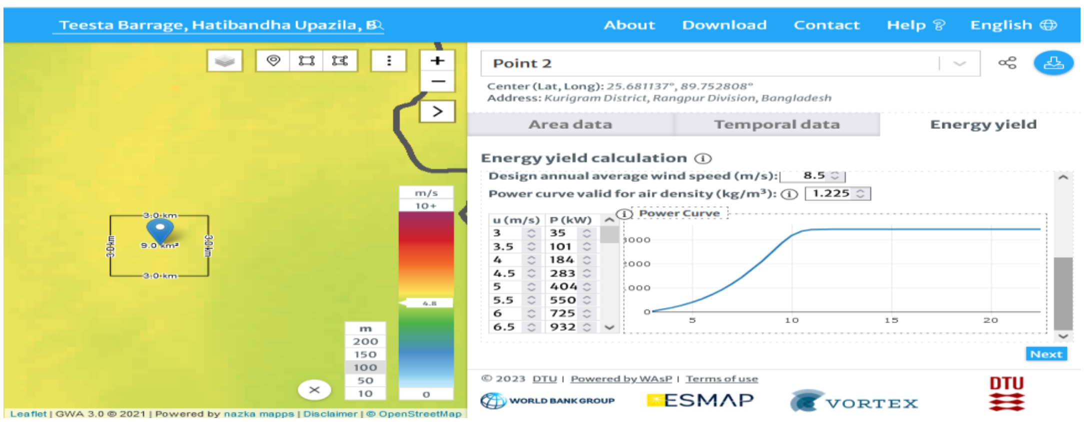


Figure 4.42: Global Wind Atlas Chilmari, Kurigram Area Data

Project	Rangpur Division
Location	Address: Global Wind Atlas *District, Rangpur Division, 5630, Bangladesh*
Geographical coordinates	26.160060°, 89.052644° (26°09'36", 089°03'10")
Time zone	UTC+06
Elevation	277.25 km2

Main Wind Speed

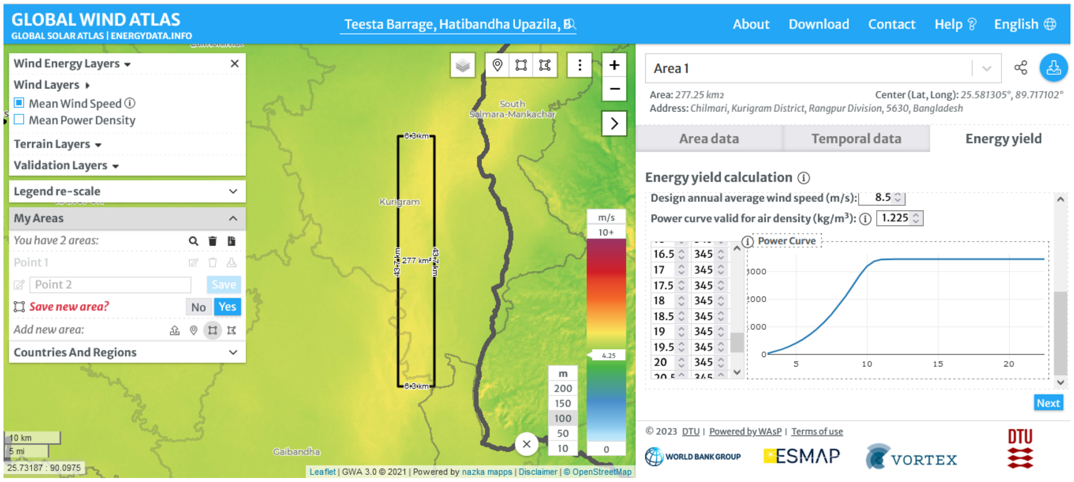


Figure 4.43: Main Wind Speed

Main Power Density

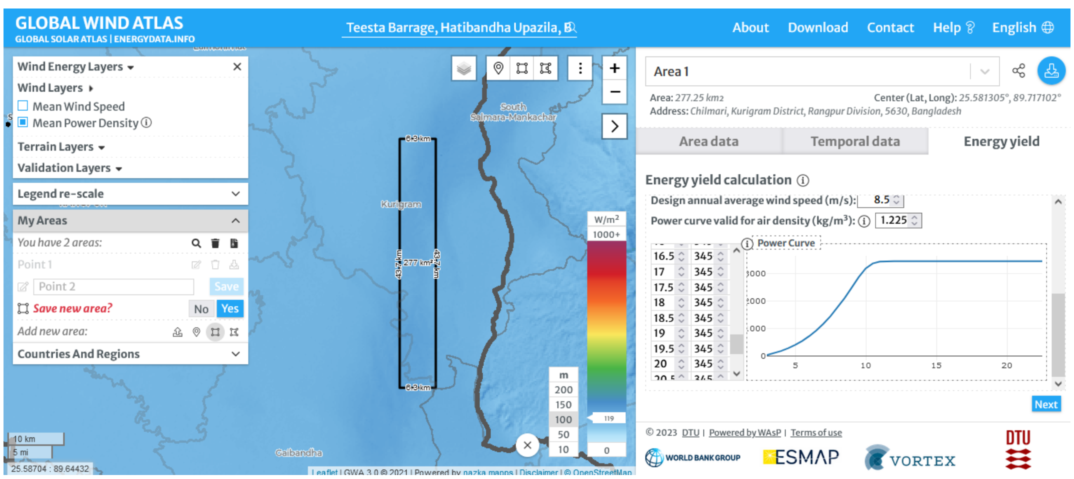


Figure 4.44: Main Power Density

Equation 3 Wind Capacity

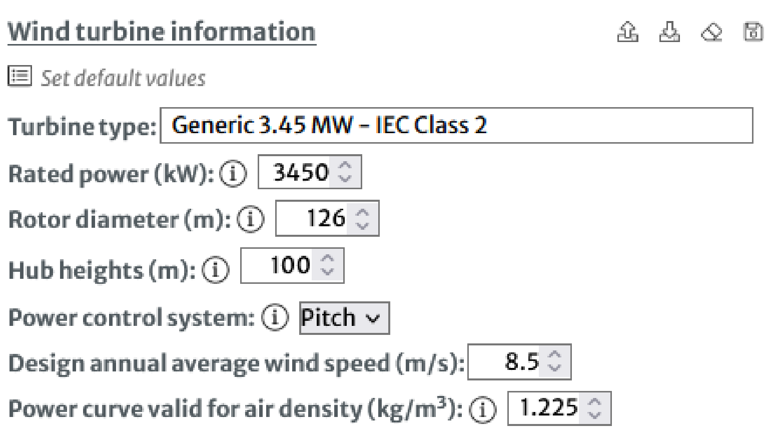


Table 4.4: Annual Data

Month	Value
January	0.9
February	0.79
March	0.98
April	1.14
May	0.98
June	1.18
July	1.23
August	1.11
September	0.9
October	0.83
November	0.99
December	0.95

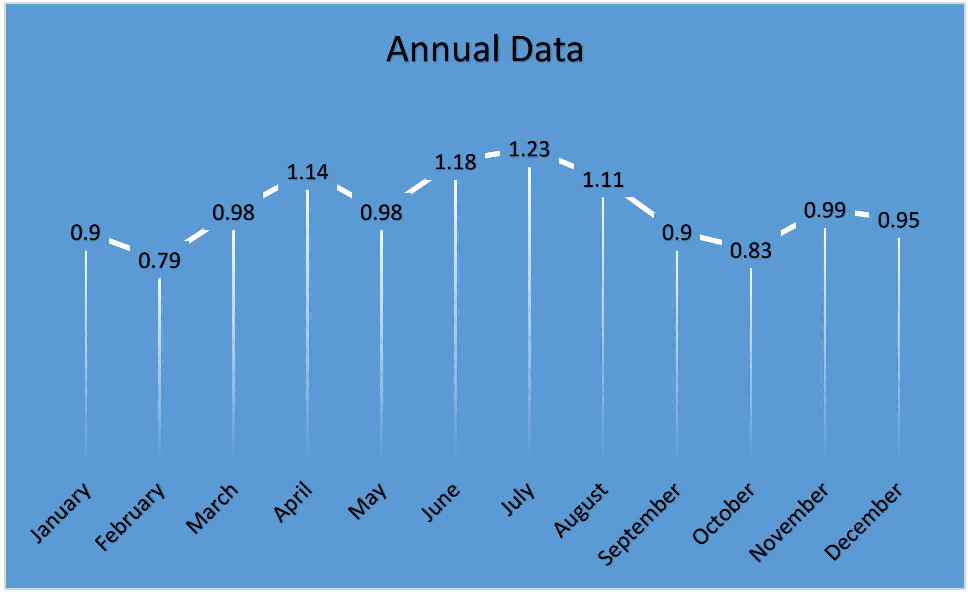


Table 4.5: Diurnal Data

Day	value	Day	value
1	1.19	16	1.04
2	1.11	17	1.06
3	1.05	18	1.07
4	0.99	19	1.09
5	0.91	20	1.1
6	0.87	21	1.13
7	0.84	22	1.15
8	0.83	23	1.17
9	0.82	24	1.18
10	0.81	25	1.2
11	0.82	26	1.3
12	0.85	27	0.99
13	0.91	28	1.21
14	0.97	29	1.22

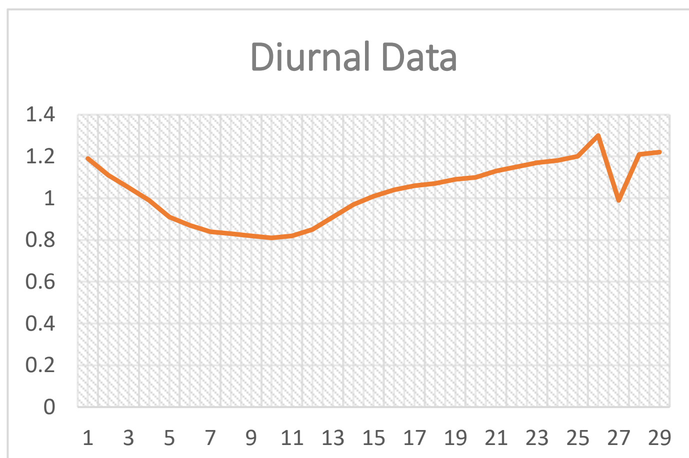
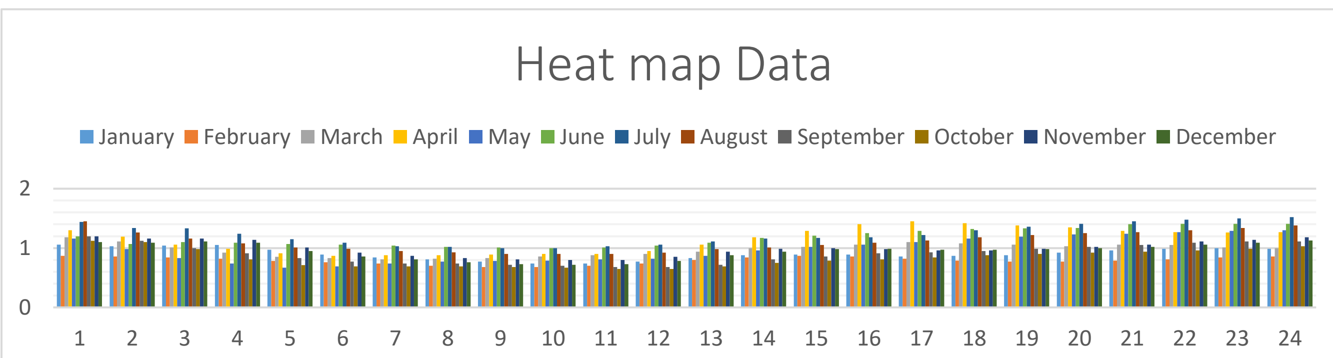


Table 4.6 Heat Map Data

January	February	March	April	May	June	July	August	September	October	November	December
1.06	0.87	1.18	1.3	1.16	1.2	1.44	1.45	1.2	1.12	1.2	1.1
1.03	0.86	1.11	1.19	0.98	1.07	1.34	1.26	1.12	1.1	1.16	1.09
1.04	0.84	1.01	1.06	0.83	1.1	1.33	1.16	1	0.98	1.16	1.11
1.05	0.82	0.92	0.99	0.74	1.09	1.24	1.08	0.91	0.81	1.14	1.09
0.97	0.78	0.85	0.91	0.67	1.07	1.15	1.01	0.83	0.71	1.01	0.95
0.89	0.76	0.83	0.87	0.69	1.06	1.09	0.99	0.77	0.69	0.92	0.86
0.84	0.74	0.81	0.88	0.74	1.04	1.03	0.95	0.74	0.69	0.87	0.81
0.81	0.7	0.82	0.88	0.77	1.02	1.02	0.93	0.74	0.69	0.83	0.76
0.77	0.68	0.83	0.89	0.78	1.01	1	0.9	0.72	0.68	0.81	0.73
0.74	0.68	0.86	0.9	0.79	1	1	0.9	0.7	0.67	0.8	0.72
0.74	0.7	0.88	0.9	0.81	1.01	1.03	0.9	0.68	0.65	0.8	0.73
0.77	0.74	0.9	0.95	0.82	1.04	1.06	0.92	0.68	0.65	0.85	0.78
0.83	0.8	0.94	1.06	0.87	1.09	1.11	0.98	0.72	0.69	0.94	0.88
0.88	0.84	1	1.18	0.96	1.17	1.16	1.01	0.81	0.75	0.99	0.94
0.89	0.87	1.02	1.29	1.02	1.21	1.17	1.05	0.86	0.79	1	0.98
0.89	0.86	1.06	1.4	1.06	1.25	1.18	1.09	0.91	0.81	0.98	0.99
0.86	0.82	1.1	1.45	1.1	1.29	1.22	1.13	0.93	0.84	0.96	0.97
0.87	0.79	1.08	1.42	1.16	1.32	1.3	1.18	0.95	0.88	0.96	0.97
0.88	0.77	1.06	1.38	1.19	1.33	1.36	1.22	0.99	0.9	0.99	0.98
0.92	0.77	1.03	1.35	1.23	1.34	1.41	1.25	1.02	0.92	1.02	1
0.96	0.79	1.06	1.29	1.24	1.4	1.45	1.27	1.05	0.94	1.06	1.02
0.99	0.81	1.05	1.27	1.27	1.41	1.48	1.3	1.09	0.96	1.11	1.06
1	0.84	1.01	1.26	1.29	1.41	1.5	1.34	1.11	0.99	1.14	1.09
0.99	0.86	1	1.27	1.3	1.41	1.52	1.38	1.11	1.03	1.18	1.13



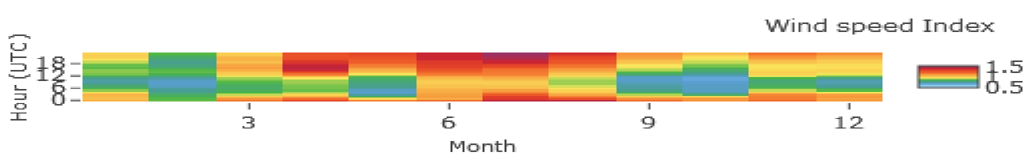


Figure 4.45: Heat map Data

Table 4.7: Inter Annual Data

Year	value
2008	0.99
2009	1
2010	1.09
2011	0.98
2012	1.03
2013	1
2014	0.98
2015	0.96
2016	0.97
2017	1
2018	1.1
2019	1.16
2020	1.15
2021	1.2

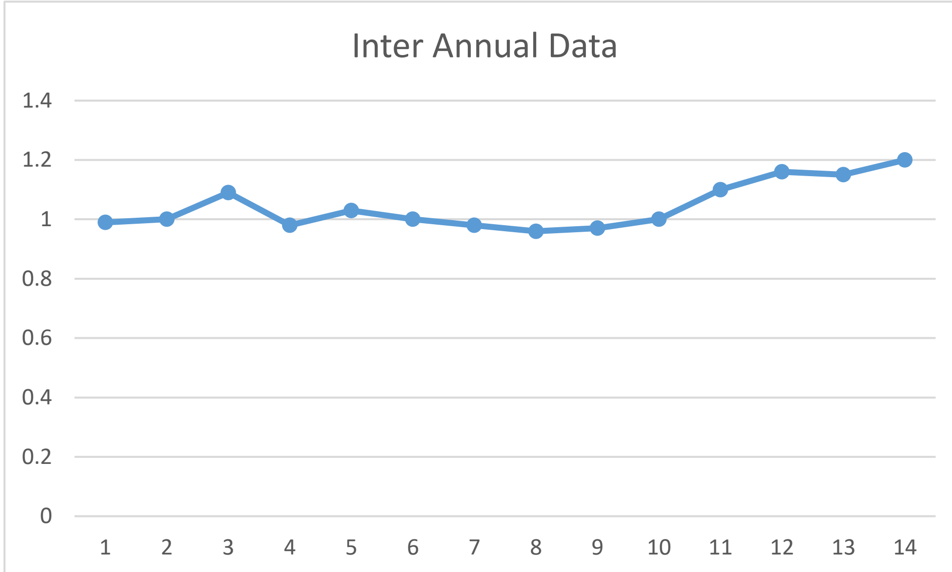


Table 4.8: Power Density

value	perc	sel_perc	value	perc	sel_perc
152.56	1.65	2	150.48	52.07	52
152.51	4.13	4	150.43	53.72	54
152.47	5.79	6	150.34	56.2	56
152.36	8.26	8	150.28	57.85	58
152.27	9.92	10	150.19	60.33	60
152.15	12.4	12	150.12	61.98	62
152.07	14.05	14	150.05	63.64	64
152	15.7	16	149.94	66.12	66
151.9	18.18	18	149.86	67.77	68
151.83	19.83	20	149.75	70.25	70
151.74	22.31	22	149.66	71.9	72
151.67	23.97	24	149.5	74.38	74
151.6	25.62	26	149.39	76.03	76
151.48	28.1	28	149.28	77.69	78
151.4	29.75	30	149.08	80.17	80
151.27	32.23	32	148.93	81.82	82
151.19	33.88	34	148.7	84.3	84
151.08	36.36	36	148.55	85.95	86
151.01	38.02	38	148.4	87.6	88
150.95	39.67	40	148.17	90.08	90
150.85	42.15	42	148.03	91.74	92
150.78	43.8	44	147.8	94.21	94
150.69	46.28	46	147.64	95.87	96
150.63	47.93	48	147.41	98.35	98

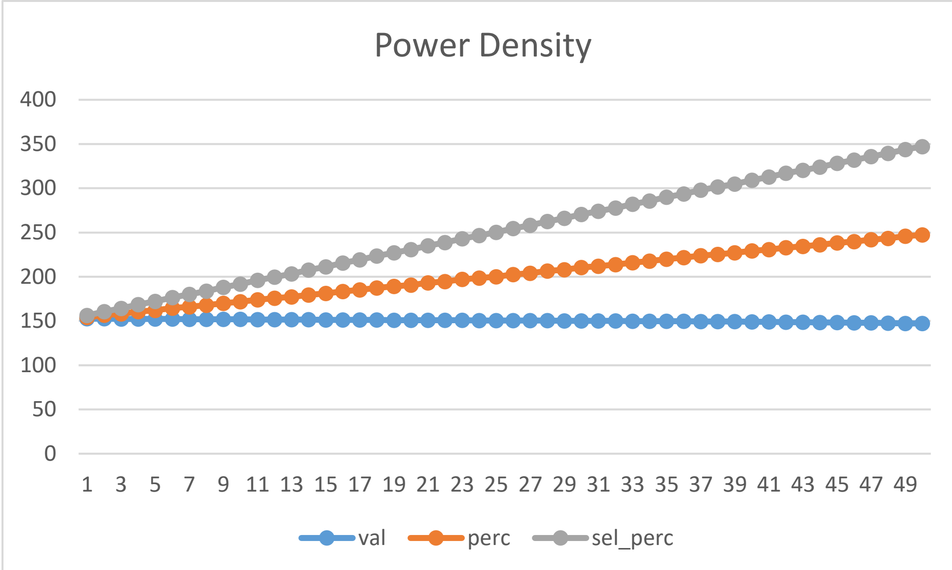


Table 4.9: Wind Power

value	sector	center degrees
0.08	1	0
0.16	2	30
0.15	3	60
0.05	4	90
0.06	5	120
0.18	6	150
0.17	7	180
0.05	8	210
0.03	9	240
0.02	10	270
0.02	11	300
0.03	12	330

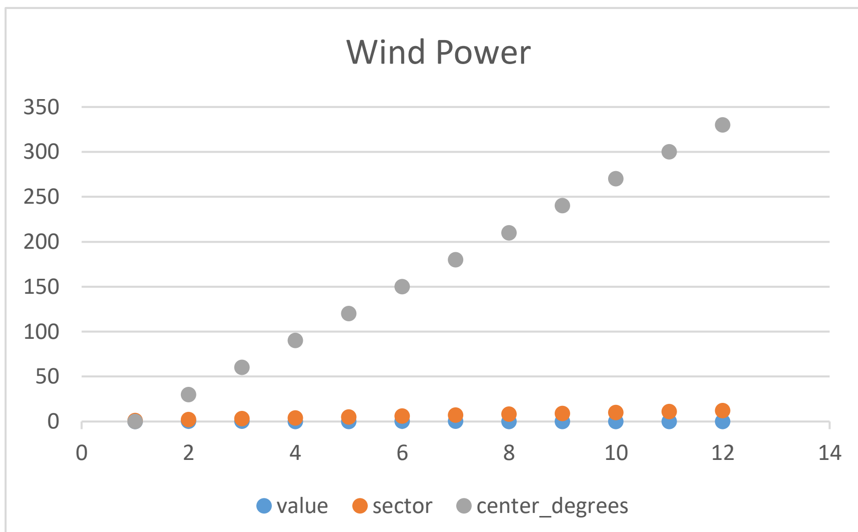
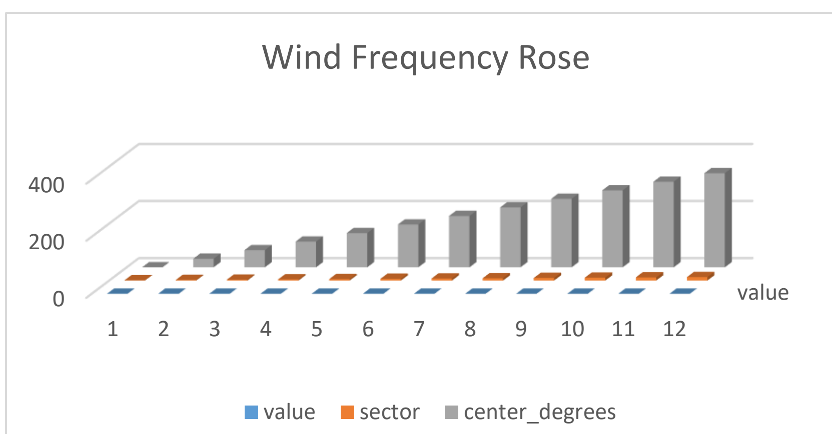


Table 4.10: Wind Frequency Rose

value	sector	center_degrees
0.02	1	0
0.12	2	30
0.22	3	60
0.02	4	90
0.07	5	120
0.32	6	150
0.18	7	180
0.02	8	210
0.01	9	240
0.01	10	270



0.01	11	300
0	12	330

Table 4.11: Wind Peak Value

value	perc	sel_perc	value	perc	sel_perc
5.24	1.65	2	5.22	52.07	52
5.24	4.13	4	5.22	53.72	54
5.24	5.79	6	5.22	56.2	56
5.24	8.26	8	5.22	57.85	58
5.23	9.92	10	5.22	60.33	60
5.23	12.4	12	5.22	61.98	62
5.23	14.05	14	5.22	63.64	64
5.23	15.7	16	5.21	66.12	66
5.23	18.18	18	5.21	67.77	68
5.23	19.83	20	5.21	70.25	70
5.23	22.31	22	5.21	71.9	72
5.23	23.97	24	5.21	74.38	74
5.23	25.62	26	5.21	76.03	76
5.23	28.1	28	5.21	77.69	78
5.23	29.75	30	5.21	80.17	80
5.23	32.23	32	5.21	81.82	82
5.23	33.88	34	5.21	84.3	84
5.22	36.36	36	5.2	85.95	86
5.22	38.02	38	5.2	87.6	88
5.22	39.67	40	5.2	90.08	90
5.22	42.15	42	5.2	91.74	92
5.22	43.8	44	5.2	94.21	94
5.22	46.28	46	5.2	95.87	96
5.22	47.93	48	5.19	98.35	98
5.22	49.59	50	5.19	100	100

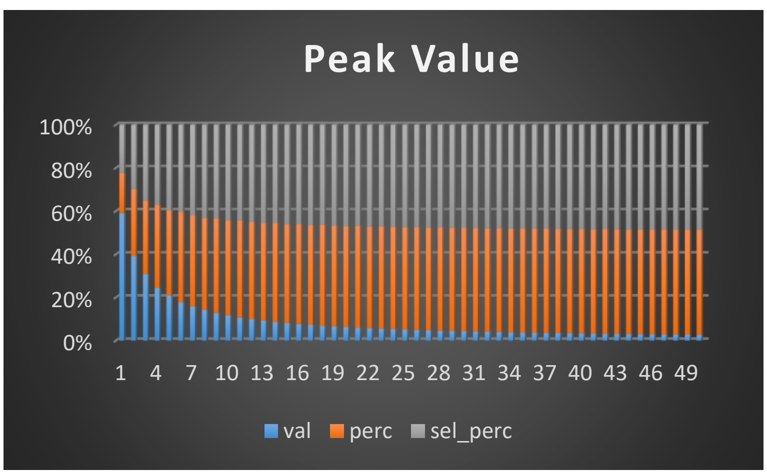
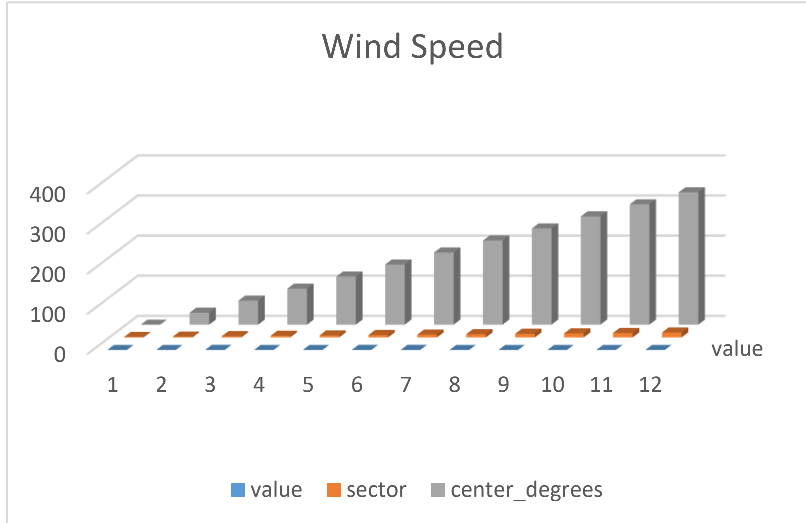


Table 4.12: Wind Speed

value	sector	center_degrees
0.05	1	0
0.15	2	30
0.18	3	60
0.03	4	90
0.06	5	120
0.24	6	150
0.19	7	180
0.04	8	210
0.02	9	240
0.01	10	270
0.01	11	300
0.01	12	330



4.7.1 Study of China and Bangladesh Wind Power Potential

China and Bangladesh have both been actively exploring and developing their wind power potential to meet their growing energy demands and promote renewable energy sources. Here is a brief overview of the wind power potential and related studies in both countries:

China:

Wind Power Potential: China has one of the largest wind power potentials in the world, thanks to its vast land area and diverse wind resources. Its coastal regions, such as the provinces of Hebei, Shandong, Jiangsu, and Guangdong, as well as the Inner Mongolia Autonomous Region, Gansu Province, and Xinjiang Uygur Autonomous Region, are known for their significant wind resources.

Wind Power Capacity: China has become the global leader in wind power installations. According to the Global Wind Energy Council, China had a total installed wind power capacity of over 281 gigawatts (GW) by the end of 2020, accounting for a significant portion of the world's wind power capacity.

Wind Power Studies: Numerous studies have been conducted in China to assess its wind power potential and optimize wind farm development. These studies include wind resource assessments, site suitability analysis, wind turbine technology advancements, grid integration studies, and socio-economic impact assessments.

Bangladesh:

Wind Power Potential: Bangladesh also possesses significant wind power potential, particularly in coastal and hilly areas. The coastal regions, including Cox's Bazar and Khulna, and hilly regions like Chittagong Hill Tracts, have favorable wind resources for wind power generation.

Wind Power Capacity: Wind power development in Bangladesh was relatively limited compared to other renewable energy sources like solar power. However, the country has been taking steps to harness its wind power potential and diversify its energy mix.

Wind Power Studies: Bangladesh has conducted wind resource assessments and feasibility studies to evaluate the viability of wind power projects. These studies aim to identify suitable locations for wind farms, assess wind patterns, estimate potential energy generation, and determine the economic feasibility of wind power investments.

It's worth noting that wind power potential and specific studies may have evolved. For the most up-to-date information and detailed studies on wind power potential in China and Bangladesh, I recommend referring to recent reports, publications, and official sources from relevant government agencies, research institutions, and renewable energy organizations in these countries.

4.7.2 Conclusion

This project looked into designing a rotor to perform in a wind tunnel at varying wind speeds. Data was collected and the non-dimensional power coefficient and speed were calculated and plotted against each other on a graph. From this we were able to scale up our model to generate a power of 10kW, mimicking a large rotor.

Our results which allowed us to calculate Cp produced the desired trend as shown on the graph. However, as the tip speed ratio drops below 10 no data points were determined from the results, this could be due to the minimum wind speed we tested at was 4ms or the angular velocity being too large, both of which would result in a larger value for the tip speed. Upon scaling up our design to generate a larger power output of 10kW, our value of approximately 10m in diameter seems reasonable when we take our peak C, value.

To improve on the results, we obtained I would retest with a broader range of wind speeds starting lower than 4 and increasing with smaller increments to produce more data points. This would improve the accuracy of C, and make any pieces of anomalous data clearer to see, as this is hard to notice when only 3 data points were collected, in addition to this using smaller masses when stalling the wind turbine would produce more accurate values for the torque. As when we were stopping the rotor it was hard to get the blade to the point where it just stopped. It is possible that we added too much weight which may have skewed our values for the torque.

Throughout the project we worked well as a team and all contributed to the labs and calculation of the results. It aided my understanding of the fluid calculations and gave some practice when producing the results sheet.

Wind power is a renewable energy source that harnesses the power of the wind to generate electricity. It has emerged as one of the fastest-growing sources of electricity worldwide and has numerous advantages and benefits. After analyzing the available information and data, we can draw the following conclusions about wind power:

Environmentally Friendly: Wind power is a clean and green energy source that produces no greenhouse gas emissions or air pollutants during operation. It helps reduce reliance on fossil fuels and mitigates the impact of climate change.

Renewable and Sustainable: Wind is an abundant and inexhaustible resource, making wind power a sustainable option for generating electricity. It provides a long-term solution to meeting energy demands without depleting finite resources.

Cost-Competitive: Over the years, technological advancements and economies of scale have significantly reduced the cost of wind power generation. It has become increasingly cost-competitive with conventional energy sources, such as coal and natural gas, and can provide stable long-term energy prices.

Job Creation and Economic Benefits: The wind power industry creates jobs across various stages, including manufacturing, installation, operation, and maintenance of wind turbines. It stimulates local economies, attracts investments, and contributes to energy independence by reducing reliance on imported fuels.

Potential for Energy Independence: Wind power reduces dependence on fossil fuel imports, enhancing energy security and independence for countries. It diversifies the energy mix and decreases vulnerability to price fluctuations and supply disruptions associated with fossil fuels.

Scalable and Modular: Wind farms can be built at various scales, from small community-level projects to large utility-scale installations. This flexibility allows for incremental capacity additions based on energy demand, making wind power a versatile option for different regions and applications.

Challenges and Limitations: Despite its numerous benefits, wind power does face some challenges. These include intermittency (as wind is not constant), visual and noise impacts on local communities, bird and bat collisions, and the need for suitable wind resources and transmission infrastructure.

In conclusion, wind power is a crucial component of a sustainable and low-carbon energy future. Its environmental benefits, cost-competitiveness, job creation potential, and scalability make it a viable and attractive option for electricity generation. However, it should be implemented responsibly, taking into account local considerations and addressing associated challenges to maximize its overall effectiveness and acceptance.

Finally, we want to say the advantages of wind energy are more than the disadvantages so our opinion that wind energy which has many benefits, such as it is less expensive than factories, less space, are easily available all over the world and non-polluting to the environment. So, wind energy is also more useful than traditional methods to create energy. Meaning that it is getting cheaper and cheaper to produce wind energy.

CHAPTER 5

CHAPTER HYDRO POWER

Figure 5.1 Teesta Barrage Area Water Flow and Flood Bypass System

5.1 Introduction

Introduction: Energy is an essential element modernity society. Electricity is viewed as a key factor in the advancement of economic and social circumstances in both industrialized and developing nations. The worldwide use of energy has been rising nearly continuously in recent years as a way to fulfill this increasing need. In addition, there has been a rise in yearly worldwide energy use for a minimum of one year. From 1800 through 2022, 22 times. One of the earliest and most abundant sources of clean power is hydropower, which uses the movement of water to produce electrical. At this moment, hydroelectricity generates 31.5% of all renewable energy produced in the US and roughly 6.3% of all electricity produced in the country. In Bangladesh, energy from renewable sources like solar, biogas, wind, and hydropower have become the most popular. the hydroelectric project at Karnaphuli the only electricity station in the nation with a 230 MW electricity collecting capacity.

On the bank of the Karnaphuli River in Kaptai, Bangladesh's Rangamati District, 65 kilometers upwards of Chittagong, is where you'll find the Kaptai Dam. It is a construction dams with a 6,477 million cubic meters of water holding capacity. The reservoirs and dams were built primarily to produce hydropower electricity.

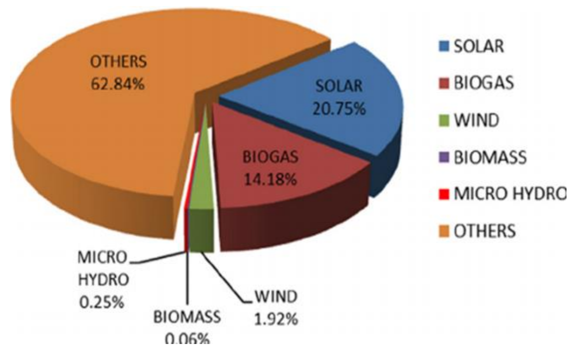


Figure 5.2: Ratio of different renewable energy sources in Bangladesh [54]

According to current indicators, global carbon dioxide emissions by concrete and petroleum products will rise by 1.0% in 2022, reaching a record high of 36.6 billion tons of CO2 (GtCO2). The 2022 Global Carbon Strategy Study is where the indicators are taken from. As global travel continues to recover during the Covid-19 crisis, the increase in fossils radiation in 2022 is typically caused by a sharp increase in oil emanations. In 2018, it registered record emanations, but it grew less rapidly. The main source of worldwide greenhouse gases from fossil fuels is the combustion of petroleum, natural gas, and coal. Approximately 40% of all fossil fuel carbon dioxide produced worldwide in 2022 will come from coal, making it the most polluting fossil fuel. With a 32% contribution, oil is the second-biggest source of geological CO2.

Concrete manufacturing, at 4%, and gas generation, at 21%, complete the industry. The percentages used represent how much of each energy source is present. In this situation, there remains an urgent issue that must be taken into account. ongoing usage [55].

Issues regarding energy safety are also raised by the limited supply of electricity that can be produced from limited energy sources. Energy usage must be maintained at least around an equal level to allow us to reside peacefully. a scenario suggested by Internationally Power. The organization wants to hasten the adoption of renewable energies and boost energy effectiveness. Environment and life near the hydroelectric power plant. Additionally, hydropower plants don't release greenhouse emissions when in operations

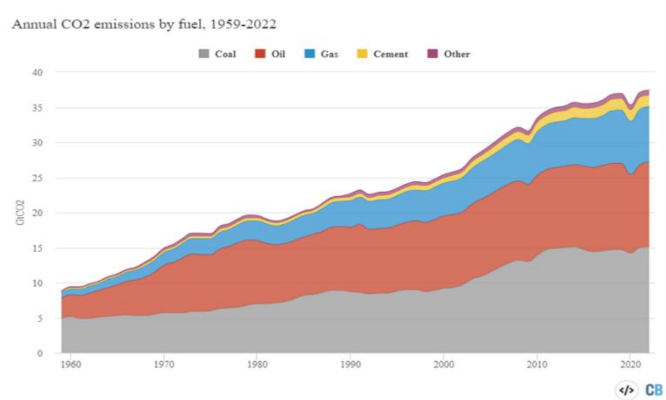


Figure 5.3: World CO2 Emissions from 1971 to 2022 [56]

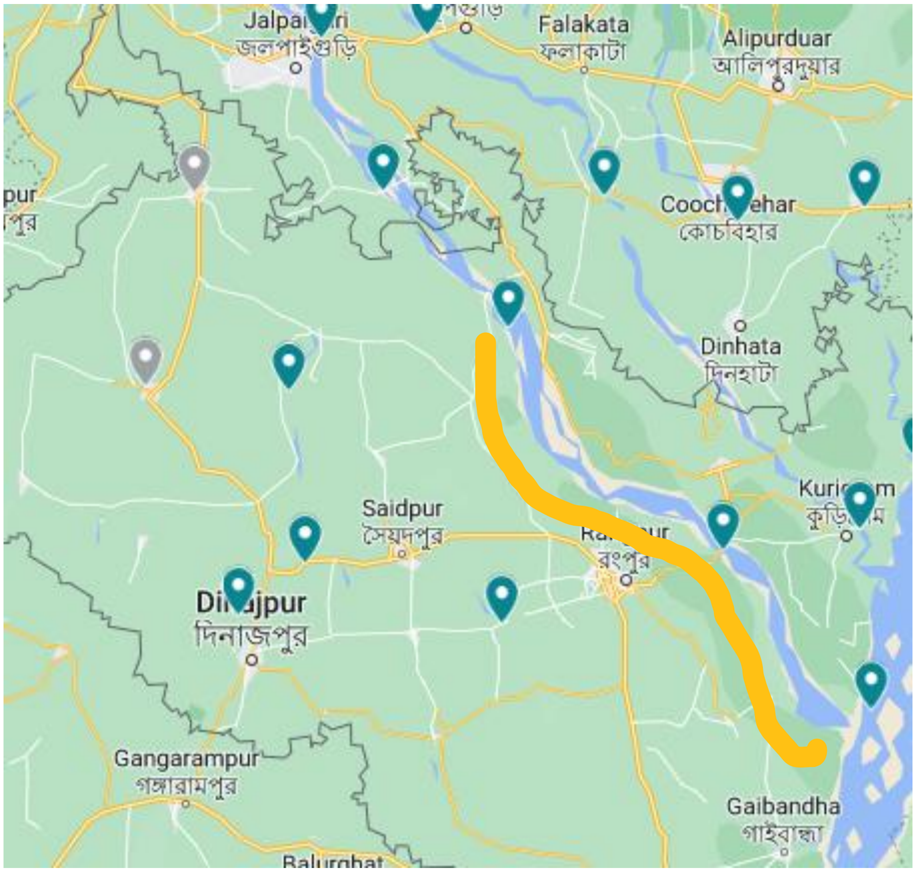


Figure 5.4: Basin map in Teesta River.

Problem Statement

❖ **The primary region for the decline in river water quality include.**

1. Disposal of commercial garbage.
2. Discharge of sewage from local governments.
3. Domestic waste.
4. Illegal encroachment and unplanned construction of building on both side of the river.
5. Alleviation of scarcity of fresh water.
6. Alleviation of unwanted flood situations.

Surface water contamination and declining water quality are mostly caused by anthropogenic activities such untreated industrial effluents, inadequately deposited residential rash, and agricultural runoff.

- **Hydropower**

A structure called a dam or additional structure which alters the natural flow of a river or different type of water is used to produce hydroelectricity, often known as hydroelectricity. Among the earliest and most significant types of sustainable power, hydroelectric electricity or hydro energy, harnesses the natural process of water that moves to produce electrical. The function of an electrical generator is founded on the principles established by Faraday. A hydroelectric turbine turns the power of water that flows into mechanical power, which is then converted into power by a hydropower generating. Humans have been using this power for eons. Greeks have been successfully utilizing water that flows to turn its mill's wheel and turn wheat into bread for nearly 2,000 years.

Impediment infrastructure, the most common type of hydropower generating facility, are one of the three fundamental types. To control the quantity of water that's supplied in an aquarium or storage tank, a dam is utilized in an impediment plant. When more energy is needed, water is released into the dams. Hydroelectricity, often known as hydro energy, is a type of sustainable energy that makes use of water from rivers and dams to operate hydroelectric plants. The third kind of structure is referred to as a "pumped-storage facility". This plant gathers and safeguards electricity produced by sunshine, wind, and nuclear power for usage later on.

The organism stores power by moving water upward through a body of water at lower ground level to a reservoir at a higher altitude. Whenever there's a substantial need for energy, water is discharged from the upper pool. As the water flows to the upper storage tank, it powers an engine to generate additional electricity. Hydropower is used to produce 16%–18% of the electricity [57].

In the 1960s, a sizable hydroelectric facility employing the Karnaphuli river was built in the Kaptai region. This capability, which is 230 MW, aids in providing electricity for our nation. Compared to other fuels in our nation, the cost of power generation is extremely low. Bhutan has a capacity of 25,000 megawatts in this area. Currently this nation produced 1500MW, and they plan to produce 6300MW with help from India. Together, our government and the corporate sector plan to invest in Nepal to benefit energy production from hydroelectricity. The largest hydropower facility in the world is in China. In the Three Gorges Dam, to be precise. In 2014, this installed capacity was 22500MW.

Figure 5.5: The world largest hydropower in China [58]

5.1.1 Mini Hydropower Plants

This mini-hydro station will serve the extensive age of the neighborhood power grid, improving hydroelectric power control to a degree that is commendable for nearby communities and industries. Typical age capacities vary from 1 to 20 megawatts, with little hydropower. More to 100 kilowatts of electricity can often be produced by micro-hydro systems. The majority of hydroelectric dams utilized by property holders, small company the owners, landowners, and other landowners fall under this category.

5.1.2 Small Hydropower Plants

Usually, small hydro plants are placed in rivers and linked to catchments by rivers.200 km2 or less. The water column and its potential have an impact on the flow's energy. The process of converting power into energy that is utilized.

River energy is often captured utilizing the following elements in small hydropower plants:

- **Weirs:** In micro-hydro plants, weirs act as the water entry mechanism. Upstream detour to cove.
- **System of conveyors:** A intake is where the incoming water is taken in this system. Continue water discharge into upstream pipes, tunnels, or conveyor channels 8th place spillways, penstocks, and turbines. These parts' primary function is to guide the water's useable energy, which can be used to turn turbines.
- **Hydraulic Turbine:** Uses flow from a conveyor turbine-spinning system.
- **Generator rotor:** The generator receives mechanical power in the form of motion of rotation. The electrical power generated by shank generators is sent to the network.
- **Grid connection:** Facilitates the movement and supply of electricity from suppliers to the necessary end users.

5.1.3 Weir

A weir's primary function is to regulate the flow of water through an inlet as a sum set. Weirs are used to collect water discharges and control and regulate the water supply. I have a clumsy mind. The drop height affects how much water is held in reserve. In low pressure systems, drainage is typically kept in place to maintain a steady upstream water level as a fixed amount. The principal job of a weir is to be control the water flow via an intake power system in hydro.

Using guarded overflows or fixed weirs with movable gates. In order to maintain a steady water level, turbines are also controlled in this manner. When the volume of water discharged to the turbine is excessive. Water that is too much for the turbines must drain into the riverbed.

There are also permanent constructions, such as weirs and dams, if the location has a steep drop. spillways applicable. These types of structure level are allowed. In addition, the fixed of structure has the advantage of lower cost and simple maintenance.

5.1.4 Transport System

The conditioned wastewater entered the water intake and directs the water to the tailings pond. one of the very important criteria in intake design relate to the minimum immersion value. Addiction Depending on the inlet geometry, vortex formation may occur at the following dive values: Minimum immersion value. The appearance of a vortex entrains air,

There is solid material at the inlet, reduced systems efficient. one of the methods of determining the minimum immersion value to avoid vortex formation is determined using the following formula:

$$S/d = C\, v/\sqrt{gd}$$

where S is the immersion depth (m), d is the inlet opening (m), V is the average flow velocity at the inlet (m/s),

g is 9.8 m/s

2, C for symmetric flow is 1.7 and C for asymmetric flow is 2.3.

The water then enters the sedimentation tank. This tank slows down water passing through

Particles contained in flowing water settle. trash can set

It is placed near tailings ponds to filter out large underwater objects such as dead leaves.

garbage.

5.1.5 Floodgate

Gates to block, allow, or release bodies of water:

Floodgate: designed to reduce the occurrence of A sluice gate, also called a shutter gate, is an adjustable gate used to control the flow of water in a seawall, reservoir, river, stream, or levee system. They can be designed to set the spillway height of dams, regulate the flow of locks and canals, or completely stop the flow of water as part of a dyke or storm surge system. Most of these devices are also called ridge gates because they work by controlling the level of water that is retracted or directed. In flood avoidance systems, locks are also used to lower water levels in the major river or canal channels by allowing more water into flood avoidance or reservoirs when the major rivers or canals are approaching the flood stage [59].

Penstock frameworks and penstocks are utilized to carry water from the forecastle to the waterwheel. Weight line highlights incorporate a valve at the gulf to the weight line. Empty the water within the lines amid framework blackouts or support. In the event that this circumstance occurs, Water runoff is occupied to flood trench or sewers.

5.1.6 Hydro Electric Turbine

A hydroelectric turbine could be a gadget that can change over the motor vitality of water into mechanical vitality. They are fundamentally part of hydroelectric control plants and have a really tall yield. It is assessed that turbines can change over 90% of the motor vitality of water into mechanical energy. The turbine design is essentially the same as well. A revolving shafts or disk is equipped with a number of blades. Following that, water flows through a turbine that has blades, turning the inside shaft. The generator receives this rotary motion and produces power. Various kinds of generators are most suitable for use in various contexts. The kind of turbine chosen for a certain electricity project depends on the head—the height and speed of the entering water—and the hydraulic discharge—the volume of water that flows. Cost and effectiveness are also important factors [60].

Turbine Flow: The way water travels through a hydroelectric generator can be used to categorize them. Water can go down a variety of Through the turbine's blades it goes. This creates three distinct groups for the water movement that passes the turbine:

Axial flow: Water flowing perpendicular to the turbine's axis of circulation.

Radial flow: Water that moves radially to the turbine's plane of revolution.

Water moves across it in an alternating flow that combines axial and peripheral flow. For instance, water leaves a Francis turbine horizontally despite flowing laterally. Also, another measure for classifying turbines is whether the weight of the liquid changes because it streams through the turbine. Two sorts of turbines are created from this classification, which are depicted below.

Impulse Turbine

Impulse turbines are ideal for high water levels. Recoil turbines are suitable for relatively low water levels. Impulse turbines are suitable for relatively low water throughput. Reaction turbines are suitable for high water flow rates. Fluid kinetic power is used by impulse-generated turbines to rotate a turbine and direct the flow of water.

utilizing a water jet at the pressure of the atmosphere. Impulse wind turbines are typically used in high output, relatively dry areas. Water jets are produced near the foot of the highwater columns by the enormous force of water that is created there. Pelton, Targo, and crossover turbines are common illustrations of this kind of turbine.

Reaction Turbine

A turbine which turns utilizing either the force of gravity and the speed of flowing water is called a reactive turbine. When water penetrates the casing tangentially, a response turbine is positioned in the water flow. Water is released axially outside of the turbine chamber once the blades have finished rotating. Applications for reaction turbines include: These turbines are used in wind turbines and hydroelectric power plants to generate electricity. This type of turbine achieves maximum power output from accessible low water columns and high speeds.

5.1.7 Generator System

A river or another type of the water's flow rate can be changed to generate electricity through the use of reservoirs or other diverting devices, which is a form of environmentally friendly energy. Generators in hydropower plants are responsible for transforming mechanical energy from rotors into electricity. Synchronization and asynchronous generator comprise the two various kinds of generator. Synchronous generators are appropriate for use with hydroelectric or as an independent grid. A significant source of grid electricity is this facility. Synchronous generator serves as an interconnected system in this scenario. It serves as a controller and an amplifier of reactive power. An asynchronous transmitting device, on the other hand, requires reactive power from the network. As a result, when he is cut off from the electric grid, he cannot produce power. Yet, an asynchronously generator can offer a cheap solution for poor power quality and minimal interference with manufacturing processes. The efficiency of the hydroelectric generator is small when operating at rated power of 90 to 95%. In large factories, this value can be improved up to fulfillment.

Capacity Factor

- The difference between the amount of energy produced over time and the amount of energy that could be produced if the generator were running continuously at its rated capacity is known as the electrical plant's efficiency rating. The following is the capacity factor (CF) equation:

CF = Annual Energy Produced (kW h)/Power Plant Capacity(kW)x8760(h)

- **Streamflow**

Streamflow or channel runoff refers to the movement of water using streams and other channels, and it is an essential component of the water cycles. It is a step in the method of getting water from the ground to waterbodies; the other step is surface runoff. The sources of the water flowing through channels are water released from pipelines, groundwater flow out of the earth, and surface runoff from neighboring hillslopes. Stream gauges are used to measure the flow of water in a channel, or the Manning equation can be used to estimate it. The term "hydrograph" refers to the record of flow through time.

Flooding happens when the amount of water surpasses the channel's capacity. The water discharge that flows on the site river is one of the most crucial elements in evaluating the potential energy of a hydropower plant.

Even though a site has excellent geographic characteristics, the ability to harvest river energy ultimately depends on the water's flow. Knowing or estimating the water discharge data throughout the year is crucial for making the most use of the energy that is now available. Hydrology research will likely characterize some data [61].

• The operating discharge (design discharge) sizing of a plant, based on river runoff data. The size of the water intake and the size of the diversion circuit will also be included in this data.

• Flood/peak flows serve as the foundation for the peak flow design.

The size of the dam/weir and the diversion channel on the plant will be decided by those facts.

There are a numbers methods that can be used to establish whether a location has enough water available for the construction of hydropower, depending on the data that is available.
This data can be used if it is accessible through a gauging station, which is typically not the case.
However, it's crucial to guarantee that the data is consistently evaluated.
However, the data must also be adequate and timely.
At the very least, 40 years' worth of data should be expected.
The analysis of rainfall and streamflow based on catchment area, evapotranspiration, and geology is carried out if there are no data or not enough data is available. By multiplying the average cross section area and flow velocity, streamflow is calculated. The process is cheap. Because the discharge is calculated using simply volume and time, it is an absolute technique. There are two parts to steam flow. The first is stream velocity, while the second is stream volume.

5.1.8 Drainage Basin

These water reservoirs, whether they be man-made or natural, are directed to power plants to boost the creation of renewable energy. a water-collecting area with a hydropower basin. It can be either natural, like a lake, or constructed, like a dam, if it prevents the flow of water.
A watershed depicts the area of terrain through which water flows to the common lowest point or basin. This water travels through the network of rivers and tributaries, which is made up of numerous and diverse streams. The river system, which acts as a conduit for extra water or water runoff from a catchment area, is lowest in comparison to its surroundings.
The topographical study, which depicts the hilltop with its own river channel, establishes the borders of the watershed. In actuality, the boundaries are established by drawing a line dividing the hilltops in accordance with their relief from the terrain. Sub-catchment zones are another way in which these boundaries might be split up. The water drain from these places will supply the tributaries, which will discharge into the main river channel.

5.1.9 Precipitation in a Catchment Zone

A hydrological unit is a catchment area. If it doesn't evaporate, every precipitation drop that enters a catchment region eventually flows into the same river and finally the sea. It might, however, take a very long time. Watersheds divide catchment areas from one another.
The water supply pouring into a river or reservoir is determined by the precipitation that occurs within a catchment area. In order to measure the timely quantity of data, it is essential to deploy a number of rain gauges within the catchment region. However, because the rain gauge is frequently not put at the catchment region while hydropower construction is taking place, it is occasionally required to sample a few stations that are close to the planned site.
The number of rain gauges, catchment area size, meteorological variables, and geography all play a role in the sampling procedure' inherent error. Therefore, it is crucial to have more rain gauges in the area to further reduce the errors. However, in the case of area in our country, it is frequently discovered that the data provided by the location of the rain gauge station is quite limited, making the data provided from that station useless.
Estimating the amount of precipitation can also be done in the area between gauges if there are no rain gauges in the watershed of interest. Using rain gauge data from a region with comparable vegetation can be a rough technique to estimate the amount of precipitation in the area of interest. After weighing each rain gauge's data by its proximity to the area of interest, it is possible to calculate the average value of a few nearby rain gauges to obtain a more accurate data estimation. [62]

Table 5.1: Rainfall Situation up to 0900 Hours on: 15-06-2023 (in millimeter)

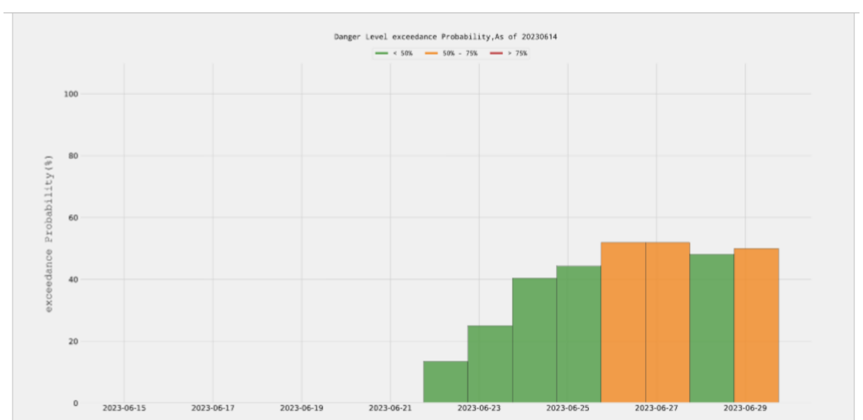
Location	Normal for June	Rainfall on 13-06-2023	14-06-2023	15-06-2023	Monthly cumulative (up to 15-06-2023
Bramaputra Basin					
Bogra	341.4	8	2.5	0	26.9
Chilmari	444	0	63.5	4	160.5
Dalia	481.7	0	17	34	102
Dewanganj	422.4	0	10	0	20
Dhaka	348.6	58	0	0	96.3
Gaibandha	375.5	0	6	2	23
Jamalpur	486	0	15	0	83.5
Kaunia	482.1	0	123	6	178
Kurigram	526.8	18	100.5	9.7	182.7
Mymensingh	482.5	0	24	0	44
Rangpur	460	7.5	44	0	86.5
Sirajgonj	326.1	4.6	9.8	0	15.2
Tangail	350.7	4	8	0	96

Table 5.2 Forecast Data

FORECAST DATA

Date	15-06	16-06	17-06	18-06	19-06	20-06	21-06	22-06	23-06	24-06	25-06	26-06	27-06	28-06	29-06
Q.75	15497	17795	20908	25539	31881	38674	45320	51980	56563	61199	62591	64058	65766	64548	64744
Med	15396	17473	20375	24568	30107	36242	42333	46841	50129	52743	55226	57644	56991	55623	56111
Q.25	15302	17308	19950	23467	28532	33888	38040	40575	42844	44473	45873	47552	48581	49945	49794

NB. Q.75: 0.75 Quantile, Med: Median & Q.25: 0.25 Quantile



DANGER LEVEL EXCEEDENCE PROBABILITY

Date	15-06	16-06	17-06	18-06	19-06	20-06	21-06	22-06	23-06	24-06	25-06	26-06	27-06	28-06	29-06
% P	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.46	25.00	40.38	44.23	51.92	51.92	48.08	50.00

Figure 5.6: Danger Level exceedance Probability [63]

5.1.10 Water Adjust Strategies

There are a number of potential approaches, including the creation of additional groundwater or surface water sources, conservation, reuse, demand control, and higher use of current supplies, such as through improved operations or water transfer from one location to another. Using unusual methods like managing the bush or influencing the weather.

The water balance approach analyzes water input and output in a particular location and at a certain time to determine if there is an excess or a shortage of water. Consequently, with that knowledge, water resources may be used effectively. The water balancing methods can be used to determine the site's water discharge for hydropower production.

The Thernadite -Mather technique offers a model to determine the annual amount of water used on a monthly basis, including runoff. This method requires information on soil water storage capacity, air temperature, and a correction factor based on the latitude of the site. These findings will reveal how much water plants utilize through evapotranspiration and reveal whether there is an excess or shortage of water in the soil.

This method employs a bookkeeping model using monthly precipitation numbers and potential evapotranspiration values to estimate monthly actual evapotranspiration.

The following are the steps for calculating the water discharge using the Thernadite-Mather method:

• Calculate temperature and precipitation data for the same time series and time step. The Biro Pusat Statistic or Badan Meteorology, Climatology dan Geophysical (BMKG) are the sources for temperature and precipitation data in Indonesia (BPS).

• Using the same time series, calculate the potential evapotranspiration.

• Determine how much water is present in the soil at each interval of time. The amount of water at time t.

Accurate predictions of various processes, water components, and water fluxes are necessary for the hydrological cycle's determination of water balance in every ecosystem. This chapter begins by addressing the idea of the hydrological cycle and water balance at several spatial scales (from the plot to the global/continental). The hydrological cycle's elements and fluxes are next examined, with a special emphasis on air, surface, and subsurface waters. Finally, a summary of the various methods for calculating the water balance is provided, including both hydrological modeling and in-situ measuring techniques.

- **Structure of Energetic**

The most typical form of hydroelectric power plant is an impoundment facility. To contain river water in a reservoir, a dam is utilized in an impoundment facility, which is often a large hydroelectric plant. When water is released from the reservoir, it travels through a turbine, spinning it up to start a generator that produces electricity.

The pipelines may experience a surge or an irregular flow during hydroelectric power plant operations. A change in the water volume flow will result in a change in the pressure in the turbine area because of the inertia of the water. To determine whether a hydroelectric plant might tolerate a change in hydraulic circuit pressure, hydraulic transient studies must be performed during the preliminary design phase.

Since the plant's flow variations are foreseen, it is important to appropriately design the impacted parts, including the pipe, turbine, and generator. Additionally, unstable conditions brought on by human error or adverse environmental factors must be taken into account.

Thus, preliminary transient water hammer analysis for fundamental scenarios and maneuvers must be completed at this early stage of power plant development. This study's goal is to "ensure a practical and affordable solution without additional protection devices, or to forecast operating constraints or the kind of protection that will be specified later." New technology is being developed by Hydrogen for hydropower projects. All components that make up a power plant, such as a dam, intake, tunnel system, power plant, hydropower system, and outflows from waterways, will be included in the activities.

5.1.11 Wave Oscillation

A type of electricity created by harnessing the upward and downward movement of the ocean's waves is recognized as sea wave energy, and it is often referred to as wave electricity. Wave energy is frequently produced using movable turbine stations or buoys which fluctuate according to the waves.

The three main varieties are over topping conversion devices, oscillation body conversion devices, which are floating or underwater machines utilizing wave motion (up/down, forward/backward, side-to-side), and oscillate water sections, which use trapped air sacs in the water pillar to generate energy for a turbine's blades.

A slower transient situation known as surge oscillation exists in the pipe in addition to the relatively quick water hammer state. A surge chamber may need to be installed between the intake and turbine in order to account for this situation. The increase in the chamber's capacity to store waters in the case of a decreased demand will help the system's management if it is used. As the demand increases, a surge tank may provide extra water.

Because the surge's oscillations are shorter than the hammering of water, the momentum of the water has no impact on the oscillation. There is no waste, pollution, or harmful residue produced when waves are used to generate clean energy.

It is as predictable as clockwork; just as our weather can be predicted, the amount of energy waves will release in advance can also be calculated.

5.1.12 Water Hammer

Piping systems that use valves to regulate the flow of liquids or vapors are susceptible to a phenomenon known as "water hammer."

When a fluid in motion suddenly changes direction or stops, it creates a pressure surge or high-pressure shock wave that propagates through the pipes system, caused water hammer.

Fast-acting solenoid valves that abruptly stop the flow of water through the pipes and create a shock wave that causes the water to vibrate and "shudder" are the two main causes of water hammer in high pressure such as mains pressure water systems.

A temporary situation known as "water hammer" causes abrupt pressure changes in a pipe system. The system may collapse if this pressure exceeds the pipe's capacity, causing damage to the pipe or ruptured valves. Understanding the physics behind these pressure variations and analyzing the potential maximum and minimum changeable of the pressures in a piping system require research into water hammer.

The hydraulic system's transient circumstances are propagated as an elastic wave-like flow with velocity that can be measured. This value is dependent on the fluid type and the elastic characteristics of the hydraulic circuit's components. Water hammer can become a problem when a longer pipe is added. The water in the pipe experiences a shockwave when a valve closes quickly. When the water's velocity is abruptly stopped, it crashes inside the system and makes an audible banging noise.

When a faucet or shower is abruptly turned off, a loud hammering sound called a "water hammer" frequently results. When suddenly stopped, the water pressure running through the pipes can be so intense that it can produce sounds resembling a jackhammer.

- **Economic**

The abundance of low-cost energy that underpins the power grid is one of the most important economic advantages of hydropower. Fuel-burning power plants are cheaper to operate, reducing the overall cost of generating electricity. It also withstands rising fossil fuel costs.

Bangladesh will surpass many other Asian nations, including India, in terms of GDP growth when it reaches 8% by 2020. Bangladesh has established a goal to become a developed country by 2041. The

country is now severely underdeveloped, but Bangladesh is being helped along by a strong industrial sector and a major growth in infrastructure. The golden anniversary of the country's independence falls on the same day as this lofty goal.
Hydropower plant development investments are particularly site-specific and might vary from location to location. When compared to other energy sources, hydropower can offer affordable, reliable, clean electricity because it is an established technology. Comparing the Leveling Cost of Energy that's mean LCOE, which measures the amount of a project's price per unit of energy, is one approach to compare the price of energy.
Few elements make up the cost structure for developing a hydroelectric project; these elements are categorized as capital expenses, operating and maintenance price, and indirect price. The construction of hydropower plants requires a lot of capital investment, with the majority of the costs going toward equipment and civil engineering projects. Any construction required to develop the site, from the road access through the dam development, is included in the civil works. A large hydropower plant's capital expenses may account for between 75% and 90% of the total investment expenditures. The fact that hydropower plants have very low Operation and Maintenance (O&M) costs is one of their financial advantages. The annual investment costs are typically used to compute the O&M costs, with an average value of roughly 2 to 5%.
Due to its geology and location, Bangladesh does not have much potential for hydroelectricity, and currently energy growth has mostly focused on thermal projects. Bangladesh is attempting to boost its hydropower output in order to fulfill the needs of the industrial sector. The nation is attempting to use hydropower from the Himalayan countries of Nepal and Bhutan by building a transmission line through India, for instance.
In Bangladesh's primarily flat terrain, barely 50% of the potential hydroelectric capacity has been utilized domestically. A thorough map of Bangladesh's hydroelectric potential must still be necessary in order for there to be further hydropower development.

Time Value of Money (TVM)

The TVM theory holds that possibilities made feasible by financial resources will increase the value of money now rather than making it more valuable in the future. This idea can be utilized to convey the Future Value (FV) of a currency using the Present Value (PV) of money. The connection between FV and PV (n) is determined by the discount rate (r) and the amount of years' distinction, as indicated in formula.

$$PV0 = FVn / (1 + r) n = 1 / (1 + r) n * FVn$$

Investors usually employ this equation to comprehend the current worth of a currency compared to its worth in the not-too-distant future, which is beneficial to comprehending the value of cash in connection to time (the temporal value of money, or TVM).

Internal Rate of Return (IRR)

Internal rate of return (IRR) is a metric used by financial professionals to assess the financial viability of possible projects. The rate of discount applied to a forecasted revenue stream is the IRR.

The inner rate of return, or IRR, is the return on a security. The percentage of interest when an investment had a net present worth of 0 or at where the total of the discounted revenue equals the investment is known as the internal rate of return (IRR). In order to reduce the net present values (NPV) of every money flow to zero, the IRR w analyses is computed through trial and error.

Net Present Value (NPV)
In the previous instance, the NPV technique offers a benefit over IRR because it is able to account for various discounts or varying cash flow orientations. The NPV method is more flexible when examining specific time frames since the earnings from each calendar year can be depreciated separately of all of them.

The net current value is calculated as the sum of the current value of potential earnings at the suitable discount rate, minus the cash value of the investing charges.

In other words, NPV illustrates the value, in terms of present value, that a project will produce during its lifetime. A project should only be taken into consideration for development if and only if the NPV is positive.

Payback Period (PBP)
PBP displays the amount of time, typically expressed in years, that must pass before the project will be profitable. With the fastest PBP, the most liquid project is shown through this way of study. In order for the small hydro project to be profitable, the payback ratio must not be more than seven years.
Benefit to Cost Ratio (BCR)
In BCR, the capital investment is contrasted with the benefit that has been present value-adjusted. The BCR value typically needs to be more than 1 for a project to be deemed feasible. It is a good place to begin when figuring out whether a project is doable and valuable. Calculating the ratio is not too difficult if the inputs (cash flows and discount rate) are known. The discount rate used in the ratio takes time worth of money into consideration.

5.1.13 Sensitivity Analysis
A hydropower project's risks are mapped using sensitivity analysis, which also displays risks that could have an influence on the project. Since there are more assumptions made during a project, it's critical to know which ones have the greatest potential to alter the results.
Some of the project's assumptions are changed for the sensitivity analysis, while others are left at their initial (base) values. As a result, the influence of a given set of assumptions may be evaluated by comparing the new project's results to the baseline results.
Financial factors and assumptions are essential to the viability of a hydropower project. According to standard procedures, one of the few parameters possibilities that is typically different in the preliminary investigation is the total interest rate and installation costs.

5.2 Design of a Power Plant and A Hydrology Study
This chapter describes the presentation of the possible hydropower site at the location, the preliminary layout considerated, and the processing of the hydrology data. These procedures provided the annual river power that is used to calculate the annual energy production and build power plants. The financial research and site characteristics are used to determine which designs are the most ideal.

- **Locational Information**

The location of the sites is the teesta river in Bangladesh. The Teesta River basin stretches from Sikkim in the eastern Himalayas of India through West Bengal to the northern Rangpur region of Bangladesh. Before flowing into the Bay of Bengal, the river merges with the Ganges and the Meghna in Bangladesh before joining the Brahmaputra. It passes through the districts of Lalmonirhat, Rangpur, Kurigram, and Gaibandha in Bangladesh. It merges with the Brahmaputra River in Bangladesh's Phulchhari Upazila. The river's length is 305 km (190 mi) in India and 109 km (68 mi) in Bangladesh.

5.2.1 Watershed

It is a region of land that directs precipitation and snowmelt into creeks, streams, and rivers, finally flowing into reservoirs, bays, and the ocean as outflow sites. The goal of this study is to evaluate the watershed management system for hydropower plant sustainability. Water flow and head are the two primary factors required to generate electrical energy. The area of the watershed, the amount of rainfall, and the kind of land cover all influence the volume of runoff and infiltration. A good land cover has a big infiltration volume, which allows rainwater to seep into the ground and become the water that is saved to keep the base flow throughout the dry season.

5.2.2 Calculating Water Discharge

The velocity of a stream, measured in feet per second (V), is the product of the stream's flow. times the water's depth (D - unit of length) width twice (W of the water - units of length).

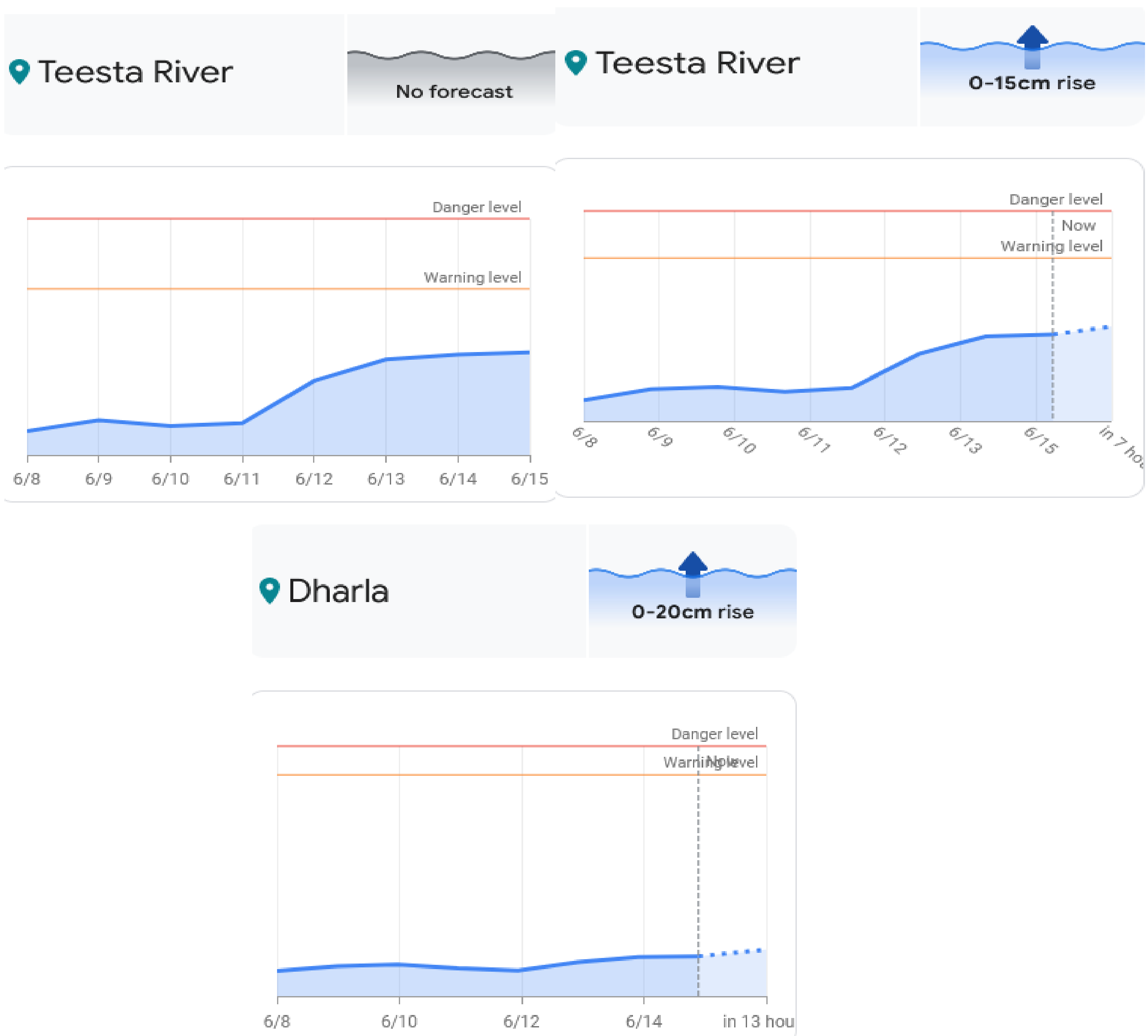


Figure 5.7: Teesta and Dharla River Forecast and Rise Data [63]

Table 5.3: Flood Foercasting as River situation

FLOOD FORECASTING AND WARNING CENTER, BWDB
RIVER SITUATION AS ON 15-06-2023 AT 09:00 HOURS

SL	RIVER	STATION NAME	RHWL	D.L.	14-06-2023	15-06-2023	Rise(+) Fall(-)	Above(+) Below(-) D.L.
			m MSL	m MSL	m MSL	m MSL	in cm	in cm
	BRAHMAPUTRA BASIN							
1	DUDHKUMAR	PATESWARI	30.97	29.60	26.43	26.64	+21	-296
2	DHARLA	KURIGRAM	27.38	26.05	22.33	22.41	+8	-364
3	TEESTA	DALIA	52.84	52.15	51.05	51.2	+15	-95
4	TEESTA	KAUNIA	30.06	28.75	27.28	27.42	+14	-133
5	JAMUNESWARI	BADARGANJ	33.15	31.70	27.28	27.34	+6	-436
6	GHAGOT	GAIBANDHA	22.35	21.25	16.32	16.54	+22	-471
7	KARATOA	CHAK RAHIMPUR	20.95	19.70	13.98	13.98	0	-572
8	KARATOA	BOGURA	16.99	15.85	10.64	10.64	0	-521
9	BANGALI	SHIMUBARI	18.76	17.75	11.55	11.58	+3	-617
10	BRAHMAPUTRA	NOONKHAWA	27.61	26.05	22.58	22.64	+6	-341
11	BRAHMAPUTRA	HATIA	25.84	24.30	20.64	20.79	+15	-351
12	BRAHMAPUTRA	CHILMARI	24.61	23.25	19.63	19.77	+14	-348

- **Design of Basic Power Plants**

5.2.3 Design Discharge of a Turbine

In order to be determine the best power plant design that can be deliver the best results economically and structurally, design discharge is computed. A flow duration curve is set up to the understand characteristics of the river stem flow in order to calculate the design discharge using the water discharge information from the previous section. This curve displays the percentage of times that a certain discharging is exceeded over the course of a particular time.

5.2.4 Turbine Design Hydro

Hydroelectric projects employ a variety of water turbine designs to generate rotary turning action at rotational speeds ranging from middle to high. Additionally, by installing an electrical generator, water turbines—more precisely, A hydroelectric power system for the home may include hydro rotors.

Unlike a pump for water, whose operation is mechanically driven by a generator or wind turbine and employs suction to move the liquid through it, a conventional water turbine layout utilizes nozzle and difference pressure from the water to produce a turbine's spin and outputs.

The mechanical power of water's force is transformed by a water turbine, to put it another way. At this point, it is essential to comprehend the differences between a turbine that spins water design and a water engine design, which we discuss in the next section. A simple but significant round wheel built of wood, metal, or both is referred to as a waterwheel. The wheel is surrounded by buckets and slowly revolves as water runs over or under it. This generates a lot of electrical torque that is used to operate auxiliary machinery. A water turbine, which is a significantly smaller and lighter device made of cast steel or aluminum with carefully positioned suction nozzles, transforms the kinetic energy of the water into mechanical power.

The water turbine is the heart of any hydroelectric power facility. It is created power.

Any hydroelectric generation plant's heartbeat is its water turbine. It is formed up of many metal or plastic knives that are fastened to a shaft that turns or plates in the middle. The enclosed turbine's blades are struck by water streaming through its casing, creating torque and rotating the shaft as a result of the water's pressure and speed. Water pressure and velocity decrease as it pushes against the turbine blades, causing energy to be wasted as the turbine shaft rotates.

hydroelectric facility Pico Hydro has a capacity of 0.005 MW. Micro Hydro 0.1 MW or less 1 MW Mini Hydro Low-power hydro between 1 and 100 MW >100 MW Medium Hydro >500 MW Large Hydro.

5.3 Dynamics of Systems

The calculations for the water hammer are shown in this part. These computations produce the head envelope profiles, the penstocks' pressure data tabulations, the turbine's hydraulic head plot, and water discharge plot during valve closure.

The main component of a hydropower plant, the hydro-turbine governing system (HTGS), is crucial to the steady functioning of the power plant. The stability and vibration of the HTGS have drawn attention and worry as the head and capacity of the hydropower unit have increased.

- **Power Calculation of Geographical Location**

RangpurDistrict Name River/chara/stream Bhuri khora Chikli at Nizbari Potential of electrical energy in 32 KW and other sites on Fulkumar at Raigang Bazar Potential of electrical energy in 48 KW in Some potential little hydro sites have been discovered by BPDB and BWDB.

5.3.1 Assumptions for Calculation

According to the Bangladesh Power Development Board, the typical cost to produce a unit of electricity at diesel-powered plants is Tk22, Tk10 at LNG-powered plants, Tk4-6 at coal-fired plants, and Tk12 at furnace oil-powered plants whereas at the Kaptai hydropower plant, the expense is Tk0. 3-1.

5.3.2 Calculation Process

$$PT = (kW) = PH\ (kW) * \eta$$

The overall output, which includes losses in the turbine, generator, and electrical panel, is the percentage illustrating the total losses throughout the power-generation process.

Power output over time is measured in terms of energy (energy = power times time).

The equation for the energy produced by a turbine

The most accurate formula for the electricity generated by a wind turbine is P = 0.5 Cp

R2, V3, where Cp is the coefficient of performance (efficiency factor, in percent), is the air density (in kg/m3), R is the blade length (in meters), and V is the wind speed. (In Watts). (In meters per second).

Table 5.4: Peak Water Level (in m PWD) with Dates during the Monsoon-2020

SL No	River name	Station	Peak WL-2020	Date
1	DHARLA	KURIGRAM	27.53	14/07/20
2	TEESTA	DALIA	53.12	13/07/20
3	TEESTA	KAUNIA	29.35	13/07/20
4	JAMUNESWARI	BADARGANJ	32.92	29/09/20
5	GHAGOT	GAIBANDHA	22.64	15/07/20
6	KARATOA	CHAK RAHIMPUR	21.31	2/10/2020
7	KARATOA	BOGRA	15.54	8/10/2020
8	BRAHMAPUTRA	NOONKHAWA	27.46	15/07/20
9	BRAHMAPUTRA	CHILMARI	24.73	15/07/20

Table 5.5: Comparison of 2020 Water Level (in m PWD) at Some Important Stations in the Brahmaputra Basin with Historical Events in 2007 and 1998

Sl.No	River	Station	Previously Recorded Maximum	Danger Level	Peak of the year			Days above Danger level		
					2020	2007	1998	2020	2007	1998
1	Dharla	Kurigram	27.84	26.50	27.53	27.56	27.22	47	15	30
2	Teesta	*Dalia	53.12	52.60	53.15	52.95	52.20	14	2	-
3	Teesta	Kaunia	30.52	29.20	29.35	29.66	29.91	4	4	-
4	Jamuneswari	Badarganj	33.61	32.15	32.92	31.50	33.00	5	0	6
5	Ghagot	Gaibandha	22.81	21.70	22.64	22.56	22.30	38	16	51
6	Karatoa	Chakrahimpur	21.41	20.15	21.31	20.73	20.86	25	11	-
7	Karatoa	Bogra	17.45	16.32	15.54	15.7	15.57	0	0	-
8	Brahmaputra	Noonkhawa	28.10	26.50	27.46	27.91	27.35	28	24	29
9	Brahmaputra	Chilmari	25.07	23.70	24.73	24.81	24.77	36	23	22

Table 5.6: Recorded Historical Highest Water Levels (in m PWD) with Dates

Sl. No.	River	Station	Danger Level	Recorded Highest WL before 2020 with Date	WL in 2020 Exceeding Previous Level with Date
1	Dharla	Kurigram	26.50	27.84 (14.07.96)	-
2	Teesta	Dalia	52.40	53.12 (12.07.19)	**53.15 (13.07.2020)**
3	Teesta	Kaunia	30.00	30.52 (06.01.68)	-
4	Jamuneswari	Badarganj	32.16	33.61 (15.08.17)	-
5	Brahmaputra	Noonkhawa	27.25	28.10	-
6	Brahmaputra	Chilmari	24.00	25.07 (23.08.62)	-

Comparison of Hydro graph on Dharla at Kurigram

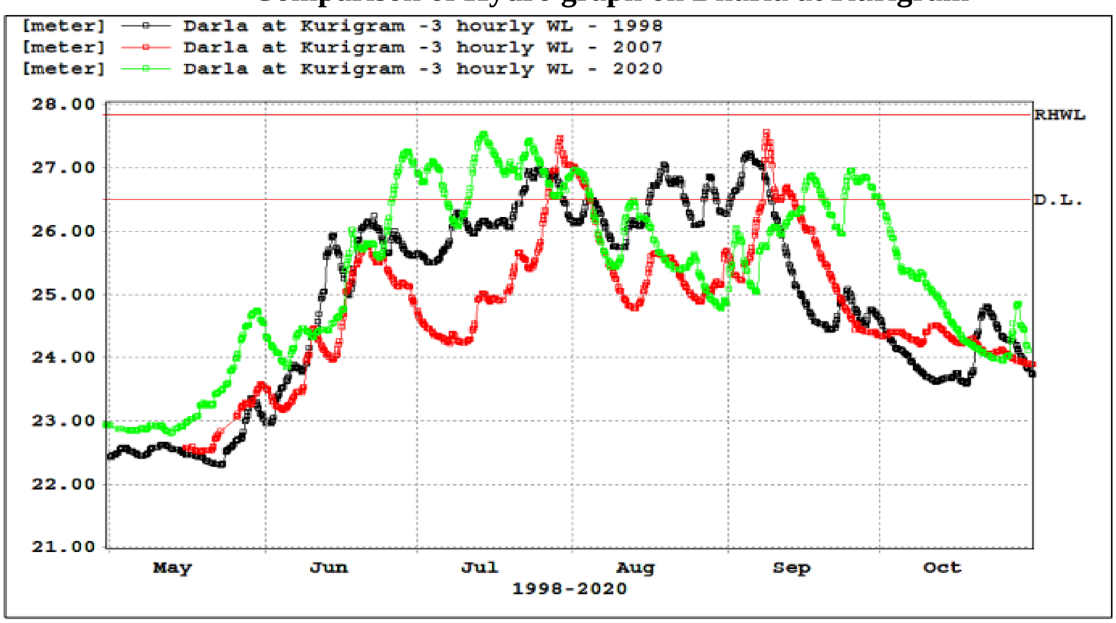


Figure 5.8: Comparison of Hydro graph on Dharla at Kurigram [63]

Comparison of Hydrograph on Teesta at Dalia

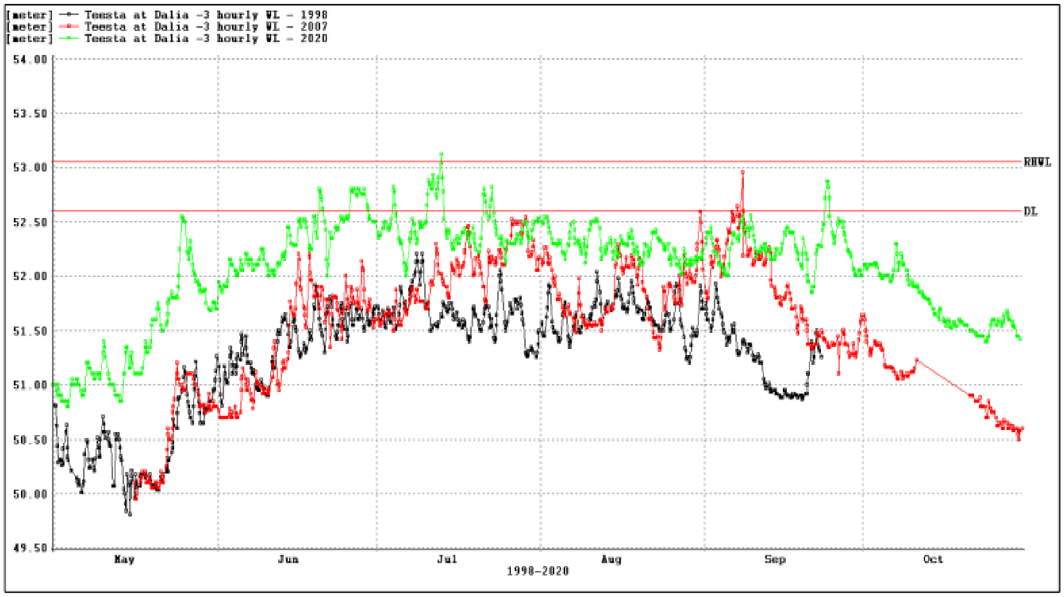
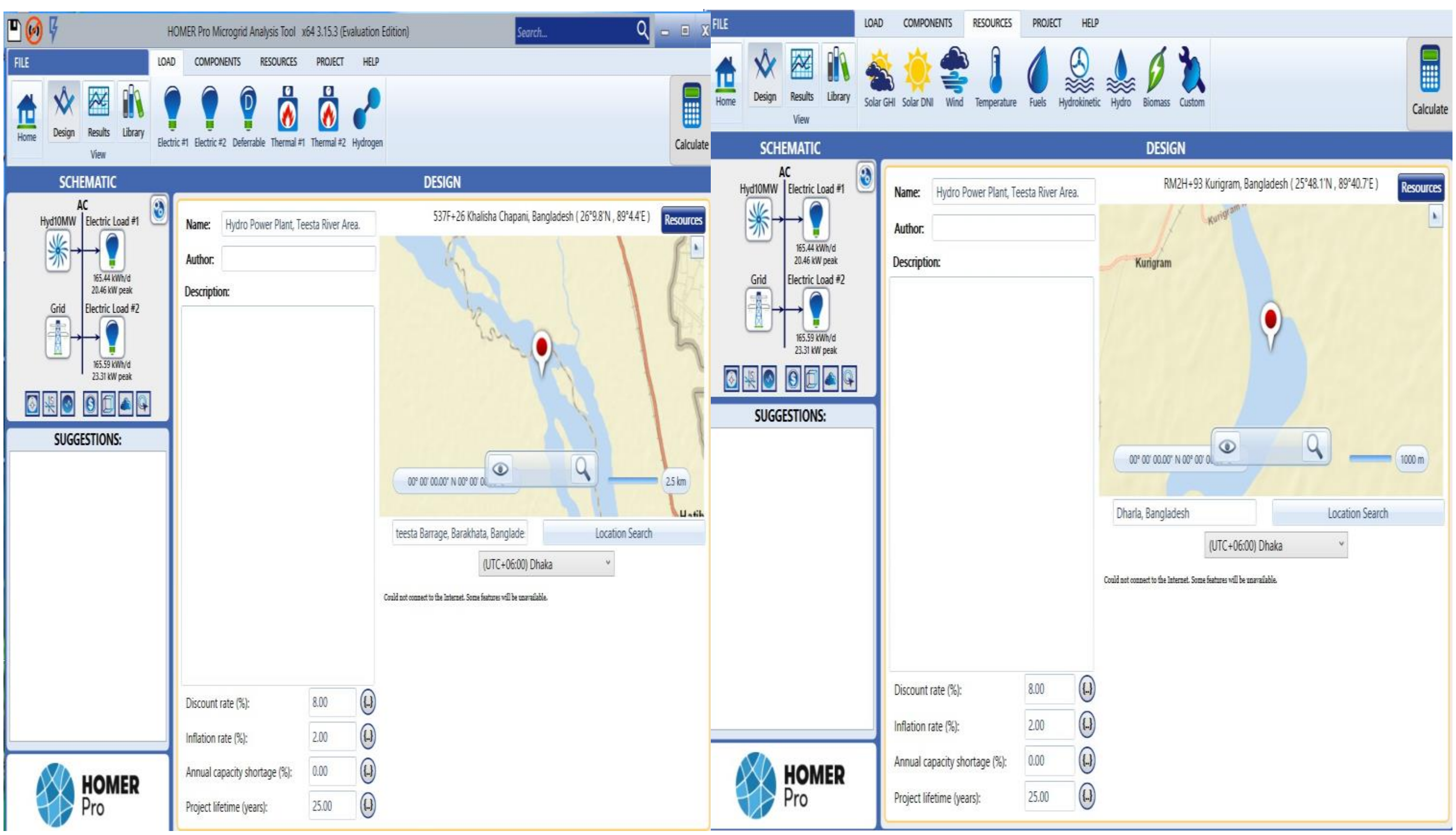


Figure 5.9: Comparison of Hydrograph on Teesta at Dalia [63]

5.3.3 Results of Calculation

System design By Homer Pro Softwer



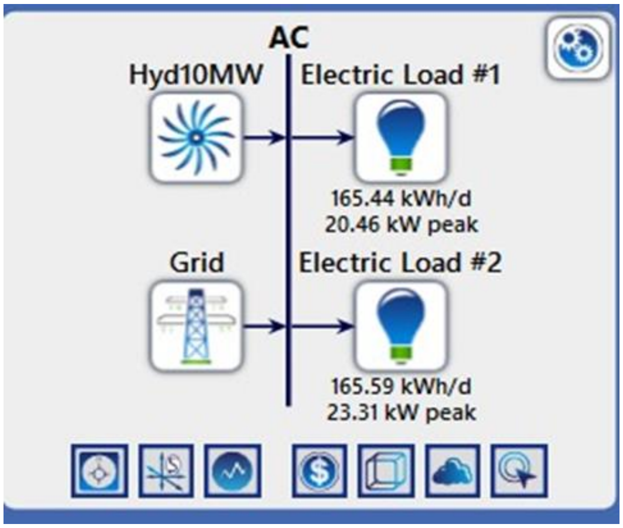


Figure 5.10: Fig: Schematic of the grid connected plant

Electric Loaded Profile

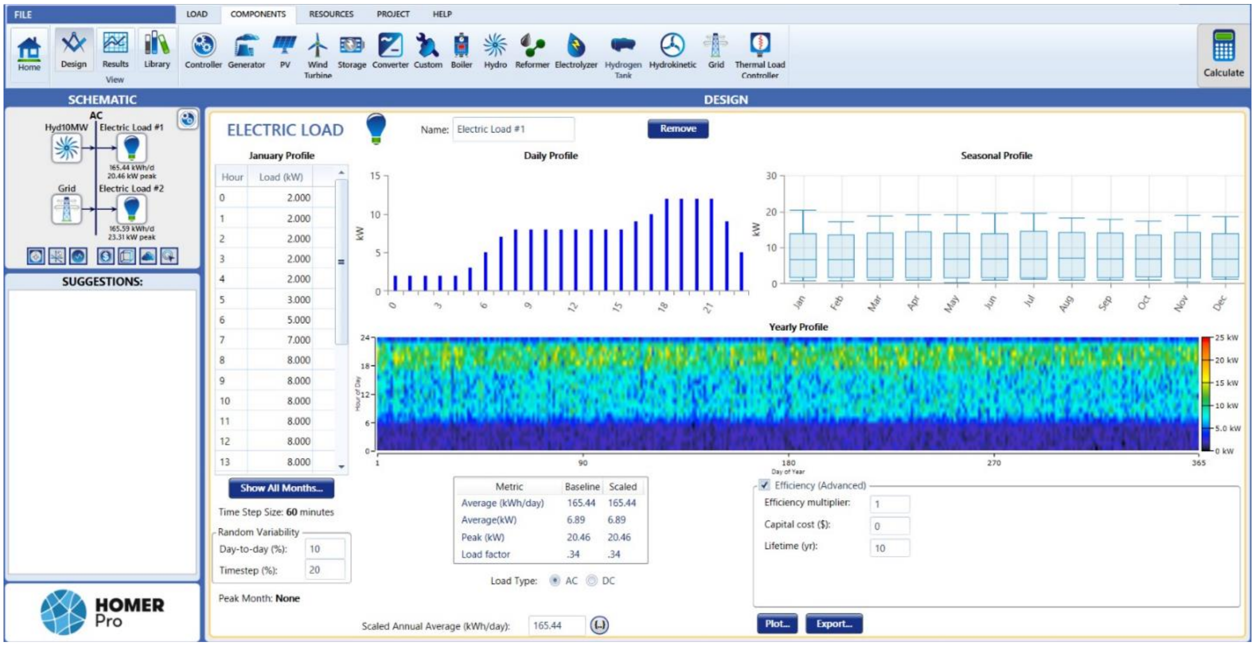


Figure 5.11: Electric Loaded Profile

Daily Loaded Profile

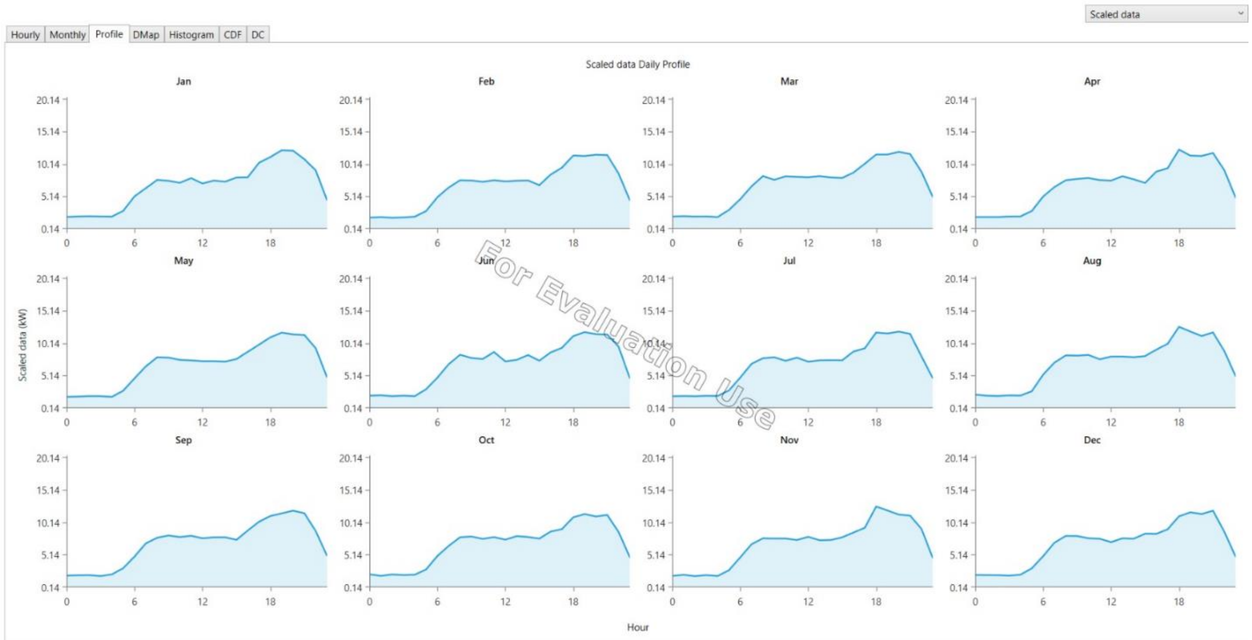


Figure5.12: Daily Loaded Profile

Steam Flow Monthly Average

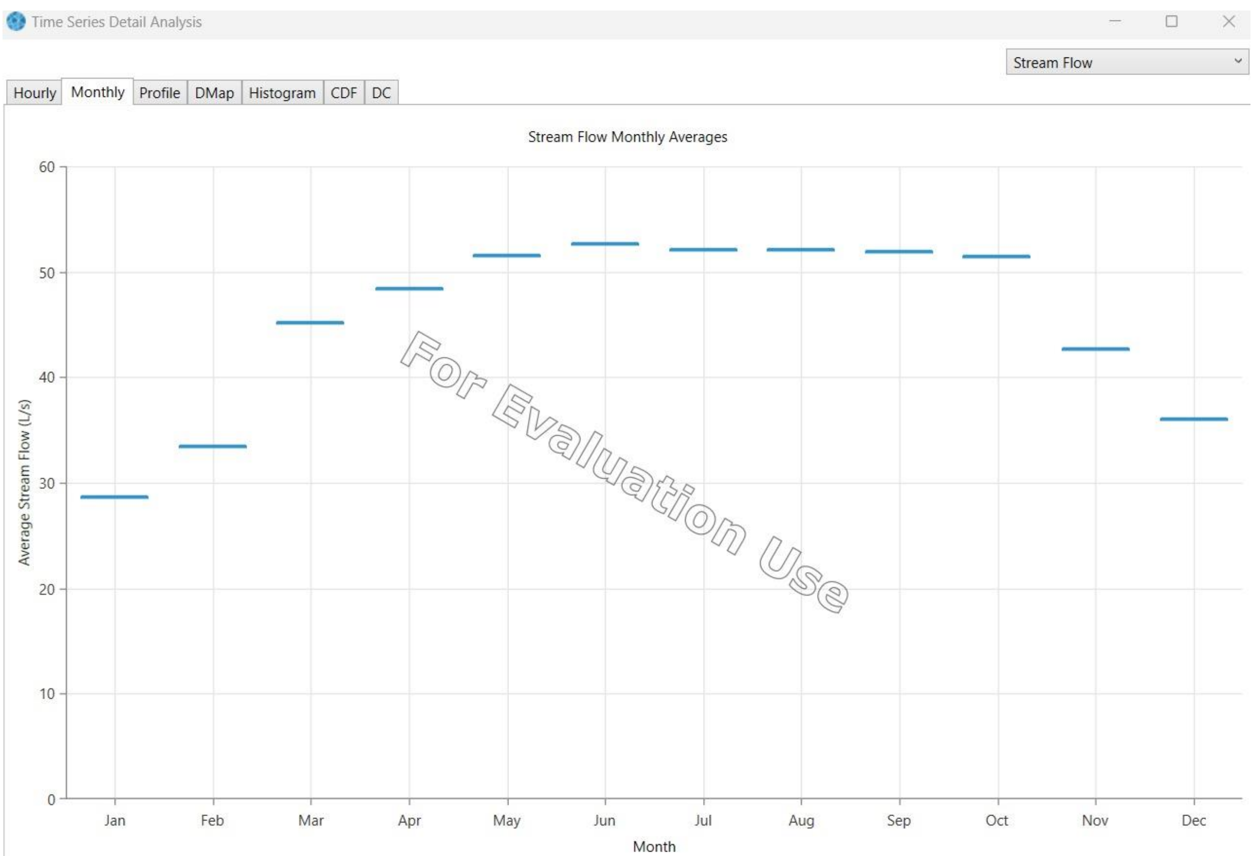


Figure 5.13: Steam Flow Monthly Average

Compare economics

For the current system we can compare with base system. In our current system which consists

Table 5.7: Compare economics of cash Flow

Compare Economics

Display:

- Graph / Table
- Both / Difference
- Annual / Cumulative
- Nominal / Discounted

	Nominal Cash Flows						Discounted Cash Flows					
	Proposed System		Base System		Difference		Proposed System		Base System		Difference	
Year	Annual	Cumulativ	Annual	Cumulativ	Annual	Cumulativ	Annual	Cumulativ	Annual	Cumulativ	Annual	Cumulativ
0	($15,000,(	($15,000,(	($15,000,(	($15,000,(	$0	$0	($15,000,(	($15,000,(	($15,000,(	($15,000,(	$0	$0
1	($462,082	($15,462,(	($462,082	($15,462,(	$0	$0	($436,411	($15,436,4	($436,411	($15,436,4	$0	$0
2	($462,082	($15,924,1	($462,082	($15,924,1	$0	$0	($412,166	($15,848,5	($412,166	($15,848,5	$0	$0
3	($462,082	($16,386,2	($462,082	($16,386,2	$0	$0	($389,268	($16,237,8	($389,268	($16,237,8	$0	$0
4	($462,082	($16,848,3	($462,082	($16,848,3	$0	$0	($367,642	($16,605,4	($367,642	($16,605,4	$0	$0
5	($462,082	($17,310,4	($462,082	($17,310,4	$0	$0	($347,217	($16,952,7	($347,217	($16,952,7	$0	$0
6	($462,082	($17,772,4	($462,082	($17,772,4	$0	$0	($327,927	($17,280,6	($327,927	($17,280,6	$0	$0
7	($462,082	($18,234,5	($462,082	($18,234,5	$0	$0	($309,709	($17,590,3	($309,709	($17,590,3	$0	$0
8	($462,082	($18,696,6	($462,082	($18,696,6	$0	$0	($292,503	($17,882,8	($292,503	($17,882,8	$0	$0
9	($462,082	($19,158,7	($462,082	($19,158,7	$0	$0	($276,253	($18,159,1	($276,253	($18,159,1	$0	$0
10	($462,082	($19,620,8	($462,082	($19,620,8	$0	$0	($260,905	($18,420,(	($260,905	($18,420,(	$0	$0
11	($462,082	($20,082,9	($462,082	($20,082,9	$0	$0	($246,411	($18,666,4	($246,411	($18,666,4	$0	$0
12	($462,082	($20,544,9	($462,082	($20,544,9	$0	$0	($232,721	($18,899,1	($232,721	($18,899,1	$0	$0
13	($462,082	($21,007,(	($462,082	($21,007,(	$0	$0	($219,792	($19,118,9	($219,792	($19,118,9	$0	$0
14	($462,082	($21,469,1	($462,082	($21,469,1	$0	$0	($207,581	($19,326,5	($207,581	($19,326,5	$0	$0
15	($462,082	($21,931,2	($462,082	($21,931,2	$0	$0	($196,049	($19,522,5	($196,049	($19,522,5	$0	$0
16	($462,082	($22,393,3	($462,082	($22,393,3	$0	$0	($185,157	($19,707,7	($185,157	($19,707,7	$0	$0
17	($462,082	($22,855,4	($462,082	($22,855,4	$0	$0	($174,871	($19,882,5	($174,871	($19,882,5	$0	$0
18	($462,082	($23,317,4	($462,082	($23,317,4	$0	$0	($165,156	($20,047,7	($165,156	($20,047,7	$0	$0
19	($462,082	($23,779,5	($462,082	($23,779,5	$0	$0	($155,980	($20,203,7	($155,980	($20,203,7	$0	$0
20	($462,082	($24,241,6	($462,082	($24,241,6	$0	$0	($147,315	($20,351,(	($147,315	($20,351,(	$0	$0
21	($462,082	($24,703,7	($462,082	($24,703,7	$0	$0	($139,131	($20,490,1	($139,131	($20,490,1	$0	$0
22	($462,082	($25,165,8	($462,082	($25,165,8	$0	$0	($131,401	($20,621,5	($131,401	($20,621,5	$0	$0
23	($462,082	($25,627,9	($462,082	($25,627,9	$0	$0	($124,101	($20,745,6	($124,101	($20,745,6	$0	$0

Table 5.8: Compare economics of Cost

Simulation Results

System Architecture: HOMER Cycle Charging
Grid (999,999 kW)
10MW Generic (10,595 kW)

Total NPC:	$20,674,140.00
Levelized COE:	$13.24
Operating Cost:	$438,919.20

Cost Summary | Cash Flow | Compare Economics | Electrical | Renewable Penetration | Grid | 10MW Generic | Emissions

You may choose a different base case using the Compare Economics button on the Results Summary Table.

	Architecture					Cost	
			Grid (kW)	Hyd10MW (kW)	Efficiency1	NPC ($)	CAPEX ($)
Base system			999,999	10,595	0	$20.7M	$15.0M
Proposed system			999,999	10,595	0	$20.7M	$15.0M

Metric	Value
Present worth ($)	$0
Annual worth ($/yr)	$0
Return on investment (%)	0.0
Internal rate of return (%)	n/a
Simple payback (yr)	n/a
Discounted payback (yr)	n/a

Charts...

Create Proposal | Time Series Plot | Other...

Electric production:

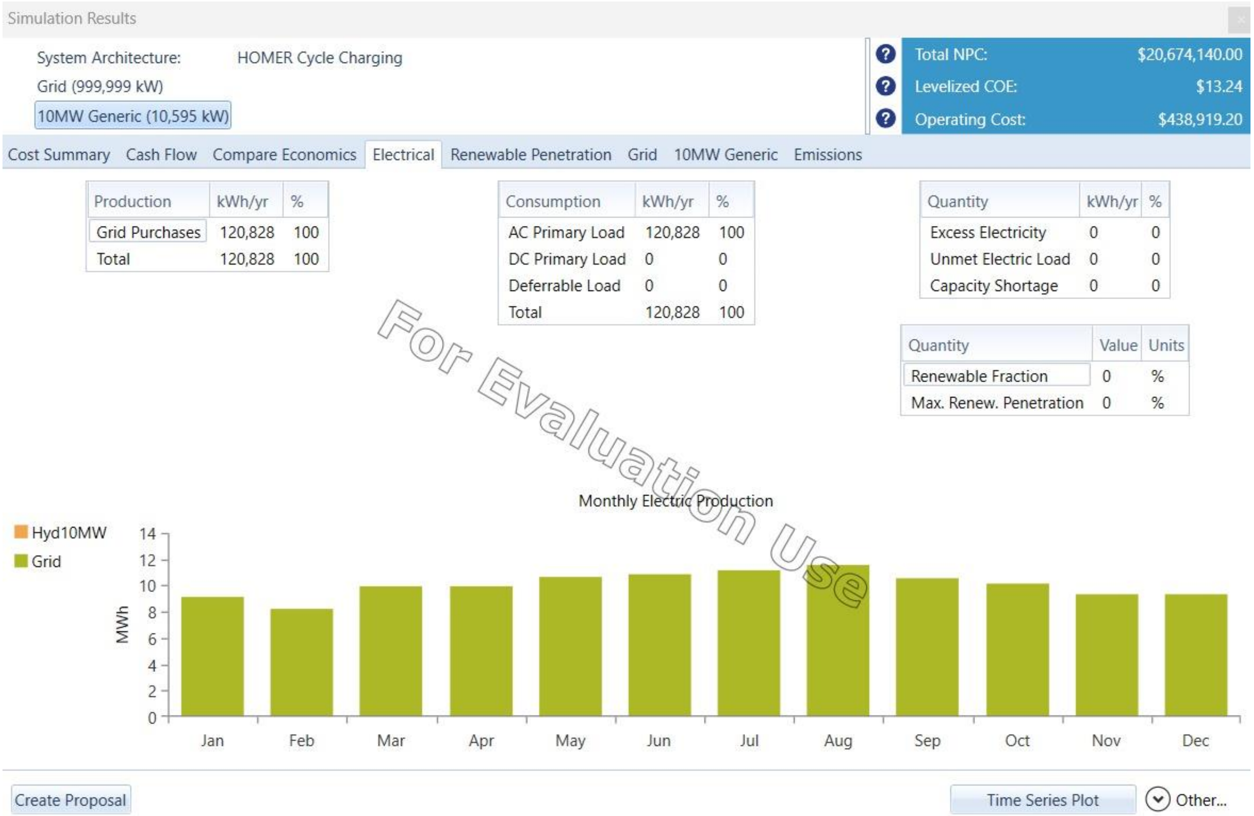


Figure 5.14: Electric production

10 MW Generic Hydro Output

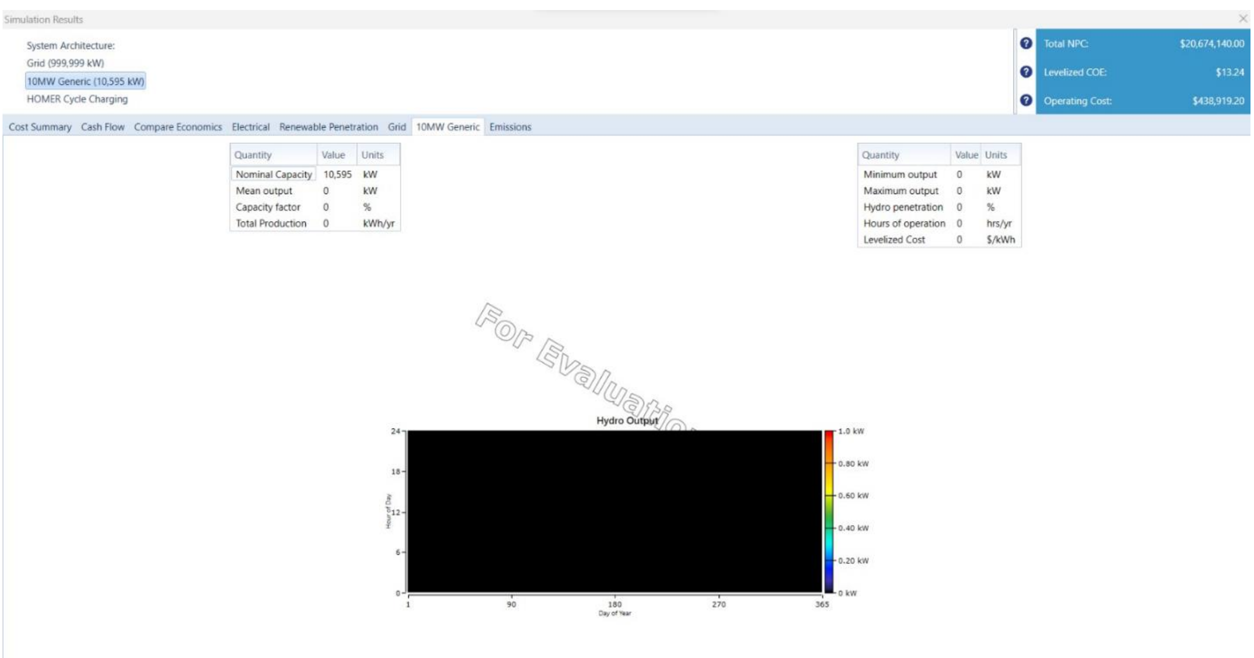


Figure 5.15: 10 MW Generic Hydro Output

Emission

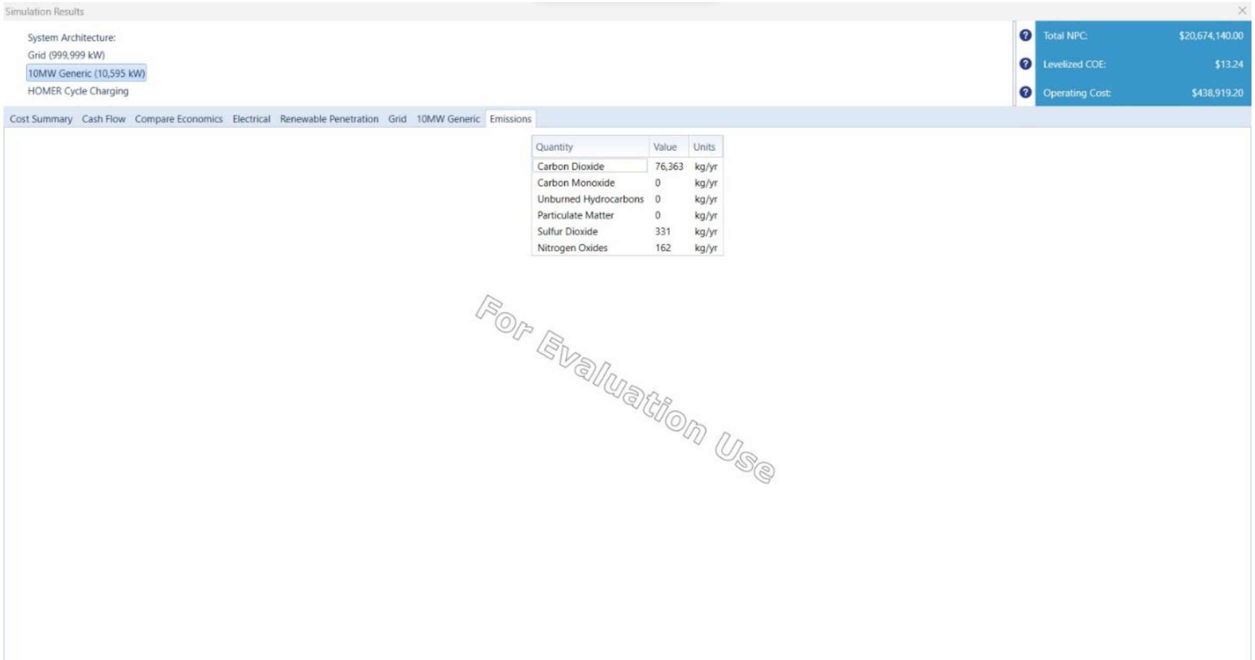


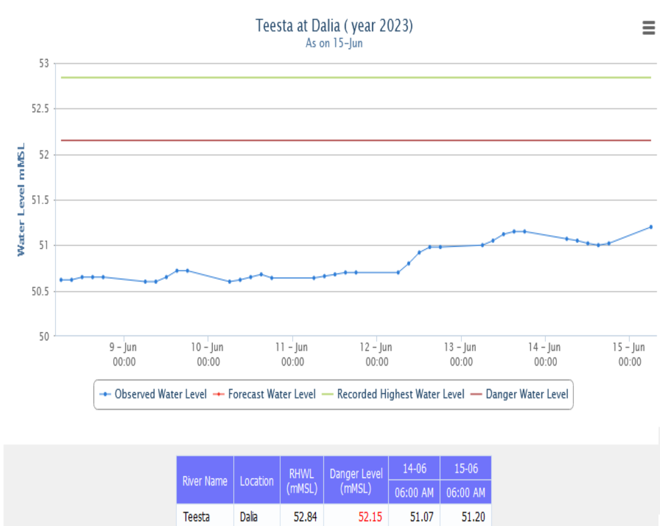
Figure 5.16: Emission

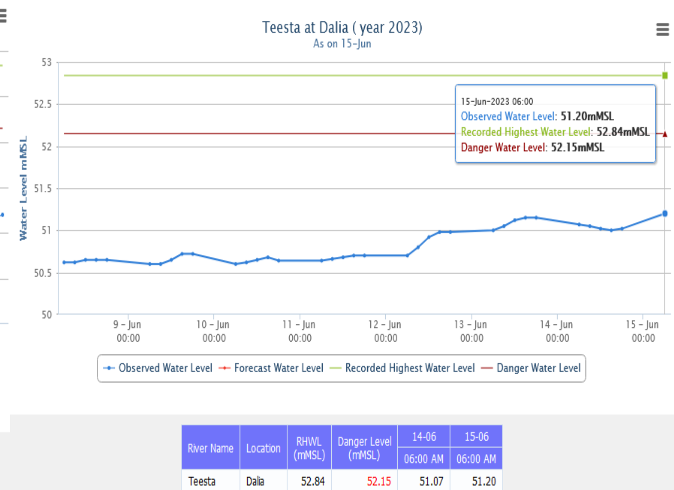
5.3.4 Teesta Barrage Site 1

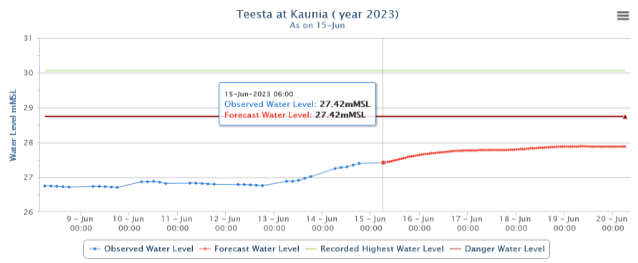
Project Teesta Barrage (TB Project)

Boundaries and Project Area

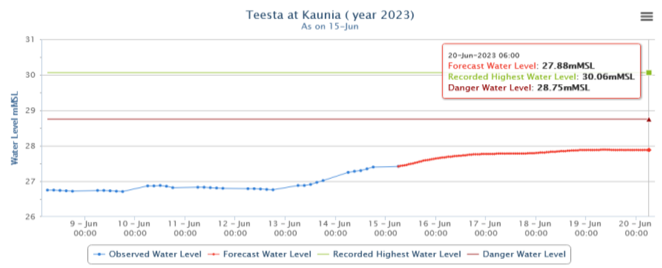
The TBIP is Bangladesh's biggest irrigation project. At Dalia-Doani point in the Lalmonirhat region, it is located across the Teesta River. The project is bordered to the north by the Teesta River, to the west by the Atrai River, to the south by the Shantahar-Bogra Railway Line, and to the east by the Bogra-Kaunia Railway Line. A command region of 750,000 hectares, of which 540,000 hectares are irrigable, is utilizing it for irrigation, flood control, and drainage. Seven districts in northern Bangladesh are included in the initiative. The barrage itself is located at Doani in the district of Lalmonirhat, but the TBIP command region also includes portions of the administrative districts of Nilphamari, Rangpur, Dinajpur, Bogra, Gaibandha, and Joypurhat.



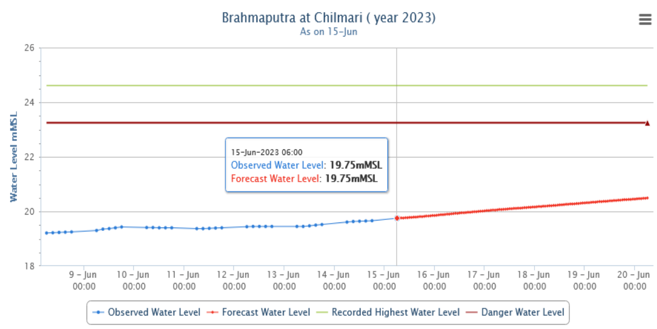




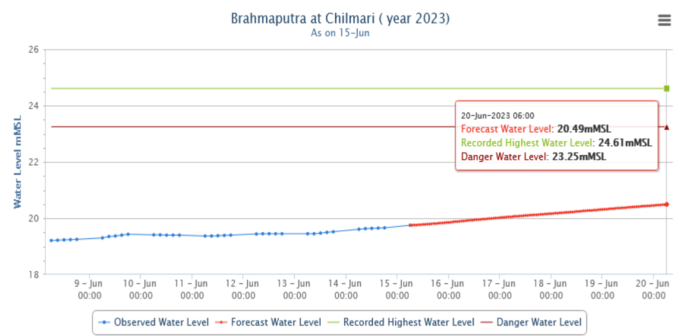
River Name	Location	RHWL (mMSL)	Danger Level (mMSL)	14-06 06:00 AM	15-06 06:00 AM	16-06 06:00 AM	17-06 06:00 AM	18-06 06:00 AM	19-06 06:00 AM	20-06 06:00 AM
Teesta	Kaunia	30.06	28.75	27.25	27.42	27.69	27.78	27.82	27.88	27.88



River Name	Location	RHWL (mMSL)	Danger Level (mMSL)	14-06 06:00 AM	15-06 06:00 AM	16-06 06:00 AM	17-06 06:00 AM	18-06 06:00 AM	19-06 06:00 AM	20-06 06:00 AM
Teesta	Kaunia	30.06	28.75	27.25	27.42	27.69	27.78	27.82	27.88	27.88



River Name	Location	RHWL (mMSL)	Danger Level (mMSL)	14-06 06:00 AM	15-06 06:00 AM	16-06 06:00 AM	17-06 06:00 AM	18-06 06:00 AM	19-06 06:00 AM	20-06 06:00 AM
Brahmaputra	Chilmari	24.61	23.25	19.61	19.75	19.90	20.06	20.20	20.35	20.49

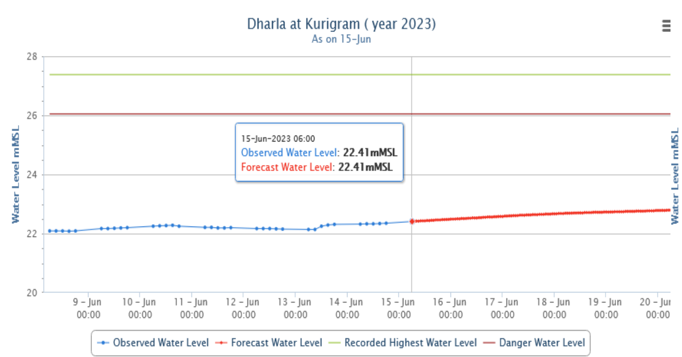


River Name	Location	RHWL (mMSL)	Danger Level (mMSL)	14-06 06:00 AM	15-06 06:00 AM	16-06 06:00 AM	17-06 06:00 AM	18-06 06:00 AM	19-06 06:00 AM	20-06 06:00 AM
Brahmaputra	Chilmari	24.61	23.25	19.61	19.75	19.90	20.06	20.20	20.35	20.49

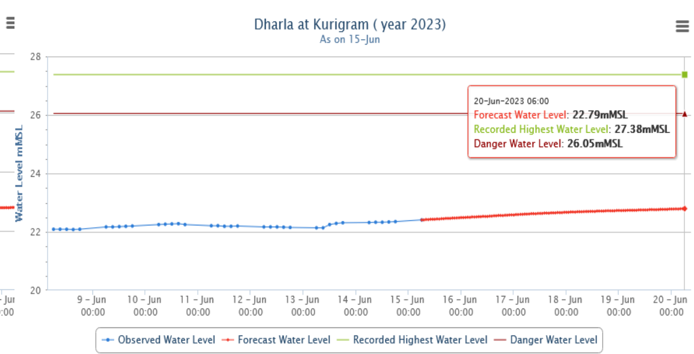
Figure 5.17: Teesta at Dalia, Kaunia & Brahmaputra at Chilmari Water level [63]

5.3.5 Dharla River Site 2

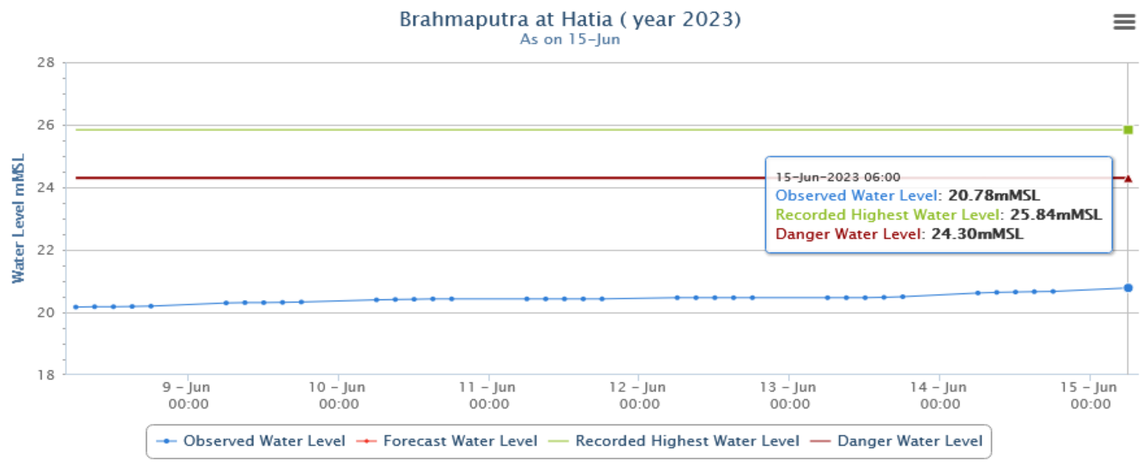
In the Kurigram origin, the river's greatest depth is 12 feet (3.7 m), and its average depth is 12 feet (3.7 m). In 2007, the erosion caused by the rivers Dharla and Jamuna reached a critical point in Lalmonirhat. In Lalmonirhat, the Dharla consumed about 2 kilometers (1.2 mi) of a 7 kilometers (4.3 mi) long flood control embankment. A large area of arable territory with crops, three mosques, two temples, a madrassah, a primary school, and other structures were devoured by the river, leaving about three thousand people destitute. At Kurigram, there is a garden next to the Dharla. An overpass is also present. In the summer, the river only has water that is knee-deep; during the rainy season, it is full. Silt buildup has resulted in the creation of there are many little islands (chars) in the waterway.



River Name	Location	RHWL (mMSL)	Danger Level (mMSL)	14-06 06:00 AM	15-06 06:00 AM	16-06 06:00 AM	17-06 06:00 AM	18-06 06:00 AM	19-06 06:00 AM	20-06 06:00 AM
Dharla	Kurigram	27.38	26.05	22.32	22.41	22.51	22.61	22.69	22.74	22.79



River Name	Location	RHWL (mMSL)	Danger Level (mMSL)	14-06 06:00 AM	15-06 06:00 AM	16-06 06:00 AM	17-06 06:00 AM	18-06 06:00 AM	19-06 06:00 AM	20-06 06:00 AM
Dharla	Kurigram	27.38	26.05	22.32	22.41	22.51	22.61	22.69	22.74	22.79



River Name	Location	RHWL (mMSL)	Danger Level (mMSL)	14-06 06:00 AM	15-06 06:00 AM
Brahmaputra	Hatia	25.84	24.30	20.62	20.78

Figure 5.18: Dharla at Kurigram & Brahmaputra at Hatia Water level [63]

5.3.6 Teesta barrage Project (Demonstration project of Teesta River comprehensive management) China

The Bangladeshi government and China collaborated to construct the Teesta River Comprehensive Management and Restoration Project (TRCMRP), which seeks to solve the long-standing Teesta River water issue. Since the Teesta River is situated in a desolate area, agriculture is the primary industry in the region. Rice and veggies for Bangladesh are largely imported from this region. This transboundary rive has about 35 barrages to divert water before it reaches Bangladesh from India. As a result, when the river reaches Bangladesh, it is weaker and has less water.

The Teesta River will be properly managed through river governance, its water carrying capacity will be increased through dredging, existing dams on both sides of the river will be repaired, 102 km of new dams will be built on both sides of the river, 50 Groynes will be established, and 170 square kilometers of land will be recovered for dredging purposes on both sides of the river by filling.

5.4 Analysis of the Financial Sensitivity to Energy Production

In this chapter, the yearly energy production is computed using the most optimal power plant design selected in the previous chapter. Financial sensitivity analysis was also done to determine the economic feasibility of these ideal solutions.

5.4.1 Energy Productions Per Year

Due to its significant environmental benefit, resource abundance, and improved efficiency, small-scale hydropower technology is a significant subclass of renewable and sustainable energy that is attracting focus on a global scale. Bangladesh's abundance of waterways and canals, which provide plenty of water for hydropower production, makes it extremely likely that SSHT will occur. Despite this, Bangladesh's energy generation is almost entirely accounted for by SSHT, at 2.34%. Reviewing SSHT technology for Bangladeshi adoption is necessary to is improve the SSHT generation potential.

Location of Rangpur District in Testa River area Khalisha Chapani (26 9.8 N, 89°44′E), & Dharala River area Kurigram in Bangladesh (25°48.1 N, 89°40.7°E). The hydro power name of model 10 MW Generic of the hydro power 18000MW in Yearly power of service its daily to continue May to September steam flow depended on power is 50MW is Continually 6 months its mainly medium hydro power plant but China Teesta Project finished the work then the 12-month 50MW Production of Power. This paper hydro power mainly feasibility study Location of Rangpur District in Testa and Dharala River included view of some area in power consumption of flooded time in half of year continually and China Teesta Project completed work then fully supported in electricity and cost of summary Lowest type costing but benefit overall fully. So, this electricity is very important part of irrigation and energy of power supported in this area of Rangpur.

5.4.2 Analysis of the Financial Sensitivity

By reducing the pollution brought on by the used of fossil fuels, the improved reliability of power production from renewable resources will have a beneficial to effect on the environment. According to the Ministry of New and Renewable Energy (MNRE), SHS causes negligible damage to vegetation and fauna, little deforestation, and little submersion. Kosnik added that the size of the technology has an effect on how the technology affects the environment. According to this study, SHS has less of an effect on rivers than large-scale hydro. In addition, IEA thought that SHS's minimal environmental effect was caused by construction work and changes to the water quality.

There will likely be 1,132 GW of additional hydropower capacity installed globally in 2018. More than 20 GW of new capacity were introduced in 2018 to reach this overall capacity. More than 35% of fresh deployments have been made in China, making it the leader. Numerous studies have also evaluated the possibility for hydropower. Lehner et al. calculated the gross hydropower potential of Europe using a model-based approach while considering socioeconomic changes and the climate into consideration.

5.4.3 Conclusion

The globe depends on hydropower plants as a source of electricity. Water is a reliable and effective fuel. It is necessary to continue pursuing the use, construction, and development of power plants. A dam or other construction that alters the natural flow of a river or other body of water is used to generate power from hydroelectricity, an alternative source of energy. Teesta barrage Project (Demonstration project of Teesta River comprehensive management), China, demonstrates that the locations are displaying promising economical results, according to hydropower plant research in the Teesta Region. Yet there are still a number of measures that must be taken to completely guarantee whether the venture is technically and economically possible. Based on the design discharge value, the hydropower plants capacity is calculated from the water discharge information collected to produce a flow duration curve. Based on the information that is readily available in that area, preliminary hydrological research was conducted. To evaluate the hydraulic circuit under transient conditions, a hydraulic study was conducted.

A water hammering model is developed using the Method of Characteristics (MOC) and then simulated for a few instances depending on various valve closure times. To ascertain the hydropower project's economic aspects, an economic evaluation was conducted. The annual generated energy is a key factor in this the study's revenue. However, both of the locations continue to provide positive Net Present Value, making them highly desirable development sites.

CHAPTER 6

HYBRID GRID SYSTEM

6.1 Introduction

6.1.1 Introduction:

The importance of electrical energy for social and economic growth is now well acknowledged. Unfortunately, a third of the world's population continues to reside in nations that are developing or transitioning without access to electricity. The figure demonstrates that emerging nations, where the majority of people reside in rural, isolated locations, are experiencing the greatest population increase. Geographical, financial, and societal limitations make electricity grid expansion difficult and expensive. The majority of diesel gensets have been employed so far to electrify rural areas. Because of the high cost of fuel and maintenance, as well as the fact that it is not environmentally friendly, this is a poor alternative. In such cases, using locally accessible renewable energy sources and implementing modular, extendable, and task-oriented system designs are alternatives that provide affordable and sustainable energy supplies, particularly for remote and rural locations.[64]

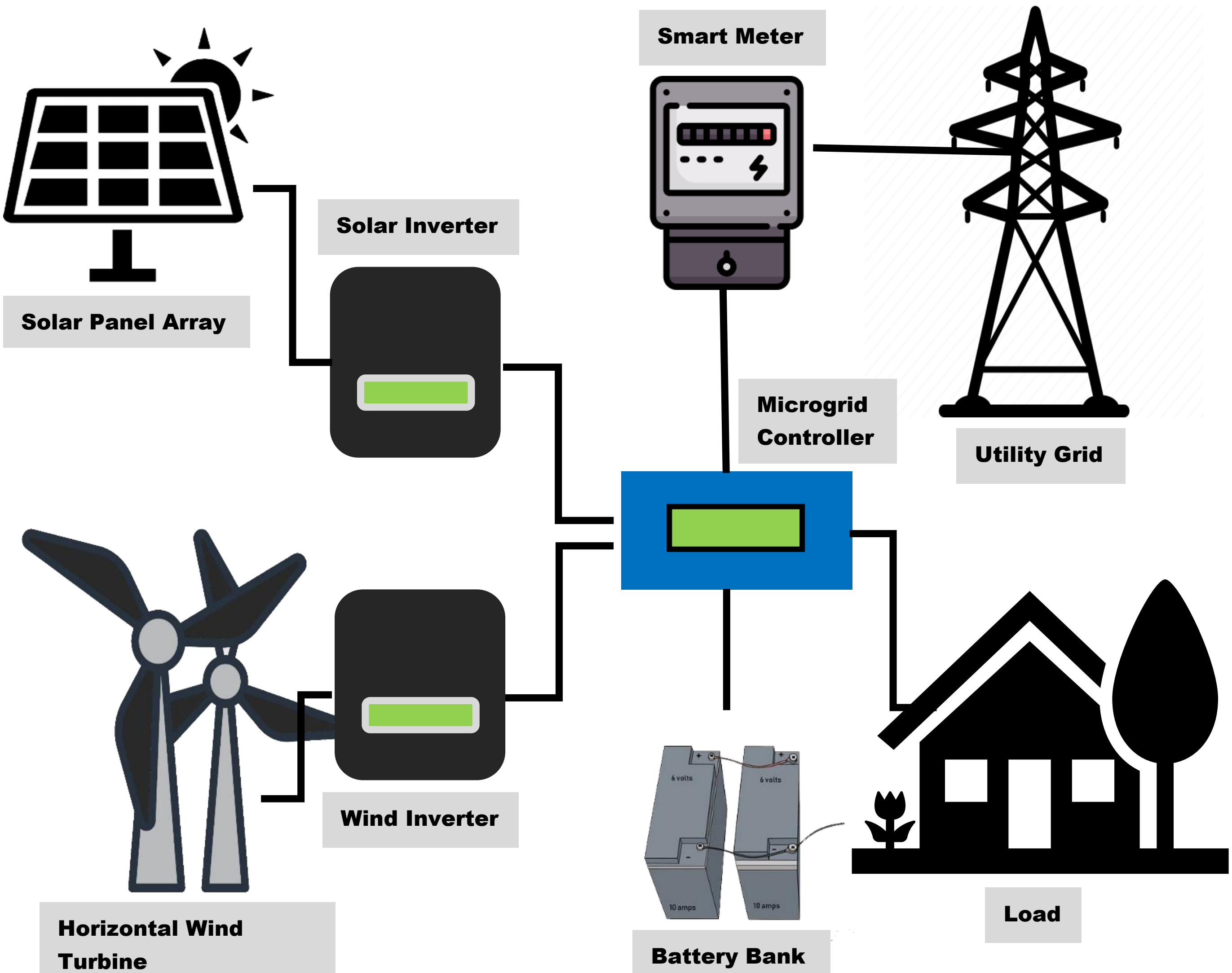


Figure 6.1: Hybrid System Block Diagram

Hybrid power System architectures of many different kinds have been used. The graphic displays the many potential architectures. Each system has benefits and drawbacks of its own. The layout that is chosen for a certain place is influenced by geographical, economic, and technical reasons. For this research project, the centralized AC-bus architecture was chosen because to its applicability to the target location, Bangladesh, teesta barage. A micro hydro power plant serves as the primary component of the HPS, which will be explored, in terms of an isolated grid formation, in addition to what was already described. The utilization of a water reservoir as the energy storage device is another significant shift. Up until now, the energy storage component has been a battery bank. There will be no longer be any issues with the battery system's drawbacks.

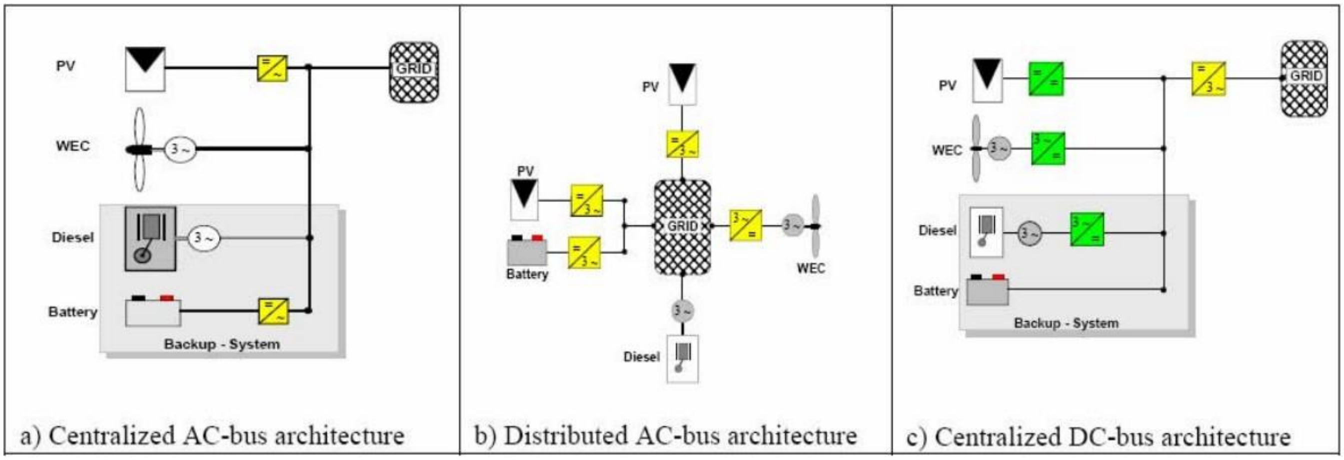


Figure 6.2: various hybrid power system architectures

6.1.2 Problem formulation:

The Teesta Barrage issue between Bangladesh and India refers to a longstanding water-sharing dispute over the Teesta River, which flows through both countries. The Teesta River is a crucial water resource for both Bangladesh and the Indian state of West Bengal, as it supports irrigation, agriculture, and hydroelectric power generation in the region.

The problem stems from the unequal distribution of water between the two countries during the dry season. Bangladesh insists on a fair and equitable water-sharing arrangement that takes into account its downstream needs, while India seeks to maintain a larger share of the river's water.

Negotiations and discussions have been ongoing between Bangladesh and India for many years, with multiple attempts to reach a water-sharing agreement. However, a mutually acceptable solution has yet to be achieved, leading to frustration and tensions between the two countries.

The issue has socio-economic and environmental implications for Bangladesh, as the availability of water from the Teesta River directly affects agricultural productivity and livelihoods of people in the region. It also has implications for bilateral relations between Bangladesh and India.

Efforts continue to find a resolution to the Teesta Barrage issue through diplomatic negotiations and dialogue between the governments of both countries. The aim is to establish a fair and mutually beneficial water-sharing arrangement that addresses the concerns and needs of both Bangladesh and India.

Electronic load controllers [ELCs] are used in the majority of installed medium hydro power plants to regulate frequency. This indicates that because there is no mechanical governor, medium hydro operates continuously at full load. It is obvious that there is a significant disparity between base load and peak load in rural locations. A bigger unit must be added in order to handle the peak demand, increasing the system's cost. Apart from peak hours, the system operates under half load.

Another issue is that a medium hydro system can only partially provide the demand in locations with extremely tiny rivers but significant load demand. These issues are the main topic of this research. The goal is to construct HPS that is affordable utilizing micro hydro as the primary unit. The optimum option, given the weather circumstances, is to combine PV with medium hydro systems. A PV system by itself cannot always meet the demand. The bigger PV module array and the storage facility should be employed if just a PV system is used in order to collect adequate solar electricity[65].

Additionally, during the wet season, medium hydro power output rises while PV system output declines. Both PV and medium hydro systems have their weaknesses and are weather-dependent. On the other hand, these two systems each offer certain benefits that balance out the imperfection of the others. It is feasible to create a stable power system by combining these two power systems. A water reservoir is necessary to accommodate fluctuations in the load, water flow, irradiation, etc.

6.1.3 Research's Purpose and Approach

The construction of an HPS, as well as its ideal control structure, simulation model, and micro-controller-based energy management unit, are the main topics of the study stated above.

Objective:

1. Energy conversion system modeling for various HPS individual systems.
2. Establishment of a micro hydro based HPS with an integrated PV system, water reservoir, and diesel generator.
3. Creation of a micro-controller-based energy management device that is affordable, small, and ideal.
4. A thorough system's economic study for emerging nations.

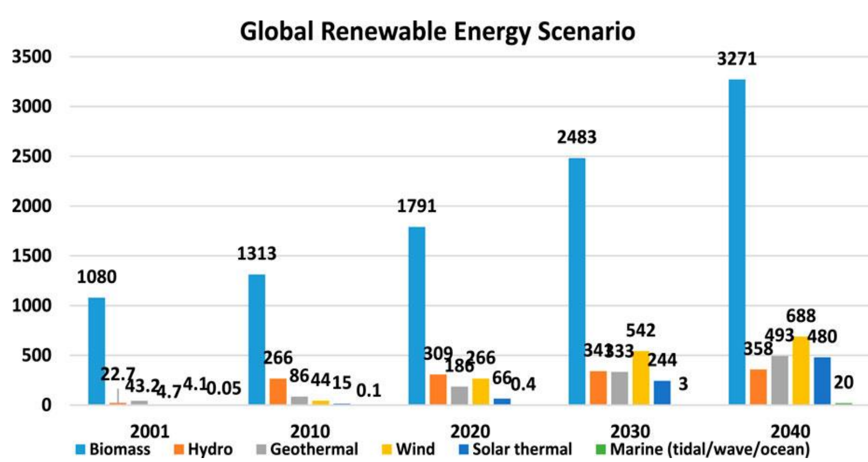


Figure 6.3: Global Renewable Energy Scenario [66]

6.1.4 Methodology

On the basis of the technique depicted in fig. ………, the goal of this study effort is accomplished.

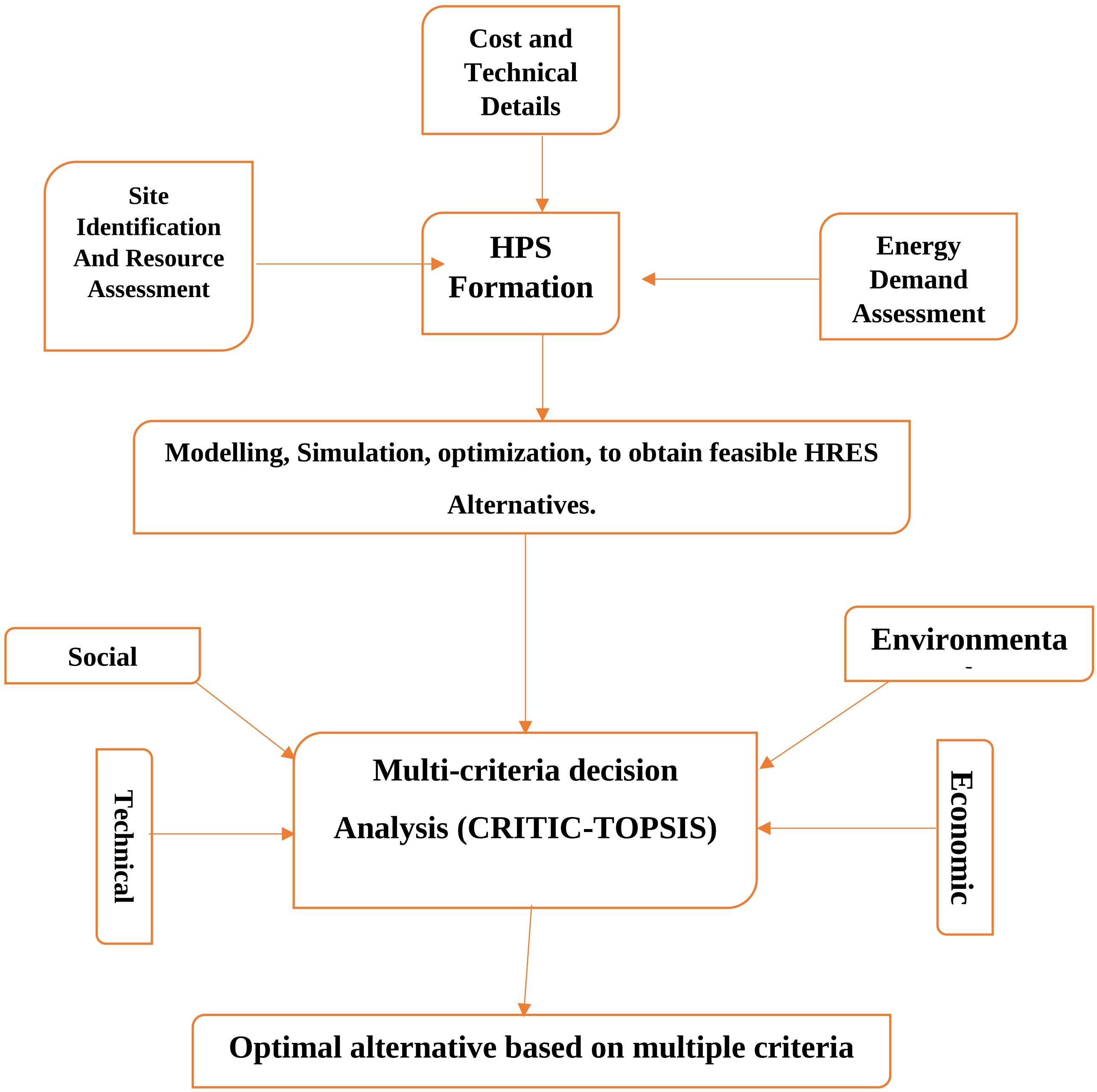


Figure 6.4: HPS Formation

6.2 Sustainable Electricity Supply

6.2.1 Power system stability and control

Power system stability refers to the ability of a power grid to maintain a balanced and reliable operation under normal and abnormal conditions. It involves maintaining a stable frequency, voltage levels, and ensuring that power generation matches power consumption. Power system stability is crucial for the reliable and efficient operation of electrical grids.

A hybrid grid system refers to a power system that incorporates multiple sources of energy and integrates different types of generation technologies. It typically combines conventional power plants, such as coal, gas, or nuclear, with renewable energy sources like solar, wind, or hydro. Hybrid grids also incorporate energy storage systems to balance the intermittency of renewable sources and improve system reliability.

Stability and control in hybrid grid systems are essential to ensure the efficient operation and integration of diverse energy sources. Here are some key aspects related to power system stability and control in hybrid grid systems:

6.2.2 Frequency Stability & Voltage stability

Frequency and Voltage Control: Maintaining a stable frequency and voltage is critical for power system stability. In a hybrid grid, control mechanisms are necessary to regulate frequency and voltage levels, considering the characteristics of both conventional and renewable generation sources. Control strategies may include automatic generation control (AGC) to balance generation and load, as well as voltage regulation techniques.

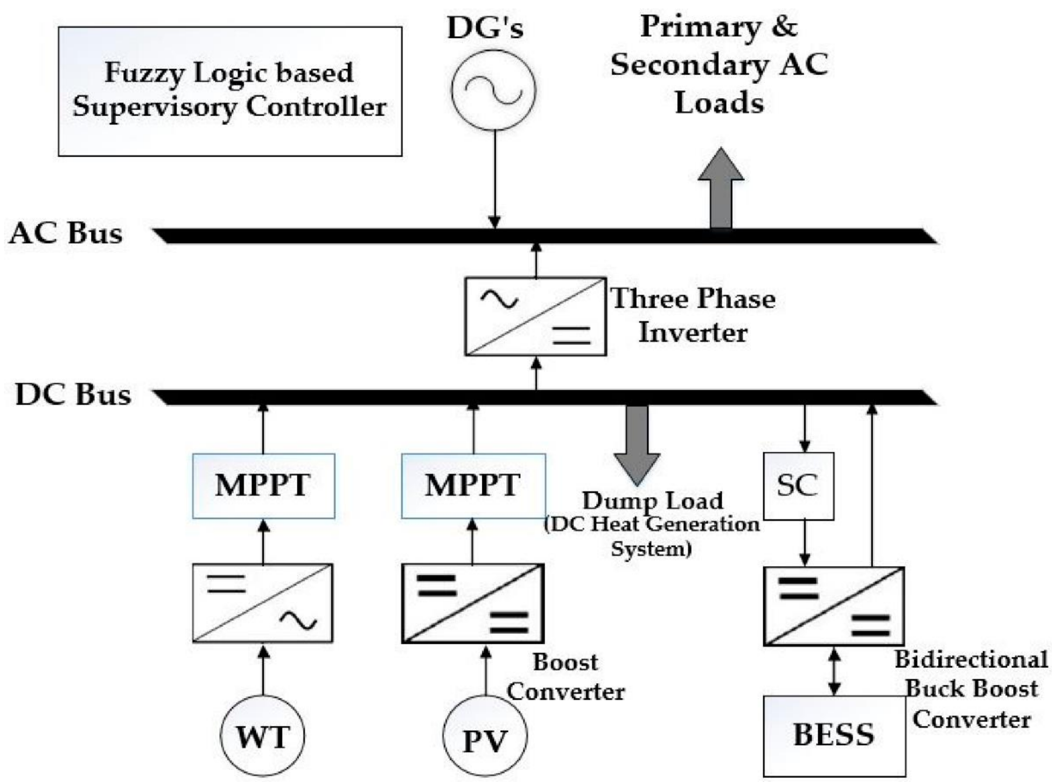


Figure 6.5: Frequency Stability & Voltage stability

6.2.3 Solar Energy Substation to Grid

When connecting a solar energy system to the grid, a solar energy substation is typically employed to facilitate the integration and transmission of power between the solar installation and the grid. Here's an overview of the process:

Solar Power Generation: The solar energy system consists of photovoltaic (PV) panels that convert sunlight into DC (direct current) electricity. Multiple solar panels are usually connected in series and parallel to form an array, which generates electricity when exposed to sunlight.

Inverter Conversion: The DC electricity generated by the solar panels needs to be converted into AC (alternating current) electricity to match the grid's AC power characteristics. Inverters are used for this purpose. They convert the DC power from the solar panels into AC power, which is synchronized with the grid frequency and voltage levels.
Step-Up Transformer: After the power is converted to AC, it goes through a step-up transformer. The transformer increases the voltage level of the AC power to match the grid's transmission voltage. This step is necessary to minimize transmission losses during the power transfer from the substation to the grid.
Monitoring and Control: The solar energy substation incorporates monitoring and control systems to ensure the smooth and reliable operation of the solar energy system. These systems monitor the performance of the solar panels, inverters, and other equipment, collecting data on power generation, voltage levels, and other parameters. Control mechanisms may be implemented to regulate the output of the solar energy system based on grid requirements or to comply with grid codes and regulations.
Grid Connection: Once the power has been stepped up to the appropriate voltage level, it is connected to the grid through transmission lines or distribution networks. The solar energy substation usually includes protection devices, such as circuit breakers and relays, to detect and isolate any faults that may occur during the connection to the grid.
Metering and Billing: Metering systems are installed to measure the amount of electricity generated by the solar energy system. These meters can provide data on the energy generated, exported to the grid, or consumed on-site. The electricity generated by the solar energy system can be used to offset the electricity consumed from the grid, potentially leading to net metering or feed-in tariff arrangements, depending on local regulations.
It's important to note that the specific configuration and components of a solar energy substation can vary depending on the scale of the solar installation, grid requirements, and regional regulations. Local electrical codes and grid interconnection standards should be followed to ensure compliance and safe operation.

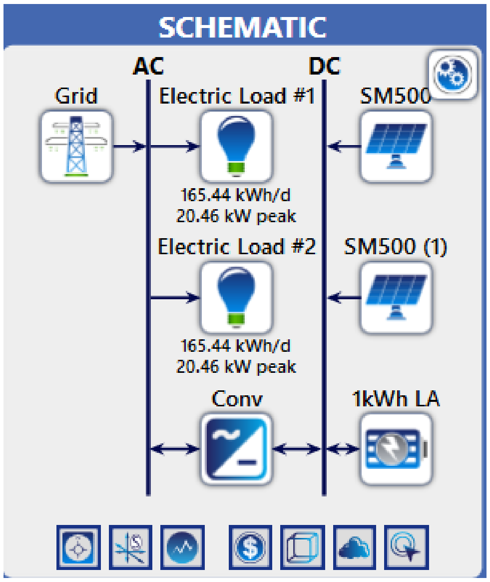


Figure 6.6: Solar Power Schematic Diagram

6.2.4 Wind Energy Substation to Grid

When connecting a wind energy system to the grid, a wind energy substation is typically used to facilitate the integration and transmission of power between the wind turbines and the grid. Here's an overview of the process:
Wind Turbine Power Generation: Wind turbines convert the kinetic energy of the wind into mechanical energy through their rotating blades. The mechanical energy is then converted into electrical energy using

a generator within the turbine. Multiple wind turbines are usually installed in an array, forming a wind farm.

Collection and Step-Up Transformers: The electrical energy generated by the wind turbines is collected through an array of underground or overhead cables, depending on the wind farm's layout. These cables carry the electricity to a collection substation, where step-up transformers are employed. The step-up transformers increase the voltage level of the electricity to match the grid's transmission voltage, minimizing transmission losses.

Monitoring and Control: The wind energy substation incorporates monitoring and control systems to ensure the efficient and reliable operation of the wind farm. These systems monitor the performance of the wind turbines, transformers, and other equipment, collecting data on power generation, voltage levels, and other parameters. Control mechanisms may be implemented to optimize the wind turbine output, regulate reactive power, or comply with grid codes and regulations.

Grid Connection: After the power is stepped up to the appropriate voltage level, it is connected to the grid through transmission lines or distribution networks. The wind energy substation includes protection devices, such as circuit breakers and relays, to detect and isolate any faults that may occur during the connection to the grid.

Metering and Billing: Metering systems are installed to measure the amount of electricity generated by the wind farm. These meters provide data on the energy generated, exported to the grid, or consumed on-site. Similar to solar energy systems, wind energy systems may also be eligible for net metering or feed-in tariff arrangements, depending on local regulations.

Ancillary Services and Grid Integration: In addition to power generation, wind farms can provide ancillary services to support grid stability and reliability. These services may include frequency regulation, voltage control, or reactive power support. Wind farms with advanced control capabilities can actively participate in grid management through various grid integration mechanisms such as grid codes, power purchase agreements, or energy market participation.

It's important to note that the specific configuration and components of a wind energy substation can vary depending on factors such as the wind farm's capacity, grid requirements, and regional regulations. Local electrical codes and grid interconnection standards should be followed to ensure compliance and safe operation.

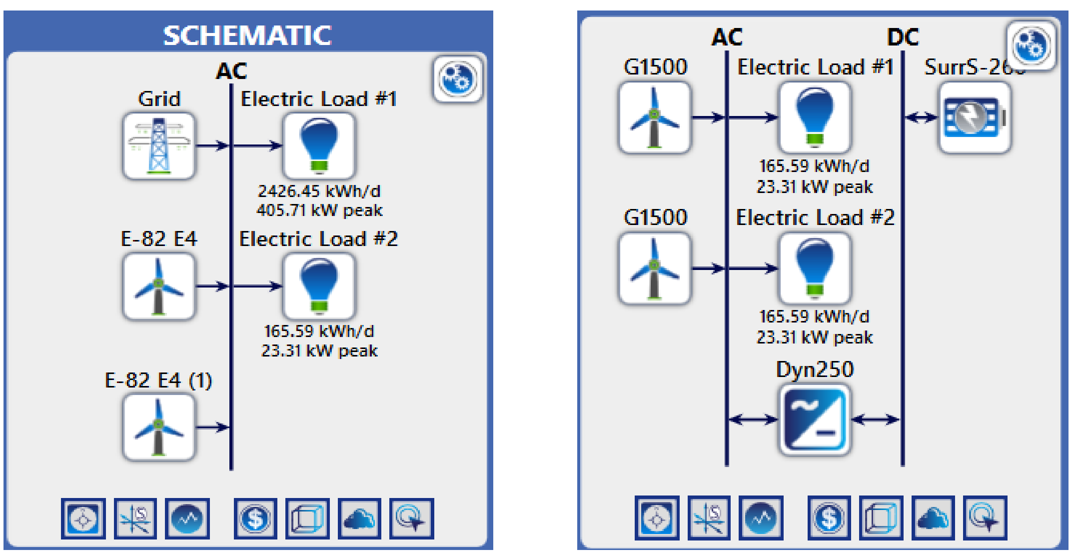


Figure 6.7: Wind Power Schematic Diagram

6.2.5 Hydro Energy Substation to Grid

connecting a hydro energy system to the grid, a hydro energy substation is typically used to facilitate the integration and transmission of power between the hydroelectric power plant and the grid. Here's an overview of the process:

Hydroelectric Power Generation: A hydroelectric power plant harnesses the potential energy of water stored in a reservoir or flowing in a river. The water is directed through turbines, which convert the kinetic energy of the water into mechanical energy. The turbines are connected to generators, which then convert the mechanical energy into electrical energy.

Generator Step-Up Transformer: The electrical energy generated by the hydro turbines is typically in the form of low-voltage AC (alternating current). The voltage is increased through a generator step-up transformer to match the grid's transmission voltage. This step-up transformer is responsible for increasing the voltage level, minimizing transmission losses, and facilitating power transfer.

Monitoring and Control: The hydro energy substation includes monitoring and control systems to ensure the efficient and reliable operation of the hydroelectric power plant. These systems monitor parameters such as power output, water flow rates, voltage levels, and other operational parameters. Control mechanisms may be implemented to optimize the power generation, synchronize the hydro units with the grid, and regulate reactive power.

Grid Connection: Once the power has been stepped up to the appropriate voltage level, it is connected to the grid through transmission lines or distribution networks. The hydro energy substation incorporates protection devices, such as circuit breakers and relays, to detect and isolate any faults that may occur during the connection to the grid.

Metering and Billing: Metering systems are installed to measure the amount of electricity generated by the hydroelectric power plant. These meters provide data on the energy generated, exported to the grid, or consumed on-site. Similar to other renewable energy sources, hydroelectric power plants may be eligible for net metering or feed-in tariff arrangements, depending on local regulations.

Ancillary Services and Grid Support: Hydroelectric power plants can provide ancillary services to support grid stability and reliability. They can quickly adjust their power output to help balance supply and demand, provide frequency regulation, and offer reactive power support. These services contribute to the stable operation of the grid and assist in maintaining voltage and frequency levels within acceptable limits.

It's important to note that the specific configuration and components of a hydro energy substation can vary depending on factors such as the capacity of the hydroelectric power plant, grid requirements, and regional regulations. Local electrical codes and grid interconnection standards should be followed to ensure compliance and safe operation.

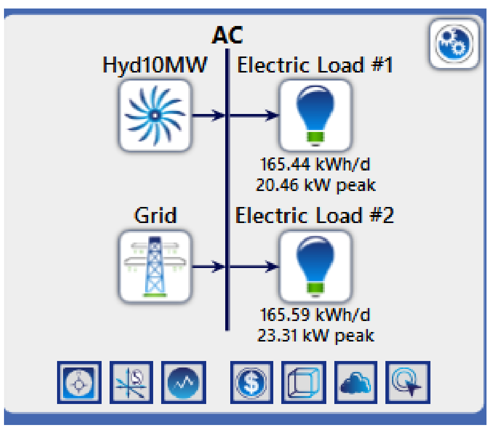


Figure 6.8: Hydro Power Schematic Diagram

6.3 Lesson Farms in gride Stability

6.3.1 Gride control

Intermittency Management: Renewable energy sources like solar and wind can be intermittent, meaning their power output fluctuates with weather conditions. Energy storage systems, such as batteries or pumped hydro, can help smooth out these fluctuations by storing excess energy during periods of high generation and supplying it during low generation. Advanced control algorithms are employed to optimize the use of storage systems and mitigate the impacts of intermittency.

6.3.2 Primary Control

Grid Synchronization: Hybrid grid systems often involve the integration of different types of generators, each with its own characteristics and control requirements. Grid synchronization ensures that the different generators operate in synchronization with each other and with the grid. Control techniques, such as phase-locked loops (PLL), are employed to achieve accurate synchronization and maintain stable grid operation.

6.3.3 Secondary control

Power Flow Control: Power flow control in hybrid grids involves managing the flow of power between different energy sources, energy storage systems, and the grid. This control is essential to ensure that power is efficiently dispatched, maintain grid stability, and prevent overloading of transmission lines. Advanced power flow control methods, including optimal power flow (OPF) and flexible AC transmission systems (FACTS) devices, are used to optimize power flow and maintain system stability. [67]

6.3.4 Weather Dependency of Renewable Energy Sources

Fault Detection and Isolation: Hybrid grid systems require effective fault detection and isolation mechanisms to identify and isolate faults promptly. Faults can occur due to various reasons, such as equipment failures or disturbances in the grid. Rapid fault detection and isolation help minimize the impact of faults, prevent cascading failures, and ensure system stability. Protective relays, fault detection algorithms, and communication systems play a crucial role in fault detection and isolation.

Overall, power system stability and control in hybrid grid systems require a combination of advanced control algorithms, monitoring systems, and integration techniques to manage the diverse generation sources and maintain a reliable and stable operation. Continuous research and development in this field are essential to address the challenges and optimize the performance of hybrid grid systems.

6.4 Lesson Electricity Supply in Bangladesh

6.4.1 Geography

Bangladesh is situated in the northeastern region of South Asia and shares its closest neighbor, India, with its longest three geographic borders approximately (4000 km), which are separated by 2410'0″N latitude in the north and 9010'0″E longitude in the east. The Bay of Bengal is the southern border, and Myanmar is in the far southeast. Geographically, it occupies a geographical area of 147,570 sq km and is primarily covered by a low-lying land delta by the river zones of the Brahmaputra and Ganges. One of the most populous countries in the world, Bangladesh has 1156 inhabitants per square kilometer. 80 percent of the country's inland portions are in floodplain zones, and the mean elevation in coastal areas is 0.8 meters. However, some southeast and northeast zones are over 1000 m above sea level, and north-east basin zones can be found up to 3-6 m above sea level in their mean altitude. Bangladesh is located in the Gangetic delta, which normally has an unsteady monsoon climate that is warm and wet in the summer and dry in the winter.

The lowest average temperature occurs in January, averaging around 10-15°C, and the highest average temperature is between April and July, averaging around 33–41°C. The usual climate is primarily humid, with annual rainfall ranging from 1525 mm (60 in.) to 5080 mm (200 in.) depending on the area. The country gets relatively dry weather throughout the year, with the heaviest rain falling from June to September. As a sub-tropical zone, it is extremely hot and humid with a wide range of rainfall.

6.4.2 Climate

Bangladesh's electricity will be produced by fossil fuels in 2022 approximately hundred percentage. To fulfill its rising demand, it still mainly relies on gas (59%), but coal's proportion in the energy mix has increased recently (from 3% in 2015 to 15% in 2022). The 2022 power crisis was largely caused by two things: an intense dependence on gas and a lack of alternative, clean energy capability.

Bangladesh lags other Asian nations in the decarbonization of its electrical industry by a wide margin. Bangladesh has only just begun its solar and wind adventure, according to Ember's Global Electricity Review 2023, with less than 1% of the nation's electricity coming from these sources in 2022. Its non-fossil generating share decreased from 3% to 2% between 2015 and 2022. while the average for Asia went from 24% to 32%. Compared to other South Asian nations like Pakistan (43%), Sri Lanka (38%) and India (23%), it has the least percentage of clean energy. The target of 25% of its electricity being clean by 2030 is now being considered for Bangladesh's forthcoming Integrated Energy and Power Master Plan (IEPMP). According to the IEA, Bangladesh must fully decarbonize its power by 2040 and achieve net-zero status by 2050 in order to keep warming worldwide to 1.5C.

Bangladesh's climate is evolving in accordance with a worldwide trend. Solar, wind and hydro power consumed not climate impact of the environmental policy making system. In recent years, Bangladesh has experienced an upward trend in temperature and yearly precipitation, changes in seasonal patterns of rain, greater severity and frequency of severe droughts, and an elevation in the salinity of river water. Climate change will have a variety of impacts on Bangladesh's power production, transmission, and consumption. Bangladesh's energy sector already faces a number of serious issues, such as high system losses, low plant efficiency, a significant supply-demand mismatch, etc. Extreme weather events and a variable climate can make these issues worse. Early intervention can significantly lessen the harmful effects of climate change on Bangladesh's power sector. The report focuses on how the climate is changing. And associated extreme weather occurrences, as well as any potential effects on Bangladesh's power sector and any potential remedial actions. It is anticipated that this research will help a variety of interested parties and lawmakers in the nation better understand the effects of climate change on the power sector and will aid in directing the development of policy.

6.4.3 Economy

In Bangladesh's industrial and agricultural industries, electrical is a key source of power. The combined contribution of these two industries to Bangladesh's GDP is 50.3%. Modern life is impossible without electricity, which is also crucial to the economy of the nation. Electricity is used by people to run appliances, computers, electronics, machinery, and public transit systems as well as for lighting, heating, cooling, and refrigeration. Approximately 7% of the GDP and 35% of governmental investment are made in the power sector. For the nation's economy to grow, a dependable electrical supply is essential. Bangladesh's primary sources of energy that are environmentally friendly include wind, hydro, and solar electricity. Reduced fuel costs result in decreased production costs for electricity. It also implies that, unlike with natural gas or coal, the price of electricity is not affected by changes in the price of fuels. Over time, this might result in energy prices that are more stable. Bangladesh now uses only 3.5% of its energy from renewable energies, includes off-grid sources. In comparison to other international economies, Bangladesh has made ambitious goals for the use of clean energy at COP26. A target of 4,100 MW of green power is mentioned in the Nationally Determined Contribution (NDC) for the year 2030.

6.4.4 Electricity Avidity in Bangladesh

Bangladesh has already adopted a master plan in the area of clean energy, despite the country's proportion of environmentally friendly energy in the current energy mix being barely 3%.

Agricultural land and solar projects:

The acute lack of land available is the singular largest obstacle to the large-scale adoption of solar PV electricity. Land accessibility is less of a concern than the regulation, which completely prohibits the use of agricultural land for solar projects. Due to the extreme land fragmentation in Bangladesh, it is very challenging to obtain continuous land to build even a 50 MW solar park without encroaching on land used for agriculture. As a result, rather than outright prohibiting it, a policy may be created that allows a specific percentage of cultivated land, say 25% of the total land area of a single solar park, for a maximum of 200 acres per project. Only 1% of Bangladesh's entirety of agricultural land might be used to build solar energy plants with a combined capacity of about 50,000 MW. The electricity generated from a single percent of land used for agriculture is almost 82,000 GWh, which is greater than the entire consumption in 2020 using an average capacity factor of 4.5 hours per day for Bangladesh. The financial benefits will exceed five times when the cost of fuel saved is contrasted with the output of even three crops per acre of land. By avoiding spoilage brought on by a shortage of chilly storage and other processing facilities, the agricultural yield lost by only one percent of land can be readily made up.

6.5 Lesson Backup System

6.5.1 Battery System

Any electronic device that controls a battery that can be recharged, such as by safeguarding it from working outside of its safe operating range, monitoring its condition, figuring out secondary information, reporting that data, regulating the environment in which it operates, authenticating it, and/or balancing it, is referred to as a battery managing system.

6.5.2 Diesel Generator Set

6.5.3 Frequency And Voltage Control Concept

voltage control concept: The generator's frequency or stimulation (flux) are directly related to its voltage. The stimulation is used to regulate the voltage while maintaining a consistent speed. Consequently, the automated voltage regulator (AVR) or excitation control system is another name for the voltage management system. A significant problem in the operation of a power system is the management of voltage and reactive energy. Different tactics have developed as a result of the topological variations among transmission as well as distribution networks.

Frequency Control Concept: A synchronous electricity grid has constant frequency throughout. It is thought that one crucial condition for power system performance is to maintain a frequency that is almost constant (one may allow the frequency to change across a very narrow range). In a power framework, frequency and electrical power generated by synchronous turbines are connected. The acceleration of a generator's rotor is controlled by the difference between mechanically and electrical torques.

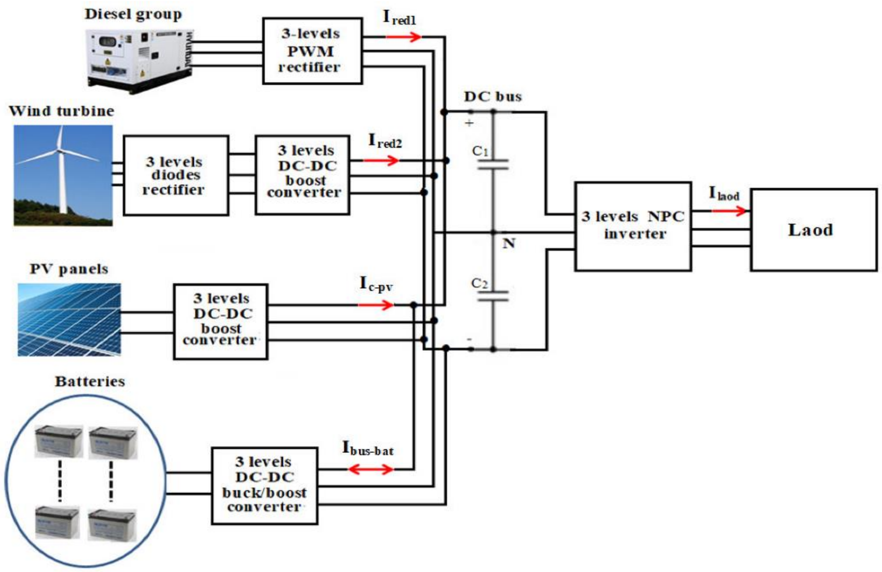


Figure 6.9: Frequency control concept

6.6 Lesson Overview of HOMER Software

6.6.1 System Sizing Using Homer

The entire amount of energy used by electrical equipment in a domestic, or home, environment, is known as a domestic demand. This varies naturally across households and dramatically between various nations.

Table 6.1: Cost Analysis

PV System			
Size (kW)	Capital ($)	Replacement ($)	O&M ($/yr)
12	22,473	13,620	150
Generator			
Size (kW)	Capital ($)	Replacement ($)	O&M ($/hr)
2,600	2,475,000	1,500,000	52
Batteries			
Quantity	Capital ($)	Replacement ($)	O&M ($/yr)
24	53,987	32,719	240
Converter			
Size (kW)	Capital ($)	Replacement ($)	O&M ($/yr)
100	31,755	19,246	120

The hybrid evaluation framework for electrical power that is renewable (HOMER) makes it simple to assess the technical and financial viability of various technological choices while accounting for changes in technology prices and the availability of energy resources. A Using HOMER, an energy system designer may give a crucial overview that contrasts the costs and viability of various configurations and assesses the technical efficacy of the power system. Homer ver. a free program from the National Renewable Energy Laboratory, is utilized in this investigation.

6.6.2 System Block Diagram

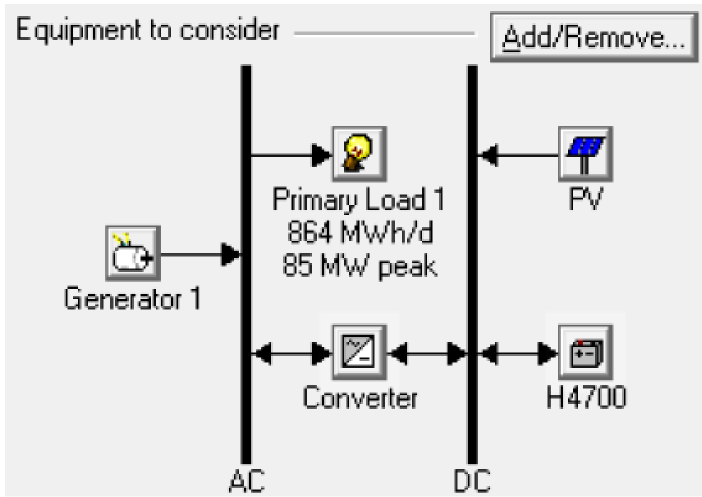


Figure 6.10: Block Diagram

6.6.3 Optimized System

PV (kW)	Gen1 (kW)	H4700	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Diesel (L)	Gen1 (hrs)	Batt. Lf. (yr)
76800	62400	3360	55000	$ 228,250,624	49,173,968	$ 856,859,008	0.213	0.32	71,004,416	6,897	20.0
	62400	4560	20000	$ 76,008,528	61,106,280	$ 857,151,872	0.213	0.00	90,582,080	8,554	20.0
	70200			$ 66,825,000	67,978,608	$ 935,819,840	0.232	0.00	99,838,216	8,760	
100800	70200		55000	$ 273,063,456	58,314,064	$ 1,018,512,896	0.253	0.34	83,226,944	7,441	

Figure 6.11: Cost Optimized System

Table 6.2: Power Output

PV	76,800 kW
Generator sets	62,400 kW
Inverter	55,000 kW
Rectifier	55,000 kW
Batteries	3,360

6.6.4 Cost Analysis

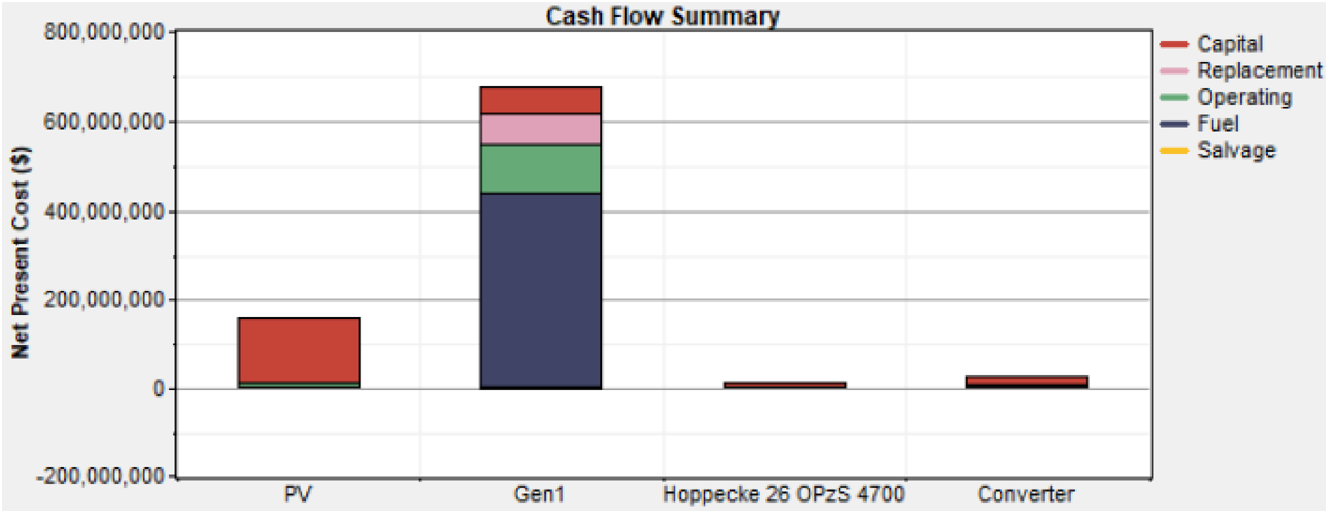


Figure 6.12: Cash Flow

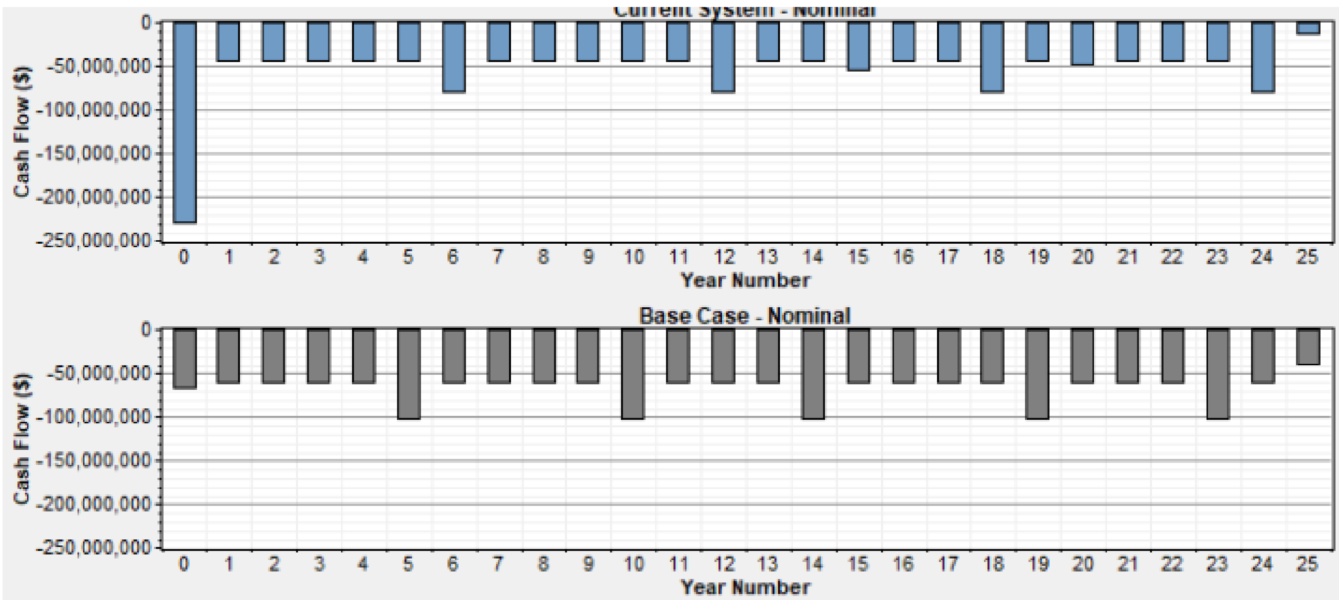


Figure 6.13: Data Analysis

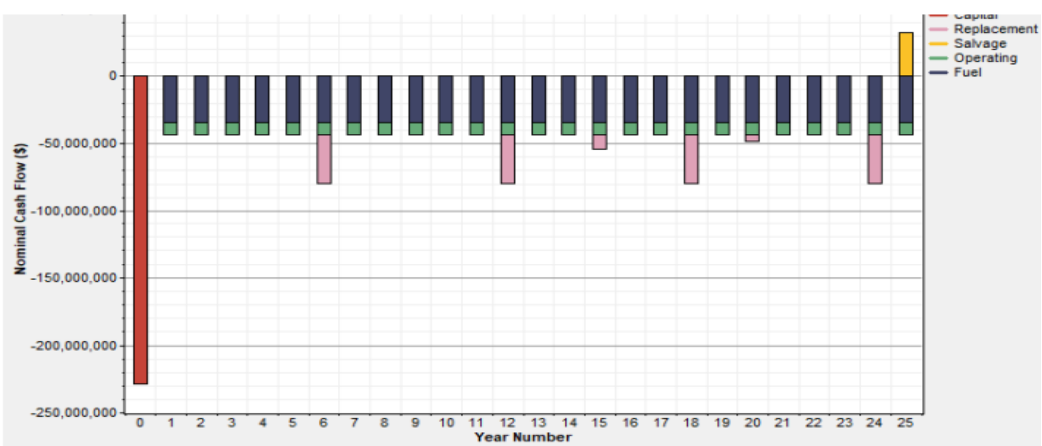


Figure 6.14: Nominal Cost

6.6.5 Monthly Average Electric Production

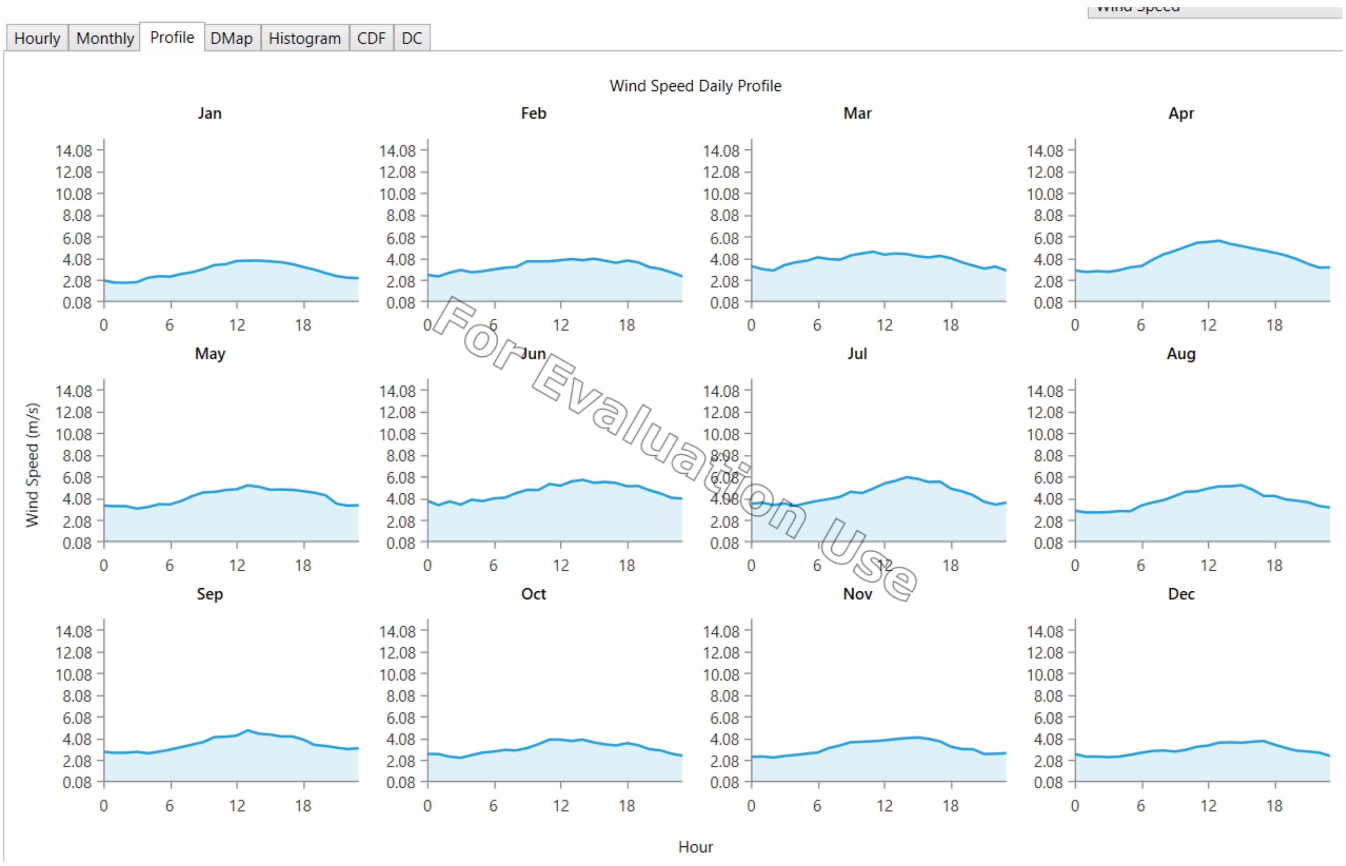


Figure 6.15: Monthly Average Electric Production

6.6.6 Irrigation System Load

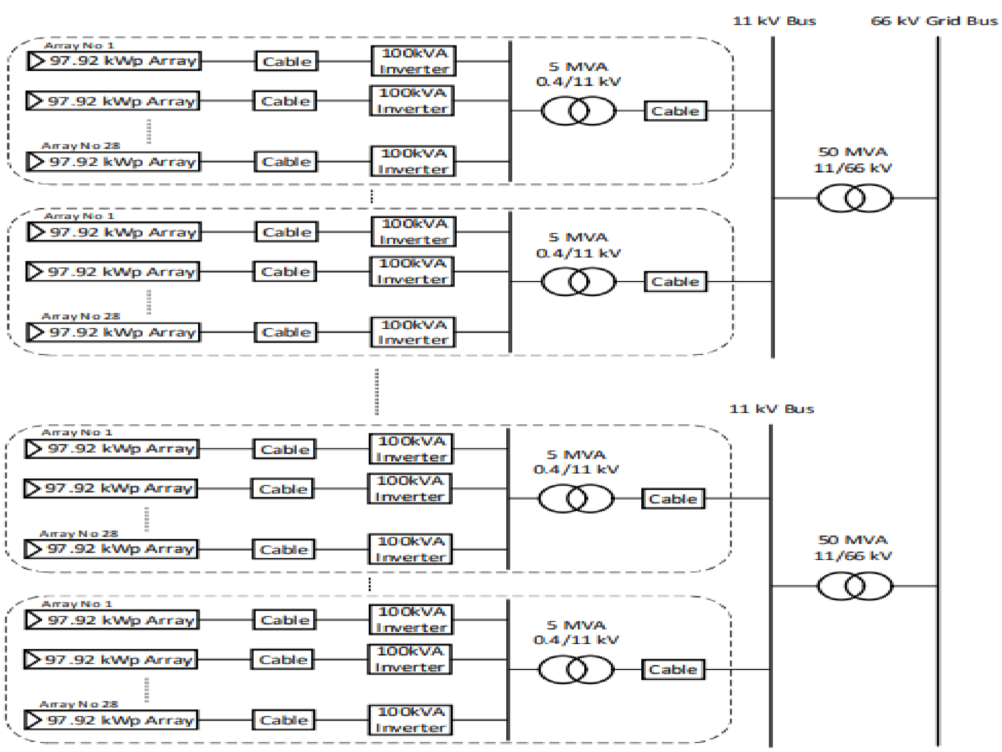


Figure 6.16: Load Busbar System

Water is artificially delivered to the soil by a variety of tube, pump, and spraying systems. In regions with erratic rainfall, dry spells, or potential drought, irrigation is frequently employed. There are many different kinds of irrigation systems, where water is distributed evenly throughout the entire area.

6.7 Lesson Optimization Input of Hybrid System

6.7.1 Electricity load input

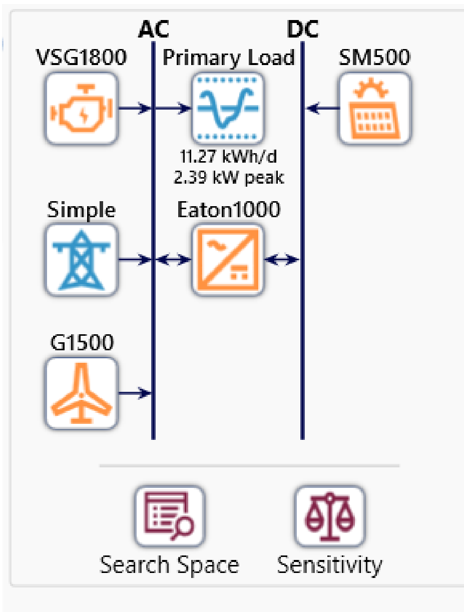


Figure6.17: Electric Load Input

6.7.2 Economic Optimization Result and Financial Analysis

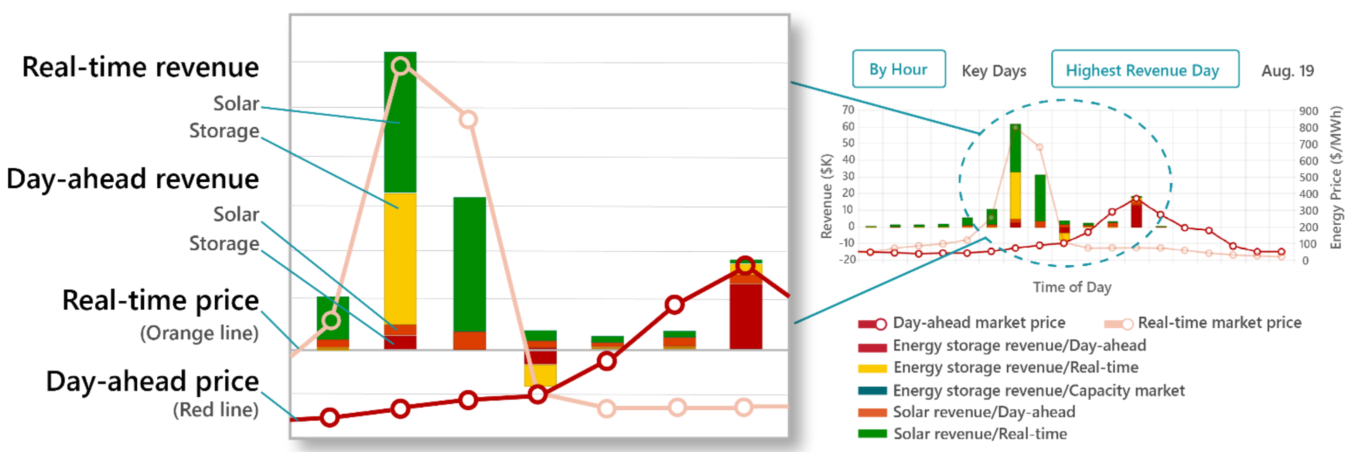


Figure 6.18: Economic Optimization Result and Financial Analysis

6.7.3 Newton-Raphson Method

Newton's Method in the Case f′(α) = 0

The Newton–Raphson method was derived under the assumption that $f'(x) \neq 0$, implying in particular that $f'(\alpha) \neq 0$. Let us now consider the general solution were

(11.258) $f(\alpha)=f'(\alpha)=\ldots fm-1(\alpha)=0$

with $f^m(\alpha) \neq 0$, where $m \geq 1$. If we set $x = \alpha + h$, the for-Newton's process, namely

(11.259) $G(x)=x-f(x)f'(x)$

can be expanded in powers of h to give

(11.260) $G(\alpha+h) =\alpha+h-(m!)\ -1fm(\alpha)hm+O(hm-1)\ (m-1)!\ -1fm(\alpha)hm-1+O(hm)$

or

(11.261) $G(\alpha+h) =\alpha+h-1\cdot hm+O(h2)$

From this we find

(11.262) $G'(\alpha)=limh\rightarrow 0G(\alpha+h)\ -G(\alpha)h=1-1m$

Thus, if $m \neq 1$, and $G'(\alpha) \neq 0$, the condition for proved earlier as $G'(\alpha) = 0$ is not satisfied. However, the preceding analysis shows how to modify the iteration function in order to achieve quadratic convergence. If we set

(11.263) $G(x)=\alpha-mf(x)f'(x)$, for $x\neq\alpha=\alpha$, for $x=\alpha$

then a computation similar to the one performed before shows that $G'(\alpha) = 0$. By the theorem of quadratic convergence, the sequence defined by

(11.264) $xn+1=xn-mf(xn)f'(xn)$, for $n=0,1, \ldots$

converges to α quadratically provided that x_0 is sufficiently close to α. For $m = 1$, the algorithm reduces to the ordinary Newton process. Although only rarely, in practice, have we *a priori* knowledge of the fact $f'(x) = 0$ at a solution of $f(x) = 0$, the method has been used successfully in many cases (vide Greenspan) and m is chosen in a heuristic fashion to lie somewhere between 1 and 2.

The Newton-Raphson Method

As in the previous discussions, we consider a single root, x_r, of the function f(x). The Newton-Raphson method begins with an initial estimate of the root, denoted $x_0 \neq x_r$, and uses the tangent off(x) at x_0 to improve on the estimate of the root. In particular, the improvement, denoted x_1, is obtained from determining where the two f(x) at x_0 crosses the x-axis. This represents a single iteration of the Newton-Raphson method and is illustrated. The next iteration uses the line tangent to f(x) at x_1 to generate x_2 in exactly the same way. The direction of the is determined by the sign of the local gradient at each x_n and, although the illustration has a positive local gradient, the method works analogously for functions with a negative local gradient.

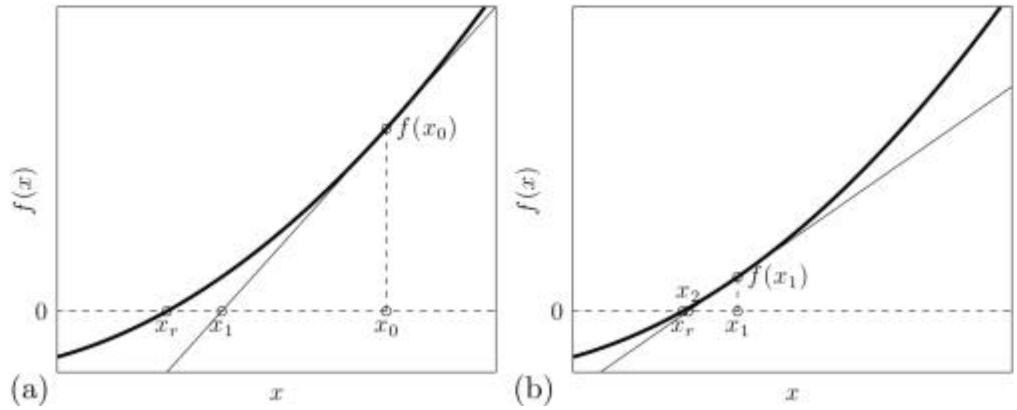


Figure 6.19: Newton-Raphson method Data Carve

Illustratio gent line at $f(x_0)$. (b) Second iteration leading to x_2 from the tangent line at $f(x_1)$.

Before we discuss the termination criteria for the Newton-Raphson method, it is important to consider the mathematical formulation of the first iteration of the process. Essentially, we require a expression that gives x_1 from x_0 and the properties of $f(x)$ at x_0. The gradient of the line tangent to $f(x)$ at x_0 is, by definition, $f'(x_0)$ which can be determined from the expression of $f(x)$. We can also form an approximation to this gradient from the fact that the tangent line crosses the points $(x_0, f(x_0))$ and $(x_1, f(x_1)) \approx (x_1,0)$; which of course arises from the definition of x_1. The gradient is then

$f(x_0)\ -0 x_0 - x_1$

which is equated to $f'(x_0)$ and rearranged to give

$x_1 = x_0 - f(x_0)\ f'(x_0)$

That is, we have an expression for estimate x_1 determined entirely from known properties of the function at x_0. Clearly the expression assumes that $f'(x_0) \neq 0$. If this was the case, the tangent line of the function at x_0 would be horizontal and not cross the x-axis; the Newton-Raphson method would then have failed to improve on x_0.

CHAPTER 7

7.1 CHAPTER RESULTS AND DISCUSSIONS

7.1.1 RESULTS

Bangladesh has significant potential for utilizing a variety of sources of clean energy, which might create new opportunities for the country's electricity production and energy security. Solar, wind, and hydropower are a few examples of renewable energy sources with good potential for producing electricity. The total amount of anticipated green energy in the thesis is pretty astounding when looking at the production of electricity from renewable sources. This paper mainly planning Rangpur Division for human life development,energy crisis solved, land recovery, clean energy etc.Location of Khalisha Chapani,Dimla Upazila,Bangladesh in solar plant another of places wind turbine in Chilmari,Kurigram remote area, hydro power in the two sites area of Khalisha and Chilmari .This paper mainly result calculated some of software name is Global Solar Atlas, Global wind atlas,CFD Support & GoLab and Homer Pro .Then the software of Homer Pro will display a variety of outputs after receiving the desired input. We opt for the least expensive and most efficient system. Once a choice has been made, each component's details will be displayed. Irrigation of this system in remote area in Out of the total amount of solar pumps, 1,270 were built using funding provided by the Infrastructure Development Company Ltd. a state-owned non-bank financial enterprise. A total of 28.78 megawatts per hour may be generated by these solar irrigation pumps. Its hopes to have 50,000 solar irrigation pumps installed by the year 2025. In order to achieve this, the government gave the firm low-interest finance. The government intends to switch out diesel-powered pumps with solar-powered ones that can produce 150 megawatts of electricity, according to a senior official at Bangladesh's Sustainable and Renewable Energy Development Authority (SREDA). Numerous groups and institutions are encouraging the use of solar-powered irrigation pumps around the country as a way to reduce carbon emissions. There are already 1,446 solar irrigation pumps in the country, with a combined 31 megawatts of hourly generation capacity. Irrigation of solar power available in our probably generated power produced loved of the Teesta besides area and over ally Rangpur division area site. Yearly total PV Panels are generated is 49640 MW Generated by Electricity by the Sunway solar panel 500-watt is the model of panel. Annual Averages is the one Wind Turbine production the power 10384MWh, some losses so, approximately power is 912.5MWh in year. One 3.00MW wind turbine is about 9864m in size. Wind turbine total 49 Inverter, batteries and others equipment added in plant. This paper power of the total Solar plant power per day 136MW continually, Wind Plant Produce the power daily 118.58MW and the Hydro Power plant two sites of Teesta and Dharla flooded time the power plant Produced the power is 97.99MW is Continually 6 months in May to September yearly fully supported. So, the total power is approximately 352.57MW daily power generated. The most significant industry is solar power generating, which can produce around of 140MW loaded in daily power. Rangpur Division area power Sources of Northern Electricity Supply Company (NESCO) said that the electricity demand in Rangpur division including rural electricity is 950 to 1000 MW at night. And the daily demand is 760 to 780 MW. This power is daily added in grid and Rangpur area most of people irrigated solution available power.

7.1.2 DISCUSSIONS

The total of hybrid energy this paper daily loaded approximately three hundred twenty-megawatt generated power so the remote area Rangpur Division demand energy safe is big opportunity for the country power system and overall, the total human life impacts this energy generated. The hybrid model load compares to the load in demand one third of this area power system. Some of load included area and effects of electricity this humanity, irrigated, land replaces of the main grid connected. Over time, fossil fuel-generated power is losing ground to green power in terms of cost-effectiveness. Future needs for electricity can be met and greenhouse emissions of gases can be significantly reduced thanks to clean energy sources. For the project to be implemented, a cost study is crucial. For the industry of electricity generating, cost management is a crucial factor. Bangladesh needs to place more emphasis on the execution of power stations costs. Government decision-making will be aided by cost analyses of electricity projects. The potential sources of renewable energy are presented in this thesis.

CHAPTER 8
CONCLUSION AND FUTURE WORK

8.1 CONCLUSION FOR FUTURE WORK

Bangladesh is currently on the cusp of using conventional fossil fuels to generate power. There is no other option to transition power production from fossil fuels to sustainable energy sources for the purpose of future energy security. Projects like imported power or utilizing non-renewable power are all possible for immediate solutions.

Cost continues to be the main obstacle to more market-driven adoption of solar technologies. Policies that favor solar energy are primarily to blame for its current expansion. Given current technology and predictions of their future advancements over the short to medium range, continuation and expansion of expensive existing supports would be necessary for several decades in order to increase the further deployment of solar energy in both developed and developing countries. It will take significant additional spending to support practical research and development and to pay the estimated expenses of first developments in commercial-scale upgraded technology manufacturing capacity in order to overcome the current technological and economic constraints. In our perspective, wind energy has numerous positives, such being less expensive than factories, using less space, being freely accessible worldwide, and not harming the environment, hence the benefits outweigh the drawbacks. As a result, wind energy is also more practical than conventional energy production techniques. indicating that producing wind energy is becoming more and more affordable. Our thesis Project area in Rangpur Division and Location of total area overview Chilmari, Kurigram District, & Khalisha Chapani, Dimla Upazila, Rangpur, Bangladesh. A solar power plant uncultivated Land generates about 136 MW of electricity each day. Another of power produce wind energy 49 turbines in a wind farm produce 118.58 MW of power daily on average. From May October, a hydroelectric power plant continuously produces 97.99 MW of electricity. Finally, 352.57 MW is the total amount of power. Economic impact can lead to job growth in the renewable energy industry and lower project operating and capital costs. Impact on society in nations with restricted access to energy, this technology is absolutely essential. Global impact reducing greenhouse gas emissions and other pollution linked to fossil fuels, Homer-based models help slow down climate change.

Electricity generation from hydropower facilities is a necessity for the entire world. A dependable and efficient fuel is water. It is essential to keep pursuing the use, development, and building of power plants. Hydroelectricity, a different form of energy, is produced by altering the natural flow of a river or other body of water by a dam or other structure. According to hydropower plant studies in the Teesta Region, the Teesta barrage Project (Demonstration project of Teesta River comprehensive management), China, reveals that the locations are showing good economic benefits. To fully ensure that the endeavor is technically and commercially feasible, however, a number of steps still need to be completed. To ascertain the hydropower project's economic aspects, an economic evaluation was conducted. The annual generated energy is a key factor in this the study's revenue. However, both of the locations continue to provide positive Net Present Value, making them highly desirable development sites. As a result, the procedure of the hybrid power system is very eco-friendly. we are able to meet the ability deficit whereas additionally lowering the value of electricity generated from renewable energy sources, lowering the value and value of electricity for patrons. With the assistance of a star PV plant, wind and hydro we might be able to deliver electricity to approximately 352.57 MW of power are produced per day overall. the total NPC of this system is lowest amount of per unit electricity. So, to construct a hybrid grid-connected solar, wind, hydro project, it is necessary to reduce the load to get higher efficiency.

So, in any case of the analysis and discussion, we've determined that sustainable employing a hybrid grid system tie is that the best resolution.

8.2 Future Scope for Work

In this thesis, only the potential of solar energy at the village is included. This analysis can be extended to other places of Bangladesh where the renewable sources are available. Solar panels can be used with more advanced technologies. For the precise calculation of solar power generation potential through conducting field surveys and data analysis, more methodological work is required. Wind power system area increased and hydro power plant beside the river this thesis paper area in Rangpur division. Teesta barrage Project (Demonstration project of management) China is feasibility study and work future plan of power, Land recovery, human life development. So, over ally more research can be done in cost analysis by using real cost data of Bangladesh's existing power plants. More field survey is required to make decision about whether it is efficient or not in the perspective of Bangladesh.

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